PG&E Calculation 357S-DC

Unit(s): 1&2 File No.: SAP Calculation No.: 9000041128-001

Design Calculation: ☒ YES ☐ NO System No.: 63 Legacy No.: 357S-DC Rev 1

Responsible Group: EDE Quality Classification: Q

Structure, System or Component: 4.16 kV Bus Under-Voltage Relay & Timer

Subject: 4.16 kV Bus FLUR & SLUR Setpoint and Tech Spec Basis Calculation

Computer/Electronic Calculation: ☐ YES ☒ NO

Computer ID	Application Name and Version	Date of Latest Installation/Validation Test

Calculation Page Index

Calculation Package	Contains pages	No. of pages
Cover Sheet	1	1
Record of revisions	2	1
Calculation checklist	3 to 5	3
Calculation body	Pages 6 to 78	73
Attachments	Pages 79 to 152	74
Appendices		
Other:		
TOTAL		152

SAP Calculation No.: 9000041128-001

Legacy No.: 357S-DC Rev 1

Rev No./ Ver. No.	Status	Pages affected	Reason for Revision (Requesting Document No.)	Prepared By	LBIE AD/ Screen	LBIE Eval	Check Method*	LBIE Evaluation Approval		Checked	Supervisor	Registered Professional Engineer	Owner's Acceptance per CF3.ID17
				Initials/ LAN ID/ Date	Yes/ No/ NA	Yes/ No/ NA		PSRC Mtg No.	PSRC Mtg Date	Initials/ LAN ID/ Date	Initials/ LAN ID/ Date	Signature/ LAN ID/ Date	Initials/ LAN ID/ Date
0	S	ALL	This calculation supports resolution of notification 50301167 and DDP 1*429 for replacing FLUR/SLUR relays and establishing new setpoints and Tech Specs. This calc supersedes calculation 357R.	HAM8 5/6/11	[x] Yes [ ] No [ ] N/A	[ ] Yes [ ] No [X] N/A	[X] A [ ] B [ ] C			AXM0	PLJ6	HAM8	
1	P	ALL	Revision 1 fixes the typo on Page 16. Time delay setpoint for T1A relays was incorrectly entered as 7 seconds. Correct value is 8 seconds.	HAM8 6/22/11 [signature]	[x] Yes [ ] No [ ] N/A	[ ] Yes [ ] No [X] N/A	[X] A [ ] B [ ] C			AXMO 6/23/11 [signature]	PLJ6	HAM8 6/23/11 [signature]	

* Check Method: A = Detailed Check B = Alternate Method (note added pages) C = Critical Point Check

A. Insert PE stamp or seal below:

REGISTERED PROFESSIONAL ENGINEER
HIGINIO ARIEL MONTOYA
E-18248
EXP. 12/31/11
ELECTRICAL
STATE OF CALIFORNIA
[signature] 6/23/11

B. Insert stamp directing to the PE stamp or seal:

Item to Verify	Complete (enter N/A if not applicable)	
	Preparer Lan ID	Checker Lan ID
Correct calculation number taken out in SAP - document number, part number, version number.	HAM8	AXMO
Originating document is entered in SAP as superior document (e.g., DCP number) and/or on Object Links tab (notification number).	HAM8	AXMO
Cover Page		
Calculation number reflects SAP number and Legacy number.	HAM8	AXMO
Unit number is entered	HAM8	AXMO
Subject clearly stated.	HAM8	AXMO
If computer calculation, computer/application/validation information filled in.	HAM8	AXMO
Calculation Page Index completed.	HAM8	AXMO
Record of Revisions Page		
Rev No., revised pages and reason for revision clearly identified.	HAM8	AXMO
Status matches status in SAP (except if it is PI in SAP, status is F here).	HAM8	AXMO
Prepared by, checked by and registered professional engineer blocks signed (full signature).	HAM8	AXMO
CF3.ID17 block signed if contractor-completed calc.	NA ~~HAM8~~	NA
PE stamp block completed.	HAM8	AXMO
Calculation Body		
Purpose is clear and includes the requesting document reference (e.g., DCP No).	HAM8	AXMO
Background is established clearly so that the reader can understand the situation without going back to the author.	HAM8	AXMO
Assumptions are validated or clearly indicated "Preliminary" if verification is required. If preliminary, SAP Notification No.: SAPO 68012804 operation 150	HAM8	AXMO
Inputs validated or clearly indicated "Preliminary" if verification is required. If preliminary, SAP Notification No.: ____________	HAM8	AXMO
As-built configuration is verified as required (steps 5.3.2d.7 and 5.3.2d.9).	NA	NA
Methodology described is concise and clear.	HAM8	AXMO
Acceptance criteria provided are clear.	HAM8	AXMO
Body of the calculation is clear so that another person can understand the analysis and the logic without going back to the author.	HAM8	AXMO
Results provides a precise solution to the stated purpose.	HAM8	AXMO

Item to Verify	Complete (enter N/A if not applicable)	
	Preparer Lan ID	Checker Lan ID
Margin assessment includes affect on existing margin (quantitative) or a qualitative assessment.	HAM8	AXMO
Margin data recorded using SRM module	NA	NA
Conclusion includes applicability and limitations.	HAM8	AXMO
Impact on other documents is performed (step 5.3.2k).	HAM8	AXMO
References are clearly identified as input, output and other references.	HAM8	AXMO
Attachments include references not readily retrievable.	HAM8	AXMO
All revised pages have the correct calc no, revision/version number (9*xxxx-yyy-zz).	HAM8	AXMO
LBIE AD/Screen completed.	HAM8	AXMO
LBIE evaluation completed, when necessary.	NA	NA
Calculation input and output references correctly entered in SAP on Calculation record Object Links tab.	HAM8	AXMO
Verification		
Check method A - Independent Review Of Calculation		AXMO
Check method B - Alternate Calculation		
• Comparison to a sufficient number of simplified calculations to support the calculation.		N/A
• Comparison to an analysis by an alternate verified method.		↓
• Comparison to a similar verified calculation.		↓
• Comparison to test results.		↓
• Comparison to measured and documented plant data for a comparable design.		↓
• Comparison to published data and correlation confirmed by industry experience.		↓
• Other (describe) ____		↓
Check method C - Critical Point Check		↓
Approval:		
Operations concurrence documented for any operator action(s).	NA	NA
Eng director approval to issue design with calc in "Preliminary" status. Ref.: ____	NA	NA
Calc Approved/Preliminary has a tracking operation off the closure order and is included on design engineering review requirements. No.: SAPO 68012804 operation 150	HAM8	AXMO
PSRC approval if LBIE evaluation is required.	NA	
PE stamp current for person signing as PE.	HAM8	
Approve as Final.	NA	

Item to Verify	Complete (enter N/A if not applicable)	
	Preparer Lan ID	Checker Lan ID
Processing Approved Calc:		
Calc status updated in SAP.	HAM8	[redacted]
Calc Approved/Pending implementation has a tracking operation off the closure order.	NA	NA
Working copy of Approved Calculation package is transmitted to document services for filing in Library or if it is not stored in Library, returned to designated storage location.	HAM8	[redacted]
Copy of the approved revision transmitted to engineering department clerk for transmitting to RMS.	HAM8	[redacted]

Section Page

1. Purpose

This calculation establishes the basis for technical specifications and setpoints of the vital 4kV busses' First Level Undervoltage Relays and Second Level Undervoltage Relays (referred to as FLUR and SLUR respectively throughout this calculation). This calculation supports the resolution of notification 50301167 and the replacement of the Unit 1 and Unit 2 First Level and Second Level Undervoltage Relays (FLUR and SLUR). A licence amendment request will be submitted to the NRC requesting approval for replacing the FLUR's and SLUR's with models of greater accuracy and for re-designing the relay logic to address outstanding concerns over the adequacy of the equipment protection provided by the FLUR's and SLUR's.

The First Level Undervoltage Protection consists of the 27HxB2 (Transfer to startup & diesel start) relays, the 27HxT1 (Time Delay Load Shed) relay and the 27HxT2 (Instantaneous Load Shed permissive) relay. The subject modification will change the make and model for the FLUR Instantaneous Load Shed Relay (27HxT2) and the FLUR Time Delay Load Shed Relay (27HxT1). The FLUR Time Delay Load Shed Relay will now be made up of 3 independent relays for each bus (27HxT1A, 27HxT1B, 27HxT1C). Each relay will initiate load shed timing at different levels of voltage degradation on the bus (LOW VOLTAGE, LOW-LOW VOLTAGE & LOSS OF VOLTAGE) respectively. The FLUR relay responsible for transfer to startup and diesel start (27HxB2) will not be modified, however its tech spec and setpoint basis are included as part of this calculation. For the 27H*B2 relays, the pickup setpoint is not adjustable and it is a function of dropout. This calculation also provides an analysis of relay performance of the 27H*B2 relays based on recent calibration data.

The Second Level Undervoltage (Voltage Sensing) Relays and their associated timers will also be replaced with more accurate models. The setpoints will be changed to enhance equipment protection and optimize availability of offsite power. The Tech Spec limits for the SLUR setpoints will not be changed.

Throughout this document, the under-voltage setpoint activated due to drop in the bus voltage is referred to as "dropout setpoint" and the reset activated due to rise in bus voltage is referred to as "pickup setpoint". This calculation also computes the burden on each potential transformer that reduces the 4kV bus voltage to ~120VAC measurable signal.

The following devices are within the scope of this calculation:

Table 1.1

FLOC	Description	Make	Model	Location
DC-1/2-63-E-XF-SHF(G,H)12PT	Potential Transformer	GE	JVM-3	A-119
DC-1/2-63-E-R-27HF(G,H)B3	SLUR Relay	ABB	59N	A-119
DC-1/2-63-E-R-27HF(G,H)B4	SLUR Relay	ABB	59N	A-119
DC-1/2-63-E-R-62HF(G,H)3A	SLUR Timer (EDG Start)	ABB	62T	A-119
DC-1/2-63-E-R-62HF(G,H)3B	SLUR Timer (EDG Start)	ABB	62T	A-119
DC-1/2-63-E-R-27HF(G,H)T1A	FLUR (Time Delayed Load Shed LOW VOLTAGE)	ABB	27N	A-119
DC-1/2-63-E-R-27HF(G,H)T1B	FLUR (Time Delayed Load Shed LOW-LOW VOLTAGE)	ABB	27N	A-119
DC-1/2-63-E-R-27HF(G,H)T1C	FLUR (Time Delayed Load Shed LOSS OF VOLTAGE)	ABB	27N	A-119
DC-1/2-63-E-R-27HF(G,H)T2	FLUR (Instantaneous Load Shed)	ABB	59N	A-119

FLOC	Description	Make	Model	Location
DC-1/2-63-E-R-27HF(G,H)B2	FLUR (EDG Start on Low, Low-Low & Loss of Voltage)	Basler	BE1-GPS	A-119

2. Background

Per FSAR Section 8.3.1.1.8.2, the DCPP emergency electrical power system including each vital bus and its control protection, and instrumentation was originally designed in accordance with IEEE Standards 308-1971 and 279-1971. These standards required loss of voltage detection and initiation of protection signals which were implemented via a first level of undervoltage protection. The original design function of this first level of undervoltage protection was detection and recovery of loss of voltage.

PG&E received additional requirements for a second level of undervoltage protection relays in a letter from the NRC dated November 22, 1977. These requirements were reflected in DCPP SSER 9. The following discussion defines each criteria and how it is satisfied by the FLUR/SLUR relays or a DCPP calculation or analysis.

(1) *We require that a second level of voltage protection for the onsite power system be provided and that this second level of voltage protection shall satisfy the following requirements:*

a) *The selection of voltage and time set points shall be determined from an analysis of the voltage requirements of the safety-related loads at all onsite steam distribution levels;*

- Voltage studies have been performed of vital 4kV motor starting and steady state loading to determine motor protective device trip times and adequacy in calculation 170-DC [ref. 12.1.58]. These trip times have been considered in establishing FLUR and SLUR load shed setpoints.
- Voltage studies have been performed of vital 480VAC loads for starting and steady state to determine motor protective device trip times and adequacy in calculation 9000041185 [ref. 12.1.59]. These trip times have been considered in establishing FLUR and SLUR load shed setpoings.
- Voltage studies have been performed of vital loads fed at each vital power distribution level by fuses in calculation 9000041186 [ref. 12.1.60]. Impacts of degraded voltage on vital loads fed by fuses have been considred in establishing FLUR and SLUR load shed setpoints.

b) *The voltage protection shall include coincidence logic to preclude spurious trips of the offsite power source;*

- The FLUR relays require a 2 out of 2 coincident logic in order to load shed the vital 4kV busses.
- The SLUR relays require a 2 out of 2 coincident logic in order to load shed the vital 4kV busses and start the emergency diesel generators.

c) *The time delay selection shall be based on the following conditions:*

(i) *The allowable time delay, including margin, shall not exceed the maximum time delay that is assumed in the FSAR accident analyses;*

- Per Notification 50301167 Task 18 and Design Input Transmittal 50301167-1-0, Westinghouse has evaluated the impact of the maximum SLUR load shed time delay on the DCPP safety analyses. This calculation ensures that all relay actuations (including setpoint and uncertainty) occur within the 20 second SLUR load shed Tech Spec limit assumed in the safety analyses.

(ii) *The time delay shall minimize the effect of short duration disturbances from reducing the availability of the offsite power source(s);*

- The adequacy of the SLUR and FLUR relay time delays and their impact on the availability of the offsite power source is evaluated in calculation 359-DC.

(iii) *The allowable time duration of a degraded voltage condition at all distribution system levels shall not result in failure of safety systems or components;*

- Calculation 170-DC [ref. 12.2.10] will take the voltage and time setpoints for the FLUR and SLUR relays and determine adequacy of motor protection for vital 4kV loads.
- Calculation 9000041185 [ref. 12.2.11] will take the voltage and time setpoints for the FLUR and SLUR relays and determine adequacy of load protection for vital 480VAC loads.
- Calculation 9000041186 [ref. 12.1.60] will take setpoints from this calculation and determine adequacy of load protection for loads fed by vital fuses.

(iv) *The voltage sensors shall automatically initiate the disconnection of offsite power sources whenever the voltage set point and time delay limits have been exceeded;*

The following description of the FLUR and SLUR relay functions describe the automatic actions of these relays.

FLUR

The first level under-voltage protection relays (FLUR) detect the degraded and the loss of voltage conditions on the vital 4.16Kv busses. The first level under-voltage protection relays are made up of 5 different relays each with its own voltage sensing setpoint and time delay.

The 27HxB2 relay is a microprocessor based relay with a three step voltage vs time profile. This relay is responsible for initiating the transfer to start up and diesel generator start signals when its voltage and time setpoints are met. After a sufficient time delay they allow the transfer of vital busses to the startup transformer. Diesel generators are automatically started on sustained bus under-voltage.

The 27HxT1A, B and C relays provide a three tier voltage vs. time profile for load shedding the vital 4kV bus. The 27HxT1A detects low vital bus voltage, the 27HxT1B detects low-low vital bus voltage and the 27HxT1C detects loss of vital bus voltage. The time delay associated with each "T1" relay decreases with lower bus voltage setpoint.

The 27HxT2 relay is an instantaneous relay with one voltage setpoint. The function of the "T2" relay is to provide coincidence logic to preclude spurious trips of the offsite power sources. Actuation of either of the three "T1" relays and the "T2" relay will load shed the respective vital 4.16Kv bus. If the transfer to the Startup Transformer is unsuccessful, the FLURs will shed the vital bus motor loads. Diesel breaker closing is time delayed approximately 2 seconds to allow the motor breakers to trip and bus voltage to decay. After the diesel generator breaker closes, the vital bus will be loaded in a predetermined sequence.

SLUR

The second level undervoltage relays (SLUR) detect bus voltage approaching the 3785V limit (approximately 90% of bus voltage) and provide diesel generator start and vital 4.16kV bus load shed signals. The 3785V setting is based on NRC second level undervoltage relay setting requirements [Ref. 12.1.12, page 43]. The second level under-voltage protection relays are made up of 4 different relays each with its own voltage sensing setpoint and time delay.

The 27HxB3 relay is a solid state near instantaneous relay with one voltage setpoint. Similarly the 27HxB4 relay is also a solid state near instantaneous relay with one voltage setpoint. Together these relays provide undervoltage protection and two out of two coincidence logic is required to preclude spurious trips of the offsite power sources. When the coincidence logic is made up, the undervoltage signal initiates two separate timing relays 62Hx3A and 62Hx3B.

The 62Hx3A relay initiates diesel start after a maximum time delay of 10 seconds. This maximum time delay for diesel starts is accounted for in DCPP's accident analyses.

The 62Hx3B relay initiates vital 4.16kV bus load shed after a maximum time delay of 20 seconds. The maximum time delay of 20 seconds is based on allowed short time overheating of motors due to undervoltage. This time is based on motor manufacturer's maximum motor starting time of 20 seconds [Ref. 12.1.12].

(v) *The voltage sensors shall be designed to satisfy the applicable requirements of IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations;" and*

- Per FSAR Section 8.3.1.1.8.2, the DCPP emergency electrical power system including each vital bus and its control protection, and instrumentation was originally designed in accordance with IEEE Standards 308-1971 and 279-1971.

(vi) The Technical Specification shall include limiting condition for operation, surveillance requirements, trip setpoints with minimum and maximum limits, and allowable values for the second-level voltage protection sensors and associated time delay devices.

- DCPP TS 3.3.5.3 provides a minimum voltage value for the FLUR and SLUR TS limits. Calculation 357S-DC establishes the technical specification bases, TS minimum voltage and maximum time delay limits and allowable maximum and minimum as-found values for the FLUR/SLUR calibration acceptance criteria. NUREG-1431 provides a minimum and maximum voltage value for the FLUR and SLUR TS limits. DCPP technical specifications have never had maximum limits for the FLUR/SLUR voltage sensing trip setpoints. A maximum setpoint would be non-conservative in that it would reduce the margin available for offsite power availability. The configuration at DCPP was approved in SSER 9. Additionally, a review of industry technical specifications concluded that the following plants provide only a minimum voltage value for the FLUR and SLUR TS limits: Catawba Units 1 and 2, Braidwood Units 1 and 2, Beaver Valley Units 1 and 2, Millstone Unit 3, McGuire Units 1 and 2, Indian Point Unit 3, Point Beach Units 1 and 2, Salem Unit 1, Seabrook Unit 1, Sequoyah Unit 1, South Texas Units 1 and 2, Summer Unit 1, Vogtle Units 1 and 2, and Wolf Creek Unit 1.

BLOCK DIAGRAM:

The following simplified block diagram depicts the function of each relay and the analytical limits associated with voltage dropout and time delay settings.

Tables 2.1 & 2.2 summarize the setpoint of each device and provides analytical limits as referenced on the block diagram.

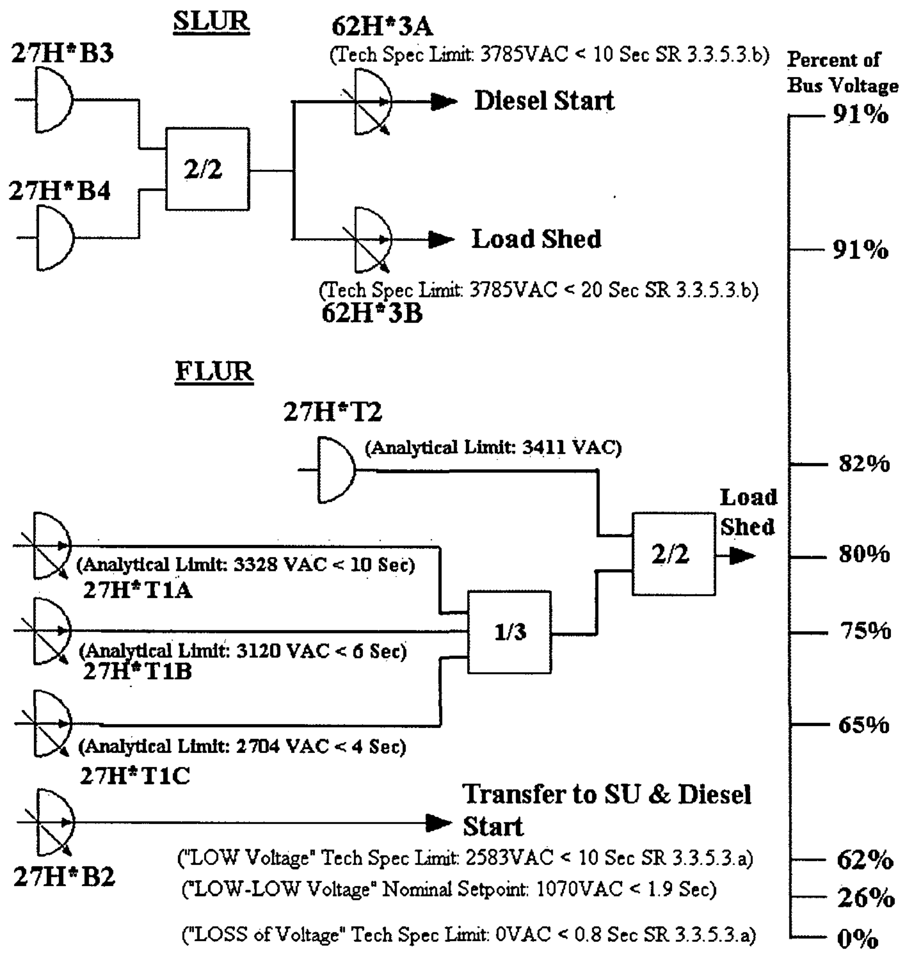


Table 2.1, FLUR & SLUR Setpoint Summary

Device	Undervoltage Setpoint (VAC)	PT Ratio*	Bus Equivalent Voltage	Time Delay Setpoint (Sec)	Analytical Limit
1-27HFB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
1-27HGB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
1-27HHB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
1-27HFT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
1-27HGT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
1-27HHT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
1-27HFT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
1-27HGT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
1-27HHT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
1-27HFT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
1-27HGT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
1-27HHT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
1-27HFT2	98	35.182	3448	NA	3411V
1-27HGT2	98	35.287	3458	NA	3411V
1-27HHT2	98	35.224	3452	NA	3411V
1-27HFB3	109.25	34.951	3818	See 1-62HF3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-27HGB3	109.25	34.951	3818	See 1-62HG3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-27HHB3	109.25	34.951	3818	See 1-62HH3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-27HFB4	109.25	35.182	3844	See 1-62HF3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-27HGB4	109.25	35.287	3855	See 1-62HG3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-27HHB4	109.25	35.224	3848	See 1-62HH3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
1-62HF3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
1-62HG3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
1-62HH3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
1-62HF3B	NA	NA	NA	18.5 sec	<20 sec Load shed
1-62HG3B	NA	NA	NA	18.5 sec	<20 sec Load shed
1-62HH3B	NA	NA	NA	18.5 sec	<20 sec Load shed
2-27HFB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
2-27HGB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
2-27HHB2	27P: 76.3 127P: 30.6 27X: 23.4	34.951	27P: 2667 127P: 1070 27X: 818	27P: 4.7 127P: 1.9 27X: 0.65	27P: 2583V @ < 10 sec 127P: NA 27X: 0V @ < 0.8 sec
2-27HFT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
2-27HGT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
2-27HHT1A	96.5	34.951	3373	8 sec	3328V @ < 10 Sec
2-27HFT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
2-27HGT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
2-27HHT1B	90.5	34.951	3163	5 sec	3120V @ < 6 Sec
2-27HFT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
2-27HGT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
2-27HHT1C	78.6	34.951	2747	3 sec	2704V @ < 4 Sec
2-27HFT2	98	35.182	3448	NA	3411V
2-27HGT2	98	35.287	3458	NA	3411V
2-27HHT2	98	35.224	3452	NA	3411V
2-27HFB3	109.25	34.951	3818	See 2-62HF3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed

2-27HGB3	109.25	34.951	3818	See 2-62HG3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
2-27HHB3	109.25	34.951	3818	See 2-62HH3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
2-27HFB4	109.25	35.182	3843	See 2-62HF3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
2-27HGB4	109.25	35.287	3855	See 2-62HG3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
2-27HHB4	109.25	35.224	3848	See 2-62HH3A/B	3785V @ < 10 sec EDG Start & < 20 Sec Load Shed
2-62HF3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
2-62HG3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
2-62HH3A	NA	NA	NA	8.5 sec	<10 sec EDG Start
2-62HF3B	NA	NA	NA	18.5 sec	<20 sec Load shed
2-62HG3B	NA	NA	NA	18.5 sec	<20 sec Load shed
2-62HH3B	NA	NA	NA	18.5 sec	<20 sec Load shed

* PT Ratio is from Attachment "1"

3. Assumptions

3.1. The undervoltage relays are located in the turbine building, Area "A" elevation 119' in the 4KV switchgear room [FLOC]. The normal operation profile in this room is specified to be within 39°F(3.9°C) to 104°F(40°C) [Ref. 12.1.10]. Following a high energy line break, the maximum temperature in the 4KV switchgear room is calculated to be 95.3°F(35.2°C) [Ref. 12.1.55 & Attachment 7]. Therefore, for the purpose of calculating the temperature effect on these relays the upper limit of 95.3°F(35.2°C) will be used. The DCM T-20 lower temperature limit of 39°F(3.9°C) is based on lowest ambient temperature recorded from 1973 to 1982. Since the 4KV switchgear room is sufficiently isolated from outside environment and the relays are located in cabinets with energized components, it will be assumed that the lowest temperature these switches are exposed to is 50°F(10°C). The range of extreme temperatures for these switches is 95.3°F(35.2°C) – 50°F(10°C) = 45.3°F(25.2°F).

3.2. Basler does not specify a temperature effect for the BE1 relays for both the undervoltage and timing functions. Since the relays are located in a mild environment [see paragraph 3.1], it will be assumed that relay reference accuracy includes any temperature effect.

3.3. Maintenance Procedure MP E-50.61 [Ref. 12.1.6] was written for the old style 27H*T1 relays Basler BE1-27. The new ABB 27N relays do not have a maintenance procedure yet however it will be assumed that the same measurement and test equipment used to calibrate in MP E-50.61 will be used to calibrate the voltage dropout and pickup functions of the new ABB 27N relays. In addition the ABB 27N relays will have a time delay function that must be calibrated. It is assumed that the M&TE specified in MP E-50.30B [Ref. 12.1.5] for calibrating the time delay of Agastat ETR relays will be used.

3.4. Maintenance Procedure MP E-50.33A [Ref.12.1.4] was written for the old style 27H*T2, 27H*B3 and 27H*B4 relays Westinghouse SSV-T. The new ABB 59N relays do not have a maintenance procedure yet. However it will be assumed that the same measurement and test equipment used to calibrate in MP E-50.33A will be used to calibrate the voltage dropout and pickup functions of the new ABB 59N relays. In addition the ABB 59N relays will have a time delay function that must be calibrated. It is assumed that the M&TE specified in MP E-50.30B [Ref. 12.1.5] for calibrating the time delay of Agastat ETR relays will be used.

3.5. Maintenance Procedure MP E-50.30B [Ref. 12.1.5] was written for the old style 62H*3A and 62H*3B relays Agastat ETR. The new ABB 62T relays do not have a maintenance procedure yet. However it will be assumed that the same measurement and test equipment used to calibrate in MP E-50.30B will be used to calibrate the time delay functions of the new ABB 62T relays.

3.6. The ABB 27N and 59N relays are not currently in use at DCPP. Hence drift data is not available from calibration records. In addition ABB does not publish drift values for these relays. Per CF6.NE1 [reference 12.1.1] Appendix 8.2 Section 2.3 in absence of calibration data and vendor published drift values, the default drift value to be used is ±2% of sensor span. Setpoints for ABB 27N and 59N relays are set using a combination of a fixed tap resistor and a potentiometer which is common for all available taps [reference 12.1.51]. ABB was contacted to provide the setpoint span for each tap setting of these relays. ABB performed limited testing on one ABB 27N relay [reference 12.1.57]. The results support the assumption that the potentiometer allows for setpoint adjustment of -12% to +5% of tap setting. Due to the similarity between ABB 27N and 59N relays, a preliminary assumption will be made to apply this setpoint span to both the ABB 27N and 59N relays. This span will be used in calculating the default drift values per CF6.NE1. The assumption will be validated via future testing by the DCPP maintenance department on both the 27N and 59N models to be used at DCPP. This testing is tracked to completion by SAP order 68012804 operation 150 and is required prior to return to service.

3.7. The ABB 27N and 59N relays allow for setting the Dropout (Actuate) setting as a percentage of the Pickup (Reset) setting. This calculation will specify a setpoint for the dropout setting and the pickup will be calculated as a percentage of the dropout setting. Accordingly, this calculation assumes that the uncertainty impacts the dropout setting and that the dropout and pickup settings will drift together in the same direction and not independently of each other.

4. Inputs

4.1. Basler BE1-GPS100 Reference Accuracy for undervoltage function: ±2% of reading or ±1V whichever is greater [Ref. 12.1.50]. The use of 1V reference accuracy for the 127P and 27X devices will result in an over conservatism. Inspection of the historical As-Left calibration data shows that the 127P and 27X devices of these relays have been calibrated well within ±0.3V and ±0.2V respectively. To be conservative but not overly conservative only the ±2% reference accuracy will be used in this calculation.

4.2. Basler BE1-GPS100 Reference Accuracy for time delay function: ±5% or ±3 cycles whichever is greater [Ref. 12.1.50]. Three cycles translate to 0.05 seconds (3c / 60c/S).

4.3. ABB 27N and 59N Reference Accuracy for undervoltage function: ±0.1% of pickup and dropout settings [Ref. 12.1.51].

4.4. ABB 27N and 59N Reference Accuracy for time delay function: ±10% or ±20ms whichever is greater [Ref. 12.1.51].

4.5. ABB 62T timer reference accuracy: ±0.5% or ±15ms or ± 1 digit of setting (whichever is greater) [Ref.12.1.52].

4.6. To calibrate the Basler BE1-GPS100 undervoltage function, an AC Voltmeter, 0-150V range, with accuracy of ±(0.06% of reading + 0.03% of range) [Ref. 12.1.7] is used. Range of the HP 34401A is 1 to 750 VAC [Attachment 6].

4.7. To calibrate the ABB 27N, 59N & BE1-GPS100 time delay function, Manta MTS-1710 Advanced Universal Protective Relay Test System is used [Ref. 12.1.6 & 12.1.7]. The accuracy of this test equipment for a 0-9.9999 sec scale is:

M&TE = ±0.5 mSec ±1 least significant digit = ±0.0006 sec

For all other scales it is:

M&TE = ±(0.005% of reading +1digit), 1 digit = 0.1 mS [Attachment 4].

4.8. To calibrate the ABB 27N and 59N undervoltage function an AC Voltmeter, range 0-150 VAC with accuracy of ±(0.06% of reading + 0.03% of range) is used [Ref. 12.1.6]. Range of the HP 34401A is 1 to 750 VAC [Attachment 5].

4.9. To calibrate the ABB 62T Timers, it is assumed that similar to the existing calibration procedure, the new calibration procedure [Ref. 12.1.5] will provide the option of using either a Manta MTS-1710 Advanced Universal Protective Relay Test System or a timer with accuracy of 0.01% of elapsed time +10 mSec or better.

At 8.5 and 18.5 seconds setpoint the accuracy of the specified generic timer is:

MTE = ±(0.01% X 8.5 + 0.010) = ±0.011 Sec

MTE = ±(0.01% X 18.5 + 0.010) = ±0.012 Sec

These values are larger than the Manta test system calculated in section 4.7. For the purpose of conservatism, the uncertainty of a generic timer will be used for the M&TE effect for 62H*3A/B timers.

4.10. The ABB 27N and 59N relays equipped with harmonic filter have a temperature effect of ±0.4% over a temperature range of 50°F(10°C) to 104°F(40°C) (range of 54°F) [reference 12.1.51]. Per paragraph 3.1 it is assumed that the relays are exposed to a temperature range of 45.3°F. Therefore, the temperature effect should be scaled in accordance with reference 12.1.1, Attachment 8.2, section 5.5 as follows:

$$TE = \pm\frac{0.4\% \times (45.3°F)}{[54°F]} = 0.33\%$$

ABB does not specify a temperature effect for the Time Delay function of the 27N and 59N relays. Since the relays are located in a mild environment [see paragraph 3.1], it will be assumed that relay reference accuracy includes any temperature effect for the time delay function.

4.11. The ABB 62T relays have a temperature effect of ±2%, ±20ms or ±1 digit (which ever is greater) over a temperature range of -4°F(-20°C) to 158°F(70°C) (range of 162°F) [reference 12.1.52]. The 1 digit on a relay with a range of 0.01-9.99 seconds is equal to 10 milliseconds. On a 0.01 to 99.9 seconds range it is equal to 100 milliseconds.

Per paragraph 3.1 it is assumed that the relays are exposed to a temperature range of 45.3°F. Therefore, the temperature effect should be scaled in accordance with reference 12.1.1, Attachment 8.2, section 5.5 as follows:

$$TE = \pm\frac{2\% \times (45.3°F)}{[162°F]} = 0.6\%$$

At 8.5 and 18.5VAC setpoints, the temperature effects are respectively 51 and 111 milliseconds.

4.12. Basler GPS100 Relay: The vendor does not provide any information as to the control voltage effect. But it provides a spec for the 125vdc power supply which is capable to perform its function for control voltages from 35 to 150 Vdc.[Ref. 12.1.50]. Hence RME term will be 0 for the GPS100 Relay.

4.13. ABB 27N and 59N Relay: The vendor datasheet provides a repeat accuracy of 0.1% over the allowable dc control power range of 100-140 VDC. This value is independent of the manufacturer's reference accuracy. [Ref. 12.1.51]. ABB does not specify a control power range effect on the time delay feature of these relays. RME term is 0 for time delay.

4.14. ABB 62T: The vendor datasheet provides an accuracy of ± 2% or ± 15ms or ± 1 digit (whichever is greater) over the allowable control power range of -20%, +10% of the nominal control voltage. [Ref. 12.1.52]. On a device with a range of 0.01 to 9.99 sec, the 1 digit translates to 10 milliseconds. On a 0.1 to 99.9 seconds range device, the 1 digit translates to 100 milliseconds. The 2% temperature effect at 8.5 seconds setpoint translates to 170 milliseconds and at a 18.5 seconds setpoint it translates to 370 milliseconds.

5. Methodology

The following methodology is used in the determination of FLUR & SLUR Channel Uncertainty (CU), setpoints (STP) and Acceptable As-Found (AAF) values

5.1. Channel Uncertainty (CU) Methodology:

Determination of the relay actuation and time delay uncertainty (CU) is based on the following algorithm provided in Reference 12.1.1.

$$CU = EA + B \pm \sqrt{\begin{Bmatrix} PMA^2 + PEA^2 + SCA^2 + SMTE^2 + SD^2 + STE^2 + SPE^2 \\ + \sum [\, RCA_i^2 + RMTE_i^2 + RD_i^2 + RTE_i^2 + RME_i^2 \,] \end{Bmatrix}}$$

The above equation however is customized for each application as follows:

EA: The EA term is associated with the environmental allowance following a design bases accident. Since, the relays are located in the switchgear room in the fuel handling building and the environmental condition following LOCA and HELB is enveloped by plant normal conditions, the EA term will be removed from the above equation.

PEA: This term is associated with flow metering devices. Therefore it will be removed from the above equation.

SCA, SD, SMTE, SPE & STE: The relays will be treated as rack components and the uncertainty terms associated with the sensor will be removed.

PMA: Since error associated with the measurement of line voltage is treated as bias due to burden effect on the instrument potential transformer, the PMA term will be removed.

RME: The only potential miscellaneous effect is the effect of control voltage variation on the relay function.

For the purpose of this calculation the above equation will be modified for both the actuation and time delay as follows:

$$CU = \pm(\sqrt{RCA^2 + RMTE^2 + RD^2 + RME^2 + RTE^2}$$

CU = Channel Uncertainty - The total uncertainty of an instrument channel. This is the minimum allowable difference between the design value and the nominal setpoint value.

RCA = Rack Component or "String" Calibration Accuracy.

RMTE = Rack Component or "String" Measuring and Test Equipment Uncertainty.

RD = Rack Component or "String" Drift or Stability.

RTE = Rack Component or "String" Ambient Temperature Effects.

RME = Rack Component or "String" Miscellaneous Effects.

5.2. Coincident Logic Considerations (Dropout)

The channel uncertainty will be calculated at 95% probability of actuation. That means there is a 2.5% chance that the relay will actuate below "setpoint – uncertainty" and 2.5% chance that the relay will actuate at above "setpoint + uncertainty". Therefore, at the point of concern which is the lower limit, there is 97.5% chance that the relay will actuate above "setpoint – uncertainty". Calculation of the point at which there is 95% probability that both relays will actuate is easier for SLURs because they are both ABB 59N relays with the same mean and standard deviation of error. For SLUR dropout, when both relays have to actuate to initiate the timers, the probability of both timers to actuate above the lower limit is 97.5% X 97.5% = 95%. Therefore, the two sided random channel uncertainty calculated at 95% probability will correspond to 95% single sided uncertainty of a coincident logic. Therefore, for SLUR relays further scaling of uncertainty will not be required.

The setpoints of FLUR undervoltage relays for load shed; T1A, B, C & T2, have different Analytical Limit of actuation. T2 which is an instantaneous relay must actuate before the 4KV bus voltage reaches 3411VAC. But load shed will occur only if the bus voltage continues to degrade and further degradation is sensed by T1A, B or C undervoltage relays. The three T1 relays are setup in a voltage tier such that T1A will actuate at the highest voltage but will have the longest time delay of the three. T1C will have the lowest actuation voltage and will have the shortest time delay. T1B is between the other two. This has been configured such that it maximizes equipment protection against degraded voltage yet meets the criteria of the analytical limits.

Since the coincident logic for actuation of load shed has to wait till actuation of one of the T1 relays, the lower tail of uncertainty distribution of T1 setpoint will be at 97.5% confidence level. The coincident logic will be based on the actuation of T1A.

Since the two sided T1A uncertainty is calculated at 95% CL ($CU_{DO} = 1.96X\sigma$), the one sided actuation point with 95% probability will be equal to (1.645 X σ) Or in other words:

$(1.645 / 1.96) * CU_{DO}$

5.3. One out of two logic considerations (Pickup)

For the pickup setpoint, the upper limit of uncertainty is of the interest. The calculated uncertainty of one relay will provide 97.5% probability that the relay will actuate below the upper limit. The probability that no relay will actuate above the "setpoint + uncertainty" is 2.5% X 2.5% = 0.0625%. On the normal curve, the "Z" value corresponding to 2.5% and 0.0625% are respectively 1.96 and 2.475. The upper limit of uncertainty for one out of two logic will be calculated by multiplying the upper limit of uncertainty by a factor of (1.96/2.475).

6. Acceptance Criteria

6.1. FLUR Acceptance Criteria

6.1.1. FLUR LOW VOLTAGE SETPOINT FOR DIESEL START (27H*B2): The 27X device in FLUR undervoltage relay detects a degraded voltage condition. The device 27X must actuate in less than 10 seconds before the 4KV bus voltage reaches Technical Specification limit of 2583VAC.

6.1.2. FLUR LOSS OF VOLTAGE SETPOINT FOR DIESEL START (27H*B2): The 27P device in FLUR undervoltage relay detects a loss of voltage condition. The device 27P must actuate in less than 0.8 seconds upon loss of voltage.

6.1.3. FLUR Degraded VOLTAGE SETPOINT FOR LOAD SHED (27H*T1A, 27H*T1B, 27H*T1C & 27H*T2): The coincident logic must actuate in less than 10 seconds before T1A senses a degraded voltage of 3328VAC on the 4KV bus. The coincident logic must actuate in less than 6 seconds before T1B senses a degraded voltage of 3120VAC on the 4KV bus. The coincident logic must actuate in less than 4 seconds before T1C senses a degraded voltage of 2704VAC on the 4KV bus. However, T2 must actuate before T1A, B or C at a voltage above the analytical limit of 3411VAC in preparation for T1 actuation.

6.2. SLUR Acceptance Criteria

6.2.1. The SLUR detects a degraded voltage condition less than or equal to 3785V on the associated 4160V Class 1E bus to protect motors from overheating.

6.2.2. If the degraded condition persists, the SLUR will initiate a diesel start signal within 10 seconds,

6.2.3. and then it will initiate bus load shed and transfer to diesel within 20 seconds. The time delays are provided by external time delay relays, devices 62H*3A and 62H*3B.

The SLUR scheme for each bus is comprised of two three phase 4160/120VAC potential transformers each supplying one SLUR. The SLUR output contacts, associated time delay relays, and various permissive contacts of other devices in the bus auto transfer scheme are supplied from the vital 125V DC System. One SLUR, device 27H*B3, is connected to the A-B phase PT and the other SLUR, device 27H*B4 is connected to the B-C phase PT. The SLUR contacts are connected in series such that both relays must dropout to initiate the diesel start and load shed time delay relays. Only one of the two SLURs is required to pick up in order to reset the diesel start and load shed time delay relays.

SLUR Dropout

The analytical limit for SLUR dropout in this calculation is the TS allowable value of 3785 volts [Ref. 12.1.2]. This limit is 91% of the nominal 4160V bus voltage and is equal to the analytical limit based on load flow calculation 357A-DC [Ref. 12.1.56]. The SLUR setpoint with all the uncertainties considered shall be higher than this limit.

SLUR Trip Avoidance Limit

DCPP Calculation 357A-DC analyzes the availability of the offsite power source against normal operating transients. To prevent actuation of the SLUR during normal operating transients, the trip avoidance limit of the SLUR shall be less than or equal to 3850VAC.

SLUR Timers

The SLUR load shed time delay should be adequate to maximize response time of LTC (Load Tap Changer) action to recover voltage. Currently the acceptance criterion for the third tap change is 16 seconds [Ref 12.1.8]. Therefore, the SLUR load shed time delay with all the uncertainties considered shall be higher than 16 seconds and lower than 20 seconds Technical Specification limit.

7. Body of Calculation

7.1. Potential Transformer Ratio Correction Factor (RCF)

The potential transformer consists of two single phase transformers. One transformer is connected to A-B phase and the other to the B-C phase. They are GE JVM-3 instrument transformer with a 35:1 turn ratio. FLOCs: DC-1/2-63-E-XF-SHF(G,H)12PT. The exact value of the PT ratio is dependent on the PT burden. The PT burden for transformers on each bus is calculated in Attachment “1”. The transformer on A-B phase is lightly loaded while on the B-C phase is heavily loaded. Using the GE “Potential Transformer Characteristic Ratio and Phase Angle Curve” (Attachment “2”), the ratio correction factor (RCF) for lightly and heavily loaded transformers on each bus is tabulated as follows:

Transformer	Burden (VA)	Burden (W)	Power Factor	RCF	PTR
Unit 1 $SHF12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 1 $SHF12PT_{B-C}$	157.72	154.76	0.98	1.0052	35.182
Unit 2 $SHF12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 2 $SHF12PT_{B-C}$	157.72	154.76	0.98	1.0052	35.182
Unit 1 $SHG12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 1 $SHG12PT_{B-C}$	178.65	161.69	0.91	1.0082	35.287
Unit 2 $SHG12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 2 $SHG12PT_{B-C}$	178.65	161.69	0.91	1.0082	35.287
Unit 1 $SHH12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 1 $SHH12PT_{B-C}$	149.32	133.82	0.90	1.0064	35.224
Unit 2 $SHH12PT_{A-B}$	22.59	22.59	1.0	0.9986	34.951
Unit 2 $SHH12PT_{B-C}$	149.32	133.82	0.90	1.0064	35.224

7.2. Bias (B)

The IR losses are considered to be negligible since the loop and associated cables are located in mild environments, and the currents are not sufficiently low so as to be comparable to leakage currents generated by extreme environmental conditions. As the PT and the degraded voltage relays are located within the same switchgear room, the voltage drop between the two devices can be considered negligible. No other source of bias term has been identified for the relay. Therefore,

B = 0

7.3. Rack Calibration Accuracy (RCA)

7.3.1. RCA - 27H*B2 Undervoltage Function

Make and Model: Basler BE1-GPS100E4N1H0

AL_{27P}: ±1.48VAC [Ref. 12.1.7] LOW Voltage" Setpoint

AL_{127P}: ±0.60VAC [Ref. 12.1.7] LOW-LOW Setpoint

AL_{27X}: ±0.46VAC [Ref. 12.1.7] LOSS of Voltage Setpoint

Per input 4:

VRF_{27P} = ±2% X 76.3VAC = ±1.53 VAC

VRF_{127P} = ±2% X 30.6VAC = ±0.61 VAC

VRF_{27X} = ±2% X 23.4VAC = ±0.47 VAC

Since the calibration tolerance is smaller than the vendor reference accuracy, the reference accuracy will be used as Rack Calibration Accuracy (RCA_{UV}). Since the pickup occurs at approximately 102% of dropout [Ref. 12.1.50], the RCA value applies to both the dropout and pickup (Note: The dropout and pickup terminology used in this calculation is the opposite of that used in MP E-50.62 procedure).

$RCA_{UV\_27P}^{DO} = RCA_{UV\_27P}^{PU}$ = ±1.53VAC

$RCA_{UV\_127P}^{DO} = RCA_{UV\_127P}^{PU}$ = ±0.61VAC

$RCA_{UV\_27X}^{DO} = RCA_{UV\_27X}^{PU}$ = ±0.47VAC

7.3.2. RCA - 27H*B2 Time Delay Function

Make and Model: Basler BE1-GPS100E4N1H0

AL_{27P}: ±0.30 Sec [FLOC] LOW Voltage" Setpoint

AL_{127P}: ±0.10 Sec [FLOC] LOW-LOW Setpoint

AL_{27X}: ±0.05 Sec [FLOC] LOSS of Voltage Setpoint

Per input 4.2:

VRF_{27P} = ±5% X 4.7 Sec = ±0.235000 Sec

VRF_{127P} = ±5% X 1.9 Sec = ±0.095000 Sec

VRF_{27X} = larger of ±5% X 0.65 Sec and ±0.05 Sec

Since the calibration tolerance is larger than the vendor reference accuracy, the AL tolerance will be used as Rack Calibration Accuracy (RCA_{TD})

RCA_{TD_27P}: ±0.30 Sec

RCA_{TD_127P}: ±0.10 Sec

RCA_{TD_27X}: ±0.05 Sec

7.3.3. RCA - 27H*T1A Undervoltage Function:

Make and Model: ABB 27N

Dropout **LOW VOLTAGE SETPOINT**

At 96.5VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 96.5 VAC = ±0.1 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.3]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC.

7.3.4. RCA - 27H*T1B Undervoltage Function:

Make and Model: ABB 27N

Dropout **LOW LOW VOLTAGE SETPOINT**

At 90.5VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 90.5 VAC = ±0.09 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.4]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC.

7.3.5. RCA - 27H*T1C Undervoltage Function:

Make and Model: ABB 27N

Dropout **LOSS OF VOLTAGE SETPOINT**

At 78.6VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 78.6 VAC = ±0.08 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.5]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC.

7.3.6. RCA - 27H*T1A Time Delay Function (LOW VOLTAGE):

Make and Model: ABB Type 27N

At 8 sec setting, the vendor reference accuracy per input 4.4 is:

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater.

VRF_{TD} = ±10% x 8 sec = ±0.8 sec.

This value is larger than 20ms.

To allow for margin, recommended AL_{TD} tolerance is ±1.0sec.

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{TD} and AL_{TD} . Hence:

RCA_{UV_TD} = ±1.0 sec.

7.3.7. RCA - 27H*T1B Time Delay Function (LOW-LOW VOLTAGE):

Make and Model: ABB Type 27N

At 5 sec setting, the vendor reference accuracy per input 4.4 is:

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater.

VRF_{TD} = ±10% x 5 sec = ±0.5 sec.

This value is larger than 20ms.

To allow for margin, recommended AL_{TD} tolerance is ±0.7sec.

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{TD} and AL_{TD} . Hence:

RCA_{UV_TD} = ±0.7 sec.

7.3.8. RCA - 27H*T1C Time Delay Function (LOSS OF VOLTAGE):

Make and Model: ABB Type 27N

At 3 sec setting, the vendor reference accuracy per input 4.4 is:

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater.

VRF_{TD} = ±10% x 3 sec = ±0.3 sec.

This value is larger than 20ms.

To allow for margin, recommended AL_{TD} tolerance is ±0.5sec.

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{TD} and AL_{TD} . Hence:

RCA_{UV_TD} = ±0.5 sec.

7.3.9. RCA - 27H*T2 Undervoltage Function

Make and Model: ABB Type 59N

Dropout

At 98.0VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 98.0 VAC = ±0.098 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.9]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC.

7.3.10. RCA - 27H*T2 Time Delay Function (Pickup = Reset)

Make and Model: ABB Type 59N

Due to the use of the harmonic filter on the T2 relays, an instantaneous model cannot be used. Hence a definite time delay relay will be used with the time delay dialed to the minimum setpoint of 0.1 second. This time delay occurs on the pickup action of the relay.

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater [Ref.12.1.51].

The uncertainty at the lowest time delay setting per vendor reference accuracy is 20 milliseconds. This means that the pick up can occur anywhere between 80 to 120 milliseconds. Therefore,

RCA_{TD} = ±0.02 sec.

7.3.11. RCA - 27H*B3 Undervoltage Function

Make and Model: ABB Type 59N

Dropout

At 109.25VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 109.25 VAC = ±0.11 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.11]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC

7.3.12. RCA - 27H*B3 Time Delay Function

Make and Model: ABB Type 59N

Due to the use of the harmonic filter on the B2 relays, an instantaneous model cannot be used. Hence a definite time delay relay will be used with the time delay dialed to the minimum setpoint of 0.1 second. This time delay occurs on the pickup action of the relay.

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater [Ref. 12.1.51].

The uncertainty at the lowest time delay setting per vendor reference accuracy is 20 milliseconds. This means that the pick up can occur anywhere between 80 to 120 milliseconds. Therefore,

RCA_{TD} = ±0.02 sec.

7.3.13. RCA - 27H*B4 Undervoltage Function

Make and Model: ABB Type 59N

Dropout

At 109.25VAC setting, the vendor reference accuracy per input 4.3 is:

VRF_{DO} = ±0.1% X 109.25 VAC = ±0.11 VAC

M&TE used to calibrate this relay cannot achieve the vendor reference accuracy. Hence the recommended AL_{DO} tolerance is ±0.5VAC. [See Section 7.4.13]

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{UV}) is the larger of VRF_{DO} and AL_{DO} . Hence:

RCA_{UV_DO} = ±0.5VAC.

7.3.14. RCA - 27H*B4 Time Delay Function

Make and Model: ABB Type 59N

Due to the use of the harmonic filter on the B4 relays, an instantaneous model cannot be used. Hence a definite time delay relay will be used with the time delay dialed to the minimum setpoint of 0.1 second. This time delay occurs on the pickup action of the relay.

Reference Accuracy for time delay function is ±10% of setting or ±20 ms whichever is greater [Ref. 12.1.51].

The uncertainty at the lowest time delay setting per vendor reference accuracy is 20 milliseconds. This means that the pick up can occur anywhere between 80 to 120 milliseconds. Therefore,

RCA_{TD} = ±0.02 sec.

7.3.15. RCA – 62H*3A Time Delay Function

Make and Model: ABB 62T

Per input 4.5, ABB 62T timer reference accuracy at 8.5 seconds time delay is ±0.5% or ±15ms or ± 1 digit of setting (whichever is greater).

VRF_{TD} = ±0.5% x 8.5 sec = ±0.0425 sec. This is larger than 15ms or 1 digit which is 10 ms.

The M&TE is capable of calibration to a tolerance of 0.6 milliseconds [See Section 7.4.15]. Therefore for the purpose of conservatism a calibration tolerance of 50 milliseconds will be assumed.

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{TD}) is the larger of VRF_{TD} and AL_{TD} . Hence:

RCA_{TD} = ±0.05 sec.

7.3.16. RCA – 62H*3B Time Delay Function

Make and Model: ABB 62T

Per input 4.5, ABB 62T timer reference accuracy at 18.5 seconds time delay is ±0.5% or ±15ms or ± 1 digit of setting (whichever is greater).

VRF_{TD} = ±0.5% x 18.5 sec = ±0.0925 sec.

One digit of the setting corresponds to 100 ms. Since this is larger than the calculated VRF_{TD} and larger than 15ms, VRF_{TD} will be ± 0.1 sec.

The M&TE is capable of calibration to a tolerance of 10 milliseconds [See Section 7.4.16]. Therefore for the purpose of conservatism a calibration tolerance of 100 milliseconds will be assumed.

Per CF6.NE1 [ref. 12.1.1] Rack Calibration Accuracy (RCA_{TD}) is the larger of VRF_{TD} and AL_{TD} . Hence:

RCA_{TD} = ±0.1 sec.

7.4. Rack Measurement & Test Equipment Effect (RMTE)

The Rack Measurement & Test Equipment Effect (RMTE) is the "As-Left Tolerance AL".

7.4.1. RMTE - 27H*B2 Undervoltage Function

STP_{27P}: 76.3 VAC [FLOC] LOW Voltage" Setpoint

STP_{127P}: 30.6 VAC [FLOC] LOW-LOW Setpoint

STP_{27X}: 23.4 VAC [FLOC] LOSS of Voltage Setpoint

Per input 4.6, the M&TE tolerance is computed at each setpoint as follows:

$RMTE_{27P}$ = ±(0.06% X 76.3 + 0.03% X 750)VAC = ±0.271 VAC

$RMTE_{127P}$ = ±(0.06% X 30.6 + 0.03% X 750)VAC = ±0.243 VAC

$RMTE_{27X}$ = ±(0.06% X 23.4 + 0.03% X 750)VAC = ±0.239 VAC

7.4.2. RMTE - 27H*B2 Time Delay Function

STP_{27P}: 4.7 Sec [FLOC] LOW Voltage Setpoint

STP_{127P}: 1.9 Sec [FLOC] LOW-LOW Setpoint

STP_{27X}: 0.65 Sec [FLOC] LOSS of Voltage Setpoint

Per input 4.7, the M&TE tolerance is computed at each setpoint as follows:

$RMTE_{27P}$ = ±(0.005% X 4.7 + 0.0001) Sec = ±0.000335 Sec

$RMTE_{127P}$ = ±(0.005% X 1.9 + 0.0001) Sec = ±0.000195 Sec

$RMTE_{27X}$ = ±(0.005% X 0.65 + 0.0001) Sec = ±0.000133 Sec

7.4.3. RMTE - 27H*T1A Undervoltage Function:

STP_{DO}: 96.5 VAC LOW Voltage Setpoint

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 96.5 + 0.03% X 750) VAC = ±0.28VAC

7.4.4. RMTE - 27H*T1B Undervoltage Function:

STP_{DO}: 90.5 VAC LOW-LOW Voltage Setpoint

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 90.5 + 0.03% X 750) VAC = ±0.28VAC

7.4.5. RMTE - 27H*T1C Undervoltage Function:

STP_{DO}: 78.6 VAC LOSS of Voltage Setpoint

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 78.6 + 0.03% X 750) VAC = ±0.27VAC

7.4.6. RMTE - 27H*T1A Time Delay Function:

STP_{TD}: 8.0 sec LOW Voltage Setpoint

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 8.0 + 0.01) sec = ±0.01sec

7.4.7. RMTE - 27H*T1B Time Delay Function:

STP_{TD}: 5.0 sec LOW-LOW Voltage Setpoint

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 5.0 + 0.01) sec = ±0.01sec

7.4.8. RMTE - 27H*T1C Time Delay Function:

STP_{TD}: 3.0 sec LOSS of Voltage Setpoint

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 3.0 + 0.01) sec = ±0.01sec

7.4.9. RMTE - 27H*T2 Undervoltage Function:

STP_{DO}: 98.0 VAC

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 98.0 + 0.03% X 750) VAC = ±0.28VAC

7.4.10. RMTE - 27H*T2 Time Delay Function:

STP_{TD}: 0.1 sec (Time Delay on Pickup)

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 0.1 + 0.01) sec = ±0.01sec

7.4.11. RMTE - 27H*B3 Undervoltage Function

STP_{DO}: 109.25 VAC [FLOC]

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 109.25 + 0.03% X 750) VAC = ±0.29VAC

7.4.12. RMTE - 27H*B3 Time Delay Function

STP_{TD} = 0.1 Sec

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 0.1 + 0.01) Sec = 0.01 Sec

7.4.13. RMTE - 27H*B4 Undervoltage Function

STP_{DO}: 109.25 VAC [FLOC]

Per input 4.8, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.06% X 109.25 + 0.03% X 750) VAC = ±0.29VAC

7.4.14. RMTE - 27H*B4 Time Delay Function

STP_{TD} = 0.1 Sec

Per input 4.7, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 0.1 + 0.01) Sec = 0.01 Sec

7.4.15. RMTE – 62H*3A Time Delay Function

STP_{TD} = 8.5 Sec

Per input 4.9, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 8.5 + 0.01) Sec = 0.01 Sec

7.4.16. RMTE – 62H*3B Time Delay Function

STP_{TD} = 18.5 Sec

Per input 4.9, the M&TE tolerance at the measured setpoint is as follows:

RMTE = ±(0.01% X 18.5 + 0.01) Sec = 0.01 Sec

7.5. Rack Drift (RD) [as calculated in Attachment 3]

7.5.1. RD - 27H*B2 Undervoltage Function

$DR_{27P\ Dropout}$: ±0.50 VAC

$DR_{127P\ Dropout}$: ±0.30 VAC

$DR_{27X\ Dropout}$: ±0.40 VAC

7.5.2. RD - 27H*B2 Time Delay Function

$DR_{27P\ Dropout}$: ±0.1 sec

$DR_{127P\ Dropout}$: ±0.05 sec

$DR_{27X\ Dropout}$: ±0.05 sec

7.5.3. RD - 27H*T1A Undervoltage Dropout Function:

RD_{DO} = ±0.34VAC

7.5.4. RD - 27H*T1A Time Delay Function:

RD_{TD} = ±0.18sec

7.5.5. RD - 27H*T1B Undervoltage Function

RD_{DO} = ±0.31VAC

7.5.6. RD - 27H*T1B Time Delay Function:

RD_{TD} = ±0.18sec

7.5.7. RD - 27H*T1C Undervoltage Function

RD_{DO} = ±0.27VAC

7.5.8. RD - 27H*T1C Time Delay Function:

RD_{TD} = ±0.18sec

7.5.9. RD - 27H*T2 Undervoltage Function

RD_{DO} = ±0.34VAC

7.5.10. RD - 27H*T2 Time Delay Function (on Pickup)

RD_{TD} = ±0.02sec

7.5.11. RD - 27H*B3 Undervoltage Function

RD_{DO} = ±0.37VAC

7.5.12. RD - 27H*B3 Time Delay Function (on Pickup)

RD_{TD} = ±0.02sec

7.5.13. RD - 27H*B4 Undervoltage Function

RD = ±0.37VAC

7.5.14. RD - 27H*B4 Time Delay Function (on Pickup)

RD_{TD} = ±0.02 Sec

7.5.15. RD – 62H*3A Time Delay Function

RD = ±0.17 Sec

7.5.16. RD – 62H*3B Time Delay Function

RD = ±0.37 Sec

7.6. Rack Temperature Effect (RTE)

7.6.1. RTE - 27H*B2 Undervoltage Function

Make and Model: Basler BE1-GPS100E4N1H0

RTE = 0 [Assumption 3.2]

7.6.2. RTE - 27H*B2 Time Delay Function

Make and Model: Basler BE1-GPS100E4N1H0

RTE = 0 [Assumption 3.2]

7.6.3. RTE - 27H*T1A Undervoltage Function:

Make and Model: ABB 27N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 96.5 VAC

RTE = 0.32 VAC

7.6.4. RTE - 27H*T1B Undervoltage Function:

Make and Model: ABB 27N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 90.5 VAC

RTE = 0.3 VAC

7.6.5. RTE - 27H*T1C Undervoltage Function:

Make and Model: ABB 27N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 78.6 VAC

RTE = 0.26 VAC

7.6.6. RTE - 27H*T1A Time Delay Function:

Make and Model: ABB 27N

RTE = 0 [Assumption 4.10]

7.6.7. RTE - 27H*T1B Time Delay Function:

Make and Model: ABB 27N

RTE = 0 [Assumption 4.10]

7.6.8. RTE - 27H*T1C Time Delay Function:

Make and Model: ABB 27N

RTE = 0 [Assumption 4.10]

7.6.9. RTE - 27H*T2 Undervoltage Function:

Make and Model: ABB 59N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 98.0 VAC

RTE = 0.32 VAC

7.6.10. RTE - 27H*T2 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RTE = 0 [Assumption 4.10]

7.6.11. RTE - 27H*B3 Undervoltage Function:

Make and Model: ABB 59N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 109.25 VAC

RTE = 0.36 VAC

7.6.12. RTE - 27H*B3 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RTE = 0 [Assumption 4.10]

7.6.13. RTE - 27H*B4 Undervoltage Function:

Make and Model: ABB 59N

RTE = 0.33% x Setpoint [Assumption 4.10]

RTE = 0.33% x 109.25 VAC

RTE = 0.36 VAC

7.6.14. RTE - 27H*B4 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RTE = 0 [Assumption 4.10]

7.6.15. RTE – 62H*3A Time Delay Function

Make and Model: ABB 62T

RTE = 0.05 Sec [see 4.11]

7.6.16. RTE – 62H*3B Time Delay Function

Make and Model: ABB 62T

RTE = 0.11 Sec [see 4.11]

7.7. Rack Miscellaneous Effects (RME)

7.7.1. RME - 27H*T1A Undervoltage Function:

Make and Model: ABB 27N

RME = 0.1% x Setpoint [see 4.13]

RME = 0.1% x 96.5 VAC

RME = 0.1 VAC

7.7.2. RME - 27H*T1B Undervoltage Function:

Make and Model: ABB 27N

RME = 0.1% x Setpoint [see 4.13]

RME = 0.1% x 90.5 VAC

RME = 0.09 VAC

7.7.3. RME - 27H*T1C Undervoltage Function:

Make and Model: ABB 27N

RME = 0.1% x Setpoint [see 4.13]

RME = 0.1% x 78.6 VAC

RME = 0.08 VAC

7.7.4. RME - 27H*T1A Time Delay Function:

Make and Model: ABB 27N

RME = 0 [see 4.13]

7.7.5. RME - 27H*T1B Time Delay Function:

Make and Model: ABB 27N

RME = 0 [see 4.13]

7.7.6. RME - 27H*T1C Time Delay Function:

Make and Model: ABB 27N

RME = 0 [see 4.13]

7.7.7. RME - 27H*T2 Undervoltage Function:

Make and Model: ABB 59N

RME = 0.1% x Setpoint [see 4.13]

RME = 0.1% x 98 VAC

RME = 0.1 VAC

7.7.8. RME - 27H*T2 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RME = 0 [see 4.13]

7.7.9. RME - 27H*B3 Undervoltage Function:

Make and Model: ABB 59N

RME = 0.1% x Setpoint [see 4.124.13]

RME = 0.1% x 109.25 VAC

RME = 0.11 VAC

7.7.10. RME - 27H*B3 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RME = 0 [see 4.124.13]

7.7.11. RME - 27H*B4 Undervoltage Function:

Make and Model: ABB 59N

RME = 0.1% x Setpoint [see 4.124.13]

RME = 0.1% x 109.25 VAC

RME = 0.11 VAC

7.7.12. RME - 27H*B4 Time Delay Function (on Pickup):

Make and Model: ABB 59N

RME = 0 [see 4.13]

7.7.13. RME – 62H*3A Time Delay Function

Make and Model: ABB 62T

RME = 0.17 sec [see 4.14]

7.7.14. RME – 62H*3B Time Delay Function

Make and Model: ABB 62T

RME = 0.37 sec [see 4.14]

7.8. Device Level Uncertainty

7.8.1. 27H*B2 Undervoltage Actuation Uncertainty – CU_{27H*B2}

Undervoltage Setpoints [Ref. 12.1.7]:

27P: 76.3 VAC

127P: 30.6 VAC

27X: 23.4 VAC

$$CU_{27H*B2} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2}\right)$$
$$CU^{DO}_{27H*B2\_27P} = 0 \pm \left(\sqrt{1.53^2 + 0.271^2 + 0.50^2 + 0^2}\right) = \pm 1.632\,VAC$$
$$CU^{DO}_{27H*B2\_127P} = 0 \pm \left(\sqrt{0.61^2 + 0.243^2 + 0.30^2 + 0^2}\right) = \pm 0.722\,VAC$$
$$CU^{DO}_{27H*B2\_27X} = 0 \pm \left(\sqrt{0.47^2 + 0.239^2 + 0.4^2 + 0^2}\right) = \pm 0.662\,VAC$$

7.8.2. 27H*B2 Time Delay Uncertainty – CU^{TD}_{27H*B2}

Undervoltage Setpoints [Ref. 12.1.7]:

27P: 4.7 Sec

127P: 1.9 Sec

27X: 0.65 Sec

$$CU_{27H*B2} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2}\right)$$
$$CU^{TD}_{27H*B2\_27P} = 0 \pm \left(\sqrt{0.300^2 + 0.000335^2 + 0.1^2 + 0^2}\right) = \pm 0.316\,\sec$$
$$CU^{TD}_{27H*B2\_127P} = 0 \pm \left(\sqrt{0.100^2 + 0.000195^2 + 0.05^2 + 0^2}\right) = \pm 0.112\,\sec$$
$$CU^{TD}_{27H*B2\_27X} = 0 \pm \left(\sqrt{0.050^2 + 0.000133^2 + 0.05^2 + 0^2}\right) = \pm 0.071\,\sec$$

7.8.3. 27H*T1A Actuation Uncertainty – $CU_{27H*T1A}$

$$CU_{27H*T1A} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$
$$CU_{27H*T1A} = 0 \pm \left(\sqrt{0.5^2 + 0.28^2 + 0.34^2 + 0.32^2 + 0.1^2}\right) = \pm 0.75\,VAC$$

7.8.4. 27H*T1B Actuation Uncertainty – $CU_{27H*T1B}$

$$CU_{27H*T1B} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$
$$CU_{27H*T1B} = 0 \pm \left(\sqrt{0.5^2 + 0.28^2 + 0.31^2 + 0.30^2 + 0.09^2}\right) = \pm 0.72\,VAC$$

7.8.5. 27H*T1C Actuation Uncertainty – $CU_{27H*T1C}$

$$CU_{27H*T1C} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU_{27H*T1C} = 0 \pm \left(\sqrt{0.5^2 + 0.27^2 + 0.27^2 + 0.26^2 + 0.08^2}\right) = \pm 0.69\,VAC$$

7.8.6. 27H*T1A Time Delay Uncertainty – $CU^{TD}_{27H*T1A}$

$$CU^{TD}_{27H*T1A} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{27H*T1A} = 0 \pm \left(\sqrt{1.0^2 + 0.01^2 + 0.18^2 + 0^2 + 0^2}\right) = \pm 1.02\,\text{sec}$$

7.8.7. 27H*T1B Time Delay Uncertainty – $CU^{TD}_{27H*T1B}$

$$CU^{TD}_{27H*T1B} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{27H*T1B} = 0 \pm \left(\sqrt{0.7^2 + 0.01^2 + 0.18^2 + 0^2 + 0^2}\right) = \pm 0.72\,\text{sec}$$

7.8.8. 27H*T1C Time Delay Uncertainty – $CU^{TD}_{27H*T1C}$

$$CU^{TD}_{27H*T1C} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{27H*T1C} = 0 \pm \left(\sqrt{0.5^2 + 0.01^2 + 0.18^2 + 0^2 + 0^2}\right) = \pm 0.53\text{ sec}$$

7.8.9. 27H*T2 Actuation Uncertainty – CU_{27H*T2}

$$CU_{27H*T2} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU_{27H*T2} = 0 \pm \left(\sqrt{0.5^2 + 0.28^2 + 0.34^2 + 0.32^2 + 0.1^2}\right) = \pm 0.75\ VAC$$

7.8.10. 27H*T2 Time Delay Uncertainty (on Pickup) – CU^{TD}_{27H*T2}

$$CU^{TD}_{27H*T2} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{27H*T2} = 0 \pm \left(\sqrt{0.02^2 + 0.01^2 + 0.02^2 + 0^2 + 0^2}\right) = \pm 0.03\text{ sec}$$

7.8.11. 27H*B3 Undervoltage Actuation Uncertainty – CU_{27H*B3}

$$CU_{27H*B3} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU_{27H*B3} = 0 \pm \left(\sqrt{0.5^2 + 0.29^2 + 0.37^2 + 0.36^2 + 0.11^2}\right) = \pm 0.78\,VAC$$

7.8.12. 27H*B3 Time Delay Actuation Uncertainty (on Pickup) – CU^{TD}_{27H*B3}

$$CU^{TD}_{27H*B3} = \pm\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}$$

$$CU^{TD}_{27H*B3} = 0 \pm \left(\sqrt{0.02^2 + 0.01^2 + 0.02^2 + 0^2 + 0^2}\right) = \pm 0.03 \text{ sec}$$

7.8.13. 27H*B4 Actuation Uncertainty – CU_{27H*B4}

$$CU_{27H*B4} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU_{27H*B4} = 0 \pm \left(\sqrt{0.5^2 + 0.29^2 + 0.37^2 + 0.36^2 + 0.11^2}\right) = \pm 0.78\ VAC$$

7.8.14. 27H*B4 Time Delay Uncertainty (on Pickup) – CU^{TD}_{27H*B4}

$$CU^{TD}_{27H*B4} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{27H*B4} = 0 \pm \left(\sqrt{0.02^2 + 0.01^2 + 0.02^2 + 0^2 + 0^2}\right) = \pm 0.03 \text{ sec}$$

7.8.15. 62H*3A Time Delay Uncertainty – CU^{TD}_{62H*3A}

$$CU^{TD}_{62H*3A} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{62H*3A} = 0 \pm \left(\sqrt{0.05^2 + 0.01^2 + 0.17^2 + 0.05^2 + 0.17^2}\right) = \pm 0.25 \text{ sec}$$

7.8.16. 62H*3B Time Delay Uncertainty – CU^{TD}_{62H*3B}

$$CU^{TD}_{62H*3B} = B \pm \left(\sqrt{RCA^2 + RMTE^2 + RD^2 + RTE^2 + RME^2}\right)$$

$$CU^{TD}_{62H*3B} = 0 \pm \left(\sqrt{0.1^2 + 0.01^2 + 0.37^2 + 0.11^2 + 0.37^2}\right) = \pm 0.54 \text{ sec}$$

7.9. FLUR 2/2 Logic Undervoltage Load Shed Dropout Uncertainty (CU_{FLUR_DO})

Per section 5.2,

$CU_{FLUR\_DO} = \pm(1.645/1.96) \times CU^{DO}_{27H*T1}$

Since the T1 relays have lower setpoints than the T2, the 2/2 logic actuation is determined by the lowest bus voltage sensed by T1A at **3373V**. This can be tested as follows:

The T1A 95% single sided voltage uncertainty is 0.75V X (1.645/1.96) = 0.63V

T1A Trip Avoidance Limit = 96.5V + 0.63V = 97.13V

T1A Trip Avoidance limit = 97.13V * 34.951 = 3395V (81.61%)

The lowest T1A sensed voltage = 96.5 – 0.63 = 95.87V

The lowest bus voltage = 95.87V * 34.951 = 3351V

The T1A 95% single sided time delay uncertainty is 1.02s X (1.645/1.96) = 0.86

Maximum time delay = 8.0 s + 0.86 = 8.86s.

The T1B 95% single sided voltage uncertainty is 0.72V X (1.645/1.96) = 0.60V

T1B Trip Avoidance Limit = 90.50V + 0.60V = 91.10V

T1B Trip Avoidance limit = 91.10V * 34.951 = 3184V (76.54%)

The lowest T1B sensed voltage = 90.5 – 0.60 = 89.90V

The lowest bus voltage = 89.90V * 34.951 = 3142V

The T1B 95% single sided time delay uncertainty is 0.72s X (1.645/1.96) = 0.60

Maximum time delay = 5.0 s + 0.60 = 5.60s.

The T1C 95% single sided voltage uncertainty is 0.69V X (1.645/1.96) = 0.58V

T1C Trip Avoidance Limit = 78.60V + 0.58V = 79.18V

T1C Trip Avoidance limit = 79.18V * 34.951 = 2767V (66.52%)

The lowest T1C sensed voltage = 78.6 – 0.58 = 78.02V

The lowest bus voltage = 78.02V * 34.951 = 2727V

The T1C 95% single sided time delay uncertainty is 0.53s X (1.645/1.96) = 0.44

Maximum time delay = 3.0 s + 0.44 = 3.44s.

7.10. SLUR 2/2 Logic Dropout Uncertainty (CU_{SLUR_DO})

Per section 5.2,

$CU_{SLUR\_DO} = CU^{DO}_{27H*B3} = CU^{DO}_{27H*B4}$

CU_{SLUR_DO} = ±0.78 VAC

B3 lowest trip voltage = (109.25 – 0.78)V X 34.951 = 3791V

B4 lowest trip voltage = (109.25 – 0.78)V X 35.182 = 3816V

Since during bus voltage degradation B3 actuates after B4 the 2/2 logic for SLUR actuation is 3791V or 91.13% bus voltage

7.11. Analytical Limits (AL)

7.11.1. 27H*T1A (Time Delayed) Low Voltage

The analytical limit for the time delayed initiation of load shed is established at 3328VAC (~80% bus voltage) within 10 seconds. There is no analytical limit for relay pickup. The 80% limit at 10 seconds is selected to ensure the motors will start and if they are running their protection relays will not trip prior to shedding the bus. This ensures availability of the motors during an accident.

7.11.2. 27H*T1B (Time Delayed) Low-Low Voltage

The analytical limit for the time delayed initiation of load shed is established at 3120VAC (~75% bus voltage) within 6 seconds. There is no analytical limit for relay pickup. The 75% limit at 6 seconds is selected to maximize the time needed for voltage recovery without tripping the motor over load protection prior to shedding the bus. This ensures availability of the motors during an accident.

7.11.3. 27H*T1C (Time Delayed) Loss of Voltage

The analytical limit for the time delayed initiation of load shed is established at 2704VAC (~65% bus voltage) within 4 seconds. There is no analytical limit for relay pickup. The 65% limit is selected to allow for clearing of a temporary fault and successful bus transfer to offsite power during a loss of voltage event. This prevents spurious transfers to diesel generators during availability of offsite power.

7.11.4. 27H*T2 (Instantaneous)

The analytical limit for the instantaneous initiation of load shed is established at 3411VAC (~82% bus voltage). There is no analytical limit for relay pickup.

7.11.5. 27H*B2 (Time Delayed)

The 27H*B2 relay has two diesel start analytical limits for "LOW voltage", and "LOSS of Voltage" and one diesel start nominal setpoint at "LOW-LOW Voltage". The "LOW" diesel start analytical limit is 2583VAC (~62% bus voltage) within 10 seconds [Ref. 12.1.2]. The "LOSS of Voltage" diesel start analytical limit is 0VAC within 0.8 seconds. The "LOW-LOW Voltage" nominal setpoint is established at bus voltage of 1070VAC (~26% bus voltage) within 1.9 seconds. There is no analytical limit for relay pickup.

7.11.6. 27H*B3 & B4 (Initiate Timer)

The analytical limit for second level voltage protection is established at 3785VAC (~91% bus voltage) [Ref. 12.1.3]. The pickup should occur at a voltage below the worst case 4KV bus voltage CWP pump starts. This level is established at 3866 VAC in Ref. 12.1.56.

7.11.7. 62H*3A (Timer)

The analytical limit for time delayed diesel start is established at 10 seconds [Ref. 12.1.3].

7.11.8. 62H*3B (Timer)

The analytical limit for time delayed initiation of load shed is established at 20 seconds [Ref. 12.1.3].

7.12. Determination of Setpoint Limits and Acceptable As-Found Settings

7.12.1. 27H*B2 Undervoltage Setpoint Limit (Low Voltage)

STP_{27P}^{DO}: 76.3VAC [Ref. 12.1.7]

PT Ratio: 34.951 [Attachment 1]

STP_{27P}^{DO} Bus Equivalent Setpoint: 76.3 X 34.951 = 2667VAC

STP_{27P}^{DO} Tech Spec Limit @ 4KV Bus: 2583 VAC [Ref. 12.1.2]

STP_{27P}^{DO} Tech Spec Limit @ Relay = (2583/34.951) VAC = 73.90 VAC

$STP_{27P}^{DO} - CU_{27H*B2\_27P}^{DO}$ = (76.3 – 1.63)VAC = 74.67VAC

$STP_{27P}^{DO} + CU_{27H*B2\_27P}^{DO}$ = (76.3 + 1.63)VAC = 77.93VAC

STP_{27P}^{DO} Min. Bus Equivalent STP: 74.67VAC X 34.951 = 2610VAC

STP_{27P}^{DO} Max. Bus Equivalent STP: 77.93VAC X 34.951 = 2724VAC

STP_{27P}^{DO} Margin to TS Limit = (2610 – 2583)VAC = 27VAC

STP_{27P}^{DO} Margin to TS Limit @ Relay = 27VAC/34.951 = 0.77VAC

STP_{27P}^{DO} Limit: ≥ (76.30 - 0.77)VAC ≥ 75.53 AC

7.12.2. 27H*B2 Undervoltage Setpoint Limit (Low-Low Voltage)

STP_{127P}^{DO}: 30.6VAC [Ref. 12.1.7]

$STP_{127P}^{DO} - CU_{27H*B2\_127P}^{DO}$ = (30.6 – 0.722)VAC = 29.878VAC

$STP_{127P}^{DO} + CU_{27H*B2\_127P}^{DO}$ = (30.6 + 0.722)VAC = 31.322VAC

STP_{127P}^{DO} Min. Bus Equivalent STP: 29.878VAC X 34.951 = 1044VAC

STP_{127P}^{DO} Max. Bus Equivalent STP: 31.322VAC X 34.951 = 1095VAC

Since the "Low-Low Voltage" setpoint is not associated with a Technical Specification limit, its nominal limits are the "Low Voltage" (Device 27P) and "Loss of Voltage" (Device 27X) setpoints.

7.12.3. 27H*B2 Undervoltage Setpoint Limit (Loss of Voltage)

STP_{27X}^{DO} : 23.4VAC [Ref. 12.1.7]

STP_{27X}^{DO} Bus Equivalent Setpoint: 23.4 X 34.951 = 818VAC

$STP_{27X}^{DO} - CU_{27H*B2\_27X}^{DO}$ = (23.40 – 0.66)VAC = 22.74VAC

$STP_{27X}^{DO} + CU_{27H*B2\_27X}^{DO}$ = (23.40 + 0.66)VAC = 24.06VAC

STP_{27X}^{DO} Minimum Bus Equivalent Setpoint: 22.74VAC X 34.951 = 795VAC

STP_{27X}^{DO} Maximum Bus Equivalent Setpoint: 24.06VAC X 34.951 = 841VAC

STP_{27X}^{DO} Margin to TS Limit = (795 – 0)VAC = 795VAC

STP_{27X}^{DO} Margin to TS Limit @ Relay = 795VAC/34.951 = 22.75VAC

STP_{27X}^{DO} Limit: ≥ (22.75 -22.75)VAC ≥ 0VAC

7.12.4. 27H*B2 Time Delay Setpoint Limit (Low Voltage)

STP_{27P}^{TD}: 4.7 Sec [Ref. 12.1.7]

$STP_{27P}^{TD} + CU_{27H*B2\_27P}^{TD}$ = (4.7 + 0.32)VAC = 5.02 Sec

STP_{27P}^{TD} Margin to TS Limit = (10.0 – 5.02)Sec = 4.98 Sec

STP_{27P}^{TD} Limit: ≤ (4.7+4.98)VAC ≤ 9.68 Sec

7.12.5. 27H*B2 Time Delay Setpoint Limit (Loss of Voltage)

STP_{27X}^{TD} : 0.65 Sec [Ref. 12.1.7]

$STP_{27X}^{TD} + CU_{27H*B2\_27X}^{TD}$ = (0.65 + 0.07)VAC = 0.72 Sec

STP_{27X}^{TD} Margin to TS Limit = (0.80 – 0.72)VAC = 0.08 Sec

STP_{27X}^{TD} Limit: ≤ (0.65 + 0.08)VAC ≤ 0.73 Sec

7.12.6. 27H*B2 Undervoltage Acceptable As-Found (AAF) Determination

STP_{27P}^{DO}: 76.3VAC [Ref. 12.1.7]

STP_{27P}^{DO} Drift: ±0.50VAC [see section 7.5.1]

STP_{27P}^{DO} MTE Effect: ±0.27VAC [see section 7.4.1]

STP_{27P}^{DO} AAF Tolerance: ±(DR + MTE) = ±(0.50+0.27)VAC = ±0.77VAC

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±1.53 VAC.

STP_{27P}^{DO} Acceptable As-Found Range: 74.77 to 77.83 VAC

STP_{127P}^{DO}: 30.6VAC [Ref. 12.1.7]

STP_{127P}^{DO} Drift: ±0.3VAC [see section 7.5.1]

STP_{127P}^{DO} MTE Effect: ±0.24VAC [see section 7.4.1]

STP_{127P}^{DO} AAF Tolerance: ±(DR + MTE) = ±(0.30+0.24)VAC = ±0.54VAC

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±0.61 VAC.

STP_{127P}^{DO} Acceptable As-Found Range: 29.99 to 31.21 VAC

STP_{27X}^{DO}: 23.4VAC [Ref. 12.1.7]

STP_{27X}^{DO} Drift = ±0.40VAC [see section 7.5.1]

STP_{27X}^{DO} MTE Effect = ±0.24VAC [see section 7.4.1]

STP_{27X}^{DO} AAF Tolerance: ±(DR + MTE) = ±(0.40+0.24)VAC = ±0.64VAC

STP_{27X}^{DO} Acceptable As-Found Range: 22.76 to 24.04 VAC

7.12.7. 27H*B2 Time Delay Acceptable As-Found (AAF) Determination

STP_{27P}^{TD} Setpoint: 4.7 Sec [Ref. 12.1.7]

STP_{27P}^{TD} Setpoint Drift: ±0.1 Sec [see section 7.5.2]

STP_{27P}^{TD} MTE Effect: ±0.0003 Sec [see section 7.4.2]

STP_{27P}^{TD} AAF Tolerance: ±(DR + MTE) = ±(0.1+0.0003)Sec = ±0.10 Sec

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±0.3 sec.

STP_{27P}^{TD} Acceptable As-Found Range: 4.40 to 5.0 Sec

STP_{127P}^{TD} Setpoint: 1.9 Sec [Ref. 12.1.7]

STP_{127P}^{TD} Setpoint Drift: ±0.05 Sec [see section 7.5.2]

STP_{127P}^{TD} MTE Effect: ±0.0002 Sec [see section 7.4.2]

STP_{127P}^{TD} AAF Tolerance: ±(DR + MTE) = ±(0.05+0.0002)Sec = ±0.05 Sec

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±0.1 sec.

STP_{127P}^{TD} Acceptable As-Found Range: 1.80 to 2.00 Sec

STP_{27X}^{TD} Setpoint: 0.65 Sec [Ref. 12.1.7]

STP_{27X}^{TD} Setpoint Drift = ±0.05 Sec [see section 7.5.2]

STP_{27X}^{TD} MTE Effect = ±0.0001 Sec [see section 7.4.2]

STP_{27X}^{TD} AAF Tolerance: ±(DR + MTE) = ±(0.05+0.0001)Sec = ±0.05Sec

STP_{27X}^{TD} Acceptable As-Found Range: 0.60 to 0.70 Sec

7.12.8. 27H*T1A Undervoltage Setpoint Limit (Low Voltage)

STP^{DO}: 96.5VAC

PT Ratio: 34.951 [Heavily burdened transformers on all three phases per Attachment 1]

STP^{DO} Bus Equivalent Setpoint: 96.5 X 34.951 = 3373VAC

$STP^{DO} - CU^{DO}_{27H*T1A}$ = (96.5 –0.75)VAC = 95.75VAC

STP^{DO} Min. Bus Equivalent STP: 95.75VAC X 34.951 = 3347VAC

STP^{DO} Margin to Analytical Limit = (3347– 3328)VAC = 19VAC

STP^{DO} Margin to Analytical Limit @ Relay = 19VAC/34.951 = 0.54VAC

STP^{DO} Limit: ≥ (96.5 –0.54)VAC ≥ 95.96VAC

7.12.9. 27H*T1B Undervoltage Setpoint Limit (Low-Low Voltage)

STP^{DO}: 90.5VAC

PT Ratio: 34.951 [Heavily burdened transformers on all three phases per Attachment 1]

STP^{DO} Bus Equivalent Setpoint: 90.5 X 34.951 = 3163VAC

$STP^{DO} - CU^{DO}_{27H*T1B}$ = (90.5 – 0.72)VAC = 89.78VAC

STP^{DO} Min. Bus Equivalent STP: 89.78VAC X 34.951 = 3138VAC

STP^{DO} Margin to Analytical Limit = (3138 – 3120)VAC = 18VAC

STP^{DO} Margin to Analytical Limit @ Relay = 18VAC/34.951 = 0.52VAC

STP^{DO} Limit: ≥ (90.5 – 0.52)VAC ≥ 89.98VAC

7.12.10. 27H*T1C Undervoltage Setpoint Limit (Loss of Voltage)

STP^{DO}: 78.6VAC

PT Ratio: 34.951 [Heavily burdened transformers on all three phases per Attachment 1]

STP^{DO} Bus Equivalent Setpoint: 78.6 X 34.951 = 2747VAC

$STP^{DO} - CU^{DO}_{27H*T1C}$ = (78.6 – 0.69)VAC = 77.91VAC

STP^{DO} Min. Bus Equivalent STP: 77.91VAC X 34.951 = 2723VAC

STP^{DO} Margin to Analytical Limit = (2723 – 2704)VAC = 19VAC

STP^{DO} Margin to Analytical Limit @ Relay = 19VAC/34.951 = 0.54VAC

STP^{DO} Limit: ≥ (78.6 – 0.54)VAC ≥ 78.06VAC

7.12.11.27H*T1A Undervoltage Acceptable As-Found (AAF) Determination

$STP^{DO}_{27H*T1A}$: 96.5VAC

$STP^{DO}_{27H*T1A}$ Drift: ±0.34VAC [see section7.5.3]

$STP^{DO}_{27H*T1A}$ MTE Effect: ±0.28VAC [see section7.4.3]

$STP^{DO}_{27H*T1A}$ AAF Tolerance: ±(DR + MTE) = ±(0.34+0.28)VAC = ±0.62VAC

$STP^{DO}_{27H*T1A}$ Acceptable As-Found Range: 95.88 to 97.12 VAC

7.12.12.27H*T1B Undervoltage Acceptable As-Found (AAF) Determination

$STP^{DO}_{27H*T1B}$: 90.5VAC

$STP^{DO}_{27H*T1B}$ Drift: ±0.31VAC [see section7.5.5]

$STP^{DO}_{27H*T1B}$ MTE Effect: ±0.28VAC [see section7.4.4]

$STP^{DO}_{27H*T1B}$ AAF Tolerance: ±(DR + MTE) = ±(0.31+0.28)VAC = ±0.59VAC

$STP^{DO}_{27H*T1B}$ Acceptable As-Found Range: 89.91 to 91.09 VAC

7.12.13.27H*T1C Undervoltage Acceptable As-Found (AAF) Determination

$STP^{DO}_{27H*T1C}$: 78.6VAC

$STP^{DO}_{27H*T1C}$ Drift: ±0.27VAC [see section7.5.7]

$STP^{DO}_{27H*T1C}$ MTE Effect: ±0.27VAC [see section7.4.5]

$STP^{DO}_{27H*T1C}$ AAF Tolerance: ±(DR + MTE) = ±(0.27+0.27)VAC = ±0.54VAC

$STP^{DO}_{27H*T1C}$ Acceptable As-Found Range: 78.06 to 79.14 VAC

7.12.14.27H*T1A Time Delay Setpoint Limit (Low Voltage)

STP^{TD}: 8.0 sec

$STP^{TD} + CU^{TD}_{27H*T1A}$ = (8.0 + 1.02)sec = 9.02 sec

STP^{TD} Margin to Analytical Limit = (10 – 9.02)sec = 0.98sec

STP^{TD} Limit: ≤ (8.0 + 0.98)sec ≤ 8.98sec

7.12.15. 27H*T1B Time Delay Setpoint Limit (Low-Low Voltage)

STP^{TD} : 5.0 sec

STP^{TD} + $CU^{TD}_{27H*T1B}$ = (5.0 + 0.72)sec = 5.72 sec

STP^{TD} Margin to Analytical Limit = (6 – 5.72)sec = 0.28sec

STP^{TD} Limit: ≤ (5.0 + 0.28)sec ≤ 5.28sec

7.12.16. 27H*T1C Time Delay Setpoint Limit (Loss of Voltage)

STP^{TD} : 3.0 sec

STP^{TD} + $CU^{TD}_{27H*T1C}$ = (3.0 + 0.53) sec = 3.53 sec

STP^{TD} Margin to Analytical Limit = (4 – 3.53) sec = 0.47sec

STP^{TD} Limit: ≤ (3.0 + 0.47) sec ≤ 3.47sec

7.12.17. 27H*T1A Time Delay Acceptable As-Found (AAF) Determination

$STP^{TD}_{27H*T1A}$: 8.0 sec

$STP^{TD}_{27H*T1A}$ Drift: ±0.18 sec [see section7.5.4]

$STP^{TD}_{27H*T1A}$ MTE Effect: ±0.01 sec [see section7.4.6]

$STP^{TD}_{27H*T1A}$ AAF Tolerance: ±(DR + MTE) = ±(0.18+0.01)sec = ±0.19sec

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±1.0 sec.

$STP^{TD}_{27H*T1A}$ Acceptable As-Found Range: 7.00 to 9.00 sec

7.12.18. 27H*T1B Time Delay Acceptable As-Found (AAF) Determination

$STP^{TD}_{27H*T1B}$: 5.0 sec

$STP^{TD}_{27H*T1B}$ Drift: ±0.18 sec [see section7.5.6]

$STP^{TD}_{27H*T1B}$ MTE Effect: ±0.01 sec [see section7.4.7]

$STP^{TD}_{27H*T1B}$ AAF Tolerance: ±(DR + MTE) = ±(0.18+0.01)sec = ±0.19sec

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±0.7 sec

$STP^{TD}_{27H*T1B}$ Acceptable As-Found Range: 4.30 to 5.70 sec

7.12.19. 27H*T1C Time Delay Acceptable As-Found (AAF) Determination

$STP^{TD}_{27H*T1C}$: 3.0 sec

$STP^{TD}_{27H*T1C}$ Drift: ±0.18 sec [see section7.5.8]

$STP^{TD}_{27H*T1C}$ MTE Effect: ±0.01 sec [see section7.4.8]

$STP^{TD}_{27H*T1C}$ AAF Tolerance: ±(DR + MTE) = ±(0.18+0.01)sec = ±0.19sec

Since this value is less than the Rack Calibration Accuracy RCA, the acceptable as found tolerance will be ±0.5 sec

$STP^{TD}_{27H*T1C}$ Acceptable As-Found Range: 2.50 to 3.50 sec

7.12.20. 27H*T2 Undervoltage Setpoint Limit (Instantaneous)

STP^{DO} : 98.0VAC

PT Ratio: 35.182 [Bus F is most conservative per Attachment 1]

STP^{DO} Bus Equivalent Setpoint: 98.0 X 35.182 = 3448VAC

$STP^{DO} - CU^{DO}_{27H*T2}$ = (98.0 – 0.75)VAC = 97.25VAC

STP^{DO} Min. Bus Equivalent STP: 97.25VAC X 35.182 = 3422VAC

STP^{DO} Margin to Analytical Limit = (3422 – 3411)VAC = 11VAC

STP^{DO} Margin to Analytical Limit @ Relay = 11VAC/35.182 = 0.31VAC

STP^{DO} Limit: ≥ (98.0 – 0.31)VAC ≥ 97.69VAC

7.12.21. 27H*T2 Undervoltage Acceptable As-Found (AAF) Determination

STP^{DO}_{27H*T2} : 98.0VAC

STP^{DO}_{27H*T2} Drift: ±0.34VAC [see section7.5.9]

STP^{DO}_{27H*T2} MTE Effect: ±0.28VAC [see section7.4.9]

STP^{DO}_{27H*T2} AAF Tolerance: ±(DR + MTE) = ±(0.34+0.28)VAC = ±0.62VAC

STP^{DO}_{27H*T2} Acceptable As-Found Range: 97.38 to 98.62 VAC

7.12.22. 27H*B3 Undervoltage Setpoint Limit (Low Voltage)

STP^{DO}_{27H*B3}: 109.25 VAC

PT Ratio: 34.951 [Attachment "1"]

STP_{27H*B3}^{DO} Bus Equivalent Setpoint: 109.25 X 34.951 = 3818VAC

STP_{27H*B3}^{DO} - CU_{27H*B3}^{DO} = (109.25 – 0.78)VAC = 108.47VAC

STP_{27H*B3}^{DO} Min. Bus Equivalent STP: 108.47VAC X 34.951 = 3791VAC

Technical Specification Limit: 3785VAC [Ref. 12.1.3]

STP_{27H*B3}^{DO} Margin to TS Limit = (3791 – 3785)VAC = 6VAC

STP_{27H*B3}^{DO} Margin to TS Limit @ Relay = 6VAC/34.951 = 0.17VAC

STP_{27H*B3}^{DO} Limit: ≥ (109.25 – 0.17)VAC ≥ 109.08VAC

7.12.23. <u>27H*B3 Undervoltage Acceptable As-Found (AAF) Determination</u>

STP_{27H*B3}^{DO}: 109.25VAC

STP_{27H*B3}^{DO} Drift: ±0.37VAC [see section7.5.11]

STP_{27H*B3}^{DO} MTE Effect: ±0.29VAC [see section 7.4.11]

STP_{27H*B3}^{DO} AAF Tolerance: ±(DR + MTE) = ±(0.37+0.29)VAC ≈ ±0.66VAC

STP_{27H*B3}^{DO} Acceptable As-Found Range: 108.59 to 109.91 VAC

7.12.24. <u>27H*B4 Undervoltage Setpoint Limit (Low Voltage)</u>

STP_{27H*B4}^{DO}: 109.25 VAC

Worst Case PT Ratio: 35.182 [Attachment "1"]

STP_{27H*B4}^{DO} Bus Equivalent Setpoint: 109.25 X 35.182 = 3843VAC

STP_{27H*B4}^{DO} - CU_{27H*B4}^{DO} = (109.25 – 0.78)VAC = 108.47VAC

STP_{27H*B4}^{DO} Min. Bus Equivalent STP: 108.47VAC X 35.182 = 3816VAC

Technical Specification Limit: 3785VAC [Ref. 12.1.3]

STP_{27H*B4}^{DO} Margin to TS Limit = (3816 – 3785)VAC = 31VAC

STP_{27H*B4}^{DO} Margin to TS Limit @ Relay = 31VAC/35.182 = 0.89VAC

STP_{27H*B4}^{DO} Limit: ≥ (109.25 -0.89)VAC ≥ 108.36VAC

7.12.25. <u>27H*B4 Undervoltage Acceptable As-Found (AAF) Determination</u>

STP_{27H*B4}^{DO}: 109.25VAC

STP_{27H*B4}^{DO} Drift: ±0.37VAC [see section 7.5.13]

STP_{27H*B4}^{DO} MTE Effect: ±0.29VAC [see section 7.4.13]

STP_{27H*B4}^{DO} AAF Tolerance: ±(DR + MTE) = ±(0.37+0.29)VAC ≈ ±0.66VAC

STP_{27H*B4}^{DO} Acceptable As-Found Range: 108.59 to 109.91 VAC

7.12.26.62H*3A Time Delay Setpoint Limit

STP_{62H*3A}^{TD}: 8.5 Sec

$STP_{62H*3A}^{TD} + CU_{62H*3A}^{TD}$ = (8.5 + 0.25) Sec = 8.75 Sec

STP_{62H*3A}^{TD} Margin to TS Limit = (10 – 8.75) Sec = 1.25 Sec

STP_{62H*3A}^{TD} Limit: ≤ (8.5 + 1.25)VAC ≤ 9.75 Sec

7.12.27.62H*3A Time Delay Acceptable As-Found (AAF) Determination

STP_{62H*3A}^{TD}: 8.5 Sec

STP_{62H*3A}^{TD} Drift: ±0.17 Sec [see section 7.5.15]

STP_{62H*3A}^{TD} MTE Effect: ±0.01 Sec [see section 7.4.15]

STP_{62H*3A}^{TD} AAF Tolerance: ±(DR + MTE) = ±(0.17+0.01)Sec ≈ ±0.18 Sec

STP_{62H*3A}^{TD} Acceptable As-Found Range: 8.32 to 8.68 Sec

7.12.28.62H*3B Time Delay Setpoint Limit

STP_{62H*3B}^{TD}: 18.5 Sec

$STP_{62H*3B}^{TD} + CU_{62H*3B}^{TD}$ = (18.5 + 0.54) Sec = 19.04 Sec

STP_{62H*3B}^{TD} Margin to TS Limit = (20 – 19.04) Sec = 0.96 Sec

STP_{62H*3B}^{TD} Limit: ≤ (18.5 + 0.96)VAC ≤ 19.46 Sec

7.12.29.62H*3B Time Delay Acceptable As-Found (AAF) Determination

STP_{62H*3B}^{TD}: 18.5 Sec

STP_{62H*3B}^{TD} Drift: ±0.37 Sec [see section 7.5.16]

STP_{62H*3B}^{TD} MTE Effect: ±0.01 Sec [see section 7.4.16]

STP^{TD}_{62H*3B} AAF Tolerance: ±(DR + MTE) = ±(0.37+0.01)Sec = ±0.38Sec

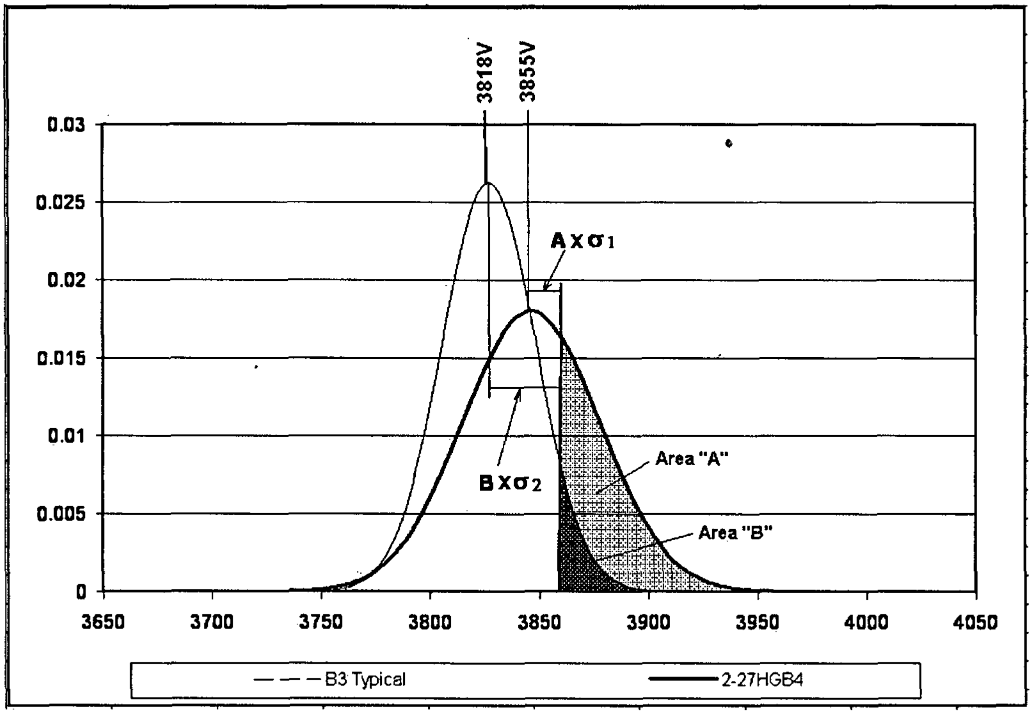
STP^{TD}_{62H*3B} Acceptable As-Found Range: 18.12 to 18.88 Sec

7.12.30. SLUR Dropout Avoidance Limit

B3 dropout voltage is 3818VAC (Typical) with an uncertainty of 27.36V (0.78*34.951). The standard deviation of uncertainty = 27.36/1.96 = 13.96V

The highest B4 dropout voltage is related to Bus "G" with a setpoint of 3855V and an uncertainty of 27.63V (0.78V*35.287). The standard deviation of uncertainty = 27.63V/1.96 = 14.10V

Since both relays must actuate for the dropout function, we have to find the highest voltage at which there is more than 5% probability that both relays will actuate. Graphically under the normal distribution curve, the product of Area "A" and "B" should be less than 0.05.



At 3840V the probability of B3 actuating is:

Z = (3840-3818) / 13.96 = 1.58

This "z" value corresponds to 5.71% probability

At 3840V the probability of B4 actuating is:

Z = (3840 – 3855) / 14.10 = -1.06

Since the Z value is negative, the probability will be 50% + (50% - probability of absolute value of Z value 1.06).

This "Z" value corresponds to 14.46% probability

Hence the probability of B4 actuating at 3840 is 50% + 50% - 14.46% = 85.54%

The probability of both B3 and B4 actuating is 5.71% * 85.54% = 4.9%

Therefore:

The SLUR Trip Avoidance Limit is 3840V or 92.31% of bus rated voltage

7.13. Maximum Pickup Voltage (Reset)

7.13.1. 27H*B2 Diesel Start Reset

Per Attachment 11, the lowest reset dropout ratios for B2 diesel start function are as follows:

Device	Average Dropout Ratio	Lower Limit of Dropout Ratio
1/2-27H*B2 - 27P	0.98127	0.97670
1/2-27H*B2 - 127P	0.98066	0.97653
1/2-27H*B2 - 27X	0.98104	0.97527

Setpoint and Reset Voltage for Diesel Start (27P)	Bus Voltage (VAC)
Setpoint for Diesel Start in 4.7 Sec:	2667
Average Reset for Diesel Start in 4.7 Sec: (2667/0.98127)	2718
Maximum Setpoint for Diesel Start in 4.7 Sec: [STP + CU*(1.645/1.96)] (95% confidence limit single Sided) 2667 + (1.632*34.951)*(1.645/1.96)	2715
Maximum Reset Voltage for Diesel Start in 4.7 Sec: (2715/0.97670)	**2780**

Setpoint and Reset Voltage for Diesel Start (127P)	Bus Voltage (VAC)
Setpoint for Diesel Start in 1.9 Sec:	1070
Average Reset for Diesel Start in 1.9 Sec: (1070/0.98066)	1091
Maximum Setpoint for Diesel Start in 1.9 Sec: [STP + CU*(1.645/1.96)] (95% confidence limit single Sided) 1070 + (0.722*34.951)*(1.645/1.96)	1091
Maximum Reset Voltage for Diesel Start in 1.9 Sec: (1091/0.97653)	**1117**

Setpoint and Reset Voltage for Diesel Start (27X)	**Bus Voltage (VAC)**
Setpoint for Diesel Start in 0.65 Sec:	818
Average Reset for Diesel Start in 0.65 Sec: (818/0.98104)	834
Maximum Setpoint for Diesel Start in 0.65 Sec: [STP + CU*(1.645/1.96)] (95% confidence limit single Sided) 818 + (0.662*34.951)*(1.645/1.96)	838
Maximum Reset Voltage for Diesel Start in 0.65 Sec: (837 / 0.97527)	**859**

7.13.2. 27H*T1 & 27H*T2 Load Shed Reset

Since for the Load Shed reset a "1-out-of-2" logic is employed, the T1 relays will reset sooner than the T2 due to their lower setpoints (and thus reset points).

Per assumption 3.7, the ABB 27N and 59N relays allow for setting the Dropout (Actuate) setting as a percentage of the Pickup (Reset) setting. This calculation has taken the position of calculating a setpoint for the dropout of the relays and the pickup will be calculated as a percentage of the dropout setting. Accordingly, this calculation assumes that the uncertainty impacts the dropout setting and that the dropout and pickup settings will drift together in the same direction and not independently of each other. Hence there will be no additional uncertainty applied to the pickup setting.

Reset of the FLUR Load Shed will only occur once 27H*T1A has reset. Since the reset of 27H*T1A will be set as a percentage of the dropout, it is conservative to assume the highest dropout voltage for 27H*T1A.

Highest dropout = 96.5 + .75VAC = 97.25VAC

The dropout will be set at 99% of the pickup setting. Hence pickup will be:

Highest pickup = 97.25VAC / 99% = 98.24VAC

This corresponds to a bus voltage of 98.24 x 34.951 = 3433VAC

The highest bus voltage that a reset will occur by a T1A device is 3433V or 82.52%.

Reset of the FLUR Load Shed will only occur once 27H*T1B has reset. Since the reset of 27H*T1B will be set as a percentage of the dropout, it is conservative to assume the highest dropout voltage for 27H*T1B.

Highest dropout = 90.5 + .72VAC = 91.22VAC

The dropout will be set at 99% of the pickup setting. Hence pickup will be:

Highest pickup = 91.22VAC / 99% = 92.14VAC

This corresponds to a bus voltage of 92.14 x 34.951 = 3220VAC

The highest bus voltage that a reset will occur by a T1B device is 3220V or 77.41%.

Reset of the FLUR Load Shed will only occur once 27H*T1C has reset. Since the reset of 27H*T1C will be set as a percentage of the dropout, it is conservative to assume the highest dropout voltage for 27H*T1C.

Highest dropout = 78.6 + .69VAC = 79.29VAC

The dropout will be set at 99% of the pickup setting. Hence pickup will be:

Highest pickup = 79.29VAC / 99% = 80.09VAC

This corresponds to a bus voltage of 80.09 x 34.951 = 2799VAC

The highest bus voltage that a reset will occur by a T1C device is 2799V or 67.29%.

7.13.3. SLUR Diesel Start & Load Shed Reset

The setpoints for SLUR undervoltage relays (27H*B3 & 27H*B4) are selected such that the corresponding bus voltage will be as close to each other as possible. Therefore, in calculating the "1-out-o-2" logic, a voltage must be selected that the probability of at least one relay resetting will equate to 95%. This is accomplished using the following procedure:

(1) The setpoints both at the relay and corresponding voltages on the bus, channel uncertainty and pickup ratio are tabulated in the following tables.

(2) The expected average reset is equal to the device setpoint divided by the average pickup ratio for that device.

(3) The highest reset is related to the uncertainty associated with the pickup ratio. In the previous revision of this calculation an uncertainty of 0.59% was calculated for the existing Westinghouse hardware. In this calculation, for the purpose of conservatism an uncertainty of 0.7% will be assumed for the new ABB relay.

(4) For each pair of devices a voltage is selected. The difference between this selected value and the highest reset voltage calculated in step 3 divided by the standard deviation of uncertainty will provide us with the "Z" value for the standard Gaussian table. The calculated uncertainty of the drop out (CU_{DO}) is calculated at 95% confidence level for a two sided distribution (i.e.; 1.96 X σ). The standard deviation of error is calculated for each device by dividing the dropout uncertainty by 1.96.

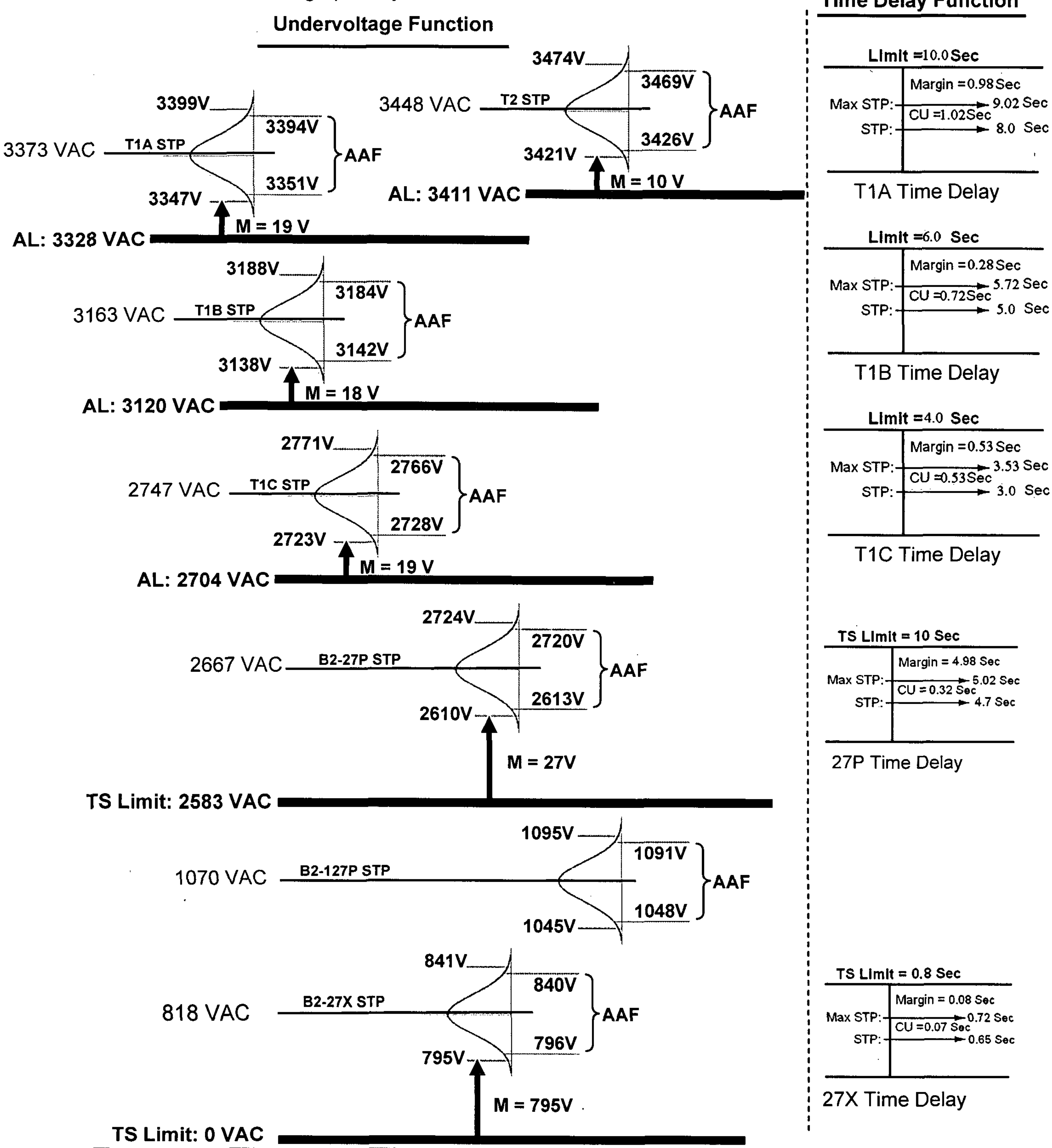
(5) Using the standard Gaussian distribution table the probability for each "Z" value is obtained. The probability of each device not resetting is the area under normal distribution curve corresponding to this "Z" value. The probability of each device not resetting is calculated. The probability of neither devices resetting is the product of the probability of each device not resetting. The selected voltage will be adjusted till the probability of neither device resetting is less than 5%. The probability of at least one device resetting is equal to one minus this latter value.

The result of the above procedure is tabulated in the following tables:

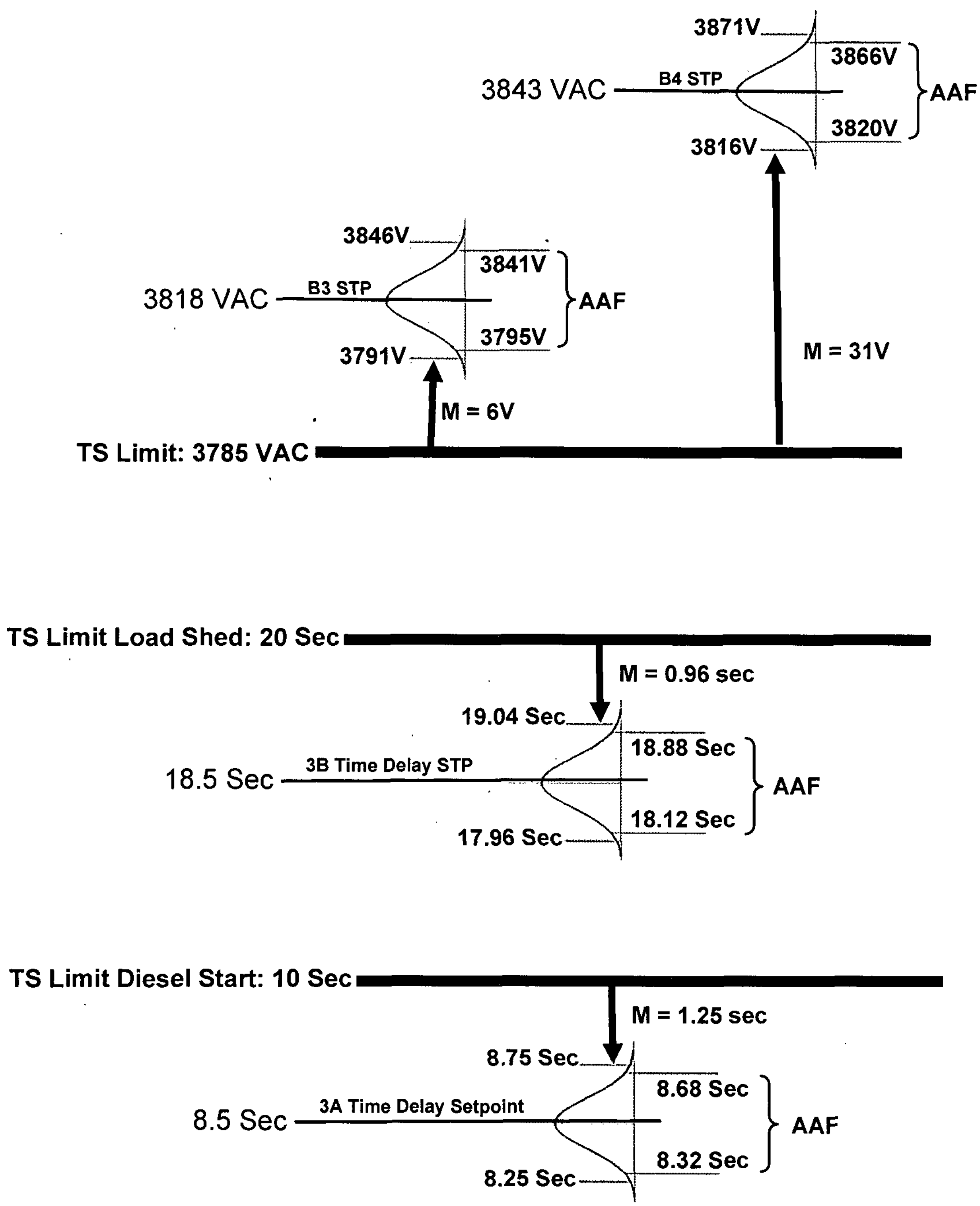
Units 1&2, Second Level Undervoltage Relay (SLUR) Reset Summary

Device	27HFB3	27HFB4	27HGB3	27HGB4	27HHB3	27HHB4
Setpoint @ Relay	109.25	109.25	109.25	109.25	109.25	109.25
PT Ratio	34.951	35.182	34.951	35.287	34.951	35.224
Setpoint @ 4KV Bus	3818	3844	3818	3855	3818	3848
Relay Uncertainty	0.78	0.78	0.78	0.78	0.78	0.78
Uncertainty @ Bus	27	27	27	28	27	27
Standard Deviation of Uncertainty @ Bus	13.9	14.0	13.9	14.0	13.9	14.0
Pickup (Reset) Ratio	0.99	0.99	0.99	0.99	0.99	0.99
Average Reset Point (VAC)	**3857**	**3882**	**3857**	**3894**	**3857**	**3887**
Highest Reset (VAC)	3884	3910	3884	3922	3884	3915
Setpoint (% Bus Voltage)	91.79%	92.40%	91.79%	92.67%	91.79%	92.51%
Highest Rest (% Bus Voltage)	93.37%	93.99%	93.37%	94.27%	93.37%	94.10%
Voltage corresponding to 95% Reset	**3877**		**3879**		**3878**	
% Bus Voltage corresponding to 95% Reset	**93.20%**		**93.25%**		**93.22%**	
Z Value	1.44	-0.39	1.58	-1.07	1.51	-0.65
Probability Not Resetting	7.49%	65.17%	5.71%	85.77%	6.55%	74.22%
Probability of 1-out-of-2 Reset	95.12%		95.10%		95.14%	

8. Results: Presented graphically as follows



SLUR Setpoints



Note: This graph represents the worst case uncertainty and not a typical value

Results presented in tabular format:

First Level Undervoltage Relay (FLUR) Setpoint Summary

Device	Setpoint @ Relay	PT Ratio	Setpoint @ 4KV Bus	TS Limit @ Bus	TS Limit @ Relay	Relay Uncertainty Terms	Relay Uncertainty	Uncertainty @ Bus	AAF @ Relay	AAF @ Bus	Setpoint Margin to TS Limit @ 4KV Bus	Setpoint Margin to TS Limit @ Relay
1/2-27H*B2-27P (Undervoltage-VAC)	76.3	34.951	2667	2583	73.90	RCA: 1.53 RMTE: 0.271 RD: 0.5 RTE: 0	1.632	57	From: 74.77 To: 77.83	From: 2613 To: 2720	27	0.76
1/2-27H*B2-127P (Undervoltage-VAC)	30.6	34.951	1070	NA	NA	RCA: 0.61 RMTE: 0.243 RD: 0.3 RTE: 0	0.722	25	From: 29.99 To: 31.21	From: 1048 To: 1091	NA	NA
1/2-27H*B2-27X (Undervoltage-VAC)	23.4	34.951	818	0	0.00	RCA: 0.5 RMTE: 0.239 RD: 0.4 RTE: 0	0.662	23	From: 22.76 To: 24.04	From: 796 To: 840	795	22.74
1/2-27H*B2-27P (Time Delay-Sec)	4.7	NA	4.7	10	10	RCA: 0.3 RMTE: 0.0003 RD: 0.1 RTE: 0	0.316	0.316	From: 4.40 To: 5.0	From: 4.40 To: 5.0	4.98	4.98
1/2-27H*B2-127P (Time Delay-Sec)	1.9	NA	1.9	NA	NA	RCA: 0.1 RMTE: 0.0002 RD: 0.05 RTE: 0	0.112	0.112	From: 1.80 To: 2.0	From: 1.80 To: 2.0	NA	NA
1/2-27H*B2-27X (Time Delay-Sec)	0.65	NA	0.65	0.8	0.8	RCA: 0.05 RMTE: 0.0001 RD: 0.05 RTE: 0	0.071	0.071	From: 0.60 To: 0.70	From: 0.60 To: 0.70	0.08	0.08
1/2-27H*T1A (Undervoltage-VAC)	96.5	34.951	3373	3328	95.2	RCA: 0.5 RMTE: 0.28 RD: 0.34 RTE: 0.32 RME: 0.1	0.75	26	From: 95.88 To: 97.12	From: 3351 To: 3394	19	0.54

First Level Undervoltage Relay (FLUR) Setpoint Summary

Device	Setpoint @ Relay	PT Ratio	Setpoint @ 4KV Bus	TS Limit @ Bus	TS Limit @ Relay	Relay Uncertainty Terms		Relay Uncertainty	Uncertainty @ Bus	AAF @ Relay	AAF @ Bus	Setpoint Margin to TS Limit @ 4KV Bus	Setpoint Margin to TS Limit @ Relay
1/2-27H*T1B (Undervoltage-VAC)	90.5	34.951	3163	3120	89.3	RCA:	0.5	0.72	25	From: 89.91	From: 3142	18	0.51
						RMTE:	0.28			To: 91.09	To: 3184		
						RD:	0.31						
						RTE:	0.30						
						RME:	0.09						
1/2-27H*T1C (Undervoltage-VAC)	78.6	34.951	2747	2704	77.4	RCA:	0.5	0.69	24	From: 78.06	From: 2728	19	0.55
						RMTE:	0.27			To: 79.14	To: 2766		
						RD:	0.27						
						RTE:	0.26						
						RME:	0.08						
1/2-27H*T1A (Time Delay-Sec)	8.0	NA	8.0	10.0	10.0	RCA:	1.0	1.02	1.02	From: 7.00	From: 7.00	0.98	0.98
						RMTE:	0.01			To: 9.00	To: 9.00		
						RD:	0.18						
						RTE:	0.0						
						RME:	0.0						
1/2-27H*T1B (Time Delay-Sec)	5.0	NA	5.0	6.0	6.0	RCA:	0.7	0.72	0.72	From: 4.30	From: 4.30	0.28	0.28
						RMTE:	0.01			To: 5.70	To: 5.70		
						RD:	0.18						
						RTE:	0.0						
						RME:	0.0						
1/2-27H*T1C (Time Delay-Sec)	3.0	NA	3.0	4.0	4.0	RCA:	0.50	0.53	0.53	From: 2.50	From: 2.50	0.47	0.47
						RMTE:	0.01			To: 3.50	To: 3.50		
						RD:	0.18						
						RTE:	0.0						
						RME:	0.0						

First Level Undervoltage Relay (FLUR) Setpoint Summary

Device	Setpoint @ Relay	PT Ratio	Setpoint @ 4KV Bus	TS Limit @ Bus	TS Limit @ Relay	Relay Uncertainty Terms		Relay Uncertainty	Uncertainty @ Bus	AAF @ Relay	AAF @ Bus	Setpoint Margin to TS Limit @ 4KV Bus	Setpoint Margin to TS Limit @ Relay
1/2-27HFT2 (Undervoltage-VAC)	98.0	35.182	3448	3411	96.95	RCA:	0.5	0.75	26	From: 97.38	From: 3426	11	0.31
						RMTE:	0.28						
						RD:	0.34			To: 98.62	To: 3470		
						RTE:	0.32						
						RME:	0.10						
1/2-27HGT2 (Undervoltage-VAC)	98.0	35.287	3458	3411	96.66	RCA:	0.5	0.75	26	From: 97.38	From: 3436	21	0.60
						RMTE:	0.28						
						RD:	0.34			To: 98.62	To: 3480		
						RTE:	0.32						
						RME:	0.10						
1/2-27HHT2 (Undervoltage-VAC)	98.0	35.224	3452	3411	96.84	RCA:	0.5	0.75	26	From: 97.38	From: 3430	15	0.42
						RMTE:	0.28						
						RD:	0.34			To: 98.62	To: 3474		
						RTE:	0.32						
						RME:	0.10						

Second Level Undervoltage Relay (SLUR) Setpoint Summary

Device	Setpoint @ Relay	PT Ratio	Setpoint @ 4KV Bus	TS Limit @ Bus	TS Limit @ Relay	Relay Uncertainty Terms	Relay Uncertainty	Uncertainty @ Bus	AAF @ Relay	AAF @ Bus	Setpoint Margin to TS Limit @ 4KV Bus	Setpoint Margin to TS Limit @ Relay
1/2-27HF/G/HB3	109.25	34.951	3818	3785	108.29	RCA: 0.50 RMTE: 0.29 RD: 0.37 RTE: 0.36 RME: 0.11	0.78	27	From: 108.59 To: 109.91	From: 3795 To: 3841	6	0.17
1/2-27HFB4	109.25	35.182	3844	3785	107.58	RCA: 0.11 RMTE: 0.50 RD: 0.37 RTE: 0.36 RME: 0.11	0.78	28	From: 108.59 To: 109.91	From: 3820 To: 3867	31	0.89
1/2-27HGB4	109.25	35.287	3855	3785	107.26	RCA: 0.50 RMTE: 0.29 RD: 0.37 RTE: 0.36 RME: 0.11	0.78	28	From: 108.59 To: 109.91	From: 3832 To: 3878	42	1.20
1/2-27HHB4	109.25	35.224	3848	3785	107.46	RCA: 0.50 RMTE: 0.29 RD: 0.37 RTE: 0.36 RME: 0.11	0.78	28	From: 108.59 To: 109.91	From: 3825 To: 3871	35	1.00
1/2-62HF/G/H3A	8.5	NA	8.5	10.0	10.00	RCA: 0.05 RMTE: 0.01 RD: 0.17 RTE: 0.05 RME: 0.17	0.25	0.25	From: 8.32 To: 8.68	From: 8.32 To: 8.68	1.25	1.25
1/2-62HF/G/H3B	18.5	NA	18.5	20.0	20.00	RCA: 0.1 RMTE: 0.01 RD: 0.37 RTE: 0.11 RME: 0.37	0.54	0.54	From: 18.12 To: 18.88	From: 18.12 To: 18.88	0.96	0.96

Inputs to other Calculations

FLUR 2/2 T1A&T2 Logic Load Shed Lowest Voltage:
3351V or 80.55% < 8.86 sec [Section 7.9]

FLUR 2/2 T1B&T2 Logic Load Shed Lowest Voltage:
3142V or 75. 5% < 5.60 sec [Section 7.9]

FLUR 2/2 T1C&T2 Logic Load Shed Lowest Voltage:
2727V or 65.55% < 3.44 sec [Section 7.9]

FLUR 1/2 T1A &T2 Logic Load Shed Maximum Reset Voltage:
3433V or 82.52% [section 7.13.2]

FLUR 1/2 T1B &T2 Logic Load Shed Maximum Reset Voltage:
3220V or 77.41% [section 7.13.2]

FLUR 1/2 T1C &T2 Logic Load Shed Maximum Reset Voltage:
2799V or 67.29% [section 7.13.2]

FLUR 2/2 T1A & T2 Load Shed Trip Avoidance Limit:
3395V or 81.61% [Section7.9]

FLUR 2/2 T1B & T2 Load Shed Trip Avoidance Limit:
3184V or 76.54% [Section7.9]

FLUR 2/2 T1C & T2 Load Shed Trip Avoidance Limit:
2767V or 66.52% [Section 7.9]

FLUR Diesel Start Minimum & Maximum Bus Voltage
B2-27P: Setpoint = 2667V Bus Voltage (64.10%) [Section 7.12.1]
From 2610V to 2724 (62.73% to 65.48%), EDG starts within 4.7 Sec ±0.32 Sec

B2-127P: Setpoint = 1070V Bus Voltage (25.71%) [Section 7.12.2]
From 1044V to 1095V (25.10% to 26.32%), EDG starts within 1.9 Sec ±0.11 Sec

B2-27X: Setpoint = 818V Bus Voltage (19.66%) [Section 7.12.3]
From 795V to 841 (19.11% to 20.22%), EDG starts within 0.65 Sec ±0.07 Sec

FLUR Diesel Start Maximum Reset Voltage – Section 7.13.1
B2-27P: 2780V or 66.38% bus voltage
B2-127P: 1117V or 26.85% bus voltage
B2-27X: 859V or 20.65% bus voltage

SLUR 2/2 Logic for Diesel Start & Load Shed Lowest Voltage – Section 7.10
3791V or 91.13% bus voltage

SLUR 1/2 Logic Diesel Start & Load Shed Maximum Reset Voltage – Section 7.13.3
3879V or 93.25% bus voltage

SLUR 2/2 Trip Avoidance Limit – Section 7.12.30
3840V or 92.31% bus voltage

SLUR Timer Min & Max Timeout
EDG Start Setpoint = 8.5Sec ± 0.25Sec [Section 7.12.26]
Single sided uncertainty (CU * 1.645/1.96) = -0.21Sec OR +0.21Sec
Load Shed Actuation = 18.5Sec ± 0.54Sec [Section 7.12.28]
Single sided uncertainty (CU * 1.645/1.96) = -0.45Sec OR +0.45Sec

9. Margin Assessment

FLUR Setpoints				
Device	**Setpoint**	**TS Limit**	**Margin @ Relay**	**Margin @ 4KV Bus**
27H*B2-27X	23.4 VAC @ 0.65 Sec	0VAC @ <0.8 Sec	22.74VAC 0.08 Sec	795 VAC 0.08 Sec
27H*B2-27P	76.3 VAC @ 4.7 Sec	2583VAC @ <10 Sec	0.76 VAC 4.98 Sec	27 VAC 4.98 Sec
27H*T1A	96.5 VAC @ 8.0 Sec	3328VAC @ < 10 Sec	0.54 VAC 0.98 Sec	19VAC 0.98 Sec
27H*T1B	90.5 VAC @ 5.0 Sec	3120VAC @ < 6 Sec	0.51 VAC 0.28 Sec	18 VAC 0.28 Sec
27H*T1C	78.6 VAC @ 3.0 Sec	2704VAC @ < 4 Sec	0.55 VAC 0.47 Sec	19 VAC 0.47 Sec
27H*T2	98.0 VAC instantaneous	3411 VAC instantaneous	0.31 VAC	11 VAC

SLUR Setpoints				
Device	**Setpoint**	**TS Limit**	**Margin @ Relay**	**Margin @ 4KV Bus**
27H*B3	109.25 VAC	3785 VAC	0.17 VAC	6 VAC
27H*B4	109.25 VAC	3785 VAC	0.89 VAC	31 VAC
62H*3A	8.5 Sec	10 Sec	1.25 Sec	1.25 Sec
62H*3B	18.5 Sec	20 Sec	0.96 Sec	0.96 Sec

10. Conclusion

10.1. The FLUR dropout undervoltage and time delay setpoints adequate margin from TS allowable values [Acceptance criteria 6.1].

10.2. The SLUR dropout undervoltage and time delay setpoints provide adequate margin from TS allowable values [Acceptance criteria 6.2].

10.3. The adequacy of SLUR and FLUR to protect vital 4kV motors from tripping on an undervoltage event will be evaluated in calculation 170-DC.

10.4. The adequacy of SLUR dropout setpoint to prevent unnecessary and spurious actuation of protection system shall be evaluated in calculation 359-DC.

10.5. The impact of highest SLUR reset voltage on ability to maintain connection to offsite power source will be evaluated in 357A-DC [Ref. 12.1.56].

10.6. The adequacy of diesel generator time delay shall be evaluated in calculation 357A-DC.

10.7. The maximum time of 16 seconds established as the acceptance criteria for the load tap change in sections 7.3.8 and 7.5.8 of the electrical maintenance procedure MP E-62.3 [Ref. 12.1.8] provides more than 95% probability that the SLUR will not actuate before voltage is recovered by the load tap changer. The SLUR timer uncertainty is 0.54 sec. The standard deviation of uncertainty = 0.54 sec /1.96 = 0.28 sec. The margin between the nominal setpoint of 18.5 seconds and 16 seconds LTC acceptance criteria is 1 sec or equal to 8.93Z (Z = [18.5 sec-16 sec] / stdev). Based on standard normal distribution table, the 8.93Z corresponds to ≤ 0.01%. This means there is greater than a 99.99% probability that the SLUR will not actuate before completion of the third load tap change.

11. Impact Evaluation

11.1. The change in FLUR Analytical Limits will require a change to Technical Specifications Surveillance Requirements SR 3.3.5.3 as well as the Technical Specification Bases. This change is currently being tracked by notification 50301167 Task 13 and will require submittal of an LAR.

11.2. MP E-50.33A requires revision to remove the FLUR's and SLUR's from the scope of this procedure. The FLUR's and SLUR's will no longer use SSV-T relays hence this procedure no longer applies to them. This is being tracked by Order 68012804 Operation 30.

11.3. MP E-50.61 requires revision to remove the 27H*T1 relays from the scope of this procedure. The "T1" relays will not longer use Basler BE1-27 relays hence this procedure no longer applies to them. This is being tracked by Order 68012804 Operation 40.

11.4. MP E-50.62: The Acceptable As-Found values established in this calculation are based on the historical performance of the undervoltage relays and timers. These values are more restrictive than those used in the calibration procedures. As-Found setpoints outside the limits established in this calculation could be early sign of relay degradation and should trigger performance monitoring at a higher frequency. This calibration procedure should be revised to reflect the Acceptable-As-Found values established in this calculation. This will be tracked by order 68012804 Operation 140.

11.5. STP M-75F, G & H require a complete revision based on the design change to the hardware as well as changes to setpoints and acceptable as-left tolerences via this calculation. This will be tracked by order 68012804 Operation 50.

11.6. STP M-13F, G & H require revision based on the design change to the hardware as well as changes to setpoints and acceptable as-left tolerences via this calculation. This will be tracked by order 68012804 Operation 60.

11.7. Calculation 359-DC must be evaluated for impact. Order 68012804 Operation 70 has been created to track evaluation of potential impact on calculation 359-DC.

11.8. Calculation 357R-DC shall be superseded by this calculation. Order 68012804 Operation 80 has been created to track voiding this calculation.

11.9. Calculation 357A-DC must be evaluated for impact. Order 68012804 Operation 90 has been created to track evaluation of potential impact on calculation 357A-DC.

11.10. Calculation 170-DC must be evaluated for impact. Order 68012804 Operation 100 has been created to track evaluation of potential impact on calculation 170-DC.

11.11. FSAR section 8.3 will require revision based on the changes in design and per this calculation. Order 68012804 Operation 110 has been created to track revision FSAR Section 8.3.

11.12. DCM T-18 will require revision based on the changes in design and per this calculation. Order 68012804 Operation 120 has been created to track revision to DCM T-18.

11.13. DCM S-63 will require revision based on the changes in design and per this calculation. Order 68012804 Operation 130 has been created to track revision to DCM S-63.

12. References

12.1. Input References:

12.1.1. CF6.NE1, Revision 3, Instrument Channel Uncertainty and Setpoint
12.1.2. Technical Specifications 3.3.5 (SR 3.3.5.3.a), Unit 1 Amendment 200, Unit 2 Amendment 201
12.1.3. Technical Specifications 3.3.5 (SR 3.3.5.3.b), Unit 1 Amendment 200, Unit 2 Amendment 201
12.1.4. MP E-50.33A, Rev. 9
12.1.5. MP E-50.30B, Rev. 12 [Agastat Type ETR relay calibration]
12.1.6. MP E-50.61, Rev. 3 [Basler BE1-27 relay calibration]
12.1.7. MP E-50.62, Rev. 4 [Basler BE1-GPS100 relay calibration]
12.1.8. MP E-62.3, Revision 2 [Tap Changer Functional Test for SU Transformer]
12.1.9. STP M-75, Revision 30
12.1.10. DCM T-20, Revision 9A, Table A4.2-1
12.1.11. DCM S-23D, Revision 16, Section 4.3.1.g
12.1.12. DCM S-63, Revision 15A (or latest revision)
12.1.13. 437568 R3
12.1.14. 441229 R17
12.1.15. 441340 R29
12.1.16. 445399 R7
12.1.17. 441315 R16
12.1.18. 441345 R17
12.1.19. 441349 R17
12.1.20. 441311 R23
12.1.21. 441309 R22
12.1.22. 441307 R16
12.1.23. 441302 R21
12.1.24. 441356 R13
12.1.25. 441230 R26
12.1.26. 441313 R26
12.1.27. 441354 R30
12.1.28. 4008751 R8
12.1.29. 4008756 R8
12.1.30. 437533 R40
12.1.31. 437583 R19
12.1.32. 437589 R16
12.1.33. 437590 R19
12.1.34. 437591 R23
12.1.35. 437593 R31
12.1.36. 437594 R30
12.1.37. 437595 R30
12.1.38. 437600 R31
12.1.39. 437614 R33
12.1.40. 437621 R23
12.1.41. 437626 R32
12.1.42. 437627 R32
12.1.43. 437664 R17
12.1.44. 437666 R30

12.1.45. 441287 R26
12.1.46. 441312 R26
12.1.47. 441353 R29
12.1.48. 445077 R3
12.1.49. 496276 R7
12.1.50. 663332-220-1 [Basler BE1-GPS100 Relay Vendor Manual]
12.1.51. [ABB 27N/59N Relay Vendor Manual]
12.1.52. [ABB 62T Relay Vendor Manual]
12.1.53. A0520041
12.1.54. RPE E-07664
12.1.55. Calculation M-447, Rev. 1
12.1.56. Calculation 357A-DC, Rev 12 (SAP 9000033359-00-012)
12.1.57. Determination of setpoint span by ABB. E-mail. See Attachment 12.
12.1.58. Calculation 170-DC
12.1.59. Calculation 9000041185 “Voltage Study of Vital 480VAC Loads”
12.1.60. Calculation 9000041186 “Voltage Study of Vital Fuse Loads”

12.2. Output References:

12.2.1. STP M-75
12.2.2. STP M-13F/G/H
12.2.3. MP E-50.33A
12.2.4. MP E-50.61
12.2.5. MP E-50.62
12.2.6. DCM S-63
12.2.7. DCM T-18
12.2.8. Calculation 357A-DC
12.2.9. Calculation 359-DC
12.2.10. Calculation 170-DC
12.2.11. Calculation 9000041185 “Voltage Study of Vital 480VAC Loads”
12.2.12. Calculation 9000041186 “Voltage Study of Vital Fuse Loads”

12.3. Other References:

12.3.1. Notification 50301167

Enclosures and Attachments

Attachment 1; PT Burden Calculation (28 pages)

Attachment 2; Potential Transformer Characteristic Ratio and Phase Angle Curve (1 page)

Attachment 3; Drift Calculation (20 pages)

Attachment 4; Manta MTS-1710 vendor information (3 pages)

Attachment 5; HP 34401A Multimeter Accuracy Spec. (2 pages)

Attachment 6; Calculation M-447 Rev. 1 used to establish maximum temperature in the 4KV switchgear room following a DBA. (1 page)

Attachment 7; NIST analysis on human reaction time when using stop watch (4 pages)

Attachment 8; Calculation 357A-DC, Revision 12, Study Case 009GS (1 page)

Attachment 9; Calculation 357A-DC, Revision 12, Summary (1 page)

Attachment 10, FLUR Pickup Ratio Based on Historical Data (8 pages)

Attachment 11; E-mail from ABB. Justification for Assumption 3.6 (1 page)

Attachment 12; Applicability Determination (4 pages)

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus F

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437533 R40	VM	H01	WE	KA241		1.79			1.75		
437614 R33	27HFB4	TBD	ABB	59N		0.5			0.5		
437614 R33	27HFB3	TBD	ABB	59N	0.5			0.5			
437614 R33 & Basler Publication 9318700990 Page 1-13	27HFB2	SHF12	Basler	BE1-GPS100E4N1H0	1			1			
437614 R33	27HFB1	SHF12	ABB	47H-412N0275-V	0.5	0.5		0.5	0.5		
437614 R33	27HFT1A	TBD	ABB	27N	0.5			0.5			
437614 R33	27HFT1B	TBD	ABB	27N	0.5			0.5			
437614 R33	27HFT1C	TBD	ABB	27N	0.5			0.5			
437614 R33	27HFT2	TBD	ABB	59N		0.5			0.5		
437614 R33 & 445077 R3	YM418A	CHF (VB4)	Action Instruments	AP6380	5			5			
437614 R33 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6	3.66			3.66			
437614 R33 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6		3.66			3.66		
437614 R33 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
437614 R33	W LT	CHF	WE	EZC	3.6			3.6			
437614 R33 & 437666 R30	W LT	SHF7	GE	ET-16		5.33			5.33		
437614 R33 & 437594 R30	W LT	CNAS	WE	EZC		3.6			3.6		
437614 R33 & 437594 R30	W LT	SHF8	GE	ET-16		5.33			5.33		
437614 R33 & 437583 R24	W LT	SHF9	GE	ET-16		5.33			5.33		
437614 R33 & 437583 R24	W LT	CB	WE	EZC		3.6			3.6		
437614 R33 & 437664 R17	W LT	SHF13	WE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	37HF12	SHF12	Rochester	1200L		0.5			0.5		
437614 R33 & 437589 R16	W LT	SHF15	GE	ET-16		5.33			5.33		
437614 R33 & 437589 R16	W LT	CNSI	WE	EZC		3.6			3.6		
437614 R33 & 437621 R23	W LT	SHF14	GE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	W LT	CNCC	WE	EZC		3.6			3.6		
437614 R33 & 437593 R31	W LT	SHF12	GE	ET-16		5.33			5.33		
437614 R33 & 437595 R30	W LT	SHF11	GE	ET-16		5.33			5.33		
437614 R33 & 437595 R30	W LT	CNV	WE	EZC		3.6			3.6		
437533 R40	WM	CHF	WE	KP241	2.5	2.5		2.5	2.5		
437533 R40	VAR	CHF	WE	KP241	2.5	2.5		2.5	2.5		
437595 R30	1HF11/TD	SHF11	AGASTAT	ETR-14I3A		6			6		
437595 R30	2HF11/TD	SHF11	AGASTAT	ETR-14I3B		6			6		
437595 R30	1HF11A/TD	SHF11	AGASTAT	ETR-14I3A		6			6		
437595 R30	2HF11A/TD	SHF11	AGASTAT	ETR-14I3D		6			6		
437594 R30	2HF8	SHF8	AGASTAT	ETR-14I3D		6			6		
437594 R30	2HF8A	SHF8	AGASTAT	ETR-14I3D		6			6		

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus F

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437583 R24	2HF9	SHF9	AGASTAT	ETR-14I3D		6			6		
437583 R24	2HF9A	SHF9	AGASTAT	ETR-14I3D		6			6		
437589 R16	2HF15	SHF15	AGASTAT	ETR-14I3B		6			6		
437600 R31	K608XF2	SPF	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	K609XF1	SPF	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	4HFXF1	SPF	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	4HFXF2	SPF	P&B	KHU-17A16-120		1.2			0.47		
437593 R31	1HF12/TD	SHF12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HF12/TD	SHF12	AGASTAT	ETR-14I3D		6			6		
437593 R31	1HF12A/TD	SHF12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HF12A/TD	SHF12	AGASTAT	ETR-14I3B		6			6		
				$\sum =$	22.59	157.72		22.59	154.76		
				$PF = \sum_W / \sum_{VA} =$	1.00	0.98					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.98 & 157.72VA Burden: 1.0052 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0052 X 35 = 35.182

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus G

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437533 R40	VM	H01	WE	KA241		1.79			1.75		
437614 R33	27HGB4	TBD	ABB	59N		0.5			0.5		
437614 R33	27HGB3	TBD	ABB	59N	0.5			0.5			
437614 R33 & Basler Publication 9318700990 Page 1-13	27HGB2	SHG12	Basler	BE1-GPS100E4N1H0	1			1			
437614 R33	27HGB1	SHG12	ABB	47H-412N0275-V	0.5	0.5		0.5	0.5		
437614 R33	27HGT1A	TBD	ABB	27N	0.5			0.5			
437614 R33	27HGT1B	TBD	ABB	27N	0.5			0.5			
437614 R33	27HGT1C	TBD	ABB	27N	0.5			0.5			
437614 R33	27HGT2	TBD	ABB	59N		0.5			0.5		
437614 R33 & 445077 R3	YM419B	CHG (VB5)	Action Instruments	AP6380	5			5			
437614 R33 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6	3.66			3.66			
437614 R33 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6		3.66			3.66		
437614 R33 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
437614 R33	W LT	CHG	WE	EZC	3.6			3.6			
437614 R33 & 437666 R30	W LT	SHG5	GE	ET-16		5.33			5.33		
437614 R33 & 437664 R17	W LT	SHG13	GE	ET-16		5.33			5.33		
437614 R33 & 437621 R23	W LT	SHG14	GE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	W LT	SHG12	GE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	W LT	CNCC	WE	EZC		3.6			3.6		
437614 R33 & 437593 R31	37HG12	SHG12	Rochester	1200L		0.5			0.5		
437614 R33 & 437591 R23	W LT	SHG8	GE	ET-16		5.33			5.33		
437614 R33 & 437591 R23	W LT	CNR	WE	EZC		3.6			3.6		
437614 R33 & 437590 R19	W LT	SHG7	GE	ET-16		5.33			5.33		
437614 R33 & 437590 R19	W LT	CNCS	WE	EZC		3.6			3.6		
437614 R33 & 437594 R30	W LT	SHG6	GE	ET-16		5.33			5.33		
437614 R33 & 437594 R30	W LT	CNAS	WE	EZC		3.6			3.6		
437614 R33 & 4008756 R8	W LT	SHG11	GE	ET-16		5.33			5.33		
437614 R33 & 4008756 R8	W LT	CNV	WE	EZC		3.6			3.6		
437614 R33 & 437595 R30	W LT	SHG9	GE	ET-16		5.33			5.33		
437614 R33 & 437595 R30	W LT	CNV	WE	EZC		3.6			3.6		
437533 R40	WM	CHG	WE	KP241	2.5	2.5		2.5	2.5		
437533 R40	VAR	CHG	WE	KP241	2.5	2.5		2.5	2.5		
437595 R30	1HG9/TD	SHG9	AGASTAT	ETR-1413A		6			6		
437595 R30	2HG9/TD	SHG9	AGASTAT	ETR-1413B		6			6		
437595 R30	1HG9A/TD	SHG9	AGASTAT	ETR-1413A		6			6		

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus G

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437595 R30	2HG9A/TD	SHG9	AGASTAT	ETR-14I3D		6			6		
437594 R30	2HG6	SHG6	AGASTAT	ETR-14I3D		6			6		
437594 R30	2HG6A	SHG6	AGASTAT	ETR-14I3D		6			6		
437590 R19 & RPE E-07664	K645BX	SHG7	P&B	MDR-4103-1		18			4		
437593 R31	1HG12/TD	SHG12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HG12/TD	SHG12	AGASTAT	ETR-14I3D		6			6		
437593 R31	1HG12A/TD	SHG12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HG12A/TD	SHG12	AGASTAT	ETR-14I3B		6			6		
437600 R31	K608XG1	SPG	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	K609XG2	SPG	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	4HGXG1	SPG	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	4HGXG2	SPG	P&B	KHU-17A16-120		1.2			0.47		
437591 R25	2HG8/TD	SHG8	AGASTAT	ETR-14I3B		6			6		
437626 R32	2K617	RNSOB	AGASTAT	ETR-14I3D		6			6		
				$\sum =$	22.59	178.65		22.59	161.69		
				PF $= \sum_W / \sum_{VA} =$	1.00	0.91					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.91 & 178.65VA Burden: 1.006 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0082 X 35 = 35.287

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus H

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437533 R40	VM	H01	WE	KA241		1.79			1.75		
437614 R33	27HHB4	TBD	ABB	59N		0.5			0.5		
437614 R33	27HHB3	TBD	ABB	59N	0.5			0.5			
437614 R33 & Basler Publication 9318700990 Page 1-13	27HHB2	SHH12	Basler	BE1-GPS100E4N1H0	1			1			
437614 R33	27HHB1	SHH12	ABB	47H-412N0275-V	0.5	0.5		0.5	0.5		
437614 R33	27HHT1A	TBD	ABB	27N	0.5			0.5			
437614 R33	27HHT1B	TBD	ABB	27N	0.5			0.5			
437614 R33	27HHT1C	TBD	ABB	27N	0.5			0.5			
437614 R33	27HHT2	TBD	ABB	59N		0.5			0.5		
437614 R33 & 445077 R3	YM420D	CHH (VB5)	Action Instruments	AP6380	5			5			
437614 R33 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6	3.66			3.66			
437614 R33 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6		3.66			3.66		
437614 R33 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
437614 R33	W LT	CHH	WE	EZC	3.6			3.6			
437614 R33 & 437666 R30	W LT	SHH7	GE	ET-16		5.33			5.33		
437614 R33 & 437621 R23	W LT	SHH14	GE	ET-16		5.33			5.33		
437614 R33 & 437664 R17	W LT	SHH13	GE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	W LT	SHH12	WE	ET-16		5.33			5.33		
437614 R33 & 437593 R31	W LT	CNCC	WE	EZC		3.6			3.6		
437614 R33 & 437593 R31	37HH12	SHH12	Rochester	1200L		0.5			0.5		
437614 R33 & 437589 R16	W LT	SHH15	GE	ET-16		5.33			5.33		
437614 R33 & 437589 R16	W LT	CNSI	WE	EZC		3.6			3.6		
437614 R33 & 437591 R23	W LT	SHH11	GE	ET-16		5.33			5.33		
437614 R33 & 437591 R23	W LT	CNR	WE	EZC		3.6			3.6		
437614 R33 & 437590 R19	W LT	SHH9	GE	ET-16		5.33			5.33		
437614 R33 & 437590 R19	W LT	CNCS	WE	EZC		3.6			3.6		
437614 R33 & 437583 R19	W LT	SHH8	GE	ET-16		5.33			5.33		
437614 R33 & 437583 R19	W LT	CB	WE	EZC		3.6			3.6		
437533 R40	WM	CHH	WE	KP241	2.5	2.5		2.5	2.5		
437533 R40	VAR	CHH	WE	KP241	2.5	2.5		2.5	2.5		
437593 R31	1HH12/TD	SHH12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HH12/TD	SHH12	AGASTAT	ETR-14I3D		6			6		
437593 R31	1HH12A/TD	SHH12	AGASTAT	ETR-14I3A		6			6		
437593 R31	2HH12A/TD	SHH12	AGASTAT	ETR-14I3B		6			6		

ATTACHMENT "1"

PT Burden Calculation

UNIT 1
PT Burden of 4.16 KV Bus H

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
437583 R24	2HH8	SHH8	AGASTAT	ETR-14I3D		6			6		
437583 R24	2HH8A	SHH8	AGASTAT	ETR-14I3D		6			6		
437589 R16	2HH15	SHH15	AGASTAT	ETR-14I3B		6			6		
437590 R19 & RPE E-07664	K645AX	SHH9	P&B	MDR-4103-1		18			4		
437600 R31	K609XH1	SPH	P&B	KHU-17A16-120		1.2			0.47		
437600 R31	4HHXH1	SPH	P&B	KHU-17A16-120		1.2			0.47		
437591 R30	2HH11/TD	SHH11	AGASTAT	ETR-14I3B		6			6		
437627 R32	2K617	RNSOA	AGASTAT	ETR-14I3D		6			6		
				$\sum =$	22.59	149.32		22.59	133.82		
				$PF = \sum_W / \sum_{VA} =$	1.00	0.90					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.90 & 149.32VA Burden: 1.0064 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0064 X 35 = 35.224

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus F

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441229 R17	VM	H01	WE	KA241		1.79			1.75		
441340 R29	27HFB4	TBD	ABB	59N		0.5			0.5		
441340 R29	27HFB3	TBD	ABB	59N	0.5			0.5			
441340 R29 & Basler Publication 9318700990 Page 1-13	27HFB2	SHF12	Basler	BE1-GPS100E4N1H0	1			1			
441340 R29	27HFB1	SHF12	ABB	47H-412N0275-V	0.5	0.5		0.5	0.5		
441340 R29	27HFT1A	TBD	ABB	27N	0.5			0.5			
441340 R29	27HFT1B	TBD	ABB	27N	0.5			0.5			
441340 R29	27HFT1C	TBD	ABB	27N	0.5			0.5			
441340 R29	27HFT2	TBD	ABB	59N		0.5			0.5		
441340 R29 & 445399 R7	YM418A	CHF (VB4)	Action Instruments	AP6380	5			5			
441340 R29 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6	3.66			3.66			
441340 R29 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6		3.66			3.66		
441340 R29 & A0520041	W LT (1)	SHF12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
441340 R29 & A0520041	W LT	CHF	WE	EZC	3.6			3.6			
441340 R29 & 441315 R16	W LT	SHF15	GE	ET-16		5.33			5.33		
441340 R29 & 441315 R16	W LT	CNSI	WE	EZC		3.6			3.6		
441340 R29 & 441345 R17	W LT	SHF14	GE	ET-16		5.33			5.33		
441340 R29 & 441349 R17	W LT	SHF13	WE	ET-16		5.33			3.6		
441340 R29 & 441311 R23	W LT	SHF12	GE	ET-16		5.33			5.33		
441340 R29 & 441311 R23 & A0520041	W LT	CNCC	WE	EZC		3.6			3.6		
441340 R29 & 441311 R23	37HF12	SHF12	Rochester	1200L		0.5			0.5		
441340 R29 & 496276 R7	W LT	SHF7	GE	ET-16		5.33			5.33		
441340 R29 & 441287 R26 & A0520041	W LT	CNAS	WE	EZC		3.6			3.6		
441340 R29 & 441287 R26	W LT	SHF8	GE	ET-16		5.33			5.33		
441340 R29 & 441302 R21	W LT	SHF9	GE	ET-16		5.33			5.33		
441340 R29 & 441302 R21 & A0520041	W LT	CB	WE	EZC		3.6			3.6		
441340 R29 & 441312 R26	W LT	SHF11	GE	ET-16		5.33			5.33		
441340 R29 & 441312 R26	W LT	CNV	WE	EZC		3.6			3.6		
441229 R17	WM	CHF	WE	KP241	2.5	2.5		2.5	2.5		
441229 R17	VAR	CHF	WE	KP241	2.5	2.5		2.5	2.5		
441311 R23	1HF12/TD	SHF12	AGASTAT	ETR-14I3A		6			6		

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus F

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441311 R23	2HF12/TD	SHF12	AGASTAT	ETR-14I3D		6			6		
441311 R23	1HF12A/TD	SHF12	AGASTAT	ETR-14I3A		6			6		
441311 R23	2HF12A/TD	SHF12	AGASTAT	ETR-14I3B		6			6		
441312 R26	1HF11	SHF11	AGASTAT	ETR-14I3A		6			6		
441312 R26	1HF11A	SHF11	AGASTAT	ETR-14I3A		6			6		
441312 R26	2HF11	SHF11	AGASTAT	ETR-14I3B		6			6		
441312 R26	2HF11A	SHF11	AGASTAT	ETR-14I3D		6			6		
441302 R 21	2HF9	SHF9	AGASTAT	ETR-14I3D		6			6		
441302 R 21	2HF9A	SHF9	AGASTAT	ETR-14I3D		6			6		
441287 R26	2HF8	SHF8	AGASTAT	ETR-14I3D		6			6		
441287 R26	2HF8A	SHF8	AGASTAT	ETR-14I3D		6			6		
441315 R16	2HF15	SHF15	AGASTAT	ETR-14I3B		6			6		
441313 R26	K608XF2	SPF	P&B	KHU17A16-120		1.2			0.47		
441313 R26	K609XF1	SPF	P&B	KHU17A16-120		1.2			0.47		
441313 R26	4HFXF1	SPF	P&B	KHU17A16-120		1.2			0.47		
441313 R26	4HFXF2	SPF	P&B	KHU17A16-120		1.2			0.47		
				$\sum =$	22.59	157.72		22.59	154.76		
				$PF = \sum_W / \sum_{VA} =$	1.00	0.98					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.98 & 157.72VA Burden: 1.0050 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0052 X 35 = 35.182

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus G

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441230 R26	VM	H01	WE	KA241		1.79			1.75		
441340 R29	27HGB4	TBD	ABB	59N		0.5			0.5		
441340 R29	27HGB3	TBD	ABB	59N	0.5			0.5			
441340 R29 & Basler Publication 9318700990 Page 1-13	27HGB2	SHG12	Basler	BE1-GPS100E4N1H0	1			1			
441340 R29	27HGB1	SHG12	ABB	412N0275-V	0.5	0.5		0.5	0.5		
441340 R29	27HGT1A	TBD	ABB	27N	0.5			0.5			
441340 R29	27HGT1B	TBD	ABB	27N	0.5			0.5			
441340 R29	27HGT1C	TBD	ABB	27N	0.5			0.5			
441340 R29	27HGT2	TBD	ABB	59N		0.5			0.5		
441340 R29 & 445399 R7	YM419B	CHG (VB5)	Action Instruments	AP6380	5			5			
441340 R29 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6	3.66			3.66			
441340 R29 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6		3.66			3.66		
441340 R29 & A0520041	W LT (1)	SHG12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
441340 R29 & A0520041	W LT	CHG	WE	EZC	3.6			3.6			
441340 R29 & 4008751 R8	W LT	SHG11	GE	ET-16		5.33			5.33		
441340 R29 & 4008751 R8	W LT	CNV	WE	EZC		3.6			3.6		
441340 R29 & 441345 R17	W LT	SHG14	GE	ET-16		5.33			5.33		
441340 R29 & 441349 R17	W LT	SHG13	GE	ET-16		5.33			5.33		
441340 R29 & 441311 R23	W LT	SHG12	GE	ET-16		5.33			5.33		
441340 R29 & 441311 R23 & A0520041	W LT	CNCC	WE	EZC		3.6			3.6		
441340 R29 & 441311 R23	37HG12	SHG12	Rochester	1200L		0.5			0.5		
441340 R29 & 441309 R22	W LT	SHG8	GE	ET-16		5.33			5.33		
441340 R29 & 441309 R22 & A0520041	W LT	CNR	WE	EZC		3.6			3.6		
441340 R29 & 441307 R16	W LT	SHG7	GE	ET-16		5.33			5.33		
441340 R29 & 441307 R16 & A0520041	W LT	CNCS	WE	EZC		3.6			3.6		
441340 R29 & 441287 R26	W LT	SHG6	GE	ET-16		5.33			5.33		
441340 R29 & 441287 R26	W LT	CNAS	WE	EZC		3.6			3.6		
441340 R29 & 441312 R26	W LT	SHG9	GE	ET-16		5.33			5.33		
441340 R29 & 441312 R26	W LT	CNV	WE	EZC		3.6			3.6		
441340 R29 & 441356 R13	W LT	SHG5	GE	ET-16		5.33			5.33		
441230 R26	WM	CHG	WE	KP241	2.5	2.5		2.5	2.5		

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus G

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441230 R26	VAR	CHG	WE	KP241	2.5	2.5		2.5	2.5		
441311 R23	1HG12/TD	SHG12	AGASTAT	ETR-14I3A		6			6		
441311 R23	2HG12/TD	SHG12	AGASTAT	ETR-14I3D		6			6		
441311 R23	1HG12A/TD	SHG12	AGASTAT	ETR-14I3A		6			6		
441311 R23	2HG12A/TD	SHG12	AGASTAT	ETR-14I3B		6			6		
441287 R26	2HG6/TD	SHG6	AGASTAT	ETR-14I3D		6			6		
441287 R26	2HG6A/TD	SHG6	AGASTAT	ETR-14I3D		6			6		
441312 R26	1HG9/TD	SHG9	AGASTAT	ETR-14I3A		6			6		
441312 R26	1HG9A/TD	SHG9	AGASTAT	ETR-14I3A		6			6		
441312 R26	2HG9/TD	SHG9	AGASTAT	ETR-14I3B		6			6		
441312 R26	2HG9A/TD	SHG9	AGASTAT	ETR-14I3D		6			6		
441307 R16 & RPE E-07664	K645BX	SHG7	P&B	MDR-4103-1		18			4		
441309 R22	2HG8/TD	SHG8	AGASTAT	ETR-14I3B		6			6		
441313 R26	K609XG1	SPG	P&B	KHU-17A16-120		1.2			0.47		
441313 R26	K608XG1	SPG	P&B	KHU-17A16-120		1.2			0.47		
441313 R26	4HGXG1	SPG	P&B	KHU-17A16-120		1.2			0.47		
441313 R26	4HGXG2	SPG	P&B	KHU-17A16-120		1.2			0.47		
441353 R29	2K617	RNSOB	AGASTAT	ETR-14I3D		6			6		
				$\sum =$	22.59	178.65		22.59	161.69		
				PF $=\sum_W / \sum_{VA} =$	1.00	0.91					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.91 & 178.65VA Burden: 1.0082 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0082 X 35 = 35.287

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus H

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441230 R26	VM	H01	WE	KA241		1.79			1.75		
441340 R29	27HHB4	TBD	ABB	59N		0.5			0.5		
441340 R29	27HHB3	TBD	ABB	59N	0.5			0.5			
441340 R29 & Basler Publication 9318700990 Page 1-13	27HHB2	SHH12	Basler	BE1-GPS100E4N1H0	1			1			
441340 R29	27HHB1	SHH12	ABB	412N0275-V	0.5	0.5		0.5	0.5		
441340 R29	27HHT1A	TBD	ABB	27N	0.5			0.5			
441340 R29	27HHT1B	TBD	ABB	27N	0.5			0.5			
441340 R29	27HHT1C	TBD	ABB	27N	0.5			0.5			
441340 R29	27HHT2	TBD	ABB	59N		0.5			0.5		
441340 R29 & 445399 R7	YM420D	CHH (VB5)	Action Instruments	AP6380	5			5			
441340 R29 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6	3.66			3.66			
441340 R29 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6		3.66			3.66		
441340 R29 & A0520041	W LT (1)	SHH12	GE	24EX/ET-6	1.83	1.83	3.66	1.83	1.83	3.66	Load divided on two transformers
441340 R29 & A0520041	W LT	CHH	WE	EZC	3.6			3.6			
441340 R29 & 441315 R16	W LT	SHH15	GE	ET-16		5.33			5.33		
441340 R29 & 441315 R16	W LT	CNSI	WE	EZC		3.6			3.6		
441340 R29 & 441345 R17	W LT	SHH14	GE	ET-16		5.33			5.33		
441340 R29 & 441349 R17	W LT	SHH13	GE	ET-16		5.33			5.33		
441340 R29 & 441311 R23	W LT	SHH12	GE	ET-16		5.33			5.33		
441340 R29 & 441311 R23 & A0520041	W LT	CNCC	WE	EZC		3.6			3.6		
441340 R29 & 441311 R23	37HH12	SHH12	Rochester	1200L		0.5			0.5		
441340 R29 & 441309 R22	W LT	SHH11	GE	ET-16		5.33			5.33		
441340 R29 & 441309 R22 & A0520041	W LT	CNR	WE	EZC		3.6			3.6		
441340 R29 & 441307 R16	W LT	SHH9	GE	ET-16		5.33			5.33		
441340 R29 & 441307 R16 & A0520041	W LT	CNCS	WE	EZC		3.6			3.6		
441340 R29 & 441302 R21	W LT	SHH8	GE	ET-16		5.33			5.33		
441340 R29 & 441302 R21 & A0520041	W LT	CB	WE	EZC		3.6			3.6		
441340 R29 & 441356 R13	W LT	SHH7	GE	ET-16		5.33			5.33		
441230 R26	WM	CHH	WE	KP241	2.5	2.5		2.5	2.5		
441230 R26	VAR	CHH	WE	KP241	2.5	2.5		2.5	2.5		
441311 R23	1HH12/TD	SHH12	AGASTAT	ETR-1413A		6			6		
441311 R23	2HH12/TD	SHH12	AGASTAT	ETR-1413D		6			6		
441311 R23	1HH12A/TD	SHH12	AGASTAT	ETR-1413A		6			6		
441311 R23	2HH12A/TD	SHH12	AGASTAT	ETR-1413B		6			6		

ATTACHMENT "1"

PT Burden Calculation

UNIT 2
PT Burden of 4.16 KV Bus H

REF DWG NO.	TAG NO.	ELECT. LOC	MFR	MODEL	VA PHASE A-B	VA PHASE B-C	VA PHASE A-C	W PHASE A-B	W PHASE B-C	W PHASE A-C	Remarks
441302 R21	2HH8	SHH8	AGASTAT	ETR-14I3D		6			6		
441302 R21	2HH8A	SHH8	AGASTAT	ETR-14I3D		6			6		
441315 R16	2HH15	SHH15	AGASTAT	ETR-14I3B		6			6		
441307 R16 & RPE E-07664	K645AX	SHH9	P&B	MDR-4103-1		18			4		
441309 R22	2HH11/TD	SHH11	AGASTAT	ETR-14I3B		6			6		
441313 R26	K609XH1	SPH	P&B	KHU-17A16-120		1.2			0.47		
441313 R26	4HHXH1	SPH	P&B	KHU-17A16-120		1.2			0.47		
441354 R30	2K617	RNSOA	AGASTAT	ETR-14I3D		6			6		
				$\sum =$	22.59	149.32		22.59	133.82		
				$PF = \sum_W / \sum_{VA} =$	1.00	0.90					

Based on the GE "Potential Transformer Characteristic Ratio and Phase Angle Curve" [Attachment 2], the ratio correction factor for the transformer with nominal 35:1 ratio is

For PF 1.00 & 22.59VA Burden: 0.9986 (A-B Phase)

For PF 0.90 & 149.32VA Burden: 1.0064 (B-C Phase)

Therefore the corrected transformer ratio is:

A-B Phase: 0.9986 X 35 = 34.951

B-C Phase: 1.0064 X 35 = 35.224

ATTACHMENT "1"

PT Burden Calculation

Summary

Unit 1			Unit 2		
Device	Phase	PT Ratio	Device	Phase	PT Ratio
1-27HFB2	A-B	34.951	2-27HFB2	A-B	34.951
1-27HGB2	A-B	34.951	2-27HGB2	A-B	34.951
1-27HHB2	A-B	34.951	2-27HHB2	A-B	34.951
1-27HFT1	A-B	34.951	2-27HFT1	A-B	34.951
1-27HGT1	A-B	34.951	2-27HGT1	A-B	34.951
1-27HHT1	A-B	34.951	2-27HHT1	A-B	34.951
1-27HFT2	B-C	35.182	2-27HFT2	B-C	35.182
1-27HGT2	B-C	35.287	2-27HGT2	B-C	35.287
1-27HHT2	B-C	35.224	2-27HHT2	B-C	35.224
1-27HFB3	A-B	34.951	2-27HFB3	A-B	34.951
1-27HGB3	A-B	34.951	2-27HGB3	A-B	34.951
1-27HHB3	A-B	34.951	2-27HHB3	A-B	34.951
1-27HFB4	B-C	35.182	2-27HFB4	B-C	35.182
1-27HGB4	B-C	35.287	2-27HGB4	B-C	35.287
1-27HHB4	B-C	35.224	2-27HHB4	B-C	35.224

ATTACHMENT "1"

PT Burden Calculation

Exhibit (1): Westinghouse Voltmeter KA241 Burden

Page 4

Ac Instruments Loss Data, 60 Hertz
Circular Scale K-241, K-231, K-261

WESTINGHOUSE

CALC # 174B-DC, REV. 1
ATTACH. 8.3
PG. ~~20~~ 23 OF ~~21~~ 25

1

Ac Instruments Loss Data, 60 Cycles. Circular Scale K-241, K-231, K-261
Burden on Current Transformers at 5 Amps

Instrument and Rating	Type	Impedance: Ohms	Resistance: Ohms	Inductance: Henries	Volt-Amperes	Power Factor	Watts	Reactive Volt-Amperes
Ammeters, 5 Amps:								
Spiral Vane	KA	.036	.026	.000066	.9	.72	.65	.625
Repulsion-Attraction ①	KA	.015	.012	.000024	.375	.80	.30	.625
Rectifier	KC	.002	.0016	—	.05	.80	.04	—
Wattmeters and Varmeters (Per Element) 5 Amps	KP, KV	.08	.016	.0002	2.0	.20	.4	2.0
Power Factor Meters, 5 Amps	KI	.174	.14	—	4.35	.82	1.12	—
	KJ	.045	.045	—	1.12	1.0	1.12	—

Burden on Voltage Transformers at 120 Volts

Instrument and Rating	Type	Impedance: Ohms	Resistance: Ohms	Inductance: Henries	Volt-Amperes	Power Factor	Watts	Reactive Volt-Amperes
Voltmeters, 0-150 Volts: 120 Volts								
Spiral Vane	KA	8640	8420	5.1	1.79	.98	1.75	.40
Repulsion-Attraction ①	KA	7530	7500	1.6	1.92	.996	1.92	—
Rectifier	KC	150,000	150,000	—	.096	1.0	.096	—
Wattmeters and Varmeters, 120 Volts:								
Single Phase	KP, KV	9,000	9,000	—	2.5	1.0	2.5	—
Polyphase	KP, KV	18,000	18,000	—	1.25	1.0	1.25	—
Phase Shifter	PS-2, MV-832	—	—	—	1.4	.36	.5	1.3
Frequency Meters, 120 Volts	KR3	4,000	4,000	—	3.6	1.0	3.6	—
Power Factor Meters, 120 Volts:								
Single Phase	KI	—	—	—	4.6	.45	2.0	4.1
	KJ	12,000	12,000	—	1.2	1.0	1.2	—
Polyphase	KI	—	—	—	2.2	1.0	2.2	—
	KJ	14,000	14,000	—	1.2	1.0	1.2	—
Synchroscopes, 120 Volts:								
Running	KI	—	—	—	4.5	.45	2.0	4.1
Incoming	KI	—	—	—	4.6	.60	3.7	2.8

① All Hi-Shock types and commercial types manufactured prior to 1977 are repulsion-attraction.

ATTACHMENT "1"

PT Burden Calculation

Exhibit (2) ABB 27N & 59N Undervoltage Relay Burden

Descriptive Bulletin
41-233S

Page 2

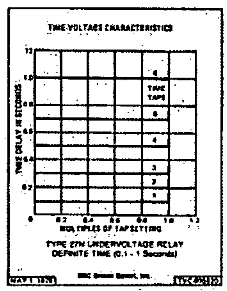
ABB

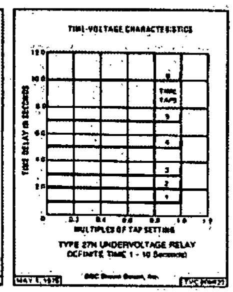
Specifications

Input Circuit Rating:	Type 27N 150 Vac Maximum Continuous Type 59N 160 Vac Maximum Continuous
Burden:	Less than 0.5 VA at 120 Vac
Frequency:	50/60 Hz.
Output Circuit:	Each contact at 125 Vdc: 30A Tripping Duty 5A Continuous 1A Break, Resistive 0.3A Break, Inductive.
Control Power:	Rated at 48/125, 250 Vdc at 0.05 ampere maximum.
Temperature:	ANSI range −20°C to +55°C Must operate −30°C to +70°C
Tolerances: (Without harmonic filter module, after 10 minute warm-up.)	Pickup and dropout settings with respect to printed dial markings (factory calibration) = ±2%. Pickup and dropout settings, repeatability at constant temperature and constant control voltage = ±0.1%. (See Note) Pickup and dropout settings, repeatability over DC control power range of 100-140 volts = ±0.1%. (See Note) Pickup and dropout settings, repeatability over temperature range: (See Note) −20°C to +55°C ±0.4% −20°C to +70°C ±0.7% 0°C to +40°C ±0.2% **Note:** The three tolerances shown should be considered independent and may be cumulative. Tolerances assume pure sine wave input signal. Time Delay Instantaneous model: 3 cycles or less operating time. Definite Time models (see appropriate curve). ±10% or ±20 milliseconds, whichever is greater.
Tolerances: (With harmonic filter module)	All ratings are the same except: Pickup and dropout settings, repeatability over temperature range: 0°C to +55°C ±0.75% +10°C to +40°C ±0.40% −20°C to +70°C ±1.50%
Reset Time:	Less than 2 cycles (Type 27N). Less than 3 cycles (Type 59N). (The relay resets when the input voltage goes above the pickup setting −27N, below the dropout setting −59N.)
Seismic Capability:	More than 6g ZPA either AXIS biaxial broadband multifrequency vibration without damage or malfunction ANSI/IEEE C37.98.
Transient Immunity:	More than 2500V, 1MHz bursts at 400 Hz repetition rate, continuous (ANSI C37.90.1 SWC); Fast transient test, EMI test.
Dielectric:	2000 Vac RMS 60 seconds all circuits to ground.
Weight:	Unboxed - 3.7 lbs. (1.7 kg) Boxed - 4.3 lbs. (2.0 kg) Volume - 0.26 cubic feet

How To Specify

Voltage Relay shall be Asea Brown Boveri Type 27N, Type 59N or approved equal, draw-out case, capable of withstanding up to 6g ZPA seismic stress without damage or malfunction, at minimum voltage and time settings. A magnetic operation indicator shall be provided which retains position on loss of control power. Built-in means shall be provided to allow operational tests without additional equipment.





Note: Time delays associated with the time taps for the Type 59N Overvoltage Relay are identical to those of the Type 27N Undervoltage Relay, except the delay occurs on pickup; i.e., when voltage increases to above the pickup tap setting.

How To Order

For a complete listing of available versions of single and three phase voltage relays see TD 41-025.

Models are available for 48 to 250 Vdc control power, and 120 Vac potential transformers. For other control voltages contact the nearest ABB Representative.

To place an order, or for further information, contact the nearest ABB Representative.

Further Information

List Prices: PL 41-020
Technical Data: TD 41-025
Instruction Book: IB 7.4.1.7-7
Other Protective Relays:
Application Selector Guide, TD 41-016

Printed in U.S.A.

Exhibit (3): Basler BE1-GPS100 Undervoltage Relay Burden

GENERAL SPECIFICATIONS

AC Current Inputs

5 Ampere CT

Continuous Rating:	20 A
One Second Rating:	400 A For other current levels, use the formula: $I = (K/t)^{½}$ where t = time in seconds, K=160,000(All Case styles)
Saturation Limit:	150 A
Burden:	<10 milliohms

1 Ampere CT

Continuous Rating:	4 A
One Second Rating:	80 A For other current levels, use the formula: $I = (K/t)^{½}$ where t = time in seconds, K = 160,000 (S1 case), K = 90,000 (H1 case)
Saturation Limit:	30 A
Burden:	10 milliohms or Less at 1A

Phase AC Voltage Inputs

Continuous Rating:	300 V, Line to Line
One Second Rating:	600 V, Line to Neutral
Burden:	<1 VA @ 300Vac

ATTACHMENT "1"

PT Burden Calculation

Exhibit (4): ABB 47H Undervoltage Relay Burden

IB 7.4.1.7-2
Page 8

Three-Phase Undervoltage Relays

SPECIFICATIONS

Input Circuit:

Rating: 120v models: 160vac, continuous, 50 or 60 Hz.
208v models: 270vac, continuous, 50 or 60 Hz.

Burden: 120v models: less than 1 VA, 1.0 PF at 120 volts.
208v models: less than 1 VA, 1.0 PF at 208 volts.

Taps: available models include:

Types 47, 47D, 47H : Pickup 90, 100, 110, 120 vac.
Pickup 155, 175, 190, 208 vac.
Dropout 70, 80, 90, 98% of pickup.

Types 47D, 47H: Pickup 90, 100, 110, 120 vac.
Dropout 30, 40, 50, 60% of pickup.

Vendor Catalog Information

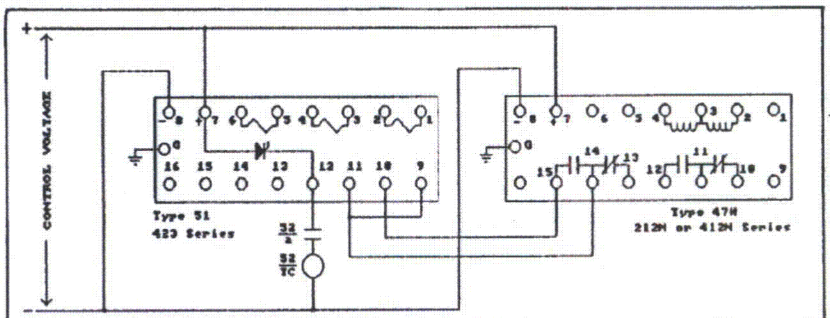
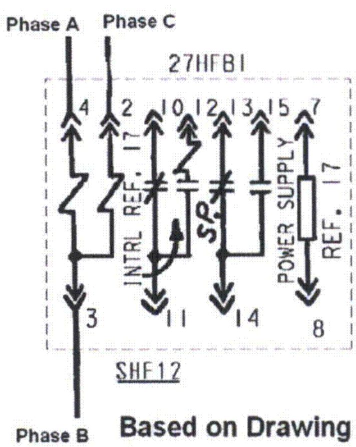


Figure 3a: Typical Control Connections - Voltage Controlled Overcurrent Relay (51V)
Type 51 Catalog Series 423 (3 phase) and Type 47H Catalog Series 412N



Half of the 1 VA burden is on phase A and the other half on phase C

Based on Drawing 441340

ATTACHMENT "1"

PT Burden Calculation

Exhibit (5): GE 24EX / ET-6 Lamp:

a 2
1, 1979
ve Oct. 1, 1979

Indicating Lamps[1]

Types ET-5, ET-6

CATION—ET-5, ET-6

ype ET-5 metal base indicating ...s available for ⅛- and ¼-inch- ...anels under one catalog number, ...ler another catalog number for 1-, , and 2-inch-thick panels. Also available for thin-panel applications, up to ¼- is the molded-base Type ET-6 lamp. ...ese indicating-lamp combinations ...ld be applied where good visible in...tion, long lamp life, and low-wattage ...umption are desirable. They can be . for signal-light indication or in ...bination with control switches to ... circuit-breaker position.

ATURES

Each unit is compact and simple in ...truction. Requires only one hole for ...l mounting.

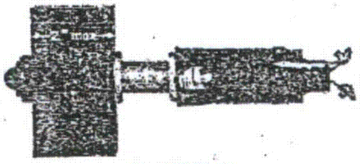
2. Series resistor prevents the possibility of a short circuit from a broken lamp filament thus eliminating the need for special fuses and assuring long lamp life.

3. Low-wattage consumption results in economy and cool operation.

4. These devices include the GE telephone lamp, Type T2, slide base lamp rated 24 volts, 0.032– 0.038 ampere. The special Code 24X lamp is used in the ET-5 and Code 24EX lamp is used on ET-6.

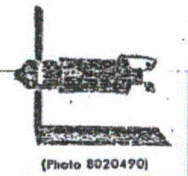
5. Color caps are designed for maximum visibility. See Table 1 for available colors.

6. Terminals are readily accessible and have facilities for soldered or clamped connections.



(Photo 8020489)

Fig. 1. Type ET-5 indicating lamp mounted on insulating panel



(Photo 8020490)

Fig. 2. Type ET-6 indicating lamp mounted on metal panel

GE ET-6 rated 125VDC is used in 120AC circuit (Per 357K-DC Rev. 3)

CING INFORMATION—ET-5 AND ET-6 INDICATING LAMPS

Power Systems Management-P(R21000)

Circuit Voltage ...ed	Circuit Voltage Minimum	Circuit Voltage Maximum	Resistance of Series Resistor in Ohms	Cat. No. (Includes Lamp Color Cap, and Resistor)	Group No. ET-5 for Up to ¼ In. Panels	Group No. ET-5 for 9/32 to 2 In. Panels	Group No. ET-6 for Up to ¼ In. Panels*	★ Net Price, Each ‡	★ 25 or More Net Price, Each ‡§
ptacle Complete Where Lamp is Operated at One Brilliancy									
dc	22	26	110	6105700	G1 ✣	G19 ✣	G41 ✣	$8.30	$7.55
dc	44	56	900	6105700	G2 ✣	G20 ✣	G42 ✣	8.30	7.55
dc	110	140	3300	6105700	G3 ✣	G21 ✣	G43 ✣	8.30	7.55
	220	280	7200	6105700	G4 ✣	G22 ✣	G44 ✣	8.30	7.55
	500	750	20,000	6105700	G5	G23	G45	8.30	7.55
	95	125	2800	6105700	G9 ✣	G27 ✣	G49 ✣	8.30	7.55
	190	250	6300	6105700	G10 ✣	G28 ✣	G50 ✣	8.30	7.55
	380	500	13,000	6105700	G11 ✣	G29	G51 ✣	11.40	10.15
	500	630	17,000	6105700	G12 ✣	G30	G52	11.40	10.15

ORDERING TABLE 1—Color Cap

Cat. No.	Color Cap Color	Color Cap Cat. No.
6105700G*	None	None
6105700G*C	Clear ¤	257A5729P1
6105700G*R	Red ◊	257A5729P2
6105700G*G	Green ◊	257A5729P3
6105700G*Y	Yellow ◊	257A5729P4
6105700G*W	White ◊	257A5729P5
6105700G*B	Blue ¤	257A5729P6
6105700G*A	Amber ¤	257A5729P7
6105700G*D	Green ¤	257A5729P8
6105700G*E	Red ¤	257A5729P9

NOTE:

GE Type ET-6 indicating lamps are rated 125VDC for use in 120VAC circuits

ET-6 Rating = 125VDC, ET-6 Resistance = 3300Ω

Bulb rating = 24VDC, Bulb Maximum current = 0.038A,

Bulb maximum wattage: 24 X 0.038 = 0.912W

Bulb resistance = 0.912 / $(0.038)^2$ = 632 Ω

Total socket & bulb resistance = 3300 + 632 = 3932 Ω

Current at 120VAC = (120V)/(3932 Ω) = 0.0305A

Burden = $(0.305)^2$ X 3932 Ω = 3.66W

ATTACHMENT "1"

PT Burden Calculation

Exhibit (6): Westinghouse Lamp Type EZC Burden:

DB 34-350 Page 2

663100-245 Sec. 9

CALC # 1743-DC, REV. 1

ATTACH. 8.3

PG. ~~16~~ 19 OF ~~21~~ 25

Westinghouse

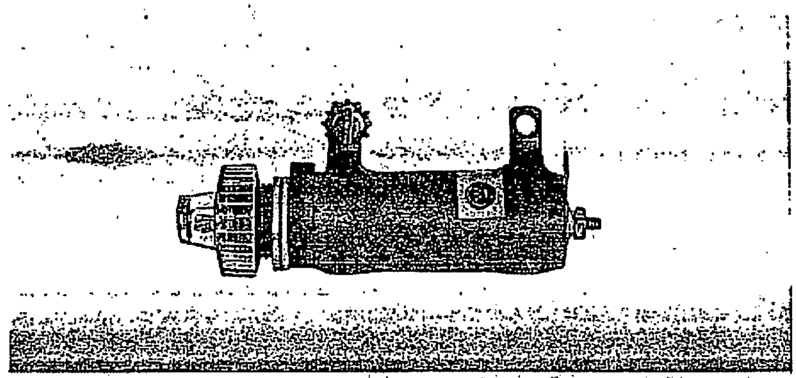
Indicating Lamps

EZC Minalite

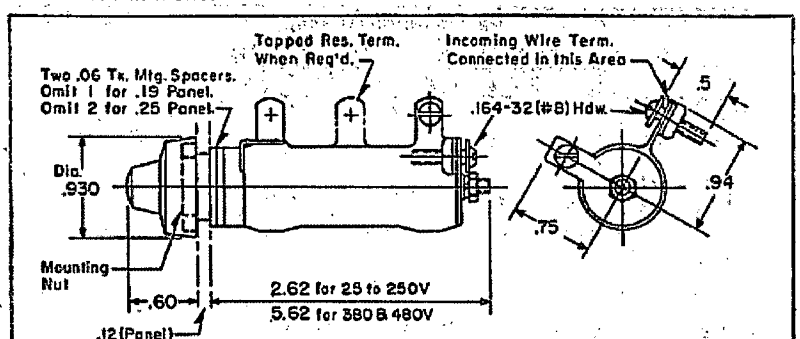
The Type EZC Minalite is a compact indicating lamp, designed for general indicating or signaling purposes on switchboards, control desks, etc. A complete lamp consists of a standard resistor, receptacle, a low drain telephone type slide base bulb, annular spacers, octagon mounting nut, lens and terminal hardware. The resistor, receptacle, bulb and lens are shipped assembled. The other parts are enclosed in an envelope. These two items are incorporated into a single package which is identified by a single style number for the required lamp.

The EZC indicating lamp is suitable for mounting on panels, up to and including ¼ inch thickness, and are of a design that permits quick and easy installation. They are inserted from the rear of the panel, after unscrewing lens from resistor-receptacle assembly, through annular spacers as required for panel thickness. Tightening the octagon nut from the front of the panel mounts the assembly. The one-piece molded lens is then screwed on, enclosing the lamp receptacle and the front mounting nut. Wiring connections are easily made at the rear end of the assembly.

The round receptacle and lens affords accurate alignment on the panel. The rear terminal, located on the axial tie rod, can be rotated 360 degrees and bent up 90 degrees to positions best suited to wiring requirements.



Dimensions In Inches



Drilling Plan

Notes:

1. Two .062 mounting spacers furnished for .125 THK panel mounting. Omit for .25 THK panel.
2. Mounting nut is underneath removable lens and assembled against front of panel.
3. Rear terminals are factory set spaced 90° apart but can be adjusted to suit taking precaution for electrical clearance between terminals.

Lamp Data

Service Voltage Ac – Dc	Style Numbers and Lens Color Red	Green	White	Blue	Amber	Clear	Total Watts (Approx.) at Service Voltage
25	449D187G10	449D187G20	449D187G30	449D187G40	449D187G50	449D187G60	0.9
50	449D187G11	449D187G21	449D187G31	449D187G41	449D187G51	449D187G61	1.6
70	449D187G12	449D187G22	449D187G32	449D187G42	449D187G52	449D187G62	2.3
115	449D187G13	449D187G23	449D187G33	449D187G43	449D187G53	449D187G63	3.6 ←
125	449D187G14	449D187G24	449D187G34	449D187G44	449D187G54	449D187G64	4.0
208	449D187G15	449D187G25	449D187G35	449D187G45	449D187G55	449D187G65	6.6
230	449D187G16	449D187G26	449D187G36	449D187G46	449D187G56	449D187G66	7.3
250	449D187G17	449D187G27	449D187G37	449D187G47	449D187G57	449D187G67	7.9
380	449D187G18	449D187G28	449D187G38	449D187G48	449D187G58	449D187G68	11.8
480	449D187G19	449D187G29	449D187G39	449D187G49	449D187G59	449D187G69	15.3

ATTACHMENT "1"

PT Burden Calculation

Exhibit (7): GE ET-16 Lamp Burden

Indicating Lamps

Types ET-16 and ET-17

CALC #357K-DC, REV.3
ATTACH. 4
PG 16 OF 17.

APPLICATION ET-16, ET-17

The ET-16 (Incandescent) and ET-17 (Neon) indicating lamps are designed for application on switchboard panels up to and including ¼-inch thickness. The lamps economize on space and permit easy replacement of bulb and resistor.

FEATURES

1. The simple "push-twist" type plug has been adopted for both the bulb and the resistor. This was accomplished by incorporating a bayonet base on both components.

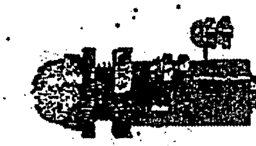
2. Standard GE extra-long-life bulbs are specified for all lamps. The ET-16 uses GE ~~Cat. No.~~ 1819 for the 24 dc lamp and GE Cat. No. 1835 for the balance of the ratings. ET-17 uses GE Cat. No. BIA.

3. Terminals are readily available. They are designed for either AMP "FASTON" type connectors, solder, or screws.

4. Nine basic color caps designed for maximum visibility are available for ET-16: Translucent—red, green, yellow, white. Transparent—amber, red, green, blue, and clear. Amber, clear, and transparent red caps are offered for ET-17. (Note: Because of the special properties of neon, only these lenses are suitable.)

5. The ET-16 is also available for dim-bright applications.

(Photo 1185877)
ET-16 indicating lamp



(Photo 1185876)
ET-17 indicating lamp

☆ET-16—INDICATING LAMP

Power Systems Management-P(R21000)

Circuit Voltage			Cat. No. (Includes Lamp, Color Cap, and Resistor)	Resistor—0165A7844		Bulb GE Cat. No.	Receptacle	Color Cap	Out line
Rated	Minimum	Maximum		Part No.	Ohmic Value				
* 24 Dc	22	28	0116867086G1	1	10	1819	0114867090G1	See Ordering Table 1	0165A7659
48 Dc	44	56	0116867086G2	2	200				
⇒ 125 Dc	110	140	0116867086G3	3	2000				
250 Dc	220	280	0116867086G4	4	3100				
70 Ac	55	76	0116867086G7	7	250	1835			
→ 120 Ac	95	130	0116867086G5	8	1900				
130 Ac	105	140	0116867086G8	15	2300				
240 Ac	195	260	0116867086G6	6	4800				

☆ET-16—FOR DIM-BRIGHT APPLICATION

Circuit Voltage			Cat. No. (Includes Lamp, Color Cap, and Resistor)	Resistor—0165A9217			Bulb GE Cat. No.	Receptacle	Color Cap	Out line
Rated	Minimum	Maximum		Part No.	Resistance-Ohms Total	Tap				
48 Dc	44	56	0127881086G1	1	450	80	1835	0114867090G3	See Ordering Table 1	0165A9216
125 Dc	110	140	0127881086G2	2	2550	1700				
250 Dc	220	280	0127881086G3	3	6000	4400				
120 Ac	95	130	0127881086G4	4	2450	1600				
240 Ac	195	260	0127881086G5	5	5700	4200				

☆ET-17—INDICATING LAMP

Voltage Range Ac/Dc	Cat. No. (Includes Lamp, Color Cap, and Resistor)	Resistor—0165A7956		Bulb GE Cat. No.	Receptacle	Color Cap	Out line
		Part No.	Ohmic Value				
110-139	011686734G1	1	220 K	BIA	0116867090G1	See Ordering Table 2	0165A7955
140-219	011686734G2	2	560 K				
220-299	011686734G3	3	820 K				
300-374	011686734G4	4	1 Meg				
375-449	011686734G5	5	1.2 Meg				
450-600	011686734G6	6	1.6 Meg				

§ The price for quantities of 25 or more applies to any combination of ET-16 and 17 lamps.
¶ Recognized under the Component Program of Underwriters' Laboratories, Inc.

ORDERING TABLE 1—Color Cap

Cat. No.	Color Cap	
	Color	Cat. No.
0116867086G*	None	None
0116867086G*C	Clear♯	208A3768P1
0116867086G*R	Red◊	208A3768P2
0116867086G*G	Green◊	208A3768P3
0116867086G*Y	Yellow◊	208A3768P4
0116867086G*W	White◊	208A3768P5 ⇐
0116867086G*B	Blue♯	208A3768P6
0116867086G*A	Amber♯	208A3768P7
0116867086G*D	Green♯	208A3768P8
0116867086G*E	Red♯	208A3768P9

NOTE:
When ordering red or green lens for ET-16 lamps, transparent caps will be provided unless customer specifies translucent.

ORDERING TABLE 2—Color Cap

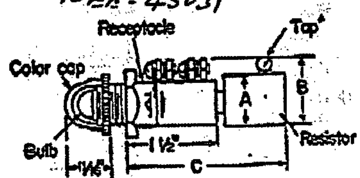
Cat. No.	Color Cap	
	Color	Cat. No.
011686734G*	None	None
011686734G*C	Clear	208A3768P1
011686734G*E	Red♯	208A3768P9
011686734G*A	Amber	208A3768P7

* = Group No. per Voltage Selected.
♯ Transparent
◊ Translucent

HOW TO ORDER

Order by complete Cat. No. and specify color cap.

* DC LIGHTS WERE ORDERED FOR DCN 1-EE-45031



* ET-16 Dim-Bright only

DIMENSIONS— Subject to change. Should not be used for construction without approval.

Indicating Lamp Combination Type	Panel		Dimensions in Inches		
	Type	Drilling	A	B	C
ET-16	Metal, up to ¼-in. thick	21/32-in. hole	7/8	...	2⅝
ET-16 Dim Bright	Metal, up to ¼ in. thick	21/32-in. hole	7/8	1⅛	3⅝
ET-17	Metal, up to ¼ in. thick	21/32-in. hole	13/32	...	23/16

☆PRICING

Refer to Section 7213.

ATTACHMENT "1"

PT Burden Calculation

AUG-28-98 11:04 FROM:DUKE ENG SAN RAMOM ID:15102754682 PAGE 4/

Miniature Lamps

Lamp Trade No.	Unit Pack Product Number 046677-	Bulb	Service and Special Description	Vac(B) or Gas(C)	Design Volts	Design Amps.	Design Watts	Approx. Mean Spherical Candela (MSCd)	Rated Avg. Life (Hours)	Base	Filament Designation	Light Center Length in.	Light Center Length mm	Max. Overall Length in.	Max. Overall Length mm
1616	28241-8	T-3¼	Aviation and Auto	B	13.00	.33	4.29	3.00	1000	Min. Bay.	C-2V	5/8	15.9	1 3/16	31
1819	28247-5	T-3¼	Aviation and Indicator	B	28.00	.04	1.12	.34	4000	Min. Bay.	C-2V	5/8	15.9	1 3/16	31
1820	28252-5	T-3¼	Aviation	B	28.00	.10	2.80	1.60	1000	Min. Bay.	C-2F	5/8	15.9	1 3/16	31
1828	28265-7	T-3¼	Indicator	B	37.50	.05	1.68	.65	3000	Min. Bay.	C-2F	5/8	15.9	1 3/16	31
1829	28267-3	T-3¼	Coin Machine and Indicator	B	28.00	.07	1.96	1.00	1000	Min. Bay.	C-2F	5/8	15.9	1 3/16	31
1835	28278-0	T-3¼	Indicator	B	55.00	.05	2.75	1.10	5000	Min. Bay.	C-5	5/8	15.9	1 3/16	31
1847	28284-8	T-3¼	Radio, TV and Indicator	B	6.30	.15	.95	.38	15,000	Min. Bay.	C-2R	[illegible]	18.0	1 3/16	31
1864	36214-5	T-3¼	Aviation	B	28.00	.17	4.76	3.00	1500	Min. Bay.	C-2F	5/8	15.9	1 3/16	31
1866	28294-7	T-3¼	Radio, TV and Indicator	B	6.30	.25	1.58	.65	5000	Min. Bay.	C-2R	[illegible]	18.0	1 3/16	31
1889	28302-8	T-3¼	Auto	B	14.00	.27	3.78	2.00	3500	Min. Bay.	C-2F	9/16	14.2	1 3/16	31
1891	28304-4	T-3¼	Auto Radio and Indicator	B	14.00	.24	3.36	2.10	500	Min. Bay.	C-2F	[illegible]	[illegible]	[illegible]	[illegible]

GE Type ET-16 Bulb Spec: 28V, 0.04A, 1.12W

GE Type ET-16 Socket Spec: 2000 Ω

Bulb Resistance = (1.12W)/(0.04A) = 700 Ω

Total Resistance = 2000 Ω + 700 Ω = 2700Ω

Current at 120V = (120V)/(2700 Ω) = 0.044A

Burden = $(0.044A)^2$ X 2700 Ω = 5.33W

ATTACHMENT "1"

PT Burden Calculation

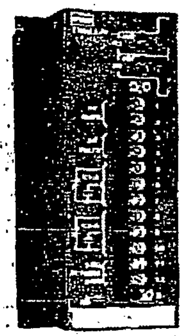
Exhibit (8): Rochester Alarm Relay 1200L Burden

ROCHESTER 1200L

CALC# 174B-DC, REV. 1
ATTACH. 8.3 20
PG. 72 OF 25

ET-1200 AC Current/Voltage Alarms

These single and dual trip alarms accept ac current or voltage inputs (field alterable) and provide one DPDT 5 amp (ET-1200L/U) or two SPDT 5 amp (ET-1202L/U) universal relay contact outputs. Basic input spans of 16 to 200 Vac or 0-1 to 0-7.5 amps. All models come with fixed deadband less than 0.5% of span. Response time is less than 400 milliseconds. The frequency range of all models is 50-500 Hz. Series 1200 ac current/voltage alarms conform to the IEEE SWC test. Refer to the *Options* section (pages 11-13) for a complete list of options for each model.



Available Models

	ET-1200L/U	ET-1202L/U
Description	Single trip ac current/voltage alarm	Dual trip ac current/voltage alarm
Input Signals S	Any ac current from 0-1 amp to 0-7.5 amps ac, burden less than 0.5 VA ac voltage—any 0-16 to 0-200 Vac signal, burden less than 1.5 VA	
Input Frequency Range	50-500 Hz	
Input Surge Capability	ac current—20 amps continuous; 250 amps for 1 second per hour ac voltage—200% of input specified, continuous	
Deadband	Fixed deadband: less than 0.5% of span	
Controls	20 turn trip-set potentiometer with clockwise rotation to increase setting	Two 20 turn trip-set potentiometers with clockwise rotation to increase setting
Trip-Set Adjustment	0-100% continuous, independent adjustment per trip-set point by infinite resolution potentiometer	
Trip Point Stability and Drift	±0.5% of span maximum for a 50°F (28°C) change in ambient temperature; ±0.2% typical	
LED—Visual Indication of Alarm Condition	One	Two
Relay Action—Specify Normally Energized (Failsafe) or De-Energized (Non-Failsafe) S	Hi Trip or Lo Trip	Hi/Lo Trip, Lo/Hi Trip, Hi/Hi Trip, or Lo/Lo Trip

S Customer must select variable(s) and specify when ordering.

ATTACHMENT "1"

PT Burden Calculation

Exhibit (9): Westinghouse VAR & Wattmeter KP241 Burden

Page 4

Ac Instruments Loss Data, 60 Hertz
Circular Scale K-241, K-231, K-261

Ac Instruments Loss Data, 60 Cycles. Circular Scale K-241, K-231, K-261
Burden on Current Transformers at 5 Amps

Instrument and Rating	Type	Impedance: Ohms	Resistance: Ohms	Inductance: Henries	Volt-Amperes	Power Factor	Watts	Reactive Volt-Amperes
Ammeters, 5 Amps:								
Spiral Vane	KA	.036	.028	.000066	.9	.72	.65	.625
Repulsion-Attraction ①	KA	.015	.012	.000024	.375	.80	.30	.625
Rectifier	KC	.002	.0016	—	.05	.80	.04	—
Wattmeters and Varmeters (Per Element) 5 Amps	KP, KV	.08	.016	.0002	2.0	.20	.4	2.0
Power Factor Meters, Amps	KI	.174	.14	—	4.35	.82	1.12	—
	KJ	.045	.045	—	1.12	1.0	1.12	—

Burden on Voltage Transformers at 120 Volts

Instrument and Rating	Type	Impedance: Ohms	Resistance: Ohms	Inductance: Henries	Volt-Amperes	Power Factor	Watts	Reactive Volt-Amperes
Voltmeters, 0-150 Volts: 120 Volts								
Spiral Vane	KA	8640	8420	5.1	1.79	.98	1.75	.40
Repulsion-Attraction ①	KA	7530	7500	1.6	1.92	.996	1.92	—
Rectifier	KC	150,000	150,000	—	.098	1.0	.098	—
Wattmeters and Varmeters, 120 Volts:								
Single Phase	KP, KV	9,000	9,000	—	2.5	1.0	2.5	—
Polyphase	KP, KV	18,000	18,000	—	1.25	1.0	1.25	—
Phase Shifter	PS-2, MV-832	—	—	—	1.4	.36	.5	1.3
Frequency Meters, Volts	KR3	4,000	4,000	—	3.6	1.0	3.6	—
Power Factor Meters, 120 Volts:								
Single Phase	KI	—	—	—	4.5	.45	2.0	4.1
	KJ	12,000	12,000	—	1.2	1.0	1.2	—
Polyphase	KI	—	—	—	2.2	1.0	2.2	—
	KJ	14,000	14,000	—	1.2	1.0	1.2	—
Synchroscopes, 120 Volts:								
Running	KI	—	—	—	4.5	.45	2.0	4.1
Incoming					4.6	.80	3.7	2.8

① All Hi-Shock types and commercial types manufactured prior to 1977 are repulsion-attraction.

DC 663100-245-6 PG 583

ATTACHMENT "1"

PT Burden Calculation

Exhibit (10): Agastat ETR Time Delay Relay Burden

1

Agastat®control relays TR series time delay

CALC# 1748-DG REV 1R
ATTACH. 8.3
PG. 18 OF 21 25

specifications

Operating voltage
+10% −15%

D.C.	A.C.
24 VDC	120V 50–60 Hz
125 VDC	

Timing ranges

.15 to 3 Sec.	4 to 120 Sec.
.55 to 15 Sec.	10 to 300 Sec.
1 to 30 Sec.	2 to 60 Min.
2 to 60 Sec.	1 to 30 Min.

Repeat Accuracy
Repeat accuracy at any fixed temperature is defined as:
*The repeat accuracy deviation (A_R) of a time-delay relay is a measure of the maximum deviation in the time-delay that will be experienced in 100 successive operations at any particular time setting of the relay and for any particular operating voltage or current.

Repeat accuracy is obtained from the following formula:

$$A_R = 100 \frac{(T_1 - T_2)}{(T_1 + T_2)}$$

Where —
T_1 = Maximum observed time.
T_2 = Minimum observed time.

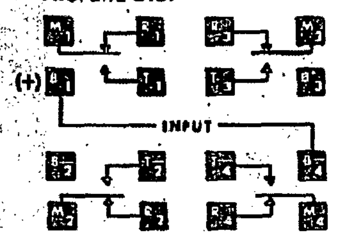
*NEMA part ICS 2-218 .07
Repeat Accuracy ±2% at fixed temperature, voltage, and off-time.

Overall Accuracy ±5% over combined rated extremes of temperature and voltage.

Contacts
Relay 4 PDT 10 amps
See GP series specifications: "Contacts."

Operating temperature range
0°C to 50°C

Wiring Diagram
A.C. and D.C.

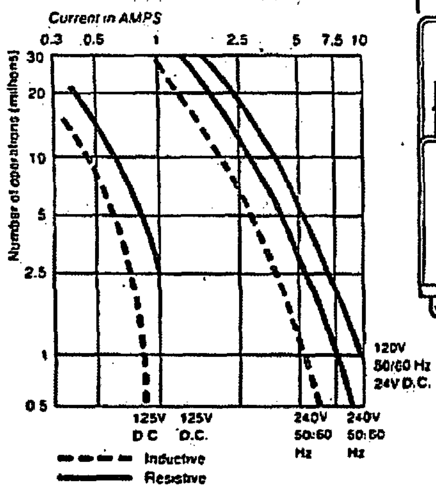


Timing Adjustment
Internal Fixed.
Internal potentiometer.

Mounting/terminals
16 flat base pins which may be soldered. Screw terminal or quick-connect sockets are available.

Life
Load life — see chart
Mechanical life — 100 million operations.

Load life characteristics



Transient Protection
A 1500 volt transient of less than 100 microseconds, or 1000 volts of less than 1 millisecond will not affect timing accuracy.

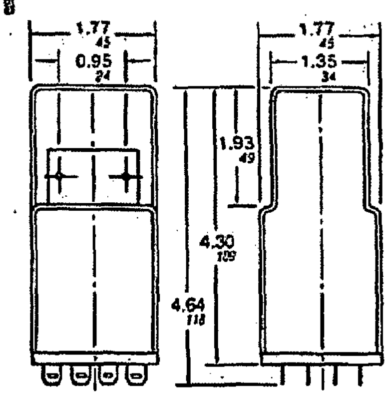
Insulation Resistance
Between all non-connected terminals as well as between non-connected terminals and the relay yoke: 1,000 megohms at 500 volts D.C.

Power Consumption
Typical power consumption at rated voltage is:
6VA for A.C. coils.
6 Watts for D.C. coils.

Dielectric
2000 VAC between terminals and case and between mutually-isolated contacts.

Weight
11 oz. Net.

Dimensions



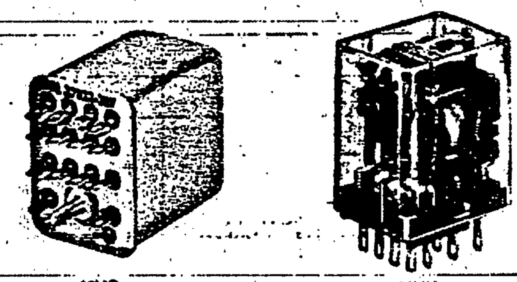
ATTACHMENT "1"

PT Burden Calculation

Exhibit (11): Potter & Brumfield KH Series Relay Burden

POTTER & BRUMFIELD RELAYS

CALC 357K-DC, REV. 3
ATTACH 4
PG. 17 OF 17



KHS — KHU

KH series

GENERAL PURPOSE MULTICONTACT AC or DC RELAY

UL File E22575
CSA File LR15734
UL File 29244 (Limited recognition of 5 pole version.)

GENERAL INFORMATION

Only slightly larger than a cubic inch, the KH Series AC and DC relays represent an added dimension in electromagnetic switching reliability. These miniature relays are specifically designed to meet the exacting requirements of data processing, photocopier, process control and other applications.

Design variations, including a variety of case and termination options, result in relays having different designators. Several of the versions available are UL Recognized and/or CSA Certified. The standard contacts are rated 1/10 HP, 3 amps, 120V AC; 3 amps, 30V DC, resistive. Models with contacts rated to 5 amps are also available.

The KHS is hermetically sealed and UL approved for Class 1, Division 2 hazardous locations.

For quick selection of features available for KH Series relays, please refer to the Ordering Information table.

ENGINEERING DATA

CONTACT DATA

Arrangements: 2 Form C (DPDT), 4 Form C (4PDT) and 5 Form C (5PDT) (KHS & KHU only). Other arrangements available on special order.
Ratings: See contact ratings table.
Material: See contact ratings table.
Expected Life: 10 million operations, mechanical; 100,000 operations minimum at rated loads. Ratings are based on tests of relays with ungrounded frames.
Initial Breakdown Voltage: 500V rms, 60 Hz. between open contacts. 1240V rms, 60 Hz. between all other elements.

CONTACT RATINGS

Contact Code	Material	Resistive Rating	
		Minimum	Maximum
1	Silver	100mA @ 12VAC/12VDC	3A @ 120VAC/28VDC
2	Silver-cadmium oxide	500mA @ 12VAC/12VDC	5A @ 120VAC/28VDC
3	Gold-silver-nickel	10mA @ 12VAC/12VDC	2A @ 120VAC/28VDC
4	Palladium	100mA @ 12VAC/12VDC	3A @ 120VAC/28VDC
5	Silver alloy	500mA @ 12VAC/12VDC	3A @ 120VAC/28VDC
6	Bifurcated cross bar, gold overlay silver	Dry circuit	1A @ 120VAC/28VDC
7	Gold alloy	500 µA @ 3VAC/3VDC	1A @ 120VAC/28VDC
8	Gold diffused silver	50mA @ 12VAC/12VDC	3A @ 120VAC/28VDC

NOTE: Relays should only carry a maximum of 15 amps continuously for all poles combined.

COIL DATA

Voltage: From 6 to 120V DC, and 6 to 240V AC, 50/60 Hz.
Nom. Power: DC coils—0.9 watt; 0.5 watt minimum operate @ 25°C.
AC coils—1.2 VA; 0.55 VA minimum operate @ 25°C.
Max. Power: DC coils—2.0 watts @ 25°C.
Duty Cycle: Continuous.
Initial Breakdown Voltage: 500V rms, 60 Hz.

OPERATE DATA

Must-Operate Voltage: DC: 75% of nominal voltage @ 25°C.
AC: 85% of nominal voltage @ 25°C.
Operate Time: 13 milliseconds typical @ nominal voltage and +25°C (excluding bounce).
Release Time: 6 milliseconds typical @ nominal voltage and +25°C (excluding bounce).

ENVIRONMENTAL DATA

Temperature Range: −45°C to +70°C.

MECHANICAL DATA

Mountings: #3-48 stud, sockets with printed circuit or solder terminals, or bracket plate with #6-32 threaded stud.
Termination: Printed circuit, solder/socket or taper tab terminals. Printed circuit terminals are available for KHS on a special order basis.
Insulating Material: Molded high-dielectric material.
Enclosures: See Ordering Information table. Cover colors are available in black, red, blue, yellow and green by special order.
Weight: 1.6 oz. approx. (45 gms.)

COIL DATA FOR KH SERIES

DC COILS			AC COILS	
Nominal Voltage	Resistance in Ohms ± 10% @ 25°C	Nominal Inductance in Henrys	Resistance in Ohms ±15%	Nominal AC Current in mA
6	40	.08	10.5	200
12	160	.28	43	100
24	650	1.0	160	52
48	2,600	4.5	650	25
80	8,000	13.5	—	—
110 •	11,000	17.0	—	—
120 •	13,500	—	3,900	11.0
240	—	—	12,000	6.0

*Note: For 220 and 240V DC, use series dropping 5W resistor of 11,000Ω.

ATTACHMENT "1"

PT Burden Calculation

VA Spec for AC Coil = 1.2 VA

Wattage = $(0.011)^2$ X 3900Ω = 0.47W

ATTACHMENT "1"

PT Burden Calculation

Exhibit (12): Action Pak AP6380 Isolator Burden

Specifications

Input Ranges (selectable)
Voltage: 50mV AC to 200V AC
Current: 5mA AC to 100mA AC

Input Frequency
DC-1KHz, factory calibrated at 60Hz

Input Impedance
Voltage: >100K Ohms
Current: 20 Ohms typical

Input Overload (without damage)
Voltage: 300V AC
Current: 200mA AC, 60V peak

Common Mode Voltage
1500V DC, input to ground

Output Ranges (selectable)
Voltage: 0-5V DC, 0-10V DC
Current: 4-20mA DC, 0-1mA DC

Output Source
Impedance
Voltage: <10 Ohms
Current: >100K Ohms

Output Drive
Voltage: 10mA, max (1K Ohms min. @ 10V)
Current: 20VDC compliance (1K Ohms max @ 20mA)

Span Turn Down
50% of full scale range

Zero Turn Up
50% of full scale range

LED Indication
8Hz flash when input is 10% above full scale configuration

Accuracy (including hysteresis and linearity)
±0.1% of span, typical
±0.5% of span, maximum

Response Time
250mSec, typical

Stability
±0.025% of full scale per °C, typical

Common Mode Rejection
120dB, DC to 60Hz

Isolation (input to output to power)
1500V DC or peak AC

Temperature Range
Operating: 0 to 60°C (32 to 140°F)
Storage: -15 to 70°C (5 to 158°F)

Humidity (Non-Condensing)
10 to 95% RH at 45°C

Power
Consumption: 3W typical, 5W max
Standard: Selectable 120/240V AC (±10%, 50-60Hz)

Weight
0.60lbs

Agency Approvals
CSA certified per standard C22.2, No. M1982 (File No. LR42272-38).
UL recognized per standard UL508 (File No. E150323).

Mounting

All Action Paks feature plug-in installation. Model AP6380 uses an 8-pin base, either molded socket (M008) or DIN rail socket (MD08).

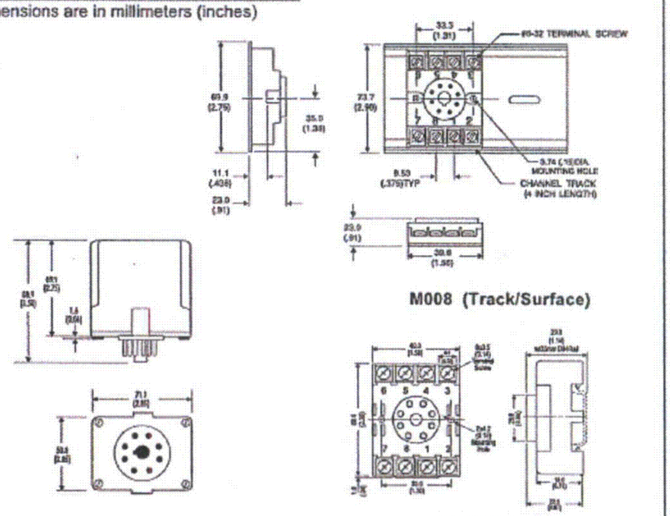
Ordering Information

Specify:
1. Model: AP6380-0000.
2. Option U (see text).
3. Line Power (see specs).
4. Optional Factory Calibration (C620): Specify input range, output range and power.
5. C006 (0.1 Ohm shunt for 1 to 5 Amp current inputs).

Pin Connections
1 AC Power (Hot)
2 Shield (GND)
3 AC Power (Neu)
4 Spare Termination
5 Input
6 Input
7 Output (+)
8 Output (-)

Dimensions

Dimensions are in millimeters (inches)



invensys
EUROTHERM
Eurotherm Controls
741-F Miller Drive
Leesburg, VA 20175-8993
703-443-0000
info@eurotherm.com
actionio.com

Factory Assistance
For additional information on calibration, operation and installation contact our Technical Services Group:
703-669-1318
actionsupport@eurotherm.com

ATTACHMENT "1"

PT Burden Calculation

Exhibit (13): Potter & Brumfield MDR-4103 Burden

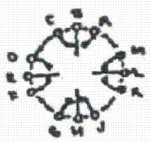
SHEET 1 OF 1

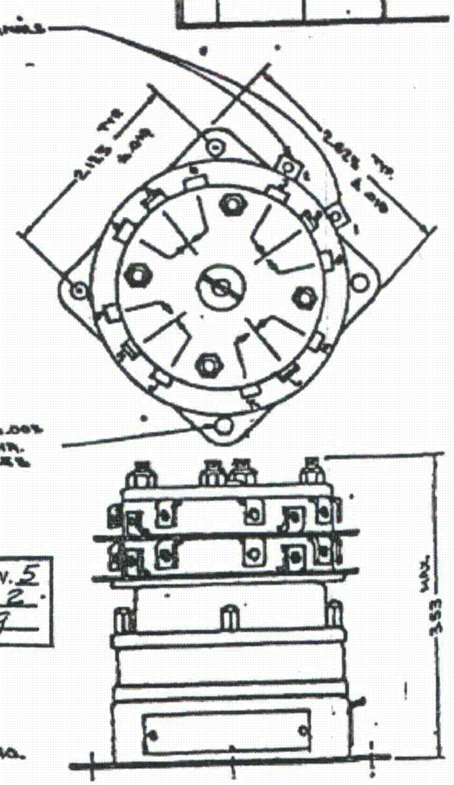
AMF POTTER & BRUMFIELD	CUSTOMER DATA	NAME: MDR-RELAY SMALL NON-LATCHING	PART NO. MDR-4103
DIVISION OF AMF INCORPORATED	DRWN. [illegible] APP. CHECKED		CUSTOMER NO.

RATED COIL VOLTAGE: 115 V.AC 60 Hz.
OPERATE VOLTAGE: LESS THAN 92 V.AC
RELEASE VOLTAGE: MORE THAN 12 V.AC
DC RESISTANCE OF COIL: 66 OHMS
POWER (STEADY STATE): 4.0 WATTS
INRUSH CURRENT: 0.57 AMP.
CURRENT (STEADY STATE): 0.150 AMP.
OPERATE TIME: 5.0 TO 12.0 MS TYPICAL
RELEASE TIME: 5.0 TO 18.0 MS TYPICAL
CONTACT RATINGS:
SINGLE CONTACTS
10 AMPS 115 VAC 50% PF
3 AMPS 28 VDC RESISTIVE
0.5 AMPS 125 VDC RESISTIVE
TWO CONTACTS IN SERIES
3 AMPS 440 VAC 50% PF
15 AMPS 115 VAC 50% PF
1.5 AMPS 125 VDC RESISTIVE
ENDURANCE CATEGORY: A (500,000 CYCLES)
TEMPERATURE RANGE: 0°C. TO +65°C.

VA = 120V X 0.15A = 18VA
W = 4.0W

TWO CONTACT SECTIONS (8 PDT TOTAL)





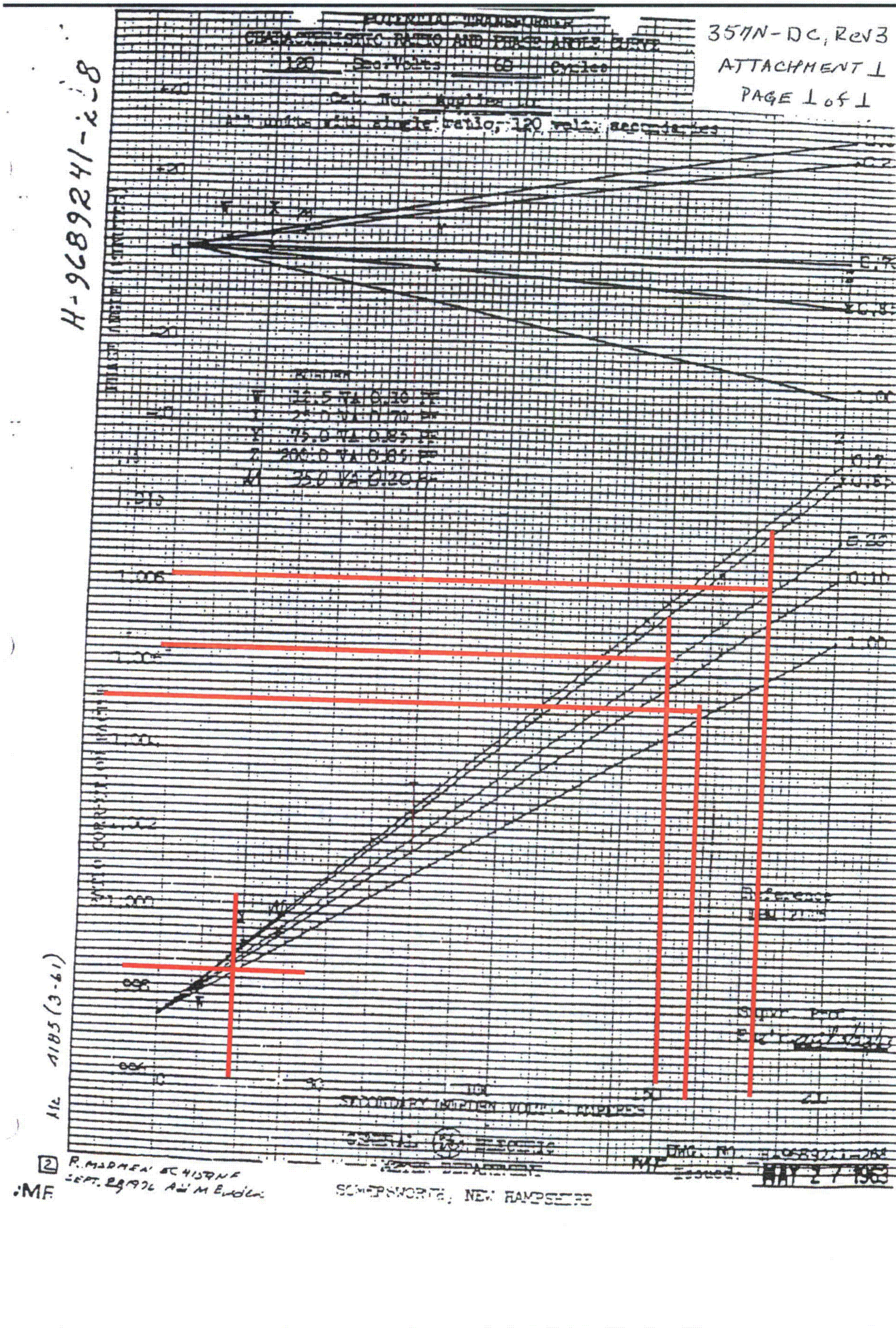
RPE E 7664 REV. 5
MC ___ ATTACH 2
SHEET 4 of 9

NOTE: COIL AND CONTACT TERMINAL SCREWS #8-40.

NOTE:
ELECTRICAL VALUES GIVEN ABOVE MEASURED AT APPROXIMATELY 25 DEGREES C. SLIGHT DIFFERENCES MUST BE EXPECTED DUE TO NORMAL MANUFACTURING VARIATIONS.

ATTACHMENT "2"

Potential Transformer Characteristic Ratio and Phase Angle Curve



ATTACHMENT "3"

Basler BE1-GPS100 Drift Calculation
(Units 1&2: 27HFB2, 27HGB2 & 27HHB2)

SUMMARY

Based on the analysis of 7 years of calibration data on Basler BE1-GPS100 the following conservatively determined drift values will be assumed:

Device 27P Dropout Undervoltage Drift: ±0.50 VAC
Device 127P Dropout Undervoltage Drift: ±0.30 VAC
Device 27X Dropout Undervoltage Drift: ±0.40 VAC
Device 27P Time Delay Drift: ±0.10 Sec
Device 127P Time Delay Drift: ±0.05 Sec
Device 27X Time Delay Drift: ±0.05 Sec

ANALYSIS

Table 1; Raw Calibration Data & Undervoltage Drift – Device 27P

Unit #	Test Date	Period (Days)	RLOC	Device 27P					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
1-27HFB2	10/8/2000		07776-5672-5712	NA	76.21		NA	76.84	
1-27HFB2	6/19/2001	254	07913-3476-3509	76.59	76.18	0.38	77.5	77.73	0.66
1-27HFB2	5/3/2002	318	08054-3891-3926	76.16	76.16	-0.02	77.75	77.75	0.02
1-27HFB2	12/2/2003	578	51000-3609	76.15	76.15	-0.01	77.62	77.62	-0.13
1-27HFB2	8/10/2004	252	51001-5789	76.2	76.2	0.05	77.5	77.5	-0.12
1-27HFB2	8/9/2005	364	51002-7688	76.1	76.1	-0.1	77.75	77.75	0.25
1-27HFB2	9/6/2006	393	51004-7319	76.11	76.11	0.01	77.63	77.63	-0.12
1-27HFB2	5/13/2007	249	51004-8749	76.3	76.3	0.19	77.68	77.68	0.05
2-27HFB2	4/18/2001		07891-4274-4315	76.35	76.35		77.6	77.6	
2-27HFB2	2/26/2002	314	08032-1194-1232	76.25	76.25	-0.1	77.71	77.71	0.11
2-27HFB2	2/14/2003	353	50000-0930	76.23	76.23	-0.02	77.7	77.7	-0.01
2-27HFB2	7/14/2004	516	51001-4626	76.17	76.17	-0.06	77.72	77.72	0.02
2-27HFB2	3/22/2005	251	51002-4097	76.21	76.21	0.04	77.67	77.67	-0.05
2-27HFB2	2/23/2006	338	51003-5697	76.2	76.2	-0.01	77.66	77.66	-0.01
2-27HFB2	2/21/2007	363	51004-5691	76.1	76.1	-0.1	77.71	77.71	0.05
2-27HFB2	2/20/2008	364	51006-0503	76.16	76.16	0.06	77.66	77.66	-0.05
1-27HGB2	10/8/2000		07777-1871-1912	NA	76.43		NA	76.76	
1-27HGB2	10/23/2000	15	51000-3610	76.25	76.25	-0.18	77.71	77.71	0.95
1-27HGB2	7/10/2001	260	07921-3913-3947	NA	76.28	NA	NA	77.75	NA
1-27HGB2	5/7/2002	301	08054-3927-3964	76.26	76.26	-0.02	77.76	77.76	0.01
1-27HGB2	10/23/2003	534		76.25	76.25	-0.01	77.71	77.71	-0.05
1-27HGB2	4/17/2004	177	51001-2307	76.1	76.1	-0.15	77.9	77.9	0.19
1-27HGB2	8/17/2005	487	51002-7687	76.1	76.1	0	77.717	77.717	-0.183
1-27HGB2	8/30/2006	378	51004-7316	76.23	76.23	0.13	77.69	77.69	-0.027
2-27HGB2	4/18/2001		07891-4316-4356	76.14	76.2		77.67	77.69	
2-27HGB2	3/19/2002	335	08039-3291-3330	76.14	76.14	-0.06	77.68	77.68	-0.01

ATTACHMENT "3"

Unit #	Test Date	Period (Days)	RLOC	Device 27P					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
2-27HGB2	12/9/2002	265	08164-1654-1690	76.19	76.19	0.05	77.7	77.7	0.02
2-27HGB2	9/29/2003	294	51000-2933	76.16	76.16	-0.03	77.62	77.62	-0.08
2-27HGB2	11/18/2004	416	51001-9565	76.05	76.05	-0.11	77.66	77.66	0.04
2-27HGB2	3/16/2006	483	51003-8344	76.16	76.16	0.11	77.66	77.66	0
2-27HGB2	2/14/2007	335	51004-6457	76.14	76.14	-0.02	77.65	77.65	-0.01
2-27HGB2	11/7/2007	266	51005-4535	76.17	76.17	0.03	77.63	77.63	-0.02
1-27HHB2	10/8/2000		07776-5672-5712	NA	76.51		NA	77.72	
1-27HHB2	7/31/2001	296	07955-3350-3384	76.2	76.2	-0.31	77.29	77.71	-0.43
1-27HHB2	5/11/2002	284	08063-0380-3964	76.27	76.22	0.07	77.73	77.73	0.02
1-27HHB2	11/18/2003	556	51000-3367	76.03	76.03	-0.19	77.74	77.74	0.01
1-27HHB2	8/23/2004	279	51001-4291	76.27	76.27	0.24	77.75	77.75	0.01
1-27HHB2	11/13/2005	447	51003-2881	75.86	75.86	-0.41	77.7	77.7	-0.05
1-27HHB2	3/7/2007	479	51004-6458	76.29	76.29	0.43	77.77	77.77	0.07
1-27HHB2	12/12/2007	280	51005-6658	76.25	76.25	-0.04	77.72	77.72	-0.05
2-27HHB2	4/18/2001		07891-4274-4315	76.16	76.27		77.66	77.62	
2-27HHB2	3/12/2002	328	08039-2154-2192	76.19	76.22	-0.08	77.75	77.73	0.13
2-27HHB2	11/16/2002	249	08179-0328-0365	76.19	76.19	-0.03	77	77	-0.73
2-27HHB2	10/20/2003	338	51000-3368	76.2	76.2	0.01	77.7	77.7	0.7
2-27HHB2	3/8/2005	505	51002-3638	76.2	76.2	0	77.64	77.64	-0.06
2-27HHB2	5/8/2005	61	51003-8587	76.12	76.12	-0.08	77.63	77.63	-0.01
2-27HHB2	1/10/2007	612	51004-6057	76.17	76.17	0.05	77.67	77.67	0.04
2-27HHB2	3/5/2008	420	51006-1369	76.16	76.16	-0.01	77.66	77.66	-0.01

ATTACHMENT "3"

Table 2; Raw Calibration Data & Undervoltage Drift – Device 127P

Unit #	Test Date	Period (Days)	RLOC	Device 127P					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
1-27HFB2	10/8/2000		07776-5672-5712	NA	30.59		NA	31.12	
1-27HFB2	6/19/2001	254	07913-3476-3509	30.5	30.5	-0.09	31.11	31.15	-0.01
1-27HFB2	5/3/2002	318	08054-3891-3926	30.54	30.54	0.04	31.1	31.1	-0.05
1-27HFB2	12/2/2003	578	51000-3609	30.51	30.51	-0.03	31.1	31.1	0
1-27HFB2	8/10/2004	252	51001-5789	30.6	30.6	0.09	31.1	31.1	0
1-27HFB2	8/9/2005	364	51002-7688	30.5	30.5	-0.1	31.154	31.154	0.054
1-27HFB2	9/6/2006	393	51004-7319	30.52	30.52	0.02	31.07	31.07	-0.084
1-27HFB2	5/13/2007	249	51004-8749	30.52	30.52	0	31.1	31.1	0.03
2-27HFB2	4/18/2001		07891-4274-4315	30.53	30.53		31.12	31.12	
2-27HFB2	2/26/2002	314	08032-1194-1232	30.54	30.54		31.16	31.16	
2-27HFB2	2/14/2003	353	50000-0930	30.58	30.58	0.04	31.13	31.13	-0.03
2-27HFB2	7/14/2004	516	51001-4626	30.42	30.42	-0.16	31.19	31.19	0.06
2-27HFB2	3/22/2005	251	51002-4097	30.57	30.57	0.15	31.15	31.15	-0.04
2-27HFB2	2/23/2006	338	51003-5697	30.56	30.56	-0.01	31.14	31.14	-0.01
2-27HFB2	2/21/2007	363	51004-5691	30.53	30.53	-0.03	31.08	31.08	-0.06
2-27HFB2	2/20/2008	364	51006-0503	30.55	30.55	0.02	31.13	31.13	0.05
1-27HGB2	10/8/2000		07777-1871-1912	NA	30.63		NA	31.18	
1-27HGB2	10/23/2000	15	51000-3610	30.57	30.57	-0.06	31.15	31.15	-0.03
1-27HGB2	7/10/2001	260	07921-3913-3947	NA	30.6		NA	31.16	
1-27HGB2	5/7/2002	301	08054-3927-3964	30.6	30.6	0	31.18	31.18	0.02
1-27HGB2	10/23/2003	534		30.57	30.57	-0.03	31.15	31.15	-0.03
1-27HGB2	4/17/2004	177	51001-2307	30.5	30.5	-0.07	31.27	31.27	0.12
1-27HGB2	8/17/2005	487	51002-7687	30.543	30.543	0.043	31.203	31.203	-0.067
1-27HGB2	8/30/2006	378	51004-7316	30.57	30.57	0.027	31.13	31.13	-0.073
2-27HGB2	4/18/2001		07891-4316-4356	30.57	30.62		31.19	31.21	
2-27HGB2	3/19/2002	335	08039-3291-3330	30.5	30.5	-0.12	31.12	31.12	-0.09
2-27HGB2	12/9/2002	265	08164-1654-1690	30.49	30.49	-0.01	31.15	31.15	0.03
2-27HGB2	9/29/2003	294	51000-2933	30.52	30.52	0.03	31.1	31.1	-0.05
2-27HGB2	11/18/2004	416	51001-9565	30.5	30.5	-0.02	31	31	-0.1
2-27HGB2	3/16/2006	483	51003-8344	30.53	30.53	0.03	31.12	31.12	0.12
2-27HGB2	2/14/2007	335	51004-6457	30.53	30.53	0	31.09	31.09	-0.03
2-27HGB2	11/7/2007	266	51005-4535	30.55	30.55	0.02	31.1	31.1	0.01
1-27HHB2	10/8/2000		07776-5672-5712	NA	30.59		NA	31.06	
1-27HHB2	7/31/2001	296	07955-3350-3384	30.55	30.52	-0.04	31.14	31.18	0.08
1-27HHB2	5/11/2002	284	08063-0380-3964	30.57	30.57	0.05	31.16	31.15	-0.02
1-27HHB2	11/18/2003	556	51000-3367	30.59	30.59	0.02	31.18	31.18	0.03
1-27HHB2	8/23/2004	279	51001-4291	30.56	30.56	-0.03	31.13	31.13	-0.05
1-27HHB2	11/13/2005	447	51003-2881	30.38	30.38	-0.18	31.23	31.23	0.1
1-27HHB2	3/7/2007	479	51004-6458	30.61	30.61	0.23	31.16	31.16	-0.07
1-27HHB2	12/12/2007	280	51005-6658	30.6	30.6	-0.01	31.14	31.14	-0.02
2-27HHB2	4/18/2001		07891-4274-4315	30.49	30.53		31.15	31.15	
2-27HHB2	3/12/2002	328	08039-2154-2192	30.57	30.56	0.04	31.17	31.17	0.02
2-27HHB2	11/16/2002	249	08179-0328-0365	30.53	30.53	-0.03	31.15	31.15	-0.02
2-27HHB2	10/20/2003	338	51000-3368	30.53	30.53	0	31.14	31.14	-0.01
2-27HHB2	3/8/2005	505	51002-3638	30.59	30.59	0.06	31.1	31.1	-0.04

ATTACHMENT "3"

Unit #	Test Date	Period (Days)	RLOC	Device 127P					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
2-27HHB2	5/8/2005	61	51003-8587	30.37	30.37	-0.22	31.28	31.28	0.18
2-27HHB2	1/10/2007	612	51004-6057	30.56	30.56	0.19	31.12	31.12	-0.16
2-27HHB2	3/5/2008	420	51006-1369	30.55	30.55	-0.01	31.13	31.13	0.01

Table 3; Raw Calibration Data & Undervoltage Drift – Device 27X

Unit #	Test Date	Period (Days)	RLOC	Device 27X					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
1-27HFB2	10/8/2000		07776-5672-5712	NA	23.520		NA	23.710	
1-27HFB2	6/19/2001	254	07913-3476-3509	23.4	23.35	-0.120	23.64	23.86	-0.070
1-27HFB2	5/3/2002	318	08054-3891-3926	23.37	23.37	0.020	23.82	23.82	-0.040
1-27HFB2	12/2/2003	578	51000-3609	23.37	23.37	0.000	23.77	23.77	-0.050
1-27HFB2	8/10/2004	252	51001-5789	23.4	23.4	0.030	23.8	23.8	0.030
1-27HFB2	8/9/2005	364	51002-7688	23.34	23.34	-0.060	23.89	23.89	0.090
1-27HFB2	9/6/2006	393	51004-7319	23.38	23.38	0.040	23.82	23.82	-0.070
1-27HFB2	5/13/2007	249	51004-8749	23.5	23.5	0.120	23.82	23.82	0.000
2-27HFB2	4/18/2001		07891-4274-4315	23.31	23.31		23.86	23.86	
2-27HFB2	2/26/2002	314	08032-1194-1232	23.39	23.39		23.87	23.87	
2-27HFB2	2/14/2003	353	50000-0930	23.4	23.4	0.01	23.85	23.85	-0.020
2-27HFB2	7/14/2004	516	51001-4626	23.33	23.33	-0.07	23.82	23.82	-0.030
2-27HFB2	3/22/2005	251	51002-4097	23.4	23.4	0.07	23.86	23.86	0.040
2-27HFB2	2/23/2006	338	51003-5697	23.37	23.37	-0.03	23.78	23.78	-0.080
2-27HFB2	2/21/2007	363	51004-5691	23.42	23.42	0.05	23.86	23.86	0.080
2-27HFB2	2/20/2008	364	51006-0503	23.36	23.36	-0.06	23.82	23.82	-0.040
1-27HGB2	10/8/2000		07777-1871-1912	N.A*	23.49		N.A*	23.82	
1-27HGB2	10/23/2000	15	51000-3610	23.38	23.38	-0.11	23.78	23.78	-0.04
1-27HGB2	7/10/2001	260	07921-3913-3947	?	23.36		?	23.8	
1-27HGB2	5/7/2002	301	08054-3927-3964	23.35	23.35	-0.01	23.8	23.8	0
1-27HGB2	10/23/2003	534		23.38	23.38	0.03	23.78	23.78	-0.02
1-27HGB2	4/17/2004	177	51001-2307	23.28	23.28	-0.1	23.87	23.87	0.09
1-27HGB2	8/17/2005	487	51002-7687	23.316	23.316	0.036	23.904	23.904	0.034
1-27HGB2	8/30/2006	378	51004-7316	23.38	23.38	0.064	23.81	23.81	-0.094
2-27HGB2	4/18/2001		07891-4316-4356	23.31	23.300		23.78	23.750	
2-27HGB2	3/19/2002	335	08039-3291-3330	23.31	23.31	0.01	23.82	23.82	0.07
2-27HGB2	12/9/2002	265	08164-1654-1690	23.34	23.34	0.03	23.82	23.82	0
2-27HGB2	9/29/2003	294	51000-2933	23.36	23.36	0.02	23.8	23.8	-0.02
2-27HGB2	11/18/2004	416	51001-9565	23.36	23.36	0	23.8	23.8	0
2-27HGB2	3/16/2006	483	51003-8344	23.34	23.34	-0.02	23.79	23.79	-0.01
2-27HGB2	2/14/2007	335	51004-6457	23.34	23.34	0	23.63	23.63	-0.16
2-27HGB2	11/7/2007	266	51005-4535	23.37	23.37	0.03	23.79	23.79	0.16
1-27HHB2	10/8/2000		07776-5672-5712	N.A.*	23.350		N.A.*	23.810	
1-27HHB2	7/31/2001	296	07955-3350-3384	23.37	23.37	0.02	23.84	23.81	0.03
1-27HHB2	5/11/2002	284	08063-0380-3964	23.38	23.38	0.01	23.83	23.83	0.02
1-27HHB2	11/18/2003	556	51000-3367	23.34	23.34	-0.04	23.71	23.71	-0.12

ATTACHMENT "3"

Unit #	Test Date	Period (Days)	RLOC	Device 27X					
				Dropout (VAC)			Pickup (VAC)		
				As Found	As-Left	Drift	As Found	As-Left	Drift
1-27HHB2	8/23/2004	279	51001-4291	23.42	23.42	0.08	23.82	23.82	0.11
1-27HHB2	11/13/2005	447	51003-2881	23.08	23.08	-0.34	23.86	23.86	0.04
1-27HHB2	3/7/2007	479	51004-6458	23.41	23.41	0.33	23.83	23.83	-0.03
1-27HHB2	12/12/2007	280	51005-6658	23.39	23.39	-0.02	23.8	23.8	-0.03
2-27HHB2	4/18/2001		07891-4274-4315	23.3	23.34		23.89	23.81	
2-27HHB2	3/12/2002	328	08039-2154-2192	23.37	23.37	0.03	23.83	23.86	0.02
2-27HHB2	11/16/2002	249	08179-0328-0365	23.37	23.37	0	23.82	23.82	-0.04
2-27HHB2	10/20/2003	338	51000-3368	23.34	23.34	-0.03	23.77	23.77	-0.05
2-27HHB2	3/8/2005	505	51002-3638	23.41	23.41	0.07	23.81	23.81	0.04
2-27HHB2	5/8/2005	61	51003-8587	23.36	23.36	-0.05	23.8	23.8	-0.01
2-27HHB2	1/10/2007	612	51004-6057	23.42	23.42	0.06	23.83	23.83	0.03
2-27HHB2	3/5/2008	420	51006-1369	23.36	23.36	-0.06	23.8	23.8	-0.03

Table 4; Raw Calibration Data & Time Delay Drift – Device 27X

Unit #	Test Date	Period (Days)	RLOC	Time Delay (sec) at 72 VAC			Time Delay (sec) at 28 VAC			Time Delay (sec) at 20 VAC		
				As Found	As-Left	Drift	As Found	As-Left	Drift	As Found	As-Left	Drift
				NA	4.690		NA	1.890		NA	0.654	
1-27HFB2	6/19/2001	254	07913-3476-3509	4.670	4.730	-0.02	1.87	1.900	-0.02	0.66	0.680	0.006
1-27HFB2	5/3/2002	318	08054-3891-3926	4.700	4.700	-0.03	1.93	1.93	0.03	0.68	0.68	0
1-27HFB2	12/2/2003	578	51000-3609	4.710	4.710	0.01	1.91	1.910	-0.02	0.68	0.680	0
1-27HFB2	8/10/2004	252	51001-5789	4.730	4.730	0.02	1.92	1.920	0.01	0.67	0.670	-0.01
1-27HFB2	8/9/2005	364	51002-7688	4.700	4.700	-0.03	1.9	1.900	-0.02	0.68	0.680	0.01
1-27HFB2	9/6/2006	393	51004-7319	4.710	4.710	0.01	1.92	1.920	0.02	0.69	0.690	0.01
1-27HFB2	5/13/2007	249	51004-8749	4.700	4.700	-0.01	1.900	1.9	-0.02	0.66	0.660	-0.03
2-27HFB2	4/18/2001		07891-4274-4315	4.710	4.710		1.9	1.900		0.67	0.670	
2-27HFB2	2/26/2002	314	08032-1194-1232	4.720	4.720	0.010	1.91	1.91	0.01	0.691	0.691	0.021
2-27HFB2	2/14/2003	353	50000-0930	4.710	4.710	-0.01	1.92	1.92	0.01	0.69	0.69	-0.001
2-27HFB2	7/14/2004	516	51001-4626	4.700	4.700	-0.01	1.9	1.900	-0.02	0.68	0.680	-0.01
2-27HFB2	3/22/2005	251	51002-4097	4.720	4.720	0.02	1.93	1.930	0.03	0.69	0.690	0.01
2-27HFB2	2/23/2006	338	51003-5697	4.710	4.710	-0.01	1.93	1.930	0	0.67	0.670	-0.02
2-27HFB2	2/21/2007	363	51004-5691	4.720	4.720	0.01	1.91	1.910	-0.02	0.68	0.680	0.01
2-27HFB2	2/20/2008	364	51006-0503	4.710	4.710	-0.01	1.92	1.920	0.01	0.68	0.680	0
1-27HGB2	10/8/2000		07777-1871-1912	N.A*	4.660		N.A*	1.89		N.A*	0.65	
1-27HGB2	10/23/2000	15	51000-3610	4.720	4.720	0.06	1.92	1.920	0.03	0.69	0.690	0.04
1-27HGB2	7/10/2001	260	07921-3913-3947	NA	4.700		NA	1.9		NA	0.671	
1-27HGB2	5/7/2002	301	08054-3927-3964	4.700	4.700	0	1.920	1.920	0.02	0.695	0.695	0.024
1-27HGB2	10/23/2003	534		4.720	4.720	0.02	1.920	1.920	0	0.69	0.69	-0.005
1-27HGB2	4/17/2004	177	51001-2307	4.700	4.700	-0.02	1.92	1.920	0	0.67	0.670	-0.02
1-27HGB2	8/17/2005	487	51002-7687	4.700	4.700	0	1.9	1.900	-0.02	0.68	0.680	0.01
1-27HGB2	8/30/2006	378	51004-7316	4.710	4.710	0.01	1.91	1.910	0.01	0.67	0.670	-0.01
2-27HGB2	4/18/2001		07891-4316-4356	4.720	4.720		1.92	1.920		0.67	0.680	
2-27HGB2	3/19/2002	335	08039-3291-3330	4.720	4.720	0	1.92	1.92	0	0.683	0.683	0.003

ATTACHMENT "3"

Unit #	Test Date	Period (Days)	RLOC	Time Delay (sec) at 72 VAC			Time Delay (sec) at 28 VAC			Time Delay (sec) at 20 VAC		
				As Found	As-Left	Drift	As Found	As-Left	Drift	As Found	As-Left	Drift
2-27HGB2	12/9/2002	265	08164-1654-1690	4.700	4.700	-0.02	1.91	1.91	-0.01	0.68	0.68	-0.003
2-27HGB2	9/29/2003	294	51000-2933	4.720	4.720	0.02	1.92	1.92	0.01	0.68	0.68	0
2-27HGB2	11/18/2004	416	51001-9565	4.710	4.710	-0.01	1.91	1.910	-0.01	0.67	0.670	-0.01
2-27HGB2	3/16/2006	483	51003-8344	4.700	4.700	-0.01	1.91	1.910	0	0.68	0.680	0.01
2-27HGB2	2/14/2007	335	51004-6457	4.700	4.700	0	1.9	1.900	-0.01	0.69	0.690	0.01
2-27HGB2	11/7/2007	266	51005-4535	4.720	4.720	0.02	1.91	1.910	0.01	0.67	0.670	-0.02
1-27HHB2	10/8/2000		07776-5672-5712	N.A.*	4.67		N.A.*	1.88		N.A.*	0.64	
1-27HHB2	7/31/2001	296	07955-3350-3384	4.67	4.70	0.00	1.89	1.92	0.01	0.642	0.673	0.002
1-27HHB2	5/11/2002	284	08063-0380-3964	4.72	4.71	0.02	1.93	1.93	0.01	0.68	0.69	0.007
1-27HHB2	11/18/2003	556	51000-3367	4.72	4.72	0.01	1.92	1.92	-0.01	0.69	0.69	0.000
1-27HHB2	8/23/2004	279	51001-4291	4.72	4.72	0.00	1.90	1.90	-0.02	0.68	0.68	-0.010
1-27HHB2	11/13/2005	447	51003-2881	4.70	4.70	-0.02	1.91	1.91	0.01	0.67	0.67	-0.010
1-27HHB2	3/7/2007	479	51004-6458	4.71	4.71	0.01	1.93	1.93	0.02	0.68	0.68	0.010
1-27HHB2	12/12/2007	280	51005-6658	4.70	4.70	-0.01	1.91	1.91	-0.02	0.68	0.68	0.000
2-27HHB2	4/18/2001		07891-4274-4315	4.70	4.72		1.90	1.91		0.69	0.69	
2-27HHB2	3/12/2002	328	08039-2154-2192	4.70	4.70	-0.02	1.91	1.90	0.00	0.68	0.68	-0.01
2-27HHB2	11/16/2002	249	08179-0328-0365	4.72	4.72	0.02	1.93	1.93	0.03	0.68	0.68	0.00
2-27HHB2	10/20/2003	338	51000-3368	4.70	4.70	-0.02	1.90	1.90	-0.03	0.68	0.68	0.00
2-27HHB2	3/8/2005	505	51002-3638	4.70	4.70	0.00	1.91	1.91	0.01	0.68	0.68	0.00
2-27HHB2	5/8/2005	61	51003-8587	4.73	4.73	0.03	1.92	1.92	0.01	0.69	0.69	0.01
2-27HHB2	1/10/2007	612	51004-6057	4.71	4.71	-0.02	1.90	1.90	-0.02	0.69	0.69	0.00
2-27HHB2	3/5/2008	420	51006-1369	4.70	4.70	-0.01	1.90	1.90	0.00	0.69	0.69	0.00

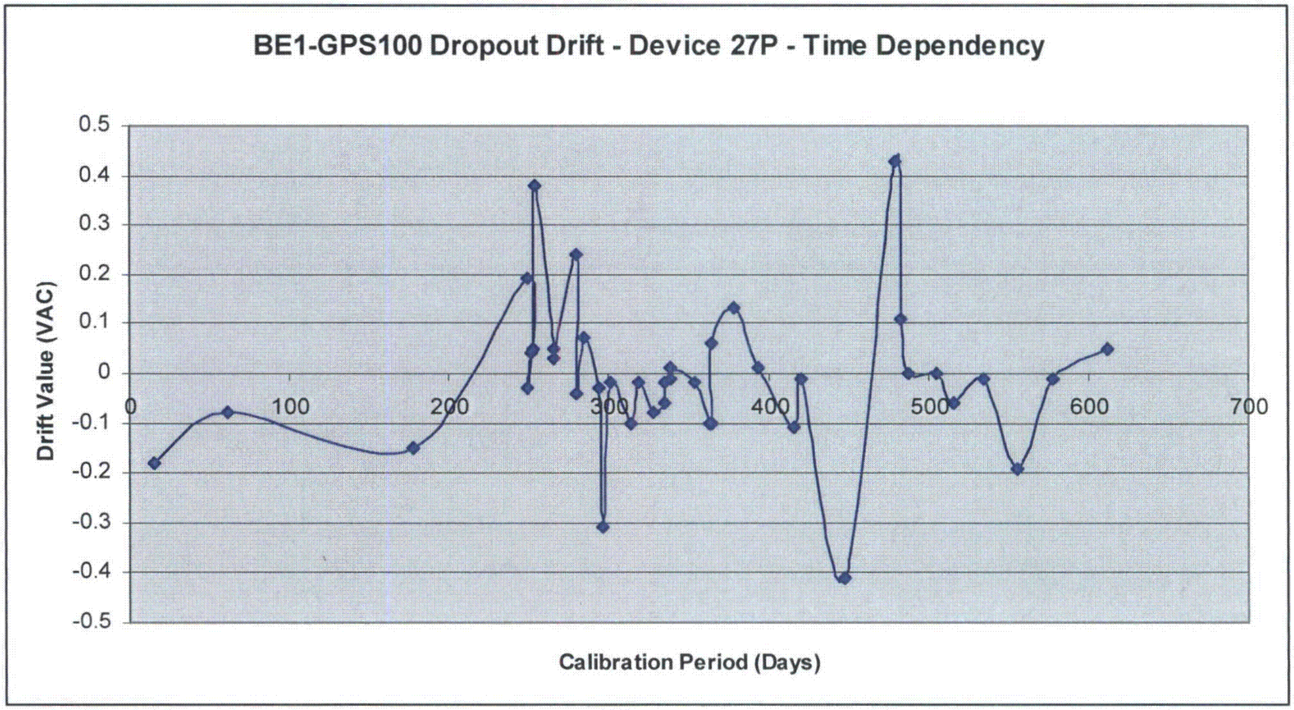
ATTACHMENT "3"

Time Dependency Test - Undervoltage Dropout Drift:

Device 27P

The correlation between calibration period and magnitude of drift is equal to 0.044. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

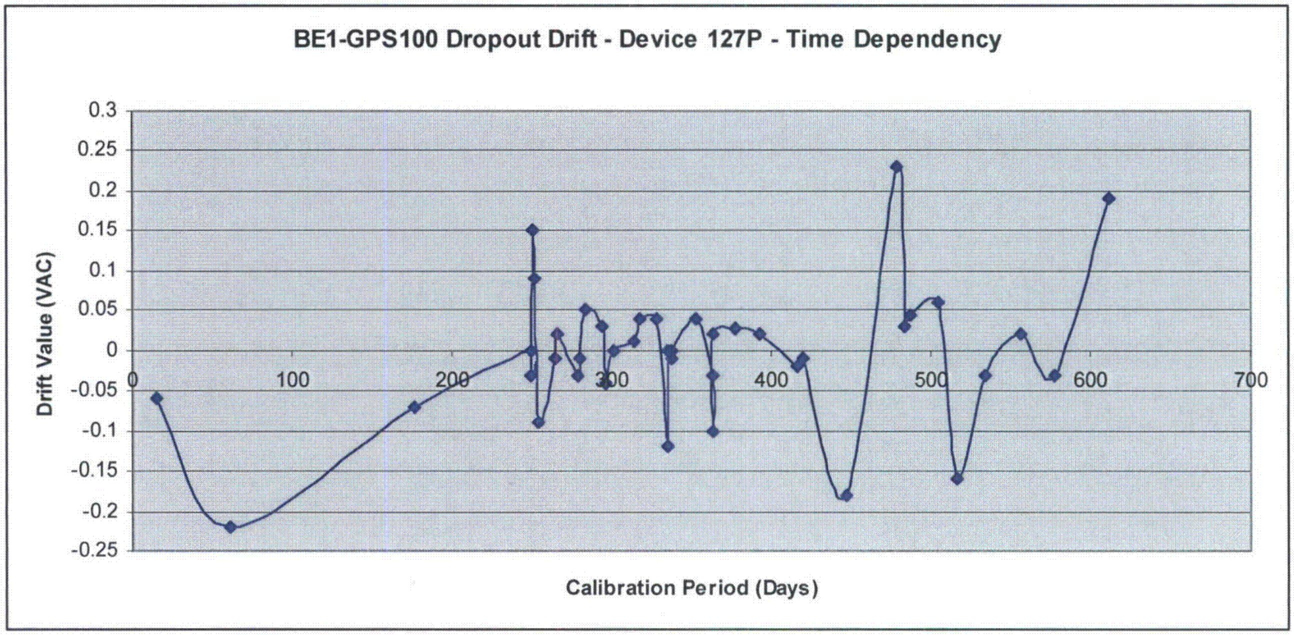
Minimum calibration period: 15 days with -0.18VAC drift and maximum 612 days (~20 months) calibration period with 0.05 VAC drift.



Device 127P

The correlation between calibration period and magnitude of drift is equal to 0.295. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

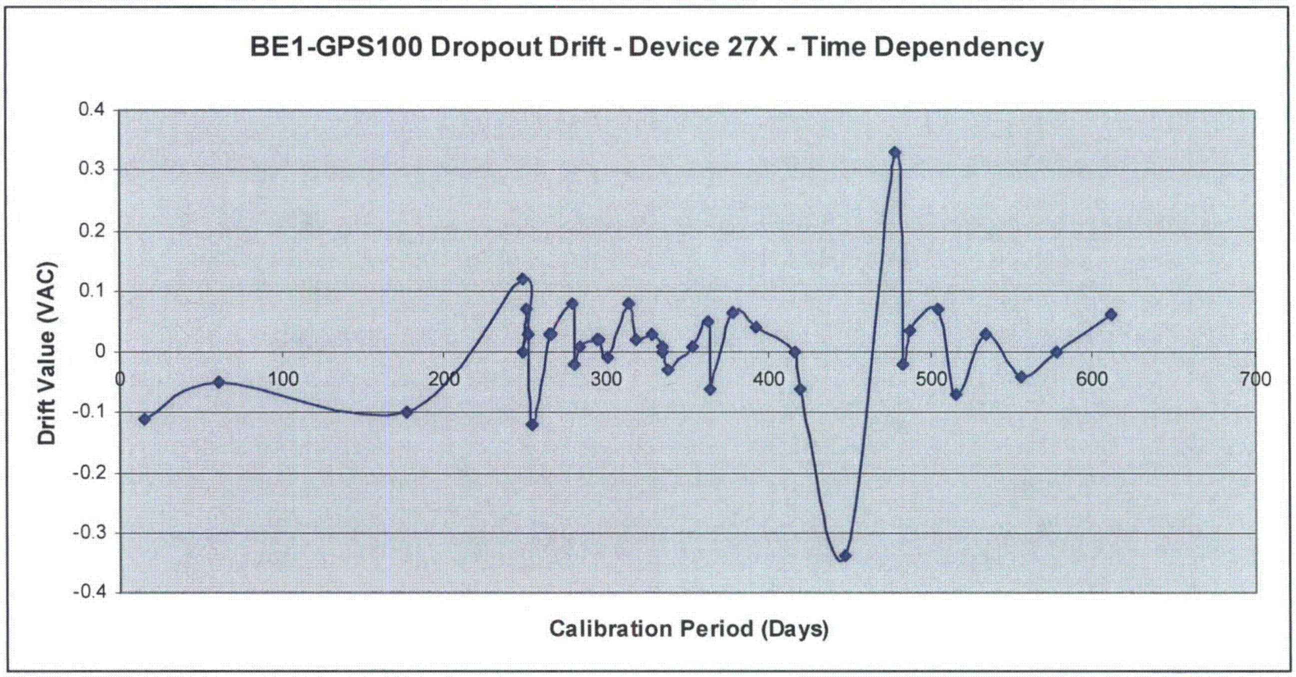
Minimum calibration period: 15 days with -0.06VAC drift and maximum 612 days (~20 months) calibration period with 0.19 VAC drift.



Device 27X

The correlation between calibration period and magnitude of drift is equal to 0.14. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

Minimum calibration period: 15 days with -0.11VAC drift and maximum 612 days (~20 months) calibration period with 0.06 VAC drift.



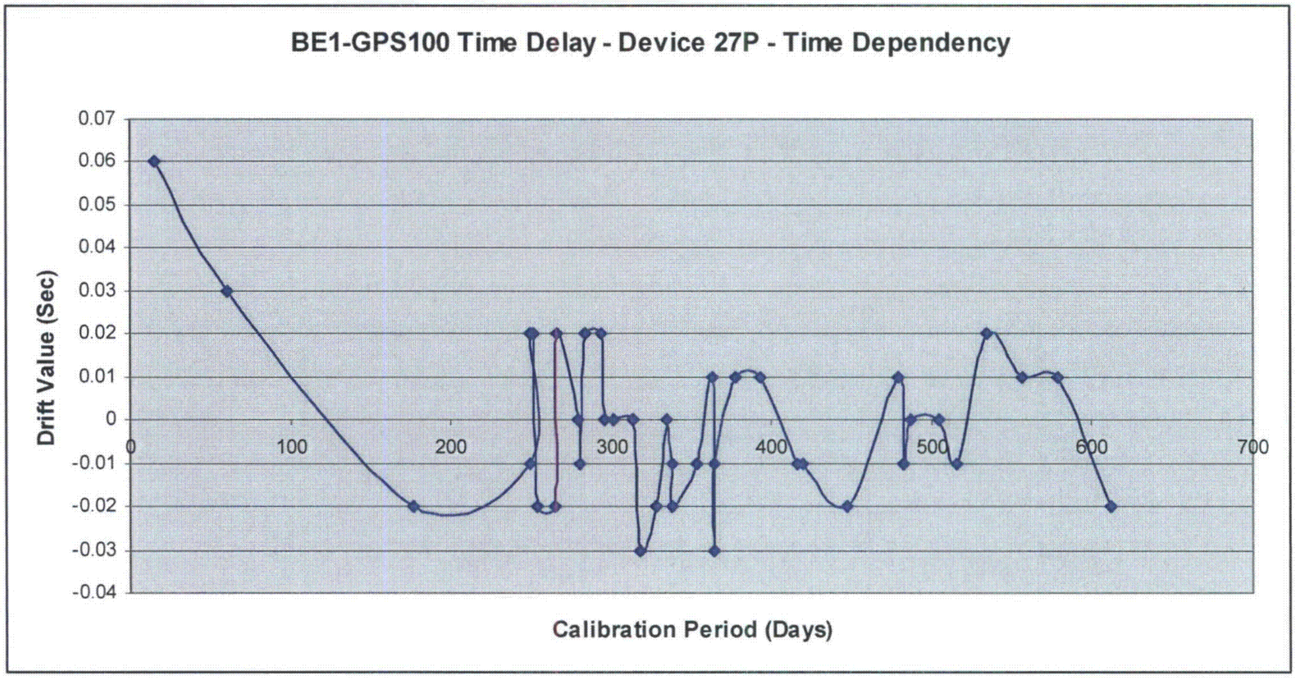
Time Dependency Test - Undervoltage Time Delay Drift:

ATTACHMENT "3"

Device 27P

The correlation between calibration period and magnitude of drift is equal to -0.33. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

Minimum calibration period: 15 days with 0.06 Sec drift and maximum 612 days (~20 months) calibration period with -0.02 Sec drift.

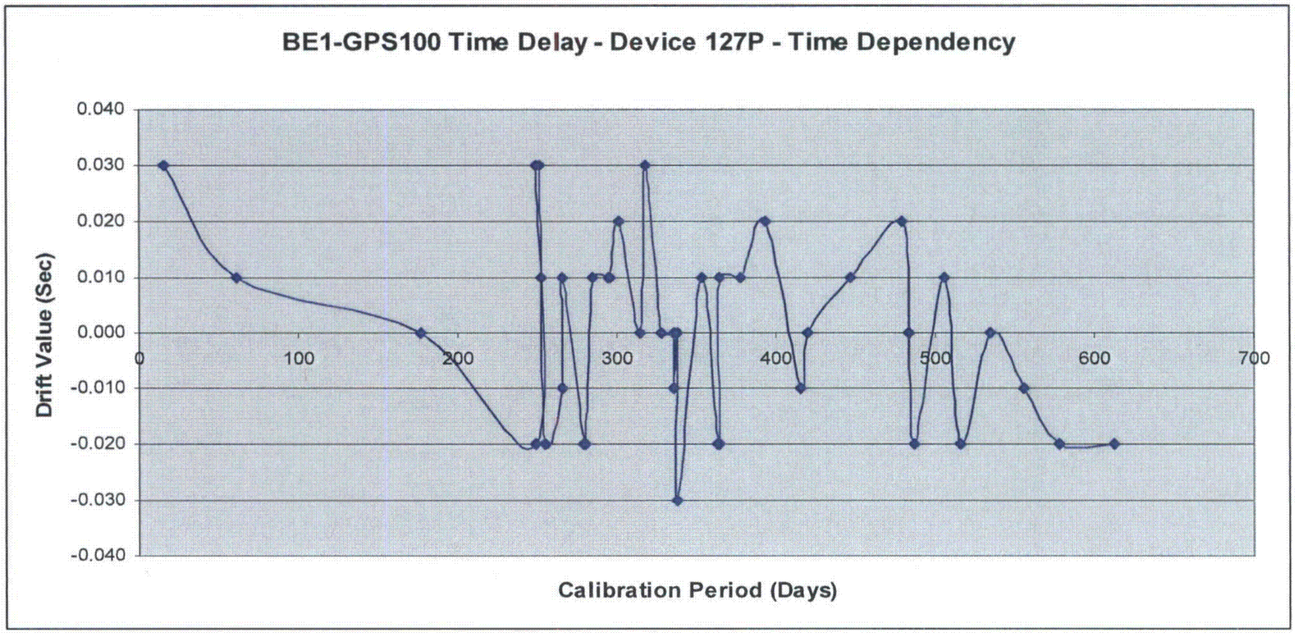


Device 127P

The correlation between calibration period and magnitude of drift is equal to -0.34. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

Minimum calibration period: 15 days with 0.03 Sec drift and maximum 612 days (~20 months) calibration period with -0.02 Sec drift.

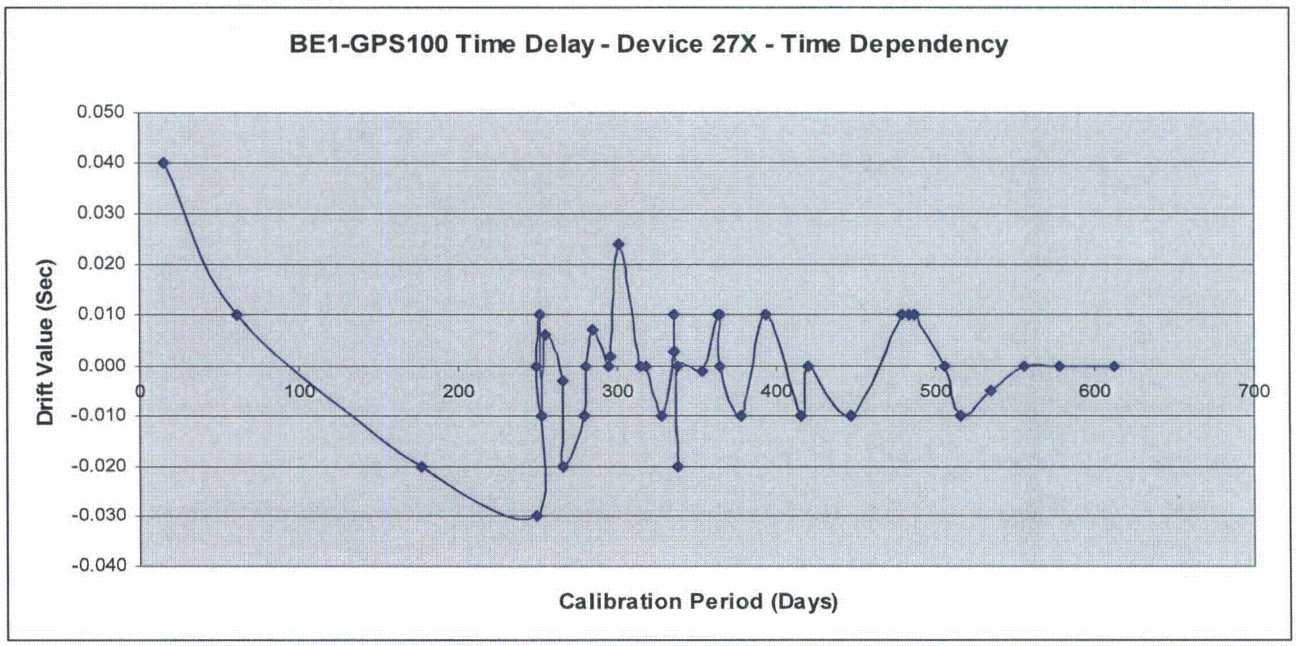
ATTACHMENT "3"



Device 27X

The correlation between calibration period and magnitude of drift is equal to -0.15. Since this value is less than 0.4 criteria established in CF6.NE1, Appendix 8.4, paragraph 4.8, it is concluded that there is no correlation between calibration period and magnitude of drift.

Minimum calibration period: 15 days with 0.04 Sec drift and maximum 612 days (~20 months) calibration period with 0 Sec drift.



ATTACHMENT "3"

Dropout Setpoint Drift Normalcy Test

Device 27P

Number of Data Points	41
Kurtosis	2.759
Skewness	0.462
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Device 127P

Number of Data Points	41
Kurtosis	1.827
Skewness	0.095
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Device 27X

Number of Data Points	41
Kurtosis	7.342
Skewness	-0.247
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Time Delay Setpoint Drift Normalcy Test

Device 27P

Number of Data Points	41
Kurtosis	1.254
Skewness	0.751
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Device 127P

Number of Data Points	41
Kurtosis	-0.925
Skewness	0.088
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Device 27X

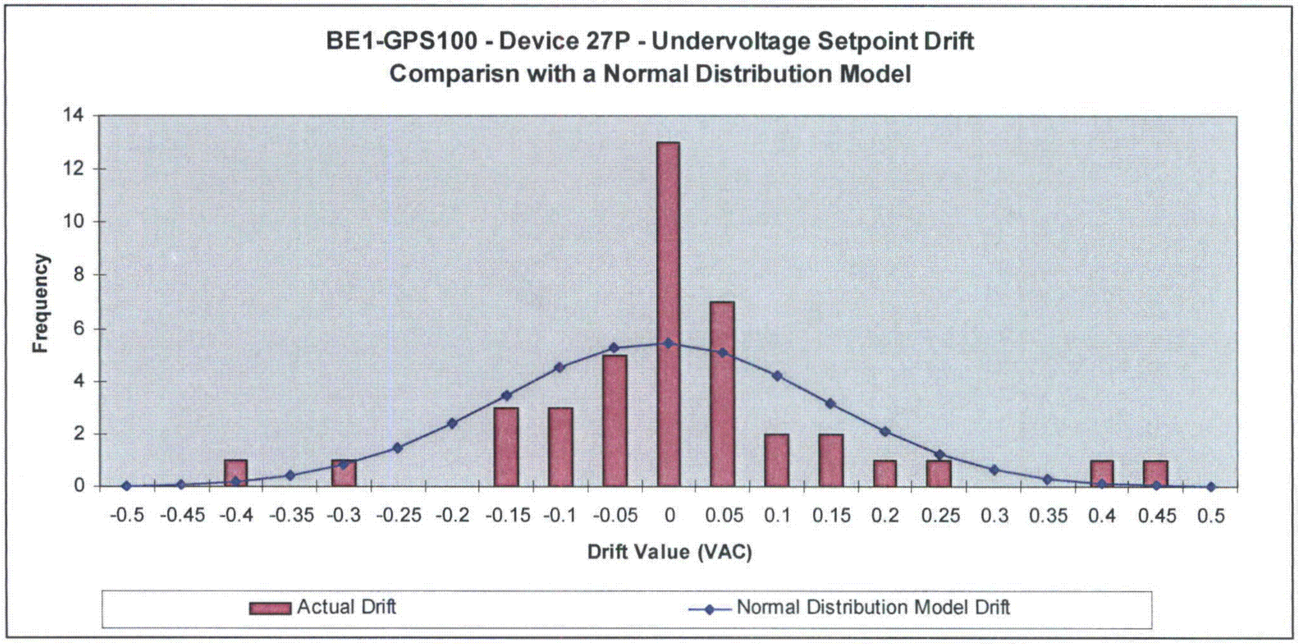
Number of Data Points	41
Kurtosis	7.342
Skewness	-0.247
Limits of Kurtosis (CF6.NE1, Table 8.4-3)	>-0.882 & <+1.364 (Note: Limits established by extrapolation)
Limit of Skewness (CF6.NE1, Table 8.4-2)	<0.587

Data fails the normalcy test

Undervoltage Dropout Setpoint Drift – Limits Determination

Device 27P

Mean	-0.0073 VAC
Standard Deviation	0.149 VAC
Min Drift	-0.41 VAC
Max Drift	+0.43 VAC



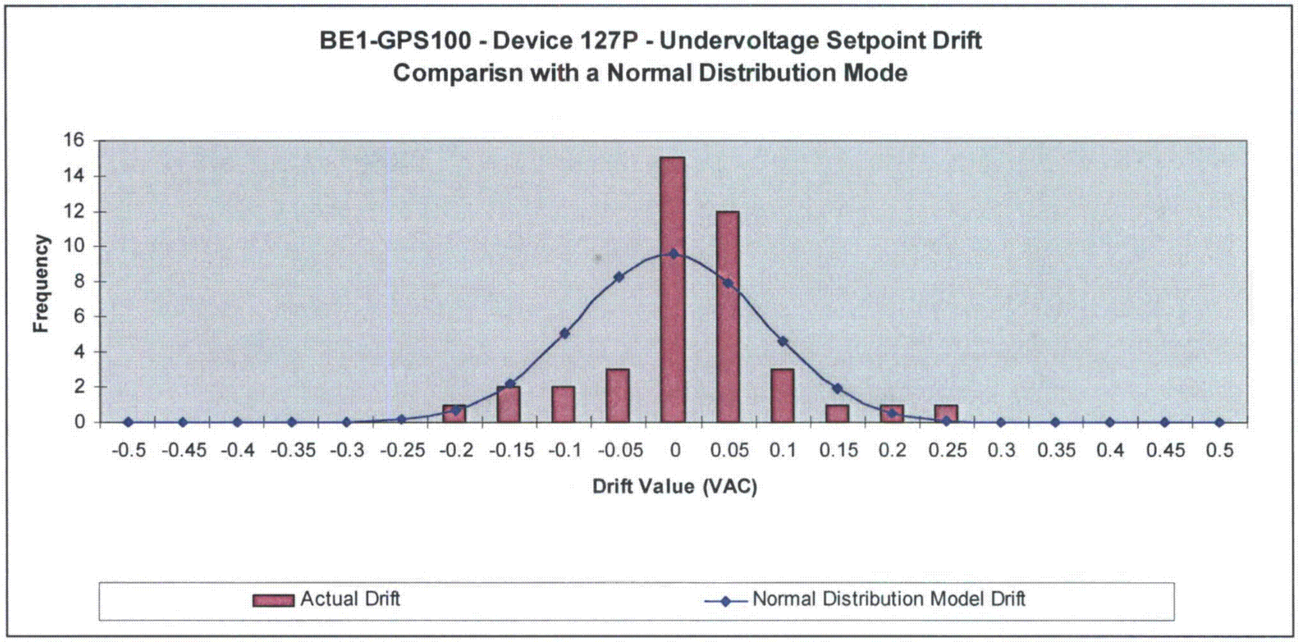
Although the drift data fails the normalcy test since all historical drift data falls within -0.45 to + 0.45VAC, for the purpose of conservatism a drift value of ±0.50 VAC will be used for Device 27P.

DR_{27P} = ±0.50 VAC

Device 127P

Mean	-0.0037 VAC
Standard Deviation	0.085 VAC
Min Drift	-0.22 VAC
Max Drift	+0.23 VAC

ATTACHMENT "3"

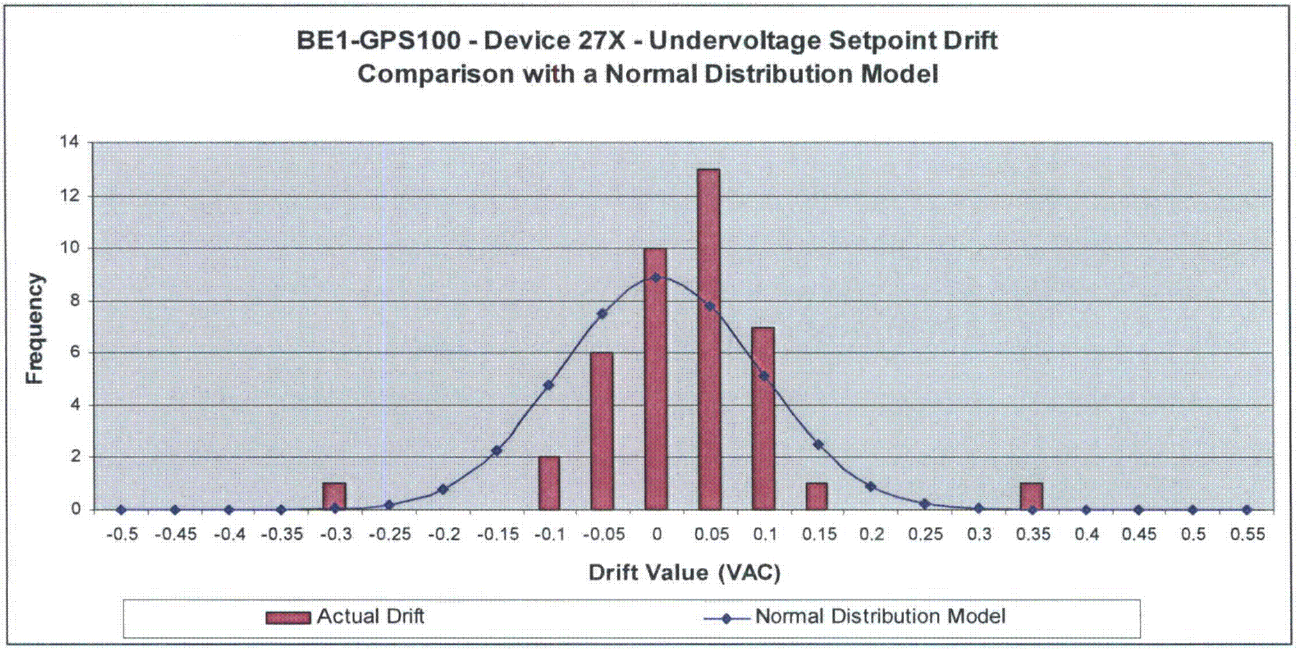


Although the drift data fails the normalcy test since all historical drift data falls within -0.25 to + 0.25VAC, for the purpose of conservatism a drift value of ±0.30 VAC will be used for Device 127P.

DR_{127P} = ±0.30 VAC

Device 27X

Mean	0.0029 VAC
Standard Deviation	0.092 VAC
Min Drift	-0.34 VAC
Max Drift	+0.33 VAC



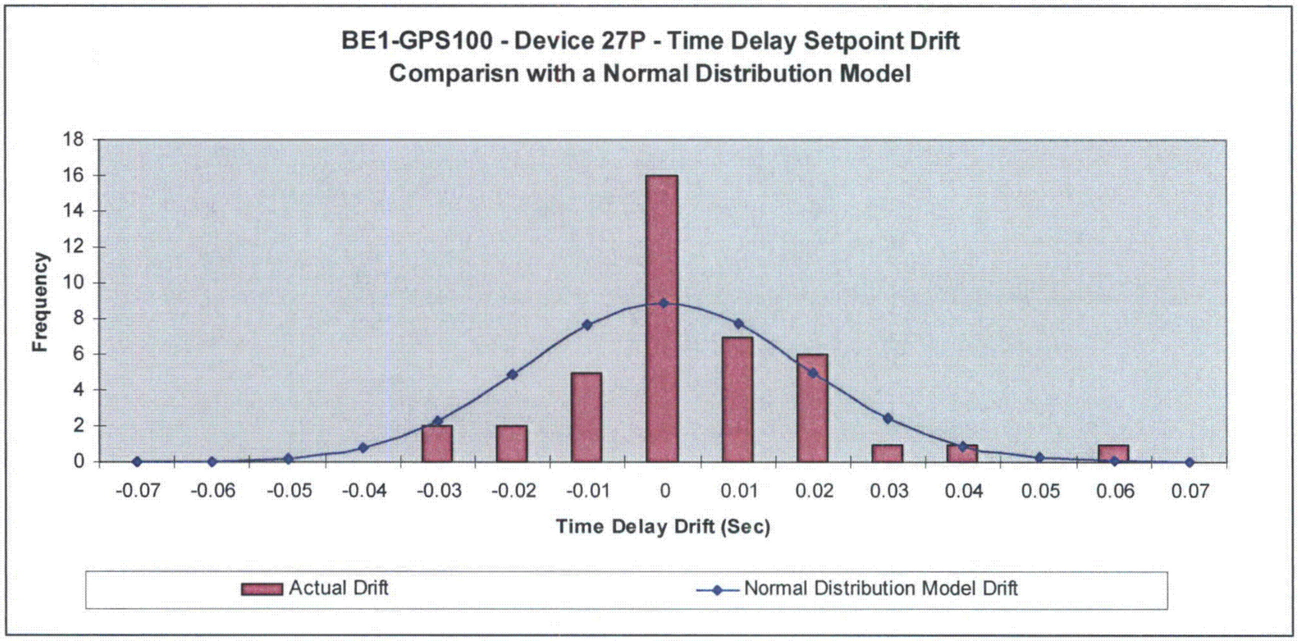
Although the drift data fails the normalcy test since all historical drift data falls within -0.35 to + 0.35VAC, for the purpose of conservatism a drift value of ±0.40 VAC will be used for Device 27X.

DR_{27X} = ±0.40 VAC

Undervoltage Time Delay Setpoint Drift – Limits Determination

Device 27P

Mean	-0.0002 Sec
Standard Deviation	0.0184 Sec
Min Drift	-0.03 Sec
Max Drift	+0.06 Sec

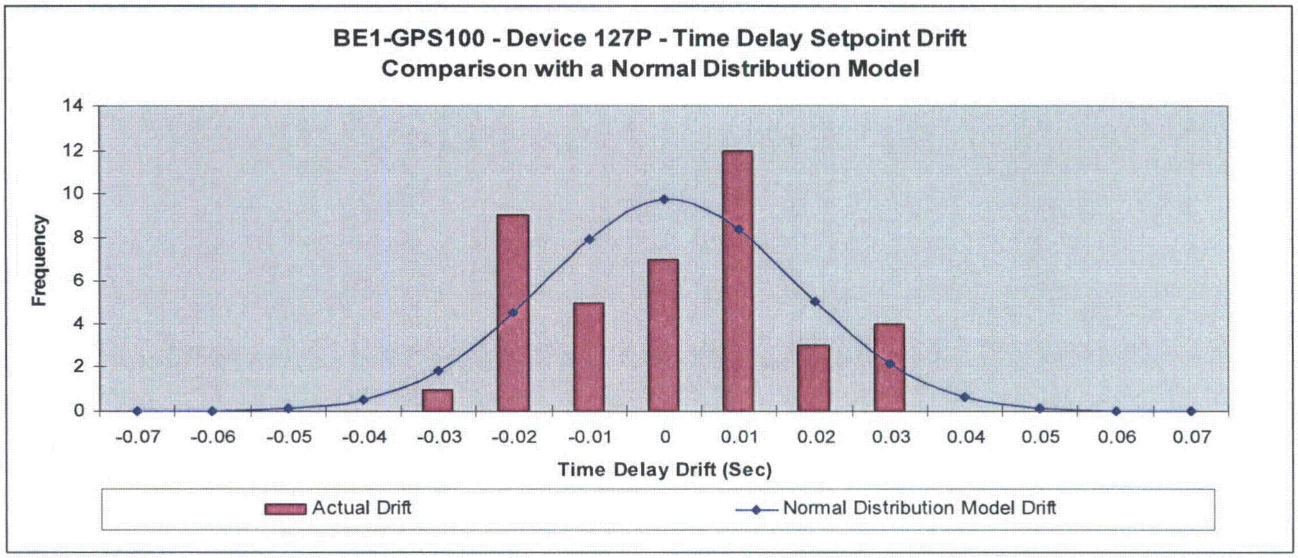


Although the drift data fails the normalcy test since all historical drift data at falls within -0.03 to + 0.06 Sec, for the purpose of conservatism a drift value of ±0.1 Sec will be used for Device 27P.

DR_{27P} = ±0.1 Sec

Device 127P

Mean	0.0007 Sec
Standard Deviation	0.017 Sec
Min Drift	-0.03 Sec
Max Drift	+0.03 Sec

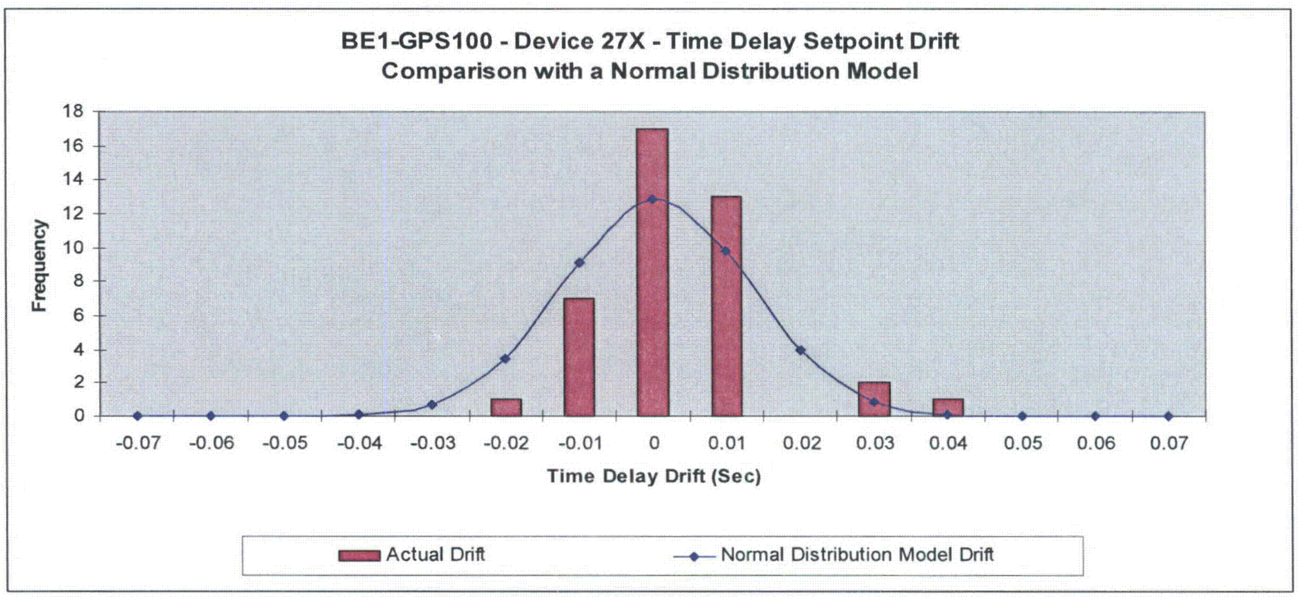


Although the drift data fails the normalcy test since all historical drift data falls within -0.03 to + 0.03 Sec, for the purpose of conservatism a drift value of ±0.05 Sec will be used for Device 127P.

DR_{127P} = ±0.05 Sec

Device 27X

Mean	0.0006 Sec
Standard Deviation	0.013 Sec
Min Drift	-0.03 Sec
Max Drift	+0.04 Sec



Although the drift data fails the normalcy test since all historical drift data falls within -0.03 to + 0.04 Sec, for the purpose of conservatism a drift value of ±0.05 Sec will be used for Device 27X.

DR_{27X} = ±0.05 Sec

ATTACHMENT "3"

ABB 27N Drift Calculation
(Units 1&2: 27H*T1A, , 27H*T1B & 27H*T1C)
* is F for Bus "F", G for Bus "G" and H for bus "H"

SUMMARY

DCPP does not currently have calibration data for the ABB 27N. In addition ABB does not publish drift values for the ABB 27N series of relays. Per CF6.NE1 [Reference 12.1.1] section 2.3, in the absence of vendor supplied drift data or calibration data, sensor drift value will default to ±2.0% of span. For the ABB 27N series of relays, the pick-up setting is first selected using a combination of a voltage tap and a potentiometer [Reference 12.1.51]. ABB was contacted to determine the range of the potentiometer for each tap setting. ABB tested one 27N relay at the 70V, 80V and high end of the 120V tap [Reference 12.1.57]. The conclusions of this test determine that the potentiometer allows a span of -12% of tap setting and +5% of tap setting. Hence this calculation assumes [Assumption 3.6] that the range is established as such. In addition the dropout voltage is set as a percentage of the pick-up voltage. This calculation will specify a setpoint for the dropout setting and the pickup will be calculated as a percentage of the dropout setting. Accordingly, this calculation assumes that the uncertainty impacts the dropout setting and that the dropout and pickup settings will drift together in the same direction and not independently of each other. [Assumption 3.7]. For this calculation pickup uncertainty will not be a factor.

27HxT1A Dropout Voltage Drift: ±0.34 VAC
27HxT1A Time Delay Drift: ±0.18 Sec
27HxT1B Dropout Voltage Drift: ±0.31 VAC
27HxT1B Time Delay Drift: ±0.18 Sec
27HxT1C Dropout Voltage Drift: ±0.27 VAC
27HxT1C Time Delay Drift: ±0.18 Sec

ANALYSIS

27HxT1A Pickup Voltage Drift:

Per Reference 12.1.51, the Pickup voltage point is set as follows:

The Pickup tap is set to the nearest value to the desired setting. The calibration potentiometer [R27] will allow fine tuning of the pickup setting to a span from -12% of tap setting to +5% of tap setting.

Per Reference 12.1.51, Pickup tap has values of 60, 70, 80, 90, 100 or 110 volts.

Setpoint = 96.5 VAC
Tap = 100 VAC
Span = 100-12%:100+5% = 88VAC:105VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 88 and 105 volts or 0.34 volts.

27HxT1A Time Delay Drift:

Per Reference 12.1.51, ABB 27N relays are available with a definite time delay. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range. The T1A relays will all be set with a time delay of 8 seconds hence only models using the 1-10 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 1-10 seconds or 0.18 seconds.

27HxT1B Pickup Voltage Drift:

Setpoint = 90.5 VAC
Tap = 90 VAC
Span = 90-12%:90+5% = 79.2VAC:94.5VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 79.2 and 94.5 volts or 0.31 volts.

27HxT1B Time Delay Drift:

Per Reference 12.1.51, ABB 27N relays are available with a definite time delay. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range. The T1B relays will all be set with a time delay of 5 seconds hence only models using the 1-10 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 1-10 seconds or 0.18 seconds.

27HxT1C Pickup Voltage Drift:

Setpoint = 78.6 VAC
Tap = 80 VAC
Span = 80-12%:80+5% = 70.4VAC:84VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 70.4 and 84 volts or 0.27 volts.

27HxT1C Time Delay Drift:

Per Reference 12.1.51, ABB 27N relays are available with a definite time delay. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range. The T1A relays will all be set with a time delay of 3 seconds hence only models using the 1-10 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 1-10 seconds or 0.18 seconds.

ATTACHMENT "3"

ABB 59N Drift Calculation
(Units 1&2: 27HFT2, 27HGT2, 27HHT2, 27HFB3/4, 27HGB3/4 & 27HHB3/4)

SUMMARY

DCPP does not currently have calibration data for the ABB 59N. In addition ABB does not publish drift values for the ABB 59N series of relays. Per CF6.NE1 [Reference 12.1.1] section 2.3, in the absence of vendor supplied drift data or calibration data, sensor drift value will default to ±2.0% of span. For the ABB 59N series of relays, the pick-up setting is first selected using a combination of a voltage tap and a potentiometer [Reference 12.1.51]. ABB was contacted to determine the range of the potentiometer for each tap setting. ABB tested one 27N relay at the 70V, 80V and high end of the 120V tap [Reference 12.1.57]. The conclusions of this test determine that the potentiometer allows a span of -12% of tap setting and +5% of tap setting. Due to the similarity in the 27N and 59N relay design, this calculation assumes [Assumption 3.6] that the range for the 59N relays is established in the same manner as the 27N relay. In addition the dropout voltage is set as a percentage of the pick-up voltage. This calculation will specify a setpoint for the dropout setting and the pickup will be calculated as a percentage of the dropout setting. Accordingly, this calculation assumes that the uncertainty impacts the dropout setting and that the dropout and pickup settings will drift together in the same direction and not independently of each other. [Assumption 3.7]. For this calculation pickup uncertainty will not be a factor.

27HxT2 Dropout Voltage Drift: ±0.34 VAC
27HxT2 Time Delay Drift: ±0.02 Sec
27HxB3 Dropout Voltage Drift: ±0.37 VAC
27HxB3 Time Delay Drift: ±0.02 Sec
27HxB4 Dropout Voltage Drift: ±0.37 VAC
27HxB4 Time Delay Drift: ±0.02 Sec

ANALYSIS

27HxT2 Pickup Voltage Drift:

Per Reference 12.1.51, the Pickup voltage point is set as follows:

The Pickup tap is set to the nearest value to the desired setting. The calibration potentiometer [R27] will allow fine tuning of the pickup setting to a span from -12% of tap setting to +5% of tap setting.

Per Reference 12.1.51, Pickup tap has values of 100, 110, 120, 130, 140 or 150 volts.

Setpoint = 98 VAC
Tap = 100 VAC
Span = 100-12%:100+5% = 88VAC:105VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 88 and 105 volts or 0.34 volts.

27HxT2 Time Delay Drift (on Pickup):

Per Reference 12.1.51, ABB 59N relays are available with a definite time delay. In order to use the harmonic filter on the 59N relays, a time delay must be used. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range and will apply to the relay pickup (reset). The T2 relays will all be set with a time delay of 0.1 seconds hence only models using the 0.1-1 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 0.1-1 seconds or 0.02 seconds.

27HxB3 Pickup Voltage Drift:

Setpoint = 109.25 VAC
Tap = 110 VAC
Span = 110-12%:110+5% = 96.8VAC:115.5VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 96.8 and 115.5 volts or 0.37 volts.

27HxB3 Time Delay Drift (on Pickup):

Per Reference 12.1.51, ABB 59N relays are available with a definite time delay. In order to use the harmonic filter on the 59N relays, a time delay must be used. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range and will apply to the relay pickup (reset). The B3 relays will all be set with a time delay of 0.1 seconds hence only models using the 0.1-1 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 0.1-1 seconds or 0.02 seconds.

27HxB4 Pickup Voltage Drift:

Setpoint = 108.25 VAC
Tap = 110 VAC
Span = 110-12%:110+5% = 96.8VAC:115.5VAC

Hence per the guidance of CF6.NE1 the Dropout Voltage Drift value for a 30 month calibration period is assumed to be 2% of the span between 96.8 and 115.5 volts or 0.37 volts.

27HxB4 Time Delay Drift (on Pickup):

Per Reference 12.1.51, ABB 59N relays are available with a definite time delay. In order to use the harmonic filter on the 59N relays, a time delay must be used. The time delay is available with a 0.1-1 second range, 1-10 second range, 2-20 second range and a 10-100 second range and will apply to the relay pickup (reset). The B3 relays will all be set with a time delay of 0.1 seconds hence only models using the 0.1-1 second range will be used.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 0.1-1 seconds or 0.02 seconds.

ABB 62T Time Delay Relay Drift Calculation
(Units 1&2: 62HF3A, 62HG3A, 62HH3A, 62HF3B, 62HG3B, 62HH3B)

SUMMARY
DCPP does not currently have calibration data for the ABB 62T. In addition ABB does not publish drift values for the ABB 62T series of relays. Per CF6.NE1 [Reference 12.1.1] section 2.3, in the absence of vendor supplied drift data or calibration data, sensor drift value will default to ±2.0% of span [Reference 12.1.52]:

Time Delay Drift 62H*3A Relays: ±0.17 Sec
Time Delay Drift 62H*3B Relays: ±0.37 Sec

ANALYSIS

Time Delay Drift:

Per Reference 12.1.52, ABB 62T relays are solid state digital timers. The time delay is available with a 0.001-0.999 second range, 0.01-9.99 second range, 00.1-99.9 second range and a 001-999 second range.

The 62H*3A relays will use the 0.01-9.99 second range. However since the setpoint is set using thumbwheels in a digital circuit, the drift only applies to the oscillator circuit for the duration of the timing. Hence the span considered for drift will only be from 0 to the 8.5 sec setpoint.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 0-8.50 seconds or 0.17 seconds.

The 62H*3B relays will use the 0.1-99.9 second range. However since the setpoint is set using thumbwheels in a digital circuit, the drift only applies to the oscillator circuit for the duration of the timing. Hence the span considered for drift will only be from 0 to the 18.5 sec setpoint.

Per the guidance of CF6.NE1 the Time Delay Drift value for a 30 month calibration period is assumed to be 2% of the span between 0-18.50 seconds or 0.37 seconds

MTS-1710 Universal Protective Relay Test System
Condensed Specifications

NOTE: This product has been superceded by the MTS-5000 Protective Relay Test System

Power Supply

Single phase 105-130 VAC @ 15A max (or 210-250 VAC @8A max when ordered with option 15), factory set, 47-63 Hz

---

Outputs

3-phase wye voltage:

- 0-150V rms phase-neutral, direct coupled
- 85 VA (1.13A) per phase maximum @ 75V phase-neutral output, P.F.=1.0
- 120 VA per phase maximum @ 150V phase-neutral output, P.F.=1

Single phase current:

- Switched to 3 phase output terminals, direct coupled

- 0-30A rms, 400 VA maximum, 44V rms maximum

Additional current modes:

- For simultaneous 3-phase current, MTS-1720 required
- 0-6A DC mode
- Two mixed harmonic current modes for harmonic restraint testing:
  - Sum of fundamental frequency current and pure second harmonic current
  - Sum of fundamental frequency current and half-wave rectified fundamental DC current
- High AC current 0-75A @3V mode for instantaneous tests (7.5 maximum compliance voltage)
- Parallel current mode allows paralleling of current outputs of MTS-1710 & MTS-1720 for up to 90amps max, 1000VA max, 44Vrms max
- Dual AC current mode for slope tests (I1: 60A maximum, 50A @3.5V, I2: see single phase current)

Note: For all current outputs, maximum obtainable current will vary inversely with load impedance.

Output frequency:

- Power line (frequency and phase locked)
- 2nd through 10th harmonic of power line
- Variable
  - 40.00 - 80.00 Hz (0.001 Hz resolution, 0.01% accuracy)
  - 80 - 800 Hz (0.01 Hz resolution, 0.02% accuracy)
- 25 Hz frequency mode

Four output level settings:

- Off, prefault, fault, postfault

Phase control:

- Phase between current and any voltage is adjustable from 0 through 360 degrees
- Adjustment resolution: 0.25 degrees

Inputs

Start/Stop trigger inputs:

- For externally triggering fault initiation/termination
- NC or NO wet/dry contact sensing
- DC/AC voltage sensing (10V threshold level, 52k ohms input impedance minimum)

ATTACHMENT "4"

Metering

AC Voltage measurements:

- A-N, B-N, C-N, A-B, B-C, C-A
- True RMS responding, autoranging
- Voltage scales (approx):0-82V, 82-327V
- Accuracy: +/-0.5% of reading +/-0.2% of scale

AC Current measurements:

- Measures actual output current
- True RMS responding, autoranging
- Current scales (approx): 0-8.2A, 8.2-32.7A
- High current scales (approx): 0-24.5A, 24.5-98.3A
- Accuracy: +/-0.5% of reading +/-0.2% of scale

DC Current measurement:

- 0 - 10.00A scale
- Accuracy: +/-1% of reading +/-0.2% of scale

Phase measurement:

- Accuracy: +/-0.5 degrees
- 0-359.9 deg. or 0 - +/-180 deg. display modes
- Selectable V-leads-I or I-leads-V measurement reference

Time measurement:

- Measures interval from either fault initiation or external start trigger signal
- 0 - 99999 sec, autoranging scale
- 0 - 99999 cycles, autoranging scale
- Best resolution: 0.1 ms/ 0.1 cycles
- Two-wire pulse timing mode
- Accuracy: 0 - 9.9999 sec scale: +/-0.5ms +/- 1LS digit, all other scales: +/-0.005% +/-1 digit

Frequency measurement:

- Power line frequency measurement (accuracy & resolution: 0.01 Hz)
- Variable frequency value displayed to 0.001 Hz resolution

Computed measurements

- Impedance (V/I, V/2I , V/SQRT(3)I, V/(1+kI)) with programmable k-factor
- Resistance (Re[V/I], Re[V/2I] , Re[V/SQRT(3)I], Re[V/(1+kI)]) with programmable k-factor
- Reactance (Im[V/I], Im[V/2I] , Im[V/SQRT(3)I], Im[V/(1+kI)]) with programmable k-factor
- Single phase power (Watts, Vars, VA, PF)
- I1/I2, I2/I1, ABS(I1-I2)/((I1+I2)/2) & I2/((2 I1+I2)/2) with programmable CT tap values for I1, I2
- Volts-per-Hz
- Breaker advance time, breaker closing angle

HP 34401A Multimeter

Uncompromising performance for benchtop and system testing

- **Measure up to 1000 volts with 6 1/2 digits resolution**
- **dc accuracy of 0.0015%**
- **ac accuracy of 0.06%**
- **3Hz to 300kHz ac bandwidth**
- **1000 readings/sec. direct to HP-IB**

Superior performance

The HP 34401A multimeter gives you the performance you need for fast, accurate bench and systems testing. The HP 34401A provides a combination of resolution, accuracy and speed that rivals DMMs costing many times more. A 6 1/2-digit display, 0.0015% Basic 24-hr dcV accuracy and 1,000 readings/sec direct to HP-IB assure you of results that are accurate, fast, and repeatable.

Use it on your benchtop

The HP 34401A was designed with your bench needs in mind. Functions commonly associated with pure bench operation, like continuity and diode test, are built in. A Null feature allows you to remove lead resistance or other fixed offsets in your measurements. Other capabilities like min/max/avg readouts and direct dB and dBm measurements make checkout with your DMM faster and easier.

When you want to store readings for future reference, the HP 34401A gives you the ability to store up to 512 readings in internal memory. For troubleshooting, a reading hold feature lets you concentrate on placing your test leads without having to constantly glance at the display.

Use it for systems testing

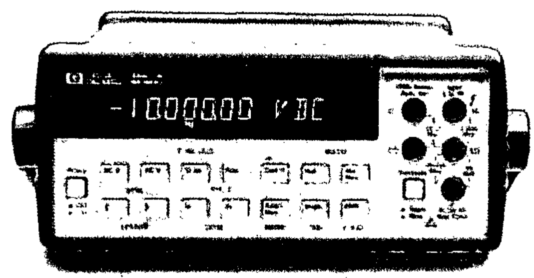
For systems use, the HP 34401A gives you faster bus throughput than any other DMM in its class. The HP 34401A can send up to 1,000 readings/sec directly across HP-IB in user-friendly ASCII format.

You also get both HP-IB and RS-232 interfaces as standard features. Voltmeter Complete and External Trigger signals are provided so you can synchronize to other instruments in your test system. In addition, a TTL output indicates Pass/Fail results when limit testing is used.

To ensure both forward and backward compatibility, the HP 34401A includes three command languages (SCPI, HP 3478A and Fluke 8840A /42A), so you don't have to rewrite your existing test software. An optional rack mount kit is available.

Easy to use

To save you time and trouble, all major functions, like selecting the function, range and number of digits, can be accessed on the front panel with one push of a button.



Advanced features are available using menu functions that let you optimize the HP 34401A for your applications.

To further increase your productivity, the HP 34401A can be used in conjunction with HP 34812A BenchLink Meter software. The Windows-based program lets you configure and initiate measurements from your computer, and transfer results from your test instrument to your PC. It even enables direct temperature measurements with the HP 34401A and an RTD or thermistor probe. HP BenchLink Meter also lets you create graphs, charts and histograms to help you evaluate results.

3-year warranty

With your HP 34401A, you get full documentation, a high-quality test lead set, calibration certificate with test data, and a 3-year warranty, all for one low price.

ATTACHMENT "5"

Accuracy Specifications ± (% of reading + % of range)[1]

Function	Range[3]	Frequency, etc.	24 Hour[2] 23°C ± 1°C	90 Day 23°C ± 5°C	1 Year 23°C ± 5°C	Temperature Coefficient 0°C – 18°C 28°C – 55°C
dc Voltage	100.0000 mV		0.0030 + 0.0030	0.0040 + 0.0035	0.0050 + 0.0035	0.0005 + 0.0005
	1.000000 V		0.0020 + 0.0006	0.0030 + 0.0007	0.0040 + 0.0007	0.0005 + 0.0001
	10.00000 V		**0.0015 + 0.0004**	**0.0020 + 0.0005**	**0.0035 + 0.0005**	**0.0005 + 0.0001**
	100.0000 V		0.0020 + 0.0006	0.0035 + 0.0006	0.0045 + 0.0006	0.0005 + 0.0001
	1000.000 V		0.0020 + 0.0006	0.0035 + 0.0010	0.0045 + 0.0010	0.0005 + 0.0001
True rms ac Voltage[4]	100.0000 mV	3 Hz - 5 Hz	1.00 + 0.03	1.00 + 0.04	1.00 + 0.04	0.100 + 0.004
		5 Hz - 10 Hz	0.35 + 0.03	0.35 + 0.04	0.35 + 0.04	0.035 + 0.004
		10 Hz - 20 kHz	0.04 + 0.03	0.05 + 0.04	0.06 + 0.04	0.005 + 0.004
		20 kHz - 50 kHz	0.10 + 0.05	0.11 + 0.05	0.12 + 0.04	0.011 + 0.005
		50 kHz - 100 kHz	0.55 + 0.08	0.60 + 0.08	0.60 + 0.08	0.060 + 0.008
		100 kHz - 300 kHz[6]	4.00 + 0.50	4.00 + 0.50	4.00 + 0.50	0.20 + 0.02
	1.000000 V to 750.000 V	3 Hz - 5 Hz	1.00 + 0.02	1.00 + 0.03	1.00 + 0.03	0.100 + 0.003
		5 Hz - 10 Hz	0.35 + 0.02	0.35 + 0.03	0.35 + 0.03	0.035 + 0.003
		10 Hz - 20 kHz	**0.04 + 0.02**	**0.05 + 0.03**	**0.06 + 0.03**	**0.005 + 0.003**
		20 kHz - 50 kHz	0.10 + 0.04	0.11 + 0.05	0.12 + 0.05	0.011 + 0.005
		50 kHz - 100 kHz[5]	0.55 + 0.08	0.60 + 0.08	0.60 + 0.08	0.060 + 0.008
		100 kHz - 300 kHz[6]	4.00 + 0.50	4.00 + 0.50	4.00 + 0.50	0.20 + 0.02
Resistance[7]	100.0000 Ω	1 mA Current Source	0.0030 + 0.0030	0.008 + 0.004	0.010 + 0.004	0.0006 + 0.0005
	1.000000 kΩ	1 mA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	10.00000 kΩ	100 µA	**0.0020 + 0.0005**	**0.008 + 0.001**	**0.010 + 0.001**	**0.0006 + 0.0001**
	100.0000 kΩ	10 µA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	1.000000 MΩ	5.0 µA	0.002 + 0.001	0.008 + 0.001	0.010 + 0.001	0.0010 + 0.0002
	10.00000 MΩ	500 nA	0.015 + 0.001	0.020 + 0.001	0.040 + 0.001	0.0030 + 0.0004
	100.0000 MΩ	500 nA || 10 MΩ	0.300 + 0.010	0.800 + 0.010	0.800 + 0.010	0.1500 + 0.0002
dc Current	10.00000 mA	<0.1 V Burden Voltage	0.005 + 0.010	0.030 + 0.020	0.050 + 0.020	0.002 + 0.0020
	100.0000 mA	<0.6 V	**0.010 + 0.004**	**0.030 + 0.005**	**0.050 + 0.005**	**0.002 + 0.0005**
	1.000000 A	<1 V	0.050 + 0.006	0.080 + 0.010	0.100 + 0.010	0.005 + 0.0010
	3.00000 A	<2 V	0.100 + 0.020	0.120 + 0.020	0.120 + 0.020	0.005 + 0.0020
True rms ac Current[4]	**1.000000 A**	3 Hz - 5 Hz	1.00 + 0.04	1.00 + 0.04	1.00 + 0.04	0.100 + 0.006
		5 Hz - 10 Hz	0.30 + 0.04	0.30 + 0.04	0.30 + 0.04	0.035 + 0.006
		10 Hz - 5 kHz	**0.10 + 0.04**	**0.10 + 0.04**	**0.10 + 0.04**	**0.015 + 0.006**
	3.00000 A	3 Hz - 5 Hz	1.10 + 0.06	1.10 + 0.06	1.10 + 0.06	0.100 + 0.006
		5 Hz - 10 Hz	0.35 + 0.06	0.35 + 0.06	0.35 + 0.06	0.035 + 0.006
		10 Hz - 5 kHz	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.015 + 0.006
Frequency or Period[8]	100 mV to 750 V	3 Hz - 5 Hz	0.10	0.10	0.10	0.005
		5 Hz - 10 Hz	0.05	0.05	0.05	0.005
		10 Hz - 40 Hz	0.03	0.03	0.03	0.001
		40 Hz - 300 kHz	**0.006**	**0.01**	**0.01**	**0.001**
Continuity	1000.0 Ω	1 mA Test Current	0.002 + 0.010	0.008 + 0.020	0.010 + 0.020	0.001 + 0.002
Diode Test	1.0000 V	1 mA Test Current	0.002 + 0.010	0.008 + 0.020	0.010 + 0.020	0.001 + 0.002

[1] Specifications are for 1hr warm-up and 6½ digits, Slow ac filter.
[2] Relative to calibration standards.
[3] 20% over range on all ranges except 1000 Vdc and 750 Vac ranges.
[4] For sinewave input >5% of range. For inputs from 1% to 5% of range and < 50 kHz, add 0.1% of range additional error.
[5] 750 V range limited to 100 kHz or 8×10^7 Volt-Hz.
[6] Typically 30% of reading error at 1 MHz.
[7] Specifications are for 4-wire ohms function or 2-wire ohms using Math Null. Without Math Null, add 0.2 Ω additional error in 2-wire ohms function.
[8] Input >100 mV. For 10 mV inputs multiply % of reading error x10.

ATTACHMENT "6"

M-447
Sht. 3 of 45

ATT 2 OF 3
CALC M-447
REV. 1

M-447
Rev. 1
11-18-83

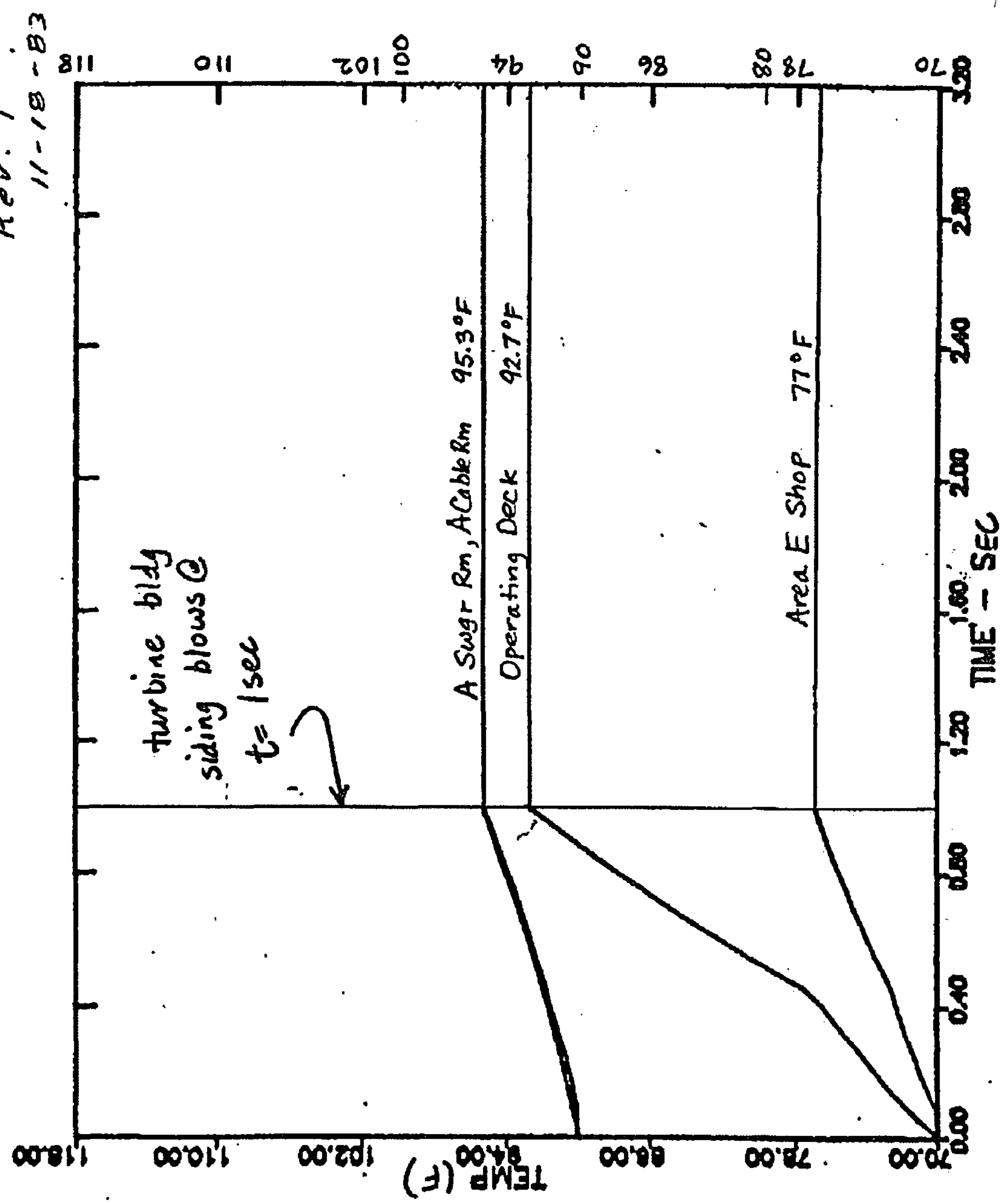
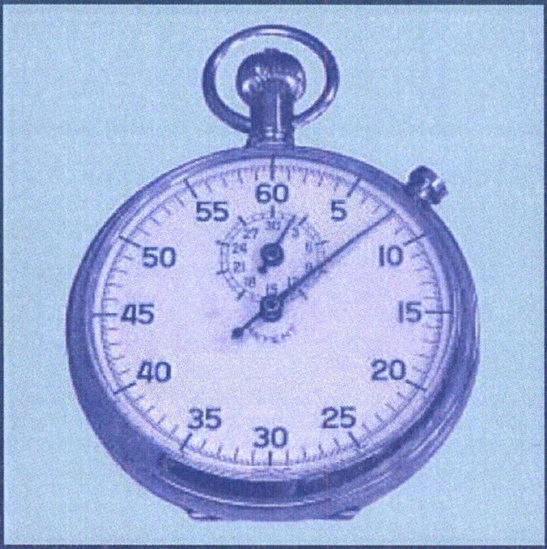


Figure 4-2 Turbine Building, Pressure vs. Time Response, MSLB at El. 140', (DER) Steam with Entrainment.

practice guide

NIST recommended

Stopwatch and Timer Calibrations



Jeff C. Gust
Robert M. Graham
Michael A. Lombardi

NIST
National Institute of Standards and Technology
Technology Administration
U.S. Department of Commerce

Special Publication 960-12

5.A.2. Uncertainty Due to Human Reaction Time

To understand the effect of human reaction time on stopwatch and timer calibration uncertainties, a small study was conducted. Four individuals were selected, and asked to calibrate a standard stopwatch using the Direct Comparison Method. Two separate experiments were conducted. In the first experiment, the operators were asked to use a traceable audio time signal, and in the second experiment, the operators were asked to use a traceable time display. The time base of the stopwatch was measured before and after each test (using the Time Base Method), and its offset from nominal was found to be small enough that it would not influence the test. Therefore, differences in readings between the stopwatch being tested and the standard would only be due to the operator's reaction time.

Each operator was asked to repeat the measurement process ten times, and the resulting difference between the standard and the stopwatch were recorded and plotted (Figure 14).

As shown in Figure 14, the average reaction time was usually less than ±100 ms, with a worst-case reaction time exceeding 700 ms.

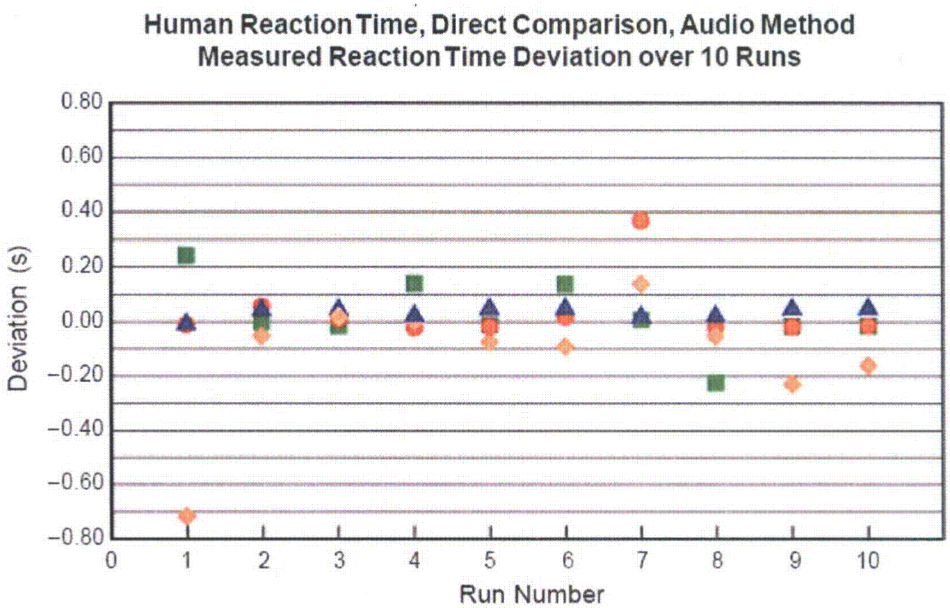


Figure 14. *Reaction time measurements (four operators, ten runs each) for the Direct Comparison Method.*

The mean and standard deviation for each operator was computed and graphed in Figure 15. This graph indicates that the average (mean) reaction time of the operator can be either negative (anticipating the audible tone) or positive (reacting after the audible tone). Figure 15 also shows that in addition to the average reaction time having a bias, the data is somewhat dispersed, so both elements of uncertainty will need to be accounted for in a complete uncertainty budget. For this experiment, the worst case mean reaction time was 120 ms and the worst case standard deviation was 230 ms. It should be noted that in the measurements recorded in Figure 15, Operators 1 and 2 had no previous experience calibrating stopwatches. Based on these results, it is recommended that each calibration laboratory perform tests to determine their operator reaction time uncertainty value.

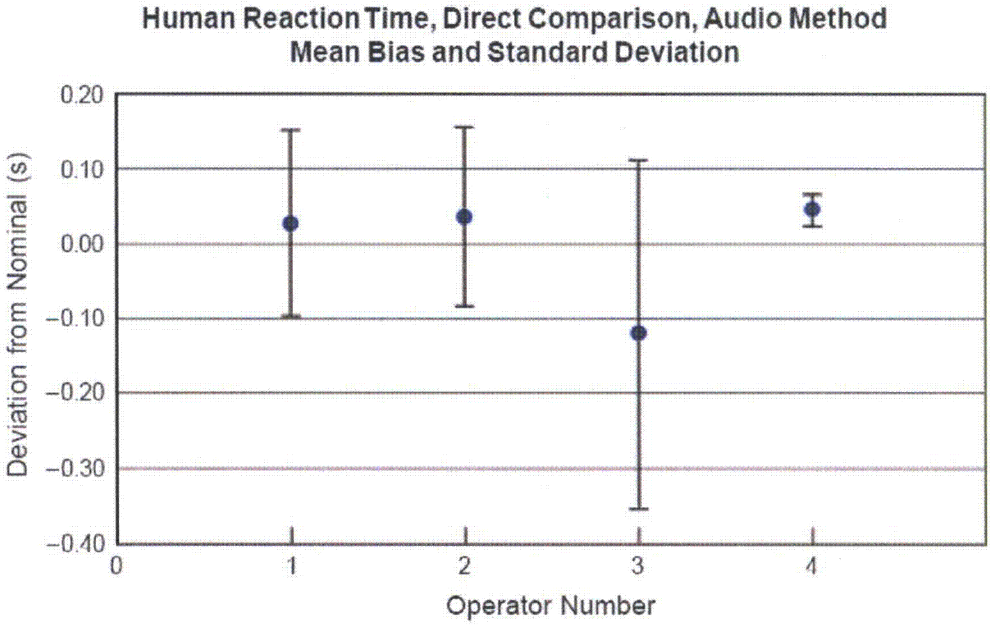


Figure 15. *Averaging measurement results for four different operators.*

When a traceable time display was used, the uncertainty due to human reaction time was found to be approximately the same as the human reaction time for an audible tone. Keep in mind that the data presented here is presented to illustrate the nature of uncertainty due to human reaction time and to provide a very rough estimate of its magnitude. We strongly encourage each person performing stopwatch and timer calibrations to perform repeatability and reproducibility experiments to determine the uncertainty due to human reaction time for the specific calibration method used by the laboratory.

ATTACHMENT "7"

Table 8: **Uncertainty Analysis for Direct Comparison Method (Digital DUT) Using Land Line**

Source of Uncertainty	Magnitude	Method of Evaluation	Distribution	Sensitivity Coefficient	Standard Uncertainty
Human reaction time bias	120 ms	Type B	Rectangular	1	69 ms
Human reaction time standard deviation	230 ms	Type B	Normal (k = 1)	1	230 ms
Telephone delay deviation	30 ms	Type B	Rectangular	1	17 ms
½ DUT resolution	5 ms	Type B	Rectangular	1	2.9 ms
Combined uncertainty					240 ms
Expanded uncertainty (k = 2, representing approximately a 95 % level of confidence)					480 ms

Table 9: **Uncertainty Analysis for Direct Comparison Method (Digital DUT) Using Cell Phone**

Source of Uncertainty	Magnitude	Method of Evaluation	Distribution	Sensitivity Coefficient	Standard Uncertainty
Human reaction time bias	120 ms	Type B	Rectangular	1	69 ms
Human reaction time standard deviation	230 ms	Type B	Normal (k = 1)	1	230 ms
Telephone delay deviation	250 ms	Type B	Rectangular	1	144 ms
½ DUT resolution	5 ms	Type B	Rectangular	1	2.9 ms
Combined uncertainty					280 ms
Expanded uncertainty (k = 2, representing approximately a 95 % level of confidence)					560 ms

ATTACHMENT "8"

Project:	Calc 357A-DC Rev. 12	ETAP		Page:	67
Location:	Diablo Canyon Power Plant	5.0.3N		Date:	08-29-2007
Contract:	Run 009-971			SN:	PACIFICG&E
Engineer:	Design Engineering	Study Case:	009GS	Revision:	B-009-971
Filename:	DCPP20070814			Config.:	Z-AO-AO-009

Objective: Determine Min 525KV Volts; V525Grid=510KV

Conditions: Unit 1 Cold Shutdown; Unit 2 LOCA

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	% PF	% Tap
								TEE 1UAT 4D	-1.413	-0.928	245.1	83.6	
								Serv Bus 230kV Swyd	0.099	0.048	15.9	90.0	
4KV BUS 1E	4.160	96.435	-0.7	0	0	0	0	XFMR 13E-PRI	0.093	0.059	15.8	84.3	
								XFMR 12E-PRI	0.410	0.197	65.4	90.1	
								XFMR 11E-PRI	0.209	0.137	35.9	83.6	
								XFMR 14E-PRI	0.326	0.194	54.6	86.0	
								XFMR 15E-PRI	0.416	0.248	69.7	85.8	
								UAT12-TER	-1.951	-1.077	320.7	87.6	
								Serv Bus 500kV Swyd	0.498	0.242	79.7	89.9	
4KV BUS 1F	4.160	95.709	-1.3	0	0	0.374	0.195	XFMR 1F-PRI	0.526	0.314	88.9	85.9	
								1-CCWP1 MT	0.343	0.187	56.6	87.8	
								TEE 1UAT 4F	-1.243	-0.696	206.6	87.3	
4KV BUS 1G	4.160	95.704	-1.3	0	0	0.280	0.106	XFMR 1G-PRI	0.489	0.293	82.7	85.8	
								1-CCWP2 MT	0.343	0.187	56.6	87.8	
								TEE 1UAT 4G	-1.112	-0.585	182.3	88.5	
4KV BUS 1H	4.160	95.701	-1.3	0	0	0	0	XFMR 1H-PRI	0.670	0.410	114.0	85.3	
								1-CCWP3 MT	0.000	0.000	0.0	100.0	
								BD 1UAT 4H	-0.670	-0.410	114.0	85.3	
4KV BUS 2D	4.160	93.361	-3.5	0	0	-0.002	-0.001	XFMR 23D-PRI	0.856	0.179	130.1	97.9	
								XFMR 22D-PRI	0.631	0.476	117.5	79.8	
								XFMR 21D-PRI	0.682	0.532	128.6	78.8	
								XFMR 24D-PRI	0.346	0.195	59.1	87.1	
								XFMR 25D-PRI	0.453	0.331	83.4	80.7	
								TEE 2UAT 4D	-2.966	-1.713	509.1	86.6	
4KV BUS 2E	4.160	95.306	-1.7	0	0	2.110	0.957	XFMR 25E-PRI	0.597	0.459	109.7	79.3	
								XFMR 24E-PRI	0.188	0.119	32.4	84.5	
								XFMR 21E-PRI	0.285	0.199	50.6	82.0	
								XFMR 22E-PRI	0.458	0.468	95.4	70.0	
								XFMR 23E-PRI	0.529	0.159	80.4	95.8	
								UAT22-TER	-4.167	-2.362	697.5	87.0	
4KV BUS 2F	4.160	93.313	-3.5	0	0	1.714	0.809	XFMR 2F-PRI	0.606	0.564	123.1	73.2	
								2-CCWP1 MT	0.343	0.187	58.1	87.8	
								TEE 2UAT 4F	-2.663	-1.560	459.0	86.3	
4KV BUS 2G	4.160	93.291	-3.5	0	0	1.952	0.883	XFMR 2G-PRI	0.508	0.538	110.1	68.7	
								2-CCWP2 MT	0.343	0.187	58.1	87.8	
								TEE 2UAT 4G	-2.803	-1.608	480.7	86.7	
4KV BUS 2H	4.160	93.277	-3.5	0	0	1.501	0.692	XFMR 2H-PRI	0.776	0.580	144.1	80.1	
								2-CCWP3 MT	0.343	0.187	58.1	87.8	
								BD 2UAT 4H	-2.620	-1.459	446.1	87.4	

93.277% X 4160VAC = 3880VAC

approach to ensure adequate voltage when backfeeding from the 500 kV grid is to check 4 kV and 480 Volt bus voltages if the grid drops below 514.5 kV (98 percent) or goes above 535.5 kV (102 percent) (Ref. 12.2.12). The 4 kV vital buses should be maintained above 3,866 Volts (92.93 percent, SLUR trip avoidance limit, Ref. 12.1.2f) and 480 Volt motor control centers should be below 506 Volts to ensure 460 Volt loads are not subjected to overvoltage during lightly loaded conditions. Motor control center voltages above 511 Volts will result in overvoltage on control power transformer 120 Vac circuits.

Steady state voltages throughout the distribution system via the StartUp source are acceptable for 230 kV grid voltage range of 207-241.5 kV. The evaluation of transient effects associated unit trip and bus transfer schemes is addressed in Reference 12.2.1.

A 4 kV bus should not be aligned to the Startup source with the corresponding LTC in automatic at the elevated setpoint, except for as allowed in Reference 12.2.10.

The StartUp Buses shall not be paralleled while supplying any Reactor Coolant Pumps due to the potential loss of adequate containment penetration protection.

Any motor can be started via the Aux offsite source without initiating a SLUR under voltage diesel generator start. Starting a 12 kV motor via the StartUp source may cause the diesels associated with that Unit to start. Diesel starting can be precluded by placing the associated LTC in manual and adjusting the StartUp Bus voltage to 12.48 kV (i.e. 104 percent) prior to starting the motor. This starting configuration relies on the insertion of one 230 kV capacitor bank.

Condensate Train 11 was satisfactorily started via the StartUp source with the LTC in manual. Condensate Train 11 is fed from the same StartUp transformer winding that feeds the vital buses. Therefore, any one of the condensate trains could be started. The SLUR protective function reset before the diesel generators started. The simulated loading for the Condensate Pump was 1112 bhp (i.e. 89 percent of the motor rating, normal operating load). The Booster Pump was loaded at 2580 bhp (i.e. 86 percent of the motor rating, normal operating load). This represents a combined starting load of 3692 hp, which exceeds the combined load of 1430 hp that could be sequenced on automatically while the plant is in Modes 5 or 6 (i.e. 2 ASW pumps @465 hp plus 5 CFC Units @100 hp, Ref. 12.1.1c, Table 4.3-1). Therefore, during plant Modes 5&6 and all buses aligned to StartUp (i.e. no potential automatic bus transfers), it is acceptable to have the LTC in manual provided the selected tap yields nominal StartUp Bus voltage.

11.0 IMPACT EVALUATION

Attachment 7.8 of procedure CF3.ID4 was used for guidance in performing the following impact evaluation.

ATTACHMENT "10"

FLUR Pickup Ratio Based on Historical Data

SUMMARY

The dropout setpoint is adjustable for the 27H*T1A, B, C, 27H*T2, 27H*B3 and 27H*B4 relays. For the 27H*B2 relays the dropout point is a function of the setpoint. Hence the dropout point for the 27H*B2 relays will be determined using the concept of a dropout ratio. The dropout ratio will be determined using historical calibration data and the analysis described below. The average and lowest undervoltage dropout ratio are summarized below at 95% confidence limit:

Device	Average Dropout Ratio (μ)	Lower Limit of Dropout Ratio (μ - 1.645 X σ)
1/2-27H*B2 - 27P	0.98127	0.97670
1/2-27H*B2 - 127P	0.98066	0.97653
1/2-27H*B2 - 27X	0.98104	0.97527

ATTACHMENT “10”

DETAILS

Device	Test Date	RLOC	Device 27P				Device 27P	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
1-27HFB2	10/8/2000	07776-5672-5712	N.A.*	76.21	N.A.*	76.84		0.991801
1-27HFB2	6/19/2001	07913-3476-3509	76.59	76.18	77.5	77.73	0.988258	0.980059
1-27HFB2	5/3/2002	08054-3891-3926	76.16	76.16	77.75	77.75	0.97955	0.97955
1-27HFB2	12/2/2003	51000-3609	76.15	76.15	77.62	77.62	0.981062	0.981062
1-27HFB2	8/10/2004	51001-5789	76.2	76.2	77.5	77.5	0.983226	0.983226
1-27HFB2	8/9/2005	51002-7688	76.1	76.1	77.75	77.75	0.978778	0.978778
1-27HFB2	9/6/2006	51004-7319	76.11	76.11	77.63	77.63	0.98042	0.98042
1-27HFB2	5/13/2007	51004-8749	76.3	76.3	77.68	77.68	0.982235	0.982235
2-27HFB2	4/18/2001	07891-4274-4315	76.35	76.35	77.6	77.6	0.983892	0.983892
2-27HFB2	4/18/2001	07879-1731-1770	76.35	76.35	77.6	77.6	0.983892	0.983892
2-27HFB2	2/26/2002	08032-1194-1232	76.25	76.25	77.71	77.71	0.981212	0.981212
2-27HFB2	2/14/2003	50000-0930	76.23	76.23	77.7	77.7	0.981081	0.981081
2-27HFB2	7/14/2004	51001-4626	76.17	76.17	77.72	77.72	0.980057	0.980057
2-27HFB2	3/22/2005	51002-4097	76.21	76.21	77.67	77.67	0.981203	0.981203
2-27HFB2	2/23/2006	51003-5697	76.2	76.2	77.66	77.66	0.9812	0.9812
2-27HFB2	2/21/2007	51004-5691	76.1	76.1	77.71	77.71	0.979282	0.979282
2-27HFB2	2/20/2008	51006-0503	76.16	76.16	77.66	77.66	0.980685	0.980685
1-27HGB2	10/8/2000	07777-1871-1912	N.A*	76.43	N.A*	76.76		0.995701
1-27HGB2	10/23/2000	51000-3610	76.25	76.25	77.71	77.71	0.981212	0.981212
1-27HGB2	7/10/2001	07921-3913-3947	?	76.28	?	77.75		0.981093
1-27HGB2	5/7/2002	08054-3927-3964	76.26	76.26	77.76	77.76	0.98071	0.98071
1-27HGB2	10/23/2003		76.25	76.25	77.71	77.71	0.981212	0.981212
1-27HGB2	4/17/2004	51001-2307	76.1	76.1	77.9	77.9	0.976893	0.976893
1-27HGB2	8/17/2005	51002-7687	76.1	76.1	77.717	77.717	0.979194	0.979194
1-27HGB2	8/30/2006	51004-7316	76.23	76.23	77.69	77.69	0.981207	0.981207
2-27HGB2	4/18/2001	07891-4274-4315	76.14	76.2	77.67	77.69	0.980301	0.980821
2-27HGB2	4/18/2001	07891-4316-4356	76.14	76.2	77.67	77.69	0.980301	0.980821
2-27HGB2	3/19/2002	08039-3291-3330	76.14	76.14	77.68	77.68	0.980175	0.980175
2-27HGB2	12/9/2002	08164-1654-1690	76.19	76.19	77.7	77.7	0.980566	0.980566
2-27HGB2	9/29/2003	51000-2933	76.16	76.16	77.62	77.62	0.98119	0.98119

ATTACHMENT "10"

Device	Test Date	RLOC	Device 27P				Device 27P	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
2-27HGB2	11/18/2004	51001-9565	76.05	76.05	77.66	77.66	0.979269	0.979269
2-27HGB2	3/16/2006	51003-8344	76.16	76.16	77.66	77.66	0.980685	0.980685
2-27HGB2	2/14/2007	51004-6457	76.14	76.14	77.65	77.65	0.980554	0.980554
2-27HGB2	11/7/2007	51005-4535	76.17	76.17	77.63	77.63	0.981193	0.981193
1-27HHB2	10/8/2000	07776-5672-5712	N.A.*	76.51	N.A.*	77.72		0.984431
1-27HHB2	7/31/2001	07955-3350-3384	76.2	76.2	77.29	77.71	0.985897	0.980569
1-27HHB2	5/11/2002	08063-0380-3964	76.27	76.22	77.73	77.73	0.981217	0.980574
1-27HHB2	11/18/2003	51000-3367	76.03	76.03	77.74	77.74	0.978004	0.978004
1-27HHB2	8/23/2004	51001-4291	76.27	76.27	77.75	77.75	0.980965	0.980965
1-27HHB2	11/13/2005	51003-2881	75.86	75.86	77.7	77.7	0.976319	0.976319
1-27HHB2	3/7/2007	51004-6458	76.29	76.29	77.77	77.77	0.98097	0.98097
1-27HHB2	12/12/2007	51005-6658	76.25	76.25	77.72	77.72	0.981086	0.981086
2-27HHB2	4/18/2001	07891-4274-4315	76.16	76.27	77.66	77.62	0.980685	0.982608
2-27HHB2	4/18/2001	07891-4274-4315	76.16	76.27	77.66	77.62	0.980685	0.982608
2-27HHB2	3/12/2002	08039-2154-2192	76.19	76.22	77.75	77.73	0.979936	0.980574
2-27HHB2	11/16/2002	08179-0328-0365	76.19	76.19	77	77	0.989481	0.989481
2-27HHB2	10/20/2003	51000-3368	76.2	76.2	77.7	77.7	0.980695	0.980695
2-27HHB2	3/8/2005	51002-3638	76.2	76.2	77.64	77.64	0.981453	0.981453
2-27HHB2	5/8/2005	51003-8587	76.12	76.12	77.63	77.63	0.980549	0.980549
2-27HHB2	1/10/2007	51004-6057	76.17	76.17	77.67	77.67	0.980688	0.980688
2-27HHB2	3/5/2008	51006-1369	76.16	76.16	77.66	77.66	0.980685	0.980685

ATTACHMENT "10"

Device	Test Date	RLOC	Device 127P				Device 127P	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
1-27HFB2	10/8/2000	07776-5672-5712	N.A.*	30.59	N.A.*	31.12		0.982969
1-27HFB2	6/19/2001	07913-3476-3509	30.5	30.5	31.11	31.15	0.980392	0.979133
1-27HFB2	5/3/2002	08054-3891-3926	30.54	30.54	31.1	31.1	0.981994	0.981994
1-27HFB2	12/2/2003	51000-3609	30.51	30.51	31.1	31.1	0.981029	0.981029
1-27HFB2	8/10/2004	51001-5789	30.6	30.6	31.1	31.1	0.983923	0.983923
1-27HFB2	8/9/2005	51002-7688	30.5	30.5	31.154	31.154	0.979008	0.979008
1-27HFB2	9/6/2006	51004-7319	30.52	30.52	31.07	31.07	0.982298	0.982298
1-27HFB2	5/13/2007	51004-8749	30.52	30.52	31.1	31.1	0.98135	0.98135
2-27HFB2	4/18/2001	07891-4274-4315	30.53	30.53	31.12	31.12	0.981041	0.981041
2-27HFB2	4/18/2001	07879-1731-1770	30.53	30.53	31.12	31.12	0.981041	0.981041
2-27HFB2	2/26/2002	08032-1194-1232	30.54	30.54	31.16	31.16	0.980103	0.980103
2-27HFB2	2/14/2003	50000-0930	30.58	30.58	31.13	31.13	0.982332	0.982332
2-27HFB2	7/14/2004	51001-4626	30.42	30.42	31.19	31.19	0.975313	0.975313
2-27HFB2	3/22/2005	51002-4097	30.57	30.57	31.15	31.15	0.98138	0.98138
2-27HFB2	2/23/2006	51003-5697	30.56	30.56	31.14	31.14	0.981374	0.981374
2-27HFB2	2/21/2007	51004-5691	30.53	30.53	31.08	31.08	0.982304	0.982304
2-27HFB2	2/20/2008	51006-0503	30.55	30.55	31.13	31.13	0.981368	0.981368
1-27HGB2	10/8/2000	07777-1871-1912	N.A*	30.63	N.A*	31.18		0.98236
1-27HGB2	10/23/2000	51000-3610	30.57	30.57	31.15	31.15	0.98138	0.98138
1-27HGB2	7/10/2001	07921-3913-3947	?	30.6	?	31.16		0.982028
1-27HGB2	5/7/2002	08054-3927-3964	30.6	30.6	31.18	31.18	0.981398	0.981398
1-27HGB2	10/23/2003		30.57	30.57	31.15	31.15	0.98138	0.98138
1-27HGB2	4/17/2004	51001-2307	30.5	30.5	31.27	31.27	0.975376	0.975376
1-27HGB2	8/17/2005	51002-7687	30.543	30.543	31.203	31.203	0.978848	0.978848
1-27HGB2	8/30/2006	51004-7316	30.57	30.57	31.13	31.13	0.982011	0.982011
2-27HGB2	4/18/2001	07891-4274-4315	30.57	30.62	31.19	31.21	0.980122	0.981096
2-27HGB2	4/18/2001	07891-4316-4356	30.57	30.62	31.19	31.21	0.980122	0.981096
2-27HGB2	3/19/2002	08039-3291-3330	30.5	30.5	31.12	31.12	0.980077	0.980077
2-27HGB2	12/9/2002	08164-1654-1690	30.49	30.49	31.15	31.15	0.978812	0.978812
2-27HGB2	9/29/2003	51000-2933	30.52	30.52	31.1	31.1	0.98135	0.98135

ATTACHMENT "10"

Device	Test Date	RLOC	Device 127P				Device 127P	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
2-27HGB2	11/18/2004	51001-9565	30.5	30.5	31	31	0.983871	0.983871
2-27HGB2	3/16/2006	51003-8344	30.53	30.53	31.12	31.12	0.981041	0.981041
2-27HGB2	2/14/2007	51004-6457	30.53	30.53	31.09	31.09	0.981988	0.981988
2-27HGB2	11/7/2007	51005-4535	30.55	30.55	31.1	31.1	0.982315	0.982315
1-27HHB2	10/8/2000	07776-5672-5712	N.A.*	30.59	N.A.*	31.06		0.984868
1-27HHB2	7/31/2001	07955-3350-3384	30.55	30.52	31.14	31.18	0.981053	0.978833
1-27HHB2	5/11/2002	08063-0380-3964	30.57	30.57	31.16	31.15	0.981065	0.98138
1-27HHB2	11/18/2003	51000-3367	30.59	30.59	31.18	31.18	0.981078	0.981078
1-27HHB2	8/23/2004	51001-4291	30.56	30.56	31.13	31.13	0.98169	0.98169
1-27HHB2	11/13/2005	51003-2881	30.38	30.38	31.23	31.23	0.972783	0.972783
1-27HHB2	3/7/2007	51004-6458	30.61	30.61	31.16	31.16	0.982349	0.982349
1-27HHB2	12/12/2007	51005-6658	30.6	30.6	31.14	31.14	0.982659	0.982659
2-27HHB2	4/18/2001	07891-4274-4315	30.49	30.53	31.15	31.15	0.978812	0.980096
2-27HHB2	4/18/2001	07891-4274-4315	30.49	30.53	31.15	31.15	0.978812	0.980096
2-27HHB2	3/12/2002	08039-2154-2192	30.57	30.56	31.17	31.17	0.980751	0.98043
2-27HHB2	11/16/2002	08179-0328-0365	30.53	30.53	31.15	31.15	0.980096	0.980096
2-27HHB2	10/20/2003	51000-3368	30.53	30.53	31.14	31.14	0.980411	0.980411
2-27HHB2	3/8/2005	51002-3638	30.59	30.59	31.1	31.1	0.983601	0.983601
2-27HHB2	5/8/2005	51003-8587	30.37	30.37	31.28	31.28	0.970908	0.970908
2-27HHB2	1/10/2007	51004-6057	30.56	30.56	31.12	31.12	0.982005	0.982005
2-27HHB2	3/5/2008	51006-1369	30.55	30.55	31.13	31.13	0.981368	0.981368

ATTACHMENT “10”

e

Device	Test Date	RLOC	Device 27X				Device 27X	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
1-27HFB2	10/8/2000	07776-5672-5712	N.A.*	23.520	N.A.*	23.710		0.991987
1-27HFB2	6/19/2001	07913-3476-3509	23.4	23.35	23.64	23.86	0.989848	0.978625
1-27HFB2	5/3/2002	08054-3891-3926	23.37	23.37	23.82	23.82	0.981108	0.981108
1-27HFB2	12/2/2003	51000-3609	23.37	23.37	23.77	23.77	0.983172	0.983172
1-27HFB2	8/10/2004	51001-5789	23.4	23.4	23.8	23.8	0.983193	0.983193
1-27HFB2	8/9/2005	51002-7688	23.34	23.34	23.89	23.89	0.976978	0.976978
1-27HFB2	9/6/2006	51004-7319	23.38	23.38	23.82	23.82	0.981528	0.981528
1-27HFB2	5/13/2007	51004-8749	23.5	23.5	23.82	23.82	0.986566	0.986566
2-27HFB2	4/18/2001	07891-4274-4315	23.31	23.31	23.86	23.86	0.976949	0.976949
2-27HFB2	4/18/2001	07879-1731-1770	23.31	23.31	23.86	23.86	0.976949	0.976949
2-27HFB2	2/26/2002	08032-1194-1232	23.39	23.39	23.87	23.87	0.979891	0.979891
2-27HFB2	2/14/2003	50000-0930	23.4	23.4	23.85	23.85	0.981132	0.981132
2-27HFB2	7/14/2004	51001-4626	23.33	23.33	23.82	23.82	0.979429	0.979429
2-27HFB2	3/22/2005	51002-4097	23.4	23.4	23.86	23.86	0.980721	0.980721
2-27HFB2	2/23/2006	51003-5697	23.37	23.37	23.78	23.78	0.982759	0.982759
2-27HFB2	2/21/2007	51004-5691	23.42	23.42	23.86	23.86	0.981559	0.981559
2-27HFB2	2/20/2008	51006-0503	23.36	23.36	23.82	23.82	0.980688	0.980688
1-27HGB2	10/8/2000	07777-1871-1912	N.A*	23.49	N.A*	23.82		0.986146
1-27HGB2	10/23/2000	51000-3610	23.38	23.38	23.78	23.78	0.983179	0.983179
1-27HGB2	7/10/2001	07921-3913-3947	?	23.36	?	23.8		0.981513
1-27HGB2	5/7/2002	08054-3927-3964	23.35	23.35	23.8	23.8	0.981092	0.981092
1-27HGB2	10/23/2003		23.38	23.38	23.78	23.78	0.983179	0.983179
1-27HGB2	4/17/2004	51001-2307	23.28	23.28	23.87	23.87	0.975283	0.975283
1-27HGB2	8/17/2005	51002-7687	23.316	23.316	23.904	23.904	0.975402	0.975402
1-27HGB2	8/30/2006	51004-7316	23.38	23.38	23.81	23.81	0.98194	0.98194
2-27HGB2	4/18/2001	07891-4274-4315	23.31	23.300	23.78	23.750	0.980235	0.981053
2-27HGB2	4/18/2001	07891-4316-4356	23.31	23.300	23.78	23.750	0.980235	0.981053
2-27HGB2	3/19/2002	08039-3291-3330	23.31	23.31	23.82	23.82	0.978589	0.978589
2-27HGB2	12/9/2002	08164-1654-1690	23.34	23.34	23.82	23.82	0.979849	0.979849
2-27HGB2	9/29/2003	51000-2933	23.36	23.36	23.8	23.8	0.981513	0.981513
2-27HGB2	11/18/2004	51001-9565	23.36	23.36	23.8	23.8	0.981513	0.981513

ATTACHMENT "10"

Device	Test Date	RLOC	Device 27X				Device 27X	
			Dropout (VAC)		Pickup (VAC)		Dropout Ratio	
			As Found	As-Left	As Found	As-Left	As-Found	As-Left
2-27HGB2	3/16/2006	51003-8344	23.34	23.34	23.79	23.79	0.981084	0.981084
2-27HGB2	2/14/2007	51004-6457	23.34	23.34	23.63	23.63	0.987727	0.987727
2-27HGB2	11/7/2007	51005-4535	23.37	23.37	23.79	23.79	0.982346	0.982346
1-27HHB2	10/8/2000	07776-5672-5712	N.A.*	23.350	N.A.*	23.810		0.98068
1-27HHB2	7/31/2001	07955-3350-3384	23.37	23.37	23.84	23.81	0.980285	0.98152
1-27HHB2	5/11/2002	08063-0380-3964	23.38	23.38	23.83	23.83	0.981116	0.981116
1-27HHB2	11/18/2003	51000-3367	23.34	23.34	23.71	23.71	0.984395	0.984395
1-27HHB2	8/23/2004	51001-4291	23.42	23.42	23.82	23.82	0.983207	0.983207
1-27HHB2	11/13/2005	51003-2881	23.08	23.08	23.86	23.86	0.967309	0.967309
1-27HHB2	3/7/2007	51004-6458	23.41	23.41	23.83	23.83	0.982375	0.982375
1-27HHB2	12/12/2007	51005-6658	23.39	23.39	23.8	23.8	0.982773	0.982773
2-27HHB2	4/18/2001	07891-4274-4315	23.3	23.34	23.89	23.81	0.975303	0.98026
2-27HHB2	4/18/2001	07891-4274-4315	23.3	23.34	23.89	23.81	0.975303	0.98026
2-27HHB2	3/12/2002	08039-2154-2192	23.37	23.37	23.83	23.86	0.980697	0.979464
2-27HHB2	11/16/2002	08179-0328-0365	23.37	23.37	23.82	23.82	0.981108	0.981108
2-27HHB2	10/20/2003	51000-3368	23.34	23.34	23.77	23.77	0.98191	0.98191
2-27HHB2	3/8/2005	51002-3638	23.41	23.41	23.81	23.81	0.9832	0.9832
2-27HHB2	5/8/2005	51003-8587	23.36	23.36	23.8	23.8	0.981513	0.981513
2-27HHB2	1/10/2007	51004-6057	23.42	23.42	23.83	23.83	0.982795	0.982795
2-27HHB2	3/5/2008	51006-1369	23.36	23.36	23.8	23.8	0.981513	0.981513

ATTACHMENT "10"

B2 FLUR Dropout Ratio" Statistics			
B2 Device:	**27P**	**127P**	**27X**
Average:	0.98127	0.98066	0.98104
Standard Deviation:	0.00278	0.00251	0.00350
Max:	0.99570	0.98487	0.99199
Min:	0.97632	0.97091	0.96731
1.645 X σ Low:	0.97670	0.97653	0.97527
1.645 X σ High:	0.98584	0.98480	0.98680

Setpoints and Reset Voltage for Diesel Start	**Bus Voltage (VAC)**
(B2-27P) Setpoint for Diesel Start in 4.7 Sec:	2667
Average Rest for Diesel Start in 4.7 Sec:	2718
Maximum Setpoint for Diesel Start in 4.7 Sec:	2715
Maximum Reset Voltage for Diesel Start in 4.7 Sec:	**2780**
(B2-127P) Setpoint for Diesel Start in 1.9 Sec:	1070
Average Rest for Diesel Start in 1.9 Sec:	1091
Maximum Setpoint for Diesel Start in 1.9 Sec:	1091
Maximum Reset Voltage for Diesel Start in 1.9 Sec:	**1117**
(B2-27X) Setpoint for Diesel Start in 0.65 Sec:	818
Average Rest for Diesel Start in 0.65 Sec:	834
Maximum Setpoint for Diesel Start in 0.65 Sec:	837
Maximum Reset Voltage for Diesel Start in 0.65 Sec:	**858**

ATTACHMENT "11"

Montoya, Ariel

From: Glenn Goldfarb [glenn.goldfarb@us.abb.com]
Sent: Monday, February 28, 2011 2:07 PM
To: Montoya, Ariel
Subject: 27N
Importance: High

Hi Ariel,

The 70V tap was adjustable from 61 to 74V.

The 80V tap was adjustable from 69 to 85V.

The 120V tap was adjustable to 128v max.

Thanks and Best Regards,

Glenn Goldfarb
Sr. Customer Service Engineer
ph: 954-825-0619
cell: 386-848-7339
fax: 954-345-5329
mailto:glenn.goldfarb@us.abb.com

ABB Selection Guide Link:
http://search.abb.com/library/Download.aspx?DocumentID=abbsetup.exe&LanguageCode=en&DocumentPartID=&Action=Launch

ABB Website: http://www.abb.com/substationautomation

FT-1 Switch Configuration: http://ft1switch.com/

LBIE Screen – Applicability Determination

1. Proposed Activity/Implementing Document No: Calculation 357S-DC (SAP 9*41128)	Unit: ☐ 1 ☐ 2 ☒ 1&2	Imp Doc Rev No: 1

Briefly describe what is being changed and why:

Notification 50301167 identified a degraded condition with the vital 4.16 kV bus under-voltage protective relays and timers These relays are also known as the FLURs and SLURs. As a result the protective relaying scheme is being modified with new relay hardware and setpoints for both Unit 1 and 2 to implement better under-voltage protection. The change requires the development of a new setpoint and uncertainty calculation to supersede the existing 4.16 kV bus under-voltage protective relay calculation 357R-DC. The changes are defined as follows:

1. Supersede calculation 357R-DC which establishes setpoint bases and allowable values for the existing 4.16kV bus under-voltage protective relaying.
2. Create a new calculation 357S-DC which establishes new setpoint bases and allowable values for the new 4.16kV bus under-voltage protective relaying design as follows:
   a. Replace first level undervoltage load shed relay 27HxT1 with three relays each with a voltage and time delay setpoint.
   b. Replace first level undervoltage instantaneous load shed relay 27HxT2 with a new more accurate relay and new undervoltage setpoint.
   c. Replace second level undervoltage voltage sensing relays 27HxB3 and 27HxB4 with new more accurate relays and new undervoltage setpoints.
   d. Replace second level undervoltage time delay relays 62Hx3A and 62Hx3B with new more accurate relays and new time delay setpoints.
3. Establish new tech spec limits for 27HxT1A, B & C relays and 27HxT2 relays.
4. Administrative change: Bring all existing information and calculations related to the bus transfer and diesel start relay 27HxB2 from superseded calculation (357R-DC) to the new calculation (357S-DC).

Revision 1 of this calculation has been performed to correct a TYPO on page 16 of this calculation. Specifically the summary of set points for the T1A relays listed the nominal time delay set point as 7 seconds as opposed to the required 8.

2. Applicability Determination (refer to TS3.ID2, Appendix 7.1 Section 2 for instructions) Does the proposed activity **involve**:			Ref. TS3.ID2 Appendix 7.1
2.a A change to the Facility/ISFSI Operating License (OL), Environmental Protection Plan (EPP) or Technical Specifications (TS)?	☒ Y	☐ N	Block 2.a
2.b A change to the Quality Assurance Program?	☐ Y	☒ N	Block 2.b
2.c A change to the Security Plan?	☐ Y	☒ N	Block 2.c
2.d A change to the Emergency Plan?	☐ Y	☒ N	Block 2.d
2.e A change to the Inservice Testing (IST) Program Plan?	☐ Y	☒ N	Block 2.e
2.f A change to the Inservice Inspection (ISI) Program Plan?	☐ Y	☒ N	Block 2.f
2.g A change to the Fire Protection Program?	☐ Y	☒ N	Block 2.g
2.h A noncompliance with the Environmental Protection Plan or may create a situation adverse to the environment?	☐ Y	☒ N	Block 2.h
2.i A change to the FSARU (including documents incorporated by reference) excluded from the requirement to perform a 50.59/72.48 review?	☐ Y	☒ N	Block 2.i
2.j Maintenance that restores SSCs to their original or newly approved designed condition? (Check "No" if activity is related to ISFSI.)	☐ Y	☒ N	Block 2.j
2.k A temporary alteration supporting maintenance that will be in effect during at-power operations for 90 days or less? (Check "No" if activity is related to ISFSI.)	☐ Y	☒ N	Block 2.k
2.l Managerial or administrative procedure/process controlled under 10 CFR 50, App. B?	☒ Y	☐ N	Block 2.l
2.m Regulatory commitment not covered by another regulatory based change process?	☐ Y	☒ N	Block 2.m

2.n An impact to other plant specific programs (e.g., the ODCM) that are controlled by regulations, the OL, or TS?	☐ Y	☒ N	Block 2.n

3. Applicability Determination Conclusions (refer to TS3.ID2, Appendix 7.1 Section 3 for instructions):

   ☒ **A 10 CFR 50.59 or 72.48 screen is NOT required** because ALL aspects of the activity are controlled by one or more of the processes listed above, or have been approved by the NRC, or covered in full in another LBIE review.

   ☐ **A 10 CFR 50.59 or 72.48 screen will be completed** because some or all the aspects of the activity are not controlled by any of the processes listed above or cannot be exempted from the 10 CFR 50.59/72.48 screen.

4. Does the proposed activity involve a change to the plant where the change requires a safety assessment? (refer to TS3.ID2, Appendix 7.1 Section 4 for instructions)	☐ Y	☒ N

5. Remarks: (Use this section to provide sufficient justification(s) per TS3.ID2, step 5.1.3 for determinations in step 2 and conclusion in step 3.)

Block 2 Section 2.A: Changes To The Facility License

This calculation establishes setpoints, allowable values and tech spec bases for the 4.16kV undervoltage protection relays. As a result of the new design, the tech specs associated with the 27HxT1 relays and the 27HxT2 relays will change. This requires a license amendment. Regulatory services has been contacted. A license amendment request is being processed and tracked per notification 50301167 Task 13.

Block 2 Section 2.B: Screen For Changes To The Quality Assurance Program.

This calculation is performed to analyze protective device setting and does not have any impact to the quality assurance program as described in Chapter 17 of the FSARU. Therefore this question may be answered no.

Block 2 Section 2.C Security Plan Screen

This change does not impact the security plan or any item listed in Appendix 7.5 of TS3.ID2, therefore, this screen question may be answered no.

Block 2 Section 2.D Emergency Plan Screen

This calculation will not impact the manner in which PG&E, government agencies and other organizations respond to an emergency at DCPP as described in Appendix 7.4 of TS3.ID2. Therefore, this screen question may be answered no.

Block 2 Section 2.E Inservice Testing (IST) Program Plan

This calculation will not impact the manner in which PG&E performs its inservice testing program at DCPP. Therefore, this screen question may be answered no.

Block 2 Section 2.F Inservice Inspection (ISI) Program Plan

This calculation will not impact the manner in which PG&E performs its inservice inspection program at DCPP. Therefore, this screen question may be answered no.

Block 2 Section 2.G Fire Protection Program Screen

Evaluation of the 4.16kV undervoltage protective devices does not impact the ability of the plant to achieve and maintain safe shutdown in the event of a fire. There is no impact to any elements of the fire protection program, procedures or equipment as described in Chapter 9, Appendix 9.5 of the FSARU. Therefore, this screen question may be answered no.

Block 2 Section 2.H Environmental Protection Screen

This setpoint change calculation will have no impact on any of the items listed in Appendix 7.3 of TS3.ID2, therefore, this screen question may be answered no.

Block 2 Section 2.I FSARU Change

Chapter 8.3 of the FSARU will require revision as a result of this change. The revision is being prepared and tracked along with the License Amendment request.

Block 2 section 2.j screen for maintenance activities (not applicable to sscs controlled by the ISFSI license)

This is not a maintenance activity. This calculation provides optimal protective device settings. Therefore this screen question is answered no.

Block 2 Section 2.K Temporary Alteration

This calculation is not a temporary alteration that supports maintenance that will be in effect during at-power operations for 90 days or less, nor is it related to ISFSI. Therefore, this question may be answered no.

Block 2 Section 2.L Managerial / Administrative Changes Controlled Under 10-CFR-50 Appendix B

The incorporation of setpoint calculation information for the 27HxB2 relays described in Block 1 are controlled under 10-CFR-50 Appendix B. Therefore, this screen question is answered Yes.

Block 2 Section 2.M Screen For Regulatory Commitments Not Covered By Another Regulatory Based

Change Process

A review of the procedure commitment data base (PCD) has determined that the scope of this calculation will not impact any regulatory commitments not covered by another regulatory based change process. Therefore, this screen question may be answered no.

Block 2 Section 2.N Screen For Other Programs, (Not Covered Above).

Evaluation of the 4.16kV undervoltage protective devices does not impact any other plant specific programs which are controlled by regulations, the operating license or the technical specifications. This screen question is therefore answered no.

Block 4 Screen For The Necessity Of A Safety Assessment

Per review of Appendix 7.6 this change does not involve a special test, abnormal plant configuration or mode of operation that could have a significant or adverse impact on nuclear safety. This change to undervoltage protective device settings provides desired protective function to protect equipment should an abnormal condition occur and is in compliance with engineering and industry standards. There is no potential to cause a major transient or increase the probability of a plant trip. This change requires a license amendment request. Hence, a LBIE is not required. Therefore, this screen question may be answered no.

	Date	Print Last Name
Preparer Signature: (Qual: TLBIEAD or TLBIE) [signature]	Date: 6/22/11	Print Last Name: Montoya
Reviewer Signature: (Qual: TLBIEAD or TLBIE) [signature]	Date: 6/23/11	Print Last Name: Moarefy
PG&E Acceptance Signature: (Qual: TLBIEAD or TLBIE) (N/A if performed or reviewed by PG&E)	Date:	Print Last Name:

Refer to TS3.ID2, Section 6, for instructions on handling completed forms.