INSTRUCTION MANUAL

DISTANCE RELAY

WITH INTEGRAL DIGITAL COMMUNICATION

GRZ100 - 211B, 214B, 216B, 311B
- 221B, 224B, 226B, 321B, 323B

TOSHIBA CORPORATION

(Ver. 0.3)

Safety Precautions

Before using this product, please read this chapter carefully.

This chapter describes the safety precautions recommended when using the GRZ100. Before installing and using the equipment, this chapter must be thoroughly read and understood.

Explanation of symbols used

Signal words such as DANGER, WARNING, and two kinds of CAUTION, will be followed by important safety information that must be carefully reviewed.

⚠ DANGER	Indicates an imminently hazardous situation which will result in death or serious injury if you do not follow the instructions.
⚠WARNING	Indicates a potentially hazardous situation which could result in death or serious injury if you do not follow the instructions.
⚠CAUTION	Indicates a potentially hazardous situation which if not avoided, may result in minor injury or moderate injury.
CAUTION	Indicates a potentially hazardous situation which if not avoided, may result in property damage.

⚠ DANGER

- **Current transformer circuit**

Never allow the current transformer (CT) secondary circuit connected to this equipment to be opened while the primary system is live. Opening the CT circuit will produce a dangerously high voltage.

⚠WARNING

- **Exposed terminals**

Do not touch the terminals of this equipment while the power is on, as the high voltage generated is dangerous.

- **Residual voltage**

Hazardous voltage can be present in the DC circuit just after switching off the DC power supply. It takes about 30 seconds for the voltage to discharge.

- **Fiber optic**

Invisible laser radiation
Do not view directly with optical instruments.
Class 1M laser product

- the maximum output of laser radiation:	0.2 mW
- the pulse duration:	79.2 ns
- the emitted wavelength(s):	1310 nm

⚠CAUTION

- **Earth**

The earthing terminal of the equipment must be securely earthed.

CAUTION

- **Operating environment**

The equipment must only be used within the range of ambient temperature, humidity and dust, etc. detailed in the specification and in an environment free of abnormal vibration.

- **Ratings**

Before applying AC voltage and current or the DC power supply to the equipment, check that they conform to the equipment ratings.

- **Printed circuit board**

Do not attach and remove printed circuit boards when the DC power to the equipment is on, as this may cause the equipment to malfunction.

- **External circuit**

When connecting the output contacts of the equipment to an external circuit, carefully check the supply voltage used in order to prevent the connected circuit from overheating.

- **Connection cable**

Carefully handle the connection cable without applying excessive force.

- **Modification**

Do not modify this equipment, as this may cause the equipment to malfunction.

- **Short-link**

Do not remove a short-link which is mounted at the terminal block on the rear of the relay before shipment, as this may cause the performance of this equipment such as withstand voltage, etc., to reduce.

- **Disposal**

When disposing of this equipment, do so in a safe manner according to local regulations.

Contents

Safety Precautions **1**

1. Introduction **9**

2. Application Notes **12**

2.1 Power System Protection - Basic Concepts 12
2.1.1 The Function of The Protection Relay 12
2.1.2 Protection Relay Requirements 12
2.1.3 Main Protection and Backup Protection 14
2.1.4 Distance Relay - General Performance 14
2.1.5 Power Swing and Out-of-Step 15
2.2 Principle of Distance Measurement 17
2.2.1 Phase Fault 17
2.2.2 Earth Fault 18
2.3 Multi-Terminal Line Protection 20
2.3.1 Increased Use of Multi-Terminal Lines 20
2.3.2 Protection Problems on Three-Terminal Application 20
2.3.3 Three-Terminal Line Protection 22
2.4 Protection Scheme 24
2.4.1 Time-Stepped Distance Protection 24
2.4.2 Zone 1 Extension Protection 40
2.4.3 Command Protection 43
2.4.4 High-Resistance Earth Fault Protection 60
2.4.5 Overcurrent Backup Protection 67
2.4.6 Thermal Overload Protection 71
2.4.7 Switch-Onto-Fault Protection 73
2.4.8 Stub Protection 75
2.4.9 Overvoltage and Undervoltage Protection 76
2.4.10 Broken Conductor Protection 83
2.4.11 Transfer Trip Function 86
2.4.12 Breaker Failure Protection 88
2.4.13 Out-of-Step Protection 91
2.4.14 Voltage Transformer Failure Supervision 93
2.4.15 Power Swing Blocking 95
2.4.16 Tripping Output Signals 99
2.5 Communication System 100
2.5.1 Integral Digital Communication Interface 100
2.5.2 External Communication Interface 110
2.6 Characteristics of Measuring Elements 113
2.6.1 Distance Measuring Elements Z1, Z1X, Z2, ZF, Z3, Z4, ZR1, ZR2, ZND and PSB 113
2.6.2 Phase Selection Element UVC 121
2.6.3 Directional Earth Fault Elements DEFF and DEFR 122

		2.6.4 Inverse Definite Minimum Time Overcurrent Element IDMT	123
		2.6.5 Out-of-Step Element OST	124
		2.6.6 Voltage and Synchronism Check Elements OVL, UVL, OVB, UVB, and SYN	125
		2.6.7 Current Change Detection Elements OCD and OCDP	126
		2.6.8 Negative Sequence Directional Elements DOCNF and DOCNR	127
		2.6.9 Level Detectors	128
	2.7	Autoreclose	129
		2.7.1 Application	129
		2.7.2 Scheme Logic	131
		2.7.3 Setting	141
		2.7.4 Autoreclose Output Signals	144
	2.8	Fault Locator	145
		2.8.1 Application	145
		2.8.2 Starting Calculation	146
		2.8.3 Displaying Location	146
		2.8.4 Distance to Fault Calculation	146
		2.8.5 Setting	150
3.	**Technical Description**		**152**
	3.1	Hardware Description	152
		3.1.1 Outline of Hardware Modules	152
		3.1.2 Transformer Module	156
		3.1.3 Signal Processing Module	157
		3.1.4 Binary Input and Output Module	158
		3.1.5 Human Machine Interface (HMI) Module	163
	3.2	Input and Output Signals	165
		3.2.1 Input Signals	165
		3.2.2 Binary Output Signals	169
		3.2.3 PLC (Programmable Logic Controller) Function	170
	3.3	Automatic Supervision	171
		3.3.1 Basic Concept of Supervision	171
		3.3.2 Relay Monitoring and Testing	171
		3.3.3 CT Circuit Current Monitoring	172
		3.3.4 Signal Channel Monitoring for Integral Digital Communication	172
		3.3.5 Signal Channel Monitoring and Testing for External Communication	173
		3.3.6 Relay Address Monitoring	174
		3.3.7 Disconnector Monitoring	174
		3.3.8 Failure Alarms	174
		3.3.9 Trip Blocking	175
		3.3.10 Setting	176
	3.4	Recording Function	178
		3.4.1 Fault Recording	178
		3.4.2 Event Recording	180
		3.4.3 Disturbance Recording	180
	3.5	Metering Function	182

4.	**User Interface**	**183**
4.1	Outline of User Interface	183
	4.1.1 Front Panel	183
	4.1.2 Communication Ports	185
4.2	Operation of the User Interface	187
	4.2.1 LCD and LED Displays	187
	4.2.2 Relay Menu	189
	4.2.3 Displaying Records	192
	4.2.4 Displaying Status Information	197
	4.2.5 Viewing the Settings	202
	4.2.6 Changing the Settings	203
	4.2.7 Testing	227
4.3	Personal Computer Interface	234
4.4	Relay Setting and Monitoring System	234
4.5	IEC 60870-5-103 Interface	235
4.6	Clock Function	235
5.	**Installation**	**236**
5.1	Receipt of Relays	236
5.2	Relay Mounting	236
5.3	Electrostatic Discharge	236
5.4	Handling Precautions	236
5.5	External Connections	237
6.	**Commissioning and Maintenance**	**239**
6.1	Outline of Commissioning Tests	239
6.2	Cautions	240
	6.2.1 Safety Precautions	240
	6.2.2 Cautions on Tests	240
6.3	Preparations	241
6.4	Hardware Tests	242
	6.4.1 User Interfaces	242
	6.4.2 Binary Input Circuit	243
	6.4.3 Binary Output Circuit	244
	6.4.4 AC Input Circuits	245
6.5	Function Test	246
	6.5.1 Measuring Element	246
	6.5.2 Timer Test	265
	6.5.3 Protection Scheme	266
	6.5.4 Metering and Recording	272
	6.5.5 Fault Locator	272
6.6	Conjunctive Tests	273
	6.6.1 On Load Test	273
	6.6.2 Signaling Circuit Test	273
	6.6.3 Tripping and Reclosing Circuit Test	275
6.7	Maintenance	277

6.7.1 Regular Testing 277
6.7.2 Failure Tracing and Repair 277
6.7.3 Replacing Failed Modules 279
6.7.4 Resumption of Service 281
6.7.5 Storage 281
7. Putting Relay into Service 282

Appendix A	**Block Diagrams**	**283**
Appendix B	**Signal List**	**287**
Appendix C	**Variable Timer List**	**323**
Appendix D	**Binary Input/Output Default Setting List**	**325**
Appendix E	**Details of Relay Menu and LCD & Button Operation**	**333**
Appendix F	**Case Outline**	**343**
Appendix G	**External Connections**	**351**
Appendix H	**Relay Setting Sheet**	**357**
Appendix I	**Commissioning Test Sheet (sample)**	**383**
Appendix J	**Return Repair Form**	**389**
Appendix K	**Technical Data**	**395**
Appendix L	**Symbols Used in Scheme Logic**	**407**
Appendix M	**Example of Setting Calculation**	**411**
Appendix N	**IEC60870-5-103: Interoperability**	**423**
Appendix O	**Programmable Reset Characteristics and Implementation of Thermal Model to IEC60255-8**	**435**
Appendix P	**Data Transmission Format**	**439**
Appendix Q	**Relay Operation under Communication Failure in Backup Carrier Scheme**	**443**
Appendix R	**Inverse Time Characteristics**	**447**
Appendix S	**Failed Module Tracing and Replacement**	**451**
Appendix S	**Ordering**	**459**

■ The data given in this manual are subject to change without notice. (Ver.0.3)

1. Introduction

GRZ100 is a fully numeric distance protection incorporating integral digital communication channels for teleprotection signalling. Either one or two communication channels are provided, suitable for relay-to-relay connection via fibre-optic links, or via electrical interfaces to a digital communication network. GRZ100 can be configured using the integral communication channels to support the following functions:

- Phase-segregated command protection distance schemes (PUP, POP, BOP and UOP with week infeed and current reversal logic).
- Phase-segregated command protection DEF schemes (POP, BOP and UOP).
- Command protection signalling for tripping during a power swing.
- Command protection for 2- or 3-terminal applications.
- Single-phase autoreclosing available for carrier tripping.
- Phase-segregated transfer trip (intertripping).
- Transmission of binary signals for user-configurable applications.
- Transmission of measured values to be displayed at the remote terminals.
- Synchronisation of the clocks at the various terminals.
- Fault-location by use of remote-end data in the case of 3-terminal applications.
- Continuous monitoring of the communication channels, with capability to provide dual-redundant channels in the case of a 2-ended system, and automatic re-routing of signals in the event of a communication channel failure in a 3-ended system.

GRZ100 can be also applied with conventional external communication channels.

Other features of GRZ100 are as follows:

GRZ100 provides the following protection schemes.

- Time-stepped distance protection with four forward zones, three reverse zones, and one non-directional zone
- Zone 1 extension protection
- High-resistance earth fault protection
- Broken conductor detection
- Overcurrent backup protection
- Thermal overload protection
- Switch-on-to-fault and stub protection
- Breaker failure protection
- Out-of-step trip protection
- Power swing blocking

The GRZ100 actuates high-speed single-shot autoreclose or multi-shot autoreclose.

The GRZ100 is a member of the G-series family of numerical relays which utilise common hardware modules with the common features:

The GRZ100 provides the following metering and recording functions.

- Metering
- Fault record
- Event record
- Fault location
- Disturbance record

The GRZ100 provides the following menu-driven human interfaces for relay setting or viewing of stored data.

- Relay front panel; 4 × 40 character LCD, LED display and operation keys
- Local PC
- Remote PC

Password protection is provided to change settings. Eight active setting groups are provided. This allows the user to set one group for normal operating conditions while other groups may be set to cover alternative operating conditions.

GRZ100 provides either two or three serial ports, and an IRIG-B port for an external clock connection. A local PC can be connected via the RS232C port on the front panel of the relay. Either one or two rear ports (RS485 or fibre optic) are provided for connection to a remote PC and for IEC60870-5-103 communication with a substation control and automation system. Further, Ethernet LAN port can be provided as option.

Further, the GRZ100 provides the following functions.

- Configurable binary inputs and outputs
- Programmable logic for I/O configuration, alarms, indications, recording, etc.
- Automatic supervision

The GRZ100 has the following models:

Relay Type and Model

Relay Type:
- Type GRZ100; Numerical distance relay
Relay Model:
- For two terminal line, With autoreclose for single breaker scheme • Model 211B; 18 binary inputs, 22 binary outputs, 6 binary outputs for tripping • Model 214B; 22 binary inputs, 18 binary outputs, 3 binary outputs for tripping • Model 216B; 25 binary inputs, 36 binary outputs, 3 binary outputs for tripping
- For two terminal line, With autoreclose for one-and-a-half breaker scheme • Model 311B; 18 binary inputs, 22 binary outputs, 6 binary outputs for tripping
- For three terminal line, With autoreclose for single breaker scheme • Model 221B; 18 binary inputs, 22 binary outputs, 6 binary outputs for tripping • Model 224B; 22 binary inputs, 18 binary outputs, 3 binary outputs for tripping • Model 226B; 25 binary inputs, 36 binary outputs, 3 binary outputs for tripping
- For three terminal line, With autoreclose for one-and-a-half breaker scheme • Model 321B; 18 binary inputs, 22 binary outputs, 6 binary outputs for tripping • Model 323B; 18 binary inputs, 40 binary outputs, 6 binary outputs for tripping

Table 1.1.1 shows the measuring elements incorporated.

Table 1.1.1 Incorporated Measuring Elements

Measuring elements		211B, 214B, 216B	311B	221B, 224B, 226B	321B, 323B
Z1S, Z1SX, Z2S, Z3S, ZFS, ZR1S, ZR2S, Z4S, ZNDS	Distance element (phase fault)	✓	✓	✓	✓
Z1G, Z1GX, Z2G, Z3G, ZFG, ZR1G, ZR2G, Z4G, ZNDG	Distance element (earth fault)	✓	✓	✓	✓
UVC	Phase selection element	✓	✓	✓	✓
DEFF, DEFR	Directional earth fault element	✓	✓	✓	✓
OC, OCI	Overcurrent element (phase fault)	✓	✓	✓	✓
EF, EFI	Overcurrent element (earth fault)	✓	✓	✓	✓
SOTF (OCH)	Switch-onto-fault protection	✓	✓	✓	✓
THM	Thermal overload protection	✓	✓	✓	✓
VTF (OVG, UVF, OCD)	VT failure supervision	✓	✓	✓	✓
PSBS, PSBG	Power swing blocking	✓	✓	✓	✓
OST	Out-of-step tripping	✓	✓	✓	✓
BF	Breaker failure protection	✓	✓	✓	✓
FL	Fault locator	✓	✓	✓	✓
ARC (SYN, UV, OV)	Autoreclose function	1CB	2CB	1CB	2CB
OVS1,OVS2,OVG1,OVG2, UVS1,UVS2,UVG1,UVG2	Overvoltage & undervoltage protection	✓	✓	✓	✓
BCD	Broken conductor detection	✓	✓	✓	✓

Z4S and Z4G are not for backup protection and used for command protection.

2. Application Notes

2.1 Power System Protection - Basic Concepts

2.1.1 The Function of The Protection Relay

The protection relay, which protects the power system from various faults, plays an extremely important role in power system stability. Its main functions are as follows:

Prevention of power supply interruption:

Fault clearance and resumption of healthy power transmission as soon as possible.

Prevention of damage to equipment:

Consecutive system faults will eventually lead to damage to primary plant, for example destruction of insulators, rupture of lines, burning of transformers, etc. The protection relay can help prevent such damage to equipment.

Prevention of system instability:

is necessary to remove Power system faults at high speed by using protection relays as the existence of a system fault for an extended period of time may initiate a generator out-of-step condition.

2.1.2 Protection Relay Requirements

The protection relay, which plays the important role of protecting the power system from faults, must meet several requirements. These requirements can be summarized as follows:

a) Selectivity: All faults that occur on the power system should be removed but at the same time it must be ensured that only the minimum section of the power system must be isolated in order to clear the fault. Figure 2.1.2.1 shows typical different protection zones on the power system. In order to provide complete coverage by the protection, the neighboring protection zones are set to overlap. Figure 2.1.2.2 shows the relationship between the circuit breaker and CT locations. In Figure (a), the CTs are installed on both sides of the circuit breaker, one for line protection and the other for busbar protection, enabling the protection coverage to overlap. Figure (b) shows the case where the same CT is used for both the line protection and busbar protection. In this case, the line protection would operate for a fault which occurred midway between the CT and circuit breaker, but the busbar protection would not operate, thus failing to remove the fault. It is important to prevent blind spots in power system protection design.

b) High speed: In order to avoid damage to equipment or power system instability, it is important to shorten the duration of faults by applying high-speed protection relays. The GRZ100 has a minimum operating time of 18 ms. However, the operating time of the circuit breaker and transmission delay in the case of carrier protection, etc. must also be taken into consideration.

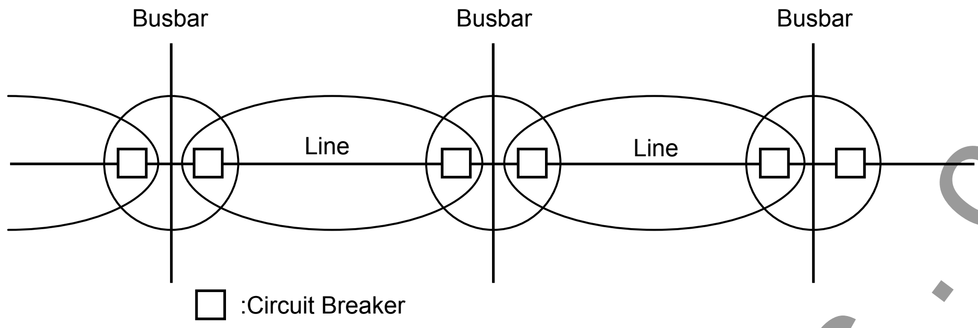


Figure 2.1.2.1 Protection Zones

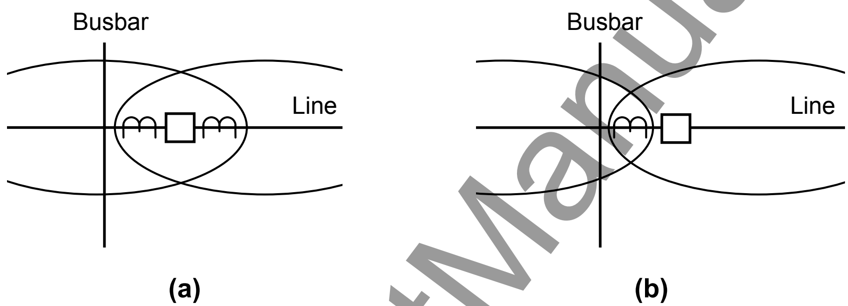


Figure 2.1.2.2 Protection Zone and CB, CT

c) Reliability: The protection relay is normally in a quiescent state and is available to respond to faults that may occur on the power system in the protection zone. In order that this may be achieved the availability of the protection relay is checked even in its quiescent state.

A fundamental requirement to ensure that the reliability of the protection relay is high is that its components must be extremely reliable. This can be achieved by using high quality components and reducing the number of components. The GRZ100 reduces the number of parts by using state-of-the-art highly integrated semiconductor components.

To maintain high reliability, not only must the relay have a robust hardware structure but it is also important to detect any fault immediately and not to leave the relay in a faulted state for prolonged periods. Therefore, the GRZ100 is equipped with an automatic supervision function. Whenever a hardware fault occurs, an alarm is issued to inform the operator of the problem to permit remedial action.

In order to dramatically improve the operating reliability of the relay in the event of a system fault, there are two options: to use a protection relay with a duplicated protection system or to provide an additional fault detection relay within the relay with AND logic.

2.1.3 Main Protection and Backup Protection

The power system protection system generally consists of a main protection and a backup protection to reliably remove all faults. In principle, system faults must be removed in the shortest possible time and cause the minimum outage. This important function is served by the main protection. In distance protection, this function is served by the zone 1 element and command protection, etc. However, the main protection may not always function perfectly. For example, the main protection relay may not be able to function correctly due to a power supply failure, CVT failure, data transmission device failure, circuit breaker failure or failure of the main protection relay itself. In such cases, power system integrity depends on the backup protection.

The backup protection provides power system protection with a set time delay, its timer value is set in a range that allows coordination with the main protection. To achieve time coordination with the main protection, the time delay of the backup protection is determined with a margin in consideration of the following factors:

- Operating time of main protection relay
- Operating time of circuit breaker
- Reset time of backup protection relay

There are two types of backup protection: remote backup protection that provides backup from a remote substation at a different location to the main protection, and local backup protection installed in the same location as that of the main protection that provides backup from that substation.

Each of these protections has the following features:

Remote backup protection: Possible causes for main protection failures include relay faults, power supply faults, and various other factors. It is therefore important to provide backup protection from a remote substation to prevent the backup protection from failing due to the same causes as the local main protection. The zone 2 and zone 3 elements of distance relays, etc. provide as these remote backup protection functions.

Local backup protection: Provides backup protection at the same substation as that of the main protection and often has the purpose of providing backup when the circuit breaker fails to operate.

2.1.4 Distance Relay - General Performance

For distance relays, the reach of the zone 1 protection is usually set to approximately 80 to 90% of the length of the transmission line. This is to ensure that overreach tripping does not occur for external faults that occur beyond the busbar at the remote end. For internal faults that occur beyond the reach of zone 1, time delayed tripping by the zone 2 element is applied. High-speed tripping can be achieved by means of a "command protection system" that exchanges relay operation information with the remote end.

There are various causes for measuring errors in a distance relay. In the case of a fault with resistance, the reactance component seen by the relay at the power sending terminal is smaller than the actual value and it tends to overreach. On the contrary, the reactance component seen by the relay at the power receiving terminal is greater than the actual value and it tends to underreach. The line impedance has different values in different phases. When its average value is used for the relay setting, underreach will occur in a phase with a greater impedance than the average value. In the case of fault resistance, its impedance is greater for earth faults where the fault is grounded via a steel tower or tree rather than a phase fault consisting of arc resistance only. Therefore, measuring errors in the earth fault relay are generally greater than those in the phase fault relay. The fault arc is considered to be almost equivalent to pure resistance. But if the phase of a current that flows into a fault point from the remote end is different from the phase of the local current, the voltage at the fault will have a phase angle difference with respect to the local current, producing a measuring error in the distance relay with the principle of measuring the reactance component. The existence of a zero-sequence current on the protected line and adjacent line can also cause errors in the earth fault relay. The zero-sequence current normally acts in the direction of relay underreaching due to the effect of the induced voltage. The compensation method will be described in detail in the next section. The earth fault relay contains more errors than the phase fault relays even with these compensation methods. Therefore, the earth fault relays are usually set with a greater margin than the phase fault relays.

Regarding protection relay measuring errors, it is also necessary to consider hardware errors in the relay itself, errors introduced by coupling capacitor voltage transformers (CCVT), and transient overreach errors caused by the DC component of the fault current. For GRZ100, the total of these errors is specified to be less than 5%.

2.1.5 Power Swing and Out-of-Step

Power swings occur when the output voltages of generators at different points in the power system slip relative to each other, as a result of system instabilities which may be caused by sudden changes in load magnitude or direction, or by power system faults and their subsequent clearance. During the course of such a power swing, the impedance seen by a distance relay may move (relatively slowly) from the load area into the distance protection operating characteristic. In fact, this phenomenon appears to the distance protection measuring elements like a three phase fault condition and may result in tripping if no countermeasure is applied. Most power swings are transient conditions from which the power system can recover after a short period of time, and distance protection tripping is therefore highly undesirable in such cases. GRZ100 provides a power swing blocking function (PSB) to prevent unwanted tripping during a power swing. Figure 2.1.5.1 illustrates the typical impedance locus as seen by a distance relay during a transient power swing.

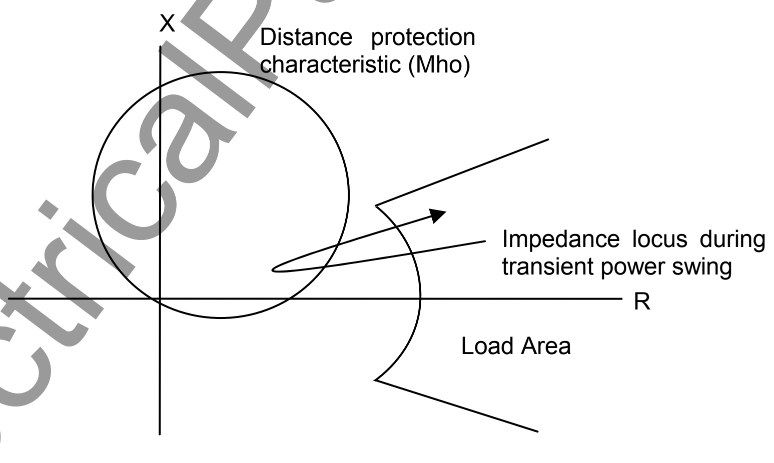


Figure 2 1.5.1 Impedance Locus during Transient Power Swing

A special case of the power swing condition occurs when the power system disturbance is so severe that generators lose synchronism with each other and are said to be out-of-step. During an out-of-step condition the phase angle between generators continues to increase and pass through 180°, at which point a distance relay measures an impedance equal to that for a three phase fault at the centre of the power system. The impedance locus typically describes an arc passing through the electrical centre, as shown in Figure 2.1.5.2.

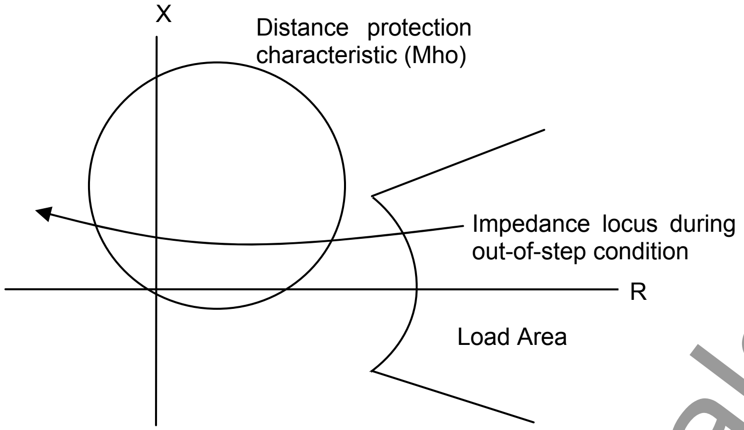


Figure 2.1.5.2 Impedance Locus during Out-of-Step Condition

In the case of a full out-of-step condition (as opposed to a transient power swing) it is desirable to separate the system in the vicinity of the centre of the out-of-step condition. GRZ100 provides an out-of-step detection element (OST) which can provide tripping in these circumstances.

Although the power swing and out-of-step conditions are very closely related (in fact one is simply the most severe form of the other), completely different actions are required from the protection relay. The PSB function must ensure stability of the distance protection during transient power system conditions, while the OST element initiates system separation by tripping in the event that a severe power swing results in potentially irrecoverable loss of stability in the power system. The PSB and OST elements are therefore completely separate functions within the GRZ100 relay, with different characteristics, separate scheme logic and different settings.

2.2 Principle of Distance Measurement

2.2.1 Phase Fault

The phase-fault distance relay measures the impedance from the relay to the fault point using a delta voltage and current. The positive-sequence impedance is used as the line impedance. The principle is described below.

Figure 2.2.1.1 shows the circuit in the event of a two-phase fault. Suppose that the impedance from the relay to the fault is the same in both phase B and phase C, and that the self impedance is Z_s and the mutual impedance between phases is Z_m. If the voltages and currents of phase B and phase C are V_b, V_c, I_b and I_c and the fault point voltage is V_F, then V_b and V_c are given by the following equations.

$$V_b = Z_s \times I_b + Z_m \times I_c + V_F \quad \text{.......................} (2\text{-}1)$$

$$V_c = Z_s \times I_c + Z_m \times I_b + V_F \quad \text{.......................} (2\text{-}2)$$

From equations (2-1) and (2-2), the following equation is obtained.

$$V_b - V_c = (Z_s - Z_m) \times (I_b - I_c) \quad \text{.........................} (2\text{-}3)$$

where,

Z_s: Self impedance

Z_m: Mutual impedance

Since the effect of the phase A current is small and is almost canceled when introducing equation (2-3), it is omitted in equations (2-1) and (2-2).

When each phase of the line is symmetric to the other, the positive-sequence and zero-sequence impedance Z_1 and Z_0 according to the method of symmetrical components are defined by the following equations, using self impedance Z_s and mutual impedance Z_m:

$$Z1 = Zs - Zm \quad \text{...} (2\text{-}4)$$

$$Z0 = Zs + 2Zm \quad \text{...} (2\text{-}5)$$

where,

Z_1: Positive-sequence impedance

Z_0: Zero-sequence impedance

Equation (2-3) can be rewritten as follows:

$$Z_1 = (V_b - V_c)/(I_b - I_c) \quad \text{.............................} (2\text{-}6)$$

As shown above, the positive-sequence impedance is used for the phase fault relay setting.

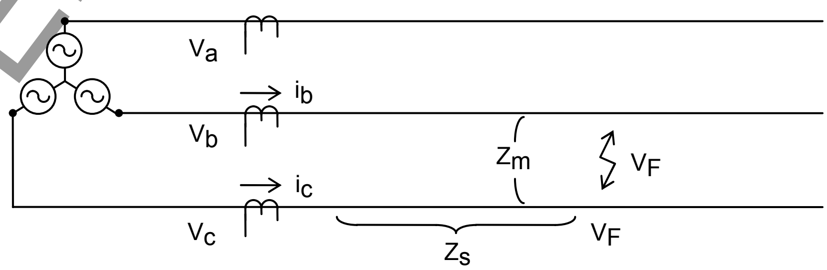


Figure 2.2.1.1 Two-Phase Fault

2.2.2 Earth Fault

Figure 2.2.2.1 shows the circuit in the event of a single-phase earth fault. It is not simple to exactly measure the distance up to the fault point for a single-phase earth fault.

This is because the impedance of the zero-sequence circuit including the earth return is generally different from the positive-sequence impedance. Therefore, the faulted phase voltage is not simply proportional to the faulted phase current.

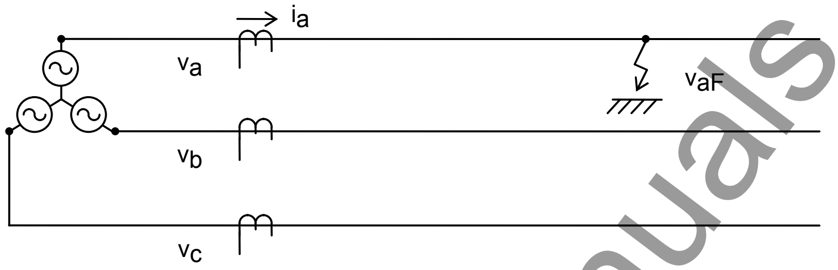


Figure 2.2.2.1 Single-Phase Earth Fault

It is necessary to analyze the impedance seen by the relay in the event of a single-phase earth fault according to the method of symmetrical components. Figure 2.2.2.2 shows an equivalent circuit for the single-phase earth fault based on the method of symmetrical components. Assuming the positive-sequence, negative-sequence and zero-sequence voltages are V_{1F}, V_{2F} and V_{0F}, the voltage at the relay point of each symmetrical circuit is given by the following equation. However, suppose that the positive-sequence impedance and negative-sequence impedance are the same and influences of the fault resistance are ignored.

$$V_1 = Z_1 \times I_1 + V_{1F} \quad \text{(2-7)}$$

$$V_2 = Z_1 \times I_2 + V_{2F} \quad \text{(2-8)}$$

$$V_0 = Z_0 \times I_0 + Z_{0m} \times I_{0m} + V_{0F} \quad \text{(2-9)}$$

where, V_1: Relay point positive-sequence voltage
V_2: Relay point negative-sequence voltage
V_0: Relay point zero-sequence voltage
V_{1F}: Fault point positive-sequence voltage
V_{2F}: Fault point negative-sequence voltage
V_{0F}: Fault point zero-sequence voltage
I_1: Relay point positive-sequence current
I_2: Relay point negative-sequence current
I_0: Relay point zero-sequence current
I_{0m}: Adjacent line zero-sequence current
Z_1: Fault point - relay point positive-sequence impedance
Z_0: Fault point - relay point zero-sequence impedance
Z_{0m}: Adjacent line zero-sequence mutual impedance

Taking account of the fact that the faulted phase voltage V_{aF} at the point of fault is,

$$V_{aF} = V_{1F} + V_{2F} + V_{0F} = 0 \quad \text{(2-10)}$$

phase A voltage V_a at the relay is calculated from the following equation:

$$V_a = V_1 + V_2 + V_0$$
$$= Z_1(I_a + (Z_0 - Z_1)/Z_1 \times I_0 + Z_{0m}/Z_1 \times I_{0m}) \quad \text{......(2-11)}$$

Where, I_a is the current at phase "a" relay point and is defined in the following equation by the symmetrical component of the current:

$$I_a = I_1 + I_2 + I_0 \quad \text{......(2-12)}$$

Here, defining the current synthesized by the phase "a" relay as $I_{a'}$, and

$$I_{a'} = I_a + (Z_0 - Z_1)/Z_1 \times I_0 + Z_{0m}/Z_1 \times I_{0m} \quad \text{......(2-13)}$$

then equation (2-11) can be rewritten as the following equation:

$$V_a = Z_1 \times I_{a'} \quad \text{......(2-14)}$$

That is, positive-sequence impedance Z_1 up to the fault point can be obtained from the simple ratio of phase "a" voltage V_a to compensated current $I_{a'}$ according to equation (2-14).

Obtaining the compensated current according to equation (2-13) is called "zero-sequence compensation." Note in this zero-sequence compensation, the compensation coefficient $(Z_0 - Z_1)/Z_1$ and Z_{0m}/Z_1 are not real numbers, but complex numbers. The GRZ100 relay has a configuration that allows this compensation coefficient to be set as a complex number and setting the coefficient correctly makes it possible to measure exactly the distance up to the fault point.

In equations (2-7) to (2-9), the fault resistance was ignored. Since the measurement of the distance up to the fault point based on equation (2-14) is carried out using the reactance component, in principle there is no influence on the voltage component due to the fault resistance. However, under real operating conditions, distance measurement errors are produced as a result of the fault resistance combined with the power flow or the current flowing into the fault point from the point opposite the relay location.

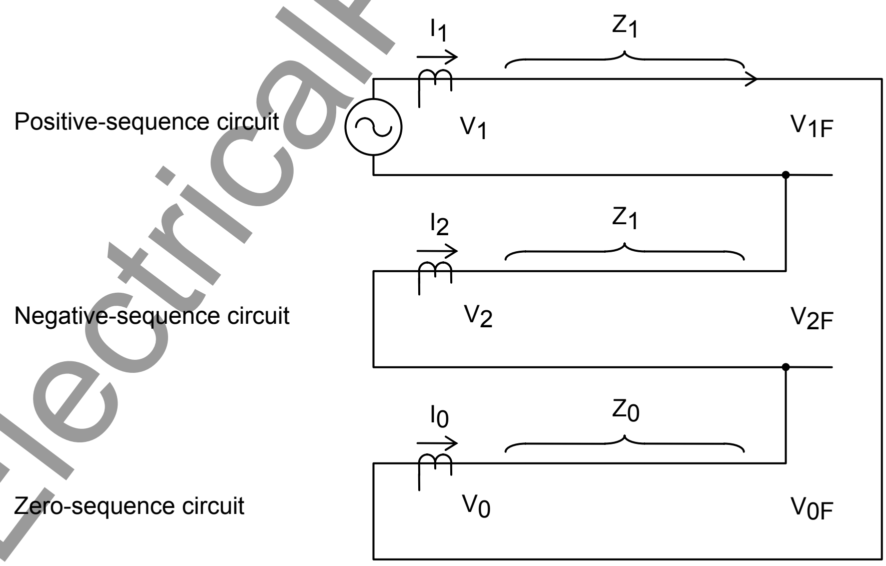


Figure 2.2.2.2 Equivalent Circuit of Single-Phase Earth Fault

2.3 Multi-Terminal Line Protection

2.3.1 Increased Use of Multi-Terminal Lines

The number of multi-terminal transmission lines has increased in recent years, mainly for economic reasons. For example, connecting three substations through three-terminal transmission lines can reduce the construction cost considerably compared to connecting substations through individual lines. On the other hand, from the standpoint of protection, multi-terminal lines cause various difficulties. Taking an example of a three-terminal line, these problems are illustrated below.

2.3.2 Protection Problems on Three-Terminal Application

2.3.2.1 Underreach in the Case of an Internal Fault Further than the Branch Point

In the three-terminal line shown in Figure 2.3.2.1, if a phase fault occurs near terminal C, the fault current flows in from both terminal A and terminal B and the voltages at terminal A and terminal B are influenced by the current from one another, have represented by the following equations:

$V_A = I_A \times (Z_1 + Z_3) + I_B \times Z_3$ .... (2-15)

$V_B = I_B \times (Z_2 + Z_3) + I_A \times Z_3$ .... (2-16)

where,
- V_A: Voltage at terminal A
- V_B: Voltage at terminal B
- I_A: Current at terminal A
- I_B: Current at terminal B
- Z_1: Impedance from terminal A to branch point
- Z_2: Impedance from terminal B to branch point
- Z_3: Impedance from fault point to branch point

From equations (2-15) and (2-16), impedance Z_A and impedance Z_B seen from the relay at terminal A and terminal B are given by the following equations:

$Z_A = V_A/I_A = (Z_1 + Z_3) + Z_3 \times I_B/I_A$ .... (2-17)

$Z_B = V_B/I_B = (Z_2 + Z_3) + Z_3 \times I_A/I_B$ .... (2-18)

From equation (2-17), the impedance seen from the relay at terminal A is greater than the actual impedance $(Z_1 + Z_3)$ up to the fault point by $(Z_3 \times I_B/I_A)$. That is, if the current infeed from local terminal A is large its influence is small, but if the current infeed from local terminal B is large the relay sees the fault point much further than the actual distance.

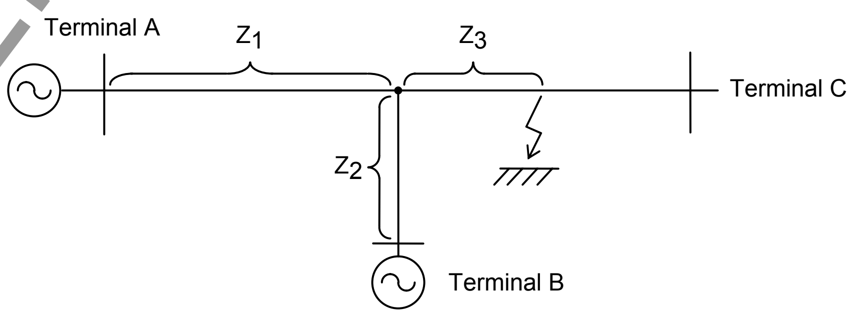


Figure 2.3.2.1 Three-terminal line

2.3.2.2 Current Outfeed in the Event of an Internal Fault

In the event of an internal fault in a multi-terminal system, a fault current may flow out of a specific terminal. An example is shown using a three-terminal system with two parallel lines shown in Figure 2.3.2.2. The figure shows the case where only one circuit is used and another circuit is open at terminal A. If a fault occurs at a close to terminal C, there is a route through which the current flows from terminal B via the adjacent line into terminal C and part of the fault current flows out of terminal B and flows into terminal C again. The magnitude of the outfeed current is a maximum of approximately 1/2 of the infeed current from terminal A. If the fault point is examined from terminal A, the impedance of the adjacent circuit between terminal B and terminal C enters in parallel, and consequently the relay at terminal A sees it as smaller than the actual impedance up to the fault point, which means this relay tends to overreach.

It is difficult to protect the system when a fault current flows out of one end. Since an ordinary directional comparison method judges an external fault at one end and sends a block signal, it may fail to remove the fault.

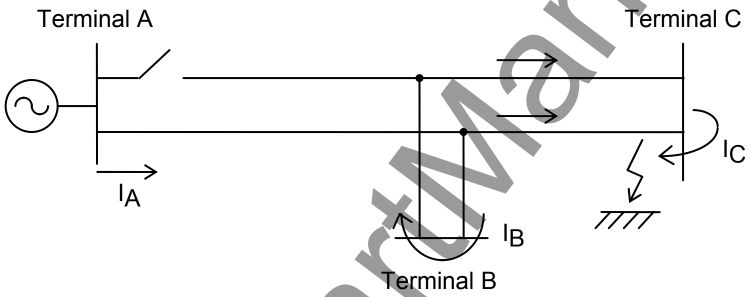


Figure 2.3.2.2 Current Outfeed in Event of Internal Fault

2.3.2.3 Diversion of Outfeed Current in the Event of an External Fault

If an external fault occurs at terminal C in the three-terminal system shown in Figure 2.3.2.3, the fault current that flows into terminal A may not only flow out of terminal C but may also flow out of terminal B and flow into the fault point. In this case, outfeed currents I_B from terminal B and I_C from terminal C become smaller than infeed current I_A from terminal A. That is,

(Outfeed current) < (infeed current) .... (2-19)

The directional comparison method sometimes cannot detect external faults under such conditions, increasing the possibility of unwanted operation due to detection of an internal fault from terminal A.

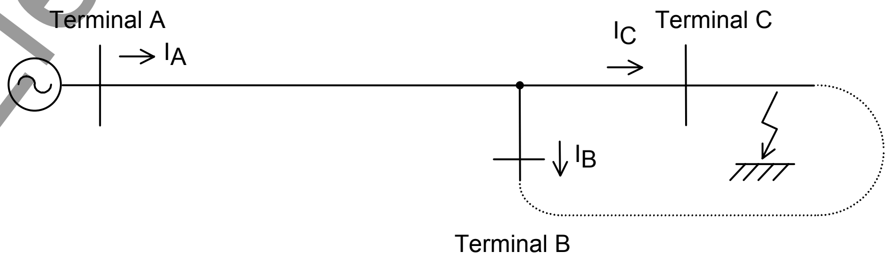


Figure 2.3.2.3 Outfeed Current in Event of External Fault

2.3.2.4 Possible Attenuation of Carrier Wave in Power Line Carrier

There are no particular problems related to power line carrier or multi-terminal lines. However, when the distance of the line from a branch point is 1/4, 3/4, 5/4 and 7/4, etc. of the wavelength of the carrier wave, the reflected wave from the branch line may cause considerable attenuation of the carrier signal, and thus care is required in selecting the carrier frequency. Furthermore, when the same carrier frequency is used for each terminal, the signal from each terminal may not be received due to the beat phenomenon, and thus it is desirable to use the carrier wave for each terminal with a different frequency in a multi-terminal system.

2.3.3 Three-Terminal Line Protection

2.3.3.1 Distance Relay Protection

The relay at terminal A in Figure 2.3.2.1 will underreach due to an infeed current from terminal B. However, the zone 1 element of distance relay should not overreach for a fault on the busbar at the remote end under any conditions. Therefore, the relay at terminal A is set so that it may operate correctly for faults within the protected zone in the absence of a power source at terminal B. This makes it unavoidable for the relay at terminal A to permit considerable underreach for an infeed current from terminal B.

When there is a branch point on the line between terminal A and terminal B and it is connected with terminal C via a short-distance line as shown in Figure 2.3.3.1, the setting range of the zone 1 element at terminal A and terminal B can only include part of the entire length of the line as shown in the figure to avoid unwanted operations for external faults at terminal C. Therefore, for most of the faults on this line, one end is delayed-tripped by the zone 2 element. To avoid such a problem a directional comparison method or current differential method must be used.

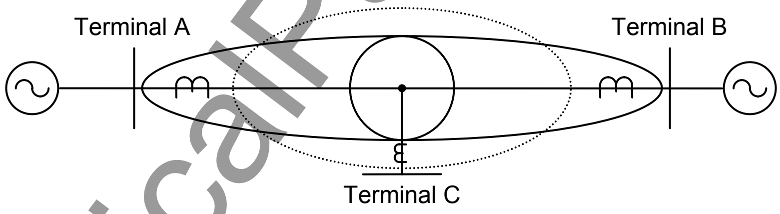


Figure 2.3.3.1 Short-Distance Tapped Line (1)

2.3.3.2 Command Protection

Permissive Underreach Protection (PUP)

With the Permissive Underreach Protection (PUP) method, all the terminals are tripped via transmission if zone 1 element operates at least at one terminal. In this system, a common power line carrier is available.

In the system shown in Figure 2.3.3.2 where both terminal B and terminal C are near the branch point and connected via a short-distance line, the distance relay at terminal B and terminal C must unavoidably be set to an extremely short distance to prevent unwanted operations by busbar faults at each other's end. In order for the relay at terminal A not to operate on a busbar fault at terminal B or terminal C, it may not be able to set the branch point within the protection range, containing a zone in which it is impossible to detect the fault as an internal fault. The fault in this zone is removed by tripping of zone 2. When a current flows out of terminal B in the event of a fault inside terminal C as shown in the example in Figure 2.3.2.2, the PUP system performs tripping of terminal B sequentially following the tripping of terminal C.

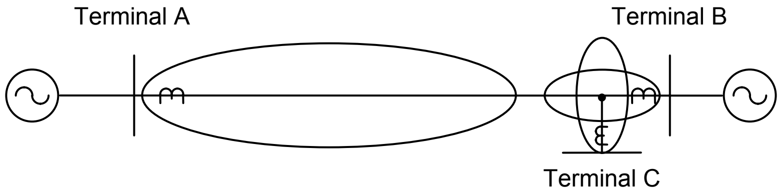


Figure 2.3.3.2 Short-Distance Tapped Line (2)

Permissive Overreach Protection (POP)

The Permissive Overreach Protection (POP) method carries out tripping on condition that zone 2 of each terminal (or zone 3 depending on the setting) has operated for an internal fault. Accordingly it needs to use a different transmission channel when applied to three terminals.

Zone 2 in the POP method basically covers up to and including the busbar of all terminals at the remote end of the protected zone. If the source behind each terminal is strong enough, in this scheme all terminals will operate their distance relays for a fault in the protected zone. However, if the impedance behind the power source changes, there is a tendency to underreach as a consequence of the "branch effect." Therefore, it is necessary to check that the relay can operate for faults in the protected zone even under the worst power source conditions.

Blocking Schemes

With the blocking scheme, a terminal sends a blocking signal to the other terminal for an external fault and a common power line carrier channel can be used. It can also perform high-speed tripping even if one end of the multi-terminal line is a non-power source and there is no fault current infeed.

In the blocking scheme, it is necessary to pay attention to diversion of the outfeed current in the event of an external fault. In the system shown in Figure 2.3.2.3, if a fault current flows out of terminals B and C for an external fault, the outfeed currents of terminal B and terminal C are smaller than the infeed current at terminal A due to the diversion. Therefore, it may be difficult to operate the external detection relay of one terminal depending on the ratio of diversion.

2.4 Protection Scheme

The GRZ100 series has the following protection schemes and is applied to transmission lines of directly earthed networks. The function of high-speed detection and clearance of faults ensures that the disturbance to the power system is kept to a minimum in combination with the built-in autoreclose functions. Appendix A shows block diagrams of the GRZ100 series.

- time-stepped distance protection
- zone 1 extension protection
- command protection (distance protection using telecommunication)
- high-resistance earth fault protection
- overcurrent backup protection
- thermal overload protection
- SOTF and stub protection
- overvoltage and undervoltage protection
- broken conductor detection
- circuit breaker failure protection
- out-of-step protection

2.4.1 Time-Stepped Distance Protection

2.4.1.1 Application

Using reach and tripping time settings coordinated with adjacent lines, the GRZ100 provides up to four steps of distance protection for forward faults and backup protection for reverse faults. These are used as the main protection when telecommunications are not available, or as backup protection for the protected line and adjacent lines.

The GRZ100 has maximum eight distance measuring zones for both phase and earth faults, maximum four zones for forward faults and maximum three zones for reverse faults respectively. There is also one non-directional zone. The zones can be defined with either mho-based characteristic or quadrilateral characteristic. The characteristic is selected by setting the scheme switch [ZS-C] for phase fault and [ZG-C] for earth fault to "Mho" or "Quad".

Figure 2.4.1.1 shows the mho-based characteristics. Zone 1 (Z1), Zone 1X (Z1X), Zone 2 (Z2), additional forward Zone F (ZF) and reverse Zone R1 (ZR1) have a complex characteristic combining the reactance element, mho element and blinder element, while Zone 3 (Z3), additional reverse Zone R2 (ZR2) and Z4 elements have a complex characteristic combining the mho element and blinder element. ZND elements have a complex characteristic combining the impedance element and blinder element. Z3 is also used for detection of forward faults in command protection. If Z3 is dedicated to command protection, ZF can be used for Zone 3 instead of Z3 in time-stepped distance protection.

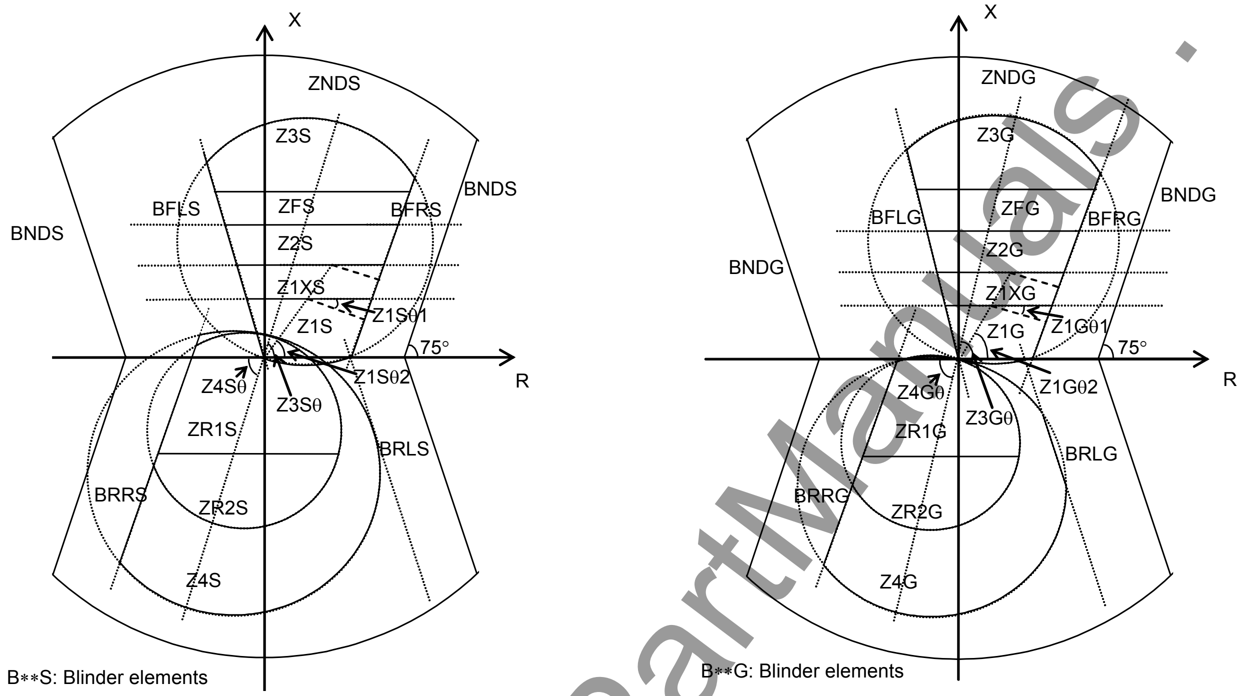
The blinder element (BFR) can be provided for each forward zone. The setting of blinder element can be set independently or set common to forward zones by the scheme switch [BLZONE].Figures 2.4.1.1 and 2.4.1.2 show the characteristics with an independent setting.

Since the Z4 is used for detection of reverse faults in command protection, the Z4 for phase faults has an offset characteristic with an offset mho element which assures detection of close-up phase faults. The operation of Z4 for phase faults in the event of internal faults is inhibited by the operations of Z2, ZF and Z3.

Figure 2.4.1.2 shows the quadrilateral characteristics. These have a complex characteristic combining the reactance element, directional element and blinder element.

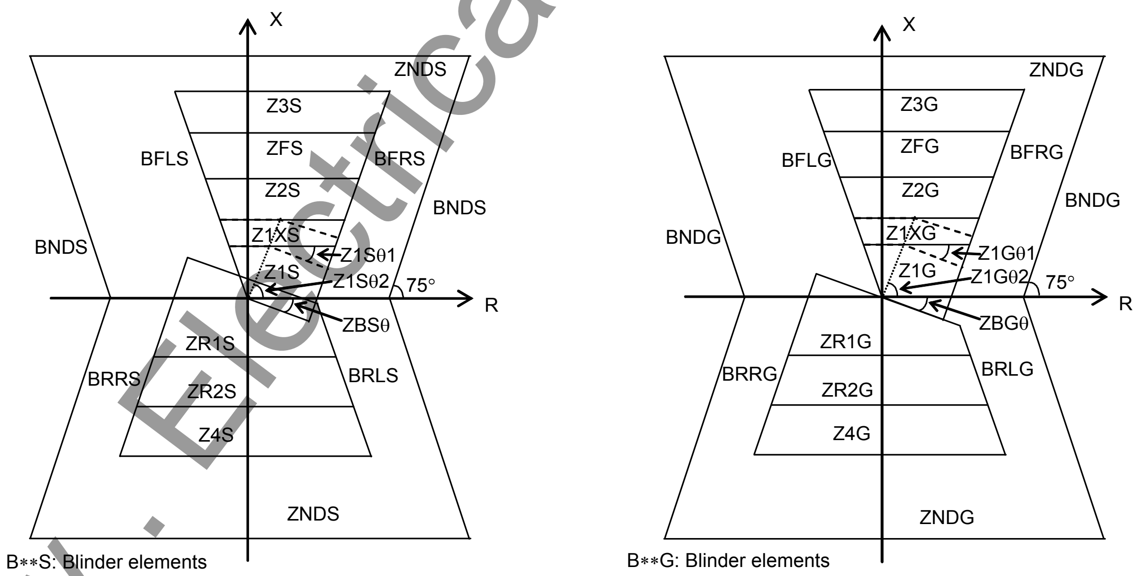
The Z4 for phase faults has an offset characteristic with an offset directional element which assures detection of close-up phase faults.

The operation is the same as the mho-based characteristics.



(a) Phase fault element **(b) Earth fault element**

Figure 2.4.1.1 Mho-based Characteristics



(a) Phase fault element **(b) Earth fault element**

Figure 2.4.1.2 Quadrilateral Characteristics

Figure 2.4.1.3 shows typical time-distance characteristics of the time-stepped distance protection provided at terminal A.

Zone 1 is set to cover about 80% of the protected line. When GRZ100 is used as the main protection, zone 1 generally provides instantaneous tripping but if used as a backup protection, time delayed tripping can be provided. With the GRZ100, 5 types of zone 1 tripping modes can be set using the trip mode setting switch.

Zone 2 is set to cover about 120% or more of the protected line, providing protection for the rest of the protected line not covered by zone 1 and backup protection of the remote end busbar. In order to coordinate the fault clearance time by the main protection, with the zone 1 protection of the adjacent lines or by the remote end busbar protection, zone 2 carries out time delayed tripping.

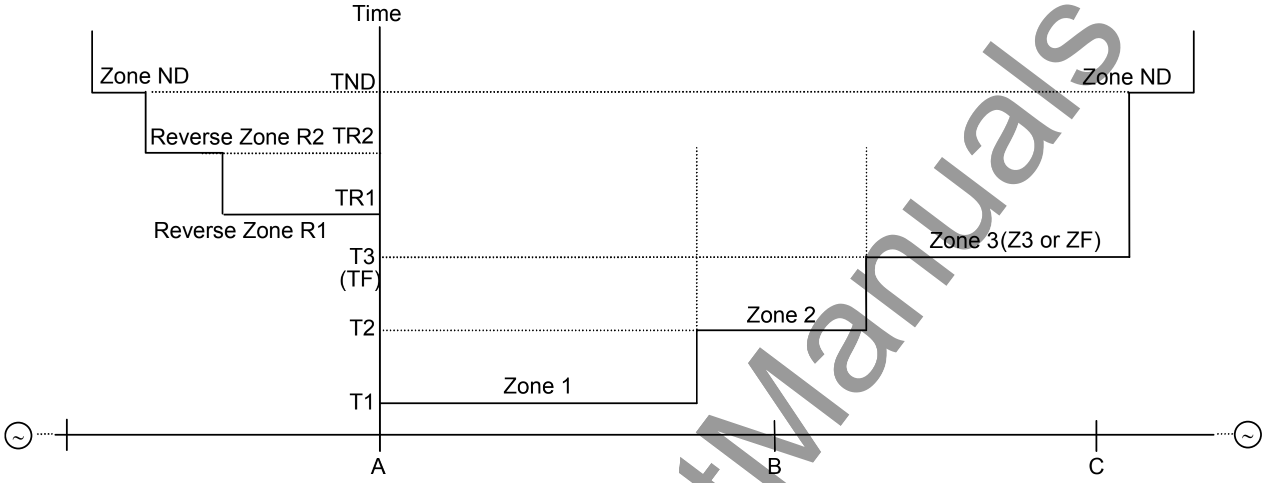


Figure 2.4.1.3 Time/Distance Characteristics of Time-Stepped Distance Protection

Zone 3 is mainly provided for remote backup protection of adjacent lines. Its reach is set to at least 1.2 times the sum of the impedance of the protected line and the longest adjacent line. The zone 3 time delay is set so that it coordinates with the fault clearance time provided by zone 2 of adjacent lines. (Z3 is applied to Zone 3. Z3 is also used for detection of forward faults in command protection. If Z3 is dedicated to command protection, ZF can be used for Zone 3 instead of the Z3.)

The reverse looking zone R1 and R2 elements are used for time delayed local backup protection for busbar faults and transformer faults. Furthermore, when applied to multi-terminal lines, it is effective as the backup protection for adjacent lines behind the relaying point instead of the zone 3 protection at the remote terminal. This is because it is difficult for zone 3 at terminals A and C to provide remote backup protection for the fault shown in Figure 2.4.1.4 due to fault infeed from the other terminal, whereas reverse looking zone of terminal B is not affected by this.

Z4 element is used for reverse fault detection in command protection, but not for backup protection.

The non-directional zone ND is used for time delayed backup protection including overall zones.

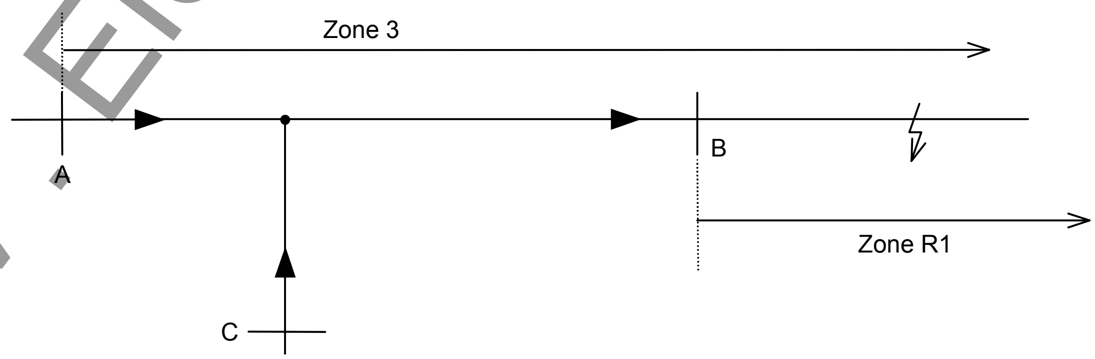


Figure 2.4.1.4 Reverse Zone Protection

To maintain stable operation for close-up three-phase faults which cause the voltages of all phases to drop to 0 or close to 0, zone 1 for phase faults, once operated, changes its element to a reverse offset element. This continues until the fault is cleared, and thus it is effective for time delayed protection.

The reactance element characteristics of zone 1, zone 1 extension, zone 2, zone F and zone R1 are parallel lines to the R axis and provide sufficient coverage for high-resistance faults. The reactance element characteristics of zone 1 and zone 1 extension can be transformed to a broken line depending on the load flow direction in order to avoid overreaching by the influence of load current. The characteristic in the resistive direction is limited by the mho characteristic of zone 3. The reactive reach setting is independent for each zone. It is also possible to have independent settings for each individual phase fault and earth fault elements.

With a long-distance line or heavily loaded line, it is possible for the load impedance to encroach on the operation zone of the mho element. Blinders are provided to limit the operation of the mho element in the load impedance area.

Zero-sequence current compensation is applied to zone 1, zone 2 and reverse zone R1 for earth fault protection. This compensates measuring errors caused by the earth return of zero-sequence current. This allows the faulted phase reactance element to precisely measure the positive-sequence impedance up to the fault point. Furthermore, in the case of double-circuit lines, zero-sequence current from the parallel line is introduced to compensate for influences from zero-sequence mutual coupling. (R1 is not provided with zero sequence mutual coupling compensation for the parallel line.) Considering the case where the impedance angle of positive-sequence impedance and zero-sequence impedance differ which is the most common in cable circuits, GRZ100 carries out vectorial zero-sequence current compensation.

The autoreclose schemes are utilised with instantaneous zone 1 tripping. When single-phase autoreclose or single- and three-phase autoreclose are selected, zone 1 executes single-phase tripping for a single-phase earth fault. In order to achieve reliable fault phase selection even for faults on heavily loaded long-distance lines or irrespective of variations in power source conditions behind the relaying point, an undervoltage element with current compensation is used as a phase selector. Other zones only execute three-phase tripping, and do not initiate autoreclose.

2.4.1.2 Scheme Logic

Figure 2.4.1.5 shows the scheme logic for the time-stepped distance protection. For zone 1 tripping, as described later, it is possible to select instantaneous tripping or time delayed tripping using the scheme switch [Z1CNT] in the trip mode control logic. (Detail of the [Z1CNT] is described after.) Zone 2, zone 3, zone F, zone R1, zone R2 and zone ND give time delayed tripping. However, these zones can trip instantaneously by PLC signals Z∗_INST_TP. Timers TZ2, TZ3, TZF, TZR1, TZR2 and TZND with time delayed tripping can be set for earth faults and phase faults separately. Zone F, zone R1, zone R2 and zone ND backup tripping can be disabled by the scheme switch [Z∗BT].

Note: For the symbols used in the scheme logic, see Appendix L.

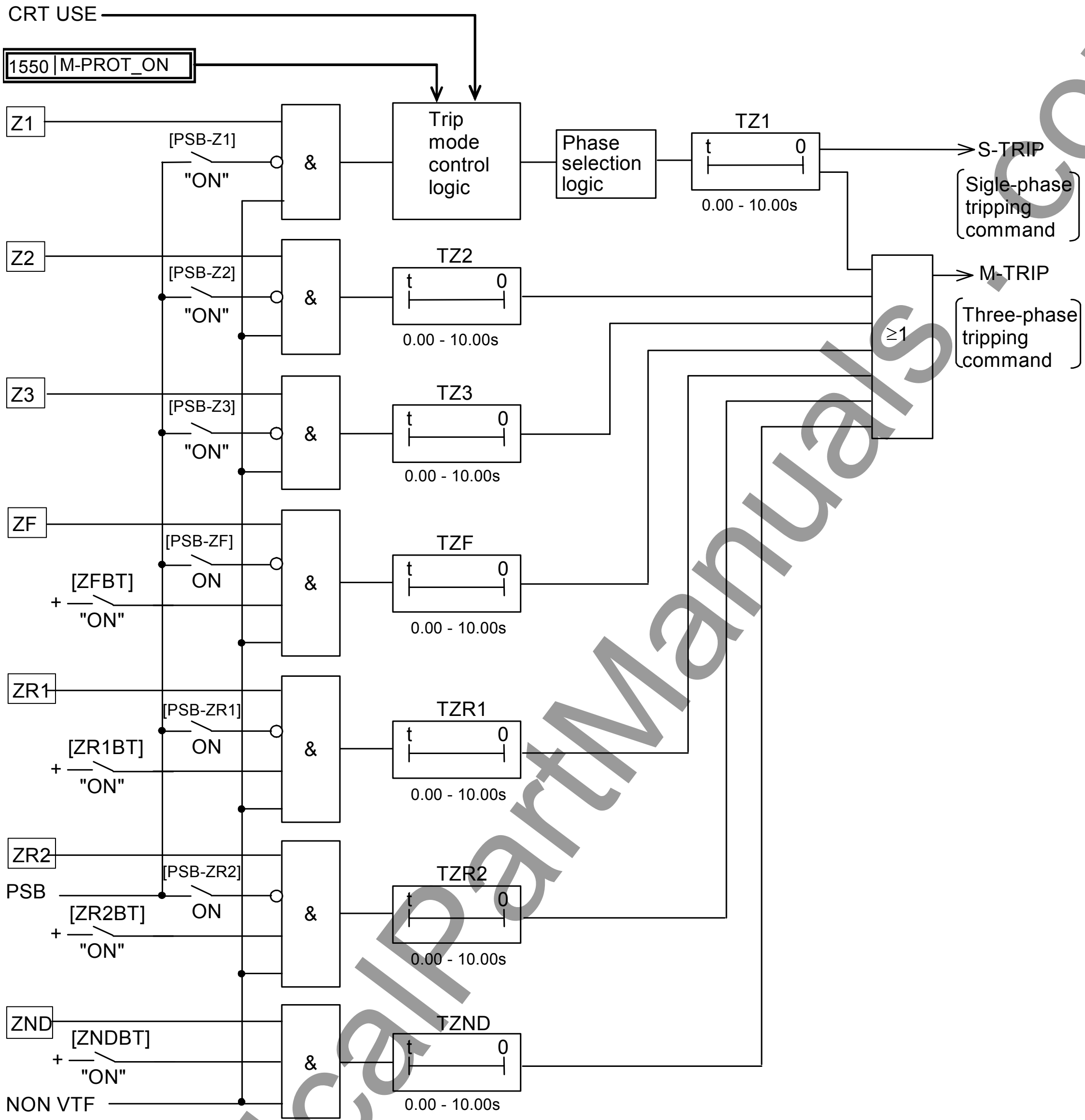


Figure 2.4.1.5 Scheme Logic of Time-stepped Distance Protection

Tripping by each zone can be blocked the binary input signal (PLC signal) Z∗_BLOCK. The tripping can be also blocked in the event of a failure of the secondary circuit of the voltage transformer or power swing. The former is detected by the VT failure detection function. The signal VTF becomes 1 when a failure is detected. The latter is detected by the power swing blocking function. The signal PSB becomes 1 when power swing is detected. The zone in which tripping will be blocked during a power swing can be set using the selection switches [PSB-Z1] to [PSB-ZR2]. For zone ND backup tripping, power swing blocking is inhibited. For the VTF and PSB, see Section 2.4.12 and Section 2.4.13, respectively.

By using the trip mode control logic, Zone 1 can implement different trip modes. The trip modes as shown in Table 2.4.1.1 can be selected according to the position of the scheme switch [Z1CNT] and whether or not the command protection is in or out of service.

Note: When permissive underreach protection is applied as the command protection, instantaneous tripping is required for zone 1 and autoreclose must be started. Therefore, position 1 or 4 must be selected for [Z1CNT].

The service condition of the command protection is judged by the service condition of the telecommunication and the main protection. The telecommunication in-service signal CRT_USE is established when the binary input signal (PLC signal) CRT_BLOCK is "0" and the scheme switch [CRSCM] is set to "ON" as shown in Figure 2.4.1.6.

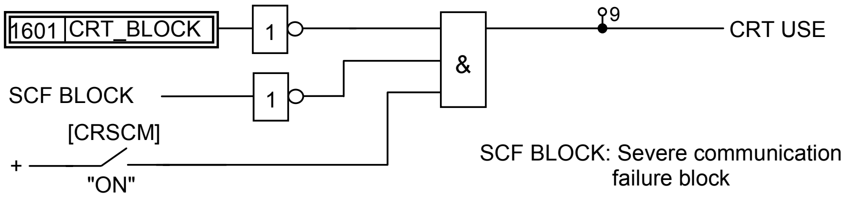


Figure 2.4.1.6 Communication Service Logic

The service condition of the external main protection in duplicated scheme is input with the binary input signal (PLC signal) M-PTOT_ON. The command protection in Table 2.4.1.1 is out of service when both main protections are out of service.

Table 2.4.1.1 Zone 1 Trip Mode Control

Z1CNT Position	COMMAND PROTECTION IN SERVICE	COMMAND PROTECTION OUT OF SERVICE
1	INST. TRIP & AUTO-REC	INST. FINAL TRIP
2	DELAYED FINAL TRIP	INST. FINAL TRIP
3	TRIP BLOCKED	INST. FINAL TRIP
4	INST. TRIP & AUTO-REC	
5	INST. FINAL TRIP	

The zone 1 tripping mode at each position of the switch [Z1CNT] is as follows:

Position 1: When the command protection is in service, zone 1 executes instantaneous tripping and starts autoreclose. Zone 1 performs single-phase tripping and reclosing or three-phase tripping and reclosing depending on the reclose mode of the autoreclose function and the type of faults (single-phase faults or multi-phase faults). If the autoreclose is out of service, zone 1 performs instantaneous three-phase final tripping for all faults.

If the command protection is out of service, zone 1 performs instantaneous three-phase final tripping.

Position 2: Zone 1 performs three-phase tripping with a time delay using timer TZ1 if the command protection is in service, and it performs three-phase tripping instantaneously if the command protection is out of service and does not start the autoreclose.

Position 3: Zone 1 tripping is blocked if the command protection is in service, and instantaneous three-phase tripping is performed if it is out of service. Autoreclose is not started.

Position 4: Zone 1 executes instantaneous tripping irrespective of the command protection conditions and initiates autoreclose. This instantaneous tripping becomes single-phase tripping or three-phase tripping depending on the autoreclose mode and type of faults (single-phase faults or multi-phase faults). If the autoreclose is out of service, zone 1 performs instantaneous three-phase final tripping.

Position 5: Zone 1 performs instantaneous three-phase final tripping irrespective of the command protection.

Zone 1 Trip Mode Control is performed using PLC function as shown in Figure 2.4.1.7. By changing the PLC default setting, the Z1 trip can be controlled independently of the [Z1CNT] setting.

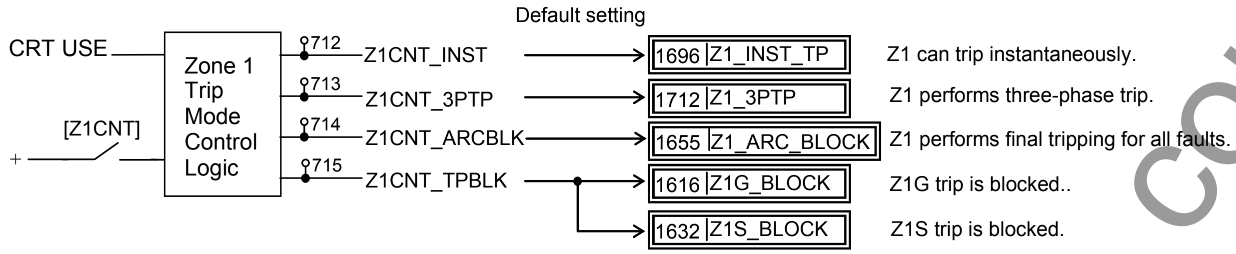


Figure 2.4.1.7 Zone 1 Trip Mode Control Circuit

When zone 1 extension is used, normal zone 1 tripping is blocked. However, the blocking is released by an autoreclose command that follows zone 1 extension tripping. Final tripping to the reclose-on-to-permanent-fault is performed under the time-stepped distance protection including zone 1.

Zone 1 tripping is provided with an additional phase selection element UVC and phase selection logic to make sure the faulted phase is selected for the single-phase earth fault.

Figure 2.4.1.8 gives details of the phase selection logic in Figure 2.4.1.5. In case of single-phase earth fault, the earth fault measuring zone 1 element Z1G with a certain phase and the phase selection element UVC with the same phase operate together, and a single-phase tripping command S-TRIP can be output to the phase.

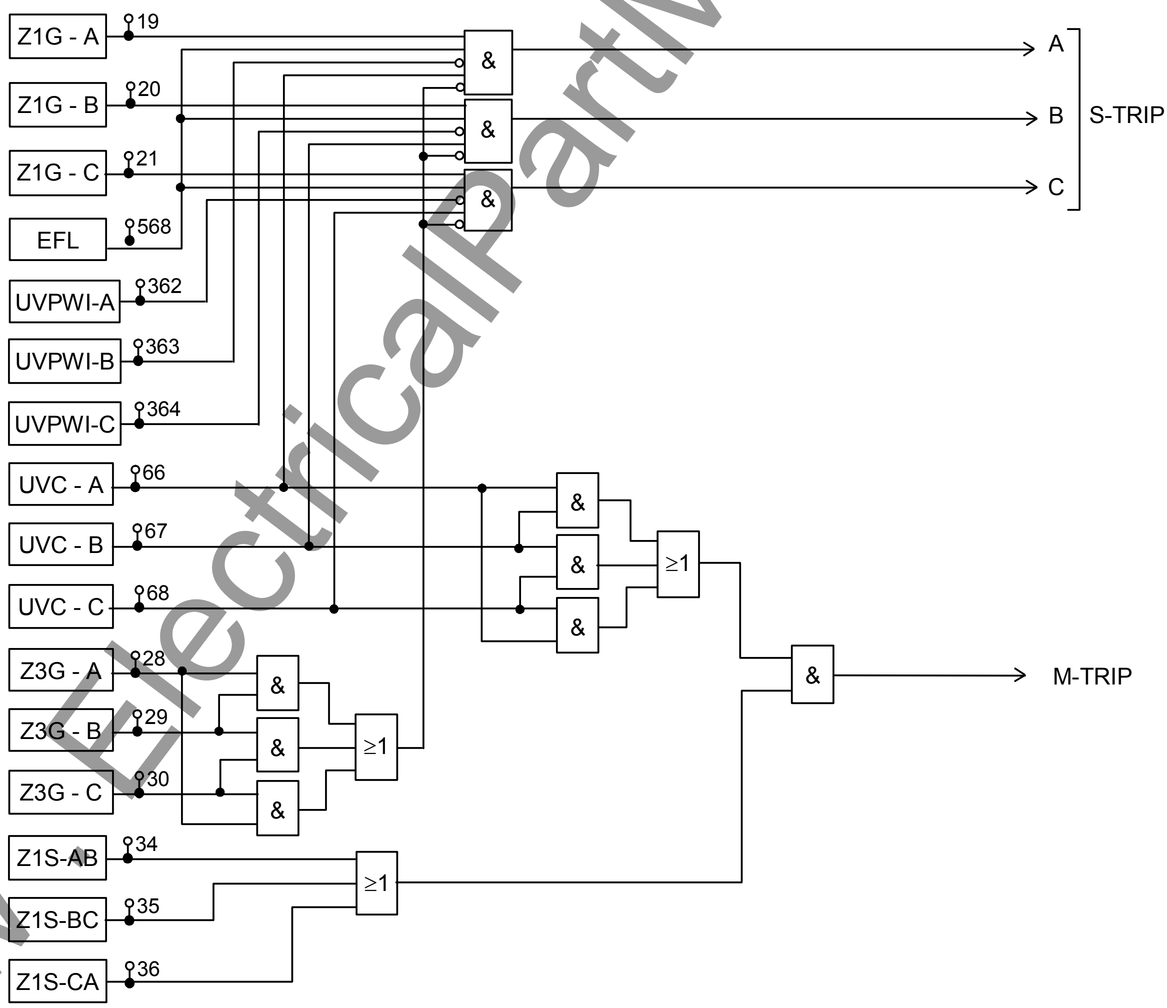


Figure 2.4.1.8 Phase Selection Logic for Zone 1 Protection

Depending on the setting of the scheme switch [Z1CNT] or [ARC-M] which selects reclosing mode, single-phase tripping may be converted to a three-phase tripping command. This is not shown in the figure.

In case of multi-phase fault, the phase fault measuring zone 1 element Z1S and the two phases of the UVC operate together, the Z1G trip is blocked and the three-phase tripping command M-TRIP is always output. The condition for the UVC two-phase operation is to inhibit the Z1S from overreaching in the event of a single-phase earth fault.

The UVC element is applied to the zone 1 distance elements.

EFL is an earth fault detection element, and UVPWI is a phase undervoltage relay to provide countermeasures for overreaching of a leading-phase distance element at positive phase weak infeed condition. These elements are applied to all earth fault distance elements. (Refer to Appendix A.) The UVPWI can be disabled by the scheme switch [UVPWIEN].

2.4.1.3 Setting

The following shows the necessary distance protection elements and their setting ranges.

Element	Range	Step	Default	Remarks
VT	1 - 20000	1	2000	
CT	1 - 20000	1	400	
Phase fault protection				
ZS-C	Mho - Quad		Mho	Characteristic selection
Z1S	0.01 - 50.00Ω	0.01Ω	1.60Ω	Z1 reach
	(0.10 - 250.00Ω	0.10Ω	8.00Ω) (*1)	
Z1S θ1	0° - 45°	1°	0°	Gradient of reactance element
Z1S θ2	45° - 90°	1°	90°	
Z2S	0.01 - 50.00Ω	0.01Ω	3.00Ω	Z2 reach
	(0.10 - 250.00Ω	0.01Ω	15.00Ω)	
ZFS	0.01 - 50.00Ω	0.01Ω	4.00Ω	ZF reach
	(0.1 – 250.0Ω	0.1Ω	20.0Ω)	
Z3S	0.01 - 50.00Ω	0.01Ω	6.00Ω	Z3 reach
	(0.1 – 250.0Ω	0.1Ω	30.0Ω)	
Z3S θ(*2)	45 - 90°	1°	85°	Characteristic angle of mho element
ZBS θ(*3)	0 - 45°	1°	5°	Angle of directional element
BFR1S	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z1S
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRXS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z1XS
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFR2S	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z2S
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRFS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for ZFS
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z3S or Common
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	setting of BLZONE
BFLS θ	90° - 135°	1°	120°	Forward left blinder angle
ZR1S	0.01 - 50.00Ω	0.01Ω	2.00Ω	ZR1 reach
	(0.1 – 250.0Ω	0.1Ω	10.0Ω)	
ZR2S	0.01 - 50.00Ω	0.01Ω	4.00Ω	ZR2 reach
	(0.1 – 250.0Ω	0.1Ω	20.0Ω)	

Element	Range	Step	Default	Remarks
Z4S	0.01 - 50.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 250.0Ω	0.1Ω	40.0Ω)	
BRRS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
ZNDS	0.01 - 50.00Ω	0.01Ω	10.00Ω	ZND reach
	(0.1 – 250.0Ω	0.1Ω	50.0Ω)	
BNDS	0.10 - 20.00Ω	0.01Ω	12.00Ω	ZNDS blinder reach
	(0.5 - 100.0Ω	0.1Ω	60.0Ω)	
TZ1S	0.00 - 10.00 s	0.01 s	0.00 s	Zone 1 timer
TZ2S	0.00 - 10.00 s	0.01 s	0.30 s	Zone 2 timer
TZFS	0.00 - 10.00 s	0.01 s	0.35 s	Zone F timer
TZ3S	0.00 - 10.00 s	0.01 s	0.40 s	Zone 3 timer
TZR1S	0.00 - 10.00 s	0.01 s	0.50 s	Zone R1 timer
TZR2S	0.00 - 10.00 s	0.01 s	0.60 s	Zone R2 timer
TZNDS	0.00 - 10.00 s	0.01 s	0.70 s	Zone ND timer
Earth fault protection				
ZG-C	Mho - Quad		Mho	Characteristic selection
Z1G	0.01 - 50.00Ω	0.01Ω	1.60Ω	Z1 reach
	(0.10 - 250.00Ω	0.10Ω	8.00Ω)	
Z1G θ1	0° - 45°	1°	0°	Gradient of reactance element
Z1G θ2	45° - 90°	1°	90°	
Z2G	0.01 - 50.00Ω	0.01Ω	4.00Ω	Z2 reach
	(0.10 - 250.00Ω	0.10Ω	20.00Ω)	
ZFG	0.01 - 100.00Ω	0.01Ω	6.00Ω	ZF reach
	(0.1 – 500.0Ω	0.1Ω	30.0Ω)	
Z3G	0.01 - 100.00Ω	0.01Ω	8.00Ω	Z3 reach
	(0.1 – 500.0Ω	0.1Ω	40.0Ω)	
Z3G θ(*2)	45 - 90°	1°	85°	Characteristic angle of mho element
ZBGθ(*3)	0° - 45°	1°	30°	Angle of directional element
BFR1G	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z1G
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRXG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z1XG
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFR2G	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z2G
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRFG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for ZFG
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
BFRG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Forward right blinder reach for Z3G or Common
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	setting of BLZONE
BFLG θ	90° - 135°	1°	120°	Forward left blinder angle
ZR1G	0.01 - 100.00Ω	0.01Ω	2.00Ω	ZR1 reach
	(0.1 – 500.0Ω	0.1Ω	10.0Ω)	
ZR2G	0.01 - 100.00Ω	0.01Ω	4.00Ω	ZR2 reach
	(0.1 – 500.0Ω	0.1Ω	20.0Ω)	
Z4G	0.01 - 100.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 500.0Ω	0.1Ω	40.0Ω)	
BRRG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	

Element	Range	Step	Default	Remarks
ZNDG	0.01 - 100.00Ω	0.01Ω	10.00Ω	ZND reach
	(0.1 – 500.0Ω	0.1Ω	50.0Ω)	
BNDG	0.10 - 20.00Ω	0.01Ω	12.00Ω	ZNDG blinder reach
	(0.5 - 100.0Ω	0.1Ω	60.0Ω)	
Krs	0 - 1000 %	1%	340%	Residual current compensation = R0/R1
Kxs	0 - 1000 %	1%	340%	Residual current compensation = X0/X1
Krm	0 - 1000 %	1%	300%	Mutual coupling compensation = ROM/R1
Kxm	0 - 1000 %	1%	300%	Mutual coupling compensation = XOM/X1
KrsR	0 - 1000 %	1%	100%	Residual current compensation for ZR = R0/R1
KxsR	0 - 1000 %	1%	100%	Residual current compensation for ZR = X0/X1
TZ1G	0.00 - 10.00 s	0.01 s	0.00 s	Zone 1 timer
TZ2G	0.00 - 10.00 s	0.01 s	0.30 s	Zone 2 timer
TZFG	0.00 - 10.00 s	0.01 s	0.35 s	Zone F timer
TZ3G	0.00 - 10.00 s	0.01 s	0.40 s	Zone 3 timer
TZR1G	0.00 - 10.00 s	0.01 s	0.50 s	Zone R1 timer
TZR2G	0.00 - 10.00 s	0.01 s	0.60 s	Zone R2 timer
TZNDG	0.00 - 10.00 s	0.01 s	0.70 s	Zone ND timer
UVC				Phase selection element
UVCV	10 - 60 V	1 V	48 V	Voltage setting
UVCZ	0.0 - 50.0Ω	0.1Ω	2.0Ω	Reach setting
	(0 - 250Ω	1Ω	10Ω)	
UVC θ	45° - 90°	1°	85°	Characteristic angle
EFL	0.5 – 5.0 A	0.1 A	1.0 A	Earth fault detection
	(0.10 – 1.00 A	0.01 A	0.20 A)	
UVPWI	30 V fixed			UV for positive weak infeed
Scheme switch				
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP /BOP/POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection
CRSCM	OFF/ON		ON	Telecommunication service
BLZONE	COM/IND		COM	Common or independent setting for blinder
Z1CNT	1/2/3/4/5		1	Zone 1 trip mode selection
PSB - Z1	OFF/ON		ON	Z1 power swing blocking
PSB - Z2	OFF/ON		ON	Z2 power swing blocking
PSB - Z3	OFF/ON		OFF	Z3 power swing blocking
PSB - ZF	OFF/ON		OFF	ZF power swing blocking
PSB - ZR1	OFF/ON		OFF	ZR1 power swing blocking
PSB - ZR2	OFF/ON		OFF	ZR2 power swing blocking
ZFBT	OFF/ON		OFF	ZF backup tripping
ZR1BT	OFF/ON		OFF	ZR1 backup tripping
ZR2BT	OFF/ON		OFF	ZR2 backup tripping
ZNDBT	OFF/ON		OFF	ND zone backup tripping
UVPWIEN	OFF/ON		OFF	Countermeasures for overreaching of a leading-phase distance element at positive phase weak infeed condition

(*1) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.
(*2) Valid only when mho-based characteristic is selected by ZS-C and ZG-C.
(*3) Valid only when quadrilateral characteristic is selected by ZS-C and ZG-C.

The following elements have fixed setting values or their settings are interlinked with other elements listed above. So no setting operation is required.

Element	Setting	Remarks
Z1BS	Fixed to 1.5Ω (Fixed to 7.5Ω)(*1)	Z1 reverse offset reach
BFRS θ	Fixed to 75°	Angle of forward right blinder BFRS
Z4BS	Fixed to 1.5Ω (Fixed to 7.5Ω)	Z4 offset reach. This is also the offset reach for Z1RS and Z2RS. However, in these cases the offset reach is limited by the Z1S setting when Z1RS and Z2RS are used for backup tripping.
Z4S θ(*2)	Interlinked with Z3S θ	Characteristic angle of zone 4 mho element
Z4BS θ(*3)	Interlinked with ZBS θ	Angle of Z4 offset directional element
BRRS θ	Fixed to 75°	Angle of reverse right blinder BRRS
BRLS	Interlinked with BRRS	Reverse left blinder
BRLS θ	Interlinked with BFLS θ	Angle of reverse left blinder BRLS
BFRG θ	Fixed to 75°	Angle of forward right blinder BFRG
BNDSθ	Fixed to 75°	Angle of BNDS blinder
Z4G θ(*2)	Interlinked with Z3G θ	Characteristic angle of Z4 mho element
Z4BG θ(*3)	Interlinked with ZBG θ	Angle of offset directional element
BRRG θ	Fixed to 75°	Angle of reverse right blinder BRRG
BRLG	Interlinked with BRRG	Reverse left blinder
BRLG θ	Interlinked with BFLG θ	Angle of reverse left blinder BRLG
BNDGθ	Fixed to 75°	Angle of BNDG blinder

(*1)Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

(*2) Valid when mho-based characteristic is selected by ZS-C.

(*3) Valid when quadrilateral characteristic is selected by ZS-C.

In order to coordinate with the distance protection provided for adjacent lines, care is required in setting the reach and timer setting. Figure 2.4.1.9 shows an ideal zone and time coordination between terminals.

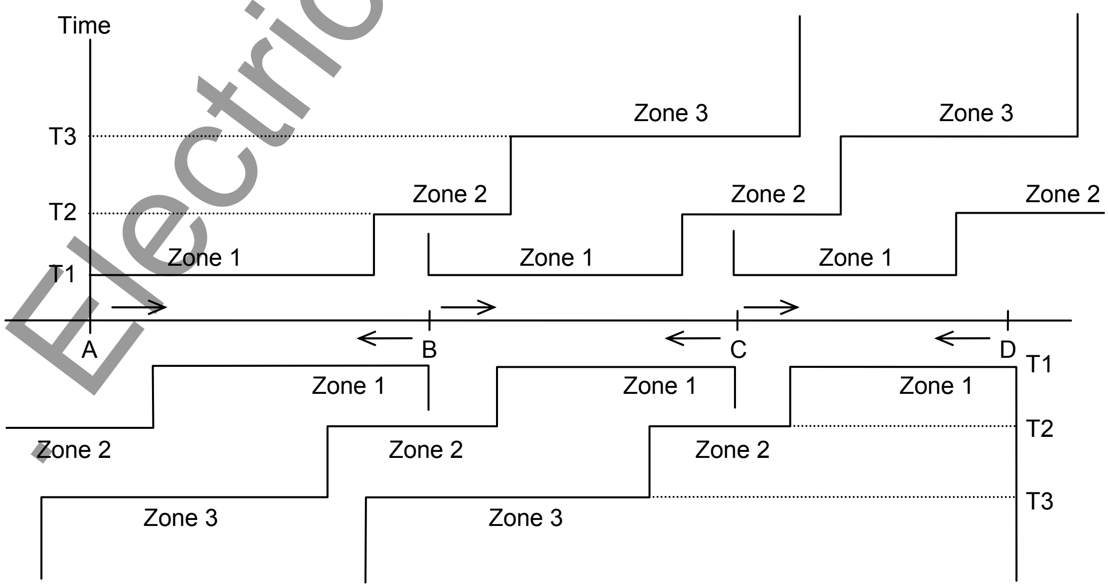


Figure 2.4.1.9 Typical Zone/Time Coordination among A-D Terminals

Zone 1 setting

Since instantaneous tripping is allowed in zone 1, it is desirable to select a setting that will cover the widest possible range of the protected line. Conversely, zone 1 elements must not respond to faults further than the remote end. Therefore, the setting of the zone 1 reach is set to 80 to 90% of the impedance of the protected line taking account of VT and CT errors and measurement error. The reach is set on the X-axis.

In order to change the reactance element characteristic into a broken line, Z1S(G)θ1 and Z1S(G)θ2 in Figure 2.4.1.1 or Figure 2.4.1.2 must be set.

Time delayed tripping of zone 1 is selected when instantaneous tripping by another main protection is given priority. The time delay TZ1 is set to ensure that coordination is maintained with fault clearance by the main protection. Suppose that the maximum operating time of the main protection is Tp, the opening time of the circuit breaker is Tcb, the minimum operating time of zone 1 element is T1 and the reset time of the zone 1 element is Tzone 1, then TZ1 must satisfy the following condition:

$$TZ1 > Tp + Tcb + Tzone\ 1 - T1$$

Zone 2 setting

Zone 2 is required to cover 10 to 20% of the remote end zone not covered by zone 1. To assure this protection, it is set to 120% or greater of the protected line impedance. To maintain the selectivity with zone 1 of the adjacent lines, the zone 2 reach should not exceed the zone 1 reach of the shortest adjacent line. The reach is set on the X-axis.

Time delay TZ2 is set so that it may be coordinated with fault clearance afforded by the main protection of the adjacent lines. If time delayed tripping is selected for zone 1 of the protected line, coordination with the time delay should also be taken into account. Suppose that the main protection operating time on the adjacent lines is Tp', the opening time of the circuit breaker is Tcb', the minimum operating time of zone 2 element is T2 and the reset time of local terminal zone 2 element is Tzone 2, then TZ2 must satisfy the following two conditions:

$$TZ2 > Tp' + Tcb' + Tzone\ 2 - T2$$

$$TZ2 > TZ1$$

If the adjacent lines are too short for zone 2 to coordinate with zone 1 of the adjacent lines in reach setting, it is necessary to set a much greater time delay for zone 2 as shown in Figure 2.4.1.10.

Generally, in setting the zone 2, consideration should be given to ensure selectivity with even the slowest timer of the following protections:

- Remote end busbar protection
- Remote end transformer protection
- Line protection of adjacent lines
- Remote end breaker failure protection

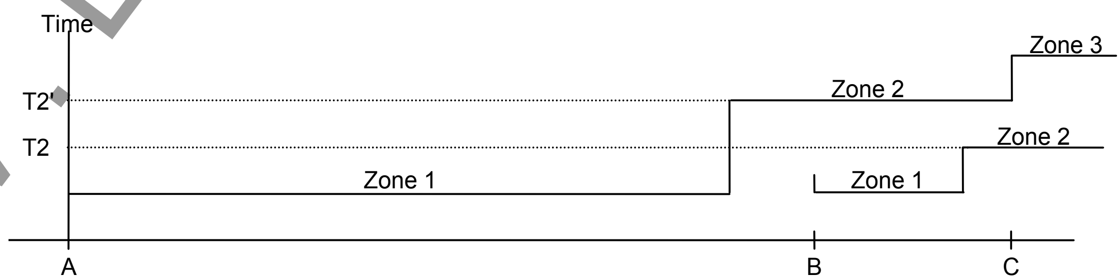


Figure 2.4.1.10 Zone 2 Setting (When one of the adjacent lines is very short)

Zone 3 setting

Zone 3, in cooperation with zone 2, affords backup protection for faults that have occurred on adjacent lines. The reach should be set to exceed the remote end of the longest adjacent line whenever possible. It is also necessary to take into account the effect of fault infeed at the remote busbars. If an ideal reach setting as shown in Figure 2.4.1.9 is possible, the timer setting for zone 3 needs only to consider the coordination with the timer setting in zone 2 of the protected lines and adjacent lines.

However, as shown in Figure 2.4.1.11, if there are short-distance adjacent lines and it is impossible to establish coordination only by the reach setting, there may also be a case where the time delay for zone 3 will need to be set greater than that of the adjacent lines.

The zone 3 reach is set on the characteristic angle when the mho characteristic is selected or set on the X axis when the quadrilateral characteristic is selected.

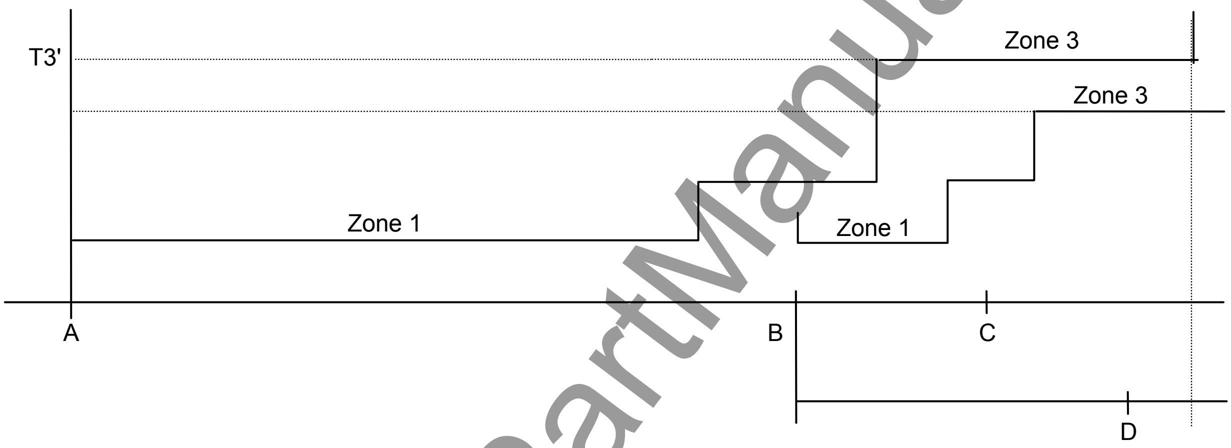


Figure 2.4.1.11 Zone 3 Setting (When one of the adjacent lines is very short)

Zone F setting

When zone F is used for the zone 3 instead of Z3, above zone 3 setting is applied. If the zone F is used separately from zone 3, the settings of zone F reach and time delay are set to be less than the zone 3 settings.

Zone R1 setting

The setting of the zone R1 reach is set so as to exceed the end of the adjacent line behind the relaying point. The reach is set on the X-axis. The time delay is set to be greater than that of the zone 3 backup protection. The scheme switch [ZR1BT] is set to “ON”, and the scheme switch [ZR2BT] must be set to “ON” and the zone R2 reach must be set greater than the zone R1 reach even though the zone R2 is not used.

Zone R2 setting

The setting of the zone R2 reach is set so as to include the busbar of the adjacent terminal behind the relaying point. The time delay is set to be greater than that of the zone R1.

The zone R2 reach is set on the characteristic angle when the mho characteristic is selected or set on the X axis when the quadrilateral characteristic is selected. The scheme switch [ZR2BT] is set to “ON”.

Zone ND setting

The setting of the zone ND reach is set so as to include all zone settings and the time delay is set the greatest of all zones. The scheme switch [ZNDBT] is set to “ON”.

Blinder setting

BFR and BRR reaches are set to the minimum load impedance with a margin. The minimum load impedance is calculated using the minimum operating voltage and the maximum load current.

The blinder element (BFR) can be provided for each forward zone. The setting of blinder element can be set independently or set common to forward zones by [BLZONE]=IND or [BLZONE]=COM setting. In the [BLZONE]=IND setting, the forward zone blinder setting should be set BFR1∗≤BFRX∗≤BFR2∗≤BFR∗. If BFR∗≤BFR1∗, for example, the reach of BFR1∗ is limited to the BFR∗ setting reach as shown in Figure 2.4.1.12(b). The BFRF∗ can be set larger than the BFR∗. If the BFRF∗ is larger than the maximum resistive reach of Z3, the area exceeding the Z3 is invalid. The BFRF∗ is limited to Z3 operating zone as shown in Figure 2.4.1.12(C).

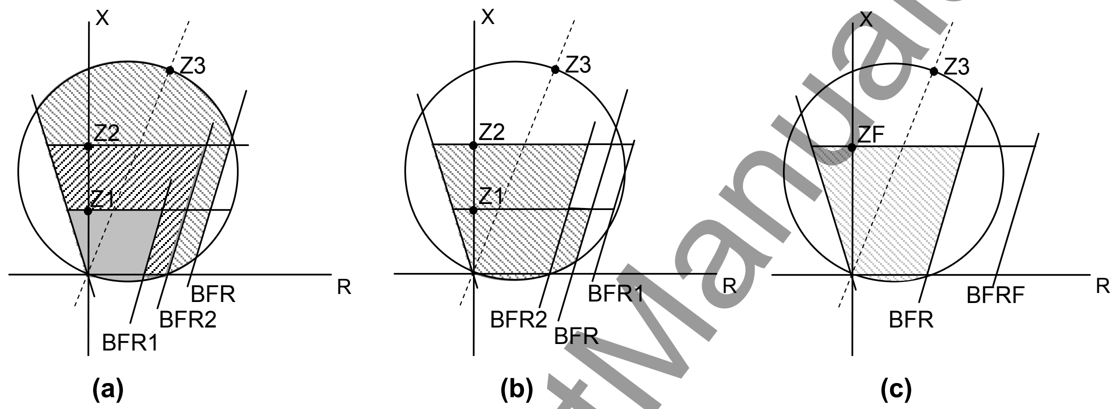


Figure 2.4.1.12 BFR Reach

The BFL angle can be set to 90 to 135° and is set to 120° as a default. The BRL angle is linked with the BFL angle.

Figure 2.4.1.12 shows an example of the blinder setting when the minimum load impedance is Z_{Lmin} and Z'_{Lmin} under the load transmitting and receiving conditions.

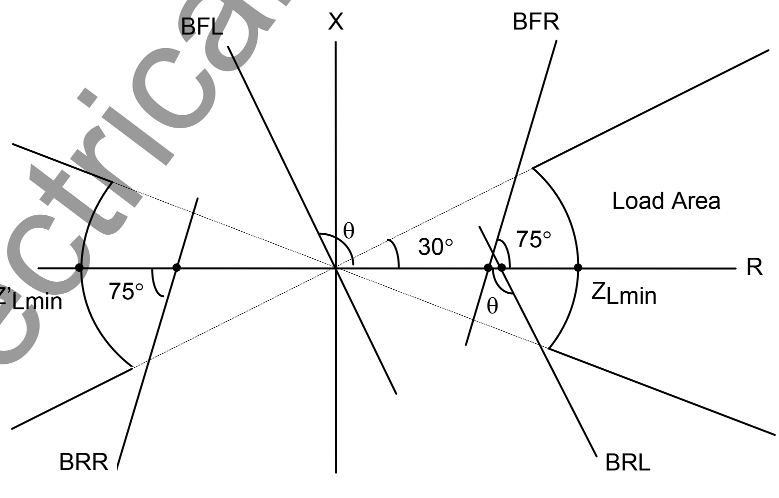


Figure 2.4.1.13 Blinder Setting

When Z4 is used for overreaching command protection ie. POP, UOP and BOP, it is necessary when setting BRR to take account of the setting of the remote end BFR to ensure coordination. That is, the BRR is set to a value greater than the set value of the remote end BFR (e.g., 120% of BFR). This ensures that a reverse fault that causes remote end zone 2 or zone 3 to operate is detected in local zone R1 or R2 and false tripping is blocked.

Setting of earth fault compensation factor (zero sequence compensation)

In order to correctly measure the positive-sequence impedance to the fault point, the current input to the earth fault measuring elements is compensated by the residual current ($3I_0$) of the protected line in the case of a single circuit line and by residual current ($3I_0$) of the protected line and residual current ($3I_0$') of the parallel line in the case of a double circuit line.

Generally, the following equation is used to compensate the zero-sequence voltage drop in the case of phase "a".

$$V_a = (I_a - I_0)Z_1 + I_0 \times Z_0 + I_{om} \times Z_{om} \qquad (1)$$

where,

V_a: Phase "a" voltage

I_a: Phase "a" current

I_0: Zero-sequence current of the protected line

I_{0m}: Zero-sequence current of the parallel line

Z_1: Positive-sequence impedance ($Z_1 = R_1 + jX_1$)

Z_0: Zero-sequence impedance ($Z_0 = R_0 + jX_0$)

Z_{0m}: Zero-sequence mutual impedance ($Z_{om} = R_{om} + jX_{om}$)

Equation (1) can be written as follows:

$$V_a = (R_1 + jX_1)I_a + \{(R_0 - R_1) + j(X_0 - X_1)\}I_0 + (R_{om} + jX_{om})I_{om}$$

$$= R_1(I_a + \frac{R_0 - R_1}{R_1}I_0 + \frac{R_{om}}{R_1}I_{om}) + jX_1(I_a + \frac{X_0 - X_1}{X_1}I_0 + \frac{X_{om}}{X_1}I_{om})$$

In the GRZ100, the voltage is compensated independently for resistance and reactance components as shown in equation (2) in stead of general equation (1).

$$\begin{aligned}
V_{aR} + jV_{aX} = \; & \{R_1(I_{aR} + \frac{\frac{K_{rs}}{100} - 1}{3} \times 3I_{0R} + \frac{\frac{K_{rm}}{100}}{3} \times 3I_{omR}) \\
& - X_1(I_{aX} + \frac{\frac{K_{xs}}{100} - 1}{3} \times 3I_{0X} + \frac{\frac{K_{xm}}{100}}{3} \times 3I_{omX})\} \\
& + j\{R_1(I_{aX} + \frac{\frac{K_{rs}}{100} - 1}{3} \times 3I_{0X} + \frac{\frac{K_{rm}}{100}}{3} \times 3I_{omX}) \\
& + X_1(I_{aR} + \frac{\frac{K_{xs}}{100} - 1}{3} \times 3I_{0R} + \frac{\frac{K_{xm}}{100}}{3} \times 3I_{omR})\} \qquad (2)
\end{aligned}$$

where,

K_{xs}: compensation factor ($K_{xs} = X_0/X_1 \times 100$)

K_{rs}: compensation factor ($K_{rs} = R_0/R_1 \times 100$)

K_{xm}: compensation factor ($K_{xm} = X_{om}/X_1 \times 100$)

K_{rm}: compensation factor ($K_{rm} = R_{om}/R_1 \times 100$)

X: imaginary part of the measured impedance

R: real part of the measured impedance

V_{aX}: imaginary part of phase "a" voltage

V_{aR}: real part of phase "a" voltage

I_{aX}: imaginary part of phase "a" current

I_{aR}: real part of phase "a" current

I_{0X}: imaginary part of zero-sequence current of the protected line

I_{0R}: real part of zero-sequence current of the protected line

I_{omX}: imaginary part of zero-sequence current of the parallel line

I_{omR}: real part of zero-sequence current of the parallel line

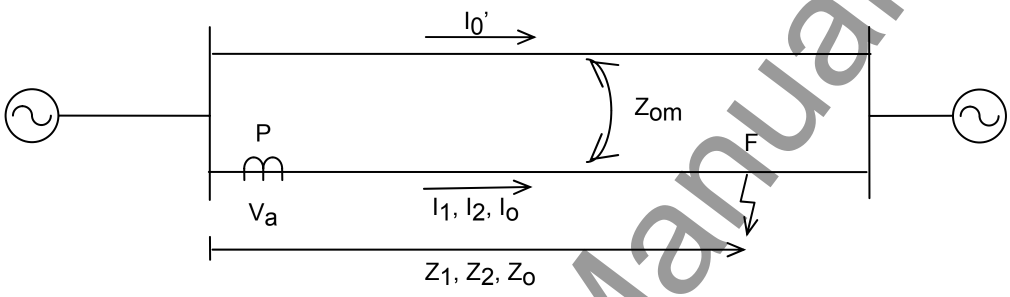


Figure 2.4.1.14 Earth Fault Compensation

The zero-sequence compensation factors are applied to the earth fault measuring elements as shown in the table below

Element	Protected line	Parallel line
Z1G	Krs, Kxs	Krm, Kxm
Z1XG	Krs, Kxs	Krm, Kxm
Z2G	Krs, Kxs	Krm, Kxm
Z3G	–	–
ZFG	–	–
ZR1G	KrsR, KxsR	–
ZR2G	–	–
Z4G	–	–
ZNDG	–	–

–: Compensation is not provided.

The zero-sequence compensation of the parallel line is controlled by the ZPCC (Zero-sequence Current Compensation) element.

When an earth fault occurs on the protected line, the ZPCC operates and parallel line compensation is performed to prevent underreach caused by the mutual zero-sequence current of the parallel line.

When an earth fault on the parallel line occurs, the ZPCC does not operate and the compensation of parallel line is not performed to prevent overreach. The operating condition of the ZPCC is as follows:

$$3I_0 / 3I_{om} \geq 0.8$$

Charging current compensation

When distance protection is applied to underground cables or long-distance overhead lines, the effect of charging current cannot be ignored. It appears as a distance measurement error in the fault.

To suppress the effect of the charging current and maintain the highly accurate distance measurement capability, the GRZ100 has a charging current compensation function.

The compensation is recommended if the minimum fault current can be less than three times the charging current.

The setting value of ZIC should be the charging current at the rated voltage Vn.

Element	Range	Step	Default	Remarks
ZIC	0.00 - 5.00 A	0.01 A	0.0 0	Charging current setting
	(0.00 - 1.00 A	0.01 A	0.00 A) (*)	
Vn	100 - 120	1 V	110 V	Rated line voltage

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

Setting of phase selection element

Phase selection is required only for faults on the protected line. Therefore, impedance reach setting UVCZ is set to 120% of the positive-sequence impedance of the protected line. Impedance angle setting UVC θ is set the same as the protected line angle.

Undervoltage setting UVCV is set higher than the estimated maximum fault voltage at the fault point for a single-phase earth fault.

2.4.2 Zone 1 Extension Protection

Application

The disadvantage of time-stepped distance protection is that faults near the remote end of the protected line can only be cleared in zone 2 time, thus high speed protection cannot be performed for all faults on the protected line. If telecommunication is available, this disadvantage can be solved by command protection. If telecommunication is not available, zone 1 extension protection using autoreclose will implement high speed protection at both terminals.

Zone 1 extension (zone 1X) has a complex characteristic combining the reactance element, mho element and blinder element, and its characteristic is the same as zone 1.

Zone 1X for earth faults is provided with the same residual current compensation as zone 1 and zone 2.

As shown in Figure 2.4.2.1, zone 1X is set to overreach the protected line and performs instantaneous tripping. This tripping is followed by autoreclose. In the selected autoreclose mode, one of three-phase tripping and autoreclose, single-phase tripping and autoreclose, or single- and three-phase tripping and autoreclose is executed.

The zone 1 extension protection clears a fault on the protected line including an end zone fault at high speed, displaying the performance equivalent to that of command protection.

On the other hand, unlike command protection, overreaching zone 1X also acts instantaneously for a fault on adjacent lines and executes tripping. If the fault is a transient fault, power transmission can be recovered by autoreclose with a transient loss of power supply.

High speed zone 1X tripping is not desirable following reclosure onto a permanent fault on an adjacent line because more of the network is lost than necessary. Therefore, tripping by zone 1X is blocked prior to the reclosing command to the circuit breaker. Whether or not the permanent fault is on the protected line or on an adjacent line, tripping is performed under time-stepped distance protection.

When autoreclose is out of service, the zone 1 extension protection is blocked.

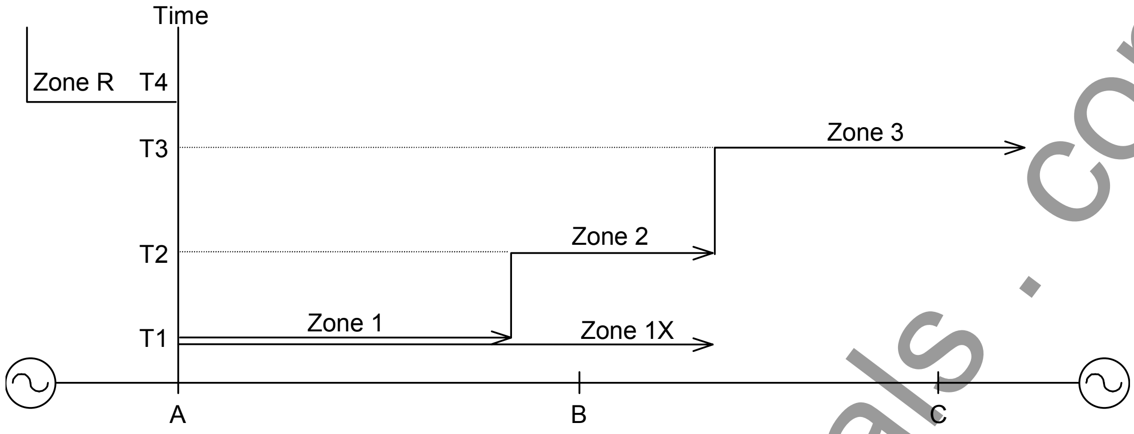


Figure 2.4.2.1 Time/Distance Characteristics of Zone 1 Extension Protection and Time-Stepped Distance Protection

Scheme Logic

The scheme logic of the zone 1 extension protection is shown in Figure 2.4.2.2. Zone 1X outputs single-phase tripping signal S-TRIP or three-phase tripping signal M-TRIP through phase selection logic on condition that the reclosing mode selection switch [ARC-M] of autoreclose be set to "TPAR" or "SPAR & TPAR" and condition REC-READY1 = 1 be established. The phase selection logic is the same as that for the zone 1 protection shown in Figure 2.4.1.7, except that Z1XG and Z1XS are employed instead of Z1G and Z1S. When a power swing is detected (PSB = 1) and when a VT failure is detected (VTF = 1), tripping is blocked. Power swing blocking can be disabled by the scheme switch [PSB-Z1X].

The zone 1 extension protection is disabled by the binary input signal (PLC signal) Z1XG_BLOCK and Z1XS_BLOCK.

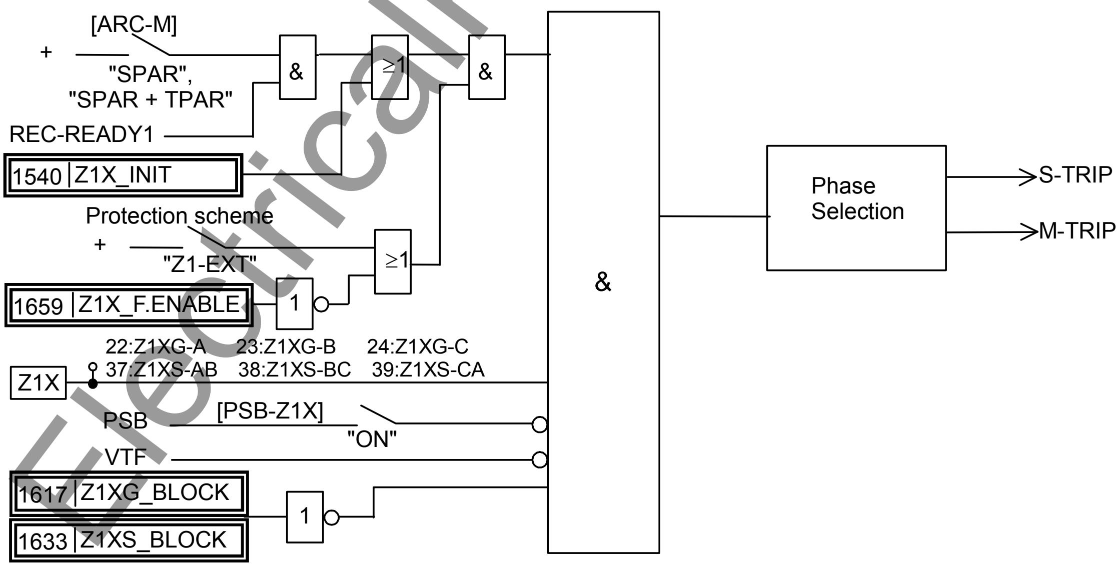


Figure 2.4.2.2 Zone 1 Extension Scheme Logic

REC-READY1 is a signal in the autoreclose function, and as shown in Figure 2.4.2.3, REC-READY1 = 1 is established when the reclaim time has elapsed, that is, when autoreclose is ready, and reset when a reclosing command is output.

Zone 1 extension can provide protection in the case of evolving faults provided that they occur before the reclosing command is output. Otherwise, in the case of a permanent fault, it will not respond to a reclose-on-to-fault.

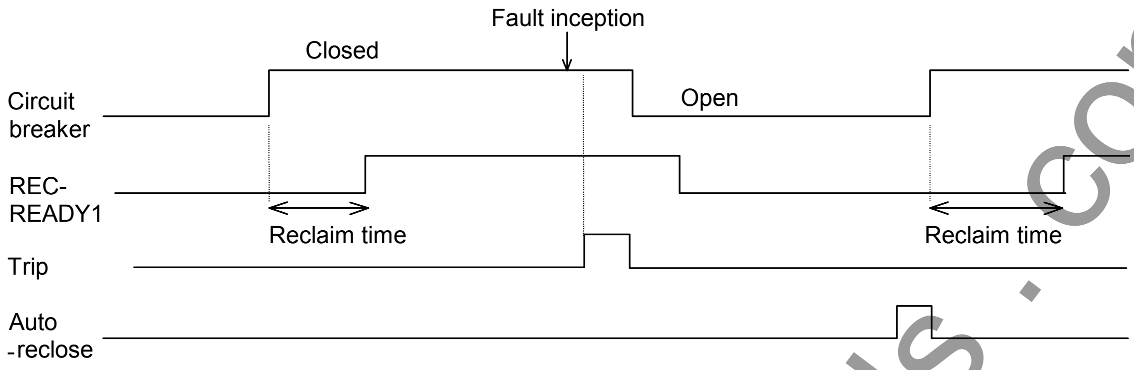


Figure 2.4.2.3 Sequence Diagram of Zone 1 Extension

Zone 1 extension executes single-phase tripping and autoreclose for single-phase to earth faults when the reclosing mode selection switch [ARC-M] is set to "SPAR & TPAR". A phase selection element UVC and phase selection logic are used for reliable selection of the faulted phases. Phase selection logic for zone 1X can be seen in Figure 2.4.1.7 by replacing zone 1 measuring elements with zone 1X measuring elements.

Setting

The following table shows the setting elements necessary for zone 1 extension protection and their setting ranges.

Element	Range	Step	Default	Remarks
Z1XS	0.01 – 50.00Ω	0.01Ω	2.40Ω	Zone 1 extension reach
	(0.10 – 250.00Ω	0.01Ω	12.00Ω) (*)	
Z1S θ1	0° - 45°	1°	0°	Gradient of reactance element
Z1S θ2	45° - 90°	1°	90°	
BFRXS	0.10 – 20.00Ω	0.01Ω	5.10Ω	Forward night blinder reach for Z1XS
	(0.5 – 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
Z1XG	0.01 – 50.00Ω	0.01Ω	2.40Ω	Zone 1 extension reach
	(0.10 – 250.00Ω	0.01Ω	12.00Ω)	
Z1G θ1	0° - 45°	1°	0°	Gradient of reactance element
Z1G θ2	45° - 90°	1°	90°	
BFRXG	0.10 – 20.00Ω	0.01Ω	5.10Ω	Forward night blinder reach for Z1XG
	(0.5 – 100.0Ω	0.1Ω	25.5Ω)	Required if [BLZONE]=IND
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP/BOP/POP +DEF/UOP+DEF/BOP+DEF/ PUP+DEF		POP	Scheme selection
Autoreclose mode (ARC – M)	Disabled/SPAR/TPAR/ SPAR & TPAR/EXT1P/EXT3P		SPAR & TPAR	Autoreclose mode selection"SPAR" or "SPAR & TPAR" should be selected
BLZONE	COM/IND		COM	Common or independent setting for blinder
PSB - Z1X	OFF/ON		ON	Power swing blocking

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

The reach for zone 1 extension is set, for example, to 120% so as to completely cover the protected line. It is not necessary to set the earth fault compensation factors because the same compensation factors as those of zone 1 and zone 2 are used. The reach is set on the X-axis.

When the reactance element characteristic of zone 1 takes a broken line, that of zone 1 extension follows it automatically.

When using zone 1 extension protection, either "SPAR & TPAR" or "TPAR" must be selected as the reclosing mode of the autoreclose.

2.4.3 Command Protection

If operational information from the distance relays located at each end of the protected line is exchanged by means of telecommunication, it is possible to accurately determine whether or not the fault is internal or external to the protected line. Each terminal can provide high-speed protection for any fault along the whole length of the protected line. The GRZ100 provides the following command protection using the distance measuring elements.

- Permissive underreach protection (PUP)
- Permissive overreach protection (POP)
- Unblocking overreach protection (UOP)
- Blocking overreach protection (BOP)

Each command protection can initiate high-speed autoreclose. These protections perform single-phase or three-phase tripping depending on the setting of the reclosing mode and the fault type.

Each command protection includes the aforementioned time-stepped distance protection as backup protection.

2.4.3.1 Permissive Underreach Protection

Application

In permissive underreach protection (PUP), the underreaching zone 1 protection operates and trips the local circuit breakers and at the same time sends a trip permission signal to the remote terminal. The terminal which receives this signal executes instantaneous tripping on condition that the local overreaching element has operated. The overreaching element can be selected as either zone 2 or zone 3.

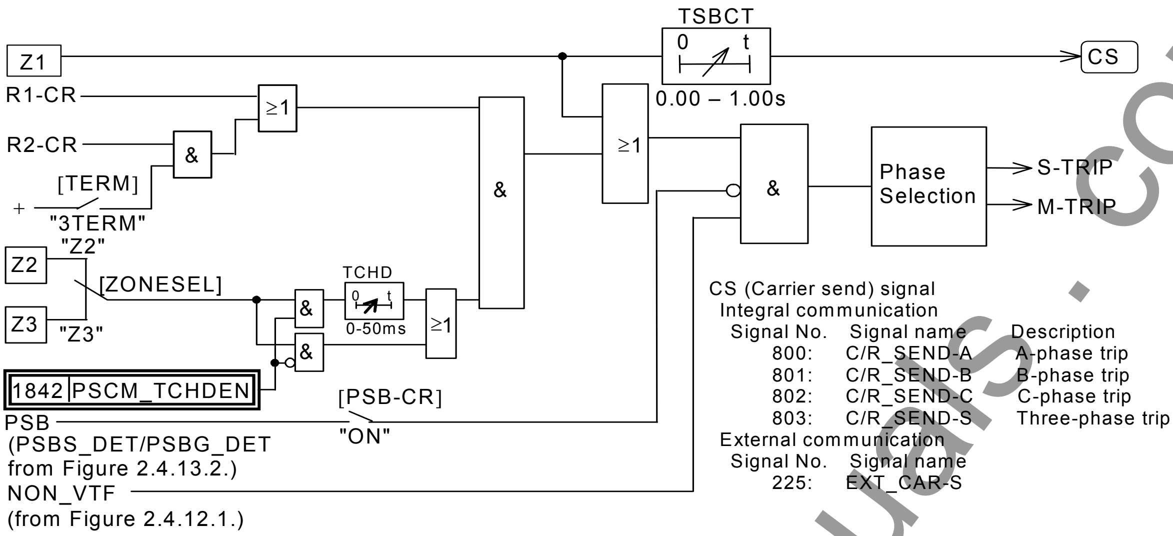
Since the trip permission signal is sent only when it is sure that the fault exists in the operating zone of zone 1, the PUP provides excellent security. On the other hand, the PUP does not provide sufficient dependability for faults on lines that contain open terminals or weak infeed terminals for which zone 1 cannot operate. Faults near open terminals or weak infeed terminals are removed by delayed tripping of zone 2 elements at remote terminals.

Since only the operating signal of the underreaching element is transmitted, it is not necessary to distinguish a transmit signal from a receive signal. That is, the telecommunication channel can be shared by the terminals and a simplex channel can be used.

Scheme Logic

Figure 2.4.3.1 shows the scheme logic of the PUP. Once zone 1 starts to operate, it outputs a single-phase tripping signal S-TRIP or three-phase tripping signal M-TRIP to the local terminal instantaneously and at the same time sends a trip permission signal CS to the remote terminals. When the trip permission signal R1-CR or R2-CR or both is received from the remote terminals, PUP executes instantaneous tripping on condition that either zone 2 or zone 3 has operated. Whether or not zone 2 or zone 3 is used can be selected by the scheme switch [ZONESEL]. If the PLC signal PSCM_TCHDEN is established, the delayed pick-up timer TCHD is provided.

When the integral communication channel is used, the trip permission signals sent and received contain three phase-segregated signals for earth faults and one signal for phase faults. When the external communication channel is used, a single trip permission signal is common to all fault types.



R1-CR: Trip permission signal from the remote terminal 1 in 3 terminal application, or
Trip permission signal from remote terminal in 2 terminal application.
In integral communication, it is a phase-segregated signal as follows:

Signal No.	Signal name	Description
1728:	CAR-A-R1	Distance carrier command A-phase trip
1729:	CAR-B-R1	Distance carrier command B-phase trip
1730:	CAR-C-R1	Distance carrier command C-phase trip
1731:	CAR-S-R1	Distance carrier command Three-phase trip

In external communication, it is the following signal:

Signal No.	Signal name	Description
1568:	EXT_CAR.R1-1	Trip carrier signal from remote terminal 1
1569:	EXT_CAR.R1-2	Guard/And carrier signal from remote terminal 1

R2-CR: Trip permission signal from the remote terminal 2 in 3 terminal application.
In integral communication, it is a phase-segregated signal as follows:

Signal No.	Signal name	Description
1760:	CAR-A-R2	Distance carrier command A-phase trip
1761:	CAR-B-R2	Distance carrier command B-phase trip
1762:	CAR-C-R2	Distance carrier command C-phase trip
1763:	CAR-S-R2	Distance carrier command Three-phase trip

In external communication, it is the following signal:

Signal No.	Signal name	Description
1584:	EXT_CAR.R2-1	Trip carrier signal from remote terminal 2
1585:	EXT_CAR.R2-2	Guard/And carrier signal from remote terminal 2

Figure 2.4.3.1 PUP Scheme Logic

To select the faulted phases reliably, phase selection is performed using the phase selection element UVC. Phase selection logic in zone 1 tripping is shown in Figure 2.4.1.7 and its operation is described in Section 2.4.1. Phase selection logic in command tripping is shown in Figure 2.4.3.9. Refer to Section 2.4.3.7.

Off-delay timer TSBCT is provided for the following purpose:

In many cases, most of the overreaching elements at both ends operate almost simultaneously. However, there may be some cases where they cannot operate simultaneously due to unbalanced distribution of fault currents. Non-operation of the overreaching elements can occur at a terminal far from the fault, but they can operate if the other terminal trips. Transmission of the trip permission signal continues for the setting time of TSBCT after reset of zone 1, and thus even the terminal for which the overreaching element has delayed-picked up can also trip.

Setting

The following shows the setting elements necessary for the PUP and their setting ranges. For the settings of Z1, Z2, Z3 and UVC, refer to Section 2.4.1.

Element	Range	Step	Default	Remarks
TCHD	0 - 50 ms	1 ms	12 ms	Channel delay time
CO. LINK	Int / Ext		Int	Communication link (Integral or External)

TSBCT	0.00 – 1.00s	0.01s	0.10s	
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP /BOP/POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection
TERM	2TERM/3TERM		2TERM	Terminal selection
Open1	OFF/ON		OFF	Remote terminal 1 out of service
Open2	OFF/ON		OFF	Remote terminal 2 out of service
ZONESEL	Z2/Z3		Z2	Overreaching element selection
PSB - CR	OFF/ON		ON	Power swing blocking

2.4.3.2 Permissive Overreach Protection

Application

In permissive overreach protection (POP), the terminal on which the forward overreaching element operates transmits a trip permission signal to the other terminal. The circuit breaker at the local terminal is tripped on condition that the overreaching element of the local terminal has operated and that a trip permission signal has been received from the remote terminal. That is, POP determines that the fault exists inside the protected line based on the overlapping operation of the forward overreaching elements at both terminals. It is possible to use zone 2 or zone 3, as the forward overreaching element.

The POP is provided with an echo function and weak infeed trip function so that even when the protection is applied to a line with open terminals or weak infeed terminals, it enables fast tripping of both terminals for any fault along the whole length of the protected line. An undervoltage element UVL is provided for weak infeed tripping. (See Section 2.4.3.5 for protection for weak infeed terminal.)

When a sequential fault clearance occurs for a fault on a parallel line, the direction of the current on the healthy line is reversed. The status of the forward overreaching element changes from an operating to a reset state at the terminal where the current is reversed from an inward to an outward direction, and from a non-operating status to operating status at the other terminal. In this process, if the operating periods of the forward overreaching element of both terminals overlap, the healthy line may be tripped erroneously. To prevent this, current reversal logic (CRL) is provided. (See Section 2.4.3.6 for current reversal.)

Since the POP transmits a trip permission signal with the operation of the overreaching element, it requires multiplex signaling channels or one channel for each direction. This ensures that the transmitting terminal does not trip erroneously due to reception of its own transmit signal during an external fault in the overreaching zone.

Scheme Logic

Figure 2.4.3.2 shows the scheme logic for the POP. The POP transmits a trip permission signal to the other terminal for any of the following conditions.

- The forward overreaching zone 2 or zone 3 selected by scheme switch [ZONESEL] operates and the current reversal logic (CRL) has not picked up. If the PLC signal PSCM_TCHDEN is established, the delayed pick-up timer TCHD is provided.
- The circuit breaker is opened and a trip permission signal CR is received from the other terminal.
- The forward overreaching zone 2 or zone 3 and reverse looking Z4 have not operated and a trip permission signal is received from the other terminal.

The last two are implemented when an echo function (ECH) is selected. (Refer to Section 2.4.3.5 for echo function.)

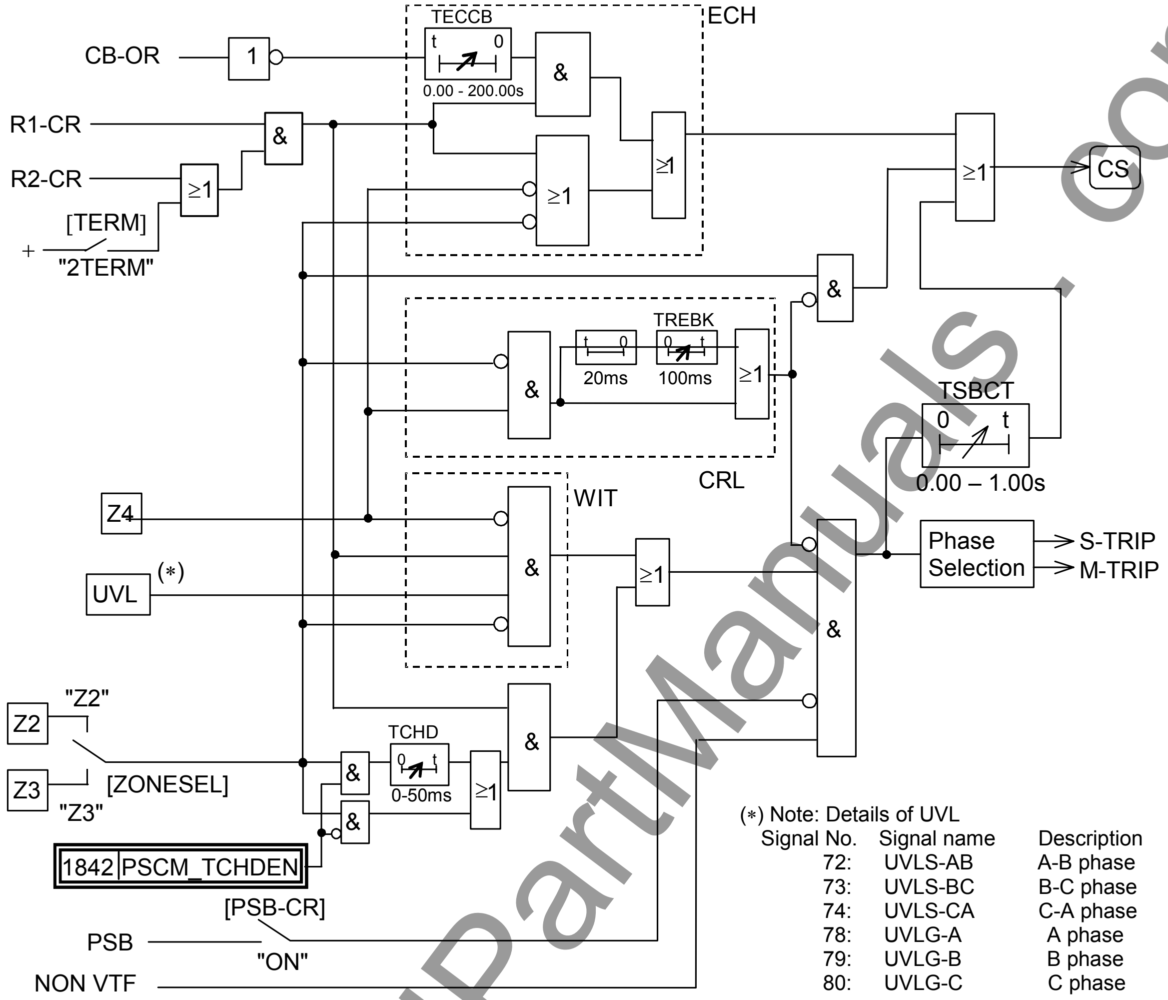


Figure 2.4.3.2 POP Scheme Logic

Transmission of the trip permission signal continues for the TSBCT setting even after the local terminal is tripped by the delayed drop-off timer TSBCT. This is to ensure that command tripping is executed at the remote terminal.

The POP outputs single-phase tripping signal S-TRIP or three-phase tripping signal M-TRIP to the local terminal when the trip permission signal R1-CR and R2-CR are received from the remote terminals, the current reversal logic (CRL) is not picked up and one of the following conditions is established.

- The forward overreaching element operates.
- The undervoltage element UVL (UVLS or UVLG) operates and the forward overreaching and the reverse looking elements do not operate.

The latter is implemented when the weak infeed trip function is selected. (Refer to Section 2.4.3.5 for weak infeed trip function.)

When the integral communication channel is used, the trip permission signals sent and received contain three phase-segregated signals for earth faults and one signal for phase faults. When the external communication channel is used, a single trip permission signal is common to all fault types.

To select the faulted phase reliably, phase selection is performed using the phase selection element UVC. Phase selection logic is described in Section 2.4.3.7.

Setting

The following shows the setting elements necessary for the POP and their setting ranges. For the settings of Z2, Z3 and UVC, refer to Section 2.4.1.

Element	Range	Step	Default	Remarks
CO. LINK	Int / Ext		Int	Communication link (Integral or External)
UVL				Weak infeed trip element
UVLS	50 - 100 V	1V	77V	Undervoltage detection (phase fault)
UVLG	10 - 60 V	1V	45V	Undervoltage detection (earth fault)
Z4S	0.01 - 50.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 250.0Ω	0.1Ω	40.0Ω) (*)	
BRRS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
Z4G	0.01 – 100.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 500.0Ω	0.1Ω	40.0Ω)	
BRRG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
TCHD	0 - 50 ms	1 ms	12 ms	Channel delay time
TREBK	0.00 - 10.00s	0.01s	0.10s	Current reversal block time
TSBCT	0.00 – 1.00s	0.01s	0.10s	
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP/ BOP/POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection
TERM	2TERM/3TERM		2TERM	Terminal selection
Open1	OFF/ON		OFF	Remote terminal 1 out of service
Open2	OFF/ON		OFF	Remote terminal 2 out of service
ZONESEL	Z2/Z3		Z2	Overreaching element selection
PSB - CR	OFF/ON		ON	Power swing blocking
ECHO	OFF/ON		ON	Echo function
WKIT	OFF/ON		ON	Weak infeed trip function

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

The following elements have fixed setting values or their settings are interlinked with other elements listed above. So no setting operation is required.

Element	Setting	Remarks
Z4BS	Fixed to 1.5Ω	Z4 reverse offset reach
	(Fixed to 7.5Ω) (*1)	
Z4S θ(*2)	Interlinked with Z3S θ	Characteristic angle of Z4 mho element
Z4BS θ(*3)	Interlinked with ZBS θ	Angle of Z4 directional element
BRRS θ	Fixed to 75°	Angle of reverse right blinder BRRS
BRLS	Interlinked with BRRS	Reverse left blinder
BRLS θ	Interlinked with BFLS θ	Angle of reverse left blinder BRLS
Z4G θ(*2)	Interlinked with Z3G θ	Characteristic angle of Z4 mho element
Z4BG θ(*3)	Interlinked with ZBG θ	Angle of Z4 directional element
BRRG θ	Fixed to 75°	Angle of reverse right blinder BRRG
BRLG	Interlinked with BRRG	Reverse left blinder
BRLG θ	Interlinked with BFLG θ	Angle of reverse left blinder BRLG

(*1)Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

(*2) Valid only when mho-based characteristic is selected by ZS-C.

(*3) Valid only when quadrilateral characteristic is selected by ZS-C.

The reverse looking Z4 (G,S), BRR (G,S) and BRL (G,S) must always operate for reverse faults for which the forward overreaching element of the remote end operates. The following setting coordination is required.

When zone 2 is selected as the forward looking element:

Z4 setting = 1.2 × (Zone 2 setting at remote end)

When zone 3 is selected:

Z4 setting = 1.2 × (Zone 3 setting at remote end)

In both cases:

BRR setting = 1.2 × (BFR setting at remote end)

2.4.3.3 Unblocking Overreach Protection

Application

If a power line carrier is used as the telecommunication media, there is a possibility that the dependability of the PUP and POP could be reduced. This is because the trip permission signal must be transmitted through the fault point and the attenuation of the signal may cause the PUP and POP to fail to operate. To solve this problem, unblocking overreach protection (UOP) is applied.

The signal transmitted under the UOP is a trip block signal and this is transmitted continuously during non-fault conditions. When the forward overreaching element operates, transmission is stopped. At the remote end, the non-receipt of a trip block signal is recognized as an actual trip permission signal and tripping is executed on condition that the local forward overreaching element operates.

In this system, the transmitted signal is a trip block signal, and transmission of that signal is required only in the case of external faults. Therefore, even if power line carrier is used, a failure to operate or false operation due to attenuation of the signal would not be experienced.

If the modulation method of the telecommunication circuits is a frequency shift method in external communication, frequencies f1 and f2 are assigned to the trip block signal and trip permission signal, respectively. The receive end recognizes signals CR1 and CR2 as corresponding to respective frequencies as the actual trip permission signals when either one of the following conditions is established and executes tripping on condition that the overreaching element should operate.

- CR1 is lost and only CR2 is received.
- Both CR1 and CR2 are lost.

The latter is also applicable if there is a telecommunication circuit failure in addition to attenuation of the signal at the fault point. Therefore, when the latter condition continues for a certain period or longer, the UOP is blocked and a telecommunication circuit failure alarm is output.

The UOP is provided with an echo function and weak infeed trip function and even when applied to a line with open terminals or weak infeed terminals, it allows fast tripping of both terminals for any fault along the whole length of the protected line. An undervoltage element UVL is provided for weak infeed tripping. (See Section 2.4.3.5 for protection for weak infeed terminal.)

When a sequential fault clearance occurs for a fault on a parallel line, the direction of the current on the healthy line is reversed. The status of the forward overreaching element changes from an operating to a reset state at the terminal where the current is reversed from an inward to an outward direction, and from a non-operating status to an operating status at the other terminal. In this process, if the operating periods of the forward overreaching element of both terminals overlap, the healthy line may be tripped erroneously. To prevent this, current reversal logic is provided. (See Section 2.4.3.6 for current reversal.)

For the external communication channel, a single channel shared by different terminals or multiplex channels, one channel for each direction can be used.

Scheme Logic

Figure 2.4.3.3 shows the scheme logic of the UOP. The logic level of transmit signal CS and receive signal R1-CR and R2-CR is "1" for a trip block signal and "0" for a trip permission signal.

The UOP changes its transmit signal CS from a trip block signal to trip permission signal under one of the following conditions. The logic level of CS changes from 1 to 0.

- The forward overreaching zone 2 or zone 3 selected by the scheme switch [ZONESEL] operates and the current reversal logic (CRL) is not picked up. If the PLC signal PSCM_TCHDEN is established, the delayed pick-up timer TCHD is provided.
- The circuit breaker is open and the trip permission signal (R1-CR=0, R2-CR=0) is received from the other terminals.
- The forward overreaching zone 2 or zone 3 and reverse looking Z4 are not operating and a trip permission signal is received from the other terminal.

The last two are implemented when an echo function (ECH) is selected. (Refer to Section 2.4.3.5 for echo function.)

Transmission of a trip permission signal continues for the TSBCT setting even after the local terminal is tripped. This is to ensure that command tripping is executed at the remote terminal.

The UOP outputs single-phase tripping signal S-TRIP or three-phase tripping signal M-TRIP to the local terminal when the trip permission signal (R1-CR=0, R2-CR=0) is received from the remote terminals, the current reversal logic (CRL) is not picked up and one of the following conditions is established.

- The forward overreaching element operates.
- The undervoltage element UVL (UVLS or UVLG) operates and the forward overreaching and the reverse looking elements do not operate.

The latter is implemented when the weak infeed trip function is selected.

When the integral communication channel is used, the trip permission signals sent and received contain three phase-segregated signals for earth faults and one signal for phase faults. When the external communication channel is used, a single trip permission signal is common to all fault types.

To select the faulted phase reliably, phase selection is performed using the phase selection element UVC. Phase selection logic is described in Section 2.4.3.7.

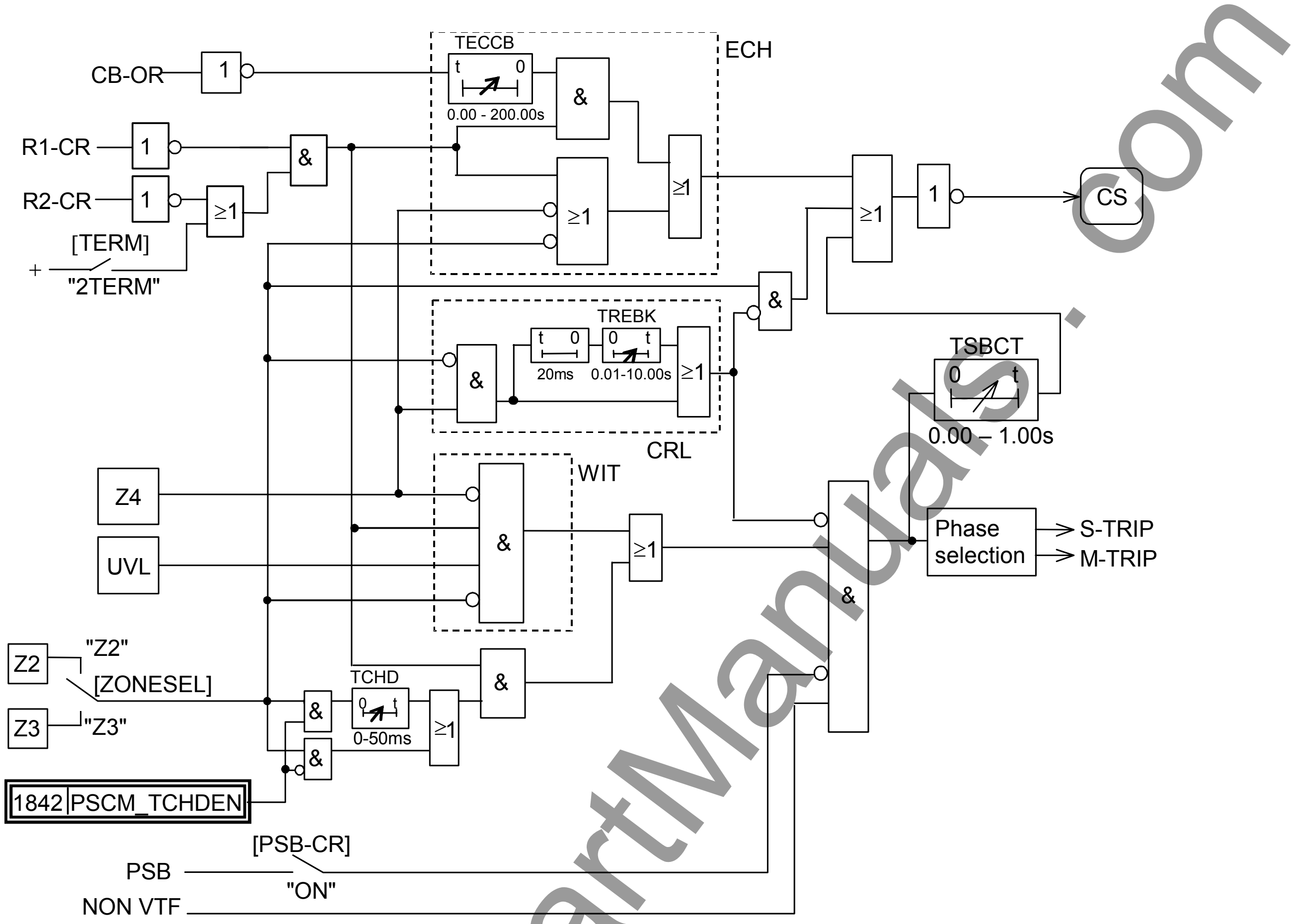


Figure 2.4.3.3 UOP Scheme Logic

Setting

The following shows the setting elements necessary for the UOP and their setting ranges. For the settings of Z2, Z3, and UVC, refer to Section 2.4.1.

Element	Range	Step	Default	Remarks
CO. LINK	Int / Ext		Int	Communication link (Integral or External)
UVL				Weak infeed trip element
UVLS	50 - 100 V	1V	77V	Undervoltage detection (phase fault)
UVLG	10 - 60 V	1V	45V	Undervoltage detection (earth fault)
Z4S	0.01 - 50.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 250.0Ω	0.1Ω	40.0Ω) (*)	
BRRS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
Z4G	0.01 - 100.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 500.0Ω	0.1Ω	40.0Ω)	
BRRG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
TCHD	0 - 50 ms	1 ms	12 ms	Channel delay time
TREBK	0.00 - 10.00s	0.01s	0.10s	Current reversal block time
TSBCT	0.00 – 1.00s	0.01s	0.10s	
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP/ BOP /POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection

TERM	2TERM/3TERM	2TERM	Terminal selection
Open1	OFF/ON	OFF	Remote terminal 1 out of service
Open2	OFF/ON	OFF	Remote terminal 2 out of service
ZONESEL	Z2/Z3	Z2	Overreaching element selection
PSB - CR	OFF/ON	ON	Power swing blocking
ECHO	OFF/ON	ON	Echo function
WKIT	OFF/ON	ON	Weak infeed trip function

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

The following elements have fixed setting values or their settings are interlinked with other elements listed above. So no setting operation is required.

Element	Setting	Remarks
Z4BS	Fixed to 1.5Ω (Fixed to 7.5Ω)(*1)	Z4 reverse offset reach
Z4S θ(*2)	Interlinked with Z3S θ	Characteristic angle of zone 4 mho element
Z4BS θ(*3)	Interlinked with ZBS θ	Angle of Z4 directional element
BRRS θ	Fixed to 75°	Angle of reverse right blinder BRRS
BRLS	Interlinked with BRRS	Reverse left blinder
BRLS θ	Interlinked with BFLS θ	Angle of reverse right blinder BRRS
Z4G θ(*2)	Interlinked with Z3G θ	Characteristic angle of Z4 mho element
Z4BG θ(*3)	Interlinked with ZBG θ	Angle of Z4 directional element
BRRG θ	Fixed to 75°	Angle of reverse blinder BRRG
BRLG	Interlinked with BRRG	Reverse left blinder
BRLG θ	Interlinked with BFLG θ	Angle of reverse left blinder BRLG

(*1) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

(*2) Valid only when mho-based characteristic is selected by ZS-C.

(*3) Valid only when quadrilateral characteristic is selected by ZS-C.

The reverse looking elements Z4 (G,S), BRR (G,S) and BRL (G,S) must always operate for reverse faults for which the forward overreaching element of the remote end operates. The following setting coordination is required.

When zone 2 is selected as the forward-looking element,

Z4 setting = 1.2 × (Zone 2 setting at remote end)

When zone 3 is selected,

Z4 setting = 1.2 × (Zone 3 setting at remote end)

In both cases,

BRR setting = 1.2 × (BFR setting at remote end)

2.4.3.4 Blocking Overreach Protection

Application

In blocking overreach protection (BOP), each terminal normally transmits a trip permission signal, and transmits a trip block signal if the reverse looking Z4 operates and the forward overreaching element does not operate. Tripping of the local circuit breaker is performed on condition that the forward overreaching element has operated and a trip permission signal has been received. As the forward overreaching element, it is possible to use zone 2 or zone 3.

In external communication, if signal modulation is performed by an ON/OFF method, the signal is not normally transmitted and a trip block signal is transmitted only when the reverse looking element operates. Tripping is performed on condition that the forward overreaching element has operated and no signal has been received. In this signaling system, the signal transmitted is a trip block signal and transmission of this signal is only required in the event of an external fault. Therefore, even if power line carrier is used, there will be no failure to operate or false operation due to attenuation of signals caused by signal transmission through the fault.

The BOP receives a trip permission signal all the time. Therefore, when a forward external fault occurs, the infeed terminal on which the forward overreaching element has operated attempts to perform instantaneous tripping. At this time, at the remote outfeed terminal, the reverse looking element operates and transmits a trip block signal. This signal is received at the infeed terminal after a channel delay time. Therefore, a short delay is required for the tripping to check for the reception of a trip block signal.

The BOP performs fast tripping for any fault along the whole length of the protected line even if an open terminal exists. A strong infeed terminal operates for all internal faults even if a weak infeed terminal exists. Therefore, no echo function is required. However, since no weak infeed logic is applicable to the BOP, the weak infeed terminal cannot operate.

When a sequential fault clearance occurs for a fault on a parallel line, the direction of the current on the healthy line is reversed. The status of the forward overreaching element changes from an operating to a reset state at the terminal where the current is reversed from the inward direction to outward direction, and from a non-operating status to an operating status at the other terminal. In this process, if the operating periods of the forward overreaching element of both terminals overlap, the healthy line may be tripped erroneously. To prevent this, current reversal logic is provided. (See Section 2.4.3.6 for current reversal.)

Scheme Logic

Figure 2.4.3.4 shows the scheme logic of the BOP. The logic level of transmit signal CS and receive signal R1-CR or R2-CR is "1" for a trip block signal and "0" for a trip permission signal.

The transmit signal is controlled in the BOP as follows:

In the normal state, the logic level of transmit signal CS is 0, and a trip permission signal is transmitted. If the reverse looking zone 4 operates and at the same time the forward overreaching element zone 2 or zone 3 selected by the scheme switch [ZONESEL] does not operate, CS becomes 1 and a trip block signal is transmitted. When this condition continues for 20 ms or more, current reversal logic is picked up and a drop-off delay time of TREBK setting is given to reset the transmission of the trip block signal.

Transmission of a trip permission signal continues for the TSBCT setting even after the local terminal is tripped, assuring command tripping of the remote terminal.

The BOP outputs single-phase tripping signal S-TRIP or three-phase tripping signal M-TRIP to the local terminal when zone 3 or zone 2 operates and at the same time the trip permission signal is received (R1-CR=0, R2-CR=0). The delayed pick-up timer TCHD is provided to allow for the transmission delay for receipt of the trip block signal from the remote terminal in the event of a forward external fault.

When the integral communication channel is used, the trip permission signals sent and received contain three phase-segregated signals for earth faults and one signal for phase faults. When the external communication channel is used, a single trip permission signal is common to all fault types.

To select the faulted phase reliably, phase selection is performed using the phase selection element UVC. The phase selection logic is described in Section 2.4.3.7.

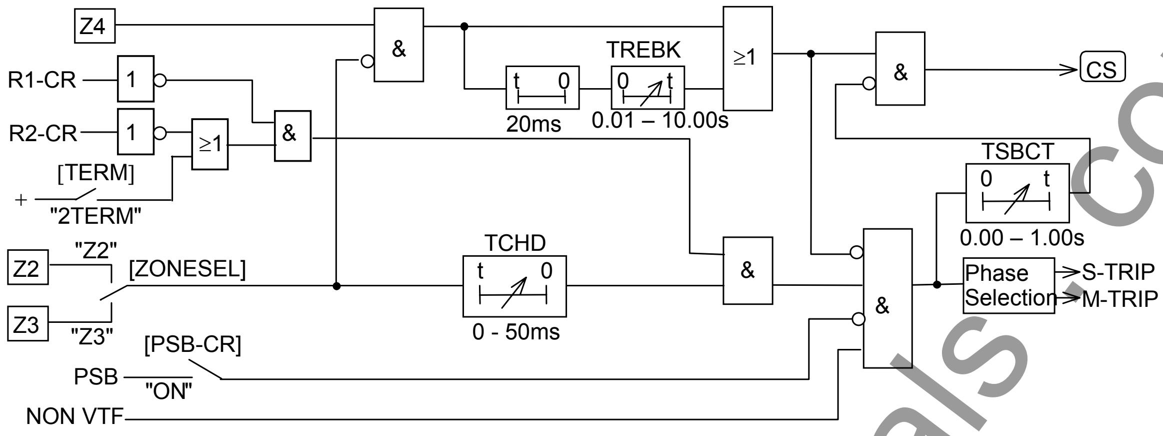


Figure 2.4.3.4 BOP Scheme Logic

Setting

The following shows the setting elements necessary for the BOP and their setting ranges. For the settings of Z2, Z3 and UVC, refer to Section 2.4.1.

Element	Range	Step	Default	Remarks
CO. LINK	Int / Ext		Int	Communication link (Integral or External)
Z4S	0.01 - 50.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 250.0Ω	0.1Ω	40.0Ω) (*)	
BRRS	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
Z4G	0.01 - 100.00Ω	0.01Ω	8.00Ω	Z4 reach
	(0.1 – 500.0Ω	0.1Ω	40.0Ω)	
BRRG	0.10 - 20.00Ω	0.01Ω	5.10Ω	Reverse right blinder reach
	(0.5 - 100.0Ω	0.1Ω	25.5Ω)	
TCHD	0 - 50 ms	1 ms	12 ms	Channel delay time
TREBK	0.00 - 10.00s	0.01s	0.10s	Current reversal block time
TSBCT	0.00 – 1.00s	0.01s	0.10s	
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP/ BOP/POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection
TERM	2TERM/3TERM		2TERM	Terminal selection
Open1	OFF/ON		OFF	Remote terminal 1 out of service
Open2	OFF/ON		OFF	Remote terminal 2 out of service
ZONESEL	Z2/Z3		Z2	Overreaching element selection
PSB - CR	OFF/ON		ON	Power swing blocking

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

The following elements have fixed setting values or their settings are interlinked with other elements listed above. So no setting operation is required.

Element	Setting	Remarks
Z4BS	Fixed to 1.5Ω (Fixed to 7.5Ω)(*1)	Z4 reverse offset reach
Z4S θ(*2)	Interlinked with Z3S θ	Characteristic angle of Z4 mho element
Z4BS θ(*3)	Interlinked with ZBS θ	Angle of Z4 directional element
BRRS θ	Fixed to 75°	Angle of reverse right blinder BRRS
BRLS	Interlinked with BRRS	Reverse left blinder

Element	Setting	Remarks
BRLS θ	Interlinked with BFLS θ	Angle of reverse left blinder BRLS
Z4G θ(*2)	Interlinked with Z3G θ	Characteristic angle of Z4 mho element
Z4BGθ(*3)	Interlinked with ZBG θ	Angle of Z4 directional element
BRRG θ	Fixed to 75°	Angle of reverse right blinder BRRG
BRLG	Interlinked with BRRG	Reverse blinder
BRLG θ	Interlinked with BFLG θ	Angle of reverse left blinder BRLG

(*1)Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

(*2) Valid only when mho-based characteristic is selected by ZS-C.

(*3) Valid only when quadrilateral characteristic is selected by ZS-C.

The reverse looking elements Z4 (G,S), BRR (G,S) and BRL (G,S) must always operate for reverse faults for which the forward overreaching element of the remote end operates. The following setting coordination is required.

When zone 2 is selected as the forward-looking element,

Z4 setting = 1.2 × (Zone 3 setting at remote end)

or

Z4 setting = α × (Zone 2 setting at remote end)

Note: α should be determined in consideration of the extension of zone 2 by zero-sequence compensation.

When zone 3 is selected,

Z4 setting = 1.2 × (Zone 3 setting at remote end)

In both cases,

BRR setting = 1.2 × (BFR setting at remote end)

The delayed pick-up timer TCHD is set as follows taking into account the transmission delay time of the blocking signal and a safety margin of 5 ms.

TCHD setting = maximum signal transmission delay time(*) + 5ms

(*) includes delay time of binary output and binary input for the blocking signal when the external communication is used.

2.4.3.5 Protection for Weak Infeed Terminal

The POP and UOP are provided with an echo function and weak infeed trip function. Both functions are used for lines with weak infeed terminals.

Figure 2.4.3.5 shows the scheme logic for the echo function.

With the POP, when a trip permission signal is received (R1-CR=1, R2-CR=1) if neither forward overreaching zone 2 or zone 3 nor reverse looking Z4 have operated, the echo function sends back the received signal to the remote terminal. With the UOP, when reception of a blocking signal is stopped (R1-CR=0, R2-CR=0) if neither forward overreaching zone 2 (or zone 3) nor reverse looking Z4 have operated, the echo function stops sending the blocking signal to the remote terminal. When the circuit breaker is open (CB-OR = 1), too, the echo function sends back the trip permission signal or stops sending the blocking signal. Timer TECCB is used to set the time from CB opened to the echo logic enabled.

The terminal on which the forward overreaching element has operated can be tripped at high speed by this echoed signal.

Once the forward overreaching element or reverse looking element have operated, transmission of the echo signal is inhibited for 250 ms by delayed drop-off timer T1 even after they have reset.

In order to prevent any spurious echo signal from looping round between the terminals in a healthy state, the echo signal is restricted to last for 200 ms by delayed pickup timer T2.

The echo function can be disabled by the scheme switch [ECHO] and the PLC signal ECHO_BLOCK.

The setting element necessary for the echo function and its setting range is as follows:

Element	Range	Step	Default	Remarks
TECCB	0.00 – 200.00 s	0.01 s	0.10 s	Echo enable timer
ECHO	OFF/ON		ON	Echo function

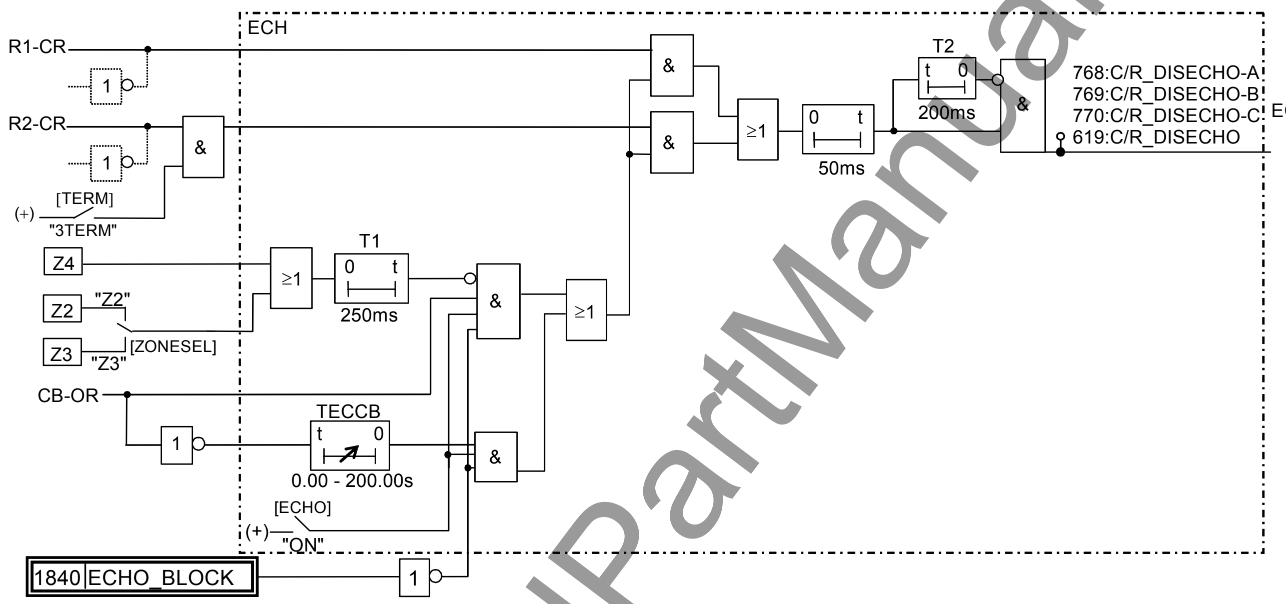


Figure 2.4.3.5 Echo Logic

Figure 2.4.3.6 shows the scheme logic of the weak infeed trip function. Weak infeed tripping is executed on condition that a trip permission signal has been received (R1-CR=1, R2-CR=0) for the POP, and reception of a trip block signal has stopped (R1-CR=0, R2-CR=0) for the UOP, the undervoltage element UVL (UVLS or UVLG) operates and neither forward overreaching zone 2 or zone 3 nor reverse looking Z4 operates.

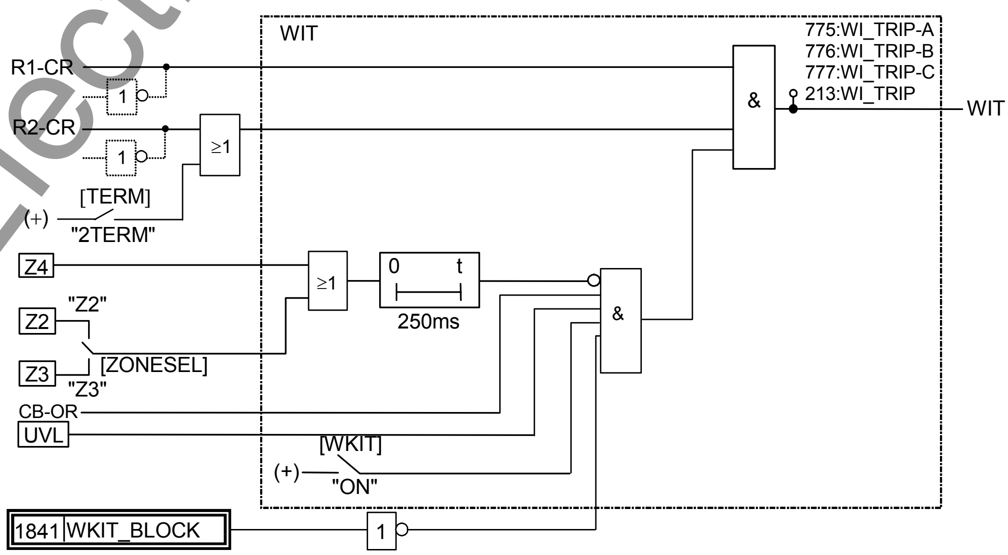


Figure 2.4.3.6 Weak Infeed Trip Logic

The undervoltage element responds to three phase-to-phase voltages and three phase-to-ground voltages. The undervoltage element prevents false weak infeed tripping due to spurious operation of the channel.

Single-phase tripping or three-phase tripping is also applicable to weak infeed tripping according to the reclosing mode of the autoreclose function.

The weak infeed trip function can be disabled by the scheme switch [WKIT] and the PLC signal WKIT_BLOCK.

2.4.3.6 Measure for Current Reversal

In response to faults on parallel lines, sequential opening of the circuit breaker may cause a fault current reversal on healthy lines. This phenomenon may cause false operation of the POP, UOP and BOP schemes in the worst case. To prevent this, the POP, UOP and BOP are provided with current reversal logic.

With the parallel line arrangement as shown in Figure 2.4.3.7 (a), suppose that a fault occurs at time t1 at point F of line L1, A1 trips at time t2 first and then B1 trips at time t3. The direction of the current that flows in healthy line L2 can be reversed at time t2. That is, the current flows from terminal B to terminal A as indicated by a solid line in the period from time t1 to t2, and from terminal A to terminal B as indicated by a broken line in the period from time t2 to t3. This current reversal phenomenon may occur with the presence of an external looped circuit if not for parallel lines.

Figure 2.4.3.7 (b) shows a sequence diagram of Z3 and Z4 and the current reversal logic CRL on healthy line L2 before and after the occurrence of a current reversal. When the current is reversed, Z3 operation and Z4 reset are seen at terminal A, while reset of Z3 and operation of Z4 are seen at terminal B. If at this time, Z3 of A2 operates before Z3 of B2 is reset, this may cause false operation of the POP, UOP and BOP on line L2.

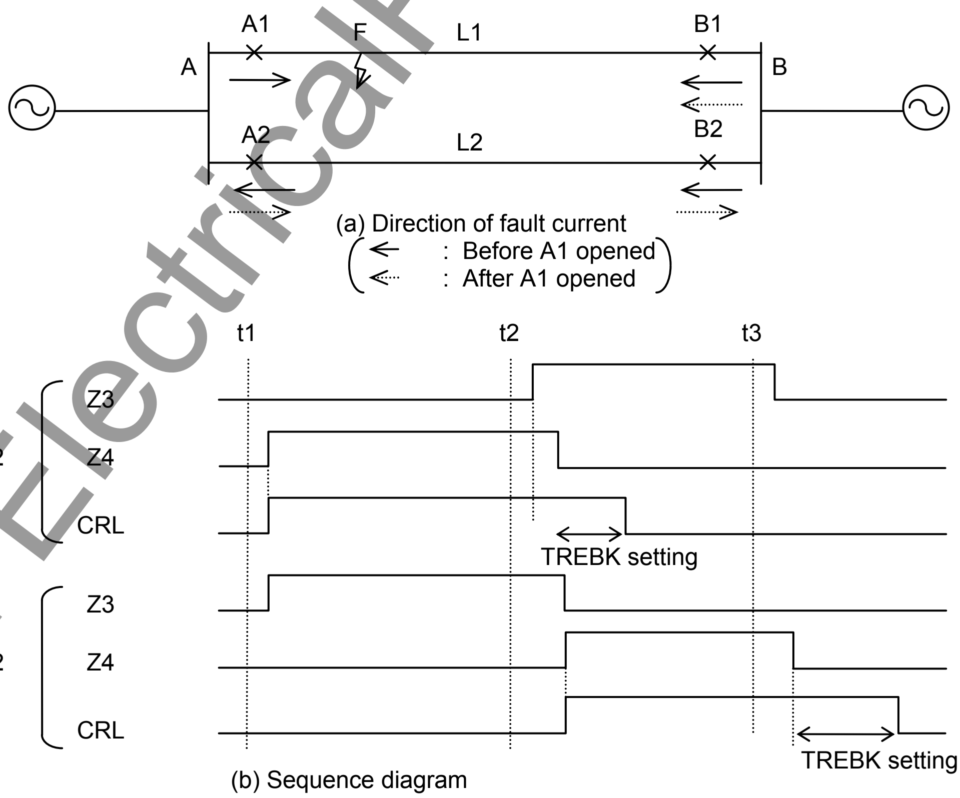


Figure 2.4.3.7 Current Reversal Phenomenon

Figure 2.4.3.8 shows the current reversal logic. The current reversal logic is picked up on condition that reverse looking Z4 has operated and forward overreaching zone 2 or zone 3 have not operated, and the output CRL immediately controls the send signal to a trip block signal and at the same time blocks local tripping. If the condition above continues longer than 20ms, the output CRL will last for the TREBK setting even after the condition above ceases to exist.

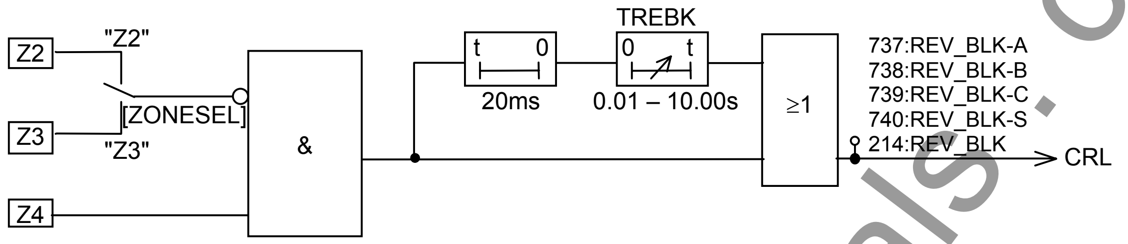


Figure 2.4.3.8 Current Reversal Logic

The operation of the current reversal logic and its effect in the event of a fault shown in Figure 2.4.3.7 (a) are as follows. As shown in Figure 2.4.3.7 (b), the current reversal logic of terminal A2 operates (CRL = 1) immediately after the fault occurs. This operation lasts for TREBK setting even after the current is reversed and Z3 operates, continuously blocking the local tripping and transmitting a trip block signal to the terminal B2.

Even if overlap arises due to current reversal on the operation of Z3 at terminal A2 and terminal B2, it will disappear while the current reversal logic is operating, thus avoiding false tripping of the healthy line of parallel lines. When a current reversal occurs in the direction opposite to the above, the current reversal logic at terminal B2 will respond similarly.

Current reversal logic is not picked up for internal faults, thus not obstructing high-speed operation of any protection scheme.

2.4.3.7 Phase Selection Logic

Every command protection has phase selection logic for single-phase tripping. Figure 2.4.3.9 gives details of the phase selection logic displayed in blocks in Figures 2.4.3.1 to 2.4.3.4.

Tripping command signal TRIP of each command protection can be classified by the phase selection logic as a single-phase tripping command or a three-phase tripping command. If the distance measuring element for earth fault Z3G (or Z2G depending on the setting of the scheme switch [ZONESEL]) is operating when a TRIP is input, a single-phase tripping command S-TRIP is output to the phase in which the phase selection element UVC is operating. If the UVC is operating with two or more phases, a three-phase tripping command M-TRIP is output.

The undervoltage detection element UVLS, not shown in Figure 2.4.3.9, is used for the phase selection logic as phase fault detector. The UVLS is also used for fault location.

If the distance measuring element for phase fault Z3S (or Z2S) is operating when a TRIP is input, a three-phase tripping command M-TRIP is output.

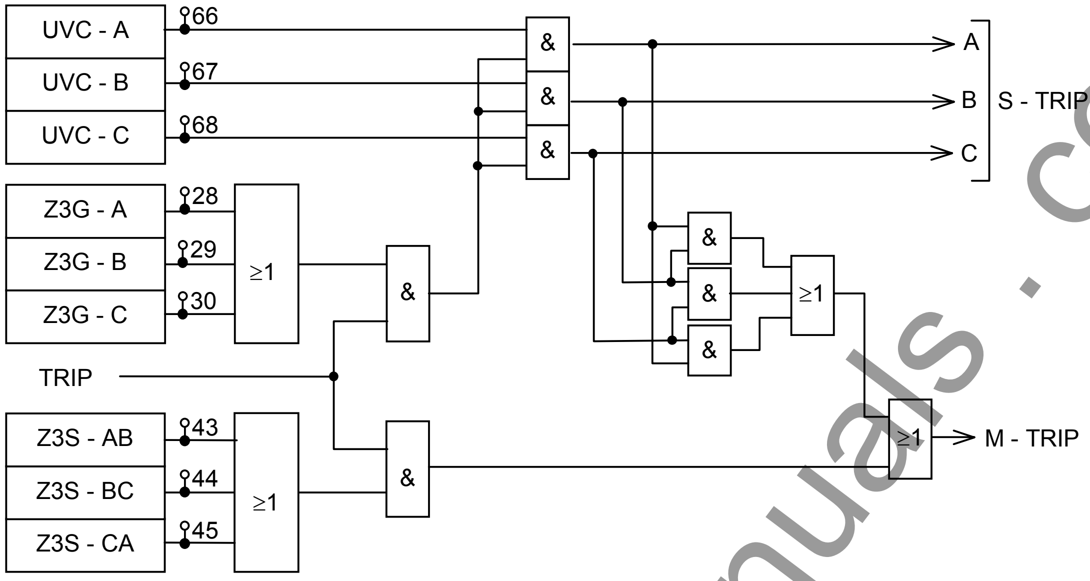


Figure 2.4.3.9 Phase Selection Logic for Command Protection

2.4.3.8 Backup Carrier Scheme

If a communication failure occurs on a channel of integral digital communication in a three-terminal application, GRZ100 can maintain the command protection by passing communication data via the healthy channels. If a communication channel fails as shown in Figure 2.4.3.10, relay A receives the communication data of relay B via backup carrier route. The coordination time TCHD of the relay A is extended for TCHDE setting time for channel delay time coordination in BOP scheme. Therefore, the total coordination time results in (TCHD set time) + (TCHDE set time). (For communication system, see Section 2.5.)

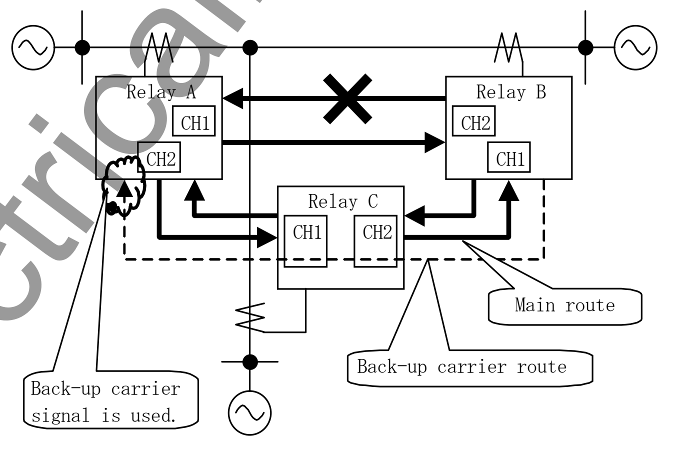


Figure 2.4.3.10 Backup Carrier Scheme

Relay operation under a communication failure in the backup carrier protection is shown in Appendix Q.

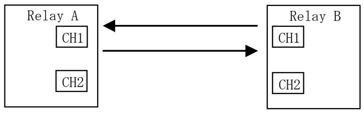
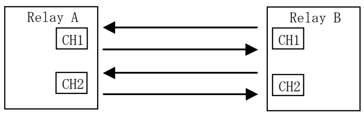
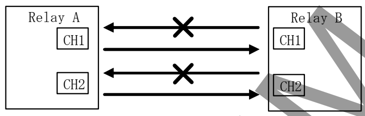
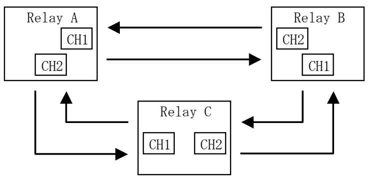
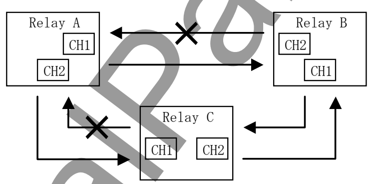
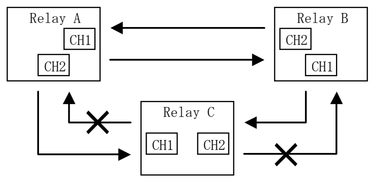
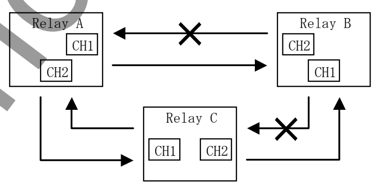
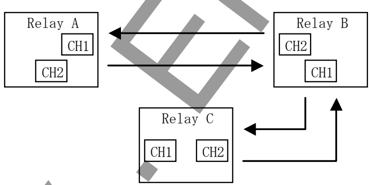
If the failure is a severe CF (communication failure) that cannot receive remote terminal signals at all, however, GRZ100 cannot operate correctly. Table 2.4.3.1.shows the severe CF mode.

GRZ100 provides the scheme switch [SCFCNT] to block a carrier trip (command trip) or not when a severe CF occurs. Set "BLK" to block a carrier trip. Set to "Trip" to allow a carrier trip. The default setting is "BLK".

The setting element necessary for the backup carrier scheme and its setting range is as follows:

Element	Range	Step	Default	Remarks
TCHDE	0 – 100 ms	1 ms	20 ms	Three terminal application
SCFCNT	Trip / BLK		BLK	

Table 2.4.3.1 Severe CF Mode

<table>
<tr><th>Terminal Application</th><th colspan="2">Severe CF Mode</th></tr>
<tr><td>Two-terminal and Single-communication

</td><td colspan="2">Any CF occurs.</td></tr>
<tr><td>Two-terminal and Dual-communication

</td><td colspan="2">Relay A cannot receive any signals of Relay B.

</td></tr>
<tr><td rowspan="2">Three-terminal and Ring-topology

</td><td>Relay A cannot receive any signals of Relay B and Relay C..

</td><td>Relay A cannot receive any signals of Relay C.

</td></tr>
<tr><td>Relay A cannot receive any signals of Relay B.

</td><td></td></tr>
<tr><td>Three-terminal and Chain-topology

</td><td>Any CF occurs.</td><td></td></tr>
</table>

2.4.4 High-Resistance Earth Fault Protection

For a high-resistance earth fault for which the impedance measuring elements cannot operate, the GRZ100 uses a directional earth fault element (DEF) to provide the following protections.

- Directional earth fault command protection
- Directional inverse or definite time earth fault protection

Figure 2.4.4.1 shows the scheme logic for the directional earth fault protection. The four kinds of protection above can be enabled or disabled by the scheme switches [SCHEME], [CRSCM], [DEFFEN] and [DEFREN]. The DEF and EF protections issue an alarm individually for the backup trip for earth fault. The DEF protection can be blocked by the binary input signal (PLC signal) DEF_BLOCK.

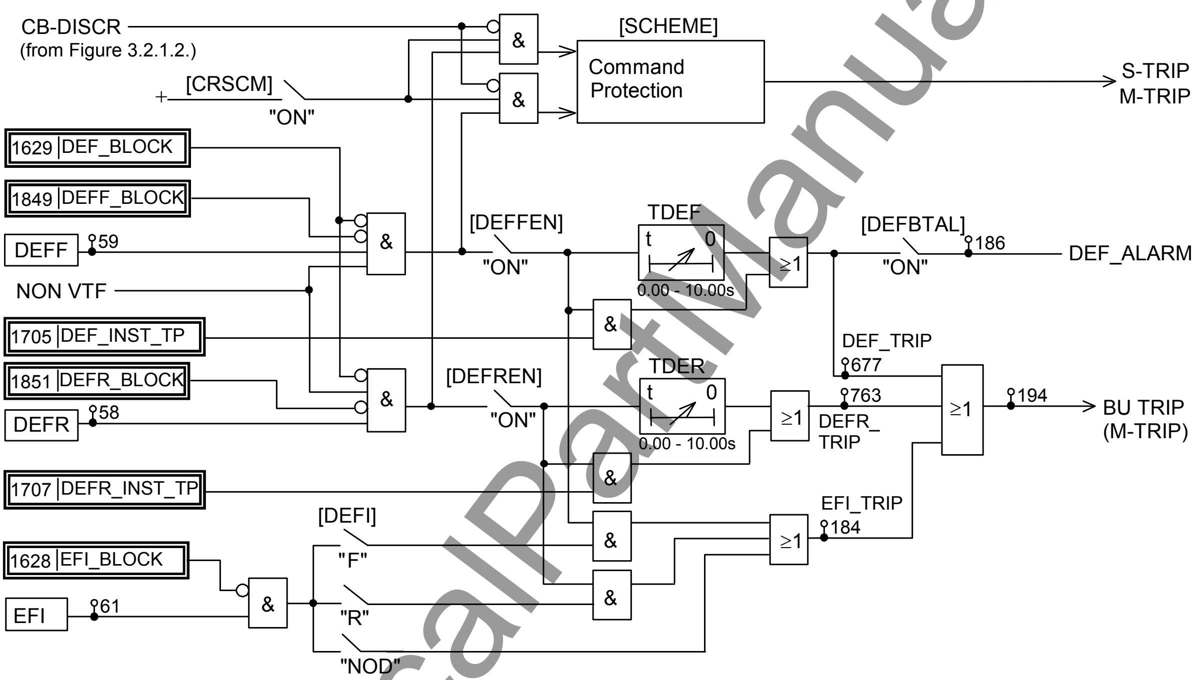


Figure 2.4.4.1 Directional Earth Fault Protection

The directional earth fault command protection provides the POP, UOP and BOP schemes using forward looking DEFF and reverse looking DEFR elements. All schemes execute three-phase tripping and autoreclose.

The command protection is disabled during a single-phase autoreclosing period (CB-DISCR=1).

The directional earth fault protection as backup protection is described in Section 2.4.4.2.

The directional earth fault element DEF provides selective protection against a high-resistance earth fault. The direction of earth fault is determined by the lagging angle (θ) of the residual current ($3I_0$) with respect to the residual voltage ($-3V_0$). The residual voltage and residual current are derived from the vector summation of the three-phase voltages and three-phase currents inside the relay.

The phase angle θ in the event of an internal fault is equal to the angle of the zero-sequence impedance of the system and in the directly-earthed system this value ranges approximately from 50° to 90°. θ of the DEF can be set from 0° to 90°. The minimum voltage necessary to maintain directionality can be set from 1.7 to 21.0 V.

2.4.4.1 Directional Earth Fault Command Protection

High-speed directional earth fault command protection is provided using the forward looking directional earth fault element DEFF and reverse looking directional earth fault element DEFR. The signaling channel of DEF command protection can be shared with or separated from distance protection by the scheme switch [CH-DEF].

The DEF command protections are applied in combination with the distance command protection POP, UOP, BOP and PUP and enabled when the scheme switch [SCHEME] is set to "POP+DEF", "UOP+DEF", "BOP+DEF" or "PUP+DEF". These protections are called as the DEF POP, DEF UOP, DEF BOP and DEF PUP hereafter. The POP, UOP or BOP schemes can be selected as a common scheme. However, in the DEF PUP, distance protection takes the PUP scheme but DEF command protection takes the POP scheme and signaling channels of distance and DEF command protections are always separated (CH1: distance, CH2: DEF, see Section 2.4.3.9.).

The DEF command protection can select fast tripping or delayed tripping by a timer setting. Delayed tripping is used when it is desired to give priority to distance protection.

The DEF command protection is blocked during a single-phase autoreclose period by the distance protection (CB-DISCR=1). The signal CB-DISCR is generated with the binary input signals (PLC signals) of circuit breaker auxiliary contact (refer to Section 3.2.1).

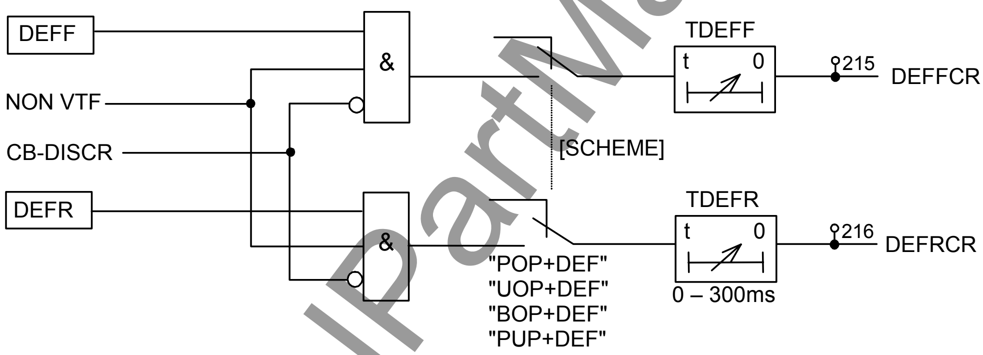
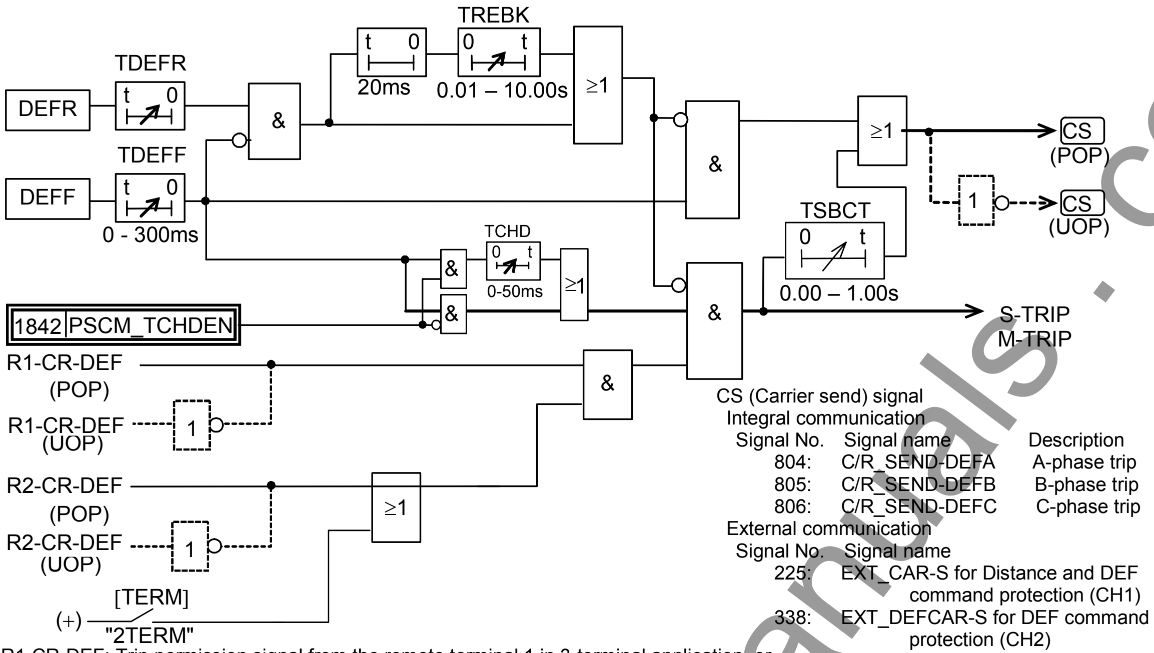


Figure 2.4.4.2 DEF Command Protection

DEF POP, DEF UOP and DEF PUP scheme logic

Figure 2.4.4.3 shows the scheme logic of the DEF POP and DEF UOP.

When the PUP+DEF scheme logic is selected, the DEF scheme logic is constructed same as the DEF POP scheme logic in Figure 2.4.4.3.



R1-CR-DEF: Trip permission signal from the remote terminal 1 in 3-terminal application, or Trip permission signal from remote terminal in 2-terminal application.
In integral communication, it is a phase-segregated signal as follows:

Signal No.	Signal name	Description
1732:	DEFCAR-A-R1	A-phase trip from remote terminal 1
1733:	DEFCAR-B-R1	B-phase trip from remote terminal 1
1734:	DEFCAR-C-R1	C-phase trip from remote terminal 1

In external communication, it is the following signal:

Signal No.	Signal name	Description
1568:	EXT_CAR.R1-1	Trip carrier signal from remote terminal 1
1569:	EXT_CAR.R1-2	Guard/And carrier signal from remote terminal 1

R2-CR-DEF: Trip permission signal from the remote terminal 2 in 3-terminal application.
In integral communication, it is a phase-segregated signal as follows:

Signal No.	Signal name	Description
1764:	DEFCAR-A-R2	A-phase trip from remote terminal 2
1765:	DEFCAR-B-R2	B-phase trip from remote terminal 2
1766:	DEFCAR-C-R2	C-phase trip from remote terminal 2

In external communication, it is the following signal:

Signal No.	Signal name	Description
1584:	EXT_CAR.R2-1	Trip carrier signal from remote terminal 2
1585:	EXT_CAR.R2-2	Guard/And carrier signal from remote terminal 2

Figure 2.4.4.3 DEF POP and DEF UOP Scheme Logic

The signal transmitted is a trip permission signal for the POP and a trip block signal for the UOP. In the event of an internal fault, the POP transmits a signal, while the UOP stops transmission. In Figure 2.4.4.3, a signal is transmitted when CS becomes 1, and when the signal is received CR-DEF becomes 1.

When the DEFF operates, CS becomes 1 for the POP and a signal (that is, a trip permission signal) is transmitted. For the UOP, CS becomes 0 and transmission of the signal (that is, a trip block signal) is stopped.

When a signal is received in the POP, or no signal is received in the UOP, tripping is executed on condition that the DEFF has operated. In order to assure tripping of the remote terminal, transmission of a trip permission signal or stoppage of a trip block signal continues for the TSBCT setting time even after the DEFF reset.

When the integral communication channel is used, the trip permission signals sent and received contain three phase-segregated signals for earth faults and one signal for phase faults. When the external communication channel is used, a single trip permission signal is common to all fault types.

The DEFR is used for the current reversal logic in the same manner as reverse looking Z4 in the distance protection (for the current reversal, refer to Section 2.4.3.6).

When operation of the DEFR and no-operation of the DEFF continue for 20 ms or more, even if the DEFF operates or the DEFR is reset later, tripping of the local terminal or transmission of the trip permission signal is blocked for the TREBK setting time.

The POP or UOP can be set for instantaneous operation or delayed operation by setting on-delay timer TDEFF and TDEFR.

The DEF command protection is provided with an echo function and weak infeed trip function. Both functions are used for lined with weak infeed terminals.

The echo function allows fast tripping of the terminal on which the DEFF has operated when applied to a line with an open terminal or a weak infeed earth fault current terminal. The scheme logic is shown in Figure 2.4.4.4.

With the POP, when a trip permission signal is received (R1-CR-DEF = 1) if neither the forward looking DEFF nor the reverse looking DEFR operates, the echo function sends back the received signal to the remote terminal. With the UOP, when reception of a blocking signal is stopped (R1-CR-DEF = 0), if the DEFF and DEFR do not operate, the echo function stops transmission of the blocking signal likewise. When the circuit breaker is open, the echo function also sends back the trip permission signal or stops transmission of the blocking signal.

Once the DEFF or the DEFR operates, transmission of the echo signal is inhibited for 250 ms by delayed drop-off timer T1 even after they are reset.

In order to prevent any spurious echo signal from looping round between terminals in a healthy state, the echo signal is restricted to last 200 ms by delayed pick-up timer T2.

The echo function can be disabled by the scheme switch [ECHO] and the PLC signal ECHO_BLOCK.

When a signaling channel is shared by the distance protection and DEF protection, it is necessary to unite the scheme logic of both echo functions so that the echo function may not be picked up in the event of an external fault. The echo function at this time is blocked by Z2 (or Z3) and Z4 indicated by a dotted line in Figure 2.4.4.4.

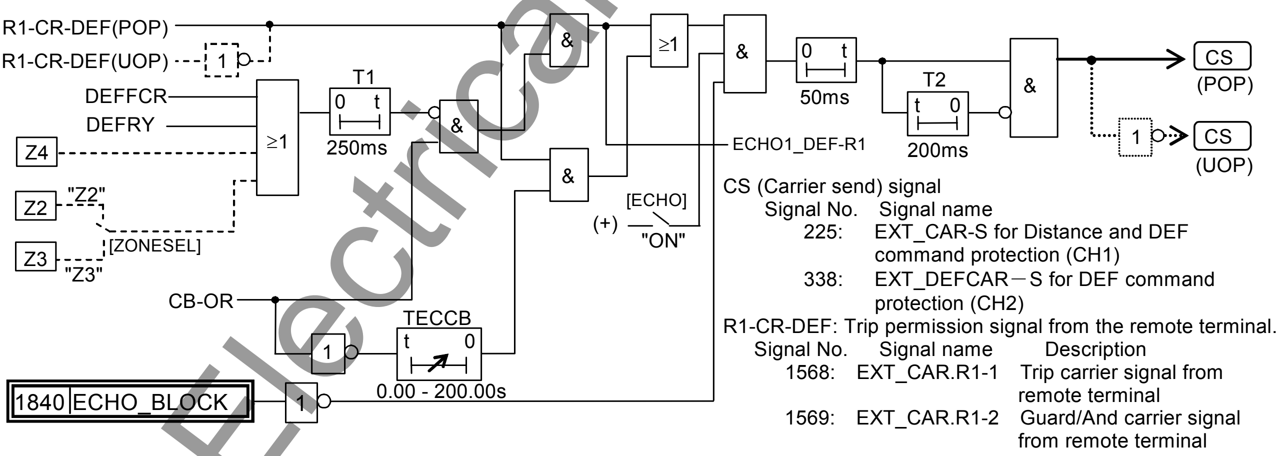


Figure 2.4.4.4 Echo Function in DEF POP and DEF UOP Scheme Logic

Figure 2.4.4.5 shows the scheme logic of the weak infeed trip function. Weak infeed tripping is executed on condition that a trip permission signal has been received (ECHO1_DEF-R1=1) for the POP, the undervoltage element UVL (UVLS or UVLG) operates.

The undervoltage element responds to three phase-to-phase voltages and three phase-to-ground voltages. The undervoltage element prevents false weak infeed tripping due to spurious operation of the channel.

Single-phase tripping or three-phase tripping is also applicable to weak infeed tripping according to the reclosing mode of the autoreclose function.

The weak infeed trip function can be disabled by the scheme switch [WKIT].

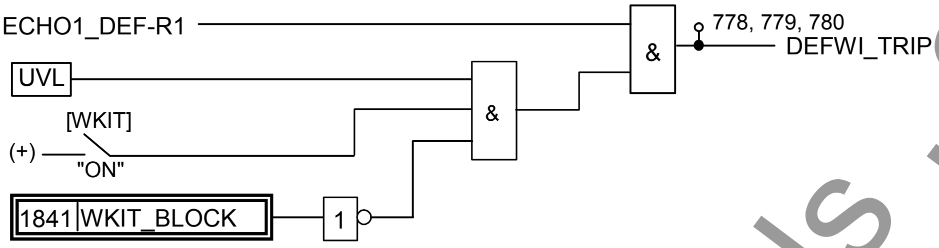


Figure 2.4.4.5 Weak Infeed Trip Logic

When the signaling channel of DEF POP or DEF UOP is separated from that of distance command protection, the signal S-DEF2 is used for CS and assigned to a user configurable binary output relay (see Section 3.2.2.).

DEF BOP scheme logic

Figure 2.4.4.6 shows the scheme logic of the DEF BOP.

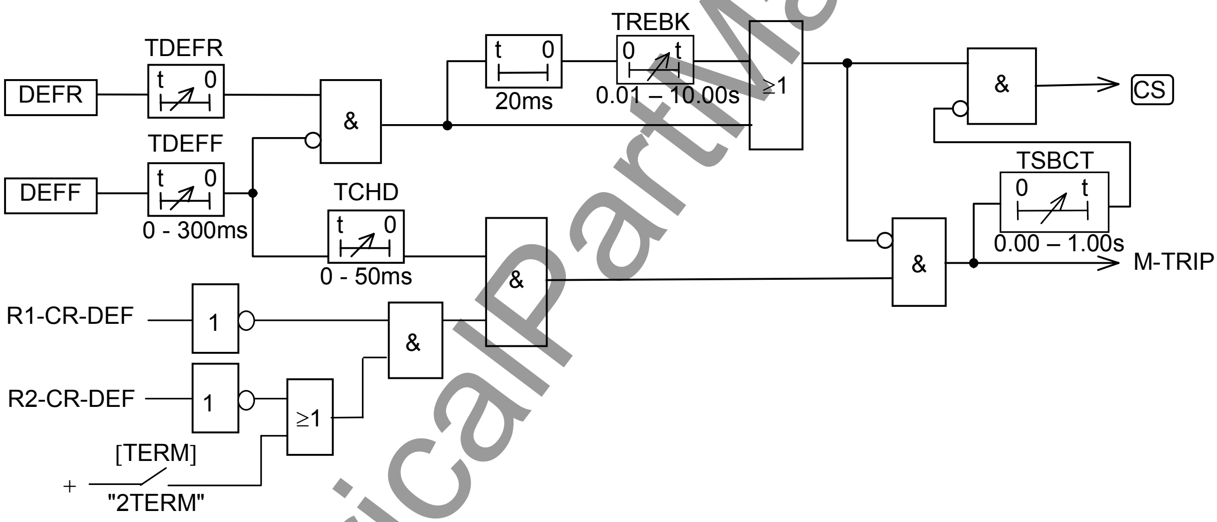


Figure 2.4.4.6 DEF BOP Scheme Logic

With the BOP, the signal transmitted is a trip block signal. When the reverse looking DEFR operates, the logic level of the transmit signal CS becomes 1 and a trip block signal is transmitted. When the trip block signal is received, R1-CR-DEF and R2-CR-DEF become 1.

When the forward looking DEFF operates, it executes tripping on condition that no trip blocking signal should be received.

The delayed pick-up timer TCHD is provided to allow for the transmission delay of the trip block signal from the remote terminal. Therefore, the time is set depending on the channel delay time.

TCHD setting = maximum signal transmission delay time(*) + 5ms

(*) includes delay time of binary output and binary input for the blocking signal when the external communication is used.

The DEFR is also used for the current reversal logic (for current reversal, see Section 2.4.3.6). When operation of the DEFR and non-operation of the DEFF last for 20 ms or more, even if the DEFF operates or the DEFR is reset later, tripping of the local terminal is blocked for the TREBK setting time and transmission of the trip block signal continues for the TSBCT setting time.

When the signaling channel of DEF BOP is separated from that of distance command protection, the signal S-DEFBOP2 is used for CS and assigned to a user configurable binary output relay (see Section 3.2.2).

Setting

The following setting is required for the DEF command protection:

Element	Range	Step	Default	Remarks
DEFF				Forward looking DEF
DEFFI	0.5 - 5.0 A	0.1 A	1.0 A	Residual current
	(0.10 - 1.00 A	0.01 A	0.2 A) (*)	
DEFFV	1.7 – 21.0 V	0.1 V	2.0 V	Residual voltage
TDEFF	0.00 - 0.30 s	0.01 s	0.15 s	Delayed tripping
DEFR				Reverse looking DEF
DEFRI	0.5 - 5.0 A	0.1 A	1.0 A	Residual current
	(0.10 - 1.00 A	0.01 A	0.20 A)	
DEFRV	1.7 – 21.0 V	0.1 V	2.0 V	Residual voltage
TDEFR	0.00 - 0.30 s	0.01 s	0.14 s	Delayed tripping
DEF θ	0 - 90°	1°	85°	Characteristic angle
PROTECTION SCHEME	3ZONE/Z1EXT/PUP/POP/UOP/ BOP/ POP+DEF/UOP+DEF/ BOP+DEF/PUP+DEF		POP	Scheme selection
CHSEL	Single/Guard/And		Single	
CH-DEF	CH1/CH2		CH1	
BODEFSW	Active / Inactive		Active	BO for DEF: active or inactive

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

When the DEFF at the remote end operates, the local DEFR must always operate for reverse faults. The setting levels of the residual current and residual voltage for the DEFR must be lower than that for the DEFF.

The following setting elements are used in common with the distance protection or its setting is interlinked with other elements listed above. So no setting operation is required here.

Element	Range	Step	Default	Remarks
TCHD	0-50 ms	1 ms	12 ms	Used in common with BOP
TREBK	0.00 - 10.00s	0.01s	0.10s	
TSBCT	0.00 - 1.00s	0.01s	0.10s	
ECHO	OFF/ON		OFF	Used in common with BOP

2.4.4.2 Directional Earth Fault Protection

The scheme logic is shown in Figure 2.4.4.1.

The directional inverse or definite time earth fault protection as backup protection executes three-phase final tripping. The forward looking DEFF or reverse looking DEFR can be selected. The directional inverse and definite time earth fault protections are available to trip instantaneously by binary input DEF∗_INST-TRIP except for [DEF∗EN]= “OFF” setting.

In order to give priority to the distance protection, the directional earth fault protection enables inverse time or definite time delayed tripping by the scheme switch [DEF∗EN].

Setting

The settings necessary for the directional earth fault protection are as follows:

Element	Range	Step	Default	Remarks
DEFF				Forward looking DEF
DEFFI	0.5 - 5.0 A	0.1 A	1.0 A	Residual current
	(0.10 - 1.00 A	0.01 A	0.20 A) (*)	
DEFFV	1.7 – 21.0 V	0.1 V	2.0 V	Residual voltage
TDEF	0.00 - 0.30 s	0.01 s	2.0 s	Definite time setting
DEFR				Reverse looking DEF
DEFRI	0.5 - 5.0 A	0.1 A	1.0 A	Residual current
	(0.10 - 1.00 A	0.01 A	0.2 A) (*)	
DEFRV	1.7 – 21.0 V	0.1 V	2.0 V	Residual voltage
TDER	0.00 - 0.30 s	0.01 s	2.0 s	Definite time setting
DEF θ	0 - 90°	1°	85°	Characteristic angle
DEFFEN	OFF/ON		OFF	Forward DEF backup trip enable
DEFREN	OFF/ON		OFF	Reverse DEF backup trip enable
DEFI	OFF/NOD/F/R		OFF	EFI directional control
DEFBTAL	OFF/ON		ON	DEF backup trip alarm

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The DEF element is shared with the command protection.

2.4.5 Overcurrent Backup Protection

Inverse time and definite time overcurrent protections are provided for phase faults and earth faults respectively.

Scheme logic

The scheme logic of the overcurrent backup protection is shown in Figure 2.4.5.1. The phase overcurrent protection issues single-phase tripping signals in the operation of OC and OCI, and can issue a three-phase tripping signal BU-TRIP by PLC signals OC_3PTP and OCI_3PTP. The default of the phase overcurrent backup protection is a three-phase tripping since both of the PLC signals OC_3PTP and OCI_3PTP are assigned to “1(=logic level)” (Signal No. =1). The earth fault protection issues a three-phase tripping signal BU-TRIP in the operation of EF or EFI element.

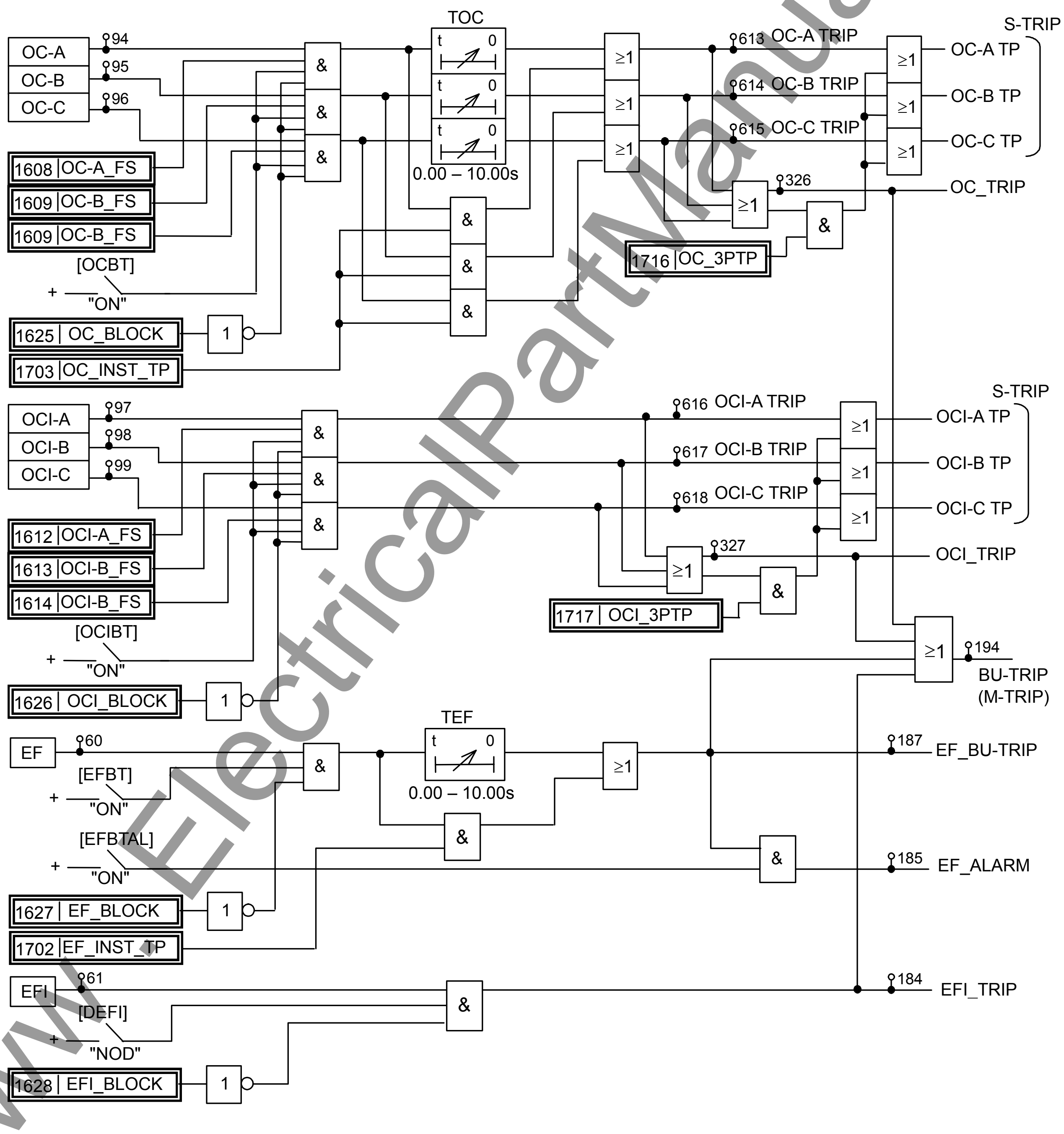


Figure 2.4.5.1 Overcurrent Backup Protection

The overcurrent backup protection can provide a fail-safe function by assigning the PLC signals OC-∗_FS and OCI-∗_FS to an output of relay element, etc. The PLC signals OC-∗_FS and OCI-∗_FS are assigned to "1" (Signal No. =1) as default.

Tripping by each element can be disabled by the scheme switches [OCBT], [OCIBT], [EFBT]and [EFIBT], and also can be disabled by the binary input signals (PLC signals) OC_BLOCK, OCI_BLOCK, EF_BLOCK and EFIBLOCK. The EF element issues an alarm for the backup trip for earth fault. The alarm can be disabled by the scheme switch [EFBTAL]. The OC and EF protections can trip instantaneously by PLC signal OC_INST_TP and EF_INST_TP.

2.4.5.1 Inverse Time Overcurrent Protection

In a system in which the fault current is mostly determined by the fault location, without being greatly affected by changes in the power source impedance, it is advantageous to use inverse definite minimum time (IDMT) overcurrent protection. Reasonably fast tripping can be obtained even at a terminal close to the power source by using inverse time characteristics. In the IDMT overcurrent protection function, one of the following three IEC-standard-compliant inverse time characteristics and one long time inverse characteristic is available.

- standard inverse IEC 60255-3
- very inverse IEC 60255-3
- extremely inverse IEC 60255-3

The IDMT element has a reset feature with definite time reset.

If the reset time is set to instantaneous, then no intentional delay is added. As soon as the energizing current falls below the reset threshold, the element returns to its reset condition.

If the reset time is set to some value in seconds, then an intentional delay is added to the reset period. If the energizing current exceeds the setting for a transient period without causing tripping, then resetting is delayed for a user-definable period. When the energizing current falls below the reset threshold, the integral state (the point towards operation the it has travelled) of the timing function (IDMT) is held for that period.

This does not apply following a trip operation, in which case resetting is always instantaneous.

Setting

The following table shows the setting elements necessary for the inverse time overcurrent backup protection and their setting ranges.

Element	Range	Step	Default	Remarks
OCI	0.5 - 25.0 A	0.1 A	10.0 A	
	(0.10 - 5.00 A	0.01 A	2.00 A) (*)	
TOCI	0.05 - 1.00	0.01	0.50	OCI time setting
TOCIR	0.0 – 10.0 s	0.1 s	0.0 s	OCI definite time reset delay
[MOCI]	Long/Std/Very/Ext		Std	OCI inverse characteristic selection
[OCIBT]	ON/OFF		ON	OCI backup protection
EFI	0.5 - 5.0 A	0.1 A	5.0 A	Earth fault EFI setting
	(0.10 - 1.00 A	0.01 A	1.00 A) (*)	
TEFI	0.05 - 1.00	0.01	0.50	EFI time setting
TEFIR	0.0 – 10.0 s	0.1 s	0.0 s	EFI definite time reset delay
[MEFI]	Long/Std/Very/Ext		Std	EFI inverse characteristic selection
[DEFI]	ON/NOD/F/R		OFF	EFI directional control

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The scheme switches [MOCI] and [MEFI] are used to select one of the four inverse time characteristics. The DEFI is the scheme switch for directional control selection and if NOD is selected, the inverse time overcurrent protection executes non-directional operation. If F or R is selected, it executes forward operation or reverse operation in combination with the DEFF or DEFR. If OFF is selected, the inverse time overcurrent protection is blocked.

Current setting

In Figure 2.4.5.2, the current setting at terminal A is set lower than the minimum fault current in the event of a fault at remote end F1. Furthermore, when considering also backup protection of a fault on an adjacent line, it is set lower than the minimum fault current in the event of a fault at remote end F3. For grading of the current settings, the terminal furthest from the power source is set to the lowest value and the terminals closer to the power source are set to a higher value.

The minimum setting is restricted so as not to operate on false zero-sequence currents caused by an unbalance in the load current, errors in the current transformer circuits or zero-sequence mutual coupling of parallel lines.

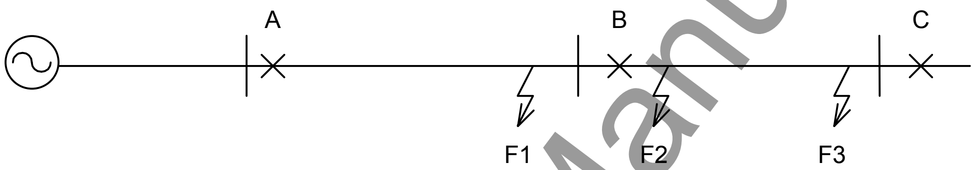


Figure 2.4.5.2 Current Settings in Radial System

Time setting

Time setting is performed to provide selectivity in relation to the relays on adjacent lines. Consider a minimum source impedance when the current flowing in the relay becomes a maximum. In Figure 2.4.5.2, in the event of a fault at the near end, F2 of the adjacent line, the operating time is set so that terminal A may operate by time grading Tc behind terminal B. The current flowing in the relays may sometimes be greater when the remote end of the adjacent line is open. At this time, time coordination must also be kept.

The reason why the operating time is set when the fault current reaches a maximum is that if time coordination is obtained for a large fault current, then time coordination can also be obtained for small fault current as long as relays with the same operating characteristic are used for each terminal.

The grading margin Tc of terminal A and terminal B is given by the following expression for a fault at point F2 in Figure 2.4.5.2.

$Tc = T_1 + T_2 + T_m$

where, T_1: circuit breaker clearance time at B

T_2: relay reset time at A

T_m: time margin

When single-phase autoreclose is used, the minimum time of the earth fault overcurrent protection must be set longer than the time from fault occurrence to reclosing of the circuit breaker. This is to prevent three-phase final tripping from being executed by the overcurrent protection during a single-phase autoreclose cycle.

2.4.5.2 Definite Time Overcurrent Backup Protection

In a system in which the fault current does not vary a great deal in relation to the position of the fault, the advantages of the IDMT characteristics are not fully used. In this case, definite time overcurrent protection is applied. The operating time can be set irrespective of the magnitude of the fault current.

The definite time overcurrent protection consists of instantaneous overcurrent elements and delayed pick-up timers started by them.

Identical current values can be set for terminals, but graded settings are better than identical settings in order to provide a margin for current sensitivity. The farther from the power source the terminal is located, the higher sensitivity (i.e. the lower setting) is required.

The operating time of the overcurrent element at each terminal is constant irrespective of the magnitude of the fault current and selective protection is implemented by graded settings of the delayed pick-up timer. As a result, the circuit breaker of the terminal most remote from the power source is tripped in the shortest time.

When setting the delayed pick-up timers, time grading margin Tc is obtained in the same way as explained in Section 2.4.5.1.

Setting

The setting elements necessary for the definite time overcurrent backup protection and their setting ranges are shown below.

Element	Range	Step	Default	Remarks
OC	0.5 - 100.0 A	0.1 A	6.0 A	Phase overcurrent
	(0.1 - 20.0 A	0.1 A	1.2 A) (*)	
TOC	0.00 - 10.00 s	0.01 s	3.00 s	OC delayed tripping
EF	0.5 - 5.0 A	0.1 A	1.0 A	Residual overcurrent
	(0.10 - 1.00 A	0.01 A	0.20 A) (*)	
TEF	0.00 - 10.00 s	0.01 s	3.00 s	EF delayed tripping
[OCBT]	OFF/ON		ON	OC backup protection
[EFBT]	OFF/ON		ON	EF backup protection
[EFBTAL]	OFF/ON		ON	EF backup trip alarm

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

2.4.6 Thermal Overload Protection

The temperature of electrical plant rises according to an I^2t function and the thermal overload protection in GRZ100 provides a good protection against damage caused by sustained overloading. The protection simulates the changing thermal state in the plant using a thermal model.

The thermal state of the electrical system can be shown by equation (1).

$$\theta = \frac{I^2}{I_{AOL}^2}\left(1 - e^{-t/\tau}\right) \times 100\% \qquad (1)$$

where:

θ = thermal state of the system as a percentage of allowable thermal capacity,

I = applied load current,

I_{AOL} = allowable overload current of the system,

τ = thermal time constant of the system.

The thermal state 0% represents the cold state and 100% represents the thermal limit, which is the point at which no further temperature rise can be safely tolerated and the system should be disconnected. The thermal limit for any given system is fixed by the thermal setting I_{AOL}. The relay gives a trip output when $\theta = 100\%$.

The thermal overload protection measures the largest of the three phase currents and operates according to the characteristics defined in IEC60255-8. (Refer to Appendix O for the implementation of the thermal model for IEC60255-8.)

Time to trip depends not only on the level of overload, but also on the level of load current prior to the overload - that is, on whether the overload was applied from ‘cold’ or from ‘hot’.

Independent thresholds for trip and alarm are available.

The characteristic of the thermal overload element is defined by equation (2) and equation (3) for ‘cold’ and ‘hot’. The cold curve is a special case of the hot curve where prior load current Ip is zero, catering to the situation where a cold system is switched on to an immediate overload.

$$t = \tau \cdot Ln\left[\frac{I^2}{I^2 - I_{AOL}^2}\right] \qquad (2)$$

$$t = \tau \cdot Ln\left[\frac{I^2 - I_P^2}{I^2 - I_{AOL}^2}\right] \qquad (3)$$

where:

t = time to trip for constant overload current I (seconds)

I = overload current (largest phase current) (amps)

I_{AOL} = allowable overload current (amps)

I_P = previous load current (amps)

τ = thermal time constant (seconds)

Ln = natural logarithm

Figure 2.4.6.1 illustrates the IEC60255-8 curves for a range of time constant settings. The left-hand chart shows the ‘cold’ condition where an overload has been switched onto a previously un-loaded system. The right-hand chart shows the ‘hot’ condition where an overload is switched onto a system that has previously been loaded to 90% of its capacity.

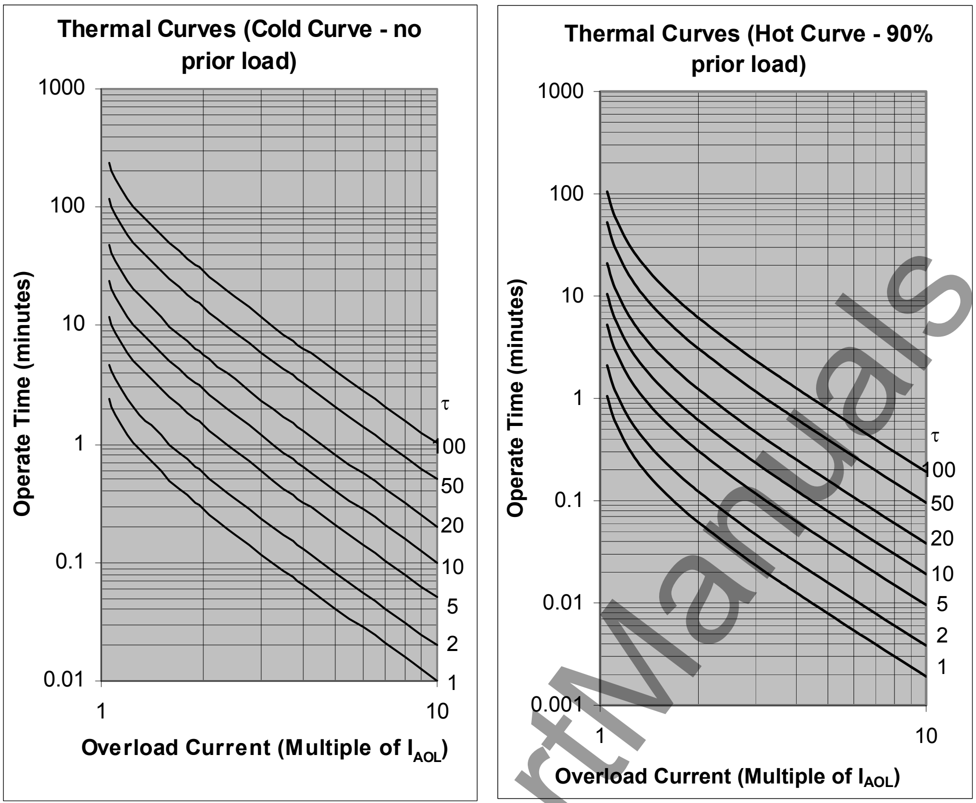


Figure 2.4.6.1 Thermal Curves

Scheme Logic

Figure 2.4.6.2 shows the scheme logic of the thermal overload protection.

The thermal overload element THM has independent thresholds for alarm and trip, and outputs alarm signal THM_ALARM and trip signal THM_TRIP. The alarming threshold level is set as a percentage of the tripping threshold.

The alarming and tripping can be disabled by the scheme switches [THMAL] and [THMT] respectively or binary input signals THMA_BLOCK and THM_BLOCK.

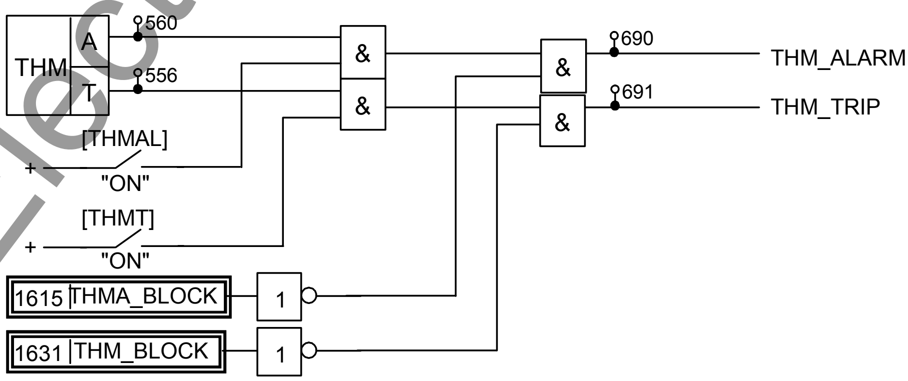


Figure 2.4.6.2 Thermal Overload Protection Scheme Logic

Setting

The table below shows the setting elements necessary for the thermal overload protection and their setting ranges.

Element	Range	Step	Default	Remarks
THM	2.0 – 10.0 A (0.40 – 2.00 A)(*)	0.1 A (0.01 A)	5.0 A (1.00 A)	Thermal overload setting. (THM = I_{AOL}: allowable overload current)
THMIP	0.0 – 5.0 A (0.00 – 1.00 A)(*)	0.1 A (0.01 A)	0.0 A (0.00 A)	Previous load current
TTHM	0.5 - 300.0 min	0.1 min	10.0 min	Thermal time constant
THMA	50 – 99 %	1 %	80 %	Thermal alarm setting. (Percentage of THM setting.)
[THMT]	Off / On		Off	Thermal OL enable
[THMAL]	Off / On		Off	Thermal alarm enable

(*) Current values shown in the parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

Note: THMIP sets a minimum level of previous load current to be used by the thermal element, and is typically used when testing the element. For the majority of applications, THMIP should be set to its default value of zero, in which case the previous load current, Ip, is calculated internally by the thermal model, providing memory of conditions occurring before an overload.

2.4.7 Switch-Onto-Fault Protection

In order to quickly remove a fault which may occur when a faulted line or busbar is energized, the switch-onto-fault (SOTF) protection functions for a certain period after the circuit breaker is closed.

The SOTF protection is performed by a non-directional overcurrent element and distance measuring elements. The overcurrent protection is effective in detecting close-up three-phase faults on the line in particular when the voltage transformer is installed on the line side. This is because the voltage input to the distance measuring elements is absent continuously before and after the fault, and thus it is difficult for the distance measuring elements to detect the fault.

The distance measuring elements can operate for faults other than close-up three-phase faults. One of the zone 1 to zone ND elements can be used for the SOTF protection.

Scheme logic

The scheme logic for the SOTF protection is shown in Figure 2.4.7.1. The SOTF protection issues a three-phase tripping signal SOTF-TRIP for the operation of an overcurrent element OCH or distance measuring elements Z1 to ZND for 500 ms after the circuit breaker is closed (CB-OR = 1) and/or for 500ms after the undervoltage dead line detector resets. The method of controlling the SOTF protection by CB closing and/or by undervoltage dead line detection is selected by scheme switch [SOTF-DL]. Elements UVFS and UVLG provide undervoltage dead line detection.

Tripping by each element can be disabled by the scheme switches [SOTF-OC] to [SOTF-ZND]. When a VT failure is detected (NON VTF = 0), tripping by the distance measuring elements is blocked.

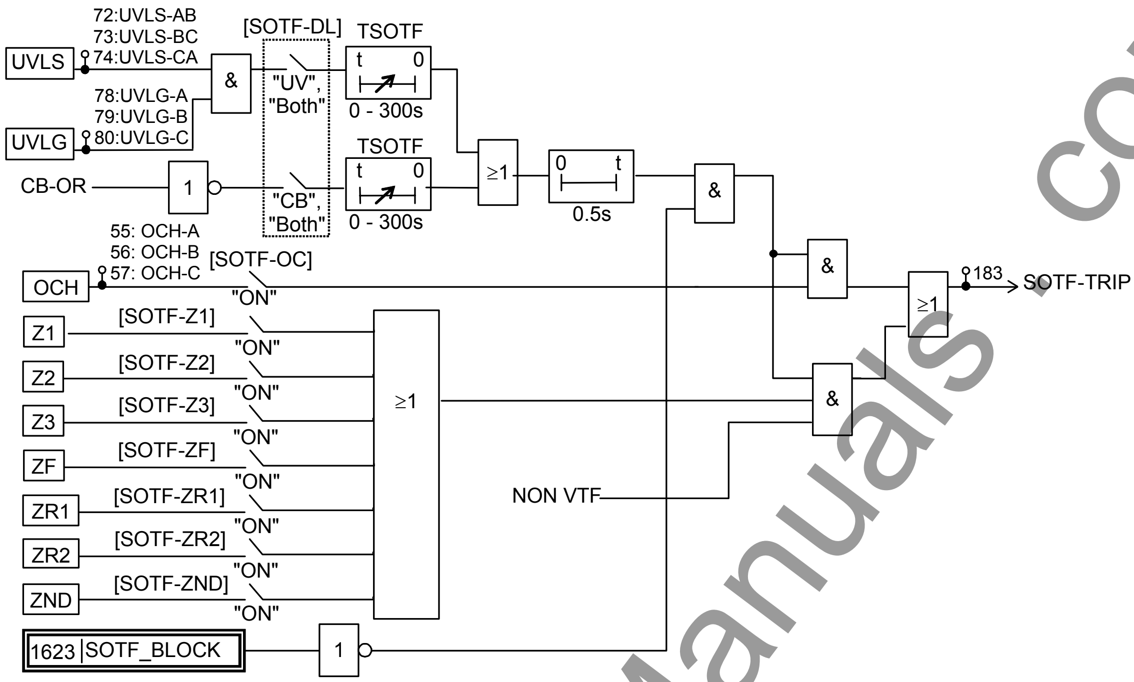


Figure 2.4.7.1 SOTF Scheme Logic

Setting

The setting elements necessary for the SOTF protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
OCH	2.0 - 15.0 A	0.1 A	6.0 A	Overcurrent setting
	(0.4 - 3.0 A	0.1 A	1.2 A) (*)	
TSOTF	0 – 300 s	1 s	5 s	SOTF check timer
SOTF - OC	OFF/ON		ON	Overcurrent tripping
SOTF - Z1	OFF/ON		OFF	Zone 1 tripping
SOTF - Z2	OFF/ON		OFF	Zone 2 tripping
SOTF - Z2	OFF/ON		OFF	Zone 3 tripping
SOTF - ZF	OFF/ON		OFF	Zone F tripping
SOTF - ZR1	OFF/ON		OFF	Zone R1 tripping
SOTF - ZR2	OFF/ON		OFF	Zone R2 tripping
SOTF - ZND	OFF/ON		OFF	Zone ND tripping
SOTF-DL	CB/UV/BOTH		CB	SOTF control

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The OCH element and its setting are common with the stub protection.

2.4.8 Stub Protection

In the case of a busbar with a one-and-a-half breaker arrangement, the VT is generally installed on the line side. If the line is separated from the busbar, the distance protection does not cover to the "stub" area between the two CTs and line isolator. This is because the line VT cannot supply a correct voltage for a fault in the "stub" area. For a fault in the stub area under such conditions, fast overcurrent protection is applied.

Scheme logic

The scheme logic for the stub protection is shown in Figure 2.4.8.1. The stub protection performs three-phase tripping on the condition that the line disconnector is open (DS_N/O_CONT = 0) and the overcurrent element has operated (OCH = 1). CB condition (STUB_CB) can be added by using programmable BI function (PLC function). Tripping can be disabled by the scheme switch [STUB].

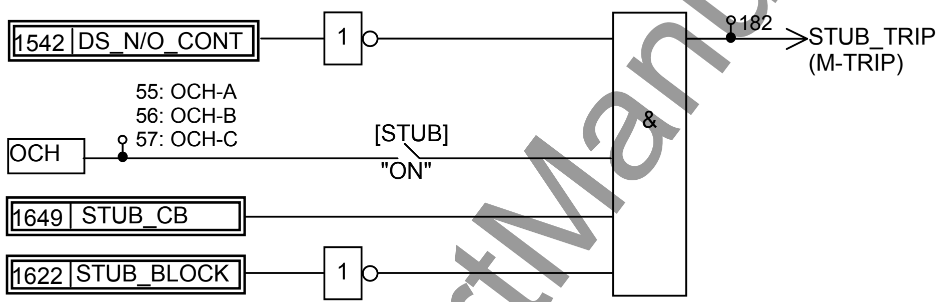


Figure 2.4.8.1 Stub Protection Scheme Logic

Setting

The setting elements necessary for the stub protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
OCH	2.0 - 10.0 A	0.1 A	6.0 A	Overcurrent setting
	(0.4 - 2.0 A	0.1 A	1.2 A) (*)	
STUB	OFF/ON		OFF	Stub protection

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The OCH element and its setting are common with the SOTF protection.

2.4.9 Overvoltage and Undervoltage Protection

2.4.9.1 Overvoltage Protection

GRZ100 provides four independent overvoltage elements with programmable dropoff/pickup(DO/PU) ratio for phase-to-phase voltage input and phase voltage input. OVS1 and OVS2 are used for phase-to-phase voltage input, and OVG1 and OVG2 for phase voltage input. OVS1 and OVG1 are programmable for inverse time (IDMT) or definite time (DT) operation. OVS2 and OVG2 have definite time characteristic only.

The OVS1 and OVG1 overvoltage protection elements have an IDMT characteristic defined by equation (1):

$$t = TMS \times \left[\frac{1}{\left(V/_{Vs} \right) - 1} \right] \qquad (1)$$

where:

t = operating time for constant voltage V (seconds),

V = energising voltage (V),

Vs = overvoltage setting (V),

TMS = time multiplier setting.

The IDMT characteristic is illustrated in Figure 2.4.9.1.

The OVS2 and OVG2 elements are used for definite time overvoltage protection.

Definite time reset

The definite time resetting characteristic is applied to the OVS1 and OVG1 elements when the inverse time delay is used.

If definite time resetting is selected, and the delay period is set to instantaneous, then no intentional delay is added. As soon as the energising voltage falls below the reset threshold, the element returns to its reset condition.

If the delay period is set to some value in seconds, then an intentional delay is added to the reset period. If the energising voltage exceeds the setting for a transient period without causing tripping, then resetting is delayed for a user-definable period. When the energising voltage falls below the reset threshold, the integral state (the point towards operation that it has travelled) of the timing function (IDMT) is held for that period.

This does not apply following a trip operation, in which case resetting is always instantaneous.

Overvoltage elements OVS1, OVS2, OVG1 and OVG2 have a programmable dropoff/pickup (DO/PU) ratio.

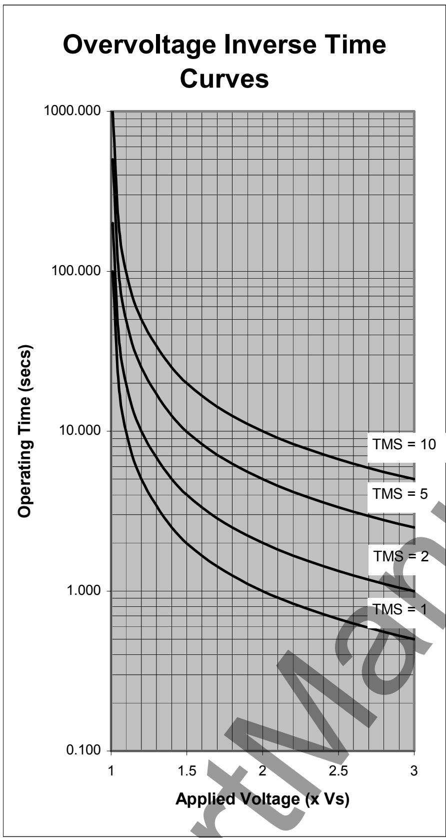


Figure 2.4.9.1 IDMT Characteristic

Scheme Logic

Figures 2.4.9.2 and 2.4.9.4 show the scheme logic of the OVS1 and OVG1 overvoltage protection with selective definite time or inverse time characteristic. The definite time protection is selected by setting [OV∗1EN] to "DT", and trip signal OV∗1_TRIP is given through the delayed pick-up timer TO∗1. The inverse time protection is selected by setting [OV∗1EN] to "IDMT", and trip signal OV∗1_TRIP is given.

The OVS1 and OVG1 protections can be disabled by the scheme switch [OV∗1EN] or the PLC signal OV∗1_BLOCK.

These protections are available to trip instantaneously by the PLC signal OV∗1_INST_TP except for [OV∗1EN]="OFF" setting.

Figures 2.4.9.3 and 2.4.9.5 show the scheme logic of the OVS2 and OVG2 protection with definite time characteristic. The OV∗2 gives the PLC signal OV∗2_ALARM through delayed pick-up timer TO∗2.

The OV∗2_ALARM can be blocked by incorporated scheme switch [OV∗2EN] and the PLC signal OV∗2_BLOCK.

These protections are also available to alarm instantaneously by the PLC signal OV∗2_INST_TP.

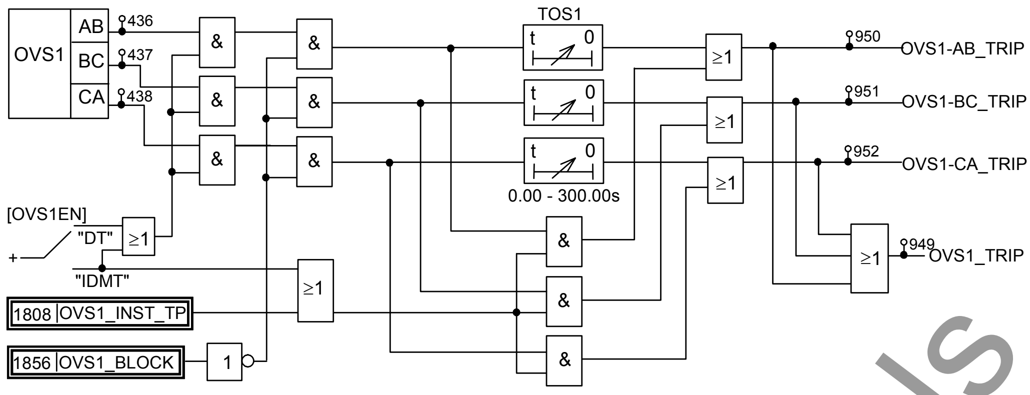


Figure 2.4.9.2 OVS1 Overvoltage Protection

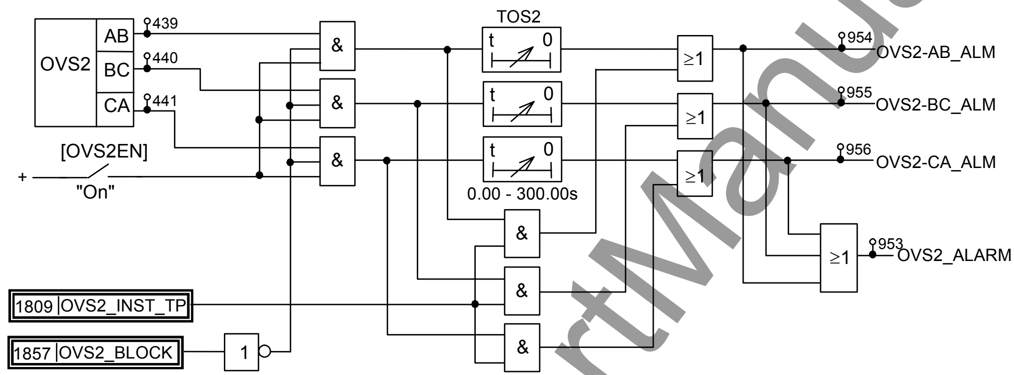


Figure 2.4.9.3 OVS2 Overvoltage Protection

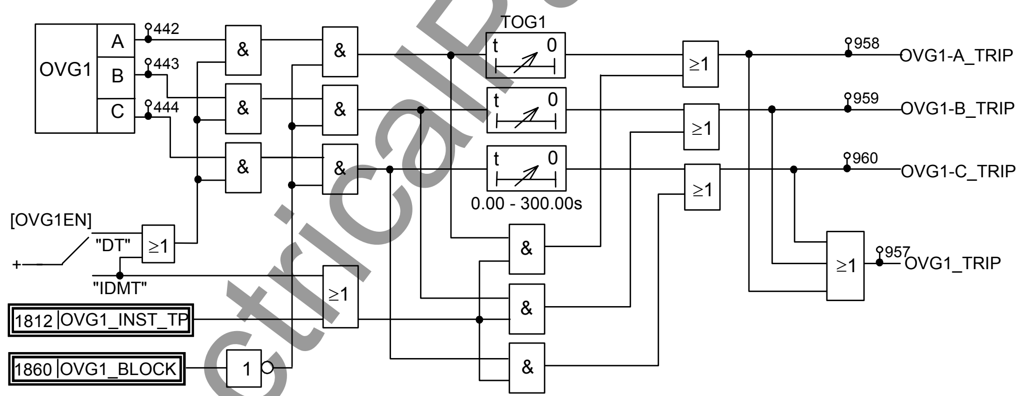


Figure 2.4.9.4 OVG1 Overvoltage Protection

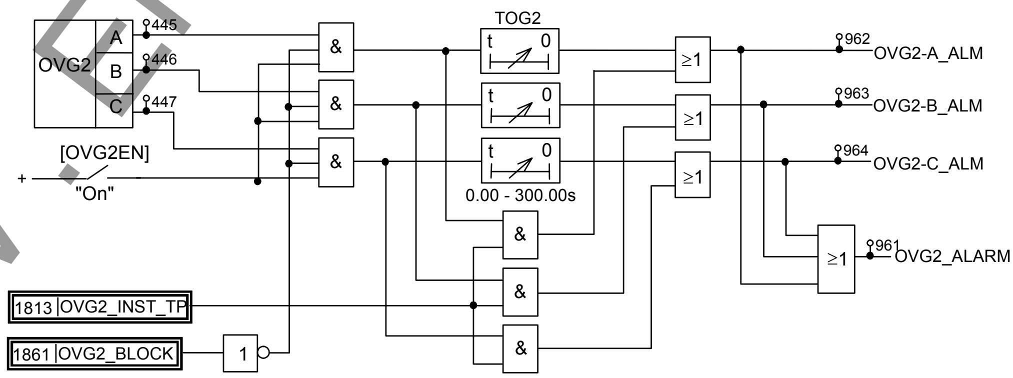


Figure 2.4.9.5 OVG2 Overvoltage Protection

Setting

The table shows the setting elements necessary for the overvoltage protection and their setting ranges.

Element	Range	Step	Default	Remarks
OVS1	5.0 – 150.0 V	0.1 V	120.0 V	OVS1 threshold setting.
TOS1I	0.05 – 100.00	0.01	10.00	OVS1 time multiplier setting. Required if [OVS1EN] = IDMT.
TOS1	0.00 – 300.00 s	0.01 s	0.10 s	OVS1 definite time setting. Required if [OVS1EN] = DT.
TOS1R	0.0 – 300.0 s	0.1 s	0.0 s	OVS1 definite time delayed reset.
OS1DP	10 – 98 %	1 %	95 %	OVS1 DO/PU ratio setting.
OVS2	5.0 – 150.0 V	0.1 V	140.0 V	OVS2 threshold setting.
TOS2	0.00 – 300.00 s	0.01 s	1.00 s	OVS2 definite time setting.
OS2DP	10 - 98 %	1 %	95 %	OVS2 DO/PU ratio setting.
OVG1	5.0 – 150.0 V	0.1V	70.0 V	OVG1 threshold setting.
TOG1I	0.05 – 100.00	0.01	10.00	OVG1 time multiplier setting. Required if [OVG1EN]=IDMT.
TOG1	0.00 – 300.00 s	0.01 s	0.10 s	OVG1 definite time setting. Required if [ZOV1EN]=DT.
TOG1R	0.0 – 300.0 s	0.1 s	0.0 s	OVG1 definite time delayed reset.
OG1DP	10 – 98 %	1 %	95 %	OVG1 DO/PU ratio
OVG2	5.0 – 150.0 V	0.1V	80.0 V	OVG2 threshold setting
TOG2	0.00 – 300.00 s	0.01 s	0.10 s	OVG2 definite time setting
OG2DP	10 – 98 %	1 %	95 %	OVG2 DO/PU ratio
[OVS1EN]	Off / DT / IDMT		Off	OVS1 Enable
[OVS2EN]	Off / On		Off	OVS2 Enable
[OVG1EN]	Off / DT / IDMT		Off	OVG1 Enable
[OVG2EN]	Off / On		Off	OVG2 Enable

2.4.9.2 Undervoltage Protection

GRZ100 provides four independent undervoltage elements for phase and earth fault protection. UVS1 and UVS2 are used for phase fault protection, and UVG1 and UVG2 for earth fault protection. UVS1 and UVG1 are programmable for inverse time (IDMT) or definite time (DT) operation. UVS2 and UVG2 have definite time characteristic only.

The UVS1 and UVG1 undervoltage protection elements have an IDMT characteristic defined by equation (2):

$$t = TMS \times \left[\frac{1}{1 - \left(V/_{Vs} \right)} \right] \qquad (2)$$

where:

t = operating time for constant voltage V (seconds),

V = energising voltage (V),

Vs = undervoltage setting (V),

TMS = time multiplier setting.

The IDMT characteristic is illustrated in Figure 2.4.9.6.

The UVS2 and UVG2 elements are used for definite time undervoltage protection.

Definite time reset

The definite time resetting characteristic is applied to the UVS1 and UVG1 elements when the inverse time delay is used.

If definite time resetting is selected, and the delay period is set to instantaneous, then no intentional delay is added. As soon as the energising voltage rises above the reset threshold, the element returns to its reset condition.

If the delay period is set to some value in seconds, then an intentional delay is added to the reset period. If the energising voltage is below the undercurrent setting for a transient period without causing tripping, then resetting is delayed for a user-definable period. When the energising voltage rises above the reset threshold, the integral state (the point towards operation that it has travelled) of the timing function (IDMT) is held for that period.

This does not apply following a trip operation, in which case resetting is always instantaneous.

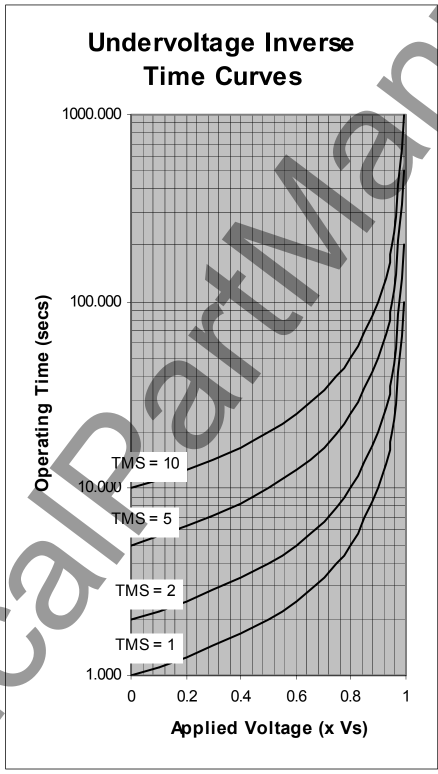


Figure 2.4.9.6 IDMT Characteristic

Scheme Logic

Figures 2.4.9.7 and 2.4.9.9 show the scheme logic of the UVS1 and UVG1 undervoltage protection with selective definite time or inverse time characteristic. The definite time protection is selected by setting [UV∗1EN] to “DT”, and trip signal UV∗1_TRIP is given through the delayed pick-up timer TU∗1. The inverse time protection is selected by setting [UV∗1EN] to “IDMT”, and trip signal UV∗1_TRIP is given.

The UVS1 and UVG1 protections can be disabled by the scheme switch [UV∗1EN] or the PLC signal UV∗1_BLOCK.

These protections are available to trip instantaneously by the PLC signal UV∗1_INST_TP except for [UV∗1EN]=“OFF” setting.

Figures 2.4.9.8 and 2.4.9.10 show the scheme logic of the UVS2 and UVG2 protection with definite time characteristic. The UV∗2 gives the PLC signal UV∗2_ALARM through delayed pick-up timer TU∗2.

The UV∗2_ALARM can be blocked by incorporated scheme switch [UV∗2EN] and the PLC signal UV∗2_BLOCK.

These protections are also available to alarm instantaneously by the PLC signal UV∗2_INST_TP.

In addition, there is user programmable voltage threshold UVSBLK and UVGBLK. If all three phase voltages drop below this setting, then both UV∗1 and UV∗2 are prevented from operating. This function can be blocked by the scheme switch [VBLKEN]. The [VBLKEN] should be set to “OFF” (not used) when the UV elements are used as fault detectors, and set to “ON” (used) when used for load shedding.

Note: The UVSBLK and UVGBLK must be set lower than any other UV setting values.

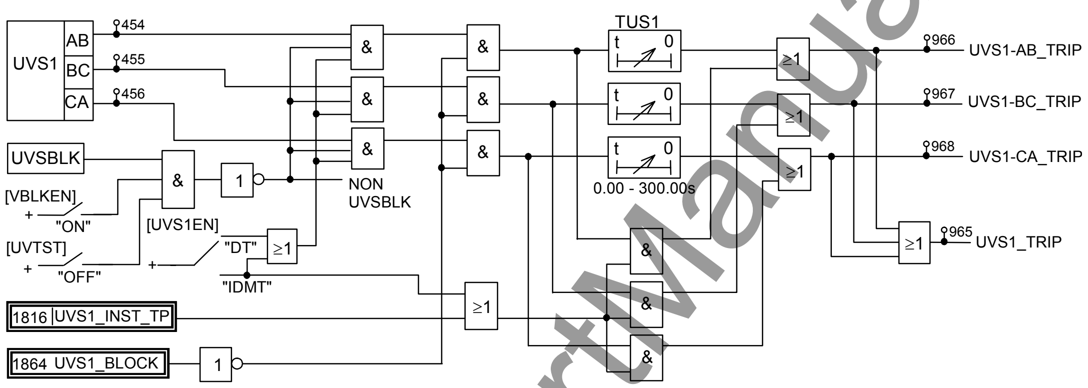


Figure 2.4.9.7 UVS1 Undervoltage Protection

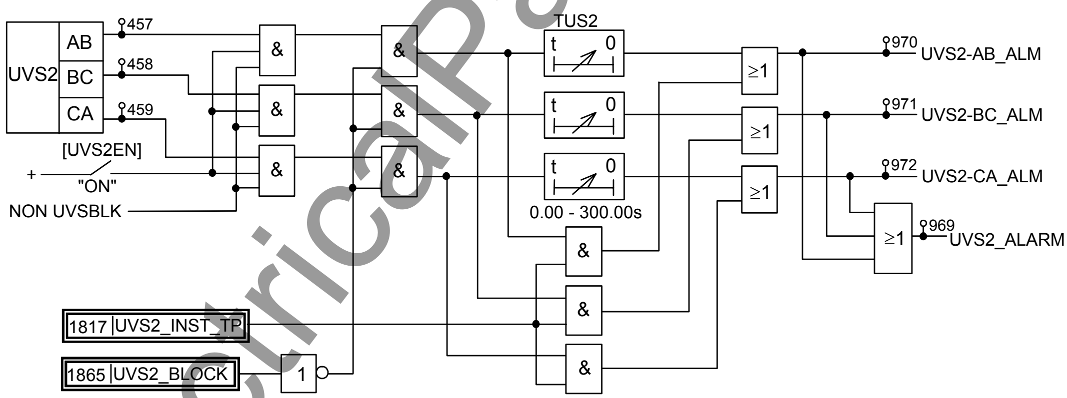


Figure 2.4.9.8 UVS2 Undervoltage Protection

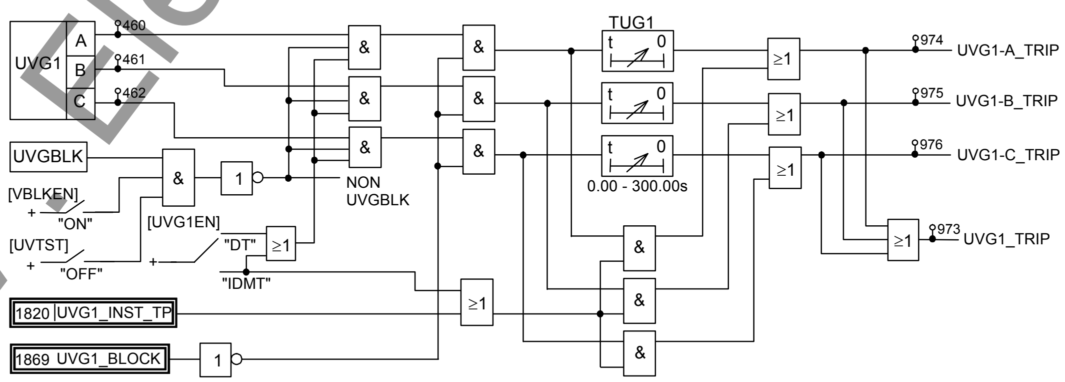


Figure 2.4.9.9 UVG1 Undervoltage Protection

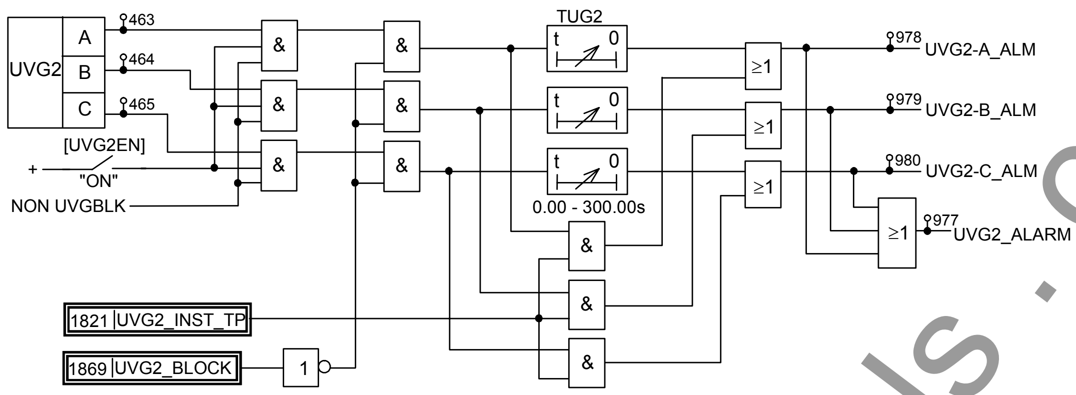


Figure 2.4.9.10 UVG2 Undervoltage Protection

Setting

The table shows the setting elements necessary for the undervoltage protection and their setting ranges.

Element	Range	Step	Default	Remarks
UVS1	5.0 – 150.0 V	0.1 V	60.0 V	UVS1 threshold setting
TUS1I	0.05– 100.00	0.01	10.00	UVSI time multiplier setting. Required if [UVS1EN] = IDMT.
TUS1	0.00 – 300.00 s	0.01 s	0.10 s	UVS1 definite time setting. Required if [UV1EN] = DT.
TUS1R	0.0 – 300.0 s	0.1 s	0.0 s	UVS1 definite time delayed reset.
UVS2	5.0 – 150.0 V	0.1 V	40.0 V	UV2 threshold setting.
TUS2	0.00 – 300.00 s	0.01 s	0.10 s	UV2 definite time setting.
VSBLK	5.0 – 20.0 V	0.1 V	10.0 V	Undervoltage block threshold setting.
UVG1	5.0 – 150.0 V	0.1 V	35.0 V	UVS1 threshold setting
TUG1I	0.05– 100.00	0.01	10.00	UVSI time multiplier setting. Required if [UVS1EN] = IDMT.
TUG1	0.00 – 300.00 s	0.01 s	0.10 s	UVS1 definite time setting. Required if [UV1EN] = DT.
TUG1R	0.0 – 300.0 s	0.1 s	0.0 s	UVS1 definite time delayed reset.
UVG2	5.0 – 150.0 V	0.1 V	25.0 V	UV2 threshold setting.
TUG2	0.00 – 300.00 s	0.01 s	0.10 s	UV2 definite time setting.
VGBLK	5.0 – 20.0 V	0.1 V	10.0 V	Undervoltage block threshold setting.
[UVS1EN]	Off / DT / IDMT		DT	UVS1 Enable
[UVG1EN]	Off / DT / IDMT		DT	UVG1 Enable
[VBLKEN]	Off / On		Off	UV block Enable
[UVS2EN]	Off / On		Off	UVS2 Enable
[UVG2EN]	Off / On		Off	UVG2 Enable

2.4.10 Broken Conductor Protection

Series faults or open circuit faults which do not accompany any earth faults or phase faults are caused by broken conductors, breaker contact failure, operation of fuses, or false operation of single-phase switchgear.

Figure 2.4.10.1 shows the sequence network connection diagram in the case of a single-phase series fault assuming that the positive, negative and zero sequence impedance of the left and right side system of the fault location is in the ratio of k_1 to $(1 – k_1)$, k_2 to $(1 – k_2)$ and k_0 to $(1 – k_0)$.

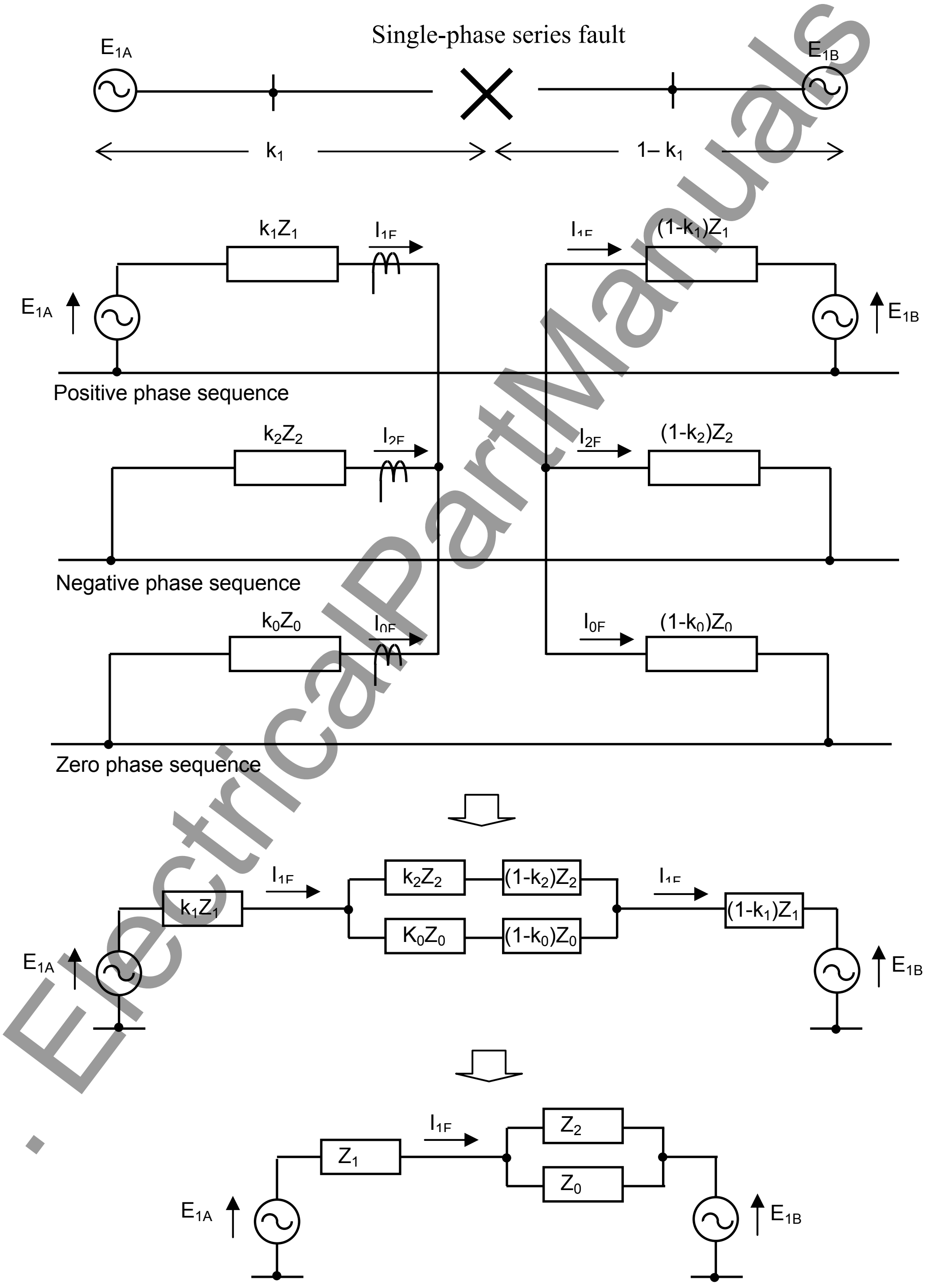


Figure 2.4.10.1 Equivalent Circuit for a Single-phase Series Fault

Positive phase sequence current I_{1F}, negative phase sequence current I_{2F} and zero phase sequence current I_{0F} at fault location in a single-phase series fault are given by:

$I_{1F} + I_{2F} + I_{0F} = 0$ (1)

$Z_{2F}I_{2F} - Z_{0F}I_{0F} = 0$ (2)

$E_{1A} - E_{1B} = Z_{1F}I_{1F} - Z_{2F}I_{2F}$ (3)

where,

E_{1A}, E_{1B}: power source voltage

Z_1: positive sequence impedance

Z_2: negative sequence impedance

Z_0: zero sequence impedance

From the equations (1), (2) and (3), the following equations are derived.

$$I_{1F} = \frac{Z_2 + Z_0}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

$$I_{2F} = \frac{-Z_0}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

$$I_{0F} = \frac{-Z_2}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

The magnitude of the fault current depends on the overall system impedance, difference in phase angle and magnitude between the power source voltages behind both ends.

Broken conductor protection element BCD detects series faults by measuring the ratio of negative to positive phase sequence currents (I_{2F} / I_{1F}). This ratio is given with negative and zero sequence impedance of the system:

$$\frac{I_{2F}}{I_{1F}} = \frac{|I_{2F}|}{|I_{1F}|} = \frac{Z_0}{Z_2 + Z_0}$$

The ratio is higher than 0.5 in a system when the zero sequence impedance is larger than the negative sequence impedance. It will approach 1.0 in a high-impedance earthed or a one-end earthed system.

The characteristic of BCD element is shown in Figure 2.4.10.2 to obtain the stable operation.

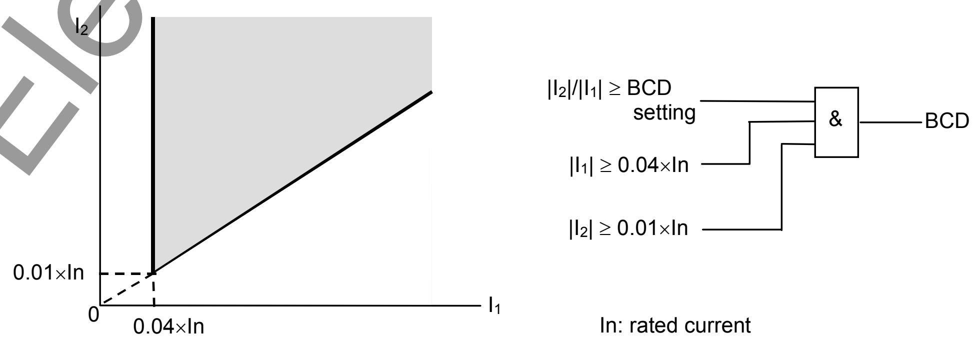


Figure 2.4.10.2 BCD Element Characteristic

Scheme Logic

Figure 2.4.10.3 shows the scheme logic of the broken conductor protection. BCD element outputs trip signals BCD TRIP through a delayed pick-up timer TBCD.

The tripping can be disabled by the scheme switch [BCDEN] or the PLC signal BCD BLOCK.

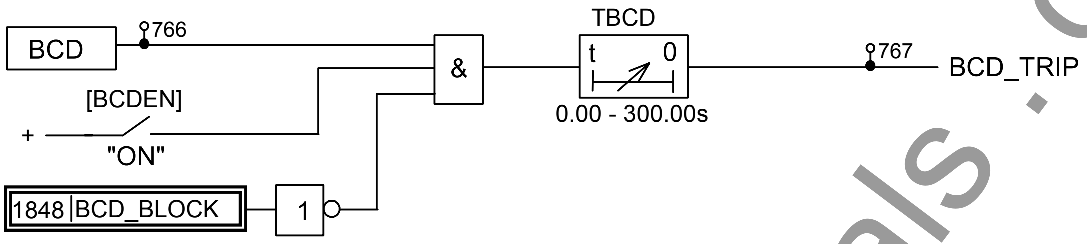


Figure 2.4.10.3 Broken Conductor Protection Scheme Logic

Settings

The table below shows the setting elements necessary for the broken conductor protection and their setting ranges.

Element	Range	Step	Default	Remarks
BCD	0.10 – 1.00	0.01	0.20	I_2 / I_1
TBCD	0.00 – 300.00s	0.01s	1.00 s	BCD definite time setting
[BCDEN]	Off / On		Off	BCD Enable

Minimum setting of the BC threshold is restricted by the negative phase sequence current normally present on the system. The ratio I_2 / I_1 of the system is measured in the relay continuously and displayed on the metering screen of the relay front panel, along with the maximum value of the last 15 minutes I_{21} max. It is recommended to check the display at the commissioning stage. The BCD setting should be 130 to 150% of I_2 / I_1 displayed.

Note: It must be noted that I_2 / I_1 is displayed only when the positive phase sequence current (or load current) in the secondary circuit is larger than 2 % of the rated secondary circuit current.

TBCD should be set to more than 1 cycle to prevent unwanted operation caused by a transient operation such as CB closing.

2.4.11 Transfer Trip Function

The GRZ100 provides a transfer trip function which receives a trip signal from the remote terminal and outputs a trip command. Two transfer trip commands are provided. The scheme logic is shown in Figure 2.4.11.1. When the scheme switch [TTSW∗] is set to "TRIP", the binary output for tripping is driven. When set to "BO", the binary output for tripping is not driven and only user-configurable binary output is driven.

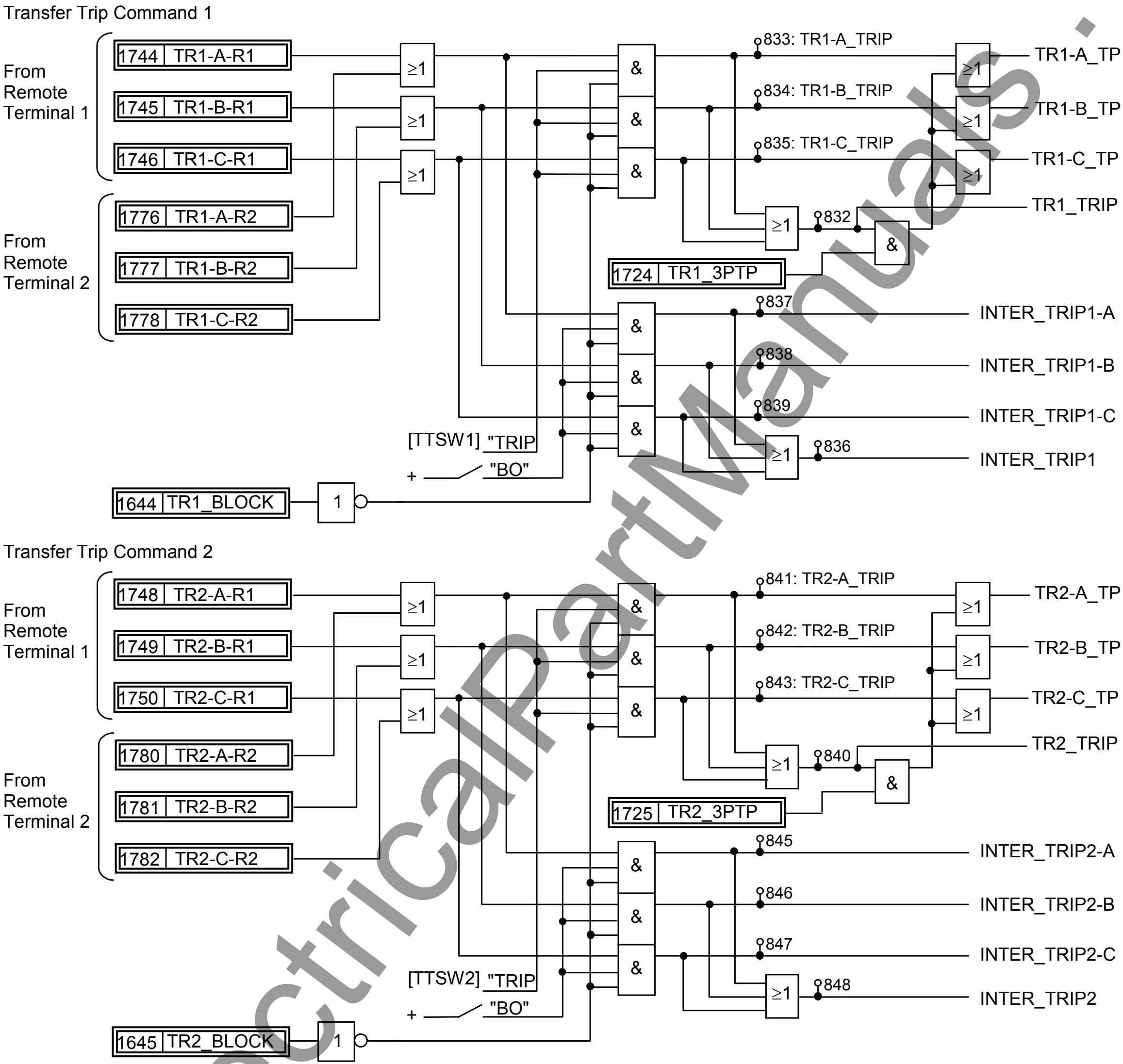


Figure 2.4.11.1 Transfer Trip Scheme Logic

The sending signal is configured by PLC function. If the sending signal is assigned on a per phase basis by PLC, a single-phase tripping is available.

Figure 2.4.11.2 shows an example of the assigning signal.

The transfer trip function is available for using integral digital communication.

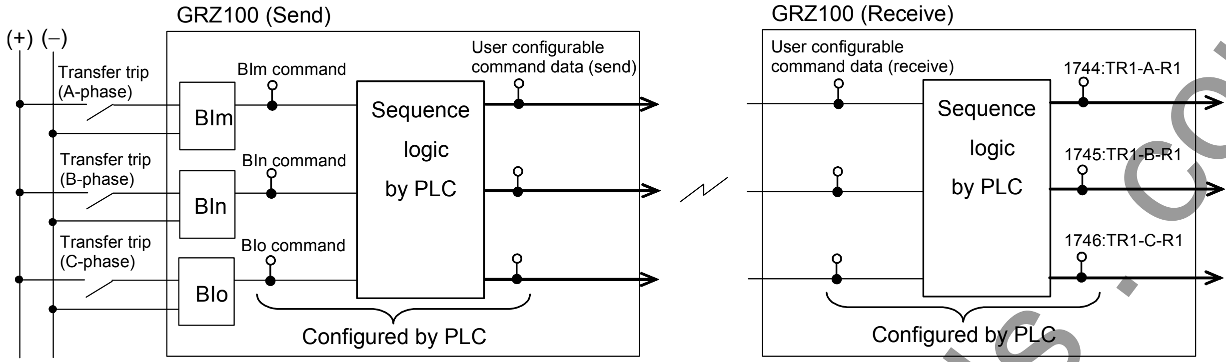


Figure 2.4.11.2 Example of Signal Assign

2.4.12 Breaker Failure Protection

When fault clearance fails due to a breaker failure, the breaker failure protection (BFP) clears the fault by backtripping adjacent circuit breakers.

If the current continues to flow even after a trip command is output, the BFP judges it as a breaker failure. The existence of the current is detected by an overcurrent element provided for each phase. For high-speed operation of the BFP, a high-speed reset overcurrent element is used.

In order to prevent the BFP from starting by accident during maintenance work and testing, and thus tripping adjacent breakers, the BFP has the optional function of retripping the original breaker. To make sure that the breaker has actually failed, a trip command is made to the original breaker again before tripping the adjacent breakers to prevent unnecessary tripping of the adjacent breakers following the erroneous start-up of the BFP. It is possible to choose not to use retripping at all, or use retripping with trip command plus delayed pick-up timer, or retripping with trip command plus overcurrent detection plus delayed pick-up timer.

Tripping by the BFP is three-phase final tripping and autoreclose is blocked.

An overcurrent element and delayed pick-up timer are provided for each phase which also operate correctly during the breaker failure routine in the event of an evolving fault.

Scheme logic

The BFP is performed on an individual phase basis. Figure 2.4.12.1 shows the scheme logic for one phase. The BFP is started by an initiation signal EXT_CBFIN from the external line protection or an internal initiation signal CBF_INIT. The external initiation signals EXT_CBFIN-A, -B, -C are assigned by binary input signals (PLC signals). Starting with an external initiation signal can be disabled by the scheme switch [BFEXT]. These signals must continuously exist as long as the fault is present.

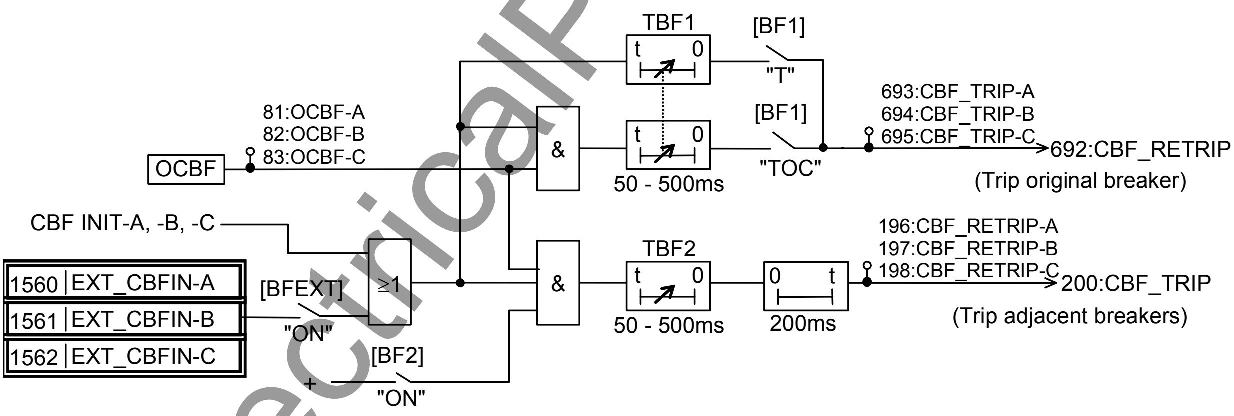


Figure 2.4.12.1 BFP Scheme Logic

The backtripping signal to the adjacent breakers CBF-TRIP is output if the overcurrent element OCBF operates continuously for the setting time of the delayed pick-up timer TBF2 after initiation. Tripping of adjacent breakers can be blocked with the scheme switch [BF2].

There are two kinds of modes of the retrip signal to the original breaker RETRIP, the mode in which RETRIP is controlled by the overcurrent element OCBF, and the direct trip mode in which RETRIP is not controlled. The retrip mode together with the trip block can be selected with the scheme switch [BF1].

Figure 2.4.12.2 shows a sequence diagram for the BFP when a retrip and backup trip are used. If the circuit breaker trips normally, the OCBF is reset before timer TBF1 or TBF2 is picked up and the BFP is reset.

If the OCBF continues to operate, a retrip command is given to the original breaker after the setting time of TBF1. Unless the breaker fails, the OCBF is reset by retrip. TBF2 does not time-out and the BFP is reset. This sequence of events may happen if the BFP is initiated by mistake and unnecessary tripping of the original breaker is unavoidable.

If the original breaker fails, retrip has no effect and the OCBF continues operating and the TBF2 finally picks up. A trip command CBF-TRIP is given to the adjacent breakers and the BFP is completed.

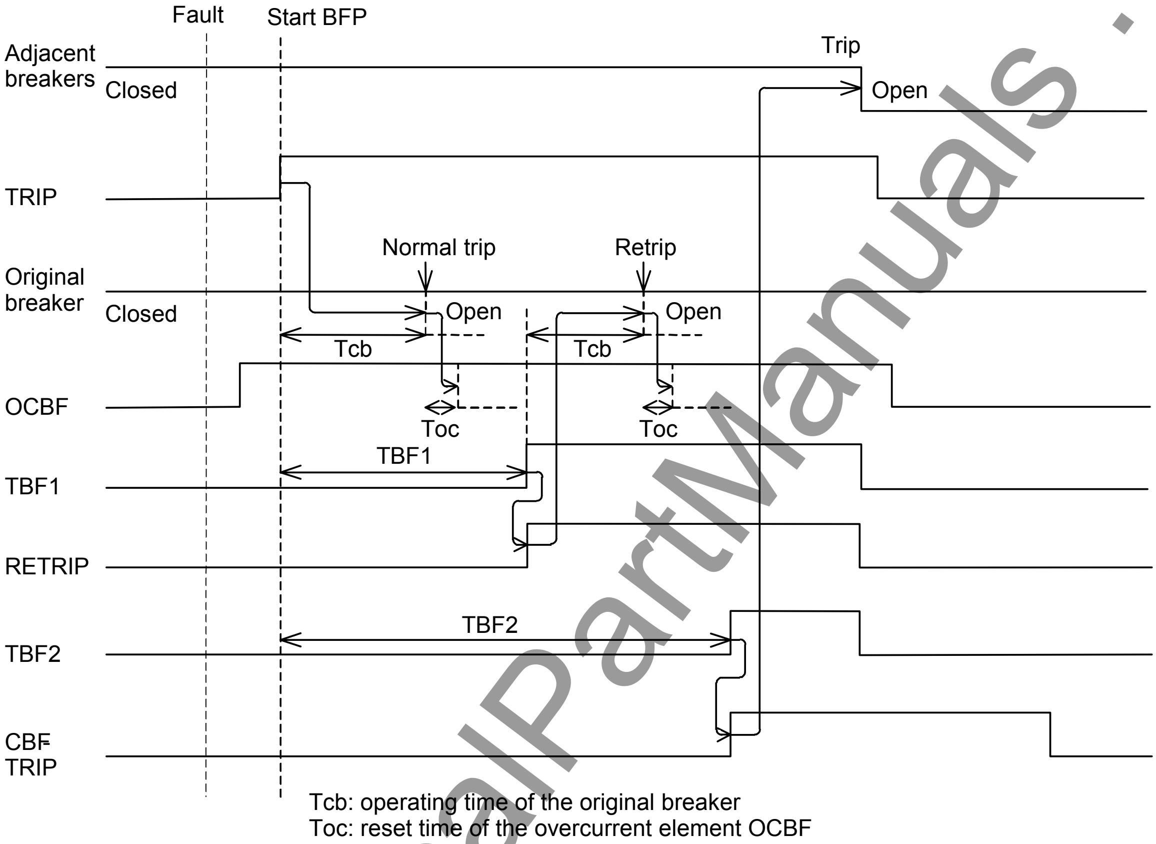


Figure 2.4.12.2 Sequence Diagram

Setting

The setting elements necessary for the breaker failure protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
OCBF	0.5 – 10.0 A	0.1 A	4.0 A	Overcurrent setting
	(0.1 - 2.0 A	0.1 A	0.8 A) (*)	
TBF1	50 - 500 ms	1 ms	150 ms	Retrip timer
TBF2	50 - 500 ms	1 ms	200 ms	Related breaker trip timer
BFEXT	OFF/ON		OFF	External start
BF1	OFF/T/TOC		OFF	Retrip mode
BF2	OFF/ON		OFF	Related breaker trip

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The overcurrent element OCBF checks that the circuit breaker has opened and that the current has disappeared. Therefore, since it is allowed to respond to load current, it can be set to 10 to 200% of the rated current.

The settings of TBF1 and TBF2 are determined by the opening time of the original circuit breaker (Tcb in Figure 2.4.12.2) and the reset time of the overcurrent element (Toc in Figure 2.4.12.2). The timer setting example when using retrip can be obtained as follows.

Setting of TBF1 = Breaker opening time + OCBF reset time + Margin
= 40ms + 10ms + 20ms
= 70ms

Setting of TBF2 = TBF1 + Output relay operating time + Breaker opening time + OCBF reset time + Margin
= 70ms + 10ms + 40ms + 10ms + 10ms
= 140ms

If retrip is not used, the setting of the TBF2 can be the same as the setting of the TBF1.

2.4.13 Out-of-Step Protection

Application

For an out-of-step condition on a power system, power system separation is executed in order to recover power system stability or prevent the failure from extending to the entire system. Power system separation by the distance protection with several operating zones is not desirable because it is not always carried out at the optimal points. For optimal power system separation, the GRZ100 has an out-of-step tripping (OST) function. The OST function uses independent impedance measuring elements to discriminate against transient power swings and reliably detects out-of-steps and operates only when the out-of-step locus crosses the protected line.

Scheme logic

The out-of-step element has three operating areas A, B and C by combining two impedance measuring elements ZM and ZN as shown in Figure 2.4.13.1.

If an out-of-step occurs, the impedance viewed from the impedance measuring element moves through the areas A, B and C in the sequence of A → B → C or C → B → A. The out-of-step tripping logic shown in Figure 2.4.13.2 outputs a three-phase tripping command M-TRIP to the circuit breaker when the impedance viewed from the impedance measuring element passes through those areas in the sequence above and enters the third area and it stays in area A and area C for the time set with the timers TOST1 and TOST2. The tripping command continues for 100 ms. The output signal is blocked when the scheme switch [OST] is set to "OFF" or binary signal OST_BLOCK is input. The tripping signal of the out-of-step protection can be separated from other protection tripping signals by the switch [OST]. In this case, the switch [OST] is set to "BO" and the tripping signal OST-BO is assigned to a desired binary output number (for details, see Section 4.2.6.9). When the tripping signal of the out-of-step protection is not separated from other protection tripping signals, the switch [OST] is set to "TRIP".

The tripping logic does not operate for cases other than out-of-steps, for example, a power swing in which the impedance moves from areas A → B → A or C → B → C or a system fault in which the impedance passes through area A or C instantaneously.

Out-of-step tripping can be disabled with the scheme switch [OST].

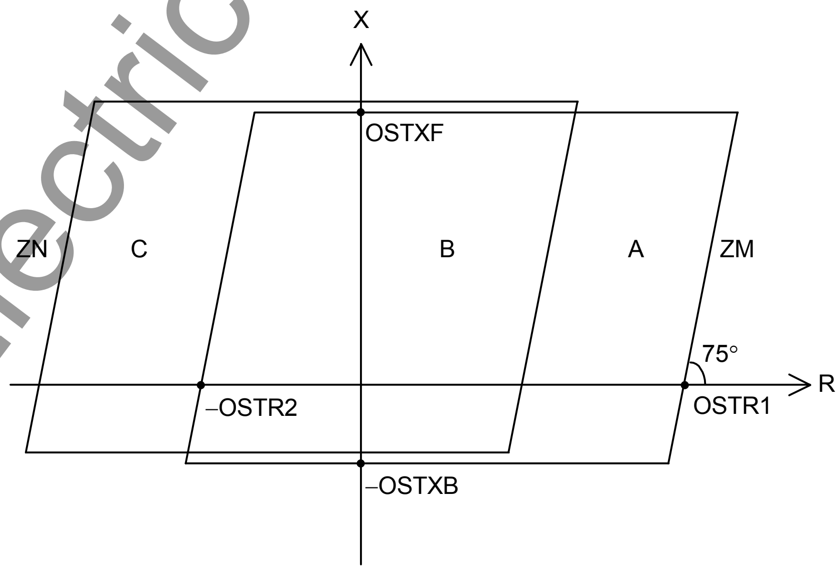


Figure 2.4.13.1 Out-of-Step Element

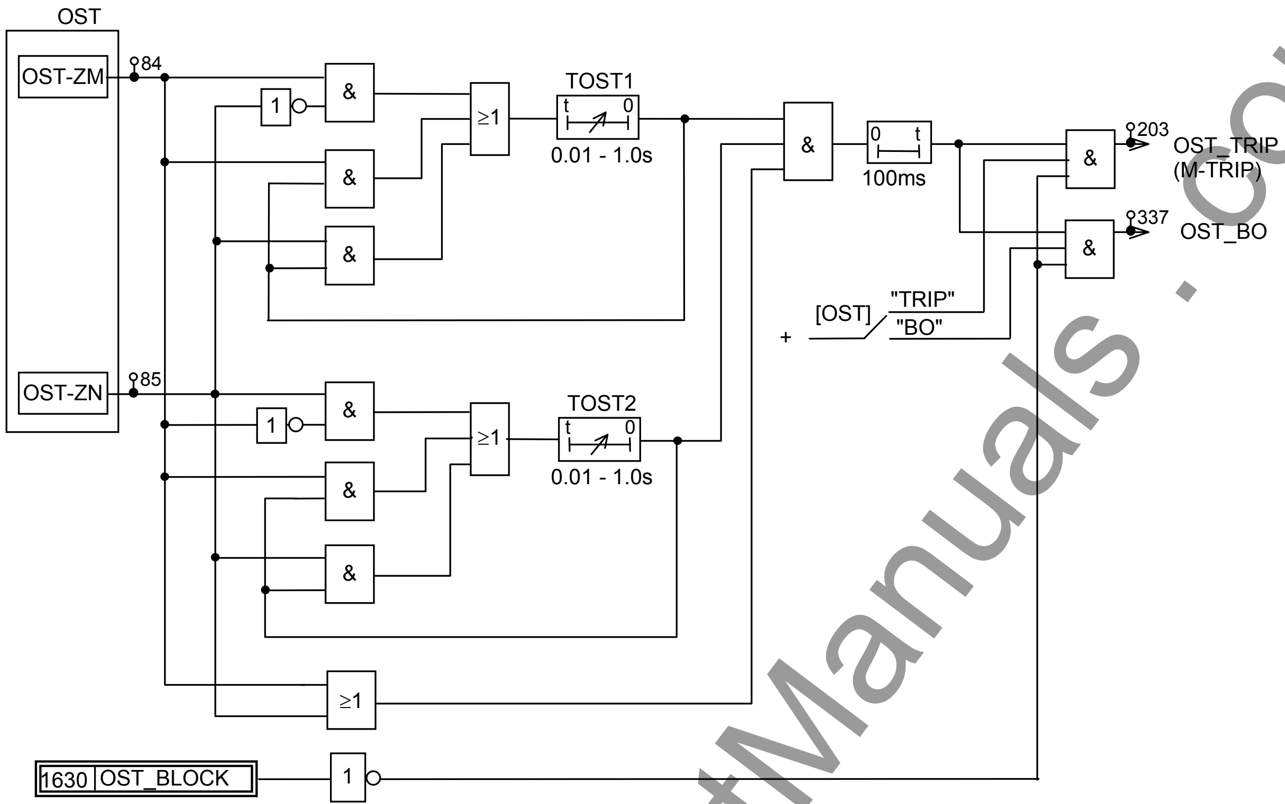


Figure 2.4.13.2 Out-of-Step Tripping Logic

Setting

The setting elements for the out-of-step protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
OSTXF	1.0 - 50.0Ω	0.1Ω	6.0Ω	Forward reactive reach
	(5 - 250Ω	1Ω	30Ω) (*)	
OSTXB	O.2 - 10.0Ω	0.1Ω	1.0Ω	Reverse offset reach
	(1 - 50Ω	1Ω	5Ω)	
OSTR1	3.0 - 30.0Ω	0.1Ω	5.1Ω	Resistive reach (right)
	(15 - 150Ω	1Ω	25Ω)	
OSTR2	1.0 - 10.0Ω	0.1Ω	2.5Ω	Resistive reach (left)
	(5 - 50Ω	1Ω	12Ω)	
TOST1	0.01 - 1.00 s	0.01 s	0.04 s	Out - of - step timer
TOST2	0.01 - 1.00 s	0.01 s	0.04 s	Out - of - step timer
OST	OFF/TRIP/BO		OFF	Out - of - step protection

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5 A rating.

2.4.14 Voltage Transformer Failure Supervision

When a fault occurs in the secondary circuit of the voltage transformer (VT), the voltage dependent measuring elements may operate incorrectly. GRZ100 incorporates a VT failure supervision function (VTFS) as a measure against such incorrect operation. When the VTFS detects a VT failure, it blocks the following voltage dependent protections instantaneously. In 10 seconds, it displays the VT failure and outputs an alarm.

- Zone 1-3, F, R1, R2 and ND distance protection
- Zone 1 extension protection
- Directional earth fault protection
- Command protection

Resetting of the blocks above and resetting of the display and alarm are automatically performed when it is confirmed that all three phases are healthy.

A binary input signal to indicate a miniature circuit breaker trip in the VT circuits is also available for the VTFS.

Scheme logic

Figure 2.4.14.1 shows the scheme logic for the VTFS. VT failures are detected under any one of the following conditions and then a trip block signal VTF is output.

VTF1: The phase-to-phase undervoltage element UVFS or phase-to-earth undervoltage element UVFG operates (UVFS = 1 or UVFG =1) when the three phases of the circuit breaker are closed (CB-AND = 1) and the phase current change detection element OCD does not operate (OCD = 0).

VTF2: The residual overcurrent element EFL does not operate (EFL = 0), the residual overvoltage element OVG operates (OVG = 1) and the phase current change detection element OCD does not operate (OCD = 0).

In order to prevent detection of false VT failures due to unequal pole closing of the circuit breaker, the VTFS is blocked for 200 ms after line energisation.

The trip block signal VTF is reset 100 milliseconds after the VT failure condition has reset. When the VTF continues for 10s or more, an alarm signal VTF-ALARM is output.

Further, the VT failure is detected when the binary input signal (PLC signal) EXT_VTF is received.

This function can be enabled or disabled by the scheme switch [VTF1EN] or [VTF2EN] and has a programmable reset characteristic. When set to “ON”, the latched operation for VTF1 is reset by reset of UVFS/UVFG element, and that for VTF2 is reset by reset of OVG element. Set to “OPT-ON” to reset the latched operation also when OCD or EFL operates.

The VTFS can be disabled by the PLC signal VTF_BLOCK.

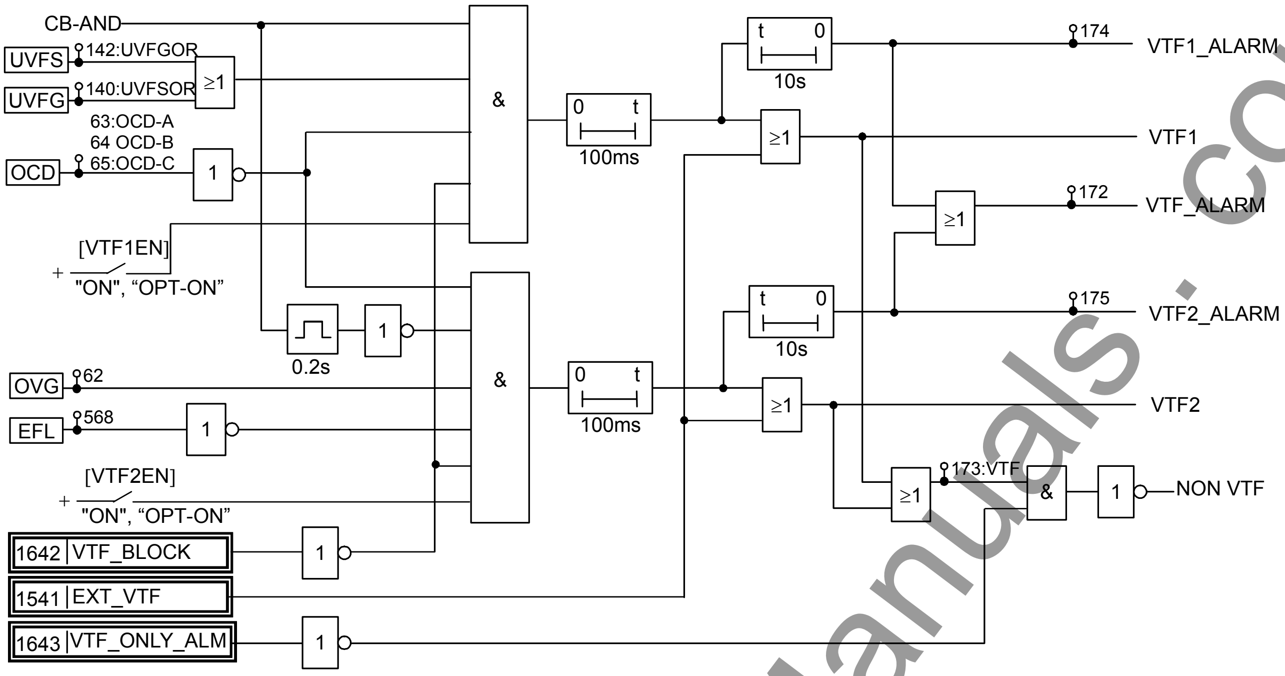


Figure 2.4.14.1 VTFS Logic

Setting

The setting elements necessary for the VTFS and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
UVFS	50 - 100 V	1 V	88 V	Phase - to - phase undervoltage
UVFG	10 - 60 V	1 V	51 V	Phase - to - earth undervoltage
EFL	0.5 - 5.0 A	0.1 A	1.0 A	Residual overcurrent
	(0.10 - 1.00 A	0.01 A	0.20 A) (*)	
[VTF1EN]	Off/On/OPT-On		On	VTF1 supervision
[VTF2EN]	Off/On/OPT-On		On	VTF2 supervision
[VTF-Z4]	Off / On		On	Z4 blocked by VTF

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The following elements have fixed setting values.

Element	Setting	Remarks
OCD	Fixed to 0.5 A	Current change detection
	(Fixed to 0.1 A)	
OVG	Fixed to 20 V	Residual overvoltage

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current value is in the case of 5 A rating.

When setting the UVFS, UVFG and EFL, the maximum detection sensitivity of each element should be set with a margin of 15 to 20% taking account of variations in the system voltage, the asymmetry of the primary system and CT and VT error.

2.4.15 Power Swing Blocking

When a power swing occurs on the power system, the impedance seen by the distance measuring element moves away from the load impedance area into the operating zone of the distance measuring element. The operation of the distance measuring element due to the power swing occurs in many points of interconnected power systems. Therefore, tripping due to the operation of the distance measuring element during a power swing is generally not allowed. The power swing blocking function (PSB) of the GRZ100 detects the power swing and blocks tripping by the distance measuring element. The GRZ100 provides PSBSZ and PSBGZ for phase fault measuring elements and earth fault measuring elements. Their functions and characteristics are same.

Once the PSB is in operation, tripping of zone 1 to zone 3 of the time-stepped distance protection, zone 1 extension protection, additional forward zone ZF, backup protection for reverse faults and command protection using distance measuring elements can be blocked. These tripping blocks can be disabled by setting the scheme switches.

Tripping of the non-directional zone ZND is not blocked. If a zero-phase current has been detected, the PSB is inhibited. This allows tripping in the event of an earth fault during a power swing or high resistance earth fault by which the resistance at the fault point changes gradually.

GRZ100 can provide a high-speed protection for one- and two-phase faults which occur during a power swing by using negative sequence directional element and any of the command protection PUP, POP, UOP and BOP.

Three-phase faults during a power swing are eliminated by distance and overcurrent backup protection.

Scheme logic

A power swing is detected by using two PSB elements PSBIN and PSBOUT. They are composed of blinder elements and reactance elements as shown in Figure 2.4.15.1. PSBOUT encloses PSBIN with a settable width of PSBZ.

Figure 2.4.15.2 shows the power swing detection logic. During a power swing, the impedance viewed from the PSB elements passes through the area between the PSBOUT and PSBIN in a certain time. In the event of a system fault, the impedance passes through this area instantaneously. Therefore, a power swing is detected in a time which commences on operation of the PSBOUT until PSBIN starts to operate, if longer than the set value of delayed pick-up timer TPSB. If the residual overcurrent element EFL operates, detection of the power swing is inhibited.

The trip block signal PSB generated as a result of the detection of a power swing is reset 500 ms after the PSBOUT is reset by delayed timer T2.

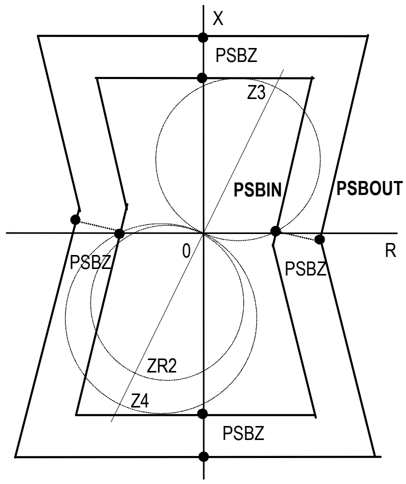


Figure 2.4.15.1 Power Swing Blocking Element

PSBSZ and PSBGZ have same functions and characteristics as shown in Figures 2.4.15.1 and 2.4.15.2, and block tripping of phase and earth fault elements respectively.

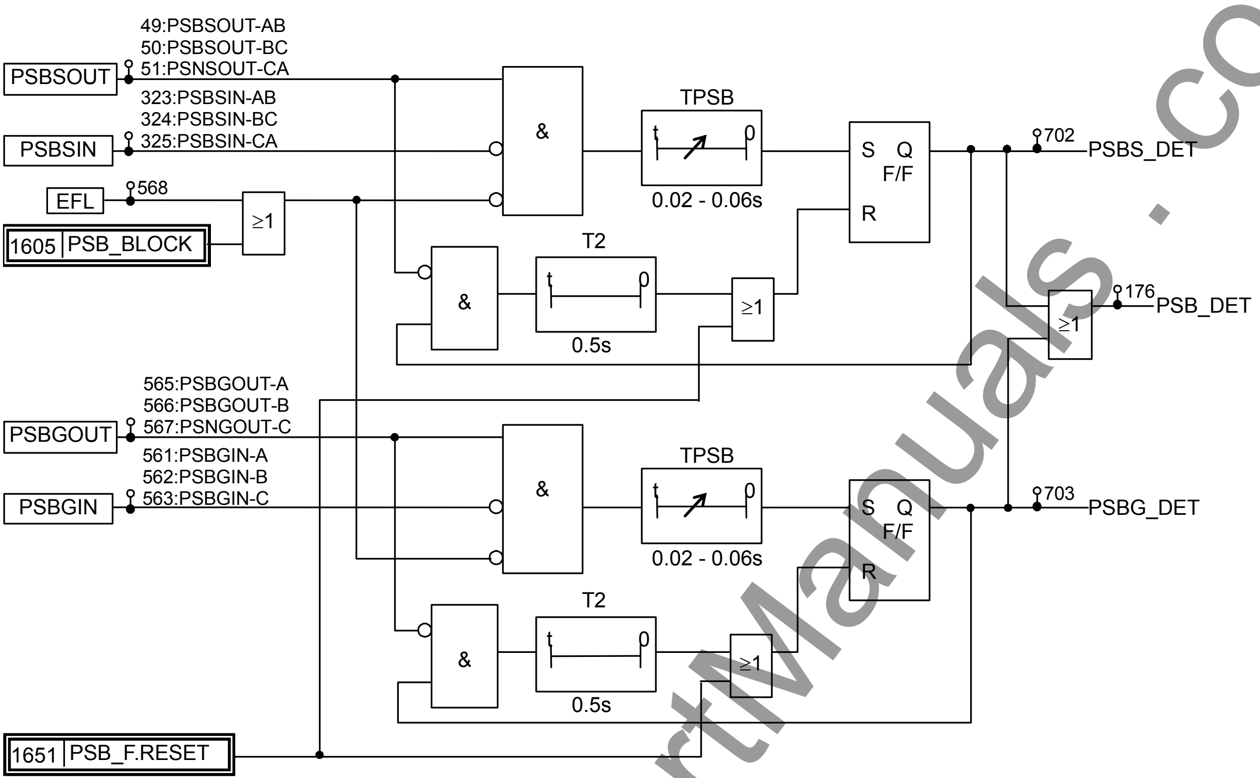


Figure 2.4.15.2 Power Swing Detection Logic

One- and two-phase faults can be protected with the command protection even during a power swing.

The PSB can be disabled or reset by the PLC signal PSB_BLOCK or PSB_F.RESET.

Figure 2.4.15.3 shows the scheme logic to control the sending signal of PUP, POP, UOP or BOP in the external communication. The scheme logic is valid when the scheme switch [PSB-TP] is set to "ON". CS1 is an original sending signal for the distance and DEF command protection and CS2 is a controlled sending signal. When a power swing is continuing (PSB_DET=1) and an internal fault is not detected (PSB-CS=0), the sending signal of PUP or POP is forced to be 0 (that is, a trip permission signal sending is blocked), and that of UOP or BOP is forced to be 1 (that is, a trip block signal is continuously sent).

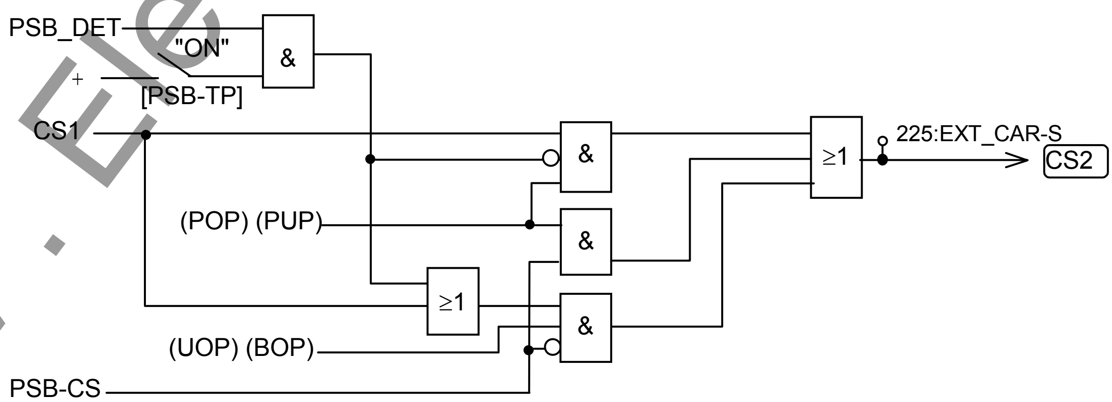


Figure 2.4.15.3 Sending Signal Control in External Communication

When an internal fault occurs during the power swing and all of the following conditions are established, C/R SEND-PSB (PSB-CS) becomes 1 and the trip permission signal is sent for the PUP or POP, and the trip block signal sending is stopped for the UOP or BOP as shown in Figure 2.4.15.4.

- Power swing is continuing (PSB_DET=1).
- Current change detection element operates (OCDP=1).
- Reverse looking negative sequence directional element does not operate (DOCNR=0).
- Forward looking negative sequence directional element operates (DOCNF=1).
- Scheme switch PSB-TP is on.
- Command protection is in service.

When a trip permission signal is received for the PUP or POP (CR=1), or no trip block signal is received for the UOP or BOP (CR=0) as well as the conditions mentioned above are established (PSB-CS=1), three-phase tripping signal is output (M-TRIP=1).

Reverse looking DOCNR is used for the current reversal logic (for current reversal logic, see Section 2.4.3.6) in all the command protections.

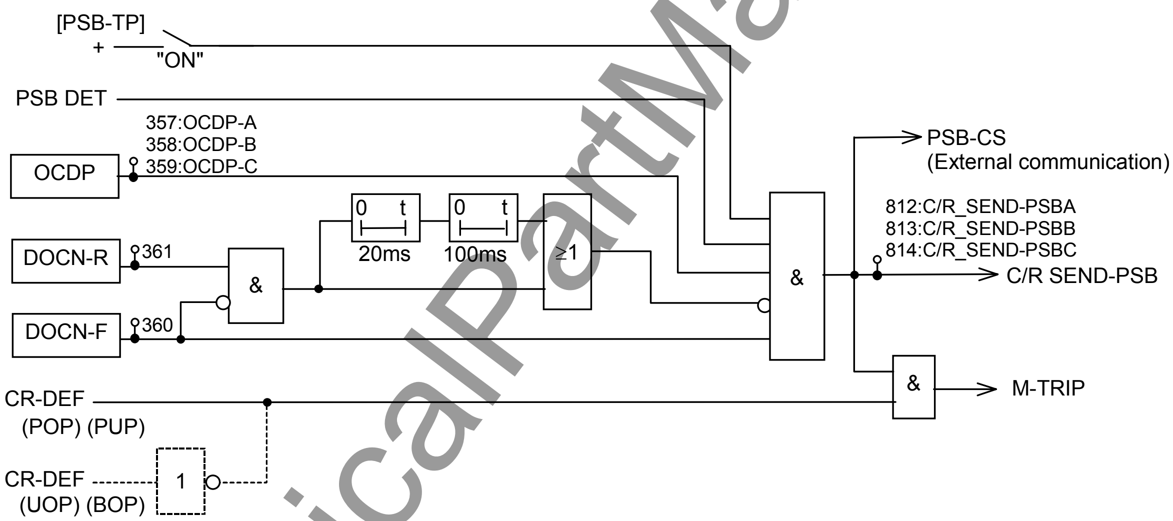


Figure 2.4.15.4 Scheme Logic to Protect Faults during Power Swing

Setting

The setting elements necessary for the PSB and their setting ranges are as shown in the table below.

Element	Range	Step	Default	Remarks
PSBSZ	0.50 - 15.00Ω	0.01Ω	2.00Ω	PSBS detection zone
	(2.5 - 75.0Ω	0.1Ω	10.0Ω) (*)	
PSBGZ	0.50 - 15.00Ω	0.01Ω	2.00Ω	PSBG detection zone
	(2.5 - 75.0Ω	0.1Ω	10.0Ω) (*)	
EFL	0.5 - 5.0 A	0.1 A	1.0 A	Residual overcurrent
	(0.10 - 1.00 A	0.01 A	0.20 A)	
TPSB	20 - 60	1 ms	40 ms	Power swing timer
OCDP	0.5 – 10.0 A	0.1A	4.0 A	Current change
	(0.1 – 2.0 A	0.1 A	0.8 A)	detection element
DOCNF	4.0 A fixed			Forward looking negative
	(0.8A fixed)			sequence directional element

Element	Range	Step	Default	Remarks
	6 V fixed			
DOCNR	4.0 A fixed			Reverse looking negative
	(0.8A fixed)			sequence directional element
	6 V fixed			
PSB-Z1	OFF/ON		ON	Z1 blocked under power swing
PSB-Z1X	OFF/ON		ON	Z1X blocked under power swing
PSB-Z2	OFF/ON		ON	Z2 blocked under power swing
PSB-Z3	OFF/ON		OFF	Z3 blocked under power swing
PSB-CR	OFF/ON		ON	Carrier trip blocked under power swing
PSB-ZF	OFF/ON		OFF	ZF blocked under power swing
PSB-ZR1	OFF/ON		OFF	ZR1 blocked under power swing
PSB-ZR2	OFF/ON		OFF	ZR2 blocked under power swing
PSB-TP	OFF/ON		ON	Command protection for faults under power swing

(*) Values shown in the parentheses are in the case of 1A rating. Other values are in the case of 5A rating.

Residual overcurrent element EFL is used in common with the following functions.

- VT failure detection
- Earth fault distance protection

The PSBIN reach is set automatically to coordinate with the Z3 and Z4 settings.

Note: In the case of the quadrilateral characteristic, if the ZF and ZR2 reach is larger than the Z3 and Z4 respectively, the PEB-IN reach depends on the ZF and ZR2 reach. Therefore, the ZF and ZR2 must be set less than the Z3 and Z4 respectively whether the ZF and ZR2 used or not.

The right side forward and reverse blinders for PSBIN are shared with the right side forward and reverse blinders of the distance protection characteristic, BFRS/BFRG and BRRS/BRRG respectively, ensuring that the PSB element coordinates properly with the protection, for both mho and quadrilateral characteristics.

The positive reactive reach setting is fixed so that the setting makes the reactance element tangential to the Z3 distance element when the Z3 is mho-based or takes the same value as the Z3 reactive reach setting when the Z3 is quadrilateral-based.

The negative resistive reach takes the same value as that of the positive reach. The negative reactive reach setting is fixed so that the setting makes the reactance element tangential to the Z4 distance element when the Z4 is mho-based or takes the same value as the Z4 reactive reach setting when the Z4 is quadrilateral-based.

PSBOUT encloses PSBIN and the margin between the two is determined by the user-settable power swing detection zone width, PSBSZ and PSBGZ, for phase and earth fault characteristics respectively.

2.4.16 Tripping Output Signals

The single-phase tripping signals drive the high-speed tripping output relays according to the tripping logic in Figure 2.4.16.1.

Two sets of output relays are provided for each phase and each relay has one normally open contact.

The tripping output relays reset 60ms(*) after the S-TRIP or M-TRIP signal disappears by clearing the fault. The tripping circuit must be opened with a circuit breaker auxiliary contact prior to the trip relay resetting in order to prevent the tripping relay from directly interrupting the circuit breaker tripping coil current.

(*) Reset time is adjustable by PLC function. Default setting is 60ms.

In the following cases, per-phase-based tripping is converted to three-phase tripping.

- When autoreclose is prohibited by a binary input signal (ARC_BLOCK = 1)
- When the autoreclose mode selection switch [ARC-M] is set to "EXT3P"
- PLC command "3P_TRIP" is established.

For the following trips, the logic level of M-TRIPA becomes 1, and single-phase tripping is then forced to convert to three-phase tripping. For details of M-TRIPA, see Figure 2.7.2.1.

- Tripping while reclaim is in progress.
- Tripping when the reclose mode selection switch [ARC-M] is set to "Disabled" or "TPAR"

The signals TRIP-A, TRIP-B and TRIP-C are used to start the autoreclose.

The signal TRIP is used to initiate the breaker failure protection.

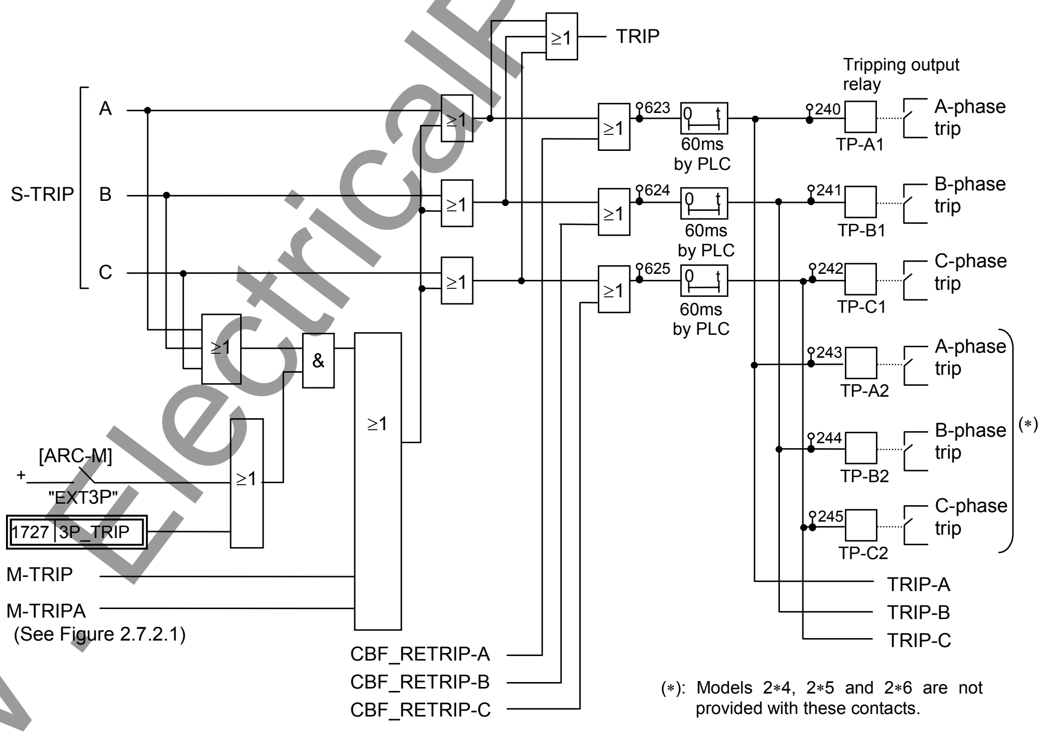


Figure 2.4.16.1 Tripping Logic

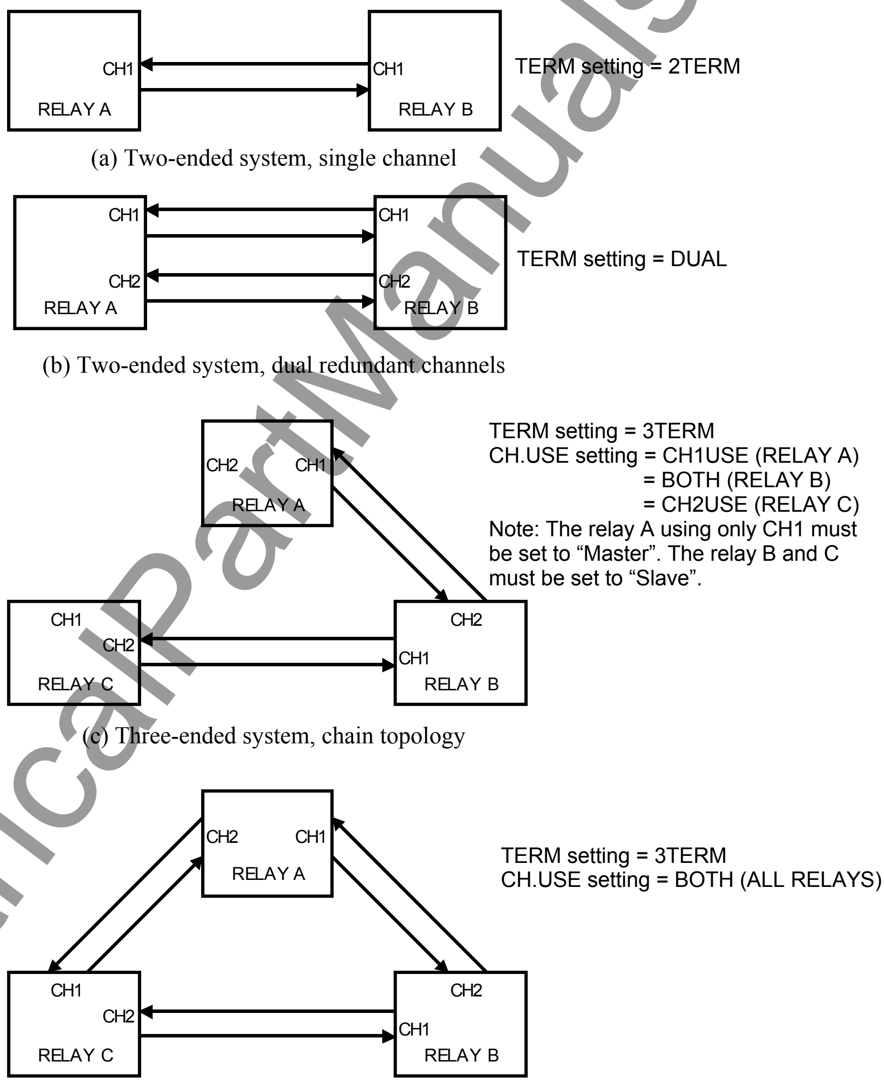
A tripping output relay is user configurable for the adjacent breakers tripping in the breaker failure protection. For the default setting, see Appendix D.

2.5 Communication System

2.5.1 Integral Digital Communication Interface

2.5.1.1 Communication System Topologies

GRZ100 provides an integral digital communication channel for protection signaling. Four communication topologies are available depending on the model. Models 211/214/216/311B support configuration (a) only in Figure 2.5.1.1. Models 221/224/226/321/323B can support all configurations. Configuration (b) and (d) offer security against failure of a communication link.



(a) Two-ended system, single channel

(b) Two-ended system, dual redundant channels

(c) Three-ended system, chain topology

(d) Three-ended system, ring topology

Figure 2.5.1.1 Communication System Topologies

GRZ100 transmits the local data to the remote terminal by coded serial messages. One signaling channel (including send and receive) per GRZ100 is required for two-terminal line protection, two for three-terminal line protection and two for dual redundant communication for two-terminal line as shown in Figure 2.5.1.1.

The variation of the channel delay time due to switching the route of the channel is automatically corrected in the relay and does not influence the synchronized sampling provided the sending and receiving channels take the same route. If the routes are separate, the transmission delay difference time must be set with TCDT1 and TCDT2.

In the dual redundant communication system, if the transmission delay time of CH1 is large without reference to that of CH2, the carrier tripping time at the remote terminal is delay.

2.5.1.2 Transmission Data

The following data are transmitted to the remote terminal via the 64kb/s digital link:

Positive sequence current

Positive sequence voltage

User programmable 14 commands (sent every 30 electrical degrees)

User programmable 4 commands (sent every power cycle)

Measured value (every one second)

Clock time (every one second)

Sampling synchronization control signal

Current and voltage data are instantaneous values which are sampled every 30 electrical degrees (12 times per cycle) and consist of eleven data bits and one sign bit. This data is transmitted every 3 samples to the remote terminal.

Other data is transmitted once every power cycle.

The data transmission format is shown in Appendix N.

In addition to the above data, cyclic redundancy check bits and fixed check bits are transmitted to monitor the communication channel. If a channel failure is detected at the local terminal, command bits are held to the value before failure.

User programmable commands

Any signals (On/off data) shown in Appendix B can be assigned to COM1-S to COM14-S and SUB_COM1-S to SUB_COM4-S as user programmable commands by using the PLC function. The default setting is as follows:

Command	Default	
	Signal No.	Signal name
COM1-S	800	C/R_SEND-A
COM2-S	801	C/R_SEND-B
COM3-S	802	C/R_SEND-C
COM4-S	803	C/R_SEND-S
COM5-S	804	C/R_SEND-DEFA
COM6-S	805	C/R_SEND-DEFB
COM7-S	806	C/R_SEND-DEFC
COM8-S	815	C/R_SEND-PSB
COM9-S	516	BI4_COMMAND
COM10-S	--	--
COM11-S	--	--
COM12-S	--	--
COM13-S	--	--
COM14-S	--	--
SUB_COM1-S	--	--
SUB_COM2-S	--	--
SUB_COM3-S	848	LOCAL_TEST
SUB_COM4-S	881	SEVERE_CF-L

2.5.1.3 Synchronized Sampling

The synchronized sampling is required for the following functions:

- Fault location for three-terminal line
- Indication for electric power quantities of remote terminal(s)
- Time synchronization with remote terminal

The GRZ100 performs synchronized simultaneous sampling at all terminals of the protected line. This synchronized sampling requires neither an external reference clock nor synchronization of the internal clocks of the relays at different terminals.

In synchronized sampling, the sampling timing error between terminals is kept within ±10μs or ±20μs for two- or three-terminal applications.

The sampling synchronization is realized through timing synchronization control and sampling address synchronization control. These controls are performed once every power cycle.

Timing synchronization

One of the terminals is selected as the time reference terminal and set as the master terminal. The other terminal is set as the slave terminal. The scheme switch [SP.SYN] is used for the settings.

Note: The master and slave terminals are set only for the convenience of the sampling timing synchronization.

To perform timing synchronization for the slave terminal, the sampling time difference between master and slave terminals is measured. The measurement principle of the sampling time difference ΔT is indicated in Figure 2.5.1.2. The master terminal and slave terminal perform their own sampling and send a signal that becomes the timing reference for the other terminal.

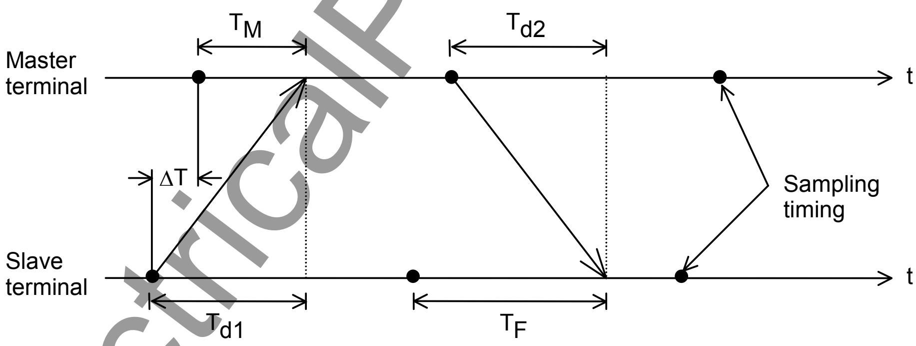


Figure 2.5.1.2 Timing Synchronization

Each terminal measures the time T_M and T_F from its own sampling instant to the arrival of the signal from the other terminal. As is evident from the figure, the times T_M and T_F can be obtained by equation (1) and (2) where T_{d1} and T_{d2} are the transmission delay of the channel in each direction. The sampling time difference ΔT can be obtained from the resulting equation (3).

$$T_M = T_{d1} - \Delta T \quad (1)$$

$$T_F = T_{d2} + \Delta T \quad (2)$$

$$\Delta T = \{(T_F - T_M) + (T_{d1} - T_{d2})\}/2 \quad (3)$$

The slave terminal advances or retards its sampling timing based on the time ΔT calculated from equation (3), thereby reducing the sampling time difference with the master terminal to zero. This adjustment is performed by varying the interval of the sampling pulse generated by an oscillator in the slave terminal.

The difference of the transmission delay time T_{dd} (= $T_{d1} - T_{d2}$) is set to zero when sending and receiving take the same route and exhibit equal delays. When the route is separate and the sending and receiving delays are different, T_{dd} must be set at each terminal to be equal to the sending delay time minus the receiving delay time. The maximum T_{dd} that can be set is 10ms. (For setting, see Section 4.2.6.7. The setting elements of transmission delay time difference are TCDT1 and TCDT2.)

The time T_M measured at the master terminal is sent to the slave terminal together with the current data and is used to calculate the ΔT.

The permissible maximum transmission delay time of the channel is 10ms.

In case of the three-terminal line application, the communication ports of the GRZ100 are interlinked with each other as shown in Figure 2.5.1.3, that is, port CH1 of one terminal and port CH2 of the other terminal are interlinked. For the setup of the communication system, see Section 2.5.1.6.

When terminal A is set as the master terminal by the scheme switch [SP.SYN], the synchronization control is performed between terminals A and B, and terminals B and C. The terminal B follows the terminal A and the terminal C follows the terminal B. The slave terminals perform the follow-up control at their communication port CH2.

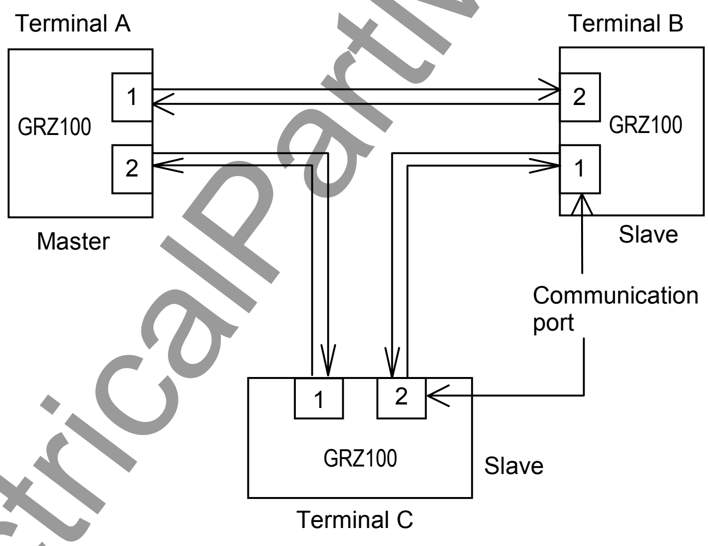


Figure 2.5.1.3 Communication Link in Three-terminal Line

Sampling address synchronization

The principle of sampling address synchronization control is indicated in Figure 2.5.1.4. After time synchronization has been established, the slave terminal measures the time from sending its own timing reference signal until it returns from the master terminal. The transmission delay time T_{d1} from slave to master terminal can be calculated from equation (4).

$$T_d = (\{T_o - (T - T_M)\}/2 + T_{dd})/2 \qquad (4)$$

The calculated transmission delay time T_{d1} is divided by the sampling interval T. The mantissa is truncated and the quotient is expressed as an integer. If the integer is set to P, the reception at the slave terminal of the signal sent from the master terminal occurs at P sampling intervals from the transmission. Accordingly, by performing control so that the sampling address of the slave terminal equals integer P when the sampling address = 0 signal is received from the master terminal, the sampling address of the slave terminal can be made the same as the master terminal.

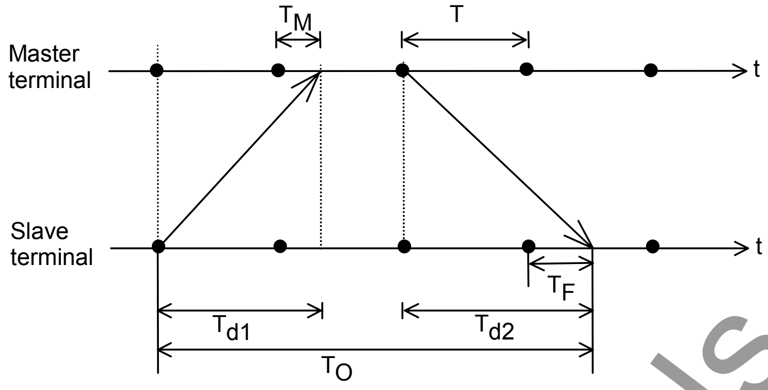


Figure 2.5.1.4 Sampling Address Synchronization

2.5.1.4 Connection to Communication Circuit

The GRZ100 can be provided with one of the following interfaces by order type and connected to a dedicated optical fiber communication circuit or multiplexed communication circuit.

- Optical interface (1310nm, SM, 30km class)
- Optical interface (1550nm, DSF(Dispersion Shifted Fibre), 80km class)(*)
- Optical interface (820nm, GI, 2km class)
- Electrical interface in accordance with CCITT-G703-1.2.1
- Electrical interface in accordance with CCITT-G703-1.2.2 and 1.2.3
- Electrical interface in accordance with CCITT X.21
- Electrical interface in accordance with RS422, RS530

Note (*): When using the 80km class optical interface, it is necessary to ensure that the received optical power does not exceed –10dB, in order to avoid communication failure due to overloading of the receiver.

When testing in loop-back mode, for instance, the sending terminal should be connected to the receiving terminal via an optical attenuator with 10dB or more attention.

Even if the sending terminal is directly connected to the receiving terminal, the optical transceiver will not damaged, but communication failures may occur.
- Fibre Coupled Power: –5 to 0 dBm
- Input Power Range: –34 to –10 dBm
- Optical Damage Input Level: 3 dBm

Alternative links to the telecommunication circuit are shown in Figure 2.5.1.5 (a) to (c).

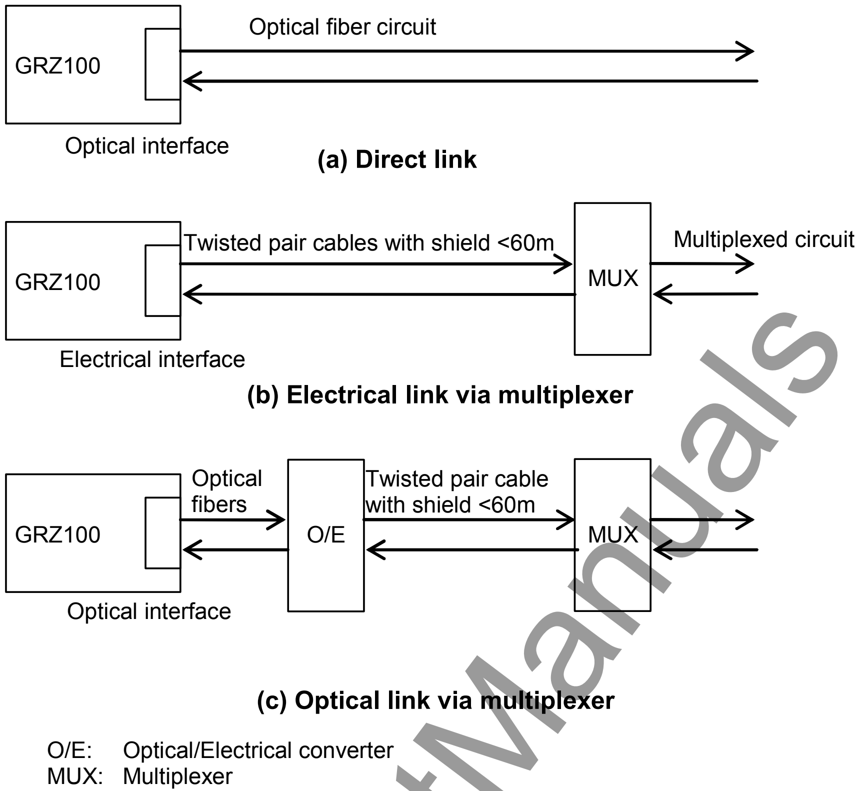


Figure 2.5.1.5 Link to Communication Circuit

Direct link

When connected to single-mode (SM) 10/125μm type of dedicated optical fiber communication circuits and using Duplex LC type connector for 30km class, the optical transmitter is an LD with output power of more than –13dBm and the optical receiver is a PIN diode with a sensitivity of less than –30dBm. For 80km class, the optical transmitter is an LD with output power of more than –5dBm and the optical receiver is a PIN diode with a sensitivity of less than –34dBm.

When connected to graded-index (GI) multi-mode 50/125μm type or 62.5/125μm type of dedicated optical fiber telecommunication circuit and using an ST type connector, the optical transmitter is an LED with output power of more than –19dBm or –16dBm and the optical receiver is a PIN diode with a sensitivity of less than –24dBm.

For details, refer to Appendix K.

Link via multiplexer

The GRZ100 can be linked to a multiplexed communication circuit with an electrical or optical interface. The electrical interface supports CCITT G703-1.2.1, G703-1.2.2 and 1.2.3, X.21(RS530) or RS422. Twisted pair cable with shield (<60m) is used for connecting the relay and multiplexer.

In the optical interface, optical fibers of graded-index multi-mode 50/125μm or 62.5/125μm type are used and an optical to electrical converter is provided at the end of the multiplexer. The electrical interface between the converter and the multiplexer supports CCITT G703-1.2.1, G703-1.2.2 and 1.2.3, X.21(RS530) or RS422..

A D-sub connector (DB-25) or an ST connector is used for electrical linking and optical linking, respectively.

2.5.1.5 Setup of Communication Circuit

The GRZ100 is provided with one set of transmit and receive signal terminals for two-terminal application models and two sets of signal terminals for three-terminal application models.

In case of two-terminal applications, the communication circuit is set as shown in Figure 2.5.1.6. In the figure, TX and RX are the transmit and receive signal terminals. CK is the receive terminal for the multiplexer clock signal and is used when the interface supports CCITT G703-1.2.2, 1.2.3. and X.21(RS530).

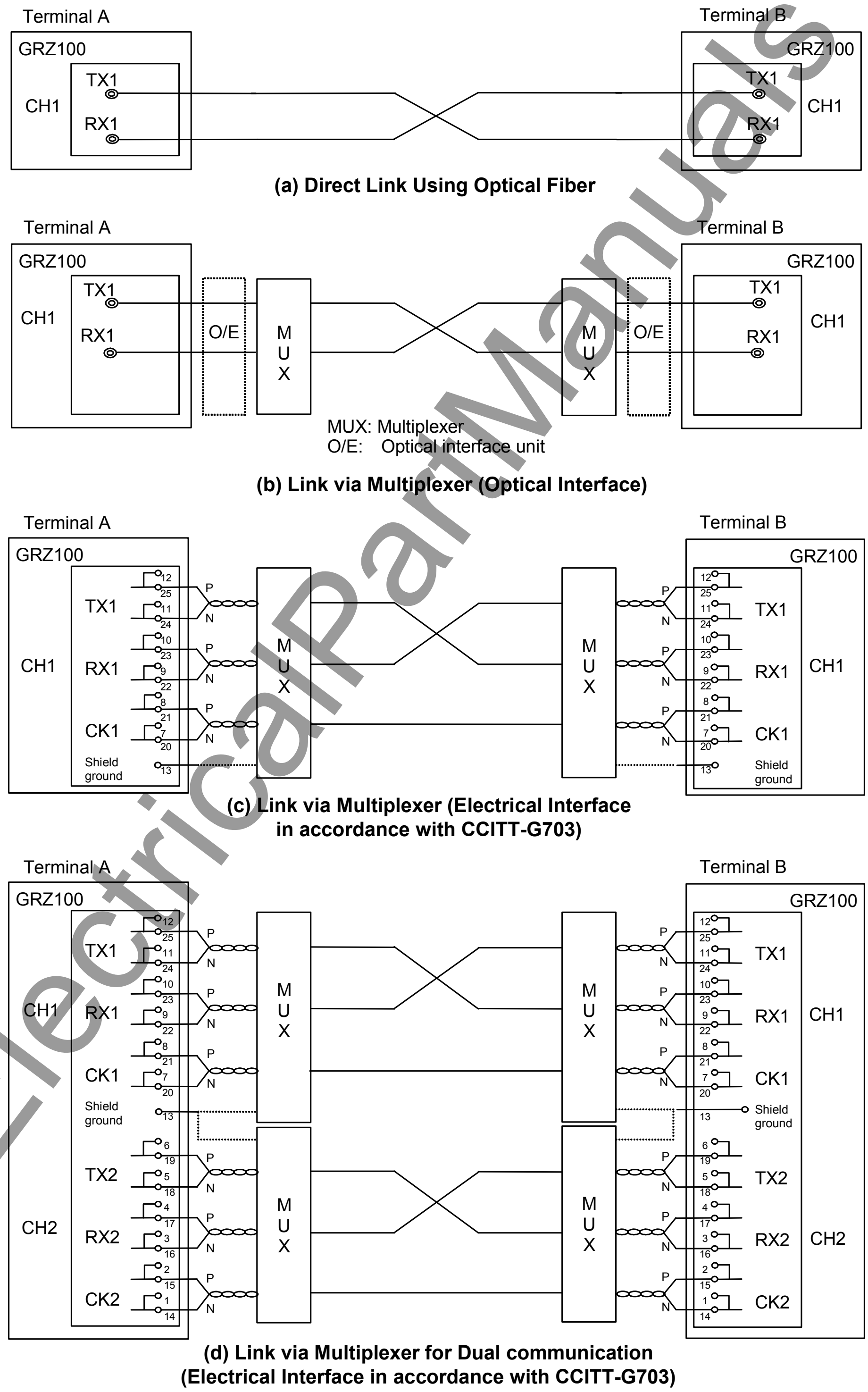
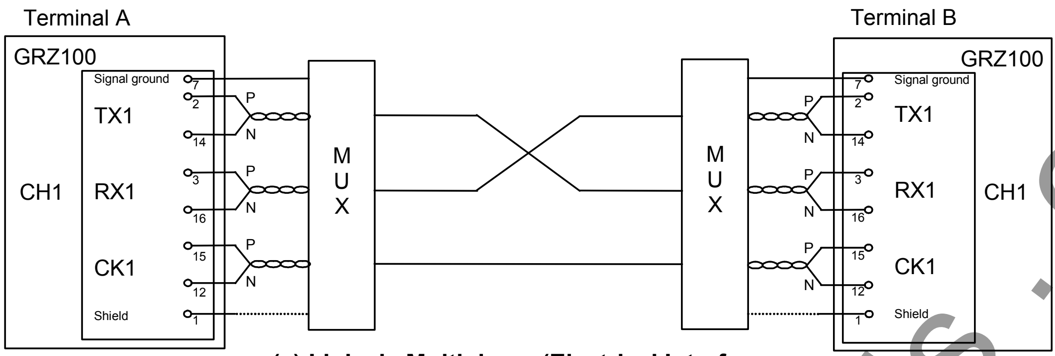
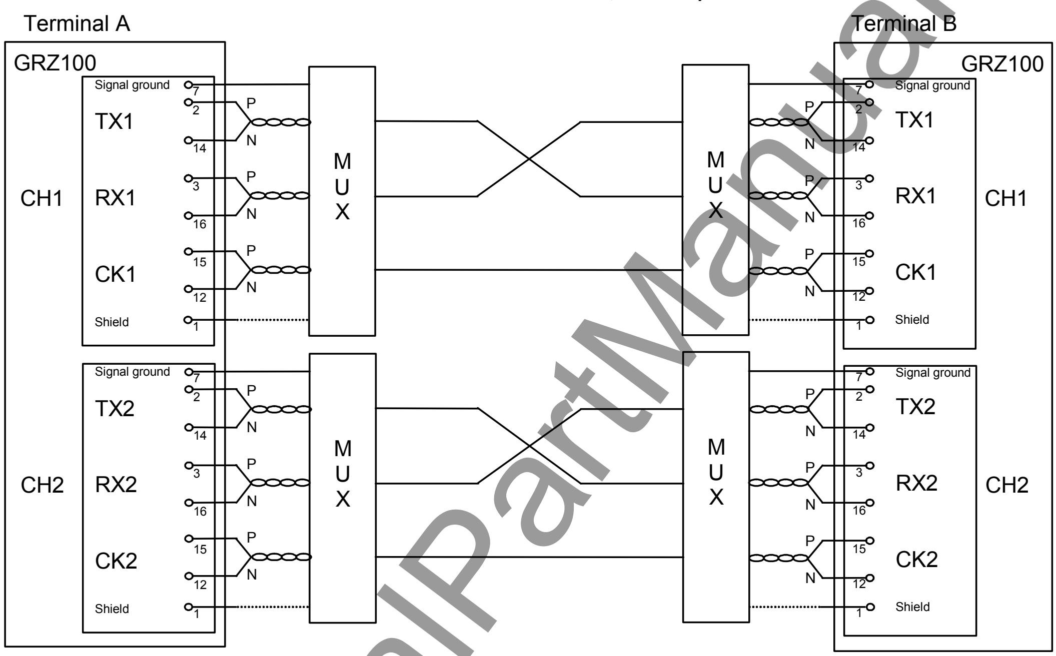


Figure 2.5.1.6 Communication Circuit Setup in Two-terminal Application



(e) Link via Multiplexer (Electrical Interface in accordance with X.21, RS530)



(f) Link via Multiplexer for Dual communication (Electrical Interface in accordance with X.21, RS530)

Figure 2.5.1.6 Communication Circuit Setup in Two-terminal Application (continued)

In case of three-terminal applications, signal terminals CH1-TX1, -RX1 and -CK1 which have the same function as CH2-TX1, -RX1 and -CK1 are added.

Figure 2.5.1.7 shows the communication circuit arrangement for three-terminal applications. Note that the CH1 signal terminals TX1, RX1 and CK1 of one terminal are interlinked with the CH2 signal terminals TX2, RX2 and CK2 of another terminal and that the scheme switch [TERM] is set to "3-TERM". If the same channel is interlinked between both terminals such as the CH1 signal terminals of one terminal are interlinked with the CH1 signal terminals of another terminal, the scheme switch setting [CH. CON] should be set to “Exchange”.

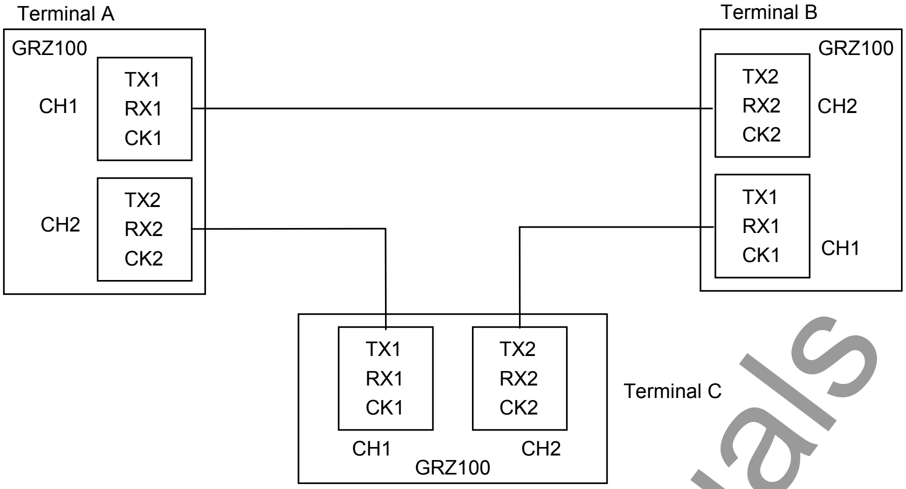


Figure 2.5.1.7 Communication Circuit Setup for Three-terminal Applications

The three-terminal line application models can be applied to a two-terminal line. In this case, same channel's TX, RX and CK of both terminals are interlinked and scheme switch [TERM] is set to "2-TERM".

The three-terminal models also have dual communication mode as shown in Figure 2.5.1.8. In this case, the [TERM] setting must be set to "Dual".

Note: The both same cannels are connected each other.

Figure 2.5.1.8 Dual Communication Mode

2.5.1.6 Setting

The setting elements necessary for the integral digital communication and their setting ranges are as shown in the table below.

Element	Range	Step	Default	Remarks
CO. LINK	Int / Ext		Int	Communication link (Integral or External)
SP. SYN	Master / Slave		Master	SP synchronization setting
TERM	2TERM / 3TERM / Dual		3TERM	Terminal selection (3 terminal model)
CH. USE	Both / CH1USE / CH2USE		Both	Channel selection for chain topology (3 terminal model)
CH.CON	Normal / Exchange		Normal	Channel exchanger (3 terminal model)
T.SFT1	OFF / ON		OFF	Shift send signal by half-bit. (for CH1)
T.SFT2	OFF / ON		OFF	Shift send signal by half-bit. (for CH2)
B.SYN1	OFF / ON		ON	CH1 bit synchronization for multiplexer
B.SYN2	OFF / ON		ON	CH2 bit synchronization for multiplexer
TDSV	100 - 16000	1μs	6000μs	Transmission delay time threshold setting for alarm (*2)
TCDT1	–10000 – 10000	1μs	0μs	Transmission delay time difference setting for channel 1 (*1)

Element	Range	Step	Default	Remarks
TCDT2	–10000 – 10000	1μs	0μs	Transmission delay time difference setting for channel 2 (*1)

(*1) This setting is only used when there is a fixed difference between the sending and receiving transmission delay time. When the delay times are equal, the default setting of 0μs must be used.

(*2) If the channel delay time of CH1 or CH2 exceeds the TDSV setting, then the alarm "Td1 over" or "Td2 over" is given respectively.

CO. LINK: To set Integral digital communication or External communication.

SP. SYN: One of terminals must be set to MASTER and others SLAVE. If not, the synchronized sampling fails.

Note: As the simultaneous setting change at all terminals is not practical, it is not recommended to change the settings when the relay is in service.

TERM: To set two-terminal or three-terminal application.

CH. USE: Set the using channel CH1 or CH2 when the chain topology is applied.

CH.CON: In case of the two-terminal line application, the communication ports of the GRZ100 are interlinked with port CH1 as shown in Figure 2.5.1.9(a) and (b). In case of three-terminal application, port CH1 of one terminal and port CH2 of the other terminal are linked as shown in Figure 2.5.1.9(c). In these normal linkages, the communication port exchange switch [CH.CON] is set to "Normal".

T.SFT1, T.SFT2: The T.SFT1 and T.SFT2 are used to synchronize the relay with the multiplexer by shifting the send signal by a half-bit when the distance from the relay to the multiplexer is long. When electrical interface X.21, CCITT G.703-1.2.2 or -1.2.3 is applied and the distance (cable length from relay to multiplexer) is 300m or more, the setting is set to "ON"

B.SYN1, B.SYN2: The B.SYN1 and B.SYN2 are set to "ON" when the relay is linked via multiplexer, and set to "OFF" when direct link is applied.

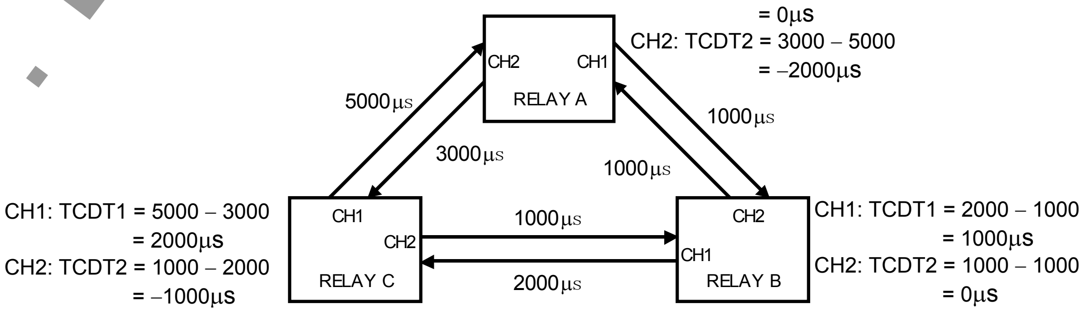
This setting is available for CCITT G.703-1.2.1, 1.2.2, 1.2.3, X21 and optical interface (short distance: 2km class). In the case of optical interface 30km and 80km class, this setting is neglected.

TDSV: The TDSV is a transmission delay time threshold setting. GRZ100 gives an alarm if the transmission delay time exceeds TDSV. The alarm messages are "Td1 over" for CH1 and "Td2 over" for CH2.

TCDT1, TCDT2: The TCDT1 and TCDT2 are transmission time delay difference settings for CH1 and CH2 respectively. If there is a permanent and constant difference of more than 100μs between the send and receive channel delay times, then the TCDT setting is used to compensate for that difference. The setting is calculated as follows:

TCDT∗ = (Sending delay time) – (Receiving delay time)

(Example)



2.5.2 External Communication Interface

2.5.2.1 Interface with Signaling Equipment

GRZ100 interfaces with protection signaling equipment through binary input and output circuits as shown in Figure 2.5.2.1.
Receiving command signals for remote terminal 1 from the signaling equipment are input to photo-coupler circuits BIn and BIm. A guard signal in frequency shift signaling or an alternative trip signal is input to BIm. BIn and BIm output signals R1-CH1 and R1-CH2 through logic level inversion (NOT logic) circuit by PLC function (refer to Section 3.2.3). The signals for remote 2 are same as those of remote 1.

A sending command signal CS to the signaling equipment should be output to the auxiliary relay BO13 through a logic level inversion circuit (Logic level inversion of CS can be performed by BOSW switch or also by PLC function.). BO13 has one normally open contact.

In the BOP scheme, a signal channel automatic test function is available. Sending test signal SBT can be assigned to any of the user configurable output relays BOn through a logic level inversion circuit by PLC function. BOn has one normally close contact.

Note: In setting the signal SBT, the 0.2s delayed drop-off timer in the logic level inversion circuit must be disabled by setting the scheme switch [BOTDn] to "OFF".

S-DEF2 or S-DEFBOP2 is a sending command signal used for DEF command protection and assigned to any of the user configurable output relays BOn. (See Section 2.4.4.1.)

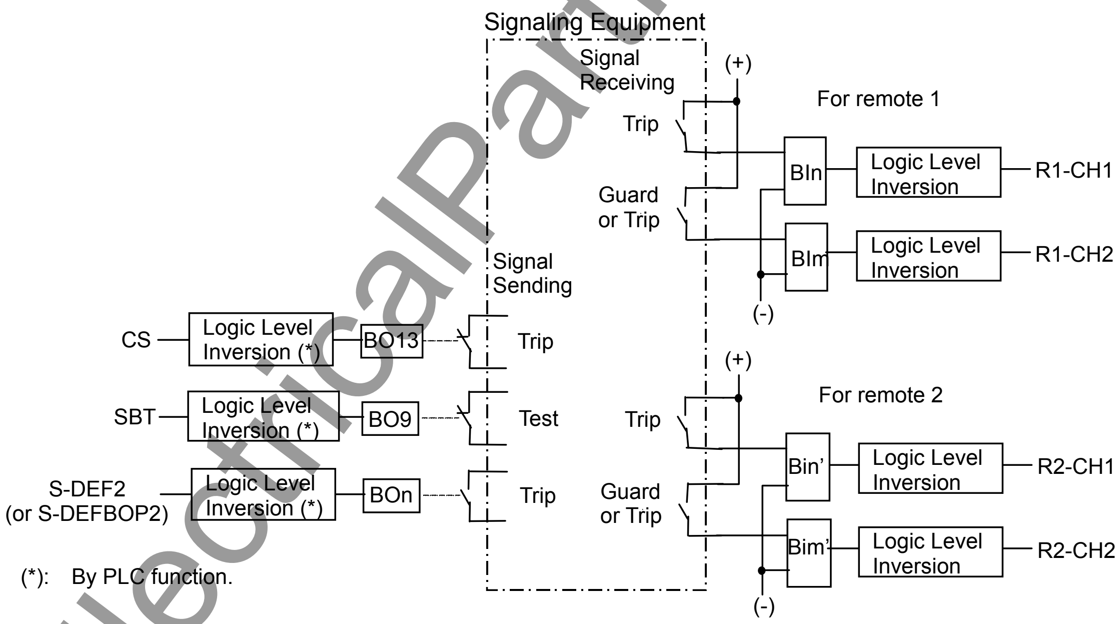


Figure 2.5.2.1 Interface with Signaling Equipment in External Communication

2.5.2.2 Signaling Channel

Table 2.5.2.1 shows the protection scheme and required signaling channel. "Simplex" here means that a transmit signal is shared by all terminals. "Multiplex" means that a specific channel is used for each terminal.

Table 2.5.2.1 Protection Scheme and Signaling Channel

	Simplex	Multiplex
PUP	×	×
POP		×
UOP	×	×
BOP	×	×

Since the PUP transmits a trip permission signal through operation of the underreaching element, it is not necessary to distinguish a transmit signal from a receive signal and a simplex channel suffices. Of course, a multiplex channel can also be applied.

Since the POP transmits a trip permission signal through operation of the overreaching element, it is necessary to distinguish a transmit signal from a receive signal to prevent false operation in case of a fault in the overreaching zone. Therefore, a multiplex channel is necessary.

Since the UOP and BOP transmit a trip block signal, a simplex channel suffices. A multiplex channel can also be applied.

The signal received from the protection signaling equipment is generally a single one, while with frequency shift signaling, two signals, a trip signal and a guard signal, are received. The GRZ100 is equipped with signal receive logic shown in Figure 2.5.2.2 to respond to either case. In the case of a single signal, a signal from the signaling equipment is input to R1-CH1 and the scheme switch [CHSEL] is set to "Single". In the case of two signals, a trip signal is input to R1-CH1, a guard signal or an alternative trip signal is input to R1-CH2 and the [CHSEL] is set to "Guard". Signal R1-CR selected by this scheme switch is used as a receive signal in command protection.

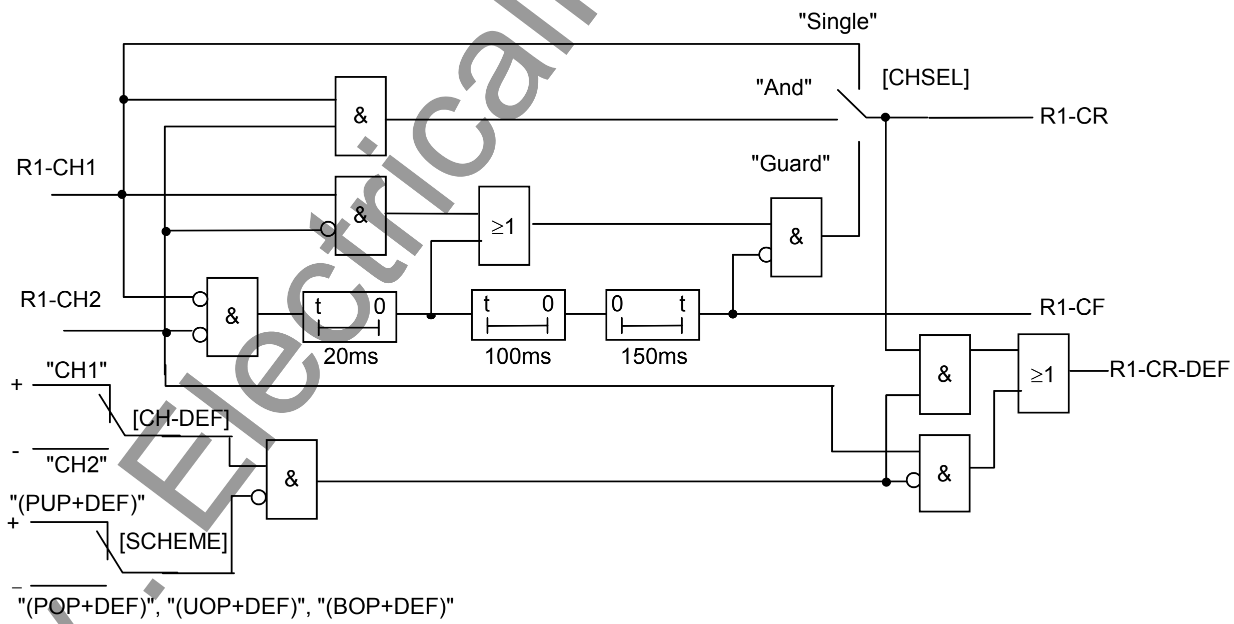


Figure 2.5.2.2 Signal Receive Logic

When two signals are utilized, the signal receive logic outputs signal R1-CR only when receiving a trip signal only or no trip signal nor guard signal is received for more than 20 ms. However, the output by the latter lasts only for 100 ms. When the latter continues for more than 100 ms, a telecommunication circuits failure alarm signal R1-CF is output.

Selecting "And" for the scheme switch [CHSEL] in two signals reception will allow ANDing of two signals to be set as signal R1-CR.

When directional earth fault command protection (see Section 2.4.4.1) is used with POP, UOP or BOP scheme of distance protection and two channels are available, signal channel can be separated from distance protection by setting the scheme switch [CHSEL] to "Single" and [CH-DEF] to “CH2”. In this case, signals CH1 and CH2 are used for distance protection and directional earth protection respectively. If the scheme switch [CH-DEF] is set to “CH1”, signal CH1 is shared by the both protections.

When directional earth fault command protection is used with PUP scheme, signal channel is separated irrespective of [CH-DEF] setting.

In three-terminal application, the signal receive logic for remote 2 is same as that of remote 1 shown in Figure 2.5.2.2.

Following table shows the scheme switch settings and usable signals:

Scheme	CHSEL setting	CH-DEF setting	Use of signal	
			CH1	CH2
PUP+DEF	Single	CH1	PUP	DEF
		CH2	PUP	DEF
POP+DEF	Single	CH1	POP and DEF (*)	--
		CH2	POP	DEF
UOP+DEF	Single	CH1	UOP and DEF (*)	--
		CH2	UOP	DEF
BOP+DEF	Single	CH1	BOP and DEF (*)	--
		CH2	BOP	DEF

(*) CH1 is shared by the distance and directional earth fault command protections.

Setting

Element	Range	Step	Default	Remarks
CHSEL	Single/Guard/And		Single	Signal receiving
CH-DEF	CH1/CH2		CH1	Channel separation

2.6 Characteristics of Measuring Elements

2.6.1 Distance Measuring Elements Z1, Z1X, Z2, ZF, Z3, Z4, ZR1, ZR2, ZND and PSB

The GRZ100 provides eight distance measuring zones with mho-based characteristics or quadrilateral characteristics.

As shown in Figure 2.6.1.1, mho-based zone characteristics are composed of mho element, offset mho element, impedance element, reactance element, and blinder element for phase fault protection and earth fault protection.

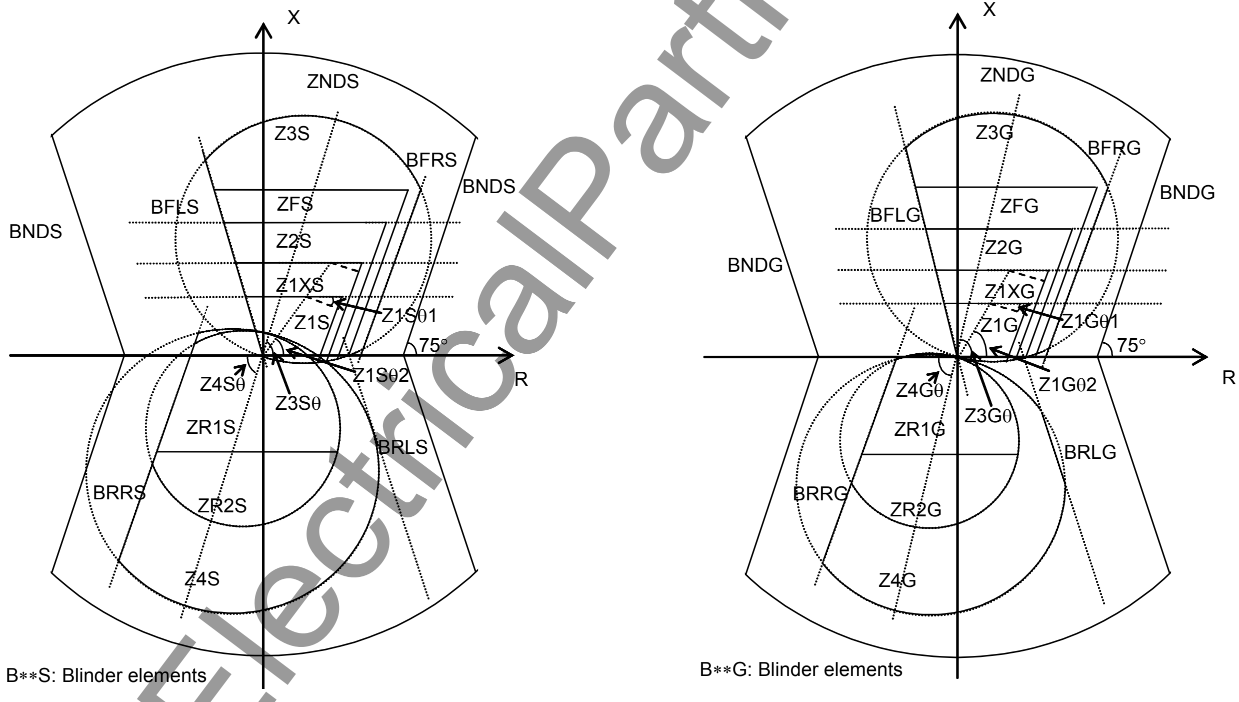
Z1 (zone 1), Z1X (zone 1 extension), Z2 (zone 2), ZF (zone F) and ZR1 (reverse zone 1) are a combination of the reactance element, mho element and blinder element.

Z3 (zone 3), ZR2 (reverse zone 2), and Z4 use the mho element and blinder element, but Z4 for phase faults uses the offset mho element instead of mho element. This makes it possible to detect a reverse close-up fault at high speed if Z4 for phase faults is used for the command protection.

ZND (non-directional zone) uses the impedance element and blinder element.

The blinder element is normally used to restrict the resistive reach of the mho or offset mho element if their operating range encroaches upon the load impedance.

The blinder element (BFR) can be provided for each forward zone. The setting of blinder element can be set independently or set common to forward zones by the scheme switch [BLZONE].

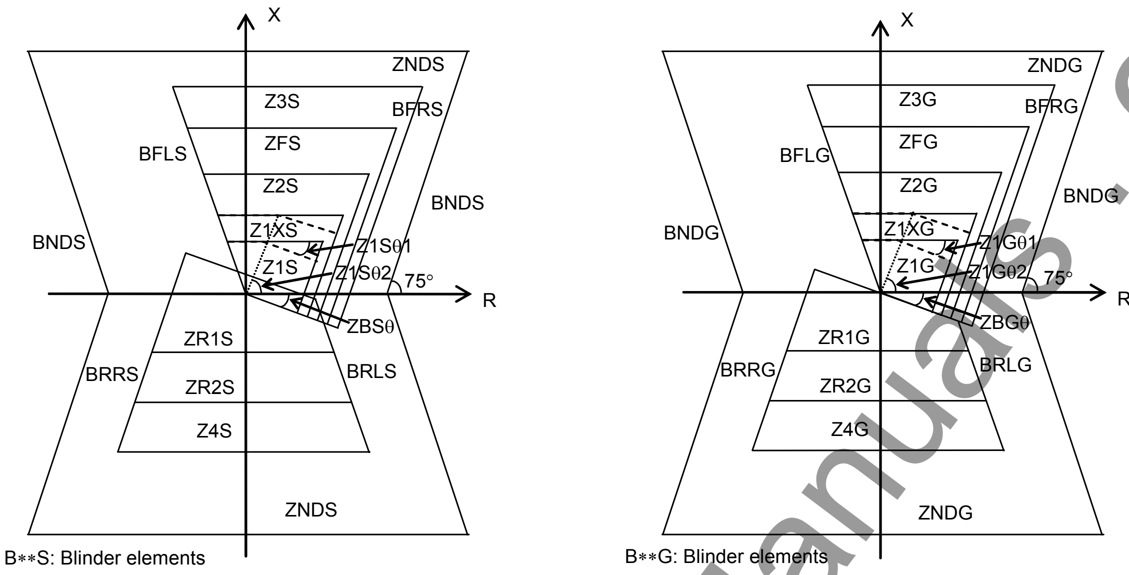


(a) Phase fault element **(b) Earth fault element**

Figure 2.6.1.1 Mho-based Characteristics

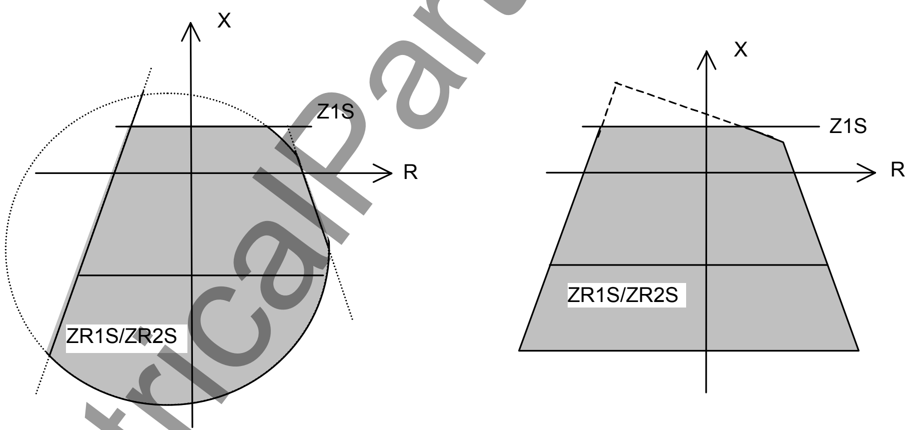
As shown in Figure 2.6.1.2, quadrilateral zone characteristics are composed of reactance element, directional element and blinder element. Z4 for phase faults uses the offset directional element to ensure a reverse close-up fault detection.

The forward offset reach of reverse zones (ZR1, ZR2) for both mho-based and quadrilateral characteristics is fixed as 7.5 ohms for 1A rating or 1.5 ohms for 5A rating. However, when they are used for back-up tripping ([ZR∗BT]= "ON"), the forward offset reach is limited to the zone 1 reach setting, as shown in Figure 2.6.1.3. Z4, on the other hand, is normally used to provide blocking in the command schemes, and its offset is not limited by the zone 1 reach setting. It is fixed at 7.5Ω (or 1.5Ω) in order to give reliable, fast blocking for a close-up reverse fault.



(a) Phase fault element **(b) Earth fault element**

Figure 2.6.1.2 Quadrilateral Four Zone Characteristics



(a) Mho-based characteristic (b) Quadrilateral characteristic

Figure 2.6.1.3 ZR1S and ZR2S Characteristic Offset Reach for Backup Tripping

Zone 1, zone 1X, zone 2 and zone F can trip on condition that zone 3 has operated, in both characteristics.

The power swing blocking elements (PSBS and PSBG) are a combination of the reactance element and blinder element as shown in Figure 2.6.1.4. The outer element PSBOUT encloses the inner element PSBIN with a settable width of PSBZ.

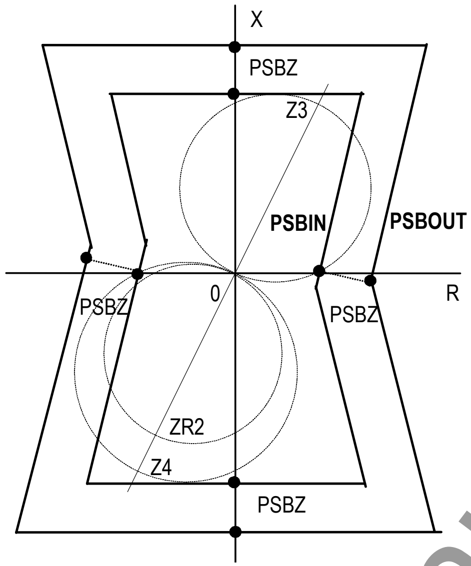


Figure 2.6.1.4 Power Swing Blocking Element

Mho element

The characteristic of the mho element is obtained by comparing the phases between signals S1 and S2. If the angle between these signals is 90° or more, it means that the fault is within the mho characteristic, and the mho element will operate.

$S1 = V - IZs$

$S2 = Vp$

where,

V = fault voltage

I = fault current

Zs = zone reach setting

Vp = polarizing voltage

Figure 2.6.1.5 is a voltage diagram, which shows that the mho characteristic is obtained by the phase comparison if V and Vp are in-phase.

The mho characteristic on the impedance plane is obtained by dividing the voltage in Figure 2.6.1.5 by current I.

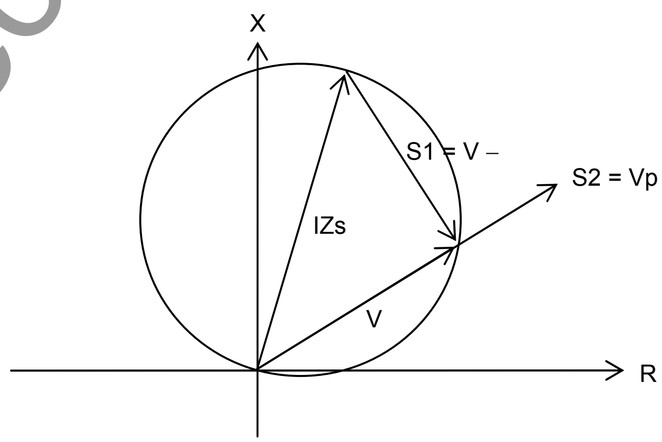


Figure 2.6.1.5 Mho Element

Both the phase fault mho element and earth fault mho element of the GRZ100 employ a dual polarization (self-polarization plus cross-polarization). Its polarizing voltage Vp is expressed by the following equations.

For B-to-C-phase phase fault element

$$V_{pbc} = \sqrt{3}\,(V_a - V_0)\angle -90° + V_{bc}$$

For an A-phase earth fault element

$$V_{pa} = \sqrt{3}\,(V_a - V_0) + V_{bc}\angle 90°$$

where,

V_a = A-phase voltage

V_0 = zero-sequence voltage

V_{bc} = B-to-C-phase voltage

The dual-polarization improves the directional security when applied to heavily loaded lines or weak infeed terminals.

The polarizing voltage for the phase fault mho element has a memory action for the close-up three-phase fault. V_a and V_{bc} mentioned above are the memorized pre-fault voltages. This memory is retained for two cycles after a fault occurs. The polarizing voltage for the earth fault mho element has no memory action.

When a three-phase fault occurs within zone 1, the phase fault mho element for zone 1 is modified to an offset mho characteristic as shown in Figure 2.6.1.6. This, together with voltage memory action, enables zone 1 to perform tripping with a time delay as well as instantaneous tripping for the close-up three-phase fault.

The Z1X, Z2, ZF and Z3 do not have the modifying function mentioned above.

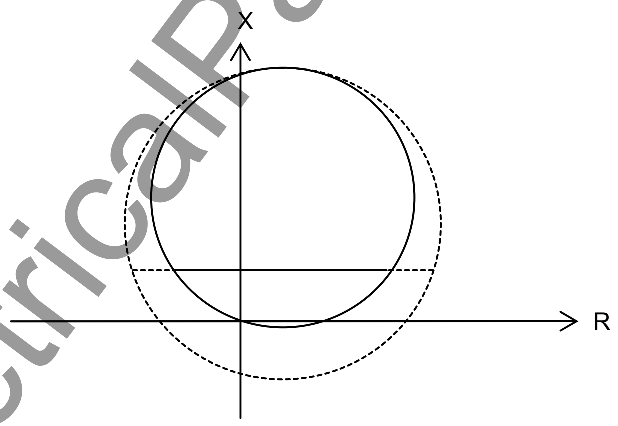


Figure 2.6.1.6 Offset of Z1 in Three-phase Fault

Offset mho element

Three independent offset mho elements are used for Z1 for phase faults, reverse zone ZR2 and Z4 for phase faults.

The characteristics of each offset mho element are obtained by comparing the phases between signals S1 and S2.

If the angle between these signals is 90° or more, the offset mho element operates.

$S1 = V - IZs$

$S2 = V + IZso$

where,

V = fault voltage

I = fault current

Zs = zone reach setting

Zso = offset zone reach setting

Figure 2.6.1.7 is a voltage diagram showing the offset mho characteristics obtained by the phase comparison between S1 and S2.

The offset mho characteristic on the impedance plane is obtained by dividing the voltage in Figure 2.6.1.7 by current I.

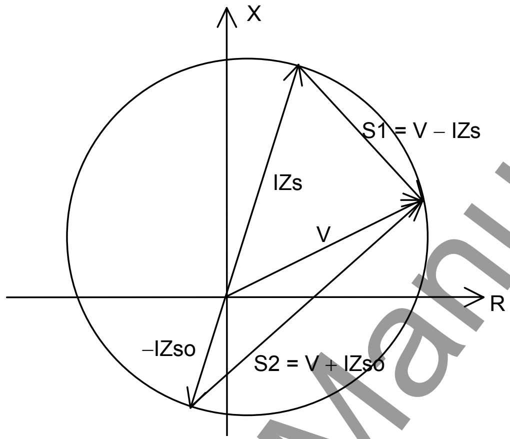


Figure 2.6.1.7 Offset Mho Element

Reactance element

The reactance elements of Z1 and Z1X have a composite characteristic with the two straight lines, one is parallel and the other is gradual descent toward the R-axis as shown in Figure 2.6.1.8.

The characteristic is defined by the reach setting Xs and the angle settings θ1 and θ2. This composite characteristic is obtained only when the load current is transmitted from local to remote terminal. When the load current flows from remote to local terminal or the load current does not flow or θ1 is set to 0°, the reactance element characteristic is a horizontal line which is parallel to the R-axis.

The characteristic is expressed by the following equations.

For horizontal characteristic

$X \leq Xs$

For gradient characteristic

$R \leq Xs \tan (90° - \theta 2) + (Xs - X) \tan (90° - \theta 1)$

where,

R = resistance component of measured impedance

X = reactance component of measured impedance

Xs = reach setting

The reactance element characteristic of Z2, ZF and ZR1 is given by a parallel line to the R axis.

R and X are calculated using an integration approximation algorithm. The reactance element provides high measurement accuracy even in the presence of power system frequency fluctuations and distorted transient waveforms containing low-frequency spectral components.

A decision to operate is made 6 times in each power frequency cycle using the above-mentioned equation. The reactance element operates when two consecutive measurements are made if the distance to a fault is within 90% of the reach setting. If the distance to a fault is more than 90%, the reactance element operates when four consecutive measurements are made.

This decision method prevents transient overreaching occurring for faults close to the element boundary.

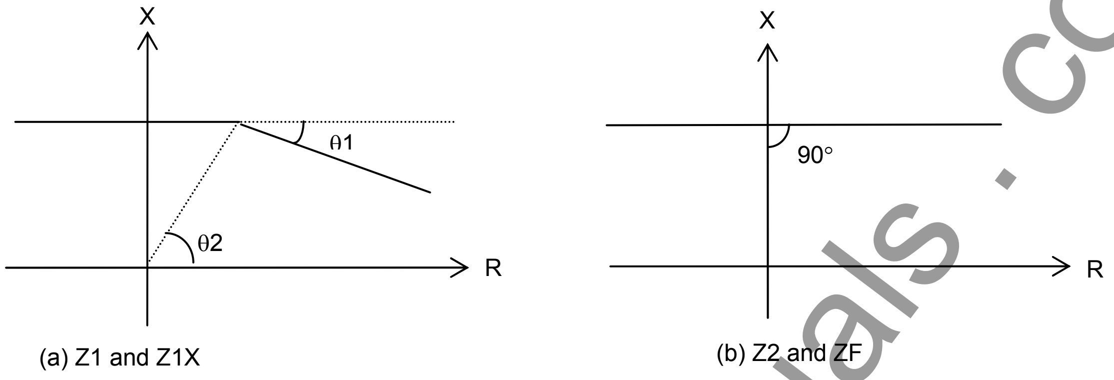


Figure 2.6.1.8 Reactance Element

The setting of θ1(Z1θ1) and θ2(Z1θ2) are set to the following:

$Z1\theta2 < \tan^{-1}(X / R_F)$

Where,

X = reactance component

R_F = fault resistance

$Z1\theta1 < \tan^{-1}\{I_{Lmax} / (I_{Lmax} + I_{Fmin})\}$

I_{Lmax} = maximum load current

I_{Fmin} = minimum fault current

Blinder element

The blinder element is commonly applicable to Z1, Z1X, Z2, ZF, Z3, ZR1, ZR2 and Z4. As shown in Figure 2.6.1.9, the blinder element provides the forward blinder and the reverse blinder. The operating area of the forward blinder is the zone enclosed by the lines BFR and BFL, and that of the reverse blinder is the zone enclosed by the lines BRR and BRL. The BFR has an angle of 75° to the R-axis and BFL 90° to 135°. The angle of BRL is linked with that of BFL.

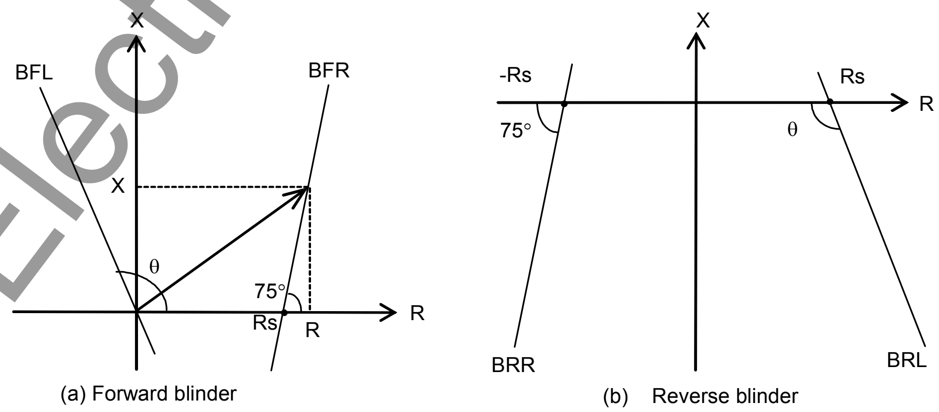


Figure 2.6.1.9 Blinder element

The characteristic of the BFR is obtained by the following equation.

$X \geq (R - Rs) \tan 75°$

where,

R = resistance component of measured impedance

X = reactance component of measured impedance

Rs = reach setting

The characteristic BFL is obtained by the following equation. Polarizing voltage employed is the same as employed for mho element.

$$Vp\ I \cos(\phi + \theta - 90°) > 0$$

where,

Vp = polarizing voltage

I = fault current

ϕ = lagging angle of I to Vp

θ = angle setting

A blinder applicable to the offset mho element for the power swing blocking also has the same characteristics as BFR.

The characteristics of BRR and BRL are expressed by the following equations.

For BRR

$$X \le (R + Rs) \tan 75°$$

For BRL

$$X \le (R - Rs) \tan (180° - \theta)$$

where,

R = resistance component of measured impedance

X = reactance component of measured impedance

Rs = reach setting

The reach settings of BFR and BRR are made on the R-axis. The BRL setting is interlinked with the BRR setting.

If the minimum load impedance is known, then assuming a worst case load angle of 30° and a margin of 80%, then the following equation can be used to calculate the blinder element resistive settings:

$$R_{set} < 0.8 \times Z_{Lmin} \times (\cos 30° - \frac{\sin 30°}{\tan 75°})$$

Directional element

The directional element is used for the quadrilateral four zone characteristics.

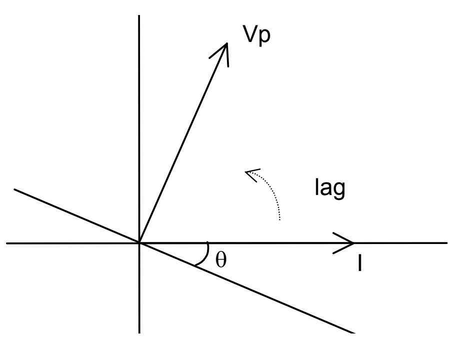


Figure 2.6.1.10 Directional Element

The characteristic of the directional element is obtained by the following equation.

$I \cdot Vp \cos(\theta - \phi) \geq 0$

where,

I = fault current

Vp = polarizing voltage

ϕ = lagging angle of I to Vp

θ = directional angle setting

The polarizing voltage Vp is the same one as employed in the mho element.

For B-to-C-phase phase fault element

$V_{pbc} = \sqrt{3}\,(V_a - V_0) \angle -90° + V_{bc}$

For an A-phase earth fault element

$V_{pa} = \sqrt{3}\,(V_a - V_0) + V_{bc} \angle 90°$

where,

V_a = A-phase voltage

V_0 = zero-sequence voltage

V_{bc} = B-to-C-phase voltage

The polarizing voltage for the phase fault element has a memory action for the close-up three-phase fault. V_a and V_{bc} mentioned above are the memorized pre-fault voltages. This memory is retained for two cycles after a fault occurs. The polarizing voltage for the earth fault element has no memory action.

When a three-phase fault occurs within zone 1, the phase fault element for zone 1 is modified to an offset characteristic as shown in Figure 2.6.1.11. This, together with voltage memory action, enables zone 1 to perform tripping with a time delay as well as instantaneous tripping for the close-up three-phase fault.

The Z1X, Z2, ZF and Z3 do not have the modifying function mentioned above.

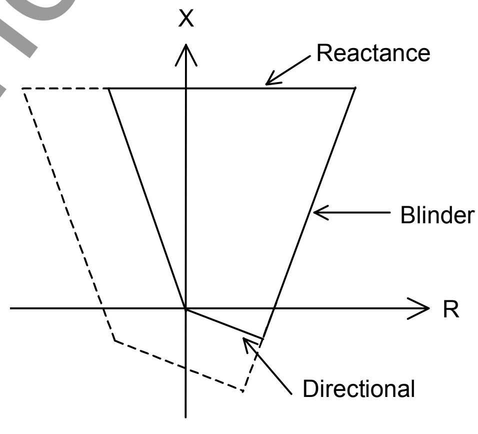


Figure 2.6.1.11 Quadrilateral characteristic

Offset directional element

The offset directional element is used only in Z4 for phase faults in the quadrilateral four zone characteristics.

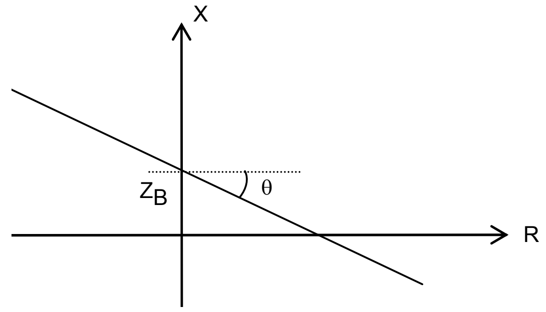


Figure 2.6.1.12 Offset Directional Element

The characteristic of the offset directional element is obtained by the following equation.

$$X + R \tan\theta \leqq Z_B$$

where,

X = reactance component of measured impedance

R = resistance component of measured impedance

θ = directional angle setting (interlinked with directional element angle setting)

Z_B = offset reach setting (fixed to 1.5 Ω in 5A rating and 7.5 Ω in 1A rating)

2.6.2 Phase Selection Element UVC

The phase selection element has the undervoltage characteristic shown in Figure 2.6.2.1 and is used to select a faulty phase in case of a single-phase-to-earth fault.

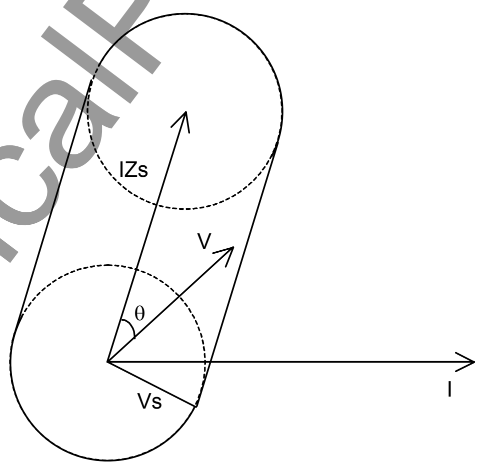


Figure 2.6.2.1 Phase Selection Element

The characteristic is obtained by a combination of the equations below. If equation (1) or equation (2), or both equations (3) and (4) are established, the UVC operates.

$|V| \leq Vs$ (1)

$|V - IZs| \leq Vs$ (2)

$-Vs \leq V \sin\theta \leq Vs$ (3)

$0 \leq V \cos\theta \leq |IZs|$ (4)

where,

V = fault voltage

I = fault current

θ = angle difference between V and IZs

Zs = impedance setting

Vs = undervoltage setting

When the value and angle of Zs are set to those similar to the impedance of the protected line, the phase selection element will detect all single-phase earth faults that have occurred on the protected line even with a strong source and the voltage drop is small.

As a result of current compensation, the operating zone expands only in the direction leading the current by the line impedance angle. Therefore, the effect of current compensation is very small under load conditions where the current and voltage have almost the same phase angle.

2.6.3 Directional Earth Fault Elements DEFF and DEFR

There are two types of directional earth fault element, the forward looking element (DEFF) and reverse looking element (DEFR). Their characteristics are shown in Figure 2.6.3.1.

Both the DEFF and DEFR use a residual voltage as their polarizing voltage and determine the fault direction based on the phase relationship between the residual current and polarizing voltage.

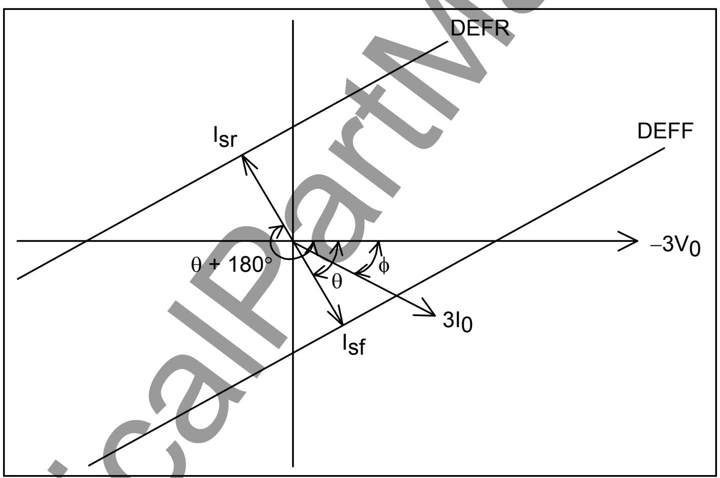


Figure 2.6.3.1 Directional Earth Fault Element

The operation decision is made using the following equation.

DEFF

$$3I_0 \cdot \cos(\phi - \theta) \geq I_{sf}$$

$$3V_0 \geq V_{sf}$$

DEFR

$$3I_0 \cos(\phi - \theta - 180°) \geq I_{sr}$$

$$3V_0 \geq V_{sr}$$

where,

$3I_0$ = residual current

$3V_0$ = residual voltage

$-3V_0$ = polarizing voltage

ϕ = lagging angle of $(3I_0)$ to $(-3V_0)$

θ = characteristic angle setting (lagging to polarizing voltage)

I_{sf}, I_{sr} = current setting

V_{sf}, V_{sr} = voltage setting

2.6.4 Inverse Definite Minimum Time Overcurrent Element IDMT

As shown in Figure 2.6.4.1, the IDMT element has one long time inverse characteristic and three inverse time characteristics in conformity with IEC 60255-3. One of these characteristics can be selected.

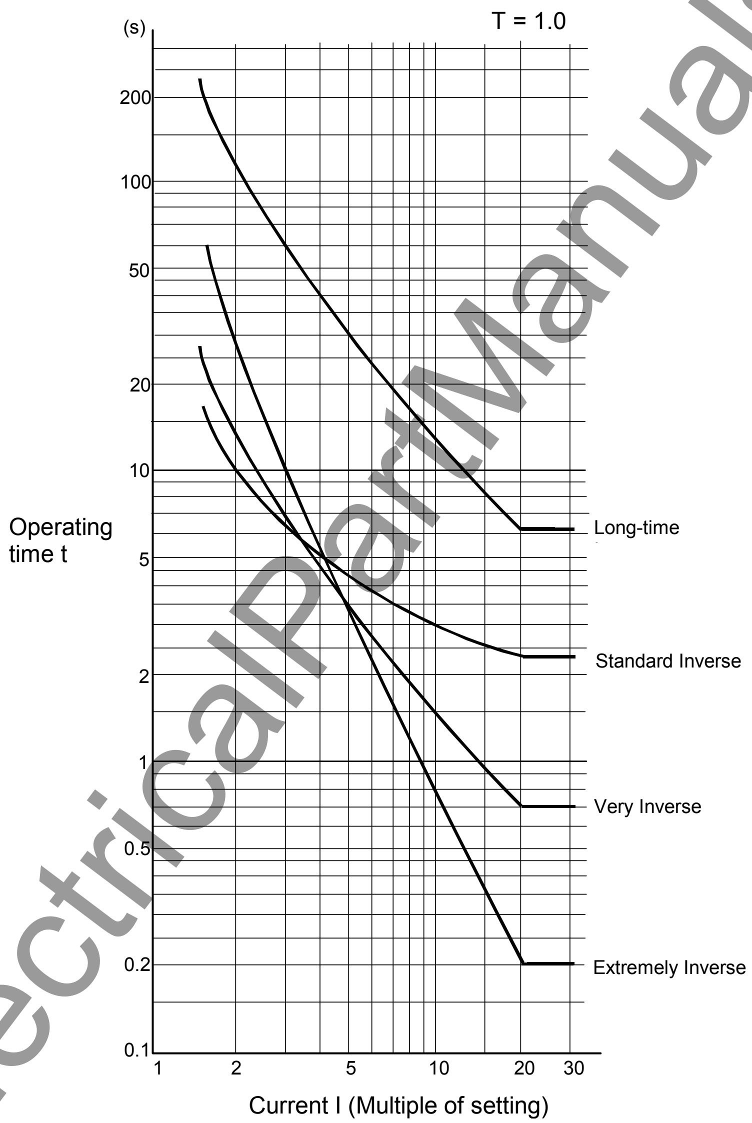


Figure 2.6.4.1 IDMT Characteristics

These characteristics are expressed by the following equations.

Long Time Inverse

$$t = T \times \frac{120}{(I/Is)-1}$$

Standard Inverse

$$t = T \times \frac{0.14}{(I/Is)^{0.02} - 1}$$

Very Inverse

$$t = T \times \frac{13.5}{(I/Is) - 1}$$

Extremely Inverse

$$t = T \times \frac{80}{(I/Is)^2 - 1}$$

where,

t = operating time

I = fault current

Is = current setting

T = time multiplier setting

Definite time reset

The definite time resetting characteristic is provided.

If the delay period is set to instantaneous (TOCIR=0.0s), then no intentional delay is added. As soon as the energising current falls below the reset threshold, the element returns to its reset condition.

If the delay period is set to some value in seconds, then an intentional delay is added to the reset period. If the energising current exceeds the setting for a transient period without causing tripping, then resetting is delayed for a user-definable period. When the energising current falls below the reset threshold, the integral state (the point towards operation that it has travelled) of the timing function (IDMT) is held for that period.

This does not apply following a trip operation, in which case resetting is always instantaneous.

2.6.5 Out-of-Step Element OST

The out-of-step element used for out-of-step tripping contains two impedance measuring elements with quadrilateral characteristics, ZM and ZN. Figure 2.6.5.1 shows their characteristics. The quadrilateral characteristic of ZM is formed by the reactance lines parallel to the R-axis and the ohm lines with a leading angle of 75° to the R-axis.

The characteristics of ZN can be obtained by shifting ZM in the −R-axis direction by (OSTR1-OSTR2).

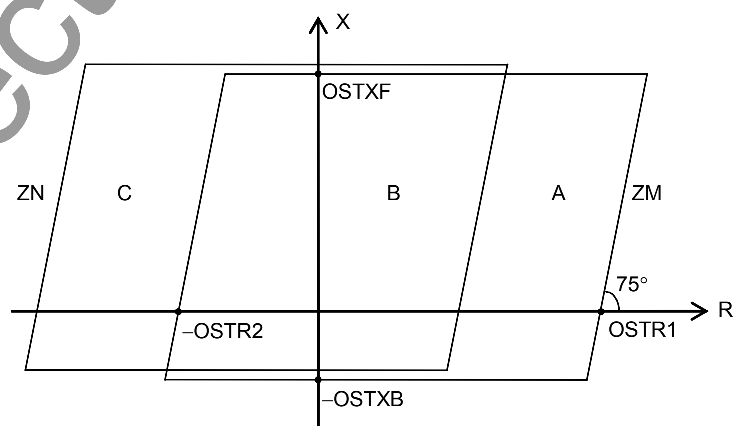


Figure 2.6.5.1 Out-of-Step Element

Operation of the impedance measuring element Z1 is expressed by the following equations.

$-OSTXB \leq X \leq OSTXF$

$(R - OSTR1)\tan 75° \leq X \leq (R - OSTR2)\tan 75°$

where,

X = measured reactance

R = measured resistance

OSTXB, OSTXF = reactive reach setting

OSTR1, OSTR2 = resistive reach setting

2.6.6 Voltage and Synchronism Check Elements OVL, UVL, OVB, UVB, and SYN

The voltage check and synchronism check elements are used for autoreclose.

The output of the voltage check element is used to check whether the line and busbar are dead or live. The voltage check element has undervoltage detectors UVL and UVB, and overvoltage detectors OVL and OVB for the line voltage and busbar voltage check. The under voltage detector checks that the line or busbar is dead while the overvoltage detector checks that it is live. These detectors function in the same manner as other level detectors described later.

Figure 2.6.6.1 shows the characteristics of the synchronism check element used for the autoreclose if the line and busbar are live.

The synchronism check element operates if both the voltage difference and phase angle difference are within their setting values.

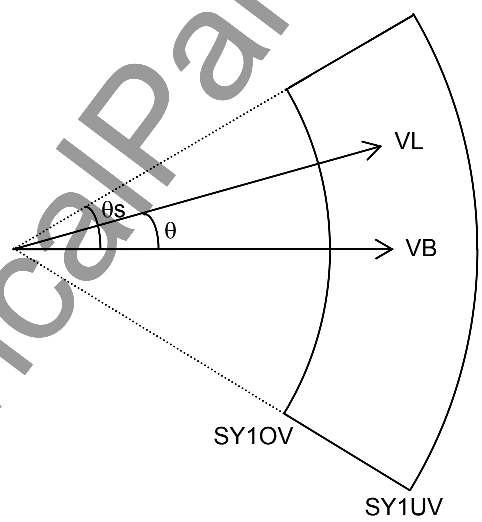


Figure 2.6.6.1 Synchronism Check Element

For the element SYN1, the voltage difference is checked by the following equations.

$SY1OV \leq VB \leq SY1UV$

$SY1OV \leq VL \leq SY1UV$

where,

VB = busbar voltage

VL = line voltage

SY1OV = lower voltage setting

SY1UV = upper voltage setting

The phase difference is checked by the following equations.

$$VB \cdot VL \cos\theta \geq 0$$

$$VB \cdot VL \sin(SY1\theta s) \geq VB \cdot VL \sin\theta$$

where,

θ = phase difference between VB and VL

$SY1\theta s$ = phase difference setting

A detected slip cycle is determined by the following equation:

$$f = \frac{\theta s}{180° \times TSYN}$$

where,

f = slip cycle

TSYN = synchronism check timer setting

2.6.7 Current Change Detection Elements OCD and OCDP

As shown in Figure 2.6.7.1, the current change detection element operates if the vectorial difference between currents I_M and I_N observed one cycle apart is larger than the fixed setting. Therefore, the operating sensitivity of this element is not affected by the quiescent load current and can detect a fault current with high sensitivity.

The OCD element is used for the VT failure supervision circuit and the OCDP element used for the fault detection during a power swing.

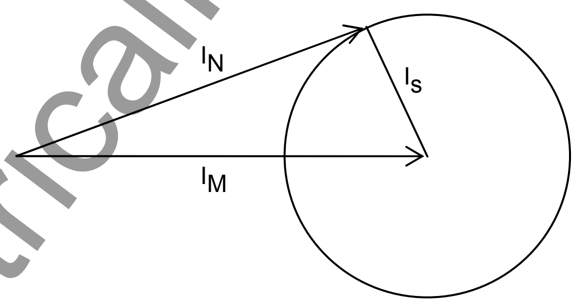


Figure 2.6.7.1 Current Change Detection

The operation decision is made by the following equation.

$$|I_M - I_N| > Is$$

where,

I_M = present current

I_N = current one cycle before

I_S = fixed setting (10% of rated current)

2.6.8 Negative Sequence Directional Elements DOCNF and DOCNR

There are two types of negative sequence directional element, the forward looking element (DOCNF) and reverse looking element (DOCNR). They are used to detect faults during a power swing. Their characteristics are shown in Figure 2.6.8.1.

Both the DOCNF and DOCNR use negative sequence current and voltage and determine a fault direction based on the phase relationship between the current and voltage.

The operation decision is made using the following equation.

DOCNF

$$Z_k I_2^2 - V_2 I_2 \sin\phi \geq V_{2k} |I_2|$$

$$I_2 \geq I_{2k}$$

DOCNR

$$Z_k I_2^2 + V_2 I_2 \sin\phi \geq V_{2k} |I_2|$$

$$I_2 \geq I_{2k}$$

where,

I_2 = negative sequence current

V_2 = negative sequence voltage

ϕ = lagging angle of I_2 to V_2

I_{2k} = 0.267 × rated current (fixed)

V_{2k} = 6 V (fixed)

Z_k = 2.5 ohm (1A rating, fixed) / 0.5 ohm (5A rating, fixed)

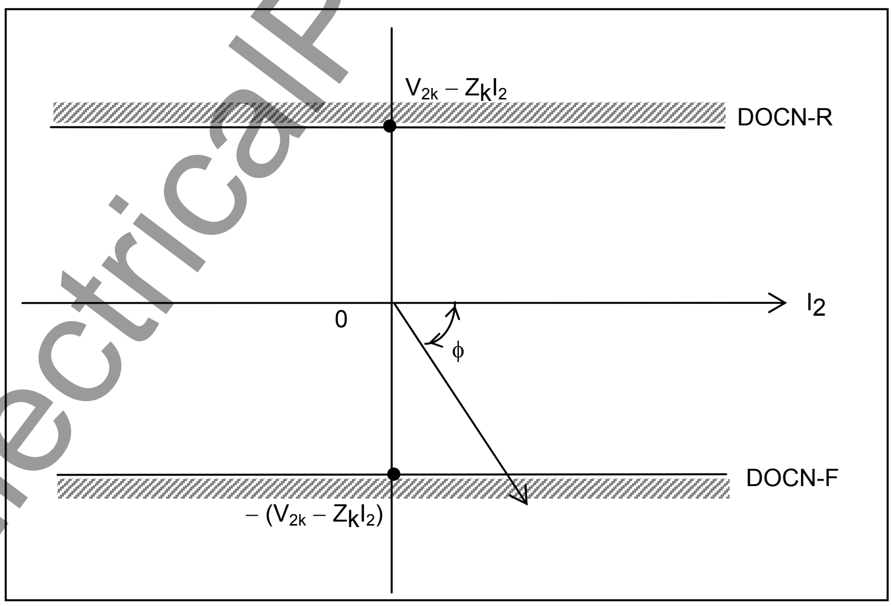


Figure 2.6.8.1 Negative Sequence Directional Element

2.6.9 Level Detectors

In addition to those explained above, GRZ100 has overcurrent, overvoltage, and undervoltage level detectors described below.

All level detectors except for undervoltage level detectors UVFS and UVFG, and overcurrent level detector OCBF which require high-speed operation, operate in a similar manner.

That is, the operation decision is made by comparing the current or voltage amplitude with the relevant setting.

Overcurrent detector OCH and OC

This detector measures A, B, and C phase currents and its sensitivity can be set. The detector OCH is commonly used for the SOTF and stub protection. The detector OC is commonly used for backup protection.

Residual overcurrent detector EF and EFL

This detector measures a residual current and its sensitivity can be set. The EF is used for backup protection. The EFL is used for the earth fault detection of distance protection and VT failure supervision.

Overvoltage detector OVS1/OVS2/OVG1/OVG2 and undervoltage detector UVS1/UVS2/UVG1/UVG2

The OVS∗ and UVS∗ measure a phase-to-phase voltage while the OVG∗ and UVG∗ measure a phase-to-earth voltage. These detectors are used for overvoltage and undervoltage protection as described in Section 2.4.9.

Residual overvoltage detector OVG

This detector measures a residual voltage and its sensitivity is fixed at 20V. This detector is used for supervision of VT failure.

Undervoltage detector UVLS and UVLG

The UVLS measures a phase-to-phase voltage while the UVLG measures a phase-to-earth voltage. Their sensitivity can be set. These detectors are used for weak infeed tripping.

Undervoltage detector UVFS and UVFG

The UVFS measures a phase-to-phase voltage while the UVFG measures a phase-to-earth voltage. Their sensitivity can be set. These detectors are commonly used for the VT failure supervision and signal channel test.

Undervoltage detector UVPWI

The UVPWI measures a phase-to-earth voltage and its sensitivity is 30V fixed. The UVPWI is used for countermeasures for overreaching of a leading-phase distance element at positive phase weak infeed condition.

Broken conductor detector BCD

The BCD measures the ratio of negative to positive phase sequence currents (I_{2F} / I_{1F}).

Overcurrent detector OCBF

This detector measures A, B, and C phase currents and its sensitivity can be set. This detector is used for breaker failure protection and resets when the current falls below 80% of the operating value.

2.7 Autoreclose

2.7.1 Application

Most faults that occur on high voltage or extra-high voltage overhead lines are transient faults caused by lightning. If a transient fault occurs, the circuit breaker is tripped to isolate the fault, and then reclosed following a time delay to ensure that the gases caused by the fault arc have de-ionized. This makes it possible to recover power transmission.

The time between clearing the fault and reclosing the circuit breaker, that is, the dead time, should be made as short as possible to keep the power system stable. From the viewpoint of de-ionization of the fault arc, the fault arc is de-ionized more thoroughly as the period of this dead time is extended. The de-ionization commences when the circuit breakers for all terminals of the line are tripped. Therefore, the dead time can be set at its minimum level if all terminals of the line are tripped at the same time.

Autoreclose of the GRZ100 is started by any of the following protections that ensure high-speed protection of all terminals.

- command protection
- zone 1 extension protection
- specific zone 1 tripping

The GRZ100 provides two autoreclose systems, single-shot autoreclose and multi-shot autoreclose.

Single-shot autoreclose

Three types of single-shot autoreclose modes are provided: single-phase autoreclose, three-phase autoreclose, and single- and three-phase autoreclose. An optimal mode is selected form among "Off (disable)" "SPAR", "TPAR", "SPAR&TPAR", "EXT1P" and "EXT3P" by the autoreclose mode selection switch [ARC-M] or PLC signals (No.1683 – 1688). The PLC signals have priority over the switch [ARC-M] setting. In any case, autoreclose is performed only once. If the fault state still continues after reclosing, three-phases final tripping is activated.

Single-phase autoreclose:

In this mode, only the faulty phase is tripped, and then reclosed if a single-phase earth fault occurs. In the case of a multi-phase fault, three phases are tripped, but reclosing is not made. Since power can be transmitted through healthy phases even during dead time, this mode is convenient for maintaining power system stablility. On the other hand, the capacitive coupling effect between the healthy phase and faulty phase may cause a longer de-ionization time when compared to a three-phase autoreclose. As a result, a longer dead time is required.

It is essential to correctly determine a faulty phase. The GRZ100 is equipped with an undervoltage element with current compensation to correctly determine the faulty phase(s).

For single-phase autoreclose, each phase of the circuit breaker must be segregated.

This reclosing mode is simply expressed as "SPAR" in the following descriptions.

Three-phase autoreclose:

In this autoreclose mode, three phases are tripped, and then reclosed regardless of the fault mode, whether single-phase fault or multi-phase fault. A shorter dead time can be set in this mode when compared to the single-phase autoreclose. For the three-phase autoreclose, synchronism check and voltage check between the busbar and the line are required.

This reclosing mode is simply expressed as "TPAR" in the following descriptions.

Single- and three-phase autoreclose:

In this autoreclose mode, single-phase tripping and reclosing are performed if a single-phase fault occurs, while three-phase tripping and reclosing are performed if a multi-phase fault occurs.

This reclosing mode is simply expressed as "SPAR & TPAR" in the following descriptions.

Shingle-shot autoreclose can be applied to one-breaker reclosing and two-breaker reclosing in the one-and-a-half breaker busbar system.

Multi-shot autoreclose

In the multi-shot autoreclose, any of two- to four-shot reclosing can be selected. In any case, the first shot is selected from three types of autoreclose modes as described in the above single-shot autoreclose. All successive shots (up to three times), which are applied if the first shot fails, are three-phase tripping and reclosing.

Multi-shot autoreclose cannot be applied to two-breaker reclosing in the one-and-a-half breaker busbar system..

The autoreclose can also be activated from an external line protection. At this time, all autoreclose modes described above are effective.

If a fault occurs under the following conditions, three-phase final tripping is performed and autoreclose is blocked.

- Reclosing block signal is received from external unit locally or remotely.
- Throughout the reclaim time

For evolving faults that occurred during the dead time between single-phase tripping and reclosing, "SPAR & TPAR" functions as follows.

For evolving faults that occurred within the period of time set from the first fault, the reclosing mode enters the three-phase autoreclose mode. At this time, the total dead time becomes the dead time for three-phase autoreclose added to the dead time for single-phase autoreclose which has been used until the evolving fault occurs.

For evolving faults occurred after the set time, three-phase final tripping is performed, and reclosing is not performed.

If an evolving fault occurs when "SPAR" is selected, three-phase final tripping is performed, and reclosing is not performed.

2.7.2 Scheme Logic

2.7.2.1 One-breaker Autoreclose

Figure 2.7.2.1 shows the simplified scheme logic for the single-shot autoreclose. Autoreclose for a further fault incident is available when the circuit breaker is closed and ready for autoreclose (CB1 READY=1), the autoreclose mode by the switch [ARC-M] or the PLC is set to "SPAR", "TPAR" or "SPAR & TPAR" and the on-delay timer TRDY1 is picked up. The TRDY1 is used to determine the reclaim time.

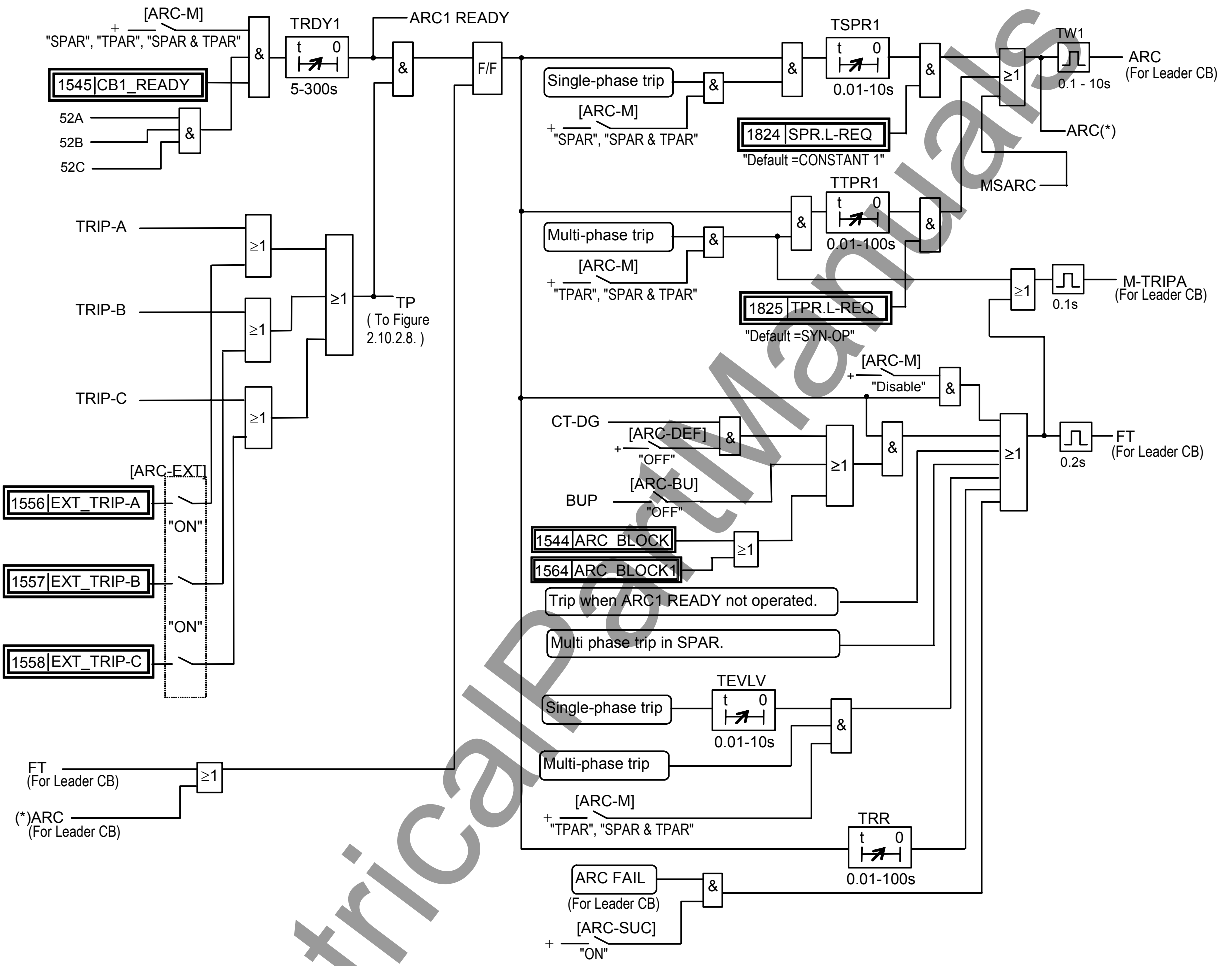


Figure 2.7.2.1 Autoreclose Scheme Logic

If the autoreclose is ready, the internal tripping signal TRIP-A, B, C or external tripping signal EXT_TRIP-A, B, C for each phase of the circuit breaker activates the autoreclose. These tripping signals are output from the command protection, zone 1 extension protection, and specific zone 1 tripping. Whether or not the external trip signals are used to activate the reclosing is selected by the scheme switch [ARC-EXT].

Once this autoreclose is activated, it is maintained by a flip-flop circuit until one reclosing cycle is completed.

Autoreclose is not activated in the following conditions.

- When the tripping is output by the directional earth fault command protection (CT-DG =1) and the autoreclose selection switch [ARC-DEF] is set to "OFF".
- When the tripping is performed by the out-of-step protection (OSTT =1), stub fault protection (STUB=1), switch-onto-fault protection (SOTF =1) breaker failure protection (RETRIP=1) or time-delayed backup protection (BUP =1).

- When an autoreclose prohibiting binary input signal is applied (ARC_BLOCK =1)

If autoreclosing is not ready, a three-phase tripping command M-TRIP is output for all tripping modes. At this time, autoreclose is not activated.

Autoreclose for single-phase fault

If the autoreclose mode is set to "SPAR" or "SPAR & TPAR", single-phase tripping is performed. The dead time counter TSPR for single-phase reclosing is started by any of the tripping signals TRIP-A to C. After the dead time has elapsed, reclosing command ARC is output.

If the autoreclose mode is set to "TPAR", three-phase tripping is performed and the dead time counter TTPR1 for three-phase reclosing is started. After the dead time has elapsed, reclosing command ARC is output based on the operating conditions of the voltage and synchronism check elements output signal SYN-OP. (The SYN-OP is assigned by the PLC as a default setting.)

If the autoreclose mode is set to "Disable"("Off"), three-phase tripping is performed and autoreclose is not started. Even though the autoreclose is started, the autoreclose is reset if all phases of the CB are closing.

Autoreclose for multi-phase fault

Regardless of the autoreclose mode, three-phase tripping is performed and TRIP-A to C are activated. If the autoreclose mode is set to "TPAR" or "SPAR & TPAR", the dead time counter TTPR1 for three-phase reclosing is started. After the dead time has elapsed, reclosing command ARC is output based on the operating conditions of the voltage and synchronism check elements output signal SYN-OP. (The SYN-OP is assigned by the PLC as a default setting.)

If the autoreclose mode is set to "SPAR" or "Disable"("Off"), autoreclose is not activated.

If the operating conditions of the voltage and synchronism check elements are not satisfied during three-phase reclosing, TRR is then picked up and reclosing is reset.

Autoreclose for evolving fault

Figure 2.7.2.2 shows the sequence diagram of autoreclose for an evolving fault. If single-phase tripping is performed, the evolving fault detection timer TEVLV is started at the same time as the TSPR is started. If no evolving faults occur, single-phase reclosing is performed when TSPR is picked up.

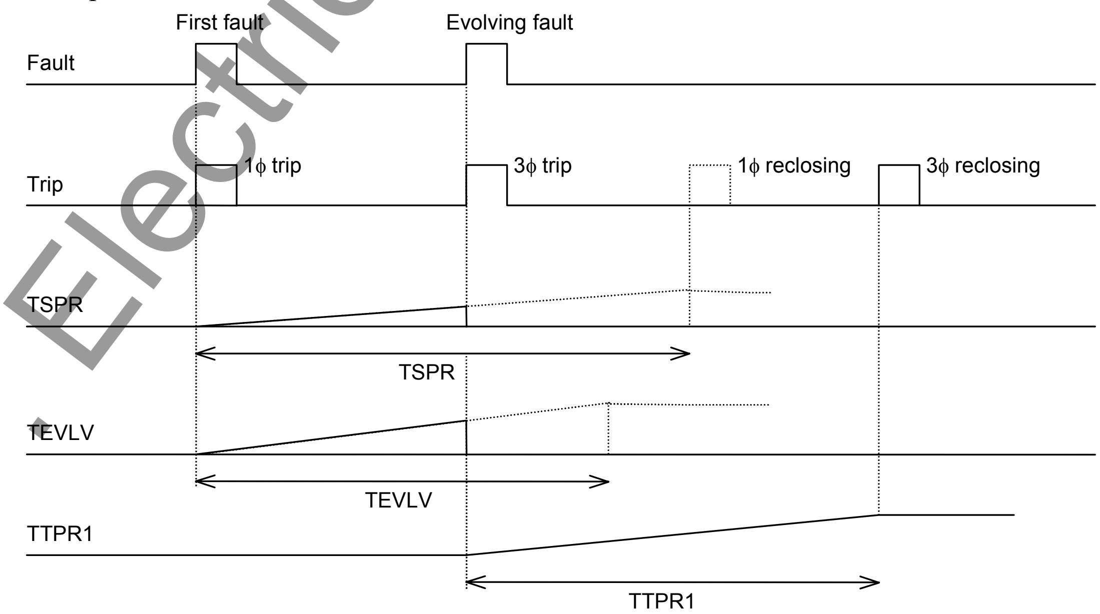


Figure 2.7.2.2 Autoreclose for Evolving Fault

As shown in the figure, if an evolving fault occurs before TEVLV is picked up, three-phase tripping is performed. If this occurs, TSPR and TEVLV are reset, and TTPR1 is now started.

After TTPR1 is picked up, three-phase reclosing is performed based on the status of the voltage and synchronism check elements output signal SYN-OP. If an evolving fault occurs after the TEVLV has picked up, autoreclose is reset and reclosing is not performed.

Voltage and synchronism check

There are four voltage modes as shown below when all three phases of the circuit breaker are opened. The voltage and synchronism check is applicable to voltage modes 1 to 3 and controls the energizing process of the lines and busbars in the three-phase autoreclose mode.

Voltage Mode	1	2	3	4
Busbar voltage (V_B)	live	live	dead	dead
Line voltage (V_L)	live	dead	live	dead

The synchronism check is performed for voltage mode 1 while the voltage check is performed for voltage modes 2 and 3.

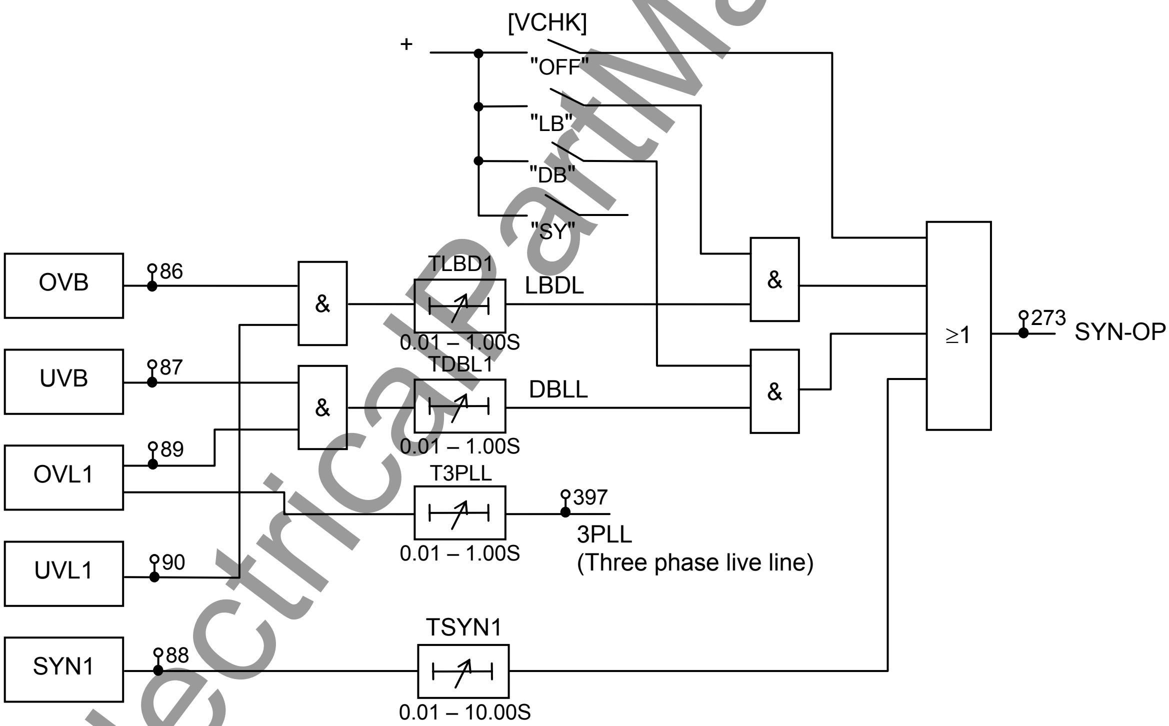


Figure 2.7.2.3 Energizing Control Scheme

Figure 2.7.2.3 shows the energizing control scheme. The voltage and synchronism check output signal SYN-OP is generated when the following conditions have been established;

- Synchronism check element SYN1 operates and on-delay timer TSYN1 is picked up.
- Busbar overvoltage detector OVB and line undervoltage detector UVL1 operate, and on-delay timer TLBD1 is picked up. (This detects live bus and dead line condition.)
- Busbar undervoltage detector UVB and line overvoltage detector OVL1 operate, and on-delay timer TDBL1 is picked up. (This detects dead bus and live line condition.)

Using the scheme switch [VCHK], the energizing direction can be selected.

Setting of [VCHK]	Energizing control
LB	Reclosed under "live bus and dead line" condition or with synchronism check
DB	Reclosed under "dead bus and live line" condition or with synchronism check
SY	Reclosed with synchronism check only.
OFF	Reclosed without voltage and synchronism check.

When [VCHK] is set to "LB", the line is energized in the direction from the busbar to line under the "live bus and dead line" condition. When [VCHK] is set to "DB", the lines are energized in the direction from the line to busbar under the "dead bus and live line" condition.

When a synchronism check output exists, autoreclose is executed regardless of the position of the scheme switch.

When [VCHK] is set to "SY", a three-phase autoreclose is performed with synchronism check only.

When [VCHK] is set to "OFF", three-phase autoreclose is performed without voltage and synchronism check.

The voltage and synchronism check require a single-phase voltage from the busbar or line as a reference voltage. If the three-phase voltages that are used for the distance protection are supplied from the line voltage transformer, the reference voltage has to be supplied from the busbar voltage transformer. On the contrary, if the three-phase voltages that are used for the distance protection are supplied from the busbar voltage transformer, the reference voltage has to be supplied from the line voltage transformer.

Additionally, it is not necessary to fix the phase of the reference voltage.

The signal 3PLL shown in Figure 2.7.2.3 is output when all three phase voltages are live, and it is available by the [3PH-VT] = LINE setting.

To match the busbar voltage and line voltage for the voltage and synchronism check option mentioned above, the GRZ100 has the following three switches and VT ratio settings as shown in Figure 2.7.2.4.

[VTPH-SEL]: This switch is used to match the voltage phases. If the A-phase voltage or A-phase to B-phase voltage is used as a reference voltage, "A" is selected.

[VT-RATE]: This switch is used to match the magnitude and phase angle. "PH/G" is selected when the reference voltage is a single-phase voltage while "PH/PH" is selected when it is a phase-to-phase voltage.

[3PH-VT]: "Bus" is selected when the three-phase voltages are busbar voltages while "Line" is selected when they are the line voltages.

VT: This setting is set to the VT ratio of busbar or line voltage for distance protection.

VTs1: This setting is set to the VT ratio of line or busbar reference voltage for voltage check and synchronism check.

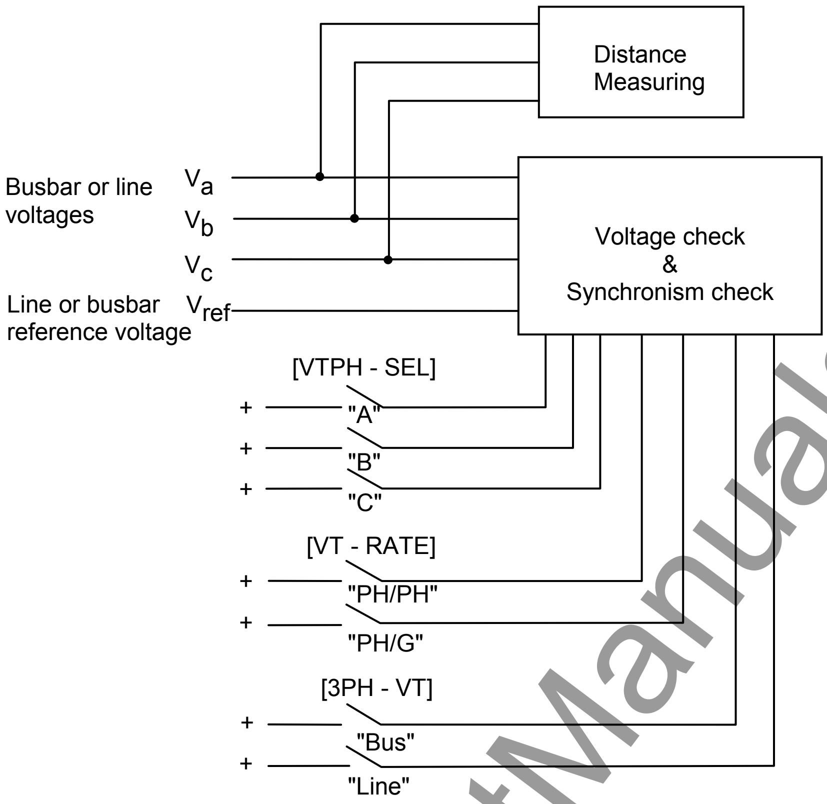


Figure 2.7.2.4 Matching of Busbar Voltage and Line Voltage

Autoreclosing requirement

Using PLC function, various reclose requirements can be designed. In Figure 2.7.2.1, a reclose requirement for "SPAR", "TPAR" or "SPAR&TPAR" can be respectively assigned to the following signals by PLC:

"SPAR": [SPR.L-REQ]

"TPAR": [TPR.L-REQ]

"SPAR&TPAR": [SPR.L-REQ], [TPR.L-REQ]

The default setting is as follows:

Reclose requirement	Default setting	Remarks
"SPAR"	[SPR.L-REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.L-REQ] = SYP-ON	Voltage and synchronism check

Permanent fault

When reclose-onto-a-fault is activated when a permanent fault exists, three-phase final tripping is performed. However, this operation is performed only in the single-shot autoreclose mode. In the multi-shot autoreclose mode, reclosing is retried as described below.

Multi-shot autoreclose

In multi-shot autoreclose, low-speed autoreclose is executed up to three times after high-speed autoreclose fails. The first shot is high-speed autoreclose that functions in the same manner as described for single-shot autoreclose. Figure 2.7.2.5 shows the simplified scheme logic for the low-speed autoreclose of the second to fourth shot.

The multi-shot mode, two to four shots, is set with the scheme switch [ARC-SM].

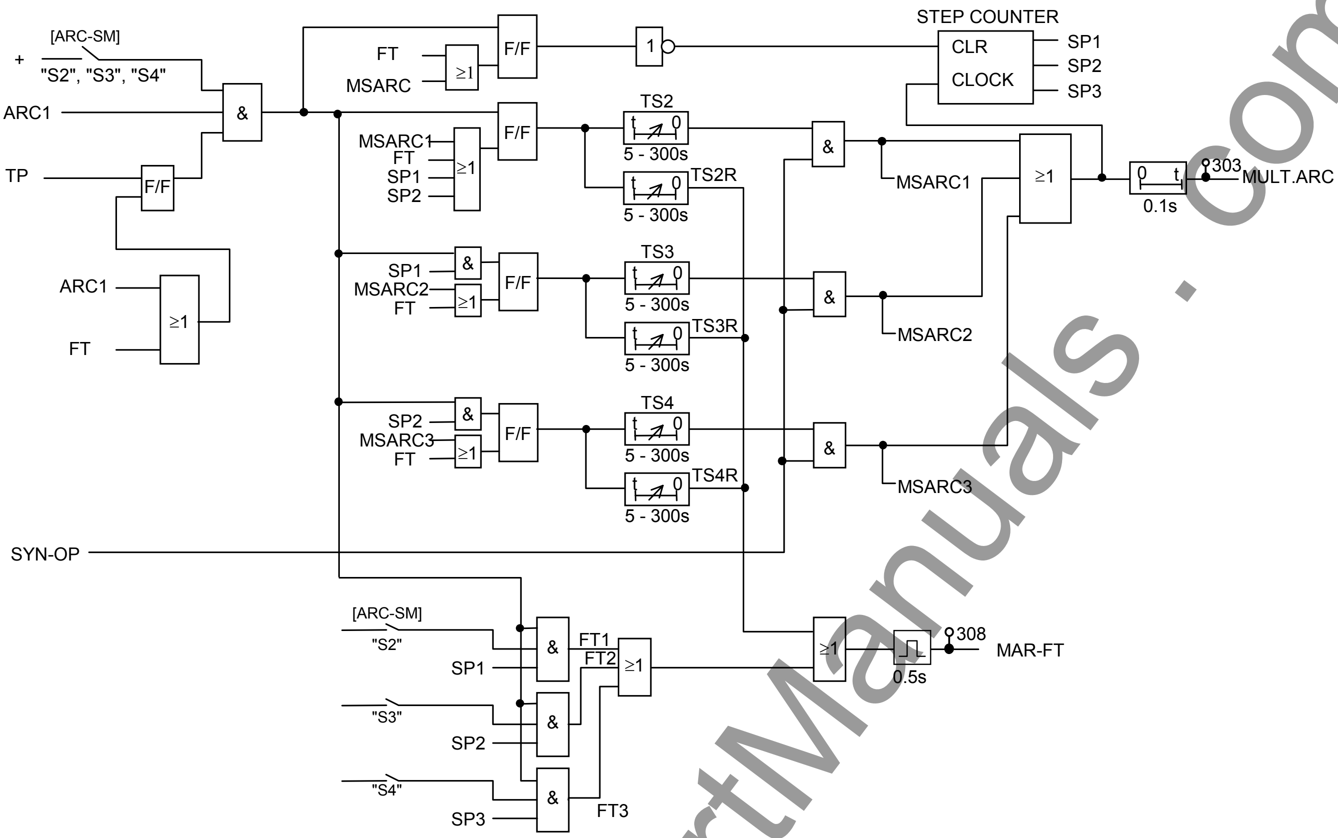


Figure 2.7.2.5 Scheme Logic for Multi-Shot Autoreclose

In low-speed autoreclose, the dead time counter TS2 for the second shot is activated if high-speed autoreclose is performed (ARC = 1), but tripping occurs again (TP = 1). Second shot autoreclose is performed only when the voltage and synchronism check element operates (SYN-OP = 1) after a period of time set on TS2 has elapsed. At this time, outputs of the step counter are: SP1 = 1, SP2 = 0, and SP3 = 0.

Autoreclose is completed at this step if the two-shot mode is selected for the multi-shot mode. Therefore, the tripping following the "reclose-onto-a-fault" becomes the final tripping (FT1 = 1).

If the voltage and synchronism check element does not operate within the period of time set on the timer TS2R which is started at the same time as TS2 is started, the multi-shot autoreclose is cancelled (MAR-FT = 1).

When the three shots mode is selected for the multi-shot mode, autoreclose is further retried after the above tripping occurs. At this time, the TS3 and TS3R are started. The third shot autoreclose is performed only when the voltage and synchronism check element operates after the period of time set on the TS3 has elapsed. At this time, outputs of the step counter are: SP1 = 0, SP2 = 1, and SP3 = 0.

The three shot mode of autoreclose is then completed. Therefore, the tripping following the "reclose-onto-a-fault" becomes the final tripping (FT2 = 1).

If the voltage and synchronism check element does not function within the period of time set on the TS3R, multi-shot autoreclose is cancelled.

When four-shot autoreclose is selected, low-speed autoreclose is further retried once again for tripping that occurs after the "reclose-onto-a-fault". This functions in the same manner as the three-shot autoreclose.

Use of external automatic reclosing equipment

To use external automatic reclosing equipment instead of the built-in autoreclose function of the GRZ100, the autoreclose mode is set to "EXT1P" or "EXT3P". When "EXT1P" is selected, the GRZ100 performs single-phase tripping for a single-phase fault and three-phase tripping for a multi-phase fault. When "EXT3P" is selected, three-phase tripping is performed for all faults. At the same time, one binary signal for individual phase is output as an autoreclose start signal.

2.7.2.2 Two-breaker autoreclose

As shown in Figure 2.7.2.6, in the one-and-a-half breaker busbar arrangement, two circuit breakers, the busbar breaker and the center breaker, must be reclosed. The GRZ100-300 series are provided with the two-breaker autoreclose scheme.

Multi-shot autoreclose is not applicable to two-breaker autoreclose; the scheme switch [ARC-SM] is set to "OFF" for a default setting.

Autoreclose is not activated when an autoreclose prohibiting binary input signal is applied at the local or remote terminal.

- ARC_BLOCK signal common for leader and follower CB
- ARC_BLOCK1 signal for leader CB
- ARC_BLOCK2 signal for follower CB

The autoreclose scheme is different depending on the reclosing mode.

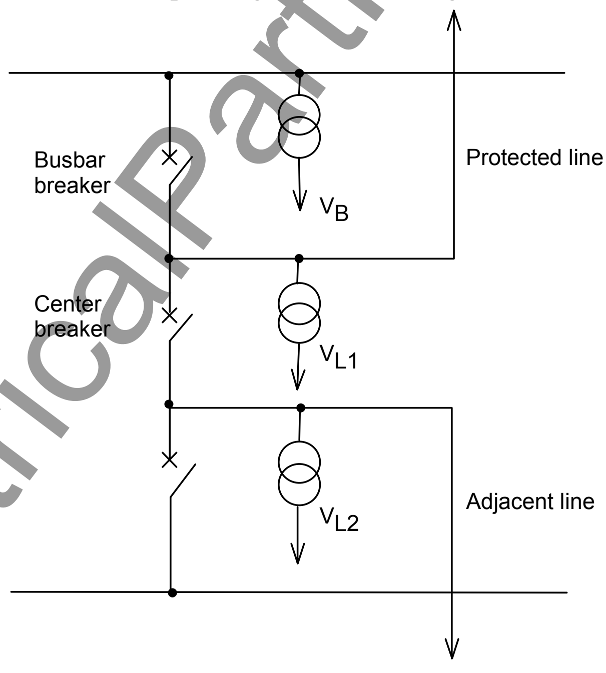


Figure 2.7.2.6 One-and-a-Half Breaker Busbar Arrangement

Single-phase autoreclose and single- and three-phase autoreclose

The breaker(s) to be reclosed and the reclosing order can be set by the scheme switch [ARC-CB] as follows:

Setting of [ARC-CB]	Autoreclose mode
ONE	(Set when applied to a one-breaker system)
O1	Only the busbar breaker is reclosed and the center breaker is subjected to final tripping.
O2	Only the center breaker is reclosed and the busbar breaker is subjected to final tripping.

Setting of [ARC-CB]	Autoreclose mode
L1	Single-phase autoreclose: Both breakers are reclosed simultaneously. (*1) Three-phase autoreclose: The busbar breaker is reclosed first. If successful, then the center breaker is reclosed.
L2	Single-phase autoreclose: Both breakers are reclosed simultaneously. (*1) Three-phase autoreclose: The center breaker is reclosed first. If successful, then the busbar breaker is reclosed.

Note: "ONE" is set only when the relay is applied to a one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

(∗1): Sequential autoreclose can be applied by changing of the dead timer setting or the PLC setting.

The autoreclose scheme logic for the two circuit breakers is independent of each other and is almost the same. The autoreclose scheme logic of the circuit breaker to be reclosed first (lead breaker) is the same as that shown in Figure 2.7.2.1. The scheme logic of the circuit breaker to be reclosed later (follower breaker) is different from that shown in Figure 2.7.2.7 in that the condition that a reclosing command is output to the leader breaker is added to the start of the dead time counter of the three-phase autoreclose.

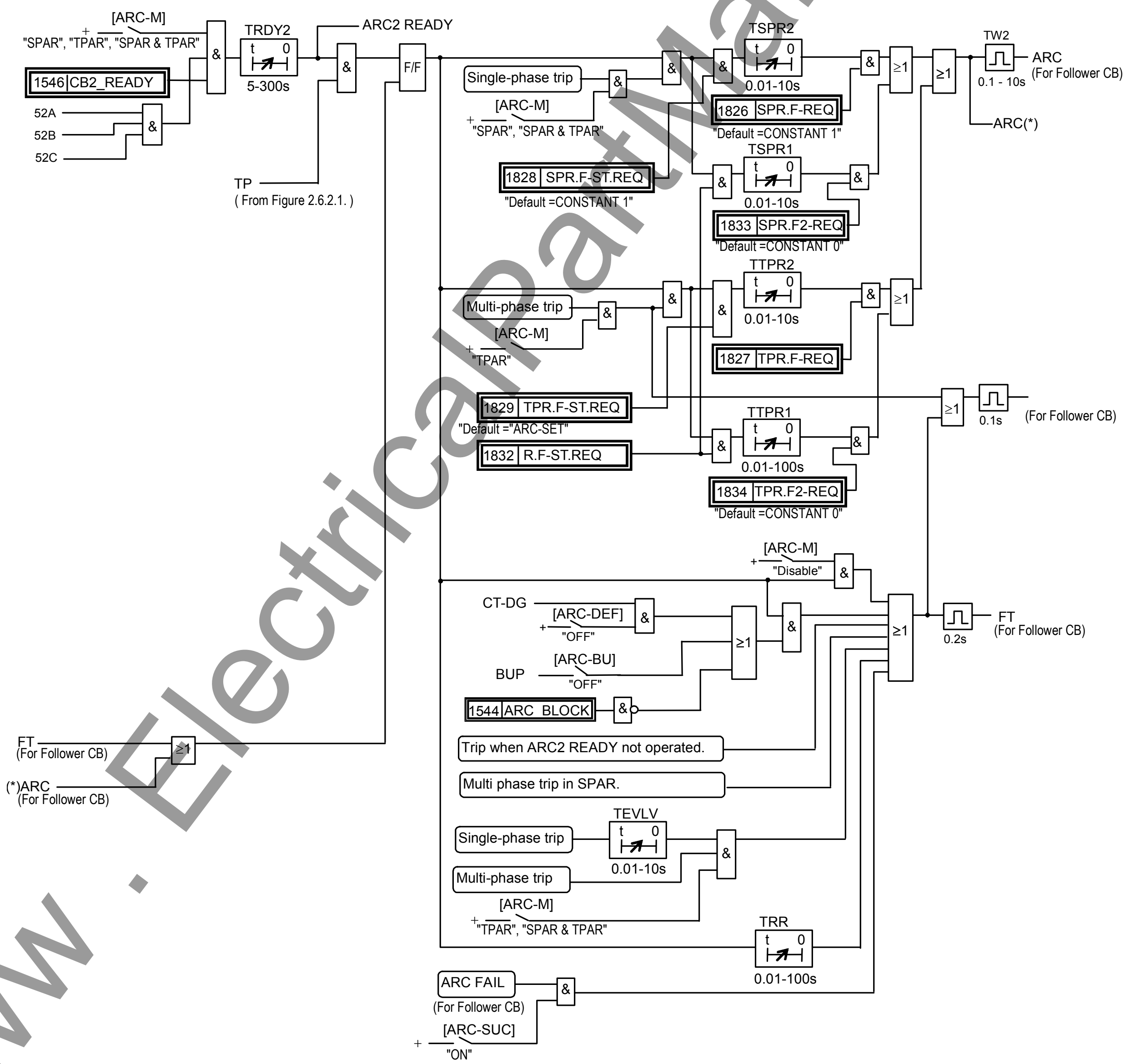


Figure 2.7.2.7 Autoreclose Scheme for Follower Breaker

The start of the dead time counter can be configured by the PLC. In the default setting, the single-phase autoreclose is started instantaneously after tripping, and the three-phase autoreclose is started after the ARC-SET condition is satisfied.

The "ARC-SET" is a scheme signal whose logical level becomes 1 when a lead breaker's autoreclose command is output.

In default setting, therefore, the dead time of the follower breaker is as follows:

- Three-phase autoreclose: equal to the sum of the dead time setting of the two breakers. (TTPR1 + TTPR2)
- Single-phase autoreclose: TSPR2

However, the dead time can be set that of the leader breaker by the PLC setting "RF.ST-REQ". The shortening of the dead time can be also applied when the leader breaker is final-tripped because it is no ready.

Autoreclose start requirement

Using PLC function, various autoreclose start requirements can be designed. In Figure 2.6.2.7, a reclose start requirement for "SPAR", "TPAR" or "SPAR&TPAR" can be respectively assigned to the following signals by PLC:

"SPAR": [SPR.F-ST.REQ]

"TPAR": [TPR.F-ST.REQ]

"SPAR&TPAR": [SPR.F-ST.REQ], [TPR.F-ST.REQ]

The default setting for the follower CB autoreclose start requirement is as follows:

Reclose start requirement	Default setting	Remarks
"SPAR"	[SPR.F-ST.REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.F-ST.REQ] = ARC-SET	ARC-SET becomes "1" when the leader CB is reclosed.

Autoreclose requirement

The autoreclose requirement can be designed by assigning a reclose requirement to the signals [SPR.F-ST.REQ] and [TPR.F-ST.REQ] same as above.

The default setting for the follower CB autoreclose requirement is as follows:

Reclose requirement	Default setting	Remarks
"SPAR"	[SPR.F-ST.REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.F-ST.REQ] = SYP-ON	Voltage and synchronism check

Others

If the autoreclose start requirement is designed such as starting the follower CB in no-ready condition of the leader CB, it is assigned to the signal [R.F-ST.REQ].

By assigning the autoreclose start requirement to the signal [R.F-ST.REQ], both the leader CB and the follower CB are set the same dead time. The reclose requirement is assigned to the signals [SPR.F2-ST.REQ] and [TPR.F2-ST.REQ].

The default setting for the follower CB is as follows:

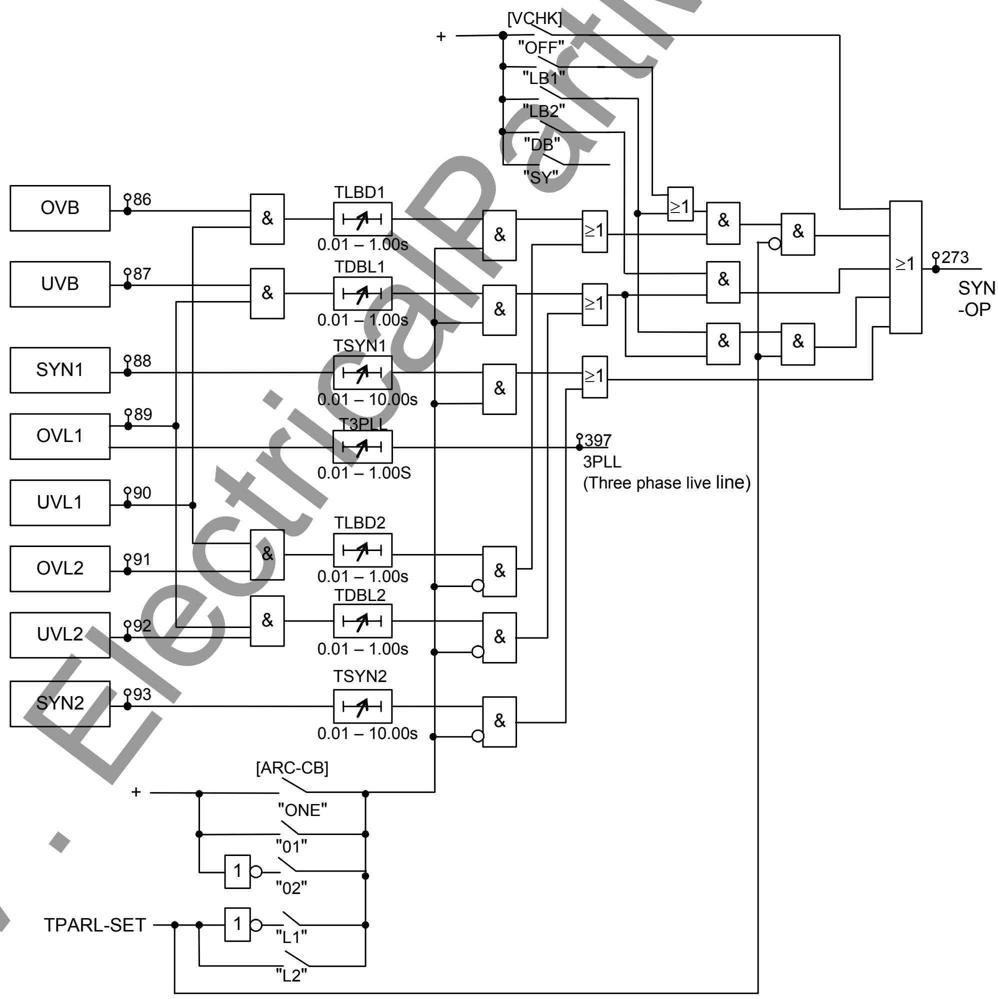
Requirement	Default setting	
Reclose requirement	[R.F-ST.REQ] = CONSTANT_0	(No used)
Reclose start requirement		
"SPAR"	[SPR.F2-REQ] = CONSTANT_0	(No used)
"TPAR"	[TPR.F2-REQ] = CONSTANT_0	(No used)

Figure 2.7.2.8 shows the energizing control scheme of the two circuit breakers in the three-phase autoreclose. OVB and UVB are the overvoltage and undervoltage detectors of busbar voltage V_B in Figure 2.7.2.6. OVL1 and UVL1 are likewise the overvoltage and undervoltage detectors of line voltage V_{L1}.

OVL2 and UVL2 are likewise the overvoltage and undervoltage detectors of line voltage V_{L2}. V_{L2} in the center breaker is equivalent to the busbar voltage V_B in the busbar breaker.

SYN1 and SYN2 are the synchronism check elements to check synchronization between the two sides of the busbar and center breakers, respectively.

TPARL-SET is a scheme signal whose logical level becomes 1 when a three-phase autoreclose command is output to the lead breaker. SYN-OP is a voltage and synchronism check output.



Note: [ARC-CB] is set to "ONE" only when the relay is applied to one-breaker system.
Trip and reclose commands are output only for CB1(bus CB).

Figure 2.7.2.8 Energizing Control Scheme for Two Circuit Breakers

The voltage and synchronism check is performed as shown below according to the [ARC-CB] settings:

Setting of [ARC-CB]	Voltage and synchronism check
ONE or O1	A voltage and synchronism check is performed using voltages V_B and V_{L1}.
O2	A voltage and synchronism check is performed using voltages V_{L1} and V_{L2}.
L1	Since the logical level of TPARL-SET is 0, a voltage and synchronism check is performed for the busbar breaker using voltages V_B and V_{L1}. Then, the logical level of TPARL-SET becomes 1 and a voltage and synchronism check is performed for the center breaker using voltages V_{L1} and V_{L2} and a reclosing command is output to the center breaker.
L2	A voltage and synchronism check is performed for the center breaker using voltages V_{L1} and V_{L2}. Then, the logical level of TPARL-SET becomes 1 and a voltage and synchronism check is performed for the busbar breaker using voltages V_B and V_{L1}.

Note: "ONE" is set only when the relay is applied to one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

The energizing control for the two circuit breakers can be set by the scheme switch [VCHK] as follows:

Setting of [VCHK]	Energizing control
LB1	The lead breaker is reclosed under the "live bus and dead line" condition or with synchronism check, and the follower breaker is reclosed with synchronism check only.
LB2	The leader breaker is reclosed under the "live bus and dead line" condition or with synchronism check, and the follower breaker is reclosed under the "dead bus and live line" condition or with synchronism check.
DB	Both breakers are reclosed under the "dead bus and live line" condition or with synchronism check.
SYN	Both breakers are reclosed with synchronism check only.
OFF	Both breakers are reclosed without voltage and synchronism check.

The scheme switch [ARC-SUC] is used to check the autoreclose succeeds. If all three phase CB contacts have been closed within TSUC time after ARC shot output, it is judged that the autoreclose has succeeded (AS). If not, it is judged that the autoreclose has failed (AF), and becomes the final tripping (FT).

The relay provides the user configurable switch [UARCSW] with three-positions (P1, P2, P3) to be programmed by using PLC function. Any position can be selected. If this switch is not used for the PLC setting, it is invalid.

2.7.3 Setting

The setting elements necessary for the autoreclose and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
VT	1 - 20000	1	2000	VT ratio for distance protection
VTs1	1 - 20000	1	2000	VT ratio for voltage and synchronism check SYN1
TSPR1	0.01 - 10.00 s	0.01 s	0.80 s	Dead time for single - phase autoreclose
TTPR1	0.01 - 100.00 s	0.01 s	0.60 s	Dead time for three - phase autoreclose

Element	Range	Step	Default	Remarks
TRR	0.01 - 100.00 s	0.01 s	2.00 s	Autoreclose reset time
TEVLV	0.01 - 10.00 s	0.01 s	0.30 s	Dead time reset for evolving fault
TRDY1	5 - 300 s	1 s	60 s	Reclaim time
SYN1				Synchronism check
SY1 θ	5 - 75°	1°	30°	
SY1UV	10 - 150 V	1 V	83 V	
SY1OV	10 - 150 V	1 V	51 V	
OVB	10 - 150 V	1 V	51 V	Live bus check
UVB	10 - 150 V	1 V	13 V	Dead bus check
OVL1	10 - 150 V	1 V	51 V	Live line check
UVL1	10 - 150 V	1 V	13 V	Dead line check
TSYN1	0.01 - 10.00 s	0.01 s	1.00 s	Synchronism check time
TLBD1	0.01 - 1.00 s	0.01 s	0.05 s	Voltage check time
TDBL1	0.01 - 1.00 s	0.01 s	0.05 s	Voltage check time
T3PLL	0.01 - 1.00 s	0.01 s	0.05 s	Three phase live line check
TW1	0.1 - 10.0 s	0.1 s	0.2 s	Reclosing signal output time
TS2	5.0 - 300.0 s	0.1 s	20.0 s	Second shot dead time
TS3	5.0 - 300.0 s	0.1 s	20.0 s	Third shot dead time
TS4	5.0 - 300.0 s	0.1 s	20.0 s	Fourth shot dead time
TS2R	5.0 - 300.0 s	0.1 s	30.0 s	Second shot reset time
TS3R	5.0 - 300.0 s	0.1 s	30.0 s	Third shot reset time
TS4R	5.0 - 300.0 s	0.1 s	30.0 s	Fourth shot reset time
ARC - M	Disabled/SPAR/TPAR/ SPAR & TPAR/EXT1P/EXT3P		SPAR & TPAR	Autoreclose mode
ARC - DEF	OFF/ON		OFF	DEF autoreclose
ARC-BU	OFF/ON		OFF	Backup trip autoreclose
ARC-EXT	OFF/ON		OFF	External start
ARC - SM	OFF/S2/S3/S4		OFF	Multi - shot autoreclose mode
ARC-SUC	OFF/ON		OFF	Autoreclose success checking
VCHK	OFF/LB/DB/SY		LB	Energizing direction
VTPHSEL	A/B/C		A	Phase of reference voltage
VT - RATE	PH/G / PH/PH		PH/G	VT rating
3PH - VT	BUS/LINE		LINE	Location of three - phase VTs
[UARCSW]	P1/P2/P3		(P1)(∗)	User ARC switch for PLC

(∗) If this switch is not used for PLC setting, it is invalid.

"VT" is VT ratio setting of distance protection, and "VTs1" is VT ratio setting of a reference voltage input for voltage and synchronism check element as shown in Figure 2.7.3.1.

In a voltage setting, set "SY1UV", "SY1OV", "OVB", "UVB", "OVL1" and "UVL1" based on the VT rating for voltage and synchronism check. (When a voltage rating between line VT and busbar VT is different as shown in Figure 2.7.3.1, the voltage input from "VT" is matched to the rating of "VTs1" using the setting of "VT" and "VTs1".)

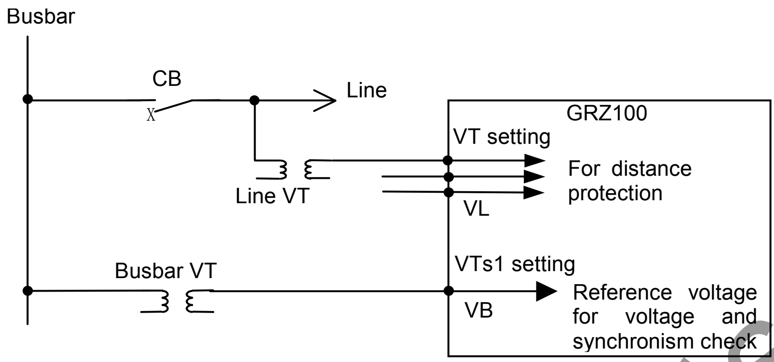


Figure 2.7.3.1 VT and VTs1 Ratio Setting for Busbar or Line Voltage

To determine the dead time, it is essential to find an optimal value while taking factors, de-ionization time and power system stability, into consideration which normally contradict one other.

Normally, a longer de-ionization time is required for a higher line voltage or larger fault current. For three-phase autoreclose, the dead time is generally 15 to 30 cycles. In single-phase autoreclose, the secondary arc current induced from the healthy phases may affect the de-ionization time. Therefore, it is necessary to set a longer dead time for single-phase autoreclose compared to that for three-phase autoreclose.

In three-phase autoreclose, if the voltage and synchronism check does not operate within the period of time set on the delayed pick-up timer TRR which is started at the same time as the dead time counter TTPR1 is started, reclosing is not performed and three-phase autoreclose is reset to its initial state. Therefore, for example, TRR is set to the time setting of the TTPR1 plus 100 ms.

The TEVLV determines the possibility of three-phase reclosing for an evolving fault.

When the TEVLV is set to the same setting as the TSPR, three-phase reclosing is performed for all evolving faults. As the setting for the TEVLV is made shorter, the possibility of three-phase reclosing for an evolving fault becomes small and that of three-phase final tripping becomes large.

For the two-breaker autoreclose, the following additional settings are required.

Element	Range	Step	Default	Remarks
VTs2	1 - 20000	1	2000	VT ratio for voltage and synchronism check SYN2
TSPR2	0.1 – 10.0s	0.1s	0.1s	Dead time for single-phase autoreclose of follower breaker
TTPR2	0.1 – 10.0s	0.1s	0.1s	Dead time for three-phase autoreclose of follower breaker
TRDY2	5 – 300s	1s	60s	Reclaim time of follower breaker
SYN2				Synchronism check
SY2 θ	5 – 75°	1°	30°	
SY2UV	10 – 150V	1V	83V	
SY2OV	10 – 150V	1V	51V	
OVL2	10 – 150V	1V	51V	Live line check
UVL2	10 – 150V	1V	13V	Dead line check
TSYN2	0.01 – 10.00s	0.01s	1.00s	Synchronism check time
TLBD2	0.01 – 1.00s	0.01s	0.05s	Voltage check time
TDBL2	0.01 – 1.00s	0.01s	0.05s	Voltage check time
TW2	0.1 – 10.0s	0.1s	0.2s	Reclosing signal output time
[ARC-CB]	ONE/O1/O2/L1/L2		L1	Two breaker autoreclose mode
[VCHK]	OFF/LB1/LB2/DB/SYN		LB1	Energizing direction

Note : [ARC-CB] is set to "ONE" only when the relay is applied to one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

2.7.4 Autoreclose Output Signals

The autoreclose scheme logic has two output reclosing signals: ARC1 and ARC2. ARC1 is a reclosing signal for a single breaker autoreclose or a reclosing signal for the busbar breaker in a two-breaker autoreclose scheme.

ARC2 is the reclosing signal for the center breaker of the two-breaker autoreclose scheme.

The assignment of these reclosing signals to the output relays can be configured, which is done using the setting menu. For more information on this, see Section 3.2.2 and 4.2.6.9. For the default setting, see Appendix D.

2.8 Fault Locator

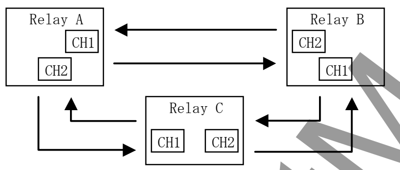
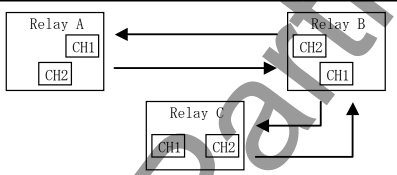
2.8.1 Application

GRZ100 provides the following two type fault location methods:

- Fault location using the only local end data for two terminal application
- Fault location using the local and remote end data (only for integral communication and three terminal application)

The fault locator using the only local end data is applied when the scheme switch “CO.LINK” is set to “Ext”. When the scheme switch “CO.LINK” set to “Int”, both types of fault locator are applied in three-terminal application. Table 2.8.1.1 shows type of fault locator in integral communication and three-terminal application.

Table 2.8.1.1 Type of Fault Location

Communication system		Fault location calculated by
Ring-topology		Relay A: Local and remote ends data Relay B: Local and remote ends data Relay C: Local and remote ends data
Chain-topology		Relay A: Local end data Relay B: Local and remote ends data Relay C: Local end data

The measurement result is expressed as a percentage (%) of the line length and the distance (km) and is displayed on the LCD on the relay front panel. In three-terminal application, however, the measurement result is expressed as a fault section instead of a percentage. It is also output to a local PC or RSM (relay setting and monitoring) system.

To measure the distance to fault, the fault locator requires minimum 3 cycles as a fault duration time.

In distance to fault calculations, the change in the current before and after the fault has occurred is used as a reference current, alleviating influences of the load current and arc voltage. As a result, the location error in fault location using only local end data is a maximum of ±2.5 km for faults at a distance of up to 100 km, and a maximum of ±2.5% for faults at a distance between 100 km and 399.9 km. The location error in fault location using local and remote ends data is a maximum of ±2.0 km for faults at a distance of up to 100 km, and a maximum of ±2.0% for faults at a distance between 100 km and 399.9 km at the positive differential current more than In (rated current). If a fault current is more than 25×In, the location error is larger than above. (See Appendix K.)

Note: If abnormal settings far from actual transmission line impedance, e.g. resistance value so larger than reactance value, etc., are done, the location error will be larger.

The fault locator cannot correctly measure the distance to fault during a power swing.

Fault location is enabled or disabled by setting "Fault locator" to "ON" or "OFF" on the "Fault record" screen in the "Record" sub-menu.

2.8.2 Starting Calculation

Calculation of the fault location cab be initiated by one of the following tripping signals.

- command protection trip
- zone 1 trip
- zone 2 trip
- zone 3 trip
- zone F trip
- zone 1 extension trip
- external main protection trip

2.8.3 Displaying Location

The measurement result is stored in the "Fault record" and displayed on the LCD of the relay front panel or on the local or remote PC. For displaying on the LCD, see Section 4.2.3.1.

In the two-terminal line, the location is displayed as a distance (km) and a percentage (%) of the line length.

In the three-terminal line, the location is displayed as a distance (km). To discriminate faults in the second and the third section, the fault section is supplemented.

"∗OB", "∗OJ", and "∗NC" and may display after the location result. These mean the followings:

∗OB: Fault point is over the boundary.

∗OJ: Fault point is over the junction in three-terminal line application.

∗NC: Fault calculation has not converged.

In case of a fault such as a fault duration time is too short, the fault location is not displayed and the "---" marked is displayed.

2.8.4 Distance to Fault Calculation

2.8.4.1 Fault location using the only local end data

The distance to fault x_1 is calculated from equation (1) and (2) using the local voltage and current of the fault phase and a current change before and after the fault occurrence. The current change before and after the fault occurrence represented by Iβ" and Iα" is used as the reference current. The impedance imbalance compensation factor is used to maintain high measuring accuracy even when the impedance of each phase has great variations.

Distance calculation for phase fault (in the case of BC-phase fault)

$$x_1 = \frac{I_m(V_{bc} \cdot I\beta'') \times L}{\{I_m(R_1 \cdot I_{bc} \times I\beta'') + R_e(X_1 \cdot I_{bc} \cdot I\beta'')\} \times K_{bc}} \qquad (1)$$

where,

V_{bc} = fault voltage between faulted phases = $V_b - V_c$

I_{bc} = fault current between faulted phases = $I_b - I_c$

$I\beta''$ = change of fault current before and after fault occurrence = $(I_b\text{-}I_c) - (I_{Lb}\text{-}I_{Lc})$

I_{Lb}, I_{Lc} = load current

R_1 = resistance component of line positive sequence impedance

X_1 = reactance component of line positive sequence impedance

K_{bc} = impedance imbalance compensation factor

$I_m(\ )$ = imaginary part in parentheses

$R_e(\ )$ = real part in parentheses

L = line length (km)

Distance calculation for earth fault (in the case of A-phase earth fault)

$$x_1 = \frac{I_m(V_a \cdot I_\alpha'') \times L}{\{I_m(R_1 \cdot I_\alpha \cdot I_\alpha'' + R_0 \cdot I_{0S} \cdot I_\alpha'' + R_{0m} \cdot I_{0m} \cdot I_\alpha'') + R_e(X_1 \cdot I_\alpha \cdot I_\alpha'' + X_0 \cdot I_{0S} \cdot I_\alpha'' + X_{0m} \cdot I_{0m} \cdot I_\alpha'')\} \times K_a} \qquad (2)$$

where,

V_a = fault voltage

I_α = fault current = $(2I_a - I_b - I_c)/3$

I_α'' = change of fault current before and after fault occurrence

$= \dfrac{2I_a - I_b - I_c}{3} - \dfrac{2I_{La} - I_{Lb} - I_{Lc}}{3}$

I_a, I_b, I_c = fault current

I_{La}, I_{Lb}, I_{Lc} = load current

I_{0s} = zero sequence current

I_{0m} = zero sequence current of parallel line

R_1 = resistance component of line positive sequence impedance

X_1 = reactance component of line positive sequence impedance

R_0 = resistance component of line zero sequence impedance

X_0 = reactance component of line zero sequence impedance

R_{0m} = resistance component of line mutual zero sequence impedance

X_{0m} = reactance component of line mutual zero sequence impedance

K_a = impedance imbalance compensation factor

$I_m(\ )$ = imaginary part in parentheses

$R_e(\ )$ = real part in parentheses

L = line length (km)

Equations (1) and (2) are general expressions when lines are treated as having lumped constants and these expressions are sufficient for lines within 100 km. For lines exceeding 100 km, influences of the distributed capacitance must be considered. For this fault locator, the following equation is used irrespective of line length to find the compensated distance x_2 with respect to distance x_1 which was obtained in equation (1) or (2).

$$x_2 = x_1 - k^2 \cdot \frac{x_1^3}{3} \qquad (3)$$

where,

k = propagation constant of the protected line = 0.001km^{-1} (fixed)

2.8.4.2 Fault location using the local and remote end data

Calculation Principle

In the case of a two-terminal line as shown in Figure 2.8.4.1, the relationship between the voltages at the local and remote terminals and the voltage at the fault point are expressed by Equations (1) and (2).

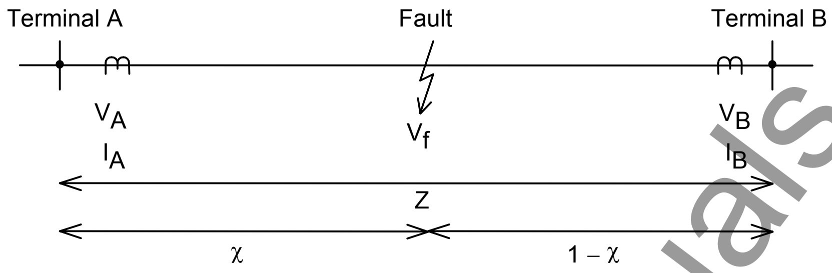


Figure 2.8.4.1 Two-terminal Model

$$V_A - \chi Z I_A = V_f \qquad (1)$$

$$V_B - (1 - \chi) Z I_B = V_f \qquad (2)$$

where,

- V_A = voltage at terminal A
- I_A = current at terminal A
- V_B = voltage at terminal B
- I_B = current at terminal B
- χ = distance from terminal A to fault point as a ratio to line length
- V_f = voltage at fault point
- Z = line impedance

The distance χ is given by Equation (3) by eliminating V_f,

$$\chi = (V_A - V_B + ZI_B) / Z(I_A + I_B) \qquad (3)$$

As $(I_A + I_B)$ is equal to differential current Id, χ is calculated with the differential current obtained as follows:

$$\chi = (V_A - V_B + ZI_B) / ZI_d \qquad (4)$$

The distance calculation principle mentioned above can be applied to three-terminal lines. But in case of three-terminal application, the distance measurement equation varies according to which zone the fault is in, this side or beyond the junction. Terminal A measures the distance using Equations (5), (6) or (7).

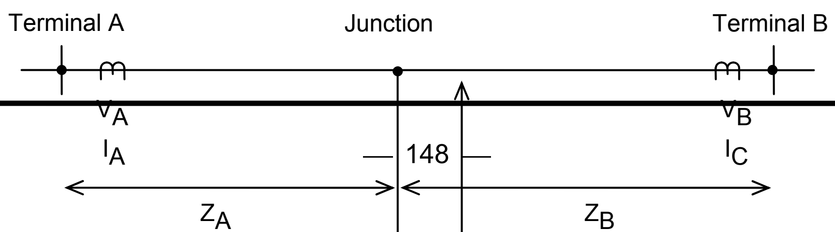


Figure 2.8.4.2 Three-terminal Model

$$\chi_A = (V_A - V_B + Z_A(I_B + I_C) + Z_B I_B) / Z_A I_d \qquad (5)$$

$$\chi_{JB} = (V_A - V_B + Z_B I_B - Z_A I_A) / Z_B I_d \qquad (6)$$

$$\chi_{JC} = (V_A - V_C + Z_C I_C - Z_A I_A) / Z_C I_d \qquad (7)$$

where,

$I_d = I_A + I_B + I_C$

V_C = voltage at terminal C

I_C = current at terminal C

χ_A = distance from terminal A to fault point as a ratio to line length from terminal A to junction

χ_{JB} , χ_{JC} = distance from junction to fault point as a ratio to line length from junction to terminal B or C

Z_A ,Z_B ,Z_C = impedance from each terminal to junction

Firstly, χ_A is calculated using Equation (5) assuming that the fault is between terminal A and the junction. If the result does not match the input line data, then χ_{JB} is calculated using Equation (6) assuming that the fault is between the junction and terminal B. If the result does not match the input line data, the calculation is repeated using Equation (7) assuming that the fault is between the junction and terminal C.

Calculation Method

In the calculation, the sequence quantities of voltages and currents are employed instead of the phase quantities. Thus, equation (4) is combined with Equation (8) to give:

$$\chi = \frac{V_{A1} - V_{B1} + (Z_{11} I_{B1} + Z_{12} I_{B2} + Z_{10} I_{B0})}{Z_{11} I_{d1} + Z_{12} I_{d2} + Z_{10} I_{d0}} \qquad (8)$$

where,

V_{A1} = positive sequence voltage at terminal A

V_{B1} = positive sequence voltage at terminal B

I_{B1}, I_{B2} and I_{B0} = positive, negative and zero sequence current at terminal B

I_{d1},I_{d2} and I_{d0} = positive, negative and zero sequence differential current

Z_{11}, Z_{12} and Z_{10} are expressed by the following equations assuming that $Z_{ab} = Z_{ba}$, $Z_{bc} = Z_{cb}$ and $Z_{ca} = Z_{ac}$:

$$
\begin{aligned}
Z_{11} &= (Z_{aa} + Z_{bb} + Z_{cc} - Z_{ab} - Z_{bc} - Z_{ca})/3 \\
Z_{12} &= (Z_{aa} + a^2 Z_{bb} + aZ_{cc} + 2(aZ_{ab} + Z_{bc} + a^2 Z_{ca}))/3 \qquad (9) \\
Z_{10} &= (Z_{aa} + aZ_{bb} + a^2 Z_{cc} - a^2 Z_{ab} - Z_{bc} - aZ_{ca})/3
\end{aligned}
$$

where, Z_{aa}, Z_{bb} and Z_{cc} are self-impedances and Z_{ab}, Z_{bc} and Z_{ca} are mutual impedances.

If $Z_{aa} = Z_{bb} = Z_{cc}$ and $Z_{ab} = Z_{bc} = Z_{ca}$, then Z_{11} is equal to the positive sequence impedance, and Z12 and Z10 are zero. For setting, the positive-sequence impedance is input using the expression of the resistive component R1 and reactive component X1.

2.8.5 Setting

The setting items necessary for the fault location and their setting ranges are shown in the table below. The settings of R_{0m} and X_{0m} are only required for the double circuit lines. The reactance and resistance values are input in expressions on the secondary side of CT and VT.

When there are great variations in the impedance of each phase, equation (10) is used to find the positive sequence impedance, zero sequence impedance and zero sequence mutual impedance, while equation (11) is used to find imbalance compensation factors K_{ab} to K_a.

When variations in impedance of each phase can be ignored, the imbalance compensation factor is set to 100%.

$$
\left.
\begin{aligned}
Z_1 &= \{(Z_{aa} + Z_{bb} + Z_{cc}) - (Z_{ab} + Z_{bc} + Z_{ca})\}/3 \\
Z_0 &= \{(Z_{aa} + Z_{bb} + Z_{cc}) + 2(Z_{ab} + Z_{bc} + Z_{ca})\}/3 \\
Z_{0m} &= (Z_{am} + Z_{bm} + Z_{cm})/3
\end{aligned}
\right] \qquad (10)
$$

$$
\left.
\begin{aligned}
K_{ab} &= \{(Z_{aa} + Z_{bb})/2 - Z_{ab}\}/Z_1 \\
K_{bc} &= \{(Z_{bb} + Z_{cc})/2 - Z_{bc}\}/Z_1 \\
K_{ca} &= \{(Z_{cc} + Z_{aa})/2 - Z_{ca}\}/Z_1 \\
K_a &= \{Z_{aa} - (Z_{ab} + Z_{ca})/2\}/Z_1 \\
K_b &= \{Z_{bb} - (Z_{bc} + Z_{ab})/2\}/Z_1 \\
K_c &= \{Z_{cc} - (Z_{ca} + Z_{ab})/2\}/Z_1
\end{aligned}
\right] \qquad (11)
$$

The scheme switch [FL-Z0B] is used when zero sequence compensation of the parallel line is not performed in double circuit line.

The switch [FL-Z0B] is set to "OFF" when the current input to the earth fault measuring element is compensated by residual current of the parallel line. When not, the switch [FL-Z0B] is set to "ON" and Z0B-L, Z0B-R, R_{0m} and X_{0m} are set.

Z0B-L = zero sequence back source impedance at local terminal

Z0B-R = zero sequence back source impedance at remote terminal

In double circuit line, however, it is recommended that the current input compensated by residual current of the parallel line is used in order for the earth fault measuring element to correctly measure the impedance.

In the case of single circuit line, the switch [FL-Z0B] is set to "OFF".

Item	Range	Step	Default	Remarks
Section 1				
R_1	0.0 - 199.99 Ω	0.01 Ω	0.20Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0Ω) (*)	
X_1	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
R_0	0.0 - 999.99 Ω	0.01 Ω	0.70Ω	
	(0.0 - 999.9 Ω	0.1 Ω	3.5Ω)	
X_0	0.0 - 199.99 Ω	0.01 Ω	6.80Ω	
	(0.0 - 999.9 Ω	0.1 Ω	34.0Ω)	
R_{0m}	0.0 - 199.99 Ω	0.01 Ω	0.20Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0Ω)	
X_{0m}	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
K_{ab}	80 - 120%	1%	100%	
K_{bc}	80 - 120%	1%	100%	
K_{ca}	80 - 120%	1%	100%	
K_a	80 - 120%	1%	100%	
K_b	80 - 120%	1%	100%	
K_c	80 - 120%	1%	100%	
Line	0.0 - 399.9 km	0.1 km	50.0km	Line length from local terminal to junction if three-terminal application
FL-Z0B	OFF/ON		OFF	
ZOB-L	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
ZOB-R	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
UVLS	50 – 100V	1V	77V	Phase fault detection
Section 2				For three terminal line
$2R_1$	0.0 - 199.99 Ω	0.01 Ω	0.20Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0Ω)	
$2X_1$	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
2Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from junction to remote terminal 1
Section 3				For three terminal line
$3R_1$	0.0 - 199.99 Ω	0.01 Ω	0.20Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0Ω)	
$3X_1$	0.0 - 199.99 Ω	0.01 Ω	2.00Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0Ω)	
3Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from junction to remote terminal 2

(*) Ohmic values shown in the parentheses are in the case of 1 A rating. Other ohmic values are in the case of 5A rating.

3. Technical Description

3.1 Hardware Description

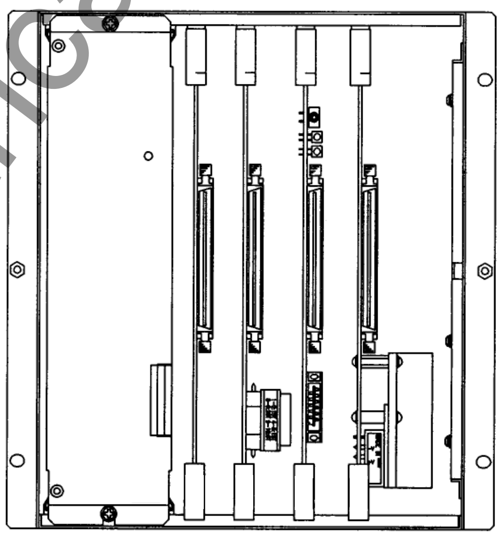
3.1.1 Outline of Hardware Modules

The GRZ100 models are classified into two types by their case size. Models 211, 214, 221, 224, 311 and 321 have type A case, while models 216, 226 and 323 have type B cases. Case outlines are shown in Appendix F.

The hardware structures of their models are shown in Figure 3.1.1.1 and Figure 3.1.1.2. The front view shows the equipment without the human machine interface module.

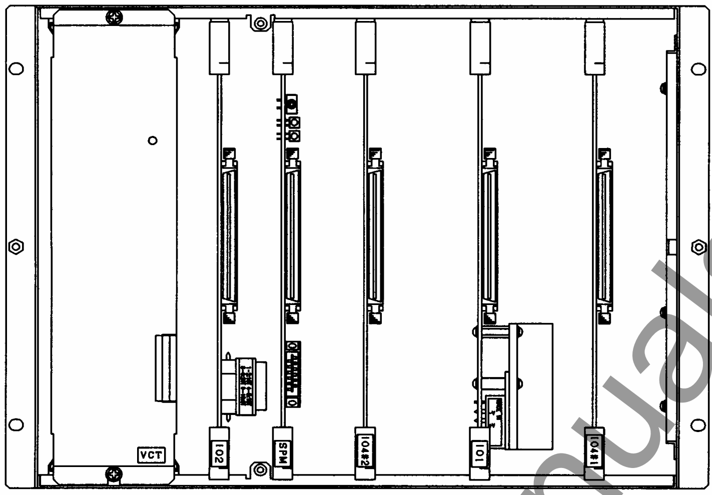
The GRZ100 consists of the following hardware modules. The human machine interface module is provided with the front panel. The hardware modules depend on the relay model.

- Transformer module (VCT)
- Signal processing module (SPM)
- Binary input and output module 1 (IO1)
- Binary input and output module 2 (IO2)
- Binary output module 3 (IO3)
- Binary input and output module 4 (IO4)
- Binary input and output module 5 (IO5)
- Binary input and output module 6 (IO6)
- Binary input and output module 8 (IO8)
- Human machine interface module (HMI)



IO#1: IO1(Model 211, 221, 311, 321), IO8(Model 214, 224)
IO#2: IO2
IO#3: IO3(Model 211, 221, 311, 321), IO6(Model 214, 224)

Figure 3.1.1.1 Hardware Structure (Model: 211, 214, 221, 224, 311, 321)



IO#1: IO1(Model 323), IO8(Model 216, 226)
IO#2: IO2
IO#3: IO4(Model 323), IO5(Model 216, 226)
IO#4: IO4

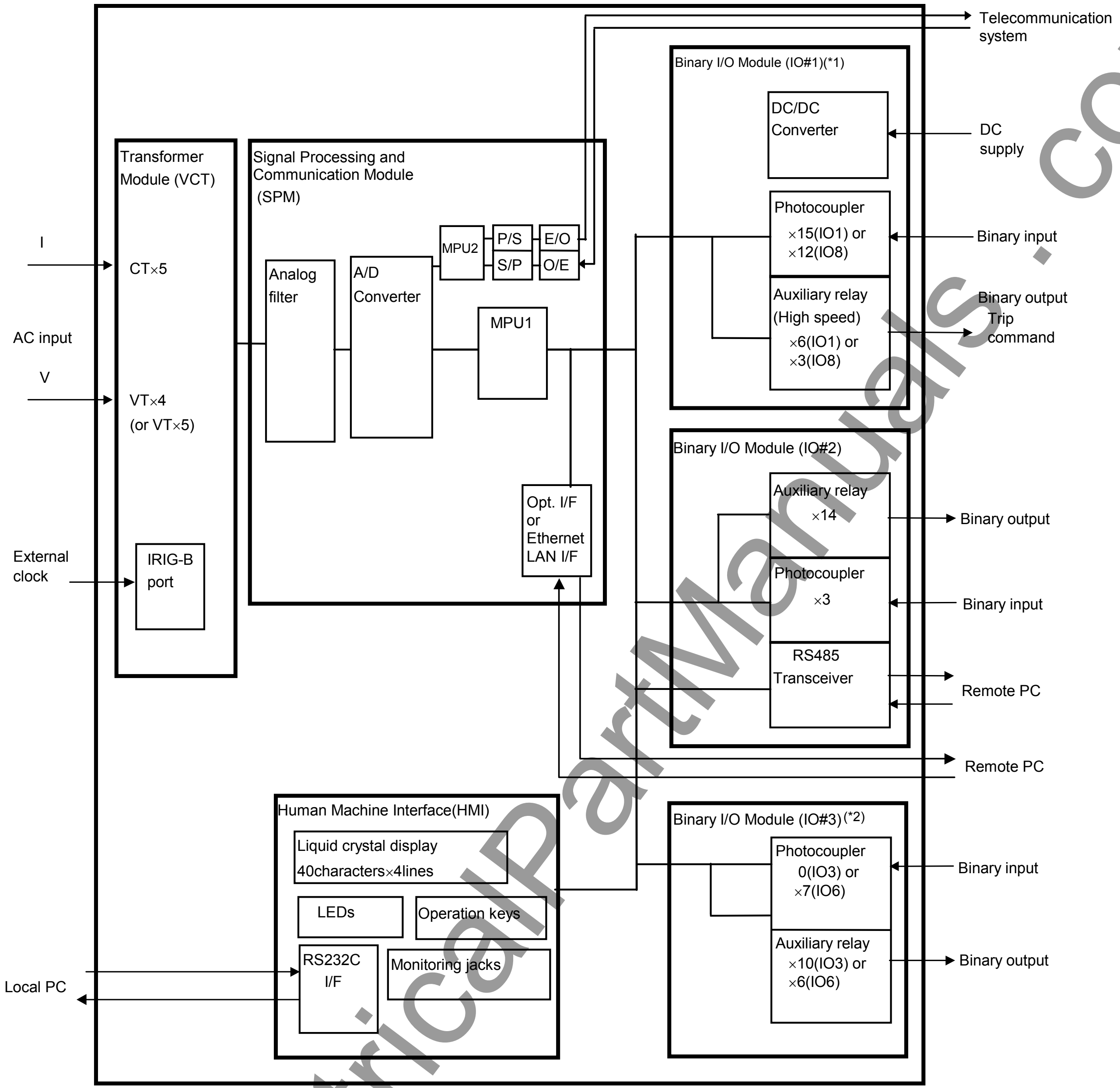
Figure 3.1.1.2 Hardware Structure (Model: 216, 226, 323)

The relationship between each model and module used is as follows:

Module \ Models	211, 221 311, 321	214 224	216 226	323
VCT	×	×	×	×
SPM	×	×	×	×
IO1	×			×
IO2	×	×	×	×
IO3	×			
IO4			×	×
IO5			×	×
IO6		×		
IO8		×	×	
HMI	×	×	×	×

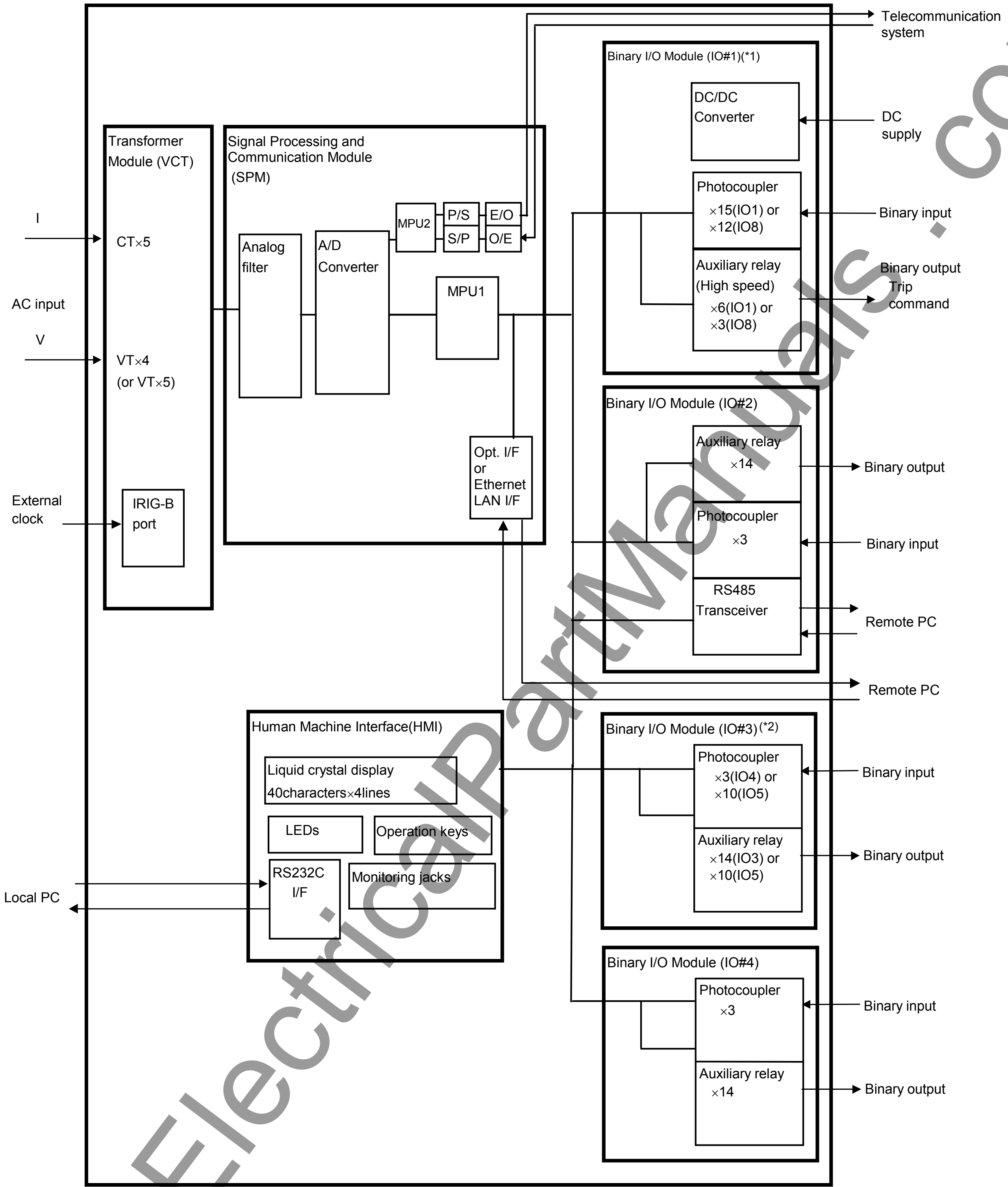
Note: The SPM module is not interchangeable among different models.

The hardware block diagrams of the GRZ100 using these modules are shown in Figure 3.1.1.3 and Figure 3.1.1.4.



(*1): IO1 required for models 211, 221, 311 and 321
IO8 required for models 214 and 224
(*2): IO3 required for models 211, 221, 311, 321 and 323
IO6 required for models 214 and 224

Figure 3.1.1.3 Hardware Block Diagram (Models 211, 214, 221, 224, 311 and 321)



(*1): IO1 required for model 323
IO8 required for models 216 and 226
(*2): IO4 required for model 323
IO5 required for models 216 and 226

Figure 3.1.1.4 Hardware Block Diagram (Models 216, 226 and 323)

3.1.2 Transformer Module

The transformer module (VCT module) provides isolation between the internal and external AC circuits through an auxiliary transformer and transforms the magnitude of AC input signals to suit the electronic circuits. The AC input signals are as follows:

- three-phase currents (I_a, I_b and I_c)
- residual current (3 I_0)
- residual current of parallel line (3 I_{0m})
- three-phase voltages (V_a, V_b and V_c)
- autoreclose reference voltage (V_{s1})
- autoreclose reference voltage (V_{s2})

Figure 3.1.2.1 shows a block diagram of the transformer module. There are 5 auxiliary CTs mounted in the transformer module, and 4 or 5 auxiliary VTs depending on the relay model. (The relationship between the relay model and number of AC input signals, is given in Table 3.2.1.1.)

"$3I_{0m}$" in Figure 3.1.2.1 is the residual current from the parallel line in a double-circuit line, and is used for mutual coupling compensation. V_{s1} and V_{s2} are the busbar or line voltages necessary for the voltage and synchronism check for the autoreclose.

The transformer module is also provided with an IRIG-B port. This port collects the serial IRIG-B format data from the external clock for synchronization of the relay calendar clock. The IRIG-B port is insulated from the external circuit by a photo-coupler. A BNC connector is used as the input connector.

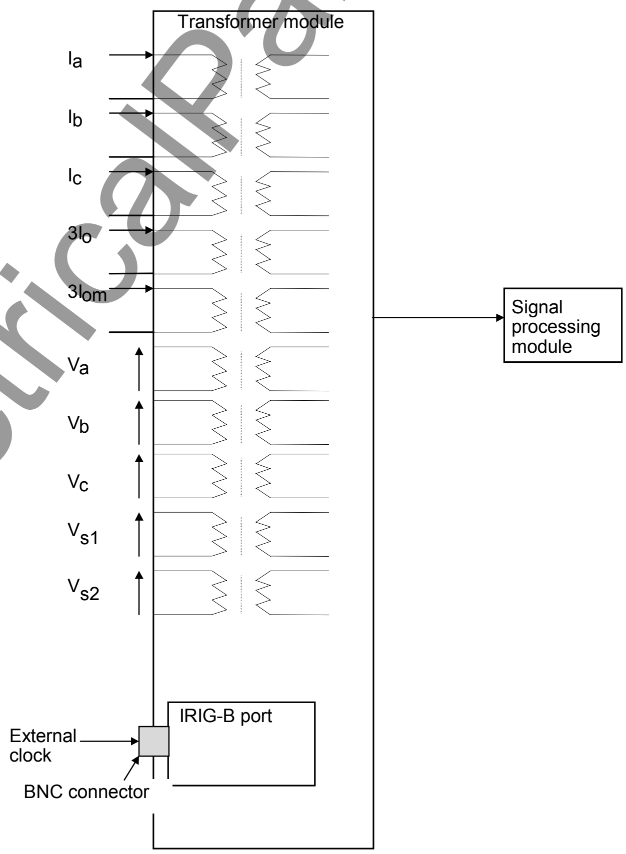


Figure 3.1.2.1 Transformer Module

3.1.3 Signal Processing Module

The signal processing and communication module (SPM) incorporates a signal processing circuit and a telecommunication control circuit. Figure 3.1.3.1 shows the block diagram. The telecommunication control circuit is incorporated in the sub-module GCOM.

The signal processing circuit consists of an analog filter, multiplexer, analog to digital (A/D) converter, main processing unit (MPU1) and memories (RAM and ROM), and executes all kinds of processing including protection, measurement, recording and display.

The analog filter performs low-pass filtering for the corresponding current and voltage signals.

The A/D converter has a resolution of 16 bits and samples input signals at sampling frequencies of 2400Hz (at 50Hz) and 2880Hz (at 60Hz).

The MPU1 carries out operations for the measuring elements and scheme logic operations for protection, recording, displaying and signal transmission control. It implements 60 MIPS and uses two RISC (Reduced Instruction Set Computer) type 32-bit microprocessors.

The telecommunication control circuit consists of MPU2 executing control processing of local and received data, memories (RAM and ROM), parallel-to-serial and serial-to-parallel data converter, and electrical-to-optical and optical-to-electrical converter.

The SPM can be provide with Optical interface or Ethernet LAN interface for serial communication system.

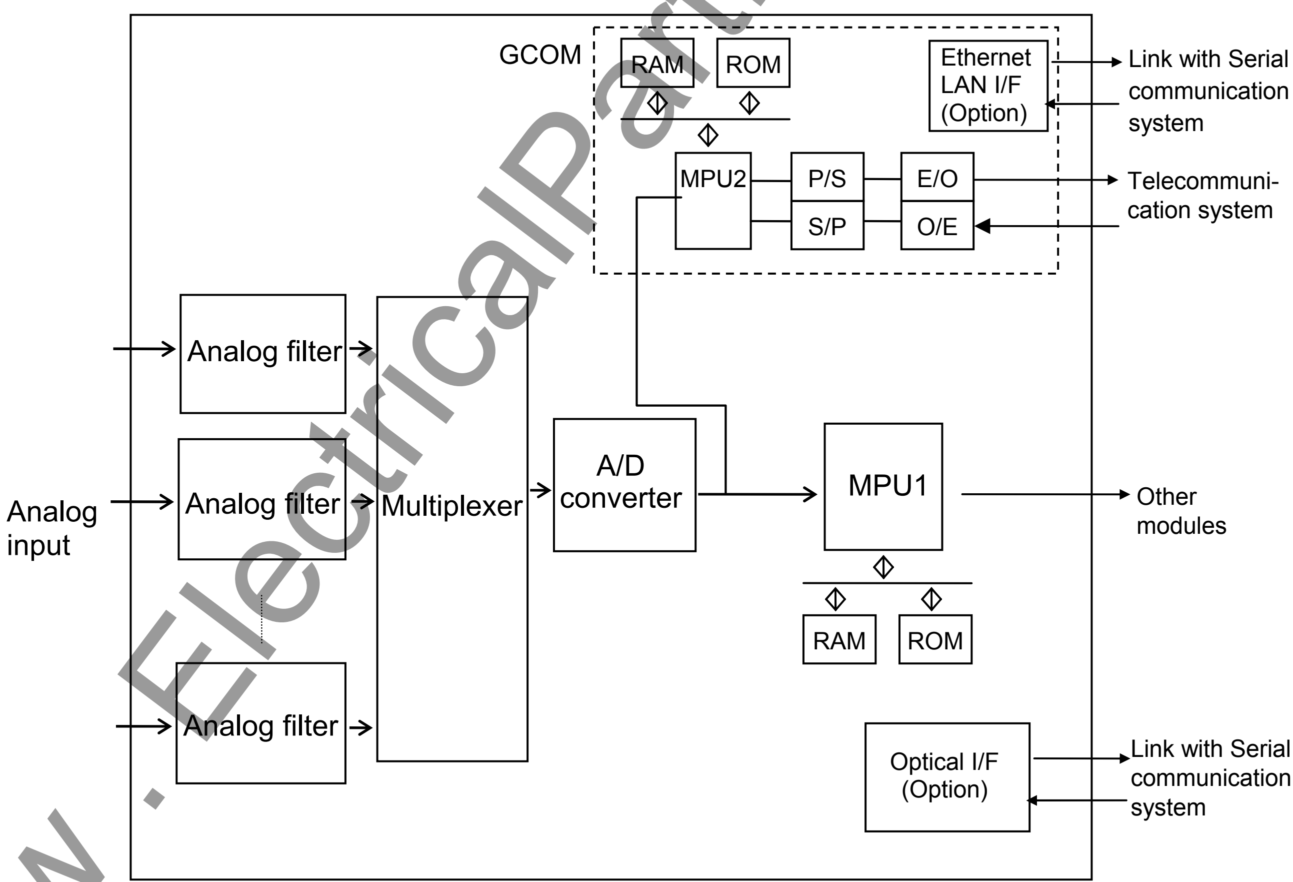


Figure 3.1.3.1 Signal Processing and Communication Module

3.1.4 Binary Input and Output Module

3.1.4.1 IO1 and IO8 Module

IO1 and IO8 provide a DC/DC converter, binary inputs and binary outputs for tripping.

As shown in Figure 3.1.4.1, the IO1 module incorporates a DC/DC converter, 15 photo-coupler circuits (BI) for binary input signals and 6 auxiliary relays (TP-A1 to TP-C2) dedicated to the circuit breaker tripping command.

As shown in Figure 3.1.4.2, the IO8 module incorporates a DC/DC converter, 12 photo-coupler circuits (BI) for binary input signals and 3 auxiliary relays (TP) dedicated to the circuit breaker tripping command. The 12 binary inputs have dedicated positive and negative inputs suitable for double-pole switching.

The input voltage rating of the DC/DC converter is 24V, 48V, 110V/125V or 220V/250V. The normal range of input voltage is −20% to +20%.

The six or three tripping command auxiliary relays are the high-speed operation type and have one normally open output contact.

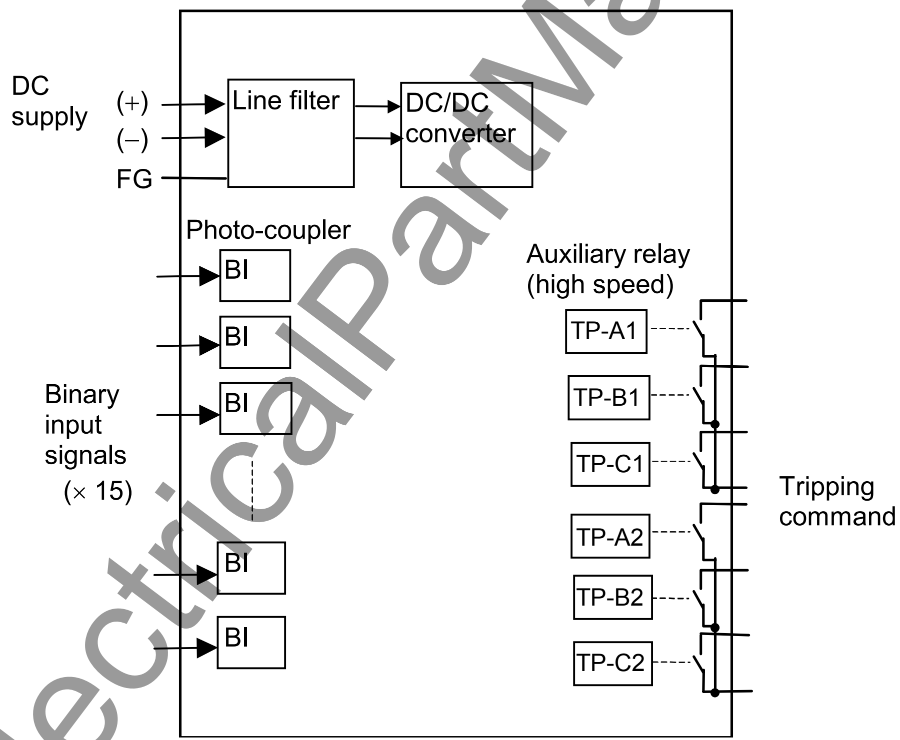


Figure 3.1.4.1 IO1 Module

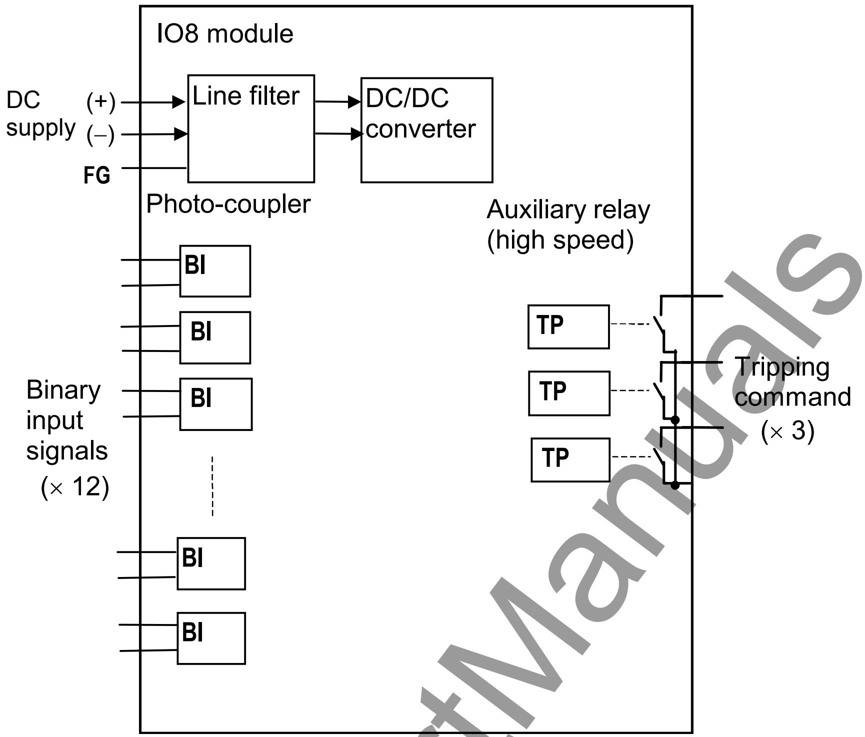


Figure 3.1.4.2 IO8 Module

3.1.4.2 IO2 Module

As shown in Figure 3.1.4.3, the IO2 module incorporates 3 photo-coupler circuits (BI) for binary input signals, 14 auxiliary relays (BOs and FAIL) for binary output signals and an RS485 transceiver.

The auxiliary relay FAIL has one normally closed contact, and operates when a relay failure or abnormality in the DC circuit is detected. Each BO has one normally open contact. BO13 is a high-speed operation type.

The RS485 is used for the link with serial communication system such as RSM (Relay Setting and Monitoring) or IEC60870-5-103 etc. The external signal is isolated from the relay internal signal.

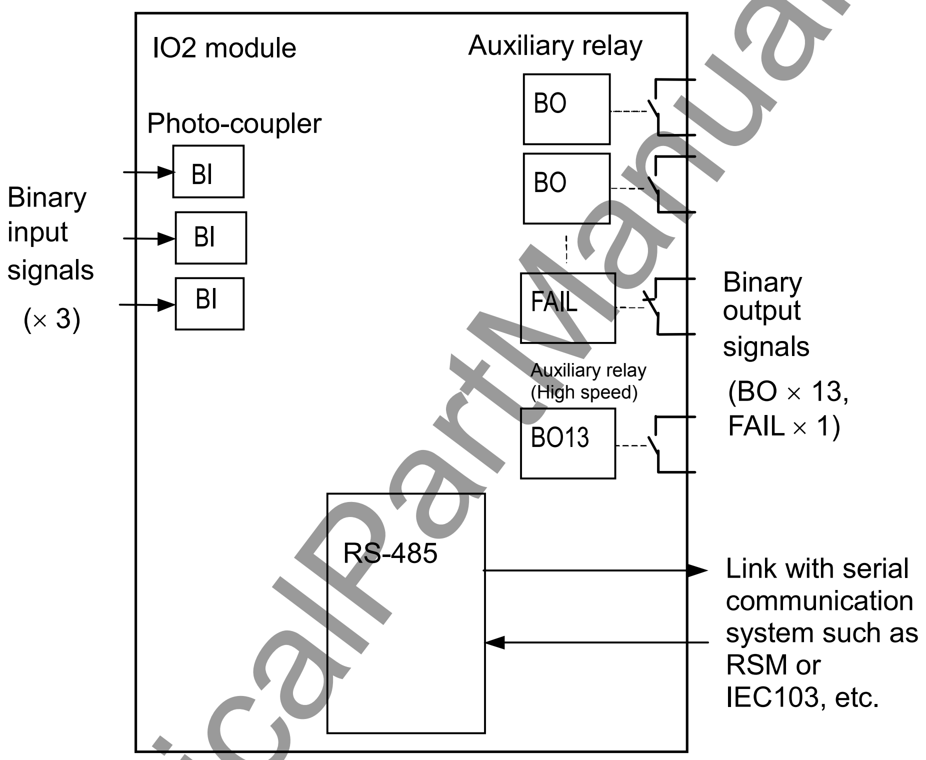


Figure 3.1.4.3 IO2 Module

3.1.4.3 IO3 and IO4 Modules

The IO3 and IO4 modules are used to increase the number of binary outputs.

The IO3 module incorporates 10 auxiliary relays (BO) for binary outputs. The IO4 module incorporates 14 auxiliary relays (BO) for binary outputs and 3 photo-coupler circuits (BI). All auxiliary relays each have one normally open contact.

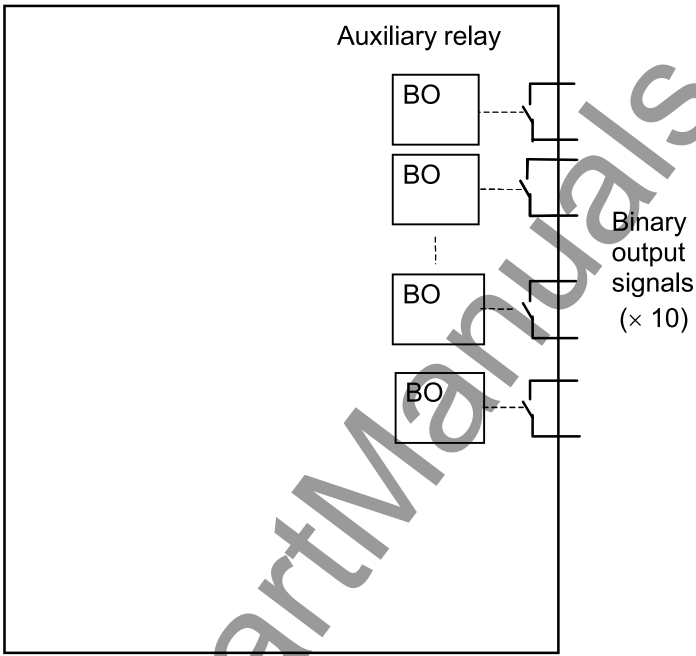


Figure 3.1.4.4 IO3 Module

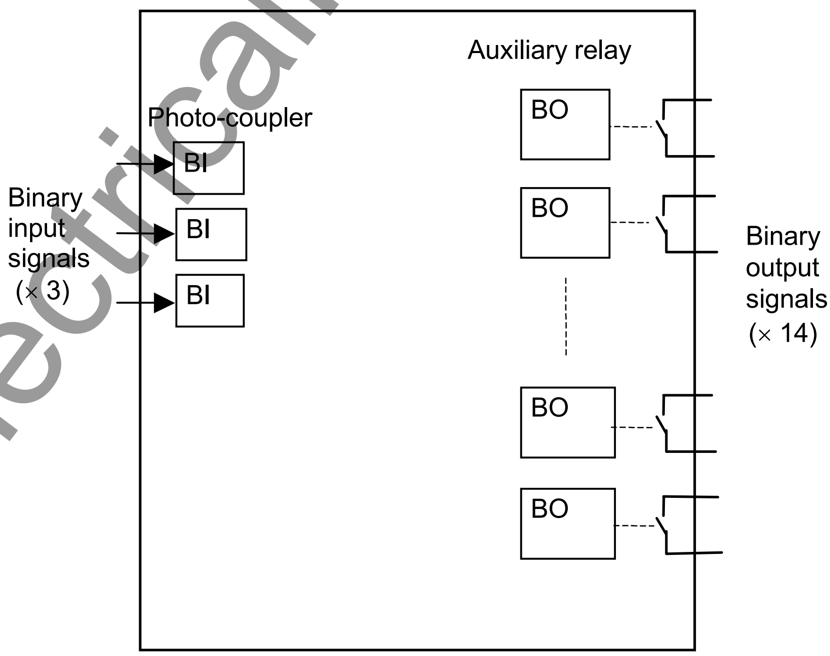


Figure 3.1.4.5 IO4 Module

3.1.4.4 IO5 and IO6 Modules

The IO5 and IO6 modules are used to increase the number of binary inputs and outputs.

The IO5 module incorporates 10 photo-coupler circuits (BI) for binary inputs and 10 auxiliary relays (BO) for binary outputs. The IO6 module incorporates 7 photo-coupler circuits (BI) for binary inputs and 6 auxiliary relays (BO) for binary outputs. All auxiliary relays each have one normally open contact.

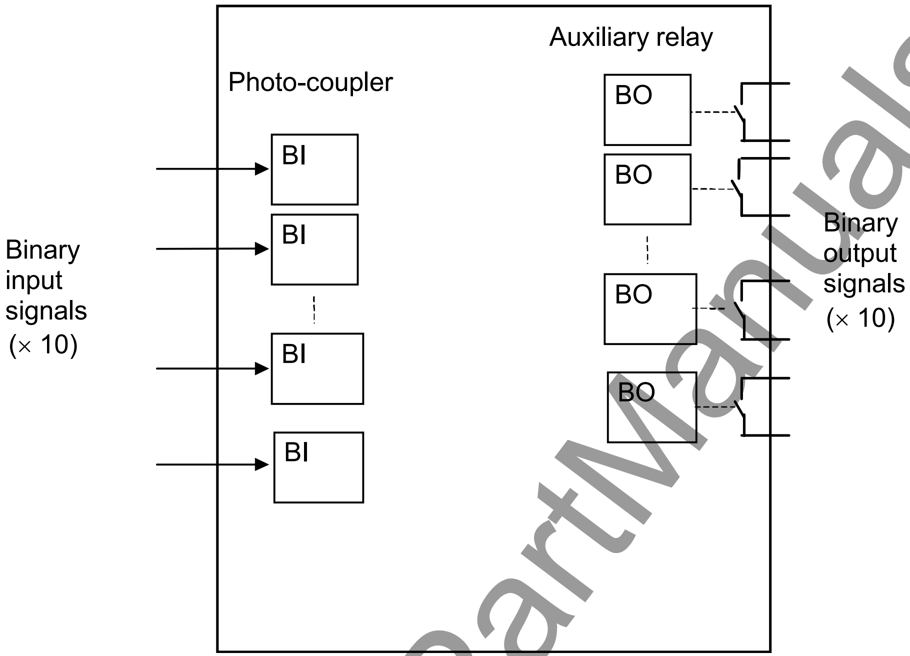


Figure 3.1.4.6 IO5 Module

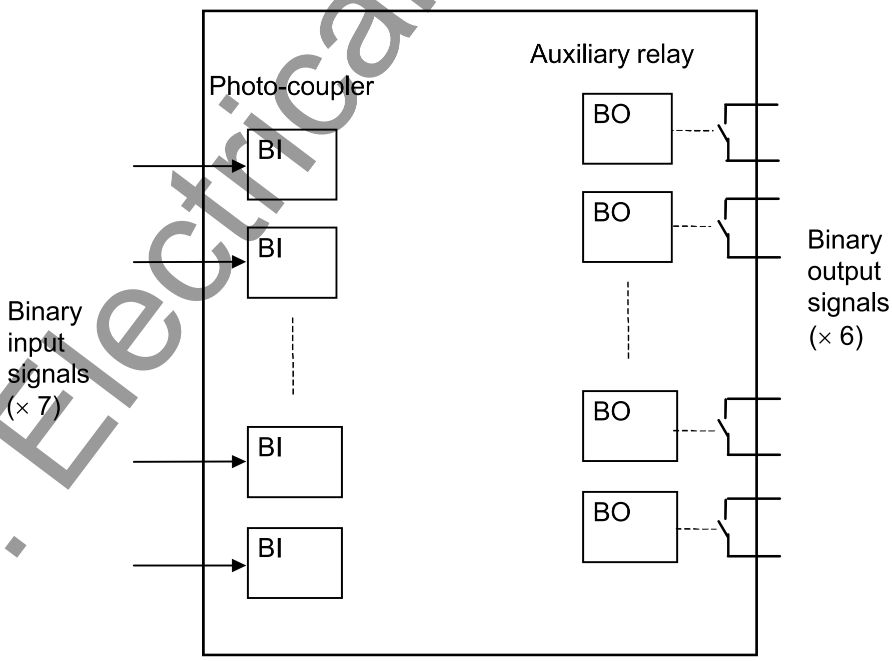


Figure 3.1.4.7 IO6 Module

3.1.5 Human Machine Interface (HMI) Module

The operator can access the GRZ100 via the human machine interface (HMI) module. As shown in Figure 3.1.5.1, the HMI module has a liquid crystal display (LCD), light emitting diodes (LED), view and reset keys, operation keys, monitoring jacks and an RS232C connector on the front panel.

The LCD consists of 40 columns by 4 rows with a backlight and displays record, status and setting data.

There are a total of 8 LED indicators and their signal labels and LED colors are defined as follows:

Label	Color	Remarks
IN SERVICE	Green	Lit when relay is in service.
TRIP	Red	Lit when trip command is issued.
ALARM	Red	Lit when failure is detected.
TESTING	Red	Lit when automatic monitoring function is off.
LED1	Red	Configurable LED to assign signals with or without latch when relay operates.
LED2	Red	Configurable LED to assign signals with or without latch when relay operates.
LED3	Red	Configurable LED to assign signals with or without latch when relay operates.
LED4	Red	Configurable LED to assign signals with or without latch when relay operates.

LED1 to LED4 are user-configurable. Each is driven via a logic gate which can be programmed for OR gate or AND gate operation. Further, each LED has a programmable reset characteristic, settable for instantaneous drop-off, or for latching operation. For the setting, see Section 4.2.6.10. For the operation, see Section 4.2.1.

The GRZ100 provides the scheme switch [AOLED] which controls whether the TRIP LED is lit or not by an output of alarm element such as THM_ALARM, OV∗2_ALARM and UV∗2_ALARM, etc.

The $\boxed{\text{VIEW}}$ key starts the LCD indication and switches between windows. The reset key clears the LCD indication and turns off the LCD backlight.

The operation keys are used to display the record, status and setting data on the LCD, input the settings or change the settings.

The monitoring jacks and two pairs of LEDs, A and B, on top of the jacks can be used while the test mode is selected in the LCD window. Signals can be displayed on LED A or LED B by selecting the signal to be observed from the "Signal List" or "Variable Timer List" and setting it in the window and the signals can be output to an oscilloscope via the monitoring jacks. (For the "Signal List" or "Variable Timer List", see Appendix B or C.)

The RS232C connector is a 9-way D-type connector for serial RS232C connection. This connector is used for connection with a local personal computer.

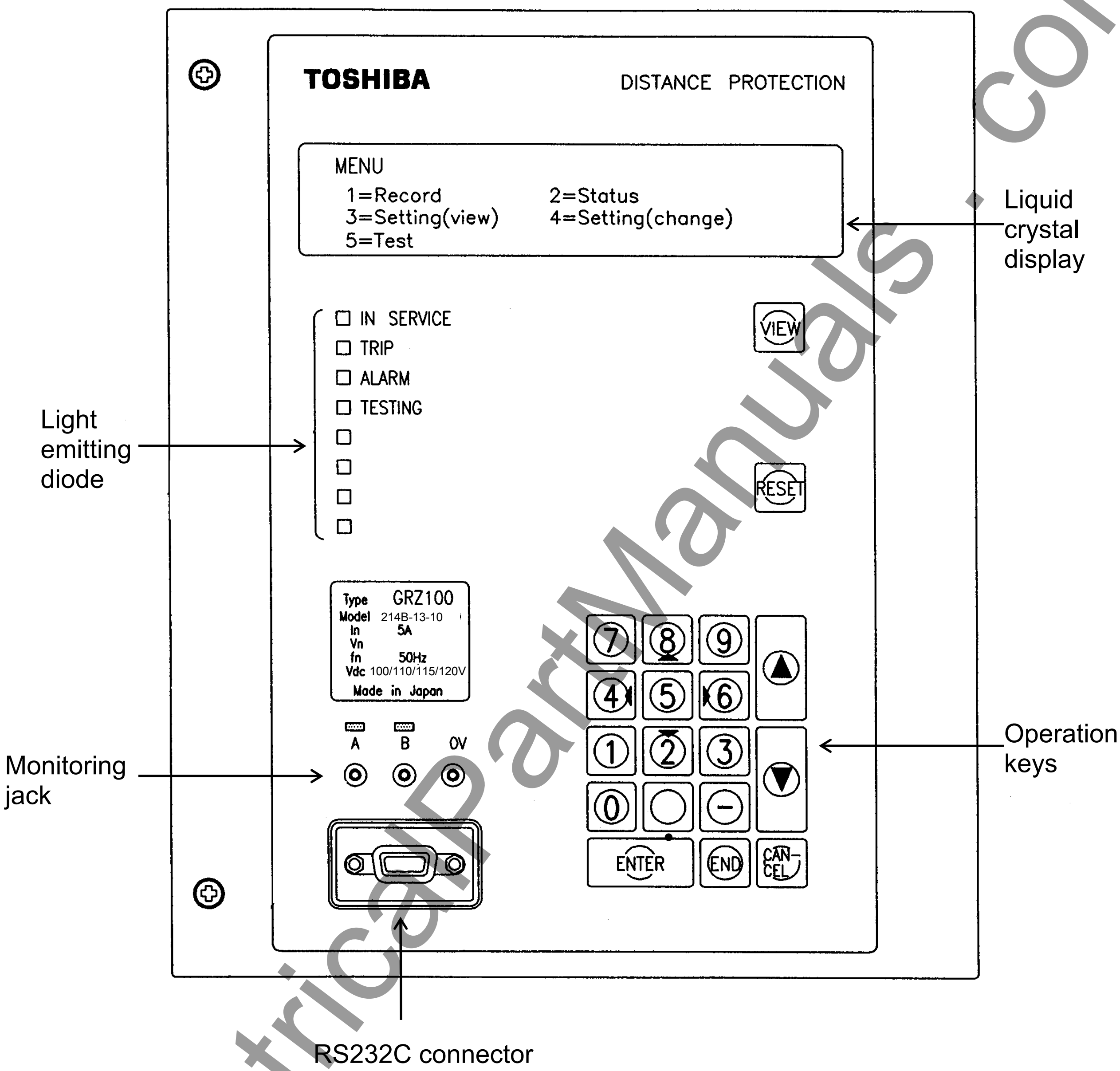


Figure 3.1.5.1 Front Panel

3.2 Input and Output Signals

3.2.1 Input Signals

AC input signals

Table 3.2.1.1 shows the AC input signals necessary for each of the GRZ100 models and their respective input terminal numbers. The AC input signals are input via terminal block TB1 for all models.

For single or double busbar applications, one voltage signal is required for voltage and synchronism check of autoreclose function, while for one-and-a-half circuit breaker arrangements, two voltage signals are required.

Table 3.2.1.1 AC Input Signals

Terminal No.	GRZ100-211, 214, 216, 221, 224, 226	GRZ100-311, 321, 323
1-2	A phase Current	A phase Current
3-4	B phase Current	B phase Current
5-6	C phase Current	C phase Current
7-8	Residual Current (Protected line)	Residual Current (Protected line)
9-10	Residual Current (Parallel line)	Residual Current (Parallel line)
11-14	A phase Voltage	A phase Voltage
12-14	B phase Voltage	B phase Voltage
13-14	C phase Voltage	C phase Voltage
15-16	Voltage for Autoreclose	Voltage for Autoreclose
17-18		Voltage for Autoreclose
20	(earth)	(earth)

Binary input signals

Input signals are configurable and depend on the GRZ100 models. See Appendix G for the default settings and external connections.

The binary input circuit of the GRZ100 is provided with a logic level inversion function as shown in Figure 3.2.1.1. Each input circuit has a binary switch BISW which can be used to select either normal or inverted operation. This allows the inputs to be driven either by normally open or normally closed contact.

If a signal is not input, the function concerned is disabled.

Further, all binary input functions are programmable by PLC (Programmable Logic Controller) function.

The default setting of the binary input is shown in Table 3.2.2.

The operating voltage (pick-up) of binary input signal is typical 74V DC at 110V/125V DC rating and 138V DC at 220/250V DC. The minimum operating voltage is 70V DC at 110/125V DC rating and 125V DC at 220/250V DC.

Table 3.2.1.2 (a) Default Binary Input Allocation of Model 211B, 221B

Module Name	BI No.	Contents	Setting		
			Signal No. & Signal Name		Norm or Inv
IO#1	BI1	CB AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP 1 (3-PHASE TRIP)	1724	TR1_3PTP	
	BI5	Z1X INITIATION	1540	Z1X_INIT	
	BI6	EXTERNAL MCCB TRIP	1541	EXT_VTF	
	BI7	DISCONNECTOR NORMALLY OPEN CONTACT	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY CLOSE CONTACT	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1615	CRT_BLOCK	
	BI10	CB READY FOR AUTORECLOSE	1545	CB1_READY	
	BI11	Spare		Spare	
	BI12	BLOCK AUTORECLOSE	1544	ARC_BLOCK	
	BI13	INDICATION RESET	1548	IND.RESET	
	BI14	MAIN PROTECTION TRIP	1549	M-PROT_TRIP	
	BI15	MAIN PROTECTION IN SERVICE	1550	M-PROT_ON	
IO#2	BI16	EXTERNAL TRIP - A Ph	1552	EXT_TRIP-A	
	BI17	EXTERNAL TRIP - B Ph	1553	EXT_TRIP-B	
	BI18	EXTERNAL TRIP - C Ph	1554	EXT_TRIP-C	

Table 3.2.1.2 (b) Default Binary Input Allocation of Model 214B, 224B

Module Name	BI No.	Contents	Setting		
			Signal No. & Signal Name		Norm or Inv
IO#1	BI1	CB AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP 1 (3-PHASE TRIP)	1724	TR1_3PTP	
	BI5	TRANSFER TRIP 2 (3-PHASE TRIP)	1725	TR2_3PTP	
	BI6	EXTERNAL MCCB TRIP	1541	EXT_VTF	
	BI7	DISCONNECTOR NORMALLY OPEN CONTACT	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY CLOSE CONTACT	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1615	CRT_BLOCK	
	BI10	INDICATION RESET	1548	IND.RESET	
	BI11	BLOCK PROTECTION	1584	PROT_BLOCK	
	BI12	Z1X INITIATION	1540	Z1X_INIT	
IO#2	BI16	EXTERNAL TRIP - A Ph	1552	EXT_TRIP-A	
	BI17	EXTERNAL TRIP - B Ph	1553	EXT_TRIP-B	
	BI18	EXTERNAL TRIP - C Ph	1554	EXT_TRIP-C	
IO#3	BI19	BLOCK IDMT OVERCURRENT PROTECTION	1595	OCI_BLOCK	
	BI20	BLOCK IDMT EARTH FAULT PROTECTION	1597	EFI_BLOCK	
	BI21	BLOCK OVERCURRENT PROTECTION	1594	OC_BLOCK	
	BI22	BLOCK DEF PROTECTION	1598	DEF_BLOCK	
	BI23	BLOCK EXTERNAL TRIP	1603	EXTTP_BLOCK	
	BI24	BLOCK STUB PROTECTION	1592	STUB_BLOCK	
	BI25	BLOCK SOTF PROTECTION	1593	SOTF_BLOCK	

Table 3.2.1.2(c) Default Binary Input Allocation of Model 216B, 226B

Module Name	BI No.	Contents	Setting		
			Signal No. & Signal Name		Norm or Inv
IO#1	BI1	CB AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP 1 (3-PHASE TRIP)	1724	TR1_3PTP	
	BI5	TRANSFER TRIP 2 (3-PHASE TRIP)	1725	TR2_3PTP	
	BI6	EXTERNAL MCCB TRIP	1541	EXT_VTF	
	BI7	DISCONNECTOR NORMALLY CLOSED	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY OPEN	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1615	CRT_BLOCK	
	BI10	INDICATION RESET	1548	IND.RESET	
	BI11	BLOCK PROTECTION	1584	PROT_BLOCK	
	BI12	Z1X INITIATION	1540	Z1X_INIT	
IO#2	BI16	EXTERNAL TRIP - A Ph	1552	EXT_TRIP-A	
	BI17	EXTERNAL TRIP - B Ph	1553	EXT_TRIP-B	
	BI18	EXTERNAL TRIP - C Ph	1554	EXT_TRIP-C	
IO#3	BI19	BLOCK IDMT OVERCURRENT PROTECTION	1595	OCI_BLOCK	
	BI20	BLOCK IDMT EARTH FAULT PROTECTION	1597	EFI_BLOCK	
	BI21	BLOCK OVERCURRENT PROTECTION	1594	OC_BLOCK	
	BI22	BLOCK DEF PROTECTION	1598	DEF_BLOCK	
	BI23	BLOCK EXTERNAL TRIP	1603	EXTTP_BLOCK	
	BI24	BLOCK STUB PROTECTION	1592	STUB_BLOCK	
	BI25	BLOCK SOTF PROTECTION	1593	SOTF_BLOCK	
	BI26	BLOCK AUTORECLOSE	1547	ARC_BLOCK	
	BI27	CB READY FOR AUTORECLOSE	1545	CB1_READY	
	BI28	BLOCK CB FAIL PROTECTION	1601	CBF_BLOCK	
IO#4	BI34	Spare			
	BI35	Spare			
	BI36	Spare			

Table 3.2.1.2(d) Default Binary Input Allocation of Model 311B, 321B

Module Name	BI No.	Contents	Setting		
			Signal No. & Signal Name		Norm or Inv
IO#1	BI1	CB AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP 1 (3-PHASE TRIP)	1724	TR1_3PTP	
	BI5	Z1X INITIATION	1540	Z1X_INIT	
	BI6	EXTERNAL MCCB TRIP	1541	EXT_VTF	
	BI7	DISCONNECTOR NORMALLY OPEN CONTACT	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY CLOSE CONTACT	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1615	CRT_BLOCK	
	BI10	CB1 READY FOR AUTORECLOSE	1545	CB1_READY	
	BI11	CB2 READY FOR AUTORECLOSE	1546	CB2_READY	
	BI12	BLOCK AUTORECLOSE	1544	ARC_BLOCK	
	BI13	INDICATION RESET	1548	IND.RESET	
	BI14	MAIN PROTECTION TRIP	1549	M-PROT_TRIP	
	BI15	MAIN PROTECTION IN SERVICE	1550	M-PROT_ON	
IO#2	BI16	EXTERNAL TRIP - A Ph	1552	EXT_TRIP-A	
	BI17	EXTERNAL TRIP - B Ph	1553	EXT_TRIP-B	
	BI18	EXTERNAL TRIP - C Ph	1554	EXT_TRIP-C	

Table 3.2.1.2(e) Default Binary Input Allocation of Model 323B

Module Name	BI No.	Contents	Setting		
			Signal No. & Signal Name		Norm or Inv
IO#1	BI1	CB1 AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB1 AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB1 AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP 1 (3-PHASE TRIP)	1724	TR1_3PTP	
	BI5	Z1X INITIATION	1540	Z1X_INIT	
	BI6	EXTERNAL MCCB TRIP	1541	EXT_VTF	
	BI7	DISCONNECTOR NORMALLY OPEN CONTACT	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY CLOSE CONTAC	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1615	CRT_BLOCK	
	BI10	CB1 READY FOR AUTORECLOSE	1545	CB1_READY	
	BI11	CB2 READY FOR AUTORECLOSE	1546	CB2_READY	
	BI12	BLOCK AUTORECLOSE	1544	ARC_BLOCK	
	BI13	INDICATION RESET	1548	IND.RESET	
	BI14	MAIN PROTECTION TRIP	1549	M-PROT_TRIP	
	BI15	MAIN PROTECTION IN SERVICE	1550	M-PROT_ON	
IO#2	BI16	EXTERNAL TRIP - A Ph	1552	EXT_TRIP-A	
	BI17	EXTERNAL TRIP - B Ph	1553	EXT_TRIP-B	
	BI18	EXTERNAL TRIP - C Ph	1554	EXT_TRIP-C	
IO#3	BI19	CB2 AUXILIARY CONTACT - A Ph	1552	CB2_CONT-A	
	BI20	CB2 AUXILIARY CONTACT - B Ph	1553	CB2_CONT-B	
	BI21	CB2 AUXILIARY CONTACT - C Ph	1554	CB2_CONT-C	
IO#4	BI34	Spare			
	BI35	Spare			
	BI36	Spare			

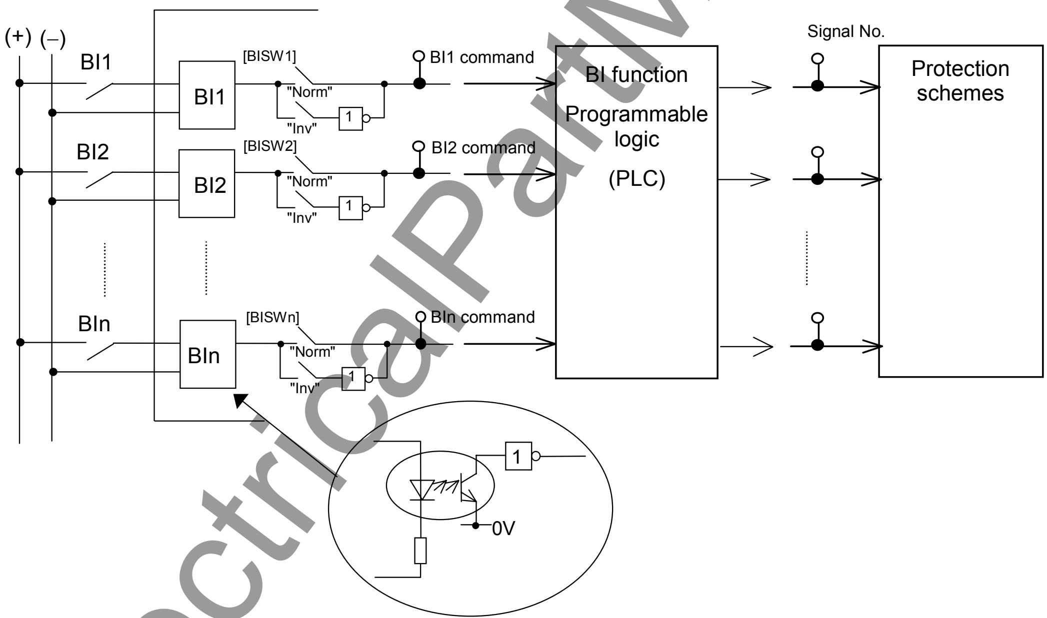


Figure 3.2.1.1 Binary Input Circuit

The binary input signals of circuit breaker auxiliary contact are transformed as shown in Figure 3.2.1.2 to use in the scheme logic.

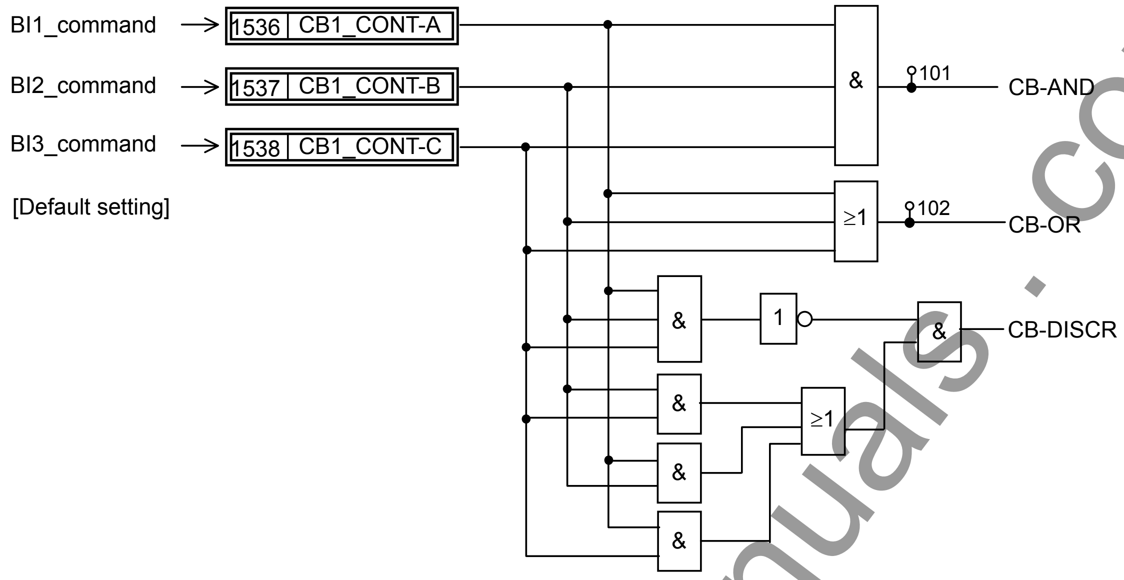


Figure 3.2.1.2 Circuit Breaker Signals Transformation

3.2.2 Binary Output Signals

The number of binary output signals and their output terminals vary depending on the relay models. For all models, all outputs except the tripping command and relay failure signal can be configured.

The signals shown in the signal list in Appendix B can be assigned to the output relay individually or in arbitrary combinations. Signals can be combined using either an AND circuit or OR circuit with 6 gates each as shown in Figure 3.2.2.1. The output circuit can be configured according to the setting menu. Appendix D shows the factory default settings.

A 0.2s delayed drop-off timer can be attached to these assigned signals. The delayed drop-off time is disabled by the scheme switch [BOTD].

In the external communication, a binary output is required for signal transmission. The transmission signal is assigned to BO13 of IO2 by the binary output setting.

The relay failure contact closes the contact when a relay defect or abnormality in the DC power supply circuit is detected.

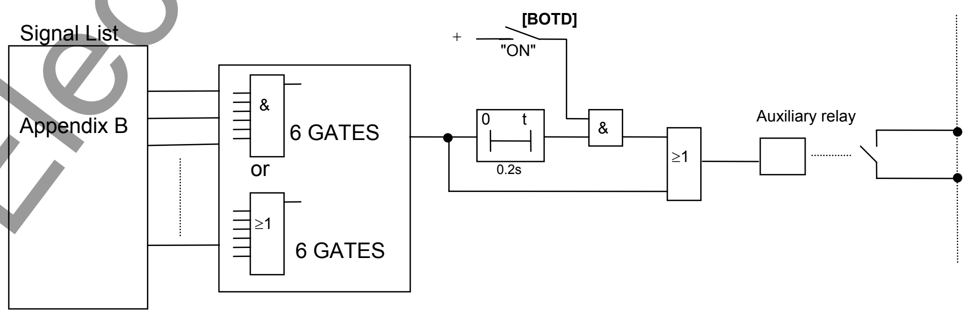


Figure 3.2.2.1 Configurable Output

3.2.3 PLC (Programmable Logic Controller) Function

GRZ100 is provided with a PLC function allowing user-configurable sequence logics on binary signals. The sequence logics with timers, flip-flops, AND, OR, XOR, NOT logics, etc. can be produced by using the PC software “PLC tool” and linked to signals corresponding to relay elements or binary circuits.

Configurable binary inputs, binary outputs and LEDs, and the initiation trigger of disturbance record are programmed by the PLC function. Temporary signals are provided for complicated logics or for using a user-configured signal in many logic sequences.

PLC logic is assigned to protection signals by using the PLC tool. For PLC tool, refer to PLC tool instruction manual.

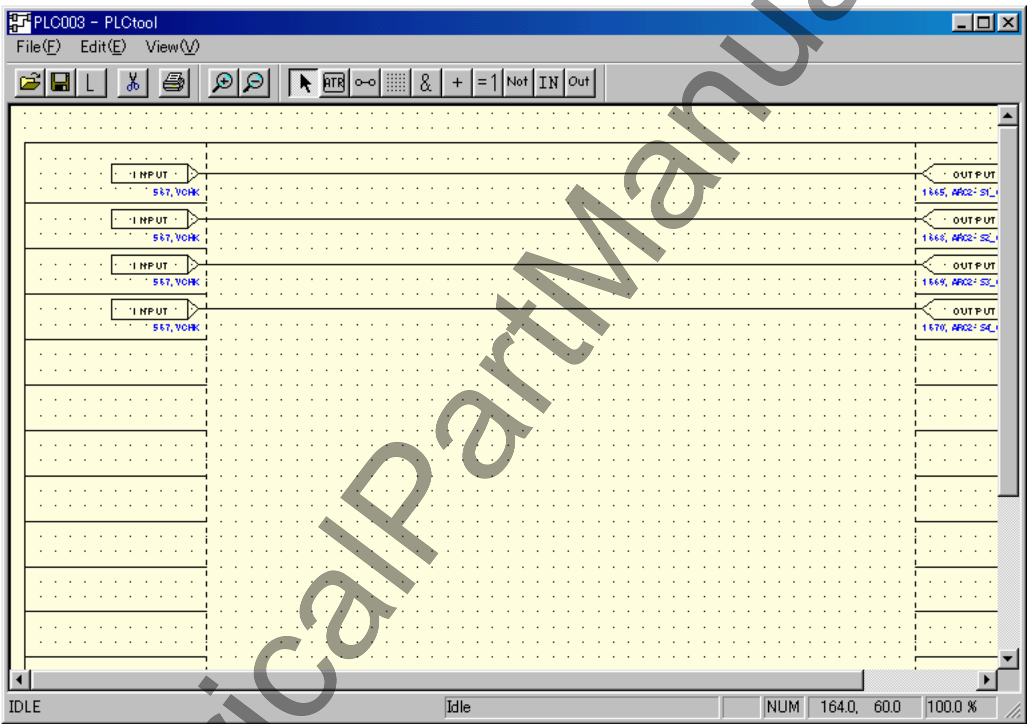


Figure 3.2.3.1 Sample Screen of PLC Tool

3.3 Automatic Supervision

3.3.1 Basic Concept of Supervision

Though the protection system is in non-operating state under normal conditions, it is waiting for a power system fault to occur at any time and must operate for the fault without fail. Therefore, the automatic supervision function, which checks the health of the protection system during normal operation, plays an important role. The numerical relay based on the microprocessor operations is suitable for implementing this automatic supervision function of the protection system. The GRZ100 implements the automatic supervision function taking advantage of this feature based on the following concept:

- The supervising function should not affect protection performance.
- Perform supervision with no omissions wherever possible.
- When a failure occurs, it should be able to easily identify the location of the failure.

Note: Automatic supervision function includes automatic monitor function and automatic test function. For the terminology, refer to IEC IEV 448.

In a fault during automatic testing, the tripping outputs are blocked for approximately 100 ms.

3.3.2 Relay Monitoring and Testing

The following items are supervised:

AC input imbalance monitoring

The AC voltage and current inputs are monitored to check that the following equations are satisfied and the health of the AC input circuits is checked.

- Zero sequence voltage monitoring

  $|V_a + V_b + V_c| / 3 \geq 6.35$ (V)

- Negative sequence voltage monitoring

  $|V_a + a^2V_b + aV_c| / 3 \geq 6.35$ (V)

  where,

  a = Phase shifter of 120°

- Zero sequence current monitoring

  $|I_a + I_b + I_c - I_n| / 3 \geq 0.1 \times \mathrm{Max}(|I_a|, |I_b|, |I_c|) + k_0$

  where,

  I_n = Residual current

  $\mathrm{Max}(|I_a|, |I_b|, |I_c|)$ = Maximum amplitude among I_a, I_b and I_c

  k_0 = 5% of rated current

These zero sequence monitoring and negative sequence monitoring allow high sensitivity detection of failures that have occurred in the AC input circuits.

The negative sequence voltage monitoring allows high sensitivity detection of failures in the voltage input circuit, and it is effective for detection particularly when cables have been connected with the incorrect phase sequence.

The zero sequence current monitoring allows high sensitivity detection of failures irrespective of the presence of the zero sequence current on the power system by introduction of the residual circuit current.

Only zero sequence monitoring is carried out for the current input circuit, because zero sequence monitoring with the introduction of the residual circuit current can be performed with higher sensitivity than negative sequence monitoring.

A/D accuracy checking

An analog reference voltage is input to a prescribed channel in the analog-to-digital (A/D) converter, and it is checked that the data after A/D conversion is within a prescribed range and that the A/D conversion characteristics are correct.

Memory monitoring

The memories are monitored as follows depending on the type of the memory and checked that the memory circuits are healthy:

- Random access memory monitoring: Writes/reads prescribed data and checks the storage function.
- Program memory monitoring: Checks the checksum value of the written data.
- Setting value monitoring: Checks discrepancy between the setting values stored in duplicate.

Watch Dog Timer

A hardware timer which is cleared periodically by software is provided and it is checked that the software is running normally.

DC Supply monitoring

The secondary voltage level of the built-in DC/DC converter is monitored and checked that the DC voltage is within a prescribed range.

3.3.3 CT Circuit Current Monitoring

The CT circuit is monitored to check that the following equation is satisfied and the health of the CT circuit is checked.

$$\mathrm{Max}(|I_a|, |I_b|, |I_c|) - 4 \times \mathrm{Min}(|I_a|, |I_b|, |I_c|) \geq k_0$$

where,

$\mathrm{Max}(|I_a|, |I_b|, |I_c|)$ = Maximum amplitude among I_a, I_b and I_c
$\mathrm{Min}(|I_a|, |I_b|, |I_c|)$ = Minimum amplitude among I_a, I_b and I_c
k_0 = 20% of rated current

The CT circuit current monitoring allows high sensitivity detection of failures that have occurred in the AC input circuit. This monitoring can be disabled by the scheme switch [CTSV].

3.3.4 Signal Channel Monitoring for Integral Digital Communication

Signal channel monitoring

If a failure occurs or noise causes a disturbance in the communication channel, it may interrupt the data transmission or generate erroneous data, thus causing the relay to operate incorrectly.

The GRZ100 detects data failures by performing a cyclic redundancy check and a fixed bit check on the data. The checks are carried out for every sampling.

If a data failure occurs between the local terminal and remote terminal 1 and lasts for ten seconds, failure alarms "Com1 fail" and "Com1 fail-R" are issued at the local and remote terminals respectively. "Com1 fail" is a failure detected by the local terminal relay, and "Com1 fail-R" is a failure detected by the remote terminal relay. If the failure occurs between the local terminal and remote terminal 2, "Com2 fail" and "Com2 fail-R" are issued.

Note: The remote terminal 1 and 2 are those with which the local communication port 1 (CH1) and 2 (CH2) are linking with.

In the case that the GRZ100 is linked directly to a dedicated optical fiber communication circuit, sending and receiving signal levels are monitored and error messages "TX1 level err" of CH1 or "TX2 level err" of CH2 for sending signal and "RX1 level err" of CH1 or "RX2 level err" of CH2 for receiving signal are output when the levels fall below the minimum allowed.

In the communication setup in which the GRZ100 receives the clock signal from the multiplexer, an error message "CLK1 fail" of CH1 or "CLK2 fail" of CH2 is output when the signal is interrupted.

Note: Messages "Com2 fail", "RX2 level err", "TX2 level err" and "CLK2 fail" are valid in three-terminal applications.

If the failure lasts for ten seconds, a communication failure alarm is issued.

The output blocking ceases instantly when the failure recovers.

If the failure is a severe CF (Communication Failure) such that the remote terminal signal cannot be received at all, the command protection can be blocked by setting the scheme switch [SCFCNT] to “BLK”.

Communication channel delay time monitoring

The channel delay time is measured at the receiving end. If the time exceeds the timer TDSV setting, an alarm is issued.

3.3.5 Signal Channel Monitoring and Testing for External Communication

Signal channel monitoring

In the PUP, POP or UOP schemes, when a trip permission signal is received consecutively for 10 seconds, this is considered to be an error of the signal channel and an alarm is issued. When the signal modulation is a frequency shift method, if neither the trip permission signal nor the guard signal can be received, an alarm of "Ch-R1. fail" and/or "Ch-R2. fail" is issued.

Signal channel testing

In the BOP scheme, the signal circuit including the remote end is automatically tested at a prescribed time interval. Testing commences when a signal is transmitted from the local to remote end. When the remote end receives the signal, it returns the signal on condition that there is no fault on the power system. The terminal which is carrying out the testing checks that the transmission path is healthy by receiving the return signal from the remote end within a prescribed time after the carrier signal is transmitted from the local end.

If the signal cannot be received after the prescribed time, an alarm signal of SIGNAL CHANNEL FAILURE is generated and a message "Remote 1 fail" and/or "Remote 2 fail" is displayed on the LCD when manual testing.

To start the channel testing, the switch [CHMON] is set to "ON" and set the channel test interval. The channel test interval can be set from 1 to 12 hours. And then, the OR logic output of the signal No.225:EXT_CAR-S and the signal No.252:SBT is assigned the binary output BO13 of IO2.

Note 1: The time count for test interval is initialized when manual test is started or DC supply is turned on.

Note 2: Under any of the following conditions, the signal channel test does not start.

- BOP is not selected as the protection scheme.
- Telecommunication equipment is out-of-service.
- Scheme switch [CHMON] is set to "Off".
- Undervoltage elements operate.
- Circuit breaker is open.

3.3.6 Relay Address Monitoring

In applications where the telecommunication channel can be switched, it is possible that the data could be communicated to the wrong terminal. To avoid this, the relay address can be assigned and monitored at each terminal to check that the data is communicated to the correct terminal.

The different address must be assigned to a relay at each terminal.

The monitoring is enabled by setting the scheme switch [RYIDSV] to "ON".

3.3.7 Disconnector Monitoring

The disconnector is monitored because a disconnector contact signal is used for the stub fault protection in a one-and-a-half circuit breaker arrangement.

To monitor the disconnector, one pair of normally open contact and normally closed contact is introduced. Disconnector failure is detected when both contacts are simultaneously in the open or closed state for a prescribed period.

Monitoring is blocked by setting the scheme switch [LSSV] to "OFF". Default setting of the [LSSV] is "OFF" to prevent a false failure detection when the disconnector contacts are not introduced.

3.3.8 Failure Alarms

When a failure is detected by the automatic supervision, it is followed with an LCD message, LED indication, external alarm and event recording. Table 3.3.8.1 summarizes the supervision items and alarms.

The alarms are retained until the failure has recovered.

The alarms can be disabled collectively by setting the scheme switch [AMF] to "OFF". The setting is used to block unnecessary alarms during commissioning, test or maintenance.

When the Watch Dog Timer detects that the software is not running normally, LCD display and event recording of the failure may not function normally.

Table 3.3.8.1 Supervision Items and Alarms

Supervision item	LCD message	LED "IN SERVICE"	LED "ALARM"	External alarm	Event record message
AC input imbalance monitoring A/D accuracy check Memory monitoring	(1)	off	on	(3)	Relay fail
Watch Dog Timer	—	off	on	(3)	—
DC supply monitoring	—	off	(2)	(3)	Relay fail-A (2)
Signal channel monitoring for integral communication (receive) Ditto (send)	Comm.1 fail / Comm.2 fail Comm.1 fail-R / Comm.2 fail-R	on	on	(4)	Comm.1 fail / Comm.2 fail Comm.1 fail-R / Comm.2 fail-R
Channel delay time monitoring for integral communication	Td1 over / Td2 over	off	on	(4)	Td1 over / Td2 over
Signal channel monitoring for external communication	Ch-R1. fail / Ch-R2. fail	on	on	(4)	Ch-R1. fail / Ch-R2. fail
Sampling Synchronization monitoring	Sync. 1 fail Sync. 2 fail (*)	on	on	(4)	Sync. 1 fail Sync. 2 fail (*)
Send signal level monitoring	TX 1 level err TX 2 level err (*)	on	on	(4)	Relay fail
Receive signal level monitoring	RX 1 level err RX 2 level err (*)	on	off	(4)	—
Clock monitoring	CLK. 1 fail CLK. 2 fail (*)	on	off	(4)	—
Ready signal monitoring	Term. 1 rdy off Term. 2 rdy off (*)	on	on	(4)	Term. 1 rdy Term. 2 rdy (*)
Relay address monitoring	RYID1 err / RYID2 err	off	on	(4)	RYID1 err / RYID2 err
Disconnector monitoring	DS fail	on	on	(4)	DS fail
VT monitoring	VT fail	on	on	(4)	VTF

(*) In case of three-terminal line application

(1) There are various messages such as "···err" and "···fail "as shown in the table in Section 6.7.2.
(2) It depends on the degree of voltage drop.
(3) The binary output relay "FAIL" operates.
(4) The user configurable binary output relays operate if assigned.

3.3.9 Trip Blocking

When a failure is detected by the following supervision items, the trip function is blocked as long as the failure exists and is restored when the failure is removed:

- A/D accuracy checking
- Memory monitoring
- Watch Dog Timer
- DC supply monitoring

The trip function is valid when a failure is detected by tripping output monitoring or disconnector monitoring.

When a failure is detected by AC input imbalance monitoring or CT circuit current monitoring, the scheme switch [SVCNT] or [CTSV] setting can be used to determine if both tripping is blocked and an alarm is output, or, if only an alarm is output. The CT circuit current monitoring can be disabled by the [CTSV].

When a failure is detected by relay address monitoring in integral digital communication, a command protection is blocked.

3.3.10 Setting

The setting elements necessary for the automatic supervision and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
[LSSV]	OFF/ON		OFF	Disconnector monitoring
[SVCNT]	ALM&BLK/ALM		ALM&BLK	Alarming and/or blocking selection
[RYIDSV]	OFF/ON		ON	Relay address supervision
RYID	0-63		0	Local relay address
RYID1	0-63		0	Remote 1 relay address
RYID2	0-63		0	Remote 2 relay address
[SCFCNT]	BLK/Trip		Trip	Command protection trip control under severe CF
TDSV	100-16,000μs		6,000μs	Channel delay monitoring
Chann	1-24 hours	1 hour	8 hours	Signal channel testing interval for external communication
[CTSV]	OFF/ALM&BLK/ ALM		OFF	CT circuit monitoring

Setting of RYID, RYID1 and RYID2

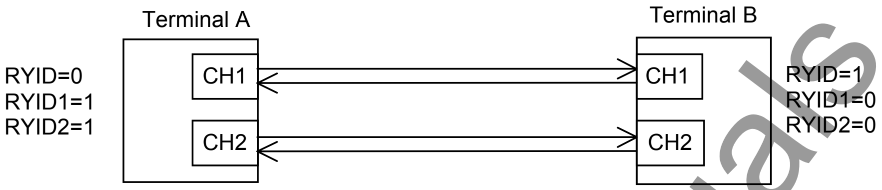
Relay address number must take a different number at each terminal. If the relay address monitoring switch [RYIDSV] is "OFF", their settings are ignored. The RYID2 setting is enabled by setting the [TERM] to "3TERM" or “Dual”.

Two-terminal application: Set the local relay address number to RYID and the remote relay address number to RYID1. The RYID1 is equal to the RYID of the remote relay. See Figure 3.3.10.1. In “Dual” setting, the RYID2 setting must be the same as the RYID1 setting.

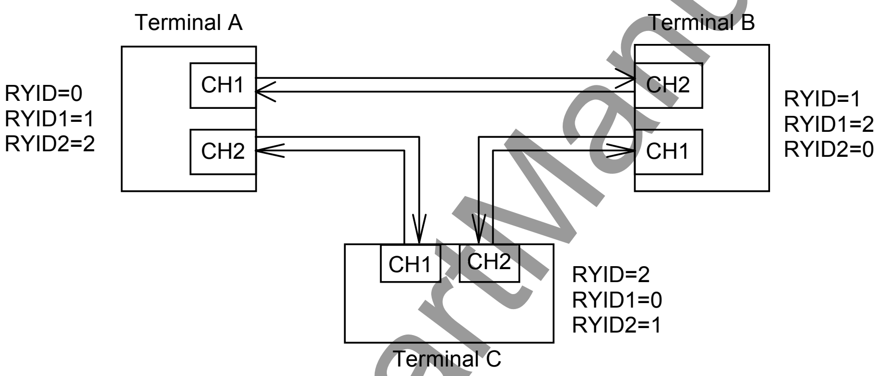
Three-terminal application: Set the local relay address number to RYID and the remote relay 1 address number to RYID1 and the remote relay 2 address number to RYID2. The RYID1 is equal to the RYID of the remote 1 relay and the RYID2 equal to the RYID of the remote 2 relay. See Figure 3.3.10.1.

Note: The remote 1 relay is connected by CH1 and the remote 2 relay by CH2.

(a) Two-terminal Application



(b) Two-terminal Application (Dual)



(c) Three-terminal Application

Figure 3.3.10.1 Relay Address Setting

3.4 Recording Function

The GRZ100 is provided with the following recording functions:

Fault recording

Event recording

Disturbance recording

These records are displayed on the LCD of the relay front panel or on the local or remote PC.

3.4.1 Fault Recording

Fault recording is started by a tripping command of the GRZ100, a tripping command of the external main protection or PLC command by user setting (max. 4) and the following items are recorded for one fault:

Date and time of fault occurrence

Faulted phase

Tripping phase

Tripping mode

Fault location

Relevant events

Power system quantities

Up to 8 most-recent faults are stored as fault records. If a new fault occurs when 8 faults have been stored, the record of the oldest fault is deleted and the record of the latest fault is then stored.

Date and time of fault occurrence

The time resolution is 1 ms using the relay internal clock.

To be precise, this is the time at which a tripping command has been output, and thus it is approximately 10 ms after the occurrence of the fault.

Fault phase

The faulted phase is displayed when tripping by a distance measuring element. The fault phase is determined by the "fault phase detection logic". However, the fault phase depends on the setting of the phase selection element UVC.

In case of the tripping by a backup protection, the fault phase is not displayed and the "---" marked is displayed.

Tripping phase

This is the phase to which a tripping command is output.

Tripping mode

This shows the protection scheme that outputted the tripping command.

Fault location

The fault location is displayed against the fault within the protected line tripped by a distance measuring element. The distance to the fault point calculated by the fault locator is recorded.

The distance is expressed in km and as a percentage (%) of the line length. In three-terminal application, however, the measurement result is expressed as a fault section instead of a percentage.

For the fault locator, see Section 2.8.3

Relevant events

Such events as autoreclose, re-tripping following the reclose-on-to-a fault or autoreclose and tripping for evolving faults are recorded with time-tags.

Power system quantities

The following power system quantities in pre-faults and post-faults are recorded. The pre-fault power system quantities are values at 10 seconds before tripping.

(However, the power system quantities are not recorded for evolving faults.)

- Magnitude and phase angle of phase voltage (V_a, V_b, V_c)
- Magnitude and phase angle of phase-to-phase voltage (V_{ab}, V_{bc}, V_{ca})
- Magnitude and phase angle of symmetrical component voltage (V_1, V_2, V_0)
- Magnitude and phase angle of phase voltage for autoreclose (V_{s1}, V_{s2})
- Magnitude and phase angle of phase current (I_a, I_b, I_c)
- Magnitude and phase angle of phase-to-phase current (I_{ab}, I_{bc}, I_{ca})
- Magnitude and phase angle of symmetrical component current (I_1, I_2, I_0)
- Magnitude of parallel line zero sequence current (I_{0m})
- Resistive and reactive component of phase impedance (R_a, R_b, R_c, X_a, X_b, X_c)
- Resistive and reactive component of phase-to-phase impedance (R_{ab}, R_{bc}, R_{ca}, X_{ab}, X_{bc}, X_{ca})
- Percentage of thermal capacity (THM%)

Phase angles above are expressed taking that of positive sequence voltage as a reference phase angle. Phase impedance and phase-to-phase impedance are the ones seen by the reactance elements.

3.4.2 Event Recording

The events shown are recorded with a 1 ms resolution time-tag when the status changes. The user can set a maximum of 128 recording items, and their status change mode. The event items can be assigned to a signal number in the signal list. The status change mode is set to "On" (only recording On transitions) or "On/Off"(recording both On and Off transitions) mode by setting. The "On/Off" mode events are specified by "Bi-trigger events" setting. If the "Bi-trigger events" is set to "100", No.1 to 100 events are "On/Off" mode and No.101 to 128 events are "On" mode.

The name of an event cannot be set on LCD. It can set only by RSM100. Maximum 22 characters can be set and can be viewed on both of the LCD and RSM Setting(view) screen. But the LCD screen of event record displays only 11 characters. Therefore, it is recommended the maximum 11 characters are set.

The elements necessary for event recording and their setting ranges are shown in the table below. The default setting of event record is shown in Appendix H.

Element	Range	Step	Default	Remarks
BITRN	0 - 128	1	100	Number of bi-trigger(on/off) events
EV1 – EV128	0 - 3071			Assign the signal number

Up to 480 records can be stored. If an additional event occurs when 480 records have been stored, the oldest event record is deleted and the latest event record is then stored.

3.4.3 Disturbance Recording

Disturbance recording is started when overcurrent or undervoltage starter elements operate or a tripping command is output, or PLC command by user-setting (max. 4) is outputted. The records include 8 analog signals (V_a, V_b, V_c, I_a, I_b, I_c, $3I_0$, $3I_{0m}$), 32 binary signals and the dates and times at which recording started. Any binary signal in shown in Appendix B can be assigned by the binary signal setting of disturbance record. The default setting of binary signal is shown in Appendix H.

The name of binary signal can be set only by RSM100. Maximum 22 characters can be set and can be viewed on both of the LCD and RSM Setting(view) screen. But the waveform data analysis screen of disturbance record displays up to 11 characters of them. Therefore, it is recommended the maximum 11 characters are set.

The LCD display only shows the dates and times of the disturbance records stored. Details can be displayed on a PC. For how to obtain disturbance records on the PC, see the PC software instruction manual.

The pre-fault recording time is fixed at 0.3s and the post-fault recording time can be set between 0.1 and 3.0s and the default setting is 1.0s.

The number of records stored depends on the post-fault recording time and the relay model. The typical number of records stored in 50Hz and 60Hz power system is shown in Table 3.4.3.1.

Note: If the recording time setting is changed, the records stored so far are deleted.

Table 3.4.3.1 Post Fault Recording Time and Number of Disturbance Records Stored

Recording time	0.1s	0.5s	1.0s	1.5s	2.0s	2.5s	3.0s
50Hz	40	25	15	12	8	7	6
60Hz	40	20	12	9	7	6	5

Settings

The elements necessary for initiating a disturbance recording and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
Timer	0.1-3.0 s	0.1 s	1.0 s	Post-fault recording time
OCP-S	0.5-250.0 A	0.1 A	10.0 A	Overcurrent detection (phase fault)
	(0.1-50.0 A	0.1 A	2.0 A) (*)	
OCP-G	0.5-250.0 A	0.1 A	5.0 A	Overcurrent detection (earth fault)
	(0.1-50.0 A	0.1 A	1.0 A)	
UVP-S	0-132 V	1 V	88 V	Undervoltage detection (phase fault)
UVP-G	0-76 V	1 V	51 V	Undervoltage detection (earth fault)

(*) Current values shown in the parentheses are for the case of a 1A rating. Other current values are for the case of a 5A rating.

Starting the disturbance recording by a tripping command or the starter elements listed above is enabled or disabled by setting the following scheme switches with identical names with the starter elements except the switch [TRIP].

Element	Range	Step	Default	Remarks
TRIP	OFF/ON		ON	Start by tripping command
OCP-S	OFF/ON		ON	Start by OCP-S operation
OCP-G	OFF/ON		ON	Start by OCP-G operation
UVP-S	OFF/ON		ON	Start by UVP-S operation
UVP-G	OFF/ON		ON	Start by UVP-G operation

3.5 Metering Function

The GRZ100 performs continuous measurement of the analog input quantities. The currents and voltages at remote terminals can be also displayed. The measurement data shown below is updated every second and displayed on the LCD of the relay front panel or on the local or remote PC.

[Local terminal]

- Magnitude and phase angle of phase voltage (V_a, V_b, V_c)
- Magnitude and phase angle of phase-to-phase voltage (V_{ab}, V_{bc}, V_{ca})
- Magnitude and phase angle of symmetrical component voltage (V_1, V_2, V_0)
- Magnitude and phase angle of phase voltage for autoreclose (V_{s1}, V_{s2})
- Magnitude and phase angle of phase current (I_a, I_b, I_c)
- Magnitude and phase angle of phase-to-phase current (I_{ab}, I_{bc}, I_{ca})
- Magnitude and phase angle of symmetrical component current (I_1, I_2, I_0)
- Magnitude of parallel line zero sequence current (I_{0m})
- Percentage of thermal capacity (THM%)
- Active power and reactive power (P, Q)
- Frequency
- Telecommunication delay time 1 at the remote terminal 1
- Telecommunication delay time 2 at the remote terminal 2

[Remote terminal 1]

- Magnitude and phase angle of phase voltage (V_{a1}, V_{b1}, V_{c1})
- Magnitude and phase angle of phase-to-phase voltage (V_{ab1}, V_{bc1}, V_{ca1})
- Magnitude and phase angle of symmetrical component voltage (V_{11}, V_{21}, V_{01})
- Magnitude and phase angle of phase current (I_{a1}, I_{b1}, I_{c1})
- Magnitude and phase angle of phase-to-phase current (I_{ab1}, I_{bc1}, I_{ca1})
- Magnitude and phase angle of symmetrical component current (I_{11}, I_{21}, I_{01})

[Remote terminal 2]

- Magnitude and phase angle of phase voltage (V_{a2}, V_{b2}, V_{c2})
- Magnitude and phase angle of phase-to-phase voltage (V_{ab2}, V_{bc2}, V_{ca2})
- Magnitude and phase angle of symmetrical component voltage (V_{12}, V_{22}, V_{02})
- Magnitude and phase angle of phase current (I_{a2}, I_{b2}, I_{c2})
- Magnitude and phase angle of phase-to-phase current (I_{ab2}, I_{bc2}, I_{ca2})
- Magnitude and phase angle of symmetrical component current (I_{12}, I_{22}, I_{02})

Phase angles above are expressed taking the positive sequence voltage as a reference phase angle, where leading phase angles are expressed as positive, (+).

The above system quantities are displayed in values on the primary side or on the secondary side determined by the setting. To display accurate values, it is necessary to set the CT ratio and VT ratio as well. For the setting method, see "Setting the line parameters" in 4.2.6.7.

The signing of active and reactive power flow direction can be set positive for either power sending or power receiving. The signing of reactive power can be also set positive for either lagging phase or leading phase. For the setting method, see 4.2.6.6.

4. User Interface

4.1 Outline of User Interface

The user can access the relay from the front panel.

Local communication with the relay is also possible using a personal computer (PC) via an RS232C port. Furthermore, remote communication is also possible using RSM (Relay Setting and Monitoring), IEC103 communication via an RS485, optical fibre or Ethernet LAN etc.

This section describes the front panel configuration and the basic configuration of the menu tree of the local human machine communication ports and HMI (Human Machine Interface).

4.1.1 Front Panel

As shown in Figure 4.1.1.1, the front panel is provided with a liquid crystal display (LCD), light emitting diode (LED), operation keys, view and reset keys, monitoring jack and RS232C connector.

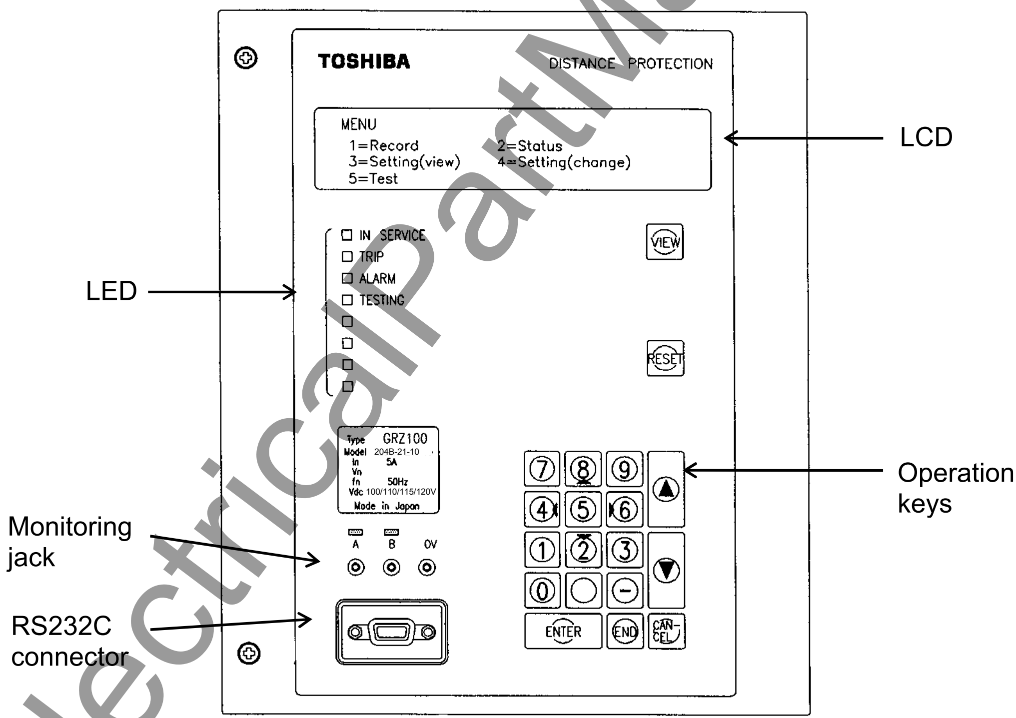


Figure 4.1.1.1 Front Panel

LCD

The LCD screen, provided with a 4-line, 40-character back light, provides the user with detailed information of the relay interior such as records, status and setting. The LCD screen is normally unlit, but pressing the VIEW key will display the digest screen and pressing any key other than VIEW and RESET will display the menu screen.

These screens go OFF by pressing the RESET key or END key. Leaving any display without operation for 5 minutes or more causes the back light to go OFF.

LED

There are 8 LED displays. The signal labels and LED colors are defined as follows:

Label	Color	Remarks
IN SERVICE	Green	Lit when the relay is in service.
TRIP	Red	Lit when a trip command is issued.
ALARM	Red	Lit when a failure is detected.
TESTING	Red	Lit when disabling automatic monitoring function and operating a binary output forcibly, etc..
LED1	Red	Configurable LED to assign signals with or without latch when relay operates.
LED2	Red	Configurable LED to assign signals with or without latch when relay operates.
LED3	Red	Configurable LED to assign signals with or without latch when relay operates.
LED4	Red	Configurable LED to assign signals with or without latch when relay operates.

The TRIP LED lights up once the relay is operating and remains lit even after the trip command goes off.

Operation keys

The operation keys are used to display records, status, and set values on the LCD, to input or change set values. The function of each operation key is as follows:

① 0-9, –: Used to enter a selected number, numerical values and a text string. Keys 2, 4, 6 and 8 marked with ▼, ◀, ▶, and ▲ are also used to enter a text string.

② ▼, ▲: Used to move lines displayed within a screen

③ CANCEL: Used to cancel entries and return to the upper screen

④ END: Used to end entering operation, return to the upper screen or turn off the display

⑤ ENTER: Used to store or establish entries

VIEW and RESET keys

Pressing VIEW key displays digest screens such as "Metering", "Latest fault" and "Auto-supervision".

Pressing RESET key turns off the display.

Monitoring jacks

The two monitoring jacks A and B and their respective LEDs can be used when the test mode is selected on the LCD screen. By selecting the signal to be observed from the "Signal List" in Appendix B and setting it on the screen, the signal can be displayed on LED A or LED B, or output to an oscillo-scope via a monitoring jack.

RS232C connector

The RS232C connector is a 9-way D-type connector (straight type) for serial RS232C connection. This connector is used to connect with a local personal computer.

4.1.2 Communication Ports

The following 4 individual interfaces are mounted as the communication ports:

- RS232C port
- Serial communication port (RS485 port, optional Fibre optic or Ethernet LAN etc.)
- IRIG-B port
- Interface port for telecommunication link

(1) RS232C port

This connector is a standard 9-way D-type connector for serial port RS232C transmission and mounted on the front panel. By connecting with a personal computer using this connector, setting operation and display functions can be performed on the personal computer.

(2) Serial communication port

One or two serial communication ports can be provided. In the single-port type, it is connected to the RSM (Relay Setting and Monitoring system) via the protocol converter G1PR2 or IEC60870-5-103 communication via BCU/RTU (Bay Control Unit / Remote Terminal Unit) to connect between relays and to construct a network communication system. (See Figure 4.4.1 in Section 4.4.)

In the case of the two-port type, one port (COM1 or OP1) can be used for the relay setting and monitoring (RSM) system or IEC60870-5-103 communication, while the other port (COM2 or OP2) is used for IEC60870-5-103 communication only.

Screw terminal for RS485, ST connector for fibre optic or RJ45 connector for Ethernet LAN (10Base-T) is provided on the back of the relay as shown in Figure 4.1.2.1.

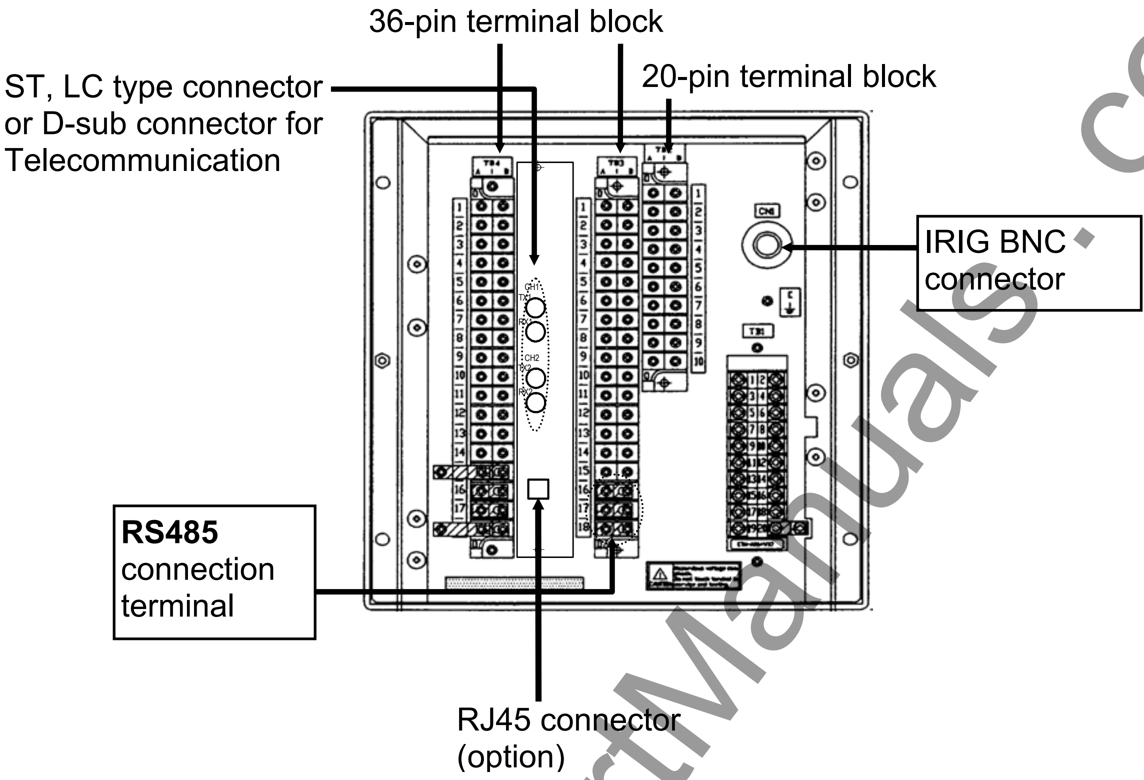
(3) IRIG-B port

The IRIG-B port is mounted on the transformer module. This port collects serial IRIG-B format data from the external clock to synchronize the relay calendar clock. The IRIG-B port is isolated from the external circuit by using a photocoupler. A BNC connector is used as the input connector.

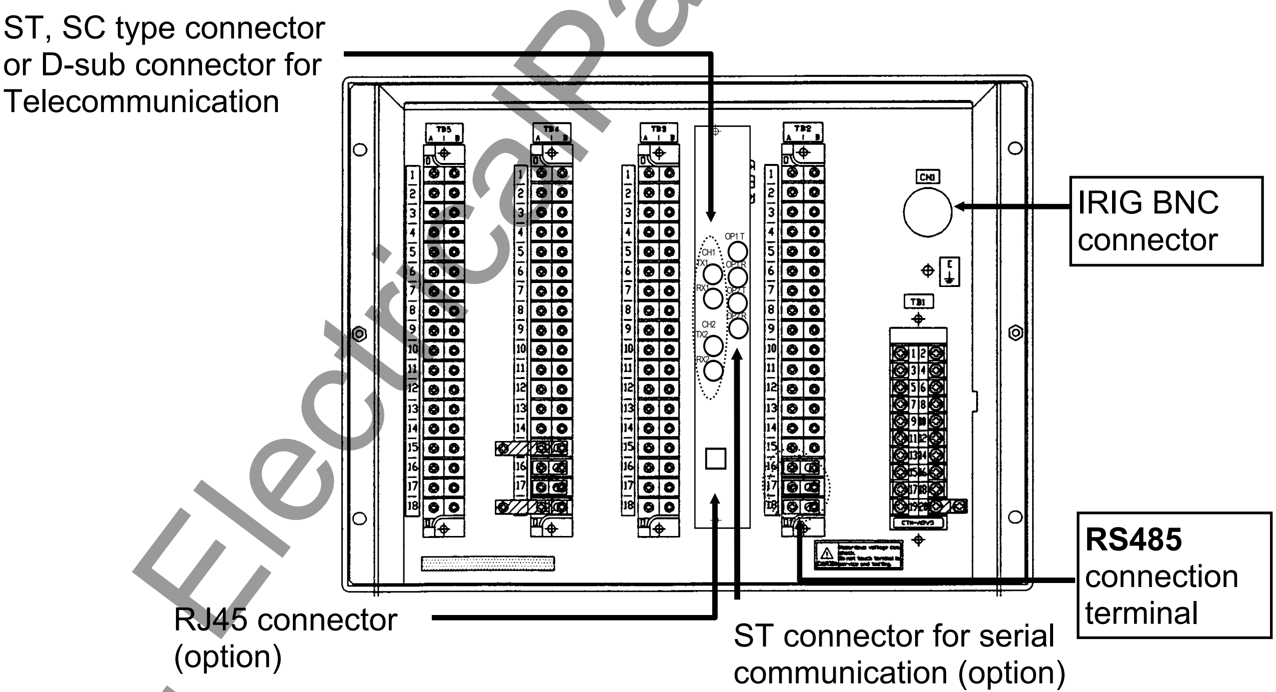
This port is provided on the back of the relay and Figure 4.1.2.1 shows the location of this connector.

(4) Interface port for telecommunication link

The optical or electrical interface port for telecommunication link is provided on the back of the relay as shown in Figure 4.1.2.1. The connector using for the optical interface port is the ST type or LC type connector and the connector for the electrical interface port is the D-sub connector.



Relay rear view (Case Type A)



Relay rear view (Case Type B)

Figure 4.1.2.1 Locations of Communication Port

4.2 Operation of the User Interface

The user can access such functions as recording, measurement, relay setting and testing with the LCD display and operation keys.

Note: LCD screens depend on the relay model and the scheme switch setting. Therefore, LCD screens described in this section are samples of typical model.

4.2.1 LCD and LED Displays

Displays during normal operation

When the GRZ100 is operating normally, the green "IN SERVICE" LED is lit and the LCD is off.

Press the VIEW key when the LCD is off to display the LCD will display the "Metering", "Latest fault" and "Auto-supervision" screens in turn. The last two screens are displayed only when there is some data. These are the digest screens and can be displayed without entering the menu screens.

```
Metering1                   08/Dec/1997   22:56
Vab  220.0kV    Ia   1.05kA    + 370.25MW
Vbc  219.8kV    Ib   1.05kA    -  30.13MVar
Vca  220.0kV    Ic   1.05kA         60.1Hz
```

```
Metering2                   08/Dec/1997   22:56
Vab1  220.0kV    Ia1   0.55kA
Vbc1  219.8kV    Ib1   0.55kA
Vca1  220.0kV    Ic1   0.55kA
```

```
Metering3                   08/Dec/1997   22:56
Vab1  220.0kV    Ia1   0.50kA
Vbc1  219.8kV    Ib1   0.50kA
Vca1  220.0kV    Ic1   0.50kA
```

Press the RESET key to turn off the LCD.

For any display, the back-light is automatically turned off after five minutes.

Displays in tripping

```
Latest fault   08/Dec/1997   22:56:38.250
Phase  A N            Trip  A
Z1, CRT
 59.3km  (***%)   *OB*NC*CF
```

Note: 2 terminal application

```
Latest fault   08/Dec/1997   22:56:38.250
Phase  A N            Trip  A
Z1, CRT
 59.3km  (Junction-Remote1)  *OB*NC
```

Note: 3 terminal application

If a fault occurs and a tripping command is output when the LCD is off, the red "TRIP" LED and other configurable LED if signals assigned to trigger by tripping.

Press the VIEW key to scroll the LCD screen to read the rest of messages.

Press the RESET key to turn off the LEDs and LCD display.

Notes:

1) When configurable LEDs (LED1 through LED4) are assigned to latch signals by trigger of tripping, press the RESET key more than 3s until the LCD screens relight. Confirm turning off the configurable LEDs. Refer to Table 4.2.1 Step 1.
2) Then, press the RESET key again on the "Latest fault" screen in short period, confirm turning off the "TRIP" LED. Refer to Table 4.2.1 Step 2.
3) When only the "TRIP" LED is go off by pressing the RESET key in short period, press the RESET key again to reset remained LEDs in the manner 1) on the "Latest fault" screen or other digest screens. LED1 through LED4 will remain lit in case the assigned signals are still active state.

Table 4.2.1 Turning off latch LED operation

	Operation	LED lighting status	
		"TRIP" LED	Configurable LED (LED1 - LED4)
Step 1	Press the RESET key more than 3s on the "Latest fault" screen	continue to lit	turn off
Step 2	Then, press the RESET key in short period on the "Latest fault" screen	turn off	

When any of the menu screens is displayed, the VIEW and RESET keys do not function.

To return from menu screen to the digest "Latest fault" screen, do the following:

- Return to the top screen of the menu by repeatedly pressing the END key.
- Press the END key to turn off the LCD.
- Press the VIEW key to display the digest "Latest fault" screen.

Displays in automatic supervision operation

```
Auto-supervision    08/Dec/1997   22:56

 DIO err
```

If the automatic supervision function detects a failure while the LCD is off, the "Auto-supervision" screen is displayed automatically, showing the location of the failure and the "ALARM" LED lights.

Press the VIEW key to display other digest screens in turn including the "Metering" and "Latest fault" screens.

Press the RESET key to turn off the LEDs and LCD display. However, if the failure continues, the "ALARM" LED remains lit.

After recovery from a failure, the "ALARM" LED and "Auto-supervision" display turn off automatically.

If a failure is detected while any of the screens is displayed, the current screen remains displayed and the "ALARM" LED lights.

Notes:
1) When configurable LEDs (LED1 through LED4) are assigned to latch signals by issuing an alarm, press the RESET key more than 3s until all LEDs reset except "IN SERVICE" LED.
2) When configurable LED is still lit by pressing RESET key in short period, press RESET key again to reset remained LED in the above manner.
3) LED1 through LED4 will remain lit in case the assigned signals are still active state.

While any of the menu screen is displayed, the VIEW and RESET keys do not function. To return to the digest "Auto-supervision" screen, do the following:

- Return to the top screen of the menu by repeatedly pressing the END key.
- Press the END key to turn off the LCD.
- Press the VIEW key to display the digest screen.
- Press the RESET key to turn off the LCD.

4.2.2 Relay Menu

Figure 4.2.2.1 shows the menu hierarchy in the GRZ100. The main menu has five sub-menus, "Record", "Status", "Setting (view)", "Setting (change)", and "Test". For details of the menu hierarchy, see Appendix E.

- Menu
  - Record
    - Fault record
    - Event record
    - Disturbance record
    - Automatic test
    - Autoreclose count
  - Status
    - Metering
    - Binary I/O
    - Relay element
    - Time sync source
    - Clock adjustment
    - Direction
  - Setting (view)
    - Version
    - Description
    - Communication
    - Record
    - Status
    - Protection
    - Binary input
    - Binary output
    - LED
  - Setting (change)
    - Password
    - Description
    - Communication
    - Record
    - Status
    - Protection
    - Binary input
    - Binary output
    - LED
  - Test
    - Switch
    - Manual test
    - Binary output
    - Timer
    - Logic circuit

Figure 4.2.2.1 Relay Menu

Record

In the "Record" menu, the fault record, event record and disturbance record can be displayed or erased. Furthermore, autoreclose and automatic test functions can be displayed in a counter form or reset.

Status

The "Status" menu displays the power system quantities, binary input and output status, relay measuring element status, signal source for time synchronization (IRIG-B, RSM, IEC or RMT) and adjusts the clock.

Setting (view)

The "Setting (view)" menu displays the relay version, plant name, and the current settings of relay address, IP address and RS232C baud rate, etc. in communication, record, status, protection, configurable binary inputs, configurable binary outputs and configurable LEDs.

Setting (change)

The "Setting (change)" menu is used to set or change the settings of password, plant name, relay address, IP address and RS232C baud rate, etc. in communication, record, status, protection, configurable binary inputs, configurable binary outputs and configurable LEDs.

Since this is an important menu and is used to set or change settings related to relay tripping, it has password security protection.

Test

The "Test" menu is used to set testing switches, to test the trip circuit, to forcibly operate binary output relays, to measure variable timer time and to observe the binary signals in the logic circuit.

When the LCD is off, press any key other than the VIEW and RESET keys to display the top "MENU" screen and then proceed to the relay menus.

```
   MENU
1=Record                2=Status
3=Setting(view)         4=Setting(change)
5=Test
```

To display the "MENU" screen when the digest screen is displayed, press the RESET key to turn off the LCD, then press any key other than the VIEW and RESET keys.

Press the END key when the top screen is displayed to turn off the LCD.

An example of the sub-menu screen is shown below. The top line shows the hierarchical layer of the screen, screen title and total number of lines of the screen. The last item is not displayed for all screens. "/6" displayed on the far left, for example, means that the screen is in the sixth hierarchical layer, while 1/8 displayed on the far right means that the screen has eight lines excluding the top line and the cursor is on the first line.

To move the cursor downward or upward for setting or for viewing other lines not displayed on the window, use the ▼ and ▲ keys.

```
/6 Scheme switch                                    1/10
ARC-EXT  0=Off   1=On                               0 _
ARC-DEF  0=Off   1=On                               0
ARC-BU   0=Off   1=On                               0
VCHK     0=Off   1=LB   2=DB   3=SY                 1
ARC-SM   0=Off   1=S2   2=S3   3=S4                 0
ARC-SUC  0=Off   1=On                               0
VTPHSEL  1=A  2=B  3=C                              1
VT-RATE  1=PH/G  2=PH/PH                            1
3PH-VT   1=Bus  2=Line                              1
UARCSW   1=P1   2=P2   3=P3                         1
```

To move to the lower screen or move from the left side screen to the right screen in Appendix E, select the appropriate number on the screen. To return to the higher screen or move from the right side screen to the left side screen, press the END key.

The CANCEL key can also be used to return to the higher screen but it must be used carefully because it may cancel entries made so far.

To move between screens of the same depth, first return to the higher screen and then move to the lower screen.

4.2.3 Displaying Records

The sub-menu of "Records" is used to display fault records, event records, disturbance records and autoreclosing output count.

4.2.3.1 Displaying Fault Records

To display fault records, do the following:

- Open the top "MENU" screen by pressing any keys other than the VIEW and RESET keys.
- Select 1 (= Record) to display the "Record" sub-menu.

```
/1 Record
1=Fault record          2=Event record
3=Disturbance record    4=Automatic test
5=Autoreclose count
```

- Select 1 (= Fault record) to display the "Fault record" screen.

```
/2 Fault record
1=Display     2=Clear
```

- Select 1 (= Display) to display the dates and times of fault records stored in the relay from the top in new-to-old sequence.

```
/3 Fault record                                 1/ 8
#1   16/Oct/1997 18:13:57.031
#2   20/Sep/1997 15:29:22.463
#3   04/Jul/1997 11:54:53.977
```

- Move the cursor to the fault record line to be displayed using the ▲ and ▼ keys and press the ENTER key to display the details of the fault record.

```
                    /4 Fault record #1                      3/  *
Date and Time  -->  04/Nov/1997  15:09:58.442
Fault phase    -->  Phase  ABCN           Trip  ABC  <-- Tripping phase
Tripping mode  -->   Z1
Fault location -->  ***.*km  (***%)  *OB*NC
                    ***.*km  (Junction-Remote1)  *OB*NC
                    Prefault values
                    Va   ***.*kV   ***.*°   Ia   **.**kA   ***.*°
                    Vb   ***.*kV   ***.*°   Ib   **.**kA   ***.*°
                    Vc   ***.*kV   ***.*°   Ic   **.**kA   ***.*°
                    Vab  ***.*kV   ***.*°   Iab  **.**kA   ***.*°
                    Vbc  ***.*kV   ***.*°   Ibc  **.**kA   ***.*°
                    Vca  ***.*kV   ***.*°   Ica  **.**kA   ***.*°
                    Vs1  ***.*kV   ***.*
                    V1   ***.*kV     0.0°   I1   **.**kA   ***.*°
                    V2   ***.*kV   ***.*°   I2   **.**kA   ***.*°
                    V0   ***.*kV   ***.*°   I0   **.**kA   ***.*°
Power system   -->                          I0m  **.**kA   ***.*°
quantities          Fault values
                    Va   ***.*kV   ***.*°   Ia   **.**kA   ***.*°
                    Vb   ***.*kV   ***.*°   Ib   **.**kA   ***.*°
                    Vc   ***.*kV   ***.*°   Ic   **.**kA   ***.*°
                    Vab  ***.*kV   ***.*°   Iab  **.**kA   ***.*°
                    Vbc  ***.*kV   ***.*°   Ibc  **.**kA   ***.*°
                    Vca  ***.*kV   ***.*°   Ica  **.**kA   ***.*°
                    Vs1  ***.*kV   ***.*
                    V1   ***.*kV     0.0°   I1   **.**kA   ***.*°
                    V2   ***.*kV   ***.*°   I2   **.**kA   ***.*°
                    V0   ***.*kV   ***.*°   I0   **.**kA   ***.*°
                                            I0m  **.**kA   ***.*°
                    Ra   ****.** Ω          Xa   ****.** Ω
                    Rb   ****.** Ω          Xb   ****.** Ω
                    Rc   ****.** Ω          Xc   ****.** Ω
                    Rab  ****.** Ω          Xab  ****.** Ω
                    Rbc  ****.** Ω          Xbc  ****.** Ω
                    Rca  ****.** Ω          Xca  ****.** Ω
                    THM  ****.* %

                    04/Nov/1997  15:09:59.817
Relevant events --> TPAR1, TPAR2
                    04/Nov/1997  15:10:00.029
                    Z1, CRT, FT1、FT2
```

The lines which are not displayed in the window can be displayed by pressing the ▲ and ▼ keys.

To clear fault records, do the following:

- Open the "Record" sub-menu.
- Select 1 (= Fault record) to display the "Fault record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Fault record
Clear all fault records?
          ENTER=Yes     CANCEL=No
```

- Press the ENTER (= Yes) key to clear all the fault records stored in non-volatile memory.

If all fault records have been cleared, the "Latest fault" screen of the digest screens is not displayed.

4.2.3.2 Displaying Event Records

To display events records, do the following:

- Open the top "MENU" screen by pressing any keys other than the VIEW and RESET keys.
- Select 1 (= Record) to display the "Record" sub-menu.
- Select 2 (= Event record) to display the "Event record" screen.

```
/2 Event record
1=Display     2=Clear
```

- Select 1 (= Display) to display the events with date and time from the top in new-to-old sequence.

```
/3 Event record                           2/96
16/Oct/1998 23:18:04.294   Trip          Off
16/Oct/1998 23:18:03.913   Trip          On
12/Feb/1998 03:51:37.622   Rly.set change
```

The lines which are not displayed in the window can be displayed by pressing the ▲and ▼ keys.

To clear event records, do the following:

- Open the "Record" sub-menu.
- Select 2 (= Event record) to display the "Event record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Event record
Clear all event records?
          ENTER=Yes     CANCEL=No
```

- Press the ENTER (= Yes) key to clear all the event records stored in non-volatile memory.

4.2.3.3 Displaying Disturbance Records

Details of the disturbance records can be displayed on the PC screen only(*); the LCD displays only the recorded date and time for all disturbances stored in the relay. They are displayed in the following sequence.

(*) For the display on the PC screen, refer to RSM100 manual.

- Open the top "MENU" screen by pressing any keys other than the VIEW and RESET keys.

- Select 1 (= Record) to display the "Record" sub-menu.
- Select 3 (= Disturbance record) to display the "Disturbance record" screen.

```
/2 Disturbance record
1=Display      2=Clear
```

- Select 1 (= Display) to display the date and time of the disturbance records from the top in new-to-old sequence.

```
/3 Disturbance record                    3/12
#1  16/Oct/1997 18:13:57.031
#2  20/Sep/1997 15:29:22.463
#3  04/Jul/1997 11:54:53.977
```

The lines which are not displayed in the window can be displayed by pressing the ▲ and ▼ keys.

To clear disturbance records, do the following:

- Open the "Record" sub-menu.
- Select 3 (=Disturbance record) to display the "Disturbance record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Disturbance record
Clear all disturbance records?
        ENTER=Yes     CANCEL=No
```

- Press the ENTER (= Yes) key to clear all the disturbance records stored in non-volatile memory.

4.2.3.4 Displaying Automatic Test

The "Automatic test" screens show the cumulative number of times the automatic test has been carried out(*) and the automatic test interval(**).

(*) The manual tests described in Section 4.2.7.2 are also added to these counts.
(**) For setting the test interval, see Section 4.2.6.5.

The telecommunication channel test is carried out in all the GRZ100 models when the external communication and the BOP command protection are selected.

The test count and test interval can be displayed or the test count can be reset to zero as follows.

To display the count and interval of the telecommunication channel test on the LCD, do the following:

- Select 1 (= Record) on the top "MENU" screen to display the "Record" screen.
- Select 4 (= Automatic test) to display the "Automatic test" screen.

```
/2 Automatic test
1=Telecomm channel test
```

- Select 1 (= Telecomm channel test) to display the "Telecomm channel test" screen.

```
/3 Telecomm channel test
1=Display count & interval
2=Reset count
```

- Select 1 (= Display counts & interval) to display the test count and test interval of the telecommunication channel.

```
/4 Telecomm channel test
Test count:        11
Test interval:     12 hours
```

To reset the telecommunication channel test count, do the following:

- Select 2 (= Reset count) on the "Telecom channel test" screen to display the following confirmation screen.

```
/3 Telecomm channel test
1=Display count & interval
2=Reset count
```

- Press the ENTER key to reset the test count to zero and return to the previous screen.

4.2.3.5 Displaying Autoreclose Count

The autoreclose output counts can be displayed or can be reset to zero as follows.

To display the autoreclose output counts on the LCD, do the following:

- Select 1 (= Record) on the top "MENU" screen to display the "Record" sub-menu.
- Select 5 (= Autoreclose count) to display the "Autoreclose count" screen.

```
/2 Autoreclose count
1=Display      2=Reset
```

- Select 1 (= Display) to display the autoreclose count.

```
/3 Autoreclose count
            SPAR          TPAR
   CB1     [  46]        [  46]
```

SPAR and TPAR mean single-phase and three-phase autoreclose respectively.

To reset the autoreclose output count, do the following:

- Select 2 (= Reset) on the "Autoreclose count" screen to display the "Reset autoreclose count" screen.

```
/3 Reset autoreclose count
1=CB1
```

- Select 1 (=CB1) to display the following confirmation screen.

```
/3 Reset autoreclose count
Reset counts?
        ENTER=Yes     CANCEL=No
```

- Press the ENTER key to reset the count to zero and return to the previous screen.

4.2.4 Displaying Status Information

From the sub-menu of "Status", the following status conditions can be displayed on the LCD:

Metering data of the protected line

Status of binary inputs and outputs

Status of measuring elements output

Status of time synchronization source

Load current direction

This data is updated every second.

This sub-menu is also used to adjust the time of the internal clock.

4.2.4.1 Displaying Metering Data

To display metering data on the LCD, do the following.

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.

```
/1 Status
1=Metering              2=Binary I/O
3=Relay element         4=Time sync source
5=Clock adjustment      6=Direction
```

- Select 1 (= Metering) to display the "Metering" screen.

```
/2 Metering     12/Feb/1998   22:56     3/ 36
Va     ***.*kV  ***.*°    Ia     **.**kA  ***.*°
Vb     ***.*kV  ***.*°    Ib     **.**kA  ***.*°
Vc     ***.*kV  ***.*°    Ic     **.**kA  ***.*°
Vab    ***.*kV  ***.*°    Iab    **.**kA  ***.*°
Vbc    ***.*kV  ***.*°    Ibc    **.**kA  ***.*°
Vca    ***.*kV  ***.*°    Ica    **.**kA  ***.*°
Vs1   ***.*kV  ***.*°
V1     ***.*kV    0.0°    I1     **.**kA  ***.*°
V2     ***.*kV  ***.*°    I2     **.**kA  ***.*°
V0     ***.*kV  ***.*°    I0     **.**kA  ***.*°
                          I0m    **.**kA  ***.*°
Va1    ***.*kV  ***.*°    Ia1    **.**kA  ***.*°
Vb1    ***.*kV  ***.*°    Ib1    **.**kA  ***.*°
Vc1    ***.*kV  ***.*°    Ic1    **.**kA  ***.*°
Va2    ***.*kV  ***.*°    Ia2    **.**kA  ***.*°
Vb2    ***.*kV  ***.*°    Ib2    **.**kA  ***.*°
Vc2    ***.*kV  ***.*°    Ic2    **.**kA  ***.*°
Vab1   ***.*kV  ***.*°    Iab1   **.**kA  ***.*°
Vbc1   ***.*kV  ***.*°    Ibc1   **.**kA  ***.*°
Vca1   ***.*kV  ***.*°    Ica1   **.**kA  ***.*°
Vab2   ***.*kV  ***.*°    Iab2   **.**kA  ***.*°
Vbc2   ***.*kV  ***.*°    Ibc2   **.**kA  ***.*°
Vca2   ***.*kV  ***.*°    Ica2   **.**kA  ***.*°
V11    ***.*kV    0.0°    I11    **.**kA  ***.*°
V21    ***.*kV  ***.*°    I21    **.**kA  ***.*°
V01    ***.*kV  ***.*°    I01    **.**kA  ***.*°
V12    ***.*kV    0.0°    I12    **.**kA  ***.*°
V22    ***.*kV  ***.*°    I22    **.**kA  ***.*°
V02    ***.*kV  ***.*°    I02    **.**kA  ***.*°
I2/I1  **.**
THM ****.*%
Telecomm delay time1       *****us
Telecomm delay time2       *****us
Active power     +****.**MW
Reactive power  -****.**Mvar
Frequency               **.*Hz
```

Metering data is expressed as primary values or secondary values depending on the setting. For setting, see Section 4.2.6.6.

4.2.4.2 Displaying the Status of Binary Inputs and Outputs

To display the binary input and output status, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 2 (= Binary I/O) to display the binary input and output status.

```
/2 Binary input & output                3/ 8
Input (IO#1)          [000 000 000 000    ]
Input (IO#2)          [000                ]
Input (IO#3)          [000 000 000 0      ]
Input (IO#4)          [000                ]
Output(IO#1-trip)     [000 000            ]
Output(IO#2)          [000 000 000 000 00 ]
Output(IO#3)          [000 000 000 0      ]
Output(IO#4)          [000 000 000 000 00 ]
```

The display format is shown below.

	[■	■	■	■	■	■	■	■	■	■	■	■	■	■	■]
Input (IO#1)	BI1	BI2	BI3	BI4	BI5	BI6	BI7	BI8	BI9	BI10	BI11	BI12	—	—	—
Input (IO#2)	BI16	BI17	BI18	—	—	—	—	—	—	—	—	—	—	—	—
Input (IO#3)	BI19	BI20	BI21	BI22	BI23	BI24	BI25	BI26	BI27	BI28	—	—	—	—	—
Input (IO#4)	BI34	BI35	BI36	—	—	—	—	—	—	—	—	—	—	—	—
Output (IO#1-trip)	TPA1	TPB1	TPC1	TPA2	TPB2	TPC2	—	—	—	—	—	—	—	—	—
Output (IO#2)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	BO11	BO12	FAIL	BO13	—
Output (IO#3)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	—	—	—	—	—
Output (IO#4)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	BO11	BO12	BO13	BO14	—

Lines 1 to 4 show the binary input status. BI1 to BI36 correspond to each binary input signal. For the binary input signals, see Appendix G. The status is expressed with logical level "1" or "0" at the photo-coupler output circuit. IO#1 to IO#4 in the table indicate the name of the module containing the binary input circuits.

Lines 5 to 8 show the binary output status. TPA1 to TPC2 of line 4 correspond to the tripping command outputs. FAIL of line 6 correspond to the relay failure output. Other outputs expressed with BO1 to BO14 are configurable. The status of these outputs is expressed with logical level "1" or "0" at the input circuit of the output relay driver. That is, the output relay is energized when the status is "1".

IO#1 to IO#4 in the table indicate the names of the module containing the binary output relays.

To display all the lines, press the ▲ and ▼ keys.

4.2.4.3 Displaying the Status of Measuring Elements

To display the status of measuring elements on the LCD, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 3 (= Relay element) to display the status of the relay elements.

```
/2 Relay element                    3/ **
ZG                  [000 000 000 000 000]
ZG2                 [000 000 000 000    ]
ZS                  [000 000 000 000 000]
ZS2                 [000 000 000 000    ]
BL                  [000 000 000 000    ]
OC                  [000 000 000 000 000]
DEF, OV             [000 00             ]
OV1                 [000 000            ]
OV2                 [000 000            ]
UV1                 [000 000 000 000 000]
UV2                 [000                ]
UV3                 [000 000 000        ]
UV4                 [000 000 000        ]
CBF, PSB, OST, BCD  [000 000 000 000 00 ]
PSB, THM            [000 000 00         ]
Autoreclose         [000 000 000        ]
```

The display format is as shown below.

	[■	■	■	■	■	■	■	■	■	■	■	■	■	■	■]
ZG	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
		Z1G			Z1XG			Z2G			Z3G			Z4G	
ZG2	A	B	C	A	B	C	A	B	C	A	B	C			
		ZFG			ZR1G			ZR2G			ZNDG				
ZS	AB	BC	CA	AB	BC	CA	AB	BC	CA	AB	BC	CA	AB	BC	CA
		Z1S			Z1XS			Z2S			Z3S			Z4S	
ZS2	AB	BC	CA	AB	BC	CA	AB	BC	CA	AB	BC	CA			
		ZFS			ZR1S			ZR2S			ZNDS				
BL	AB	BC	CA	AB	BC	CA	A	B	C	A	B	C	—	—	—
		BFS			BRS			BFG			BRG				
OC	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
		OCH			OCD			OC			OCI			OCDP	
DEF, OV	DEFF	DEFR	EFI	EF	OVG	—	—	—	—	—	—	—	—	—	—
OV1	AB	BC	CA	AB	BC	CA									
		OVS1			OVS2										
OV2	A	B	C	A	B	C									
		OVG1			OVG2										
UV1	A	B	C	AB	BC	CA	AB	BC	CA	A	B	C	A	B	C
		UVC			UVFS			UVLS			UVFG			UVLG	
UV2	A	B	C												
		UVPWI													
UV3	AB	BC	CA	AB	BC	CA	AB	BC	CA						
		UVS1			UVS2			UVSBLK							
UV4	A	B	C	A	B	C	A	B	C						
		UVG1			UVG2			UVGBLK							
CBF, PSB, OST, BCD	A	B	C	AB	BC	CA	AB	BC	CA	ZM	ZN	DOCNF	DOCNR	BCD	—
		OCBF			PSBSOUT			PSBSIN		OST					
PSB, THM	A	B	C	A	B	C	A	T							
		PSBGOUT			PSNGIN		THM								
Autoreclose (Model 2∗∗B) or	OVB	UVB	SYN1	OVL1	UVL1	3PLL									
Autoreclose (Model 3∗∗B)	OVB	UVB	SYN1	OVL1	UVL1	SYN2	OVL2	UVL2	3PLL	—	—	—	—	—	—

Lines 1 to 4 show the operation status of distance measuring elements for earth faults and phase faults respectively. Line 5 shows the operation status of blinder elements.

Lines 6 to 9 show the status of overcurrent, directional earth fault and overvoltage elements. Lines 10 to 13 show the status of undervoltage elements. Line 14 shows the status of the overcurrent element for breaker failure protection, power swing blocking element, out-of-step protection element and broken conductor detection element. Line 15 shows the status of the power swing blocking element and thermal overload element.

Line 16 shows the status of elements used for autoreclose.

The status of each element is expressed with logical level "1" or "0". Status "1" means the element is in operation.

To display all the lines on the LCD, press the ▲ and ▼ keys.

4.2.4.4 Displaying the Status of the Time Synchronization Source

The inner clock of the GRZ100 can be synchronized with external clocks such as the IRIG-B time standard signal clock or RSM (rlay setting and monitoring system) clock or by an IEC60870-5-103 control system or RMT (synchronizing with remote terminal). To display on the LCD whether these clocks are active or inactive and which clock the relay is synchronized with, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 4 (= Time sync source) to display the status of time synchronization sources.

```
/2 Time synchronization source    3/ 4
*IRIG: Active
 RSM:  Inactive
 IEC:  Inactive
 RMT:  Inactive
```

The asterisk on the far left shows that the inner clock is synchronized with the marked source clock. If the marked source clock is inactive, the inner clock runs locally.

For the setting time synchronization, see Section 4.2.6.6.

4.2.4.5 Adjusting the Time

To adjust the clock when the internal clock is running locally, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 5 (= Clock adjustment) to display the setting screen.

```
/2   12/Feb/1998 22:56:19  [Local]  1/ 5
Minute(    0-   59):      41 _
Hour  (    0-   23):      22
Day   (    1-   31):      12
Month (    1-   12):       2
Year  ( 1990- 2089):    1998
```

Line 1 shows the current date, time and time synchronization source with which the internal clock is synchronized. The time can be adjusted only when [Local] is indicated on the top line, showing that the clock is running locally. When [IRIG] or [RSM] or [IEC] or [RMT] is indicated, the following adjustment is invalid.

- Enter a numerical value within the specified range for each item and press the ENTER key.
- Press the END key to adjust the internal clock to the set hours without fractions and return to the previous screen.

If a date which does not exist in the calendar is set and END key is pressed, "Error: Incorrect date" is displayed on the top line and the adjustment is discarded. Adjust again.

4.2.4.6 Displaying the Direction of Load Current

To display the direction of load current on the LCD, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 6 (= Direction) to display the status of the relay elements.

```
/2 Direction
Phase A: Forward
Phase B: Forward
Phase C: Forward
```

Note: If the load current is less than 0.04xIn, the direction is expressed as "----".
The BFL element is used to detect the direction of load current and shared with blinder. (See Figure 2.4.1.13.)

4.2.5 Viewing the Settings

The sub-menu "Setting (view)" is used to view the settings made using the sub-menu "Setting (change)".

The following items are displayed:

Relay version
Description
Relay address in the RSM or IEC60870-5-103 communication
Recording setting
Status setting
Protection setting
Binary input setting
Binary output setting
LED setting

Enter a number on the LCD to display each item as described in the previous sections.

4.2.5.1 Relay Version

To view the relay version, do the following.

- Press 3 (= Setting (view)) on the main "MENU" screen to display the "Setting (view)" screen.

```
/1 Setting(view)
1=Version       2=Description     3=Comm.
4=Record        5=Status          6=Protection
7=Binary input  8=Binary output   9=LED
```

- Press 1 (= Version) on the "Setting (view)" screen and the "Relay version" screen appears.

```
/2 Relay version                          3/ 6
Relay type:        **********************
Serial No.:        **********************
Main software:     **********************
COM software:      **********************
PLC data:          ************ (********)
IEC103 data:       ************ (********)
```

4.2.5.2 Settings

The "Description", "Comm.", "Record", "Status", "Protection", "Binary input", "Binary output" and "LED" screens display the current settings input using the "Setting (change)" sub-menu.

4.2.6 Changing the Settings

The "Setting (change)" sub-menu is used to make or change settings for the following items:

Password
Description
Address in the RSM or IEC60870-5-103 communication
Recording
Status
Protection
Binary input
Binary output
LED

All of the above settings except the password can be seen using the "Setting (view)" sub-menu.

4.2.6.1 Setting Method

There are three setting methods as follows.

- To enter a selective number
- To enter numerical values
- To enter a text string

To enter a selected number

If a screen as shown below is displayed, perform the setting as follows.

The number to the left of the cursor shows the current setting or default setting set at shipment. The cursor can be moved to upper or lower lines within the screen by pressing the ▲ and ▼ keys. If setting (change) is not required, skip the line with the ▲ and ▼ keys.

```
/3 Metering                                 3/3
Display value  1=Primary  2=Secondary  1
Power (P/Q)    1=Send     2=Receive    1
Current        1=Lag      2=Lead       1 _
```

- Move the cursor to a setting line.
- Enter the selected number. (Numbers other than those displayed cannot be entered.)
- Press the ENTER key to confirm the entry and the cursor will move to the next line below. (On the lowest line, the entered number blinks in reverse video.)
- After completing the setting on the screen, press the END key to return to the upper menu.

To correct the entered number, do the following:

- If it is before pressing the ENTER key, press the CANCEL key and enter the new number.
- If it is after pressing the ENTER key, move the cursor to the correcting line by pressing the ▲ and ▼ keys and enter the new number.

Note: If the CANCEL key is pressed after any of the entry is confirmed by pressing the ENTER key, all the entries performed so far on the screen concerned are canceled and screen returns to the upper one.

When the screen shown below is displayed, perform setting as follows.

The number to the right of "Current No. = " shows the current setting.

```
/6 Protection scheme
1=3ZONE 2=Z1-EXT 3=PUP 4=POP 5=UOP 6=BOP
7=POP+DEF 8=UOP+DEF 9=BOP+DEF 10=PUP+DEF
  Current No.= 2          Select No. = _
```

- Enter a number to the right of "Select No. = ". (Numbers other than those displayed cannot be entered.)
- Press the ENTER key to confirm the entry and the entered number blinks in reverse video.
- After completing the setting on the screen, press the END key to return to the upper screen.

To correct the entered number, do the following:

- If it is before pressing the ENTER key, press the CANCEL key and enter the new number.
- If it is after pressing the ENTER key, enter the new number.

To enter numerical values

When the screen shown below is displayed, perform the setting as follows:

The number to the left of the cursor shows the current setting or default setting set at shipment. The cursor can be moved to upper or lower lines within the screen by pressing the ▲ and ▼ keys. If setting (change) is not required, skip the line with the ▲ and ▼ keys.

```
/7 Distance                          1/36
Z1S   (  0.01- 50.00):  0.01 _       Ω
Z1XS  (  0.01- 50.00):  0.01         Ω
Z1Sθ1(      0-    45):     0         deg
```

- Move the cursor to a setting line.
- Enter the numerical value.
- Press the ENTER key to confirm the entry and the cursor will move to the next line below. (If a numerical value outside the displayed range is entered, "Error: Out of range" appears on the top line and the cursor remains on the line. Press the CANCEL key to clear the entry.)
- After completing the setting on the screen, press the END key to return to the upper screen.

To correct the entered numerical value, do the following:

- If it is before pressing the ENTER key, press the CANCEL key and enter the new numerical value.
- If it is after pressing the ENTER key, move the cursor to the correcting line by pressing the ▲ and ▼ keys and enter the new numerical value.

Note: If the CANCEL key is pressed after any of the entry is confirmed by pressing the ENTER key, all the entries performed so far on the screen concerned are canceled and screen returns to the upper one.

To enter a text string

Text strings are entered in the bracket on the "Plant name" or "Description" screen.

To select a character, use keys 2, 4, 6 and 8 to move blinking cursor down, left, right and up, "→" and "←" on each of lines 2 to 4 indicate a space and backspace, respectively. A maximum of 22 characters can be entered within the brackets.

```
/3 Plant name  [                              ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ  ()[]@_        ←→
abcdefghijklmnopqrstuvwxyz  {}*/+-<=>     ←→
0123456789 !”#$%&’:;,.^`                  ←→
```

- Set the cursor position in the bracket by selecting "→" or "←" and pressing the ENTER key.
- Move the blinking cursor to a selecting character.
- Press the ENTER key to enter the blinking character at the cursor position in the bracket on the top line.
- Press the END key to confirm the entry and return to the upper screen.

To correct the entered character, do either of the followings:

- Discard the character by selecting "←" and pressing the ENTER key, and enter the new character.
- Discard the whole entry by pressing the CANCEL key and restart the entry from the first.

To complete the setting

Even after making entries on each setting screen by pressing the ENTER key, the new settings are not yet used for operation, though stored in the memory. To validate the new settings, take the following steps.

- Press the END key to return to the upper screen. Repeat this until the confirmation screen shown below is displayed. The confirmation screen is displayed just before returning to the "Setting (change)" sub-menu.

```
/2 ******************
Change settings ?
        Enter=Yes     Cancel=No
```

- When the screen is displayed, press the ENTER key to start operation using the new settings, or press the CANCEL key to correct or cancel the entries. In the latter case, the screen turns back to the setting screen to enable reentries. Press the CANCEL key to cancel entries made so far and to turn to the "Setting (change)" sub-menu.

4.2.6.2 Password

For the sake of security of setting changes, password protection can be set as follows;

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.

```
/1 Setting(change)
1=Password    2=Description    3=Comm.
4=Record      5=Status         6=Protection
7=Binary input   8=Binary output   9=LED
```

- Press 1 (= Password) to display the "Password" screen.

```
/2 Password
     Input new password    [_   ]
    Retype new password    [    ]
```

- Enter a 4-digit number within the brackets of "Input new password" and press the ENTER key.
- For confirmation, enter the same 4-digit number in the brackets of "Retype new password" and press the ENTER key.
- Press the END key to display the confirmation screen. If the retyped number is different from that first entered, the following message is displayed on the bottom of the "Password" screen before returning to the upper screen.

  "Mismatch-password unchanged"

Reentry is then requested.

Password trap

After the password has been set, the password must be entered in order to enter the setting change screens.

If 4 (= Setting (change)) is entered on the top "MENU" screen, the password trap screen "Password" is displayed. If the password is not entered correctly, it is not possible to move to the "Setting (change)" sub-menu screens.

```
 Password
         Input password    [_   ]
```

Canceling or changing the password

To cancel the password protection, enter "0000" in the two brackets on the "Password" screen. The "Setting (change)" screen is then displayed without having to enter a password.

The password can be changed by entering a new 4-digit number on the "Password" screen in the same way as the first password setting.

If you forget the password

Press CANCEL and RESET keys together for one second on the top "MENU" screen. The screen goes off, and the password protection of the GRZ100 is canceled. Set the password again.

4.2.6.3 Description

To enter the plant name and other data, do the following. These data are attached to records.

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 2 (= Description) to display the "Description" screen.

```
/2 Description
1=Plant name     2=Description
```

- To enter the plant name, select 1 (= Plant name) on the "Description" screen.

```
/3 Plant name  [   _                                   ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ  ()[]@_      ←→
abcdefghijklmnopqrstuvwxyz  {}*/+-<=>   ←→
0123456789  !"#$%&' :;,.^`              ←→
```

To enter special items, select 2 (= Description) on the "Description" screen.

```
/3 Description [   _                                   ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ  ()[]@       ←→
abcdefghijklmnopqrstuvwxyz  {}*/+-<=>   ←→
0123456789  !"#$%&' :;,.^`              ←→
```

- Enter the text string.

The plant name and special items entered are viewed with the "Setting (view)" sub-menu and attached to disturbance records when they are displayed on a local or a remote PC.

4.2.6.4 Communication

If the relay is linked with RSM or IEC60870-5-103, the relay address must be set. Do this as follows:

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 3 (= Comm.) on the "Setting (change)" screen to display the "Communication" screen.

```
/2 Communication
1=Address/Parameter
2=Switch
```

- Press 1 (= Address/Parameter) to enter the relay address number.

```
/3 Address/Parameter                          1/ 15
HDLC   (      1-     32):        1 _
IEC    (      0-    254):        2
SYADJ  ( -9999-   9999):         0       ms
--------------------------------------------------
IP1-1  (      0-    254):        0
IP1-2  (      0-    254):        0
IP1-3  (      0-    254):        0
IP1-4  (      0-    254):        0
SM1-1  (      0-    254):        0
SM1-2  (      0-    254):        0
SM1-3  (      0-    254):        0
SM1-4  (      0-    254):        0
GW1-1  (      0-    254):        0
GW1-2  (      0-    254):        0
GW1-3  (      0-    254):        0
GW1-4  (      0-    254):        0
```

- Enter the address number on "HDLC" column for RSM and/or "IEC" column for IEC60870-5-103 and the compensation value on "SYADJ" column for adjustment of time synchronization of protocol used. (–: lags the time, +: leads the time) And enter IP address for IP1-1 to IP1-4, Subnet mask for SM1-1 to SM4, and Default gateway for GW1-1 to GW1-4.

IP address: $\underbrace{***}_{\text{IP1-1}}$, $\underbrace{***}_{\text{IP1-2}}$, $\underbrace{***}_{\text{IP1-3}}$, $\underbrace{***}_{\text{IP1-4}}$

Subnet mask SM1-1 to SM4 and Default gateway GW1-1 to GW1-4: same as above.

- Press the ENTER key.

CAUTION: Do not overlap the number in a network.

- Press 2 (= Switch) on the "Communication" screen to select the protocol and transmission speed (baud rate), etc., of the RSM or IEC60870-5-103.

```
/3 Switch                                          1/   *
PRTCL1      1=HDLC  2=IEC103                         2  _
232C        1=9.6  2=19.2  3=38.4  4=57.6            4
IECBR       1=9.6  2=19.2                            2
IECBLK      1=Normal  2=Blocked                      1
```

- Select the number corresponding to the system and press the ENTER key.

<PRTCL1>

PRTCL1 is used to select the protocol for channel 1 (COM1 or OP1) of the serial communication port RS485 or FO (fibre optic).

- When the remote RSM system applied, select 1 (=HDLC). When the IEC60870-5-103 applied, select 2 (=IEC103).

<232C>

This line is to select the RS232C baud rate when the RSM system applied.

Note: The default setting of the 232C is 9.6kbps. The 57.6kbps setting, if possible, is recommended to serve user for comfortable operation. The setting of RSM100 is also set to the same baud rate.

<IECBR>

This line is to select the baud rate when the IEC60870-5-103 system applied.

<IECBLK>

Select 2 (=Blocked) to block the monitor direction in the IEC60870-5-103 communication.

4.2.6.5 Setting the Recording

To set the recording function as described in Section 4.2.3, do the following:

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 4 (= Record) to display the "Record" screen.

```
/2 Record
1=Fault record        2=Event record
3=Disturbance record
4=Automatic test interval
```

Setting the fault recording

- Press 1 (= Fault record) to display the "Fault record" screen.

```
/3 Fault record                              1/ 1
Fault locator      0=Off     1=On            1 _
```

- Enter 1 (= On) to record the fault location.

  Enter 0 (= Off) not to record the fault location.
- Press the ENTER key.

Setting the event recording

- Press 2 (= Event record) to display the "Event record" screen.

```
/3 Event record                              1/129
BITRN(      0-    128):     128 _
EV1  (      0-   3071):       0
EV2  (      0-   3071):       1
EV3  (      0-   3071):       1
EV4  (      0-   3071):       1
EV5  (      0-   3071):    3071
EV6  (      0-   3071):    3071
EV7  (      0-   3071):    3071
EV8  (      0-   3071):    3071
EV9  (      0-   3071):    3071
EV10 (      0-   3071):    3071
                 :
                 :
                 :
EV128(      0-   3071):    3071
```

<BITRN>

- Enter the number of event to record the status change both to "On" and "Off". If enter 20, both status change is recorded for EV1 to EV20 events and only the status change to "On" is recorded for EV21 to EV128 events.

<EV∗>

- Enter the signal number to record as the event in Appendix B. It is recommended that this setting can be performed by RSM100 because the signal name cannot be entered by LCD screen. (Refer to Section 3.4.2.)

Setting the disturbance recording

- Press 3 (= Disturbance record) to display the "Disturbance record" screen.

```
/3 Disturbance record
1=Record time & starter
2=Scheme switch
3=Binary signal
```

- Press 1 (= Record time & starter) to display the "Record time & starter" screen.

```
/4 Record time & starter              1/5
Time  (   0.1-   3.0):    2.0 _       A
OCP-S(   0.5- 250.0):   10.0         A
OCP-G(   0.5- 250.0):   10.0         A
UVP-S(      0-   132):    100         V
UVP-G(      0-    76):     57         V
```

- Enter the recording time and starter element settings.

To set each starter to use or not to use, do the following:

- Press 2 (= Scheme switch) on the "Disturbance record" screen to display the "Scheme switch" screen.

```
/4 Scheme switch                      1/ 5
TRIP      0=Off   1=On                1 _
OCP-S     0=Off   1=On                1
OCP-G     0=Off   1=On                1
UVP-S     0=Off   1=On                1
UVP-G     0=Off   1=On                1
```

- Enter 1 to use as a starter.
- Press 3 (= Binary signal) on the "Disturbance record" screen to display the "Binary signal" screen.

```
/4 Binary signal                      1/32
SIG1  (      0-  3071):      1_
SIG2  (      0-  3071):      2
SIG3  (      0-  3071):      3
SIG4  (      0-  3071):      4
 :           :                :
SIG32(      0-  3071):      0
```

- Enter the signal number to record binary signals in Appendix B. It is recommended that this setting can be performed by RSM100 because the signal name cannot be entered by LCD screen. (Refer to Section 3.4.3.)

Setting the automatic testing

- Press 4 (= Automatic test interval) to display the "Automatic test interval" screen.

```
/3 Automatic test interval            1/1
Chann(      1-    24):      12 _      hrs
```

- Enter the test intervals of the signal channel.

4.2.6.6 Status

To set the status display described in Section 4.2.4, do the following.

- Press 5 (= Status) on the "Setting (change)" sub-menu to display the "Status" screen.

```
/2 Status
1=Metering
2=Time synchronization
3=Time zone
```

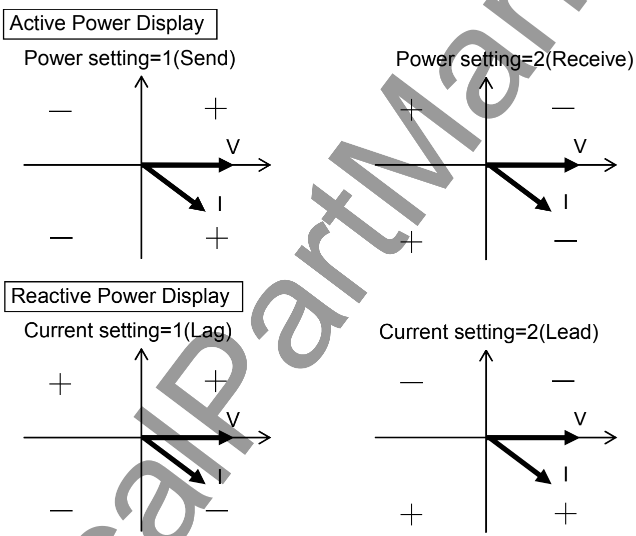
Setting the metering

- Press 1 (= Metering) to display the "Metering" screen.

```
/3 Metering                                          1/3
Display value  1=Primary   2=Secondary   1 _
Power (P/Q)    1=Send      2=Receive     1
Current        1=Lag       2=Lead        1
```

- Enter the selected number and press the ENTER key. Repeat this for all items.

Note: Power and Current setting



Setting the time synchronization

The calendar clock can run locally or be synchronized with external IRIG-B time standard signal, RSM clock or IEC60870-5-103. This is selected by setting as follows:

- Press 2 (= Time synchronization) to display the "Time synchronization" screen.

```
/3 Time synchronization
0=Off  1=IRIG  2=RSM  3=IEC  4=RMT

  Current No.=0              Select No.=_
```

- Enter the selected number and press the ENTER key.

Note: When to select IRIG-B, RSM, IEC or RMT, check that they are active on the "Time synchronization source" screen in "Status" sub-menu. If it is set to an inactive IRIG-B, RSM, IEC or RMT, the calendar clock runs locally. RMT means that the clock is synchronized with that of remote terminal. So, do not set all terminal relays to RMT. Therefore, if local terminal is set RMT, any one of remote terminals is set to the other clock setting with time synchronization source such as IRIG-B, RSM or IEC. It is recommended that the master terminal is set to the clock with time synchronization source and the slave terminal set to RMT.

Setting the time zone

When the calendar clock is synchronized with the IRIG-B time standard or GPS signal, it is possible to transform GMT to the local time.

- Press 3 (= Time zone) to display the "Time zone" screen.

```
/3 Time zone                              1/1
GMT  (   -12-   +12):      +9 _      hrs
```

- Enter the difference between GMT and local time and press the ENTER key.

4.2.6.7 Protection

The GRZ100 can have 8 setting groups for protection in order to accommodate changes in the operation of the power system. One setting group is assigned active. To set the protection, proceed as follows:

- Press 6 (= Protection) on the "Setting (change)" screen to display the "Protection" screen.

```
/2 Protection
1=Change active group
2=Change setting
3=Copy group
```

Changing the active group

- Press 1 (= Change active group) to display the "Change active group" screen.

```
/3 Change active group(Active group= *)
1=Group1   2=Group2   3=Group3   4=Group4
5=Group5   6=Group6   7=Group7   8=Group8
  Current No.= *         Select No. = _
```

- Enter the selected number and press the ENTER key.

Changing the settings

Almost all the setting items have default values that are set when the product was shipped. For the default values, see Appendix D and H.

To change the settings, do the following:

- Press 2 (= Change setting) to display the "Change setting" screen.

```
/3 Change setting      (Active group= *)
1=Group1   2=Group2   3=Group3   4=Group4
5=Group5   6=Group6   7=Group7   8=Group8
```

- Press the group number to change the settings and display the "Protection" screen.

```
/4 Protection                         (Group *)
1=Line parameter
2=Telecommunication     3=Trip
4=Autoreclose
```

Setting the line parameters

Enter the line name, VT&CT ratio and settings for the fault locator as follows:

- Press 1 (= Line parameter) on the "Protection" screen to display the "Line parameter" screen.

```
/5 Line parameter                (Group *)
1=Line name
2=VT & CT ratio
3=Fault locator
```

- Press 1 (= Line name) to display the "Line name" screen.
- Enter the line name as a text string.
- Press the END key to return the display to the "Line parameter" screen.
- Press 2 (= VT&CT ratio) to display the "VT&CT ratio" screen.

```
/6 VT & CT ratio                        1/  8
VT    (     1- 20000):    2200 _
VTs1  (     1- 20000):    2200
VTs2  (     1- 20000):    2200
VTr1  (     1- 20000):    2000
VTr2  (     1- 20000):    2000
CT    (     1- 20000):     400
CTr1  (     1- 20000):     400
CTr2  (     1- 20000):     400
```

- Enter the VT ratio for protection function and press the ENTER key.
- Enter the VTs1 ratio and/or VTs2 ratio for autoreclose function and press the ENTER key. VTs1 is used for the VT ratio setting for voltage and synchronism check of autoreclose function. VTs2 is used for the VT ratio setting for the other voltage and synchronism check at the time of two-breaker autoreclose. VTr1 and CTr1 are used for VT and CT ratios for remote terminal 1, and VTr2 and CTr2 for remote terminal 2.
- Enter the CT ratio for protection function and press the ENTER key.
- Press the END key to return the display to the "Line parameter" screen.
- Press 3 (= Fault locator) to display the "Fault locator" screen.

```
/6 Fault locator                                 1/21
X1     (  0.00 - 199.99) :   10.00 _   Ω
X0     (  0.00 - 199.99) :   34.00     Ω
X0m    (  0.00 - 199.99) :    2.00     Ω
R1     (  0.00 - 199.99) :    0.20     Ω
R0     (  0.00 - 199.99) :    0.70     Ω
R0m    (  0.00 - 199.99) :   10.00     Ω
Z0B-L  (  0.00 - 199.99) :   10.00     Ω
Z0B-R  (  0.00 - 199.99) :   10.00     Ω
Kab    (    80 -    120) :     100     %
Kbc    (    80 -    120) :     100     %
Kca    (    80 -    120) :     100     %
Ka     (    80 -    120) :     100     %
Kb     (    80 -    120) :     100     %
Kc     (    80 -    120) :     100     %
Line   (  0.0  -  399.9) :    80.0    km
2X1    (  0.00 - 199.99) :   10.00     Ω
2R1    (  0.00 - 199.99) :    0.20     Ω
2Line  (  0.0  -  399.9) :    80.0    km
3X1    (  0.00 - 199.99) :   10.00     Ω
3R1    (  0.00 - 199.99) :    0.20     Ω
3Line  (  0.0  -  399.9) :    80.0    km
```

- Enter the setting and press the ENTER key for each item.
- Press the END key after completing the settings to return the display to the "Line parameters" screen.

Setting the telecommunication

To set the scheme switches and telecommunication elements, do the following:

- Press 2 (= Telecommunication) on the "Protection" screen to display the "Telecommunication" screen.

```
/5 Telecommunication                  (Group *)
1=Scheme switch
2=Telecommunication element
```

- Press 1 (= Scheme switch) to display the "Scheme switch" screen.

  Set the [CO. LINK] to "Integral communication (=Int)" or "External communication (=Ext)" and the [SP. SYN.] to "Master" or "Slave" and the [TERM] to "2 terminal line (=2TERM)" or "3 terminal line (=3TERM)" or "Dual communication for 2 terminal line (=Dual)".

  Note: In the [SP. SYN] setting, one terminal should be set to "Master" and other terminals set to "Slave"

  The [CH. USE] is used to set the using channel when the chain topology is applied.

  The [RYIDSV] is set to “ON” when the relay address monitoring is enabled.

  The [CH.CON] is set to “Exchange” when changing the CH1 signal with the CH2 signal in the relay inside. See section 2.5.1.6.

  The [T.SFT1] and [T.SFT2] are set to “ON” to synchronize the relay with the multiplexer by shifting the send signal by a half-bit when the distance from the relay to the multiplexer is a long.

The [B.SYN1] and [B.SYN2] are set to "ON" when the relay is linked a multiplexer. Set to "OFF" when direct link is applied.

However [TERM], [CH.USE], [CH.CON], [T.SFT2] and [B.SYN2] items are not displayed in the case of 2 terminal models.

```
／6 Scheme switch                              1／ 10
CO.LINK  1=Int  2=Ext                          2 _
SP.SYN.  1=Master  2=Slave                     1
TERM     1=2TERM  2=3TERM  3=Dual              1
CH.USE   1=Both  2=CH1USE  3=CH2USE            1
RYIDSV   0=Off  1=On                           1
CH.CON   1=Normal  2=Exchange                  1
T.SFT1   0=Off  1=On                           1
T.SFT2   0=Off  1=On                           1
B.SYN1   0=Off  1=On                           1
B.SYN2   0=Off  1=On                           1
```

- Press 2 (= Telecommunication element) to display the "Telecommunication" screen. Set the relay identity numbers and delay time for supervision, and the difference of the transmission delay time TCDT1 and TCDT2 for channel 1 and 2.

RYID, RYID1, RYID2: Setting for address numbers of the local (RYID) and remote (RYID1 and RYID2) relays. The different address must be assigned to a relay at each terminal. These items are only enabled when the switch [RYIDSV] is set to "ON".

TDSV: Setting for transmission delay time to be supervised.

TCDT1, TCDT2: Adjusting the transmission delay time difference for channel 1 and 2.

```
／6 Telecommunication element                  1／  6
RYID  (       0-     63):       0 _
RYID1 (       0-     63):       0
RYID2 (       0-     63):       0
TDSV  (     100-  16000):    6000          us
TCDT1 (-10000-  10000):       0          us
TCDT2 (-10000-  10000):       0          us
```

Setting the protection function

To set the protection schemes, scheme switches and protection elements, do the following. Protection elements are the measuring elements and timers.

Note: Depending on the selected protection scheme and scheme switch setting, some of the scheme switches and protection elements are not used and so need not be set. The protection function setting menu of the GRZ100 does not display unnecessary setting items. Therefore, start by setting the protection scheme, then set the scheme switch, then the protection elements.
As a result of the above, note that some of the setting items described below may not appear in the actual setting.

- Press 2 (= Trip) on the "Protection" screen to display the "Trip" screen.

```
/5 Trip                          (Group *)
1=Protection scheme
2=Scheme switch
3=Protection element
```

Protection scheme setting

- Press 1 (= Protection scheme) on the "Trip" screen to display the "Protection scheme" screen.

```
/6 Protection scheme
1=3ZONE 2=Z1-EXT 3=PUP 4=POP 5=UOP 6=BOP
7=POP+DEF 8=UOP+DEF 9=BOP+DEF 10=PUP+DEF
  Current No.= 2          Select No. = _
```

- Select the protection scheme to be used by entering the number corresponding to the protection scheme and press the ENTER key.
- Press the END key to return to the "Trip" screen.

Setting the scheme switches

- Press 2 (= Scheme switch) on the "Trip" screen to display the "Scheme switch" screen.

```
/6 Scheme switch                              1/ **
ZS-C      1=Mho  2=Quad                       1  _
ZG-C      1=Mho  2=Quad                       1
BLZONE    1=COM  2=IND                        1
Z1CNT     1=1  2=2  3=3  4=4  5=5             1
PSB-Z1    0=Off  1=On                         1
    :                                         :
PSB-TP    0=Off  1=On                         1
UVPWIEN   0=Off  1=On                         0
SCFCNT    1=BLK  2=trip                       2
STUB      0=Off  1=On                         0
SOTF-DL   1=CB  2=UV  3=Both                  1
    :                                         :
SOTF-ND   0=Off  1=On                         0
ZFBT      0=Off  1=On                         0
    :                                         :
OCIBT     0=Off  1=On                         0
MOCI      1=Long  2=Std  3=Very  4=Ext        2
EFBT      0=Off  1=On                         0
EFBTAL    0=Off  1=On                         0
DEFFEN    0=Off  1=DT  2=IDMT                 0
DEFREN    0=Off  1=DT  2=IDMT                 0
DEFBTAL   0=Off  1=On                         0
DEFI      0=Off  1=NOD  2=F  3=R              0
MEFI      1=Long  2=Std  3=Very  4=Ext        2
OVS1EN    0=Off  1=DT  2=IDMT                 0
OVS2EN    0=Off  1=On                         0
    :                                         :
UVG1EN    0=Off  1=DT  2=IDMT                 0
UVG2EN    0=Off  1=On                         0
VBLKEN    0=Off  1=On                         0
BCDEN     0=Off  1=On                         0
CRSCM     0=Off  1=On                         1
CHSEL     1=Single  2=Guard  3=And            1
BOSW      1=Normal  2=Inverse                 1
ZONESEL   1=Z2  2=Z3                          1
ECHO      0=Off  1=On                         1
WKIT      0=Off  1=On                         1
CH-DEF    1=CH1  2=CH2                        1
BODEFSW   1=Active  2=Inactive                1
BF1       0=Off  1=T  2=TOC                   0
BF2       0=Off  1=On                         0
BFEXT     0=Off  1=On                         0
OST       0=Off  1=Trip  2=BO                 0
THMT      0=Off  1=On                         0
THMAL     0=Off  1=On                         0
VTF1EN    0=Off  1=On  2=OPT-On               1
VTF2EN    0=Off  1=On  2=OPT-On               1
VTF-Z4    0=Off  1=On                         1
CHMON     0=Off  1=On                         1
LSSV      0=Off  1=On                         0
SVCNT     0=ALM&BLK  1=ALM                    0
CTSV      0=Off  1=ALM&BLK  2=ALM             0
FL-Z0B    0=Off  1=On                         0
AOLED     0=Off  1=On                         1
```

- Enter the number corresponding to the switch status to be set and press the ENTER key for each switch.

- After setting all switches, press the END key to return to the "Trip" screen.

Setting the protection elements

- Press 3 (= Protection element) to display the "Protection element" screen.

```
/6 Protection element             (Group *)
1=Distance     2=PSB&OST     3=OC,DEF&UV
4=Command trip
```

<Distance>

- Press 1 (= Distance) to display the "Distance" screen. The measuring elements and timers used in the distance protection are set using this screen.

/7 Distance			1/ **
Z1S	(0.01- 50.00):	0.01 _	Ω
Z1XS	(0.01- 50.00):	0.01	Ω
Z1Sθ1	(0- 45):	0	deg
Z1Sθ2	(45- 90):	90	deg
BFR1S	(0.10- 20.00):	0.10	Ω
BFRXS	(0.10- 20.00):	0.10	Ω
Z2S	(0.01- 50.00):	0.01	Ω
BFR2S	(0.10- 20.00):	0.10	Ω
ZFS	(0.01- 50.00):	0.01	Ω
BFRFS	(0.10- 20.00):	0.10	Ω
Z3S	(0.01- 50.00):	1.00	Ω
Z3Sθ	(45- 90):	60	deg
ZBSθ	(0- 45):	5	deg
BFRS	(0.10- 20.00):	0.10	Ω
BFLSθ	(90- 135):	120	deg
ZR1S	(0.01- 50.00):	1.00	Ω
ZR2S	(0.01- 50.00):	1.00	Ω
Z4S	(0.01- 50.00):	1.00	Ω
BRRS	(0.10- 20.00):	0.10	Ω
ZNDS	(0.01- 50.00):	0.01	Ω
BNDS	(0.10- 20.00):	0.10	Ω
TZ1S	(0.00- 10.00):	0.00	s
:	:	:	:
TZNDS	(0.00- 10.00):	0.00	s
Z1G	(0.01- 50.00):	0.01	Ω
Z1XG	(0.01- 50.00):	0.01	Ω
Z1Gθ1	(0- 45):	0	deg
Z1Gθ2	(45- 90):	90	deg
BFR1G	(0.10- 20.00):	0.10	Ω
BFRXG	(0.10- 20.00):	0.10	Ω
Z2G	(0.01- 50.00):	0.01	Ω
BFR2G	(0.10- 20.00):	0.10	Ω
ZFG	(0.01-100.00):	0.01	Ω
BFRFG	(0.10- 20.00):	0.10	Ω
Z3G	(0.01-100.00):	1.00	Ω
Z3Gθ	(45- 90):	60	deg
ZBGθ	(0- 45):	5	deg
BFRG	(0.10- 20.00):	0.10	Ω
BFLGθ	(90- 135):	120	deg
ZR1G	(0.00- 50.00):	0.00	Ω
ZR2G	(0.00-100.00):	0.00	Ω
Z4G	(0.01-100.00):	1.00	Ω
BRRG	(0.10- 20.00):	0.10	Ω
Krs	(0- 1000):	0	%
Kxs	(0- 1000):	0	%
Krm	(0- 1000):	0	%
Kxm	(0- 1000):	0	%
KrsR	(0- 1000):	0	%
KxmR	(0- 1000):	0	%
ZNDG	(0.01-100.00):	0.01	Ω
BNDG	(0.10- 20.00):	0.10	Ω
TZ1G	(0.00- 10.00):	0.00	s
:	:	:	:
TZNDG	(0.00- 10.00):	0.00	s
ZIC	(0.00- 5.00):	0.00	A
Vn	(100- 120):	110	V

- Enter the numerical value and press the ENTER key for each element.
- After setting all elements, press the END key to return to the "Protection element" menu.

<PSB&OST>

- Press 2 (= PSB&OST) to display the "PSB & OST" screen. The measuring elements and timers used in the power swing blocking and out-of-step tripping are set using this screen.

```
/7 PSB&OST                              1/  9
PSBSZ (  0.50- 15.00):    0.50 _        Ω
PSBGZ (  0.50- 15.00):    0.50 _        Ω
TPSB  (    20-    60):      40         ms
OSTR1 (   3.0-  30.0):     1.0          Ω
OSTR2 (   1.0-  10.0):     1.0          Ω
OSTXF (   1.0-  50.0):     1.0          Ω
OSTXB (   0.2-  10.0):     0.2          Ω
TOST1 (  0.01-  1.00):    0.01          s
TOST2 (  0.01-  1.00):    0.01          s
```

- Enter the numerical value and press the ENTER key for each element.
- After setting all elements, press the END key to return to the "Protection element" menu.

<OC, DEF&UV>

- Press 3 (= OC, DEF&UV) to display the "OC, DEF&UV" screen. The overcurrent, undervoltage and directional earth fault elements and timers are set using this screen.

```
/7 OC, DEF&UV                                1/ **
OCH    (  2.0-   15.0):    2.0 _      A
TSOTF  (    0-    300):      5        s
OCBF   (  0.5-   10.0):    0.5        A
TBF1   (   50-    500):     50        ms
TBF2   (   50-    500):     50        ms
DEFFI  (  0.5-    5.0):    0.5        A
DEFFV  (  1.7-   21.0):    1.7        V
DEFRI  (  0.5-    5.0):    0.5        A
DEFRV  (  1.7-   21.0):    1.7        V
DEFθ   (    0-     90):      0        deg
TDEF   ( 0.00-  10.00):   3.00        s
TDER   ( 0.00-  10.00):   3.00        s
OC     (  0.5-  100.0):    0.5        A
TOC    ( 0.00-  10.00):   1.00        s
OCI    (  0.5-   25.0):    0.5        A
TOCI   ( 0.05-   1.00):   1.00
TOCIR  (  0.0-   10.0):    0.0        s
EF     (  0.5-    5.0):    0.5        A
TEF    ( 0.00-  10.00):   1.00        s
EFI    (  0.5-    5.0):    0.5        A
TEFI   ( 0.05-   1.00):   1.00
TEFIR  (  0.0-   10.0):    0.0        s
EFL    (  0.5-    5.0):    0.5        A
UVCV   (   10-     60):     10        V
UVCZ   (  0.0-   50.0):    0.0        Ω
UVCθ   (   45-     90):     60        deg
UVFS   (   50-    100):     50        V
UVLS   (   50-    100):     50        V
UVFG   (   10-     60):     10        V
UVLG   (   10-     60):     10        V
OCDP   (  0.5-   10.0):    4.0        A
OVS1   (  5.0-  150.0):  120.0        V
TOS1I  ( 0.05-  100.0):  10.00
TOS1   ( 0.00-300.00):   0.10         s
TOS1R  (  0.0-  300.0):    0.0        s
OS1DP  (   10-     98):     95        %
    :         :                :      :
TUG2   ( 0.00-300.00):   0.10         s
VGBLK  (  5.0-   20.0):   10.0        V
BCD    ( 0.10-   1.00):   0.20
TBCD   ( 0.00-300.00):   0.00         s
THM    (  2.0-   10.0):    5.0        A
THMIP  (  0.0-    5.0):    0.0        A
TTHM   (  0.5-  300.0):   10.0        min
THMA   (   50-     99):     80        %
```

- Enter the numerical value and press the [ENTER] key for each element.
- After setting all elements, press the [END] key to return to the "Protection element" menu.

<Command trip>

- Press 4 (= Command trip) to display the "Command trip" screen. The timers used in the command protection are set using this screen(*).

```
/7 Command trip                                1/ 7
TDEFF( 0.00-  0.30):   0.00 _      s
TDEFR( 0.00-  0.30):   0.00        s
TCHD (    0-    50):     12       ms
TCHDE(    0-   100):     20       ms
TREBK( 0.00- 10.00):   0.10        s
TECCB( 0.00-200.00):   0.10        s
TSBCT( 0.00-  1.00):   0.10        s
```

- Enter the numerical value and press the ENTER key for each timer.
- After setting all timers, press the END key to return to the "Protection element setting" menu.

  (*) As described in the "Notes on setting", if the protection scheme is set to 3ZONE, Z1-EXT, PUP, POP or UOP, no setting items are displayed in the "Command trip" screen. Press the END key to return to the upper screen.

Setting the autoreclose function

To set the autoreclose mode, scheme switches and autoreclose elements, do the following:

Note: Depending on the autoreclose mode and scheme switch setting, some of the scheme switches and autoreclose elements are not used and so do not need to be set. The autoreclose function setting menu of the GRZ100 does not display unnecessary setting items. Therefore, start by setting the autoreclose mode, and proceed to set the scheme switch, then the autoreclose elements.
As a result of the above, note that some of the setting items described below may not appear in the actual setting.

- Press 3 (= Autoreclose) on the "Protection" screen to display the "Autoreclose" screen.

```
/5 Autoreclose                      (Group *)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

Setting the Autoreclose mode

- Press 1 (= Autoreclose mode) to display the "Autoreclose mode" screen.

```
/6 Autoreclose mode
1=Disable  2=SPAR   3=TPAR   4=SPAR&TPAR
5=EXT1P    3=EXT3P
  Current No.= 4          Select No. = _
```

- Select the autoreclose mode to be used by entering the number corresponding to the autoreclose mode and press the ENTER key.
- Press the END key to return to the "Autoreclose" screen.

Setting the scheme switches

- Press 2 (= Scheme switch) to display the "Scheme switch" screen.

```
/6 Scheme switch                              1/10
ARC-EXT  0=Off  1=On                          0 _
ARC-DEF  0=Off  1=On                          0
ARC-BU   0=Off  1=On                          0
VCHK     0=Off  1=LB   2=DB   3=SY            1
ARC-SM   0=Off  1=S2   2=S3   3=S4            0
ARC-SUC  0=Off  1=On                          0
VTPHSEL  1=A  2=B  3=C                        1
VT-RATE  1=PH/G  2=PH/PH                      1
3PH-VT   1=Bus  2=Line                        1
UARCSW   1=P1   2=P2   3=P3                   1
```

- Enter the number corresponding to the switch status to be set and press the ENTER key for each switch.
- After setting all switches, press the END key to return to the "Autoreclose" screen.

Setting the autoreclose elements

- Press 3 (= Autoreclose element) to display the "Autoreclose element" screen.

```
/6 Autoreclose element             (Group *)
1=Autoreclose timer
2=Synchrocheck
```

<Autoreclose timer>

- Press 1 (= Autoreclose timer) to display the "Autoreclose timer" screen.

```
/7 Autoreclose timer                     1/13
TEVLV( 0.01-  10.0):    1.00 _       s
TRDY1(    5-   300):      60         s
TSPR1( 0.01-  10.0):    0.80         s
TTPR1( 0.01-100.00):    0.60         s
TRR  ( 0.01-100.00):    2.00         s
TW1  (   0.1-  10.0):    0.3         s
TS2  (   5.0- 300.0):   20.0         s
TS2R (   5.0- 300.0):   30.0         s
TS3  (   5.0- 300.0):   20.0         s
TS3R (   5.0- 300.0):   30.0         s
TS4  (   5.0- 300.0):   20.0         s
TS4R (   5.0- 300.0):   30.0         s
TSUC (   0.1-  10.0):    3.0         s
```

- Enter the numerical value and press the ENTER key for each timer.
- After setting all timers, press the END key to return to the "Autoreclose element" menu.

<Synchrocheck>

- Press 2 (= Synchrocheck) to display the "Synchrocheck" screen for voltage check and synchronism check elements.

```
/7 Synchrocheck                              1/11
OVB   (    10-    150):      51  _          V
UVB   (    10-    150):      13             V
OVL1  (    10-    150):      51             V
UVL1  (    10-    150):      13             V
SY1UV(     10-    150):      83             V
SY1OV(     10-    150):      51             V
SY1θ  (     5-     75):      30             deg
TSYN1( 0.01-  10.00):    0.01             s
TDBL1( 0.01-   1.00):    0.01             s
TLBD1( 0.01-   1.00):    0.01             s
T3PLL( 0.01-   1.00):    0.05             s
```

- Enter the numerical value and press the ENTER key for each element.
- After setting all elements, press the END key to return to the "Autoreclose element" menu.

Setting group copy

To copy the settings of one group and overwrite them to another group, do the following:

- Press 3 (= Copy group) on the "Protection" screen to display the "Copy group A to B" screen.

```
/3 Copy groupA to B    (Active group= *)
A     (      1-      8):        _
B     (      1-      8):
```

- Enter the group number to be copied in line A and press the ENTER key.
- Enter the group number to be overwritten by the copy in line B and press the ENTER key.

4.2.6.8 Binary Input

The logic level of binary input signals can be inverted by setting before entering the scheme logic. Inversion is used when the input contact cannot meet the requisite described in the Table 3.2.2.

- Press 7 (= Binary input) on the "Setting (change)" sub-menu to display the "Binary input" screen.

```
/2 Binary input                        1/**
BISW 1  1=Norm   2=Inv                 1
BISW 2  1=Norm   2=Inv                 1
BISW 3  1=Norm   2=Inv                 1
BISW 4  1=Norm   2=Inv                 1
BISW 5  1=Norm   2=Inv                 1
  :                                    :
BISW16  1=Norm   2=Inv                 1
BISW17  1=Norm   2=Inv                 1
BISW18  1=Norm   2=Inv                 1
  :                                    :
BISW26  1=Norm   2=Inv                 1
BISW27  1=Norm   2=Inv                 1
BISW28  1=Norm   2=Inv                 1
BISW34  1=Norm   2=Inv                 1
BISW35  1=Norm   2=Inv                 1
BISW36  1=Norm   2=Inv                 1
```

- Enter 1 (= Normal) or 2 (= Inverted) and press the ENTER key for each binary input.

4.2.6.9 Binary Output

All the binary outputs of the GRZ100 except the tripping command, signal for command protection and relay failure signal are user-configurable. It is possible to assign one signal or up to 6 ANDing or ORing signals to one output relay. Available signals are listed in Appendix B.

It is also possible to attach a delayed drop-off delay time of 0.2 seconds to these signals. The delay drop-off time is disabled by the scheme switch [BOTD].

Appendix D shows the factory default settings.

To configure the binary output signals, do the following:

Selection of output module

- Press 8 (= Binary output) on the "Setting (change)" screen to display the "Binary output" screen. The available output module(s) will be shown. (The screen differs depending on the relay model.)

```
/2 Binary output
1=IO#2      2=IO#3
```

- Press the number corresponding to the selected output module to display the "Binary output" screen.

```
/3 Binary output                    (*****)
Select BO             (  1- **)

                          Select No.= _
```

Note: This setting is required for all of the binary outputs. If any of the binary output is not used, enter 0 to the logic gates #1-#6 in assigning signals.

Selecting the output relay

- Enter the output relay number and press the ENTER key to display the "Setting" screen.

```
/4 Setting                (BO1 of IO#2)
1=Logic gate type & delay timer
2=Input to logic gate
```

Setting the logic gate type and timer

- Press 1 to display the "Logic gate type and delay timer" screen.

```
/5 Logic gate type & delay timer    1/ 2
Logic    1=OR   2=AND               1 _
BOTD     0=Off  1=On                1
```

- Enter 1 or 2 to use an OR gate or AND gate and press the ENTER key.
- Enter 0 or 1 to add 0.2s delayed drop-off time to the output relay if required and press the

ENTER key.

- Press the END key to return to the "Setting" screen.

Assigning signals

- Press 2 on the "Setting" screen to display the "Input to logic gate" screen.

```
/5 Input to logic gate              1/ 6
In #1(      0-  3071):       21 _
In #2(      0-  3071):        4
In #3(      0-  3071):       67
In #4(      0-  3071):        0
In #5(      0-  3071):        0
In #6(      0-  3071):        0
```

- Assign signals to gates (In #1- #6) by entering the number corresponding to each signal referring to Appendix B.

Note: If signals are not assigned to all the gates #1-#6, enter 0 to the unassigned gate(s).

Repeat this process for the outputs to be configured.

4.2.6.10 LED

Four LEDs of the GRZ100 are user-configurable. Each is driven via a logic gate which can be programmed for OR gate or AND gate operation. Further, each LED has a programmable reset characteristic, settable for instantaneous drop-off, or for latching operation. The signals listed in Appendix B can be assigned to each LED as follows.

Selection of LED

- Press 9 (= LED) on the "Setting (change)" screen to display the "LED" screen.

```
/2 LED
Select LED          (  1-  4)

                     Select No.= _
```

- Enter the LED number and press the ENTER key to display the "Setting" screen.

```
/3 Setting              (LED1)
1=Logic gate type & reset
2=Input to logic gate
```

Setting the logic gate type and reset

- Press 1 to display the "Logic gate type and reset" screen.

```
/4 Logic gate type & reset          1/ 2
Logic    1=OR   2=AND               1 _
Reset    0=Inst 1=Latch             1
```

- Enter 1 or 2 to use an OR gate or AND gate and press the ENTER key.

- Enter 0 or 1 to select “Instantaneous reset” or “Latch reset” and press the ENTER key.

- Press the END key to return to the "Setting" screen.

Note: To release the latch state, refer to Section 4.2.1.

Assigning signals

- Press 2 on the "Setting" screen to display the "Input to logic gate" screen.

```
/4 Input to logic gate                     1/ 4
In #1(      0-  3071):      21 _
In #2(      0-  3071):       4
In #3(      0-  3071):      67
In #4(      0-  3071):       0
```

- Assign signals to gates (In #1- #4) by entering the number corresponding to each signal referring to Appendix B.

Note: If signals are not assigned to all the gates #1-#4, enter 0 to the unassigned gate(s).

Repeat this process for other LEDs to be configured.

4.2.7 Testing

The sub-menu "Test" provides such functions as setting of test switches, manual starting of automatic tests, forced operation of binary outputs, time measurement of the variable setting timer and logic signal observation.

4.2.7.1 Setting the Switches

The automatic monitor function (A.M.F.) can be disabled by setting the switch [A.M.F] to "Off."

Disabling the A.M.F. inhibits trip blocking even in the event of a failure in the items being monitored by this function. It also prevents failures from being displayed on the "ALARM" LED and LCD described in Section 4.2.1. No events related to the A.M.F. are recorded, either.

Disabling A.M.F. is useful for blocking the output of unnecessary alarms during testing.

Note: Set the switch [A.M.F] to "Off" before applying the test inputs, when the A.M.F is disabled.

When a three-phase voltage source is not available, the distance measuring element operation can be tested using a single-phase voltage source by setting the switch [Z1S-1PH] to "On". This is not fit for the high-accuracy test, though.

The switch [ZB-CTRL] is used to test the Z1 characteristic with offset or not. When the switch [ZB-CTRL] is set to "1", the Z1 is an offset characteristic. When the switch [ZB-CTRL] is set to "2", the Z1 is a characteristic without offset.

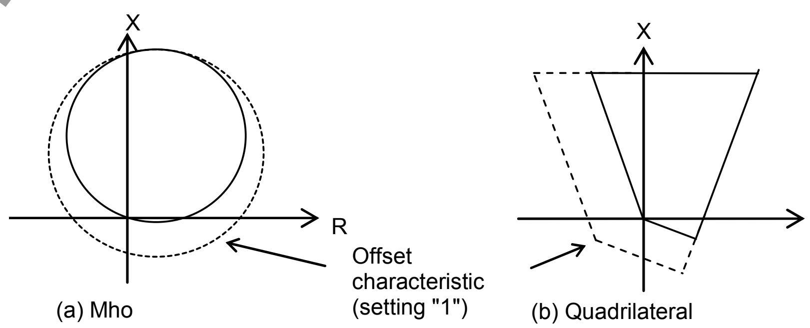


Figure 4.2.7.1 Z1 Characteristics by [ZB-CTRL] Setting

The gradient characteristic of Zone 1 and Zone 1X reactance elements is obtained only when the load current is transmitted from local to remote terminal. So, the switch [XANGLE] is used to fix the gradient characteristic for testing. When testing, the switch [XANGLE] is set to "1".

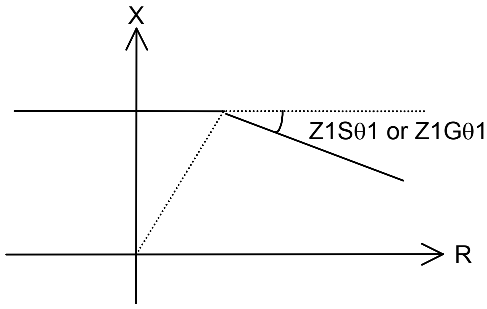


Figure 4.2.7.2 Gradient Characteristic of Zone 1 and Zone 1X

DOCN element can operate during a power swing condition. So, to test the DOCN characteristic, the switch [DOCN-C] is used. When testing, the switch [DOCN-C] is set to "1".

The switches [Z1S-1PH], [ZB-CTRL], [XANGLE] and [DOCN-C] are implemented only for the function test.

While the switch [A.M.F] is set to "0", [Z1S-1PH] is set to "1", [ZB-CTRL] is set to "1" or "2", [XANGLE] is set to "1", [DOCN-C] is set to "1", the red "TESTING" LED is lit for alarming.

Caution: Be sure to restore these switches after the tests are completed.

Disabling automatic monitoring

- Press 5 (= Test) on the top "MENU" screen to display the "Test" screen.

```
/1 Test
1=Switch                    2=Manual test
3=Binary output             4=Timer
5=Logic circuit
```

- Press 1 (= Switch) to display the Switch screen.
- Enter 0 for A.M.F to disable the automatic monitoring function and enter 1 for Z1S-1PH to enable the test to use a single-phase voltage source.

```
/2 Switch                                        1/ 29
A.M.F.      0=Off  1=On                          1 _
Z1S-1PH     0=Off  1=On                          0
ZB-CTRL     0=Norm  1=OFST  2=Non-OFST           0
XANGLE      0=Off  1=On                          0
DOCN-C      0=Off  1=On                          0
L.test      0=Off  1=On                          0
T.test      0=Off  1=On                          0
D.test      0=Off  1=On                          0
IECTST      0=Off  1=On                          0
THMRST      0=Off  1=On                          0
UVTEST      0=Off  1=On                          0
COM1        0=Off  1=On                          0
COM2        0=Off  1=On                          0
COM3        0=Off  1=On                          0
COM4        0=Off  1=On                          0
COM5        0=Off  1=On                          0
COM6        0=Off  1=On                          0
COM7        0=Off  1=On                          0
COM8        0=Off  1=On                          0
COM9        0=Off  1=On                          0
COM10       0=Off  1=On                          0
COM11       0=Off  1=On                          0
COM12       0=Off  1=On                          0
COM13       0=Off  1=On                          0
COM14       0=Off  1=On                          0
SCOM1       0=Off  1=On                          0
SCOM2       0=Off  1=On                          0
SCOM3       0=Off  1=On                          0
SCOM4       0=Off  1=On                          0
```

Testing the offset characteristic of Z1

- Enter 0 for [A.M.F] to disable the automatic monitoring function and enter 1 for [ZB-CTRL] to modify the offset characteristic forcibly.
- Press the END key to return to the "Test" screen.

Testing the gradient characteristic of Zone 1 and Zone 1X

- Enter 0 for [A.M.F] to disable the automatic monitoring function and enter 1 for [XANGLE] to modify the gradient characteristic forcibly.
- Press the END key to return to the "Test" screen.

Testing the characteristic of DOCN

- Enter 0 for A.M.F to disable the automatic monitoring function and enter 1 for [DOCN-C] to enable the DOCN element to operate.
- Press the END key to return to the "Test" screen.

L.TEST, T.TEST and D.TEST

When [L.TEST] is set to "ON", the data received from the remote terminal(s) are not used. Thus in the three-terminal application, the out-of-service terminal can carry out a local relay testing without disturbing the in-service terminals.

[T.TEST] and [D.TEST] are valid when the integral digital communication applied.

When the [T.TEST] is set to "ON", the local data is looped into the receiving circuit interrupting the data from the remote terminal as well as transmitted to the remote terminal.

Note: The switch [T. TEST] must be used only when all the terminals are out-of-service.

The [D. TEST] is used to test the relay models with an optical interface. Setting the [D. test] to "1" (= On) enables loop-back tests under the direct connection of the communication circuit.

IECTST

- Enter 1(=On) for [IECTST] to transmit 'test mode' to the control system by IEC60870-5-103 communication when testing the local relay, and press the ENTER key.
- Press the END key to return to the "Test" screen.

THMRST

The switch [THMRST] is used to perform the thermal overload element test because the resetting time is in the order of minutes. The thermal overload element is instantaneously reset when the [THMRST] is ON.

- Enter 1(=On) for testing the thermal overload element, and press the ENTER key.
- Press the END key to return to the "Test" screen.

UVTEST

- Enter 0(=Off) or 1(=On) to set disable/enable the UV blocking (UVBLK) and press the ENTER key.
- Press the END key to return to the "Test" screen.

COM∗ and SCOM∗

In the integral digital communication, it is possible to forcibly send communication data [COM1] to [COM14] and [SCOM1] to [SCOM4] for testing. If testing, a desired communication data is set to "ON" and press 1(=Telecomm channel test) on the "Manual test" screen.

4.2.7.2 Manual Testing

When the external communication is applied, the automatic test of the telecommunication circuit can be performed manually by key operations. The manual test performed here is also counted as the count displayed in Section 4.2.3.4.

- Press 2 (= Manual test) on the "Test" screen to display the "Manual test" screen.

```
/2 Manual test
1=Telecomm channel test

Press number to start test.
```

Performing the signal channel test

- Press 1 on the "Manual test" screen to start the test. The display shown below appears.

```
/2 Manual test
Telecomm channel testing...
```

If the test is completed normally, the display shown below appears on the LCD for 5 seconds and then changes to the "Manual test" screen.

```
/2 Manual test
Telecomm channel testing...
                 Completed.
```

If an abnormality is found during testing, the LCD displays the following indication for 5 seconds and returns to the "Manual test" screen. The "ALARM" LED remains lit.

```
/2 Manual test
Telecomm channel testing...
                 Remote 1 failed.
```

Note: Under any of the following conditions, the test will not start. Neither "Completed" nor the "Failed" screen is displayed.
- BOP is not selected as the protection scheme.
- Telecommunication equipment is out of service.
- Scheme switch [CHMON] is set to "OFF."
- Circuit breaker is open.

4.2.7.3 Binary Output Relay

It is possible to forcibly operate all binary output relays for checking connections with external devices. Forced operation can be performed on one or more binary outputs at a time for each module.

- Press 3 (= Binary output) on the "Test" screen to display the "Binary output" screen.

```
/2 Binary output
1=IO#1   2=IO#2   3=IO#3
```

The LCD displays the output modules mounted depending on the model.

- Enter the selected number corresponding to each module to be operated. Then the LCD displays the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.

```
/3 BO            (0=Disable 1=Enable)   1/14
IO#2   BO1                              1
IO#2   BO2                              1
IO#2   BO3                              1
IO#2   BO4                              0
IO#2   BO5                              0
IO#2   BO6                              0
IO#2   BO7                              0
IO#2   BO8                              0
IO#2   BO9                              0
IO#2   BO10                             0
IO#2   BO11                             0
IO#2   BO12                             0
IO#2   FAIL                             0
IO#2   BO13                             0
```

- Enter 1 and press the ENTER key.
- After completing the entries, press the END key. Then the LCD displays the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing 1 key to operate the output relays forcibly.
- Release the 1 key to reset the operation.
- Press the CANCEL key to return to the upper screen.

4.2.7.4 Timer

The pick-up or drop-off delay time of the variable timer used in the scheme logic can be measured with monitoring jacks A and B. Monitoring jacks A and B are used to observe the input signal and output signal to the timer respectively.

- Press 4 (= Timer) on the "Test" screen to display the "Timer" screen.

```
/2 Timer                          1/ 1
Timer(     1-    60):      1 _

```

- Enter the number corresponding to the timer to be observed and press the ENTER key. The timers and related numbers are listed in Appendix C.
- Press the END key to display the following screen.

```
/2 Timer
Press ENTER to operate.

Press CANCEL to cancel.
```

- Press the ENTER key to operate the timer. The "TESTING" LED turns on, and the timer is initiated and the following display appears. The input and output signals of the timer can be observed at monitoring jacks A and B respectively. The LEDs above monitoring jacks A or B are also lit if the input or output signal exists.

```
/2 Timer
Operating...
Press END to reset.
Press CANCEL to cancel.
```

- Press the CANCEL key to test other timers.
- Press the END key to reset the input signal to the timer. The "TESTING" LED turns off.

To measure the drop-off delayed time, press the END key after the LED above jack B lights.

4.2.7.5 Logic Circuit

It is possible to observe the binary signal level on the signals listed in Appendix B with monitoring jacks A and B.

- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.

```
/2 Logic circuit                    1/ 2
TermA(     0-   3071):      1 _
TermB(     0-   3071):     48
```

- Enter a signal number to be observed at monitoring jack A and press the ENTER key.
- Enter the other signal number to be observed at monitoring jack B and press the ENTER key.

After completing the setting, the signals can be observed by the binary logic level at monitoring jacks A and B or by the LEDs above the jacks.

On screens other than the above screen, observation with the monitoring jacks is disabled.

4.3 Personal Computer Interface

The relay can be operated from a personal computer using an RS232C port on the front panel. On the personal computer, the following analysis and display of the fault voltage and current are available in addition to the items available on the LCD screen.

- Display of voltage and current waveform: Oscillograph, vector display
- Symmetrical component analysis: On arbitrary time span
- Harmonic analysis: On arbitrary time span
- Frequency analysis: On arbitrary time span

4.4 Relay Setting and Monitoring System

The Relay Setting and Monitoring (RSM) system is a system that retrieves and analyses the data on power system quantities, fault and event records and views or changes settings in individual relays via a telecommunication network using a remote PC.

For the details, see the separate instruction manual "PC INTERFACE RSM100".

Figure 4.4.1 shows the typical configuration of the RSM system via a protocol converter G1PR2. The relays are connected through twisted pair cables, and the maximum 256 relays can be connected since the G1PR2 can provide up to 8 ports. The total length of twisted pair wires should not exceed 1200 m. Relays are mutually connected using an RS485 port on the relay rear panel and connected to a PC RS232C port via G1PR2. Terminal resistor (150 ohms) is connected the last relay. The transmission rate used is 64 kbits/s.

Figure 4.4.2 shows the configuration of the RSM system with Ethernet LAN (option). The relays are connected to HUB through UTP cable using RJ-45 connector at the rear of the relay. The relay recognizes the transmission speed automatically.

In case of the optional fiber optic interface (option), the relays are connected through graded-index multi-mode 50/125μm or 62.5/125μm type optical fiber using ST connector at the rear of the relay.

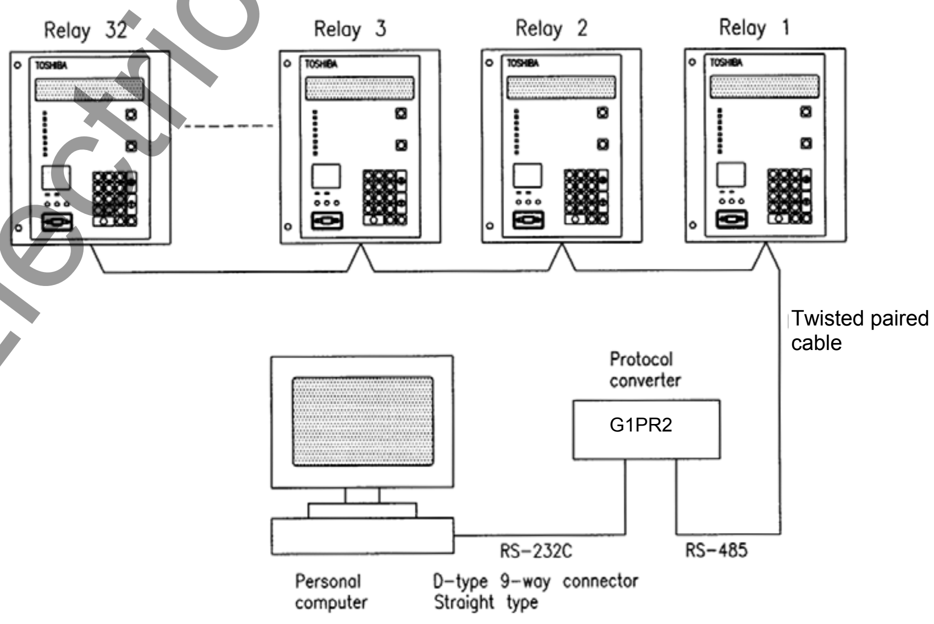


Figure 4.4.1 Relay Setting and Monitoring System (1)

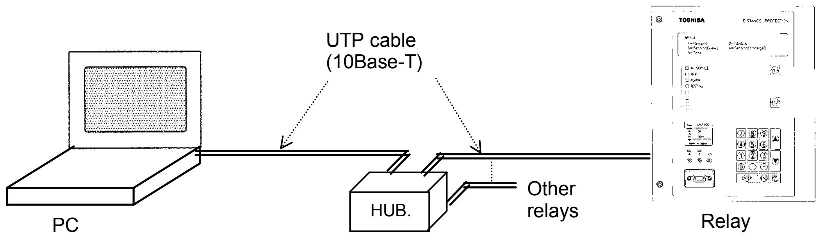


Figure 4.4.2 Relay Setting and Monitoring System (2)

4.5 IEC 60870-5-103 Interface

The GRZ100 can support the IEC60870-5-103 communication protocol. This protocol is mainly used when the relay communicates with a control system and is used to transfer the following measurand, status data and general command from the relay to the control system.

- Measurand data: current, voltage, active power, reactive power, frequency
- Status data: events, fault indications, etc.

The IEC60870-5-103 function in the relay can be customized with the original software "IEC103 configurator". It runs on a personal computer (PC) connected to the relay, and can help setting of Time-tagged messages, General command, Metering, etc. For details of the setting method, refer to "IEC103 configurator" manual. For the default setting of IEC60870-5-103, see Appendix N.

The protocol can be used through the RS485 port on the relay rear panel and can be also used through the optional fibre optical interface. The relay connection is similar to Figure 4.4.1.

The relay supports two baud-rates 9.6kbps and 19.2kbps.

The data transfer from the relay can be blocked by the setting.

For the settings, see the Section 4.2.6.4.

4.6 Clock Function

The clock function (Calendar clock) is used for time-tagging for the following purposes:

- Event records
- Disturbance records
- Fault records
- Metering
- Automatic supervision
- Display of the system quantities on the digest screen
- Display of the fault records on the digest screen
- Display of the automatic monitoring results on the digest screen

The calendar clock can run locally or be synchronized with the external IRIG-B time standard signal, RSM, IEC or RMT. This can be selected by setting. The relay with "RMT" setting is synchronized with clock of the remote terminal relay with the other setting. (For setting, see Section 4.2.6.6.)

If it is necessary to synchronize with the IRIG-B time standard signal, it is possible to transform GMT to the local time by setting.

When the relays are connected to the RSM system as shown in Figure 4.4.1, the calendar clock of each relay is synchronized with the RSM clock. If the RSM clock is synchronized with the external time standard (GPS clock etc.), then all the relay clocks are synchronized with the external time standard.

5. Installation

5.1 Receipt of Relays

When relays are received, carry out the acceptance inspection immediately. In particular, check for damage during transportation, and if any is found, contact the vendor.

Check that the following accessories are attached.

- 3 pins for the monitoring jack, packed in a plastic bag.
- An attachment kit required in rack-mounting, if ordered. (See Appendix F.)

  1 large bracket with 5 round head screws, spring washers and washers (M4×10)
  1 small bracket with 3 countersunk head screws (M4×6)
  2 bars with 4 countersunk head screws (M3×8)

Always store the relays in a clean, dry environment.

5.2 Relay Mounting

Either a rack or flush mounting relay is delivered as designated by the customer. The GRZ100 models are classified into two types by their case size, type A and type B. Appendix F shows the case outlines.

If the customer requires a rack-mounting relay, support metal fittings necessary to mount it in the 19-inch rack are also supplied with the relay.

When to mount the relay in the rack, detach the original brackets fixed on both sides of the relay and seals on the top and bottom of the relay. Attach the larger bracket and smaller bracket on the left and right side of the relay respectively and the two bars on the top and bottom of the relay.

How to mount the attachment kit, see Appendix F.

Dimensions of the attachment kits EP-101 and EP-102 is also shown in Appendix F.

5.3 Electrostatic Discharge

⚠CAUTION

Do not take out any modules outside the relay case since electronic components on the modules are very sensitive to electrostatic discharge. If it is absolutely essential to take the modules out of the case, do not touch the electronic components and terminals with your bare hands. Additionally, always put the module in a conductive anti-static bag when storing it.

5.4 Handling Precautions

A person's normal movements can easily generate electrostatic potential of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage, which often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits are completely safe from electrostatic discharge when housed in the case. Do not expose them to risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

⚠CAUTION

- Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.
- Handle the module by its front plate, frame or edges of the printed circuit board. Avoid touching the electronic components, printed circuit board or connectors.
- Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
- Place the module on an anti-static surface, or on a conducting surface which is at the same potential as yourself.
- Do not place modules in polystyrene trays.

It is strongly recommended that detailed investigations on electronic circuitry should be carried out in a Special Handling Area such as described in the IEC 60747.

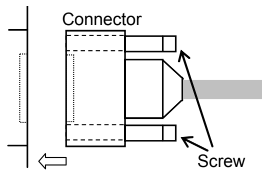
5.5 External Connections

External connections are shown in Appendix G.

Electrical interface for telecommunication

The connector should be handled as follows:

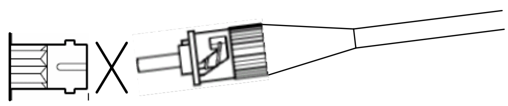
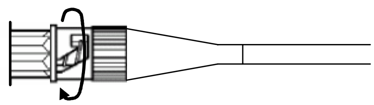
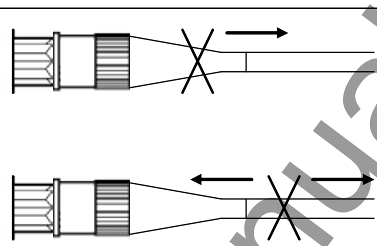
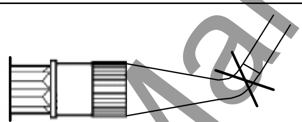
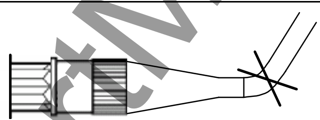
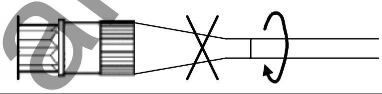
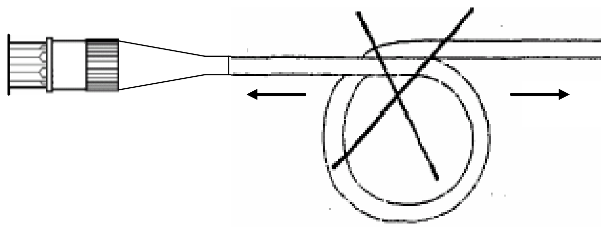
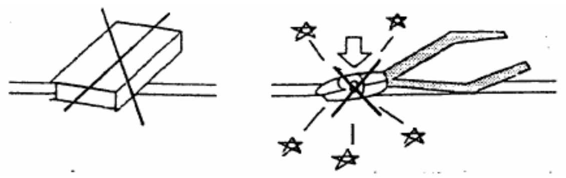
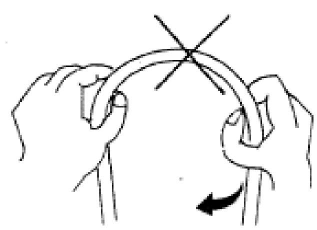
- Insert the connector horizontally and tighten both upper and lower screws alternately.
- Do not touch the connector pin with your bare hand.



Optical interface for telecommunication

The optical cables tend to come down, therefore, bending requires special attention.

Handling instructions of optical cable are as follows:

№	Instructions	
1	Do not insert the connector obliquely.	
2	Tighten the connector when connecting.	
3	Do not pull the cable.	
4	Do not bend the cable.	
5	Do not bend the neck of the connector.	
6	Do not twist the cable.	
7	Do not kink in the cable.	
8	Do not put and drop on the cable.	
9	Do not bend the cable to (*)mm or less in radius. (*)Length differs from characteristics of optical cable.	

6. Commissioning and Maintenance

6.1 Outline of Commissioning Tests

The GRZ100 is fully numerical and the hardware is continuously monitored.

Commissioning tests can be kept to a minimum and need only include hardware tests and conjunctive tests. The function tests are at the user's discretion.

In these tests, user interfaces on the front panel of the relay or local PC can be fully applied.

Test personnel must be familiar with general relay testing practices and safety precautions to avoid personal injuries or equipment damage.

Hardware tests

These tests are performed for the following hardware to ensure that there is no hardware defect. Defects of hardware circuits other than the following can be detected by monitoring which circuits functions when the DC power is supplied.

User interfaces
Binary input circuits and output circuits
AC input circuits

Function tests

These tests are performed for the following functions that are fully software-based. Tests of the protection schemes and fault locator require a dynamic test set.

Measuring elements
Timers
Protection schemes
Autoreclose
Metering and recording
Fault locator

Conjunctive tests

The tests are performed after the relay is connected with the primary equipment, telecommunication equipment and other external equipment.

The following tests are included in these tests:

On load test: phase sequence check and polarity check
Signaling circuit test
Tripping and reclosing circuit test

6.2 Cautions

6.2.1 Safety Precautions

⚠CAUTION

- The relay rack is provided with a grounding terminal.
  Before starting the work, always make sure the relay rack is grounded.
- When connecting the cable to the back of the relay, firmly fix it to the terminal block and attach the cover provided on top of it.
- Before checking the interior of the relay, be sure to turn off the power.

Failure to observe any of the precautions above may cause electric shock or malfunction.

6.2.2 Cautions on Tests

⚠CAUTION

- While the power is on, do not connect/disconnect the flat cable on the front of the printed circuit board (PCB).
- While the power is on, do not mount/dismount the PCB.
- Before turning on the power, check the following:
  - Make sure the polarity and voltage of the power supply are correct.
  - Make sure the CT circuit is not open.
  - Make sure the VT circuit is not short-circuited.
- Be careful that the transformer module is not damaged due to an overcurrent or overvoltage.
- If settings are changed for testing, remember to reset them to the original settings.

Failure to observe any of the precautions above may cause damage or malfunction of the relay.

Before mounting/dismounting the PCB, take antistatic measures such as wearing an earthed wristband.

6.3 Preparations

Test equipment

The following test equipment is required for the commissioning tests.

1 Three-phase voltage source
1 Single-phase current source
1 Dynamic three-phase test set (for protection scheme test)
1 DC power supply
3 AC voltmeters
3 Phase angle meter
1 AC ammeter
1 DC voltmeter
1 Time counter, precision timer
1 PC (not essential)

Relay settings

Before starting the tests, it must be specified whether the tests will use the user's settings or the default settings.

For the default settings, see the following appendixes:

Appendix D Binary Output Default Setting List
Appendix H Relay Setting Sheet

Visual inspection

After unpacking the product, check for any damage to the relay case. If there is any damage, the internal module might also have been affected. Contact the vendor.

Relay ratings

Check that the items described on the nameplate on the front of the relay conform to the user's specification. The items are: relay type and model, AC voltage, current and frequency ratings, and auxiliary DC supply voltage rating.

Local PC

When using a local PC, connect it with the relay via the RS232C port on the front of the relay. RSM100 software is required to run the PC.

For the details, see the separate volume "RSM100 instruction manual".

6.4 Hardware Tests

The tests can be performed without external wiring, but a DC power supply and an AC voltage and current source are required.

6.4.1 User Interfaces

This test ensures that the LCD, LEDs and keys function correctly.

LCD display

- Apply the rated DC voltage and check that the LCD is off.

  Note: If there is a failure, the LCD displays the "Auto-supervision" screen when the DC voltage is applied.

- Press the RESET key for 1 second when the LCD is off, and check that black dots appear on the whole screen.

LED display

- Apply the rated DC voltage and check that the "IN SERVICE" LED is lit in green.
- Press the RESET key for 1 second when the LCD is off, and check that seven LEDs under the "IN SERVICE" LED and two LEDs for monitoring jacks A and B are lit in red.

VIEW and RESET keys

- Press the VIEW key when the LCD is off and check that the "Metering" screen is displayed on the LCD.
- Press the RESET key and check that the LCD turns off.

Keypad

- Press any key on the keypad when the LCD is off and check that the LCD displays the "MENU" screen. Press the END key to turn off the LCD.
- Repeat this for all keys.

6.4.2 Binary Input Circuit

The testing circuit is shown in Figure 6.4.2.1.

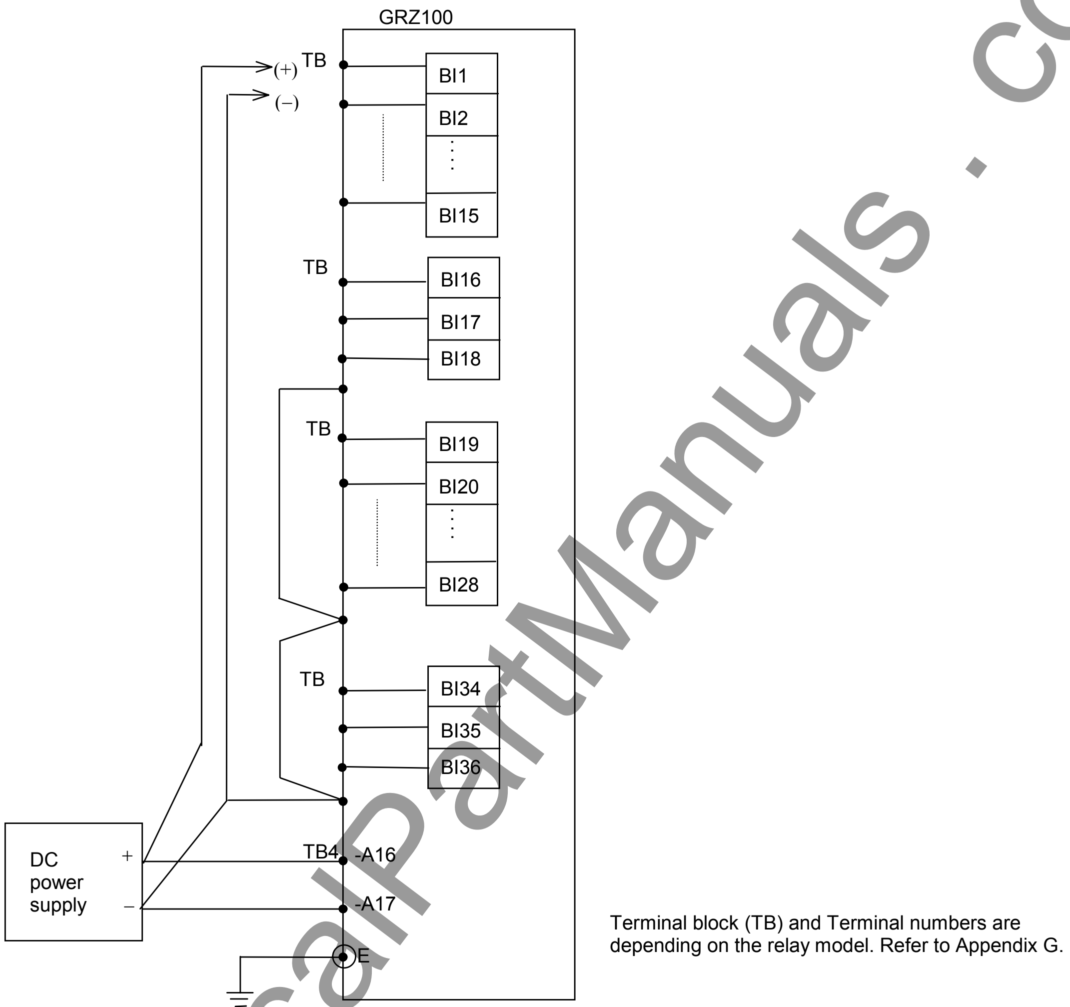


Figure 6.4.2.1 Testing Binary Input Circuit

- Display the "Binary input & output status" screen from the "Status" sub-menu.

```
/2 Binary input & output                  3/ 8
Input (IO#1)          [000 000 000 000     ]
Input (IO#2)          [000                 ]
Input (IO#3)          [000 000 000 0       ]
Input (IO#4)          [000                 ]
Output(IO#1-trip)     [000 000             ]
Output(IO#2)          [000 000 000 000 00  ]
Output(IO#3)          [000 000 000 0       ]
Output(IO#4)          [000 000 000 000 00  ]
```

- Apply rated DC voltage to terminals of each binary input circuit.

  Note: Terminal number depends on the relay model. So see Appendix G for details.

  Check that the status display corresponding to the input signal changes from 0 to 1. (For the binary input status display, see Section 4.2.4.2.)

The user will be able to perform this test for one terminal to another or for all terminals at once.

6.4.3 Binary Output Circuit

This test can be performed by using the "Test" sub-menu and forcibly operating the relay drivers and output relays. Operation of the output contacts is monitored at the output terminal. The output contact and corresponding terminal number are shown in Appendix G.

- Press 3 (= Binary output) on the "Test" screen to display the "Binary output" screen. The LCD displays the output modules installed depending on the model.
- Enter the selected number corresponding to each module to be operated. The LCD will display the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.
- Enter 1 and press the ENTER key.
- After completing the entries, press the END key. The LCD will display the screen shown below. If 1 is entered for all of the output relays, the following forcible operation can be performed collectively.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to operate the output relays forcibly.
- Check that the output contacts operate at the terminal.
- Release the 1 key to reset the operation.

6.4.4 AC Input Circuits

This test can be performed by applying known values of voltage and current to the AC input circuits and verifying that the values applied coincide with the values displayed on the LCD screen.

The testing circuit is shown in Figure 6.4.4.1. A three-phase voltage source and a single-phase current source are required.

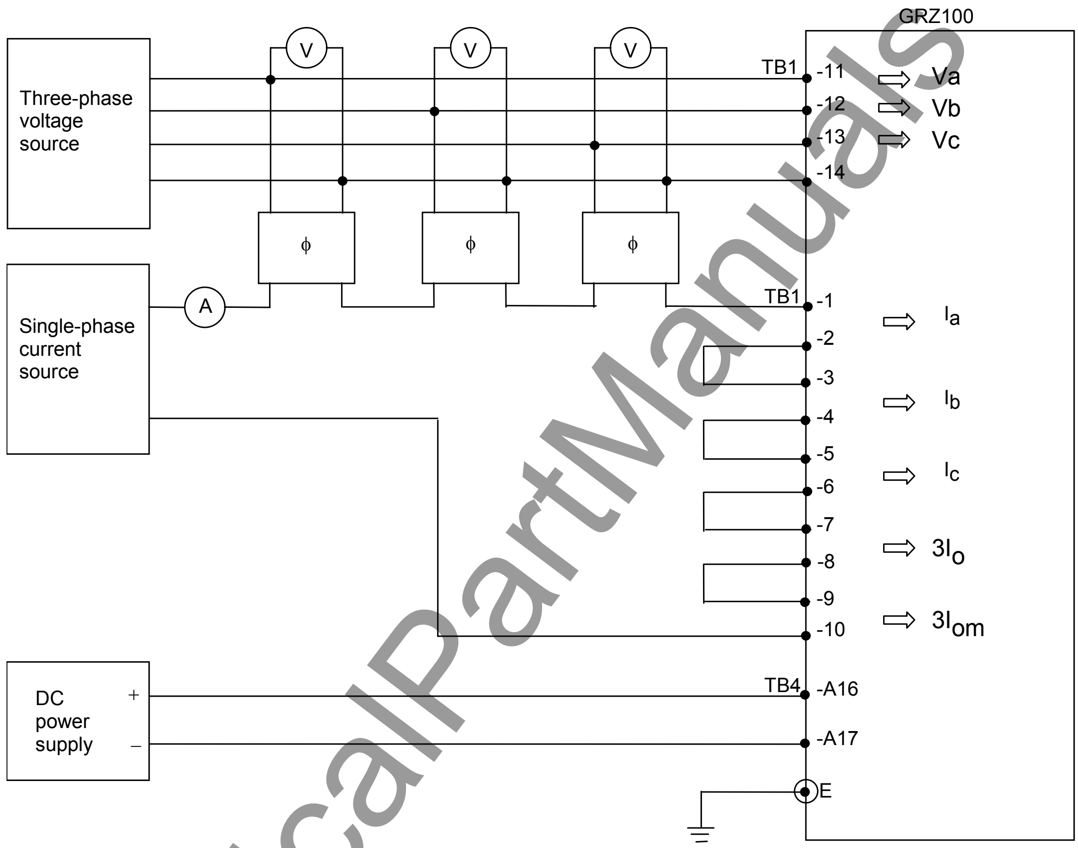


Figure 6.4.4.1 Testing AC Input Circuit

- Check that the metering data is set to be expressed as secondary values (Display value = 2) on the "Metering" screen.

  "Setting (view)" sub-menu → "Status" screen → "Metering" screen

  If the setting is Primary (Display value = 1), change the setting in the "Setting (change)" sub-menu. Remember to reset it to the initial setting after the test is finished.
- Open the "Metering" screen in the "Status" sub-menu.

  "Status" sub-menu → "Metering" screen
- Apply AC rated voltages and currents and check that the displayed values are within ± 5% of the input values.

6.5 Function Test

CAUTION

The function test may cause the output relays to operate including the tripping output relays. Therefore, the test must be performed with tripping circuits disconnected.

6.5.1 Measuring Element

Measuring element characteristics are realized by software, so it is possible to verify the overall characteristics by checking representative points.

Operation of the element under test is observed by the binary output signal at monitoring jacks A or B or by the LED indications above the jacks. In any case, the signal number corresponding to each element output must be set on the "Logic circuit" screen of the "Test" sub-menu.

```
/2 Logic circuit                    1/ 2
TermA(      0-   3071):        0 _
TermB(      0-   3071):        0
```

When a signal number is entered for the TermA line, the signal is observed at monitoring jack A and when entered for the TermB line, observed at monitoring jack B.

Note: The voltage level at the monitoring jacks is +15V ±3V for logic level "1" when measured by an instrument with 10kΩ input impedance, and less than 0.1V for logic level "0".

CAUTION

- Use test equipment with more than 1 kΩ of internal impedance when observing the output signal at the monitoring jacks.
- Do not apply an external voltage to the monitoring jacks.

In case of a three-phase element, it is enough to test a representative phase. A-phase and AB-phase elements are selected for the earth fault element and phase fault element respectively hereafter.

6.5.1.1 Distance Measuring Element Z1, Z1X, Z2, Z3, Z4, ZF, ZR1, ZR2 and PSB

Phase fault element reach test

The test voltage and current input test circuit is shown in Figure 6.5.1.1.

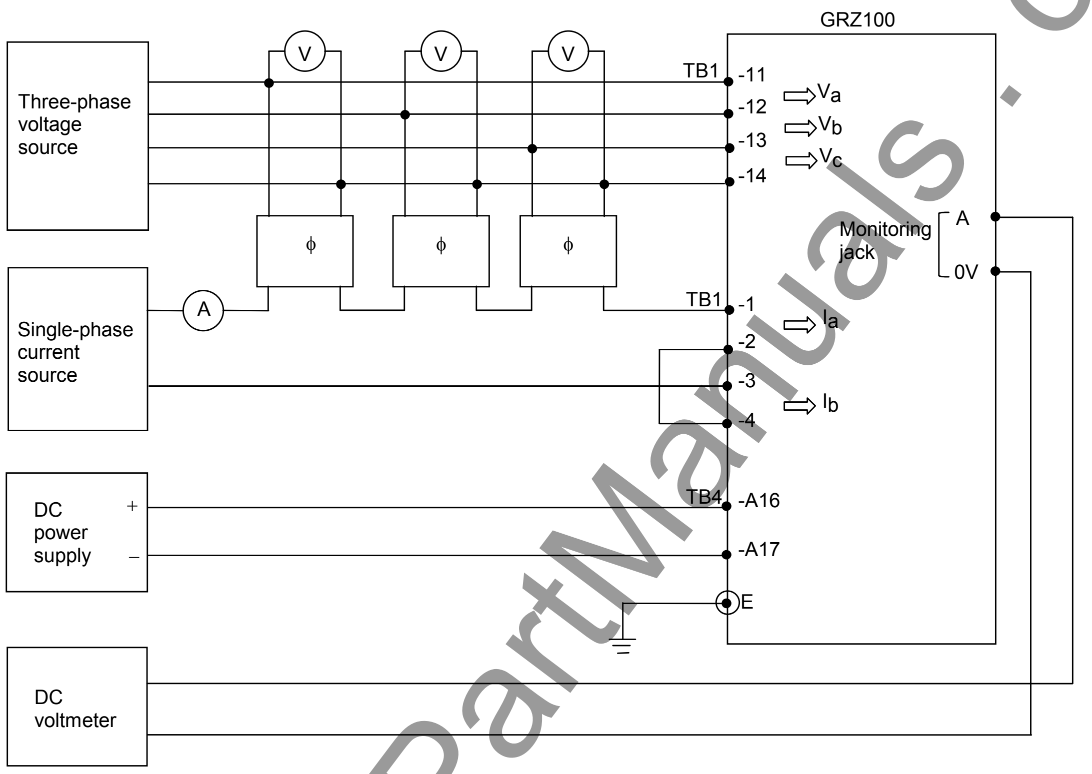


Figure 6.5.1.1 Testing Phase-Fault Element

Phase fault elements and their output signal numbers are listed below.

Measuring element	Signal number
Z1S-AB	34
Z1XS-AB	37
Z2S-AB	40
Z3S-AB	43
Z4S-AB	46
ZFS-AB	577
ZR1S-AB	553
ZR2S-AB	557
ZNDS-AB	581
PSBSIN-AB	323
PSBSOUT-AB	49

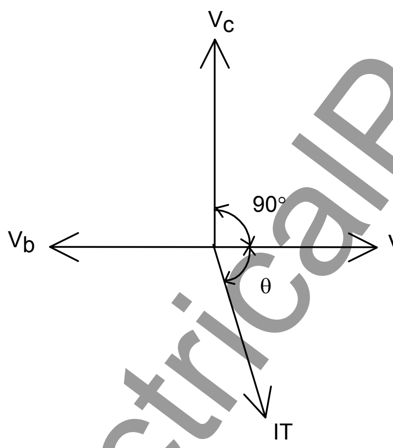
- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter a signal number to be observed at monitoring jack A and press the ENTER key.

- Apply three-phase rated voltage.
- Choose a test current IT by referring to the table below, the table shows the relationship between the reach setting, test current and measuring error.

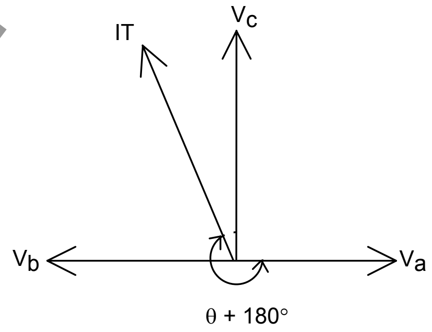
Reach setting	IT	Error
0.01 - 0.05Ω (0.1 - 0.2Ω	25A 5A)(*)	±10%
0.06 - 0.09Ω (0.3 - 0.4Ω	20A 4A)	±7%
0.10 - 1.00Ω (0.5 - 5.0Ω	10A 2A)	±5%
1.01 - 10.00Ω (5.1 - 50.0Ω	5A 1A)	±5%
10.01 - 20.00Ω (50.1 – 100.0Ω	2.5A 0.5A)	±5%
20.01 - 50.00Ω (100.1 – 250.0Ω	1A 0.2A)	±7%

(*) Values shown in parentheses are in the case of 1A rating.
Other values are in the case of 5A rating.

- Set the voltage and current phase relationship as shown below. That is, V_a lags Vc by 90°, Vb = - V_a and IT lags V_a by θ or θ + 180°. θ is 90° when testing.



Z1S, Z1XS, Z2S, Z3S and PSB



Z4S

- Adjust the magnitude of V_a and V_b while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by 2IT × ZS when the setting reach is ZS. Check that the measured voltage is within the above-mentioned error of the theoretical voltage value when it is expressed with $2V_a$ (= $V_a - V_b$).

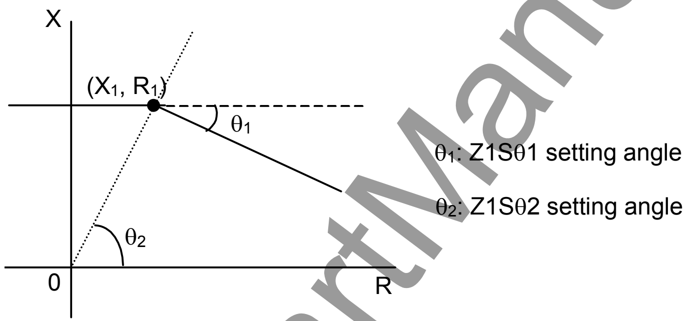
Element reach setting (ZS)	IT	2IT × ZS	Measured voltage ($2V_a$)
Z1S			
Z1XS			
Z2S			
Z3S			

Element reach setting (ZS)	IT	2IT × ZS	Measured voltage ($2V_a$)
Z4S			
ZFS			
ZR1S			
ZR2S			
ZNDS			
PSBSIN			
PSBSOUT			

[Testing of Zone 1 bending characteristic]

The test circuit and test method is same as above.

The operating voltage of Zone 1 bending characteristic can be calculated as follows:



$$V = X_p I \cdot \frac{1}{\sin\theta} = \frac{X_1\left(1+\frac{\tan\theta_1}{\tan\theta_2}\right)}{\left(1+\frac{\tan\theta_1}{\tan\theta}\right)} \cdot I \cdot \frac{1}{\sin\theta}$$

where,

X_1 is the Z1S setting reach.

θ is the angle difference between voltage and current.

Note: Toshiba recommend that a minimum of three values for θ be tested to check that the correct relay settings have been applied.
Care must be taken in choosing values of θ to ensure that the testing points come within the operating boundary defined by the Z1S θ2 setting and either the load blinder or mho settings, as appropriate.

Earth fault element reach test

The test circuit is shown in Figure 6.5.1.2.

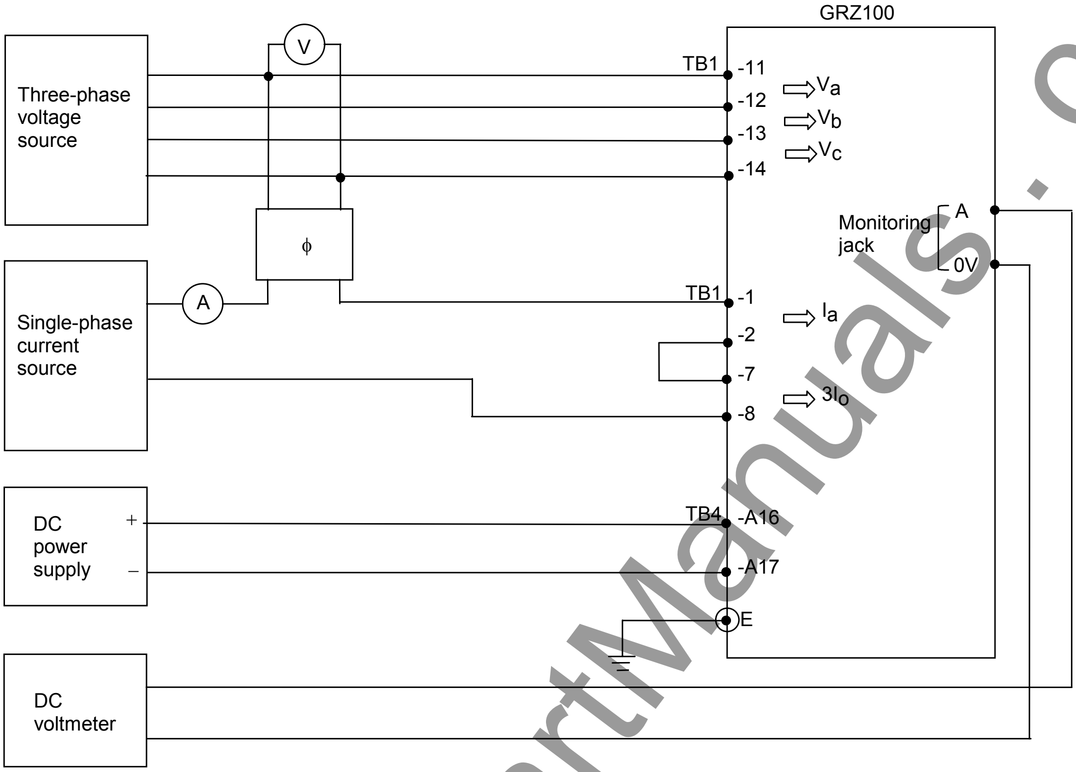


Figure 6.5.1.2 Testing Earth-Fault Element

Earth fault elements and their output signal number are listed below.

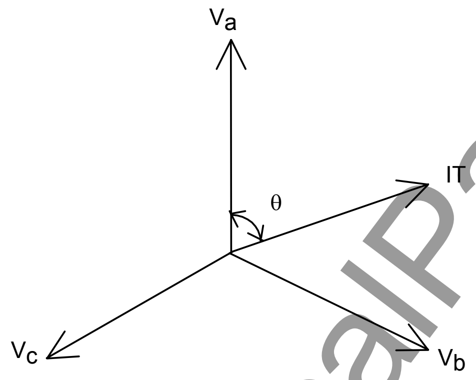
Measuring element	Signal number
Z1G-A	19
Z1XG-A	22
Z2G-A	25
Z3G-A	28
Z4G-A	31
ZFG-A	593
ZR1G-A	569
ZR2G-A	573
ZNDG-A	597
PSBGIN-A	561
PSBGOUT-A	565

- Press 5 (= Logic circuit) on the Test screen to display the Logic circuit screen.
- Enter a signal number to be observed at monitoring jack A and press the ENTER key.
- Apply three-phase rated voltage.
- Choose a test current IT by referring to the table below, the table shows the relationship between the reach setting, test current and measuring error.

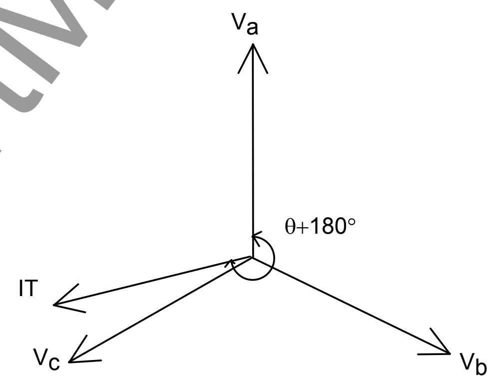
Reach setting	IT	Error
0.01 - 0.05Ω (0.1 - 0.2Ω	25A 5A)(*)	±10%
0.06 - 0.09Ω (0.3 - 0.4Ω	20A 4A)	±7%
0.1 - 1.0Ω (0.5 - 5.0Ω	10A 2A)	±5%
1.01 - 10.0Ω (5.1 - 50.0Ω	5A 1A)	±5%
10.01 - 20.0Ω (50.1 - 100Ω	2.5A 0.5A)	±5%
20.01 - 50.0Ω (100.1 - 250Ω	1A 0.2A)	±7%
50.01 - 100Ω (250.1 - 500Ω	0.6A 0.12A)	±10%

(*) Values shown in parentheses are in the case of 1A rating. Other values are in the case of 5A rating.

- Set the test voltage and test current phase relation as shown below. That is, V_a, V_b, and V_c are balanced, and IT lags V_a by θ or θ + 180°. θ is 90° when testing.



Z1G, Z1XG, Z2G, and Z3G



Z4G

- Adjust the magnitude of Va while retaining the conditions above and measure the voltage at which the element operates.
- The theoretical operating voltage Vop is obtained by the following equations when the setting reach is ZG. Check that the measured voltage is within the above-mentioned error of the theoretical voltage.

$$\text{Z1G, Z1XG, Z2G, ZR1G: Vop} = \text{ZG} \times \left(\text{IT} + \frac{\frac{K_{xs}}{100} - 1}{3} \times \text{IT} \right)$$

$$\text{Z3G, Z4G, ZR2G, ZNDG: Vop} = \text{IT} \times \text{ZG}$$

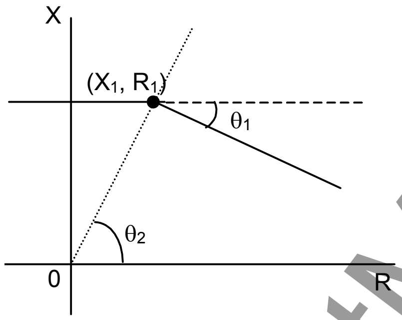
Element	ZG	IT	Vop	Measured voltage
Z1G				
Z1XG				
Z2G				
Z3G				
Z4G				
ZR1G				

Element	ZG	IT	Vop	Measured voltage
ZR2G				
ZNDG				
PSBGIN				
PSBGOUT				

[Testing of Zone 1 bending characteristic]

The test circuit and test method is same as above.

The operating voltage of Zone 1 bending characteristic can be calculated as follows:



θ_1: Z1Gθ1 setting angle

θ_2: Z1Gθ2 setting angle

$$V = X_p I'_x \cdot \frac{1}{\sin\theta} = \frac{X_1\left(1+\dfrac{\tan\theta_1}{\tan\theta_2}\right)}{\left(1+\dfrac{\tan\theta_1}{\tan\theta}\cdot\dfrac{I'_x}{I'_r}\right)} \cdot I'_x \cdot \frac{1}{\sin\theta}$$

where,

$$I'_x = I + \frac{k_{xs}-100}{100} I_0 + \frac{k_{xm}}{100} I_{0m},\quad I'_r = I + \frac{k_{rs}-100}{100} I_0 + \frac{k_{rm}}{100} I_{0m}$$

X_1 is the Z1G setting reach.

θ is the angle difference between voltage and current.

Note: Toshiba recommend that a minimum of three values for θ be tested to check that the correct relay settings have been applied.
Care must be taken in choosing values of θ to ensure that the testing points come within the operating boundary defined by the Z1G θ2 setting and either the load blinder or mho settings, as appropriate.

6.5.1.2 Out-of-step Element OST

The testing circuit is shown in Figure 6.5.1.1.

The output signal numbers of the OST-ZM and OST-ZN elements are as follows:

Measuring element	Signal number
OST-ZM	84
OST-ZN	85

The followings are the cases for OST-ZM. (The test procedure for OSTR1 and OSTR2 must be changed in case of OST-ZN.)

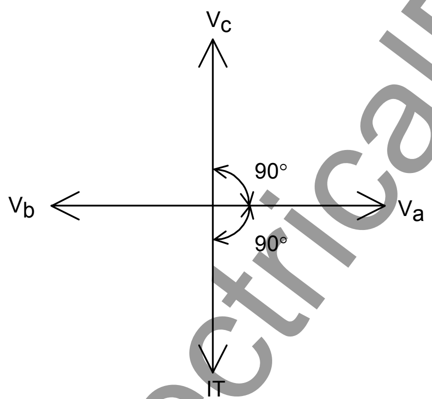
- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter 84 as a signal number to be observed at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage.
- Choose a test current IT by referring to the table below, which shows the relation of setting reach and test current.

Reach setting	IT
0.2 – 3.0Ω (1 - 15Ω	10A 2.0A)(*)
3.1 – 10.0Ω (16 - 50Ω	5A 1.0A)
10.1 – 20.0Ω (51 - 100Ω	2.5A 0.5A)
20.1 – 30.0Ω (101 - 150Ω	1.5A 0.3A)
30.1 – 50.0Ω (151 - 250Ω	1A 0.2A)

(*) Values shown in parentheses are in the case of 1A rating.
Other values are in the case of 5A rating.

OSTXF

- Set the voltage and current phase relation as shown below. That is, V_a lags V_c by 90°, $V_b = -V_a$ and IT lags V_a by 90°.

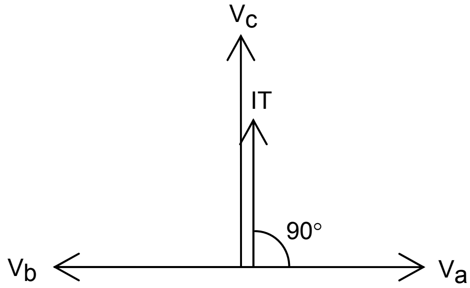


- Adjust the magnitude of V_a and V_b while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by $2IT \times Z_{OST}$ when the setting reach is Z_{OST}. Check that the measured voltage is within ±5% of the theoretical voltage value when it is expressed with $2V_a$ (= $V_a - V_b$).

Element	Z_{OST}	IT	$2IT \times Z_{OST}$	Measured voltage ($2V_a$)
OSTXF				

OSTXB

- Set the voltage and current phase relation as shown below. That is, V_a lags V_c by 90°, $V_b = -V_a$ and IT leads V_a by 90°.

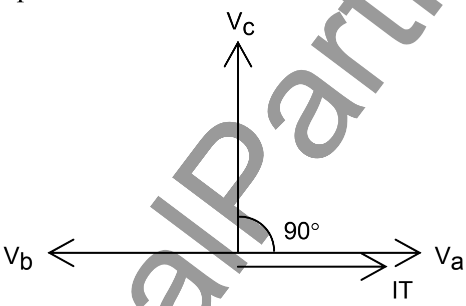


- Adjust the magnitude of V_a and V_b while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by $2IT \times Z_{OST}$ when the setting reach is Z_{OST}. Check that the measured voltage is within ±5% of the theoretical voltage value when it is expressed with $2V_a$ (= $V_a - V_b$).

Element	Z_{OST}	IT	$2IT \times Z_{OST}$	Measured voltage ($2V_a$)
OSTXB				

OSTR1

- Set the voltage and current phase relation as shown below. That is, Va lags Vc by 90°, Vb = –Va and IT is in phase with Va.

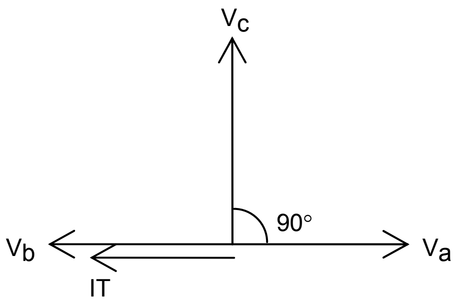


- Adjust the magnitude of V_a and V_b while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by $2IT \times Z_{OST}$ when the setting reach is Z_{OST}. Check that the measured voltage is within ±5% of the theoretical voltage value when it is expressed with $2V_a$ (= $V_a - V_b$).

Element	Z_{OST}	IT	$2IT \times Z_{OST}$	Measured voltage ($2V_a$)
OSTR1				

OSTR2

- Set the voltage and current phase relation as shown below. That is, V_a lags V_c by 90°, V_b = $-V_a$ and IT is in counter-phase with V_b.



- Adjust the magnitude of V_a and V_b while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by $2IT \times Z_{OST}$ when the setting reach is Z_{OST}. Check that the measured voltage is within ±5% of the theoretical voltage value when it is expressed with $2V_a$ (= $V_a - V_b$).

Element	Z_{OST}	IT	$2IT \times Z_{OST}$	Measured voltage ($2V_a$)
OSTR2				

6.5.1.3 Phase Selection Element UVC

The testing circuit is shown in Figure 6.5.1.2.

UVC elements and their output signal numbers are listed below.

Measuring element	Signal number
UVC-A	66
UVC-B	67
UVC-C	68

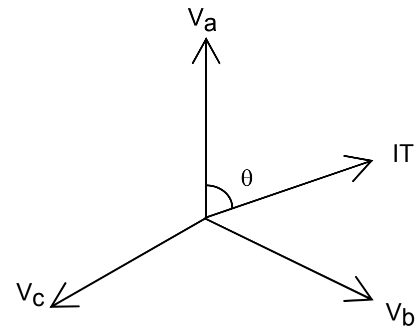
The following shows the case when testing UVC-A.

- Press 5 (= Logic circuit) on the Test screen to display the Logic circuit screen.
- Enter 66 as a signal number to be observed at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage.
- Set the test current IT to zero ampere and adjust the voltage. Measure the voltage at which the element operates. Check that the voltage is within ±5% of the setting UVCV. (The default setting of the UVCV is 48 V.)
- Choose a test current IT by referring to the table below, which shows the relation of setting reach UVCZ, test current IT and measuring error.

UVCZ	IT	Error
0.0- 2.0Ω (0 - 10Ω	10A 5A) (*)	±5%
2.1 – 10.0Ω (11 - 50Ω	5A 1A)	±5%
10.1 – 20.0Ω (51 - 100Ω	2.5A 0.5A)	±5%
20.1 – 50.0Ω (101 - 250Ω	1A 0.2A)	±7%

(*) Values shown in parentheses are in the case of 1A rating. Other values are in the case of 5A rating.

- Set the test voltage and test current phase relation as shown below. That is, V_a, V_b, and V_c are balanced, and IT lags V_a by UVC characteristic angle UVC θ.
  (The default setting of UVC θ is 85°.)



- Adjust the magnitude of V_a while retaining the conditions above and measure the voltage V_a at which the element operates.
- The theoretical operating voltage is obtained by (IT × UVCZ + UVCV) when the setting reach is UVCZ. Check that the measured voltage is within the above-mentioned error of the theoretical voltage value. (The default setting of the UVCZ is 2.0 ohm for 5A rating and 10 ohm for 1A rating.)

Element	UVCV	UVCZ	IT	IT×UVCZ + UVCV	Measured voltage
UVCZ					

6.5.1.4 Directional Earth Fault Element DEF

The testing circuit is shown in Figure 6.5.1.2.

DEF elements and their output signal number are listed below.

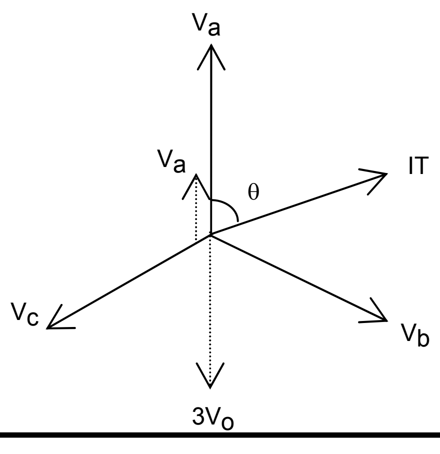
Measuring element	Signal number
DEFF	59
DEFR	58

The following shows the case when testing DEFF.

- Press 5 (= Logic circuit) on the Test screen to display the Logic circuit screen.
- Enter 59 as a signal number to be observed at monitoring jack A and press the ENTER key.

Residual current level detection is verified as follows:

- Apply three-phase rated voltage and single-phase test current IT (= $3I_o$).
  Set IT to lag V_a by DEFF characteristic angle DEF θ. (The default setting of DEF θ is 85°.)
- Lower V_a to 10 V to generate a residual voltage. Changing the magnitude of IT while retaining the phase angle with the voltages, and measure the current at which the element operates. Check that the measured current magnitude is within ± 5% of the current setting.



Residual voltage level detection is verified as follows:

- Set IT to rated current and the three-phase voltage to rated voltage. Lower the magnitude of V_a while retaining the phase angle with the current and measure the voltage V_a at which the element operates. Operating residual voltage is expressed by ($VR-V_a$), where VR is the rated voltage. Check that the ($VR-V_a$) is within 5% of the residual voltage setting.

6.5.1.5 Negative Sequence Directional Element DOCN

The testing circuit is shown in Figure 6.5.1.3.

DOCN elements and their output signal number are listed below.

Measuring element	Signal number
DOCNF	360
DOCNR	361

The following shows the case when testing DOCNF.

- Press 1 (= Switch) on the Test screen to display the switch screen and enter 1 for DOCNC to test the DOCN elements.
- Press 5 (= Logic circuit) on the Test screen to display the Logic circuit screen.
- Enter 360 as a signal number to be observed at monitoring jack A and press the ENTER key.
- Apply single-phase rated current I_a and single-phase test voltage V.
  Set V to lag I_a by 90°.
- Changing the magnitude of test voltage while retaining the phase angle with the current, and measure the voltage at which the element operates. Check that the measured voltage magnitude is within ± 5% of 15.5V.

The test of the DOCNR is same as that of DOCNF except for the voltage leading the current I_a by 90°.

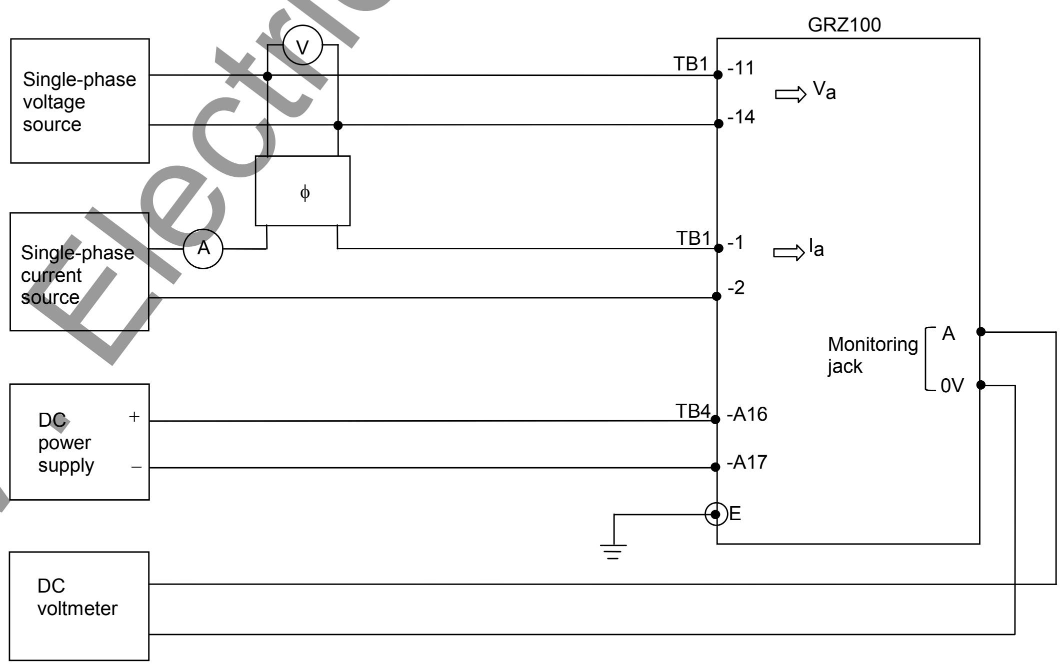


Figure 6.5.1.3 Testing DOCN Element

6.5.1.6 Inverse Definite Minimum Time Overcurrent Element (IDMT) OCI, EFI

The testing circuit is shown in Figure 6.5.1.4.

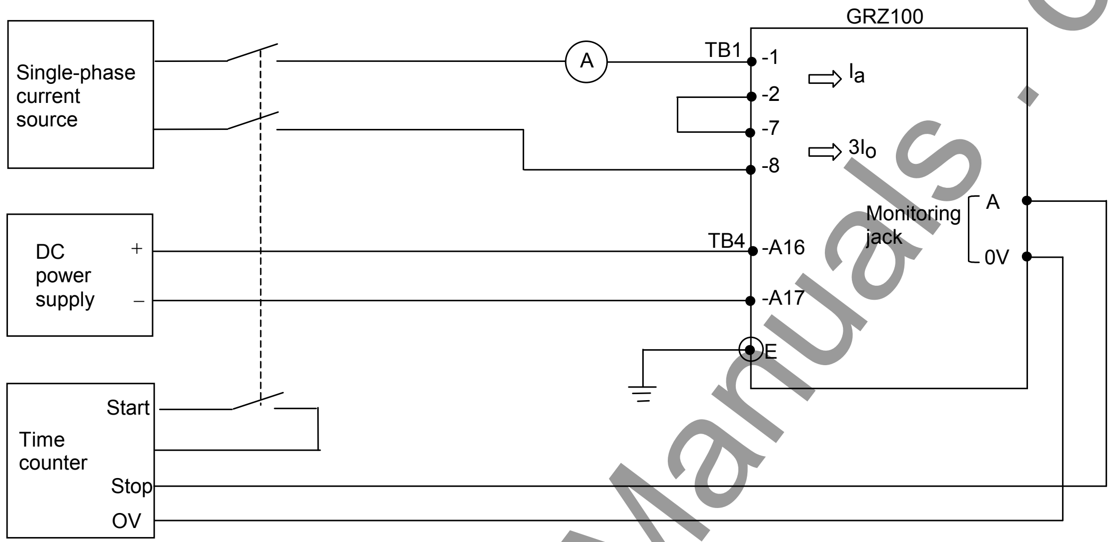


Figure 6.5.1.4 Testing IDMT

One of the four inverse time characteristics can be set, and the output signal numbers of the IDMT are as follows:

Element	Signal number
OCI-A	97
OCI-B	98
OCI-C	99
EFI	61

Fix the time characteristic to test by setting the scheme switch MEFI or MOCI on the "Scheme switch" screen.

"Setting (change)" sub-menu → "Protection" screen → "Trip" screen → "Scheme switch" screen

The test procedure is as follows:

- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter a signal number to observe the OCI or EFI output at monitoring jack A and press the ENTER key.
- Apply a test current and measure the operating time. The magnitude of the test current should be between 1.2 × I_S to 20 × I_S, where I_S is the current setting.
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.6.4. Check that the measured operating time is within IEC 60255-3 class 5 for standard, very and long-time inverse or IEC 60255-3 class 7.5 for extremely inverse.

6.5.1.7 Thermal overload element THM-A and THM-T

The testing circuit is same as the circuit shown in Figure 6.5.1.4.

The output signal of testing element is assigned to the monitoring jack A.

The output signal numbers of the elements are as follows:

Element	Signal No.
THM-A	560
THM-T	556

To test easily the thermal overload element, the scheme switch [THMRST] in the "Switch" screen on the "Test" menu is used.

- Set the scheme switch [THMRST] to "ON".
- Enter the signal number to observe the operation at the monitoring jack A as shown in Section 6.5.1.
- Apply a test current and measure the operating time. The magnitude of the test current should be between $1.2 \times I_S$ to $10 \times I_S$, where I_S is the current setting.

CAUTION

After the setting of a test current, apply the test current after checking that the THM% has become 0 on the "Metering" screen.

- Calculate the theoretical operating time using the characteristic equations shown in Section 2.4.6. Check that the measured operating time is within 5%.

6.5.1.8 Broken conductor detection element BCD

The testing circuit is shown in Figure 6.5.1.5.

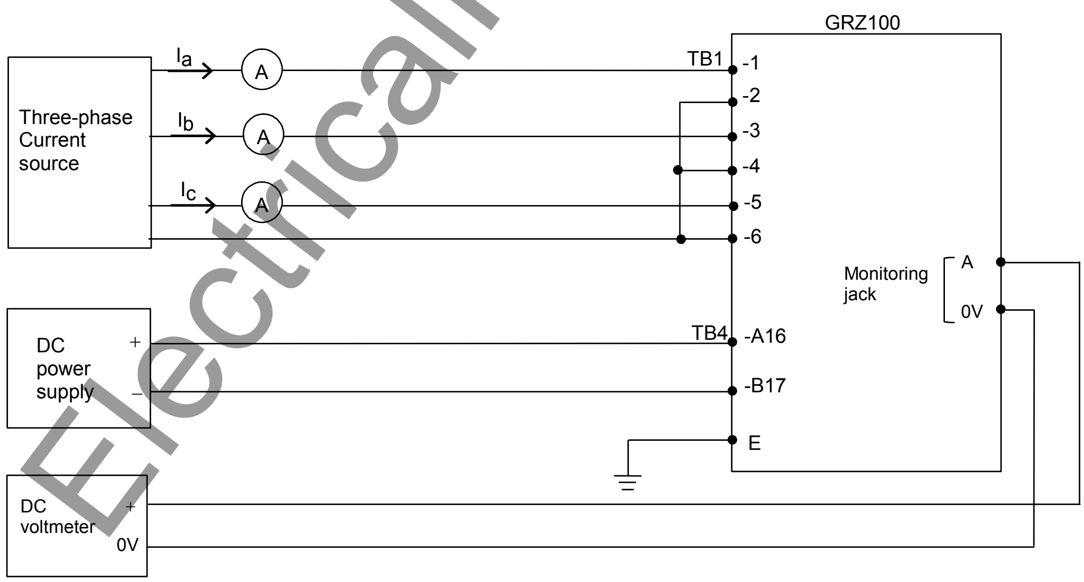


Figure 6.5.1.5 Testing BCD element

The output signal of testing element is assigned to the monitoring jack A.

The output signal numbers of the elements are as follows:

Element	Signal No.

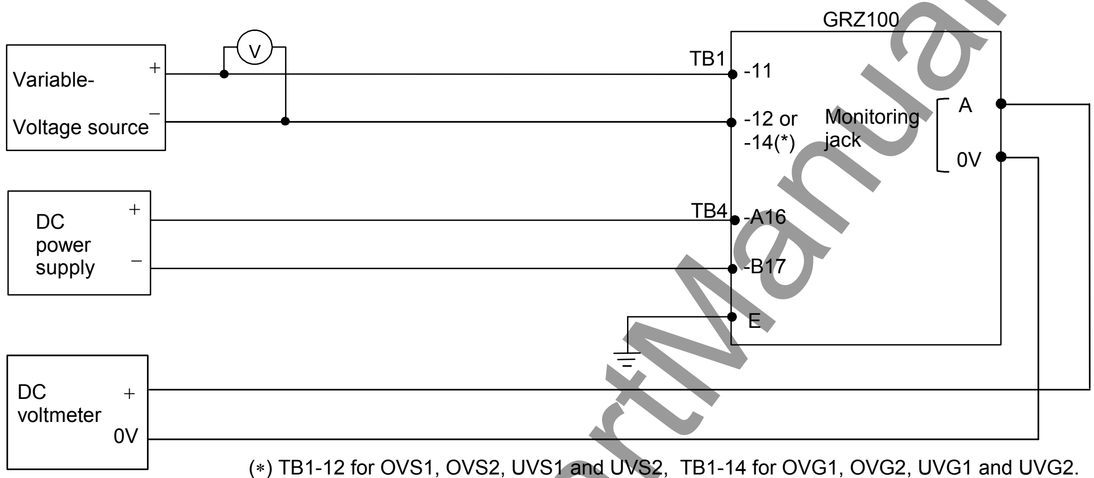
BCD	766

- Enter the signal number to observe the operation at the monitoring jack A as shown in Section 6.5.1.
- Apply the three-phase balance current at 10% of the rated current and interrupt a phase current.

Then, check the BCD element operates.

6.5.1.9 Overvoltage / undervoltage elements OVS1, OVS2, OVG1, OVG2, UVS1, UVS2, UVG1, UVG2

The testing circuit is shown in Figure 6.5.1.6.



(∗) TB1-12 for OVS1, OVS2, UVS1 and UVS2, TB1-14 for OVG1, OVG2, UVG1 and UVG2.

Figure 6.5.1.6 Operating Value Test Circuit

The output signal of testing element is assigned to the monitoring jack A.

Overvoltage and undervoltage elements and their output signal number are listed below.

Element	Signal No.
OVS1-AB	436
OVS2-AB	439
OVG1-A	442
OVG2-A	445
UVS1-AB	454
UVS2-AB	457
UVG1-A	460
UVG2-A	463

- Enter the signal number to observe the operation at the monitoring jack A as shown in Section 6.5.1.

Operating value test of OVS1, OVS2, OVG1, OVG2

- Apply a rated voltage as shown in Figure 6.5.1.6.
- Increase the voltage and measure the value at which the element operates. Check that the measured value is within ± 5% of the setting.

Operating value test of UVS1, UVS2, UVG1, UVG2

- Apply a rated voltage and frequency as shown Figure 6.5.1.6.

- Decrease the voltage and measure the value at which the element operates. Check that the measured value is within ± 5% of the setting.

Operating time check of OVS1, OVG1, UVS1, UVG1 IDMT curves

- Apply a rated voltage at the IDMT time multiplier setting 10.0 of the relay.
- Change the voltage from the rated voltage to the test voltage quickly and measure the operating time. Test voltage: 1.5 × (setting voltage) or 0.5 × (setting voltage)
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.4.9.1 and 2.4.9.2. Check the measured operating time within ±5%.

6.5.1.10 Voltage and Synchronism Check Elements

The testing circuit is shown in Figure 6.5.1.7. If scheme switch [3PH-VT] is set to "Bus", the three-phase voltage simulates the busbar voltage, and the single-phase voltage simulates the line voltage. If the switch is set to "Line", the opposite is true.

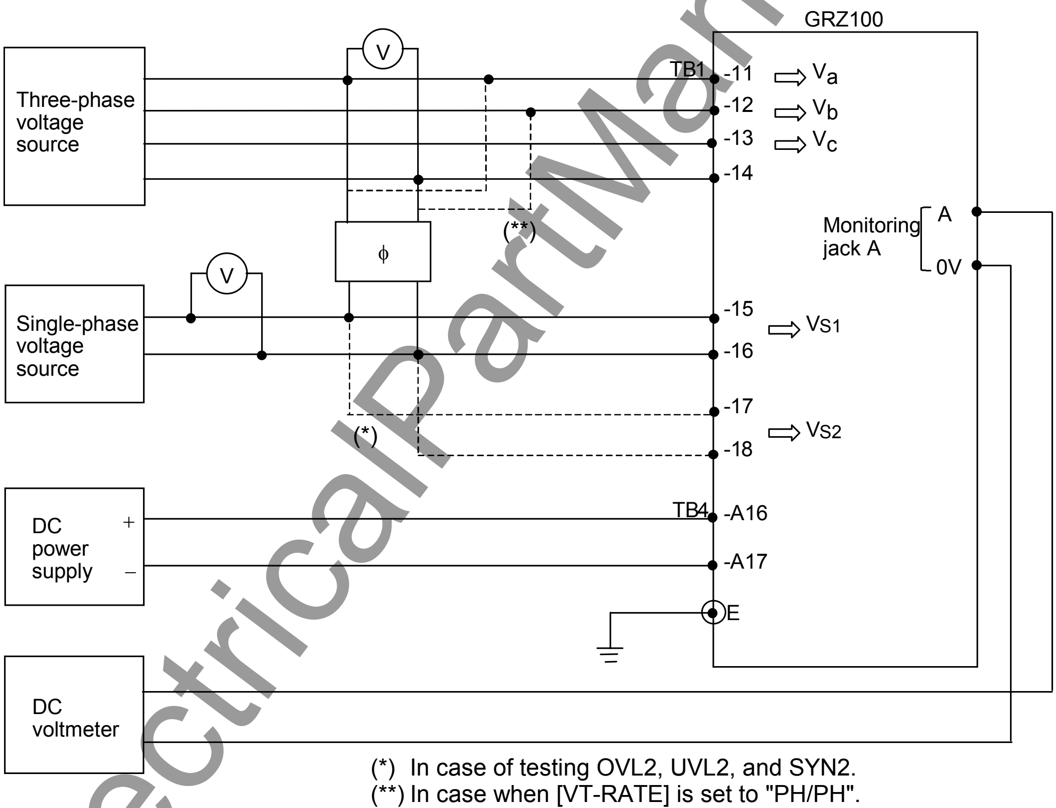


Figure 6.5.1.7 Testing Synchronism Check Elements

When testing OVL2, UVL2 and SYN2, the single-phase voltage must be applied to terminal 17 and 18, instead of 15 and 16 and 3PH-VT is set to "Line".

Voltage and synchronism check elements and their output signal number are listed below. OVL2, UVL2 and SYN2 are used for two-breaker autoreclose and provided in Model 300s.

Measuring element	Signal number
OVB	86
UVB	87
OVL1	89
UVL1	90

OVL2	91
UVL2	92
SYN1	88
SYN2	93

Connect a phase angle meter to the three-phase voltages taking the scheme switch [VT-RATE] and [VTPHSEL] setting into consideration. The phase angle meter connection shown in Figure 6.5.1.7 is the case for the default settings, that is, [VT-RATE] and [VTPHSEL] are set to "PH/G" and "A" respectively.

[VT-RATE] setting	[VTPH-SEL] setting	Meter connection phase
PH/G	A	A-N
	B	B-N
	C	C-N
PH/PH	A	A-B
	B	B-C
	C	C-A

Voltage check element OVB, UVB, OVL1, UVL1, OVL2, and UVL2

- Press 5 (= Logic circuit) on the "Test" screen to display the Logic circuit screen.
- Enter a signal number for TermA line to observe at monitoring jack A and press the ENTER key.
- Apply three-phase rated voltage and single-phase rated voltage as shown in Figure 6.5.1.7.

OVB and UVB:

- Change the magnitude of the three-phase voltage if the scheme switch [3PH-VT] is set to "Bus" or adjust the magnitude of the single-phase voltage if it is set to "Line". Measure the value at which the element operates and check that it is within ± 5% of the setting.

OVL1 and UVL1:

- Adjust the magnitude of the single-phase voltage if the scheme switch [3PH-VT] is set to "Bus"; adjust the magnitude of the three-phase voltage if the scheme switch [3PH-VT] is set to "Line". Measure the value at which the element operates and check that it is within ± 5% of the setting.

OVL2 and UVL2:

- Adjust the magnitude of voltage applied to terminal 17 and 18 and measure the value at which the element operates. Check that the measured value is within ± 5% of the setting.

Synchronism check element SYN1

- Press 5 (= Logic circuit) on the Test screen to display the Logic circuit screen.
- Enter a signal number for TermA line to observe at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage and a single-phase rated voltage as shown Figure 6.5.1.7.

Voltage check:

- Set the three-phase voltage to any value over the SY1OV setting. (The default setting of SY1OV is 51 V.)

Whilst keeping V_{s1} in-phase with V_a, increase the single-phase voltage V_{s1} from zero volt. Measure the voltage at which the element operates. Check that the measured voltage is within ± 5% of the SY1UV setting.

- Further increase V_{s1} and measure the voltage at that the element resets. Check that the measured voltage is within ±5% of the SY1OV setting.

Phase angle check:

- Set V_a and V_{s1} to any value between the SY1OV and SY1UV settings keeping V_a in-phase with V_{s1}. Then the SYN1 element operates.
- Shift the angle of V_{s1} from that of V_a, and measure the angle at which the element resets.
- Check that the measured angle is within ±5° of the SY1θ setting. (The default setting of SY1θ is 30°.)
- Change V_a and V_{s1}, and repeat the above.

Synchronism check element SYN2

- Apply a single-phase rated voltage to terminal 17 and 18 as shown with broken lines in Figure 6.5.1.5 and set the scheme switch [3PH-VT] to "Line". The test can be performed taking the same step as testing SYN1.

6.5.1.11 Current Change Detection Elements OCD and OCDP

The test circuit is shown in Figure 6.5.1.8.

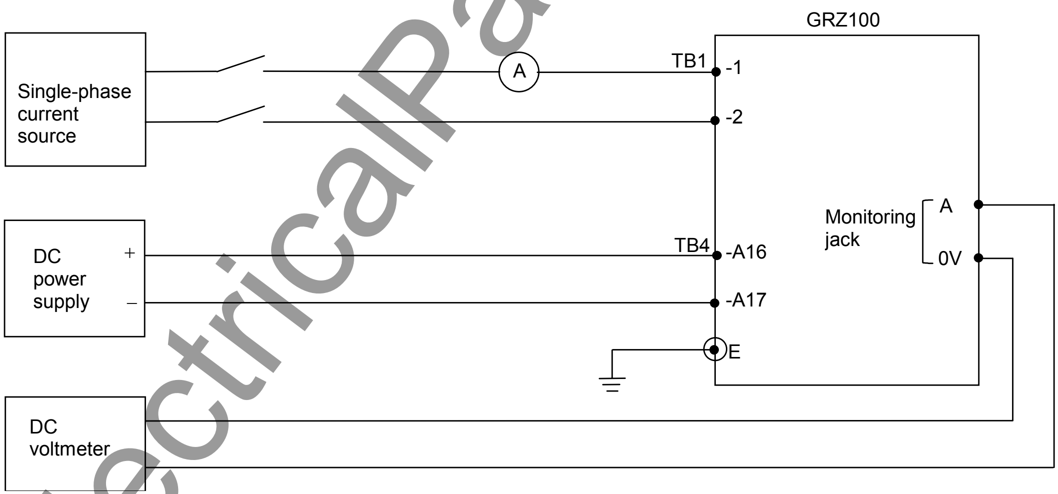


Figure 6.5.1.8 Testing Current Change Detection Element

The output signal number of the OCD and OCDP is as follows:

Measuring element	Signal number
OCD-A	63
OCD-B	64
OCD-C	65
OCDP-A	357
OCDP-B	358
OCDP-C	359

Operation must be verified by abruptly changing the test current from 0 A to 1.2 × Setting value or vice versa.

OCD has a fixed setting of 0.5 A and 0.1 A for 5 A rating and 1 A rating respectively.

6.5.1.12 Level Detectors OCH, OC, EF, EFL, OVG, UVLS and UVLG, UVFS and UVFG, OCBF

Voltage or current level detectors are tested by applying voltage or current individually. A single-phase test source is adequate for these tests.

Change the magnitude of the voltage or current applied and measure the value at which the element operates. Check that the measured value is within 5% of the setting.

Level detectors and their output signal numbers are listed below.

Measuring element	Signal number	Remarks
OCH-A	55	A-phase current
OC-A	94	A-phase current
EF	60	Residual current
EFL	568	Residual current
OVG	62	Residual voltage
UVFS-AB	69	A-to-B-phase voltage
UVFG-A	75	A-phase voltage
UVLS-AB	72	A-to-B-phase voltage
UVLG-A	78	A-phase voltage
OCBF-A	81	A-phase current

6.5.2 Timer Test

The delayed pick-up time of the variable timer can be measured by connecting the monitoring jacks A and B to a time counter as shown in Figure 6.5.2.1. Jacks A and B are used to observe the input signal and output signal of the timer respectively.

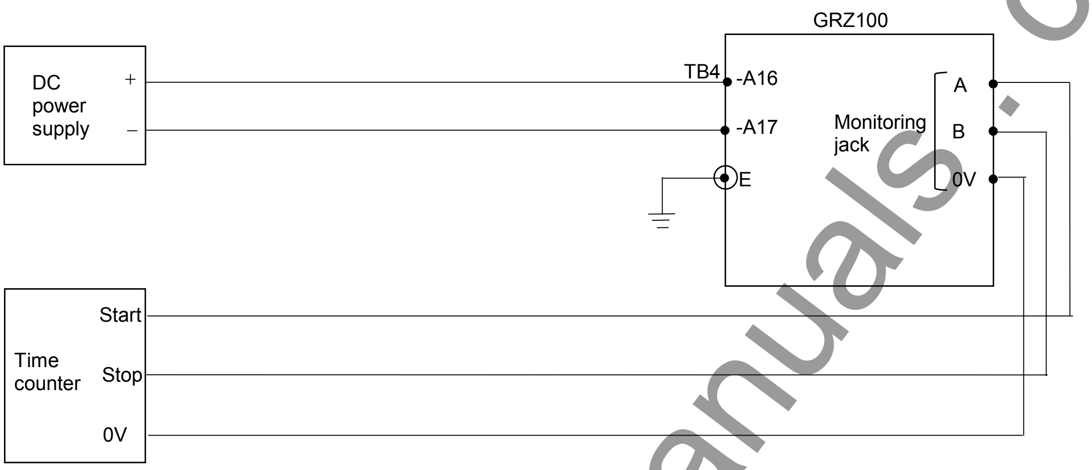


Figure 6.5.2.1 Testing Variable Timer

- Press 4 (= Timer) on the "Test" screen to display the "Timer" screen.
- Enter the number corresponding to the timer to be observed. The timers and assigned numbers are listed in Appendix C.
- After completing both settings, press the END key to display the following screen.

```
/2 Timer
Press ENTER to operate.

Press CANCEL to cancel.
```

- Press the ENTER key to operate the timer. The "TESTING" LED turns on, and the timer is initiated and the following display appears. The input and output signals of the timer can be observed at monitoring jacks A and B respectively. The LEDs above monitoring jacks A or B are also lit if the input or the output signal exists.

  Check that the measured time is within 10 ms of the setting time.

```
/2 Timer
Operating......
Press END to reset.
Press CANCEL to cancel.
```

- Press the END key to reset the input signal to the timer. The "TESTING" LED turns off.

  Press CANCEL key to test other timers. Repeat the above testing.

To measure the drop-off delay time, press the END key after the LED above jack B lights. The off-delay time is the time from a signal at the monitoring jack A resets till a signal at the monitoring jack B resets.

6.5.3 Protection Scheme

In the following protection scheme tests, a dynamic test set with a three-phase voltage source and current source is required to simulate power system pre-fault, fault and post-fault conditions.

In the following command tripping test, the remote end is not simulated. The receiving signal is simulated by energizing a binary input circuit locally in the external communication. If an end-to-end synchronized test is possible, then it should be conducted.

The autoreclose function can be tested together with these tests. A permanent fault should be applied to test a reclose-onto-fault.

Zone 1 tripping

This performs instantaneous or time-delayed, and single-phase or three-phase tripping depending on the fault types, setting of trip mode control switch [Z1CNT] and autoreclose mode switch [ARC-M].

Zone 1 tripping should be checked for the fault at 50% of the zone 1 reach setting.
Operating time is measured on operation of the trip output relay. It will typically be 1 cycle in case of instantaneous tripping.

Check that the indications and recordings are correct.

Zone 2 tripping

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set midway between zone 1 and zone 2.

Check that the operating time is 1-1.5 cycle plus zone 2 timer setting.

Check that the indications and recordings are correct.

Zone F tripping

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set midway between zone 2 and zone F.

Check that the operating time is 1-1.5 cycle plus zone F timer setting.

Check that the indications and recordings are correct.

Zone 3 tripping

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set midway between zone 2 and zone 3.

Check that the operating time is 1-1.5 cycle plus zone 3 timer setting.

Check that the indications and recordings are correct.

Zone R1 tripping

Set the scheme switches [ZR1BT] and [ZR2BT] to "On". (The [ZR1BT] and [ZR2BT] default setting is "Off".)

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set in the center of zone R1.

Check that the operating time is 1-1.5 cycle plus zone R1 timer setting.

Check that the indications and recordings are correct.

Zone R2 tripping

Set the scheme switch [ZR2BT] to "On". (The [ZR2BT] default setting is "Off".)

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set midway zone R1 and zone R2.

Check that the operating time is 1-1.5 cycle plus zone R2 timer setting.

Check that the indications and recordings are correct.

Zone ND tripping

Set the scheme switch [ZNDBT] to "On". (The [ZNDBT] default setting is "Off".)

Check that three-phase time-delayed final tripping is performed for all kinds of faults. Faults should be set midway zone 3 and zone ND.

Check that the operating time is 1-1.5 cycle plus zone ND timer setting.

Check that the indications and recordings are correct.

Zone 1X tripping

Set the scheme switch [SCHEME] to "Z1EXT", and [ARC-M] to "TPAR" or "SPAR&TPAR" or "SPAR". CB ready condition (binary input signal) and 52A, 52B and 52C must be established.

Faults should be set midway between zone 1 and zone 1X.

Check that it performs instantaneous single-phase or three-phase tripping depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Check that the operating time is 1-1.5 cycle or less.

Check that the indications and recordings are correct.

PUP tripping

(Integral digital communication)

Set the scheme switch [SCHEME] to "PUP".

Set the [T.TEST] to “ON”.

Apply a zone 1 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Apply a fault between zone 1 and zone 2. Check that PUP tripping does not occur.

Check that the indications and recordings are correct.

(External communication)

Set the scheme switch [SCHEME] to "PUP".

Energize a binary input (EXT-CAR-R1 signal is assigned) to simulate a trip permission signal reception and apply a zone 2 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

De-energize the binary input and apply a zone 2 fault. Check that PUP tripping does not occur.

Apply a zone 1 fault, and check a binary output relay (EXT-CAR-S signal is assigned) operates.

Check that the indications and recordings are correct.

POP tripping

(Integral digital communication)

Set the scheme switch [SCHEME] to "POP", [WKIT] and [ECHO] to "off".

Set the [T.TEST] to “ON”.

Apply a zone 1 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Apply a reverse zone fault, and check that the POP tripping does not occur.

Check that the indications and recordings are correct.

(External communication)

Set the scheme switch [SCHEME] to "POP", [WKIT] and [ECHO] to "off".

Energize the binary input (EXT-CAR-R1) to simulate a trip permission signal reception and apply a zone 2 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Set [WKIT] and [ECHO] to "On" and apply a weak-infeed fault. Check that instantaneous tripping is performed.

De-energize the binary input and apply a zone 2 fault. Check that POP tripping does not occur.

Apply a zone 2 fault, and check that binary output relay (EXT-CAR-S) operates.

Set the scheme switch [ECHO] to "On".

De-energize binary inputs (CB_CONT-A, -B and -C signals are assigned.) to simulate the breaker being open. Check that binary output relay (EXT-CAR-S) operates when the binary input (EXT-CAR-R1) is energized.

Apply a reverse zone fault while the binary inputs (CB_CONT-A, -B and -C) are energized, and check that the binary output relay (EXT-CAR-S) does not operate when the binary input (EXT-CAR-R1) is energized.

Check that the indications and recordings are correct.

UOP tripping

(Integral digital communication)

Set the scheme switch [SCHEME] to "UOP", [WKIT] and [ECHO] to "Off".

Set the [T.TEST] to “ON”.

Apply a zone 1 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Apply a reverse zone fault, and check that the UOP tripping does not occur.

(External communication)

Set the scheme switch [SCHEME] to "UOP", [WKIT] and [ECHO] to "Off".

De-energize the binary input (EXT-CAR-R1) to simulate interruption of a trip block signal reception and apply a zone 2 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Set [WKIT] and [ECHO] to "On" and apply a weak-infeed fault. Check that instantaneous tripping is performed.

Energize the binary input (EXT-CAR-R1) to simulate trip block signal reception and apply a zone 2 fault. Check that UOP tripping does not occur.

Check that the binary output relay (EXT-CAR-S) operates in the normal condition.

Apply a zone 2 fault, and check that the binary output relay (EXT-CAR-S) resets.

Set the scheme switch [ECHO] to "On".

De-energize the binary inputs (CB_CONT-A, -B and -C) to simulate the breaker being open. Check that the binary output relay (EXT-CAR-S) resets when the binary input (EXT-CAR-R1) is de-energized.

Apply a reverse zone fault while the binary inputs (CB_CONT-A, -B and -C) are energized, and check that the binary output relay (EXT-CAR-S) remains operated when the binary input (EXT-CAR-R1) is de-energized.

Check that the indications and recordings are correct.

BOP tripping

(Integral digital communication)

Set the scheme switch [SCHEME] to "BOP".

Set the [T.TEST] to “ON”.

Apply a zone 1 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Apply a reverse zone fault, and check that the BOP tripping does not occur.

(External communication)

Set the scheme switch [SCHEME] to "BOP".

Check that the binary input (EXT-CAR-R1) is de-energized.

Apply a zone 2 fault. Check that instantaneous single-phase or three-phase tripping is performed depending on the fault types and setting of autoreclose mode selection switch [ARC-M].

Energize the binary input (EXT-CAR-R1) to simulate trip block signal reception and apply a zone 2 fault. Check that BOP tripping does not occur.

Apply a zone 2 fault, and check that binary output relay SBX does not operate. Apply a reverse zone fault, and check that the binary output relay (EXT-CAR-S) operates.

Check that the indications and recordings are correct.

SOTF tripping

SOTF tripping is carried out by operation of distance measuring elements (Z1, Z2, Z3, ZR1, ZR2, ZF, ZND) or overcurrent element OCH operation. these elements can perform the SOTF tripping by setting.

The SOTF function is activated when the breaker has been open for timer TSOTF (0 – 300s) setting and active for an additional 500ms after the breaker is closed.

The SOTF function is checked as follows:

- Set the scheme switch [SOTF-OC] to "On" and [SOTF-Z∗] to "Off".

De-energize the binary input signals (CB_CONT-A, -B and -C) for more than TSOTF (0 – 300s) setting.

- Energize the binary input signals and apply a zone 1 fault at the same time.

Check that the operating time is within 1-1.5 cycle.

- Set the scheme switch [SOTF-OC] to "Off" and [SOTF-Z∗] to "On" and repeat the above.

Breaker failure tripping

Set the scheme switch [BF1] to "T" or "TOC" and BF2 to "On".

- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter a signal number 199 for the TermA line to observe the retrip signal at monitoring jack A and 200 for the TermB line to observe the adjacent circuit breaker trip signal at monitoring jack B and press the ENTER key.
- Apply a zone 1 fault and maintain it. Check that the retrip signal is generated after the time setting of TBF1 and the adjacent circuit breaker trip signal is generated after the time setting of the TBF2.

Out-of-step tripping

Set the scheme switch [OST] to "On".

To simulate out-of-step, the impedance seen by the OST element must be moved slowly from the first quadrant to the second quadrant or vice versa.

The following shows the case of the former.

- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter signal number 203 for the TermA line to observe the out-of-step tripping signal at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage and current.
- Gradually lower the voltage to zero, keeping the voltage and current sources in-phase. Then gradually raise the voltage from zero to the rated value, while keeping the phase angle of voltage and current in anti-phase.

During this process, keep the current at the rated value.

- Check that out-of-step tripping takes places at monitoring jack A.
- Check that out-of-step tripping does not take place if the voltage was lowered or raised steeply or was gradually raised while retaining the phase angle of voltage and current in-phase, not anti-phase.

Voltage transformer failure supervision

A voltage transformer (VT) failure is detected when an undervoltage element or residual overvoltage element operates but a current change detection element or residual overcurrent element does not operate accordingly.

VT failure detection is checked as follows:

- Set the circuit breaker closed condition by applying a "1" signal to binary inputs (CB_CONT-A, -B and -C).
- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter signal number 172 for the TermA line to observe the VT failure alarm signal, and 173 for the TermB line to observe the VT failure detection signal at monitoring jack A and B. Press the ENTER key.
- Apply a three-phase rated voltage. Then, remove single-, two- or three-phase voltage. Check

that the signals are instantly observed at jack B and observed at jack A after a 10s delay.

Blocking of the voltage-dependent protection is checked as follows:

- Apply a three-phase rated voltage. Then, remove single-, two- or three-phase voltage and at the same time apply a zone 1 fault. During this process, do not change the current.

  Check that neither zone 1 tripping nor command tripping takes place.

- In the similar manner, apply a zone 1 extension, zone 2 or zone 3 fault and check that tripping does not take place.

Check that VT failure is recorded on the event record.

Power swing blocking

A power swing is detected when the condition that the PSBSOUT element operates and PSBSIN element and residual overcurrent element EFL do not operate, for a period of TPSB setting or more.

Power swing detection is checked as follows:

- Press 5 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter signal number 176 for the TermA line to observe the power swing blocking signal at monitoring jack A and press the ENTER key.
- Apply a phase fault which is set to midway between PSBSIN and PSBSOUT. Check that the signal is generated with a delay of TPSB setting after the PSBSOUT operates. The PSBSOUT operating time will be 1-2 cycles.
- Reset the fault and check that the monitoring signal resets with a 500ms delay after PSBSOUT resets.
- Apply an earth fault which is set to midway between PSBSIN and PSBSOUT. Check that the signal is not generated.

Power swing blocking is checked as follows:

- Apply a zone 1 phase fault after generating the power swing blocking signal. The blocking signal is generated in the way as mentioned above. Check that zone 1 tripping takes place if scheme switch [PSB-Z1] is set to "Off" and does not take place if set to "On".
- In the similar manner, apply zone 1x, zone 2, zone 3, zone F, zone R1 and zone R2 faults, and check that tripping takes place or does not take place depending on the "On" or "Off" setting of scheme switch [PSB-Z1X], [-Z2], [-Z3], [-ZF], [-ZR1] and [-ZR2].

Check that power swing blocking is recorded on the event record.

6.5.4 Metering and Recording

The metering function can be checked while testing the AC input circuit. See Section 6.4.4.

Fault recording can be checked while testing the protection schemes. Open the "Fault records" screen and check that the descriptions are correct for the applied fault.

The default setting of events is shown in Appendix H. Event recording on the external events such as CB1 ready, Ind.reset, etc., can be checked by changing the status of binary input signals. Change the status in the same way as the binary input circuit test (see Section 6.4.2) and check that the description displayed on the "Event Records" screen is correct.

Note: The choice of whether to record or not can be set for each event. Change the status of the binary input signal after confirming that the related event is set to record. (The default setting enables all the events to be recorded.)

Some of the internal events such as Trip, Com1.fail, etc., can be checked in the protection scheme tests.

Disturbance recording can be checked while testing the protection schemes. The LCD display only shows the date and time when a disturbance is recorded. Open the "Disturbance records" screen and check that the descriptions are correct.

Details can be displayed on the PC. Check that the descriptions on the PC are correct. For details on how to obtain disturbance records on the PC, see the RSM100 Manual.

6.5.5 Fault Locator

In the fault locator tests, a dynamic test set with a three-phase voltage source and current source is required to simulate power system pre-fault, fault and post-fault conditions.

The fault locator starts measurement with one of the following tripping signals: command trip, zone 1, zone 2 and zone 3 trip, zone 1 extension trip and external main protection trip. Therefore, it is preferable to test it while testing the protection schemes by applying a fault.

The line parameter settings must be changed to meet those of the test set.

The measurement result is expressed as a percentage of the line length and the distance and displayed on the "Fault Record" screen of the LCD.

Note: If abnormal settings far from actual transmission line impedance, e.g. resistance value so larger than reactance value, etc., are done, the location error will be larger.

6.6 Conjunctive Tests

6.6.1 On Load Test

With the relay connected to the line which is carrying a load current, it is possible to check the polarity of the voltage transformer and current transformer and the phase rotation with the metering displays on the LCD screen.

- Open the following "Metering" screen from the "Status" sub-menu.

```
/2 Metering                                    3/13
Va   63.5V    +0.0°    Ia   2.10A    +4.9°
Vb   63.4V  -120.0°    Ib   2.10A  -115.0°
Vc   63.5V  +120.1°    Ic   2.15A  +125.1°
...
...
Active power     +   318.50MW
Reactive power   -    29.00Mvar
Frequency             60.0 Hz
```

Note: The magnitude of voltage, current and power can be set in values on the primary side or on the secondary side by the setting. (The default setting is the primary side.)
Phase angles are expressed taking that of positive sequence voltage as the reference angle.
The sign of the phase angle can be set positive for either lagging phase or leading phase. (In the default setting, it is set positive when the phase is leading to the reference angle.)
The sign of the power flow direction can be set positive for either power sending or power receiving. (The default setting is power sending.)

- Check that the phase rotation is correct.
- Verify the phase relationship between the voltage and current with the known load current direction.

6.6.2 Signaling Circuit Test

This test is performed when a command protection using a signaling channel is applied.

Integral digital communication

The test is to check whether the communication circuit is correctly connected between a local terminal and a remote terminal.

Input the voltage or current at a remote terminal relay. Check the voltage and current by the "Metering" screen from the "Status" sub-menu at a local relay.

External communication

The test is carried out after the signal receive and send contacts are connected to the telecommunication circuit.

The signal send circuit from the relay to the telecommunication equipment is checked by forcibly operating the signal send relay and monitoring the signal at the telecommunication equipment.

Signal sending is performed on the LCD using the "Test" sub-menu as follows.

- Press 3 (= Binary output) on the "Test" screen to display the "Binary output" screen. The LCD displays the output modules installed depending on the model.
- Enter 2 to select the IO#2 module, the LCD will display the screen shown below, indicating the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.

```
/3 BO           (0=Disable 1=Enable)  1/14
IO#2   BO1                             0 _
IO#2   BO2                             0
IO#2   BO3                             0
 .
 .
IO#2   BO13                            1
```

- Move the cursor to the bottom line to select the BO13 output relay by pressing the ▼ key, then enter 1 and press the ENTER key.
- After completing the entries, press the END key. The LCD will display the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to operate the BO13 output relay forcibly. Then the BO13 output contact will close. Monitor this at the telecommunication equipment.

The signal receive circuit from the telecommunication equipment to the relay is checked with the "Binary input & output" screen on the LCD as follows:

Note: The receive signal is assigned to any of the binary inputs by the user setting. The following description is the case of BI4 and BI5 assigned.

- Display the "Binary I/O" screen from the "Status" sub-menu. Position BI4 indicates a receive signal status. Position BI5 indicates the status of the guard signal in case of frequency shift signaling.

```
/2 Binary input & output                 3/ 8
Input (IO#1)          [000 000 000 000     ]
Input (IO#2)          [000                 ]
Input (IO#3)          [000 000 000 0       ]
Input (IO#4)          [000                 ]
Output(IO#1-trip)     [000                 ]
Output(IO#2)          [000 000 000 000 00  ]
Output(IO#3)          [000 000 000 0       ]
Output(IO#4)          [000 000 000 000 00  ]
```

- Send a signal or interrupt sending a signal at the telecommunication equipment and monitor on the screen that the status of BI4 or BI5 changes accordingly.

If the signaling circuit connection is completed from the local relay to the remote relay, the test above can be extended to an end-to-end test.

- Send the signal by operating the BO13 output relay at one end with the "Test" sub-menu as described above and monitor the signal reception at the other end on the "Binary input & output" screen.

In the BOP scheme, the end-to-end test can be carried out more simply on the "Manual test" screen of the "Test" sub-menu. For the details, see Section 4.2.7.2.

Note: In these tests it is recommended to block the tripping circuit to prevent false tripping.

6.6.3 Tripping and Reclosing Circuit Test

The tripping and reclosing circuit including the circuit breaker is checked by forcibly operating the output relay and monitoring the circuit breaker to confirm that it is tripped or reclosed. Forcible operation of the output relay is performed on the "Binary output" screen of the "Test" sub-menu as described in Section 6.4.3.

Tripping circuit

- Set the breaker to be closed.
- Press 3 (= Binary output) on the "Test" sub-menu screen to display the "Binary output" screen. The LCD displays the output modules mounted.
- Enter 1 to select the IO#1 module, then the LCD displays the screen shown below.

```
/3 BO           (0=Disable 1=Enable)  1/ 3
IO#1  TP-A1                            0 _
IO#1  TP-B1                            0
IO#1  TP-C1                            0
```

TP-A1, B1 and C1 are output relays with one normally open contact, and trip the A-phase, B-phase and C-phase circuit breakers.

- Enter 1 for TP-A1 and press the ENTER key.
- Press the END key. Then the LCD displays the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to operate the output relay TP-A1 and check that the A-phase breaker is tripped.
- Release the 1 key to reset the operation.
- Repeat the above for all the phases.

Reclosing circuit

The test is applied to the autoreclose function if used.

- Ensure that the circuit breaker is open.
- Press 3 (= Binary output) on the "Test" sub-menu screen to display the "Binary output" screen. The LCD displays the output modules mounted.
- Enter the selected number corresponding to each module to be operated. The LCD will display the name of the module, the name of the output relay, the name of the terminal block and the

terminal number to which the relay contact is connected.

Note: The autoreclose command is assigned to any of the output relays by the user setting. The following description is the case for the default setting of model 211.
In the default setting, the autoreclose command is set to BO10 of the IO#2 module.

- Enter 2 to select the IO#2 module, then the LCD displays the screen shown below.

```
/3 BO              (0=Disable 1=Enable)   1/14
IO#2   BO1                                0 _
IO#2   BO2                                0
IO#2   BO3                                0
 ...
IO#2   BO10                               1
IO#2   BO11                               0
IO#2   BO12                               0
IO#2   FAIL                               0
IO#2   BO13                               0
```

Note: Terminal block number depends on the relay model. So see Appendix G for details.

Move the cursor by pressing the ▼ key and select BO10. BO10 is an autoreclose command output relay with one normally open contact.

- Enter 1 and press the ENTER key.
- Press the END key. Then the LCD displays the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to forcibly operate the output relay BO10 and check that the circuit breaker is closed.
- Release the 1 key to reset the operation.
- In case of two-breaker autoreclose, repeat the forcible operation for BO11.

6.7 Maintenance

6.7.1 Regular Testing

The relay is almost completely self-supervised. The circuits which can not be supervised are binary input and output circuits and human interfaces.

Therefore regular testing can be minimized to checking the unsupervised circuits. The test procedures are the same as described in Sections 6.4.1, 6.4.2 and 6.4.3.

6.7.2 Failure Tracing and Repair

Failures will be detected by automatic supervision or regular testing.

When a failure is detected by supervision, a remote alarm is issued with the binary output signal of FAIL (*) and the failure is indicated on the front panel with LED indicators or LCD display. It is also recorded in the event record.

(*) Failure signals on the external circuits, that is signaling channel, VT circuit and isolator circuit, can be allotted to any of the binary output relays by the user. Failure signals of the signaling channel and VT circuit are set to BO12 of the IO module as the default setting.

Failures detected by supervision are traced by checking the "Auto-supervision" screen on the LCD.

If any messages are shown on the LCD, the failed module or failed external circuits can be located by referring to the Table 6.7.1.

This table shows the relationship between message displayed on the LCD and estimated failure location. The location marked with (1) has a higher probability than the location marked with (2).

As shown in the table, some of the messages cannot identify the fault location definitely but suggest plural possible failure locations. In these cases, the failure location is identified by replacing the suggested failed modules with spare modules one by one or investigating and restoring the monitored external circuits (that is signaling channel, VT circuit and isolator circuit) until the "Alarm" LED is turned off.

The replacement or investigation should be performed first for the module or circuit with higher probability in the table.

If there is a failure and the LCD is not working such as a screen is frozen or not displayed, the failure location is any one of SPM and HMI module.

Table 6.7.1 LCD Message and Failure Location

Message	Failure location											
	VCT	SPM (GCOM)	IO1 or IO8	IO2	IO3	IO4	IO5	IO6	HMI	Communi-cation Channel	Disconn-ector	AC cable
Checksum err		×										
ROM data err		×										
ROM-RAM err		×										
SRAM err		×										
BU-RAM err		×										
DPRAM err		×										
EEPROM err		×										
A/D err		×										
V0 err	× (2)	× (1)										× (2)
V2 err	× (2)	× (1)										× (2)
I0 err	× (2)	× (1)										× (2)
CT err	× (2)	× (2)										× (1)
Sampling err		×										
DIO err		× (2)	× (1)	× (1)	× (1)	× (1)	× (1)	× (1)				
RSM err		× (2)	× (1)									
DS fail		× (2)	× (2)								× (1)	
Ch.1fail, Ch. 2fail		× (2)*								× (1)*		
Com.1 fail, fail-R Com.2 fail, fail-R		× (2)								× (1)		
Sync.1 fail, Sync.2 fail		× (2)								× (1)		
TX level1 err, TX level2 err		× (2)								× (1)		
RX level1 err, RX level2 err		× (2)								× (1)		
CLK1 fail, CLK2 fail		× (2)								× (1)		
Td1 err, Td2 err		× (2)								× (1)		
Term1 rdy off, Term2 rdy off										× (*)		
RYID1 err, RYID2 err										× (*)		
VT fail	× (2)											× (1)
No-working of LCD		× (2)							× (1)			

The location marked with (1) has a higher probability than the location marked with (2).
The item of location marked with (*): also check the remote terminal relays and equipment.

If no message is shown on the LCD, this means that the failure location is either in the DC power supply circuit or in the microprocessors mounted on the SPM module. Then check the "ALARM" LED. If it is off, the failure is in the DC power supply circuit. If it is lit, open the relay front panel and check the LEDs mounted on the SPM module. If the LED is off, the failure is in the DC power supply circuit. If the LED is lit, the failure is in the microprocessors.

In the former case, check if the correct DC voltage is applied to the relay.

If so, replace the IO1 or IO8 module mounting the DC/DC converter and confirm that the "Alarm" LED is turned off.

In the latter case, replace the SPM module mounting the processors and confirm that the "Alarm" LED is turned off.

When a failure is detected during regular testing, it will not be difficult to identify the failed module to be replaced.

Note: When a failure or an abnormality is detected during the regular test, confirm the following first:

- Test circuit connections are correct.
- Modules are securely inserted in position.
- Correct DC power voltage is applied.
- Correct AC inputs are applied.
- Test procedures comply with those stated in the manual.

6.7.3 Replacing Failed Modules

If the failure is identified to be in the relay module and the user has spare modules, the user can recover the protection by replacing the failed modules.

Repair at the site should be limited to module replacement. Maintenance at the component level is not recommended.

Check that the replacement module has an identical module name (VCT, SPM, IO2, etc.) and hardware type-form as the removed module. Furthermore, the SPM and GCOM should have the same software name.

The module name is indicated on the bottom front of the relay case. The hardware type-form is indicated on the module in the following format:

Module name	Hardware type-form
VCT	G1PC1-∗∗∗∗
SPM	G1SP∗-∗∗∗∗
IO1	G1IO1-∗∗∗∗
IO2	G1IO2-∗∗∗∗
IO4	G1IO2-∗∗∗∗
IO5	G1IO3-∗∗∗∗
IO6	G1IO3-∗∗∗∗
IO8	G1IO8-∗∗∗∗
HMI	---------

The software name is indicated on the memory device on the module with letters such as GS1ZM1-∗∗∗, GS1LC1-∗∗∗, etc.

⚠ CAUTION When handling a module, take anti-static measures such as wearing an earthed wrist band and placing modules on an earthed conductive mat. Otherwise, many of the electronic components could suffer damage.

CAUTION After replacing the SPM module, check all of the settings including the PLC and IEC103 setting data are restored the original settings.

The initial replacement procedure is as follows:

- Switch off the DC power supply.
- Disconnect the trip outputs.
- Short circuit all AC current inputs and disconnect all AC voltage inputs.

⚠WARNING Hazardous voltage can be present in the DC circuit just after switching off the DC power supply. It takes approximately 30 seconds for the voltage to discharge.

- Unscrew the relay front cover.

Replacing the Human Machine Interface Module (front panel)

- Open the front panel of the relay by unscrewing the binding screw located on the left side of the front panel.
- Unplug the ribbon cable on the front panel by pushing the catch outside.
- Remove the two retaining screws and one earthing screw on the relay case side, then detach the front panel from the relay case.
- Attach the replacement module in the reverse procedure.

Replacing the Transformer Module

- Open the right-side front panel (HMI module) by unscrewing the two binding screws located on the left side of the panel.
- Open the left-side front panel (blind panel) (*) by unscrewing the two binding screws located on the right side of the panel.

  (*) This blind panel is attached only to models assembled in the type B case.

- Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.
- Unplug the ribbon cable on the SPM by nipping the catch.
- Remove the metal cover by unscrewing the binding screw located at the top and bottom of the cover.
- Pull out the module by grasping the handles.
- Insert the replacement module in the reverse procedure.

Replacing other modules

- Open the right-side front panel (HMI module) by unscrewing the two binding screws located on the left side of the panel.
- Open the left-side front panel (blind panel) (*) by unscrewing the two binding screws located on the right side of the panel.

(*) This panel is attached only to models assembled in the type B case.

- Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.
- Unplug the ribbon cable running among the modules by nipping the catch (in case of black connector) and by pushing the catch outside (in case of gray connector) on the connector.
- Pull out the module by pulling up or down at the top and bottom levers.
- Insert the replacement module in the reverse procedure.
- After replacing the SPM module, input the user setting values again.

For failed module tracing and its replacement, see Appendix R.

6.7.4 Resumption of Service

After replacing the failed module or repairing failed external circuits, take the following procedures to restore the relay to service.

- Switch on the DC power supply and confirm that the "IN SERVICE" green LED is lit and the "ALARM" red LED is not lit.

  Note: Supply DC power after checking that all the modules are in their original positions and the ribbon cables are plugged in.

- If the telecommunication circuit was repaired, perform a "Manual test" and check that the circuit is normal. For the "Manual test", refer to Section 4.2.7.2.
- Supply the AC inputs and reconnect the trip outputs.

6.7.5 Storage

The spare relay or module should be stored in a dry and clean room. Based on IEC Standard 60255-6 the storage temperature should be −25°C to +70°C, but the temperature of 0°C to +40°C is recommended for long-term storage.

7. Putting Relay into Service

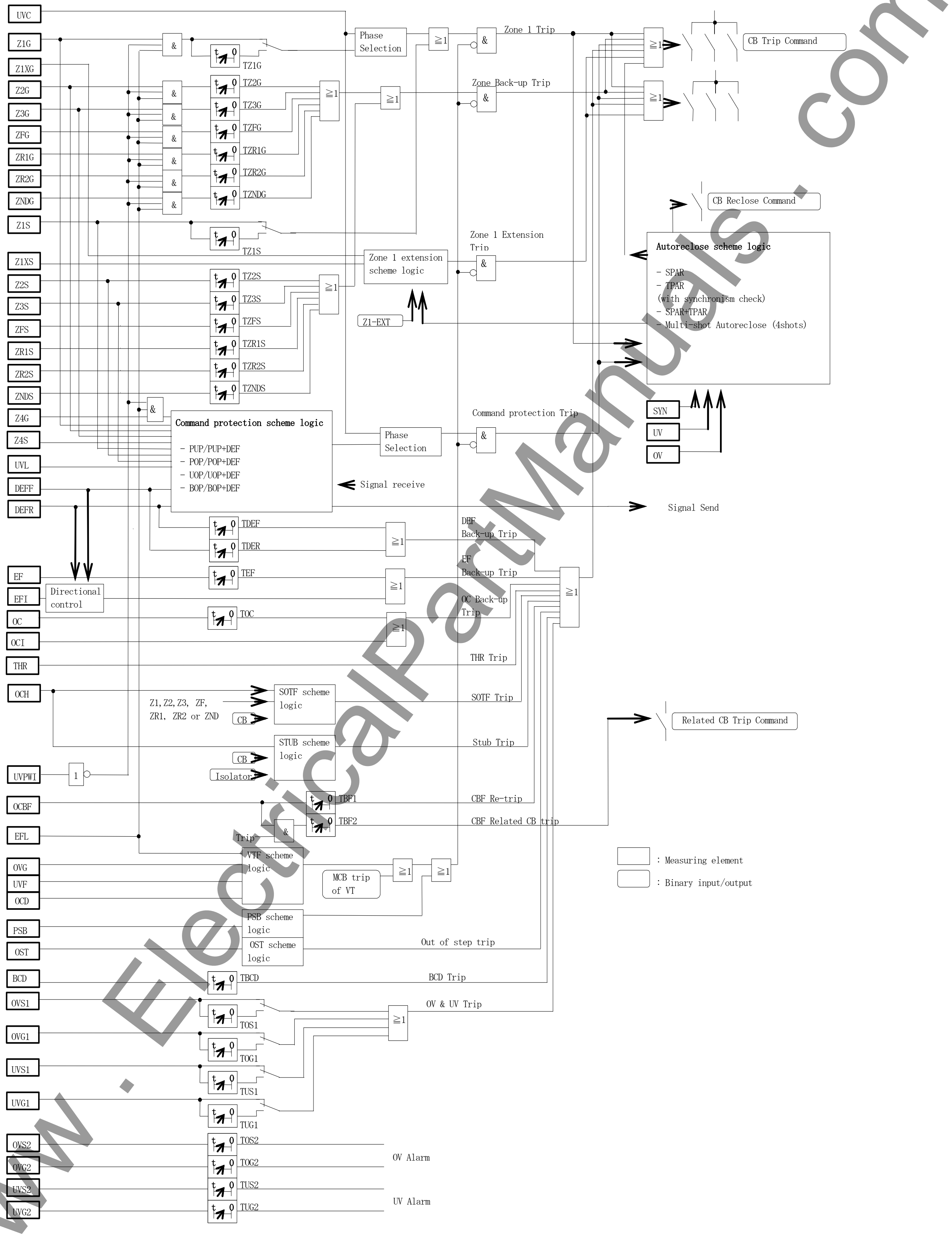
The following procedure must be adhered to when putting the relay into service after finishing commissioning or maintenance tests.

- Check that all external connections are correct.
- Check the setting of all measuring elements, timers, scheme switches, recordings and clock are correct.
  In particular, when settings are changed temporarily for testing, be sure to restore them.
- Clear any unnecessary records on faults, events and disturbances which are recorded during the tests.
- Reset the counter figures of automatic test and autoreclose, if necessary. For resetting the count, see Section 4.2.3.4 and 4.2.3.5.
- Press the VIEW key and check that no failure message is displayed on the "Auto-supervision" screen.
- Check that the green "IN SERVICE" LED is lit and no other LEDs are lit on the front panel.

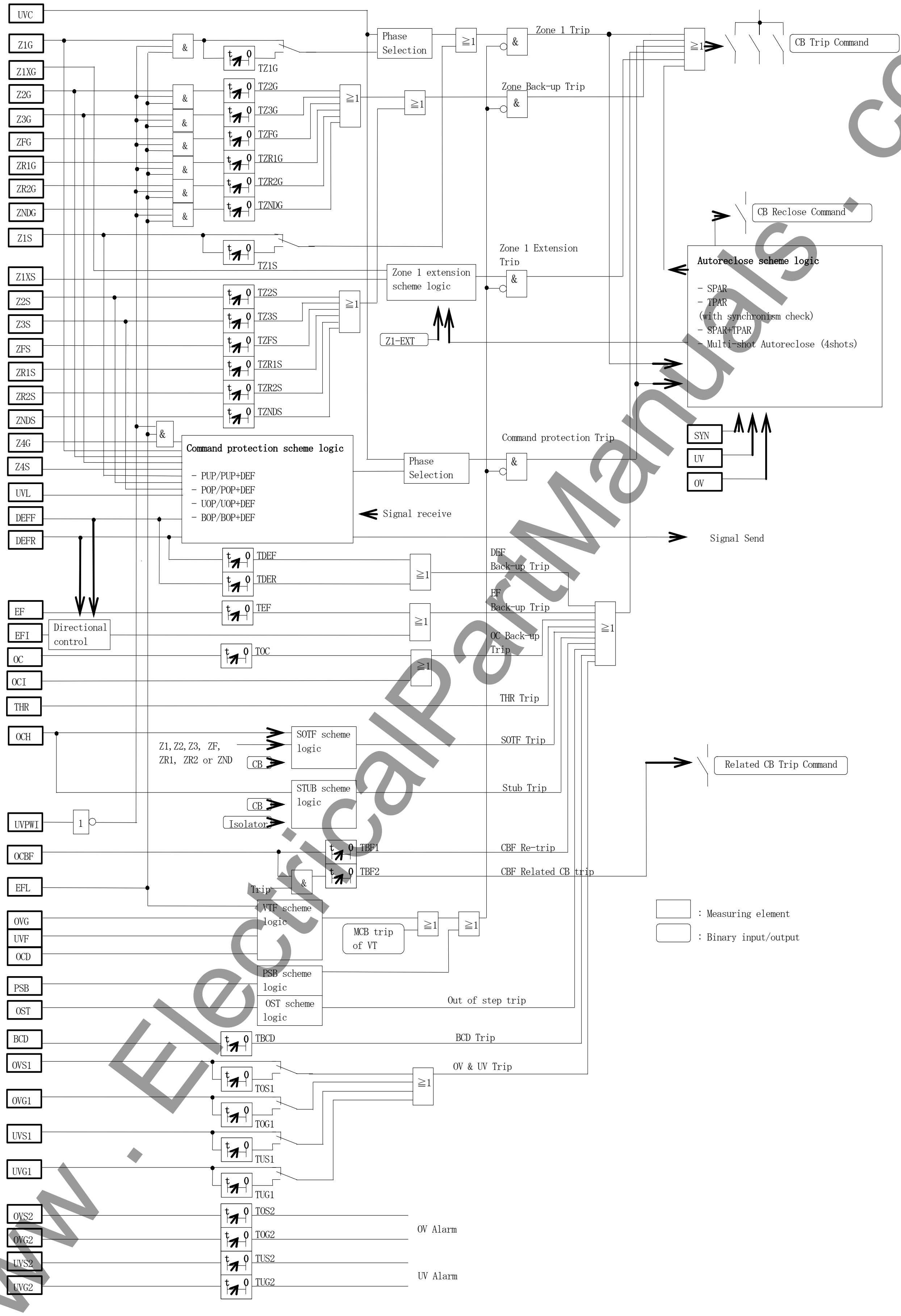
Whilst the relay is put into service at one terminal by supplying DC power and not yet at the other terminal, a communication failure will be detected by the automatic monitoring at the in-service terminal and a red "ALARM" LED is lit. But it will be reset when the relays are put into service at all terminals.

Appendix A

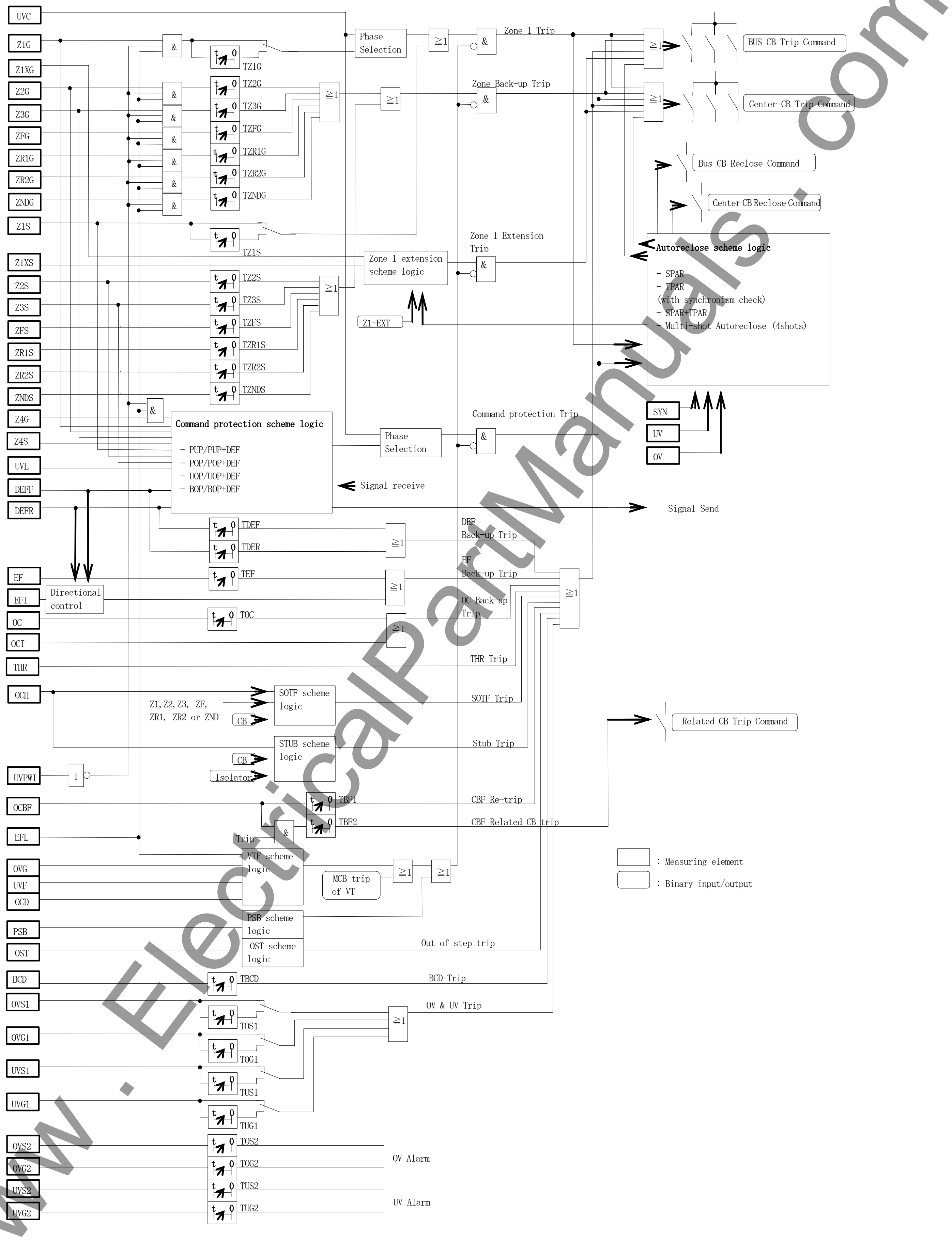
Block Diagram



Model 211B, 221B



Model 214B, 216B, 224B, 226B



Model 311B, 321B, 322B

Appendix B

Signal List

Signal list

No.	Signal Name	Contents
0	CONSTANT 0	constant 0
1	CONSTANT 1	constant 1
2		
3		
4		
5		
6		
7		
8		
9	CRT USE	CARRIER IN SERVICE
10		
11		
12		
13		
14		
15		
16		
17		
18		
19	Z1G-A	EARTH FAULT RELAY Z1G
20	Z1G-B	ditto
21	Z1G-C	ditto
22	Z1XG-A	EARTH FAULT RELAY Z1XG
23	Z1XG-B	ditto
24	Z1XG-C	ditto
25	Z2G-A	EARTH FAULT RELAY Z2G
26	Z2G-B	ditto
27	Z2G-C	ditto
28	Z3G-A	EARTH FAULT RELAY Z3G
29	Z3G-B	ditto
30	Z3G-C	ditto
31	Z4G-A	EARTH FAULT RELAY Z4G
32	Z4G-B	ditto
33	Z4G-C	ditto
34	Z1S-AB	PHASE FAULT RELAY Z1S
35	Z1S-BC	ditto
36	Z1S-CA	ditto
37	Z1XS-AB	PHASE FAULT RELAY Z1XS
38	Z1XS-BC	ditto
39	Z1XS-CA	ditto
40	Z2S-AB	PHASE FAULT RELAY Z2S
41	Z2S-BC	ditto
42	Z2S-CA	ditto
43	Z3S-AB	PHASE FAULT RELAY Z3S
44	Z3S-BC	ditto
45	Z3S-CA	ditto
46	Z4S-AB	PHASE FAULT RELAY Z4S
47	Z4S-BC	ditto
48	Z4S-CA	ditto
49	PSBSOUT-AB	POWER SWING BLOCK for ZS OUTER ELEMENT
50	PSBSOUT-BC	ditto
51	PSBSOUT-CA	ditto
52	OCCR-A	OC RELAY FOR LINE VT
53	OCCR-B	ditto
54	OCCR-C	ditto
55	OCH-A	HIGH SET OC RELAY
56	OCH-B	ditto
57	OCH-C	ditto
58	DEFR	DIRECT. EF RLY (EXTERNAL)
59	DEFF	DIRECT. EF RLY (INTERNAL)
60	EF	EARTH FAULT RELAY
61	EFI	EARTH FAULT IDMT RELAY
62	OVG	EARTH OV RELAY
63	OCD-A	CURRENT CHANGE DETEC. RELAY
64	OCD-B	ditto
65	OCD-C	ditto
66	UVC-A	UV RELAY (PHASE SELECTOR)
67	UVC-B	ditto
68	UVC-C	ditto
69	UVFS-AB	UV RELAY (High set)
70	UVFS-BC	ditto

Signal list

No.	Signal Name	Contents
71	UVFS-CA	ditto
72	UVLS-AB	UV RELAY (Low set)
73	UVLS-BC	ditto
74	UVLS-CA	ditto
75	UVFG-A	UV RELAY (High set)
76	UVFG-B	ditto
77	UVFG-C	ditto
78	UVLG-A	UV RELAY (Low set)
79	UVLG-B	ditto
80	UVLG-C	ditto
81	OCBF-A	OC RELAY FOR CBF DETECTION
82	OCBF-B	ditto
83	OCBF-C	ditto
84	OST-ZM	OST-ZM
85	OST-ZN	OST-ZN
86	OVB	OVB
87	UVB	UVB
88	SYN1	SYN1
89	OVL1	OVL1
90	UVL1	UVL1
91	OVL2	OVL2
92	UVL2	UVL2
93	SYN2	SYN2
94	OC-A	OC-A
95	OC-B	OC-B
96	OC-C	OC-C
97	OCI-A	OCI-A
98	OCI-B	OCI-B
99	OCI-C	OCI-C
100	CHECKING	CHECKING
101	CB-AND	CB CONTACT (3PHASE AND)
102	CB-OR	CB CONTACT (3PHASE OR)
103	Z1G-AX	Z1G-AX
104	Z1G-BX	Z1G-BX
105	Z1G-CX	Z1G-CX
106	Z1XG-AX	Z1XG-AX
107	Z1XG-BX	Z1XG-BX
108	Z1XG-CX	Z1XG-CX
109	Z2G-AX	Z2G-AX
110	Z2G-BX	Z2G-BX
111	Z2G-CX	Z2G-CX
112	Z3G-AX	Z3G-AX
113	Z3G-BX	Z3G-BX
114	Z3G-CX	Z3G-CX
115	Z4G-AX	Z4G-AX
116	Z4G-BX	Z4G-BX
117	Z4G-CX	Z4G-CX
118	Z1S-ABX	Z1S-ABX
119	Z1S-BCX	Z1S-BCX
120	Z1S-CAX	Z1S-CAX
121	Z1XS-ABX	Z1XS-ABX
122	Z1XS-BCX	Z1XS-BCX
123	Z1XS-CAX	Z1XS-CAX
124	Z2S-ABX	Z2S-ABX
125	Z2S-BCX	Z2S-BCX
126	Z2S-CAX	Z2S-CAX
127	Z3S-ABX	Z3S-ABX
128	Z3S-BCX	Z3S-BCX
129	Z3S-CAX	Z3S-CAX
130	Z4S-ABX	Z4S-ABX
131	Z4S-BCX	Z4S-BCX
132	Z4S-CAX	Z4S-CAX
133	PSBSOUT-ABX	PSBSOUT-ABX
134	PSBSOUT-BCX	PSBSOUT-BCX
135	PSBSOUT-CAX	PSBSOUT-CAX
136	OCCROR	OCCR0R
137	OCHOR	OCHOR
138	OCDOR	OCDOR
139	UVCOR	UVCOR
140	UVFSOR	UVFSOR

Signal list

No.	Signal Name	Contents
141	UVLSOR	UVLSOR
142	UVFGOR	UVFGOR
143	UVLGOR	UVLGOR
144	2PH	2PH
145	TZ1GA	TZ1GA
146	TZ1GB	TZ1GB
147	TZ1GC	TZ1GC
148	Z1G TRIP	Z1G TRIP
149	Z1G-A TRIP	Z1G TRIP A ph.
150	Z1G-B TRIP	Z1G TRIP B ph.
151	Z1G-C TRIP	Z1G TRIP C ph.
152		
153	Z2G TRIP	Z2G TRIP
154	Z2GOR	Z2G RELAY OR LOGIC
155		
156	Z3G TRIP	Z3G TRIP
157	Z3GOR	Z3G RELAY OR LOGIC
158	Z1PTT	ZONE1 RELAY O/P FOR PTTSCHEME
159	TZ1S	Z1S TRIP TIMER
160	Z1S TRIP	Z1S TRIP
161		
162	Z2S TRIP	Z2S TRIP
163	Z2SOR	Z2S RELAY OR LOGIC
164		
165	Z3S TRIP	Z3S TRIP
166	Z3SOR	Z3S RELAY OR LOGIC
167	Z1XG TRIP	Z1XG TRIP
168	Z1X-A TRIP	Z1XG TRIP A ph.
169	Z1X-B TRIP	Z1XG TRIP B ph.
170	Z1X-C TRIP	Z1XG TRIP C ph.
171	Z1XS TRIP	Z1XS TRIP
172	VTF ALARM	VTF ALARM
173	VTF	VTF BLOCK SIGNAL
174	VTF1 ALARM	3PH VTF DETECT.
175	VTF2 ALARM	1 OR 2PH VTF DETECT
176	PSB DET	PSB DETECTION
177	PSB-Z1	PSB FOR ZONE1 RELAY
178	PSB-Z1X	PSB FOR ZONE1X RELAY
179	PSB-Z2	PSB FOR ZONE2 RELAY
180	PSB-Z3	PSB FOR ZONE3 RELAY
181	PSB-CR	PSB FOR CARRIER TRIP
182	STUB TRIP	STUB TRIP
183	SOTF TRIP	SOTF TRIP
184	EFI TRIP	EF IDMT TRIP
185	EF ALARM	EF BACK-UP TRIP ALARM
186	DEF ALARM	DEF BACK-UP TRIP ALARM
187	EF BU-TRIP	EF or DEF BACK-UP TRIP
188	TZ4S	Z4S BACK-UP TRIP TIMER
189	ZR1S TRIP	ZR1S TRIP
190	ZR1SOR	ZR1S RELAY OR LOGIC
191	TZ4G	Z4G BACK-UP TRIP TIMER
192	ZR1G TRIP	Z4G BACK-UP TRIP
193	ZR1GOR	ZR1G RELAY OR LOGIC
194	BU TRIP	BACK-UP TRIP
195	BURECLK	BU RECLOSE BLOCK
196	CBF RETRIP-A	RE-TRIP A ph. FOR CBF
197	CBF RETRIP-B	RE-TRIP B ph. FOR CBF
198	CBF RETRIP-C	RE-TRIP C ph. FOR CBF
199	CBF DET	CBF DETECTION
200	CBF TRIP	RELATED CB TRIP FOR CBF
201	TOST1	OS DETECTION TIMER 1
202	TOST2	OS DETECTION TIMER 2
203	OST TRIP	OS TRIP
204	EXT CAR-R1	CARRIER RECEIVE FROM REMOTE TERM.1
205	C/R PUP	CARRIER SEND FOR PUTT
206	CRG-PUP	PUTT LOCAL TRIP
207	CRS-PUP	ditto
208	ZGCX	CARRIER CONTROL RELAY(Z2G/Z3G)
209	ZSCX	CARRIER CONTROL RELAY(Z2S/Z3S)
210	C/R POUP	CARRIER SEND FOR POTT/UNBLK

Signal list

No.	Signal Name	Contents
211	CRG-POP/UOP	POTT/UNBLK LOCAL TRIP
212	CRS-POP/UOP	ditto
213	WI_TRIP	WEAK INFEED TRIP
214	REV_BLK	CARRIER SEND FOR BLOCK
215	DEFFCR	DG CARRIER TRIP DELAY TIMER
216	DEFRCR	CARR. COORDINATION DGO TIMER
217	C/R_DEF	DG CARR. SEND (PUTT,POTT,UNBLK)
218	DEFCAR_TRIP	DG CARR. TRIP (ditto)
219	C/R_DEFBOP	DG CARR. SEND (BLK)
220	DEFBOP_TRIP	DG CARR. TRIP (BLK)
221	C/R_BOP	CARRIER SEND FOR BLOCKING
222	CRG-BOP	BLOCKING LOCAL TRIP
223	CRS-BOP	ditto
224	LK-BOP	CARRIER SEND FOR BLOCKING
225	EXT_CAR-S	EXTERNAL CARRIER SEND COMMAND
226	CAR-G_TRIP	CARRIER TRIP(G)
227	CAR-S_TRIP	CARRIER TRIP(S)
228	CAR-A_TRIP	DISTANCE or DG CARRIER TRIP (A ph.)
229	CAR-B_TRIP	DISTANCE or DG CARRIER TRIP (B ph.)
230	CAR-C_TRIP	DISTANCE or DG CARRIER TRIP (C ph.)
231	CAR_TRIP	DISTANCE or DG CARRIER TRIP
232	DEFCR_TRIP	DG CARRIER TRIP
233	WICAR_TRIP	WEAK CARRIER TRIP
234	TPMD3PH	TRIP MODE 3ph.
235	TRIP-A	TRIP A ph.
236	TRIP-B	TRIP B ph.
237	TRIP-C	TRIP C ph.
238	TRIP-OR	TRIP O/P OR
239	TRIP	TRIP SINGLE SHOT
240	TRIP-A1	TRIP O/P FOR BUS CB
241	TRIP-B1	ditto
242	TRIP-C1	ditto
243	TRIP-A2	TRIP O/P FOR CENTER CB
244	TRIP-B2	ditto
245	TRIP-C2	ditto
246	FDX1	FD OUTPUT 1 (OPTION)
247	FDX2	FD OUTPUT 2 (OPTION)
248	M-OR	MAIN TRIP “OR”
249	M-AND	MAIN TRIP “AND”
250	FD	FD TRIP “OR”
251	FD-AND	FD TRIP “AND”
252	SBT	CARRIER SEND FOR TEST/MONITOR
253	CHF	CARRIER CHANNEL FAILURE
254	RLYFAIL	RELAY FAILURE
255	RLY_O/P_BLK	RELAY OUTPUT BLOCK
256	SV-LOCK	SV BLOCK
257	LSSV	LS FAILURE
258	TEVLV	EVOLVING FAULT WAITING TIMER
259	TSPR1	LEAD SPAR DEAD LINE TIMER
260	TTPR1	LEAD TPAR DEAD LINE TIMER
261	TRR1	LEAD RESET TIMER
262	TPARL-SET	LEAD TPAR O/P CONFIRMED
263	TSPR2	FLW SPAR DEAD LINE TIMER
264	TTPR2	FLW TPAR TIMING
265	TRR2	FLW RESET TIMER
266	TPAR.F	FLW TPAR O/P CONFIRMED
267	LB.DL-1	LEAD LIVE BUS & DEAD LINE
268	DB.LL-1	LEAD DEAD BUS & LIVE LINE
269	LB.LL.SYN-1	LEAD LIVE BUS & LIVE LINE +SYN.
270	LB.DL-2	FLW LIVE BUS & DEAD LINE
271	DB.LL-2	FLW DEAD BUS & LIVE LINE
272	LB.LL.SYN-2	FLW LIVE BUS & LIVE LINE SYN.
273	SYN-OP	SYN. CONDITION FOR TPAR
274	SYN-SEL	SYN. ELEMENT SELECT SIGNAL
275	TDBL1	VOLTAGE CHECK TIMER
276	TLBD1	ditto
277	TSYN1	LEAD SYN CHECK TIMER
278	TDBL2	VOLTAGE CHECK TIMER
279	TLBD2	ditto
280	TSYN2	FLW SYN CHECK TIMER

Signal list		
No.	Signal Name	Contents
281	REC.READY1	LEAD REC. READY SIGNAL
282	REC.READY2	FLW REC. READY SIGNAL
283	BRIDGE1	LEAD BRIDGE CONDITION
284	BRIDGE2	FLW BRIDGE CONDITION
285	IN-PROG1	LEAD REC. IN PROGRESS
286	IN-PROG2	FLW REC. IN PROGRESS
287	SPAR1	LEAD SPAR O/P
288	SPAR2	FLW SPAR O/P
289	TPAR1	LEAD TPAR O/P
290	TPAR2	FLW TPAR O/P
291	ARC1	REC OUTPUT FOR BUS CB
292	ARC2	REC OUTPUT FOR CENTER CB
293	94TT1	LEAD REMAINING PHASE TRIP
294	94TT2	FLW REMAINING PHASE TRIP
295	FT1	LEAD FINAL TRIP SIGNAL
296	FT2	FLW FINAL TRIP SIGNAL
297	TS2	MULTI.SHOT-2 DEAD TIMER
298	TS3	MULTI.SHOT-3 DEAD TIMER
299	TS4	MULTI.SHOT-4 DEAD TIMER
300	TS2R	MULTI.SHOT-2 RESET TIMER
301	TS3R	MULTI.SHOT-3 RESET TIMER
302	TS4R	MULTI.SHOT-4 RESET TIMER
303	MULTI.ARC	MULTI. SHOT REC. OUTPUT
304	MAR-OK0	1 SHOT REC. SUCCESS
305	MAR-OK1	2 SHOT REC. SUCCESS
306	MAR-OK2	3 SHOT REC. SUCCESS
307	MAR-OK3	4 SHOT REC. SUCCESS
308	MAR-FT	MULTI. REC. FINAL TRIP
309	TRIP-H	TRIP SIGNAL HOLD
310	SBT-INV	CARRIER SEND FOR TEST/MONITOR
311	BFS-AB	BLINDER FOR ZS (FORWARD)
312	BFS-BC	ditto
313	BFS-CA	ditto
314	BRS-AB	BLINDER FOR ZS (REVERSE)
315	BRS-BC	ditto
316	BRS-CA	ditto
317	BFG-A	BLINDER FOR ZG (FORWARD)
318	BFG-B	ditto
319	BFG-C	ditto
320	BRG-A	BLINDER FOR ZG (REVERSE)
321	BRG-B	ditto
322	BRG-C	ditto
323	PSBSIN-AB	POWER SWING BLOCK FOR ZS INNER ELEMENT
324	PSBSIN-BC	ditto
325	PSBSIN-CA	ditto
326	OC_TRIP	OC BACK-UP TRIP
327	OCI_TRIP	IDMT OC BACK-UP TRIP
328	OC_BU-TRIP	OC or OCI BACK-UP TRIP
329	TSPR3	FLW DEAD LINE TIMER
330	TTPR3	FLW DEAD LINE TIMER
331	Z1GTORT	Z1G TRIP
332	Z1STT	Z1S TRIP
333		
334		
335		
336		
337	OST_BO	OST BINARY OUTPUT
338	EXT_DEFCAR-S	EXTERNAL DG CARRIER SEND COMMAND
339	S-DEFBOP2	DG CARRIER SEND2(BLOCKING)
340		
341	Z1+Z1X+CRT	MAIN TRIP
342	Z1_TRIP	ZONE1 TRIP
343	Z1X_TRIP	ZONE1 EXTENTION TRIP
344	Z2_TRIP	ZONE2 TRIP
345	Z3_TRIP	ZONE3 TRIP
346	ZR1_TRIP	ZONE-R1 TRIP
347	Z2+Z3+ZR1	ZONE2-R1 TRIP
348	Z3+ZR1	ZONE3 AND ZONE-R1 TRIP
349	EF/DEF_ALARM	EF/DEF/EFI ALARM
350	SOTF+STUB	SOTF/STUB TRIP

Signal list

No.	Signal Name	Contents
351	PUP TRIP	PUP TRIP
352	PSBSIN-ABX	PSBSIN-ABX
353	PSBSIN-BCX	PSBSIN-BCX
354	PSBSIN-CAX	PSBSIN-CAX
355	TP-2PH	Multi phase trip signal
356	TP-MPH	Multi phase trip signal
357	OCDP-A	CURRENT CHANGE DET. DURING PS
358	OCDP-B	ditto
359	OCDP-C	ditto
360	DOCN-F	NEGATIVE DIR.RELAY (FORWARD)
361	DOCN-R	NEGATIVE DIR.RELAY (REVERSE)
362	UVPWI-A	UV RELAY
363	UVPWI-B	UV RELAY
364	UVPWI-C	UV RELAY
365	TP-1PH	single phase trip
366		
367		
368	ARC COM.ON	Autorecloser active (for IEC103)
369	TELE.COM.ON	Teleprotection active (for IEC103)
370	PROT.COM.ON	Protection active (for IEC103)
371		
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393	OVL-ABC	OVL element output (for 3phase line voltage)
394	OVL-A	OVL-A element output (for 3phase line voltage)
395	OVL-B	OVL-B element output (for 3phase line voltage)
396	OVL-C	OVL-C element output (for 3phase line voltage)
397	3PLL	Three phase live line element output
398		
399		
400		
401	OCMF-L1	MULTI-STEP OC RELAY LEVEL 1
402	OCMF-L2	ditto LEVEL 2
403	OCMF-L3	ditto LEVEL 3
404	OCMF-L4	ditto LEVEL 4
405	OCMF-L5	ditto LEVEL 5
406	OCMF-L6	ditto LEVEL 6
407	OCMF-L7	ditto LEVEL 7
408	OCMF	ditto OR LOGIC
409	OCDF-A	CURRENT CHANGE DETECTION RELAY
410	OCDF-B	ditto
411	OCDF-C	ditto
412		
413		
414		
415		
416	EFF	EARTH FAULT DETECTION RELAY
417	UVSF-AB	UV RELAY
418	UVSF-BC	ditto
419	UVSF-CA	ditto
420		

Signal list

No.	Signal Name	Contents
421	UVGF-A	ditto
422	UVGF-B	ditto
423	UVGF-C	ditto
424		
425	UVDF-A	VOLTAGE CHANGE DETECTION RELAY
426	UVDF-B	ditto
427	UVDF-C	ditto
428		
429		
430		
431	52AND1	CB1 contact AND logic
432	52AND2	CB2 contact AND logic
433	LB	Selected live bus mode
434	DB	Selected dead bus mode
435	SYN	Selected Synchronism check mode
436	OVS1-AB	OVS1-AB relay element output
437	OVS1-BC	OVS1-BC relay element output
438	OVS1-CA	OVS1-CA relay element output
439	OVS2-AB	OVS2-AB relay element output
440	OVS2-BC	OVS2-BC relay element output
441	OVS2-CA	OVS2-CA relay element output
442	OVG1-A	OVG1-A relay element output
443	OVG1-B	OVG1-B relay element output
444	OVG1-C	OVG1-C relay element output
445	OVG2-A	OVG2-A relay element output
446	OVG2-B	OVG2-B relay element output
447	OVG2-C	OVG2-C relay element output
448	OVS1-AB INST	OVS1-AB relay element start
449	OVS1-BC INST	OVS1-BC relay element start
450	OVS1-CA INST	OVS1-CA relay element start
451	OVG1-A INST	OVG1-A relay element start
452	OVG1-B INST	OVG1-B relay element start
453	OVG1-C INST	OVG1-C relay element start
454	UVS1-AB	UVS1-AB relay element output
455	UVS1-BC	UVS1-BC relay element output
456	UVS1-CA	UVS1-CA relay element output
457	UVS2-AB	UVS2-AB relay element output
458	UVS2-BC	UVS2-BC relay element output
459	UVS2-CA	UVS2-CA relay element output
460	UVG1-A	UVG1-A relay element output
461	UVG1-B	UVG1-B relay element output
462	UVG1-C	UVG1-C relay element output
463	UVG2-A	UVG2-A relay element output
464	UVG2-B	UVG2-B relay element output
465	UVG2-C	UVG2-C relay element output
466	UVS1-AB INST	UVS1-AB relay element start
467	UVS1-BC INST	UVS1-BC relay element start
468	UVS1-CA INST	UVS1-CA relay element start
469	UVG1-A INST	UVG1-A relay element start
470	UVG1-B INST	UVG1-B relay element start
471	UVG1-C INST	UVG1-C relay element start
472	UVSBLK-AB	UVS BLK-AB relay element output
473	UVSBLK-BC	UVS BLK-BC relay element output
474	UVSBLK-CA	UVS BLK-CA relay element output
475	UVGBLK-A	UVG BLK-A relay element output
476	UVGBLK-B	UVG BLK-B relay element output
477	UVGBLK-C	UVG BLK-C relay element output
478		
479		
480	ARCMD OFF	Autoreclosing mode (Disable)
481	ARCMD SPAR	ditto (SPAR)
482	ARCMD TPAR	ditto (MPAR)
483	ARCMD S&T	ditto (SPAR & TPAR)
484	ARCMD EXT1P	ditto (EXT1P)
485	ARCMD EXT3P	ditto (EXT3P)
486	ARC-SET	output set signal in leader CB autoreclose
487	CB UNDRY.L ST	Starting signal for final trip with CB unready
488	TSUC1	ARC.L success reset signal
489	TSUC2	ARC.F success reset signal
490	ARC SUCCESS1	leader CB autoreclose success signal

Signal list

No.	Signal Name	Contents
491	ARC_SUCCESS2	Follower CB autoreclose success signal
492	ARC_FAIL1	leader CB autoreclose fail signal
493	ARC_FAIL2	Follower CB autoreclose fail signal
494		
495		
496		
497		
498		
499		
500		
501	UARCSW_P1	User ARC switch Position1
502	UARCSW_P2	User ARC switch Position2
503	UARCSW_P3	User ARC switch Position3
504		
505		
506		
507		
508		
509		
510		
511		
512		
513	BI1_COMMAND	Binary input signal BI1
514	BI2_COMMAND	Binary input signal BI2
515	BI3_COMMAND	Binary input signal BI3
516	BI4_COMMAND	Binary input signal BI4
517	BI5_COMMAND	Binary input signal BI5
518	BI6_COMMAND	Binary input signal BI6
519	BI7_COMMAND	Binary input signal BI7
520	BI8_COMMAND	Binary input signal BI8
521	BI9_COMMAND	Binary input signal BI9
522	BI10_COMMAND	Binary input signal BI10
523	BI11_COMMAND	Binary input signal BI11
524	BI12_COMMAND	Binary input signal BI12
525	BI13_COMMAND	Binary input signal BI13
526	BI14_COMMAND	Binary input signal BI14
527	BI15_COMMAND	Binary input signal BI15
528	BI16_COMMAND	Binary input signal BI16
529	BI17_COMMAND	Binary input signal BI17
530	BI18_COMMAND	Binary input signal BI18
531	BI19_COMMAND	Binary input signal BI19
532	BI20_COMMAND	Binary input signal BI20
533	BI21_COMMAND	Binary input signal BI21
534	BI22_COMMAND	Binary input signal BI22
535	BI23_COMMAND	Binary input signal BI23
536	BI24_COMMAND	Binary input signal BI24
537	BI25_COMMAND	Binary input signal BI25
538	BI26_COMMAND	Binary input signal BI26
539	BI27_COMMAND	Binary input signal BI27
540	BI28_COMMAND	Binary input signal BI28
541	BI34_COMMAND	Binary input signal BI34
542	BI35_COMMAND	Binary input signal BI35
543	BI36_COMMAND	Binary input signal BI36
544		
545		
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547		
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549		
550		
551		
552		
553	ZR1S-AB	PHASE FAULT RELAY ZR1S
554	ZR1S-BC	ditto
555	ZR1S-CA	ditto
556	THM-T	Thermal trip relay
557	ZR2S-AB	PHASE FAULT RELAY ZR2S
558	ZR2S-BC	ditto
559	ZR2S-CA	ditto
560	THM-A	Thermal alarm relay

Signal list

No.	Signal Name	Contents
561	PSBGIN-A	POWER SWING BLOCK FOR ZG INNER ELEMENT
562	PSBGIN-B	ditto
563	PSBGIN-C	ditto
564		
565	PSBGOUT-A	POWER SWING BLOCK for ZG OUTER ELEMENT
566	PSBGOUT-B	ditto
567	PSBGOUT-C	ditto
568	EFL	EARTH FAULT RELAY
569	ZR1G-A	EARTH FAULT RELAY ZR1G
570	ZR1G-B	ditto
571	ZR1G-C	ditto
572		
573	ZR2G-A	EARTH FAULT RELAY ZR2G
574	ZR2G-B	ditto
575	ZR2G-C	ditto
576		
577	ZFS-AB	PHASE FAULT RELAY ZFS
578	ZFS-BC	ditto
579	ZFS-CA	ditto
580		
581	ZNDS-AB	PHASE FAULT RELAY ZNDS
582	ZNDS-BC	ditto
583	ZNDS-CA	ditto
584		
585		
586		
587		
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589		
590		
591		
592		
593	ZFG-A	EARTH FAULT RELAY ZFG
594	ZFG-B	ditto
595	ZFG-C	ditto
596		
597	ZNDG-A	EARTH FAULT RELAY ZNDG
598	ZNDG-B	ditto
599	ZNDG-C	ditto
600		
601		
602		
603		
604		
605		
606		
607		
608		
609	ZR1S-ABX	ZR1S-ABX
610	ZR1S-BCX	ZR1S-BCX
611	ZR1S-CAX	ZR1S-CAX
612	EXT_CAR-R2	CARRIER RECEIVE FROM REMOTE TERM.2
613	OC_TRIP-A	OC trip signal (A-Phase)
614	OC_TRIP-B	OC trip signal (B-Phase)
615	OC_TRIP-C	OC trip signal (C-Phase)
616	OCI_TRIP-A	OCI trip signal (A-Phase)
617	OCI_TRIP-B	OCI trip signal (B-Phase)
618	OCI_TRIP-C	OCI trip signal (C-Phase)
619	C/R_DISECHO	Distance carrier echo signal
620	C/R_DEFECHO	DEF carrier echo signal
621	CHF-SV_R1	CARRIER CHANNEL FAILURE (Remote terminal-1)
622	CHF-SV_R2	CARRIER CHANNEL FAILURE (Remote terminal-2)
623	TP-A	Trip A-phase command without off-delay timer
624	TP-B	Trip B-phase command without off-delay timer
625	TP-C	Trip C-phase command without off-delay timer
626	ZFG-AX	ZFG-AX
627	ZFG-BX	ZFG-BX
628	ZFG-CX	ZFG-CX
629	ZR1G-AX	ZR1G-AX
630	ZR1G-BX	ZR1G-BX

Signal list

No.	Signal Name	Contents
631	ZR1G-CX	ZR1G-CX
632	ZR2G-AX	ZR2G-AX
633	ZR2G-BX	ZR2G-BX
634	ZR2G-CX	ZR2G-CX
635	ZFS-ABX	ZFS-ABX
636	ZFS-BCX	ZFS-BCX
637	ZFS-CAX	ZFS-CAX
638	ZR2S-ABX	ZR2S-ABX
639	ZR2S-BCX	ZR2S-BCX
640	ZR2S-CAX	ZR2S-CAX
641	Z2G-A TRIP	Z2G TRIP A ph.
642	Z2G-B TRIP	Z2G TRIP B ph.
643	Z2G-C TRIP	Z2G TRIP C ph.
644	Z3G-A TRIP	Z3G TRIP A ph.
645	Z3G-B TRIP	Z3G TRIP B ph.
646	Z3G-C TRIP	Z3G TRIP C ph.
647	ZFG TRIP	ZFG TRIP
648	ZFG-A TRIP	ZFG TRIP A ph.
649	ZFG-B TRIP	ZFG TRIP B ph.
650	ZFG-C TRIP	ZFG TRIP C ph.
651	ZFS TRIP	ZFS TRIP
652	ZR1G-A TRIP	ZR1G TRIP A ph.
653	ZR1G-B TRIP	ZR1G TRIP B ph.
654	ZR1G-C TRIP	ZR1G TRIP C ph.
655	ZR2G TRIP	ZR2G TRIP
656	ZR2G-A TRIP	ZR2G TRIP A ph.
657	ZR2G-B TRIP	ZR2G TRIP B ph.
658	ZR2G-C TRIP	ZR2G TRIP C ph.
659	ZR2S TRIP	ZR2S TRIP
660	Z1GOR	Z1G RELAY OR LOGIC
661	Z1SOR	Z1S RELAY OR LOGIC
662	ZFGOR	ZFG RELAY OR LOGIC
663	ZFSOR	ZFS RELAY OR LOGIC
664	ZR2GOR	ZR2G RELAY OR LOGIC
665	ZR2SOR	ZR2S RELAY OR LOGIC
666	ZNDG-AX	ZNDG-AX
667	ZNDG-BX	ZNDG-BX
668	ZNDG-CX	ZNDG-CX
669	ZNDS-ABX	ZNDS-ABX
670	ZNDS-BCX	ZNDS-BCX
671	ZNDS-CAX	ZNDS-CAX
672	ZNDG TRIP	ZNDG TRIP
673	ZNDG-A TRIP	ZNDG TRIP A ph.
674	ZNDG-B TRIP	ZNDG TRIP B ph.
675	ZNDG-C TRIP	ZNDG TRIP C ph.
676	ZNDS TRIP	ZNDS TRIP
677	DEF TRIP	DEF BACK-UP TRIP
678	EF TRIP	EF BACK-UP TRIP
679	STUB-A TRIP	Stub TRIP A ph.
680	STUB-B TRIP	Stub TRIP B ph.
681	STUB-C TRIP	Stub TRIP C ph.
682	SOTF-A TRIP	SOTF-OCH TRIP A ph.
683	SOTF-B TRIP	SOTF-OCH TRIP B ph.
684	SOTF-C TRIP	SOTF-OCH TRIP C ph.
685	SOTF-Z TRIP	SOTF-Zistance TRIP
686	OCH TRIP	OCH TRIP
687	OCH-A TRIP	OCH TRIP A ph.
688	OCH-B TRIP	OCH TRIP B ph.
689	OCH-C TRIP	OCH TRIP C ph.
690	THM ALARM	THERMAL ALARM
691	THM TRIP	THERMAL TRIP
692	CBF RETRIP	RE-TRIP FOR CBF
693	CBF TRIP-A	RELATED CB TRIP A ph. FOR CBF
694	CBF TRIP-B	RELATED CB TRIP B ph. FOR CBF
695	CBF TRIP-C	RELATED CB TRIP C ph. FOR CBF
696	PSBGOUT-AX	PSBGOUT-AX
697	PSBGOUT-BX	PSBGOUT-BX
698	PSBGOUT-CX	PSBGOUT-CX
699	PSBGIN-AX	PSBGIN-AX
700	PSBGIN-BX	PSBGIN-BX

Signal list

No.	Signal Name	Contents
701	PSBGIN-CX	PSBGIN-CX
702	PSBS DET	PSB for ZS DETECTION
703	PSBG DET	PSB for ZG DETECTION
704	ZF TRIP	ZONE-F TRIP
705	ZR2 TRIP	ZONE-R2 TRIP
706	ZND TRIP	ZONE-ND TRIP
707	SHOT NUM1	Trip/Auto-Reclosing shot number1 condition
708	SHOT NUM2	Trip/Auto-Reclosing shot number2 condition
709	SHOT NUM3	Trip/Auto-Reclosing shot number3 condition
710	SHOT NUM4	Trip/Auto-Reclosing shot number4 condition
711	SHOT NUM5	Trip/Auto-Reclosing shot number5 condition
712	Z1CNT INST	Z1 CONTROL COMMAND (Instantly trip)
713	Z1CNT 3PTP	Z1 CONTROL COMMAND (3-phase trip)
714	Z1CNT ARCBLK	Z1 CONTROL COMMAND (Autoreclosing block)
715	Z1CNT TPBLK	Z1 CONTROL COMMAND (Trip block)
716	ZNDGOR	ZNDG RELAY OR LOGIC
717	ZNDSOR	ZNDS RELAY OR LOGIC
718		
719		
720	ZGC-AX	CARRIER CONTROL RELAY(Z2G/Z3G-A ph.)
721	ZGC-BX	CARRIER CONTROL RELAY(Z2G/Z3G-B ph.)
722	ZGC-CX	CARRIER CONTROL RELAY(Z2G/Z3G-C ph.)
723	C/R PUP-A	CARRIER SEND FOR PUTT (ZG-A ph.)
724	C/R PUP-B	CARRIER SEND FOR PUTT (ZG-B ph.)
725	C/R PUP-C	CARRIER SEND FOR PUTT (ZG-C ph.)
726	C/R PUP-S	CARRIER SEND FOR PUTT (ZS)
727	PUP TRIP-A	PUTT LOCAL TRIP (A ph.)
728	PUP TRIP-B	PUTT LOCAL TRIP (B ph.)
729	PUP TRIP-C	PUTT LOCAL TRIP (C ph.)
730	C/R POUP-A	CARRIER SEND FOR POTT/UNBLOCK (ZG-A ph.)
731	C/R POUP-B	CARRIER SEND FOR POTT/UNBLOCK (ZG-B ph.)
732	C/R POUP-C	CARRIER SEND FOR POTT/UNBLOCK (ZG-C ph.)
733	C/R POUP-S	CARRIER SEND FOR POTT/UNBLOCK (ZS)
734	POUP TRIP-A	POTT/UNBLOCK LOCAL TRIP (A ph.)
735	POUP TRIP-B	POTT/UNBLOCK LOCAL TRIP (B ph.)
736	POUP TRIP-C	POTT/UNBLOCK LOCAL TRIP (C ph.)
737	REV BLK-A	CARRIER SEND FOR BLOCK (ZG-A ph.)
738	REV BLK-B	CARRIER SEND FOR BLOCK (ZG-B ph.)
739	REV BLK-C	CARRIER SEND FOR BLOCK (ZG-C ph.)
740	REV BLK-S	CARRIER SEND FOR BLOCK (ZS)
741	C/R BOP-A	CARRIER SEND FOR BLOCKING (ZG-A ph.)
742	C/R BOP-B	CARRIER SEND FOR BLOCKING (ZG-B ph.)
743	C/R BOP-C	CARRIER SEND FOR BLOCKING (ZG-C ph.)
744	C/R BOP-S	CARRIER SEND FOR BLOCKING (ZS)
745	BOP TRIP-A	BLOCKING LOCAL TRIP (A ph.)
746	BOP TRIP-B	BLOCKING LOCAL TRIP (B ph.)
747	BOP TRIP-C	BLOCKING LOCAL TRIP (C ph.)
748	C/R DEF-A	DG CARRIER SEND (PUTT,POTT,UNBLOCK) (A ph.)
749	C/R DEF-B	DG CARRIER SEND (PUTT,POTT,UNBLOCK) (B ph.)
750	C/R DEF-C	DG CARRIER SEND (PUTT,POTT,UNBLOCK) (C ph.)
751	DEFCR TRIP-A	DG CARRIER LOCAL TRIP (PUTT,POTT,UNBLOCK) (A ph.)
752	DEFCR TRIP-B	DG CARRIER LOCAL TRIP (PUTT,POTT,UNBLOCK) (B ph.)
753	DEFCR TRIP-C	DG CARRIER LOCAL TRIP (PUTT,POTT,UNBLOCK) (C ph.)
754	C/R DEFBOP-A	DG CARRIER SEND (BLOCKING) (A ph.)
755	C/R DEFBOP-B	DG CARRIER SEND (BLOCKING) (B ph.)
756	C/R DEFBOP-C	DG CARRIER SEND (BLOCKING) (C ph.)
757	DEFBOP TRIP-A	DG CARRIER LOCAL TRIP (BLOCKING) (A ph.)
758	DEFBOP TRIP-B	DG CARRIER LOCAL TRIP (BLOCKING) (B ph.)
759	DEFBOP TRIP-C	DG CARRIER LOCAL TRIP (BLOCKING) (C ph.)
760	POUP TRIP	POUP TRIP
761	BOP TRIP	BOP TRIP
762	REV BLK-DEF	DG.CARRIER SEND FOR BLOCK
763	DEFR TRIP	DEF BACK-UP TRIP
764	UVSBLK	UVS BLOCK
765	UVGBLK	UVG BLOCK
766	BCD	BCD relay element output
767	BCD TRIP	BCD TRIP
768	C/R DISECHO-A	CARRIER SEND FOR ECHO (ZG-A ph.)
769	C/R DISECHO-B	CARRIER SEND FOR ECHO (ZG-B ph.)
770	C/R DISECHO-C	CARRIER SEND FOR ECHO (ZG-C ph.)

Signal list

No.	Signal Name	Contents
771	C/R DISECHO-S	CARRIER SEND FOR ECHO (ZS)
772	C/R DEFECHO-A	DG CARRIER SEND FOR ECHO (A ph.)
773	C/R DEFECHO-B	DG CARRIER SEND FOR ECHO (B ph.)
774	C/R DEFECHO-C	DG CARRIER SEND FOR ECHO (C ph.)
775	WI TRIP-A	WEEK INFEED LOCAL TRIP (A ph.)
776	WI TRIP-B	WEEK INFEED LOCAL TRIP (B ph.)
777	WI TRIP-C	WEEK INFEED LOCAL TRIP (C ph.)
778	DEFWI TRIP-A	DG CARRIER WEEK INFEED LOCAL TRIP (A ph.)
779	DEFWI TRIP-B	DG CARRIER WEEK INFEED LOCAL TRIP (B ph.)
780	DEFWI TRIP-C	DG CARRIER WEEK INFEED LOCAL TRIP (C ph.)
781		
782		
783		
784	DISCR TRIP	DISTANCE CARRIER TRIP
785	DISCR-A TRIP	DISTANCE CARRIER TRIP (A ph.)
786	DISCR-B TRIP	DISTANCE CARRIER TRIP (B ph.)
787	DISCR-C TRIP	DISTANCE CARRIER TRIP (C ph.)
788	DEFCR-A TRIP	DG CARRIER TRIP (A ph.)
789	DEFCR-B TRIP	DG CARRIER TRIP (B ph.)
790	DEFCR-C TRIP	DG CARRIER TRIP (C ph.)
791	PSBTP TRIP	PSBTP CARRIER TRIP
792	PSBTP-A TRIP	PSBTP CARRIER TRIP (A ph.)
793	PSBTP-B TRIP	PSBTP CARRIER TRIP (B ph.)
794	PSBTP-C TRIP	PSBTP CARRIER TRIP (C ph.)
795		
796		
797		
798		
799		
800	C/R SEND-A	DISTANCE CARRIER SEND COMMAND (ZG-A ph.)
801	C/R SEND-B	DISTANCE CARRIER SEND COMMAND (ZG-B ph.)
802	C/R SEND-C	DISTANCE CARRIER SEND COMMAND (ZG-C ph.)
803	C/R SEND-S	DISTANCE CARRIER SEND COMMAND (ZS)
804	C/R SEND-DEFA	DG CARRIER SEND COMMAND (A ph.)
805	C/R SEND-DEFB	DG CARRIER SEND COMMAND (B ph.)
806	C/R SEND-DEFC	DG CARRIER SEND COMMAND (C ph.)
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810		
811		
812	C/R SEND-PSBA	PSBTP CARRIER SEND COMMAND (A ph.)
813	C/R SEND-PSBB	PSBTP CARRIER SEND COMMAND (B ph.)
814	C/R SEND-PSBC	PSBTP CARRIER SEND COMMAND (C ph.)
815	C/R SEND-PSB	PSBTP CARRIER SEND COMMAND
816	CAR-R-R1	Distance carrier OR signal from remote term-1
817	DEFCAR-R-R1	DEF carrier OR signal from remote term-1
818	PSBCAR-R-R1	PSB carrier OR signal from remote term-1
819		
820	CAR-R-R2	Distance carrier OR signal from remote term-2
821	DEFCAR-R-R2	DEF carrier OR signal from remote term-2
822	PSBCAR-R-R2	PSB carrier OR signal from remote term-2
823		
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830		
831		
832	TR1 TRIP	TRANSFER TRIP-1
833	TR1-A TRIP	TRANSFER TRIP-1 (A ph.)
834	TR1-B TRIP	TRANSFER TRIP-1 (B ph.)
835	TR1-C TRIP	TRANSFER TRIP-1 (C ph.)
836	INTER TRIP1	INTER TRIP-1
837	INTER TRIP1-A	INTER TRIP-1 (A ph.)
838	INTER TRIP1-B	INTER TRIP-1 (B ph.)
839	INTER TRIP1-C	INTER TRIP-1 (C ph.)
840	TR2 TRIP	TRANSFER TRIP-2

Signal list

No.	Signal Name	Contents
841	TR2-A TRIP	TRANSFER TRIP-2 (A ph.)
842	TR2-B TRIP	TRANSFER TRIP-2 (B ph.)
843	TR2-C TRIP	TRANSFER TRIP-2 (C ph.)
844	INTER TRIP2	INTER TRIP-2
845	INTER TRIP2-A	INTER TRIP-2 (A ph.)
846	INTER TRIP2-B	INTER TRIP-2 (B ph.)
847	INTER TRIP2-C	INTER TRIP-2 (C ph.)
848	LOCAL TEST	LOCAL TESTING SW ON
849	ARCMD ALARM	PLC Autoreclosing mode discrepancy alarm
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880	SEVERE CF	Severe CF detection
881	SEVERE CF-L	Severe CF detection at local terminal
882	DATA.CH1-DIS	CH1 receiving data disable
883	DATA.CH2-DIS	CH2 receiving data disable
884	BUCAR MODE	Back up carrier mode condition
885		
886		
887		
888	MASTER	Being set to master terminal
889	SLAVE	Being set to slave terminal
890	CH1.DATA USE	CH1 comm.data using
891	CH2.DATA USE	CH2 comm.data using
892		
893		
894		
895		
896	REM1 READY	Remote term.1 ready condition
897	CF1	Remote term.1 comm.fail
898	SPF1	Remote term.1 SP.sync.fail
899		
900	COMM1 FAIL	Remote term.1 Comm.fail alarm (902+903+906+907)
901	READY1	Remote term.1 Ready alarm
902	UNREADY1	Remote term.1 Un-Ready alarm
903	CFSV1	Remote term.1 Comm.fail alarm
904	SPSV1	Remote term.1 SP.sync.fail alarm
905	TX LEVEL1	Remote term.1 Transmission signal level drop alarm
906	RX LEVEL1	Remote term.1 Receiving signal level drop alarm
907	CLK1	Remote term.1 Clock signal interruption alarm
908	CFSV1-L	Remote term.1 Receiving Comm.fail alarm
909	CFSV1-R	Remote term.1 Sending Comm.fail alarm
910		

Signal list

No.	Signal Name	Contents
911		
912	REM2 READY	Remote term.2 ready condition
913	CF2	Remote term.2 comm.fail
914	SPF2	Remote term.2 SP.sync.fail
915		
916	COMM2 FAIL	Remote term.2 Comm.fail alarm (918+919+922+923)
917	READY2	Remote term.2 Ready alarm
918	UNREADY2	Remote term.2 Un-Ready alarm
919	CFSV2	Remote term.2 Comm.fail alarm
920	SPSV2	Remote term.2 SP.sync.fail alarm
921	TX LEVEL2	Remote term.2 Transmission signal level drop alarm
922	RX LEVEL2	Remote term.2 Receiving signal level drop alarm
923	CLK2	Remote term.2 Clock signal interruption alarm
924	CFSV2-L	Remote term.2 Receiving Comm.fail alarm
925	CFSV2-R	Remote term.2 Sending Comm.fail alarm
926		
927		
928	CH1 CF	Ch1 comm.fail (for Severe-CF detection)
929	CH1 CAN.CODE	Ch1 cancel-code receiving (for Severe-CF detection)
930	CH1 CF-R1	Remote term 1 Ch1 comm.fail (for Severe-CF detection)
931	CH1 CAN-R1	Remote term 1 Ch1 cancel-code (for Severe-CF detection)
932		
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944	CH2 CF	Ch2 comm.fail (for Severe-CF detection)
945	CH2 CAN.CODE	Ch2 cancel-code receiving (for Severe-CF detection)
946	CH2 CF-R1	Remote term 1 Ch2 comm.fail (for Severe-CF detection)
947	CH2 CAN-R1	Remote term 1 Ch2 cancel-code (for Severe-CF detection)
948		
949	OVS1 TRIP	OVS1 TRIP
950	OVS1-AB TRIP	OVS1-AB TRIP
951	OVS1-BC TRIP	OVS1-BC TRIP
952	OVS1-CA TRIP	OVS1-CA TRIP
953	OVS2 ALARM	OVS2 ALARM
954	OVS2-AB ALM	OVS2-AB ALARM
955	OVS2-BC ALM	OVS2-BC ALARM
956	OVS2-CA ALM	OVS2-CA ALARM
957	OVG1 TRIP	OVG1 TRIP
958	OVG1-A TRIP	OVG1-A TRIP
959	OVG1-B TRIP	OVG1-B TRIP
960	OVG1-C TRIP	OVG1-C TRIP
961	OVG2 ALARM	OVG2 ALARM
962	OVG2-A ALM	OVG2-A ALARM
963	OVG2-B ALM	OVG2-B ALARM
964	OVG2-C ALM	OVG2-C ALARM
965	UVS1 TRIP	UVS1 TRIP
966	UVS1-AB TRIP	UVS1-AB TRIP
967	UVS1-BC TRIP	UVS1-BC TRIP
968	UVS1-CA TRIP	UVS1-CA TRIP
969	UVS2 ALARM	UVS2 ALARM
970	UVS2-AB ALM	UVS2-AB ALARM
971	UVS2-BC ALM	UVS2-BC ALARM
972	UVS2-CA ALM	UVS2-CA ALARM
973	UVG1 TRIP	UVG1 TRIP
974	UVG1-A TRIP	UVG1-A TRIP
975	UVG1-B TRIP	UVG1-B TRIP
976	UVG1-C TRIP	UVG1-C TRIP
977	UVG2 ALARM	UVG2 ALARM
978	UVG2-A ALM	UVG2-A ALARM
979	UVG2-B ALM	UVG2-B ALARM
980	UVG2-C ALM	UVG2-C ALARM

Signal list

No.	Signal Name	Contents
981	OVS1-AB_RST	OVS1-AB relay element delayed reset
982	OVS1-BC_RST	OVS1-BC relay element delayed reset
983	OVS1-CA_RST	OVS1-CA relay element delayed reset
984	OVG1-A_RST	OVG1-A relay element delayed reset
985	OVG1-B_RST	OVG1-B relay element delayed reset
986	OVG1-C_RST	OVG1-C relay element delayed reset
987	UVS1-AB_RST	UVS1-AB relay element delayed reset
988	UVS1-BC_RST	UVS1-BC relay element delayed reset
989	UVS1-CA_RST	UVS1-CA relay element delayed reset
990	UVG1-A_RST	UVG1-A relay element delayed reset
991	UVG1-B_RST	UVG1-B relay element delayed reset
992	UVG1-C_RST	UVG1-C relay element delayed reset
993	OV/UV_TRIP	OV/UV trip
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1040	FAULT_PHA_A	fault_phase_A
1041	FAULT_PHA_B	fault_phase_B
1042	FAULT_PHA_C	fault_phase_C
1043	FAULT_PHA_N	fault_phase_N
1044	FL_ERR	fault location start up error
1045	FL_OB_FWD	fault location out of bounds(forward)
1046	FL_OB_BACK	fault location out of bounds(backward)
1047	FL_NC	fault location not converged
1048	FL_COMPLETED	fault location completed
1049	FL_OJ	fault location over junction
1050	FL_Z	One-terminal fault location(TERM=3TERM)

Signal list

No.	Signal Name	Contents
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1087		
1088	COM1-R1	Comm. data receive signal from remote term-1
1089	COM2-R1	ditto
1090	COM3-R1	ditto
1091	COM4-R1	ditto
1092	COM5-R1	ditto
1093	COM6-R1	ditto
1094	COM7-R1	ditto
1095	COM8-R1	ditto
1096	COM9-R1	ditto
1097	COM10-R1	ditto
1098	COM11-R1	ditto
1099	COM12-R1	ditto
1100	COM13-R1	ditto
1101	COM14-R1	ditto
1102		
1103		
1104	COM1-R1_UF	Comm. data receive signal from remote term-1 (unfiltered)
1105	COM2-R1_UF	ditto
1106	COM3-R1_UF	ditto
1107	COM4-R1_UF	ditto
1108	COM5-R1_UF	ditto
1109	COM6-R1_UF	ditto
1110	COM7-R1_UF	ditto
1111	COM8-R1_UF	ditto
1112	COM9-R1_UF	ditto
1113	COM10-R1_UF	ditto
1114	COM11-R1_UF	ditto
1115	COM12-R1_UF	ditto
1116	COM13-R1_UF	ditto
1117	COM14-R1_UF	ditto
1118		
1119		
1120	SUB_COM1-R1	Sub comm. data receive signal from term-1

Signal list

No.	Signal Name	Contents
1121	SUB_COM2-R1	ditto
1122	SUB_COM3-R1	ditto
1123	SUB_COM4-R1	ditto
1124	BUCAR-R1	Back up carrier mode in remote term-1 data
1125		
1126		
1127		
1128		
1129		
1130		
1131		
1132		
1133		
1134		
1135		
1136	COM1-R2	Comm. data receive signal from remote term-2
1137	COM2-R2	ditto
1138	COM3-R2	ditto
1139	COM4-R2	ditto
1140	COM5-R2	ditto
1141	COM6-R2	ditto
1142	COM7-R2	ditto
1143	COM8-R2	ditto
1144	COM9-R2	ditto
1145	COM10-R2	ditto
1146	COM11-R2	ditto
1147	COM12-R2	ditto
1148	COM13-R2	ditto
1149	COM14-R2	ditto
1150		
1151		
1152	COM1-R2_UF	Comm. data receive signal from remote term-2 (unfiltered)
1153	COM2-R2_UF	ditto
1154	COM3-R2_UF	ditto
1155	COM4-R2_UF	ditto
1156	COM5-R2_UF	ditto
1157	COM6-R2_UF	ditto
1158	COM7-R2_UF	ditto
1159	COM8-R2_UF	ditto
1160	COM9-R2_UF	ditto
1161	COM10-R2_UF	ditto
1162	COM11-R2_UF	ditto
1163	COM12-R2_UF	ditto
1164	COM13-R2_UF	ditto
1165	COM14-R2_UF	ditto
1166		
1167		
1168	SUB_COM1-R2	Sub comm. data receive signal from term-2
1169	SUB_COM2-R2	ditto
1170	SUB_COM3-R2	ditto
1171	SUB_COM4-R2	ditto
1172	BUCAR-R2	Back up carrier mode in remote term-2 data
1173		
1174		
1175		
1176		
1177		
1178		
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1190		

Signal list

No.	Signal Name	Contents
1191		
1192		
1193		
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1199		
1200		
1201		
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1234		
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1238		
1239		
1240		
1241	IEC_MDBLK	monitor direction blocked
1242	IEC_TESTMODE	IEC61870-5-103 testmode
1243	GROUP1_ACTIVE	group1 active
1244	GROUP2_ACTIVE	group2 active
1245	GROUP3_ACTIVE	group3 active
1246	GROUP4_ACTIVE	group4 active
1247	GROUP5_ACTIVE	group5 active
1248	GROUP6_ACTIVE	group6 active
1249	GROUP7_ACTIVE	group7 active
1250	GROUP8_ACTIVE	group8 active
1251	RLY_FAIL	RELAY FAILURE
1252	RLY_OP_BLK	RELAY OUTPUT BLOCK
1253	AMF_OFF	SV BLOCK
1254		
1255		
1256		
1257		
1258	RELAY_FAIL-A	
1259		
1260		

Signal list

No.	Signal Name	Contents
1261	TRIP-H_	Trip signal hold
1262	CT_ERR_UF	CT error(unfiltered)
1263	I0_ERR_UF	I0 error(unfiltered)
1264	V0_ERR_UF	V0 error(unfiltered)
1265	V2_ERR_UF	V2 error(unfiltered)
1266	CT_ERR	CT error
1267	I0_ERR	I0 error
1268	V0_ERR	V0 error
1269	V2_ERR	V2 error
1270		
1271		
1272		
1273		
1274		
1275		
1276	50/60Hz	Frequency pulse signal
1277		
1278		
1279	GEN_PICKUP	General start/pick-up
1280	GEN_TRIP	General trip
1281		
1282		
1283		
1284	BI1_COM_UF	Binary input signal BI1 (unfiltered)
1285	BI2_COM_UF	Binary input signal BI2 (unfiltered)
1286	BI3_COM_UF	Binary input signal BI3 (unfiltered)
1287	BI4_COM_UF	Binary input signal BI4 (unfiltered)
1288	BI5_COM_UF	Binary input signal BI5 (unfiltered)
1289	BI6_COM_UF	Binary input signal BI6 (unfiltered)
1290	BI7_COM_UF	Binary input signal BI7 (unfiltered)
1291	BI8_COM_UF	Binary input signal BI8 (unfiltered)
1292	BI9_COM_UF	Binary input signal BI9 (unfiltered)
1293	BI10_COM_UF	Binary input signal BI10 (unfiltered)
1294	BI11_COM_UF	Binary input signal BI11 (unfiltered)
1295	BI12_COM_UF	Binary input signal BI12 (unfiltered)
1296	BI13_COM_UF	Binary input signal BI13 (unfiltered)
1297	BI14_COM_UF	Binary input signal BI14 (unfiltered)
1298	BI15_COM_UF	Binary input signal BI15 (unfiltered)
1299		
1300		
1301		
1302		
1303		
1304		
1305		
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Signal list

No.	Signal Name	Contents
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1371		
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1400		

Signal list

No.	Signal Name	Contents
1401	LOCAL_OP_ACT	local operation active
1402	REMOTE_OP_ACT	remote operation active
1403	NORM_LED_ON	IN-SERVICE LED ON
1404	ALM_LED_ON	ALARM LED ON
1405	TRIP_LED_ON	TRIP LED ON
1406	TEST_LED_ON	TEST LED ON
1407		
1408	PRG_LED_RESET	Latched progammable LED RESET
1409	LED_RESET	TRIP LED RESET
1410		
1411	ARC_COM_ON	IEC103 communication command
1412	TELE_COM_ON	IEC103 communication command
1413	PROT_COM_ON	IEC103 communication command
1414	PRG_LED1_ON	PROGRAMMABLE LED1 ON
1415	PRG_LED2_ON	PROGRAMMABLE LED2 ON
1416	PRG_LED3_ON	PROGRAMMABLE LED3 ON
1417	PRG_LED4_ON	PROGRAMMABLE LED4 ON
1418		
1419		
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1433		
1434	F.Record_DONE	fault location completed
1435	F.Record_CLR	Fault record clear
1436	E.Record_CLR	Event record clear
1437	D.Record_CLR	Disturbance record clear
1438	Data_Lost	Data clear by BU-RAM memory monitoring error
1439		
1440		
1441		
1442		
1443		
1444		
1445	PLC_data_CHG	PLC data change
1446		
1447		
1448	Sys.set_change	System setting change
1449	Rly.set_change	Relay setting change
1450	Grp.set_change	Group setting change
1451		
1452		
1453		
1454		
1455		
1456	KEY-VIEW	VIEW key status (1:pressed)
1457	KEY-RESET	RESET key status (2:pressed)
1458	KEY-ENTER	ENTER key status (3:pressed)
1459	KEY-END	END key status (4:pressed)
1460	KEY-CANCEL	CANCEL key status (5:pressed)
1461		
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Signal list

No.	Signal Name	Contents
1471		
1472	SUM_err	Program ROM checksum error
1473		
1474	SRAM_err	SRAM memory monitoring error
1475	BU-RAM_err	BU-RAM memory monitoring error
1476		
1477	EEPROM_err	EEPROM memory monitoring error
1478		
1479	A/D_err	A/D accuracy checking error
1480		
1481		
1482		
1483		
1484	DIO_err	DIO card connection error
1485		
1486	LCD_err	LCD panel connection error
1487	ROM_data_err	Data ROM checksum error
1488		
1489	COM_DPRAMerr1	DP-RAM memory monitoring error
1490		
1491	COM_SUM_err	
1492		
1493	COM_SRAM_err	
1494	COM_DPRAMerr2	
1495	COM_A/D_err	
1496	COM_IRQ_err	
1497	Sync1_fail	
1498	Sync2_fail	
1499	Com1_fail	
1500	Com2_fail	
1501	Com1_fail-R	
1502	Com2_fail-R	
1503	CLK1_fail	
1504	CLK2_fail	
1505	Term1_rdy_off	
1506	Term2_rdy_off	
1507	TX_level1_err	
1508	TX_level2_err	
1509	RX_level1_err	
1510	RX_level2_err	
1511	Td1_over	
1512	Td2_over	
1513	RYID1_err	
1514	RYID2_err	
1515		
1516		
1517		
1518		
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1535		(reserved)

Signal list

No.	Signal Name	Contents
1536	CB1_CONT-A	CB1 contact (A-phase)
1537	CB1_CONT-B	(B-phase)
1538	CB1_CONT-C	(C-phase)
1539		
1540	Z1X_INIT	Z1X protection initiation command
1541	EXT_VTF	External VTF command
1542	DS_N/O_CONT	DS N/O contact
1543	DS_N/C_CONT	DS N/C contact
1544	ARC_BLOCK	Autoreclosing block command
1545	CB1_READY	Autoreclosing ready command of bus CB
1546	CB2_READY	Autoreclosing ready command of center CB
1547	ARC_RESET	Autoreclosing out of service command
1548	IND.RESET	Indication reset command
1549	M-PROT_TRIP	Duplicated Main protection trip command
1550	M-PROT_ON	Duplicated Main protection in service command
1551		
1552	CB2_CONT-A	CB2 contact (A-phase)
1553	CB2_CONT-B	(B-phase)
1554	CB2_CONT-C	(C-phase)
1555		
1556	EXT_TRIP-A	External trip comand (A-Phase)
1557	EXT_TRIP-B	(B-phase)
1558	EXT_TRIP-C	(C-phase)
1559		
1560	EXT_CBFIN-A	External CBF initiation command (A-Phase)
1561	EXT_CBFIN-B	(B-Phase)
1562	EXT_CBFIN-C	(C-Phase)
1563		
1564		
1565		
1566		
1567		
1568	EXT_CAR.R1-1	Trip carrier from remote terminal-1
1569	EXT_CAR.R1-2	Guard/And carrier from remote terminal-1
1570	OPEN_TERM-R1	Remote terminal-1 out of service command
1571	SEVERE_CF-R1	Severe CF information command from remote terminal-1
1572		
1573		
1574		
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1580		
1581		
1582		
1583		
1584	EXT_CAR.R2-1	Trip carrier from remote terminal-2
1585	EXT_CAR.R2-2	Guard/And carrier from remote terminal-1
1586	OPEN_TERM-R2	Remote terminal-2 out of service command
1587	SEVERE_CF-R2	Severe CF information command from remote terminal-2
1588		
1589		
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1592		
1593		
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1598		
1599		
1600	PROT_BLOCK	Protection block command

Signal list

No.	Signal Name	Contents
1601	CRT_BLOCK	Carrier trip block command
1602	DISCRT_BLOCK	Carrier protection out of service command
1603	DEFCRT_BLOCK	DEF carrier trip block command
1604	PSBTP_BLOCK	PSBTP block command
1605	PSB_BLOCK	PSB detection block command
1606		
1607		
1608	OC-A_FS	Fail safe command for OC-A trip
1609	OC-B_FS	Fail safe command for OC-B trip
1610	OC-C_FS	Fail safe command for OC-C trip
1611		
1612	OCI-A_FS	Fail safe command for OCI-A trip
1613	OCI-B_FS	Fail safe command for OCI-B trip
1614	OCI-C_FS	Fail safe command for OCI-C trip
1615	THMA_BLOCK	Thermal alarm block command
1616	Z1G_BLOCK	Z1G trip block command
1617	Z1XG_BLOCK	Z1XG trip block command
1618	Z2G_BLOCK	Z2G trip block command
1619	Z3G_BLOCK	Z3G trip block command
1620	ZR1G_BLOCK	ZR1G trip block command
1621	ZFG_BLOCK	ZFG trip block command
1622	STUB_BLOCK	Stub trip block command
1623	SOTF_BLOCK	SOTF trip block command
1624	OCH_BLOCK	OCH trip block command
1625	OC_BLOCK	OC trip block command
1626	OCI_BLOCK	OCI trip block command
1627	EF_BLOCK	EF trip block command
1628	EFI_BLOCK	EFI trip block command
1629	DEF_BLOCK	DEF trip block command
1630	OST_BLOCK	OST trip block command
1631	THM_BLOCK	Thermal trip block command
1632	Z1S_BLOCK	Z1S trip block command
1633	Z1XS_BLOCK	Z1XS trip block command
1634	Z2S_BLOCK	Z2S trip block command
1635	Z3S_BLOCK	Z3S trip block command
1636	ZR1S_BLOCK	ZR1S trip block command
1637	ZFS_BLOCK	ZFS trip block command
1638	ZR2G_BLOCK	ZR2G trip block command
1639	ZR2S_BLOCK	ZR2S trip block command
1640	CBF_BLOCK	CBF trip block command
1641	EXTTP_BLOCK	External trip block command
1642	VTF_BLOCK	VTF monitoering block command
1643	VTF_ONLY_ALM	VTF only alarm command
1644	TR1_BLOCK	Transfer trip 1 block command
1645	TR2_BLOCK	Transfer trip 2 block command
1646	ZNDG_BLOCK	ZNDG trip block command
1647	ZNDS_BLOCK	ZNDS trip block command
1648	Z1S_G-BLK	Z1S block by multi-phase ground fault command
1649	STUB_CB	CB close command for stub protection
1650	OCHTP_ON	OCH trip pemmisive command
1651	PSB.F_RESET	PSB forcibly reset command
1652	DEF_PHSEL-A	Fault phase selection command for DEF
1653	DEF_PHSEL-B	ditto
1654	DEF_PHSEL-C	ditto
1655	Z1_ARC_BLOCK	Auto reclosing block command by Zone1 trip
1656	Z2G-A_FS	Z2G-A fail-safe command
1657	Z2G-B_FS	Z2G-B fail-safe command
1658	Z2G-C_FS	Z2G-C fail-safe command
1659	Z1X_F.ENABLE	Z1X forcibly enable command
1660		
1661		
1662		
1663		
1664	ZFG-A_BLOCK	ZFG-A block command
1665	ZFG-B_BLOCK	ZFG-B block command
1666	ZFG-C_BLOCK	ZFG-C block command
1667		
1668	ZNDG-A_COM	ZNDG-A operating command
1669	ZNDG-B_COM	ZNDG-B operating command
1670	ZNDG-C_COM	ZNDG-C operating command

Signal list

No.	Signal Name	Contents
1671	ZNDS_COM	ZNDS operating command
1672	Z2G-A_BLOCK	Z2G-A block command
1673	Z2G-B_BLOCK	Z2G-B block command
1674	Z2G-C_BLOCK	Z2G-C block command
1675		
1676		
1677		
1678		
1679		
1680	TP-A_DELAY	Trip command off-delay timer setting
1681	TP-B_DELAY	Trip command off-delay timer setting
1682	TP-C_DELAY	Trip command off-delay timer setting
1683	ARC_OFF	Autoreclosing mode changing command
1684	ARC_SPAR	ditto
1685	ARC_TPAR	ditto
1686	ARC_S&T	ditto
1687	ARC_EXT1P	ditto
1688	ARC_EXT3P	ditto
1689		
1690		
1691		
1692		
1693		
1694		
1695		
1696	Z1_INST_TP	Z1 instantly trip command
1697		
1698	Z2_INST_TP	Z2 instantly trip command
1699	Z3_INST_TP	Z3 instantly trip command
1700	ZR1_INST_TP	ZR1 instantly trip command
1701	ZF_INST_TP	ZF instantly trip command
1702	EF_INST_TP	EF instantly trip command
1703	OC_INST_TP	OC instantly trip command
1704		
1705	DEF_INST_TP	DEF instantly trip command
1706		
1707	DEFR_INST_TP	DEF instantly trip command
1708	ZR2_INST_TP	ZR2 instantly trip command
1709	ZND_INST_TP	ZND instantly trip command
1710		
1711		
1712	Z1_3PTP	Z1 3-phase trip command
1713	Z1X_3PTP	Z1X 3-phase trip command
1714	Z2_3PTP	Z2 3-phase trip command
1715		
1716	OC_3PTP	OC 3-phase trip command
1717	OCI_3PTP	OCI 3-phase trip command
1718		
1719		
1720	CAR_3PTP	Distance CAR 3-phase trip command
1721	DEFCAR_3PTP	DG.CAR 3-phase trip command
1722	PSBTP_3PTP	PSBTP 3-phase trip command
1723		
1724	TR1_3PTP	Transfer trip 1 3-phase trip command
1725	TR2_3PTP	Transfer trip 2 3-phase trip command
1726		
1727	3P_TRIP	3-Phase trip command
1728	CAR-A-R1	Distance carrier command from remote term-1
1729	CAR-B-R1	ditto
1730	CAR-C-R1	ditto
1731	CAR-S-R1	ditto
1732	DEFCAR-A-R1	DEF carrier command from remote term-1
1733	DEFCAR-B-R1	ditto
1734	DEFCAR-C-R1	ditto
1735		
1736		
1737		
1738		
1739		
1740	PSBCAR-A-R1	PSBTP carrier command from remote term-1

Signal list

No.	Signal Name	Contents
1741	PSBCAR-B-R1	ditto
1742	PSBCAR-C-R1	ditto
1743		
1744	TR1-A-R1	Transfer trip-1 command from remote term-1
1745	TR1-B-R1	ditto
1746	TR1-C-R1	ditto
1747		
1748	TR2-A-R1	Transfer trip-2 command from remote term-1
1749	TR2-B-R1	ditto
1750	TR2-C-R1	ditto
1751		
1752		
1753		
1754		
1755		
1756		
1757		
1758		
1759		
1760	CAR-A-R2	Distance carrier command from remote term-2
1761	CAR-B-R2	ditto
1762	CAR-C-R2	ditto
1763	CAR-S-R2	ditto
1764	DEFCAR-A-R2	DEF carrier command from remote term-2
1765	DEFCAR-B-R2	ditto
1766	DEFCAR-C-R2	ditto
1767		
1768		
1769		
1770		
1771		
1772	PSBCAR-A-R2	PSBTP carrier command from remote term-2
1773	PSBCAR-B-R2	ditto
1774	PSBCAR-C-R2	ditto
1775		
1776	TR1-A-R2	Transfer trip-1 command from remote term-2
1777	TR1-B-R2	ditto
1778	TR1-C-R2	ditto
1779		
1780	TR2-A-R2	Transfer trip-2 command from remote term-2
1781	TR2-B-R2	ditto
1782	TR2-C-R2	ditto
1783		
1784		
1785		
1786		
1787		
1788		
1789		
1790		
1791		
1792	IO#1-TP-A1	Binary output signal of TP-A1
1793	IO#1-TP-B1	TP-B1
1794	IO#1-TP-C1	TP-C1
1795	IO#1-TP-A2	Binary output signal of TP-A2
1796	IO#1-TP-B2	TP-B2
1797	IO#1-TP-C2	TP-C2
1798		
1799		
1800		
1801		
1802		
1803		
1804		
1805		
1806		
1807		
1808	OVS1_INST_TP	OVS1 instantly trip command
1809	OVS2_INST_TP	OVS2 instantly trip command
1810		

Signal list

No.	Signal Name	Contents
1811		
1812	OVG1_INST_TP	OVG1 instantly trip command
1813	OVG2_INST_TP	OVG2 instantly trip command
1814		
1815		
1816	UVS1_INST_TP	UVS1 instantly trip command
1817	UVS2_INST_TP	UVS2 instantly trip command
1818		
1819		
1820	UVG1_INST_TP	UVG1 instantly trip command
1821	UVG2_INST_TP	UVG2 instantly trip command
1822		
1823		
1824	SPR.L-REQ	Leader SPAR requirement
1825	TPR.L-REQ	Leader TPAR requirement
1826	SPR.F-REQ	Follower SPAR requirement
1827	TPR.F-REQ	Follower TPAR requirement
1828	SPR.F-ST.REQ	Follower SPAR starting requirement
1829	TPR.F-ST.REQ	Follower TPAR starting requirement
1830		
1831		
1832	R.F-ST.REQ	Follower AR starting requirement
1833	SPR.F2-REQ	Follower SPAR requirement
1834	TPR.F2-REQ	Follower TPAR requirement
1835		
1836		
1837		
1838	ARC.L_TERM	Leader terminal of Autoreclosing
1839	ARC.F_TERM	Follower terminal of Autoreclosing
1840		
1841		
1842		
1843		
1844		
1845		
1846		
1847		
1848	BCD_BLOCK	BCD trip block command
1849	DEFF_BLOCK	DEFF trip block command
1850		
1851	DEFR_BLOCK	DEFR trip block command
1852		
1853		
1854		
1855		
1856	OVS1_BLOCK	OVS1 trip block command
1857	OVS2_BLOCK	OVS2 trip block command
1858		
1859		
1860	OVG1_BLOCK	OVG1 trip block command
1861	OVG2_BLOCK	OVG2 trip block command
1862		
1863		
1864	UVS1_BLOCK	UVS1 trip block command
1865	UVS2_BLOCK	UVS2 trip block command
1866		
1867		
1868	UVG1_BLOCK	UVG1 trip block command
1869	UVG2_BLOCK	UVG2 trip block command
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Signal list

No.	Signal Name	Contents
2041		
2042		
2043		
2044		
2045		
2046		
2047		
2048	COM1-S	Communication on/off data send command
2049	COM2-S	ditto
2050	COM3-S	ditto
2051	COM4-S	ditto
2052	COM5-S	ditto
2053	COM6-S	ditto
2054	COM7-S	ditto
2055	COM8-S	ditto
2056	COM9-S	ditto
2057	COM10-S	ditto
2058	COM11-S	ditto
2059	COM12-S	ditto
2060	COM13-S	ditto
2061	COM14-S	ditto
2062		
2063		
2064	SUB_COM1-S	Sub communication on/off data send command
2065	SUB_COM2-S	ditto
2066	SUB_COM3-S	ditto
2067	SUB_COM4-S	ditto
2068		
2069		
2070		
2071		
2072		
2073		
2074		
2075		
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2100		
2101		
2102		
2103		
2104		
2105		
2106		
2107		
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2580		

Signal list

No.	Signal Name	Contents
2581		
2582		
2583		
2584		
2585		
2586		
2587		
2588		
2589		
2590		
2591		
2592		
2593		
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2600		
2601		
2602		
2603		
2604		
2605		
2606		
2607		
2608		
2609		
2610	ALARM_LED_SET	Alarm LED set
2611		
2612		
2613		
2614		
2615		
2616		
2617		
2618		
2619		
2620		
2621		
2622		
2623		
2624	F.RECORD1	Fault record stored command 1
2625	F.RECORD2	Fault record stored command 2
2626	F.RECORD3	Fault record stored command 3
2627	F.RECORD4	Fault record stored command 4
2628		
2629		
2630		
2631		
2632	D.RECORD1	Disturbance record stored command 1
2633	D.RECORD2	Disturbance record stored command 2
2634	D.RECORD3	Disturbance record stored command 3
2635	D.RECORD4	Disturbance record stored command 4
2636		
2637		
2638		
2639		
2640	SET.GROUP1	Active setting group changed commamd (Change to group1)
2641	SET.GROUP2	2
2642	SET.GROUP3	3
2643	SET.GROUP4	4
2644	SET.GROUP5	5
2645	SET.GROUP6	6
2646	SET.GROUP7	7
2647	SET.GROUP8	8
2648		
2649		
2650		

Signal list		
No.	Signal Name	Contents
2651		
2652		
2653		
2654		
2655		
2656	CON_TPMD1	User configrable trip mode in fault record
2657	CON_TPMD2	ditto
2658	CON_TPMD3	ditto
2659	CON_TPMD4	ditto
2660	CON_TPMD5	ditto
2661	CON_TPMD6	ditto
2662	CON_TPMD7	ditto
2663	CON_TPMD8	ditto
2664		
2665		
2666		
2667		
2668		
2669		
2670		
2671		
2672		
2673		
2674		
2675		
2676		
2677		
2678		
2679		
2680		
2681		
2682		
2683		
2684	ARC_COM_RECV	Auto-recloser inactivate command received
2685	TELE_COM_RECV	Teleprotection inactivate command received
2686	PROT_COM_RECV	protection inactivate command received
2687		
2688	TPLED_RST_RCV	TRIP LED RESET command received
2689		
2690		
2691		
2692		
2693		
2694		
2695		
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2698		
2699		
2700		
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2714		
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2790		

Signal list		
No.	Signal Name	Contents
2791		
2792		
2793		
2794		
2795		
2796		
2797		
2798		
2799		
2800		
2801		
2802		
2803		
2804		
2805		
2806		
2807		
2808		
2809		
2810		
2811		
2812		
2813		
2814		
2815		
2816	TEMP001	
2817	TEMP002	
2818	TEMP003	
2819	TEMP004	
2820	TEMP005	
2821	TEMP006	
2822	TEMP007	
2823	TEMP008	
2824	TEMP009	
2825	TEMP010	
2826	TEMP011	
2827	TEMP012	
2828	TEMP013	
2829	TEMP014	
2830	TEMP015	
2831	TEMP016	
2832	TEMP017	
2833	TEMP018	
2834	TEMP019	
2835	TEMP020	
2836	TEMP021	
2837	TEMP022	
2838	TEMP023	
2839	TEMP024	
2840	TEMP025	
2841	TEMP026	
2842	TEMP027	
2843	TEMP028	
2844	TEMP029	
2845	TEMP030	
2846	TEMP031	
2847	TEMP032	
2848	TEMP033	
2849	TEMP034	
2850	TEMP035	
2851	TEMP036	
2852	TEMP037	
2853	TEMP038	
2854	TEMP039	
2855	TEMP040	
2856	TEMP041	
2857	TEMP042	
2858	TEMP043	
2859	TEMP044	
2860	TEMP045	

Signal list

No.	Signal Name	Contents
2861	TEMP046	
2862	TEMP047	
2863	TEMP048	
2864	TEMP049	
2865	TEMP050	
2866	TEMP051	
2867	TEMP052	
2868	TEMP053	
2869	TEMP054	
2870	TEMP055	
2871	TEMP056	
2872	TEMP057	
2873	TEMP058	
2874	TEMP059	
2875	TEMP060	
2876	TEMP061	
2877	TEMP062	
2878	TEMP063	
2879	TEMP064	
2880	TEMP065	
2881	TEMP066	
2882	TEMP067	
2883	TEMP068	
2884	TEMP069	
2885	TEMP070	
2886	TEMP071	
2887	TEMP072	
2888	TEMP073	
2889	TEMP074	
2890	TEMP075	
2891	TEMP076	
2892	TEMP077	
2893	TEMP078	
2894	TEMP079	
2895	TEMP080	
2896	TEMP081	
2897	TEMP082	
2898	TEMP083	
2899	TEMP084	
2900	TEMP085	
2901	TEMP086	
2902	TEMP087	
2903	TEMP088	
2904	TEMP089	
2905	TEMP090	
2906	TEMP091	
2907	TEMP092	
2908	TEMP093	
2909	TEMP094	
2910	TEMP095	
2911	TEMP096	
2912	TEMP097	
2913	TEMP098	
2914	TEMP099	
2915	TEMP100	
2916	TEMP101	
2917	TEMP102	
2918	TEMP103	
2919	TEMP104	
2920	TEMP105	
2921	TEMP106	
2922	TEMP107	
2923	TEMP108	
2924	TEMP109	
2925	TEMP110	
2926	TEMP111	
2927	TEMP112	
2928	TEMP113	
2929	TEMP114	
2930	TEMP115	

Signal list

No.	Signal Name	Contents
2931	TEMP116	
2932	TEMP117	
2933	TEMP118	
2934	TEMP119	
2935	TEMP120	
2936	TEMP121	
2937	TEMP122	
2938	TEMP123	
2939	TEMP124	
2940	TEMP125	
2941	TEMP126	
2942	TEMP127	
2943	TEMP128	
2944	TEMP129	
2945	TEMP130	
2946	TEMP131	
2947	TEMP132	
2948	TEMP133	
2949	TEMP134	
2950	TEMP135	
2951	TEMP136	
2952	TEMP137	
2953	TEMP138	
2954	TEMP139	
2955	TEMP140	
2956	TEMP141	
2957	TEMP142	
2958	TEMP143	
2959	TEMP144	
2960	TEMP145	
2961	TEMP146	
2962	TEMP147	
2963	TEMP148	
2964	TEMP149	
2965	TEMP150	
2966	TEMP151	
2967	TEMP152	
2968	TEMP153	
2969	TEMP154	
2970	TEMP155	
2971	TEMP156	
2972	TEMP157	
2973	TEMP158	
2974	TEMP159	
2975	TEMP160	
2976	TEMP161	
2977	TEMP162	
2978	TEMP163	
2979	TEMP164	
2980	TEMP165	
2981	TEMP166	
2982	TEMP167	
2983	TEMP168	
2984	TEMP169	
2985	TEMP170	
2986	TEMP171	
2987	TEMP172	
2988	TEMP173	
2989	TEMP174	
2990	TEMP175	
2991	TEMP176	
2992	TEMP177	
2993	TEMP178	
2994	TEMP179	
2995	TEMP180	
2996	TEMP181	
2997	TEMP182	
2998	TEMP183	
2999	TEMP184	
3000	TEMP185	

Signal list

No.	Signal Name	Contents
3001	TEMP186	
3002	TEMP187	
3003	TEMP188	
3004	TEMP189	
3005	TEMP190	
3006	TEMP191	
3007	TEMP192	
3008	TEMP193	
3009	TEMP194	
3010	TEMP195	
3011	TEMP196	
3012	TEMP197	
3013	TEMP198	
3014	TEMP199	
3015	TEMP200	
3016	TEMP201	
3017	TEMP202	
3018	TEMP203	
3019	TEMP204	
3020	TEMP205	
3021	TEMP206	
3022	TEMP207	
3023	TEMP208	
3024	TEMP209	
3025	TEMP210	
3026	TEMP211	
3027	TEMP212	
3028	TEMP213	
3029	TEMP214	
3030	TEMP215	
3031	TEMP216	
3032	TEMP217	
3033	TEMP218	
3034	TEMP219	
3035	TEMP220	
3036	TEMP221	
3037	TEMP222	
3038	TEMP223	
3039	TEMP224	
3040	TEMP225	
3041	TEMP226	
3042	TEMP227	
3043	TEMP228	
3044	TEMP229	
3045	TEMP230	
3046	TEMP231	
3047	TEMP232	
3048	TEMP233	
3049	TEMP234	
3050	TEMP235	
3051	TEMP236	
3052	TEMP237	
3053	TEMP238	
3054	TEMP239	
3055	TEMP240	
3056	TEMP241	
3057	TEMP242	
3058	TEMP243	
3059	TEMP244	
3060	TEMP245	
3061	TEMP246	
3062	TEMP247	
3063	TEMP248	
3064	TEMP249	
3065	TEMP250	
3066	TEMP251	
3067	TEMP252	
3068	TEMP253	
3069	TEMP254	
3070	TEMP255	
3071	TEMP256	

Appendix C

Variable Timer List

Variable Timer List

Timer	Timer No.	Contents
TZ1GA	1	Z1G TRIP TIMER
TZ1GB	2	ditto
TZ1GC	3	ditto
TZ2G	4	Z2G TRIP TIMER
TZ3G	5	Z3G TRIP TIMER
TZ1S	6	Z1S TRIP TIMER
TZ2S	7	Z2S TRIP TIMER
TZ3S	8	Z3S TRIP TIMER
TEF	9	EF BACK-UP TRIP TIMER
TDEF	10	DEFF BACK-UP TRIP TIMER
TZR1S	11	ZR1S BACK-UP TRIP TIMER
TZR1G	12	ZR1G BACK-UP TRIP TIMER
TBF1A	13	CBF DETECTION TIMER 1
TBF1B	14	ditto
TBF1C	15	ditto
TBF2A	16	CBF DETECTION TIMER 2
TBF2B	17	ditto
TBF2C	18	ditto
TOST1	19	OUT-OF-STEP DET. TIMER
TOST2	20	ditto
TDEFF	21	DEF CARRIER TRIP DELAY TIMER
TDEFR	22	CARR.COORDINATION DEFR TIMER
TCHD	23	CARRIER COORDINATION TIMER
TEVLV	26	EVOLVING FAULT WAITING TIMER
TRDY1	27	RECLAIM TIMER
TSPR1	28	SPAR DEAD LINE TIMER
TTPR1	29	TPAR DEAD LINE TIMER
TRR1	30	RESET TIMER
TW1	31	RECLOSING O/P FOR BUS CB
TRDY2	32	FLW RECLAIM TIMER
TSPR2	33	FLW SPAR DEAD LINE TIMER
TTPR2	34	FLW TPAR DEAD LINE TIMER
TRR2	35	FLW RESET TIMER
TW2	36	RECLOSING O/P FOR CENTER CB
TSYN1	37	LEAD SYN CHECK TIMER
TSYN2	38	FLW SYN CHECK TIMER
TDBL1	39	VOLTAGE CHECK TIMER
TDBL2	40	ditto
TLBD1	41	ditto
TLBD2	42	ditto
TS2	43	MULTI. SHOT DEAD TIMER
TS3	44	ditto
TS4	45	ditto
TS2R	46	MULTI. SHOT RESET TIMER
TS3R	47	ditto
TS4R	48	ditto
TOC	49	OC BACK-UP TRIP TIMER
TPSB	50	PSB DETECTION TIMER
TSOTF	51	SOTF CHECK TIMER
TZFG	52	ZFG TRIP TIMER
TZFS	53	ZFS TRIP TIMER
TZR2G	54	ZR2G BACK-UP TRIP TIMER
TZR2S	55	ZR2S BACK-UP TRIP TIMER
TZNDG	56	ZNDG BACK-UP TRIP TIMER
TZNDS	57	ZNDS BACK-UP TRIP TIMER
TREBK	58	CURRENT REVERSAL BLOCKING TIME
TECCB	59	ECHO ENABLE TIME FROM CB OPENED
TSBCT	60	SBCNT TIME
T3PLL	61	THREE PHASE LIVE LINE TIMER
TDER	62	DEFR BACK-UP TRIP TIMER
TOS1	63	OVS1 BACK-UP TRIP TIMER
TOS2	64	OVS2 BACK-UP TRIP TIMER
TOG1	65	OVG1 BACK-UP TRIP TIMER
TOG2	66	OVG2 BACK-UP TRIP TIMER
TUS1	67	UVS1 BACK-UP TRIP TIMER
TUS2	68	UVS2 BACK-UP TRIP TIMER
TUG1	69	UVG1 BACK-UP TRIP TIMER
TUG2	70	UVG2 BACK-UP TRIP TIMER
TBCD	71	BCD TRIP TIMER

Appendix D

Binary Input/Output Default Setting List

Binary Input Default Setting List

<table>
<tr><th rowspan="3">No</th><th colspan="9">Model</th></tr>
<tr><th colspan="2">2TERM</th><th colspan="2">3TERM</th><th>2TERM</th><th>3TERM</th><th>2TERM</th><th colspan="2">3TERM</th></tr>
<tr><th>214</th><th>216</th><th>224</th><th>226</th><th>211</th><th>221</th><th>311</th><th>321</th><th>323</th></tr>
<tr><td>BI1</td><td colspan="9">CB1-A</td></tr>
<tr><td>BI2</td><td colspan="9">CB1-B</td></tr>
<tr><td>BI3</td><td colspan="9">CB1-C</td></tr>
<tr><td>BI4</td><td colspan="9">TTR1(Transfer trip 1)</td></tr>
<tr><td>BI5</td><td colspan="4">TTR2(Transfer trip 2)</td><td colspan="5">(SPARE)</td></tr>
<tr><td>BI6</td><td colspan="9">EXT VTF</td></tr>
<tr><td>BI7</td><td colspan="9">DS N/O CONT</td></tr>
<tr><td>BI8</td><td colspan="9">DS N/C CONT</td></tr>
<tr><td>BI9</td><td colspan="9">CRT BLOCK (Carrier protection block)</td></tr>
<tr><td>BI10</td><td colspan="4">IND.RESET</td><td colspan="5">CB1 READY</td></tr>
<tr><td>BI11</td><td colspan="4">PROT BLCOK</td><td colspan="2">SPARE</td><td colspan="3">CB2 READY</td></tr>
<tr><td>BI12</td><td colspan="4">Z1X INIT</td><td colspan="5">REC BLOCK</td></tr>
<tr><td>BI13</td><td colspan="4">--</td><td colspan="5">IND.RESET</td></tr>
<tr><td>BI14</td><td colspan="4">--</td><td colspan="5">M-prot Trip</td></tr>
<tr><td>BI15</td><td colspan="4">--</td><td colspan="5">M-prot On</td></tr>
<tr><td>BI16</td><td colspan="9">EXT TRIP-A</td></tr>
<tr><td>BI17</td><td colspan="9">EXT TRIP-B</td></tr>
<tr><td>BI18</td><td colspan="9">EXT TRIP-C</td></tr>
<tr><td>BI19</td><td colspan="4">OCI BLOCK</td><td colspan="4">--</td><td>CB2-A</td></tr>
<tr><td>BI20</td><td colspan="4">EFI BLOCK</td><td colspan="4">--</td><td>CB2-B</td></tr>
<tr><td>BI21</td><td colspan="4">OC BLOCK</td><td colspan="4">--</td><td>CB2-C</td></tr>
<tr><td>BI22</td><td colspan="4">DEF BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI23</td><td colspan="4">EXTTP BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI24</td><td colspan="4">STUB BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI25</td><td colspan="4">SOTF BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI26</td><td>--</td><td>ARC BLOCK</td><td>--</td><td>ARC BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI27</td><td>--</td><td>CB1 READY</td><td>--</td><td>CB1 READY</td><td colspan="5">--</td></tr>
<tr><td>BI28</td><td>--</td><td>CBF BLOCK</td><td>--</td><td>CBF BLOCK</td><td colspan="5">--</td></tr>
<tr><td>BI34</td><td>--</td><td>(SPARE)</td><td>--</td><td>(SPARE)</td><td colspan="4">--</td><td>(SPARE)</td></tr>
<tr><td>BI35</td><td>--</td><td>(SPARE)</td><td>--</td><td>(SPARE)</td><td colspan="4">--</td><td>(SPARE)</td></tr>
<tr><td>BI36</td><td>--</td><td>(SPARE)</td><td>--</td><td>(SPARE)</td><td colspan="4">--</td><td>(SPARE)</td></tr>
</table>

Binary Output Default Setting List

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting: Signal No.	Setting: LOGIC (OR:1, AND:2)	Setting: TIMER (OFF:0, ON:1)
			TB3:					
GRZ100 -211	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	240	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	241	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	242	1	1
		BO4	A3-B3	CAR/Z1G/Z1S_TRIP	Carrier/Z1G/Z1S trip	231, 148, 160	1	1
		BO5	A4-B4	Z2G/Z3G/ZR1G/Z2S/Z3S/ ZR1S_TRIP	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_ trip	153, 156, 192, 162, 165,189	1	1
		BO6	A5-B5	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO7	A6-B6	SOTF_TRIP/STUB_TRIP	SOTF/STUB trip	183, 182	1	1
		BO8	A7-B7	BURECLK	BU Reclose block	195	1	1
		BO9	A8-B8	CBF_TRIP	Related CB trip	200	1	1
		BO10	A9-B9	ARC1	Reclose output	291	1	0
		BO11	A10-B10	VTF_ALARM/CHF	VTF alarm/Carrier channel failure	172, 253	1	1
		BO12	A11-B11	CBF_DET	CBF detection	199	1	1
		BO13	A13-B13	EXT_CAR-S	External carrier send command	225	1	0
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	240	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	241	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	242	1	1
		BO4	A4-B4	TRIP-A1	Trip A phase	240	1	1
		BO5	A5-B5	TRIP-B1	Trip B phase	241	1	1
		BO6	A6-B6	TRIP-C1	Trip C phase	242	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	240	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	241	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	242	1	1
		BO10	A10-B10	COMM1_FAIL	Remote term.1 comm.fail alarm	900	1	1
			TB3:					
GRZ100 -214	IO#2	BO1	A2-A1	Z1G_TRIP/Z1S_TRIP	Z1G TRIP/Z1S TRIP	148, 160	1	1
		BO2	A2-B1	Z2G_TRIP/Z2S_TRIP	Z2G TRIP/Z2S TRIP	153, 162	1	1
		BO3	A2-B2	Z3G_TRIP/Z3S_TRIP	Z3G TRIP/Z3S TRIP	156, 165	1	1
		BO4	A3-B3	TRIP-OR	TRIP O/P OR	238	1	1
		BO5	A4-B4	BU_TRIP	BACK-UP TRIP	194	1	1
		BO6	A5-B5	TRIP-OR	TRIP O/P OR	238	1	1
		BO7	A6-B6	Z2GOR/Z2SOR	Z2G/Z2S Relay OR LOGIC	154, 163	1	1
		BO8	A7-B7	VTF_ALARM	VTF ALARM	172	1	1
		BO9	A8-B8	EF_TRIP	EF BACK-UP TRIP	678	1	1
		BO10	A9-B9	STUB_TRIP	STUB TRIP	182	1	1
		BO11	A10-B10	SOTF_TRIP	SOTF TRIP	183	1	1
		BO12	A11-B11	COMM1_FAIL	Remote term.1 comm.fail alarm	900	1	1
		BO13	A13-B13	TR1_TRIP, TR2_TRIP, INTER_TRIP1/2	TRANSFER TRIP-1/-2, INTER TRIP-1/-2	832, 840, 836, 844	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-OR	TRIP O/P OR	238	1	1
		BO2	A2-B2	Z2GOR/Z3GOR/Z2SOR/Z 3SOR	Z2G/Z3G/Z2S/Z3S Relay OR LOGIC	154, 157, 163, 166	1	1
		BO3	A3-B3	OCI_TRIP	IDMT OC Back-up trip	327	1	1
		BO4	A4-B4	EFI_TRIP	EF IDMT trip	184	1	1
		BO5	A5-B5	OC_TRIP	OC Back-up trip	326	1	1
		BO6	A6-B6	DEF_TRIP	DEF Back-up trip	677	1	1

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB2					
GRZ100 -216	IO#2	BO1	A2-A1	Z1G_TRIP/Z1S_TRIP	Z1G TRIP/Z1S TRIP	148, 160	1	1
		BO2	A2-B1	Z2G_TRIP/Z2S_TRIP	Z2G TRIP/Z2S TRIP	153, 162	1	1
		BO3	A2-B2	Z3G_TRIP/Z3S_TRIP	Z3G TRIP/Z3S TRIP	156, 165	1	1
		BO4	A3-B3	TRIP-OR	TRIP O/P OR	238	1	1
		BO5	A4-B4	BU_TRIP	BACK-UP TRIP	194	1	1
		BO6	A5-B5	TRIP-OR	TRIP O/P OR	238	1	1
		BO7	A6-B6	Z2GOR/Z2SOR	Z2G/Z2S Relay OR LOGIC	154, 163	1	1
		BO8	A7-B7	VTF_ALARM	VTF ALARM	172	1	1
		BO9	A8-B8	EF_TRIP	EF BACK-UP TRIP	678	1	1
		BO10	A9-B9	STUB_TRIP	STUB TRIP	182	1	1
		BO11	A10-B10	SOTF_TRIP	SOTF TRIP	183	1	1
		BO12	A11-B11	COMM1_FAIL	Remote term.1 comm.fail alarm	900	1	1
		BO13	A13-B13	TR1_TRIP, TR2_TRIP, INTER_TRIP1/2	TRANSFER TRIP-1/-2, INTER TRIP-1/-2	832, 840, 836, 844	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5					
	IO#3	BO1	A1-B1	TRIP-OR	TRIP O/P OR	238	1	1
		BO2	A2-B2	Z2GOR/Z3GOR/Z2SOR/Z3SOR	Z2G/Z3G/Z2S/Z3S Relay OR LOGIC	154, 157, 163, 166	1	1
		BO3	A3-B3	OCI_TRIP	IDMT OC Back-up trip	327	1	1
		BO4	A4-B4	EFI_TRIP	EF IDMT trip	184	1	1
		BO5	A5-B5	OC_TRIP	OC Back-up trip	326	1	1
		BO6	A6-B6	DEF_TRIP	DEF Back-up trip	677	1	1
		BO7	A7-B7	ARC1	Reclose output	291	1	0
		BO8	A8-B8	ARC1	Reclose output	291	1	0
		BO9	A9-B9	BU_TRIP	Back-up trip	194	1	1
		BO10	A10-B10	IN-PROG1	Lead reclose in progress	285	1	0
			TB3:					
	IO#4	BO1	A2-A1	CBF_RETRIP-A	Retrip A-phase	196	1	1
		BO2	A2-B1	CBF_RETRIP-B	Retrip B-phase	197	1	1
		BO3	A2-B2	CBF_RETRIP-C	Retrip C-phase	198	1	1
		BO4	A3-B3	CBF_TRIP	Related CB trip	200	1	1
		BO5	A4-B4	CBF_TRIP	Related CB trip	200	1	1
		BO6	A5-B5	CBF_DET	CBF detection	199	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	240	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	241	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	242	1	1
		BO10	A9-B9	TRIP-OR	TRIP O/P OR	238	1	1
		BO11	A10-B10	TRIP-A1	Trip A phase	240	1	1
		BO12	A11-B11	TRIP-B1	Trip B phase	241	1	1
		BO13	A12-B12	TRIP-C1	Trip C phase	242	1	1
		BO14	A13-B13	TRIP-OR	TRIP O/P OR	238	1	1

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRZ100 -311	IO#2	BO1	A2-A1	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO2	A2-B1	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO3	A2-B2	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO4	A3-B3	CAR/Z1G/Z1S_TRIP	Carrier/Z1G/Z1S trip	231, 148, 160	1	1
		BO5	A4-B4	Z2G/Z3G/ZR1G/Z2S/Z3S/ ZR1S_TRIP	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_ trip	153, 156, 192, 162, 165,189	1	1
		BO6	A5-B5	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO7	A6-B6	SOTF_TRIP/STUB_TRIP	SOTF/STUB trip	183, 182	1	1
		BO8	A7-B7	BURECLK	BU Reclose block	195	1	1
		BO9	A8-B8	CBF_TRIP	Related CB trip	200	1	1
		BO10	A9-B9	ARC1	Reclose output (Bus CB)	291	1	0
		BO11	A10-B10	ARC2	Reclose output (Center CB)	292	1	0
		BO12	A11-B11	VTF_ALARM/CHF	VTF alarm/Carrier channel failure	172, 253	1	1
		BO13	A13-B13	EXT_CAR-S	External carrier send command	225	1	0
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO2	A2-B2	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO3	A3-B3	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO4	A4-B4	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO5	A5-B5	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO6	A6-B6	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO7	A7-B7	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO8	A8-B8	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO9	A9-B9	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO10	A10-B10	COMM1_FAIL	Remote term.1 comm.fail alarm	900	1	1
			TB3:					
GRZ100 -221	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	240	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	241	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	242	1	1
		BO4	A3-B3	CAR/Z1G/Z1S_TRIP	Carrier/Z1G/Z1S trip	231, 148, 160	1	1
		BO5	A4-B4	Z2G/Z3G/ZR1G/Z2S/Z3S/ ZR1S_TRIP	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_ trip	153, 156, 192, 162, 165,189	1	1
		BO6	A5-B5	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO7	A6-B6	SOTF_TRIP/STUB_TRIP	SOTF/STUB trip	183, 182	1	1
		BO8	A7-B7	BURECLK	BU Reclose block	195	1	1
		BO9	A8-B8	CBF_TRIP	Related CB trip	200	1	1
		BO10	A9-B9	ARC1	Reclose output	291	1	0
		BO11	A10-B10	VTF_ALARM/CHF	VTF alarm/Carrier channel failure	172, 253	1	1
		BO12	A11-B11	CBF_DET	CBF detection	199	1	1
		BO13	A13-B13	EXT_CAR-S	External carrier send command	225	1	0
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	240	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	241	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	242	1	1
		BO4	A4-B4	TRIP-A1	Trip A phase	240	1	1
		BO5	A5-B5	TRIP-B1	Trip B phase	241	1	1
		BO6	A6-B6	TRIP-C1	Trip C phase	242	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	240	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	241	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	242	1	1
		BO10	A10-B10	COMM1/COMM2_FAIL	Remote term.1/2 comm.fail alarm	900, 916	1	1

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRZ100 -224	IO#2	BO1	A2-A1	Z1G_TRIP/Z1S_TRIP	Z1G TRIP/Z1S TRIP	148, 160	1	1
		BO2	A2-B1	Z2G_TRIP/Z2S_TRIP	Z2G TRIP/Z2S TRIP	153, 162	1	1
		BO3	A2-B2	Z3G_TRIP/Z3S_TRIP	Z3G TRIP/Z3S TRIP	156, 165	1	1
		BO4	A3-B3	TRIP-OR	TRIP O/P OR	238	1	1
		BO5	A4-B4	BU_TRIP	BACK-UP TRIP	194	1	1
		BO6	A5-B5	TRIP-OR	TRIP O/P OR	238	1	1
		BO7	A6-B6	Z2GOR/Z2SOR	Z2G/Z2S Relay OR LOGIC	154, 163	1	1
		BO8	A7-B7	VTF_ALARM	VTF ALARM	172	1	1
		BO9	A8-B8	EF_TRIP	EF BACK-UP TRIP	678	1	1
		BO10	A9-B9	STUB_TRIP	STUB TRIP	182	1	1
		BO11	A10-B10	SOTF_TRIP	SOTF TRIP	183	1	1
		BO12	A11-B11	COMM1/COMM2_FAIL	Remote term.1/2 comm.fail alarm	900, 916	1	1
		BO13	A13-B13	TR1_TRIP, TR2_TRIP, INTER_TRIP1/2	TRANSFER TRIP-1/-2, INTER TRIP-1/-2	832, 840, 836, 844	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-OR	TRIP O/P OR	238	1	1
		BO2	A2-B2	Z2GOR/Z3GOR/Z2SOR/Z3SOR	Z2G/Z3G/Z2S/Z3S Relay OR LOGIC	154, 157, 163, 166	1	1
		BO3	A3-B3	OCI_TRIP	IDMT OC Back-up trip	327	1	1
		BO4	A4-B4	EFI_TRIP	EF IDMT trip	184	1	1
		BO5	A5-B5	OC_TRIP	OC Back-up trip	326	1	1
		BO6	A6-B6	DEF_TRIP	DEF Back-up trip	677	1	1
			TB2:					
GRZ100 -226	IO#2	BO1	A2-A1	Z1G_TRIP/Z1S_TRIP	Z1G TRIP/Z1S TRIP	148, 160	1	1
		BO2	A2-B1	Z2G_TRIP/Z2S_TRIP	Z2G TRIP/Z2S TRIP	153, 162	1	1
		BO3	A2-B2	Z3G_TRIP/Z3S_TRIP	Z3G TRIP/Z3S TRIP	156, 165	1	1
		BO4	A3-B3	TRIP-OR	TRIP O/P OR	238	1	1
		BO5	A4-B4	BU_TRIP	BACK-UP TRIP	194	1	1
		BO6	A5-B5	TRIP-OR	TRIP O/P OR	238	1	1
		BO7	A6-B6	Z2GOR/Z2SOR	Z2G/Z2S Relay OR LOGIC	154, 163	1	1
		BO8	A7-B7	VTF_ALARM	VTF ALARM	172	1	1
		BO9	A8-B8	EF_TRIP	EF BACK-UP TRIP	678	1	1
		BO10	A9-B9	STUB_TRIP	STUB TRIP	182	1	1
		BO11	A10-B10	SOTF_TRIP	SOTF TRIP	183	1	1
		BO12	A11-B11	COMM1/COMM2_FAIL	Remote term.1/2 comm.fail alarm	900, 916	1	1
		BO13	A13-B13	TR1_TRIP, TR2_TRIP, INTER_TRIP1/2	TRANSFER TRIP-1/-2, INTER TRIP-1/-2	832, 840, 836, 844	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5					
	IO#3	BO1	A1-B1	TRIP-OR	TRIP O/P OR	238	1	1
		BO2	A2-B2	Z2GOR/Z3GOR/Z2SOR/Z3SOR	Z2G/Z3G/Z2S/Z3S Relay OR LOGIC	154, 157, 163, 166	1	1
		BO3	A3-B3	OCI_TRIP	IDMT OC Back-up trip	327	1	1
		BO4	A4-B4	EFI_TRIP	EF IDMT trip	184	1	1
		BO5	A5-B5	OC_TRIP	OC Back-up trip	326	1	1
		BO6	A6-B6	DEF_TRIP	DEF Back-up trip	677	1	1
		BO7	A7-B7	ARC1	Reclose output	291	1	0
		BO8	A8-B8	ARC1	Reclose output	291	1	0
		BO9	A9-B9	BU_TRIP	Back-up trip	194	1	1
		BO10	A10-B10	IN-PROG1	Lead reclose in progress	285	1	0
			TB3:					
	IO#4	BO1	A2-A1	CBF_RETRIP-A	Retrip A-phase	196	1	1
		BO2	A2-B1	CBF_RETRIP-B	Retrip B-phase	197	1	1
		BO3	A2-B2	CBF_RETRIP-C	Retrip C-phase	198	1	1
		BO4	A3-B3	CBF_TRIP	Related CB trip	200	1	1
		BO5	A4-B4	CBF_TRIP	Related CB trip	200	1	1
		BO6	A5-B5	CBF_DET	CBF detection	199	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	240	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	241	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	242	1	1
		BO10	A9-B9	TRIP-OR	TRIP O/P OR	238	1	1
		BO11	A10-B10	TRIP-A1	Trip A phase	240	1	1
		BO12	A11-B11	TRIP-B1	Trip B phase	241	1	1
		BO13	A12-B12	TRIP-C1	Trip C phase	242	1	1
		BO14	A13-B13	TRIP-OR	TRIP O/P OR	238	1	1

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRZ100 -321	IO#2	BO1	A2-A1	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO2	A2-B1	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO3	A2-B2	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO4	A3-B3	CAR/Z1G/Z1S_TRIP	Carrier/Z1G/Z1S trip	231, 148, 160	1	1
		BO5	A4-B4	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_TRIP	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_trip	153, 156, 192, 162, 165,189	1	1
		BO6	A5-B5	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO7	A6-B6	SOTF_TRIP/STUB_TRIP	SOTF/STUB trip	183, 182	1	1
		BO8	A7-B7	BURECLK	BU Reclose block	195	1	1
		BO9	A8-B8	CBF_TRIP	Related CB trip	200	1	1
		BO10	A9-B9	ARC1	Reclose output (Bus CB)	291	1	0
		BO11	A10-B10	ARC2	Reclose output (Center CB)	292	1	0
		BO12	A11-B11	VTF_ALARM/CHF	VTF alarm/Carrier channel failure	172, 253	1	1
		BO13	A13-B13	EXT_CAR-S	External carrier send command	225	1	0
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO2	A2-B2	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO3	A3-B3	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO4	A4-B4	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO5	A5-B5	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO6	A6-B6	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO7	A7-B7	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO8	A8-B8	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO9	A9-B9	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO10	A10-B10	COMM1/COMM2_FAIL	Remote term.1/2 comm.fail alarm	900, 916	1	1

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting Signal No.	Setting LOGIC (OR:1, AND:2)	Setting TIMER (OFF:0, ON:1)
			TB2:					
GRZ100 -323	IO#2	BO1	A2-A1	TRIP-A1/TRIP-A2	Trip A phase	240, 243	1	1
		BO2	A2-B1	TRIP-B1/TRIP-B2	Trip B phase	241, 244	1	1
		BO3	A2-B2	TRIP-C1/TRIP-C2	Trip C phase	242, 245	1	1
		BO4	A3-B3	CAR/Z1G/Z1S_TRIP	Carrier/Z1G/Z1S trip	231, 148, 160	1	1
		BO5	A4-B4	Z2G/Z3G/ZR1G/Z2S/Z3S/ ZR1S_TRIP	Z2G/Z3G/ZR1G/Z2S/Z3S/ZR1S_ trip	153, 156, 192, 162, 165,189	1	1
		BO6	A5-B5	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO7	A6-B6	SOTF_TRIP/STUB_TRIP	SOTF/STUB trip	183, 182	1	1
		BO8	A7-B7	BURECLK	BU Reclose block	195	1	1
		BO9	A8-B8	CBF_TRIP	Related CB trip	200	1	1
		BO10	A9-B9	ARC1	Reclose output (Bus CB)	291	1	0
		BO11	A10-B10	ARC2	Reclose output (Center CB)	292	1	0
		BO12	A11-B11	VTF_ALARM/CHF	VTF alarm/Carrier channel failure	172, 253	1	1
		BO13	A13-B13	EXT_CAR-S	External carrier send command	225	1	0
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5					
	IO#3	BO1	A2-A1	TRIP-A1	Trip A phase	240	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	241	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	242	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	240	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	241	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	242	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	243	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	244	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	245	1	1
		BO10	A9-B9	TRIP-A1	Trip A phase	243	1	1
		BO11	A10-B10	TRIP-B1	Trip B phase	244	1	1
		BO12	A11-B11	TRIP-C1	Trip C phase	245	1	1
		BO13	A12-B12	TRIP-OR	TRIP O/P OR	238	1	1
		BO14	A13-B13	COMM1/COMM2_FAIL	Remote term.1/2 comm.fail alarm	900, 916	1	1
			TB3:					
	IO#4	BO1	A2-A1	Z1G_TRIP	Z1G trip	148	1	1
		BO2	A2-B1	Z2G_TRIP	Z2G trip	153	1	1
		BO3	A2-B2	Z3G_TRIP	Z3G trip	156	1	1
		BO4	A3-B3	Z1S_TRIP	Z1S trip	160	1	1
		BO5	A4-B4	Z2S_TRIP	Z2S trip	162	1	1
		BO6	A5-B5	Z3S_TRIP	Z3S trip	165	1	1
		BO7	A6-B6	STUB_TRIP	STUB trip	182	1	1
		BO8	A7-B7	SOTF_TRIP	SOTF trip	183	1	1
		BO9	A8-B8	EF_BU-TRIP	EF or DEF Back-up trip	187	1	1
		BO10	A9-B9	ZR1G_TRIP	ZR1G trip	192	1	1
		BO11	A10-B10	ZR1S_TRIP	ZR1S trip	189	1	1
		BO12	A11-B11	CBF_DET	CBF detection	199	1	1
		BO13	A12-B12	DEFCR/WICAR_TRIP	DG carrier trip / Weak carrier trip	232, 233	1	1
		BO14	A13-B13	ARC1/ARC2	Reclose output	291, 292	1	1

Appendix E

Details of Relay Menu and LCD & Button Operation

```
   MENU
1=Record            2=Status
3=Setting(view)     4=Setting(change)
5=Test
```

```
/1 Record
1=Fault record        2=Event record
3=Disturbance record  4=Automatic test
5=Autoreclose count
```

```
/2 Fault record
1=Display         2=Clear
```

```
/3 Fault record                    2/8
#1  16/Oct/1998 23:18:03.913
#2  12/Feb/1998 03:51:37.622
#3  30/Jan/1997 15:06:11.835
```

```
/4 Fault record #2                3/33
16/Oct/1998 23:18:03.913
Phase  BC        Trip   ABC/ABC
Z1,CRT
```

```
/2 Fault record
Clear all fault records?
      ENTER=Yes   CANCEL=No
```

```
/2 Event record
1=Display         2=Clear
```

```
/3 Event record                   2/48
16/Oct/1998 23:18:04.294 Trip      Off
16/Oct/1998 23:18:03.913 Trip       On
12/Feb/1998 03:51:37.622 Rly.set change
```

```
/2 Event record
Clear all event records ?
      ENTER=Yes   CANCEL=No
```

```
/2 Disturbance record
1=Display         2=Clear
```

```
/3 Disturbance record            1/ 11
#1  16/Oct/1998 23:18:03.913
#2  12/Feb/1998 03:51:37.622
#3  30/Jan/1997 15:06:11.835
```

```
/2 Disturbance record
Clear all disturbance records ?
      ENTER=Yes   CANCEL=No
```

```
/2 Automatic test
1=Telecomm channel test
```

```
/3 Telecomm channel test
1=Display count & interval
2=Reset count
```

```
/4 Telecomm channel test
Test count:          11
Test interval:       12 hours
```

```
/3 Telecomm channel test
Reset count ?
      ENTER=Yes   CANCEL=No
```

```
/2 Autoreclose count
1=Display      2=Reset
```

```
/3 Autoreclose count
           SPAR     TPAR
   CB1    [  46]   [  46]
```

```
/3 Reset autoreclose count
1=CB1
```

```
/3 Reset autoreclose count
Reset count ?
      ENTER=Yes   CANCEL=No
```

a-1

a-1

```
/1 Status
1=Metering           2=Binary I/O
3=Relay element      4=Time sync source
5=Clock adjustment   6=Direction
```

```
/2 Metering    12/Feb/1998  22:56  3/34
Va  ***.*kV ***.*  Ia    **.**kA  ***.*
Vb  ***.*kV ***.*  Ib    **.**kA  ***.*
Vc  ***.*kV ***.*  Ic    **.**kA  ***.*
```

```
/2 Binary input & output          3/ 8
Input (IO#1)      [000 000 000 000    ]
Input (IO#2)      [000                ]
Input (IO#3)      [000 000 000 0      ]
```

```
/2 Relay element                  3/ 12
ZG               [000 000 000 000 000]
ZG2              [000 000 000 000    ]
ZS               [000 000 000 000 000]
```

```
/2 Time synchronization source    3/ 4
*IRIG: Active
 RSM: Inactive
 IEC: Inactive
```

```
/2  12/Feb/1998  22:56:19 [local] 1/ 5
Minute (  0 -  59) :  56  _
Hour   (  0 -  23) :  22
Day    (  1 -  31) :  12
```

```
/2 Direction
Phase A: Forward
Phase B: Reverse
Phase C: _______
```

```
/1 Setting(view)
1=Version  2=Description 3=Comm.
4=Record  5=Status      6=Protection
7=Binary input  8=Binary output  9=LED
```

```
/2 Relay version                 3/ 6
Relay type :     ********************
Serial No. :     ********************
Main software:   ********************
```

```
/2 Description                   2/ 2
Plant name:      ********************
Description:     ********************
```

```
/2 Communication
1=Address/Parameter
2=Switch
```

```
/3 Address/Paameter               1/ 2
HDLC   (     1     )
IEC    (     1     )  SYADJ (    0 ms )
```

```
/3 Switch                         3/ 4
PRTCL1    1=HDLC  2=IEC103          1
232C      1=9.6 2=19.2 3=38.4 4=57.6 4
IECBR     1=9.6 2=19.2              2
```

```
/2 Record
1=Fault record          2=Event record
3=Disturbance record
4=Automatic test interval
```

```
/3 Fault record                   1/ 1
Fault locator      0=Off   1=On     1
```

```
/3 Event record
1=Signal no.
2=Event name
```

```
/3 Disturbance record
1=Record time & starter
2=Scheme switch
3=Binary signal      4=Signal name
```

```
/3 Automatic test interval        1/ 1
Chann(      6 hrs)
```

```
/4 Signal no.                     3/ 65
BITRN (  128     )  EV1    ( 3071    )
EV2   (    0     )  EV3    (    1    )
EV4   (    1     )  EV5    (    2    )
```

```
/4 Event name                     3/128
Event name1   [Event record name 1 ]
Event name2   [                    ]
Event name3   [                    ]
```

```
/4 Record time & starter          2/ 3
Time   (  3.0 s  )  OCP-S ( 50.0 A  )
OCP-G ( 50.0 A  )  UVP-S (     0 V  )
UVP-G (     0 V  )
```

```
/4 Scheme swith                   1/ 5
TRIP                0=Off   1=On    1
OCP-S               0=Off   1=On    1
OCP-G               0=Off   1=On    1
```

```
/4 Binary signal                  3/ 16
SIG1   (  128     )  SIG2  ( 3071    )
SIG3   (    0     )  SIG4  (    1    )
SIG5   (    1     )  SIG6  (    2    )
```

```
/4 Signal name                    3/ 32
Signal name1  [Signal name 1       ]
Signal name2  [                    ]
Signal name3  [                    ]
```

```
/2 Status
1=Metering
2=Time Synchronization
3=Time zone
```

```
/3 Metering                       3/ 3
Display value 1=Primary 2=Secondary 1
Power (P/Q)    1=Send    2=Receive   1
Current        1=Lag     2=Lead      1
```

```
/3 Time synchronization
0=Off 1=IRIG 2=RSM 3=IEC 4=RMT

  Current No.= 2
```

```
/3 Time zone                      1/ 1
GMT (      +9 hrs )
```

a-1 a-2

a-1 a-2

```
/2 Protection         (Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
```

```
/3 Protection                  (Group 1)
1=Line parameter
2=Telecommunication    3=Trip
4=Autoreclose
```

```
/4 Line parameter              (Group 1)
1=Line name
2=VT & CT ratio
3=Fault locator
```

```
/5 Line name                        1/ 1
Line name       ********************
```

```
/5 VT & CT ratio                    2/ 2
VT    (   2000    )  VTs1 (   2000    )
VTs1  (   2000    )  CT   (    200    )
```

```
/5 Fault locator                    3/ 7
X1    (  32.60 Ω )    X0  (   2.90 Ω )
X0m   (  14.00 Ω )    R1  (  60.00 Ω )
R0    (   5.00 Ω )    R0m (  10.00 Ω )
```

```
/4 Telecommunication           (Group 1)
1=Scheme switch
2=Telecommunication element
```

```
/5 Scheme switch                    3/10
CO.LINK  1=Int  2=Ext                  1
SP.SYN.  1=Master  2=Slave             1
TERM     1=2TERM 2=3TERM 3=DUAL        1
```

```
/5 Telecommunication element        3/ 3
RYID  (    0    )  RYID1 (    1    )
RYID2 (    2    )  TDSV  ( 6000 us )
TCDT1 (   10 us )  TCDT2 (   10 us )
```

```
/4 Trip                        (Group 1)
1=Protection scheme
2=Scheme switch
3=Protection element
```

```
/5 Protection scheme
1=3ZONE 2=Z1-EXT 3=PUP 4=POP 5=UOP 6=BOP
7=POP+DEF 8=UOP+DEF 9=BOP+DEF 10=PUP+DEF
  Current No.=7
```

```
/5 Scheme switch                    3/**
ZS-C    1=Mho  2=Quad                  1
ZG-C    1=Mho  2=Quad                  1
Z1CNT   1=1  2=2  3=3  4=4  5=5        1
```

```
/5 Protection element          (Group 1)
1=Distance    2=PSB&OST    3=OC,DEF&UV
4=Command trip
```

```
/6 Distance                         3/**
Z1S    (  0.01 Ω  )  Z1Sθ1 ( 0 deg  )
Z1Sθ2  (  90 deg  )  Z1XS  ( 0.01 Ω )
Z2S    (  0.01 Ω  )  Z3S   ( 1.0 Ω  )
```

```
/6 PSB&OST                          3/ 5
PSBSZ  (  0.50 Ω  )  PSBGZ (  0.50 Ω )
TPSB   (    40 ms )  OSTR1 (  1.0 Ω)
OSTR2  (   1.0 Ω  )  OSTXF (  0.2 Ω )
```

```
/6 OC,DEF&UV                        3/11
OCH    (   2.0 A  )  TPSB  (   40 ms )
OCBF   (   0.5 A  )  TBF1  (   50 ms )
TBF2   (    50 ms )  DEFFI (   0.5 A)
```

```
/6 Command trip                     2/ 2
TDEFF  (  0.00 s  )  TDEFR (  0.00 s )
TCHD   (    12 ms )
```

```
/4 Autoreclose                 (Group 1)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

```
/5 Autoreclose mode
1=Disable  2=SPAR 3=TPAR 4=SPAR&TPAR
5=EXT1P  6=EXT3P
  Current No.= 4
```

```
/5 Scheme switch                    3/ 8
ARC-CB   1=ONE 2=01 3=03 4=L1 5=L2  1
ARC-EXT  0=Off   1=On                  0
ARC-DEF  0=Off   1=On                  1
```

```
/5 Autoreclose element         (Group 1)
1=Autoreclose timer
2=Synchrocheck
```

```
/6 Autoreclose timer                3/ 8
TEVLV(   0.30 s  )  TRDY1(   60 s   )
TSPR (   0.80 s  )  TTPR1(  0.60 s  )
TRR  (   2.00 s  )  TW1  (   0.3 s  )
```

```
/6 Synchrocheck                     3/ 9
OVB  (    51 V  )  UVB  (   13 V   )
OVL1 (    51 V  )  UVL1 (   13 V   )
SY1UV(    83 V  )  SY1OV(   51 V   )
```

```
/3 Protection                  (Group 2)
1=Line parameter
2=Trip
3=Autoreclose relay
```

```
/3 Protection                  (Group 8)
1=Line parameter
2=Trip
3=Autoreclose relay
```

a-1 a-2

a-1 a-2

```
/2 Binary input                    3/18
BISW1  1=Norm  =Inv                1
BISW2  1=Norm  =Inv                1
BISW3  1=Norm  =Inv                1
```

```
/2 Binary output
1=IO#2     2=IO#3    3=IO#4
```

```
/3 Binary output             (IO#2) 3/12
BO1  (  1,  2,  3,  4,  5,  6) AND,D
BO2  (  1,  2,  3,  4,  5,  6)  OR,
BO3  (  1,  2,  3,  4,  5,  6)  OR,D
```

```
/3 Binary output             (IO#4) 3/12
BO1  (  1,  2,  3,  4,  5,  6) AND,D
BO2  (  1,  2,  3,  4,  5,  6)  OR,
BO3  (  1,  2,  3,  4,  5,  6)  OR,D
```

```
/2 LED                             2/ 4
LED1   (    1,  309,    0,    0) AND, I
LED2   (    0,    0,    0,    0)  OR, I
LED3   (   15,   16,   17,    0)  OR, L
```

: Password trap

```
 Password
        Input password  [_  ]
```

```
/1 Setting(change)
1=Password 2=Description  3=Comm.
4=Record    5=Status       6=Protection
7=Binary input  8=Binary output   9=LED
```

: Confirmation trap

```
/2 *************
Change settings?
         ENTER=Yes  CANCEL=No
```

```
/2 Password
    Input new password    [ _ ]
   Retype new password    [   ]
```

```
/2 Description
1=Plant name  2=Description
```

```
/3 Plant name  [ _                    ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^           ← →
```

```
/3 Description  [ _                   ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^           ← →
```

```
/2 Communication
1=Address/Parameter
2=Switch
```

```
/3 Address/Parameter            1/ 15
HDLC   (      1-      32):     1 _
IEC    (      2-     254):     2
SYADJ  ( -9999 -    9999):     0    ms
```

```
/3 Switch                         1/ 4
PRTCL1  1=HDLC  2=IEC103          1 _
232C    1=9.6 2=19.2 3=38.4 4=57.6  4
IECBR   1=9.6 2=19.2              2
```

```
/2 Record
1=Fault record            2=Event record
3=Disturbance record
4=Automatic test interval
```

```
/3 Fault record                  1/ 1
Fault locator     0=Off   1=On   1 _
```

```
/3 Event record                  1/129
BITRN (      0-     128):    128 _
EV1   (      0-    3071):      0
EV2   (      0-    3071):      1
```

```
/3 Disturbance record
1=Record time & starter
2=Scheme switch
3=Binary signal
```

```
/4 Record time & starter         1/ 5
Time   (   0.1-    3.0):    2.0  _   s
OCP-S  (   0.5- 250.0):    10.0      A
OCP-G  (   0.5- 250.0):    10.0      A
```

```
/4 Scheme switch                 1/ 5
TRIP               0=Off   1=On   1 _
OCP-S              0=Off   1=On
OCP-G              0=Off   1=On
```

```
/3 Automatic test interval       1/ 1
Chann(     1-     24):     12  _   hrs
```

```
/4 Binary signal                  3/32
SIG1   (  0 -  3071)  :  1
SIG2   (  0 -  3071)  :  1
SIG3   (  0 -  3071)  :  1  _
```

a-1 a-3

a-1 a-3

```
/2 Status
1=Metering
2=Time Synchronization
3=Time zone
```

```
/3 Metering                          1/ 3
Display value 1=Primary 2=Secondary 1_
Power (P/Q)    1=Send    2=Receive   1
Current        1=Lag     2=Lead      1
```

```
/3 Time synchronization
0=Off 1=IRIG 2=RSM 3=IEC 4=RMT

  Current No.=0        Select No.= _
```

```
/3 Time zone                         1/ 1
GMT (   -12 -   +12):    +9  _     hrs
```

```
/2 Protection
1=Change active group
2=Change setting
3=Copy group
```

```
/3Change active group(Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
  Current No.= *        Select No.= _
```

```
/3 Change setting (Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
```

```
/4 Protection                (Group 1)
1=Line parameter
2=Telecommunication    3=Trip
4=Autoreclose
```

```
/5 Line parameter            (Group 1)
1=Line name
2=VT & CT ratio
3=Fault locator
```

```
/6 Line name [ _                       ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^           ← →
```

```
/6 VT & CT ratio                     1/ 7
VT    (      1- 20000):    2200  _
VTs1  (      1- 20000):    2200
VTr1  (      1- 20000):    2000
```

```
/6 Fault locator                     1/21
X1    ( 0.00 - 199.99): 32.60  _   Ω
X0    ( 0.00 - 199.99):  2.90      Ω
X0m   ( 0.00 - 199.99):  0.10      Ω
```

```
/5 Telecommunication          (Group 1)
1=Scheme switch
2=Telecommunication element
```

```
/6 Scheme switch                     3/10
CO.LINK  1=Int  2=Ext                1 _
```

```
/6 Telecommunication element         1/ 6
RYID   (    0 -     63) :   0 _
RYID1  (    0 -     63) :   0
RYID2  (    0 -     63) :   0
```

```
/5 Trip                       (Group 1)
1=Protection scheme
2=Scheme switch
3=Protection element
```

```
/6 Protection scheme
1=3ZONE 2=Z1-EXT 3=PUP 4=POP 5=UOP 6=BOP
7=POP+DEF 8=UOP+DEF 9=BOP+DEF 10=PUP+DEF
  Current No.= 7          Select No.= _
```

```
/6 Scheme switch                     1/**
ZS-C     1=Mho   2=Quad              1  _
ZG-C     1=Mho   2=Quad              1
Z1CNT    1=1  2=2  3=3  4=4  5=5     1
```

```
/6 Protection element         (Group 1)
1=Distance     2=PSB&OST    3=OC,DEF&UV
4=Command trip
```

```
/7 Distance                          1/**
Z1S   (  0.01 -  50.00):  0.01  _   Ω
Z1XS  (  0.01 -  50.00):  0.01      Ω
Z1Sθ1 (     0 -     45):     0      deg
```

```
/7 PSB&OST                           1/ 9
PSBSZ ( 0.50 -  15.00):  0.50  _    Ω
PSBGZ ( 0.50 -  15.00):  0.50       Ω
TPSB  (   20 -     60):    40       ms
```

```
/7 OC,DEF&UV                         1/21
OCH   (   2.0 -   10.0):    2.0  _   A
TSOTF(      0 -    300):      5      s
OCBF  (   0.5 -   10.0):    0.5      A
```

```
/7 Command trip                      1/ 7
TDEFF  ( 0.00-  0.30):   0.00  _    s
TDEFR  ( 0.00-  0.30):   0.00       s
TCHD   (    0-    50):     12       ms
```

a-1 a-3 a-4 a-5 a-6

a-1 a-3 a-4 a-5 a-6

```
/5 Autoreclose                (Group 1)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

```
/6 Autoreclose mode
1=Disable  2=SPAR 3=TPAR 4=SPAR&TPAR
5=EXT1P  6=EXT3P
  Current No.= 4       Select No.= _
```

```
/6 Scheme switch                 1/ 10
ARC-EXT 0=Off   1=On                0 _
ARC-DEF 0=Off   1=On                0
ARC-BU  0=Off   1=On                0
```

```
/6 Autoreclose element        (Group 1)
1=Autoreclose timer
2=Synchrocheck
```

```
/7 Autoreclose timer                1/13
TEVLV (  0.01-  10.00):   0.30 _   s
TRDY1 (      5-   300):     60     s
TSPR1 (  0.01-  10.00):   0.80     s
```

```
/7 Synchrocheck                     1/18
OVB  (    10 -   150):     51 _    V
UVB  (    10 -   150):     13      V
OVL1 (    10 -   150):     51      V
```

```
/4 Protection                 (Group 2)
1=Line parameter
2=Trip
3=Autoreclose
```

```
/4 Protection                 (Group 8)
1=Line parameters
2=Trip
3=Autoreclose
```

```
/3 Copy groupA to B  (Active group= 1)
A    (    1-    8):              _
B    (    1-    8):
```

```
/2 Binary input                    1/18
BISW1  1=Norm  2=Inv                1 _
BISW2  1=Norm  2=Inv                1
BISW3  1=Norm  2=Inv                1
```

```
/2 Binary output
1=IO#2     2=IO#3    3=IO#4
```

```
/3 Binary output                (IO#2 )
Select BO           (  1- 12)

                   Select No.= _
```

```
/4 Setting                (BO 1 of IO#2 )
1=Logic gate type & delay timer
2=Input to logic gate
```

```
/5 Logic gate type & delay timer  1/ 2
Logic    1=OR  2=AND               1 _
BOTD     0=Off  1=On               1
```

```
/4 Setting               (BO 12 of IO#2 )
1=Logic gate type & delay timer
2=Input to logic gate
```

```
/5 Input to logic gate           3/ 6
In #1 (      0 -   3071):     21
In #2 (      0 -   3071):     67
In #3 (      0 -   3071):     12  _
```

```
/4 Binary output                (IO#4 )
Select BO            (  1-  14)

                      Select No.=_
```

```
/2 LED
Select LED          (  1 -   4)

                     Select No.=_
```

```
/3 Setting                      (LED1)
1=Logic gate type & reset
2=Input to logic gate
```

```
/4 Logic gate type & delay timer  1/ 2
Logic    1=OR    2=AND             1 _
Reset    0=Inst 1=Latch            1
```

```
/3 Setting                      (LED4)
1=Logic gate type & reset
2=Input to logic gate
```

```
/4 Input to logic gate           1/ 4
In #1 (      0 -   3071):    274  _
In #2 (      0 -   3071):    289
In #3 (      0 -   3071):    295
```

a-1

a-1

```
/1 Test
1=Switch                  2=Manual test
3=Binary output           4=Timer
5=Logic circuit
```

```
/2 Switch                              1/8
A.M.F.    0=Off  1=On                  1 _
Z1S-1PH   0=Off  1=On                  0
ZB-CTRL   0=Norm 1=OFST 2=Non-OFST     0
```

```
/2 Manual test
1=Telecomm channel test

Press number to start test.
```

```
/2 Manual test
Telecom channel testing . . .
```

```
/2 Manual test
Telecom channel testing . . .
              Completed.
```

```
/2 Binary output
1=IO#1  2=IO#2  3=IO#3  4=IO#4
```

```
/3 BO        (0=Disable 1=Enable)  1/ 3
IO#1 TP-A1                         1 _
IO#1 TP-B1                         1
IO#1 TP-C1                         1
```

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

```
/3 BO        (0=Disable 1=Enable)  1/14
IO#4  BO1                          1 _
IO#4  BO2                          1
IO#4  BO3                          1
```

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

```
/2 Timer                           1/ 1
Timer(     1 -     60):       8 _
```

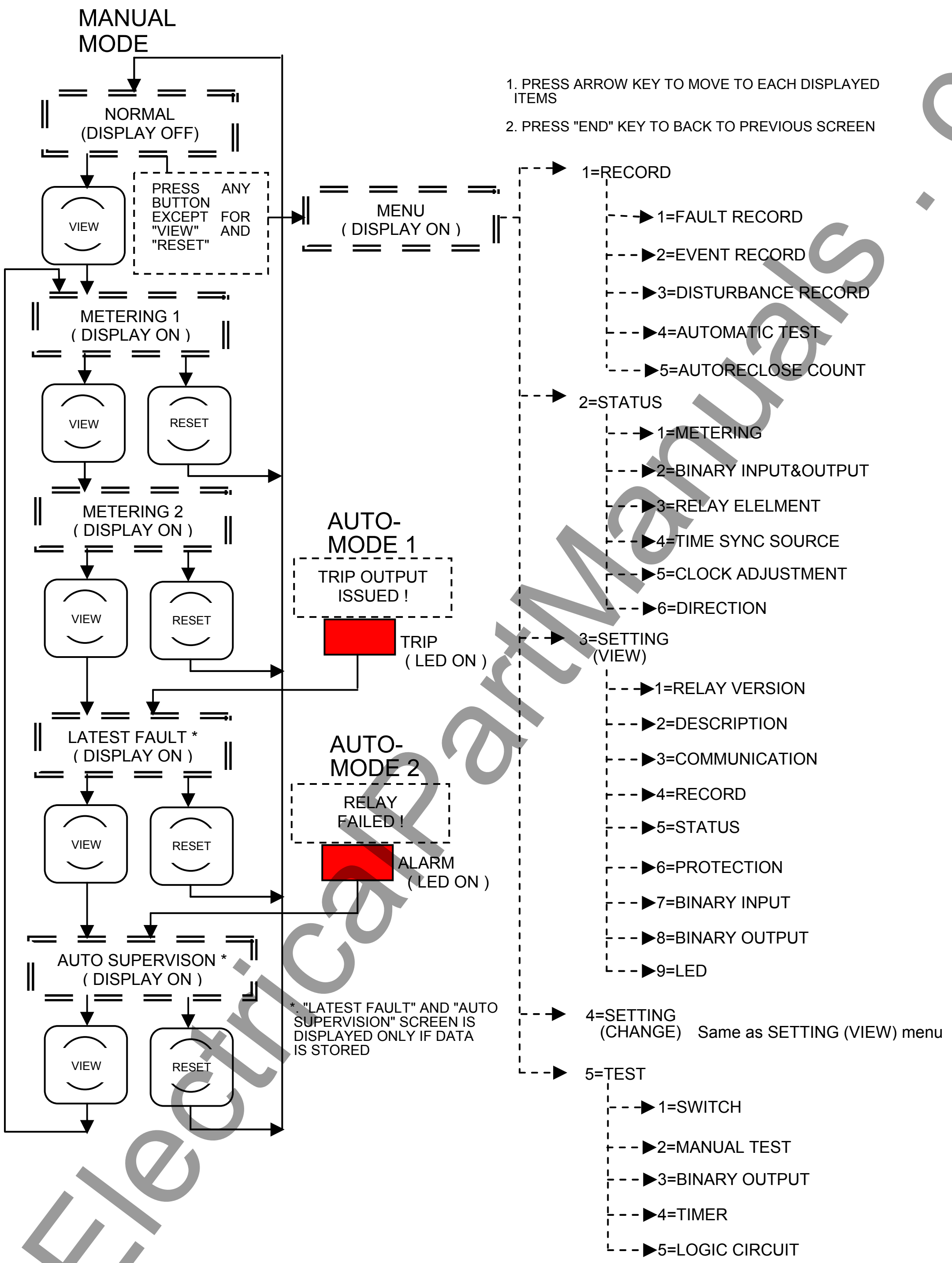
```
/2 Timer                           1/ 1
Press ENTER to operate.

Press CANCEL to cancel.
```

```
/2 Timer                           1/ 1
Operating . . .
Press END to reset.
Press CANCEL to cancel.
```

```
/2 Logic circuit                    1/ 2
TermA(     0 -   3071):       12  _
TermB(     0 -   3071):       48
```

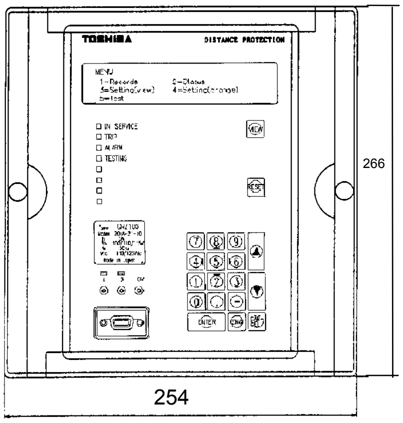
LCD AND BUTTON OPERATION INSTRUCTION



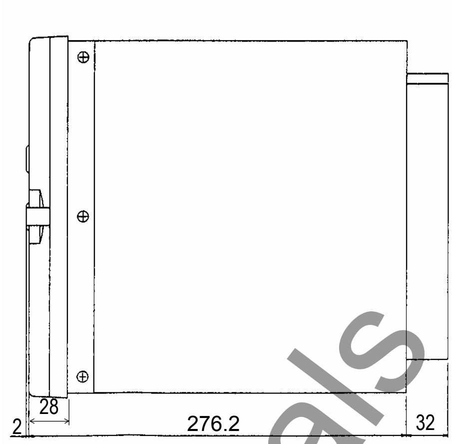
Appendix F

Case Outline

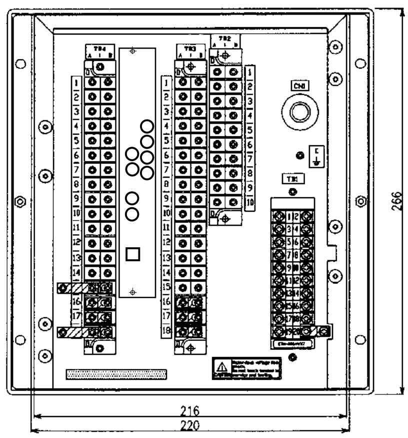
- Case Type-A: Flush Mount Type
- Case Type-B: Flush Mount Type
- Case Type-A, B: Rack Mount Type



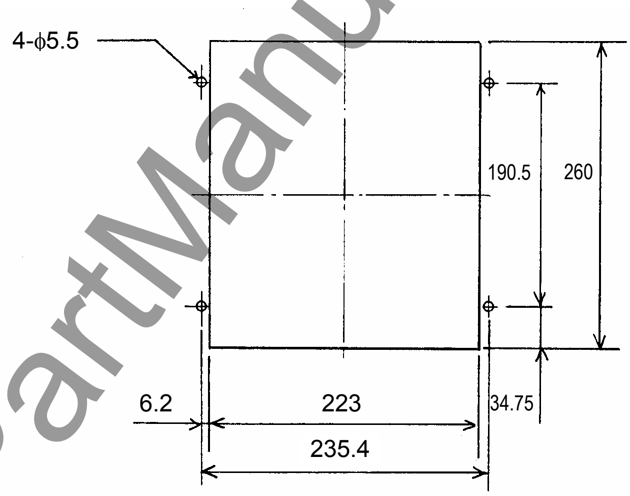
Front View



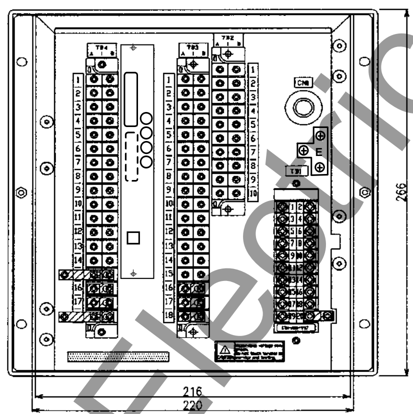
Side view



Optical interface

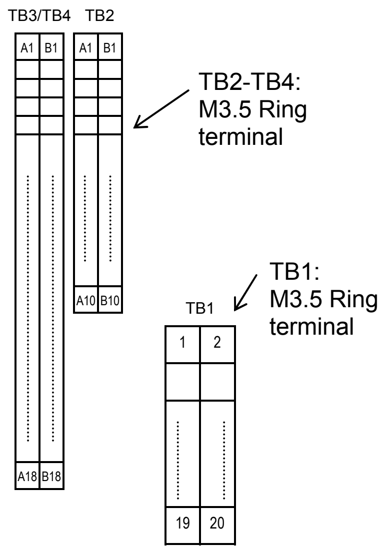


Panel Cut-out



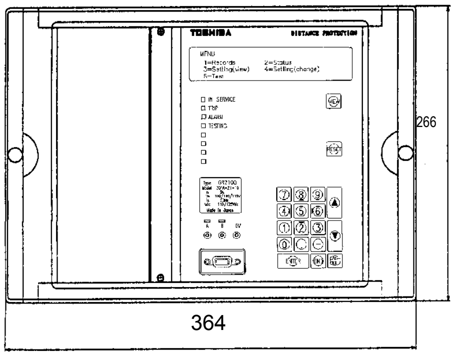
Electrical interface

Rear View

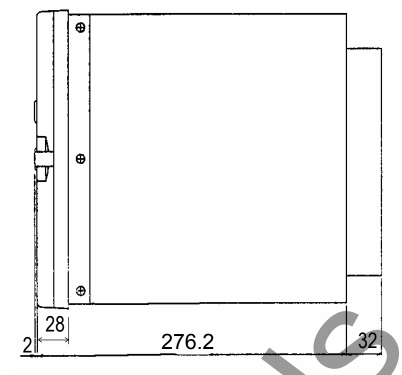


Terminal Block

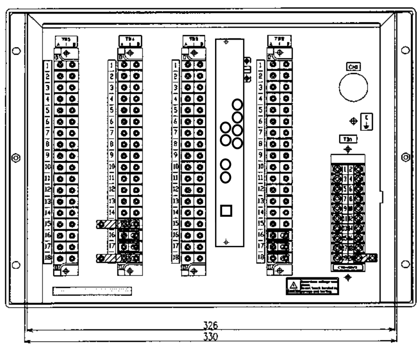
Case Type-A: Flush Mount Type for Model 211, 214, 221, 224, 311, 321



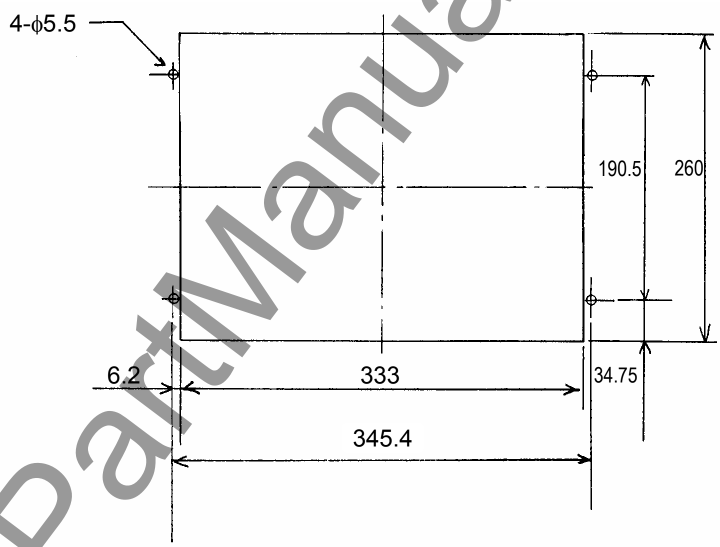
Front View



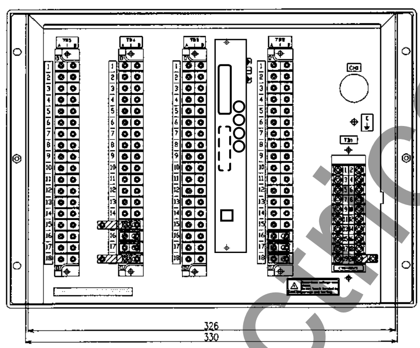
Side view



Optical interface

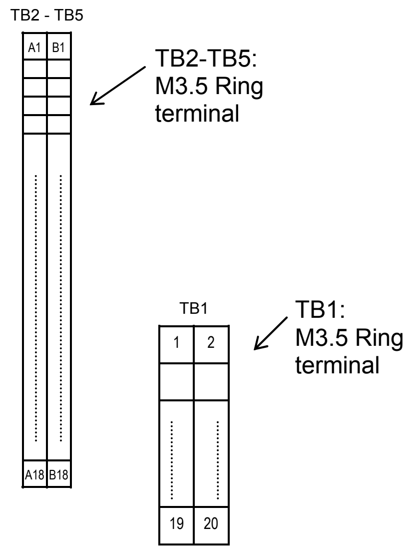


Panel Cut-out



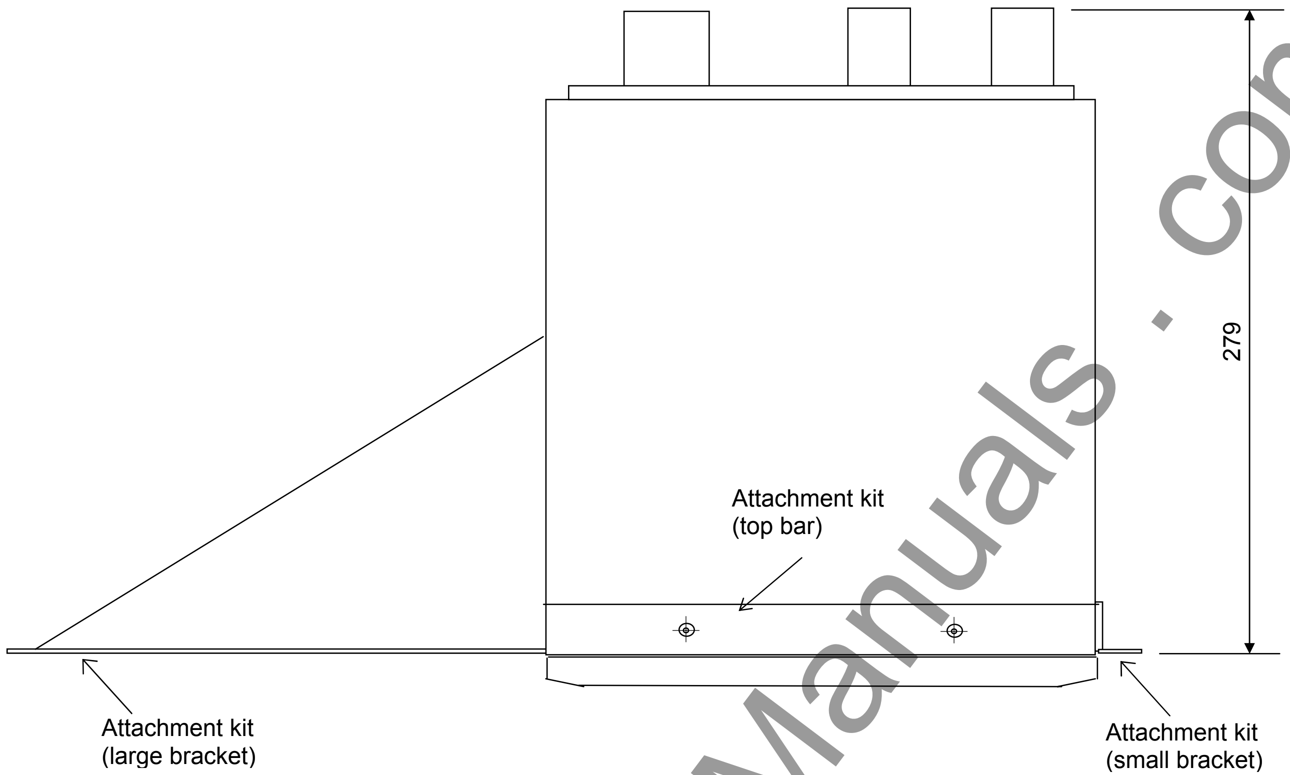
Electrical interface

Rear View

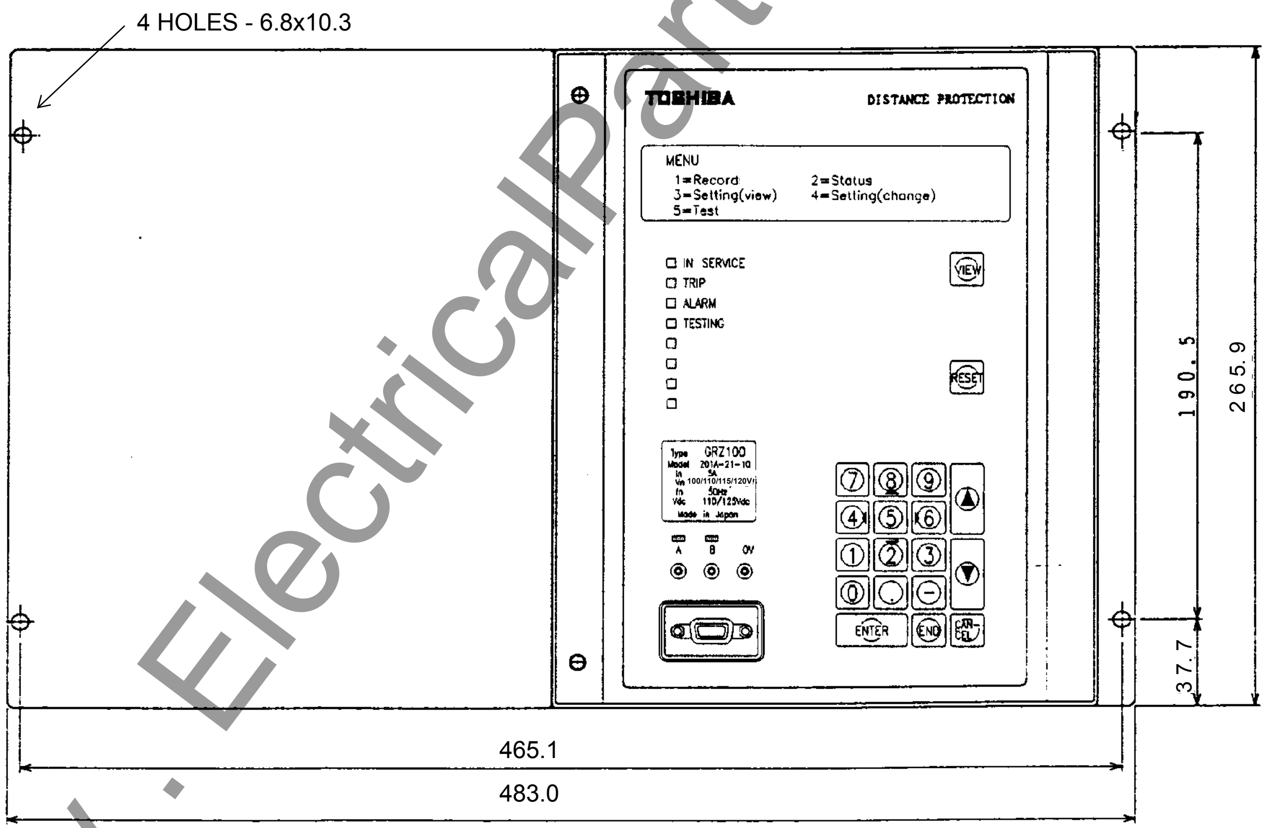


Terminal Block

Case Type-B: Flush Mount Type for Model 216, 226, 323

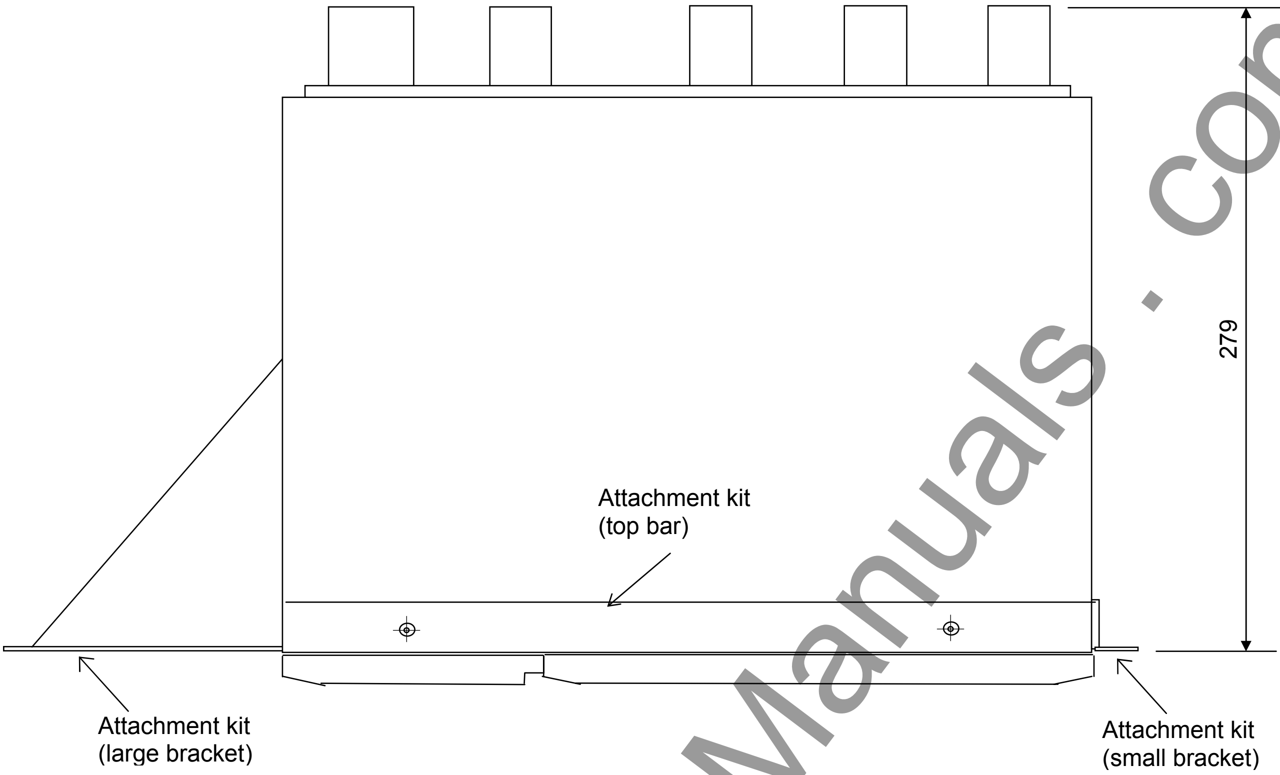


Top View

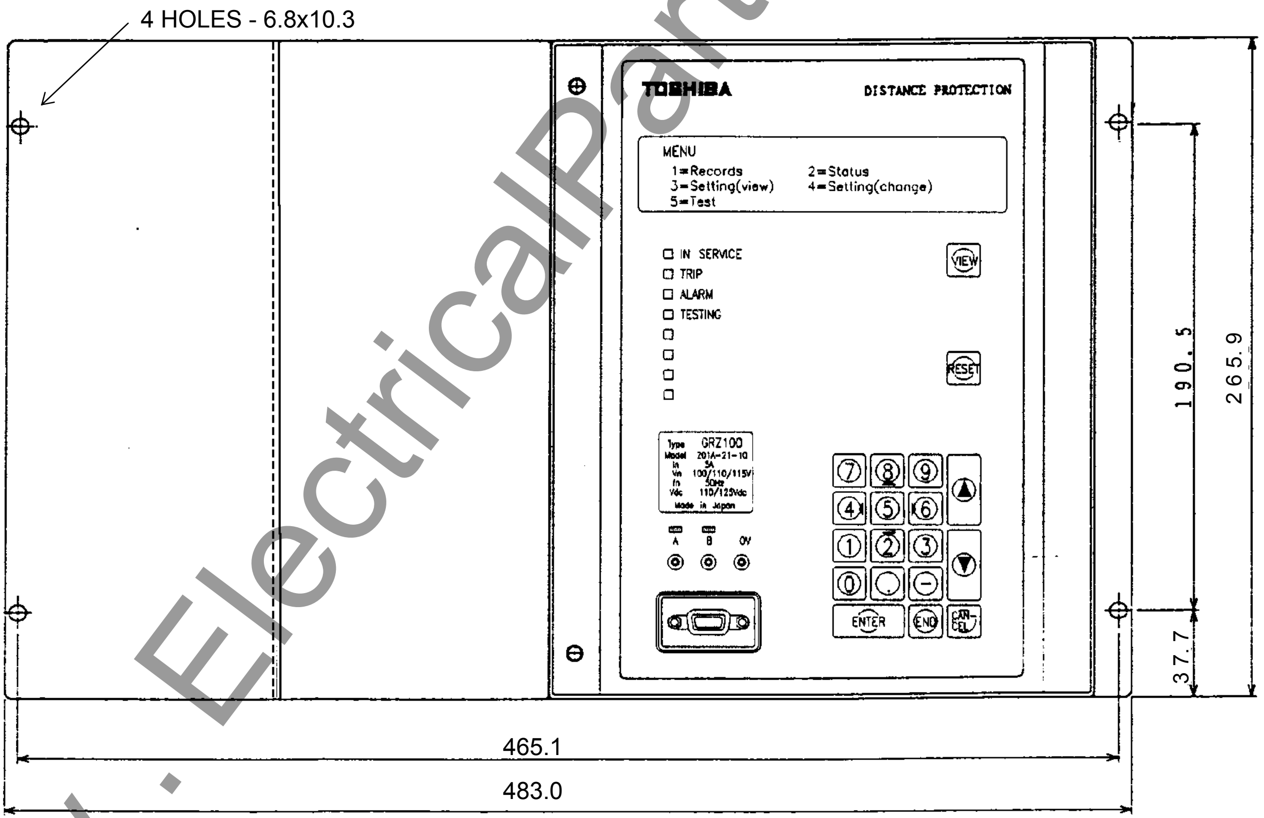


Front View

Rack Mount Type: Case Type-A for Model 211, 214, 221, 224, 311, 321

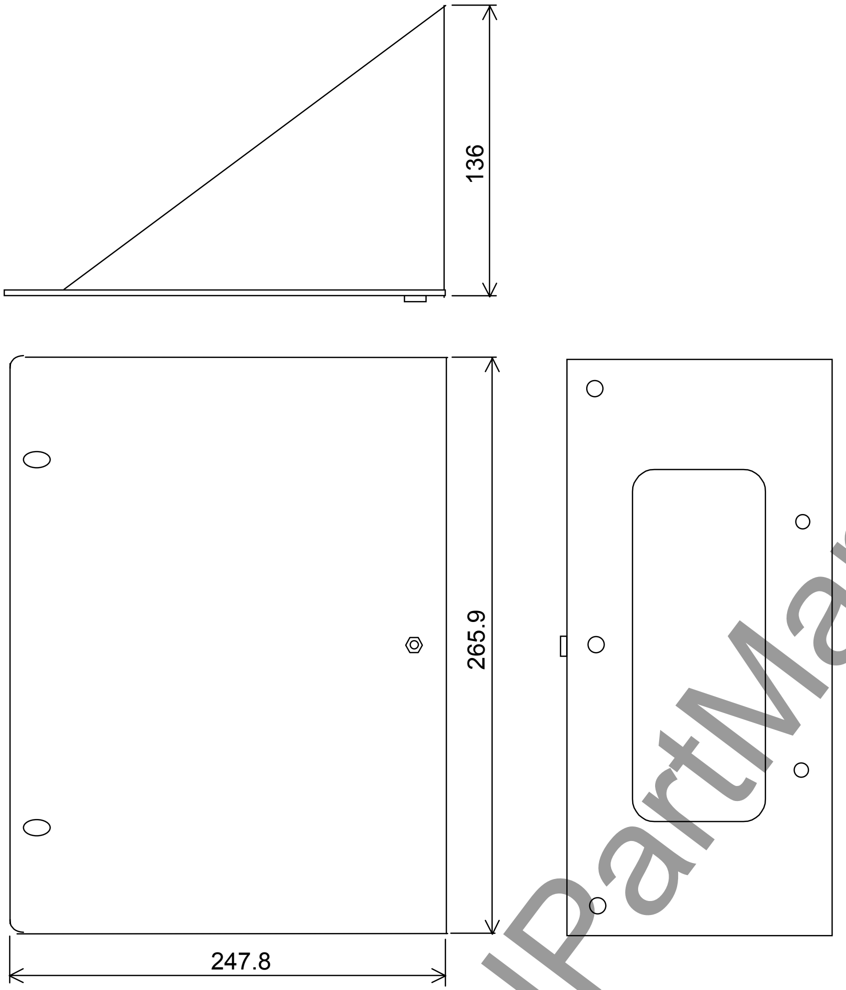


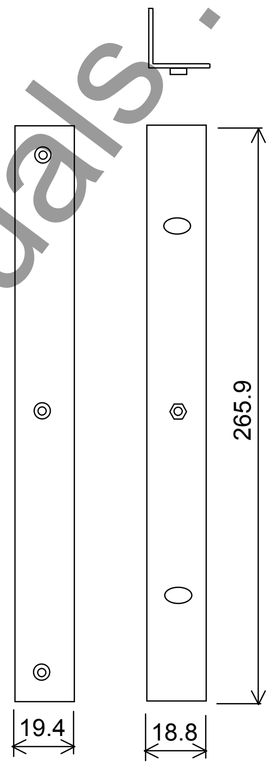
Top View



Front View

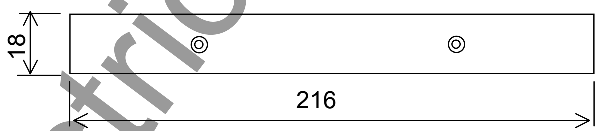
Rack Mount: Case Type-B for Model 216, 226, 323





(a) Large Bracket

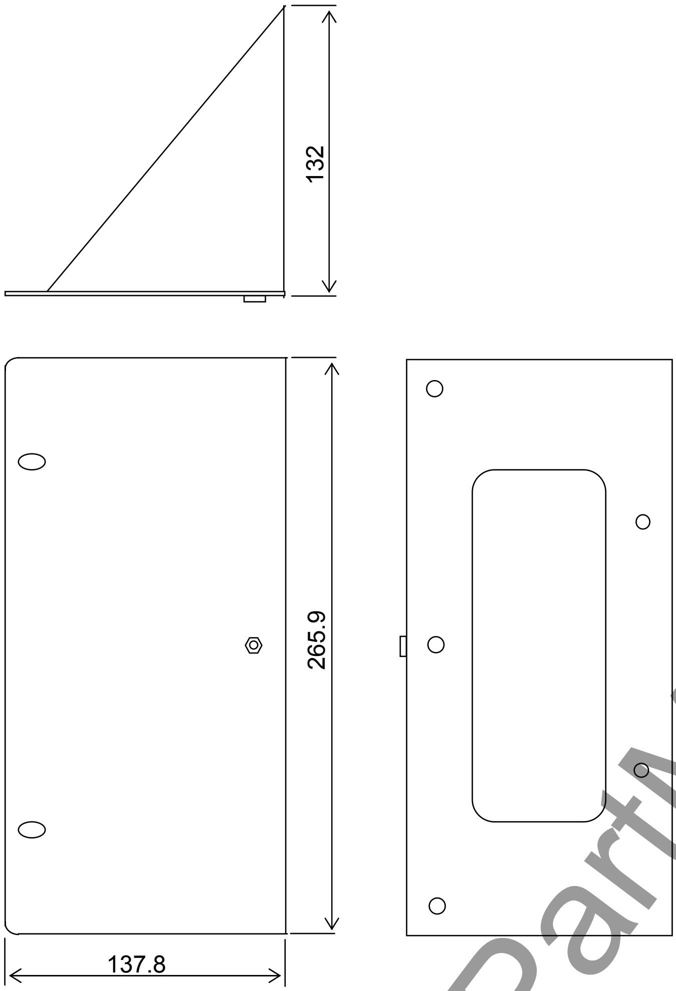
(b) Small Bracket

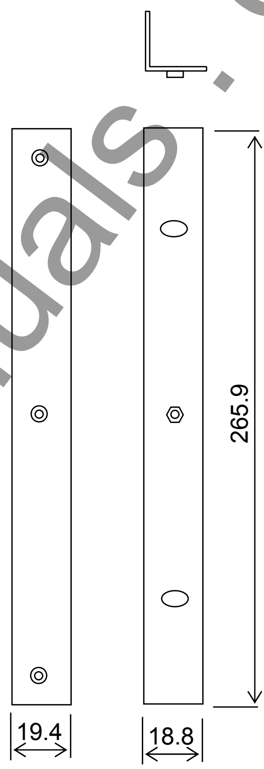


(c) Bar for Top and Bottom of Relay

	Parts
(a)	1 Large bracket, 5 Round head screws with spring washers and washers (M4x10)
(b)	1 Small bracket, 3 Countersunk head screws (M4x6)
(c)	2 Bars, 4 Countersunk head screws (M3x8)

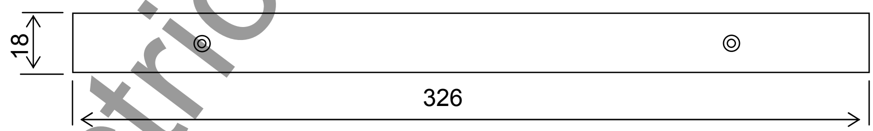
Dimensions of Attachment Kit EP-101





(a) Large Bracket

(b) Small Bracket



(c) Bar for Top and Bottom of Relay

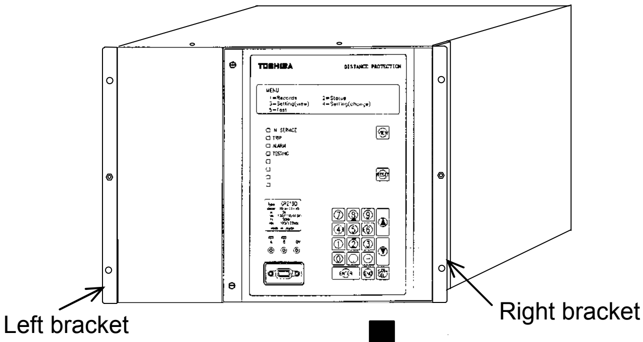
	Parts
(a)	1 Large bracket, 5 Round head screws with spring washers and washers (M4x10)
(b)	1 Small bracket, 3 Countersunk head screws (M4x6)
(c)	2 Bars, 4 Countersunk head screws (M3x8)

Dimensions of Attachment Kit EP-102

How to Mount Attachment Kit for Rack-Mounting

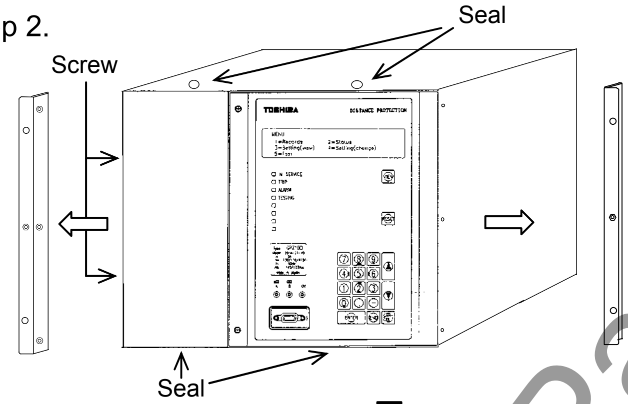
Caution: Be careful that the relay modules or terminal blocks, etc., are not damage while mounting.
Tighten screws to the specified torque according to the size of screw.

Step 1.



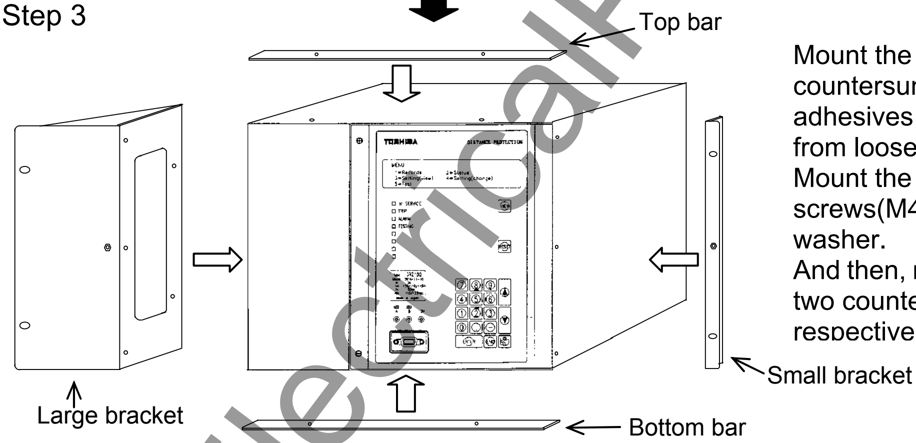
Remove case cover.

Step 2.



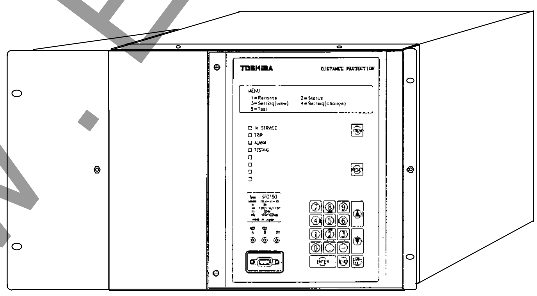
Remove the left and right brackets by unscrewing the three screws respectively, then remove two screws on left side of the relay.
And then, remove four seals on the top and bottom of the relay.

Step 3



Mount the small bracket by screwing three countersunk head screws(M4x6) and apply adhesives to the screws to prevent them from loosening.
Mount the large bracket by five round head screws(M4x10) with washer and spring washer.
And then, mount the top and bottom bars by two countersunk head screws(M3x8) respectively.

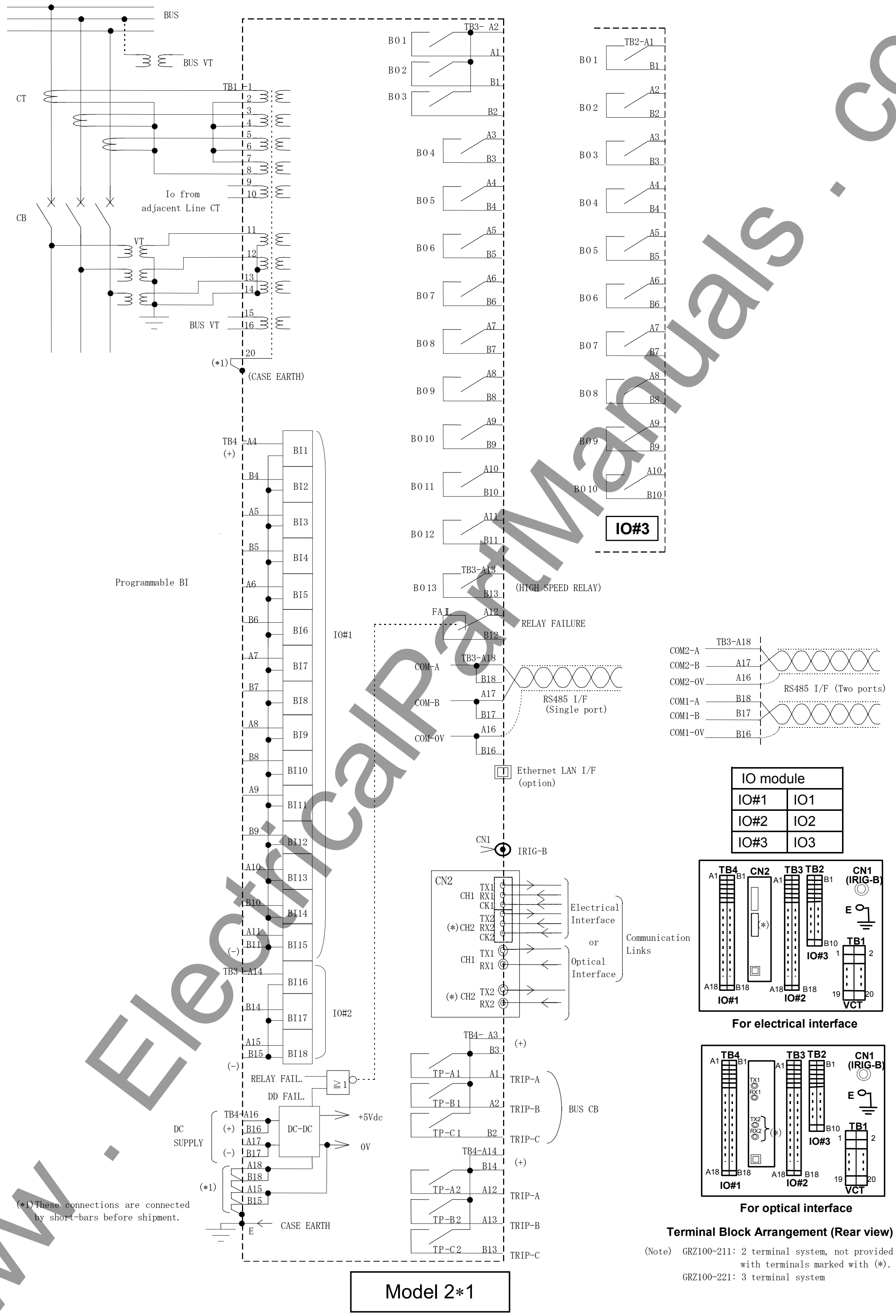
Step 4

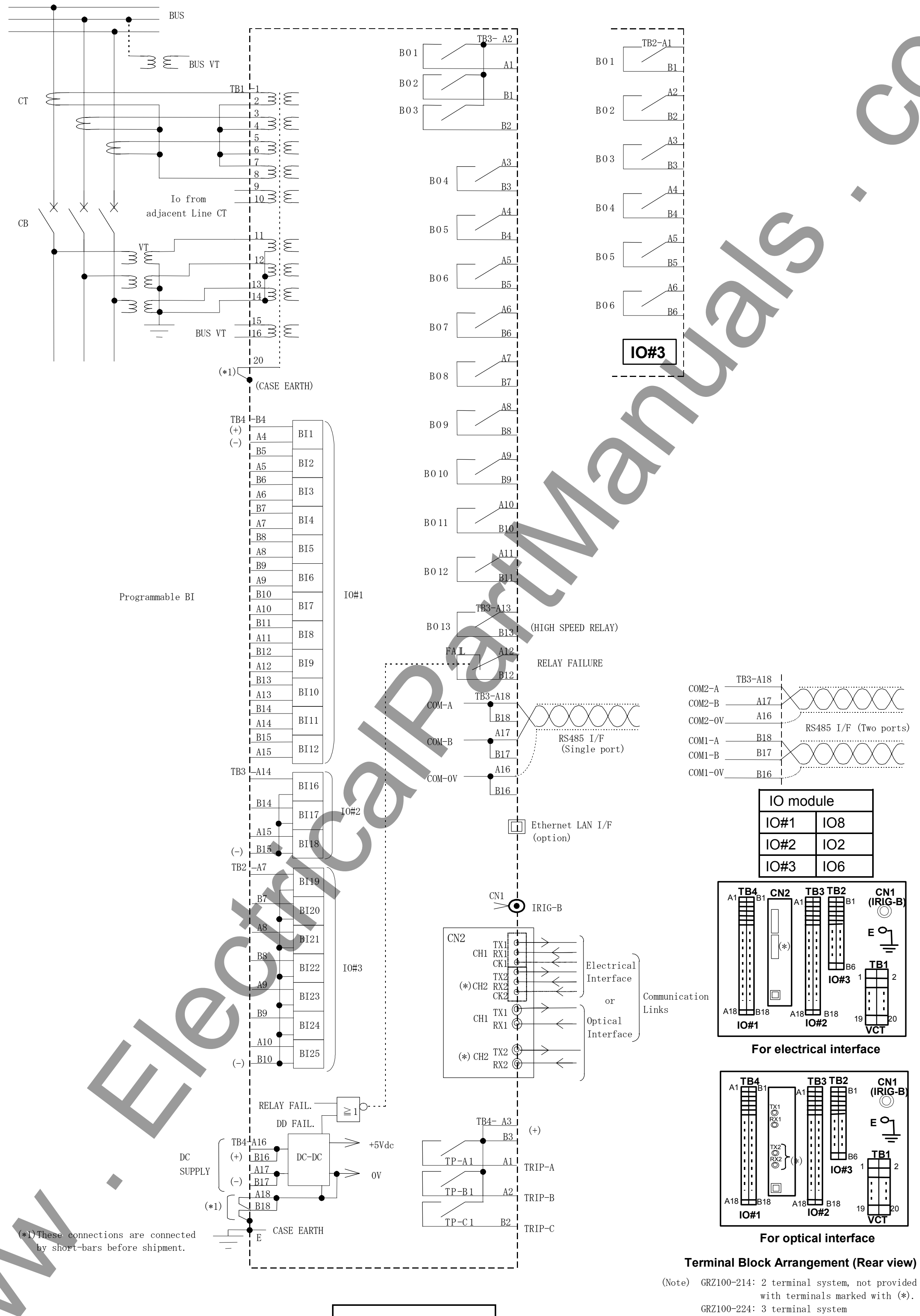


Completed.

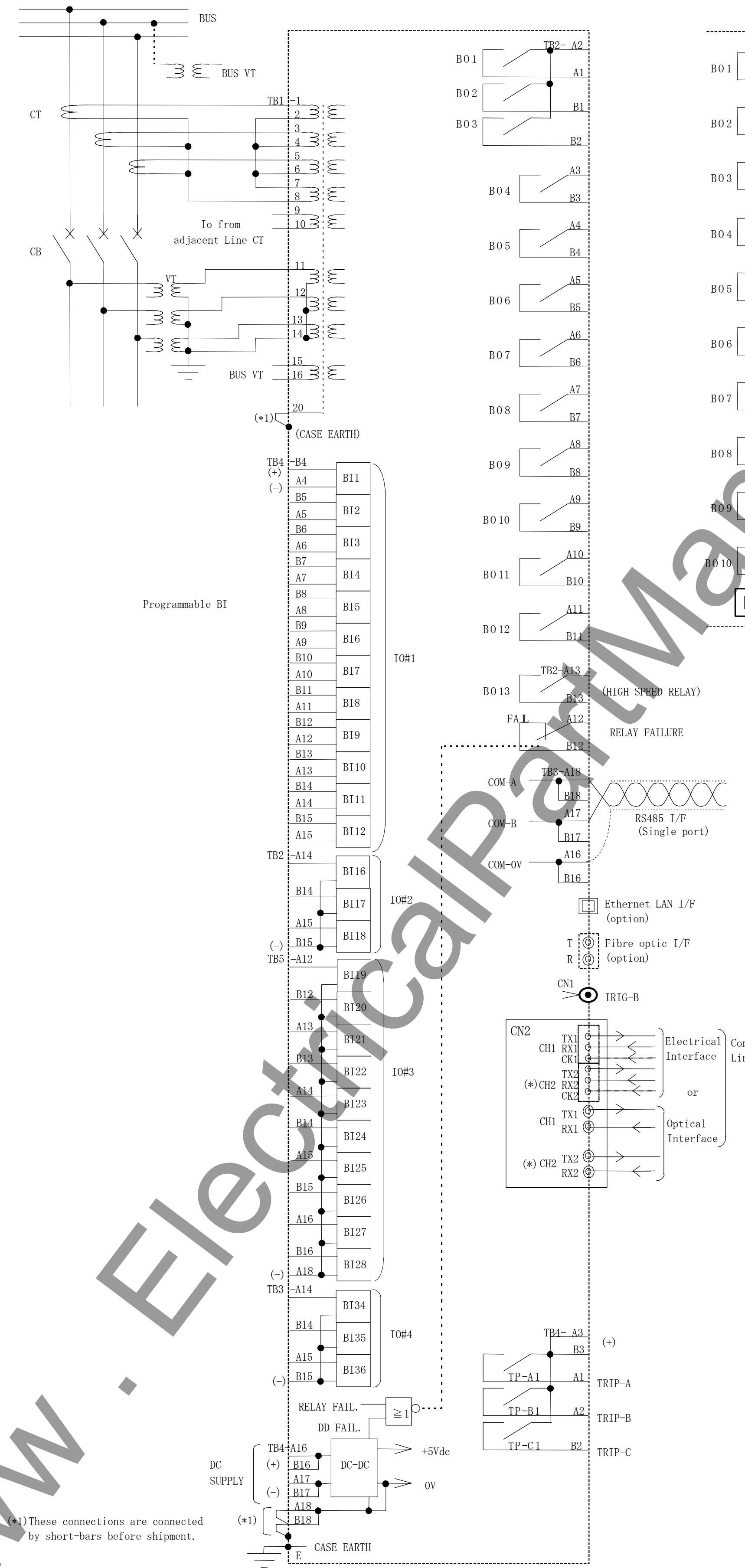
Appendix G

External Connections

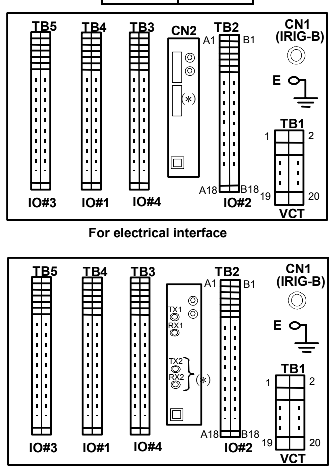

BUS
BUS VT
CT
TB1
Io from
adjacent Line CT
CB
VT
BUS VT
(CASE EARTH)
Programmable BI
IO#1
IO#2
RELAY FAIL.
DD FAIL.
DC-DC
+5Vdc
0V
DC
SUPPLY
CASE EARTH
(*1)These connections are connected
by short-bars before shipment.
(HIGH SPEED RELAY)
RELAY FAILURE
RS485 I/F
(Single port)
Ethernet LAN I/F
(option)
IRIG-B
Electrical
Interface
or
Optical
Interface
Communication
Links
TRIP-A
TRIP-B
TRIP-C
BUS CB
IO#3
RS485 I/F (Two ports)
IO module
IO#1 IO1
IO#2 IO2
IO#3 IO3
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
(Note) GRZ100-211: 2 terminal system, not provided
with terminals marked with (*).
GRZ100-221: 3 terminal system
Model 2*1


BUS
BUS VT
CT
CB
VT
TB1
Io from adjacent Line CT
(∗1)
(CASE EARTH)
Programmable BI
TB4
TB3
TB2
IO#1
IO#2
IO#3
BI1
BI2
BI3
BI4
BI5
BI6
BI7
BI8
BI9
BI10
BI11
BI12
BI16
BI17
BI18
BI19
BI20
BI21
BI22
BI23
BI24
BI25
RELAY FAIL.
DD FAIL.
DC SUPPLY
DC-DC
+5Vdc
0V
CASE EARTH
(∗1)These connections are connected by short-bars before shipment.
BO1
BO2
BO3
BO4
BO5
BO6
BO7
BO8
BO9
BO10
BO11
BO12
BO13
(HIGH SPEED RELAY)
FAIL
RELAY FAILURE
COM-A
COM-B
COM-0V
RS485 I/F (Single port)
Ethernet LAN I/F (option)
CN1
IRIG-B
CN2
CH1
(∗)CH2
Electrical Interface
or
Optical Interface
Communication Links
TP-A1
TP-B1
TP-C1
TRIP-A
TRIP-B
TRIP-C
COM2-A
COM2-B
COM2-0V
COM1-A
COM1-B
COM1-0V
RS485 I/F (Two ports)
IO module
IO#1 IO8
IO#2 IO2
IO#3 IO6
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
(Note) GRZ100-214: 2 terminal system, not provided with terminals marked with (∗).
GRZ100-224: 3 terminal system

Model 2∗4



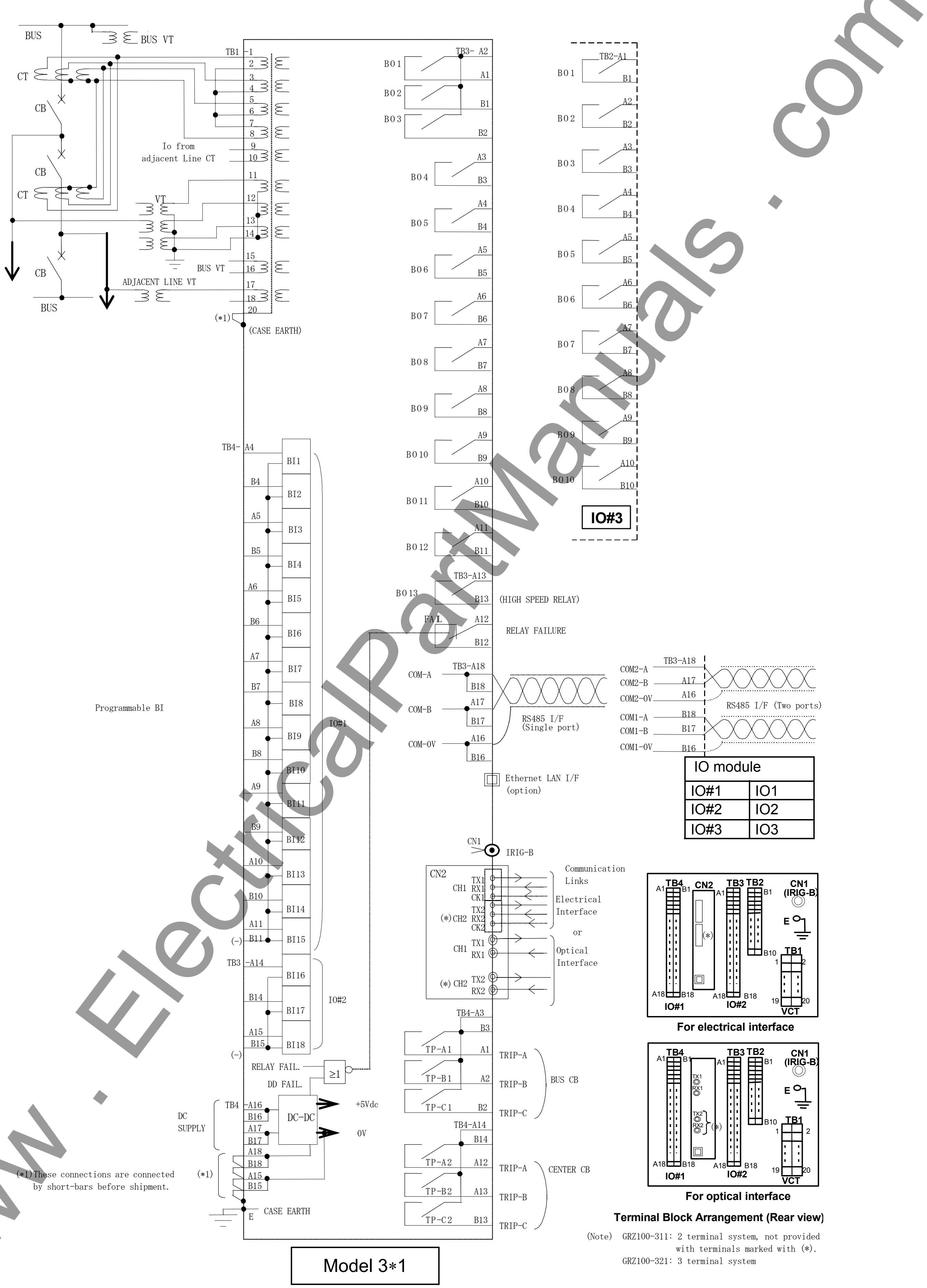
IO module	
IO#1	IO8
IO#2	IO2
IO#3	IO5
IO#4	IO4

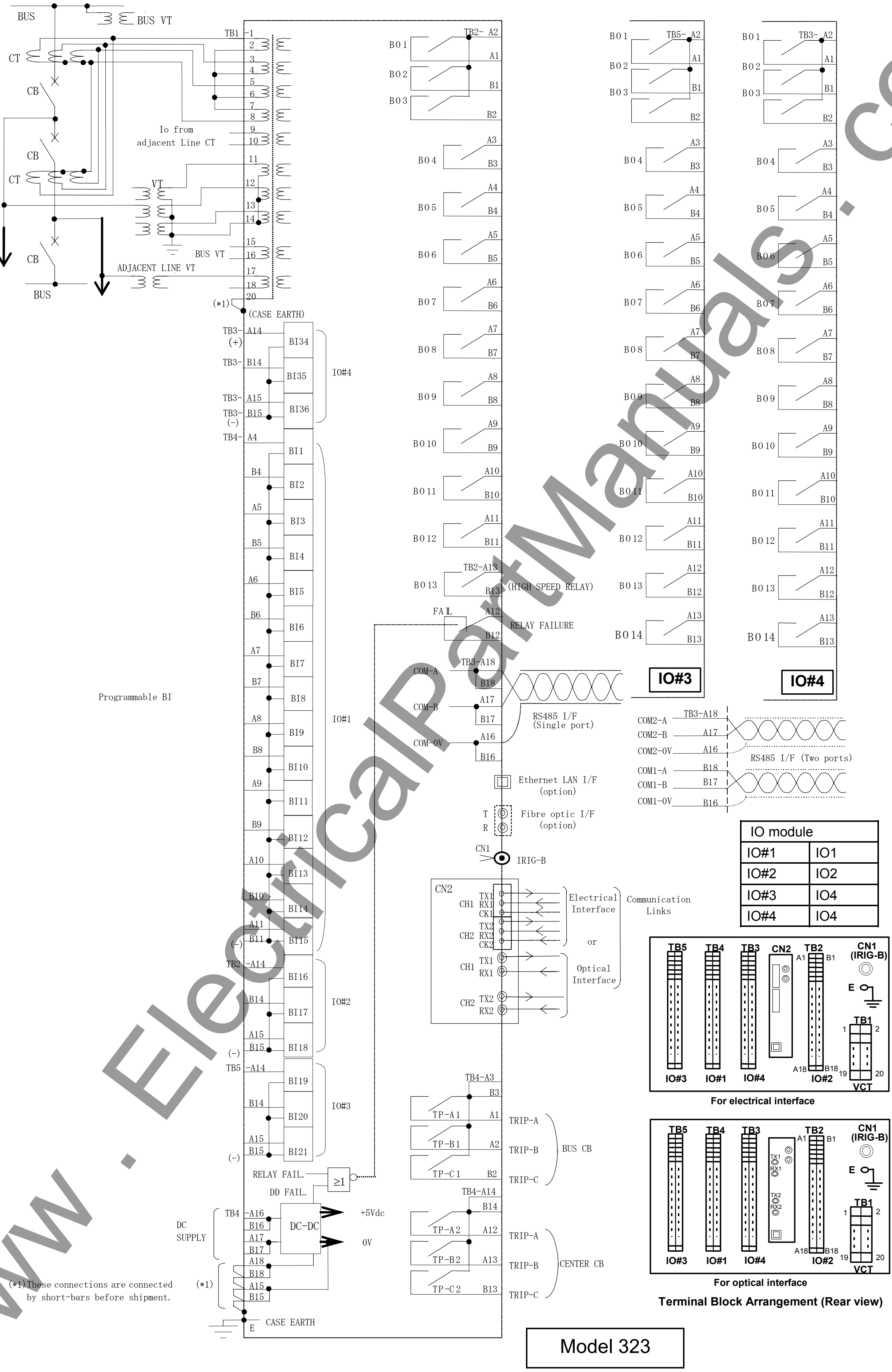


Terminal Block Arrangement (Rear view)

(Note) GRZ100-216: 2 terminal system, not provided with terminals marked with (∗).
GRZ100-226: 3 terminal system

Model 2∗6


BUS
BUS VT
CT
CB
Io from adjacent Line CT
VT
BUS VT
ADJACENT LINE VT
TB1
(CASE EARTH)
TB3- A2
BO1
BO2
BO3
BO4
BO5
BO6
BO7
BO8
BO9
BO10
BO11
BO12
BO13
(HIGH SPEED RELAY)
FAIL
RELAY FAILURE
TB2-A1
IO#3
COM-A
COM-B
COM-0V
RS485 I/F (Single port)
COM2-A
COM2-B
COM2-0V
COM1-A
COM1-B
COM1-0V
RS485 I/F (Two ports)
Ethernet LAN I/F (option)
CN1
IRIG-B
CN2
Communication Links
Electrical Interface
or
Optical Interface
Programmable BI
TB4- A4
IO#1
IO#2
RELAY FAIL.
DD FAIL.
DC SUPPLY
DC-DC
+5Vdc
0V
(*1)These connections are connected by short-bars before shipment.
CASE EARTH
TB4-A3
TRIP-A
TRIP-B
TRIP-C
BUS CB
TB4-A14
CENTER CB
IO module
IO#1 IO1
IO#2 IO2
IO#3 IO3
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
(Note) GRZ100-311: 2 terminal system, not provided with terminals marked with (*).
GRZ100-321: 3 terminal system
Model 3*1



BUS
BUS VT
CT
CB
Io from adjacent Line CT
VT
BUS VT
ADJACENT LINE VT
TB1
(CASE EARTH)
Programmable BI
IO#4
IO#1
IO#2
IO#3
BI1
BI2
BI3
BI4
BI5
BI6
BI7
BI8
BI9
BI10
BI11
BI12
BI13
BI14
BI15
BI16
BI17
BI18
BI19
BI20
BI21
BI34
BI35
BI36
RELAY FAIL.
DD FAIL.
≥1
DC SUPPLY
DC-DC
+5Vdc
0V
(*1)These connections are connected by short-bars before shipment.
CASE EARTH
BO1
BO2
BO3
BO4
BO5
BO6
BO7
BO8
BO9
BO10
BO11
BO12
BO13
BO14
(HIGH SPEED RELAY)
FAIL
RELAY FAILURE
COM-A
COM-B
COM-0V
RS485 I/F (Single port)
COM2-A
COM2-B
COM2-0V
COM1-A
COM1-B
COM1-0V
RS485 I/F (Two ports)
Ethernet LAN I/F (option)
Fibre optic I/F (option)
IRIG-B
CN1
CN2
CH1
CH2
TX1
RX1
CK1
TX2
RX2
CK2
Electrical Interface
or
Optical Interface
Communication Links
TP-A1
TP-B1
TP-C1
TRIP-A
TRIP-B
TRIP-C
BUS CB
TP-A2
TP-B2
TP-C2
CENTER CB
IO module
IO#1 IO1
IO#2 IO2
IO#3 IO4
IO#4 IO4
TB5
TB4
TB3
TB2
CN1 (IRIG-B)
VCT
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
Model 323

Appendix H

Relay Setting Sheet

- Relay Identification
  Transmission line parameters
  Distance scheme
  Autoreclose scheme
- Contacts setting
- Relay and Protection Scheme Setting Sheets

Relay Setting Sheets

1. Relay Identification

Date:

Relay type ____________
Frequency ____________
VT rating ____________
Password ____________
Active setting group ____________

Serial Number ____________
CT rating ____________
dc supply voltage ____________

2. Transmission line parameters

Line type ____________
Line impedance Z1 = ____________
Z0 = ____________
Zm = ____________
VT ratio ____________
Tripping mode 1 + 3 phase/3 phase

Line length ____________
Z0 (mutual) = ____________
CT ratio ____________

3. Distance scheme

Zone protection ____________
Zone 1 extension ____________
PUP ____________
POP ____________
UOP ____________
BOP ____________
POP + DEF ____________
UOP + DEF ____________
BOP + DEF ____________
PUP + DEF ____________

4. Autoreclose scheme

Not used ____________
SPAR ____________
SPAR + TPAR ____________
TPAR ____________
EX1P (external autoreclose SPAR + TPAR scheme) ____________
EX3P (external autoreclose TPAR scheme) ____________
1CB or 2CB reclosing ____________
Multi-shot autoreclose ____________
1 shot, 2 shots, 3 shots or 4 shots ____________

5. Contacts setting

(1) IO#2 BO1 ______________________
BO2 ______________________
BO3 ______________________
BO4 ______________________
BO5 ______________________
BO6 ______________________
BO7 ______________________
BO8 ______________________
BO9 ______________________
BO10 ______________________
BO11 ______________________
BO12 ______________________
BO13 ______________________

(2) IO#3 BO1 ______________________
BO2 ______________________
BO3 ______________________
BO4 ______________________
BO5 ______________________
BO6 ______________________
BO7 ______________________
BO8 ______________________
BO9 ______________________
BO10 ______________________
BO11 ______________________
BO12 ______________________
BO13 ______________________
BO14 ______________________

(3) IO#4 BO1 ______________________
BO2 ______________________
BO3 ______________________
BO4 ______________________
BO5 ______________________
BO6 ______________________
BO7 ______________________
BO8 ______________________
BO9 ______________________
BO10 ______________________
BO11 ______________________
BO12 ______________________
BO13 ______________________
BO14 ______________________

(Memo: For relay elements and scheme logic settings, the setting list as shown on the next page is made.)

6. Default setting

№	Name	Range		Units	Contents	Default setting (1A rating / 5A rating)									User Setting
						1CB-ARC				1CB-ARC		2CB-ARC			
						2TERM		3TERM		2TERM	3TERM	2TERM	3TERM		
		5A rating	1A rating			214	216	224	226	211	221	311	321	323	
1	Active group	1 - 8		—	Active setting group	1				1					
2	Line name	Specified by user		—	Line name	Specified by user				Specified by user					
3	VT	1 - 20000		—	VT ratio	2000				2000					
4	VTs1	1 - 20000		—	VT ratio	2000				2000					
5	VTs2	1 - 20000		—	VT ratio	--				--		2000			
6	VTr1	1 - 20000		—	VT ratio for remote terminal	2000				2000					
7	VTr2	1 - 20000		—	VT ratio for remote terminal	--		2000		--	2000	--	2000		
8	CT	1 - 20000		—	CT ratio	400				400					
9	CTr1	1 - 20000		—	CT ratio for remote terminal	400				400					
10	CTr2	1 - 20000		—	CT ratio for remote terminal	--		400		--	400	--	400		
11	X1	0.00 - 199.99	0.0 - 999.9	Ω	Fault location	2.00 / 10.0				2.00 / 10.0					
12	X0	0.00 - 199.99	0.0 - 999.9	Ω	ditto	6.80 / 34.0				6.80 / 34.0					
13	X0m	0.00 - 199.99	0.0 - 999.9	Ω	ditto	2.00 / 10.0				2.00 / 10.0					
14	R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	0.20 / 1.0				0.20 / 1.0					
15	R0	0.00 - 199.99	0.0 - 999.9	Ω	ditto	0.70 / 3.5				0.70 / 3.5					
16	R0m	0.00 - 199.99	0.0 - 999.9	Ω	ditto	0.20 / 1.0				0.20 / 1.0					
17	Z0B-L	0.00 - 199.99	0.0 - 999.9	Ω	ditto	2.00 / 10.0				2.00 / 10.0					
18	Z0B-R	0.00 - 199.99	0.0 - 999.9	Ω	ditto	2.00 / 10.0				2.00 / 10.0					
19	Kab	80 - 120		%	ditto	100				100					
20	Kbc	80 - 120		%	ditto	100				100					
21	Kca	80 - 120		%	ditto	100				100					
22	Ka	80 - 120		%	ditto	100				100					
23	Kb	80 - 120		%	ditto	100				100					
24	Kc	80 - 120		%	ditto	100				100					
25	Line	0.0 - 399.9		km	ditto	50				50					
26	2X1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.00 / 10.0		--	2.00 / 10.0	--	2.00 / 10.0		
27	2R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.20 / 1.0		--	0.20 / 1.0	--	0.20 / 1.0		
28	2Line	0.0 - 399.9		km	ditto	--		50		--	50	--	50		
29	3X1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.00 / 10.0		--	2.00 / 10.0	--	2.00 / 10.0		
30	3R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.20 / 1.0		--	0.20 / 1.0	--	0.20 / 1.0		
31	3Line	0.0 - 399.9		km	ditto	--		50		--	50	--	50		
32	Protection scheme	3ZONE - Z1-EXT - PUP - POP - UOP - BOP - POP+DEF - UOP+DEF - BOP+DEF - PUP+DEF		—	Protection scheme selection	POP				POP					
33	CO.LINK	Int - Ext		—	Communication link (External or Integral)	Int				Int					
34	SP.SYN.	Master - Slave		—	SP synchronization setting	Master				Master					
35	TERM	2TERM - 3TERM - Dual		—	Terminal selection	--		3TERM		--	3TERM	--	3TERM		
36	CH.USE	Both - CH1USE - CH2USE		—	For chain topology	--		Both		--	Both	--	Both		
37	RYIDSV	Off - On		—	Relay address supervision	On				On					
38	CH.CON	Normal - Exchange		—	Channel exchanger	--		Normal		--	Normal	--	Normal		
39	T.SFT1	Off - On		—	CH#1 bit shifter for multiplexer link	Off				Off					
40	T.SFT2	Off - On		—	CH#2 bit shifter for multiplexer link	--		Off		--	Off	--	Off		
41	B.SYN1	Off - On		—	CH#1 bit sync. for multiplexer	On				On					
42	B.SYN2	Off - On		—	CH#2 bit sync. for multiplexer	--		On		--	On	--	On		
43	RYID	0 - 63		—	Relay address for local terminal	0				0					
44	RYID1	0 - 63		—	Relay address for remote terminal 1	0				0					
45	RYID2	0 - 63		—	Relay address for remote terminal 2	--		0		--	0	--	0		
46	TDSV	100 - 16000		us	Transmission delay time supervision	6000				6000					
47	TCDT1	-10000 - 10000		us	Transmission delay time adjust (CH1)	0				0					
48	TCDT2	-10000 - 10000		us	Transmission delay time adjust (CH2)	--		0		--	0	--	0		
49	ZS-C	Mho - Quad		—	ZS relay characteristic	Mho				Mho					
50	ZG-C	Mho - Quad		—	ZG relay characteristic	Mho				Mho					
51	BLZONE	COM - IND		—	Blinder setting mode	COM				COM					
52	Z1CNT	1 - 2 - 3 - 4 - 5		—	Z1 trip mode	1				1					
53	PSB-Z1	Off - On		—	PSB for Z1 element	On				On					
54	PSB-Z1X	Off - On		—	PSB for Z1X element	On				On					
55	PSB-Z2	Off - On		—	PSB for Z2 element	On				On					
56	PSB-Z3	Off - On		—	PSB for Z3 element	Off				Off					
57	PSB-CR	Off - On		—	PSB for carrier trip	On				On					
58	PSB-ZF	Off - On		—	PSB for ZF element	Off				Off					
59	PSB-ZR1	Off - On		—	PSB for ZR1 element	Off				Off					
60	PSB-ZR2	Off - On		—	PSB for ZR2 element	Off				Off					
61	PSB-TP	Off - On		—	Trip for under PSB	On				On					
62	UVPWIEN	Off - On		—	Counter measures for overreach of leading phase at positive phase weak infeed	Off				Off					
63	SCFCNT	BLK - Trip		—	Carrier trip operation under severe CF	BLK				BLK					
64	STUB	Off - On		—	Stub protection	Off				Off					
65	SOTF-DL	CB - UV - Both		—	SOTF condition judged	CB				CB					
66	SOTF-OC	Off - On		—	SOTF OC trip	On				On					
67	SOTF-Z1	Off - On		—	SOTF Zone1 trip	Off				Off					
68	SOTF-Z2	Off - On		—	SOTF Zone2 trip	Off				Off					
69	SOTF-Z3	Off - On		—	SOTF Zone3 trip	Off				Off					
70	SOTF-F	Off - On		—	SOTF Zone-F trip	Off				Off					

№	Name		Range 5A rating	Range 1A rating	Units	Contents	Default setting (1A rating / 5A rating) 1CB-ARC 2TERM 214	216	3TERM 224	226	1CB-ARC 2TERM 211	3TERM 221	2CB-ARC 2TERM 311	3TERM 321	323	User Setting
71	SOTF-R1		Off - On		–	SOTF Zone-R1 trip	Off				Off					
72	SOTF-R2		Off - On		–	SOTF Zone-R2 trip	Off				Off					
73	SOTF-ND		Off - On		–	SOTF Zone-ND trip	Off				Off					
74	ZFBT		Off - On		–	ZF element back-up trip	Off				Off					
75	ZR1BT		Off - On		–	ZR1 element back-up trip	Off				Off					
76	ZR2BT		Off - On		–	ZR2 element back-up trip	Off				Off					
77	ZNDBT		Off - On		–	Non-directional zone back-up trip	Off				Off					
78	OCBT		Off - On		–	OC back-up trip	On				On					
79	OCIBT		Off - On		–	OCI back-up trip	On				On					
80	MOCI		Long - Std - Very - Ext		–	OCI back-up trip	Std				Std					
81	EFBT		Off - On		–	EF back-up trip	On				On					
82	EFBTAL		Off - On		–	EF back-up trip alarm	On				On					
83	DEF	DEFFEN	Off - On		–	Forward DEF back-up trip enable	Off				Off					
84	BU-trip	DEFREN	Off - On		–	Reverse DEF back-up trip enable	Off				Off					
85	DEFBTAL		Off - On		–	DEF back-up trip alarm	On				On					
86	DEFI		Off - NOD - F - R		–	DEF back-up trip	Off				Off					
87	MEFI		Long - Std - Very - Ext		–	EFI back-up trip	Std				Std					
88	OVS	OVS1EN	Off - DT - IDMT		–	OVS1 enable	Off				Off					
89		OVS2EN	Off - On		–	OVS2 enable	Off				Off					
90	OVG	OVG1EN	Off - DT - IDMT		–	OVG1 enable	Off				Off					
91		OVG2EN	Off - On		–	OVG2 enable	Off				Off					
92	UVS	UVS1EN	Off - DT - IDMT		–	UVS1 enable	Off				Off					
93		UVS2EN	Off - On		–	UVS2 enable	Off				Off					
94	UVG	UVG1EN	Off - DT - IDMT		–	UVG1 enable	Off				Off					
95		UVG2EN	Off - On		–	UVG2 enable	Off				Off					
96	UVS/UVG	VBLKEN	Off - On		–	UV block enable	Off				Off					
97	BCDEN		Off - On		–	Broken conductor enable	Off				Off					
98	CRSCM		Off - On		–	Carrier out of service	On				On					
99	CHSEL		Single - Guard - And		–	Carr.Channel configuration	Single				Single					
100	BOSW		Normal - Inverse		–	Carrier sending signal	Normal				Normal					
101	ZONESEL		Z2 - Z3		–	Carrier control element	Z2				Z2					
102	ECHO		Off - On		–	ECHO carrier send	On				On					
103	WKIT		Off - On		–	Weak carrier trip(Echo)	On				On					
104	CH-DEF		CH1 - CH2		–	DEF carrier channel setting	CH1				CH1					
105	BODEFSW		Active - Inactive		–	Binary switch for DEF carr.	Active				Active					
106	BF1		Off - T - TOC		–	CBF re-trip	Off				Off					
107	BF2		Off - On		–	CBF related trip	Off				Off					
108	BFEXT		Off - On		–	CBF initiation by ext. trip	Off				Off					
109	OST		Off - Trip - BO		–	Out of step trip	Off				Off					
110	THMT		Off - On		–	Thermal trip enable	Off				Off					
111	THMAL		Off - On		–	Thermal alarm enable	Off				Off					
112	TTSW1		Off - Trip - BO		–	Transfer trip selection (CH1)	BO				BO					
113	TTSW2		Off - Trip - BO		–	Transfer trip selection (CH2)	BO				BO					
114	VTF1EN		Off - On - OPT-On		–	VTF1 enable	On				On					
115	VTF2EN		Off - On - OPT-On		–	VTF2 enable	On				On					
116	VTF-Z4		Off - On		–	Z4-car blocked by VTF	On				On					
117	CHMON		Off - On		–	Carrier monitoring/testing	On				On					
118	LSSV		Off - On		–	LS monitoring	Off				Off					
119	SVCNT		ALM&BLK - ALM		–	Supervision control	ALM&BLK				ALM&BLK					
120	CTSV		Off - ALM&BLK - ALM		–	CT supervision control	Off				Off					
121	FL-Z0B		Off - On		–	Fault locator	Off				Off					
122	Open1		Off - On		–	Remote term.1 out of service	Off				Off					
123	Open2		Off - On		–	Remote term.2 out of service	--		Off		--	Off	--	Off		
124	AOLED		Off - On		–	ALARMLED lighting control at alarm	On				On					
125	ZS	Z1S	0.01 - 50.00	0.10 - 250.00	Ω	Z1S reactance	1.60 / 8.00				1.60 / 8.00					
126		Z1BS	1.5 (fixed)	7.5 (fixed)	Ω	Z1S mho offset (back)	--				--					
127		Z1S-Uvm	5.5 (fixed)		V	Minimum voltage phase detector	--				--					
128		Z1XS	0.01 - 50.00	0.10 - 250.00	Ω	Z1XS reactance	2.40 / 12.00				2.40 / 12.00					
129		Z1Sθ1	0 - 45		deg	Z1S angle with reference to an X-axis	0				0					
130		Z1Sθ2	45 - 90		deg	Angle for Z1S hooked point with reference to an R-axis	90				90					
131		BFR1S	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z1S forward (R)	5.10 / 25.5				5.10 / 25.5					
132		BFRXS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z1XS forward (R)	5.10 / 25.5				5.10 / 25.5					
133		Z2S	0.01 - 50.00	0.10 - 250.00	Ω	Z2S reactance	3.00 / 15.00				3.00 / 15.00					
134		BFR2S	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z2S forward (R)	5.10 / 25.5				5.10 / 25.5					
135		ZFS	0.01 - 50.00	0.1 - 250.0	Ω	ZFS reactance	4.00 / 20.00				4.00 / 20.00					
136		BFRFS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZFS forward (R)	5.10 / 25.5				5.10 / 25.5					
137		Z3S	0.01 - 50.00	0.1 - 250.0	Ω	Z3S mho	6.00 / 30.0				6.00 / 30.0					
138		Z3Sθ	45 - 90		deg	Line angle for Z3S(Mho) element	85				85					
139		ZBSθ	0 - 45		deg	Angle of direction(Quad) element	5				5					
140		BFRS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZS forward (R)	5.10 / 25.5				5.10 / 25.5					
141		BFRSθ	75 (fixed)		deg	Angle of BFRS	--				--					
142		BFLS	0 (fixed)		Ω	Blinder for ZS reverse (-R)	--				--					
143		BFLSθ	90 - 135		deg	Angle of BFLS	120				120					

№	Name		Range 5A rating	Range 1A rating	Units	Contents	Default setting (1A rating / 5A rating) 1CB-ARC 2TERM 214	1CB-ARC 2TERM 216	1CB-ARC 3TERM 224	1CB-ARC 3TERM 226	1CB-ARC 2TERM 211	1CB-ARC 3TERM 221	2CB-ARC 2TERM 311	2CB-ARC 3TERM 321	2CB-ARC 3TERM 323	User Setting
144		ZR1S	0.01 - 50.00	0.1 - 250.0	Ω	ZR1S reactance	2.00 / 10.0				2.00 / 10.0					
145		ZR2S	0.01 - 50.00	0.1 - 250.0	Ω	ZR2S reactance	4.00 / 20.0				4.00 / 20.0					
146		Z4S	0.01 - 50.00	0.1 - 250.0	Ω	Z4S mho	8.00 / 40.0				8.00 / 40.0					
147		Z4BS	1.5 (fixed)	7.5 (fixed)	Ω	Z4S offset-mho (back)	--				--					
148		Z4Sθ	45 - 90		deg	Line angle for Z4S(Mho) element	-- (Linked with Z3Sθ)				-- (Linked with Z3Sθ)					
149		Z4BSθ	0 - 45		deg	Angle of Z4S(Quad) offset	-- (Linked with ZBSθ)				-- (Linked with ZBSθ)					
150		BRRS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZS reverse (-R)	5.10 / 25.5				5.10 / 25.5					
151		BRRSθ	75 (fixed)		deg	Angle of BRRS	--				--					
152		BRLS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZS reverse (-R)	-- (Linked with BRRS)				-- (Linked with BRRS)					
153		BRLSθ	105 (fixed)		deg	Angle of BRLS	--				--					
154		ZNDS	0.01 - 50.00	0.1 - 250.0	Ω	ZNDS	10.00 / 50.0				10.00 / 50.0					
155		BNDS	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZNDS	12.00 / 60.0				12.00 / 60.0					
156		TZ1S	0.00 - 10.00		s	Z1S time-delay trip	0.00				0.00					
157		TZ2S	0.00 - 10.00		s	Z2S back-up trip timer	0.30				0.30					
158		TZFS	0.00 - 10.00		s	ZFS back-up trip timer	0.35				0.35					
159		TZ3S	0.00 - 10.00		s	Z3S back-up trip timer	0.40				0.40					
160		TZR1S	0.00 - 10.00		s	ZR1S back-up trip timer	0.50				0.50					
161		TZR2S	0.00 - 10.00		s	ZR2S back-up trip timer	0.60				0.60					
162		TZNDS	0.00 - 10.00		s	Non-directional zone trip timer	0.70				0.70					
163	ZG	Z1G	0.01 - 50.00	0.10 - 250.00	Ω	Z1G reactance	1.60 / 8.00				1.60 / 8.00					
164		Z1XG	0.01 - 50.00	0.10 - 250.00	Ω	Z1XG reactance	2.40 / 12.00				2.40 / 12.00					
165		Z1Gθ1	0 - 45		deg	Z1G angle with reference to an X-axis	0				0					
166		Z1Gθ2	45 - 90		deg	Angle for Z1G hooked point with reference to an R-axis	90				90					
167		BFR1G	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z1S forward (R)	5.10 / 25.5				5.10 / 25.5					
168		BFRXG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z1XS forward (R)	5.10 / 25.5				5.10 / 25.5					
169		Z2G	0.01 - 50.00	0.10 - 250.00	Ω	Z2G reactance	4.00 / 20.00				4.00 / 20.00					
170		BFR2G	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for Z2S forward (R)	5.10 / 25.5				5.10 / 25.5					
171		ZFG	0.01 - 100.00	0.1 - 500.0	Ω	ZFG reactance	6.00 / 30.00				6.00 / 30.00					
172		BFRFG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZFS forward (R)	5.10 / 25.5				5.10 / 25.5					
173		Z3G	0.01 - 100.00	0.1 - 500.0	Ω	Z3G mho	8.00 / 40.0				8.00 / 40.0					
174		Z3Gθ	45 - 90		deg	Line angle for Z3S(Mho) element	85				85					
175		ZBGθ	0 - 45		deg	Angle of direction(Quad) element	30				30					
176		BFRG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZG forward (R)	5.10 / 25.5				5.10 / 25.5					
177		BFRGθ	75 (fixed)		deg	Angle of BFRG	--				--					
178		BFLG	0 (fixed)		Ω	Blinder for ZG forward (-R)	--				--					
179		BFLGθ	90 - 135		deg	Angle of BFLG	120				120					
180		ZR1G	0.01 - 50.00	0.1 - 250.0	Ω	ZR1G reactance	2.00 / 10.0				2.00 / 10.0					
181		ZR2G	0.01 - 100.00	0.1 - 500.0	Ω	ZR2G reactance	4.00 / 20.0				4.00 / 20.0					
182		Z4G	0.01 - 100.00	0.1 - 500.0	Ω	Z4G mho	8.00 / 40.0				8.00 / 40.0					
183		Z4Gθ	45 - 90		deg	Line angle for Z4G(Mho) element	-- (Linked with Z3Gθ)				-- (Linked with Z3Gθ)					
184		Z4BGθ	0 - 45		deg	Angle of Z4G(Quad) offset	-- (Linked with ZBGθ)				-- (Linked with ZBGθ)					
185		BRRG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZG reverse (-R)	5.10 / 25.5				5.10 / 25.5					
186		BRRGθ	75 (fixed)		deg	Angle of BRRG	--				--					
187		BRLG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZG reverse (R)	-- (Linked with BRRG)				-- (Linked with BRRG)					
188		BRLGθ	105 (fixed)		deg	Angle of BRLG	--				--					
189		Krs	0 - 1000		%	Zero phase current factor: Self line "R0/R1"	340				340					
190		Kxs	0 - 1000		%	Zero phase current factor: Self line "X0/X1"	340				340					
191		Krm	0 - 1000		%	Zero phase current factor: Adjacent line "Rom/R1"	300				300					
192		Kxm	0 - 1000		%	Zero phase current factor: Adjacent line "Xom/X1"	300				300					
193		KrsR	0 - 1000		%	Zero phase current factor for ZR element: Self line "R0/R1"	100				100					
194		KxsR	0 - 1000		%	Zero phase current factor for Zr element: Self line "X0/X1"	100				100					
195		ZNDG	0.01 - 100.00	0.1 - 500.0	Ω	ZNDG	10.00 / 50.0				10.00 / 50.0					
196		BNDG	0.10 - 20.00	0.5 - 100.0	Ω	Blinder for ZNDG	12.00 / 60.0				12.00 / 60.0					
197		TZ1G	0.00 - 10.00		s	Z1G time-delay trip	0.00				0.00					
198		TZ2G	0.00 - 10.00		s	Z2G back-up trip timer	0.30				0.30					
199		TZFG	0.00 - 10.00		s	ZFG back-up trip timer	0.35				0.35					
200		TZ3G	0.00 - 10.00		s	Z3G back-up trip timer	0.40				0.40					
201		TZR1G	0.00 - 10.00		s	ZR1G back-up trip timer	0.50				0.50					
202		TZR2G	0.00 - 10.00		s	ZR2G back-up trip timer	0.60				0.60					
203		TZNDG	0.00 - 10.00		s	Non-directional zone trip timer	0.70				0.70					
204		ZIC	0.00 - 5.00	0.00 - 1.00	A	Charging current compensation	0.00				0.00					
205		Vn	100 - 120		V	Rated voltage	110				110					
206	ZPCC	ZPCC	0.8 (Sensitivity ratio)		–	Zero phase current	--				--					
207		OCG	0.2 (fixed)	0.04 (fixed)	A	compensation controller	--				--					
208	PSB	PSBSZ	0.50 - 15.00	2.5 - 75.0	Ω	Power swing block for Ph-Ph	2.00 / 10.0				2.00 / 10.0					
209		PSBGZ	0.50 - 15.00	2.5 - 75.0	Ω	Power swing block for Ph-G	2.00 / 10.0				2.00 / 10.0					
210		PSBRθ	75 (fixed)		deg	ditto	--				--					
211		PSBLθ	105 (fixed)		deg	ditto	--				--					
212		TPSB	20 - 60		ms	PS detection timer	40				40					

№	Name		Range 5A rating	Range 1A rating	Units	Contents	Default setting (1A rating / 5A rating) 1CB-ARC 2TERM 214, 216 / 3TERM 224, 226	Default setting (1A rating / 5A rating) 1CB-ARC 2TERM 211 / 3TERM 221; 2CB-ARC 2TERM 311 / 3TERM 321, 323	User Setting
213	OST	OSTR1	3.0 - 30.0	15 - 150	Ω	Out of step relay	5.1 / 25	5.1 / 25	
214		OSTR2	1.0 - 10.0	5 - 50	Ω	ditto	2.5 / 12	2.5 / 12	
215		OSTXF	1.0 - 50.0	5 - 250	Ω	ditto	6.0 / 30	6.0 / 30	
216		OSTXB	0.2 - 10.0	1 - 50	Ω	ditto	1.0 / 5	1.0 / 5	
217		TOST1	0.01 - 1.00		s	ditto	0.04	0.04	
218		TOST2	0.01 - 1.00		s	ditto	0.04	0.04	
219	OCH		2.0 - 15.0	0.4 - 3.0	A	Overcurrent element	6.0 / 1.2	6.0 / 1.2	
220	TSOTF		0 - 300		s	CB open detect timer for SOTF	5	5	
221	CBF	OCBF	0.5 - 10.0	0.1 - 2.0	A	Overcurrent element	4.0 / 0.8	4.0 / 0.8	
222		TBF1	50 - 500		ms	CBF timer for re-trip	150	150	
223		TBF2	50 - 500		ms	CBF timer for related trip	200	200	
224	OCD		0.5 (fixed)	0.1 (fixed)	A	Curr. change detector	--	--	
225	OCCR		0.4 (fixed)	0.08 (fixed)	A	OC element	--	--	
226	DEF	DEFFI	0.5 - 5.0	0.10 - 1.00	A	Directional earth fault element	1.0 / 0.20	1.0 / 0.20	
227		DEFFV	1.7 - 21.0		V	ditto	2.0	2.0	
228		DEFRI	0.5 - 5.0	0.10 - 1.00	A	ditto	1.0 / 0.20	1.0 / 0.20	
229		DEFRV	1.7 - 21.0		V	ditto	2.0	2.0	
230		DEFθ	0 - 90		deg	ditto	85	85	
231	DEF	TDEF	0.00 - 10.00		s	Forward definte timer	3.00	3.00	
232	BU-trip	TDER	0.00 - 10.00		s	Reverse definite timer	3.00	3.00	
233	OC	OC	0.5 - 100.0	0.1 - 20.0	A	OC element	6.0 / 1.2	6.0 / 1.2	
234		TOC	0.00 - 10.00		s	ditto	3.00	3.00	
235	OCI	OCI	0.5 - 25.0	0.10 - 5.00	A	IDMT OC element	1.0 / 0.20	1.0 / 0.20	
236		TOCI	0.05 - 1.00		—	ditto	0.50	0.50	
237		TOCIR	0.0 - 10.0		s	OC definite time reset delay	0.0	0.0	
238	EF	EF	0.5 - 5.0	0.10 - 1.00	A	Earth fault OC element	1.0 / 0.20	1.0 / 0.20	
239		TEF	0.00 - 10.00		s	ditto	3.00	3.00	
240	EFI	EFI	0.5 - 5.0	0.10 - 1.00	A	IDMT earth fault OC element	1.0 / 0.20	1.0 / 0.20	
241		TEFI	0.05 - 1.00		—	ditto	0.50	0.50	
242		TEFIR	0.0 - 10.0		s	EF definite time reset delay	0.0	0.0	
243	EFL		0.5 - 5.0	0.10 - 1.00	A	EF element for ZG fail safe	1.0 / 0.20	1.0 / 0.20	
244	UVC	UVCV	10 - 60		V	Undervoltage element with current compensation	48	48	
245		UVCZ	0.0 - 50.0	0.0 - 250.0	Ω	ditto	2.0 / 10.0	2.0 / 10.0	
246		UVCθ	45 - 90		deg	ditto	85	85	
247		UVCKrs	0 - 1000		%	ditto	-- (Linked with Krs of ZG)	-- (Linked with Krs of ZG)	
248		UVCKxs	0 - 1000		%	ditto	-- (Linked with Kxs of ZG)	-- (Linked with Kxs of ZG)	
249	OVG		20 (fixed)		V	OV element	--	--	
250	UVFS		50 - 100		V	UV ph-ph element	88	88	
251	UVLS		50 - 100		V	UV ph-ph element "L" level	77	77	
252	UVFG		10 - 60		V	UV ph-g element	51	51	
253	UVLG		10 - 60		V	UV ph-g element "L" level	45	45	
254	UVPWI		30 (fixed)		V	UV for positive weak infeed	--	--	
255	OCDP		0.5 - 10.0	0.1 - 2.0	A	Curr. change detector for fault under PSB	4.0 / 0.8	4.0 / 0.8	
256	OVS	OVS1	5.0 - 150.0		V	OVS1 element	120.0	120.0	
257		TOS1I	0.05 - 100.00		—	OVS1 IDMT timer	10.00	10.00	
258		TOS1	0.00 - 300.00		s	OVS1 definite timer	0.10	0.10	
259		TOS1R	0.0 - 300.0		s	OVS1 definite time reset delay	0.0	0.0	
260		OS1DP	10 - 98		%	OVS1 DO/PU ratio	95	95	
261		OVS2	5.0 - 150.0		V	OVS2 element	140.0	140.0	
262		TOS2	0.00 - 300.00		s	OVS2 definite timer	0.10	0.10	
263		OS2DP	10 - 98		%	OVS2 DO/PU ratio	95	95	
264	OVG	OVG1	5.0 - 150.0		V	OVG1 element	70.0	70.0	
265		TOG1I	0.05 - 100.00		—	OVG1 IDMT timer	10.00	10.00	
266		TOG1	0.00 - 300.00		s	OVG1 definite timer	0.10	0.10	
267		TOG1R	0.0 - 300.0		s	OVG1 definite time reset delay	0.0	0.0	
268		OG1DP	10 - 98		%	OVG1 DO/PU ratio	95	95	
269		OVG2	5.0 - 150.0		V	OVG2 element	80.0	80.0	
270		TOG2	0.00 - 300.00		s	OVG2 definite timer	0.10	0.10	
271		OG2DP	10 - 98		%	OVG2 DO/PU ratio	95	95	
272	UVS	UVS1	5.0 - 150.0		V	UVS1 element	60.0	60.0	
273		TUS1I	0.05 - 100.00		—	UVS1 IDMT timer	10.00	10.00	
274		TUS1	0.00 - 300.00		s	UVS1 definite timer	0.10	0.10	
275		TUS1R	0.0 - 300.0		s	UVS1 definite time reset delay	0.0	0.0	
276		UVS2	5.0 - 150.0		V	UVS2 element	40.0	40.0	
277		TUS2	0.00 - 300.00		s	UVS2 definite timer	0.10	0.10	
278		VSBLK	5.0 - 20.0		V	UVS blocking threshold	10.0	10.0	
279	UVG	UVG1	5.0 - 150.0		V	UVG1 element	35.0	35.0	
280		TUG1I	0.05 - 100.00		—	UVG1 IDMT timer	10.00	10.00	
281		TUG1	0.00 - 300.00		s	UVG1 definite timer	0.10	0.10	
282		TUG1R	0.0 - 300.0		s	UVG1 definite time reset delay	0.0	0.0	

№	Name		Range		Units	Contents	Default setting (1A rating / 5A rating)									User Setting
							1CB-ARC				1CB-ARC		2CB-ARC			
							2TERM		3TERM		2TERM	3TERM	2TERM	3TERM		
			5A rating	1A rating			214	216	224	226	211	221	311	321	323	
283		UVG2	5.0 - 150.0		V	UVG2 element	25.0				25.0					
284		TUG2	0.00 - 300.00		s	UVG2 definite timer	0.10				0.10					
285		VGBLK	5.0 - 20.0		V	UVG blocking threshold	10.0				10.0					
286	BCD	BCD	0.10 - 1.00		—	Broken conductor threshold	0.20				0.20					
287		TBCD	0.00 - 300.00		s	BCD definite timer	1.00				1.00					
288	Thermal	THM	2.0 - 10.0	0.40 - 2.00	A	Thermal overload setting	5.0 / 1.00				5.0 / 1.00					
289		THMIP	0.0 - 5.0	0.00 - 1.00	A	Prior load setting	0.0 / 0.00				0.0 / 0.00					
290		TTHM	0.5 - 300.0		min	Thermal Time Constant	10.0				10.0					
291		THMA	50 - 99		%	Thermal alarm setting	80				80					
292	DOCN	DOCNI	4.0 (fixed)	0.8 (fixed)	A	Negative OC relay	--				--					
293		DOCNV	6 (fixed)		V		--				--					
294	TDEFF		0.00 - 0.30		s	DEF carrier trip delay timer	0.15				0.15					
295	TDEFR		0.00 - 0.30		s	ditto	0.15				0.15					
296	TCHD		0 - 50		ms	Coordination timer	12				12					
297	TCHDE		0 - 100		ms	Extend coordination timer	--		20		--	20	--	20		
298	TREBK		0.00 - 10.00		s	Current reverse blocking time	0.10				0.10					
299	TECCB		0.00 - 200.00		s	Echo enable timer from CB opened	0.10				0.10					
300	TSBCT		0.00 - 1.00		s	SBCNT timer	0.10				0.10					
301	Autoreclose mode		(Off) - Disable - SPAR - TPAR - SPAR&TPAR - EXT1P - EXT3P		—	Autoreclosing mode	SPAR&TPAR				SPAR&TPAR					
302	ARC-CB		ONE - O1 - 02 - L1 - L2		—	ARC mode for 1.5CB system	--				--		L1			
303	ARC-EXT		Off - On		—	ARC initiated by ext. trip	Off				Off					
304	ARC-DEF		Off - On		—	ARC by DG carr. trip	Off				Off					
305	ARC-BU		Off - On		—	ARC by back-up trip	Off				Off					
306	VCHK	1CB	Off - LB - DB - SY		—	TPAR condition	LB				LB		--			
		2CB	Off - LB1 - LB2 - DB - SY				--				--		LB1			
307	ARC-SM		Off - S2 - S3 - S4		—	Multi. shot ARC mode	Off				Off					
308	ARC-SUC		Off - On		—	ARC success reset	Off				Off					
308	VTPHSEL		A - B - C		—	VT phase selection	A				A					
309	VT-RATE		PH/G - PH/PH		—	VT rating	PH/G				PH/G					
309	3PH-VT		Bus - Line		—	3ph. VT location	Line				Line					
310	UARCSW		P1 - P2 - P3		—	User ARC switch	NA				NA					
310	TEVLV		0.01 - 10.00		s	Dead timer reset timing	0.30				0.30					
311	TRDY1		5 - 300		s	Reclaim timer	60				60					
312	TSPR		0.01 - 10.00		s	SPAR dead line timer	0.80				0.80					
313	TTPR1		0.01 - 100.00		s	TPAR dead line timer	0.60				0.60					
314	TRR		0.01 - 100.00		s	ARC reset timer	2.00				2.00					
315	TW1		0.1 - 10.0		s	ARC output pulse timer	0.2				0.2					
316	TRDY2		5 - 300		s	Reclaim timer	--				--		60			
317	TSPR2		0.01 - 10.00		s	SPAR dead line timer	--				--		0.80			
318	TTPR2		0.1 - 10.0		s	ARC timing for follower CB	--				--		0.1			
319	TW2		0.1 - 10.0		s	ARC reset timer	--				--		0.2			
320	TS2		5.0 - 300.0		s	Multi. shot dead timer	20.0				20.0					
321	TS2R		5.0 - 300.0		s	Multi. shot reset timer	30.0				30.0					
322	TS3		5.0 - 300.0		s	Multi. shot dead timer	20.0				20.0					
323	TS3R		5.0 - 300.0		s	Multi. shot reset timer	30.0				30.0					
324	TS4		5.0 - 300.0		s	Multi. shot dead timer	20.0				20.0					
325	TS4R		5.0 - 300.0		s	Multi. shot reset timer	30.0				30.0					
326	TSUC		0.1 - 10.0		s	ARC success reset timer	3.0				3.0					
327	OVB		10 - 150		V	OV element	51				51					
328	UVB		10 - 150		V	UV element	13				13					
329	OVL1		10 - 150		V	OV element	51				51					
330	UVL1		10 - 150		V	UV element	13				13					
331	SYN1	SY1UV	10 - 150		V	Synchro. check (UV)	83				83					
332		SY1OV	10 - 150		V	Synchro. check (OV)	51				51					
333		SY1θ	5 - 75		deg	Synchro. check (ph. diff.)	30				30					
334		TSYN1	0.01 - 10.00		s	Synchronism check timer	1.00				1.00					
335		TDBL1	0.01 - 1.00		s	Voltage check timer	0.05				0.05					
336		TLBD1	0.01 - 1.00		s	Voltage check timer	0.05				0.05					
337	T3PLL		0.01 - 1.00		s	three phase live line check timer	0.05									
338	OVL2		10 - 150		V	OV element	--				--		51			
339	UVL2		10 - 150		V	UV element	--				--		13			
340	SYN2	SY2UV	10 - 150		V	Synchro. check (UV)	--				--		83			
341		SY2OV	10 - 150		V	Synchro. check (OV)	--				--		51			
342		SY2θ	5 - 75		deg	Synchro. check (ph. diff.)	--				--		30			
343		TSYN2	0.01 - 10.00		s	Synchronism check timer	--				--		1.00			
344		TDBL2	0.01 - 1.00		s	Voltage check timer	--				--		0.05			
345		TLBD2	0.01 - 1.00		s	Voltage check timer	--				--		0.05			
346	BISW1		Norm - Inv		—	Binary input	Norm				Norm					
347	BISW2		Norm - Inv		—	ditto	Norm				Norm					
348	BISW3		Norm - Inv		—	ditto	Norm				Norm					

№	Name		Range		Units	Contents	Default setting (1A rating / 5A rating)									User Setting
							1CB-ARC				1CB-ARC		2CB-ARC			
							2TERM		3TERM		2TERM	3TERM	2TERM	3TERM		
			5A rating	1A rating			214	216	224	226	211	221	311	321	323	
349	BISW4		Norm - Inv		—	ditto	Norm				Norm					
350	BISW5		Norm - Inv		—	ditto	Norm				Norm					
351	BISW6		Norm - Inv		—	ditto	Norm				Norm					
352	BISW7		Norm - Inv		—	ditto	Inv				Norm					
353	BISW8		Norm - Inv		—	ditto	Inv				Norm					
354	BISW9		Norm - Inv		—	ditto	Norm				Norm					
355	BISW10		Norm - Inv		—	ditto	Norm				Norm					
356	BISW11		Norm - Inv		—	ditto	Norm				Norm					
357	BISW12		Norm - Inv		—	ditto	Norm				Norm					
358	BISW13		Norm - Inv		—	ditto	--				Norm					
359	BISW14		Norm - Inv		—	ditto	--				Norm					
360	BISW15		Norm - Inv		—	ditto	--				Norm					
361	BISW16		Norm - Inv		—	ditto	Norm				Norm					
362	BISW17		Norm - Inv		—	ditto	Norm				Norm					
363	BISW18		Norm - Inv		—	ditto	Norm				Norm					
364	BISW19		Norm - Inv		—	ditto	Norm				--				Norm	
365	BISW20		Norm - Inv		—	ditto	Norm				--				Norm	
366	BISW21		Norm - Inv		—	ditto	Norm				--				Norm	
367	BISW22		Norm - Inv		—	ditto	Norm				--					
368	BISW23		Norm - Inv		—	ditto	Norm				--					
369	BISW24		Norm - Inv		—	ditto	Norm				--					
370	BISW25		Norm - Inv		—	ditto	Norm				--					
371	BISW26		Norm - Inv		—	ditto	--	Norm	--	Norm	--					
372	BISW27		Norm - Inv		—	ditto	--	Norm	--	Norm	--					
373	BISW28		Norm - Inv		—	ditto	--	Norm	--	Norm	--					
374	BISW34		Norm - Inv		—	ditto	--	Norm	--	Norm	--				Norm	
375	BISW35		Norm - Inv		—	ditto	--	Norm	--	Norm	--				Norm	
376	BISW36		Norm - Inv		—	ditto	--	Norm	--	Norm	--				Norm	
377	LED1	Logic	OR - AND		—	Configurable LEDs	OR				OR					
378		Reset	Inst - Latch		—		Inst				Inst					
379		In #1	0 - 3071		—		2816				0					
380		In #2	0 - 3071		—		0				0					
381		In #3	0 - 3071		—		0				0					
382		In #4	0 - 3071		—		0				0					
383	LED2	Logic	OR - AND		—	Configurable LEDs	OR				OR					
384		Reset	Inst - Latch		—		Inst				Inst					
385		In #1	0 - 3071		—		2817				0					
386		In #2	0 - 3071		—		0				0					
387		In #3	0 - 3071		—		0				0					
388		In #4	0 - 3071		—		0				0					
389	LED3	Logic	OR - AND		—	Configurable LEDs	OR				OR					
390		Reset	Inst - Latch		—		Inst				Inst					
391		In #1	0 - 3071		—		2818				0					
392		In #2	0 - 3071		—		0				0					
393		In #3	0 - 3071		—		0				0					
394		In #4	0 - 3071		—		0				0					
395	LED4	Logic	OR - AND		—	Configurable LEDs	OR				OR					
396		Reset	Inst - Latch		—		Inst				Inst					
397		In #1	0 - 3071		—		231				0					
398		In #2	0 - 3071		—		0				0					
399		In #3	0 - 3071		—		0				0					
400		In #4	0 - 3071		—		0				0					
401	Plant name		Specified by user		—	Plant name	Specified by user				Specified by user					
402	Description		ditto		—	Memorandum for user	Specified by user				Specified by user					
403	HDLC		1 - 32		—	Relay ID No. for RSM	1				1					
404	IEC		0 - 254		—	Station address for IEC103	2				2					
405	SYADJ		-9999 - 9999		ms	Time sync. Compensation	0				0					
406	IP1-1		0-254		—	IP Address	Specified by user				Specified by user					
407	IP1-2		0-254		—	IP Address	Specified by user				Specified by user					
408	IP1-3		0-254		—	IP Address	Specified by user				Specified by user					
409	IP1-4		0-254		—	IP Address	Specified by user				Specified by user					
410	SM1-1		0-255		—	Subnet Mask	Specified by user				Specified by user					
411	SM1-2		0-255		—	Subnet Mask	Specified by user				Specified by user					
412	SM1-3		0-255		—	Subnet Mask	Specified by user				Specified by user					
413	SM1-4		0-255		—	Subnet Mask	Specified by user				Specified by user					
414	GW1-1		0-254		—	Gateway Address	Specified by user				Specified by user					
415	GW1-2		0-254		—	Gateway Address	Specified by user				Specified by user					
416	GW1-3		0-254		—	Gateway Address	Specified by user				Specified by user					
417	GW1-4		0-254		—	Gateway Address	Specified by user				Specified by user					

№	Name	Range		Units	Contents	Default setting (1A rating / 5A rating)									User Setting
						1CB-ARC				1CB-ARC		2CB-ARC			
						2TERM		3TERM		2TERM	3TERM	2TERM	3TERM		
		5A rating	1A rating			214	216	224	226	211	221	311	321	323	
418	PRTCL1	HDLC - IEC103		—	CH#1 Communication protocol	1				1					
419	232C	9.6 - 19.2 - 38.4 - 57.6		—	RS-232C baud rate	9.6				9.6					
420	IECBR	9.6 - 19.2		—	IEC60870-5-103 baud rate	19.2				19.2					
421	IECBLK	Normal - Blocked		—	Monitor direction blocked	Normal				Normal					
422	Fault locator	Off - On		—	FL function use or not	On				On					
423	BITRN	0 - 128		—	Number of bi-trigger (on/off) events	100				100					
424	Time	0.1 - 3.0		s	Disturbance record	1				1					
425	OCP-S	0.5 - 250.0	0.1 - 50.0	A	OC element for disturbance	10.0 / 2.0				10.0 / 2.0					
426	OCP-G	0.5 - 250.0	0.1 - 50.0	A	recorder initiation	5.0 / 1.0				5.0 / 1.0					
427	UVP-S	0 - 132		V	UV element for disturbance	88				88					
428	UVP-G	0 - 76		V	recorder initiation	51				51					
429	TRIP	Off - On		—	Disturbance trigger	On				On					
430	OCP-S	Off - On		—	ditto	On				On					
431	OCP-G	Off - On		—	ditto	On				On					
432	UVP-S	Off - On		—	ditto	On				On					
433	UVP-G	Off - On		—	ditto	On				On					
434	Chann(Automatic test interval)	1 - 24		hrs	Carrier testing timer	8				8					
435	Display value	Primary - Secondary		—	Metering	Primary				Primary					
436	Power(P/Q)	Send - Receive		—	Metering	Send				Send					
437	Current	Lag - Lead		—	Metering	Lead				Lead					
438	Time sync	Off - IRIG - RSM - IEC - RMT		—	Time	Off				Off					
439	GMT	-12 - +12		hrs	Time	0				0					

Event record default setting

No.	Name	Range	Unit	Contents	Default setting			User setting		
					Sig. NO.	Signal name	type			
1	EV1	0 - 3071	–	Event record signal	1536	CB1 A	On/Off			
2	EV2	0 - 3071	–	ditto	1537	CB1 B	On/Off			
3	EV3	0 - 3071	–	ditto	1538	CB1 C	On/Off			
4	EV4	0 - 3071	–	ditto	1552	CB2 A	On/Off			
5	EV5	0 - 3071	–	ditto	1553	CB2 B	On/Off			
6	EV6	0 - 3071	–	ditto	1554	CB2 C	On/Off			
7	EV7	0 - 3071	–	ditto	1542	DS	On/Off			
8	EV8	0 - 3071	–	ditto	9	COM.block	On/Off			
9	EV9	0 - 3071	–	ditto	1545	CB1 ready	On/Off			
10	EV10	0 - 3071	–	ditto	1546	CB2 ready	On/Off			
11	EV11	0 - 3071	–	ditto	1547	ARC block	On/Off			
12	EV12	0 - 3071	–	ditto	1548	Ind.reset	On/Off			
13	EV13	0 - 3071	–	ditto	1549	Ext.M.trip	On/Off			
14	EV14	0 - 3071	–	ditto	1550	Ext.M.prot.	On/Off			
15	EV15	0 - 3071	–	ditto	1556	Ext.trip A	On/Off			
16	EV16	0 - 3071	–	ditto	1557	Ext.trip B	On/Off			
17	EV17	0 - 3071	–	ditto	1558	Ext.trip C	On/Off			
18	EV18	0 - 3071	–	ditto	238	Trip	On/Off			
19	EV19	0 - 3071	–	ditto	291	CB1 ARC	On/Off			
20	EV20	0 - 3071	–	ditto	292	CB2 ARC	On/Off			
21	EV21	0 - 3071	–	ditto	172	VTF	On/Off			
22	EV22	0 - 3071	–	ditto	176	PSB	On/Off			
23	EV23	0 - 3071	–	ditto	253	Ch.fail	On/Off			
24	EV24	0 - 3071	–	ditto	254	Relay fail	On/Off			
25	EV25	0 - 3071	–	ditto	1268	V0 err	On/Off			
26	EV26	0 - 3071	–	ditto	1269	V2 err	On/Off			
27	EV27	0 - 3071	–	ditto	1267	I0 err	On/Off			
28	EV28	0 - 3071	–	ditto	257	DS fail	On/Off			
29	EV29	0 - 3071	–	ditto	908	Com1 fail	On/Off			
30	EV30	0 - 3071	–	ditto	904	Sync1 fail	On/Off			
31	EV31	0 - 3071	–	ditto	924	Com2 fail	On/Off			
32	EV32	0 - 3071	–	ditto	920	Sync2 fail	On/Off			
33	EV33	0 - 3071	–	ditto	901	Term1 rdy	On/Off			
34	EV34	0 - 3071	–	ditto	917	Term2 rdy	On/Off			
35	EV35	0 - 3071	–	ditto	884	BU car mode	On/Off			
36	EV36	0 - 3071	–	ditto	880	Severe CF	On/Off			
37	EV37	0 - 3071	–	ditto	1513	RYID1 err	On/Off			
38	EV38	0 - 3071	–	ditto	1514	RYID2 err	On/Off			
39	EV39	0 - 3071	–	ditto	1511	Td1 over	On/Off			
40	EV40	0 - 3071	–	ditto	1512	Td2 over	On/Off			
41	EV41	0 - 3071	–	ditto	907	CLK1 fail	On/Off			
42	EV42	0 - 3071	–	ditto	923	CLK2 fail	On/Off			
43	EV43	0 - 3071	–	ditto	905	TX level1 err	On/Off			
44	EV44	0 - 3071	–	ditto	921	TX level2 err	On/Off			
45	EV45	0 - 3071	–	ditto	906	RX level1 err	On/Off			
46	EV46	0 - 3071	–	ditto	922	RX level2 err	On/Off			
47	EV47	0 - 3071	–	ditto	909	Com1 fail-R	On/Off			
48	EV48	0 - 3071	–	ditto	925	Com2 fail-R	On/Off			
49	EV49	0 - 3071	–	ditto	1258	Relay fail-A	On/Off			
50	EV50	0 - 3071	–	ditto	1438	Data lost	On/Off			
51	EV51	0 - 3071	–	ditto	1266	CT err	On/Off			
52	EV52	0 - 3071	–	ditto	0		On/Off			
53	EV53	0 - 3071	–	ditto	0		On/Off			
54	EV54	0 - 3071	–	ditto	0		On/Off			
55	EV55	0 - 3071	–	ditto	0		On/Off			
56	EV56	0 - 3071	–	ditto	0		On/Off			
57	EV57	0 - 3071	–	ditto	0		On/Off			
58	EV58	0 - 3071	–	ditto	0		On/Off			
59	EV59	0 - 3071	–	ditto	0		On/Off			
60	EV60	0 - 3071	–	ditto	0		On/Off			
61	EV61	0 - 3071	–	ditto	0		On/Off			
62	EV62	0 - 3071	–	ditto	0		On/Off			
63	EV63	0 - 3071	–	ditto	0		On/Off			
64	EV64	0 - 3071	–	ditto	0		On/Off			

Event record default setting

No.	Name	Range	Unit	Contents	Default setting			User setting		
					Sig. NO.	Signal name	type			
65	EV65	0 - 3071	–	ditto	0		On/Off			
66	EV66	0 - 3071	–	ditto	0		On/Off			
67	EV67	0 - 3071	–	ditto	0		On/Off			
68	EV68	0 - 3071	–	ditto	0		On/Off			
69	EV69	0 - 3071	–	ditto	0		On/Off			
70	EV70	0 - 3071	–	ditto	0		On/Off			
71	EV71	0 - 3071	–	ditto	0		On/Off			
72	EV72	0 - 3071	–	ditto	0		On/Off			
73	EV73	0 - 3071	–	ditto	0		On/Off			
74	EV74	0 - 3071	–	ditto	0		On/Off			
75	EV75	0 - 3071	–	ditto	0		On/Off			
76	EV76	0 - 3071	–	ditto	0		On/Off			
77	EV77	0 - 3071	–	ditto	0		On/Off			
78	EV78	0 - 3071	–	ditto	0		On/Off			
79	EV79	0 - 3071	–	ditto	0		On/Off			
80	EV80	0 - 3071	–	ditto	0		On/Off			
81	EV81	0 - 3071	–	ditto	0		On/Off			
82	EV82	0 - 3071	–	ditto	0		On/Off			
83	EV83	0 - 3071	–	ditto	0		On/Off			
84	EV84	0 - 3071	–	ditto	0		On/Off			
85	EV85	0 - 3071	–	ditto	0		On/Off			
86	EV86	0 - 3071	–	ditto	0		On/Off			
87	EV87	0 - 3071	–	ditto	0		On/Off			
88	EV88	0 - 3071	–	ditto	0		On/Off			
89	EV89	0 - 3071	–	ditto	0		On/Off			
90	EV90	0 - 3071	–	ditto	0		On/Off			
91	EV91	0 - 3071	–	ditto	0		On/Off			
92	EV92	0 - 3071	–	ditto	0		On/Off			
93	EV93	0 - 3071	–	ditto	0		On/Off			
94	EV94	0 - 3071	–	ditto	0		On/Off			
95	EV95	0 - 3071	–	ditto	0		On/Off			
96	EV96	0 - 3071	–	ditto	0		On/Off			
97	EV97	0 - 3071	–	ditto	0		On/Off			
98	EV98	0 - 3071	–	ditto	0		On/Off			
99	EV99	0 - 3071	–	ditto	0		On/Off			
100	EV100	0 - 3071	–	ditto	0		On/Off			
101	EV101	0 - 3071	–	ditto	1243	SET.GROUP1	On			
102	EV102	0 - 3071	–	ditto	1244	SET.GROUP2	On			
103	EV103	0 - 3071	–	ditto	1245	SET.GROUP3	On			
104	EV104	0 - 3071	–	ditto	1246	SET.GROUP4	On			
105	EV105	0 - 3071	–	ditto	1247	SET.GROUP5	On			
106	EV106	0 - 3071	–	ditto	1248	SET.GROUP6	On			
107	EV107	0 - 3071	–	ditto	1249	SET.GROUP7	On			
108	EV108	0 - 3071	–	ditto	1250	SET.GROUP8	On			
109	EV109	0 - 3071	–	ditto	1448	Sys. Set change	On			
110	EV110	0 - 3071	–	ditto	1449	Rly. Set change	On			
111	EV111	0 - 3071	–	ditto	1450	Grp. Set change	On			
112	EV112	0 - 3071	–	ditto	0		On			
113	EV113	0 - 3071	–	ditto	0		On			
114	EV114	0 - 3071	–	ditto	0		On			
115	EV115	0 - 3071	–	ditto	0		On			
116	EV116	0 - 3071	–	ditto	0		On			
117	EV117	0 - 3071	–	ditto	0		On			
118	EV118	0 - 3071	–	ditto	0		On			
119	EV119	0 - 3071	–	ditto	1445	PLC data CHG	On			
120	EV120	0 - 3071	–	ditto	0		On			
121	EV121	0 - 3071	–	ditto	1409	LED RST	On			
122	EV122	0 - 3071	–	ditto	1435	F.record_CLR	On			
123	EV123	0 - 3071	–	ditto	0		On			
124	EV124	0 - 3071	–	ditto	1436	E.record_CLR	On			
125	EV125	0 - 3071	–	ditto	1437	D.record_CLR	On			
126	EV126	0 - 3071	–	ditto	0		On			
127	EV127	0 - 3071	–	ditto	0		On			
128	EV128	0 - 3071	–	ditto	0		On			

Disturbance record default setting

No.	Name	Range	Unit	Contents	Default setting		Model				Default setting		Model				
					NO.	Signal name	214	216	224	226	NO.	Signal name	211	221	311	321	323
1	SIG1	0 - 3071	–	disturbance record triger	235	TRIP-A	✓	✓	✓	✓	235	TRIP-A	✓	✓	✓	✓	✓
2	SIG2	0 - 3071	–	ditto	236	TRIP-B	✓	✓	✓	✓	236	TRIP-B	✓	✓	✓	✓	✓
3	SIG3	0 - 3071	–	ditto	237	TRIP-C	✓	✓	✓	✓	237	TRIP-C	✓	✓	✓	✓	✓
4	SIG4	0 - 3071	–	ditto	291	ARC1	✓	✓	✓	✓	291	ARC1	✓	✓	✓	✓	✓
5	SIG5	0 - 3071	–	ditto	0	NA	--	--	--	--	292	ARC2	--	--	✓	✓	
6	SIG6	0 - 3071	–	ditto	194	BU_TRIP	✓	✓	✓	✓	194	BU_TRIP	✓	✓	✓	✓	
7	SIG7	0 - 3071	–	ditto	231	CAR_TRIP	✓	✓	✓	✓	231	CAR_TRIP	✓	✓	✓	✓	
8	SIG8	0 - 3071	–	ditto	342	Z1_TRIP	✓	✓	✓	✓	342	Z1_TRIP	✓	✓	✓	✓	
9	SIG9	0 - 3071	–	ditto	343	Z1X_TRIP	✓	✓	✓	✓	343	Z1X_TRIP	✓	✓	✓	✓	
10	SIG10	0 - 3071	–	ditto	347	Z2+Z3+ZR1	✓	✓	✓	✓	347	Z2+Z3+ZR1	✓	✓	✓	✓	
11	SIG11	0 - 3071	–	ditto	349	EF/DEF_ALARM	✓	✓	✓	✓	349	EF/DEF_ALARM	✓	✓	✓	✓	
12	SIG12	0 - 3071	–	ditto	328	OC_BU-TRIP	✓	✓	✓	✓	328	OC_BU-TRIP	✓	✓	✓	✓	
13	SIG13	0 - 3071	–	ditto	350	SOTF+STUB	✓	✓	✓	✓	350	SOTF+STUB	✓	✓	✓	✓	
14	SIG14	0 - 3071	–	ditto	176	PSB_DET	✓	✓	✓	✓	176	PSB_DET	✓	✓	✓	✓	
15	SIG15	0 - 3071	–	ditto	203	OST_TRIP	✓	✓	✓	✓	203	OST_TRIP	✓	✓	✓	✓	
16	SIG16	0 - 3071	–	ditto	800	C/R_SEND-A	✓	✓	✓	✓	800	C/R_SEND-A	✓	✓	✓	✓	
17	SIG17	0 - 3071	–	ditto	801	C/R_SEND-B	✓	✓	✓	✓	801	C/R_SEND-B	✓	✓	✓	✓	
18	SIG18	0 - 3071	–	ditto	802	C/R_SEND-C	✓	✓	✓	✓	802	C/R_SEND-C	✓	✓	✓	✓	
19	SIG19	0 - 3071	–	ditto	803	C/R_SEND-S	✓	✓	✓	✓	803	C/R_SEND-S	✓	✓	✓	✓	
20	SIG20	0 - 3071	–	ditto	816	CAR-R-R1	✓	✓	✓	✓	816	CAR-R-R1	✓	✓	✓	✓	
21	SIG21	0 - 3071	–	ditto	820	CAR-R-R2	--	--	✓	✓	820	CAR-R-R2	--	✓	--	✓	
22	SIG22	0 - 3071	–	ditto	1536	CB1_CONT-A	✓	✓	✓	✓	1540	Z1X_INIT	✓	✓	✓	✓	
23	SIG23	0 - 3071	–	ditto	1537	CB1_CONT-B	✓	✓	✓	✓	1536	CB1_CONT-A	✓	✓	✓	✓	
24	SIG24	0 - 3071	–	ditto	1538	CB1_CONT-C	✓	✓	✓	✓	1537	CB1_CONT-B	✓	✓	✓	✓	
25	SIG25	0 - 3071	–	ditto	1542	DS_N/O_CONT	✓	✓	✓	✓	1538	CB1_CONT-C	✓	✓	✓	✓	
26	SIG26	0 - 3071	–	ditto	1545	CB1_READY	✓	✓	✓	✓	1542	DS_N/O_CONT	✓	✓	✓	✓	
27	SIG27	0 - 3071	–	ditto	0	NA	--	--	--	--	1545	CB1_READY	✓	✓	✓	✓	
28	SIG28	0 - 3071	–	ditto	0	NA	--	--	--	--	1546	CB2_READY	--	--	✓	✓	
29	SIG29	0 - 3071	–	ditto	0	NA	--	--	--	--	1552	CB2_CONT-A	--	--	✓	✓	
30	SIG30	0 - 3071	–	ditto	0	NA	--	--	--	--	1553	CB2_CONT-B	--	--	✓	✓	
31	SIG31	0 - 3071	–	ditto	0	NA	--	--	--	--	1554	CB2_CONT-C	--	--	✓	✓	
32	SIG32	0 - 3071	–	ditto	0	NA	--	--	--	--	0	NA	--	--	--	--	

PLC default setting

PLC default setting

Output: №	Output: Signal	Timing: Cycle 30	Timing: Cycle 90	Timing: Cycle User	Timing: Turn	Logic expression: Relay model 2x1, 3x1, 323 (Filename: GRZ100-B1-04)	Logic expression: relay model 2x4, 2x6 (Filename: GRZ100-B2-02)	Flip Flop: Norm	Flip Flop: Back Up	Flip Flop: Release Signal	Timer: Off Delay	Timer: On Delay	Timer: One Shot	Timer: Time Value	None
1536	CB1_CONT-A	X				[513]BI1_COMMAND									X
1537	CB1_CONT-B	X				[514]BI2_COMMAND									X
1538	CB1_CONT-C	X				[515]BI3_COMMAND									X
1539															
1540	Z1X_INIT	X				--	[524]BI12_COMMAND								X
1541	EXT_VTF	X				[518]BI6_COMMAND									X
1542	DS_N/O_CONT	X				[519]BI7_COMMAND									X
1543	DS_N/C_CONT	X				[520]BI8_COMMAND									X
1544	ARC_BLOCK	X				[199]CBF_DET+[203]OST_TRIP+[691]THM_TRIP+[791]PSBTP_TRIP+[832]TR1_TRIP+[840]TR2_TRIP+[767]BCD TRIP+[993]OV/UV TRIP									X
1545	CB1_READY	X				[522]BI10_COMMAND	[539]BI27_COMMAND								X
1546	CB2_READY	X				[523]BI11_COMMAND	--								X
1547	ARC_RESET	X				[524]BI12_COMMAND	[538]BI26_COMMAND								X
1548	IND.RESET	X				[525]BI13_COMMAND	[522]BI10_COMMAND								X
1549	M-PROT_TRIP	X				[526]BI14_COMMAND	--								X
1550	M-PROT_ON	X				[527]BI15_COMMAND	--								X
1551															
1552	CB2_CONT-A	X				[531]BI19_COMMAND	--								X
1553	CB2_CONT-B	X				[532]BI20_COMMAND	--								X
1554	CB2_CONT-C	X				[533]BI21_COMMAND	--								X
1555															
1556	EXT_TRIP-A	X				[528]BI16_COMMAND									X
1557	EXT_TRIP-B	X				[529]BI17_COMMAND									X
1558	EXT_TRIP-C	X				[530]BI18_COMMAND									X
1559															
1560	EXT_CBFIN-A	X				[528]BI16_COMMAND									X
1561	EXT_CBFIN-B	X				[529]BI17_COMMAND									X
1562	EXT_CBFIN-C	X				[530]BI18_COMMAND									X
1563															
1564	ARC_BLOCK1														
1565	ARC_BLOCK2														
1566															
1567															
1568	EXT_CAR.R1-1	X				[1287]BI4_COM_UF									X
1569	EXT_CAR.R1-2	X				[1288]BI5_COM_UF	--								X
1570	OPEN_TERM-R1	X				[1122]SUB_COM3-R1									X
1571	SEVERE_CF-R1	X				[1123]SUB_COM4-R1									X
1572															
1573															
1574															
1575															
1576															
1577															
1578															
1579															
1580															
1581															
1582															
1583															
1584	EXT_CAR.R2-1	X				--	[1288]BI5_COM_UF								X
1585	EXT_CAR.R2-2														
1586	OPEN_TERM-R2	X				[1170]SUB_COM3-R2									X
1587	SEVERE_CF-R2	X				[1171]SUB_COM4-R2									X
1588															
1589															
1590															
1591															
1592															
1593															
1594															
1595															
1596															
1597															
1598															
1599															
1600	PROT_BLOCK	X				--	[523]BI11_COMMAND								
1601	CRT_BLOCK	X				[521]BI9_COMMAND + [1513]RYID1_err + [1514]RYID2_err									X
1602	DISCRT_BLOCK														
1603	DEFCRT_BLOCK														
1604	PSBTP_BLOCK														

PLC default setting

Output			Timing				Logic expression		Delay Time / Flip Flop							
			Cycle				Relay model	relay model	Flip Flop			Timer				
№	Signal		30	90	User	Turn	2x1, 3x1, 323 / Filename: GRZ100-B1-04	2x4, 2x6 / Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
1605	PSB_BLOCK															
1606																
1607																
1608	OC-A_FS			X		0	[1]CONSTANT_1									X
1609	OC-B_FS			X		0	[1]CONSTANT_1									X
1610	OC-C_FS			X		0	[1]CONSTANT_1									X
1611																
1612	OCI-A_FS			X		1	[1]CONSTANT_1									X
1613	OCI-B_FS			X		1	[1]CONSTANT_1									X
1614	OCI-C_FS			X		1	[1]CONSTANT_1									X
1615	THMA_BLOCK															
1616	Z1G_BLOCK			X		0	[715]Z1CNT_TPBLK									X
1617	Z1XG_BLOCK															
1618	Z2G_BLOCK															
1619	Z3G_BLOCK															
1620	ZR1G_BLOCK															
1621	ZFG_BLOCK															
1622	STUB_BLOCK		X				--	[536]BI24_COMMAND								X
1623	SOTF_BLOCK		X				--	[537]BI25_COMMAND								X
1624	OCH_BLOCK															
1625	OC_BLOCK		X				--	[533]BI21_COMMAND								X
1626	OCI_BLOCK		X				--	[531]BI19_COMMAND								X
1627	EF_BLOCK															
1628	EFI_BLOCK		X				--	[532]BI20_COMMAND								X
1629	DEF_BLOCK		X				--	[534]BI22_COMMAND								X
1630	OST_BLOCK															
1631	THM_BLOCK															
1632	Z1S_BLOCK			X		0	[715]Z1CNT_TPBLK									X
1633	Z1XS_BLOCK															
1634	Z2S_BLOCK															
1635	Z3S_BLOCK															
1636	ZR1S_BLOCK															
1637	ZFS_BLOCK															
1638	ZR2G_BLOCK															
1639	ZR2S_BLOCK															
1640	CBF_BLOCK															
1641	EXTTP_BLOCK		X				--	[535]BI23_COMMAND								X
1642	VTF_BLOCK															
1643	VTF_ALARM															
1644	TR1_BLOCK															
1645	TR2_BLOCK															
1646	ZNDG_BLOCK															
1647	ZNDS_BLOCK															
1648	Z1S_G-BLK															
1649	STUB_CB			X		1	[1]CONSTANT_1	[101]CB-AND								X
1650	OCHTP_ON		X				[708]SHOT_NUM2 + [709]SHOT_NUM3 + [710]SHOT_NUM4 + [711]SHOT_NUM5									X
1651	PSB.F_RESET															
1652	DEF_PHSEL-A															
1653	DEF_PHSEL-B															
1654	DEF_PHSEL-C															
1655	Z1_ARC_BLOCK			X		0	[714]Z1CNT_ARCBLK									X
1656	Z2G-A_FS			X		1	[1]CONSTANT_1									X
1657	Z2G-B_FS			X		1	[1]CONSTANT_1									X
1658	Z2G-C_FS			X		1	[1]CONSTANT_1									X
1659	Z1X_F.ENABLE															
1660																
1661																
1662																
1663																
1664	ZFG-A_BLOCK		X				[29]Z3G-B									X
1665	ZFG-B_BLOCK		X				[30]Z3G-C									X
1666	ZFG-C_BLOCK		X				[28]Z3G-A									X
1667																
1668	ZNDG-A_COM		X				[666]ZNDG-AX									X
1669	ZNDG-B_COM		X				[667]ZNDG-BX									X
1670	ZNDG-C_COM		X				[668]ZNDG-CX									X
1671	ZNDS_COM		X				[669]ZNDS-ABX + [670]ZNDS-BCX + [671]ZNDS-CAX									X
1672	Z2G-A_BLOCK		X				[29]Z3G-B									X
1673	Z2G-B_BLOCK		X				[30]Z3G-C									X

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop								
№	Signal	Cycle 30	Cycle 90	Cycle User	Turn	Relay model 2x1, 3x1, 323 Filename: GRZ100-B1-04	relay model 2x4, 2x6 Filename: GRZ100-B2-02	Flip Flop Norm	Flip Flop Back Up	Flip Flop Release Signal	Timer Off Delay	Timer On Delay	Timer One Shot	Time Value		None
1674	Z2G-C_BLOCK	X				[28]Z3G-A										X
1675																
1676																
1677																
1678																
1679																
1680	TP-A_DELAY	X				[623]TP-A					X			60	ms	
1681	TP-B_DELAY	X				[624]TP-B					X			60	ms	
1682	TP-C_DELAY	X				[625]TP-C					X			60	ms	
1683	ARC_OFF															
1684	ARC_SPAR															
1685	ARC_TPAR															
1686	ARC_S&T															
1687	ARC_EXT1P															
1688	ARC_EXT3P															
1689																
1690																
1691																
1692																
1693																
1694																
1695																
1696	Z1_INST_TP		X		0	[712]Z1CNT_INST										X
1697																
1698	Z2_INST_TP															
1699	Z3_INST_TP															
1700	ZR1_INST_TP															
1701	ZF_INST_TP															
1702	EF_INST_TP															
1703	OC_INST_TP															
1704																
1705	DEF_INST_TP															
1706																
1707	DEFR_INST_TP															
1708	ZR2_INST_TP															
1709	ZND_INST_TP															
1710																
1711																
1712	Z1_3PTP		X		0	[713]Z1CNT_3PTP										X
1713	Z1X_3PTP															
1714	Z2_3PTP		X		2	[1]CONSTANT_1										X
1715																
1716	OC_3PTP		X		2	[1]CONSTANT_1										X
1717	OCI_3PTP		X		2	[1]CONSTANT_1										X
1718																
1719																
1720	CAR_3PTP															
1721	DEFCAR_3PTP		X		2	[1]CONSTANT_1										X
1722	PSBTP_3PTP		X		2	[1]CONSTANT_1										X
1723																
1724	TR1_3PTP															
1725	TR2_3PTP															
1726																
1727	3P_TRIP															
1728	CAR-A-R1	X				[1088]COM1-R1										X
1729	CAR-B-R1	X				[1089]COM2-R1										X
1730	CAR-C-R1	X				[1090]COM3-R1										X
1731	CAR-S-R1	X				[1091]COM4-R1										X
1732	DEFCAR-A-R1	X				[1092]COM5-R1										X
1733	DEFCAR-B-R1	X				[1093]COM6-R1										X
1734	DEFCAR-C-R1	X				[1094]COM7-R1										X
1735																
1736																
1737																
1738																
1739																
1740	PSBCAR-A-R1	X				[1095]COM8-R1										X
1741	PSBCAR-B-R1	X				[1095]COM8-R1										X
1742	PSBCAR-C-R1	X				[1095]COM8-R1										X

PLC default setting

Output №	Output Signal		Timing Cycle 30	Timing Cycle 90	Timing Cycle User	Timing Turn	Logic expression: Relay model 2x1, 3x1, 323 (Filename: GRZ100-B1-04)	Logic expression: relay model 2x4, 2x6 (Filename: GRZ100-B2-02)	Flip Flop Norm	Flip Flop Back Up	Flip Flop Release Signal	Timer Off Delay	Timer On Delay	Timer One Shot	Time Value	None
1743																
1744	TR1-A-R1		X				[1096]COM9-R1									X
1745	TR1-B-R1		X				[1096]COM9-R1									X
1746	TR1-C-R1		X				[1096]COM9-R1									X
1747																
1748	TR2-A-R1		X				--	[1097]COM10-R1								X
1749	TR2-B-R1		X				--	[1097]COM10-R1								X
1750	TR2-C-R1		X				--	[1097]COM10-R1								X
1751																
1752																
1753																
1754																
1755																
1756																
1757																
1758																
1759																
1760	CAR-A-R2		X				[1136]COM1-R2									X
1761	CAR-B-R2		X				[1137]COM2-R2									X
1762	CAR-C-R2		X				[1138]COM3-R2									X
1763	CAR-S-R2		X				[1139]COM4-R2									X
1764	DEFCAR-A-R2		X				[1140]COM5-R2									X
1765	DEFCAR-B-R2		X				[1141]COM6-R2									X
1766	DEFCAR-C-R2		X				[1142]COM7-R2									X
1767																
1768																
1769																
1770																
1771																
1772	PSBCAR-A-R2		X				[1143]COM8-R2									X
1773	PSBCAR-B-R2		X				[1143]COM8-R2									X
1774	PSBCAR-C-R2		X				[1143]COM8-R2									X
1775																
1776	TR1-A-R2		X				[1144]COM9-R2									X
1777	TR1-B-R2		X				[1144]COM9-R2									X
1778	TR1-C-R2		X				[1144]COM9-R2									X
1779																
1780	TR2-A-R2		X				--	[1145]COM10-R2								X
1781	TR2-B-R2		X				--	[1145]COM10-R2								X
1782	TR2-C-R2		X				--	[1145]COM10-R2								X
1783																
1784																
1785																
1786																
1787																
1788																
1789																
1790																
1791																
1792	IO#1-TP-A1		X				[240]TRIP-A1									X
1793	IO#1-TP-B1		X				[241]TRIP-B1									X
1794	IO#1-TP-C1		X				[242]TRIP-C1									X
1795	IO#1-TP-A2		X				[243]TRIP-A2	--								X
1796	IO#1-TP-B2		X				[244]TRIP-B2	--								X
1797	IO#1-TP-C2		X				[245]TRIP-C2	--								X
1798																
1799																
1800																
1801																
1802																
1803																
1804																
1805																
1806																
1807																
1808	OVS1_INST_TP															
1809	OVS2_INST_TP															
1810																
1811																

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle			Turn	Relay model	relay model	Flip Flop			Timer				None
№	Signal	30	90	User		2x1, 3x1, 323	2x4, 2x6	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	
						Filename: GRZ100-B1-04	Filename: GRZ100-B2-02								
1812	OVG1_INST_TP														
1813	OVG2_INST_TP														
1814															
1815															
1816	UVS1_INST_TP														
1817	UVS2_INST_TP														
1818															
1819															
1820	UVG1_INST_TP														
1821	UVG2_INST_TP														
1822															
1823															
1824	SPR.L-REQ					[1]CONSTANT_1									X
1825	TPR.L-REQ					[273]SYN-OP									X
1826	SPR.F-REQ					[1]CONSTANT_1									X
1827	TPR.F-REQ					[273]SYN-OP									X
1828	SPR.F-ST.REQ					[1]CONSTANT_1									X
1829	TPR.F-ST.REQ					[486]ARC-SET									X
1830															
1831															
1832	R.F-ST.REQ														
1833	SPR.F2-REQ														
1834	TPR.F2-REQ														
1835															
1836															
1837															
1838	ARC.L_TERM														
1839	ARC.F_TERM														
1840															
1841															
1842															
1843															
1844															
1845															
1846															
1847															
1848	BCD_BLOCK														
1849	DEFF_BLOCK														
1850															
1851	DEFR_BLOCK														
1852															
1853															
1854															
1855															
1856	OVS1_BLOCK														
1857	OVS2_BLOCK														
1858															
1859															
1860	OVG1_BLOCK														
1861	OVG2_BLOCK														
1862															
1863															
1864	UVS1_BLOCK														
1865	UVS2_BLOCK														
1866															
1867															
1868	UVG1_BLOCK														
1869	UVG2_BLOCK														
1870															
1871															
1872															
1873															
1874															
1875															
1876															
:															
:															
2039															
2040															

PLC default setting

Output №	Output Signal	Timing Cycle 30	Timing Cycle 90	Timing Cycle User	Timing Turn	Logic expression: Relay model 2x1, 3x1, 323 (Filename: GRZ100-B1-04)	Logic expression: relay model 2x4, 2x6 (Filename: GRZ100-B2-02)	Flip Flop Norm	Flip Flop Back Up	Flip Flop Release Signal	Timer Off Delay	Timer On Delay	Timer One Shot	Time Value	None
2041															
2042															
2043															
2044															
2045															
2046															
2047															
2048	COM1-S	X				[800]C/R_SEND-A									X
2049	COM2-S	X				[801]C/R_SEND-B									X
2050	COM3-S	X				[802]C/R_SEND-C									X
2051	COM4-S	X				[803]C/R_SEND-S									X
2052	COM5-S	X				[804]C/R_SEND-DEFA									X
2053	COM6-S	X				[805]C/R_SEND-DEFB									X
2054	COM7-S	X				[806]C/R_SEND-DEFC									X
2055	COM8-S	X				[815]C/R_SEND-PSB									X
2056	COM9-S	X				[516]BI4_COMMAND									X
2057	COM10-S	X				--	[517]BI5_COMMAND								X
2058	COM11-S														
2059	COM12-S														
2060	COM13-S														
2061	COM14-S														
2062															
2063															
2064	SUB_COM1-S														
2065	SUB_COM2-S														
2066	SUB_COM3-S	X				[848]LOCAL_TEST									X
2067	SUB_COM4-S	X				[881]SEVERE_CF-L									X
2068															
2069															
2070															
2071															
2072															
2073															
2074															
2075															
2076															
2077															
2078															
2079															
2080															
2081															
2082															
2083															
2084															
2085															
2086															
2087															
2088															
2089															
2090															
2091															
2092															
2093															
2094															
2095															
2096															
2097															
2098															
2099															
2100															
2101															
2102															
2103															
2104															
2105															
:															
:															
2599															
2600															

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle				Relay model	relay model	Flip Flop			Timer				
№	Signal	30	90	User	Turn	2x1, 3x1, 323 Filename: GRZ100-B1-04	2x4, 2x6 Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
2601															
2602															
2603															
2604															
2605															
2606															
2607															
2608															
2609															
2610	ALARM_LED_SET	X				[909]CFSV1-R + [925]CFSV2-R									X
2611															
2612															
2613															
2614															
2615															
2616															
2617															
2618															
2619															
2620															
2621															
2622															
2623															
2624	F.RECORD1														
2625	F.RECORD2														
2626	F.RECORD3														
2627	F.RECORD4														
2628															
2629															
2630															
2631															
2632	D.RECORD1														
2633	D.RECORD2														
2634	D.RECORD3														
2635	D.RECORD4														
2636															
2637															
2638															
2639															
2640	SET.GROUP1														
2641	SET.GROUP2														
2642	SET.GROUP3														
2643	SET.GROUP4														
2644	SET.GROUP5														
2645	SET.GROUP6														
2646	SET.GROUP7														
2647	SET.GROUP8														
2648															
2649															
2650															
2651															
2652															
2653															
2654															
2655															
2656	CON_TPMD1														
2657	CON_TPMD2														
2658	CON_TPMD3														
2659	CON_TPMD4														
2660	CON_TPMD5														
2661	CON_TPMD6														
2662	CON_TPMD7														
2663	CON_TPMD8														
2664															
2665															
2666															
2667															
2668															
2669															

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle				Relay model	relay model	Flip Flop			Timer				
№	Signal	30	90	User	Turn	2x1, 3x1, 323 Filename: GRZ100-B1-04	2x4, 2x6 Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
2670															
2671															
2672															
2673															
2674															
2675															
2676															
2677															
2678															
2679															
2680															
2681															
2682															
2683															
2684	ARC_COM_RECV														
2685	TELE_COM_RECV														
2686	PROT_COM_RECV														
2687															
2688	TPLED_RST_RCV														
2689															
2690															
2691															
2692															
2693															
2694															
2695															
2696															
2697															
2698															
2699															
2700															
2701															
2702															
2703															
2704															
2705															
2706															
2707															
2708															
2709															
2710															
2711															
2712															
2713															
2714															
2715															
2716															
2717															
2718															
2719															
2720															
2721															
2722															
2723															
2724															
2725															
2726															
2727															
2728															
2729															
2730															
2731															
2732															
2733															
2734															
:															
:															
2814															
2815															

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle			Turn	Relay model	relay model	Flip Flop			Timer				None
№	Signal	30	90	User		2x1, 3x1, 323 Filename: GRZ100-B1-04	2x4, 3x6 Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	
2816	TEMP001	X				--	[148]Z1G_TRIP + [160]Z1S_TRIP								X
2817	TEMP002	X				--	[153]Z2G_TRIP + [162]Z2S_TRIP								X
2818	TEMP003	X				--	[156]Z3G_TRIP + [165]Z3S_TRIP								X
2819	TEMP004														
2820	TEMP005														
2821	TEMP006														
2822	TEMP007														
2823	TEMP008														
2824	TEMP009														
2825	TEMP010														
2826	TEMP011														
2827	TEMP012														
2828	TEMP013														
2829	TEMP014														
2830	TEMP015														
2831	TEMP016														
2832	TEMP017														
2833	TEMP018														
2834	TEMP019														
2835	TEMP020														
2836	TEMP021														
2837	TEMP022														
2838	TEMP023														
2839	TEMP024														
2840	TEMP025														
2841	TEMP026														
2842	TEMP027														
2843	TEMP028														
2844	TEMP029														
2845	TEMP030														
2846	TEMP031														
2847	TEMP032														
2848	TEMP033														
2849	TEMP034														
2850	TEMP035														
2851	TEMP036														
2852	TEMP037														
2853	TEMP038														
2854	TEMP039														
2855	TEMP040														
2856	TEMP041														
2857	TEMP042														
2858	TEMP043														
2859	TEMP044														
2860	TEMP045														
2861	TEMP046														
2862	TEMP047														
2863	TEMP048														
2864	TEMP049														
2865	TEMP050														
2866	TEMP051														
2867	TEMP052														
2868	TEMP053														
2869	TEMP054														
2870	TEMP055														
2871	TEMP056														
2872	TEMP057														
2873	TEMP058														
2874	TEMP059														
2875	TEMP060														
2876	TEMP061														
2877	TEMP062														
2878	TEMP063														
2879	TEMP064														
2880	TEMP065														
2881	TEMP066														
2882	TEMP067														
2883	TEMP068														
2884	TEMP069														

PLC default setting

Output			Timing				Logic expression		Delay Time / Flip Flop							
			Cycle			Turn	Relay model	relay model	Flip Flop			Timer				None
№	Signal		30	90	User		2x1, 3x1, 323	2x4, 2x6	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	
							Filename: GRZ100-B1-04	Filename: GRZ100-B2-02								
2885	TEMP070															
2886	TEMP071															
2887	TEMP072															
2888	TEMP073															
2889	TEMP074															
2890	TEMP075															
2891	TEMP076															
2892	TEMP077															
2893	TEMP078															
2894	TEMP079															
2895	TEMP080															
2896	TEMP081															
2897	TEMP082															
2898	TEMP083															
2899	TEMP084															
2900	TEMP085															
2901	TEMP086															
2902	TEMP087															
2903	TEMP088															
2904	TEMP089															
2905	TEMP090															
2906	TEMP091															
2907	TEMP092															
2908	TEMP093															
2909	TEMP094															
2910	TEMP095															
2911	TEMP096															
2912	TEMP097															
2913	TEMP098															
2914	TEMP099															
2915	TEMP100															
2916	TEMP101															
2917	TEMP102															
2918	TEMP103															
2919	TEMP104															
2920	TEMP105															
2921	TEMP106															
2922	TEMP107															
2923	TEMP108															
2924	TEMP109															
2925	TEMP110															
2926	TEMP111															
2927	TEMP112															
2928	TEMP113															
2929	TEMP114															
2930	TEMP115															
2931	TEMP116															
2932	TEMP117															
2933	TEMP118															
2934	TEMP119															
2935	TEMP120															
2936	TEMP121															
2937	TEMP122															
2938	TEMP123															
2939	TEMP124															
2940	TEMP125															
2941	TEMP126															
2942	TEMP127															
2943	TEMP128															
2944	TEMP129															
2945	TEMP130															
2946	TEMP131															
2947	TEMP132															
2948	TEMP133															
2949	TEMP134															
2950	TEMP135															
2951	TEMP136															
2952	TEMP137															
2953	TEMP138															

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle				Relay model	relay model	Flip Flop			Timer				
№	Signal	30	90	User	Turn	2x1, 3x1, 323 Filename: GRZ100-B1-04	2x4, 2x6 Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
2954	TEMP139														
2955	TEMP140														
2956	TEMP141														
2957	TEMP142														
2958	TEMP143														
2959	TEMP144														
2960	TEMP145														
2961	TEMP146														
2962	TEMP147														
2963	TEMP148														
2964	TEMP149														
2965	TEMP150														
2966	TEMP151														
2967	TEMP152														
2968	TEMP153														
2969	TEMP154														
2970	TEMP155														
2971	TEMP156														
2972	TEMP157														
2973	TEMP158														
2974	TEMP159														
2975	TEMP160														
2976	TEMP161														
2977	TEMP162														
2978	TEMP163														
2979	TEMP164														
2980	TEMP165														
2981	TEMP166														
2982	TEMP167														
2983	TEMP168														
2984	TEMP169														
2985	TEMP170														
2986	TEMP171														
2987	TEMP172														
2988	TEMP173														
2989	TEMP174														
2990	TEMP175														
2991	TEMP176														
2992	TEMP177														
2993	TEMP178														
2994	TEMP179														
2995	TEMP180														
2996	TEMP181														
2997	TEMP182														
2998	TEMP183														
2999	TEMP184														
3000	TEMP185														
3001	TEMP186														
3002	TEMP187														
3003	TEMP188														
3004	TEMP189														
3005	TEMP190														
3006	TEMP191														
3007	TEMP192														
3008	TEMP193														
3009	TEMP194														
3010	TEMP195														
3011	TEMP196														
3012	TEMP197														
3013	TEMP198														
3014	TEMP199														
3015	TEMP200														
3016	TEMP201														
3017	TEMP202														
3018	TEMP203														
3019	TEMP204														
3020	TEMP205														
3021	TEMP206														
3022	TEMP207														

PLC default setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle				Relay model	relay model	Flip Flop			Timer				
№	Signal	30	90	User	Turn	2x1, 3x1, 323 Filename: GRZ100-B1-04	2x4, 2x6 Filename: GRZ100-B2-02	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
3023	TEMP208														
3024	TEMP209														
3025	TEMP210														
3026	TEMP211														
3027	TEMP212														
3028	TEMP213														
3029	TEMP214														
3030	TEMP215														
3031	TEMP216														
3032	TEMP217														
3033	TEMP218														
3034	TEMP219														
3035	TEMP220														
3036	TEMP221														
3037	TEMP222														
3038	TEMP223														
3039	TEMP224														
3040	TEMP225														
3041	TEMP226														
3042	TEMP227														
3043	TEMP228														
3044	TEMP229														
3045	TEMP230														
3046	TEMP231														
3047	TEMP232														
3048	TEMP233														
3049	TEMP234														
3050	TEMP235														
3051	TEMP236														
3052	TEMP237														
3053	TEMP238														
3054	TEMP239														
3055	TEMP240														
3056	TEMP241														
3057	TEMP242														
3058	TEMP243														
3059	TEMP244														
3060	TEMP245														
3061	TEMP246														
3062	TEMP247														
3063	TEMP248														
3064	TEMP249														
3065	TEMP250														
3066	TEMP251														
3067	TEMP252														
3068	TEMP253														
3069	TEMP254														
3070	TEMP255														
3071	TEMP256														

Appendix I

Commissioning Test Sheet (sample)

1. Relay identification
2. Preliminary check
3. Hardware check
   3.1 User interface check
   3.2 Binary input/Binary output circuit check
   3.3 AC input circuit check
4. Function test
   4.1 Phase fault element ZS test
   4.2 Earth fault element ZG test
   4.3 Out-of-step element OST test
   4.4 Phase selection element UVC test
   4.5 Directional earth fault element DEF test
   4.6 Negative sequence directional element DOCN test
   4.7 Inverse definite minimum time overcurrent element (IDMT) EFI and OCI test
   4.8 Voltage and synchronism check elements test
   4.9 Thermal overload element test
   4.10 Current change detection element
   4.11 Level detectors test
   4.12 BCD elment test
   4.13 Overvoltage and undervoltage elements test
5. Protection scheme test
6. Metering and recording check
7. Conjunctive test

1. Relay identification

Type ______________________ Serial number ______________________

Model ______________________ System frequency ______________________

Station ______________________ Date ______________________

Circuit ______________________ Engineer ______________________

Protection scheme ______________________ Witness ______________________

Active settings group number __________

2. Preliminary check

Ratings	☐
CT shorting contacts	☐
DC power supply	☐
Power up	☐
Wiring	☐
Relay inoperative alarm contact	☐
Calendar and clock	☐

3. Hardware check

3.1 User interface check ☐

3.2 Binary input/Binary output circuit check

Binary input circuit	☐
Binary output circuit	☐

3.3 AC input circuit ☐

4. Function test

4.1 Phase fault element ZS test

Element	Reach setting (ZS)	IT	2IT × ZS	Measured voltage ($2V_a$)
Z1S				
Z1XS				
Z2S				
Z3S				
ZFS				
Z4S				
ZR1S				
ZR2S				
ZNDS				
PSBSIN				
PSBSOUT				

4.2 Earth fault element ZG test

Element	Reach setting (ZG)	IT	2IT × ZG	Measured voltage ($2V_a$)
Z1G				
Z1XG				
Z2G				
Z3G				
ZFG				
Z4G				
ZR1G				
ZR2G				
ZNDG				
PSBGIN				
PSBGOUT				

4.3 Out-of-step element OST test

Element	Reach setting (Z_{OST})	IT	2IT × Z_{OST}	Measured voltage ($2V_a$)
OSTXF				
OSTXB				
OSTR1				
OSTR2				

4.4 Phase selection element UVC test

Element	Reach setting (UVCZ)	IT	IT × UVCZ + UVCV	Measured voltage
UVC	0	0		

4.5 Directional earth fault element DEF test

(1)

Element	Current setting	Measured current
DEFF		
DEFR		

(2)

Element	Voltage setting	Measured voltage
DEFF		
DEFR		

4.6 Negative sequence directional element DOCN test

Element	Test current	Measured voltage
DOCN-F	I_N	
DOCN-R	I_N	

4.7 Inverse definite minimum time overcurrent element (IDMT) EFI and OCI test

Element	Test current	Measured operating time
EFI	$1.2 \times I_S$	
	$20 \times I_S$	
OCI	$1.2 \times I_S$	
	$20 \times I_S$	

4.8 Voltage and synchronism check elements test

(1) Voltage check element

Element	Setting	Measured voltage
OVB		
UVB		
OVL1		
UVL1		
OVL2		
UVL2		

(2) Synchronism check element

① Voltage check

Element	Setting	Measured voltage
SYN1 (SY1UV)		
SYN1 (SY1OV)		
SYN2 (SY2UV)		
SYN2 (SY2OV)		

② Phase angle check

Element	Setting	Measured angle
SYN1 (SY1θ)		
SYN2 (SY2θ)		

4.9 Thermal overload element test

Element	Test current	Measured operating time
THM-A	$1.2 \times I_S$	
THM-T	$10 \times I_S$	

4.10 Current change detection element

Element	Test current	Result
OCD	1.2 × Fixed setting	
OCDP	1.2 × Setting value	

4.11 Level detectors test

Element	Setting	Measured value
OCH		
EF		
EFL		
OC		
OVG		
UVLS		
UVLG		
UVFS		
UVFG		
OCBF		

4.12 BCD element check

4.13 Overvoltage and undervoltage elements test

(1) Operating value test

Element	Voltage setting	Measured voltage	Element	Voltage setting	Measured voltage
OVS1			OVG1		
OVS2			OVG2		
UVS1			UVG1		
UVS2			UVG2		

(2) Operating time test (IDMT)

Element	Voltage setting	Multiplier setting	Changed voltage	Measured time
OVS1		10.0	1.5× Voltage setting	
OVG1		10.0	1.5 × Voltage setting	
UVS1		10.0	0.5 × Voltage setting	
UVG1		10.0	0.5 × Voltage setting	

5. Protection scheme test

Scheme	Results

6. Metering and recording check

7. Conjunctive test

Scheme	Results
On load check	
Signaling circuit	
Tripping circuit	
Reclosing circuit	

Appendix J

Return Repair Form

RETURN / REPAIR FORM

Please fill in this form and return it to Toshiba Corporation with the GRZ100 to be repaired.

TOSHIBA CORPORATION Fuchu Complex

1, Toshiba-cho, Fuchu-shi, Tokyo, Japan

For: Power Systems Protection & Control Department

Quality Assurance Section

Type: GRZ100 Model: ________

(Example: Type: GRZ100 Model: 214B-22-10)

Product No.: ____________________

Serial No. : ____________________

Date: ____________________

1. Why the relay is being returned ?

☐ mal-operation

☐ does not operate

☐ increased error

☐ investigation

☐ others

____

____

____

____

2. Fault records, event records or disturbance records stored in the relay and relay settings are very helpful information to investigate the incident.

   Please inform us of this information in respect to in the incident on a Floppy Disk, or by completing the Fault Record sheet and Relay Setting sheet attached.

Fault Record

Date/Month/Year Time / / / : : .

(Example: 04/ Nov./ 1997 15:09:58.442)

Faulty phase:

Fault Locator : km (%)

Prefault values (CT ratio: kA/: A, VT ratio: kV/: V)

V_a:	kV or V∠	°	I_a:	kA or A∠	°
V_b:	kV or V∠	°	I_b:	kA or A∠	°
V_c:	kV or V∠	°	I_c:	kA or A∠	°
V_{ab}:	kV or V∠	°	I_{ab}:	kA or A∠	°
V_{bc}:	kV or V∠	°	I_{bc}:	kA or A∠	°
V_{ca}:	kV or V∠	°	I_{ca}:	kA or A∠	°
V_1:	kV or V∠	°	I_1:	kA or A∠	°
V_2:	kV or V∠	°	I_2:	kA or A∠	°
V_0:	kV or V∠	°	I_0:	kA or A∠	°
			I_{0a}:	kA or A∠	°

Fault values

V_a:	kV or V∠	°	I_a:	kA or A∠	°
V_b:	kV or V∠	°	I_b:	kA or A∠	°
V_c:	kV or V∠	°	I_c:	kA or A∠	°
V_{ab}:	kV or V∠	°	I_{ab}:	kA or A∠	°
V_{bc}:	kV or V∠	°	I_{bc}:	kA or A∠	°
V_{ca}:	kV or V∠	°	I_{ca}:	kA or A∠	°
V_1:	kV or V∠	°	I_1:	kA or A∠	°
V_2:	kV or V∠	°	I_2:	kA or A∠	°
V_0:	kV or V∠	°	I_0:	kA or A∠	°
			I_{0a}:	kA or A∠	°

R_a :	Ω	X_a :	Ω
R_b :	Ω	X_b :	Ω
R_c :	Ω	X_c :	Ω
R_{ab} :	Ω	X_{ab} :	Ω
R_{bc} :	Ω	X_{bc} :	Ω
R_{ca} :	Ω	X_{ca} :	Ω

3. What was the message on the LCD display at the time of the incident.

4. Please write the detail of the incident.

5. Date of the incident occurred.
   Day/ Month/ Year: / / /
   (Example: 10/ July/ 1998)

6. Please write any comments on the GRZ100, including the document.

Customer

Name: ____________________

Company Name: ____________________

Address: ____________________

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____

Telephone No.: ____________________

Facsimile No.: ____________________

Signature: ____________________

Appendix K

Technical Data

Ratings	
AC current I_n: AC voltage V_n: Frequency: DC power supply: AC ripple on DC supply IEC60255-11 DC supply interruption IEC60255-11 Permissive duration of DC supply voltage interruption to maintain normal operation: Restart time: Binary input circuit DC voltage	1A or 5A 100V, 110V, 115V, 120V 50Hz or 60Hz 110Vdc/125Vdc (Operative range: 88 - 150Vdc) 220Vdc/250Vdc (Operative range: 176 - 300Vdc) 48Vdc/54Vdc/60Vdc (Operative range: 38.4 - 72Vdc) 24Vdc/30Vdc Operative range: 19.2 – 36Vdc maximum 12% less than 50ms at 110V less than 10s 110Vdc/125Vdc 220Vdc/250Vdc 48Vdc/54Vdc/60Vdc 24Vdc/30Vdc
Overload Ratings	
AC current input AC voltage input	4 times rated continuous 100 times rated for 1s 2 times rated continuous 2.5 times rated for 1s
Burden	
AC current input AC voltage input DC power supply: Binary input circuit:	0.2VA per phase (at rated 5A) 0.4 VA at zero-sequence circuit (at rated 5A) 0.1VA per phase (at rated 1A) 0.3 VA at zero-sequence circuit (at rated 1A) 0.1VA (at rated voltage) less than15W (quiescent) less than 25W (operation) ≤ 0.5W/input at 110Vdc
CT Ratio Setting	
CT ratio	1 to 20000 in 1 steps
Full Scale of Current for Measurement	
Current	65 times rated current
Phase Fault Distance Measuring Element	
Z1S, Z2S and Z1XS Z1S θ1 Z1S θ2 ZFS, ZR1S and ZR2S Z3S and Z4S Characteristic angle Z1S and Z4S offset ZNDS Blinder (BFR1S, BFR2S, BFRS, BRRS, BNDS) BRLS: Linked with BRRS Characteristic angle (BFR1S, BFR2S, BFRS, BRRS, BNDS) Characteristic angle (BFLS)	0.10 to 250.00Ω in 0.01Ω steps (1A relay) 0.01 to 50.00Ω in 0.01Ω steps (5A relay) 0° to 45° in 1° steps 45° to 90° in 1° steps 0.1 to 250.0Ω in 0.1Ω steps (1A relay) 0.01 to 50.00 in 0.01Ω steps (5A relay) 0.1 to 250.0Ω in 0.1Ω steps (1A relay) 0.01 to 50.00 in 0.01Ω steps (5A relay) 45° to 90° in 1° steps 7.5Ω fixed (1A relay) 1.5Ω fixed (5A relay) 0.1 to 250.0Ω in 0.1Ω steps (1A relay) 0.01 to 50.00 in 0.01Ω steps (5A relay) 0.5 to 100.0Ω in 0.1Ω steps (1A relay) 0.10 to 20.00Ω in 0.01Ω steps (5A relay) 75° fixed 90° to 135°

Earth Fault Distance Measuring Element	
Z1G, Z2G and Z1XG	0.10 to 250.00Ω in 0.01Ω steps (1A relay) 0.01 to 50.00Ω in 0.01Ω steps (5A relay)
Z1G θ1 Z1G θ2	0° to 45° in 1° steps 45° to 90° in 1° steps
ZR1G	0.1 to 250.0Ω in 0.1Ω steps (1A relay) 0.01 to 50.00 in 0.01Ω steps (5A relay)
ZFG, Z3G, ZR2G and Z4G	0.1 to 500.0Ω in 0.1Ω steps (1A relay) 0.01 to 100.00 in 0.01Ω steps (5A relay)
Characteristic angle	45° to 90° in 1° steps
ZNDG	0.1 to 500.0Ω in 0.1Ω steps (1A relay) 0.01 to 100.00 in 0.01Ω steps (5A relay)
Blinder (BFR1G, BFR2G, BFRG, BRRG, BNDG) BRLG: Linked with BRRG	0.5 to 100.0Ω in 0.1Ω steps (1A relay) 0.10 to 20.00Ω in 0.01Ω steps (5A relay)
Characteristic angle (BFR1G, BFR2G, BFRG, BRRG, BNDG) Characteristic angle (BFLG)	75° fixed 90° to 135°
Time Setting for Zone Protection	
Time setting of Z1S, Z2S, Z3S, ZFS, ZR1S, ZR2S, ZNDS, Z1G, Z2G, Z3G, ZFG, ZR1G, ZR2G, ZNDG	0.00 to 10.00s in 0.01s steps
Command Protection	
Trip time	Note the trip time is an operating time of measuring element plus transmission delay time, etc. in the command protection.
Coordination time for BOP scheme	0 to 50ms in 1ms steps
Transfer Tripping function	
Operating time (excluding transmission delay time)	Typical 15ms from BI energisation at the sent end to trip contact closing at the receive end.
Operating and Resetting Time of Distance Measuring Element	
Typical operating time	20ms
Operating time curve (SIR curve)	Refer to Figure K-1.
Resetting time	less than 30ms (for tripping output) less than 40ms (for signal output)
Accuracy of Distance Measuring Element	
Static accuracy	±5% under SIR < 30, ±10% under 30 < SIR < 50
Static angle accuracy	±5°
Transient overreach	+5%
Minimum Operating Current	
Current	0.08A (1A relay) 0.4A (1A relay)
Residual Current Compensation	
Residual current compensation for reactance element of Z1G, Z1XG, Z2G, ZFG, ZR1G	Adjustable as follows:
Earth return compensation	0 to 1000% in 1% steps
Mutual coupling compensation (ZR1G excluded)	0 to 1000% in 1% steps
Phase Selection Element	
Undervoltage	10 to 60V in 1V steps
Impedance	0.0 to 250.0Ω in 1Ω steps (1A relay) 0.0 to 50.0Ω in 1Ω steps (5A relay)
Characteristic angle	45° to 90° in 1° steps
Residual current compensation	Automatically set according to residual current compensation setting of reactance element

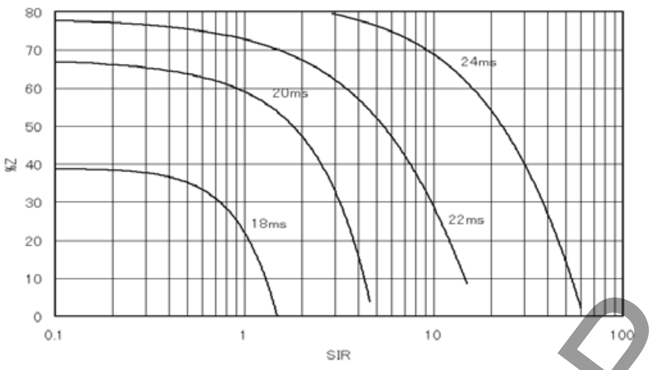
Switch-on-to-fault and Stub protection	
Overcurrent	0.4 to 3.0A in 0.1A steps (1A relay) 2.0 to 15.0A in 0.1A steps (5A relay)
Broken Conductor Detection	
Broken conductor threshold (I_2/I_1): DTL delay:	OFF, 0.10 to 1.00 in 0.01 steps 0.00 to 300.00s in 0.01s steps
Voltage Transformer Failure Supervision	
Undervoltage element (phase-to-phase)	50 to 100V in 1V steps
Undervoltage element (phase-to-earth)	10 to 60V in 1V steps
Current change detection element	0.1A fixed (1A relay) 0.5A fixed (5A relay)
Residual voltage element	20V fixed
Residual current element	Common use with earth fault detection element
Power Swing Blocking	
Detection zone (PSBZS, PSBZG)	2.5 to 75.0Ω in 0.1Ω steps (1A relay) 0.50 to 15.00 in 0.01Ω steps (5A relay)
Current change detection element	0.1 to 2.0A in 0.1A steps (1A relay) 0.5 to 10.0A in 0.1A steps (5A relay)
Detection time	30 to 60ms in 1ms steps
Resetting time	500ms fixed
Out-of-step Protection	
Resistive reach (OSTR1)	15 to 150Ω in 1Ω steps (1A relay) 3.0 to 30.0Ω in 0.1Ω steps (5A relay)
Resistive reach (OSTR2)	5 to 50Ω in 1Ω steps (1A relay) 1.0 to 10.0Ω in 0.1Ω steps (5A relay)
Resistive reach (OSTXF)	5 to 250Ω in 1Ω steps (1A relay) 1.0 to 50.0Ω in 0.1Ω steps (5A relay)
Resistive reach (OSTXF)	1 to 50Ω in 1Ω steps (1A relay) 0.2 to 10.0Ω in 0.1Ω steps (5A relay)
Detection time (TOST)	0.01 to 1.00s in 0.01s steps
Breaker Failure (BF) Protection	
Overcurrent element	0.1 to 2.0A in 0.1A steps (1A relay) 0.5 to 10.0A in 0.1A steps (5A relay)
BF timer for retry-trip of failed breaker	50 to 500ms in 1ms steps
BF timer for related breaker trip	50 to 500ms in 1ms steps
Operating time of overcurrent element	less than 20ms at 50Hz or less than 17ms at 60Hz
Resetting time of overcurrent element	less than 15ms at 50Hz or less than 13ms at 60Hz
Inverse Time Overcurrent Protection	
Overcurrent	0.10 to 5.00A in 0.01A steps (1A relay) 0.5 to 25.0A in 0.1A steps (5A relay)
Time multiplier	0.05 to 1.00 in 0.01 steps
Characteristic	Refer to Figure 8.
Accuracy of inverse time characteristics	Standard, Very and Long-time: IEC60255-3 class 5 Extremely inverse: IEC60255-3 class 7.5
Reset definite time	0.0 to 10.0s in 0.1s steps
Definite Time Overcurrent Protection	
Overcurrent	0.1 to 20.0A in 0.1A steps (1A relay) 0.5 to 100.0A in 0.1A steps (5A relay)
Time for delayed trip	0.00 to 10.00s in 0.01s steps
Operating time of overcurrent element	less than 20ms
Accuracy of pick-up value	±5%

Directional Earth Fault Protection	
Characteristic angle Polarising voltage (3V0) Zero-sequence current (3I0) Time multiplier for inverse time characteristic Definite time delay for backup trip Accuracy of pick-up value	0 to 90° in 1° steps (3I0 lags for –3V0) 1.7 to 21.0V in 0.1V steps 0.10 to 1.00A in 0.01A in 0.01A steps (1A relay) 0.5 to 5.0A in 0.1A steps (5A relay) 0.05 to 1.00 in 0.01 steps 0.00 to 10.00s in 0.01s steps ±5%
Directional Earth Fault Command Protection	
Time for delayed trip Coordination time	0.00 to 0.30s in 0.01s steps 0 to 50ms in 1ms steps
Inverse Time Earth Fault Protection	
Earth fault Time multiplier Characteristic Accuracy of inverse time characteristics Reset definite time	0.10 to 1.00A in 0.01A steps (1A relay) 0.5 to 5.0A in 0.1A steps (5A relay) 0.05 to 1.00 in 0.01 steps Refer to Figure 8. Standard, Very and Long-time: IEC60255-3 class 5 Extremely inverse: IEC60255-3 class 7.5 0.0 to 10.0s in 0.1s steps
Definite Time Earth Fault Protection	
Earth fault Time for delayed trip Accuracy of pick-up value	0.10 to 1.00A in 0.01A steps (1A relay) 0.5 to 5.0A in 0.1A steps (5A relay) 0.00 to 10.00s in 0.01s steps ±5%
Weak Infeed and Echo Protection	
Phase-to-phase undervoltage element Phase-to-earth undervoltage element	50 to 100V in 1V steps 10 to 60V in 1V steps
Thermal overload Protection	
Thermal setting (THM = k.I_{FLC}) Time constant (τ) Thermal alarm Pre-load current setting	OFF, 0.40 – 2.00A in 0.01A steps (1A rating) OFF, 2.0 – 10.0A in 0.1A steps (5A rating) 0.5 – 300.0mins in 0.1min steps OFF, 50% to 99% in 1% steps 0.00 – 1.00A in 0.01A steps (1A rating) 0.0 – 5.0A in 0.1A steps (5A rating)
Overvoltage Protection	
1st, 2nd Overvoltage thresholds: Delay type: IDMTL Time Multiplier Setting TMS: DTL delay: DO/PU ratio Reset Delay (1st threshold only):	OFF, 5.0 – 150.0V in 0.1V steps (for both phase-to-phase and phase-to-neutral voltage) DTL, IDMTL(1st threshold only) 0.05 – 100.00 in 0.01 steps 0.00 – 300.00s in 0.01s steps 10 – 98% in 1% steps 0.0 – 300.0s in 0.1s steps
Undervoltage Protection	
1st, 2nd Undervoltage thresholds: Delay type: IDMTL Time Multiplier Setting TMS: DTL delay: DO/PU ratio Reset Delay (1st threshold only):	OFF, 5.0 – 150.0V in 0.1V steps (for both phase-to-phase and phase-to-neutral voltage) DTL, IDMTL(1st threshold only) 0.05 – 100.00 in 0.01 steps 0.00 – 300.00s in 0.01s steps 10 – 98% in 1% steps 0.0 – 300.0s in 0.1s steps

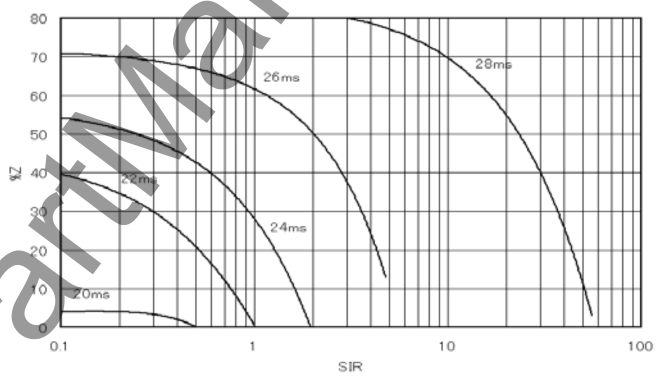
Autoreclose Function	
Number of shots	1 to 4 shots
Timer settings	
Dead time for single-phase autoreclose	0.01 to 10.00s in 0.01s steps
Dead time for three-phase autoreclose	0.01 to 100.00s in 0.01s steps
Multi-shot dead line time	5.0 to 300.0s in 0.1s steps
Multi-shot reset time	5.0 to 300.0s in 0.1s steps
Reclaim time	5 to 300s in 1s steps
Pulse width of reclosing signal output	0.1 to 10.0s in 0.1s steps
Autoreclose reset time	0.01 to 100.00s in 0.01s steps
Reset time for developing fault	0.01 to 10.00s in 0.01s steps
One-and-a-half breaker scheme	
Follower breaker autoreclose delay time	0.1 to 10.0s in 0.1s steps
Voltage and synchronism check element	
Synchronism check angle	5 to 75° in 1° steps
UV element	10 to 150V in 1V steps
OV element	10 to 150V in 1V steps
Busbar or line dead check	10 to 150V in 1V steps
Busbar or line live check	10 to 150V in 1V steps
Synchronism check time	0.01 to 10.00s in 0.01s steps
Voltage check time	0.01 to 1.00s in 0.01s steps
Operating time of synchronism check element	less than 50ms
Operating time of UV and OV elements	less than 40ms
Integral Communication Interface (Protection Signalling)	
Electrical interface (Telecomm. equipment link)	
Applicable standard	CCITT-G703-1.2.1 CCITT-G703-1.2.2 or 1.2.3 X.21
Type of code	NRZ (Non-Return to Zero)
Connector type	D-sub connector
Optical interface (2 km class)	
Type of fibre	Graded-index multi-mode 50/125μm or 62.5/125μm
Connector type	ST type
Wave length	820nm
Optical transmitter	LED, more than −19dBm or −16dBm
Optical receiver	PIN diode, less than −24dBm
Optical interface (30 km class)	
Type of fibre	Single mode 10/125μm
Connector type	Duplex LC
Wave length	1310nm
Optical transmitter	Laser, more than −13dBm
Optical receiver	PIN diode, less than −30dBm
Optical interface (80 km class)	
Type of fibre	DSF 8/125μm
Connector type	Duplex LC
Wave length	1550nm
Optical transmitter	Laser, more than −5dBm
Optical receiver	PIN diode, less than −34dBm

Fault Locator	
Line reactance and resistance setting	0.0 to 999.9Ω in 0.1Ω steps (1A relay) 0.00 to 199.99Ω in 0.01Ω steps (5A relay)
Line length	0.0 to 399.9km in 0.1km steps
Correction factor of impedance between lines	80 to 120% in 1% steps
Correction factor of impedance between in each phase	80 to 120% in 1% steps
Accuracy	
Local and remote end data used for three terminal line	±2.0km (up to 100km) or ±2.0% (up to 399.9km) at the positive sequence differential current more than In.(*) ±4.0km (up to 100km) or ±4.0% (up to 399.9km) at the positive sequence differential current more than In/2.(*) (*) Condition : (positive sequence impedance / km) = (0.05 to 6.0Ω / In)
Only local end data used for two and three terminal line	±2.5km (up to 100km) or ±2.5% (up to 399.9km) at fault current more than In/2 and at (positive sequence impedance / km) more than 0.05Ω / In.
Minimum measuring cycles	3 cycles
Disturbance Record Initiation	
Overcurrent element	0.1 to 50.0A in 0.1A steps (1A relay) 0.5 to 250.0A in 0.1A steps (5A relay)
Undervoltage element	0 to 132V in 1V steps (for phase fault) 0 to 76V in 1V steps (for earth fault)
Pre-fault time	0.3s fixed
Post-fault time	0.1 to 3.0s in 0.1s steps
Communication Port	
Front communication port (local PC)	
Connection	Point to point
Cable type	Multi-core (straight)
Cable length	15m (max.)
Connector	RS232C 9-pin D-subminiature connector female
Rear communication port (remote PC)	
RS485 I/F:	
Transmission data rate for RSM system	64kbps
Connection	Multidrop mode (max. 32 relays)
Connector	Screw terminals
Cable and length	Twisted pair cable, max. 1200m
Isolation	2kVac for 1min.
Fibre optic I/F:	ST connector, graded-index multi-mode 50/125μm or 62.5/125μm type optical fibres
Ethernet LAN I/F:	10BASE-T, RJ-45 connector
IRIG-B Port	
Connection	BNC connector
Cable type	50 ohm coaxial cable
Binary Inputs	
Operating voltage	Typical 74Vdc(min.70Vdc) for 110V/125Vdc rating Typical 138Vdc(min.125Vdc) for 220V/250Vdc rating Typical 31Vdc(min.28Vdc) for 48V/54V/60Vdc rating Typical 15Vdc(min.14Vdc) for 24Vdc rating

Contact Ratings	
Trip contacts	
Make and carry	5A continuously, 30A, 290Vdc for 0.5s (L/R=10ms)
Break	0.15A, 290Vdc (L/R=40ms)
Auxiliary contacts	
Make and carry	4A continuously, 10A, 220Vdc for 0.5s (L/R≧5ms)
Break	0.1A, 220Vdc (L/R=40ms)
Durability	
Make and carry	10,000 operations minimum
Break	100,000 operations minimum
Mechanical design	
Weight	10kg (Type-A), 13kg (Type-B)
Case colour	Munsell No. 10YR8/0.5
Installation	Flush mounting or rack mounting

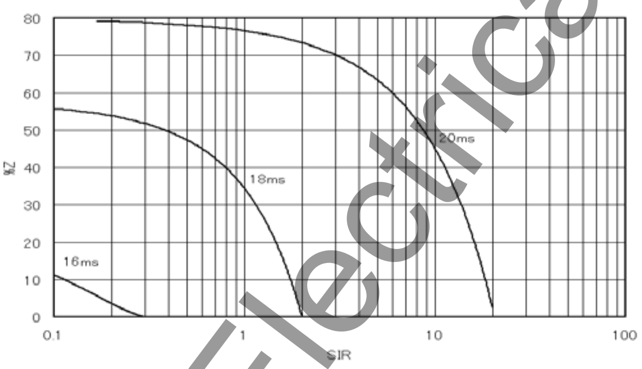


a) Minimum operating time (50Hz)

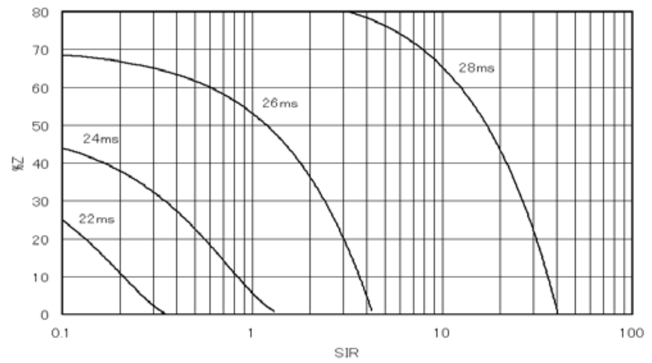


b) Maximum operating time (50Hz)

Phase to phase fault



a) Minimum operating time (50Hz)



b) Maximum operating time (50Hz)

Phase to earth fault

Note: In the case of a 60Hz relay the operate time is reduced by approximately 15% to 20%.

Figure K-1 SIR Trip Time Curves

CT Requirement

The requirement for minimum CT knee-point voltage for GRZ100 is assessed for the following three cases separately:

a) Stability for faults beyond the zone 1 reach point:

$V_k > k_1 \times I_{f\_z1\_max} \times (R_{ct} + R_2)$

b) Stability for close-up reverse faults:

$V_k > k_2 \times I_{f\_rev\_max} \times (R_{ct} + R_2)$

c) Dependability of tripping for close-up forward faults:

$V_k > k_3 \times I_{f\_max} \times (R_{ct} + R_2)$

where,

V_k: Knee point voltage.

$I_{f\_z1\_max}$: Maximum fault current at the zone 1 reach point.

$I_{f\_rev\_max}$: Maximum close-up reverse fault current.

I_{f_max}: Maximum close-up forward fault current.

R_{ct}: Resistance of CT.

R_2: Burden including connecting leads.

k_1, k_2, k_3: Transient dimensioning factor

(All values refer to the CT secondary side)

The minimum requirement for V_k is determined for each of the three cases and the highest of the three results is used to dimension the CT. k_1, k_2 and k_3 are chosen depending on the primary system time constant as follows:

Primary system time constant, Td (ms)	Transient dimensioning factor, k		
	a) Stability for faults beyond the zone 1 reach point ($I_{f\_z1\_max}$)	b) Stability for close-up reverse faults ($I_{f\_rev\_max}$)	c) Dependability of tripping for close-up forward faults (I_{f_max})
	k_1	k_2	k_3
< 35	6	2	2
< 50	7	3	2
< 75	8	6	2
< 100	8	6	2
< 150	8	6	2

Notes:

1. Knee-point voltage, V_k, is defined according to IEC 60044-1 as the minimum sinusoidal e.m.f. (r.m.s.) at rated power frequency when applied to the secondary terminals of the transformer, all other terminals being open circuited, which when increased by 10%, causes the r.m.s. exciting current to increase by no more than 50%.

2. In cases where CTs are specified as P-class protective current transformers according to IEC 60044-1 (e.g. 5P10, 5P20 etc.), the knee point voltage can be approximated as follows:

   $V_k \approx 0.8 \times n \times I_n \times (R_{ct} + R_{VA})$

where,

V_k: Knee point voltage.

I_n: Rated secondary current.

R_{ct}: Resistance of CT.

R_{VA}: Rated burden.

n: Accuracy limiting factor of CT (e.g. 20 for 5P20)

(All values refer to the CT secondary side)

3. Remanent flux has not been considered. In cases where a high level of remanent flux may be experienced, it may be necessary to include an additional margin when dimensioning the CT.

4. The data provided is valid for 50Hz and 60Hz power systems.

ENVIRONMENTAL PERFORMANCE CLAIMS

Test	Standards	Details
Atmospheric Environment		
Temperature	IEC60068-2-1/2	Operating range: -10°C to +55°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC60068-2-78	56 days at 40°C and 93% relative humidity.
Enclosure Protection	IEC60529	IP51 (Rear: IP20)
Mechanical Environment		
Vibration	IEC60255-21-1	Response - Class 1 Endurance - Class 1
Shock and Bump	IEC60255-21-2	Shock Response Class 1 Shock Withstand Class 1 Bump Class 1
Seismic	IEC60255-21-3	Class 1
Electrical Environment		
Dielectric Withstand	IEC60255-5	2kVrms for 1 minute between all terminals and earth. 2kVrms for 1 minute between independent circuits. 1kVrms for 1 minute across normally open contacts.
High Voltage Impulse	IEC60255-5	Three positive and three negative impulses of 5kV(peak), 1.2/50μs, 0.5J between all terminals and between all terminals and earth.
Electromagnetic Environment		
High Frequency Disturbance / Damped Oscillatory Wave	IEC60255-22-1 Class 3, IEC61000-4-12 / EN61000-4-12	1MHz 2.5kV applied to all ports in common mode. 1MHz 1.0kV applied to all ports in differential mode.
Electrostatic Discharge	IEC60255-22-2 Class 3, IEC61000-4-2 / EN61000-4-2	6kV contact discharge, 8kV air discharge.
Radiated RF Electromagnetic Disturbance	IEC60255-22-3 Class 3, IEC61000-4-3 / EN61000-4-3	Field strength 10V/m for frequency sweeps of 80MHz to 1GHz and 1.7GHz to 2.2GHz. Additional spot tests at 80, 160, 450, 900 and 1890MHz.
Fast Transient Disturbance	IEC60255-22-4, IEC61000-4-4 / EN61000-4-4	4kV, 2.5kHz, 5/50ns applied to all inputs.
Surge Immunity	IEC60255-22-5, IEC61000-4-5 / EN61000-4-5	1.2/50μs surge in common/differential modes: HV ports: 2kV/1kV (peak) PSU and I/O ports: 2kV/1kV (peak) RS485 port: 1kV (peak)
Conducted RF Electromagnetic Disturbance	IEC60255-22-6 Class 3, IEC61000-4-6 / EN61000-4-6	10Vrms applied over frequency range 150kHz to 100MHz. Additional spot tests at 27 and 68MHz.
Power Frequency Disturbance	IEC60255-22-7, IEC61000-4-16 / EN61000-4-16	300V 50Hz for 10s applied to ports in common mode. 150V 50Hz for 10s applied to ports in differential mode. Not applicable to AC inputs.
Conducted and Radiated Emissions	IEC60255-25, EN55022 Class A, IEC61000-6-4 / EN61000-6-4	Conducted emissions: 0.15 to 0.50MHz: <79dB (peak) or <66dB (mean) 0.50 to 30MHz: <73dB (peak) or <60dB (mean) Radiated emissions (at 30m): 30 to 230MHz: <30dB 230 to 1000MHz: <37dB

Test	Standards	Details
European Commission Directives		
CE	89/336/EEC	Compliance with the European Commission Electromagnetic Compatibility Directive is demonstrated according to EN 61000-6-2 and EN 61000-6-4.
	73/23/EEC	Compliance with the European Commission Low Voltage Directive is demonstrated according to EN 50178 and EN 60255-5.

Appendix L

Symbols Used in Scheme Logic

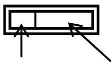
Symbols used in the scheme logic and their meanings are as follows:

Signal names

Marked with : Measuring element output signal

Marked with : Signal number

Marked with : Signal number and name of binary input by PLC function



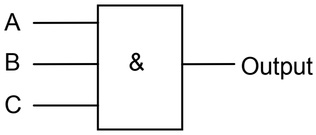
Signal No. Signal name

Marked with [ ] : Scheme switch

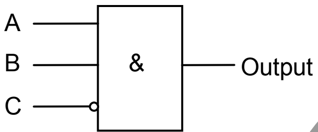
Marked with " " : Scheme switch position

Unmarked : Internal scheme logic signal

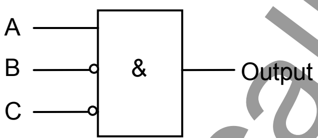
AND gates



A	B	C	Output
1	1	1	1
Other cases			0

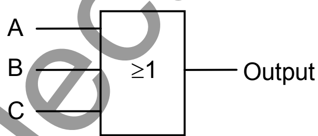


A	B	C	Output
1	1	0	1
Other cases			0

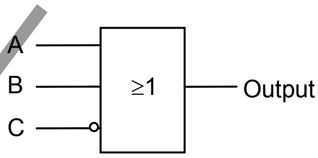


A	B	C	Output
1	0	0	1
Other cases			0

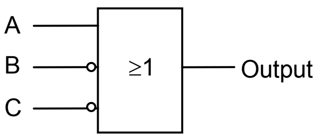
OR gates



A	B	C	Output
0	0	0	0
Other cases			1

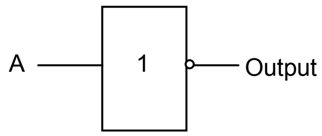


A	B	C	Output
0	0	1	0
Other cases			1



A	B	C	Output
0	1	1	0
Other cases			1

Signal inversion

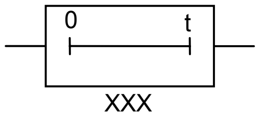


A	Output
0	1
1	0

Timer

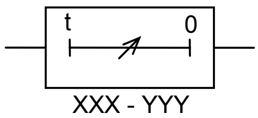
Delaye pick-up timer with fixed setting

XXX: Set time



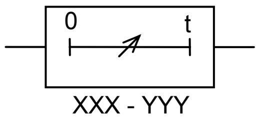
Delayed drop-off timer with fixed setting

XXX: Set time



Delaye pick-up timer with variable setting

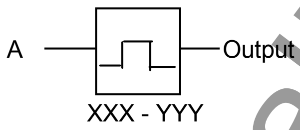
XXX - YYY: Setting range

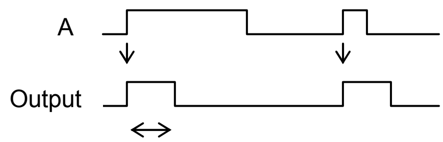


Delayed drop-off timer with variable setting

XXX - YYY: Setting range

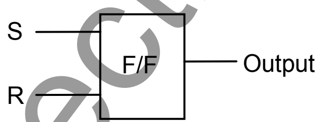
One-shot timer





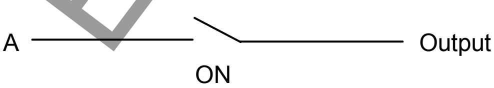
XXX - YYY: Setting range

Flip-flop

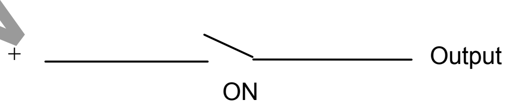


S	R	Output
0	0	No change
1	0	1
0	1	0
1	1	0

Scheme switch



A	Switch	Output
1	ON	1
Other cases		0



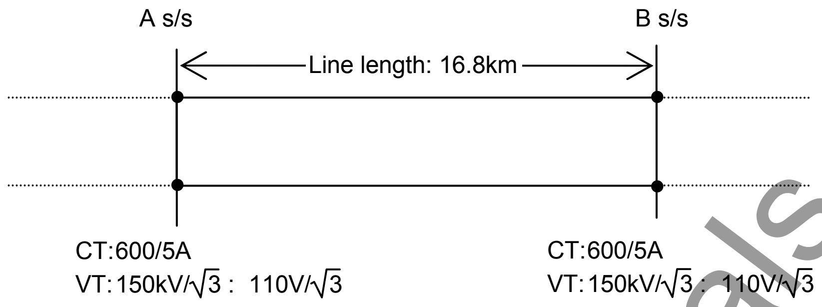
Switch	Output
ON	1
OFF	0

Appendix M

Example of Setting Calculation

1. Power System Data

[Example system]



- Line impedance of A s/s - Bs/s
  - Positive sequence impedance: 0.0197 + j0.2747 (ohms/km)
  - Zero sequence impedance: 0.4970 + j1.4387 (ohms/km)
  - Mutual impedance: 0.0212 + j0.3729 (ohms/km)
- Back impedance
  - A s/s: 0.94 (%pu) at 100MVA base
  - B s/s: 0.94 (%pu) at 100MVA base
- Normal load current: 594.7A
- Minimum fault current: 2.05kA

2. Relay Setting

- Relay application:

  Relay type: GRZ100-214

  Protection scheme: BOP (Blocking overreach protection), 3 zone time-stepped distance protection

  Autoreclose mode: 1 + 3

3. Setting Calculation

3.1 Normal load current

To calculate load current, back impedance is converted from a percent unit value to an impedance value.

Base impedance Zbase = $(\text{Vbase})^2/\text{VAbase}$

$= (150\text{kV}/\sqrt{3})^2/100\text{MVA}$

$= 75$ ohms

Therefore, load current I_L is:

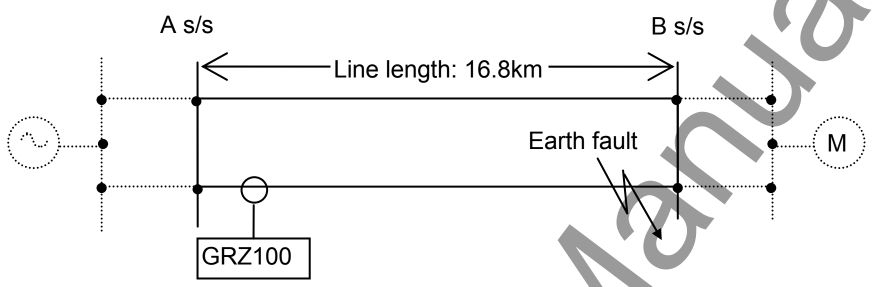
I_L = (Source voltage)/(A s/s back impedance + Line impedance + B s/s impedance)

$= (150\text{kV}/\sqrt{3}\,)/(0.94 \times 75 + 16.8 \times \sqrt{(0.0197^2 + 0.2747^2)} + 0.94 \times 75)$

$= 594.7\text{A}$

3.2 Minimum fault current

The minimum fault current I_{fmin} on a protected transmission line is the current of the phase to earth fault on the nearest remote terminal.



To calculate I_{fmin}, zero sequence earth fault current (I_o), positive sequence earth fault current (I_1) and negative earth fault current (I_2) are calculated as follows:

$I_0 = I_1 = I_2$ = (Source voltage)/{(Back impedance of A s/s)

+ (Transmission line zero sequence impedance)

+ (Transmission line positive sequence impedance) × 2*}

$= (150\text{kV}/\sqrt{3}\,)/\{(0.94 \times 75) + 16.8 \times \sqrt{(0.4970^2 + 1.4387^2)}$

$+ 2 \times 16.8 \times \sqrt{(0.0197^2 + 0.2747^2)}\,\}$

$= 822.28\text{A}$

So,

$I_{fmin} = I_0 + I_1 + I_2 = 3 \times 822.28 = 2.47\text{kA}$

***Note:** Assuming that positive sequence impedance = negative sequence impedance.

3.3 Scheme setting

Element	Contents	Setting
SCHEME	Protection scheme selection	BOP
CO.LINK	Communication link	Ext
ZS-C	Mho or Quadrilateral characteristic	Mho
ZG-C	Mho or Quadrilateral characteristic	Mho
CRSCM	Carrier out of service	ON
CHSEL	Carrier channel configuration	SINGLE
BOSW	Carrier sending signal	A
ZONESEL	Carrier control element	Z2
ECHO	ECHO carrier send	ON
WKIT	Weak carrier trip	ON
CH-DEF	DEF carrier channel	--
PSB-Z1	PSB for Z1 elements	ON
PSB-Z1X	PSB for Z1X elements	ON
PSB-Z2	PSB for Z2 elements	ON
PSB-Z3	PSB for Z3 elements	ON
PSB-CR	PSB for carrier trip	ON
PSB-ZF	PSB for ZF elements	OFF
PSB-ZR1	PSB for ZR1 elements	OFF
PSB-ZR2	PSB for ZR2 elements	OFF
PSB-TP	Trip under PSB	ON
BLZONE	Blinder setting mode	COM
Z1CNT	Z1 trip mode	1
STUB	STUB protection	OFF
SOTF-OC	SOTF OC trip	ON
SOTF-Z1	SOTF Z1 trip	OFF
SOTF-Z2	SOTF Z2 trip	OFF
SOTF-Z3	SOTF Z3 trip	OFF
SOTF-F	SOTF ZF trip	OFF
SOTF-R1	SOTF ZR1 trip	OFF
SOTF-R2	SOTF ZR2 trip	OFF
SOTF-ND	SOTF ZND trip	OFF
ZFBT	ZF element back-up trip	OFF
ZR1BT	ZR1 element back-up trip	OFF
ZR2BT	ZR2 element back-up trip	OFF
ZNDBT	ZND element back-up trip	OFF
OCBT	OC back-up trip	OFF
OCIBT	OCI back-up trip	OFF
EFBT	EF back-up trip	ON
EFBTAL	EF back-up trip alarm	ON
DEFI	DEF back-up trip	I
DEFBTAL	DEF back-up trip alarm	ON
DEFFEN	Forward DEF backup trip enable	ON
DEFREN	Reverse DEF backup trip enable	OFF
BF1	CBF re-trip	OFF

BF2	CBF related trip	OFF
BFEXT	CBF initiation by ext. trip	OFF
OST	Out of step trip	OFF
OVS1EN	OVS1 enable	OFF
OVS2EN	OVS2 enable	OFF
OVG1EN	OVG1 enable	OFF
OVG2EN	OVG2 enable	OFF
UVS1EN	UVS1 enable	OFF
UVS2EN	UVS2 enable	OFF
UVG1EN	UVG1 enable	OFF
UVG2EN	UVG2 enable	OFF
THMT	Thermal trip	OFF
THMAL	Thermal alarm	OFF
Autoreclose mode	Autoreclosing mode	SPAR&TPAR
ARC-SM	Multi. Shot ARC mode	OFF
ARC-CB	ARC mode for 1.5CB system	--
ARC-DEF	REC. by DG carr. trip	OFF
ARC-BU	ARC initiated by back-up trip	OFF
ARC-EXT	ARC initiated by ext. trip	OFF
VCHK	TPAR condition	LB
VTPHSEL	VT phase selection	A
VT-RATE	VT rating	PH/G
3PH-VT	3ph. VT location	BUS

3.4 Impedance setting

Element	Standard setting (Recommended)	Setting
Z1S	80% of protected line reactance	80%
Z1XS	120% or more of protected line reactance	130%
Z2S	120% or more of protected line reactance	130%
Z3S	100% of protected line impedance plus 150% of next line section	300%
Z4S	120% of Z3S	120% of Z3S setting
Z1G	75% - 80% of protected line reactance	75%
Z1XG	120% or more of protected line reactance	130%
Z2G	120% or more of protected line reactance	130%
Z3G	400% - 600% of protected line impedance	500%
Z4G	120% of Z3G	120% of Z3G setting
PSBSZ	2 ohms (5A rating)	2 ohms
PSBGZ	2 ohms (5A rating)	2 ohms

Step 1

Calculate the setting impedance from the given recommended reach point table.

Step 2

Multiply the actual impedance by the factor “k” to calculate the relay impedance:

Relay impedance = k × Actual impedance

Factor "k" is calculated as follows:

$$K = (CT\ ratio)/(VT\ ratio) = (600/5A)/((150kV/\sqrt{3})/(110V)/\sqrt{3})) = 0.088$$

<Z1S, Z1XS, Z2S, Z3S, Z4S, Z1G, Z1XG, Z2G element>

Z1S, Z1XS, Z2S, Z3S, Z4S, Z1G, Z1XG, Z2G element settings are calculated as shown in the following table.

<Z3G, Z4G element>

Zero sequence current compensation is not applied to Z3 or Z4. Z3G and Z4G settings should be larger than the calculated values because of the underreaching effect without zero sequence current compensation.

a. Setting condition of Z3G element:

The Z3G element must operate on all faults for which the Z2G element operates.

(lower setting limit: Z3G > Z2G)

The Z3G element must not operate on load current. (upper setting limit), so:

X3G setting = [Zline × 130%](Z2G setting) × 2.6(operating margin for no zero phase sequence current compensation) × 1.5(operating margin)

= 500% of Zline

b. Setting condition of Z4G element

The operation zone of the Z4G element includes the operating zone of the Z3G element remote terminal relay.

Element	Actual impedance (ohms)	k factor	Relay impedance (ohms)
Z1S	3.692	0.088	0.32
Z1XS	5.999		0.53
Z2S	5.999		0.53
Z3S	13.84		1.22
Z4S	16.61		1.46
Z1G	3.461		0.30
Z1XG	5.999		0.53
Z2G	5.999		0.53
Z3G	23.07		2.03
Z4G	27.68		2.44
PSBSZ	-----		2.00
PSBGZ	-----		2.00

3.5 Blinder setting

Zero sequence compensation is not applied to the blinder elements.

Recommended setting: 5.00 ohms

These elements should not operate under maximum load current:

Rset < load impedance/margin

< V rating/(2.5 times of I rating)

$= (110V/\sqrt{3})/(2.5 \times 5A)$

$= 5.08$

Element	Setting
BFRS	5.00 Ω
BFLS θ	120°
BRRS	5.00 Ω
BRLS	Linked with BFRS
BFRG	5.00 Ω
BFLG θ	120°
BRRG	5.00 Ω
BRLG	Linked with BRRG

3.6 Zero sequence compensation

In the GRZ100, vector type zero sequence compensation is applied to Zone 1 and Zone 2, and the compensation factor is given in the resistive and reactive components independently.

Step 1

Calculate the positive, zero sequence impedance and mutual impedance:

$Z_1 = [R_1: 0.0197] + j[X_1: 0.2747]$ (ohms)

$Z_0 = [R_0: 0.497] + j[X_0: 1.4287]$ (ohms)

$Z_m = [R_m: 0.0212] + j[X_m: 0.3729]$ (ohms)

Step 2

Calculate the zero and mutual sequence compensation factor setting according to the following equations:

$K_{RS} = R_0/R_1 \times 100 = 0.497/0.0197 = 2523$*

$K_{XS} = X_0/X_1 \times 100 = 1.4387/0.2747 = 524$

$K_{Rm} = R_m/R_1 \times 100 = 0.0212/0.0197 = 108$

$K_{Xm} = X_m/X_1 \times 100 = 0.3729/0.2747 = 136$

***Note:** If the calculated value exceeds 1000, then a setting of 1000 should be applied, this being considered to be the maximum practical value.

Element	Setting
K_{RS}	1000
K_{XS}	524
K_{Rm}	108
K_{Xm}	136

3.7 Current setting

a. Definite time earth fault protection (EF)

The EF element may be used either to provide back-up earth fault protection or, alternatively, open circuit protection. For example, to detect open faults of the CT circuit, the operating value of the detector should be lower than the normal load current on the line:

EF ≤ (normal load current/CT ratio) × 0.5

= (594.7 × 5/600) × 0.5

= 2.48A

Element	Setting (A)
EF	2.4

b. Directional earth fault element (DEF)

The DEF element should not be operated by the unbalance current or voltage present in normal conditions. It is recommended to set the current and voltage after measuring the actual unbalance residual current and voltage on the site.

DEFFI, DEFRI > Max. zero sequence current ($3I_0$) in normal conditions

DEFFV, DEFRV > Max. zero sequence voltage ($3V_0$) in normal conditions

Element	Setting
DEFFI	2.5 (A)
DEFRI	2.5 (A)
DEFFV	21.0 (V)
DEFRV	21.0 (V)
DEFF θ	85
DEFR θ	85

c. IDMT overcurrent element (EFI)

The EFI element should not be operated by the unbalance current present under normal conditions. It is recommended to set the current after measuring the actual unbalance residual current for the protected line.

EFI > Max. zero sequence current ($3I_0$) in normal condition

Element	Setting
EFI	2.5 (A)
TEFI	0.5
MEFI	S
DEFI	OFF

d. Switch-on-to-fault/stub protection (OCH)

The setting of the OCH element should be lower than the minimum fault current (I_{fmin}) at the busbar:

◆OCH < (I_{fmin}/CT ratio) × 0.5

= {(0.8(margin) × 2.47kA)/(600/5)} × 0.5

= 8.23A

Element	Setting
OCH	8.2 (A)

e. Breaker failure protection (BF)

The setting of the BF element should be lower than the minimum fault current:

OCBF $< (I_{fmin}/\text{CT ratio}) \times 0.5$

$= \{(0.5 \times 2.47\text{kA})/(600/5)\} \times 0.5$

$= 5.14\text{A}$

Setting of TBF1 = Breaker opening time + OCBF reset time + Margin

= 40ms + 10ms + 20ms

= 70ms

Setting of TBF2 = TBF1 + Output relay operating time + Breaker opening time + OCBF reset time + Margin

= 70ms + 10ms + 40ms + 10ms + 10ms

= 140ms

Element	Setting
OCBF	5.1 (A)
TBF1	70ms
TBF2	140ms

3.8 Undervoltage element

a. Undervoltage element with current compensation (Phase selector)

(1) Undervoltage element (UVCV)

The UVCV element should be set not to work with the current of the power system.

UVCV $<$ rated voltage $\times$ 0.7

$= 63.5\text{V} \times 0.7$

$= 44.5$

(2) Reach setting (UVCZ)

The UVCZ element is set to the line impedance value:

UVCZ $= 16.8 \times \sqrt{(0.0197^2 + 0.2747^2)} \times 0.088$

$= 0.41$ ohms

Element	Setting
UVCV	45V
UVCZ	0.41
UVC θ	85

b. VT failure supervision

The undervoltage element for VT failure supervision (UVFS, UVFG) is set to about 50% of the rated voltage.

Element	Setting
UVFS	52V
UVFG	30V

c. Weak infeed tripping function

The undervoltage element for weak infeed tripping (UVLS, UVLG) is set to 70% of the rated voltage.

Element	Setting
UVLS	77V
UVLG	45V

3.9 Time setting

a. Time delay setting for zone distance protection

b. Coordination time setting for protection signaling channel

This time setting is required only for the Blocking scheme. The time should be set larger than the time delay of protection signaling equipment (PSE) including propagation time of PLC (Power Line Carrier) or other communication link. The time setting should include an operation margin of 5ms.

Time setting = Time delay of PSE + Margin

= 12ms + 5ms

= 17ms

c. Time setting of earth fault element EF (TEF)

This time setting is for time delay of the EF element. If it is set to 3s, the trip/alarm contact will close 3s after detecting an unbalance current (residual current) such as a CT open circuit fault. In addition to CT open circuit faults, this element can detect a broken conductor condition.

d. Time setting of directional earth fault relay (TDEFB)

Set the time delay for the directional earth fault element for back-up.

Element	Setting (s)
TZ1S	0.00
TZ2S	0.30
TZ3S	0.40
TZ1G	0.00
TZ2G	0.30
TZ3G	0.40
TCHD	0.017
TEF	3.00
TDEFB	3.00

3.10 Autoreclose setting

a. Dead timer reset timing

b. Dead line timer
The SPAR and TPAR timer are provided to present the deionized time of the line. The SPAR element is initiated simultaneously by the reclose initiation for single-pole autoreclose dead time. TPAR is for three-pole autoreclose dead time.

c. Reclaim timer
The reclosing command signal is blocked during adjusted time set by reclaim timer, after the breaker is closed manually or automatically.

d. ARC reset timer
This time element starts to run upon reclosing initiation.

e. ARC output pulse timer
The duration of the reclosing pulse depends on the operation time of the breaker. The required pulse time is set by this time element.

Element	Setting (s)
TEVLV	0.30
TSPR	0.80
TTPR	0.60
TRDY	60
TRR	2.00
TW	0.2

3.11 Synchronism check element

The synchronism check element setting is as follows.

Element	Setting
SY1UV	83V
SY1OV	51V
SY1 θ	30deg.
TSYN1	1.00s
TDBL1	0.05s
TLBD1	0.05s
OVB	51V
UVB	13V
OVL1	51V
UVL1	13V

Appendix N

IEC60870-5-103: Interoperability and Troubleshooting

IEC60870-5-103 Configurator

IEC103 configurator software is included in a same CD as RSM100, and can be installed easily as follows:

Installation of IEC103 Configurator

Insert the CD-ROM (RSM100) into a CDROM drive to install this software on a PC.

Double click the "Setup.exe" of the folder "\IEC103Conf" under the root directory, and operate it according to the message.

When installation has been completed, the IEC103 Configurator will be registered in the start menu.

Starting IEC103 Configurator

Click [Start]→[Programs]→[IEC103 Configurator]→[IECConf] to the IEC103 Configurator software.

Note: The instruction manual of IEC103 Configurator can be viewed by clicking [Help]→[Manual] on IEC103 Configurator.

IEC60870-5-103: Interoperability

1. Physical Layer

1.1 Electrical interface: EIA RS-485

Number of loads, 32 for one protection equipment

1.2 Optical interface

Glass fibre (option)

ST type connector (option)

1.3 Transmission speed

User setting: 9600 or 19200 bit/s

2. Application Layer

COMMON ADDRESS of ASDU

One COMMON ADDRESS OF ASDU (identical with station address)

3. List of Information

The following items can be customized with the original software tool "IEC103 configurator". (For details, refer to "IEC103 configurator" manual No.6F2S0812.)

- Items for "Time-tagged message": Type ID(1/2), INF, FUN, Transmission condition(Signal number), COT
- Items for "Time-tagged measurands": INF, FUN, Transmission condition(Signal number), COT, Type of measurand quantities
- Items for "General command": INF, FUN, Control condition(Signal number)

- Items for "Measurands": Type ID(3/9), INF, FUN, Number of measurand, Type of measurand quantities
- Common setting
  - Transmission cycle of Measurand frame
  - FUN of System function
  - Test mode, etc.

CAUTION: To be effective the setting data written via the RS232C, turn off the DC supply of the relay and turn on again.

3. 1 IEC60870-5-103 Interface

3.1.1 Spontaneous events

The events created by the relay will be sent using Function type (FUN) / Information numbers (INF) to the IEC60870-5-103 master station.

3.1.2 General interrogation

The GI request can be used to read the status of the relay, the Function types and Information numbers that will be returned during the GI cycle are shown in the table below.

For details, refer to the standard IEC60870-5-103 section 7.4.3.

3.1.3 Cyclic measurements

The relay will produce measured values using Type ID=3 or 9 on a cyclical basis, this can be read from the relay using a Class 2 poll. The rate at which the relay produces new measured values can be customized.

3.1.4 Commands

The supported commands can be customized. The relay will respond to non-supported commands with a cause of transmission (COT) of negative acknowledgement of a command.

For details, refer to the standard IEC60870-5-103 section 7.4.4.

3.1.5 Test mode

In test mode, both spontaneous messages and polled measured values, intended for processing in the control system, are designated by means of the CAUSE OF TRANSMISSION 'test mode'. This means that CAUSE OF TRANSMISSION = 7 'test mode' is used for messages normally transmitted with COT=1 (spontaneous) or COT=2 (cyclic).

For details, refer to the standard IEC60870-5-103 section 7.4.5.

3.1.6 Blocking of monitor direction

If the blocking of the monitor direction is activated in the protection equipment, all indications and measurands are no longer transmitted.

For details, refer to the standard IEC60870-5-103 section 7.4.6.

3.2 List of Information

The followings are the default settings.

List of Information

INF	Description	Contents	IEC103 Configurator Default setting						
			GI	Type ID	COT	FUN	DPI		
							Signal No.	OFF	ON
Standard Information numbers in monitor direction									
System Function									
0	End of General Interrogation	Transmission completion of GI items.	--	8	10	255	--	--	--
0	Time Synchronization	Time Synchronization ACK.	--	6	8	255	--	--	--
2	Reset FCB	Reset FCB(toggle bit) ACK	--	5	3	128	--	--	--
3	Reset CU	Reset CU ACK	--	5	4	128	--	--	--
4	Start/Restart	Relay start/restart	--	5	5	128	--	--	--
5	Power On	Relay power on.	Not supported				--	--	--
Status Indications									
16	Auto-recloser active	If it is possible to use auto-recloser, this item is set active, if impossible, inactive.	GI	1	1, 9, 11, 12	128	1411	1	2
17	Teleprotection active	If protection using telecommunication is available, this item is set to active. If not, set to inactive.	GI	1	1, 9, 12	128	1412	1	2
18	Protection active	If the protection is available, this item is set to active. If not, set to inactive.	GI	1	1, 9, 12	128	1413	1	2
19	LED reset	Reset of latched LEDs	--	1	1, 11, 12	128	1409	--	2
20	Monitor direction blocked	Block the 103 transmission from a relay to control system. IECBLK: "Blocked" settimg.	GI	1	9, 11	128	1241	1	2
21	Test mode	Transmission of testmode situation froma relay to control system. IECTST "ON" setting.	GI	1	9, 11	128	1242	1	2
22	Local parameter Setting	When a setting change has done at the local, the event is sent to control system.	Not supported						
23	Characteristic1	Setting group 1 active	GI	1	1, 9, 11, 12	128	1243	1	2
24	Characteristic2	Setting group 2 active	GI	1	1, 9, 11, 12	128	1244	1	2
25	Characteristic3	Setting group 3 active	GI	1	1, 9, 11, 12	128	1245	1	2
26	Characteristic4	Setting group 4 active	GI	1	1, 9, 11, 12	128	1246	1	2
27	Auxiliary input1	Binary input 1	No set						
28	Auxiliary input2	Binary input 2	No set						
29	Auxiliary input3	Binary input 3	No set						
30	Auxiliary input4	Binary input 4	No set						
Supervision Indications									
32	Measurand supervision I	Zero sequence current supervision	GI	1	1, 9	128	1267	1	2
33	Measurand supervision V	Zero sequence voltage supervision	GI	1	1, 9	128	1268	1	2
35	Phase sequence supervision	Negative sequence voltage supevision	GI	1	1, 9	128	1269	1	2
36	Trip circuit supervision	Output circuit supervision	Not supported						
37	I>>backup operation		Not supported						
38	VT fuse failure	VT failure	GI	1	1, 9	128	172	1	2
39	Teleprotection disturbed	CF(Communication system Fail) supervision	GI	1	1, 9	128	253	1	2
46	Group warning	Only alarming	GI	1	1, 9	128	1258	1	2
47	Group alarm	Trip blocking and alarming	GI	1	1, 9	128	1252	1	2
Earth Fault Indications									
48	Earth Fault L1	A phase earth fault	No set						
49	Earth Fault L2	B phase earth fault	No set						
50	Earth Fault L3	C phase earth fault	No set						
51	Earth Fault Fwd	Earth fault forward	Not supported						
52	Earth Fault Rev	Earth fault reverse	Not supported						

INF	Description	Contents	IEC103 Configurator Default setting						
			GI	Type ID	COT	FUN	DPI		
							Signal NO.	OFF	ON
Fault Indications									
64	Start/pick-up L1	A phase, A-B phase or C-A phase element pick-up	No set						
65	Start/pick-up L2	B phase, A-B phase or B-C phase element pick-up	No set						
66	Start/pick-up L3	C phase, B-C phase or C-A phase element pick-up	No set						
67	Start/pick-up N	Earth fault element pick-up	No set						
68	General trip	Any trip	--	2	1	128	1280	--	2
69	Trip L1	A phase, A-B phase or C-A phase trip	No set						
70	Trip L2	B phase, A-B phase or B-C phase trip	No set						
71	Trip L3	C phase, B-C phase or C-A phase trip	No set						
72	Trip I>>(back-up)	Back up trip	--	2	1	128	194	--	2
73	Fault location X In ohms	Fault location	--	4	1	128	1048	--	--
74	Fault forward/line	Forward fault	Not supported						
75	Fault reverse/Busbar	Reverse fault	Not supported						
76	Teleprotection Signal transmitted	Carrier signal sending	Not supported						
77	Teleprotection Signal received	Carrier signal receiving	Not supported						
78	Zone1	Zone 1 trip	--	2	1	128	342	--	2
79	Zone2	Zone 2 trip	--	2	1	128	344	--	2
80	Zone3	Zone 3 trip	--	2	1	128	345	--	2
81	Zone4	Zone 4 trip	No set						
82	Zone5	Zone 5 trip	No set						
83	Zone6	Zone 6 trip	No set						
84	General Start/Pick-up	Any elements pick-up	No set						
85	Breaker Failure	CBF trip or CBF retrip	--	2	1	128	199	--	2
86	Trip measuring system L1		Not supported						
87	Trip measuring system L2		Not supported						
88	Trip measuring system L3		Not supported						
89	Trip measuring system E		Not supported						
90	Trip I>	Inverse time OC trip	--	2	1	128	327	--	2
91	Trip I>>	Definite time OC trip	--	2	1	128	326	--	2
92	Trip IN>	Inverse time earth fault OC trip	--	2	1	128	184	--	2
93	Trip IN>>	Definite time earth fault OC trip	--	2	1	128	678	--	2
Autoreclose indications									
128	CB 'ON' by Autoreclose	CB close command output	--	1	1	128	291	--	2
129	CB 'ON' by long-time Autoreclose		Not supported						
130	Autoreclose Blocked	Autoreclose block	GI	1	1, 9	128	1544	1	2

Details of Fault location settings in IEC103 configurator

INF	Tbl	Offset	Data type	Coeff
73	5	26	short	0.1

INF	Description	Contents	IEC103 configurator Default setting				
			GI	Type ID	COT	FUN	Max. No.
Measurands							
144	Measurand I	<meaurand I>	No				0
145	Measurand I,V	<meaurand I>	No				0
146	Measurand I,V,P,Q	<meaurand I>	No				0
147	Measurand IN,VEN	<meaurand I>	No				0
148	Measurand IL1,2,3, VL1,2,3, P,Q,f	Ia, Ib, Ic, Va, Vb, Vc, P, Q, f measurand <meaurand II>	--	9	2, 7	128	9
Generic Function							
240	Read Headings		Not supported				
241	Read attributes of all entries of a group		Not supported				
243	Read directory of entry		Not supported				
244	Real attribute of entry		Not supported				
245	End of GGI		Not supported				
249	Write entry with confirm		Not supported				
250	Write entry with execute		Not supported				
251	Write entry aborted		Not supported				

Details of MEA settings in IEC103 configurator

INF	MEA	Tbl	Offset	Data type	Limit		Coeff
					Lower	Upper	
148	Ia	1	36	short	0	4096	3.41333
	Ib	1	40	short	0	4096	3.41333
	Ic	1	44	short	0	4096	3.41333
	Va	1	0	short	0	4096	0.26877
	Vb	1	4	short	0	4096	0.26877
	Vc	1	8	short	0	4096	0.26877
	P	2	8	long	-4096	4096	0.00071661
	Q	2	12	long	-4096	4096	0.00071661
	f	2	16	short	0	4096	0.34133

INF	Description	Contents	IEC103 Configurator Default setting			
			Control direction	Type ID	COT	FUN
Selection of standard information numbers in control direction						
System functions						
0	Initiation of general interrogation		--	7	9	255
0	Time synchronization		--	6	8	255
General commands						
16	Auto-recloser on/off		ON/OFF	20	20	128
17	Teleprotection on/off		ON/OFF	20	20	128
18	Protection on/off	(*1)	ON/OFF	20	20	128
19	LED reset	Reset indication of latched LEDs.	ON	20	20	128
23	Activate characteristic 1	Setting Group 1	ON	20	20	128
24	Activate characteristic 2	Setting Group 2	ON	20	20	128
25	Activate characteristic 3	Setting Group 3	ON	20	20	128
26	Activate characteristic 4	Setting Group 4	ON	20	20	128
Generic functions						
240	Read headings of all defined groups		Not supported			
241	Read values or attributes of all entries of one group		Not supported			
243	Read directory of a single entry		Not supported			
244	Read values or attributes of a single entry		Not supported			
245	General Interrogation of generic data		Not supported			
248	Write entry		Not supported			
249	Write entry with confirmation		Not supported			
250	Write entry with execution		Not supported			

(∗1) Note: While the relay receives the "Protection off" command, " IN SERVICE LED" is off.

Details of Command settings in IEC103 configurator

INF	DCO			
	Sig off	Sig on	Rev	Valid time
16	2684	2684	✓	0
17	2685	2685	✓	0
18	2686	2686	✓	0
19	0	2688		200
23	0	2640		1000
24	0	2641		1000
25	0	2642		1000
26	0	2643		1000

✓: signal reverse

	Description	Contents	GRZ100 supported	Comment
Basic application functions				
	Test mode		Yes	
	Blocking of monitor direction		Yes	
	Disturbance data		No	
	Generic services		No	
	Private data		Yes	
Miscellaneous				
	Measurand		Max. MVAL = rated value times	
	Current L1	Ia	Configurable	
	Current L2	Ib	Configurable	
	Current L3	Ic	Configurable	
	Voltage L1-E	Va	Configurable	
	Voltage L2-E	Vb	Configurable	
	Voltage L3-E	Vc	Configurable	
	Active power P	P	Configurable	
	Reactive power Q	Q	Configurable	
	Frequency f	f	Configurable	
	Voltage L1 - L2	Vab	Configurable	

Details of Common settings in IEC103 configurator

- Setting file's remark: GRZ100_1.00
- Remote operation valid time [ms]: 4000
- Local operation valid time [ms]: 4000
- Measurand period [s]: 2
- Function type of System functions: 128
- Signal No. of Test mode: 1242
- Signal No. for Real time and Fault number: 1279

[Legend]

GI: General Interrogation (refer to IEC60870-5-103 section 7.4.3)

Type ID: Type Identification (refer to IEC60870-5-103 section 7.2.1)

1 : time-tagged message
2 : time-tagged message with relative time
3 : measurands I
4 : time-tagged measurands with relative time
5 : identification
6 : time synchronization
8 : general interrogation termination
9 : measurands II
10: generic data
11: generic identification
20: general command
23: list of recorded disturbances
26: ready for transmission for disturbance data
27: ready for transmission of a channel
28: ready for transmission of tags
29: transmission of tags
30: transmission of disturbance values
31: end of transmission

COT: Cause of Transmission (refer to IEC60870-5-103 section 7.2.3)

1: spontaneous
2: cyclic
3: reset frame count bit (FCB)
4: reset communication unit (CU)
5: start / restart
6: power on
7: test mode
8: time synchronization
9: general interrogation
10: termination of general interrogation
11: local operation
12: remote operation
20: positive acknowledgement of command
21: negative acknowledgement of command
31: transmission of disturbance data
40: positive acknowledgement of generic write command
41: negative acknowledgement of generic write command
42: valid data response to generic read command
43: invalid data response to generic read command
44: generic write confirmation

FUN: Function type (refer to IEC60870-5-103 section 7.2.5.1)

DPI: Double-point Information (refer to IEC60870-5-103 section 7.2.6.5)

DCO: Double Command (refer to IEC60870-5-103 section 7.2.6.4)

IEC103 setting data is recommended to be saved as follows:

(1) Naming for IEC103setting data

The file extension of IEC103 setting data is ".csv". The version name is recommended to be provided with a revision number in order to be changed in future as follows:

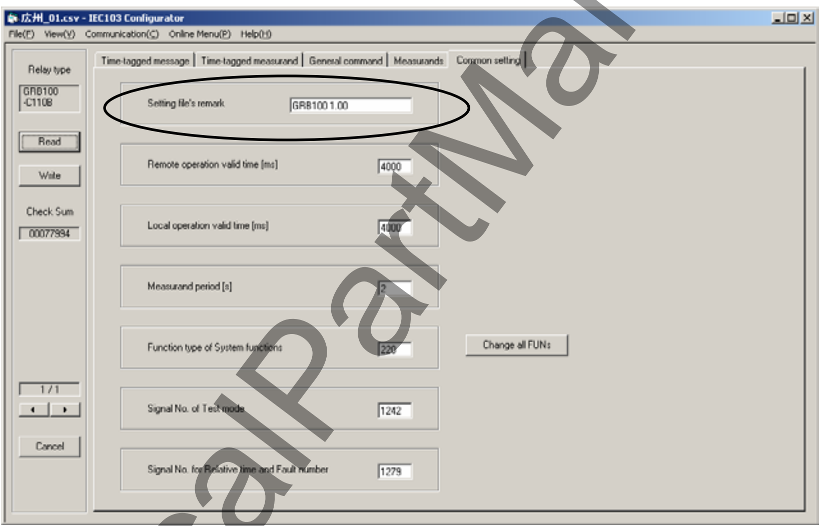
First draft: ******_01.csv

Second draft: ******_02.csv

Third draft: ******_03.csv

↑ Revision number

The name "******" is recommended to be able to discriminate the relay type such as GRZ100 or GRL100, etc. The setting files remark field of IEC103 is able to enter up to 12 one-byte characters. It is utilized for control of IEC103 setting data.



(2) Saving theIEC103 setting data

The IEC103 setting data is recommended to be saved in external media such as FD (floppy disk) or CD-R, not to remain in the folder.

Troubleshooting

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Phenomena</th><th rowspan="2">Supposed causes</th><th colspan="2">Check / Confirmation</th></tr>
<tr><th>Object</th><th>Procedure</th></tr>
<tr><td rowspan="10">1</td><td rowspan="10">Communication trouble（IEC103 communication is not available.）</td><td>Address setting is incorrect.</td><td>BCU
RY</td><td>Match address setting between BCU and relay.
Avoid duplication of address with other relay.</td></tr>
<tr><td>Transmission baud rate setting is incorrect.</td><td>BCU
RY</td><td>Match transmission baud rate setting between BCU and relay.</td></tr>
<tr><td>Start bit, stop bit and parity settings of data that BCU transmits to relay is incorrect.</td><td>BCU</td><td>Go over the following settings by BCU. Relay setting is fixed as following settings.
- Start bit: 1bit
- Stop bit: 1bit
- Parity setting: even</td></tr>
<tr><td>The PRTCL1 setting is incorrect. (The model with PRTCL1 setting.)</td><td>RY</td><td>Change the PRTCL1 setting. Relation between PRTCL1 setting and available transmission protocol is referred to the following table.<table><tr><td>RS485 port at the back of the relay</td><td>PRTCL1 =HDLC</td><td>PRTCL1 =IEC</td></tr><tr><td>COM1 (CH1)</td><td>HDLC</td><td>IEC</td></tr><tr><td>COM2 (CH2)</td><td>IEC</td><td>–</td></tr></table></td></tr>
<tr><td>RS485 or optical cable interconnection is incorrect.</td><td>Cable</td><td>- Check the connection port.(CH1/CH2)
- Check the interconnection of RS485 A/B/COM
- Check the send and received interconnection of optical cable.</td></tr>
<tr><td>The setting of converter is incorrect. (RS485/optic conversion is executed with the transmission channel, etc.)</td><td>Converter</td><td>In the event of using G1IF2, change the DIPSW setting in reference to INSTRUCTION MANUAL (6F2S0794).</td></tr>
<tr><td>The relationship between logical “0/1” of the signal and Sig.on/off is incorrect. (In the event of using optical cable)</td><td>BCU</td><td>Check the following;
Logical0 : Sig.on
Logical1:Sig.off</td></tr>
<tr><td>Terminal resistor is not offered. (Especially when RS485 cable is long.)</td><td>cable</td><td>Impose terminal resistor (150[ohms]) to both ends of RS 485 cable.</td></tr>
<tr><td>Relay cannot receive the requirement frame from BCU.
(The timing coordination of sending and receiving switch control is irregular in half-duplex communication.)</td><td>BCU</td><td>Check to secure the margin more than 15ms between receiving the reply frame from the relay and transmitting the next requirement frame on BCU.</td></tr>
<tr><td>The requirement frame from BCU and the reply frame from relay contend.
(The sending and receiving timing coordination is irregular in half-duplex communication.)</td><td>BCU</td><td>Check to set the time-out of reply frame from the relay.
Time-out setting: more than 100ms (acceptable value of response time 50ms plus margin)</td></tr>
</table>

No.	Phenomena	Supposed causes	Check / Confirmation	
			Object	Procedure
2	HMI does not display IEC103 event on the SAS side.	The relevant event sending condition is not valid.	RY	Change the event sending condition (signal number) of IEC103 configurator if there is a setting error. When the setting is correct, check the signal condition by programmable LED, etc.
		The relevant event Information Number (INF) and/or Function Type (FUN) may be different between the relay and SAS.	RY SAS	Match the relevant event Information Number (INF) or Function Type (FUN) between the relay and SAS.
		The relay is not initialised after writing IEC103 configurator setting.	RY	Check the sum value of IEC103 setting data from the LCD screen. When differing from the sum value on IEC103 configurator, initialise the relay.
		It changes to the block mode.	RY	Change the IECBR settling to Normal.
3	Time can be synchronised with IEC103 communication.	BCU does not transmit the frame of time synchronisation.	BCU	Transmit the frame of time synchronisation.
		The settling of time synchronisation source is set to other than IEC.	RY	Change the settling of time synchronisation source to IEC.

(Note) BCU: Bay control unit, RY: Relay

Appendix O

Programmable Reset Characteristics and Implementation of Thermal Model to IEC60255-8

Programmable Reset Characteristics

The overcurrent stages for phase and earth faults, OC1 and EF1, each have a programmable reset feature. Resetting may be instantaneous or definite time delayed.

Instantaneous resetting is normally applied in multi-shot auto-reclosing schemes, to ensure correct grading between relays at various points in the scheme.

The definite time delayed reset characteristic may be used to provide faster clearance of intermittent ('pecking' or 'flashing') fault conditions. An example of where such phenomena may be experienced is in plastic insulated cables, where the fault energy melts the cable insulation and temporarily extinguishes the fault, after which the insulation again breaks down and the process repeats.

An inverse time overcurrent protection with instantaneous resetting cannot detect this condition until the fault becomes permanent, thereby allowing a succession of such breakdowns to occur, with associated damage to plant and danger to personnel. If a definite time reset delay of, for example, 60 seconds is applied, on the other hand, the inverse time element does not reset immediately after each successive fault occurrence. Instead, with each new fault inception, it continues to integrate from the point reached during the previous breakdown, and therefore operates before the condition becomes permanent. Figure O-1 illustrates this theory.

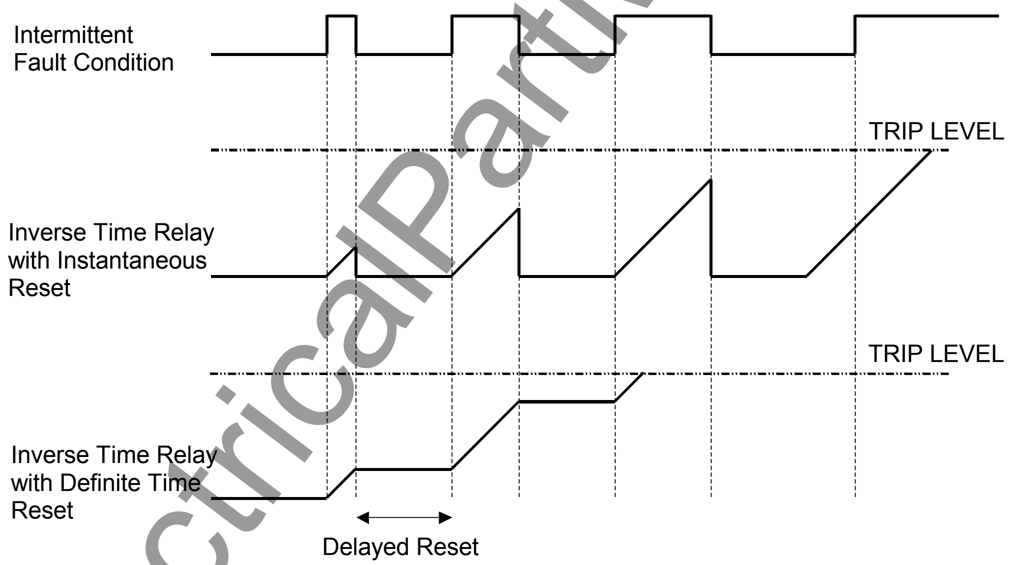


Figure O-1

Implementation of Thermal Model to IEC60255-8

Heating by overload current and cooling by dissipation of an electrical system follow exponential time constants. The thermal characteristics of the electrical system can be shown by equation (1).

$$\theta = \frac{I^2}{I_{AOL}^2}\left(1 - e^{-t/\tau}\right) \times 100\% \qquad (1)$$

where:

θ = thermal state of the system as a percentage of allowable thermal capacity,

I = applied load current,

I_{AOL} = allowable overload current of the system,

τ = thermal time constant of the system.

The thermal state θ is expressed as a percentage of the thermal capacity of the protected system, where 0% represents the cold state and 100% represents the thermal limit, that is the point at which no further temperature rise can be safely tolerated and the system should be disconnected. The thermal limit for any given electrical plant is fixed by the thermal setting I_{AOL}. The relay gives a trip output when θ = 100%.

If current I is applied to a cold system, then θ will rise exponentially from 0% to ($I^2/I_{AOL}^2 \times 100\%$), with time constant τ, as in Figure O-2. If θ = 100%, then the allowable thermal capacity of the system has been reached.

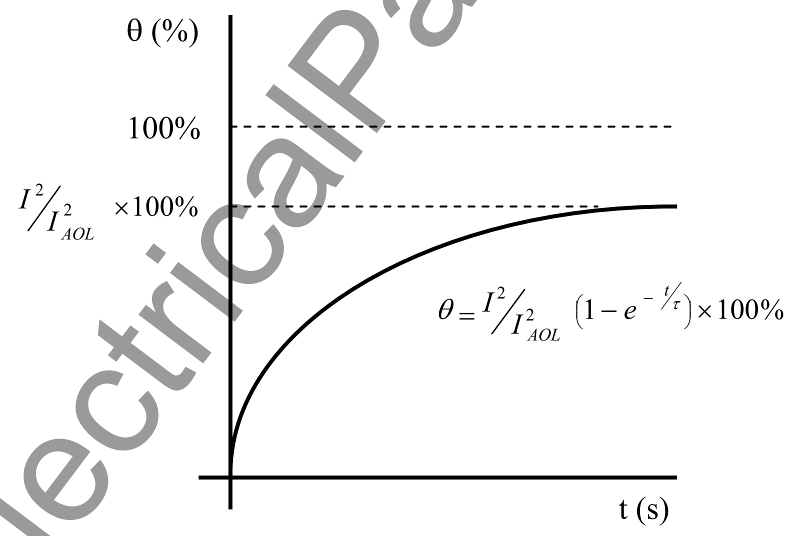


Figure O-2

A thermal overload protection relay can be designed to model this function, giving tripping times according to the IEC60255-8 'Hot' and 'Cold' curves.

$$t = \tau \cdot Ln\left[\frac{I^2}{I^2 - I_{AOL}^2}\right] \qquad (1) \quad \cdots\cdots \text{ Cold curve}$$

$$t = \tau \cdot Ln\left[\frac{I^2 - I_P{}^2}{I^2 - I_{AOL}^2}\right] \qquad (2) \quad \cdots\cdots \text{ Hot curve}$$

where:

I_P = prior load current.

In fact, the cold curve is simply a special case of the hot curve where prior load current $I_P = 0$, catering for the situation where a cold system is switched on to an immediate overload.

Figure O-3 shows a typical thermal profile for a system which initially carries normal load current, and is then subjected to an overload condition until a trip results, before finally cooling to ambient temperature.

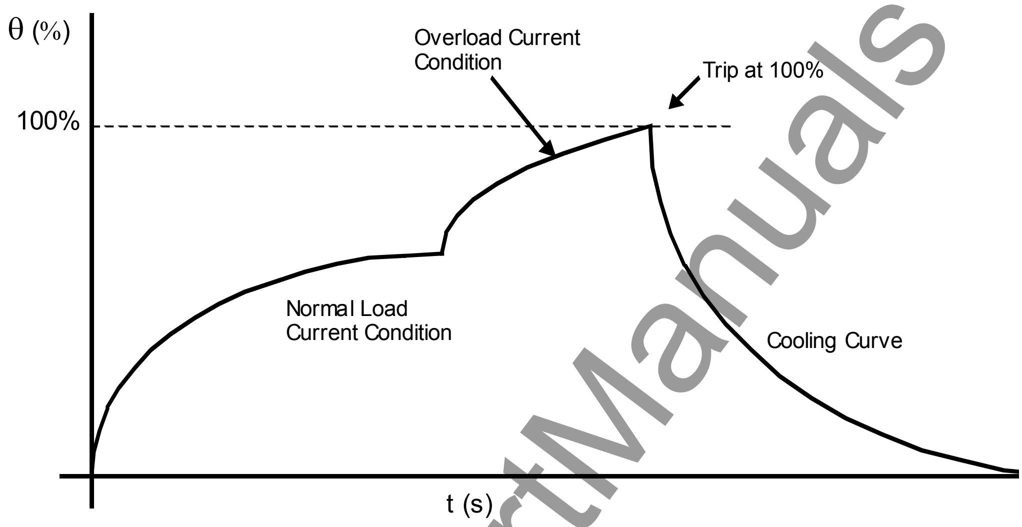


Figure O-3

Appendix P

Data Transmission Format

Transmission Format in Integral Digital Communication

Figure P-1 shows the data transmission format that applies to the data transmission between relays at the terminals of the transmission lines. The individual parts of the transmission format are described below.

(1) Frame header

Indicates the start of a frame.

(2) Analog value (positive-sequence current and voltage) for fault locator

12 bits sent every three frames (I_1 at remainder 0 of SA, I_1' at remainder 1 of SA, V_1 at remainder 2 of SA).

(3) SA flag and control data

Device data (CB,DS) and control data necessary for the protective function are transmitted by sub-communication. Sub-communication is used for signals that may be transmitted at low speed, and has the effect that 1-bit information is different from frame to frame.

Frames are identified by the SA flag, which is also transmitted by sub-communication. It detects the signal pattern of 00001 and identifies a frame number. One cycle of frame numbers covers 12 frames.

(4) SP flag and time data

The SP flag and time data for sampling time synchronization are transmitted by sub-communication. Sub-communication detects the signal pattern of 00001 and identifies a frame number.

The time data for sampling time synchronization has 16 bits.

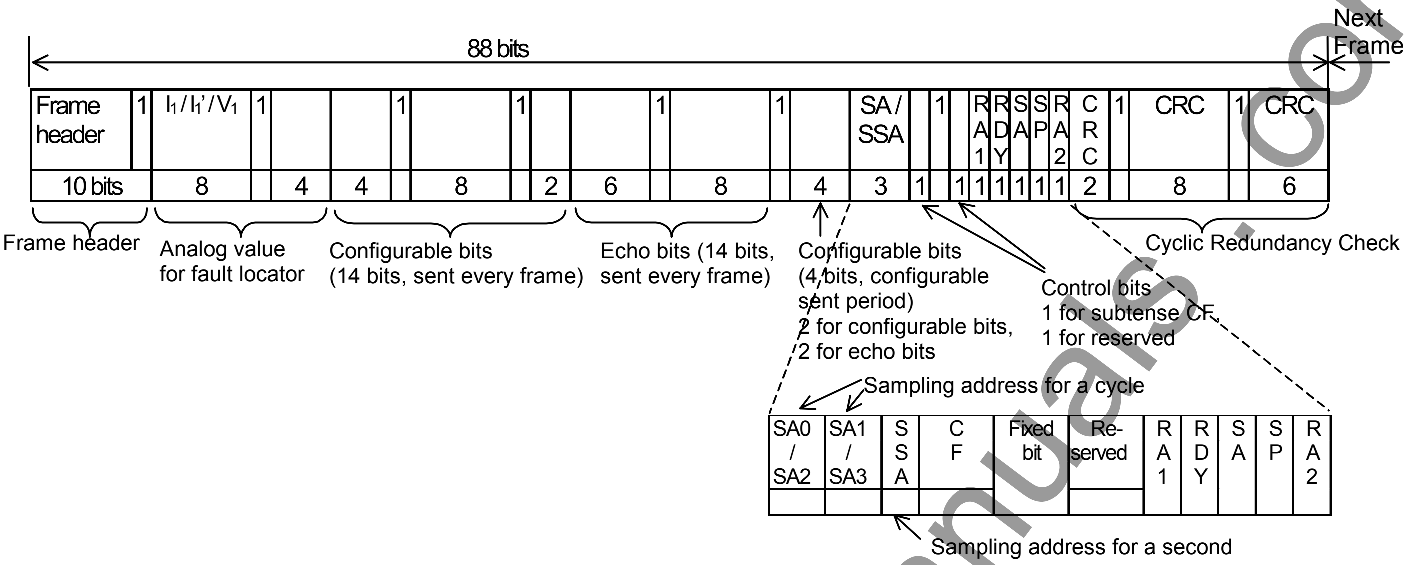
(5) CRC (Cyclic Redundancy Check) data

CRC data is added to check transmitted data for transmission errors.

Data without the frame header is divided by a polynomial and the resultant remainder is transmitted as the CRC data.

On the receiving side, the CRC data is subtracted from the transmitted data, the result divided by the same polynomial, and the remainder checked for 0.

Polynomial: $X^{16} + X^{12} + X^5 + 1$



I_1 / I_1' / V_1: 12 bits sent every three frames
(I_1 at remainder 0 of SA, I_1' at remainder 1 of SA, V_1 at remainder 2 of SA)
RDY : '1' for ready
SA : Sub-communication bit for SA synchronisation
SO : Sub-communication bit for sampling synchronisation
RA1/RA2: The relay address data

Frame No.	SSA	CBLS / RA1	SA	SP	RA2
#0 frame (SA=0)	SSA0	CBLS-A / RA0	0	2^0 / 2^8	RA3
#1	SSA1	CBLS-B / RA1	0	2^1 / 2^9	RA4
#2	SSA2	CBLS-C / RA2	0	2^2 / 2^{10}	RA5
#3	SSA3	CBLS-A / RA0	0	2^3 / 2^{11}	RA3
#4	SSA4	CBLS-B / RA1	1	SP flag	RA4
#5	SSA5	CBLS-C / RA2	REC BLOCK	2^4 / 2^{12}	RA5
#6	SSA0	CBLS-A / RA0		2^5 / 2^{13}	RA3
#7	SSA1	CBLS-B / RA1	0	2^6 / 2^{14}	RA4
#8	SSA2	CBLS-C / RA2	1	2^7 / 2^{15}	RA5
#9	SSA3	CBLS-A / RA0			RA3
#10	SSA4	CBLS-B / RA1	Transfer flag		RA4
#11	SSA5	CBLS-C / RA2	S.F.C	CMD / SLV	RA5

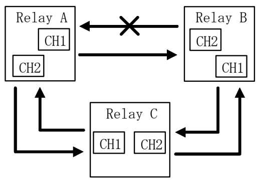
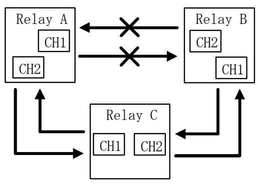
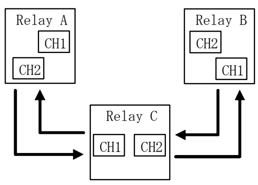
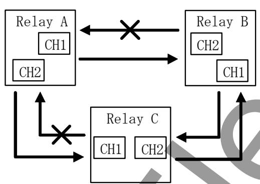
Sub-communications with slash '/ ' are sent once every two cycles.
The sub-communication before the slash is sent when SP flag is "0", while the sub-communication after the slash is sent when SP flag is "1". (SP flag is "0" once every two cycles.)
If the relay address monitoring is disabled (RYIDSV=Off setting), CBLS condition is sent.

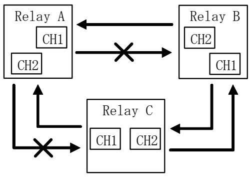
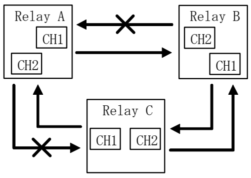
Figure P-1 Data Transmission Format

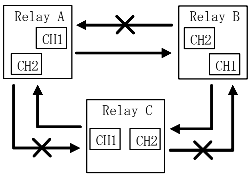
Appendix Q

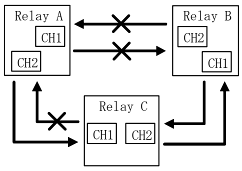
Relay Operation under Communication Failure in Backup Carrier Scheme

Relay Operation under Communication Failure (CF)

Mode No.	Communication failure mode	Relay operation			
		PUP scheme	POP or UOP scheme	BOP scheme (SCFCNT=Trip)	BOP scheme (SCFCNT=BLK)
1	CF occurs at relay A's CH1  	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip Relay C: PUP trip	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip Relay C: POP or UOP trip	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
		-Case 2 (Fault at near B-term) Relay A: PUP trip by backup carrier Relay B: Z1 trip Relay C: PUP trip	-Case 2 (Fault at near B-term) Relay A: POP or UOP trip by backup carrier Relay B: Z1 trip Relay C: POP or UOP trip	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: Trip blocked Relay C: ditto	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: Trip blocked Relay C: ditto
		-Case 3 (Fault at near C-term) Relay A: PUP trip Relay B: PUP trip Relay C: Z1 trip	-Case 3 (Fault at near C-term) Relay A: POP or UOP trip by backup carrier Relay B: POP or UOP trip Relay C: Z1 trip	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
2	CF occurs at relay A's CH1 and B's CH2.  	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip by backup carrier Relay C: PUP trip	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip by backup carrier Relay C: POP or UOP trip	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier
	Chain topology is same.  	-Case 2 (Fault at near B-term) Relay A: PUP trip by backup carrier Relay B: Z1 trip Relay C: PUP trip	-Case 2 (Fault at near B-term) Relay A: POP or UOP trip by backup carrier Relay B: Z1 trip Relay C: POP or UOP trip	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto
		-Case 3 (Fault at near C-term) Relay A: PUP trip Relay B: PUP trip Relay C: Z1 trip	-Case 3 (Fault at near C-term) Relay A: POP or UOP trip by backup carrier Relay B: POP or UOP trip Relay C: Z1 trip	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
3	CF occurs at relay A's CH2 and CH1.  	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip Relay C: PUP trip	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip Relay C: POP or UOP trip	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
	Severe CF mode	-Case 2 (Fault at near B-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: Z1 trip Relay C: PUP trip	-Case 2 (Fault at near B-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: Z1 trip Relay C: POP or UOP trip	-Case 2 (Fault at behind B-term) Relay A: BOP trip [Block command can't be received.] Relay B: BOP trip blocked Relay C: ditto	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked [Command protection blocked under Severe CF in SCFCNT=BLK] Relay B: BOP trip blocked Relay C: ditto
		-Case 3 (Fault at near C-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: PUP trip Relay C: Z1 trip	-Case 3 (Fault at near C-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: POP or UOP trip Relay C: Z1 trip	-Case 3 (Fault at behind C-term) Relay A: BOP trip [Block command can't be received.] Relay B: BOP trip blocked Relay C: ditto	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked [Command protection blocked under Severe CF in SCFCNT=BLK] Relay B: BOP trip blocked Relay C: ditto

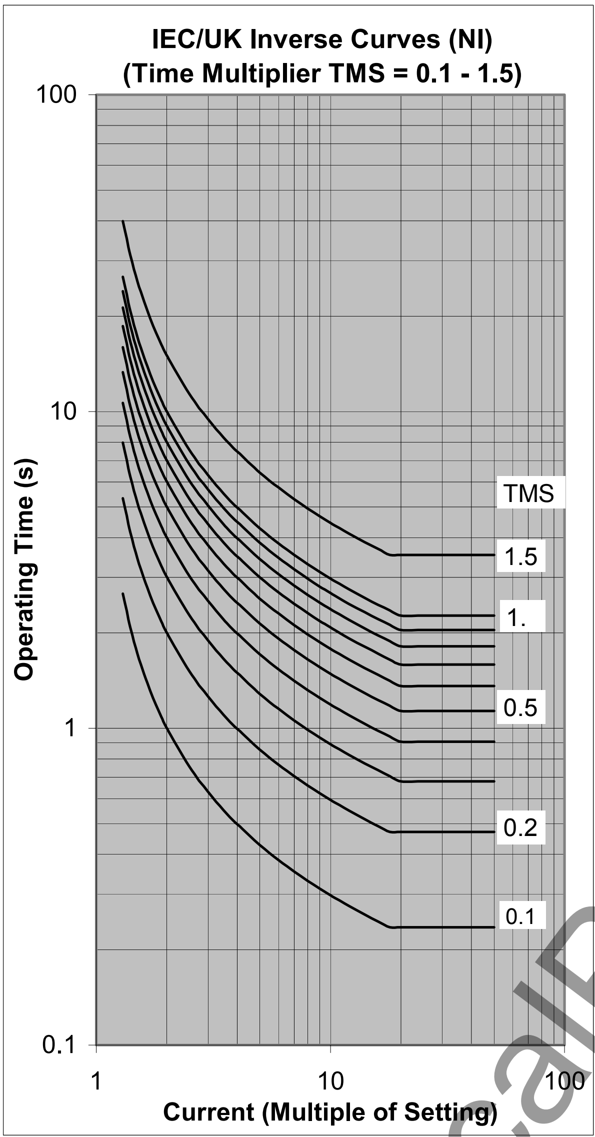
Mode No.	Communication failure mode	Relay operation			
		PUP scheme	POP or UOP scheme	BOP scheme (SCFCNT=Trip)	BOP scheme (SCFCNT=BLK)
4	CF occurs at relay B's CH2 and C's CH1 	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: Distance delay trip [Carrier trip is impossible.] Relay C: Distance delay trip [Carrier trip is impossible.]	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: Distance delay trip [Carrier trip is impossible.] Relay C: Distance delay trip [Carrier trip is impossible.]	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: BOP trip (Block command can't be received) Relay C: BOP trip (Block command can't be received)	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: BOP trip [Command protection blocked under Severe CF in SCFCNT=BLK] Relay C: BOP trip [Command protection blocked under Severe CF in SCFCNT=BLK]
	Severe CF mode	-Case 2 (Fault at near B-term) Relay A: PUP trip Relay B: Z1 trip Relay C: PUP trip	-Case 2 (Fault at near B-term) Relay A: POP or UOP trip Relay B: Z1 trip Relay C: POP or UOP trip by backup carrier	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
		-Case 3 (Fault at near C-term) Relay A: PUP trip Relay B: PUP trip Relay C: Z1 trip	-Case 3 (Fault at near C-term) Relay A: POP or UOP trip Relay B: POP or UOP trip by backup carrier Relay C: Z1 trip	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto
5	CF occurs at relay A's CH1 and C's CH1. 	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip Relay C: PUP trip by backup carrier	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip Relay C: POP or UOP trip by backup carrier	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier
		-Case 2 (Fault at near B-term) Relay A: PUP trip by backup carrier Relay B: Z1 trip Relay C: PUP trip	-Case 2 (Fault at near B-term) Relay A: POP or UOP trip by backup carrier Relay B: Z1 trip Relay C: POP or UOP trip by backup carrier	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto	-Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto
		-Case 3 (Fault at near C-term) Relay A: PUP trip Relay B: PUP trip Relay C: Z1 trip	-Case 3 (Fault at near C-term) Relay A: POP or UOP trip by backup carrier Relay B: POP or UOP trip Relay C: Z1 trip	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto	-Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: ditto Relay C: ditto

6	CF occurs at relay A's CH1 and C's CH1. 	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip Relay C: PUP trip by backup carrier -Case 2 (Fault at near B-term) Relay A: PUP trip by backup carrier Relay B: Z1 trip Relay C: PUP trip -Case 3 (Fault at near C-term) Relay A: PUP trip Relay B: PUP trip by backup carrier Relay C: Z1 trip	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip by backup carrier Relay C: POP or UOP trip by backup carrier -Case 2 (Fault at near B-term) Relay A: POP or UOP trip by backup carrier Relay B: Z1 trip Relay C: POP or UOP trip by backup carrier -Case 3 (Fault at near C-term) Relay A: POP or UOP trip by backup carrier Relay B: POP or UOP trip by backup carrier Relay C: Z1 trip	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier -Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto -Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: BOP trip blocked by backup carrier Relay C: BOP trip blocked	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: ditto Relay C: BOP trip blocked by backup carrier -Case 2 (Fault at behind B-term) Relay A: BOP trip blocked by backup carrier Relay B: BOP trip blocked Relay C: ditto -Case 3 (Fault at behind C-term) Relay A: BOP trip blocked Relay B: BOP trip blocked by backup carrier Relay C: BOP trip blocked

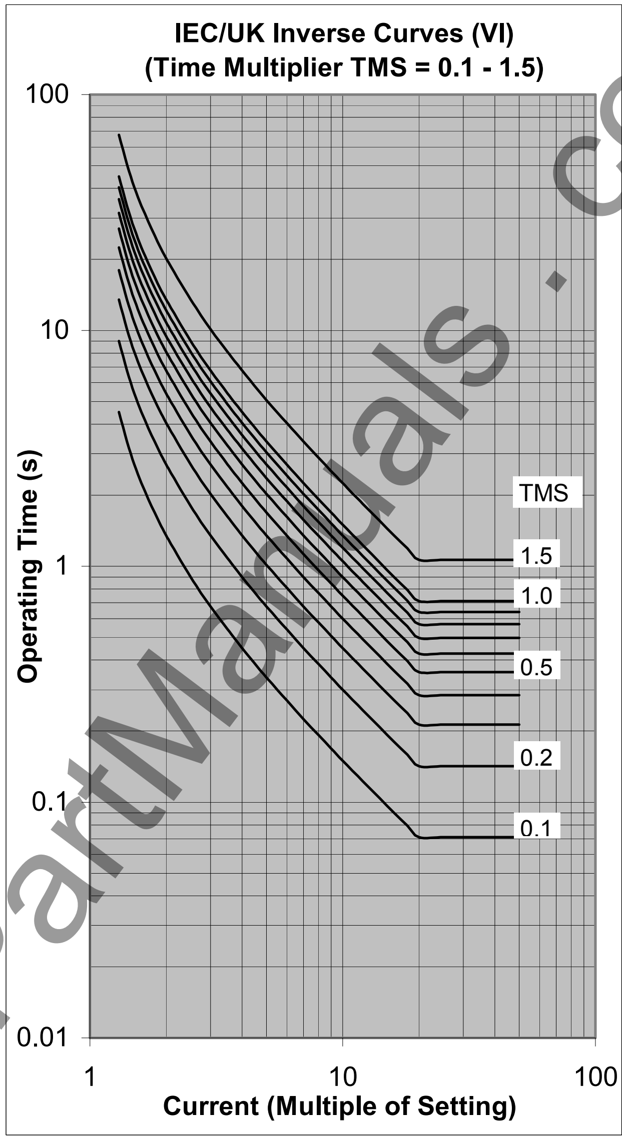
Mode No.	Communication failure mode	Relay operation			
		PUP scheme	POP or UOP scheme	BOP scheme (SCFCNT=Trip)	BOP scheme (SCFCNT=BLK)
7	CF occurs at relay A's CH1, B's CH2 and C's CH1  Severe CF mode	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: PUP trip by backup carrier Relay C: PUP trip -Case 2 (Fault at near B-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: Z1 trip Relay C: PUP trip -Case 3 (Fault at near C-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: PUP trip Relay C: Z1 trip	-Case 1 (Fault at near A-term) Relay A: Z1 trip Relay B: POP or UOP trip by backup carrier Relay C: POP or UOP trip by backup carrier -Case 2 (Fault at near B-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: Z1 trip Relay C: POP or UOP trip by backup carrier -Case 3 (Fault at near C-term) Relay A: Distance delay trip [Carrier trip is impossible.] Relay B: POP or UOP trip by backup carrier Relay C: Z1 trip	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: BOP trip blocked by backup carrier Relay C: BOP trip blocked -Case 2 (Fault at behind B-term) Relay A: BOP trip (Block command can't be received) Relay B: BOP trip blocked Relay C: ditto -Case 3 (Fault at behind C-term) Relay A: BOP trip (Block command can't be received) Relay B: BOP trip blocked Relay C: ditto	-Case 1 (Fault at behind A-term) Relay A: BOP trip blocked Relay B: BOP trip blocked by backup carrier Relay C: BOP trip blocked -Case 2 (Fault at behind B-term) Relay A: BOP trip blocked [Command protection blocked under Severe CF in SCFCNT=BLK] Relay B: BOP trip blocked Relay C: ditto -Case 3 (Fault at behind C-term) Relay A: BOP trip blocked [Command protection blocked under Severe CF in SCFCNT=BLK] Relay B: BOP trip blocked Relay C: ditto

Appendix R

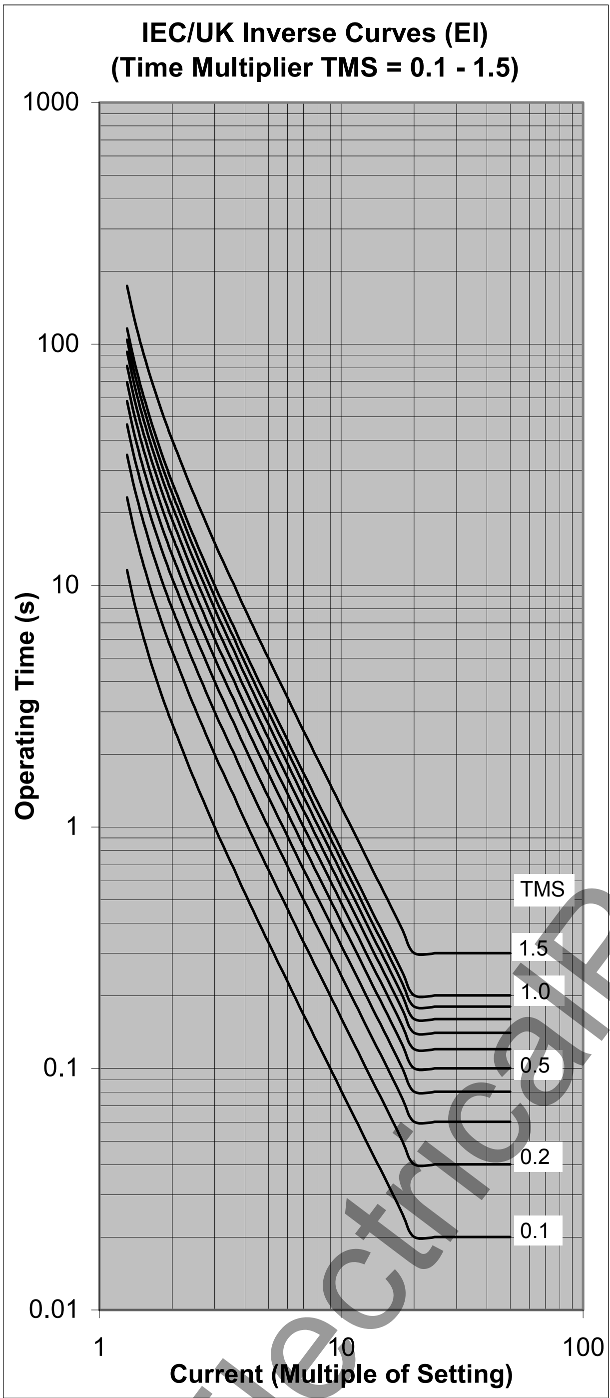
Inverse Time Characteristics



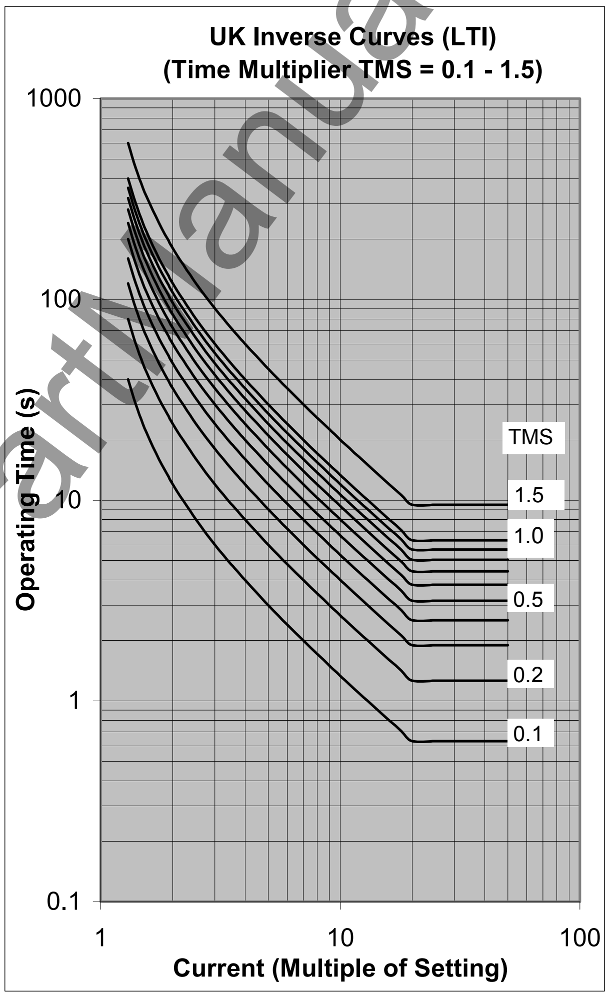
Normal Inverse



Very Inverse



Extremely Inverse



Long Time Inverse

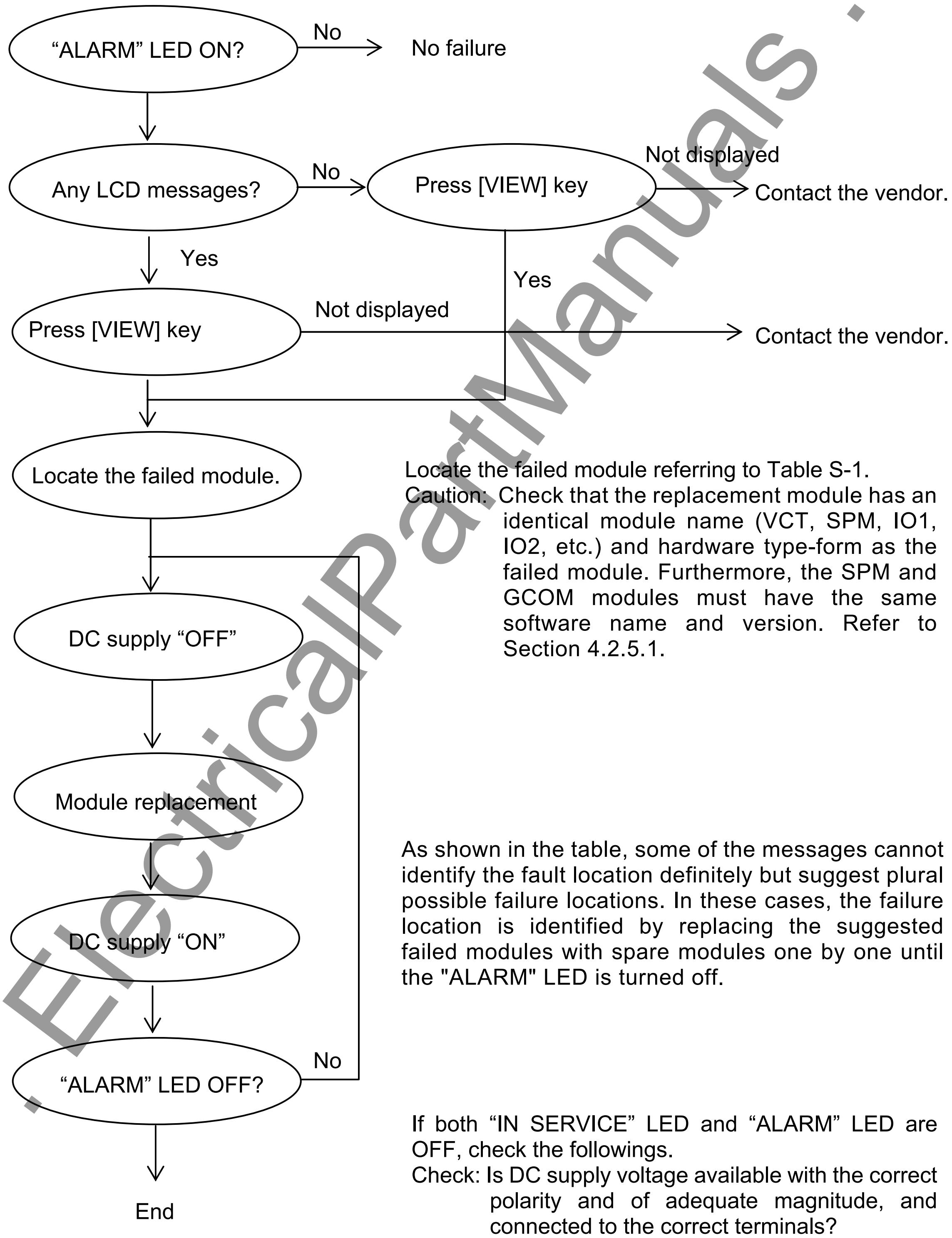
Appendix S

Failed Module Tracing and Replacement

1. Failed module tracing and its replacement

If the “ALARM” LED is ON, the following procedure is recommended. If not repaired, contact the vendor.

Procedure **Countermeasure**



Locate the failed module referring to Table S-1.
Caution: Check that the replacement module has an identical module name (VCT, SPM, IO1, IO2, etc.) and hardware type-form as the failed module. Furthermore, the SPM and GCOM modules must have the same software name and version. Refer to Section 4.2.5.1.

As shown in the table, some of the messages cannot identify the fault location definitely but suggest plural possible failure locations. In these cases, the failure location is identified by replacing the suggested failed modules with spare modules one by one until the "ALARM" LED is turned off.

If both “IN SERVICE” LED and “ALARM” LED are OFF, check the followings.
Check: Is DC supply voltage available with the correct polarity and of adequate magnitude, and connected to the correct terminals?

If any messages are shown on the LCD, the failed module or failed external circuits can be located by referring to the following table.

This table shows the relationship between messages displayed on the LCD and estimated failure location. Locations marked with (1) have a higher probability than locations marked with (2).

As shown in the table, some of the messages cannot identify the fault location definitely but suggest plural possible failure locations. In these cases, the failure location is identified by replacing the suggested failed modules with spare modules one by one until the "ALARM" LED is turned off.

The replacement or investigation should be performed first for the module or circuit with higher probability in the table.

If there is a failure and the LCD is not working such as a screen is frozen or not displayed, the failure location is any one of SPM and HMI module.

If there is a failure and no message is shown on the LCD, it means that the failure location is either in the DC power supply circuit or in the microprocessors mounted on the SPM module. In this case, check the "ALARM" LED. If it is off, the failure is in the DC power supply circuit. If it is lit, open the relay front panel and check the LEDs mounted on the SPM module. If the LED is off, the failure is in the DC power supply circuit. If the LED is lit, the failure is in the microprocessors.

In the former case, check if the correct DC voltage is applied to the relay. If it is, replace the IO#1 module mounting the DC/DC converter and confirm that the "ALARM" LED is turned off. In the latter case, replace the SPM module mounting the processors and confirm that the "ALARM" LED is turned off.

Table S-1 LCD Message and Failure Location

Message	Failure location											
	VCT	SPM (GCOM)	IO1 or IO8	IO2	IO3	IO4	IO5	IO6	HMI	Communi-cation Channel	Disconn-ector	AC cable
Checksum err		×										
ROM data err		×										
ROM-RAM err		×										
SRAM err		×										
BU-RAM err		×										
DPRAM err		×										
EEPROM err		×										
A/D err		×										
V0 err	× (2)	× (1)										× (2)
V2 err	× (2)	× (1)										× (2)
I0 err	× (2)	× (1)										× (2)
CT err	× (2)	× (2)										× (1)
Sampling err		×										
DIO err		× (2)	× (1)	× (1)	× (1)	× (1)	× (1)	× (1)				
RSM err		× (2)	× (1)									
DS fail		× (2)	× (2)								× (1)	
Ch.1fail, Ch. 2fail		× (2)*								× (1)*		
Com.1 fail, fail-R Com.2 fail, fail-R		× (2)								× (1)		
Sync.1 fail, Sync.2 fail		× (2)								× (1)		
TX level1 err, TX level2 err		× (2)								× (1)		
RX level1 err, RX level2 err		× (2)								× (1)		
CLK1 fail, CLK2 fail		× (2)								× (1)		
Td1 err, Td2 err		× (2)								× (1)		
Term1 rdy off, Term2 rdy off										× (*)		
RYID1 err, RYID2 err										× (*)		
VT fail	× (2)											× (1)
No-working of LCD		× (2)							× (1)			

The location marked with (1) has a higher probability than the location marked with (2).
The item of location marked with (*): also check the remote terminal relays and equipment.

2. Methods of Replacing the Modules

⚠ CAUTION When handling a module, take anti-static measures such as wearing an earthed wrist band and placing modules on an earthed conductive mat. Otherwise, many of the electronic components could suffer damage.

CAUTION After replacing the SPM module, check all of the settings including the PLC and IEC103 setting data are restored the original settings.

The initial replacement procedure is as follows:

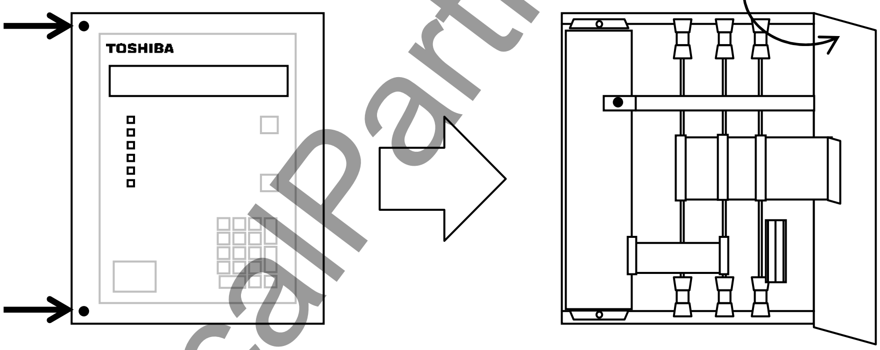
1). Switch off the DC power supply.

⚠ WARNING Hazardous voltage may remain in the DC circuit just after switching off the DC power supply. It takes about 30 seconds for the voltage to discharge.

2). Remove the front panel cover.

3). Open the front panel.

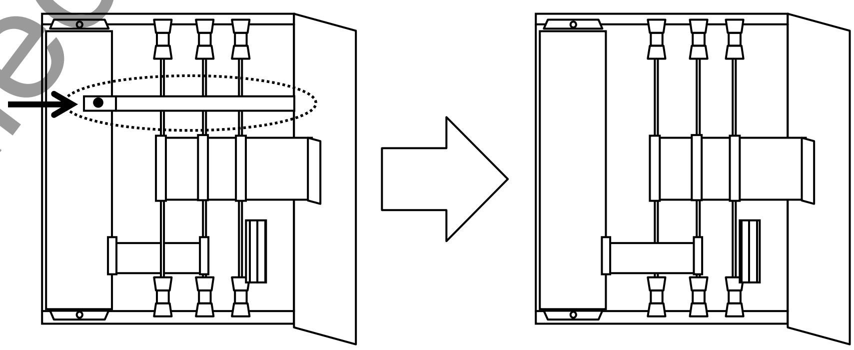
Open the front panel of the relay by unscrewing the binding screw located on the left side of the front panel.



Case size : 1/2"inchs

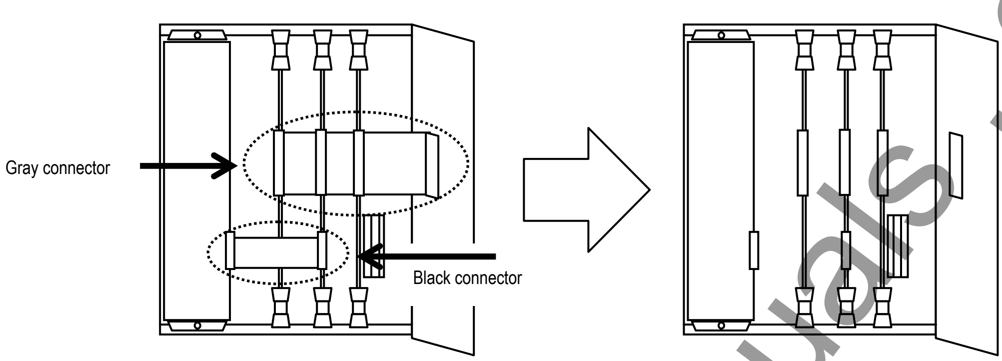
4). Detach the holding bar.

Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.



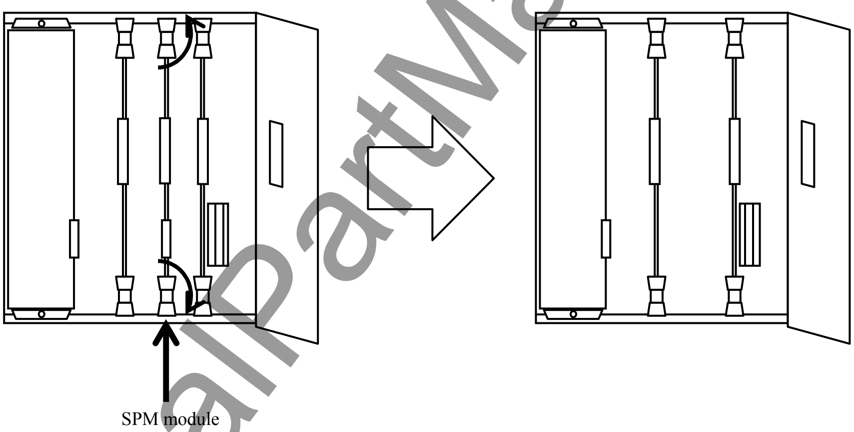
5). Unplug the cables.

Unplug the ribbon cable running among the modules by nipping the catch (in case of black connector) and by pushing the catch outside (in case of gray connector) on the connector.



6). Pull out the module.

Pull out the failure module by pulling up or down the top and bottom levers (white).



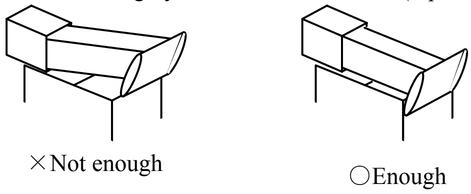
7). Insert the replacement module.

Insert the replacement module into the same slots where marked up.

8). Do the No.5 to No.1 steps in reverse order.

⚠ CAUTION Supply DC power after checking that all the modules are in their original positions and the ribbon cables are plugged in. If the ribbon cables are not plugged in enough (especially the gray connectors), the module could suffer damage.

Details of the gray connector on modules (top side)



9). Lamp Test

- RESET key is pushed 1 second or more by LCD display off.
- It checks that all LCDs and LEDs light on.

10). Check the automatic supervision functions.

- LCD not display "Auto-supervision" screens in turn, and Event Records
- Checking the "IN SERVICE" LED light on and "ALARM LED" light off.

Appendix T

Ordering

Ordering

1. Distance Relay

GRZ100 – [ ] B– [ ] [ ] – [ ] [ ] – [ ]

Relay Type:	
Distance relay with integral digital communication	GRZ100
Relay Model:	
Two-terminal line application	
-Model210: With autoreclose for single breaker scheme	
18 BIs, 22 BOs, 6 trip BOs	211
22 BIs (12-independent), 18 BOs, 3 trip BOs	214
25 BIs (12-independent), 36 BOs, 3 trip BOs	216
-Model310: With autoreclose for one and a half breaker scheme	
18 BIs, 22 BOs, 6 trip BOs	311
Three-terminal line application	
-Model220: With autoreclose for single breaker scheme	
18 BIs, 22 BOs, 6 trip BOs	221
22 BIs (12-independent), 18 BOs, 3 trip BOs	224
25 BIs (12-independent), 36 BOs, 3 trip BOs	226
-Model310: With autoreclose for one and a half breaker scheme	
18 BIs, 22 BOs, 6 trip BOs	321
18 BIs, 40 BOs, 6 trip BOs	323
Ratings:	
1A, 50Hz, 110V/125Vdc	1
1A, 60Hz, 110V/125Vdc	2
5A, 50Hz, 110V/125Vdc	3
5A, 60Hz, 110V/125Vdc	4
1A, 50Hz, 220V/250Vdc	5
1A, 60Hz, 220V/250Vdc	6
5A, 50Hz, 220V/250Vdc	7
5A, 60Hz, 220V/250Vdc	8
1A, 50Hz, 48V/54V/60Vdc	A
1A, 60Hz, 48V/54V/60Vdc	B
5A, 50Hz, 48V/54V/60Vdc	C
5A, 60Hz, 48V/54V/60Vdc	D
1A, 50Hz, 24V/30Vdc	E
1A, 60Hz, 24V/30Vdc	F
5A, 50Hz, 24V/30Vdc	G
5A, 60Hz, 24V/30Vdc	H
Integral communication interface:	
Electrical interface (CCITT-G703-1.2.1)	1
Electrical interface (CCITT-G703-1.2.2 or 1.2.3)	2
Optical interface(Short wavelength light: GI: 2km class)	3
Optical interface(Long wavelength light: SM: 30km class)	6
Optical interface(Long wavelength light: DSF: 80km class)	7
Electrical interface (RS530, X.21)	9
Communications:	
RS485	1
Fibre optic	2
Dual RS485	3
Dual fibre optic	4
RS485 + fibre optic	9
Note: Fibre optic is available for model 216,226 and 323. 10BASE-T option is available for specific configuration.	
Miscellaneous:	
None	0
GPS opt. input	1
LED label:	
Standard	None
Option: User configurable LED label	J

Version-up Records

Version No.	Date	Revised Section	Contents
0.0	May. 25, 2005	--	First issue
0.1	Dec. 28, 2006	1	Added the description in Table 1.1. (OV&UV, BCD)
		2.4	Added the description. (OV&UV, BCD)
		2.4.1.1	Modified the description and Figures 2.4.1.1 and 2.4.1.2.
		2.4.1.2	Modified the description and Figure 2.4.1.8, and added Figure 2.4.1.7.
		2.4.1.3	Modified the description in 'Blinder setting'.
		2.4.4 (2.4.4.1 – 2.4.4.4)	Modified the description and Figure 2.4.4.1.
		2.4.5	Modified the description and Figure 2.4.5.1.
		2.4.6	Added 'Note'.
		2.4.9	Added Section '2.4.9 Overvoltage and Undervoltage Protection'.
		2.4.10	Added Section '2.4.10 Broken Conductor Detection'.
		2.4.15	Added 'Note'.
		2.4.16	Modified the description and Figure 2.4.16.1.
		2.5.1.4	Modified the description in 'Note' and Figure 2.5.1.5.
		2.5.1.5	Modified the description and Figure 2.5.1.6.
		2.5.1.6	Modified the description.
		2.6.1	Modified the description and Figures 2.6.1.1 and 2.6.1.2.
		2.7.2.1	Modified the description and Figures 2.7.2.1 and 2.7.2.3.
		2.7.2.2	Modified the description and Figures 2.7.2.7 and 2.7.2.8.
		3.1.5	Modified the description.
		3.3.4, 3.3.5	Modified the description.
		3.3.10	Modified the description and added Figure 3.3.10.1.
		4.2.1	Modified the description.
		4.2.4.3, 4.2.6.7, 4.2.6.10	Modified the description and samples of LCD screens.
		4.4	Modified the description.
		6.5.1	Added Sections 6.5.1.8 and 6.5.1.9.
		Appendices	Modified Appendix A, C, E, H, I, K, N, O and R.
0.2	Feb. 1, 2007	2.1.6	Deleted Section 2.1.6.
		2.4.3.8	Modified the description.
		2.4.11	Modified the description and added Figure 2.4.11.2.
		2.8.1	Modified the description.
		3.1.5	Modified the description.
		4.2.4.3	Modified the description.
		6.7.2, 6.7.3	Modified the description and Table 6.7.1.
		Appendices	Modified Appendix C, G, K, N, Q and R.
0.3	Oct. 19, 2007	2.4.1.3	Modified the description of 'Blinder setting' and Figure 2.4.1.2.
		2.4.3.1, 2.4.3.2, 2.4.3.3,	Modified the description and Figures 2.4.3.1, 2.4.3.2 and 2.4.3.3 (TCHD).
		2.4.3.5	Modified the description and Figures 2.4.3.5 and 2.4.3.6.
		2.4.4.1	Modified the description and Figure 2.4.4.4.
		2.4.7	Modified Figure 2.4.7.1.
		2.4.9.2	Modified the setting range table.
		2.4.10	Modified the description and added Figure 2.4.10.2.
		2.5.1.4	Modified the description.
		2.8.1, 6.5.5	Added 'Note'.
		4.2.3.1	Modified the sample of the fault record screen.
		4.2.4.6	Modified the description of 'Note'.
		5.5	Added the description about interface of telecommunication.
		6.7.3	Modified the description of 'CAUTION'.
		Appendices	Added Appendix R and modified Appendix B, G, K, S and T.

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