USER MANUAL

# MTT-38/ RXT-2380

SDH/SONET Module for MTT and RXT Platforms

Please direct all questions to your local VeEX Sales Office, Representative, or Distributor. Or, contact VeEX technical support at www.veexinc.com.

**WARNING**

Using the supplied equipment in a manner not specified by VeEX Inc may impair the protection provided by the equipment.

**LASER CAUTIONS!**

- This is a class 1 laser product. Avoid looking directly at the transmitter source.
- Use of controls and procedures other than those specified in this manual may result in exposure to hazardous laser radiation.
- Unterminated optical connectors may emit laser radiation. Do not view with optical instruments.

**CAUTIONS!**

- Do not remove or insert the module while the test set is on. Inserting or removing a module with the power on may damage the module.
- Do not remove or insert the software cartridge while the test set is on. Otherwise, damage could occur to the cartridge.

**End of Life Recycling and Disposal Information**

DO NOT dispose of Waste Electrical and Electronic Equipment (WEEE) as unsorted municipal waste. For proper disposal return the product to VeEX Inc. Please contact our local offices or service centers for information on how to arrange the return and recycling of any of our products.

Phone: +1 510 651 0500

E-mail: customercare@veexinc.com

Website: www.veexinc.com

This product was put on the market after 13 Aug 2005.

**EC Directive on Waste Electrical and Electronic Equipment (WEEE)**

The Waste Electrical and Electronic Equipment Directive aims to minimize the impact of the disposal of electrical and electronic equipment on the environment. It encourages and sets criteria for the collection, treatment, recycling, recovery, and disposal of waste electrical and electronic equipment.

# SDH/SONET Module

# 1 SDH/SONET Module

The SDH/SONET module provides the necessary tools to efficiently install, maintain, and troubleshoot SDH and SONET services.

## 1.1 Module Panel

CLOCK 1.5M/2M 34M/45M/52M 155M/622M/2.5G

**Figure 1 Module Panel**

The module panel contains the following ports:

**CLK**: Clock input port using a bantam interface.

**1.5M/2M**: 1.5 Mb and 2 Mb Transmit (TX) and Receive (RX) electrical port using an RJ45 interface.

**34M/45M/52M**: 34 Mb, 45 Mb, 52 Mb Transmit (TX) and Receive (RX) electrical port using a BNC interface.

**155M/622M/2.5G**: 155 Mb, 622 Mb, and 2.5 Gb Transmit (TX) and Receive (RX) port using the following types of optical plug- in transceivers:

**Note**: If the optical interface is used, its wavelength is indicated at the top right of the screen. In Figure 5, the wavelength is 1310.

- SA582-1310SR Short Reach Dual Duplex type LC, 1310 nm transceiver:

- SA582-1550LR Long Reach Dual Duplex type LC, 1550 nm transceiver:

**CAUTION:** Use of non VeEX Inc transceivers will void the test set warranty.

*To insert a transceiver:*

1. Align the transceiver label side with the label side of module.
2. Insert the transceiver into port. There will be a click sound when the transceiver is properly seated.
3. When ready for use, remove any protective caps on the interface end of the transceiver.

*To remove a transceiver:*

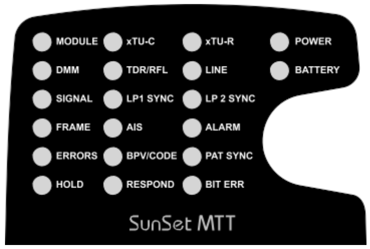
1. Install the protective cap on the interface end of the transceiver.
2. Grip the outer edge of the transceiver and pull it away from the module.

The recommended cables are shown in Table 1.

| **VeEX P/N** | **Description** |
|---|---|
| SA561 | Standard 2 meter LCUPC to SCUPC duplex multimode patch cord |
| SA562 | Optional 2 meter LCUPC tp SCUPC duplex single mode patch cord |
| SA563 | Optional 2 meter LCUPC tp FCUPC duplex single mode patch cord |

**Table 1 Cables**

## 1.2 Test Set LEDs




SSMTT-ACM, -ACM+, -EX SSMTT-B, -C

**Figure 2 Test Set LED Panels**

The module uses the following test set LEDs:

**MODULE**
- Green: Indicates that the test set is in the module mode.
- Red: Indicates that the there is an error in recognizing the module.

**SIGNAL**
- Green: The test set is receiving a signal at the correct rate.
- Red: A signal was expected, but not received.

**FRAME**
- Green: A frame alignment word is being received.
- Red: Frame alignment has been lost. If the test set is configured for a particular type of framing in TEST CONFIGURATION, it will continuously search for that type of framing. The LED will light green whenever the framing is found.

**ALARM**
- Red: Indicates an alarm condition has been detected.
- Blinking Red: The test set previously detected an alarm condition, but it is no longer present. Press HISTORY to clear.

**ERRORS**
- Red: The test set is currently detecting errors.
- Blinking Red: The test set previously detected errors but are no longer present. Press HISTORY to clear.

**PAT SYNC**
- Green: Indicates that the test set has synchronized on the test pattern in the received signal. The received pattern must match the transmitted pattern. The pattern may be observed in MEASUREMENT RESULTS. When the test set is taking measurements, it will automatically attempt to synchronize on the pattern that is being sent. If synchronization is lost, the PAT SYNC LED lights red.

- No light: Indicates that the test set is receiving live data. If measurements are started, and the test set is detecting pulses and framing but cannot achieve pattern synchronization, it will indicate LIVE which occurred previously but which is no longer present.

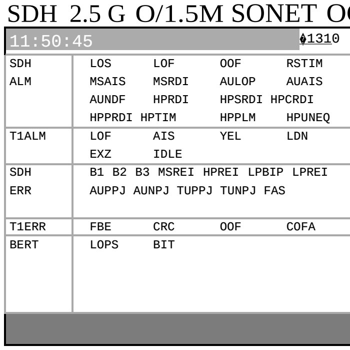
**BIT ERR**

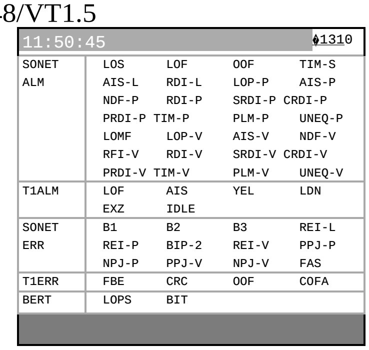
- Red: The test set is currently detecting bit errors.
- Blinking Red: The test set previously detected bit errors, but they are no longer present. Press HISTORY to clear.

## 1.3 Keypad-STATUS

In addition to the normal functions of the keypad, this module employs the STATUS key to display a status screen of the alarms and errors for the configured measurement, SDH or SONET and their specific payload. Sample screens are shown in the following figure:

SDH 2.5 G O/1.5M SONET OC-48/VT1.5




**Indicator Key**

**Blue**: No alarm or error.

**Red**: Current alarm or error. LOS is red in both screens.

**Greyed out blue**: An alarm or error has occurred, but currently is not present. Press HISTORY to clear. LOPS is a History condition in both screens.

**Figure 3 Status Screens**

See *Section 2.2* for definitions of the reported alarms and er- rors.

# 2 Menus

The module major menus are shown in the following figure:

* Feature Under Construction

MODULE
Key

SDH/SONET/ATM MAIN MENU

| | |
|---|---|
| 2.1 | SETUP |
| 2.2 | RESULTS |
| 2.3 | ALARMS/ERRORS |
| 2.4 | SDH/SONET FEATURES |
| 2.5 | PDH FEATURES* |
| 2.6 | ATM FEATURES |
| 2.7 | VIEW/PRINT RESULTS |

SETUP

| | |
|---|---|
| 2.1.1 | TEST CONFIGURATION |
| 2.1.2 | SEND TEST PATTERN |
| 2.1.3 | AUTO CONFIGURATION |
| 2.1.4 | SETUP NETWORK MODE |
| 2.1.5 | MEASUREMENT CRITERIA |
| 2.1.6 | SYSTEM PROFILES |

RESULTS

| | |
|---|---|
| 2.2.1 | MEASUREMENT RESULTS |
| 2.2.2 | HISTOGRAM ANALYSIS |
| 2.2.3 | VIEW CURRENT EVENT |

ATM MAIN MENU

| | |
|---|---|
| 2.6.1 | ATM SETUP |
| 2.6.2 | VCC SETUP |
| 2.6.3 | VCC STATISTICS |
| 2.6.4 | VCC SCAN |
| 2.6.5 | CELL CAPTURE |
| 2.6.6 | ATM IP TESTING |
| 2.6.7 | ADSL ATM TESTING |

ALARMS/ERRORS

| | |
|---|---|
| 2.3.1 | ERROR INJECTION |
| 2.3.2 | ALARM GENERATION |
| 2.3.3 | ATM ERROR INJECTION |
| 2.3.4 | ATM ALARM GENERATION |

Dependent on Network Setup

SDH FEATURE

| | |
|---|---|
| 2.4.1 | OVERHEAD CONFIG |
| 2.4.2 | SECTION OVERHEAD |
| 2.4.3 | PATH OVERHEAD |
| 2.4.4 | TRACE GENERATION |
| 2.4.5 | POINTERS |
| 2.4.6 | TRIBUTARY SCAN |
| 2.4.7 | APS TIMING |

SONET FEATURE

| | |
|---|---|
| 2.4.1 | OVERHEAD CONFIG |
| 2.4.2 | SECTION/LINE OVERHEAD |
| 2.4.3 | PATH OVERHEAD |
| 2.4.4 | TRACE GENERATION |
| 2.4.5 | POINTERS |
| 2.4.6 | TRIBUTARY SCAN |
| 2.4.7 | APS TIMING |

**Figure 4 SDH/SONET/ATM Module Menu**

## 2.1 Setup

This menu contains the following:

- TEST CONFIGURATION
- SEND TEST PATTERN
- AUTO CONFIGURATION
- SETUP NETWORK MODE
- MEASUREMENT CRITERIA
- SYSTEM PROFILES

**Notes**

- Before setting the test configuration, select the network mode, SDH or SONET in SETUP NETWORK MODE.
- In many of the setup screens, when a change is made, the test set will display a progress bar at the top of the screen. When the bar is gone, further changes can be made.

### 2.1.1 Test Configuration

Before connecting the test set to the circuit, it must be properly configured. This is the most important step in the entire test procedure. If improperly configured, the measurement results will be meaningless.

The TEST CONFIGURATION screen presented is dependent on the TEST MODE, TEST INTERFACE, and TEST PAYLOAD selected. The details of which are discussed in the following subsections.

**TEST MODE**

Options: SINGLE (F1), ATM (F2)

Select the test mode.

- SINGLE: Test a single line/single rate. If needed, configure the TEST INTERFACE signal and the TEST PAYLOAD within.
- ATM: See *Section 2.6*. Requires SDH/SONET configuration.

**TEST INTERFACE**

This is the high test rate.

- SDH choices are:
  - *Electrical*: 1.5M (F1), 2M (F2), 34M (F3), 45M (MORE, F1), 52M E (MORE, F2), 155M (MORE, F3; option SSMTT-38-155ME)
  - *Optical*: 52M 0 (MORE, F3), 155M O (MORE, F1), 622M O (MORE, F2), 2.5G O (MORE, F3)
- SONET choices are:
  - *Electrical*: DS1 (F1), E1 (F2), E3 (F3), DS3 (MORE, F1), STS-1 (MORE, F2)
  - *Optical*: OC-1 (MORE, F3), OC-3 (MORE, F1), OC-12 (MORE, F2), OC-48 (MORE, F3)

**TEST PAYLOAD**
This is the low rate signal that will be tested within the higher (TEST INTERFACE) rate signal. The options depend on the TEST INTERFACE selected.

Complete the remaining configuration items, as outlined in the following subsections.

#### 2.1.1.1 SDH Configuration

The following subsections cover SDH configuration.

##### 2.1.1.1.1 2.5G O Configuration Screen

```
                                          ⧫1310

     TEST MODE      :SINGLE
     TEST INTERFACE :2.5G O
     TEST PAYLOAD   :2M
         STM-16     2M          TxCLK
     :INTERN        FRAME    :PCM31
     TxSRC :TESTPAT PAYLOAD :2M

     MAPPING
     STM-1  :1
     AU     :
     TUG-3[1]  TUG-2[1] TU-12[1]
     OTHERCH:BROAD

      AU-4     AU-3
```

**Figure 5 2.5G O Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: 1.5M (F1), VC11B (F2), 2M (F3), VC12B (MORE, F1), 34M (MORE, F2), 45M (F3), VC3BULK (MORE, F1), VC4BULK (MORE, F2), VC4_4C (MORE, F3), VC4_16C (MORE, F1)

Select the payload rate.

- VC4_16C: Use for a concatenated rate. The test pattern will fill the entire AU4-16C payload area.
- Select a bulk (B) rate, and the test pattern will be inserted into the entire payload (VC).
- Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

- INTERN: Use the test set's internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 Mbps timing source, plugged in at the CLK port.
- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the CLK port.

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in the selected tributary. The pattern is selected in SEND TEST PATTERN.
- THRU-L: Loop the incoming signal from RX to TX. If using a through mode, TxCLK will switch to LOOP for looped timing. In this mode, all overhead bytes are passed through. The test set cannot change OH, inject errors, or generate alarms. Also called "monitor through".

**SDH Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections. Here are the additions:

**STM-16**
STM-1, 1–6
VC4-4c

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)

Determine what will fill the unused (other) channels.

- BROAD: Transmits the test pattern.
- UNEQ: Transmit the Unequipped signal.

### 2.1.1.1.2 622M O Configuration Screen

```
                                      ⧫1310

TEST MODE      :SINGLE
TEST INTERFACE :622M O
TEST PAYLOAD   :2M
    STM-4      2M        TxCLK
:INTERN        FRAME    :PCM31
TxSRC :TESTPAT PAYLOAD :2M

MAPPING
STM-1  :1
AU     :
TUG-3[1]  TUG-2[1] TU-12[1]
OTHERCH:BROAD

 AU-4    AU-3
```

**Figure 6 622M O Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: 1.5M (F1), VC11B (F2), 2M (F3), VC12B (MORE, F1), 34M (MORE, F2), 45M (MORE, F3), VC3BULK (MORE, F1), VC4BULK (MORE, F2), VC4_4C (MORE, F3)

Select the payload rate.

- VC4_4C: Test pattern will fill the entire AU4-4c payload area.
- Select a bulk (B) rate, and the test pattern will be inserted into the entire payload (VC).
- Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

- INTERN: Use the test set’s internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 Mbps timing source, plugged in at the CLK port.
- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the CLK port.

**TxSRC**
Options: TESTPAT (F1), THRU (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in the selected tributary. The pattern is configured in SEND TEST PATTERN.
- THRU-L: Loop the incoming signal from RX to TX and the TxCLK will switch to LOOP for looped timing. In this mode, all overhead bytes are passed through. The test set cannot change OH, inject errors, or generate alarms. Also called “monitor through”.

**SDH Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections. Here are the additions:

**45M**
AU-4 (F1), AU-3 (F2)
if AU-3, AU-3: 1–3
if AU-4, TUG-3: 1–3

**34M**
STM-1, 1–4
AU-4 (F1), AU-3 (F2)
if AU-3, AU-3: 1–3
if AU-4, TUG-3: 1–3

**2M**
STM-1, 1–4
AU-4 (F1), AU-3 (F2)
if AU-4, TUG-3: 1–3
if AU-3, AU-3: 1–3
TUG-2: 1–7
TU-12: 1–3

**1.5M**
STM-1, 1–4
AU-4 (F1), AU-3 (F2)
TU-11 (F1), TU-12 (F2)
if AU-3, AU-3: 1–3
if AU-4, TUG-3: 1–3
TUG-2: 1–7
TU-11: 1–4

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)

Determine what will fill the unused (other) channels.

- BROAD: Transmits the test pattern.
- UNEQ: Transmit the Unequipped signal.

**2.1.1.1.3 155M 0 Configuration Screen**

```
                                  1310

TEST MODE      :SINGLE
TEST INTERFACE :155M O
TEST PAYLOAD   :2M
    STM-1       2M      TxCLK
:INTERN        FRAME    :PCM31
TxSRC :TESTPAT PAYLOAD :2M


MAPPING
AU     :
TUG-3[1]  TUG-2[1] TU-12[1]
OTHERCH:BROAD


 AU-4    AU-3
```

**Figure 7 155M O Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: 1.5M (F1), VC11B (F2), 2M (F3), VC12B (MORE, F1), VC12B (MORE, F1), 34M (MORE, F2), 45M (MORE, F3), VC3BULK (MORE, F1), VC4BULK (MORE, F2)

Select the payload rate.

- Select a bulk rate (such as VC11B), and the test pattern will be inserted into the entire payload.
- Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

- INTERN: Use the test set's internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 Mbps timing source, plugged in at the CLK port.
- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the CLK port.

**TxSRC**
Options: TESTPAT (F1), THRU (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in the selected tributary. The pattern is configured in SEND TEST PATTERN.
- THRU-L: Loop the incoming signal from RX to TX and the TxCLK will switch to LOOP for looped timing. In this mode, all overhead bytes are passed through. The test set cannot change OH, inject errors, or generate alarms. Also called “monitor through”.

**SDH Mapping Options**

Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections. Here are the additions:

**45M**
AU-4 (F1), AU-3 (F2)
if AU-3, AU-3: 1–3
if AU-4, TUG-3: 1–3

**2M**
AU-4 (F1), AU-3 (F2)
if AU-4, TUG-3: 1–3
if AU-3, AU-3: 1–3
TUG-2: 1–7
TU-12: 1–3

**1.5M**
AU-4 (F1), AU-3 (F2)
TU-11 (F1), TU-12 (F2)
if AU-3, AU-3: 1–3
if AU-4, TUG-3: 1–3
TUG-2: 1–7
TU-11: 1–4

**OTHERCH**

Options: BROAD (F1), UNEQ (F2)

Determine what will fill the unused (other) channels.

- BROAD: Transmit a test pattern on unused channels.
- UNEQ: Transmit a Unequipped signal on unused channels.

#### 2.1.1.1.4 52M O and E Configuration Screens

```
11:50:45                         1310
TEST MODE      :SINGLE
TEST INTERFACE :52M O
TEST PAYLOAD   :2M

TxCLK :INTERN  FRAME   :PCM31
TxSRC :TESTPAT PAYLOAD :2M



MAPPING
TUG-2[ ] TU-12[1]
OTHERCH:BROAD

  1       2       3      MORE
```

```
11:50:45
TEST MODE      :SINGLE
TEST INTERFACE :52M E
TEST PAYLOAD   :2M

RxLVL :TERM    FRAME  :UNFRAME
TxLVL :DSX     PAYLOAD:2M
TxCLK :INTERN
TxSRC :TESTPAT

MAPPING
TUG-2[ ] TU-12[1]
OTHERCH:BROAD

  1        2        3      MORE
```

**Figure 8 52M O and E Interface Configuration Screens**

Configure the following:

**TEST PAYLOAD**

52O Options: 1.5M (F1), VC11B (F2), 2M (F3), VC12B (MORE, F1), 34M (MORE, F2), 45M (MORE, F3), VC3BULK (MORE, F1), VC4BULK (MORE, F2)

52E Options: 1.5M (F1), VC11B (F2), 2M (F3), VC12B (MORE, F1), 34M (MORE, F2), 45M (MORE, F3), VC3BULK (MORE, F3)

Select the payload rate.

- Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration. See the corresponding subsection for the descriptions.
- Select a bulk rate (such as VC11B), and the test pattern will be inserted into the entire payload.
- For VC3BULK, the test pattern fills the entire payload.
- For a 45M payload, the test pattern is inserted on VC3, and measurements are done on the VC3 payload.
- For a 2M Payload, the test pattern is inserted on VC12, and measurements are done on the VC12 payload.
- For a 1.5M Payload, the test pattern is inserted on VC11, and measurements are done on the VC11 payload.
- MAPPING choices will appear if 1.5M or 2M is selected.

**RxLVL** (Electrical only)

Options: TERM (F1), MONITOR (F2)

Configure the receiver.

- TERM: Terminate the received signal with a 75 Ω impedance. Use TERM whenever you disrupt the circuit for testing.
- MONITOR: Applies to resistive loss; use only at protected monitoring points.

**TxLVL** (Electrical only)

Options: DSX (F1), HIGH (F2), LOW (F3,)

Configure the transmitter.

- DSX: Use at DSX-3. 0.76V base to peak nominal voltage.
- HIGH: Square wave base to peak nominal voltage of 0.90.
- LOW: Terminated mode application for signalling points where the signal is below the standard DSX level.

**TxCLK**

Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT(MORE, F1), T1_EXT (MORE, F2)

- INTERN: Use the test set's internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 Mbps timing source, plugged in at the CLK port.
- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the CLK port.

**TxSRC**

Options: TESTPAT (F1), THRU (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in the selected tributary. The pattern is configured in SEND TEST PATTERN.
- THRU-L: Loop the incoming signal from RX to TX and the TxCLK will switch to LOOP for looped timing. In this mode, all overhead bytes are passed through. The test set cannot change OH, inject errors, or generate alarms. Also called "monitor through".

**Mapping Options**

Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections. Here are the additions:

**45M**
no mapping

**2M**
TUG-2: 1–7
TU-12: 1–3

**1.5M**
TU-11: TU-11
TUG-2: 1–7
TU-11: 1–4

**OTHERCH**

Options: BROAD (F1), UNEQ (F2)

Determine what will fill the unused (other) channels.

- BROAD: Transmit a test pattern on unused channels.
- UNEQ: Transmit a Unequipped signal on unused channels.

### 2.1.1.1.5 45M Configuration Screen

```
TEST MODE      :SINGLE
TEST INTERFACE :45M
TEST PAYLOAD   :45M
     45M
FRAME :
RxLVL :TERM
TxLVL :DSX
TxSRC :TESTPAT
TxCLK :INTERN



  M13     C-BIT  UNFRAME
```

**Figure 9 45M Interface Configuration Screen**

This is the DS3 electrical rate. Configure the following:

**TEST PAYLOAD**
Options: 45M is the only selection.

**FRAME**
Options: M13 (F1), C-BIT (F2), UNFRAME (F3)

Select the 45M framing.

**RxLVL**
Options: TERM (F1), MONITOR (F2)

Configure the receiver.

- TERM: Terminate the received signal with a 75 Ω impedance. Use TERM whenever the circuit is disrupted for testing.
- MONITOR: Applies to resistive loss; use only at protected monitoring points.

**TxLVL**
Options: DSX (F1), HIGH (F2), LOW (F3)

Configure the transmitter.

- DSX: Use at DSX-3. 0.76V base to peak nominal voltage.
- HIGH: Square wave base to peak nominal voltage of 0.90.
- LOW: Terminated mode application for signalling points where the signal is below the standard DSX level.

### 2.1.1.5 45M Configuration Screen

**TxSRC**

Options: TESTPAT (F1), THRU (F2)

Determine the source of the signal.

- TESTPAT: Transmits a test pattern in each time slot. Select the pattern in SEND TEST PATTERN.
- THRU: Loops the incoming signal from RX to TX.

**TxCLK**

Options: INTERN (F1), LOOP (F2)

Determine the timing source for the transmit signal.

- INTERN: Use the internal timing of the test set. This timing is not synchronized to the network. Used in loopback testing where synchronization is not required.
- LOOP: Uses the received signal as the source for the transmit clock. Loop timing is necessary when transmitting toward a network element that requires synchronous signals.

#### 2.1.1.1.6 34M Configuration Screen

```
TEST MODE      :SINGLE
TEST INTERFACE :34M
TEST PAYLOAD   :34M
     34M
CODE  :
FRAME :FRAME
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN
```

HDB3

**Figure 10 34M Interface Configuration Screen**

34M is the E3 electrical rate. Configure the following:

**TEST PAYLOAD**
Options: 34M is the only selection.

**CODE**
Options: HDB3 is the only selection.

**FRAME**
Options: FRAME (F1), UNFRAME (F2)

- FRAME: Transmit and search for standard FAS framing.
- UNFRAME: No framing is transmitted.

**RxLVL**
Options: TERM (F1), MONITOR (F2)

Configure the receiver. These settings let the test set electrically decode a 34 Mbit/s signal under a wide range of resistive and or cable losses. The settings also determine which electrical load will be placed on the circuit by the test set. These settings have no effect on the transmitter.

- TERM: Terminate the received signal with a 75 Ω impedance termination. The signal being tested has been transmitted over real cable. Usually, you should use TERM whenever you disrupt the circuit for testing.
- MONITOR: Used when a monitor measurement is made and the signal is provided from the protected monitor jack of a network equipment at a level of -20 dB. The network equipment has isolated the monitor signal from the live signal with a resistive circuit.

This mode is useful because the monitor jack protects the live signal from any possible disruptions caused by the testing process. It allows you to test the line while it is in service.

Note that if monitor mode is selected when a 0 dB signal is received, then the BPV/CODE LED will be red. This happens if MONITOR is selected when the test set is plugged into an OUT jack. In this case, TERM should be selected instead.

**TxSRC**
Options: TESTPAT (F1), THRU (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in each time slot. This test pattern is configured in SEND TEST PATTERN.
- THRU: Loop the incoming signal from RX to TX.

**TxCLK**
Options: INTERN (F1), LOOP (F2)

Determine the timing source for the transmit signal.

- INTERN: Use the internal timing of the test set. This timing is not synchronized to the network. Use internal timing in loopback testing where synchronization is not required.
- LOOP: Use the received signal as the source for the transmit clock. Loop timing is necessary when transmitting toward an exchange or other network element that requires synchronous signals.

```
TEST MODE      :SINGLE
TEST INTERFACE :2M
TEST PAYLOAD   :NX64
      2M
CODE  :
FRAME :UNFRAME
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN
RfCLK :2M_EXT



 HDB3     AMI
```

**Figure 11 2M Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**

Options: 2M (F1), NX64 (F2)

- 2M: Test a single 2M rate.
- NX64: Test at factional rate and select time slots in the following screen:

```
RATE:  192K
             04  05  06  07  08
 09  10  11  12  13  14  15
 17  18  19  20  21  22  23  24
 25  26  27  28  29  30  31
RATE:  192K
             04  05  06  07  08
 09  10  11  12  13  14  15
 17  18  19  20  21  22  23  24
 25  26  27  28  29  30  31
  AUTO   SELECT  UN-SEL  CLR-ALL
```

**Figure 12 Nx64K Timeslot Selection Screen**

There are 2 methods for selecting time slots, Auto and Manual:

**AUTO** (F1)
If receiving a signal which is already formatted in the N (or M) x64 kbit/s fractional 2M format, the quickest method for selecting time slots is to press AUTO (F1). When completed, press ENTER to set and return to the previous screen.

In AUTO, the test set will automatically configure time slots by looking for active data. It will configure the transmit side to be the same as the active time slots on the receive side.

The time slots specified for transmit and receive need not be the same. Also, the number of selected time slots can differ from the Tx side to the Rx side. The test set will assume that all incoming data is received byte by byte in ascending channel order.

**SELECT** (F2)-Manual Timeslot Selection
Select a desired time slot by pressing , then press SELECT (F2). Repeat until finished. Selected time slots remain highlighted, as shown in Figure 12. Press UN-SEL (F3) to deselect a time slot. CLR-ALL (F4) clears all selections.

**CODE**
Options: HDB3 (F1), AMI (F2)

Select the line coding the test set will transmit and expect to receive. HDB3 is commonly used.

**FRAME**
Options: UNFRAME (F1), PCM-30 (F2), PCM-30C (F3), PCM-31 (MORE, F1), PCM-31C (MORE, F2)

Choose the framing (or P. FRAME) appropriate for the circuit under test

- PCM-30: The test set will synchronize on both Frame Alignment Signal (FAS) and Multi Frame Alignment Signal (MFAS).
- PCM-31: The test set will synchronize only on FAS.
- C indicates CRC-4 error checking has been enabled for that framing signal.
- UNFRAME: Use if the signal is unframed.

**Note**: If the framing and CRC-4 state of the received signal doesn't match the framing and CRC-4 settings, a Loss of Frame is indicated.

**RxLVL**
Options: TERM (F1), BRIDGE (F2), MONITOR (F3)

Configure the 2.048 Mbit/s receiver. These settings let the test set electrically decode a 2.048 Mbit/s signal under a wide range resistive or cable losses. It also determines which electrical load will be placed on the circuit by the test set. The settings have no effect on the transmitter. On a 2.048 Mbit/s circuit, there must be one receiver that applies the low impedance (75/120 Ω) termination.

**CAUTION**: If uncertain, choose BRIDGE to protect the signal.

- TERM: Terminate the received signal with a 120 Ω impedance termination. Use TERM when the circuit is disrupted for testing.
- MONITOR: Used when a measurement will be made from a protected monitoring point (PMP).

  Note that if MONITOR is selected when a 0 dB signal is received, the ERRORS LED will be red. This happens if MONITOR is selected when the test set is plugged into an OUT jack. In this case, TERM should be selected instead.
- BRIDGE: The test set applies high-impedance isolation resistors to the circuit under test. This isolation circuit will protect the signal from any possible disruption.

**TxSRC**

Options: TESTPAT (F1), THRU (F2)

Determine the source of the 2M signal.

- TESTPAT: Transmit a test pattern in each time slot. The pattern is selected in SEND TEST PATTERN.
- THRU: Loop the incoming signal from RX to TX.

**TxCLK**

Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1)

- INTERN: Use the test set's internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.

**RfCLK**

Options: E1_EXT (F1), 2M_EXT (F2)

Determine the timing source for the transmit signal.

- E1_EXT: Lock the signal to an external 1.5 MHz timing source, plugged in at the CLK port.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.

#### 2.1.1.1.8 1.5M Configuration Screen

```
TEST MODE      :SINGLE
TEST INTERFACE :1.5M
TEST PAYLOAD   :NX56
          CODE
      :
FRAME :UNFRAME
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN
RfCLK :2M_EXT



 B8ZS     AMI
```

**Figure 13 1.5M Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: 1.5M (F1), NX64 (F2), NX56 (F3)

- 1.5M: Test a single 1.5M line.
- NX64K: Fractional 1.5M testing, where the fractional circuit is any number of 64 kbit/s channels within the DS1.
- NX56K: Fractional circuit is any number of 56 kbit/s channels within the DS1. In this case, the test set will transmit a 1 in the eighth (least significant) bit of each fractional T1 channel.
  - For fractional channel entry, refer to Figure 12 and its associated procedures.

**CODE**
Options: B8ZS (F1), AMI (F2)

Determine the line code that is transmitted on the test set's 1.5M signal.

- B8ZS: Bipolar 8 Zero Substitution uses intentional BPVs to encode strings of eight consecutive zeros.
- AMI: Alternate Mark Inversion uses alternating positive and negative pulses to represent successive 1 values. In AMI, there is a risk of synchronization loss with long strings of zeros.

It is not always possible to determine the line coding of a circuit. For instance, an all 1s signal will mask the presence of B8ZS coding. Be sure you choose this setting correctly. An incorrect AMI/B8ZS setting is the most common problem in setting up the test set to transmit to switches, channel banks, multiplexers, and digital cross connect systems. The test set's code setting must be the same as that of the equipment at the other end of a DS1 line.

**FRAME**

Options: UNFRAME (F1), SF-D4 (F2), ESF (F3), SLC96 (F4)

Determine the 1.5M framing.

- UNFRAME: No framing
- SF-D4: Super Frame framing
- ESF: Extended Super Frame framing
- SLC-96: SLC-96 framing

**RxLVL**

Options: TERM (F1), BRIDGE (F2), MONITOR (F3)

Configure the 1.5M receiver.

- TERM: Use when sending and receiving a T1 signal. It requires that the circuit be disrupted for testing. The received signal is terminated by the test set and it is not obtained through a monitor jack. It can have up to 36 dB of cable transmission loss (this is a different kind of loss than the 20 dB of resistive loss provided by a DSX MON jack).

  If plugging into a monitor jack in this mode, the BPV LED will probably come on. Use MONITOR mode instead.

- BRIDGE: Similar to MONITOR mode, however, in BRIDGE mode, the test set taps into a live, in-service, terminated DS1 signal with up to 36 dB cable loss. The test set applies isolation resistors to protect the circuit from a hit. Select BRIDGE before clipping onto the live circuit.

  If used on a monitor jack in this mode, there will be a total of 40 dB resistive isolation, and the test set will likely report loss of signal. Also, in some cases it may not be clear if the monitor jack being used provides a bridged access, or a 20 dB isolation monitor access. In this case, try BRIDGE first to see if this works, and then try MONITOR if it doesn't.

- MONITOR: Use when a monitor measurement is made. The signal is provided from the MON jack of a DSX, DS1 plug-in card, CSU, or NI. The DSX has isolated the monitor signal from the live signal with a high impedance circuit. The transmitter is turned on and is sending the selected test pattern.

  This mode is useful because the DSX monitor jack protects the live signal from any possible disruptions caused by the testing process. It allows you to observe the line while the customer is actually using it and to see if there are any problems.

  Note that if this mode is selected when a 3V signal is received, then the ERRORS LED will be red. This happens if MONITOR is selected when the test set is plugged into an OUT jack. In this case, TERM should be selected. In some cases, it may not be clear if the MON jack provides a bridged access or a 20 dB isolated monitor access. In this case, try BRIDGE first to see if this works, if it doesn't, then try MONITOR.

**Tx SRC**

Options: TESTPAT (F1), THRU (F2)

Determine the source of the 1.5M test signal.

- TESTPAT: Transmit a test pattern. This pattern is configured in SEND TEST PATTERN.
- THRU: Loop each of the incoming channels from the 1.5M-Rx to Tx without inserting a test pattern onto the line. When selected, the test set changes TxCLK for LOOP.

**TxCLK**

Options: INTERN (F1), LOOP (F2), T1_EXT (F3)

Determine the source of the transmit clock.

- INTERN: Use internal timing when:
  - an external frequency source is not available.
  - the test set will not be transmitting towards synchronized network equipment.
  - the test set will be supplying clock to the circuit to be tested such as a hi cap T1 loop, PBX, or remote terminal of a digital loop carrier.
  - the 5 ppm accuracy of the INTERN clock is sufficient.
  - most kinds of loopback testing is performed.
- LOOP: Loop Timing should be used when:
  - loop timing is used to drop the timing from the received signal and loop it.
  - when the test set must be synchronous with the network.
- T1_EXT: External timing should be used when:
  - precise measurements are required.
  - an external 1.544 Mbps frequency source such as the central office clock is plugged in.

**Rf CLK**

Options: T1_EXT (F1), 2M_EXT (F2)

Determine the timing source for the transmit signal.

- T1_EXT: Lock the signal to an external 1.5 MHz timing source, plugged in at the CLK port.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the CLK port.

### 2.1.1.2 SONET Configuration

The following subsections cover SONET configuration.

#### 2.1.1.2.1 OC-48 Configuration Screen

```
                                   ⧫1310

TEST MODE      :SINGLE
TEST INTERFACE :OC-48
TEST PAYLOAD   :VT2

TxCLK :        FRAME   :PCM31
TxSRC :TESTPAT PAYLOAD :2M


MAPPING
STS-1: 1 VT-Gr:1  VT2  :1
OTHERCH:BROAD


INTERN  2M_EXT  LOOP   MORE
```

**Figure 14 OC-48 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: VT1.5 (F1), VT2 (F2), E3 (F3), DS3 (MORE, F1), STS-1 (MORE, F2), STS-3C (MORE, F3), STS-12C (MORE, F1), STS-48C (MORE, F2)

Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

- INTERN: Use the test set's internal timing.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the 1.5/2M port.
- LOOP: Timing received from the Rx port is used as clock.
- E1_EXT: Lock the signal to an external 2.048 Mbps timing source, plugged in at the 1.5/2M port.
- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the 1.5/2M port.

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)

Determine the source of the signal.

- TESTPAT: Transmit a test pattern in the selected tributary. The pattern is selected in SEND TEST PATTERN.
- THRU-L: Loop the incoming signal from RX to TX. If using a through mode, TxCLK will switch to LOOP for looped timing. In this mode, all overhead bytes are passed through. The test set cannot change OH, inject errors, or generate alarms. Also called “monitor through”.

**SONET Mapping Options**

Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections based on the TEST PAYLOAD setting. The following **Test Payloads** have these options:

*VT DISPLAY: GROUP*
**STS-48C**; none
**STS-12C**; STS-12: 1–4
**STS-3C**; STS-3: 1–16
**STS-1**; STS-1: 1–48
**DS3, E3**; STS-1: 1–48
**VT2**; STS-1: 1–48, VT-Gr: 1–7, VT2: 1–3
**VT1.5**; STS-1: 1–48, VT-Gr: 1–7, VT1.5: 1–4

*VT DISPLAY: BELCORE and M13ANSI*
**STS-48C**; none
**STS-12C**; STS-12: 1–4
**STS-3C**; STS-3: 1–16
**STS-1**; STS-1: 1–48
**DS3, E3**; STS-1: 1–48
**VT2**; STS-1: 1–48, VT2: 1–21
**VT1.5**; STS-1: 1–48, VT1.5: 1–28

**OTHERCH**

Options: BROAD (F1), UNEQ (F2)

If available, determine what will fill the unused (other) channels.

- BROAD: Transmits the test pattern.
- UNEQ: Transmit the Unequipped signal.

### 2.1.1.2.2 OC-12 Configuration Screen

See Figure 14 for a sample screen and configure the following:

**TEST PAYLOAD**
Options: VT1.5 (F1), VT2 (F2), E3 (F3), DS3 (MORE, F1), STS-1 (MORE, F2), STS-3C (MORE, F3), STS-12C (MORE, F1)

Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)
See *Section 2.1.1.2.1-TxCLK.*

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)
See *Section 2.1.1.2.1-TxSRC.*

**SONET Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections based on the TEST PAYLOAD setting. The following **Test Payloads** have these options:

*VT DISPLAY: GROUP*
**STS-12C**; none
**STS-3C**; STS-3: 1–4
**STS-1**; STS-1: 1–12
**DS3, E3**; STS-1: 1–12
**VT2**; STS-1: 1–12, VT-Gr: 1–7, VT2: 1–3
**VT1.5**; STS-1: 1–12, VT-Gr: 1–7, VT1.5: 1–4

*VT DISPLAY: BELCORE and M13ANSI*
**STS-12C**; none
**STS-3C**; STS-3: 1–4
**STS-1**; STS-1: 1–12
**DS3, E3**; STS-1: 1–12
**VT2**; STS-1: 1–12, VT2: 1–21
**VT1.5**; STS-1: 1–12, VT1.5: 1–28

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)
See *Section 2.1.1.2.1-OTHERCH.*

#### 2.1.1.2.3 OC-3 Configuration

See Figure 14 for a sample screen and configure the following:

**TEST PAYLOAD**
Options: VT1.5 (F1), VT2 (F2), E3 (F3), DS3 (MORE, F1), STS-1 (MORE, F2), STS-3C (MORE, F3)

Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

See *Section 2.1.1.2.1-TxCLK.*

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)

See *Section 2.1.1.2.1-TxSRC.*

**SONET Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections based on the TEST PAYLOAD setting. The following **Test Payloads** have these options:

*VT DISPLAY: GROUP*
**STS-3C**; none
**STS-1**; STS-1: 1–3
**DS3, E3**; STS-1: 1–3
**VT2**; STS-1: 1–3, VT-Gr: 1–7, VT2: 1–3
**VT1.5**; STS-1: 1–3, VT-Gr: 1–7, VT1.5: 1–4

*VT DISPLAY: BELCORE and M13ANSI*
**STS-3C**; none
**STS-1**; STS-1: 1–3
**DS3, E3**; STS-1: 1–3
**VT2**; STS-1: 1–3, VT2: 1–21
**VT1.5**; STS-1: 1–3, VT1.5: 1–28

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)

See *Section 2.1.1.2.1-OTHERCH.*

#### 2.1.1.2.4 OC-1 Configuration

See Figure 14 for a sample screen and configure the following:

**TEST PAYLOAD**
Options: VT1.5 (F1), VT2 (F2), E3 (F3), DS3 (MORE, F1), STS-1 (MORE, F2)

Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

See *Section 2.1.1.2.1-TxCLK*.

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)

See *Section 2.1.1.2.1-TxSRC*.

**SONET Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections based on the TEST PAYLOAD setting. The following **Test Payloads** have these options:

*VT DISPLAY: GROUP*
**STS-1, DS3, E3**; none
**VT2**; VT-Gr: 1–7, VT2: 1–21
**VT1.5**; VT-Gr: 1–7, VT1.5: 1–4

*VT DISPLAY: BELCORE and M13ANSI*
**STS-1, DS3, E3**; none
**DS3, E3**; STS-1: 1–3
**VT2**; VT2: 1–21
**VT1.5**; VT1.5: 1–28

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)

See *Section 2.1.1.2.1-OTHERCH*.

#### 2.1.1.2.5 STS-1 Configuration

```
TEST MODE      :SINGLE
TEST INTERFACE :STS-1
TEST PAYLOAD   :VT2

RxLVL :TERM    FRAME   :PCM31
TxLVL :DSX     PAYLOAD :2M
TxCLK :
TxSRC :TESTPAT

MAPPING
VT-Gr:1  VT2  :1
OTHERCH:BROAD

INTERN  2M_EXT   LOOP    MORE
```

**Figure 15 STS-1 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: VT1.5 (F1), VT2 (F2), E3 (F3), DS3 (MORE, F1)

Select a rate, and that rate will be tested. Mapping appears at the bottom of the screen for configuration.

**RxLVL**
Options: TERM (F1), MONITOR (F2)

Configure the receiver.

- TERM: Use when sending and receiving a T1 signal. It requires that the circuit be disrupted for testing. The received signal is terminated by the test set and it is not obtained through a monitor jack. It can have up to 36 dB of cable transmission loss (this is a different kind of loss than the 20 dB of resistive loss provided by a DSX MON jack).

  If plugging into a monitor jack in this mode, the BPV LED will probably come on. Use MONITOR mode instead.
- MONITOR: Use when a monitor measurement is made. The signal is provided from the MON jack of a DSX, DS1 plug-in card, CSU, or NI. The DSX has isolated the monitor signal from the live signal with a high impedance circuit. The transmitter is turned on and is sending the selected test pattern.

  This mode is useful because the DSX monitor jack protects the live signal from any possible disruptions caused by the testing process. It allows you to observe the line while the customer is actually using it and to see if there are any problems.

Note that if this mode is selected when a 3V signal is received, then the ERRORS LED will be red. This happens if MONITOR is selected when the test set is plugged into an OUT jack. In this case, TERM should be selected. In some cases, it may not be clear if the MON jack provides a bridged access or a 20 dB isolated monitor access. In this case, try BRIDGE first to see if this works, if it doesn't, then try MONITOR.

**TxLVL**
Options: DSX (F1), HIGH (F2), LOW (F3)

Set the transmit signal level.

- HIGH: Delivers the highest level pulse, typically 0.9V base to peak nominal voltage.
- DSX: Delivers the GR-253-CORE standard for base to peak at a STSX-1, typically between 0.36V and 0.85V.
- LOW: Delivers a pulse typically 0.15V base to peak nominal voltage.

**TxCLK**
Options: INTERN (F1), 2M_EXT (F2), LOOP (F3), E1_EXT (MORE, F1), T1_EXT (MORE, F2)

See *Section 2.1.1.2.1-TxCLK*.

**TxSRC**
Options: TESTPAT (F1), THRU-L (F2)

See *Section 2.1.1.2.1-TxSRC*.

**SONET Mapping Options**
Set the signal mapping. In a mapped signal, the test pattern is inserted on and measurements are taken at the lowest rate. Use the F-keys to make selections based on the TEST PAYLOAD setting. The following **Test Payloads** have these options:

*VT DISPLAY: GROUP*
**STS-1, DS3, E3**; none
**VT2**; VT-Gr: 1–7, VT2: 1–3
**VT1.5**; VT-Gr: 1–7, VT1.5: 1–4

*VT DISPLAY: BELCORE and M13ANSI*
**STS-1, DS3, E3**; none
**DS3, E3**; STS-1: 1–3
**VT2**; VT2: 1–21
**VT1.5**; VT1.5: 1–28

**OTHERCH**
Options: BROAD (F1), UNEQ (F2)

See *Section 2.1.1.2.1-OTHERCH*.

#### 2.1.1.2.6 DS3 Configuration

```
TEST MODE      :SINGLE
TEST INTERFACE :DS3
TEST PAYLOAD   :

FRAME :M13
RxLVL :TERM
TxLVL :DSX
TxSRC :TESTPAT
TxCLK :INTERN



  DS3
```

**Figure 16 DS3 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: None fixed at DS3

**FRAME**
Options: M13 (F1), C-BIT (F2), UNFRAME (F3)
Select the framing.

**RxLVL**
Options: TERM (F1), MONITOR (F2)
See *Section 2.1.1.2.4-RxLVL.*

**TxLVL**
Options: DSX (F1), HIGH (F2), LOW (F3)
See *Section 2.1.1.2.4-TxLVL.*

**TxSRC**
Options: TESTPAT (F1), THRU (F2)
See *Section 2.1.1.1.8-TxSRC.*

**TxCLK**
Options: INTERN (F1), LOOP (F2)
- INTERN: Use the test set's internal timing.
- LOOP: Timing received from the Rx port is used as clock.

#### 2.1.1.2.7 E3 Configuration

```
TEST MODE      :SINGLE
TEST INTERFACE :E3
TEST PAYLOAD   :

CODE  :HDB3
FRAME :FRAME
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN



    E3
```

**Figure 17 E3 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: None, fixed at E3

**CODE**
Options: None, fixed at HDB3

**FRAME**
Options: FRAME (F1), UNFRAME (F2)
Select the framing.

**RxLVL**
Options: TERM (F1), MONITOR (F2)
See *Section 2.1.1.2.4-RxLVL.*

**TxSRC**
Options: TESTPAT (F1), THRU (F2)
See *Section 2.1.1.1.8-TxSRC.*

**TxCLK**
Options: INTERN (F1), LOOP (F2)
See *Section 2.1.1.2.1-TxCLK.*

### 2.1.1.2.8 E1 Configuration

```
TEST MODE      :SINGLE
TEST INTERFACE :E1
TEST PAYLOAD   :

CODE  :HDB3
FRAME :PCM31
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN
RfCLK :2M_EXT



  E1
```

**Figure 18 E1 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: None, fixed at E1

**CODE**
Options: HDB3 (F1), AMI (F2)
Select the line coding the test set will transmit and expect to receive. HDB3 is commonly used.

**FRAME**
Options: UNFRAME (F1), PCM30 (F2), PCM30C (F3), PCM31 (MORE, F1), PCM31C (MORE, F2)
Select the framing.

**RxLVL**
Options: TERM (F1), BRIDGE (F2), MONITOR (F3)
See *Section 2.1.1.1.8-RxLVL*.

**TxSRC**
Options: TESTPAT (F1), THRU (F2)
See *Section 2.1.1.1.8-TxSRC*.

**TxCLK**
Options: INTERN (F1), LOOP (F2)
See *Section 2.1.1.2.1-TxCLK*.

**Rf CLK**
Options: E1_EXT (F1), 2M_EXT(F2)
Determine the timing source for the transmit signal.

- E1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the 1.5/2M port.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the 1.5/2M port.

#### 2.1.1.2.9 DS1 Configuration

```
TEST MODE      :SINGLE
TEST INTERFACE :DS1
TEST PAYLOAD   :
      DS1
CODE  :B8ZS
FRAME :ESF
RxLVL :TERM
TxSRC :TESTPAT
TxCLK :INTERN
RxCLK :2M_EXT



 DS1     NX64     NX56
```

**Figure 19 DS1 Interface Configuration Screen**

Configure the following:

**TEST PAYLOAD**
Options: DS1 (F1), NX64 (F2), NX56 (F3)
Select a rate, and that rate will be tested. If an NX rate is selected, a timeslot selection screen is displayed. Make selections as shown in *Section 2.1.1.1.7-TEST PAYLOAD.*

**CODE**
Options: B8ZS (F1), AMI (F2)
See *Section 2.1.1.1.8-CODE.*

**FRAME**
Options: UNFRAME (F1), SF-D4 (F2), ESF (F3)
Select the framing.

**RxLVL**
Options: TERM (F1), BRIDGE (F2), MONITOR (F3)
See *Section 2.1.1.1.8-RxLVL.*

**Tx SRC**
Options: TESTPAT (F1), THRU (F2)
See *Section 2.1.1.1.8-TxSRC.*

**TxCLK**
Options: INTERN (F1), LOOP (F2), T1_EXT (F3)
See *Section 2.1.1.1.8-TxCLK.*

**Rf CLK**
Options: T1_EXT (F1), 2M_EXT(F2)
Determine the timing source for the transmit signal.

- T1_EXT: Lock the signal to an external 1.544 Mbps timing source, plugged in at the 1.5/2M port.
- 2M_EXT: Lock the signal to an external 2.048 MHz timing source, plugged in at the 1.5/2M port.

### 2.1.2 Send Test Pattern

```
2e23   2e20   2e15    2e11
       2e7    2e6     FOX
QRS    USER   1111    0000
1010   1100   1-8     1-16
3-24   OCT55  DLY55

PATTERN       :INVERTED
MEASURE MODE  :BER



USER   INVERT   MODE
```

**Figure 20 Send Test Pattern Screen**

This screen shows patterns for transmitting/receiving. In it:

- Use to select a test pattern. The cursor will skip patterns not available under the current configuration. As a pattern is selected, it immediately begins transmitting.
- Press INVERT (F2) to send the selected pattern in an inverted form (1s and 0s reversed), which is shown at the PATTERN line. Press INVERT again to return to NORMAL.
- Press MODE (F3) to choose your testing mode. Select BER for bit error rate testing, which relies on test pattern synchronization, or LIVE, which disables pattern detection and G.821 measurements for in-service measurement.
- When finished, press ESC to return to the previous screen.
- See *Section 4.2* for pattern definitions.
- USER (F1): In addition to the standard patterns, you may program, send, and save custom test patterns. Refer to the following subsections:

**Sending a Custom Test Pattern**

1. In SEND TEST PATTERN, press USER (F1) and a screen is displayed presenting a list of stored patterns.
2. Use to select to a pattern and press ENTER.

**Viewing a Custom Test Pattern**

1. In SEND TEST PATTERN, press USER (F1) and a screen is displayed presenting a list of stored patterns.
2. Use to select to a pattern and press VIEW (F1).
3. The selected pattern will be displayed on-screen (in binary).
4. When finished, press ESC.

**Creating Custom Test Pattern**

1. In SEND TEST PATTERN, press USER (F1) and a screen is displayed presenting a list of stored patterns.
2. Create a label for the custom test pattern by using to select a blank line and press CREATE (F1). A character entry screen is presented.
3. Press TOGGLE (F3) and the "A" will be highlighted.
4. Use to highlight a desired character and press SELECT (F4). The character appears next to the label. Repeat until the label is finished.
5. Press TOGGLE (F3) to exit the character grid.
6. Create your custom pattern by pressing to select the pattern entry (No.) line.
7. Press SHIFT and enter up to 24 bits to make up the pattern. When finished, press SHIFT.

- If you make a mistake
  - A. Press SHIFT to disable the SHIFT and select the incorrect digit.
  - B. Press INSERT (F1) or DELETE (F2) and in ether case, press SHIFT to enter a digit at the insertion point. When done, press SHIFT.

8. Press ENTER to save the pattern and return to the list screen with the new pattern label.

**Editing a Custom Test Pattern Label**

1. In SEND TEST PATTERN, press USER (F1) and a screen is displayed presenting a list of stored patterns.
2. Use to select to a pattern and press EDIT (F2).
3. When the cursor is on the LABEL code, press TOGGLE (F3) and the "A" in the character grid will be highlighted.
4. To replace a particular letter, select it and press

- INSERT (F1), select the desired replacement character and press TYPOVR (F1).
- DELETE (F2) to remove a letter.
- If you need to add letters to the label, press TOGGLE (F3) to return to the character grid. Select the desired character and press SELECT (F4). Repeat until finished.

5. Press TOGGLE (F3) to move out of the character grid and back to the LABEL line and press ENTER.

**Deleting a Custom Test Pattern**

1. In SEND TEST PATTERN, press USER (F1) and a screen is displayed presenting a list of stored patterns.
2. Use to select to a pattern and press DELETE (F3) and the pattern is deleted. When done, press ESC.

### 2.1.3 Auto Configuration

```
Signal Rate: 2.5G O
SDH Mapping: N/A

PDH Mapping: C-BIT


Pattern    :

Result     :


 STOP
```

**Figure 21 Auto Configuration Screen**

Press F1 to start auto-synchronization on the received signal, matching bit rate, mapping, payload bit rate and framing, and test pattern when performing out-of-service testing. In-service auto configuration will identify the first active channel with a valid payload. “Scanning” messages are displayed as the test set synchronizes, then a display of the status of the line (Pass or Fail). During the process F1 to stop the configuration.

### 2.1.4 Setup Network Mode

```
      SETUP NETWORK MODE

   NETWORK MODE :
   VT DISPLAY   : GROUP


 SDH    SONET
```

**Figure 22 Setup Network Mode Screen**

Configure the network mode:

**NETWORK MODE**
Options: SDH (F1), SONET (F2)

Select the type of network to be tested.

**VT DISPLAY**
Options: GROUP (F1), BELCORE (F2) M13ANSI (F3)

If SONET is selected for NETWORK MODE, determine how the virtual tributaries will be counted and displayed.

- GROUP: Displays the VTs in the group/VT number format shown in Table 2. The first digit is the VT Group number (1 through 7), the second is the VT number (1 through 4).
- BELCORE: See Standard mapping shown in Table 2.
- M13ANSI: See Sequential mapping shown in Table 2.

**Note**: If M13ANSI is selected, the module main menu screen will contain the following F-keys:
MEAS (F1): Displays the measurement results screens. See *Section 2.2.*
T_CONF (F2): Displays the test configuration screen. See *Section 2.1.1*.

Press ESC when finished.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Standard | 1-1 | 1 | 1-2 | 8 | 1-3 | 15 | 1-4 | 22 |
| | 2-1 | 2 | 2-2 | 9 | 2-3 | 16 | 2-4 | 23 |
| | 3-1 | 3 | 3-2 | 10 | 3-3 | 17 | 3-4 | 24 |
| | 4-1 | 4 | 4-2 | 11 | 4-3 | 18 | 4-4 | 25 |
| | 5-1 | 5 | 5-2 | 12 | 5-3 | 19 | 5-4 | 26 |
| | 6-1 | 6 | 6-2 | 13 | 6-3 | 20 | 6-4 | 27 |
| | 7-1 | 7 | 7-2 | 14 | 7-3 | 21 | 7-4 | 28 |
| Sequential | 1-1 | 1 | 1-2 | 2 | 1-3 | 3 | 1-4 | 4 |
| | 2-1 | 5 | 2-2 | 6 | 2-3 | 7 | 2-4 | 8 |
| | 3-1 | 9 | 3-2 | 10 | 3-3 | 11 | 3-4 | 12 |
| | 4-1 | 13 | 4-2 | 14 | 4-3 | 15 | 4-4 | 16 |
| | 5-1 | 17 | 5-2 | 18 | 5-3 | 19 | 5-4 | 20 |
| | 6-1 | 21 | 6-2 | 22 | 6-3 | 23 | 6-4 | 24 |
| | 7-1 | 25 | 7-2 | 26 | 7-3 | 27 | 7-4 | 28 |

**Table 2 VT Group Numbering**

### 2.1.5 Measurement Criteria

Press to return

```
  MEASUREMENT CRITERIA                  MEASUREMENT CRITERIA
                                       G.821       :
MEAS DURATION :                        G.826/G.828 : G.828
START         : MANUAL                 G.829    :    ON
PROG DATE YMD : ----:--:--             M.2100   :    ON
PROG TIME HMS : --:--:--               M.2101   :    ON
PRINT EVENT   : DISABLE                M.2110 : ON
T1 IDLE CODE  : 01111111
E1 IDLE CODE  : 11010101               MEAS PERIOD : 15MIN
OPTICAL TX    : ON                     HRP MODEL % : 040.0

                 more                                   more
TIMED CONTINU                          ON      OFF
```

Press

The second screen is available only in SDH Network Mode

**Figure 23 Measurement Criteria Screens**

Configure the following as required:

**MEAS DURATION**
Options: TIMED (F1), CONTINU (F2)

Set the Measurement Duration. A timed measurement will stop when the specified amount of time has elapsed. This option is useful for making measurements of a specified length; 15 minute and 1 hour tests are commonly used in the industry. When a timed test is in progress, the Remaining Time (RT) counter shows how much time is left before the end of the test.

- TIMED: Press SHIFT and enter a number between 1 minute to 999 hours and 59 minutes, using the numeric keypad.
- CONTINU: The test will run indefinitely until a RESTART F-key is pressed, or until some other setting has been changed.

**START**
Options: PROGRAM (F1), MANUAL (F2)

Select the method to begin your test measurements.

- PROGRAM: Choose a specified time in the future to begin taking measurements. Once selected, enter the desired time in the next two items.
- MANUAL: Manually begin the test.

**PROG DATE YMD**
Applies if PROGRAM has been selected for START. Enter the Year, Month, and Day to begin measurements, by pressing SHIFT and use the numeric keypad to make the entry.

**PROG TIME HMS**
Applies if PROGRAM has been selected for START Specify the Hour, Minute, and Seconds to begin measurements, by pressing SHIFT and use the numeric keypad to make the entry.

**PRINT EVENT**
Options: ENABLE (F1), DISABLE (F2)

Print a time and date-stamped error message every second that one or more errors occur by selecting ENABLE.

**T1 IDLE CODE**
Options: Any 8-bit pattern

Set the idle code to be any 8-bit pattern to be used in fractional 1.5M and 2M testing to fill up the unused channels.

**E1 IDLE CODE**
Options: Any 8-bit pattern

Set the idle code to be any 8-bit pattern to be used in fractional 1.5M and 2M testing to fill up the unused channels.

**OPTICAL TX**
Options: ON (F1), OFF (F2)

Determine whether of not the laser is transmitting.

The right screen shown in Figure 23 is available in SDH Network Mode and it can be accessed by pressing (There is no second screen in SONET mode). The screen relates to ITU-T standards for 2.048 Mbit/s transmission, G.821, G.826, and M.2100.

**G.821**
Options: ON (F1), OFF (F2)

When on, the G.821 screen is shown in MEASUREMENT RESULTS. It presents the measurement parameters specified in ITU G.821; applied to the rate under test.

**G.826/G.828**
Options: ON (F1), OFF (F2)

When on, the G.826 and or G.828 screen (as appropriate) is displayed in MEASUREMENT RESULTS. It presents the measurement parameters defined in G.826/G.828.

**G.829**
Options: ON (F1), OFF (F2)

When on, the G.821 screen is shown in MEASUREMENT RESULTS. It presents the measurement parameters specified in ITU G.829; applied to the rate under test.

**M.2100**
Options: ON (F1), OFF (F2)

When on, the M.2100 screen is displayed in MEASUREMENT RESULTS. It refers to ITU specifications used when a PDH circuit passes through international boundaries. It allocates a certain allowable error rate to each nation that carries the circuit. Enter the appropriate percentage allowed for the line under test in HRP MODEL %.

**M.2101**
Options: ON (F1), OFF (F2)

When on, the M.2101 screen is displayed in MEASUREMENT RESULTS. It refers to ITU specifications used when a SDH circuit passes through international boundaries. It allocates a certain allowable error rate to each nation that carries the circuit. Enter the appropriate percentage allowed for the line under test in HRP MODEL %.

**M.2110**
Options: ON (F1), OFF (F2)

When on, the M.2110 screen is displayed in MEASUREMENT RESULTS. It presents the measurement parameters specified in ITU M.2110; applied to the rate under test and refers to ITU specifications used for bringing into service measurements on SDH and PDH paths. It is focused on BIS (Bringing Into Service); bringing into service an international connection. Measurements are based on G.826/G.828/G.829 ES and SES, in relation to the S1 (low) and S2 (high) thresholds.

The next two settings refer to all of the M.21xx measurements:

**MEAS PERIOD**
Options: 1MIN (F1), 15MIN (F2), 2HR (F3), 1DAY (MORE, F1), 7DAY (MORE, F2)

Control how often a new result is displayed in MEASUREMENT RESULTS.

**HRP MODEL %**
Options: .1 to 63.0 %

Enter a percentage by using SHIFT and the numeric keypad.

### 2.1.6 System Profiles

Use this function to store commonly used module configuration settings.

The following screen contains a DEFAULT profile. This profile is based on the factory standard configuration of this module. To create other profiles, change the configuration settings in any available screen. Once all configuration screens are as desired, select PROFILES from the module main menu and select a blank line. Press STORE (F2) and the settings are saved with a generic filename. Use this screen to manage profiles. The screen and its functions are as follows:

**Note**: The DEFAULT file can't be deleted or unlocked.

```
          PROFILE LIST
          Free space: 17660 kbyte

 1.DEFAULT    NO    SDH
 2.P00001     NO    SDH
 3.SANTA ROSA YES   SDH
 4.
 5.
 6.
 7.
 8.
 9.
10.
  LOAD    STORE   RENAME   more

 DELETE   LOCK             more
```

**Figure 24 Profile List Screen**

The following F-keys are available:

**LOAD** (F1): Press to change all configuration settings of the module to match the selected profile. The LOADED column changes from NO to YES.

**STORE** (F2): Press to save all current configuration screens with a generic filename. Currently 10 profiles can be saved. The type of module is indicated in the MODULE column.

**RENAME** (F3): Select a filename and press F3 to change its name. A character entry screen is displayed. Use the procedure in *Section 2.7.6* to edit the name from step 4.

**DELETE** (more, F1): Press to delete a selected unlocked profile.

**LOCK/UNLOCK** (more, F2): Press to lock or unlock a selected profile. Lock a profile to prevent changes. The profiles status is indicated by a lock icon in the LOCK column. In Figure 24 DEFAULT is locked.

## 2.2 Results

This menu contains the following:

- MEASUREMENT RESULTS
- HISTOGRAM ANALYSIS
- VIEW CURRENT EVENT

### 2.2.1 Measurement Results

In all results screens:

- 'Meas' is displayed when measurements are made.
- The measurement mode is set in the SETUP > SEND TEST PATTERN screen: choose BER as the MODE (F3) for test pattern synchronization measurements; choose LIVE to take measurements from a live signal.
- These screens need not be displayed in order for measurements to be compiled.
- Measurements are automatically restarted every time the configuration is changed.
- The results screens allow for viewing the accumulated measurements and restarting of the measurement process.

The screens available will depend on the test set's configuration; each rate will have its own screens. There are, however, some common features in all the Measurement Results screens.

Measurements may have a count number displayed on the left side of the screen with the corresponding rate or percentage displayed on the same line on the right side. For example, ES, the count of errored seconds, is displayed on the left column, while %ES, the percentage of errored seconds, is displayed on the right column.

All result screens contain the following F-keys:

**CONFIG** (F1): Shortcut to the TEST CONFIGURATION screen. See *Section 2.1.1*.

**PATTERN** (F2): Shortcut to the SEND TEST PATTERN screen. See *Section 2.1.2.*

**RESTART** (F3): Press to restart all measurements, resetting all counters.

**HOLDSCR/CONTINU** (MORE, F1): HOLDSCR freezes all of the measurement displays so they may be easily observed. The measurement count is still proceeding, but the counts are updated only in memory. When finished viewing, press CONTINU to view a live display.

**HISTOGRAM** (MORE, F2): Shortcut to the CURRENT HISTOGRAM screen. See *Section 2.2.2.1.*

**LOCK/UNLOCK** (MORE, F3): Press to disable the keypad. An indicator will appear at the top of the screen. The measurement process continues as usual, but keypad strokes have no effect on the test set. This is useful if you are running a long-term test and do not wish to have the test disturbed. Press UNLOCK (F2) to re-enable the test set's keypad.

**PRINT** (MORE, F1): Press to send all of the current results to the serial port for printing.

**SAVE** (MORE, F2): Press to store the measurement results. See *Section 2.7*.

**STOP/START** (MORE, F3): Press to stop measuring, press again to restart measuring, resetting all counters.

In addition to the actual measurement data, the following information is displayed in the upper portion of the measurement screens (except in the STATUS screen):

**ET**: Elapsed Time is the time that has passed since the test was started, reconfigured in TEST CONFIGURATION, or restarted.

**RT**: Remaining Time is the time that remains until the end of testing. The factory default condition is that the test runs continuously until the user stops it. For this reason, 'CONTINU' is displayed in the RT field to denote a continuous test.

**I/P** or **INTF** and **PAY**: This is the test interface and test payload, as determined by TEST CONFIGURATION, TEST INTERFACE and TEST PAYLOAD settings.

**C/F**: This is the test interface coding and framing. Does not appear for all configurations.

**TX**: This is the test pattern the test set is transmitting.

**RX**: This is the test pattern the test set is receiving. If pattern synchronization cannot be achieved, the test set will indicate "LIVE". It will indicate "PATNLOSS" if synchronization is lost when measurements are running.

Some of the Results screens indicate in the screen name, the Section (SDH), or Path (SONET) they apply to, and the type of errors which could trigger an ES or SES.

To view screens, press . Note the bar at the right of the screen indicates the relative number of screens available.

### 2.2.1.1 Shared SDH and SONET Screens

**Status Screen**

This screen gives an overview of the status of the line. NO ERR is displayed for each line if error-free. ERR DET is displayed for each line if a problem is found. This screen is updated throughout the test.

```
                 Meas

            000:04:03

             NO ERR

CONFIG  PATTERN RESTART MORE
```

**Figure 25 Status Screen**

**Summary Screen**

This screen reports on the primary types of errors available for each rate in use. This screen is updated throughout the test.

```
                    Meas    1310
ET:000:03:00          RT:CONTINU
INTF: 155M O          PAY:2M
TX  : USER-INV        RX:USER

CODE:N/A           CODE:N/A
FASE:0             FASE:0
FREQ:155519832     BIT :0
LPK :N/A

CONFIG  PATTERN RESTART MORE
```

**Figure 26 Summary Screen**

**Frequency Results**

Frequency results are available for the higher rate in a multirate signal setup. A bar graph (if present) indicates how fast the signal is slipping in relation to the reference clock. A count of the number of clock slips is kept at the end of the bar. A clock slip occurs when the measured frequency deviates from the reference frequency by 1UI (Unit Interval). A 1.5M UI is equal to 647 ns; a 2M UI is equal to 488 ns.

```
                   Meas
ET:000:09:07       RT:CONTINU
INTF:STM-1         PAY:2M
TX:2E15            RX:2E15

      No Reference Clock

Rx  Hz   :34368000   /  0.0  ppm
MIN  Hz  :34368000   /  0.0  ppm
MAX  Hz  :34368000   /  0.0  ppm
CLKSLP :N/A
+WNDR  :N/A
-WNDR  :N/A
CONFIG PATTERN RESTART MORE
```

**Figure 27 Frequency Screen**

The following is reported:

**Rx Hz**: Current frequency measured during the last second.

**MAX, MIN Hz**: Maximum and minimum frequencies measured since the start of the test.

**CLKSLIP**: A clock slip occurs when the measured frequency deviates from the reference frequency by one unit interval. A unit interval is the amount of time it takes to transmit one pulse.

**+WNDR**: Maximum positive phase difference between the measured frequency and the reference frequency, since the start of the test. A signal whose frequency is wandering, i.e. whose frequency alternately goes faster and then slower than the reference frequency, will show both positive and negative wander.

**-WNDR**: Maximum negative phase difference between the measured frequency and the reference frequency since the start of the test.

### Optical Power Results Screen

This screen reports on the power received at the optical connector, in dBm.

```
                          Meas    1310
ET:008:22:10              RT:CONTINU
INTF:155M O               PAY:2M
TX:2E23                   RX:2E23
                               OPTICAL
POWER :                   -12.2    dBm


SATURAT


0   -3.0                  -20.0
CONFIG  PATTERN RESTART   MORE
```

**Figure 28 Optical Power Screen**

The following is reported:

**OPTICAL POWER**: Value in dBm of the received power (-12.2 dBm in Figure 28).

**SATURAT**: This number, below the graphic bar, reflects how close the optical power is to saturation.

**LOS**: This number, below the graphic bar, reflects how close the optical power is to a Loss of Signal state (defined as -35 dBm).

**Graphical bar**: The bar graphically represents the state of the optical power. It should be black in the middle of the bar if the signal is good. To the left indicates a Saturation state, and to the right a Loss of Signal state.

### 2.2.1.2 SDH Measurement Result Screens

The following screens are displayed when NETWORK MODE is set for SDH.

**G.821 Results**

This screen reports on G.821 parameters, applied to any single rate interface, or any payload. Turn G.821 results on or off in MEASUREMENT CRITERIA.

```
                        Meas
ET:008:22:07     RT:    CONTINU
I/P: 1.5M/1.5M   C/F:AMI/ESF
TX:2E23          RX:2E23

LOPS:0
CBIT:0           CBER :0.00e+00
BIT :0           BER  :0.00e+00
ES :0            %ES  :0.00
SES :0           %SES :0.00
EFS :108012      %EFS :100
AS :108012       %AS  :100
UAS :0           %UAS :0

CONFIG  PATTERN RESTART MORE
```

**Figure 29 G.821 (1.5M) Screen**

The following is reported:

**LOPS**: Loss of Pattern Synchronization measured in seconds.

**CBIT**: Number of current bit errors during a one second period.

**CBER**: Current Bit Error Rate is updated every second.

**BIT**: Count of the number of bit errors which have occurred since the start of the test. A bit error is a difference between the pattern of the incoming signal and the reference pattern detected after pattern synchronization.

*Usage*: The test set is measuring a known pattern, so the measurement covers transmission performance over the entire service, not just a local section. This is the preferred measurement for out-of-service testing, and service acceptance tests. The measurement is often performed in conjunction with a loopback device at the far end.

**BER**: Averaging Bit Error Rate, since the start of the test. This measurement is reported as N/A when the test set is not synchronized on a known received pattern.

*Usage*: The rate is sometimes used instead of a count, when the measurement is conducted for a longer period. $1x10^{-3}$ bit error rate is the threshold for non-acceptable links.

**ES**: Count of the number of Errored Seconds which have occurred since the start of the test. An ES is a one-second period in the AS during which one or more bit errors are detected. An ES is not counted during an unavailable second. The measure- ment is attractive because it takes out the effects of burstiness on service performance and because it measures the quality of service as the user actually sees it.

**%ES**: Ratio of ES to the AS expressed as a percentage.

**SES**: Count of the number of Severely Errored Seconds that have occurred since the start of the test. An SES is a one-second period in the AS during which either one or more of the follow- ing occur:

- BER is equal to or worse than 1 x $10^{-3}$
- Alarm indication signal
- Loss of signal
- Loss of frame alignment
- Loss of pattern synchronization
- Uncontrolled pattern slip

SES is a subset of ES, therefore an SES will also cause an ES count. It is not counted during an unavailable second.

**%SES**: Ratio of SES to the AS expressed as a percentage, since the start of the test.

**EFS**: Count of Error Free Seconds since start of the test. An EFS is a one-second period in the AS during which no bit errors and no pattern slips have been detected.

**%EFS**: Percentage of Error Free Seconds since the start of testing.

**AS**: Count of Available Seconds is the available time in the total observation time. It is the difference between the elapsed time and the UAS, and is expressed in seconds.

**%AS**: Percentage of Available Seconds since the start of testing.

**UAS**: Count of all the Unavailable Seconds since the start of the test. Note that T1 service is not available during an UAS. This displays the unavailable time in seconds in the total observation time. A period of unavailable time begins at the onset of a period of ten consecutive SES. The unavailable time ends with the first second of a period of ten consecutive non-SES seconds.

**%UAS**: Percentage of UAS since the start of testing.

## G.826 Results

This screen reports on G.826 parameters, applied to any single rate interface, or any payload, at the near end (BIP based) or far end (REI based). Turn G.826 results on or off in MEASUREMENT CRITERIA. This ITU standard is often used as an in-service error performance tool for monitoring the quality of links carrying LIVE traffic. The parameter definitions given in G.826 are block-based. This makes in-service measurement convenient.

```
                        Meas    1310
ET:008:22:10         RT:CONTINU
I/P:155M O           PAY:2M
TX: 2E15             RX:2E15

BE :0
BBE :0             %BBE :0.00
ES :0              %ES  :0.00
SES :108012        %SES :0.00
AS :108012         %AS  :100
UAS :0             %UAS :0

CONFIG PATTERN RESTART MORE
```

**Figure 30**
**G.826 HP Near End B3 Screen**

In addition to the previously defined items, the following is reported:

**BE**: A Block Error is a block containing one or more bit errors.

**%BE**: Percentage of errored blocks since the start of the test.

**BBE**: A Background Block Error is an errored block not occurring as part of a SES (Severely Errored Second).

**%BBE**: The percentage of errored blocks since the start of the test, excluding all blocks during SES and unavailable time.

**SES**: A Severely Errored Second is a one second period which contains greater or equal to 30% errored blocks.

**%SES**: Percentage of Severely Errored Seconds since the start of the test.

## G.828 Results

This screen reports on G.828 SDH paths. It was developed to improve the error performance analysis of digital paths that involve Path Terminal Equipment, including those that used for Tandem Connections. Near end and far end results are available for both high and low paths. The measurements presented are the same, applying to the indicated path and end defined in MEASUREMENT PARAMETERS. Turn G.828 results on or off in MEASUREMENT CRITERIA.

```
                        Meas    1310
ET:008:22:10         RT:CONTINU
INTF:STM-16          PAY:VC4_16C
TX:2E15              RX:2E15

BE :0
BBE :0             %BBE :0.00
ES :0              %ES  :0.00
SES :108012        %SES :0.00
AS :108012         %AS  :100
UAS :0             %UAS :N/A
SEP :0             SEPI :0

CONFIG PATTERN RESTART MORE
```

**Figure 31**
**G.828 HP Near End B3 Screen**

In addition to the previous items, the following is reported:

**SEP**: A Severely Errored Period is a sequence of between 3 to 9 consecutive SES. The sequence is terminated by a second which is not an SES. This measurement is not good for measurement periods of less than three seconds.

**SEPI**: This is the number Severely Errored Period Intensity events in available time, divided by the total available time in seconds.

**G.829 Results**

This screen reports G.829 parameters, applied to the Section defined in MEASUREMENT PARAMETERS, at the near end. G.829 defines error performance events for SDH Regenerator and Multiplex sections, at either end (so you will see a NEAR END or FAR END screen as appropriate for your connection). The measurements presented are the same, applying to the indicated Section and end. Turn G.829 results on or off in MEASUREMENT CRITERIA.

```
                             Meas    1310
ET:008:22:10                 RT:CONTINU
I/P:2.5G O                   PAY:VC4_16C
TX:2E23                      RX:2E23

BE  :0
BBE :0                  %BBE :0.00
ES  :0                  %ES  :0.00
SES :0                  %SES :0.00
AS  :108012             %AS  :100.00
UAS :0                  %UAS :0.00

CONFIG PATTERN RESTART MORE
```

**Figure 32**
**G.829 RS Near End B1 Screen**

Observing the statistics given in G.829 will ensure that error performance assessment on SDH Multiplex and Regenerator Sections yield compatible results.

**M.2101 Results**

This screen provides pass/fail measurements in accordance with ITU M.2101) specifications. The specification is used where an SDH circuit passes through international boundaries. It allocates a certain allowable error rate to each nation that carries the circuit. Enter the appropriate percentage that is to be allowed for the line under test. The test set makes the M.2101 calculations and reports whether the line passed or failed.

```
11:50:45                     Meas    1310
ET:008:22:10                 RT:CONTINU
INTF:STM-1                   PAY:2M
TX:2E15                      RX:2E15

FROM   : 2005/08/24 15:37:07
TO     : 2005/08/24 15:38:07
REPORT : MAINT. ACCEPTABLE
ES     :0         SES     :0
ES%    :0.00      SES%    :0.00
ES RPO :N/A       SES RPO :0
ES DPL :N/A       SES DPL :N/A
ES UPL :12        SES UPL :1
CONFIG  PATTERN  RESTART   MORE
```

**Figure 33**
**M.2100 Maintenance Screen**

Near and Far end results are available for Maintenance measurements are shown in Figure 33. BIS results are shown in Figure 34.

*Maintenance Results*

**FROM/TO**: Identifies the date and time interval of each of the reported performance results. The period interval used in Figure 33 is 1 minute. Change this interval in SETUP > MEASUREMENT CRITERIA. Valid entries are from 00 to 99 minutes.

**REPORT**: Shows whether or not the test was acceptable during the period.

**ES, ES%**: Number and percentage of M.2101 Errored Seconds since the start of the test. An errored second is any second reported on the G.826 screen for maintenance (in-service measurement).

**SES**, **SES%**: Number and percentage of Severely Errored Seconds since the start of the test. An M.2101 Severely Errored Second is any SES which has been reported on G.826.ES/SES.

**RPO**: Reference Performance Objective for the indicated error state.

**ES**/**SES DPL**: Degraded Performance Limit for the indicated error state.

**ES**/**SES UPL**: Unacceptable Performance Limit for the indicated error state.

*BIS Results*

Performance Objectives for M.2101 End-to-End International Trails are shown in the following table:

```
                     Meas    1310
ET:008:22:10         RT:CONTINU
INTF:STM-1           PAY:2M
TX:2E15              RX:2E15

FROM   : 2005/01/02 15:37:07
TO     : 2005/01/02 15:38:07
REPORT : BIS. ACCEPTED
ES     :0          SES     :0
ES%    :0.00       SES%    :0.00
ES BISO:29         SES BISO:1
ES S1  :18         SES RPO :0
ES S2  :40         SES DPL :0
CONFIG  PATTERN  RESTART MORE
```

**Figure 34 M.2100 BIS Screen**

| Bit rate: Mbit/s | ES % of time | SES % of time |
|---|---|---|
| 1.5 < rate =5 | 2 | 0.1 |
| 5 < rate =15 | 2.5 | 0.1 |
| 15 < rate = 55 | 3.75 | 0.1 |
| 55 < rate =160 | 8 | 0.1 |
| 160 < rate = 3500 | Not Applicable | 0.1 |
| > 3500 = NA (Note) | Not Applicable | 0.1 |
| Note: The BBE could be used for maintenance purposes. At the present time, this issue is under study. | | |

**Table 3 M.2101 Performance Objectives**

The following is reported:

**FROM**: Date/Time the test started.

**TO**: Date/Time the test ended.

**REPORT**: Results of the test; Accepted, Aborted, Provisional.

**ES**: Errored Seconds, based on G.821 standard.

**ES BISO**: ES Bringing into Service Objective.

**ES S1**: S1 threshold for ES.

**ES S2**: S2 threshold for ES.

**SES**: Severely Errored Seconds, based on G.821 standard.

**SES S1**: S1 threshold for SES.

**SES S2**: S2 threshold for SES.

### M.2110 Results

This screen provides acceptance measurements in accordance with ITU M.2110 specifications for bringing into service SDH and PDH paths, sections, transmission systems, and multiplex sections. Near and Far end results are available for Maintenance measurements, as are results for MS, HP, and LP.

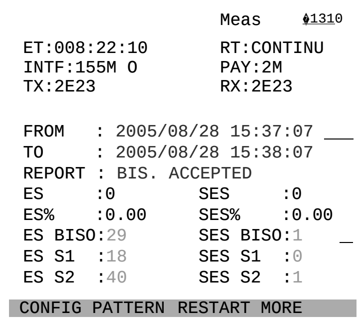



**Figure 35 M.2110 Screen**

**FROM/TO**: Identifies the date and time interval of each of the reported performance results. The period interval used in Figure 35 is 1 minute. Change this interval in SETUP > MEASUREMENT CRITERIA. Valid entries are from 1 minute to 7 days.

**REPORT**: Reports if the test was acceptable during the period.

**ES**, **ES%**: Number and percentage of M.2100 Errored Seconds since the start of the test. An ES is any second reported on the G.828/G.829 screen for maintenance (in-service measurement).

**SES**, **SES%**: Number and percentage of Severely Errored Seconds since the start of the test. An M.2100 Severely Errored Second is any SES which has been reported on G.826.

**ES BISO**: ES Bringing into Service Objective.

**ES S1**: S1 threshold for ES.

**ES S2**: S2 threshold for ES.

**SES BISO**: Severely Errored Seconds, Bringing Into Service Objective threshold.

**SES S1**: S1 threshold for SES. S1 is the lower acceptance limit. If performance is better than the S1 limit, the equipment under test may be brought into service with confidence.

**SES S2**: Threshold for SES. S2 is the upper acceptance limit; equipment with a worse than S2 limit may not be put into service.

**Alarms/Errors**

Some of the measurements available in this screen will depend on the selected rate.

The following can be reported:

```
                          Meas
ET:008:22:10   RT:    CONTINU
INTF:2M/2M     C/F:HDB3/PCM30
TX:2E23        RX:2E23

LOSS   :0
LOFS   :0
AISS   :0
FAS RAI:0
MFASRAI:0
FASE   :0        RATE:0.00e+00
CRC-4  :0        RATE:0.00e+00
E-BIT  :0        RATE:0.00e+00
CONFIG  PATTERN  RESTART MORE
```

**Figure 36 Alarms/Errors Screen (PDH)**

**LOSS**: Loss of Signal Seconds is a count of the number of seconds in which signal has been lost during the test.

**LOFS**: Count of Loss Of Frame Seconds since the start of testing.

**AISS**: Alarm Indication Signal Seconds is a count of the number of seconds in which AIS was detected. AIS is available for the Multiplex Section, the Administrative Unit, and the Tributary Unit.

**FAS RAI**: Count of seconds which have had far end FAS Remote Alarm Indications (RAI) since the start of testing.

**MFASRAI**: Count of seconds which have had far end MFAS RAI since the start of testing.

**FASE**: Count of the Frame Alignment Signal Errors received since the start of testing.

FASE **RATE**: Average FASE rate since the start of testing. **YELS**: Count of Yellow alarm Seconds since the start of the test. A yellow alarm takes different forms depending on the framing of the signal. For an SF signal, the yellow alarm is signified by a zero in bit 2 for all channels. For an ESF signal, the yellow alarm is 0000000011111111 in the facility data link.

The T1 path terminating device will send a yellow alarm on its outgoing signal in response to loss of frame on its incoming signal. Thus, the yellow alarm signifies that the other side of the T1 line has failed somewhere before the end of the circuit. **LDNS**: Low Density Seconds is a count of the number of seconds when the n(n-1) rule is broken.

**EXZS**: Excess Zero Seconds is a count of the number of seconds in which excessively long strings of zeros were detected. For AMI coding, this is 16 or more consecutive zeros, for B8ZS this is 8 or more consecutive zeros. This measurement is different than LDNS in that it looks for individual strings of zeros rather than an average ones density over a large number of bits.

**CRC**: Count of the number of CRC-6 errors which have occurred since the start of the test. This measurement is reported as N/A when the test set is not synchronized on a received ESF signal (1.5M).

CRC **Rate**: CRC error rate measured since the start of testing.

**CRC4**: Count of the number of CRC-4 block errors that have occurred since the start of the test. This measurement is reported as N/A when the test set is not synchronized on a received CRC-4 check sequence.

CRC4 **RATE**: Average CRC-4 error rate since the start of testing.

**OOF**: Count of Out-Of-Frame seconds that have occurred since the start of the test. An out-of-frame condition for 1.5M occurs when either 2-in-4 or 2-in-5 framing bits have been in error. OOF starts counting when an out-of-frame condition occurs. OOF continues incrementing until framing has been reestablished, or until 3 consecutive seconds have been OOF. In this case, LOF is declared, OOF is decremented by 3, and LOFS is incremented by 3. Once an out-of-frame condition occurs, the test set begins searching for a new framing position. The out-of-frame condition ends when framing has been reestablished. If the framing remains in the original position, then no further action takes place.

**E-BIT**: Number of E-bit errors that have occurred.

E-BIT **RATE**: Average E-bit error rate since the start of testing.

**Alarms (SDH)**

Some of the measurements available in this screen will depend on the selected rate.

```
                        Meas     1310
ET:008:22:10            RT:CONTINU
INTF:STM-1              PAY:2M
TX:2E23                 RX:2E23

LOS   :0         HP-PLM :0
LOF   :0         HP-UNEQ:0
OOF   :0         TU-AIS :0
RS-TIM:0         TU-LOM :0
MS-AIS:0         TU-LOP :0
MS-RDI:0         LP-RDI :0
AU-AIS:0         LP-PLM :0
AU-LOP:0         LP-UNEQ:0
HP-RDI:0         LP-TIM :0
HP-TIM:0         LP-RFI :0
CONFIG  PATTERN  RESTART MORE
```

**Figure 37 Alarms (SDH) Screen**

The following abbreviations are used:

**MS**: Multiplexer Section

**AU**: Administrative Unit

**HP**: Higher Order Path

**LP**: Lower Order Path

**TU**: Tributary Unit

Additions to the screen as compared to PDH Alarms:

**RDI**: Count of seconds which have had far end Remote Defect Indication since the start of testing. This signal is returned to the transmitting TE when the far end detects a LOS, LOF AIS, Trace Identifier Mismatch, or Unequipped. Available for the Multiplex Section and Higher Path, as well as for 2M signals.

**RFI**: Count of seconds which have had far end Remote Failure Indication seconds; signal failure at the far end.

**LOP**: Count of seconds which have had Loss of Pointer since the start of the test. Occurs when N invalid pointers or New Data Flags are received. Available for Administrative and Tributary Units.

**LOM**: Loss of Multiframe is declared when the multiframe alignment is in the OOM (Out of Multiframe) state. OOM is defined as errors detected in the H4 bit 7 and bit 8 sequence. Multiframe alignment shall be assumed to be recovered, and the in-multiframe (IM) state shall be entered, when in four consecutive VC-n frames an error-free H4 sequence is found.

**TIM**: Count of the number of seconds containing Tracer Identifier Mismatch. It occurs when the received path trace (J1, J2) is different from what was expected.

**PLM**: Count of the number of seconds containing Payload Label Mismatch error. It occurs when the C2/V5 signal label bytes received are different from what was expected.

**UNEQ**: Counts the number of seconds with Signal label bytes (C2 for HP or V5 for LP) designated with the Unequipped label.

### Extra Alarms

This screen displays additional alarms that are available. These SDH alarms appear for High Path (HP) and Low Path (LP).

```
                          Meas    1310
ET:008:22:10              RT:CONTINU
INTF:STM-1                PAY:2M
TX:2E23                   RX:2E23

HP-SRDI:0
HP-CRDI:0
HP-PRDI:0
LP-SRDI:0
LP-CRDI:0
LP-PRDI:0

CONFIG  PATTERN  RESTART  MORE
```

**Figure 38 Extra Optical Alarms Screen**

The alarms are:

**SRDI**: Server Remote Defect Indication.

**CRDI**: Connectivity Remote Defect Indication.

**PRDI**: Payload Remote Defect Indication.

**Errors (SDH)**

The availability of some reported items are dependent on the selected rate.

```
                   Meas    1310
ET:008:22:10       RT:CONTINU
INTF:STM-1         PAY:2M
TX:2E23            RX:2E23

FASE :0         RATE:0.00e+00
B1    :0        RATE:0.00e+00
B2    :0        RATE:0.00e+00
B3    :0        RATE:0.00e+00
MS-REI:0        RATE:0.00e+00
HP-REI:0        RATE:0.00e+00
LP-REI:0        RATE:0.00e+00
BIP-2 :0        RATE:0.00e+00

CONFIG  PATTERN RESTART   MORE
```

**Figure 39 Errors (SDH) Screen**

The following is reported:

**FASE**: Count of the Frame Alignment Signal Errors received since the start of the test.

FASE **RATE** is the average rate of received FASE since the start of the test.

**REI**: Count of seconds which have had far end Remote Error Indications (REI) since the start of the test. It indicates to the transmitting end that the receiving end has received an errored block. Available for the Multiplex Section, the Lower Order Path, or Higher Order Path sections.

**B1**: Count of the number of parity errors evaluated by the B1 byte (BIP-8) of an STM-n.

**B2**: Count of the number of parity errors received by the B2 byte (BIP-24) of an STM-n.

**B3**: Count of the number of parity errors contained by the B3 byte (BIP-8) of a VC-3 or VC-4.

**BIP-2**: Count of the number of parity errors in bits 1 and 2 of the V5 byte of a VC.

**RATE**: Rate corresponding to the indicated error measured since the start of the test.

### 2.2.1.3 SONET Measurement Result Screens

The following screens are displayed when NETWORK MODE is set for SONET.

**Note**: Items reported depend on test set configuration.

**Alarms**

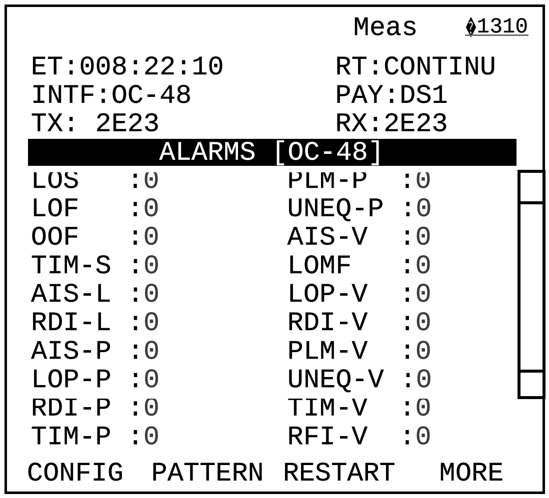



**Figure 40 Alarms Screen [OC-48]**

The following is reported:

**LOS**: Count of the number of seconds in which the signal has been lost during the test. For SONET, a loss of signal will be detected when 20 µsec of all zeros occurs. A loss of signal usually indicates that the input optical power is either too low or too high. Verify that the optical power of the signal source is within the range specified for the test set. If the power is too high, use an attenuator.

**PLM-P** and **PLM-V**: A Path or VT Payload Label Mismatch is declared when the C2 setting does not match the current configuration. The presence of an PLM defect is usually indicative that the test set configuration does not match the network. For example, the network may have a VT1.5 payload when the test set is configured for DS3/DS1. In some cases of a concatenated payload, a PLM can be essentially ignored. The default C2 value for a concatenated payload is 01 (hex). If the payload is ATM or other specific type of data transmission, the C2 may be some other value, such as 13 (hex) for ATM.

**LOF**: Count of the Loss of Frame seconds since the start of testing. An LOF occurs at 24 consecutive frames with invalid framing. LOFs are counted until the onset of 8 consecutive frames with valid framing. As with LOS, LOF can indicate an optical power level that is too high for the receiver. LOF will also occur when the received data rate does not match the test configuration of the test set. For example, the test set is configured for OC-3 and the fiber is carrying OC-12.

**UNEQ-P** and **UNEQ-V**: A Path or VT Unequipped defect is declared when the C2 byte is set to 0 for 5 consecutive frames. An unequipped SONET path is one that is active but not carrying any data, such as a backup path not in use. Unequipped serves much the same usage as an idle signal in a T-carrier network.

**OOF**: Count of the Out-Of-Frame seconds that have occurred since the start of testing. An OOF signifies the failure to acquire a valid framing pattern for 4 consecutive frames. OOF is counted until the onset of a valid framing pattern exactly 6480 bits apart.

**AIS-V**: Alarm Indication Signal-Virtual tributary are triggered by a DS1 LOS, OOF, or AIS. AIS-V sets the entire VT to all-ones, including the VT overhead. AIS-V is detected when V1-V2 are all ones for 3 consecutive frames.

**LOMF**: Loss of Multiframe is declared when the multiframe alignment is in OOM (Out of Multiframe) state. OOM is defined as errors detected in the H4 bit 7 and bit 8 sequence. Multiframe alignment shall be assumed to be recovered, and the in-multiframe (IM) state shall be entered, when in four consecutive VT-n frames an error-free H4 sequence is found.

**AIS-L**: Alarm Indication Signal-Line is a count of the number of seconds in which AIS-L was detected. Line AIS is detected when the test set receives 5 consecutive frames of 111 in the bits 2, 1, 0 (6,7,8, transmission standard) of the K2 byte. AIS-L is counted until the set receives 5 consecutive frames of patterns other than 111 in the bits 2, 1, 0 of the K2 byte. When a network element receives a LOF or LOS, it sends an AIS-L downstream.

**LOP-V** and **LOP-P**: Count of the number of seconds in which there was a loss of pointer or NDF (New Data Flag) in the Path or VT. A LOP occurs for 8 consecutive frames of invalid pointer or NDF. LOPs are counted until the onset of 3 consecutive frames of valid pointer. LOP defects are relatively rare and usually indicate a gross timing mismatch between a network element and the rest of the network.

**RDI-L**: Remote Defect Indication-Line was formally known as a FERF (Far End Remote Failure) and is the SONET equivalent to a yellow alarm over the SONET line. An RDI-L is counted when bits 6-8 of the K2 byte are “110” for 5-10 consecutive frames. When a network element receives an AIS-L, LOS, or LOF, it responds upstream with an RDI-L. Thus, the presence of an RDI-L ultimately indicates the presence of a LOS or LOF in the network, as shown in Figure 41.

**RDI-P** and **RDI-V**: Path or VT Remote Defect Indication was formally known as a FERF (Far End Remote Failure) and is the SONET equivalent to a yellow alarm over the SONET path. An RDI-P/V is counted when bit 5 of the G1 byte is set to 1. When a network element receives an AIS-P/V, it responds upstream with an RDI-L. Thus, the presence of an RDIP/V ultimately indicates the presence of a LOS or LOF in the network, as shown Figure 41.

**AIS-P**: Number of seconds that an Alarm Indication Signal-Path is detected. AIS-P is detected when the test set receives 3 consecutive frames of all ones in the H1, H2 bytes. AIS is counted until the onset of NDF with valid pointer or three successive frames with valid pointer. An AIS-P is sent when a network element receives an AIS-L which itself is sent to indicate a LOS or LOF.

**TIM-V**, **TIM-P,** and **TIM-S**: Count of Trace Identifier Mismatch occurs when the expected Section, Path, or Virtual tributary trace (J1 or J2 byte, respectively) does not match the expected value, alerting to a potential provisioning problem.

**RFI-P** and **RFI-V**: Count of Path or VT Remote Failure Indication is declared after 2.5 seconds of RDI-P/V and cleared after 10 consecutive seconds without an RDI-P/V. After approximately 2.5 seconds of RDI, an RFI is declared. Thus, the presence of an RFI represents the persistent presence of a LOS or LOF occurring on the other direction of the network.

**RFI-L**: Count of Line Remote Failure Indication is declared after 2.5 seconds of RDI-L and cleared after 10 consecutive seconds without an REI-L. After approximately 2.5 seconds of RDI, an RFI is declared. Thus, the presence of an RFI represents the persistent presence of a LOS or LOF occurring on the other direction of the network.

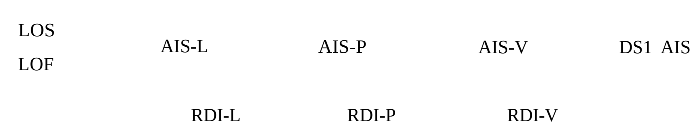



**Figure 41 SONET LOS/LOF Alarm Signals**

**Extra Alarms**

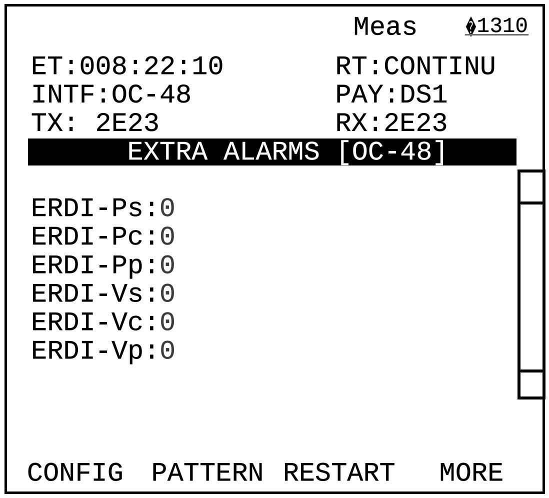



**Figure 42 Extra Alarms Screen**

The following is reported:

**ERDI-Ps**: Path Remote Defect Indication Server Defect

**ERDI-Pc**: Path Remote Defect Indication Connectivity Defect

**ERDI-Pp**: Path Remote Defect Indication Payload Defect

**ERDI-Vs**: Virtual Tributary Remote Defect Indication Server Defect

**ERDI-Vc**: Virtual Tributary Remote Defect Indication Connectivity Defect

**ERDI-Vp**: Virtual Tributary Remote Defect Indication Payload Defect

**Errors**

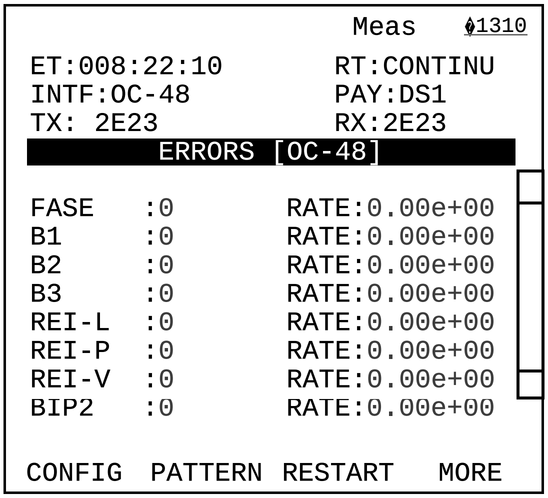



**Figure 43 Errors Screen**

The following can be reported along with its rate:

**FASE**: Count of the Frame Alignment Signal Errors received since the start of the test.

**B1**: Count of the incoming BIP-8 parity errors in the SONET signal. The B1 byte is contained in the Section Overhead. This byte provides Section error monitoring by means of bit interleaved parity 8 code using even parity. It is also called a Section Code Violation (CV-S).

**B2**: Count of the incoming Line parity errors. The B2 byte is contained in the Line Overhead and provides Line error monitoring. It is also called a Line Code Violation (CV-L).

**B3**: Count of the incoming B3 BIP-8 parity errors. The B3 byte is contained in the Path Overhead and thus, provides a Path error monitoring function. It is also called CV-P (Path Code Violation).

**REI-L**: Line Remote Error Indicator was formally known as a FEBE (Far End Block Error) and indicates the number of B2 errors detected by the downstream network equipment. This information is conveyed through bits 5-8 of the M0 byte or the entire M1 byte. Parity errors, such as B2, are used to indicate bit errors in the network. An REI-L is transmitted in response to B2 errors and thus is also an indication of bit errors.

**REI-P** and **REI-V**: Path or VT Remote Error Indicator was formally known as a FEBE (Far End Block Error) and indicates the number of B3 errors detected by the downstream network equipment. This information is conveyed through bits 1–4 of the G1 byte.

Parity errors, such as B3 or BIP-2, are used to indicate bit errors in the network. An REI-P/V is transmitted in response to B3/BIP-2 errors and thus is also an indication of bit errors.

**BIP2**: This parity calculation is used in the V5 byte VT1.5 path overhead byte. It is contained in bits 6–7.

### Alarms/Errors for the Configured Payload

DS1 (VT1.5)

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:DS1
TX: 2E23           RX:2E23

LOSS    :0
LOFS    :0
AISS    :0
YELS    :0
EXZS    :N/A
CRC     :0       RATE:0.00e+00
OOF     :0
FBE     :0

CONFIG  PATTERN RESTART  MORE
```

E1

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:E1
TX: 2E23           RX:2E23

LOSS    :0
LOFS    :0
AISS    :0
FAS RAI :0
MFASRAI :N/A
FASE    :0       RATE:0.00e+00
CRC-4   :0       RATE:0.00e+00
E-BIT   :0       RATE:0.00e+00

CONFIG  PATTERN RESTART  MORE
```

E3

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:E3
TX: 2E23           RX:2E23

LOSS    :0
LOFS    :0
AISS    :0
FAS RAI :0
FASE    :0       RATE:0.00e+00

CONFIG  PATTERN RESTART  MORE
```

DS3

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:DS3
TX: 2E23           RX:2E23

LOSS    :0
LOFS    :0
AISS    :0
YELS    :0
IDLE    :0
FEBE    :0
Pbit    :0
Cbit    :0

CONFIG  PATTERN RESTART  MORE
```

**Figure 44 Alarms/Errors Screens**

These screens are not available for STS-1, STS-3C, STS-12C, and STS-48C payload rate. They are available for DS1 (VT1.5), E1, E3, and DS3. All of the screens report:

**LOSS**: Count of the number of seconds in which the Payload signal has been lost during the test.

**LOFS**: Count of Loss Of Frame Seconds since the start of testing. For details, see the previous Alarms section.

**AISS**: Alarm Indication Signal Seconds is a count of the number of seconds in which AIS was detected.

The DS1 (VT1.5) screen reports these additional items:

**YELS**: Count of Yellow alarm Seconds since the start of testing.

**EXZS**: Excess Zero Seconds is a count of the number of seconds in which excessively long strings of zeros were detected. For AMI coding, this is 16 or more consecutive zeros, for B8ZS this is 8 or more consecutive zeros.

**CRC**: Count of the CRC-6 block errors that have occurred since the beginning of the test. Each CRC-6 block error indicates that there is at least 1 bit error within an extended super frame.

**OOF**: Count of Out Of Frame seconds since the start of the test. For details, see the previous Alarm section.

**FBE**: Count of Framing Bit Error seconds since the start of the testi.

The E1 screen reports these additional items:

**FAS RAI**: Count of seconds which have had far end FAS Remote Alarm Indications (RAI) since the beginning of the test.

**MFASRAI**: Count of seconds which have had far end MFAS RAI since the start of the test.

**FASE**: Count of the Frame Alignment Signal Errors received since the start of the test.

FASE **RATE**: Average FASE rate since the start of the test.

**CRC-4**: Count of the number of CRC-4 block errors that have occurred since the start of the test. This measurement is reported as N/A when the test set is not synchronized on a received CRC-4 check sequence.

CRC-4 **RATE**: Average CRC-4 error rate since the start of the test.

**E-BIT**: Number of E-bit errors that have occurred.

E-BIT **RATE**: Average E-bit error rate since the start of the test.

The E3 screen reports these additional items:

**FAS RAI**: Count of seconds which have had far end FAS Remote Alarm Indications (RAI) since the beginning of the test.

**FASE**: Count of the Frame Alignment Signal Errors received since the start of the test.

FASE **RATE**: Average FASE rate since the start of the test.

The DS3 screen reports these additional items:

**YELS**: Count of Yellow alarm Seconds since the start of the test.

**IDLE**: Count of DS3 Idle code received since the start of the testi.

**FEBE**: Count of Far end Block Errors received since the start of the test.

**Pbit**: Count of Pbit Parity errors since the start of the test.

**Cbit**: Count of C-bit Parity Errors since the start of the test.

**Bit Performance**

```
                         Meas   1310
ET:008:22:10        RT:CONTINU
INTF:OC-48          PAY:DS1
TX: 2E23            RX:2E23
          BIT PERFORMANCE

LOPS:0
CBIT:0           CBER:0.00e+00

ES  :0           %ES :0.00
SES :0           %SES:0.00
EFS :3500        %EFS:100.00
AS  :0           %AS :100.00
UAS :0           %UAS:0.00

CONFIG  PATTERN RESTART   MORE
```

**Figure 45 Bit Performance Screen**

The following is reported for all payloads:

**LOPS**: Loss of Pointer Seconds since the start of testing. **CBIT**:

Count of C-bit Parity Errors since the start of testing. **CBER**:

Current Bit Error Rate is updated every second, and is not averaged.

**ES**: Count of the number of Errored Seconds that have occurred since the start of testing. An errored second is any second with at least one BPV, bit error, FE or CRC-6 error. An errored second is not counted during an unavailable second. ES is used as a key tariff parameter for T1 services. Acceptance limits are often given for a number of errored seconds in a 5 minute, 15 minute, or 24-hour period. 7 errored seconds in 5 minutes and 20 errored seconds in 15 minutes are common acceptance limits, and 60 errored seconds in 5 minutes is a common immediate action limit. Some organizations accept no errors on a turn-up test.

The measurement is attractive because it takes out the effects of burstiness on service performance and because it measures the quality of service as the user actually sees it.

**%ES**: Percentage of Errored Seconds (as defined in ES) since the start of testing.

**SES**: Count of the number of Severely Errored Seconds that have occurred since the start of testing. An SES is a second with a $10^{-3}$ error rate, where error rate is measured off of BPV, bit er- ror, FE or CRC-6 errors. An out of frame error will also generate an SES. An SES is not counted during an unavailable second.

When the tenth SES is counted, the test set will transfer those 10 seconds to UAS, and the SES count will switch back to 0. The UAS counter starts at 10 (0...0...10...11...etc.). This measurement is sometimes used in combination with errored seconds to describe overall in-service transmission performance. During an SES, the customer is likely to be experiencing trouble with the service but may still be able to use the service, especially for PCM voice transmission.

**%SES**: Percentage of Severely Errored Seconds (as Defined in SES) that have occurred since the start of the test.

**EFS**: Count of Error Free Seconds since the start of testing. An EFS is a one-second period in the AS during which no bit errors and no pattern slips have been detected.

**%EFS**: Percentage of Error Free Seconds (as Defined in EFS) that have occurred since the start of the test.

**AS**: Count of Available Seconds since the start of testing.

**%AS**: Percentage of Available Seconds (as Defined in AS) that have occurred since the start of the test.

**UAS**: Count of Unavailable Seconds since the start of testing. Note that a T1 service is not available during an UAS. An UAS is any second with a LOS, LOF, LOP, or AIS. UAS are also counted at the onset of 10 consecutive SES. Once an UAS has been declared, the following seconds continue to be counted as unavailable until the service is declared to be available again. Service becomes available at the onset of 10 consecutive available non-severely errored seconds. UAS are usually not permitted in any number in a 15 minute or 1-hour test. Telephone companies typically guarantee around 3 hours maximum outage time per year on a T1 service.

**%UAS**: Percentage of Unavailable Seconds (as Defined in UAS) that have occurred since the start of the test.

**GR253 Section Layer**

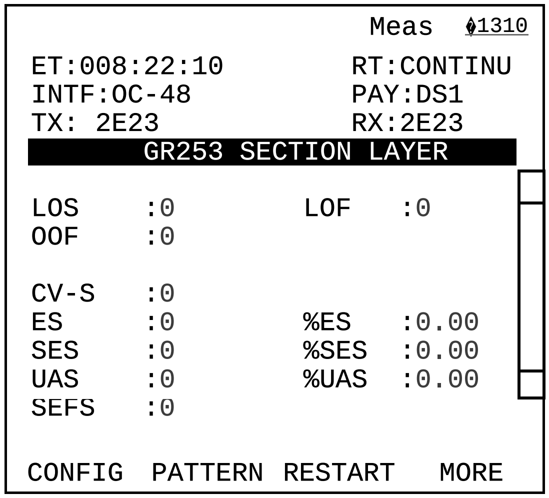



**Figure 46 GR253 Section Layer Screen**

The following is reported for all payloads for GR253 section layer:

**LOS**: Number of Loss of Signal seconds since the start of testing.

**LOF**: Number of Loss of Frame seconds since the start of testing.

**OOF**: Number of Out Of Frame seconds since the start of testing.

**CV-S**: Number of section Code Violation Seconds since the start of testing.

**ES**: Number of Error Seconds since the start of testing. For details see the Bit Performance section.

**%ES**: Percentage of Error Seconds since the start of testing. For details, see the previous Bit Performance section.

**SES**: Number of Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**%SES**: Percentage Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**UAS**: Number of Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**%UAS**: Percentage Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**SEFS**: Severely Errored Frame Seconds is the number of seconds during which 4 consecutive errored framing patterns are detected.

## GR253 Line Layer-Near End and Far End

```
                        Meas    1310                              Meas    1310
ET:008:22:10        RT:CONTINU                ET:008:22:10        RT:CONTINU
INTF:OC-48          PAY:DS1                   INTF:OC-48          PAY:DS1
TX:2E23             RX:2E23                   TX:2E23             RX:2E23

AIS-L :0                                      RDI-L :0

CV-L  :0                                      CV-LFE:0
ES    :0        %ES   :0.00                   ES    :0        %ES   :0.00
SES   :0        %SES  :0.00                   SES   :0        %SES  :0.00
UAS   :0        %UAS  :0.00                   UAS   :0        %UAS  :0.00
FC-L  :0                                      FC-LFE:0

CONFIG  PATTERN  RESTART   MORE               CONFIG  PATTERN  RESTART   MORE
```

**Figure 47 GR253 Line Layer Screens**

The following is reported for all payloads for GR253 line layer for both the near end and far end:

**ES**: Number of Error Seconds since the start of testing. For details see the Bit Performance section.

**%ES**: Percentage of Error Seconds since the start of testing. For details, see the previous Bit Performance section.

**SES**: Number of Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**%SES**: Percentage Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**UAS**: Number of Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**%UAS**: Percentage Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

The following is reported for all payloads for GR253 line layer for the near end:

**AIS-L**: Number of seconds that a Alarm Indication Signal-Line was detected since the start of the test. For details, see the previous Alarms section.

**CV-L**: Number of seconds than a Code Violation-Line was detected since the start of the test. For details, see the previous Alarm section.

**FC-L**: Number of Failure Count-Line near end defects are detected since the start of the test. For details, see the previous Alarm section.

The following is reported for all payloads for GR253 line layer for the far end:

**RDI-L**: Number of seconds that an Remote Defect Indication-

Line was detected since the stat of the test. For details, see the previous Alarms section.

**CV-LFE**: Number of seconds than a Code Violation-Line Far End was detected since the start of the test. For details, see the previous Alarm section.

**FC-LFE**: Number of Failure Count-Line Far End defects are detected since the start of the test. For details, see the previous Alarm section.

**GR253 Path Layer-Near End and Far End**

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:DS1
TX:2E23            RX:2E23

AIS-P :0      UNEQ-P:0
LOP-P :0      PLM-P :0

CV-P  :0
ES    :0      %ES   :0.00
SES   :0      %SES  :0.00
UAS   :0      %UAS  :0.00
FC-P  :0

CONFIG  PATTERN  RESTART  MORE
```

```
                   Meas   1310
ET:008:22:10       RT:CONTINU
INTF:OC-48         PAY:DS1
TX:2E23            RX:2E23

RDI-P :0

CV-PFE:0
ES    :0      %ES   :0.00
SES   :0      %SES  :0.00
UAS   :0      %UAS  :0.00
FC-PFE:0

CONFIG  PATTERN  RESTART  MORE
```

**Figure 48 GR253 Path Layer Screens**

The following is reported for all payloads for GR253 path layer for both the near end and far end:

**ES**: Number of Error Seconds since the start of testing. For details see the Bit Performance section.

**%ES**: Percentage of Error Seconds since the start of testing. For details, see the previous Bit Performance section.

**SES**: Number of Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**%SES**: Percentage Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**UAS**: Number of Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**%UAS**: Percentage Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

The following is reported for all payloads for GR253 path layer for the near end:

**AIS-P**: Number of seconds that an Alarm Indication Signal-Path was detected since the start of the test. For details, see the previous Alarms section.

**UNEQ-P**: Number of seconds that an Unequipped-Path was detected since the start of the test. For details, see the previous Alarm section.

**LOP-P**: Number of seconds that an Loss Of Pointer-Path was detected since the start of the test. For details, see the previous Alarm section.

**PLM-P**: Number of seconds that an Payload Label Mismatch-Path was detected since the start of the test. For details, see the previous Alarm section.

**CV-P**: Number of seconds than a Code Violation-Path was detected since the start of the test. For details, see the previous Alarm section.

**FC-P**: Number of Failure Count-Path near end defects are detected since the start of the test. For details, see the previous Alarm section.

The following is reported for all payloads for GR253 path layer for the far end:

**RDI-P**: Number of seconds that a Remote Defect Indication-Path was detected since the start of the test. For details, see the previous Alarm section.

**CV-PFE**: Number of seconds than a Code Violation-Path Far End was detected since the start of the test.

**FC-PFE**: Number of Failure Count-Path Far End defects are detected since the start of the test.

**GR253 VT Path Layer-Near End and Far End**

```
                          Meas   1310
ET:008:22:10         RT:CONTINU
INTF:OC-48           PAY:DS1
TX:2E23              RX:2E23

AIS-V :0        UNEQ-V:0
LOP-V :0        PLM-V :0

CV-V  :0
ES    :0        %ES   :0.00
SES   :0        %SES  :0.00
UAS   :0        %UAS  :0.00
FC-V  :0

CONFIG  PATTERN  RESTART   MORE
```

```
                          Meas   1310
ET:008:22:10         RT:CONTINU
INTF:OC-48           PAY:DS1
TX:2E23              RX:2E23

RDI-V :0        RFI-V :0

CV-VFE:0
ES    :0        %ES   :0.00
SES   :0        %SES  :0.00
UAS   :0        %UAS  :0.00
FC-VFE:0

CONFIG  PATTERN  RESTART   MORE
```

**Figure 49 GR253 VT Path Layer Screens**

The following is reported for all virtual tributary payloads for GR253 path layer for both the near end and far end:

**ES**: Number of Error Seconds since the start of testing. For details see the Bit Performance section.

**%ES**: Percentage of Error Seconds since the start of testing. For details, see the previous Bit Performance section.

**SES**:Number of Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**%SES**: Percentage Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**UAS**: Number of Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**%UAS**: Percentage Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

The following is reported for all virtual tributary payloads for GR253 path layer for the near end:

**AIS-V**: Number of seconds that an Alarm Indication Signal-Virtual tributary was detected since the start of the test. For details, see the previous Alarms section.

**UNEQ-V**: Number of seconds that an Unequipped-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**LOP-V**: Number of seconds that an Loss Of Pointer-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**PLM-V**: Number of seconds that an Payload Label Mismatch-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**CV-V**: Number of seconds than a Code Violation-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**FC-V**: Number of Failure Count-Virtual tributary near end defects are detected since the start of the test. For details, see the previous Alarm section.

The following is reported for all virtual tributary payloads for GR253 path layer for the far end:

**RDI-V**: Number of seconds that a Remote Defect Indication-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**RFI-V**: Number of seconds that a Remote Failure Indication-Virtual tributary was detected since the start of the test. For details, see the previous Alarm section.

**CV-VFE**: Number of seconds than a Code Violation-Virtual tributary Far End was detected since the start of the test.

**FC-VFE**: Number of Failure Count-Virtual tributary Far End defects are detected since the start of the test.

**DS1 Path Analysis**

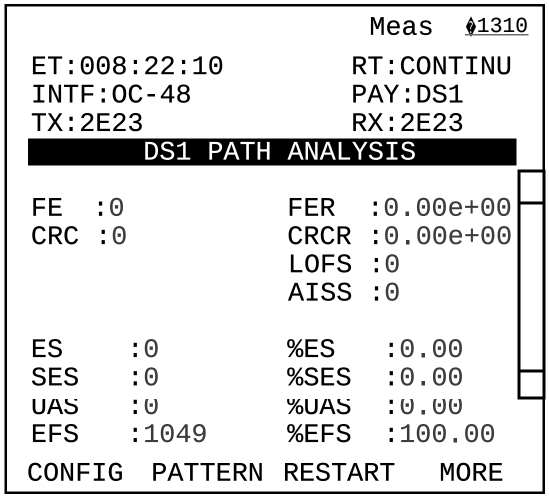



**Figure 50 DS1 Path Analysis Screen**

This screen is only available for a DS1 (VT1.5) payload. It reports the following:

**FE**: Count of Framing bit Errors that have occurred since the start of testing. This measurement is used for in-service testing of DS1 framed circuits where the customer is transmitting an unknown data stream. The advantage of the measurement is that the framing stays intact as it passes through various network elements, hence it depicts the overall transmission quality from the far end of the circuit to the test set.

One problem with the measurement is that it only measures 24 out of every 6.312 Mbits, and so it only gives a sampling of the true transmission performance.

The other problem with the measurement is that it can't measure the quality of transmission on the two outgoing directions of transmission. It can only measure the quality on the two incoming directions.

**FER**: Framing bit Error Rate since the start of testing.

**CRC**: Count of the CRC-6 block errors that have occurred since the beginning of the test. Each CRC-6 block error indicates that there is at least 1 bit error within an extended super frame.

**CRCR**: CRC-6 block errors Rate since the start of testing.

**LOFS**: Count of Loss Of Frame Seconds since the start of testing. For details, see the previous Alarm section.

**AISS**: Alarm Indication Signal Seconds is a count of the number of seconds in which AIS was detected.

**ES**: Number of Error Seconds since the start of testing. For details see the Bit Performance section.

**%ES**: Percentage of Error Seconds since the start of testing. For details, see the previous Bit Performance section.

**SES**:Number of Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**%SES**: Percentage Severely Errored Seconds since the start of testing. For details, see the previous Bit Performance section.

**UAS**: Number of Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**%UAS**: Percentage Unavailable Seconds since the start of testing. For details, see the previous Bit Performance section.

**EFS**: Count of Error Free Seconds since the start of testing. For details, see the previous Bit Performance section.

**%EFS**: Percentage of Error Free Seconds (as defined in EFS) that have occurred since the start of the test.

### 2.2.2 Histogram Analysis

This menu contains the following:

- CURRENT HISTOGRAM
- SAVED HISTOGRAM

#### 2.2.2.1 Current Histogram

In Figure 51, STARTING TIME STAMP, shows the start date and time of the current measurement. The ENDING TIME STAMP displays RUNNING.

```
                    Meas    ⧫1310

CURRENT HISTOGRAM

STARTING TIME STAMP
2005-08-25 15:51:23

ENDING TIME STAMP
RUNNING




VIEW    STORE
```

**Figure 51 Current Histogram Screen**

The following F-keys are available:

**VIEW** (F1): Press to view the current histogram. See Figure 52.

**STORE** (F2): Press to stop the measurement and save the histogram. Press ENTER to confirm stopping the measurement and to display a character entry screen. Press ESC to cancel.

**Saving a Histogram**

1. Press STORE (F2) in the CURRENT HISTOGRAM screen and press ENTER at the prompt.
2. In the character entry screen, give the histogram a name to save it with by pressing TOGGLE (F3).
3. Use to select a character and press SELECT (F4). Repeat until the LABEL is finished.

- If an error is made in the LABEL, press TOGGLE (F3) and use to select the error.
  - Press F2 to delete the character.
  - Press F1 to insert a character to the left of the cursor.

4. When finished with the LABEL, press TOGGLE (F3) and ESC. The histogram will be stored in a CSV (Comma Separated Value) format in SAVED HISTOGRAM.

**Histogram Features**

From the CURRENT HISTOGRAM screen, press VIEW (F1) or from SAVED HISTOGRAM, select a histogram and press VIEW (F1). The first screen presented is shown in the following figure:

```
          Meas �1310
DATE : 2005-08-25
RATE : STM LINE: 1
B1
B2
B3
MSREI
HPREI
LPBIP
LPREI
AUPPJ
AUNPJ
FAS

 DAY 0    15    30    45    60
  ZOOM     JUMP   HISTGRM   MORE

  RATE     TYPE    PRINT    MORE
```

Available only during Meas

```
 PTRMON                     MORE
```

**Figure 52 View Histogram-Bar View Screen**

In this screen, view the results for all errors and alarms at one time. Any error or alarm is indicated in red. Green indicates that no error or alarm condition is present. The errors and alarms are listed on the left side of the screen. The time is listed beneath the bar (DAY 0, 15, 30, etc.). Use to see additional screens of errors and alarms.

A dark area in the cursor indicates the number (k) of errors, or seconds with alarm conditions, for the time indicated, if any. In the bar graph mode, the dark area indicates the type of error. If it is moving, the error is still occurring.

The cursor is the blue line. Press or JUMP (F2) to move it. The following F-keys are available:

**ZOOM** (F1): Change the resolution to the next lower time period at the cursor location. Select second, minute, hour, or day interval as the period.

**JUMP** (F2) Move the cursor by 10 steps in the display period. Use to move the cursor one period at a time.

**HISTGM/BARGRPH** (F3): Returns to the basic Histogram screen if viewing the bar graph, and vice versa. Figure 52 is a sample bar graph view. Figure 53 is a histogram view.

```
                        Meas    ⧫1310
             CURRENT HISTOGRAM
       RATE :  STM  COUNT:1
       TYPE :  B1        LINE:  1
       1000K
        100K
         10K
          1K
         100
          10
           1
           0

        DAY 0    15    30    45    60
         ZOOM     JUMP   BARGRPH   MORE
```

**Figure 53 View Histogram-Histogram View Screen**

**RATE** (MORE, F1): Press to switch between the available rates, if the test set is in a multirate setup. A BERT is also available.

**TYPE** (MORE, F2): Select the measurement parameter type. Here is a listing of the available types for each rate. See *Section 2.2* for measurement definitions. Figure 53 is displaying B1.

- STM-x (155M, 622M, 2.5G): Code (if electrical connection), LOS, OOF, LOF, AU-LOP, MS-AIS, MS-RDI, AU-AIS, HP-RDI, HP-TIM, HP-PLM, HPUNEQ, TU-LOM, TU-LOP, TU-AIS, LP-RDI, LP-TIM, LP-PLM, LPUNEQ, B1, B2, B3, NPJ (Negative Pointer Justification), PPJ (Positive Pointer Justification)
- 139M: Code, FAS, LOS, LOF, AIS, RAI
- 45M: Code, LOS, LOF, AIS, YEL, FBE, FEBE, PBIT, CBIT
- 34M (E3): Code (if physical connection), FAS, LOS, LOF, AIS, RAI
- 2M (E1) (including fractional rates): Code (if physical connection), LOS, LOF, AIS, RAI, MFRAI, E_BIT, CRC, FAS,
- 1M (T1) (including fractional rates): FBE, CRC6, OOF, BPV, LOS, LOF, AIS, YEL, LDN, EXZ

**PRINT** (MORE, F3): Send the results to the serial port.

**PTRMON** (MORE, F1): Pointer Monitor is available in a running CURRENT HISTOGRAM in SDH/SONET configurations. It is not available in a SAVED HISTOGRAM. The screen is shown in Figure 54.

```
                                              Meas      1310
Pointer          DATE :  2005-08-25
Value            TYPE :AU     POINTER VALUE:0
Graph              800
                   600
Red dots           400
indicate           200
alarms,              0
caused by        ALARM
pointer            100
movement.           10
                     1
Pointer              0
Justification
Graph             DAY 0    15    30    45    60
                   ZOOM     JUMP   MEASMON   MORE
```

**Figure 54 View Histogram-Pointer Monitor Screen**

This histogram screen allows viewing the pointer and justification values in a graphical format (upper and bottom bars). Alarms generated by pointer movements are also shown (center line). This feature is a useful tool for the verification of the behavior of the network element; particularly useful at identifying network synchronization problems which can be reflected by pointer movement.

Press or JUMP (F2) to move the cursor. The cursor posi- tion will indicate the date, and if in hour mode the hour of the alarm.

Press MEASMON (F3) to return to the histogram screen.

#### 2.2.2.2 Saved Histogram

Use this screen to view, print, or change the label of a saved Histogram. See *Section 2.2* for an explanation of the data.

```
                     Meas    ϕ1310
              SAVED HISTOGRAM

     Size   : 000020k Free :104870k
     No. LABEL    START/END TIME
     01.          2005-08-26 05:52:44
                  2005-08-26 08:48:33
     02. IDBOI    2005-08-28 04:44:30
                  2005-08-28 07:40:30



       VIEW   PAGE-UP PAGE-DN   MORE

      DELETE    LOCK    LABEL    MORE

      CLR-ALL                    MORE
```

**Figure 55 Saved Histogram Selection Screen**

The following F-keys are available:

**VIEW** (F1): Press to view the selected record.

**PAGE-UP** (F2)/**PAGE-DN** (F3): Press to scroll through the listings of saved records.

**DELETE** (more, F1): Press to delete a selected unlocked record.

**LOCK/UNLOCK** (MORE, F2): Press to lock a selected record, so that it may not be deleted or otherwise changed. Press again to unlock the record.

**LABEL** (MORE, F3): Press to change the label of the saved histogram. See *Section 2.2.1.1-Saving a Histogram* for the procedure.

**CLR-ALL** (MORE, F1): Delete all unlocked records.

### 2.2.3 View Current Event

This screen records up to 100 events that occur during measurements. This feature is active when PRINT EVENT is enabled in the MEASUREMENT CRITERIA screen.

```
                    Meas    ◊1310
          EVENT RECORD

1.  2006-02-24 13:11:14
    MEASUREMENT START

2.  2006-02-24 13:16:30
    OC3  LOS  START

3.  2006-02-24 13:16:33
    OC3  LOS   END

4.  2006-01-24 13:16:34
    BERT  LOPS START

PAGE-UP PAGE-DN  REFRESH   MORE


 PRINT    SAVE             MORE
```

**Figure 56 Event Record Screen**

The following F-keys are available:

**PAGE-UP** (F1) **PAGE-DN** (F2): Use to scroll through the available events.

**REFRESH** (F3): Press to refresh the screen.

**PRINT** (MORE, F1): Press to send the events to the serial port for printing.

**SAVE** (MORE, F2): Press to save the events. See *Section 2.7.*

When finished, press ESC.

## 2.3 Alarms/Errors

This menu contains the following:

- ERROR INJECTION
- ALARM GENERATION
- ATM ERROR INJECTION
- ATM ALARM GENERATION

### 2.3.1 Error Injection

Press ERR INJ and the test set will insert errors on a payload rate as specified in the screen on the right:

```
                 Meas

TYPE   :
ERROR  : B1
MODE   : BURST
COUNT  : 1


SDH     PDH    COMMON
```

**Figure 57 Error Injection Screen, SDH**

**TYPE**

Options:

*SDH*: SDH (F1), PDH (F2), COMMON (F3)

*SONET*: SONET (F1), T.CARR (F2), COMMON (F3)

Determine the error types to select from. The error types will depend on your test configuration.

- SDH errors are specific to SDH rates.
- PDH errors are specific to PDH rates.
- SONET errors are specific to SONET rates.
- T.CARR errors are specific to T.CARR rates.
- COMMON errors are errors which apply to both PDH and SDH rates, such as BIT errors.

**ERROR**

COMMON Options: BIT (F1)

SDH Options: FASE (F1), B1 (F2), B2 (F3), B3 (MORE, F1), LP-BIP (MORE, F2), HP-REI (MORE, F3), LP-REI (MORE, F1), MS-REI (MORE, F2)

PDH Options: (BURST mode only) 2M FAS (F1)

Select the type of error to inject.

**MODE**

Options: RATE (F1), BURST (F2)

This item specifies the mode of error injection.

- RATE: Errors are injected at a constant rate, set at RATE.
- BURST: Errors may be inserted one at a time or injected in a larger burst in this mode.

**COUNT**

Options: 1 to 9999

For BURST MODE, choose the COUNT of errors to be inserted. Press SHIFT and use the numeric keypad to enter a number between 1 and 9999. The errors will be inserted in approximately 1 second or less, and will cause from 1 to 3 errored seconds. Applies only to BIT and CODE errors. All other errors will be injected singly.

*Programming a Burst of 10 Code Errors*

1. In the ERROR INJECTION screen, select COMMON as the error TYPE, ERROR defaults to BIT.
2. At MODE, press BURST (F2).
3. At RATE, press SHIFT and use the numeric keypad to enter 10. The COUNT line should show 10. When finished, press SHIFT.
4. Press ENTER and the test set is programmed to inject 10 BIT errors each time ERR INJ is pressed.

**RATE**

Options: 1e-9 to 2e-3

For RATE MODE, choose the error RATE number and exponent. The errors will be inserted at a continuous rate as specified in this entry, and ERR INJ will appear at the top of the screen.

*Programming a $10^{-6}$ Bit Error Rate*

1. In the ERROR INJECTION screen, select COMMON as the error TYPE. ERROR defaults to BIT.
2. At MODE, press RATE (F1).
3. At RATE, press SHIFT and use the numeric keypad to enter 1 and the multiplier position shows 1. The cursor moves to the exponent position.
4. Press 6 and a 6 is entered. When finished press SHIFT.
5. Press ENTER. The test set is now programmed to inject Bit errors at $1\times10^{-6}$ rate when ERR INJ is pressed. To turn off the error rate injection, press ERR INJ again and verify that the 'Inject' indicator at the top of the screen is no longer displayed.

### 2.3.2 Alarm Generation

Alarm generation allows testing the response of various network equipment to alarms and thus ensure that the network is performing as expected. Some alarms conflict with the transmission of other alarms or selected framing. The test set will transmit the enabled alarm when ON (F2) is pressed. Alarms can be transmitted while making measurements, viewing data, etc. The test set will display ‘Alarm’ at the top of the screen if enabled. See *Section 4.3* for alarm definitions.

```
                    Meas    ⧫1310

              ALARM GENERATION

          TYPE    : H.PATH

          ALARM   : AU_AIS

          MODE    : PERIOD

          DURATION: 10 frame

          PERIOD  : 8000 frame

          ON/OFF  : OFF
      SECTION  H.PATH  L.PATH  PDH/DSn
```

**Figure 58 Alarm Generation Screen, SDH**

**TYPE**

Options:

*SDH*: SECTION (F1), H.PATH (F2), L. PATH (F3), PDH/DSn (F4)

*SONET*: SEC/LN (F1), STS (F2), VT (F3), PDH/DSn (F4)

Choose the tributary at which the alarm will be generated. This choice affects the specific alarms that are available. The options will depend on the test configuration.

- SECTION: Alarms at generated in the Section.
- H.PATH: Alarms are generated on the Higher Path.
- L.PATH: Alarms are generated on the Low Path.
- PDH/DSn: Alarms are generated at the PDH or T-Carrier level.
- SEC/LN: Alarms are generated in the Section/Line.
- STS: Alarms are generated on the Synchronous Transport Signal.
- VT: Alarms are generated on the Virtual Tributary.

**ALARM**
Options:

*SDH*: LOS, LOF , OOF, MS_AIS, MS_RDI, AU_AIS, AU_LOP, HP_RDI, HP_PLM , HP_UNEQ, TU_AIS, TU_LOM, LP_RFI, LP_RDI, LP_PLM, LP_UNEQ

*PDH*: 2M AIS, 2M_RAI, 2M_ MRAI, 34M _AIS, 34M_RAI, 139MAIS, 139MRAI, 1.5_YEL, 45M_AIS, 45M_YEL

*T-Carrier*: 1.5_AIS, 1.5_YEL, 45M_AIS, 45M_YEL

**MODE**
Options: CONTINU (F1), PERIOD (F2), SINGLE (F3)

Choose the alarm generation mode.

- CONTINU: The alarm is generated continuously, until stopped.
- PERIOD: The alarm is generated for a specific number of frames set in the DURATION and PERIOD line. This choice is intended to test a network element's compliance to ITU-T criteria. For example, MS-AIS is declared if the receiver detects AIS (k2 byte bits 6-8 set to 111) during three consecutive frames.
- SINGLE: An alarm will be generated during n consecutive frames. The DURATION line defines n.

**DURATION**
PERIOD MODE Options: 1–1999 frames

Set the number of consecutive frames with the alarm.

SINGLE MODE Options: 1–2000 frames

Set the number of consecutive frames that carry the alarm.

**PERIOD**
Options: 1–8000 frames

Set the number of frames between the consecutive frames which carry the alarm condition. It is normally set to 8000 Frames which is the number of frames transmitted every second. For Instance, if you want to verify that network element will properly detect MS-AIS, duration must be set to 3 frames (consecutive) and period to 8000.

**ON/OFF**
Options: OFF (F1), ON (F2)

Press F2 to generate an alarm, press F1 when finished.

### 2.3.3 ATM Error Injection

Use this screen to setup ATM error injection.

```
                                   ⧫1310

      PAYLOAD : ATM
      VCC No. : 1

       TYPE  :
       MODE  :  BURST
       COUNT : 1



    LOGIC    HEC    NC-HEC
```

**Figure 59 ATM Error Injection Screen**

Configure the following:

**PAYLOAD**
This is set at ATM for ATM error injection.

**VCC No.**
Errors may be injected into VCC #1.

**TYPE**
Options: LOGIC (F1), HEC (F2), NC-HEC (F3)

Determine the error type to inject.

- LOGIC: Bit error
- HEC: Header Error Check cell
- NC-HEC: Noncorrectable Header Error Check cell

**MODE**
Options: RATE (F1), BURST (F2)

Determine how the errors will be injected.

- BURST: Use to insert a number of errors into N cells. In BURST mode, COUNT of cells will need to be set at the next line; the number of cells into which to inject an error. Enter a number between 1–999 by using SHIFT and the numeric keypad.
- RATE to send bit errors at a specific rate; 1e-3 to 9e-9. Enter the rate at the count line by using SHIFT and the numeric keypad.

**COUNT**

Determine how many cells will be injected in a burst (this is the value of N as mentioned in MODE), or the rate at which errors will be injected.

To inject errors, press ERR INJ. If inside the ATM FEATURES menu, the test set will inject the ATM error specified in this screen. If you are outside the ATM FEATURES menu, the test set will inject the non-ATM error specified in the ERROR INJECTION screen.

### 2.3.4 ATM Alarm Generation

Operation, Administration, and Maintenance (OAM) cells carry alarm, resource, and system information within the ATM network. OAM cells apply to either the F4 (virtual path) or F5 (virtual channel) flow. Furthermore, they can be carried end-to-end or just within a single segment.

For testing, you may send errors or OAM cells to verify they are properly received and transmitted. The test set can generate the following Fault Management OAM cells:

**AIS**: Alarm Indication Signal cells serve the same downstream notification purpose as AIS in the line and path SONET layers.

**RDI**: Remote Defect Indication cells are an upstream response to AIS cells in the same way an RDI-P is a response to a path AIS.

**Loopback**: These cells are used to verify two-way connectivity between two switches. When a switch receives a loopback cell, it sends the cell back on the return path and toggles a loopback indication bit within the cell. The test set automatically responds to incoming loopback cells.

**Continuity**: These cells verify connectivity between switches.

**Note**: The OAM cell header is set automatically, based on the selected flow. Do not configure a VCC using VCI 3 or 4 or PTI 100 or 101 to send OAM cells. Though these header values are correct for OAM cells, the cell payload will not be correct and these user cells will be ignored by ATM switches.

Five information hierarchies are defined for the flow of OAM, F1 to F5. They exchange information across the layers. F4 and F5 are ATM layer flows. A special Fault Management (FM) cell carries the information. All ATM network devices can perform fault detection and notification. An AIS cell notifies downstream devices of a fault. The downstream device then sends an RDI upstream to the source to notify that device of the fault. The Line and Path levels are also notified of the faults.

```
                                1310                                          1310

   ALARM & OAM GENERATION                        OAM DETAILS

F4SGAIS F4SGRDI F4SG_LB F4SG_CC       OAM TYPE: RDI

F4EEAIS F4EERDI F4EE_LB F4EE_CC       DEFECT TYPE:  00

F5SGAIS F5SGRDI F5SG_LB F5SG_CC       DEFECT LOCATION:
                                          00 00 00 00 00 00 00 00
F5EEAIS F5EERDI F5EE_LB F5EE_CC           00 00 00 00 00 00 00 00


DETAIL                  ENABLE        DECIMAL   HEX    BINARY
```

**Figure 60 Alarm & OAM Generation and Details Screens**

To generate an OAM message or alarm signal, first select the type of alarm to transmit.

**Note**: SEG=Segment, EE=End-to-End, LB=Loopback cell, and CC=Continuity Check.

An enabled OAM is indicated in red text after F4 is pressed.

The following OAM cells can be sent:

**F4/5SGAIS**: AIS on F4 (VP) or F5 (VC) flow segment.

**F4/5SGRDI**: RDI on F4 (VP) or F5 (VC) flow segment.

**F4/5SG_LB**: Loopback code on F4 (VP) or F5 (VC) flow segment.

**F4/5EEAIS**: AIS end-to-end on F4 (VP) or F5 (VC) flow.

**F4/5EERDI**: RDI end-to-end on F4 (VP) or F5 (VC) flow.

**F4/5EE_LB**: Loopback code end-to-end on F4 (VP) or F5 (VC) flow.

**F4/5EE_CC**: Code end-to-end on the F4 (VP) or F5 (VC) flow.

Once the messages are selected, press ERR INJ to transmit, or if desired, configure the details of the transmitted OAM message by pressing F1 as shown in the right screen of Figure 60.

**OAM TYPE**
Observe the OAM message type, as selected in Figure 60.

**DEFECT TYPE**
Options: DECIMAL (F1), HEX (F2), BINARY (F3)

Select the format for the defect type. This is under study.

**DEFECT LOCATION**
Use SHIFT and the numeric keypad to enter the hexadecimal information about the defect location.

When finished, press ESC and press ERR INJ to transmit the selected messages while in the ATM FEATURES menu. Once used the selected message is deselected.

## 2.4 SDH/SONET Features

The menu screen displayed is dependent on the selection made in SETUP > SETUP NETWORK MODE.

The SDH FEATURE menu contains:

- OVERHEAD CONFIG
- SECTION OVERHEAD
- PATH OVERHEAD
- TRACE GENERATION
- POINTERS
- TRIBUTARY SCAN
- APS TIMING

The SONET FEATURE menu contains:

- OVERHEAD CONFIG
- SECTION/LINE OVERHEAD
- PATH OVERHEAD
- TRACE GENERATION
- POINTERS
- TRIBUTARY SCAN
- APS TIMING

Refer to the following sections for both SDH and SONET.

### 2.4.1 Overhead Configuration

Determine which standards the overhead bytes will adhere to. This determines how the bytes will be decoded by the test set.

SDH

```
                         1310

K1/K2 DECODING  :
HP PLM DETECTION:ENABLE
LP PLM DETECTION:ENABLE
HP TCM          :ENABLE
LP TCM          :DISABLE

LINEAR   RING
```

SONET

```
                         1310

K1/K2 DECODING   :
PLM-P DETECTION :ENABLE
PLM-V DETECTION :ENABLE
STS TCM         :ENABLE
VT TCM          :DISABLE

LINEAR   RING
```

**Figure 61 Overhead Configuration Screens**

For SDH Network Mode, configure the following:

**K1/K2 DECODING**

Options: LINEAR (F1) RING (F2)

Determine the decoding standard used for K1/K2 byte. Optical networks may be linear or ring. They have slightly different protection switching schemes; therefore the decodes for the K1/K2 bytes change slightly depending on the employed scheme.

**HP PLM DETECTION**
Options: ENABLE (F1) DISABLE (F2)

High Path Payload Label Mismatch monitoring.

**LP PLM DETECTION**
Options: ENABLE is the only option

Low Path Payload Label Mismatch monitoring.

**HP TCM**
Option: ENABLE (F1), DISABLE (F2)

High Path Tandem Connections Monitoring.

**LP TCM**
Options: DISABLE is the only option.

Low Path Tandem Connections Monitoring.

For SONET Network Mode, configure the following:

**K1/K2 DECODING**
Options: LINEAR (F1) RING (F2)

See K1/K2 DECODING in the previous SDH subsection.

**PLM-P DETECTION**
Options: ENABLE (F1) DISABLE (F2)

Payload Label Mismatch-Path monitoring.

**PLM-V DETECTION**
Options: ENABLE is the only option

Payload Label Mismatch-Virtual Tributary monitoring.

**STS TCM**
Option: ENABLE (F1), DISABLE (F2)

Synchronous Transport Signal Tandem Connections Monitoring.

**VT TCM**
Options :DISABLE is the only option.

Virtual Tributary Tandem Connections Monitoring

When finished, press ESC.

### 2.4.2 Section Overhead and Section/Line Overhead

This menu contains the following:

- SOH MONITOR (SDH)/SOH/LOH MONITOR (SONET)
- SEND SOH BYTES (SDH)/SEND SOH/LOH BYTES (SONET)
- SEND K1, K2 BYTES
- SEND S1 BYTE

#### 2.4.2.1 SOH Monitor/Section Line Overhead

Use this feature to view overhead bytes.

```
                              1310                                     1310

   01 02 03                              01 02  03

 01 C3 23 20                         01 A1  A2  J0
 02    E5 A5                         02 B1  E1  F1
 03 2C FF 1B                         03 D1  D2  D3
                                     04 H1  H2  H3
 BYTE   :B1                          05 B2  K1  K2
 DECODE :BYTE                        06 D4  D5  D6
 BIP-8                               07 D7  D8  D9
                                     08 D10 D10 D12
                                     09 S1  M1  E2


 PAGE-UP  PAGE-DN  HOLDSCR   HELP                              ESCAPE
```

**Figure 62 Receive Overhead Bytes Screens**

For 155M and higher, the screen is formatted in 9 columns by 9 rows, as the Regenerator and Multiplexer Section overhead is. For 52M, the screen is 3 columns by 3 rows as shown in the left screen in Figure 62.

The following F-keys are available:

**PAGE-UP** (F1), **PAGE-DN** (F2): Use to go through the different rows (1–3, 4–6, 7–9).

**HOLDSCR/CONTINU** (F3 or MORE, F1): Allows freezing the presentation of bytes, then restart it.

**NEXTSTM** (F3): Available for 622M and 2.5G. Press to see data on the next STM-1. Note that the STM-1 under test is reported in the screen title bar.

: Select the byte you want information on. The following information is presented for a selected byte:

- **BYTE**: B1, in the left screen of Figure 62.
- **DECODE**: The decode format, shown in ASCII.
- **info**: Byte definition; BIP-8 pointer byte in the left screen of Figure 62.

**HELP** (F4): Available in some screens. Press it to see the layout of the bytes, as shown in the right screen of Figure 62.

Additional information, such as the exact bits and particular decode information is available for the K1, K2, and S1 bytes, as shown in Figure 63.

```
                                     1310

   01 02 03 04 05 06 07 08 09

04 68 93 93 39 FF FF 00 00 00
05 57 D7 90 00    00 00 00 00
06 00 00 00 00 00 00 00 00 00

BYTE :K1
DECODE:BINARY
BITS1-4:0000
REQUEST:No request
BITS5-8:000
CHANNEL:Null channel

PAGE-UP PAGE-DN HOLDSCR   HELP
```

**Figure 63 K1 Byte Screen**

In Figure 64, a sample J0 decode screen is shown on the left with it's corresponding HELP screen on the right. Use HELP to identify the location of a specific byte.

```
                              1310

   01 02 03 04 05 06 07 08 09

01 F6 F6 F6 28 28 28    02 03
02 29 00 00 00 00 00 00 00 00
03 00 00 00 00 00 00 00 00 00

BYTE   :J0
DECODE :16 BYTES
TRACE  :
A STEP AHEAD!!!

PAGE-UP PAGE-DN HOLDSCR   HELP
```

```
                                     1310

01 A1 A1 A1 A2 A2 A2 J0 XX XX
02 B1 MD MD E1 MD RR F1 XX XX
03 D1 MD MD D2 MD RR D3 RR RR
04 H1 H1 H1 H2 H2 H2 H3 H3 H3
05 B2 B2 B2 K1 RR RR K2 RR RR
06 D4 RR RR D5 RR RR K6 RR RR
07 D7 RR RR D8 RR RR D9 RR RR
08 D10RR RR D11RR RR DS1RR RR
09 S1 RR RR RR RR M1 E2 XX XX

XX: Reserved National Use
RR: Reserved International Use
MD: Media dependent

                              ESCAPE
```

**Figure 64 J0 with Help/Decode Screens**

Next is a sample S1 screen:

```
                                     1310

   01 02 03 04 05 06 07 08 09

07 00 00 00 00 00 00 00 00 00
08 00 00 00 00 00 00 00 00 00
09    00 00 00 00 00 00 00 00

BYTE   :S1
DECODE :BINARY
BITS5-8:0000
MESSAGE:Quality unknown (existi
ng Sync. Network)

PAGE-UP PAGE-DN HOLDSCR   HELP
```

**Figure 65 S1 Byte Screen**

### 2.4.2.2 Send SOH Bytes/Send SOH/LOH Bytes

Transmit SOH bytes with the Send SOH Bytes function. Press to select different bytes. The decode for the selected byte is shown below the byte field, as in the left screen of the following figure:

```
                            ◊1310

01 F6 F6 F6 28 28 28 T1 AA AA
02 -- 00 00 00 00 00 00 00 00
03 00 00 00 00 00 00 00 00 00
04 -- -- -- -- -- -- -- -- --
05 -- -- -- 00 00 00    00 00
06 00 00 00 00 00 00 00 00 00
07 00 00 00 00 00 00 00 00 00
08 00 00 00 00 00 00 00 00 00

BYTE :K2  APS
VALUE :00000000

 DETAIL         NEXTSTM   HELP
```

```
                            ◊1310

01 A1 A1 A1 A2 A2 A2 J0 XX XX
02 B1 MD MD E1 MD RR F1 XX XX
03 D1 MD MD D2 MD RR D3 RR RR
04 H1 H1 H1 H2 H2 H2 H3 H3 H3
05 B2 B2 B2 K1 RR RR    RR RR
06 D4 RR RR D5 RR RR D6 RR RR
07 D10RR RR D11RR RR D9 RR RR
08 S1 RR RR RR RR M1 E2 XX XX

BYTE :K2  APS
VALUE :00

                             ESCAPE
```

**Figure 66 Transmit SOH Screens**

The following F-keys are available:

**DETAIL** (F1): If an S1, J0, K1, K2 byte is selected, a further detailed configuration screen is available. Press F1 to enter the SEND screen for that byte. In Figure 66, the K2 byte is highlighted. If DETAIL is pressed, the SEND K1, K2 BYTE screen, which is shown in Figure 67 is displayed.

**HELP/ESCAPE** (F4): Available in some screens. Press it to see the layout of the bytes, as shown in the right screen of Figure 66. When finished, press ESCAPE.

**TOGGLE** (F2): If a byte other than S1, J0, K1 or K2 is selected, press F2 to jump to the VALUE line below the bytes field, so that the value for that byte can be set. Use <-- (F3), -->(F4) to move among the digits. Press F2 again to jump back to the bytes field. Press SEND to transmit the new value.

**HEX/BINARY** (F1): If a byte other than S1, J0, K1 or K2 is selected, press F1 to view the selected byte in hexadecimal format. Press F1 to return to the original binary display. Edit the value of the byte at the VALUE line, accessed via TOGGLE (F2).

**NEXTSTM** (F3): If the test set is in an 622M or 2.5G mode, press F3 to view the bytes of each STM.

### 2.4.2.3 Send K1, K2 Bytes

Configure and transmit the K1 and K2 bytes in this screen.

```
                                  1310

BITS 1-4 REQUEST
0000     No Request
BITS5-8  CHANNEL
0000     Null Channel

BITS1-4  CHANNEL
 000     Null Channel
BITS5    ARCHITECT
0        1+1
BITS6-8  ALARM
000      Reserved
 BIT=0    BIT=1           SEND
```

**Figure 67 Send K1, K2 Bytes Screen**

Use BIT=0 (F1) and BIT=1 (F2) to determine each bit within the two bytes. Each time a bit is changed, the label will change automatically. When done, press SEND (F4).

Standard K1 and K2 bytes meanings are shown in the following tables:

| **Code** | **Channel and Notes** |
|---|---|
| 0<br>(i.e. 0000) | Null Channel<br>• Signal degrade and signal fail requests apply to conditions detected on the protection line.<br>• For 1+1 systems, forced and manual switch requests apply to the signal line.<br>• Only code 0 is used with the lockout of protection request. |
| 1 through 14<br>(i.e. 0001 through 1110) | Working Channels<br>• Codes 1 through n apply in a 1:n architecture.<br>• Code 1 only applies in a 1+1 architecture.<br>• Conditions signal degrade and signal fail with the provisioned priority (high/low) apply to the corresponding working lines. |
| 15<br>(i.e. 1111) | Extra Traffic Channel<br>• May exist only when provisioned in a 1:n architecture.<br>• No request is only used with code 15. |

**Table 4 K1 Bits 5-8, K2 Bits 1-4, per ITU-T G.783**

| Bit 1234 | Automatically Initiated, External or State Request[1] |
|---|---|
| 1111 | Lockout of protection |
| 1110 | Forced switch |
| 1101 | Signal fail high priority[2] |
| 1100 | Signal fail low priority |
| 1011 | Signal degrade high priority[2] |
| 1010 | Signal degrade low priority |
| 1001 | Unused |
| 1000 | Manual switch |
| 0111 | Unused |
| 0110 | Wait-to-restore[3] |
| 0101 | Unused |
| 0100 | Exercise[4] |
| 0011 | Unused |
| 0010 | Reverse request[5] |
| 0001 | Do not revert[6] |
| 0000 | No request |

**Notes:**
[1]Request priority is in descending order, except that a signal fail request by the null channel (for a signal fail condition detected on the protection line) has a higher priority than a forced switch (i.e., it is between lockout of protection and forced switch).

[2]Higher priority codes apply only to the 1:n architecture.

[3]1+1 LTE provisioned for nonrevertive switching does not transmit wait-to-restore.

[4]Exercise may not be applicable in some linear APS systems.

[5]Reverse request applies only to bidirectional systems.

[6]Only 1+1 LTE provisioned for nonrervertive switching transmits do not send.

**Table 5 K1 Bits 1-4 per ITU-T G.783**

## K2 Byte

Bits 1-4 of the K2 byte indicate the channel assignment per Table 5. Bit 5 of the K2 byte indicates the following:

- 0: Provisioned (or only supported) architecture is 1+1.
- 1: Provisioned (or only supported) architecture is 1:n.

Bits 6 through 8 of the K2 byte indicates the following:

- 101: Provisioned mode is bidirectional.
- 100: Provisioned (or only supported) mode is unidirectional.
- 111: Used for detecting an incoming AIS-L.
- 110: RDI-L
- 011, 010, 001, and 000: Reserved for future use.

### 2.4.2.4 Send S1 Bytes

In this screen, configure the S1 byte for transmission.

- Press F1 to page through the screens.
- To send, select a synchronization status message with and press F2.
- The four digits on the right are the binary combination for bits 5-8 for the message.

```
                                   1310

QUALITY                      BITS5-8

Reserved                        0001
Rec. G.811                      0010
Reserved                        0011
SSU-A                           0100
Reserved                        0101
Reserved                        0110
Reserved                        0111
 PAGE-DN   SEND
```

**Figure 68 Send S1 Bytes Screen**

The following table shows G.707 S1 byte bit patterns.

| S1 Bits b5-b8 | SDH Synchronization Quality level description |
|---|---|
| 0000 | Quality unknown (Existing Synchronization Network) |
| 0001 | ITU-T G.811 |
| 0011 | Reserved |
| 0100 | SSU-A |
| 0101 | Reserved |
| 0110 | Reserved |
| 0111 | Reserved |
| 1000 | SSU-B |
| 1001 | Reserved |
| 1010 | Reserved |
| 1011 | ITU-T G.813 option (SEC) |
| 1100 | Reserved |
| 1101 | Reserved |
| 1110 | Reserved |
| 1111 | Do not use for synchronization, see note |
| **Note**: This message may be emulated by equipment failures and will be emulated by a Multiplex Section AIS signal. The assignment of the “Do not use for Synchronization” quality level message is mandatory because the receipt of a Multiplex Section AIS is not necessarily interpreted as an indication of a physical failed synchronization source interface port. This assignment allows this state to be recognized without interaction with the Multiplex Section AIS detection process. | |

**Table 6 S1 Patterns per G.707**

### 2.4.3 Path Overhead

This menu contains the following:

- POH MONITOR
- SEND POH BYTES
- EDIT C2 HP SIGNAL LABEL
- EDIT C2 LP SIGNAL LABEL
- SEND K3 HP BYTE (SDH only)
- SEND K3 LP BYTE (SDH only)
- SEND V5 BYTE
- SEND K4 BYTE (SDH only)

#### 2.4.3.1 POH Monitor

The appearance of the Path Overhead Monitor screen will vary depending on whether the test set is monitoring a Higher Path or Higher and Lower Path. The path(s) are indicated in the second line of the header; HP in the following figure.

```
                              ◊1310



  J1 9B
  B3 36
  C2  6D
  G1  DA
  F2 24
  H4 49    BYTE   :K3
  F3 93    DECODE :BINARY
  K3       BITS1-4:0000
  N1 42 CHANNEL:Working Ch 9

 HOLDSRC  FIXED  16BYTES 64BYTES
```

**Figure 69 POH Monitoring Screen**

Use to select a byte. Any additional information will appear to the right of the column of bytes. HOLDSRC/CONTINU (F1) allows freezing and restarting the presentation of data.

When monitoring the J1 Byte, two additional F-keys are available; 16 BYTES (F2) and 64 BYTES (F3). Press the key corresponding to the size of the expected J1 string. This allows monitoring either size of J1 BYTE without reconfiguring the transmit byte.

### 2.4.3.2 Send POH Bytes

The appearance of the Tx Path Overhead screen depends on whether the test set is monitoring a High or Low order Path, or both. The Path(s) are indicated in the second line of the header: HP and LP in the following figure.

```
                              �1310



J1 9B 04 V5
B3 36 T1 J2
C2 6D -- N2
G1 DA 00 K4
F2
H4 49    BYTE   :F2
F3 93    USER CHANNEL
K3 26    VALUE  : 0
N1 42

 SEND   TOGGLE    <--      -->
```

**Figure 70 Transmit Path Overhead Screen**

The following F-keys are available:

**DETAIL** (F1): If an N1, N2, J1, J2, K3, or K4 byte is selected, a detailed configuration screen is available via the this key. Press it to enter the SEND screen for that byte. For example, if pressed while the K3 byte is selected, the SEND K3 HP BYTES screen, shown in Figure 62, will be displayed.

**TOGGLE** (F3): If a byte other than N1, N2, J1, J2, K3, or K4 is selected, press F3 to move to the VALUE line , so that the value for that byte can be set. In Figure 70, the F2 byte is selected, and TOGGLE has been pressed. Use <-- (F3) and --> (F4) to move among the digits. Press F3 again to move back to the bytes field. Press SEND to transmit the new value.

**HEX/BINARY** (F1): If a byte other than N1, N2, J1, J2, K3, or K4 is selected, press F1 to see the value of the selected byte in hexadecimal format. Press F1 again to return to the binary display. Edit the value of the byte at the VALUE line by pressing TOGGLE (F2).

### 2.4.3.3 Edit HP or LP C2 Signal Labels

The C2 POH byte provides information about the High or Low Path transported payload. Figure 71 shows a High path ITU-T screen. The C2 LP byte gives information about the Low Path transported payload (VC3 path overhead). It is valid for a STM-1 electrical or optical signal with a 34M or 45M payload via an AU4.

◊1310

```
LABEL                   1  HEX
Unequipped or supervisory  00
 - unequipped
Equipped-non-specific      01

Locked TU-n                03
Asynchronous mapping of    04
 34M or 45M
Asynchronous mapping of    12
 139M
ATM mapping                13
 PAGE-DN DEFAULT EX-DATA   SEND
```

**Figure 71 Edit C2 HP Signal Label Byte Screen**

In this screen:

- Press to move among the labels.
- Press PAGE-UP (F1) to scroll between pages of labels.
- To send, select a byte/label and press SEND (F4).
- Press TX_DATA /EX_DATA (F3) and the test set will report the CURRENT signal label being transmitted, and the signal label expected, at the first line of the display. You can choose the byte you expect to receive. If the received data does not match the byte selected here as EX_DATA, the test set will declare PLM. Press SET (F4) after selecting the byte to start this function. Note that the TX and EXPECT labels may be different.
- Press DEFAULT (F2) to send the standard byte.

### 2.4.3.4 Send K3 HP or LP Byte

This screen is available for the Low Path (SEND K3 L BYTE) or High Path (SEND K3 HO BYTE), depending on test configuration. If an unavailable function selected, "Payload type is mismatched" is displayed.

Use BIT=0 (F1) and BIT=1 (F2) to determine each available bit. Each time a bit is changed, the label will change automatically. When ready, press SEND (F4).

```
                                1310

BITS 1-4 CHANNEL
 000     Null Channel

BIT=0 BIT=1                   SEND
```

**Figure 72**
**Send K3 HP Bytes Screen**

### 2.4.3.5 Send V5 Byte

This screen allows sending a V5 Byte. These bits communicate the signal label for low order paths.

The test set reports the CURRENT signal label being transmitted, and the signal label expected.

```
                                1310

LABEL                        BITS5-7
Unequipped or supervisORY     000
 -unequipped
Reserved                      010

Bit synchronous               011
Byte synchronous              100
Extended signal label         101
Test signal, 0.181            110
 specific mapping
VC-AIS                        111
 DEFAULT  TX-DATA  EX-DATA   SEND
```

**Figure 73**
**Send V5 Signal Label Byte Screen**

Press to select the byte/label and press SEND (F4). Use TX_DATA (F2) and EX_DATA (F3) to select the labels to be transmitted and received. If the received data does not match the byte selected here as EX_DATA, the test set will declare PLM. Press SET (F4) after selecting the byte to start the expected data function. Note that the TX and RX labels may be different.

- Press DEFAULT (F1) to send the standard 010 byte.

**Extended Signal Label Generation**

Select Extended signal label as the V5 byte label, then go to the Send K4 BYTES screen to determine the extended signal label.

### 2.4.3.6 Send K4 Byte

This screen is available when the Extended signal label as the V5 byte label has been selected.
Use BIT=0 (F1) and BIT=1 (F2) to determine each available bit. Each time a bit is changed, the label will change automatically. When configured as desired, press SEND (F4).

```
                                 1310


b1 TX-ESL   Interpretation
00000000 Reserved

b1 EX-ESL   Interpretation
00000000 Reserved

V5 K4
b8 b5-7 Interpretation
   100    E-RDI Server defect
BIT=0 BIT=1              SEND
```

**Figure 74**
**Send K4 Bytes Screen**

**Extended Signal Label Generation**
Select Extended signal label as the V5 byte label in the SEND V5 BYTE screen, then modify the byte in this screen to determine the extended signal label.

The following table shows the values allowed by ITU-T G.707:

| **MSB**[6] **b12/13/14/15** | **LSB**[7] **b16/17/18/19** | **Hex Code**[1] | **Interpretation** |
|---|---|---|---|
| 0 0 0 0 ... 0 0 0 0 | 0 0 0 0 ... 0 1 1 1 | 00 ... 07 | Reserved[2] |
| 0 0 0 0 | 1 0 0 0 | 08 | Experimental mapping[3] |
| 0 0 0 0 | 1 0 0 1 | 09 | ATM mapping |
| 0 0 0 0 | 1 0 1 0 | 0A | Mapping of HDLC/PPP[12], [13] framed signal |
| 0 0 0 0 | 1 0 1 1 | 0B | Mapping of HDLC/LAPS [15] framed signal |
| 0 0 0 0 | 1 1 0 0 | 0C | Virtually concatenated test signal, O.181 specific mapping[4] |
| 0 0 0 0 | 1 1 0 1 | 0D | GFP mapping |
| 1 1 0 1 ... 1 1 0 1 | 0 0 0 0 ... 1 1 1 1 | D0 ... DF | Reserved for proprietary use[5] |
| 1 1 1 1 | 1 1 1 1 | ff | Reserved |

**Notes**:
[1]There are 225 spare codes for future use. See Annex A/G.806 for details.
[2] Values 00 to 07 are reserved to give a unique name to non-extended and extended signal labels.
[3] Value 08 is only to be used for experimental activities in cases where a mapping code is note defined in this table.
[4] Any virtually concatenated mapping defined in ITU-T O.181 or successors that does not correspond to a mapping defined in G.707 falls in this category.
[5] These 16 code values will not be subject to further standardization.
[6] Most significant bit.
[7] Least significant bit.

**Table 7 Extended Signal Label Byte Coding**

### 2.4.4 Trace Generation

This menu contains the following:

- J0 SECTION TRACE GENERATION
- J1 HP TRACE GENERATION (SDH)
- J1 LP TRACE GENERATION (SDH)
- J1 STS PATH TRACE GENERATION (SONET)
- J2 PATH TRACE GENERATION (SDH)
- J2 VT PATH TRACE GENERATION (SONET)
- EXPECTED PATH TRACE DATA

#### 2.4.4.1 J0 Section Trace Generation

```
                              ⧫1310


MODE  :
LENGTH:16BYTES
TRACE :
A STEP AHEAD ! ! !

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj
Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt
Uu Vv Ww Xx Yy Zz 12 34 56 78
90 !@ #$ %^ &* () -+ {} \/ :;
<> ?: '" [] =_ ~'


 USER     THRU
```

**Figure 75 J0 Path Generation Screen**

Configure the following:

**MODE**
Options: USER (F1), THRU (F2)
Determine the type of data to transmit.

- USER: Use to send custom data. See *Entering A Custom-Message*.
- THRU: Use to retransmit the received path/section trace.

**LENGTH**
Options: FIXED (F1), 16BYTES (F2)
Determine the J0 trace length.

- FIXED: Standard one-byte format; at the TRACE line you will see BINARY reported; enter the one-byte trace in binary.
- 16BYTES: For this length, 15 bytes are used for the trace; the 16th byte is used for a CRC-7 calculation. The DEFAULT (F4) message is the VeEX Inc message. Edit the message using the character grid.

**Entering A Custom Message**

Select the message TRACE line, then use the F-keys to enter a custom message. Press TOGGLE (F3) to access the character grid.

- Press INSERT (F1) to add an extra space.
- Press DELETE (F2) to remove a character.
- Press TOGGLE (F3) to access the ASCII characters. Press to move to a character.
- Press SELECT (F4) to place the highlighted character into the label. When finished, press TOGGLE to exit the label.
- Press SEND (F4) to transmit the message.

### 2.4.4.2 J1 HP Trace Generation

Enter this feature to configure the J1 path trace. See *Section 2.4.4.1,* for instructions on using this feature.

```
                                  ϕ1310

MODE  :USER DATA
LENGTH:64BYTES
TRACE :ASCII
VEEX INC MTT SDH/SONET
HANDHELD TEST SET A STEP AHEAD
!!
Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj
Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt
Uu Vv Ww Xx Yy Zz 12 34 56 78
90 !@ #$ %^ &* () -+ {} \/ :;
<> ?: ‘“ [] =_ ~’

 USER    THRU
```

**Figure 76 J1 HP Trace Generation Screen**

Here is the only specific difference:

**LENGTH**

Options: FIXED (F1), 16BYTES (F2), 64BYTES (F3)

Determine the trace length. Normally use a 16- or 64-byte trace. The one-byte fixed trace is not generally used.

### 2.4.4.3 J1 LP Trace Generation

To generate a J1 LP trace, the test set must be in Single mode. The test interface or high rate set to 155M Electrical or Optical, and TEST PAYLOAD or LOW RATE set to 45M or 34M, mapped via AU4.

The JI HP byte belongs to the fist byte of VC4, with the AU pointer value telling where this byte is located in the AU. J1-LP applies to VC3, in the case of having 34 or 45M payload via AU4. If 45M is mapped via AU3, the J1-HP will be the byte of the VC3 container, and its position will be indicated for the AU3 pointer value.

The J1 byte is repetitively transmitted so the PTE can verify its connection to its intended transmitter. The trace may be a 64-byte freely formatted string, or a more defined 15-byte ASCII text sequence plus CRC-7 byte, depending on the circuit setup. See *Section 2.4.4.1*, for a description of how this screen works. Here is the only specific difference:

**J1 LENGTH**
Options: FIXED (F1), 16BYTES (F2), 64BYTES (F3)

Determine the trace length. Normally you will use a 16- or 64-byte trace. The one-byte fixed trace is not generally used.

### 2.4.4.4 J2 Path Trace Generation

The J2 byte is the Low Order Path Access Point Identifier trace which applies to VC12 and VC11. Like the J1, it is a path trace identifier, repetitively transmitted so the PTE can verify its connection to its intended transmitter. It is a 16-byte frame, as defined by clause 3 of the G.831 standard. The frame is identical to that used by the J0 byte. See *Section 2.4.4.1* for instructions on using this feature. Here is the only specific difference:

**J2 LENGTH**
Options: FIXED (F1), 16BYTES (F2), 64BYTES (F3)

Determine the trace length. A 16- or 64-byte trace is normally used. The one-byte fixed trace is generally not used.

### 2.4.4.5 Expected Path Trace Data

Use this feature to configure the receiver to expect a particular path trace. Once this feature has been enabled, the received trace must match the expected trace, or the test set will report a TIM (Trace Identifier Mismatch). This expected trace is available for J1, HP-TIM, and J2.

```
                                        ⧫1310

TYPE  :J1 HP
MODE  :ENABLE
LENGTH:16BYTES
TRACE :ASCII
VEEX INC MTT SDH/SONET
HANDHELD TEST SET A STEP AHEAD
!!!
Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj
Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt
Uu Vv Ww Xx Yy Zz 12 34 56 78
90 !@ #$ %^ &* () -+ {} \/ :;
<> ?: '" [] =_ ~'
 J1 HP    J1 LP
```

**Figure 77 Expected Path Trace Data Screen**

**TYPE**

Options: J1HP (F1), J1 LP (F2))

Determine the type of path trace to expect.

**MODE**

Options: ENABLE (F1), DISABLE (F2), SAVE (F4)

Determine if the received trace must match the expected trace. If set to ENABLE, the received trace must match the expected trace, or the test set will report a TIM. Press SAVE (F4) after changing this field.

**Note**: Press SAVE after selecting DISABLE when finished testing, or a TIM will be displayed when a received trace does not match the Expected data.

**LENGTH**

Options: FIXED (F1), 16BYTES (F2), SAVE (F4)

Determine the trace length to expect.

- Send USER DATA at 16BYTES.
- Press SAVE (F4) after changing this field.

See *Section 2.4.4.1* for creating a custom message.

### 2.4.5 Pointers

This menu contains the following:

- POINTER MONITOR
- POINTER ADJUSTMENT
- G.783 POINTER TEST SEQUENCES

#### 2.4.5.1 Pointer Monitor

```
                 Meas    1310

 TYPE :

 NNNNSSID IDIDIDID DECIMAL
 11101000 11010110   63

 LOSS OF POINTER SECS:33
 JUSTIFICATION       :2
 POSITIVE JUSTIF.    :2
 NEGATIVE JUSTIF.    :0
 NEW DATA FLAG SECS  :33

HOLDSCR           AU      TU
```

```
                 Meas    1310

 TYPE :

 NNNNSSID IDIDIDID DECIMAL
 11101000 11010110   63

 LOSS OF POINTER SECS:33
 JUSTIFICATION       :2
 POSITIVE JUSTIF.    :2
 NEGATIVE JUSTIF.    :0
 NEW DATA FLAG SECS  :33

HOLDSCR           AU      TU
```

**Figure 78 Pointer Monitor Screens**

Use these screens to monitor AU or TU pointers. Make this selection by selecting TYPE.

- Each byte is displayed in binary. The pointer value is displayed in decimal. Pointer measurements run at the same time as other measurements.
- Use HOLDSCR/CONTINU (F1) to freeze the screen, press again to view a live screen.

Both screens contain the following:

**LOSS OF POINTER SECS**: Number of seconds in which the pointer was lost.

**JUSTIFICATION**: Count of the number of times the pointer value has changed.

**POSITIVE JUSTIF**: Number of positive justification bytes; increase in pointer value.

**NEGATIVE JUSTIF**: Number of negative justification bytes; decrease in pointer value.

**NEW DATA FLAG SECS**: Number of seconds containing New Data Flag bits with the code that indicates a change in the payload.

### 2.4.5.2 Pointer Adjustment

This screen allows adjustment of pointers, thus stressing the network. Press SEND (F4) to put the settings in effect. Observe the effects of any adjustments in the POINTER MONITOR screen.

```
                    Meas    1310

POINTER TYPE :
NEW DATA FLAG:OFF
SET SS BITS  :10      SDH
POINTER VALUE:428
POINTER ADJ  :DEC



  AU      TU
```

**Figure 79 Pointer Adjustment Screen**

Configure the following:

**POINTER TYPE**
Options:

*SDH*: AU (F1), TU (F2)

*SONET*: STS (F1), VT (F2)

Choose the type of pointer to adjust.

**NEW DATA FLAG (NDF)**
Options: ON (F1), OFF (F2)

- ON: The test set will transmit the enabled code (1001) in the NDF bits of the H1 byte.
- OFF: The test set transmits disabled code (0110).

**SET SS BITS**
These bits sit between the NDF and the pointer value. Default value should be set to 10; the label is SDH. Use to move from one bit to another. Use BIT=0 (F1) to set the bit to 0, and BIT=1 (F2) to set it to 1. If the SS bits are set to 00, the label in front of them should be SONET. When set to 11, UNKNOWN is displayed. Press SEND (F4) to make the new settings effective.

**POINTER VALUE**
Press SHIFT and use the numeric keypad to enter any value between 0–782. Press SEND (F4) to enter the new value.

**POINTER ADJ**
Changing the Pointer Adjustment to stress the network. Press INC (F1) to increase the pointer value by one. Press DEC (F2) to decrease the pointer value by one.

### 2.4.5.3 G.783 Pointer Test Sequences

This is an important tool for qualifying and installing SDH networks. It allows stress testing the robustness and jitter tolerance of the network. The following figure shows the setup screens.

```
              Meas    1310                   Meas    1310

                T    t
TYPE    :    SEQUENCE:              INITIALIZE : 01:00  (mm:ss)
CUSTOM MOVEMENT: INC                COOL DOWN  : 00:30  (mm:ss)
        cycle ANOMALY :             MEASUREMENT: 000:15 (hhh:mm)
ADDED    N       n                  CONTINUOUS :
N       : 26
n       : 1
T       : 5272   frames(s)
t       : 8      frames(s)
CYCLE   : 48000) frames(s)
  Press ENTER to Start Test            Press ENTER to Start Test
                     more                                 more
  AU      TU                          YES      NO
```

**Figure 80 Pointer Test Sequences Setup Screens**

### Notes

- Not all configuration items are available for all setups.
- To enter numbers, press SHIFT and use the numeric keypad.

**TYPE**
Options:

*SDH*: AU (F1), TU (F2)

*SONET*: STS (F1), VT (F2)

Select the type of pointer to be affected by the test sequence.

**SEQUENCE**
Options: OPPOS (F1), SINGLE (F2), BURST (F3), TRANS (MORE, F1), PERIOD (MORE, F2), 87-3 (MORE, F3), 26-1 (MORE, F1), CUSTOM (MORE, F2)

Decide how to affect the pointer sequence.

- OPPOS: Use Opposite to increase/decrease the pointer value in alternating sequence.
- SINGLE: Increase or decrease the pointer value.
- BURST: Generate a sequence of changes in the pointer value in one direction only (increase or decrease).
- TRANS: Generate changes in the phase of the pointer adjustment.
- PERIOD: Generate periodic changes in the pointer value.
- 87-3: Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, with no adjustments).

- CUSTOM: Use to customize pointer sequences, by adjusting the settings.

**MOVEMENT**
Options: INC (F1), DEC (F2), INC/DEC (F3)

Specify whether the pointer is increasing or decreasing.

- INC: Increases the pointer value.
- DEC: Decreases the pointer value.
- INC/DEC: Alternates the pointer value (increase/decrease).

**ANOMALY**
Options: NONE (F1), ADDED (F2), CANCEL (F3)

Specify the type of anomaly, if any.

- ADDED: Adds an additional pointer value.
- CANCEL: Reduce by one the number of adjustments.

**N**
Options: 1–9999 (default=6)

Specify the number of pointer adjustments in a row.

**n** (CUSTOM SEQUENCE only)
Options: 1–9999 (default=4)

Specify the number of pointer adjustments in a row. The value of n can never be higher than the value of N.

**T**
Options: 1–9999 (default=6) frames

Specify the average pointer spacing in time. This is also known as T2 or T5 in G.783.

**t** (ADDED ANOMALY only)
Options: 1–9999 (default=6) frames

Specify the average added pointer spacing in time. This is also known as T3 or T4 in G.783.

**CYCLE**
Options: 1–9999 frames

Specify the cycle time of the sequence. If this item does not appear, the test sequence is sent only once, after the initialization and cool down period.

Press until the screen shown in the right of Figure 80 is displayed. Configure the following:

**INITIALIZE**

Options: 0–99:59 minutes: seconds (default 1:00)

Specify the initialization period. During the initialization period, the test set sends pointer increase/decreases as set in MOVEMENT.

**COOL DOWN**

Options: 0–99:59 minutes: seconds (default: 30 sec.)

Specify the cool down period. During the cool down period, the test set sends the normal periodic sequence (87-3 sequence), or no pointer adjustments (all other sequences).

**MEASUREMENT**

Options: 0–99:59 minutes: seconds (default: 15 sec.)

Specify the initialization period. Measurements are not taken during the initialization or cool down periods. In the Measurement period, the sequence continues as the test set compiles standard measurements.

Press ENTER when ready to start testing and the following screen is displayed:

```
                    Meas    �1310

            000:05:07

        NO ERR    NO ERR
                   COOL
        INITIALIZE DOWN  MEASUREMENT

      CONFIG  PATTERN  RESTART  MORE

      HOLDSCR HISTOGR  LOCK     MORE

      PRINT   SAVE     STOP     MORE
```

**Figure 81 Test Sequence-Test in Progress Screen**

The STATUS screen in Figure 81 displays the progress of each phase of the test by the progress bar at the bottom of the screen. The test duration is indicated along with an indication of error (NO ERR or ERR DETECT). As indicated by the page bar at the right use to view other test result screens. See *Sections 2.2.1 and 2.2.2* for a description of these screens.

All results screens contain the following F-keys:

**CONFIG** (F1): Shortcut to the TEST CONFIGURATION screen. See *Section 2.1.1*.

**PATTERN** (F2): Shortcut to the SEND TEST PATTERN screen. See *Section 2.1.2.*

**RESTART** (F3): Press to restart all measurements, resetting all counters.

**HOLDSCR/CONTINU** (MORE, F1): HOLDSCR freezes all of the measurement displays so they may be easily observed. The measurement count is still proceeding, but the counts are up-dated only in memory. When finished viewing, press CONTINU to view a live display.

**HISTOGRAM** (MORE, F2): Shortcut to the CURRENT HISTO-GRAM screen. See *Section 2.2.2.1.*

**LOCK/UNLOCK** (MORE, F3): Press to disable the keypad and an indicator will appear at the top of the screen. The measurement process continues as usual, but keypad strokes have no effect on the test set. This is useful if you are running a long-term test and do not wish to have the test disturbed. Press UNLOCK (F2) to re-enable the test set's keypad.

**PRINT** (MORE, F1): Press to send all of the current results to the serial port for printing.

**SAVE** (MORE, F2): Press to store the measurement results. See *Section 2.7*.

**STOP/START** (MORE, F3): Press to stop measuring, press again to restart measuring, resetting all counters.

### 2.4.6 Tributary Scan

In-service testing of the PDH/T-Carrier tributaries inside a SDH/ SONET signal is a routine application in everyday maintenance. Status verification of each tributary is important for the proper routing and operation of different SDH/SONET network elements such as DXCs and ADMs, as well as for the maintenance of legacy PDH/T-Carrier networks.

```
                                    ⧫1310

     MODE : OUTSERV
     SCAN :

     STM1 AU3  TUG2 TU12 REPORT

     1    1    1    1      PASS
     1    1    1    2      PASS
     1    1    1    3      PASS
     1    1    1    1      PASS
     1    1    1    2    SCANNING

     STOP    PAUSE   PRINT   MORE

   PAGE-UP PAGE-DN  SUMM    MORE
```

**Figure 82 Tributary Scan Screen**

Configure the following:

**MODE**

Options: IN-SERV (F1), OUTSERV (F2)

Choose the scan mode.

- IN-SERV: Use In-Service scan to monitor the status of the tributaries on the receiver side without attempting to achieve pattern synchronization. The test set will display the alarm with the highest hierarchy. If there is no alarm or error, it will display OK.
- OUTSERV: Use Out-of-Service scan to verify error-free transmission between network elements. The test set will generate an SDH signal containing a PDH tributary. It will start with the first tributary, send a PRBS pattern, and run measurements for a few seconds.

When ready, select SCAN and press F1 to start scanning. Results are displayed tributary by tributary according to the mapping scheme.

For SDH, the test set will start with STM-1[1], TUG3[1], TUG2[1] and TU12[1]. The TU will be increased first, then TUG2, then TUG3 and finally STM1 until it reaches the last one at STM1[4], TUG3[3], TUG2[7], TU12[3].

If the 2M tributary is mapped via AU3, TUG3 will be replaced with AU3. If the test interface is STM-1, the STM-1 column will be ignored (N/A), and the numbers will be displayed for TUG3, TUG2 and TU12.

The REPORT will only display one alarm per tributary, and it will be the one with higher priority. Priority will start with SDH alarms, then PDH alarms.

**Out-of-Service Results**

- PASS: This will be displayed in green if pattern synchronization is achieved, and there are no errors or alarms during those seconds.
- FAIL: This will be displayed in red if there is any alarm, error or pat sync loss. The test set will display the report for that tributary, then go to the next tributary.

**In-Service Results**

- OK: This will be displayed in green if pattern synchronization is achieved and there are no errors or alarms during those seconds.
- Faults will be reported in red if there is any alarm, error or pat sync loss. The test set will display the report for that tributary, then go to the next tributary.

The following F-keys are available:

**START/STOP** (F1): Press F1 to start scanning, press again to stop.

**PAUSE/RESUME** (F2): Press F2 to pause the test. While paused, use the PAGE-DN and PAGE-UP keys to scroll through the screens in order to look at a particular tributary. Press again to resume the test.

**PRINT** (F3): Press F3 to send the results to the serial port for printing.

**PAGE UP** (MORE, F1), **PAGE DN** (MORE, F2): Press to view the available screens of data.

**SUMM/TOTAL** (MORE, F1): Press to view a summary of the results. The screen will report “NO ERROR FOUND” or list the found errors. Press again to return to the scan screen.

### 2.4.7 APS Timing

Decide whether to connect the test set in-service or out-of-service. For most applications, traffic cannot be interrupted, so the testing will be done in-service. If a network is being installed or a new service provisioned, then testing can be done out-of-service. The test set will then generate a test pattern to simulate traffic.

APS time can be measured in either or both directions inside an SDH ring, for more information see *Section 4.3.1.4-APS*.

```
                                   ⧫1310

SENSOR            :
SWITCH TIME LIMIT : 50  ms
GATE TIME         : 100 ms

START    STOP    PRINT   TRGMODE
```

**Figure 83 APS Setup Screen**

Configure the following:

**SENSOR**
Options: *SDH*: LOS, MSAIS, AU-AIS, TU-AIS, B2

Determine which event will trigger the switching procedure by pressing TRGMODE (F4). For an out-of-service test, make sure that pattern synchronization is established before beginning the test. The errors available will depend on test configuration. Use the following:

- MS_AIS/AIS_L: Look for an AIS signal on the AU or line as appropriate.
- AU_AI/AIS_P: Look for an AIS signal on the AU or Path as appropriate.
- TU_AI: Look for an AIS signal on the TU.
- BI, B2, or B3: Look for parity error.
- AIS or LOS: Use for 2M lines.

**SWITCH TIME LIMIT**
Options: 1–200 ms

Set criteria for the maximum APS time allowed for the network to pass APS testing. After the APS time is measured, PASS or FAIL will be displayed along with the measured time. In general, this value should be set to 50 ms.

**GATE TIME**
Options: 51–5000 ms

During an automatic protection switchover, AIS may come and go as the NEs progress through their algorithm to switch traffic to the protection circuit. GATE TIME allows setting a time limit on how long to wait. GATE TIME must be longer than SWITCH TIME LIMIT, but should not be so long that other network events are mistakenly combined with the APS time measurement.

Another way to think of GATE TIME and SWITCH TIME LIMIT:

(GATE TIME) – (SWITCH TIME LIMIT) = Minimum AIS Free Interval

A typical value is 100 ms.

When ready, press F1 to start the measurement. The test set is now armed and waiting for an APS event to be detected. Initiate the APS using a network management terminal, inserting MS-AIS with test equipment, or by breaking the working circuit. The APS time is measured and displayed, along with PASS or FAIL.

The following F-keys are available:

**START** (F1) **STOP** (F2): Press F1 to start, press F2 to stop.

**PRINT** (F3): Press F3 to send the results to the serial port for printing.

## 2.5 PDH Features

This feature is under construction, it will be released at a later date.

## 2.6 ATM Main Menu

This menu contains the following:

- ATM Setup
- VCC Setup
- VCC Statistics
- VCC Scan
- Cell Capture
- ATM IP Testing
- ADSL ATM Testing

**Notes:**

- The test set must be in ATM TEST MODE in order to enter this menu. See *Section 2.1*.
- To enter numbers or hex characters, press SHIFT and use the numeric/hex keypad.

### 2.6.1 ATM Setup

Use this screen to observe and configure ATM settings.

```
                                 ◊1310

            ATM CONFIGURATION

      MAPPING         : OC3
      PDH ATM Mapping : N/A
      SCRAMBLING      :
      IDLE CELLS      : IDLE
      C2 POH hex      : 13
      PATTERN TRUNCATE:  OFF
      INTERFACE    :    UNI
      DISPLAY
        VPI/VCI       : DECIMAL
        GFC/PTI       : BINARY


        ON      OFF
```

**Figure 84 ATM Configuration Screen**

**MAPPING**
Observe the mapping (test rate) in use.

**PDH ATM MAPPING**
Observe the mapping in use. Currently this is not available.

**SCRAMBLING**
Options: ON (F1), OFF (F2)

Determine if the cell payload will be scrambled or not.

**IDLE CELLS**
Options: IDLE (F1), NULL (F2)

Determine the idle cell designation. IDLE is the default setting. NULL is the ITU-T I.361 unassigned cell designation.

**C2 POH hex**
Options: 00 to FF (hex)

Determine the value of the POH C2 byte. The standard ATM setting is 13 (hex).

**PATTERN TRUNCATE**
Options: OFF (F1), ON (F2)

When ON, the test pattern is truncated to the size of the ATM Cell or AAL payload. This is for compatibility with other equipment. When OFF, the PRBS will span multiple cells.

**INTERFACE**
Options: UNI (F1), NNI (F2)

Select the interface under test. UNI, User Network Interface. NNI, Network Network Interface.

**DISPLAY**
Configure the following two items:

**VPI/VCI**
Options: DECIMAL (F1), HEX (F2)

Determine how the VPI and VCI data will be displayed. Select between decimal or hexadecimal formats.

**DISPLAYGFC/PTI**
Options: BINARY (F1), DECIMAL (F2)

Determine how the GFC and PTI will be displayed. Note that cell payloads and most OAM files are displayed as hex.

When finished, press ESC.

### 2.6.2 VCC Setup

Use these screens to set up the configuration of the expected receive and transmit VCCs.

```
                          ⧫1310
  RECEIVE VCC CONFIGURATION

 #     GFC  VPI  VCI   PTI CLP
    X  0000 000  00000 000  0
  2 X  0000 000  00000 000  0
  3 X  0000 000  00000 000  0
  4 X  0000 000  00000 000  0
  5 X  0000 000  00000 000  0
  6 X  0000 000  00000 000  0
  7 X  0000 000  00000 000  0
  8 X  0000 000  00000 000  0


RECEIVE TRANSMT RX-->TX  SELECT
```

```
                          ⧫1310
  TRANSMIT VCC CONFIGURATION

 #     GFC  VPI  VCI   PTI CLP
    X  0000 000  00000 000  0
  2 X  0000 000  00000 000  0
  3 X  0000 000  00000 000  0
  4 X  0000 000  00000 000  0
  5 X  0000 000  00000 000  0
  6 X  0000 000  00000 000  0
  7 X  0000 000  00000 000  0
  8 X  0000 000  00000 000  0


RECEIVE TRANSMT TX-->RX  SELECT
```

```
                              ⧫1310

VCC 1
      GFC VPI    VCI  PTI CLP
Rx    0000 000  00000 000  0
Tx  X 0000 000  00000 000  0

PAYLOAD  : USER
AAL      : 0(NONE)


PATTERN : 2e15      INVERT:OFF
TRAFFIC: CBR
PCR:000.00 %

OFF (X) ON  (A)
```

**Figure 85 VCC Configuration Screens**

Use the top screens to select either Receive or Transmit VCCs using . The following F-keys are available in the top screens:

**RECEIVE** (F1): View RECEIVE VCC CONFIGURATION.

**TRANSMT** (F2): View TRANSMIT VCC CONFIGURATION.

**RX-->TX** (F3): This is available in RECEIVE VCC CONFIGURATION, it applies the RX settings to the TX side.

**TX-->RX** (F3): This is available in TRANSMIT VCC CONFIGURATION, it it applies TX settings to RX side.

**SELECT** (F4): View VCC CONFIGURATION shown at the bottom of Figure 85, of the selected VCC.

For number entry, press SHIFT or EDIT (F1) and use the numeric keypad. When finished, press SHIFT or EDIT (F1).

Use <-- (F2) to move within a field.

Use NEXT (F3) to move between fields. The display will vary depending on whether HEX or BINARY has been selected for DISPLAY. Not all fields will be applicable to all setups.

**Notes:**

- The test set shows detailed information from the first channel (configured VCC) only.
- Results are taken from VCC#1.
- Available line items depend upon the selected mapping.
- The test set begins measuring as soon the VCC is activated. Settings cannot be changed until measurements are stopped; a warning message is displayed if this is attempted. To stop measurements, select VCC STATISTICS, and press F2.

These items appear in the bottom screen of Figure 85:

**VCC**: Number of the VCC being reported on (1 in Figure 85). Note that the first channel is the foreground channel.

**A/X**: Shows the status of the corresponding VCC. Press F1 to select an off state (X). Press F2 to select an on state (A).

**GFC** (Generic Flow Control): UNDEF (all *s), 0–1 for each digit; applies only to UNI.

**VPI** (Virtual Path Indicator): UNDEF, 0–9 for each digit, binary/ 00–99 hex.

**VCI** (Virtual Channel Indicator): UNDEF, 0–9 for each digit, binary/ 0000–9999 hex.

**PTI** (Payload Type Identifier): UNDEF, 0–1 for each digit, binary/ 0–7 hex.

**CLP** (Cell Loss Priority): UNDEF, 0–1.

**PAYLOAD**

Options for VCC 1: USER (F1), TESTCEL (F2)

Determine the observed AAL in use.

- USER: Use for background channels (VCC 2 and on). Used to fill the test payload with a pattern, defined by PATTERN.
- TESTCEL: Use to fill the payload with test cells. Additional screens will be available in Measurement Results.

**AAL** (N/A for background channels)

Determine the AAL in use. The active, foreground channel is the VCC designated VCC#1, which measurements are taken from. All other channels are designated background channels.

- 0 (none) (F1): AAL is not used.
- 1 (F2): Use for T1 emulation.
- 2 (F2): Used for real-time applications like voice over DSL.
- 5 (F3): Use for IP encapsulation. When selected, the test set will insert a fixed pattern into the payload area where IP packets are normally placed.

The following settings appear, depending on the selected AAL:

**AAL1 Settings**

**CLOCK**

Options: SRTS (F1), ADAPTIV (F2)

Select a clock.

- SRTS: Synchronous Residual Time Stamp
- ADAPTIV: Adaptive recovers clock frequency from the transmitted data.

**PDH**

Options: 1.5M (F1), 2M (F2)

Determine the PDH traffic.

- 1.5M: Framed 1.544 Mbit/s signal, as the ATM payload.
- 2M: Framed 2.048 Mbit/s signal, as the ATM payload.

**PDH FRAME**

1.5M Options: UNFRAME (F1), SF-D4 (F2), ESF (F3)

2M Options: UNFRAME (F1), PCM30 (F2), PCM30c (F3), PCM31 (more, F1), PCM31C (more, F2)

Select the PDH framing. See *Section 4.3.5.2* for an explanation of framing types.

**AAL2 Settings**

**Length**

Enter the length of the AAL2 payload in bytes, from 1 to 96.

**CID**

Enter the three-digit Channel Identifier. The CID identifies the CPS connection for this management information exchange.

**UUI**

Enter the two-digit User to User Indication number. The UUI is transparently transported by the Common Part Sublayer (CPS) between peer Layer Management entities.

**AAL5 Settings**

**Note**: A pseudorandom pattern cannot be transmitted on AAL5, hence a BERT cannot be performed.

**LENGTH**

Enter the length ( 0–65535) of the AAL5 payload in bytes.

**CPCS UU**

Enter the 3-digit Common Part Convergence Sublayer User to User indication number to transparently transfer CPCS user-to-user information.

**CPI**

Enter the 3-digit Common Part Indicator that is used to align the CPCS PDU (Protocol Data Unit) trailer to 64 bits; this is coded to zero. Other functions are under study.

**FRAME RATE**

Enter a 0–10 frame rate of the AAL5 payload.

**Remaining Non-AAL Settings**

**PATTERN**

Options: 2e15, 2e20, 2e23, ALL 0, ALL 1, USER

Choose the test pattern used to fill the payload, if PATTERN has been selected for the PAYLOAD. The patterns available depend on configuration.

- USER: Enter a hex value for the four nibbles.
- Pseudorandom patterns apply only to VCC#1 (N/A with AAL5).

**INVERT**

Select OFF (F1) to send the pattern in standard form; select ON (F2) to send it inverted (1s and 0s reversed).

**TRAFFIC**

Options: CBR (F1), VBR/UBR (F2), SEQCELL (F3)

Determine the type of traffic to transmit. For AA1, this is fixed at the PDH rate.

- CBR: If Constant Bit Rate is selected, set the following:
  - PCR: Peak Cell Rate
    Options: % (F1), Mbps (F2), Cps (F3)
    Determine what percentage of the available bandwidth will be filled with the selected ATM traffic.
    - %: Set the percentage between 1–99%.
    - Mbps: Enter the numeric portion.
    - Cps: Enter a number of cells per second to transmit.

  **Note**: If multiple VCCs have been configured such that their combined cell rates exceed the allowable bandwidth, the test gives priority to the traffic with the higher slot number.
- VBR/UBR: Variable Bit Rate/Unspecified Bit Rate bursty traffic is simulated by sending out a burst of cells, then stopping. If selected, set the following:
  - PCR: Peak Cell Rate, see this item in CBR.
  - SCR: Sustained Cell Rate. See PCR in CBR for options.
  - BURST: Set the number (2–9999) of cells to burst transmit.
- SEQCEL: Cells will be inserted in sequence. If used, set:
  - NUMBER OF CELLS: Determine the number of cells (1–1000) to be inserted sequentially.
  - REPETITION
    Options: SINGLE (F1), CONTINU (F2)
    Determine how many times the cells will be inserted.
    - SINGLE: Send the sequential cells once.
    - CONTINU: Send the cells in bursts as set in:
    - DELAY: Select from 000.001–999.999 seconds.

When finished, press ESC.

### 2.6.3 VCC Statistics

After accessing this screen, the test set will gather statistics on the preconfigured VCCs. View detailed statistics on a selected VCC, and run a BERT or Quality of Service (QoS) test.

```
                                          ϕ1310

    ET: 000:00:00 RT: CONTINUOUS
# VPI   VCI  CELLCOUNT CELL RATE
1 000  00000         0 0.0000e00
2 000  00000         0 0.0000e00
3 000  00000         0 0.0000e00
4 000  00000         0 0.0000e00
5 000  00000         0 0.0000e00
6 000  00000         0 0.0000e00
7 000  00000         0 0.0000e00
8 000  00000         0 0.0000e00
TOTAL:        0 HEC  :        0
IDLE :        0 NCHEC:        0
                HECR :0.0000e-00
 DETAIL   START  HOLDSCR   more


  SAVE    PRINT   CONFIG   more
```

**Figure 86 VCC Statistics Screen**

**Note**: If Loss of Signal (LOS), Loss of Frame (LOF), or Loss of Cell Data (LCD) is present on the selected VCC, an error message will appear next to the ET.

The following is reported:

**ET**: Elapsed time that the test has been running.

**RT**: Remaining Time of a timed test. CONTINUOUS for an un-timed test.

**(CELL) COUNT**: Number of cells in the VCC.

**(CELL) RATE**: Number of cells received per second.

**TOTAL**: Number of cells received.

**HEC**: Correctable Header Error Check errors (1 bit off) count.

**IDLE**: Number of idle cells received.

**NCHEC**: Noncorrectable HEC errors (2 or more errors) count.

**HECR**: HEC error rate per second.

The following F-keys are available:

**DETAIL** (F1): Press to display VCC detail screens, which presents detailed information on the selected VCC via PAGE-UP or PAGE-DN as shown in the following:

```
                                   1310

    ET: 000:00:00 RT: CONTINUOUS
    # GFC VPI    VCI  PTI CLP
    1 0000 000  00000 000  0


 TOTAL   :         0  0.0000e00
 CURR CPS:         0
 CNGSTD  :         0  0.0000e00
 TAGGED  :         0  0.0000e00
 HEC:         0 HECR:0.0000e-00
 AAL 0
CRC: N/A
BIT: NO PATTERN SYNC
PAGE-UP  PAGE-DN START     more
```

```
HOLDSCR   SAVE    PRINT    more
```

```
ERR INJ  OAM INJ  INJCNFG   more
```

```
                                   1310

    ET: 000:00:00 RT: CONTINUOUS
    # GFC VPI    VCI  PTI CLP
    1 0000 000  00000 000  0


 VP-LOC  : 0.000e-0s  0.000e-0s
 VP-AIS  : 0.000e-0s  0.000e-0s
 VP-RDI  : 0.000e-0s  0.000e-0s
 VP-LFMF : 0.000e-0s  0.000e-0s
 VC-LOC  : 0.000e-0s  0.000e-0s
 VC-AIS  : 0.000e-0s  0.000e-0s
 VC-RDI  : 0.000e-0s  0.000e-0s
 VC-LFMF : 0.000e-0s  0.000e-0s
PAGE-UP  PAGE-DN START     more
```

```
                                   1310

    ET: 000:00:00 RT: CONTINUOUS
    # GFC VPI    VCI  PTI CLP
    1 0000 000  00000 000  0


 AIS               0          0
 RDI               0          0
 LOOPBACK          0          0
 CONCHECK          0          0

 FORWARD           0          0
 BACKWARD          0          0

PAGE-UP  PAGE-DN START     more
```

```
                                   1310

    ET: 000:00:00 RT: CONTINUOUS
    # GFC VPI    VCI  PTI CLP
    1 0000 000  00000 000  0

 AIS               0          0
 RDI               0          0
 LOOPBACK          0          0
 CONCHECK          0          0

 FORWARD           0          0
 BACKWARD          0          0

PAGE-UP  PAGE-DN START     more
```

**Figure 87 VCC Detail Screens**

Refer to *Section 2.6.3.1* for an explanation of the information presented in the VCC Detail screens. The following F-keys are contained in the VCC Detail Screens:

**PAGE-UP** (F1)/**PAGE-DN** (F2): Use to view the available screens.

**STOP/START** (F2): Press to stop or start a test.

**HOLDSCR/CONTINU** (more, F1)): Press to pause the presentation of data; press again to view live data.

**SAVE** (more, F2): Save the highlighted VCC. See *Section 2.7.*

**PRINT** (more, F3): Send the statistics to the serial port.

**ERR INJ** (more, F1)): Press to inject errors, “Inject” is displayed at the top of the screen. Press again to stop. Select errors from the module main menu > ALARMS/ERRORS > ATM ERROR INJECTION. This F-key is unavailable when the pattern is not PRBS.

**OAM INJ** (more, F2): Press to inject an OAM message. Select a alarm message from the module main menu > ALARMS/ERRORS > ATM ERROR INJECTION.

**INJCNFG** (more, F3): Press to access the ATM portion of the ALARMS/ERRORS menu screen. See *Section 2.3* for details.

When finished, press ESC to return to the VCC STATISTICS SUMMARY screen shown in Figure 86 and the rest of the F-keys:

**STOP/START** (F2): Press to stop or start a test.

**HOLDSCR/CONTINU** (F3): Press to pause the presentation of data; press again to view live data.

**SAVE** (more, F1): Save the highlighted VCC. See *Section 2.7.*

**PRINT** (more, F2): Send the statistics to the serial port.

**CONFIG** (more, F1): Press to enter VCC MEASUREMENT CONFIGURATION as follows:

Use this screen to setup the test set to automatically start testing and if desired select a test duration.

```
                                    1310

START        :
  PROG DATE MDY: --/--/----
  PROG TIME HMS: --/--/----

DURATION   : CONTINU
  TIMED DUR: ---:-- (HHH:MM)



CONTINU TIMED
```

**Figure 88 VCC Measurement Configuration Screen**

Configure the following:

**START**

Options: MANUAL (F1), PROGRAM (F2)

Select the method to begin test measurements.

- PROGRAM: Press to program a specified time to begin measurements. Enter the desired time in the next two lines:
  PROG DATE MDY: Enter the start Month, Day, and Year by pressing SHIFT and using the numeric keypad.
  PROG TIME HMS: Enter the start Hour, Minute, and Second by pressing SHIFT and using the numeric keypad.
- MANUAL: Manually begin by pressing a START F-key.

**DURATION**

Options: CONTINU (F1), TIMED (F2)

Set the measurement duration.

- TIMED: the test stops when the specified time has elapsed. Use for making measurements of a specified length; 15 minute and 1 hour tests are commonly used. When a timed test is in progress, a RT (Remaining Time) counter shows how much time is left before the end of the test. Enter a duration (1 min to 999 hr: 59 min) by using SHIFT and the numeric keypad.

- CONTINU: The test will run indefinitely until a STOP F-key is pressed or a setting is changed forcing a restart of a test.

When finished, press ESC to return to the VCC STATISTICS SUMMARY screen shown in Figure 86.

### 2.6.3.1 VCC Traffic Statistics Detail Screens

From the VCC STATISTICS SUMMARY screen, detailed information is available for the first configured VCC.
Select a VCC and press DETAIL (F1). For an F-key description for these screens, see DETAIL in *Section 2.6.3*.

```
                                        1310
   ET: 000:00:00 RT: CONTINUOUS
   # GFC VPI    VCI  PTI CLP
   1 0000 000  00000 000  0

 TOTAL   :         0  0.0000e00
 CURR CPS:         0
 CNGSTD  :         0  0.0000e00
 TAGGED  :         0  0.0000e00
 HEC:         0 HECR:0.0000e-00
 AAL 0
CRC: N/A
BIT: NO PATTERN SYNC
PAGE-UP  PAGE-DN START     more
```

**Figure 89 VCC Traffic Statistics Screen**

Figure 89 shows detailed results, depending upon configuration. Results are provided both as a straight Count of the number of cells, and as the Cells Per Second (CPS) rate. The following is reported in the previous screen:

**TOTAL**: Total number of cells in the VCC.

**CNGST**: Count or rate in cells per second of congested cells (designated in the PTI code; 01X).

**TAGGED**: Count or rate in cells per second of cells received with CLP=1.

**HEC**: Count of HEC cells; the number of correctable HEC errors.

**HECR**: HEC error rate.

**AAL**: AAL in use, if any.

**CRC**: Number of CRC errors received. CRC errors apply to O.191 test cells, AAL1 sequence number CRC protection, and AAL5 CRC.

**BIT**: Number of received bit errors; PRBS only.

**BER**: Bit Error Rate; PRBS only.

**For OAM Cell Performance**

**EDC**: Error Detection Code.

**For AAL2**

**HEC**: Number of errors in the CPS Packet Header (CPS-PH).

**STF**: Number of errors in the Start Field (STF).

Press PAGE-DN (F1) to view the next screen:

This screen reports the status of various VC (Virtual Channel) and VC (Virtual Container) alarms for both segment and end-to-end paths. They are:

**LOC**: Loss Of Continuity **AIS**: Alarm Indication Signal **RDI**: Remote Defect Indication **LFMF**: Loss of Forward Monitoring Flow

```
                                        1310

     ET: 000:00:00 RT: CONTINUOUS
     # GFC VPI    VCI  PTI CLP
     1 0000 000  00000 000  0


VP-LOC  : 0.000e-0s  0.000e-0s
VP-AIS  : 0.000e-0s  0.000e-0s
VP-RDI  : 0.000e-0s  0.000e-0s
VP-LFMF : 0.000e-0s  0.000e-0s
VC-LOC  : 0.000e-0s  0.000e-0s
VC-AIS  : 0.000e-0s  0.000e-0s
VC-RDI  : 0.000e-0s  0.000e-0s
VC-LFMF : 0.000e-0s  0.000e-0s
PAGE-UP PAGE-DN START      more
```

**Figure 90 ATM Alarms Screen**

Press PAGE-DN (F1) to view the next screen:

This screen reports F4 OAM cell count. The following is reported:

**FM** (Fault Management)
- **AIS**: Alarm Indication Signal
- **RDI**: Remote Defect Indication
- **LOOPBACK**: Loopback cell
- **CONCHECK**: Continuity check cell

**PM** (Performance Management)
- **FORWARD** direction data
- **BACKWARD** direction data

```
                                        1310

     ET: 000:00:00 RT: CONTINUOUS
     # GFC VPI    VCI  PTI CLP
     1 0000 000  00000 000  0


AIS                0          0
RDI                0          0
LOOPBACK           0          0
CONCHECK           0          0

FORWARD            0          0
BACKWARD           0          0

PAGE-UP PAGE-DN START      more
```

**Figure 91 F4 OAM Cell Count Screen**

Press PAGE-DN (F1) to view the next screen:

This screen reports F5 OAM cell count. The same items as in the previous F4 screen are reported.

```
                                        1310

     ET: 000:00:00 RT: CONTINUOUS
     # GFC VPI    VCI  PTI CLP
     1 0000 000  00000 000  0


AIS                0          0
RDI                0          0
LOOPBACK           0          0
CONCHECK           0          0

FORWARD            0          0
BACKWARD           0          0

PAGE-UP PAGE-DN START      more
```

When finished, press ESC.

**Figure 92 F5 OAM Cell Count Screen**

### 2.6.4 VCC Scan

```
                            ⧫1310
          VCC SCAN    VPI: ALL
   ST: 15:00:19 ET: 000:06:20
   UTILIZATION:  25.2   %
#   GFC  VPI  VCI   PTI CLP AAL
   0000  005 11000 000  1  1
2  0000  000 00100 000  0  0




PAGE-UP  PAGE-DN  HOLDSCR   more

 CONFIG  ALLSCAN  SAVEVCC   more

  CLEAR  CLR ALL            more
```

**Figure 93 VCC Scan Screen**

The following F-keys are available:

**PAGE-UP** (F1)/**PAGE-DN** (F2): Use to view available VCCs.

**HOLDSCR/CONTINU** (F3)): Press to pause the presentation of data; press again to view live data.

**AALSCAN** (more, F2): Scan an AAL for the highlighted VCC. An AAL field will appear at the right end of the line, indicating the AAL, N/A, or ?, depending on the results.

**SAVE VCC** (more, F3): Press to enter RECEIVE VCC CONFIGURATION, where the selected VCC's configuration can be saved. If all VCC Tx/Rx Configuration slots are full, a warning will be displayed. Press F1 to continue saving the entry (the existing timeslot will be overwritten), or F2 to cancel. Saving to VCC Rx allows for later viewing statistics of the VCC and to send data of that VCC configuration.

**CLEAR** (more, F1): Press to delete the selected VCC.

**CLR-ALL** (more, F2): Delete all of the VCCs.

**CONFIG** (more, F1) Determine how the scan function will capture and present data in the following screen:

```
                                    1310
          VCC SCAN CONFIGURATION
MOST RECENT: BOTTOM

UTILIZATION: UTIL %

VPI CAPTURE: ALL





BOTTOM    TOP
```

**Figure 94 VCC Scan Configuration Screen**

Configure the following:

**MOST RECENT**
Options: BOTTOM (F1), TOP (F2)

Determine how the VCC presentation will be arranged.

- BOTTOM to have the most recent VCCs appear at the bottom of the display.
- TOP to have the most recent VCCs appear at the top of the display.

**UTILIZATION**
Options: UTIL % (F1), UTILcps (F2), AVAIL % (F3), AV cps (F4)

Determine how the payload utilization will be presented.

- UTIL %: Display the percentage of utilization; the percent of the payload in use.
- UTILcps: Display the utilization in cells per second.
- AVAIL %: Displays the percentage of the payload still available.

**VPI CAPTURE**
Options: ALL (F1) or EDIT (F1) for a specific number

Determine which VPI the test set will scan for.

- ALL: Capture all VPIs; therefore, all VCCs.
- EDIT: Press to enter a specific VPI number to capture only VCCs with that VPI. Use numeric keypad to enter the digits. Use <-- (F2) to move the cursor backwards to change/correct the entry. Press DONE (F1) when finished.

When finished, press ESC to return to the VCC SCAN screen.

### 2.6.5 Cell Capture

Use this screen to view information on individual cells.

```
                                    ϕ1310
                  CELL CAPTURE
           ET: 000:03:35 RT: CONTINUOUS

# VPI   VCI  USER CELL OAM CELLS
  005  18560         0  3.661e06
2 000  00018         0  3.662e06
3 000  00000         0         0
4 000  00000         0         0
5 000  00000         0         0
6 000  00000         0         0
7 000  00000         0         0
8 000  00000         0         0
       TOTAL:        0  7.323e06

 DISPLAY           STOP    more


   SAVE    PRINT   CONFIG   more
```

**Figure 95 Cell Capture Screen**

The following F-keys are available:

**DISPLAY** (F1): Press to view the cells (up to 2048) for the selected VCC. See *Section 2.6.5.2.*

**STOP/START** (F3): Press to stop or start a test.

**SAVE** (more, F1): Press to save this screen. See *Section 2.7*

**PRINT** (more, F2): Press to send the screens to the serial port.

**CONFIG** (more, F3): Press to enter the CELL CAPTURE CONFIGURATION screen, to determine which kind of cells to capture, and when to capture them. Note that the test set captures cells on the first channel. See *Section 2.6.5.1*.

### 2.6.5.1 Cell Capture Configuration

```
                              ◊1310
 CELL CAPTURE CONFIGURATION

CELL TYPE  : USER

FULL BUFFER: CYCLE

START      : MANUAL
  PROG DATE MDY: --/--/----
  PROG TIME HMS: --/--/----

DURATION   : CONTINU
  TIMED DUR: ---:-- (HHH:MM)


 USER     OAM   USE+OAM
```

**Figure 96 Cell Capture Configuration Screen**

Configure the following:

**CELL TYPE**
Options: USER (F1), OAM (F2), USR+OAM (F3)

- USER: Use to only capture cells which do not contain OAM-cells.
- OAM: Use to capture only OAM cells.
- USR+OAM: Use to capture all cells.

**FULL BUFFER**
Options: CYCLE (F1), STOP (F2)

- CYCLE: Use to allow new cells to replace old cells as the buffer fills up.
- STOP: Use to stop collecting cells when the buffer is full.

Determine when and how cell measurements are taken with the following:

**START**
Options: MANUAL (F1), PROGRAM (F2)

Select the method to begin test measurements.

- PROGRAM: Press to program a specified time to begin measurements. Enter the desired time in the next two lines:
  PROG DATE MDY: Enter the start Month, Day, and Year by pressing SHIFT and using the numeric keypad.
  PROG TIME HMS: Enter the start Hour, Minute, and Second by pressing SHIFT and using the numeric keypad.
- MANUAL: Manually begin by pressing a START F-key.

**DURATION**

Options: CONTINU (F1), TIMED (F2)

Set the measurement duration.

- CONTINU: The test will run indefinitely until a STOP F-key is pressed or a setting is changed forcing a restart of the test.
- TIMED: The test stops when the specified time has elapsed. Use for making measurements of a specified length; 15 minute and 1 hour tests are commonly used. When a timed test is in progress, a RT (Remaining Time) counter shows how much time is left before the end of the test. Enter a duration (1 min to 999 hr: 59 min) by using SHIFT and the numeric keypad.

When finished, press ESC to return to the CELL CAPTURE screen shown in Figure 97.

### 2.6.5.2 Cell Display

Press F1 in the CELL CAPTURE screen to display all of the cells for the highlighted VCC as in this sceen.

It provides the following information on each cell:

**FIRST CELL**: Number of the first cell in the sequence.

**LAST CELL**: Number of the last cell in the sequence.

**CURR CELL**: Number of the cell information is currently displayed.

```
                                    1310
FIRST CELL:1      CURR CELL:1
 LAST CELL:100    GOTO CELL: 001
                  <press enter>
 90 02 00 00 07 <-- HEADER
 00 00 00 00 01 00 02 0C
 00 00 98 A8 28 00 08 00
 40 00 98 A8 48 00 18 4C
 4C 00 98 98 48 00 98 7E
 88 00 06 48 98 00 00 07
 00 00 00 00 160 00 00 00
 OAM F4 SEGAIS
 NEXTCEL PREVCEL HEADER more

   OAM     USER     SAVE     more
```

**Figure 97 Cell Display Screen**

**GOTO CELL**: Use SHIFT and the numeric keypad to enter the number of a cell to view, then press ENTER.

**HEADER**: This arrow indicates the five header bytes.

The following F-keys are available:

**NEXTCEL** (F1): Press to see the data for next cell.

**PREVCEL** (F2): Press to see data for the previous cell.

**HEADER** (F3): Press to see the decoded information for the HEADER cell, as in Figure 98.

**OAM** (more, F1): Press to see the decoded information for the OAM cell (if the current cell is an OAM cell).

**USER** (more, F2): Press to see the decoded information for the USER cell (if the current cell is an USER cell).

**SAVE** (more, F3): Press to save the selected cell. See *Section 2.7*.

## Cell Display Decodes

Cell decodes are available for Header, OAM, and User cells, via their associated F-keys in the CELL DISPLAY screen. The F-keys in the decode screens are the same as in the CELL DISPLAY screen. Press ESC to return to the CELL DISPLAY screen.

## Header Cell Display

This screen displays detailed header information. The first line indicates the type of cell (GFC, in this screen), and its bits.

The next two lines display text information such as USER CELL, NO CONGESTION, NO HALT, NULL, UNCONTROLLED, or CELL ASSIGNED.

The remainder of the screen displays:

```
                                    1310
               CURR CELL:1
GFC: 0000
 NO HAULT, NULL
 UNCONTROLLED, CELL ASSIGNED
VPI: 5      VCI: 4
 OAM F4 ETE LOOPBACK

PTI: 000       CLP: 1


HEC: 00000111

NEXTCEL PREVCEL OAM        more
```

**Figure 98 Decode Header Screen**

**PTI**: View the Payload Type Indicator bit.

**CLP**: View the Cell Loss Priority bit.

**HEC**: Observe the Header Error Check bits.

## OAM Cell Display

This screen displays descriptive information on the OAM cell.

```
                                    1310
               CURR CELL:1
F4 ETE LOOPBACK

LOOPBACK ID: 1
CORRELATION TAG: AA AA AA AA
LOOPBACK LOCATION ID:
   FF FF FF FF FF FF FF FF
   FF FF FF FF FF FF FF FF
SOURCE ID:
   FF FF FF FF FF FF FF FF
   FF FF FF FF FF FF FF FF

NEXTCEL PREVCEL   OAM     more
```

**Figure 99 Decode OAM Screen**

### 2.6.6 ATM IP Testing

This test sends a PING from a local to a destination IP address to verify continuity. Both ends must be using the same TCP-IP protocol.

A large difference between the maximum and minimum response times for each PING indicates congestion in the network. For more information, see *Section 4.3.7*.

#### 2.6.6.1 Configuration

The setup screen appears after selecting ATM IP TESTING.

```
                                       ⧫1310

              PING SETUP

MODE   :        # PINGS : 1
                 PING LEN: 53
VPI    :8       PING/SEC: 1
VCI    :25
IP TYPE:STATIC
LOCAL IP      :0  .0  .0  .0
DESTINATION IP:0  .0  .0  .0
GATEWAY       :0  .0  .0  .0



 LLC-BRG LLC-RTE  START    more
```

**Figure 100 LLC-BRG PING Setup Screen**

Configure the following:

**MODE**
Options: LLC-BRG (F1), LLC-RTE (F2), PPPoE (more, F1), PPPoA (more, F2), CLIPoA (more, F1)

Select the protocol mode for the PING test.

- LLC-BRG: LLC-Bridge protocol. This follows RFC 1483 bridge encapsulation. It supports both static and dynamic (DHCP) IP management.
- LLC-RTE: LLC-Routed protocol. It supports only static IP addressing.
- PPPoE: PPP over Ethernet, according to standard RFC 2516 PPP over Ethernet. PPPoE supports dynamic IP addressing.
- PPPoA: PPP over ATM, according to standard RFC 2364, PPP over AAL5. PPPoA supports dynamic IP addressing.
- CLIPoA: Classical IP over ATM.

This screen varies slightly for the selected MODE and is pointed out in the following settings.

**Note**: To enter numbers, press SHIFT or EDIT (F1) and use the numeric keypad. When finished, press SHIFT or EDIT (F1).

**# OF PINGS**
Range 1–65535

Select the number of PINGS to send.

**AUTHENT** (PPP only)
Options: NONE (F1), PAP (F2), CHAP (F3)

If used, enter the Authentication protocol in use on the PPP network and enter a USER ID and PASSWORD.

- PAP: Password Authentication Protocol as defined in RFC 1334. PAP is the simplest method for authentication. It involves a two-way handshake where one peer sends a user name and ID to another peer element in the network. The second peer returns an authentication-acknowledge message either accepting or rejecting the user name and password.
- CHAP: Challenge Handshake Authentication Protocol as defined in RFC 1994. It involves a three-way handshake, in which the test set sends a challenge containing its user name. The server responds with a specific identifier expected for this transaction. The test set then accepts or rejects this response, when accepted the test set starts sending data.

**PING LEN**
Range: 28–1500 (default 53)

Select the PING Length.

**VPI**
Range: 0 through 255

The default is 8, which is a typical Ethernet assignment. Along with VCI, VPI identifies the next destination of a cell as it moves through a series of ATM switches on the way to its destination. The service provider typically assigns VPI.

**PING/SEC**
Range: 1–10 (default 1)

Select the PINGs per second.

**VCI**
Range: 0 through 65535

The default is 35, which is a typical Ethernet assignment. Along with VPI, VCI identifies the next destination of a cell as it moves through a series of ATM switches on the way to its destination. The service provider typically assigns VCI.

**IP TYPE**
Options: STATIC (F1), DHCP (F2) in LLC-RTE (F2) or DYNAMIC in PPP

- STATIC: This type of IP management means that the user has a permanent IP address. For STATIC, enter the LOCAL IP; this will be the value used during the test.
- DHCP: This refers to dynamic IP management. If selected, enter the IP address for the destination.

  Dynamic management provides a way for computers to obtain protocol configuration parameters (like the local IP address) dynamically from the network. In this case, the IP address is not permanent to the terminal; instead, the terminal requests an address from the server on the network. When selecting DYNAMIC for IP ADDRESS, the module sends a request to the server; the server responds and provides an IP address. Upon selecting DYNAMIC, the LOCAL IP line disappears; the network dynamically assigns an IP address.

**LOCAL IP**
Enter a local IP address of the circuit under test. For LLC-BRG static mode and LLC-RTE, this is the local IP address used. For LLC-BRG, DHCP or PPP DYNAMIC modes, there is no LOCAL IP mode since a dynamically assigned local IP address is used.

**DESTINATION IP**
Enter the destination address of the device to be pinged. If pinging a gateway, enter the gateway's address for the Destination IP. Pinging the gateway verifies connectivity to the ISP. This is not in CLIPoA mode.

**GATEWAY**
If required, enter a gateway address. A gateway is a device that connects dissimilar networks and passes information between them. In TCP/IP, the default gateway address is the address where the Internet Protocol sends packets destined for remote networks, unless a different route is configured. This setting appears only in LLC-BRG mode.

**USER ID** (PPP only)
For authentication (PAP and CHAP), you are required to enter a user ID and/or password prior to receiving an IP address from the ISP. See *Section 2.6.6.1.1*.

**PASSWORD** (PPP only)
For authentication (PAP and CHAP), you are required to enter a user ID and/or password prior to receiving an IP address from the ISP. See *Section 2.6.6.1.1*.

When finished, press F3 to start.

### 2.6.6.1.1 Entering a User ID/Password

Follow this procedure to enter a USER ID or PASSWORD for PAP and CHAP authentication.

1. Place the cursor on USER ID.
2. Press EDIT (F1) and a character screen is displayed.
3. Press INPUT (F3) to enter the character grid. Notice a cursor appears in the grid and INPUT changes to STOP.
4. Use to move the cursor to the desired character. Press ENTER to select that character. The character will appear on the USER ID line.
5. Continue selecting characters until done. Press STOP (F3) to exit the character grid.

• If you make a mistake; press STOP (F3). Use to select the incorrect character.
  - Press DELETE (F2) to delete the character.
  - Press INSERT (F1) to add a character to the left of the selected character.
  - Press OVER (F1) to replace the selected character with a new character.

6. Select HIDE USER ID (or PASSWORD) and choose whether to hide the ID code by pressing YES (F1) or NO (F2).
7. Press F4 to save the ID and return to the setup screen.
8. Select PASSWORD and follow the previous procedure from step 2 to enter the password.

### 2.6.6.2 PING Testing

After pressing F3 to start testing in the PING SETUP screen, a PING TEST screen is displayed.

```
                                 ⧫1310

ST:11:50:45         ET:000:00:45
LOCAL IP:000.000.000.000
DEST  IP:002.003.004.005

              PING TEST

 ROUTER: PASS
 PPP    : IN PROGRESS
 PING   : -

                     STATS    STOP
```

**Figure 101 In Progress PING Test Screen**

Here are messages that may be displayed:

**ROUTER: PASS**: This means the test set has connected to the router/broadband access server (ISP). The next step will be to verify authentication.

**ROUTER: FAIL**: This means that no connection to the ISP is available.

**PPP: IN PROGRESS**: The handshaking procedure is currently in progress. A local IP address has not yet been assigned. If static IP management is selected, the LOCAL IP entered in the configuration screen is used.

**PING**: This stage has not begun yet. PING will begin as soon as the PPP stage is successfully completed.

**CLIPoA Testing**

If using CLIPoA, INARP messages can be sent. CLIP was developed to create a simple way to do IP over ATM. RFC1577 is the standard. During the PING TEST, press F2 to use InARP messages.

```
                                        ⧫1310


ST:11:50:45          ET:000:00:45
LOCAL IP:000.000.000.000
DEST  IP:002.003.004.005
            InARP TEST
InARP_REQ to far end: RECV'D
InARP_REQ SENT  :       1
InARP_RSP RECV'D:.58.012.008.007

InARP_REQ RECV'D:  2
InARP_RSP SENT  :  2
InARP_REQ from  :.58.012.008.007

                           PING
```

**Figure 102 IP InARP Test Screen**

InARP (Inverse Address Resolution Protocol) is used by a station to request an IP address corresponding to the station at the other end of the connection. The test set can send and receive InARP information. InARP is sent to the ATM device as soon as this screen is selected. The messages are as follows:

**InARP_REQ to far end**: Status of the request to the far end device.

**InARP_REQ SENT**: Number of request messages sent.

**InARP_RSP RECV'D**: Number of response messages replied by the far end to the test set's requests.

**InARP_RSP from**: IP address of the ATM device that replied with a response to the test set.

**InARP_REQ RECV'D**: Number of request messages received from the far end device.

**InARP_RSP SENT**: Number of response messages sent to the far end.

**InARP_REQ from**: Far end IP address of the ATM device that responded to the request sent.

When finished, press F4 to return to the PING TEST screen.

The next figure shows the next stage of the PPP PING test:

```
                                 ⧫1310

ST:11:50:45         ET:000:00:48
LOCAL IP:004.008.022.001
DEST  IP:002.003.004.005

              PING TEST

 ROUTER: PASS
 PPP   : PASS
 PING  : IN PROGRESS

                    STATS    STOP
```

**Figure 103 PPP PING Test Screen-IP Address Assigned**

Here are messages that may be displayed:

**ROUTER: PASS**: This means the test set has connected to the router/broadband access server (ISP). The next step will be to verify authentication.

**PPP: PASS**: This means that the authentication handshaking was successful. A local IP address has been assigned, as shown by the LOCAL IP at the top of the screen.

**PING: IN PROGRESS**: The PING test is currently in progress. As soon as the test set receives a response from the destination, it will display PASS. If no response is received from the destination, it will display FAIL.

**Dynamic Testing**
For DYNAMIC mode, the network must assign the local IP address. There are two steps for the DHCP results.

As soon as the DHCP server provides an IP address, the LOCAL IP address is updated and DHCP is PASS. After an IP address is assigned, the test set will begin transmitting PING messages using the local IP address. When it receives a reply from the destination, it displays PING PASS.

**STATS (F3)**
As shown in Figures 101 and 103, a STATS (F3) F-key is available, press to display the following screen:

```
                                    ⧫1310

ST:11:50:45           ET:000:00:48
LOCAL IP:004.008.022.001
DEST  IP:002.003.004.005
PING        : PASS

Pings  : 10    Round Trip   (ms)
Sent   : 10
State  : DONE     Crnt: 4
Recv'd : 10        Avg: 4
Unreach: 0         Max: 5
Missing: 0         Min: 3
  ECHO           SUMMARY   STOP
```

**Figure 104 PING Statistics Screen**

The following is reported:

**Pings**: Number of PINGs that the user requested to send.

**Sent**: Number of PINGs that are actually sent to the network.

**State**: Current state of test, Done or Running.

**Recv'd**: Number of correct echo response(s) received.

**Unreach**: Number of echo response(s) with unreach flag received.

**Missing**: Number of echo response(s) missing.

**Round Trip**: Indicates the measure of the round trip delay in milli seconds. It is broken down into the following measurements:

- **Crnt:** Current roundtrip delay.
- **Min**: Indicates the Minimum round trip delay.
- **Max**: Indicates the Maximum round trip delay.
- **Avg**: Indicates the average of all round trip delay.

The following F-keys are available:

**SUMMARY** (F3): Press to return to the PING TEST screen.

**ECHO** (F1): Press in an active PING Statistics screen to view the ECHO RESULT screen as shown:

```
                                  ⧫1310


ST:11:50:45         ET:000:00:48
LOCAL IP:004.008.022.001

# OF ECHOED IPs: 1
PAGE: 1
  TIME   PING FROM         TOTAL
11:50:30 002.003.004.005   2





 PAGE-UP PAGE-DN  PRINT
```

**Figure 105 Echo Result Screen**

This screen reports on the number of echo PINGs the test set has sent in response to a PING from a specific IP address. Echo PING runs in a background mode, updating results continuously.

The following is reported:

**# of ECHOED IPS**: Number of IP addresses that sent PINGs.

**PAGE**: Number of available pages. Use the PAGE-UP (F2) and PAGE-DN (F3) keys to scroll through the available screens.

**TIME**: Timestamp of the last PING received.

**PING FROM**: IP address which sent the PING.

**TOTAL**: Total number of PINGS received.

The following F-keys are available:

**PAGE-UP** (F1) **PAGE-DN** (F2): Use to scroll through the available results.

**PRINT** (F3): Press to send the results to the serial port.

When finished, press ESC.

### 2.6.7 ADSL ATM Testing

This test requires a test set at the far end. Use the following procedure to configure the test sets. See the VeEX Inc Application Note, SSxDSL and SSOCx DSLAM Installation Verification (APP-xDSL-013) for further information on conducting this test.

**ADSL Far End Configuration**

1. From the module main menu, select ATM FEATURES > ADSL ATM TESTING and set the VPI and VCI values for the ADSL link under test.
   - VPI boundaries: 0 to 1024
   - VCI boundaries: 0 to 65535

   **Note**: Normally the VPI and VCI values are the same from one ADSL link to another regarding the service deployed on the specific link, i.e. 1483 Bridge (and PPPoE) uses VPI 8 and VCI 35. PPPoA uses VPI 0 and VCI 32. The mentioned values are the ones commonly seen, however these values may change, so verify the DSLAM configuration.

2. Press F4 to start and the test set will wait for a command from the near end test set.

**ADSL Near End Configuration**

1. From the module main menu, select ATM FEATURES > ATM SETUP and configure as follows:
   INTERFACE: UNI
   DISPLAY: HEX or DEC as desired, will not affect the test.
   SCRAMBLING: ON: This is normally the default value for ATM networks, verify the setup in the DSLAM.
   For the other setting, configure as required by the circuit under test.

   When finished, press ESC.

2. Connect the test set to the optical circuit and verify that the FRAME LED is green.
3. Select ADSL ATM TESTING and configure the following:
   VPI: Enter a number from 0–1024.
   VCI: Enter a number from 0–65535.
   UPSTREAM: Press AUTO (F2) to detect the rate.
   DOWNSTREAM: Press AUTO (F2) to detect the rate.

4. Press DSL DET (F1) to scan the optical span and search for the DSL pattern, then determine the upstream and downstream rates, if no loopback is found the ASDL ATM TEST RESULTS screen is displayed, as follows:

φ1310

```
ET- 000:00:48
    ADSL ATM TEST RESULTS
VPI - 8   VCI - 25
DETECTING

|Tx RATE-    kbps Tx RATE-    kbps|
|Rx RATE-    kbps Rx RATE-    kbps|
|CELL LOSS     %  CELL LOSS     % |
|BIT:             BIT:            |
|BER:             BER:            |
|                                 |
 ERR INJ                   STOP
```

**Figure 106 ADSL ATM Test Results Screen**

This screen reports the connection and loopback status, Press F1 to inject a bit error and go to the RESULTS screen to verify measurements, see *Section 2.2*.

The screen can report the following:

**DETECTING**: The test set is looking for ADSL service. **NO**

**CONNECTION**: An ADSL signal was not detected.

**LOOPBACK DETECTED TEST STOPPED**: The test set has detected the far end test set's test pattern.

**NO RESPONSE TEST STOPPED**: The test set neither detected a loopback nor the far end test set's test pattern.

**RUNNING**: The test set has detected the far end test set's test pattern and the test is underway. When the test has completed, STOPPED is displayed.

The remaining lines report the link status, for both the Upstream and Downstream directions.

**TxRATE**: Transmitted cell rate, shown in kbits.

**RxRATE**: Received cell rate, shown in kbits.

**CELL LOSS**: Percentage of cells lost.

**BIT**: Count of bit errors.

**BER**: Total Bit Error Rate for the link.

When finished, press ESC.

## 2.7 View/Print Results

Use this screen to view, print, and manage stored results.

```
          VIEW/STORE/PRINT
             Free space:  68 kbyte

 1. SDHs001          SDHs
 2. SDHs002          SDHs
 3.
 4.
 5.
 6.
 7.
 8.
 9.
10.
  VIEW            PRINT    more


 RENAME  UN/LOCK  DELETE   more
```

**Figure 107 View/Store/Print Screen**

The following F-keys are available in this screen.

**VIEW** (F1): Allows viewing of a selected file, see *Section 2.7.2*.

**PRINT** (F3): Allows printing of a selected file, see *Section 2.7.3*.

**RENAME** (more, F1): Allows renaming a selected file, see *Section 2.7.6*.

**UN/LOCK** (more, F2): Allows locking and unlocking a file, see *Section 2.7.5*.

**DELETE** (more, F3): Allows deleting an unlocked file, see *Section 2.7.4*.

### 2.7.1 Saving a Test

1. From any screen with a STORE F-key, press it and the results are saved with a generic file name that incudes the type of measurement and the time of day.

### 2.7.2 Viewing a Stored Test

1. From the module's main menu, select VIEW/PRINT RESULTS.
2. Select the desired file with .
3. Press VIEW (F1) and the stored result will appear.
4. Use any of the available F-keys to view the stored results.
5. When finished, press ESC to return to the VIEW/STORE/PRINT screen.

### 2.7.3 Printing a Stored Test

1. Connect a SunSet printer to the serial port of the test set.

- For other types of printers or for more information, refer to the Storing and Printing chapter in the test set user's manual.

2. From the module's main menu, select VIEW/PRINT RESULTS.
3. Select the desired file with .
4. Press PRINT (F3) and the file will begin printing.
5. When finished, press ESC to return to the VIEW/STORE/PRINT screen.

### 2.7.4 Deleting a Stored Test

1. From the module's main menu, select VIEW/PRINT RESULTS.
2. Select the desired file with .
3. Press DELETE (more, F3) and the file is deleted if the file is unlocked.

### 2.7.5 Locking & Unlocking a Stored Test

1. From the module's main menu, select VIEW/PRINT RESULTS.
2. Select the desired file with .
3. Press UN/LOCK (more, F2) and the file is locked or unlocked as indicated to the right of the file name. Refer to the lock icon shown in Figure 107.

### 2.7.6 Renaming a Stored Test

1. From the module's main menu, select VIEW/PRINT RESULTS.
2. Select the desired file with .
- Press UN/LOCK (more, F2) if the file is locked as indicated by the lock icon as in Figure 107.

3. Press RENAME (more, F2) and a character screen like the one shown in Figure 108 is displayed.
4. Press INPUT (F3). Note that the 'A' character is highlighted and the INPUT F-key has changed to STOP.
5. Select the desired character by pressing .
6. Press ENTER to place the selected character in the FILENAME line. Continue this process until the name is complete. Enter up to 15 characters.

- If a mistake is made:
  - A. Press STOP (F3).
  - B. Move the FILENAME cursor to the incorrect character.
  - C. Press DELETE (F2) to delete the character or, press INSERT (F1) to insert a character.
  - D. Press INPUT (F3) to select a character. Press ENTER to insert the new character to the left of the cursor.

```
               VIEW/STORE/PRINT

     FILENAME:  DHs001

        A a B b C c D d E e F f
        G g H h I i J j K k L l
        M m N n O o P p Q q R r
        S s T t U u V v W w X x
        Y y Z z 0 1 2 3 4 5 6 7
        8 9 - _ @ ! # $ % &

      INSERT  DELETE   INPUT    SAVE


      INSERT  DELETE    STOP    SAVE
```

**Figure 108 Character Entry Screen**

7. Press SAVE (F4) to save and return to the VIEW/STORE/PRINT screen shown in Figure 107.

# 3 Applications

## 3.1 General Applications

Use these tests for SDH and SONET applications. The configurations are examples, base your configuration on the circuit under test.

### 3.1.1 Accepting a New Circuit

This test will disrupt service, so verify that the span is out of service. A loopback is required at the far end of the span.

Multi-port

MON

IN

OUT

Eq.

Connect to the test set Tx/Rx as required by the circuit under test.

Customer

Exchange

**Figure 109 Accept a New Circuit**

1. From the module main menu, select SETUP > TEST CONFIGURATION and configure as required (what follows is for a 2M circuit):

   TEST MODE: SINGLE
   TEST INTERFACE: 2M
   TEST PAYLOAD: 2M

   **2M**
   CODE: HDB3
   FRAME: PCM-30 (or as specified)
   RxLVL: TERM
   TxSRC: TESTPAT
   TxCLK: INTERN
   RfCLK: N/A
   When finished, press ENTER and ESC.
2. Connect to the circuit as shown in Figure 109.
3. Press HISTORY to acknowledge any blinking LEDs and verify that the PAT SYNC LED is green.
4. From the module main menu, select RESULTS > MEASUREMENT RESULTS and verify that the circuit performs to your company's requirements for the service delivered. If needed, refer to *Section 2.2.1* for details of the result screens.
5. When finished, press ESC to return to the main menu and remove the loopback at the far end of the circuit.

### 3.1.2 Monitoring an In-Service Circuit

This test may be performed while the span is in service.

Low Rate Tx Network Eq.

MON

High Rate Tx Network Eq.

MON

OR

Connect to a test set Rx as required by the circuit under test.

**Figure 110 Monitor a Circuit**

1. From the module main menu, select SETUP > TEST CONFIGURATION and configure as required (what follows is for a 2M circuit):

   TEST MODE: SINGLE
   TEST INTERFACE: 2M
   TEST PAYLOAD: 2M

   **2M**
   CODE: HDB3
   FRAME: PCM-30C (or as specified) RxLVL: MONITOR or BRIDGE, If unsure, use BRIDGE to protect the circuit from disruption. MONITOR may cause a disrup- tion if the test set is not plugged in to a protected monitoring point.
   TxSRC: TESTPAT
   TxCLK: INTERN
   RfCLK: N/A
   When finished, press ENTER and ESC.

2. Connect the test set to a protected MON point of the Equipment as illustrated in Figure 110.
3. Press HISTORY to acknowledge any blinking LEDs and examine them for information about the circuit.

- SIGNAL should be green, red indicates no signal.
- FRAME should be green, red indicates unexpected framing.

- A red ERRORS or BPV/CODE will indicate that the circuit is working but is experiencing trouble.
- A red ALARM will indicate a problem on the other side of the circuit.
- A red AIS indicates a trouble condition where a network element transmitting to the test set has lost its incoming signal and has been replaced with a AIS signal.

4. From the module main menu, select RESULTS > MEASUREMENT RESULTS and verify that the circuit performs to your company's requirements for the service delivered. If needed, refer to *Section 2.2.1* for details of the result screens. The results screen also shows you what kind of pattern, if any, is being received by the test set.
5. When finished, press ESC to return to the main menu and disconnect the test set from the circuit.

### 3.1.3 Viewing Overhead Bytes

Use this procedure to view the Overhead Bytes embedded within the STM-1 signal. Overhead bytes of any SDH signal may be viewed.

1. From the module main menu, select SETUP > TEST CONFIGURATION and configure as follows:

   TEST MODE: SINGLE
   TEST INTERFACE: 155M O
   TEST PAYLOAD: Any
   Configure the rest of the screen as desired.

2. Connect the test set 155M/622M/2.5G Rx port to a splitter on an STM circuit.
3. Press HISTORY to acknowledge any blinking LEDs
4. Press ESC until the module main menu is displayed and select, SDH/SONET FEATURES > SECTION OVERHEAD > SOH MONITOR. Refer to *Sections 2.4.1* and *4.3.2* for further details on the Overhead Byte screens and their contents.
5. To view the Path overhead bytes, press ESC and select PATH OVERHEAD > POH MONITOR.
6. When finished, disconnect from the circuit.

### 3.1.4 Point-to-Point Facilities End-to-End Testing

Use this test to look at each side of a structured signal. In this out-of-service test, a test set transmits towards a network, and on to another test set. This test verifies error-free transmission and troubleshoots problems (through the mux/demux process). Figure 111 shows the general setup.

Tx Rx

Network

**Figure 111 Point-to-Point Facilities End-to-End Testing**

Configure as required by the circuit, this is a 155M O example.

1. From the module main menu, select SETUP > TEST CONFIGURATION and configure as follows:

   TEST MODE: SINGLE
   INTERFACE: 155M O
   PAYLOAD: 45M

   **55M**
   FRAME: STRUCT
   TxCLK: INTERN
   TXSRC: TESTPAT

   **45M**
   FRAME: CBIT (or as required)
   PAYLOAD: 45M

   **Mapping**
   AU: AU-3 (or as required)
   AU-3-[1] (or as required)
   OTHERCH: BROAD

   When finished, press ENTER and ESC.
2. Connect the two test sets as shown in Figure 111.
3. Press HISTORY to acknowledge any blinking LEDs and observe them for any problems.
4. From the module main menu, select RESULTS > MEASUREMENT RESULTS and verify that the circuit performs to your company's requirements for the service delivered. If needed, refer to *Section 2.2.1* for details of the result screens. The results screen also shows what kind of pattern, if any, is being received by the test set.
5. When finished, press ESC to return to the main menu and disconnect the test set from the circuit.

### 3.1.5 Point-to-Point Facilities End-to-Loopback Testing

This is an out-of-service test. The test set transmits to a piece of network equipment, which has a loop in place. This allows sending a structured signal to test the multiplexer/demultiplexer (MUX).

Rx

MUX Tx

**Figure 112 Point-to-Point Facilities End-to-Loopback Testing**

## 3.2 SONET Applications

The applications in the following subsections are for SONET.

For all of these applications, set the following:

1. From the module main menu, select SETUP > SETUP NETWORK MODE and configure as follows:
   NETWORK MODE: SONET
   VT DISPLAY: As required
2. When finished, press ESC.

### 3.2.1 Viewing Overhead Bytes

Use this procedure to view the overhead bytes embedded within a SONET signal. Overhead bytes of any STS/OC signal can be viewed.

1. From the SETUP menu, select TEST CONFIGURATION and configure as follows:
   TEST MODE: SINGLE
   INTERFACE: As required, STS-1 as an example.
   PAYLOAD: As required, DS3 as an example.

   | **STS-1** | **DS3** |
   |---|---|
   | RxLVL: MONITOR | FRAME: C-BIT (or as required) |
   | TxLVL: DSX | PAYLOAD: 45M |
   | TxCLK: INTERN | TxCLK: INTERN |
   | TxSRC: THRU-L | |

   When finished, press ENTER and ESC.
2. Connect the appropriate test set module Rx jack to the OUT jack of a Maintenance Port, or to the MON jack of an STX-1.
3. Verify the FRAME and FRAME LEDs are green.
4. Press HISTORY to acknowledge any blinking LEDs and observe them for any problems.
5. From the module main menu, select SDH/SONET FEATURES > SECTION OVERHEAD > SOH/LOH MONITOR. The screen on the right shows a sample.

```
   01 02 03

01 10 00 08
02 48    B6
03 CA 9F 22

BYTE   :E1
DECODE :BYTE
Orderwire



 PAGE-UP  PAGE-DN  HOLDSCR   HELP
```

**Figure 113 SOH/LOH Screen**

Use Figure 114 as a reference to SONET Overhead Bytes.

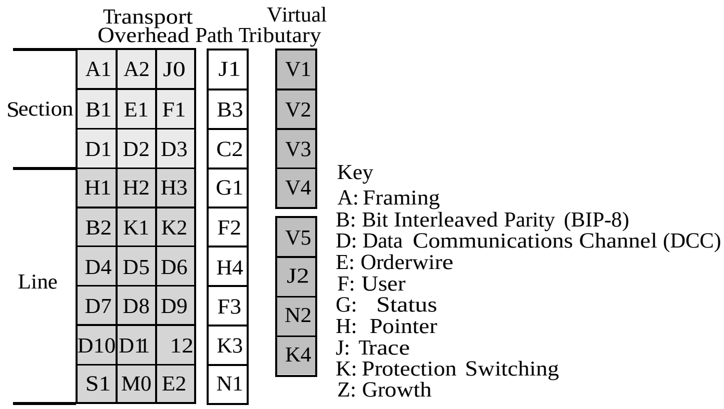



**Figure 114 SONET Overhead Bytes**

**Monitor Section Overhead**

- Verify the following:
  - Frame alignment pattern A1 = F6 and A2 = 28
  - Section bit interleaved parity code byte B1 is continuously changing.
  - Test set can detect other incoming Section Overhead bytes (J0, E1, F1, D1-D3).

**Monitor Line Overhead**

- Verify the following:
  - STS Payload Pointer (H1 and H2) and the Pointer Action (H3) bytes remain constant with no pointer adjustments.
  - The APS K1 and K2 bytes along with the M0/M1 bytes are equal to 0 when the signal is error free.
  - Line bit interleaved parity code byte B2 is continuously changing.
  - Test set can detect other incoming Overhead bytes (D4-D12, S1/Z1, and E2)

**Monitor Path Overhead**

- Press ESC to reach the SONET FEATURE menu and select PATH OVERHEAD > POH MONITOR and verify the following:
  - All 64 kbps channels of the STS path trace byte, J1, used to identify the start of the signal path are detected.
  - Path bit interleaved parity code byte B3 is continuously changing.
  - Test set can detect other incoming Path Overhead bytes (C2, G1, F2, H4, Z3-Z5).

**Monitor VT Overhead**

1. Press ESC to reach the main menu and select, SETUP > TEST CONFIGURATION.
2. At TEST PAYLOAD select VT1.5.
3. When finished press ENTER.
4. Press ESC and from the main menu select, SDH/SONET FEATURES > PATH OVERHEAD > POH MONITOR and move the cursor to the VT-POH side to access data on the VT bits.
    - The V5 byte performs signal label and error monitoring functions, including a BIP-2 parity calculation in bits 6-7, and Path Yellow Bit (also known as Remote Alarm Indication).
    - Bit 4 is used for RFI-V indication.

    The other bytes include:
    - V3: Pointer Action, Analogous to H3
    - J2: VT Signal Trace (16 ASCII characters)
    - N2 (Z6): Tandem Connection Monitoring
    - K4 (Z7): Protection Switching and Enhanced RDI-V

### 3.2.2 Transmit Overhead Bytes

Use these procedures to manipulate and send overhead bytes.

1. Configure the test set to match the network configuration.
   Here is a sample setup:

   TEST MODE: SINGLE
   INTERFACE: OC3
   PAYLOAD: VT1.5

   **OC-3**
   TxSCR: THRU-L TxCLK: LOOP (Prevents clocking differences between the test set and the network which can cause pointer movements).

   When finished press ENTER.

2. Connect the test set optical patch cords to the network element. Tx on one unit goes to Rx on the other unit and vice versa.
3. From the main menu select, SDH/SONET FEATURES > SECTION/LINE OVERHEAD > SEND SOH/LOH BYTES. In this screen, press F4 to view or change the Section Overhead bytes. The bytes labeled XX cannot be manipulated.
4. To change the transmitted overhead bytes, select the desired byte and depending on the one selected press TOGGLE (F2), use SHIFT and the numeric keypad or press DETAIL (F1) and change it in the SEND K1, K2 BYTES screen.

   OH Tx indicates that user selected overhead bytes are being transmitted. Press F4 to send the default values.

5. Press SEND, press PAGE-DN to change the Line and Path overhead.

**Send K1/K2 Bytes**

1. From the SONET FEATURE menu, select SECTION/LINE OVERHEAD > SEND K1, K2 BYTES. These bytes relay APS messages in binary code. Each byte is eight bits and each individual bit can be changed in the two K bytes.
2. To change the K bytes, select the bit to change and press 0 (F1) or 1 (F2). When ready, press F4 to send.

**J0 Section Trace**

1. From the SONET FEATURE menu, select TRACE GENERATION > J0 SECTION TRACE GENERATION. J0 is a section trace byte used to identify Section. Its length can be changed from 16 to USER by selecting the MODE; USER or FIXED. Once the length has been determined, select the message.
2. To change the message press TOGGLE (F3), then select from the various characters. When finished, press TOGGLE (F3) and select LENGTH. Press F4 to send.

**J1 Path Trace**

1. From the TRACE GENERATION menu, select J1 STS PATH TRACE GENERATION. This works just like J0 SECTION TRACE GENERATION, except for this is for path and not section. The receiving Path Terminating Element collects 64 repeating J1 bytes to verify the connectivity with the transmitting PTE.

**C2 Byte Send**

1. Select EDIT C2 SIGNAL LABEL. C2 is the signal label byte indicating the construction of the Synchronous Payload Envelope (SPE), that is, asynchronous mapping, ATM, etc. Using , select a C2 signal label byte and press F4 to send.
2. Verify that the new C2 byte has been received by the other test set.

**Z4/K3 Byte Send**

The Z4 byte is designated for future growth. In the DQDB mapping, the Z3 byte is used to carry DQDB Layer Management information. In some systems, it is renamed as K3 and is designated for High-Order Path APS signalling.

The K3 byte is still under study.

1. Select SEND Z4/K3 BYTE.
2. To change the byte, select the byte and use 0 (F1) and 1 (F2).
3. Once you are satisfied with your choice, press F4 to send.

**V5 Byte Send**

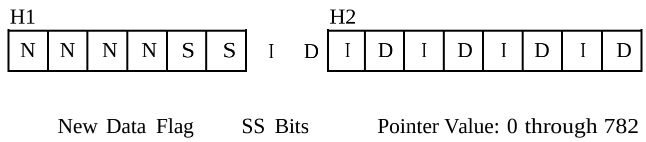
The V5 byte is the VT1.5 path overhead byte. It includes a BIP-2 parity calculation in bits 6–7, and Path Yellow (also known as Remote Alarm Indication) in bit 8. Bit 4 is spare for future use.

1. In the SETUP > TEST CONFIGURATION menu, select VT1.5 for payload. When finished, press ESC until the module main menu is displayed.
2. From the module main menu select, SDH/SONET FEATURES > PATH OVERHEAD > SEND V5 BYTE.
3. To change this byte, select one from the list using .
4. When ready, press F4 to send.

**Pointer Control**

1. From the module main menu select, SDH/SONET FEATURES > POINTERS > POINTER ADJUSTMENT.

   Pointers are very important within the SONET overhead because they help find where the next synchronous payload envelop (SPE) starts. The Pointers, shown in Figure 115, utilize the H1–H3 bytes in the Line Overhead.




**Notes**

**New Data Flag**: 0110 = Normal, 1001 = New Data Flag (NDF), other values use the '3 of 4' rule.

**SS Bits**: 00 = SONET, 10 + SDH, 01 and 11 are undefined.

**Concatenation**: In an STS-Nc signal, the first H1/H2 bytes are set normally. Subsequent H1/H2 bytes are set to 1001ss1111111111 to indicate concatenation.

**Figure 115 H1/H2 Pointers**

2. Within this menu, adjust the following;
- POINTER TYPE, STS or VT
- NEW DATA FLAG; ON or OFF, set to ON to send.
- SET SS BITS
- POINTER VALUE
- POINTER ADJ

3. When finished, press F4 to send.
4. Press ESC, and select POINTER MONITOR to view the received pointers.

### 3.2.3 Automatic Protection Switching

Verify APS functionality with this procedure. Refer to *Section 2.4.7-APS Timing* for setup. Figure 116 shows the APS byte frame and functions. For details on APS see *Section 4.3.1.4-APS*

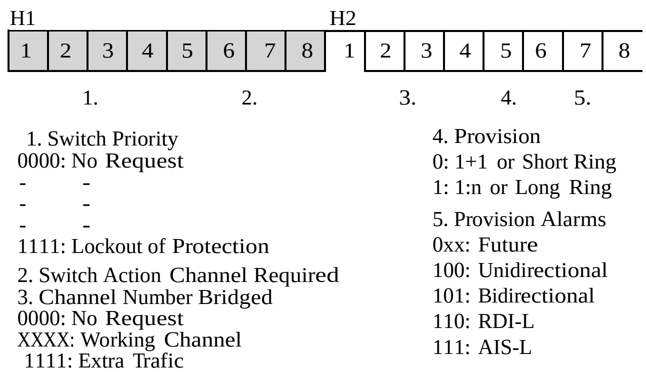



**Figure 116 APS K1 and K2 Bytes**

#### 3.2.3.1 APS Measurements

1. Once all of the connectors are properly attached and nothing but green LEDs are visible, go to step 2.
2. From the module main menu, select SDH/SONET FEATURES > APS TIMING and select SENSOR to select an event to trigger the APS event. For example, if SENSOR is set to AIS-L then it will be triggered by an Alarm Indication Signal coming from the Line overhead. Once the AIS is received, the APS event will launch. To change the trigger event, press TRGMODE (F4).
3. Select SWITCH TIME LIMIT. This limit is measured in milliseconds and represents the amount of time for the switch to occur and still pass the test. For example, if set to 20 ms, then the APS must switch between the working line and the protection line in less than 20 milliseconds or else it fails. To change the limit, press SHIFT and use the numeric keypad.
4. Select GATE TIME. This is also measured in milliseconds, and is the amount of time the test set will continue to monitor the APS event regardless if it has passed or failed the SWITCH TIME LIMIT. GATE TIME is larger than SWITCH TIME LIMIT and is used as a reference guide to the event. To change the limit, press SHIFT and use the numeric keypad to enter a limit.
5. When ready, press F1 to start the test. At this point, WAITING FOR APS EVENT is displayed and the test set is ready to measure the amount of time it will take for the ADM to switch from the working line over to the protection line once AIS has occurred.

### 3.2.3.2 Service Disruption

This is an out-of-service test of automatic protection switch times. Whereas the APS Timing feature can be used to monitor and measure an in-service network, the Service Disruption requires either another test set to send a PRBS pattern or a loopback in the network as shown in the following figure:

ADM Protection Line Working Line ADM or

**Figure 117 Service Disruption Setup**

1. Configure the test set for the appropriate interface/payload.
2. Select a PRBS test pattern, such as 2e20 or 2e31.
3. Verify that the PAT SYNC led is green and that there are no errors on the circuit, use the STATUS key for a fast check.
4. The service disruption measurement takes place automatically and requires no further action. When the test set detects a pattern loss, such as an LOS, LOF, or AIS, the test set will automatically measure the duration of the disruption.
5. To view the time and duration of the disruption, select from the module main menu RESULTS >VIEW CURRENT EVENT. A typical result may appear like this:

    1. BERT -END- NOT SYNC 13:01:05
    2. SONET –END- AIS-L 13:01:05
    3. SER DIS: 128.19 ms13:01:04
    4. BERT START NOT SYNC 13:01:04

    In this example, the service disruption lasted 128.19 ms. The EVENT RECORD screen can record an unlimited number of service disruptions while the measurement is running.

6. Service Disruption statistics can be viewed in RESULTS > BIT PERFORMANCE as follows:
    SERVICE DISRUPTION (ms)
    LAST: 128.19 MAX: 130.47
    TOTAL: 2453.28 MIN: 115.41

In this example, the sum total time of all service disruptions since the start of the test was 2453.23 ms. The most recent one was 128.19 ms. The longest was 130.47 ms and the shortest was

115.41 ms. To see when each occurred and the total number of disruptions, go to the EVENT RECORD screen.

## 3.3 ATM Applications

### 3.3.1 In-Service Monitoring

Use this procedure to monitor traffic on an ATM network from a non-intrusive monitor point, such as a DSX panel or optical splitter. The VCC Scan feature gives an up-to-the-moment snapshot of the VCCs travelling across the network. Check the number of idle cells and available bandwidth to properly gauge network usage. Alarms, defects, and network messaging contained in OAM cells can be measured and decoded.

Specific VCCs can be monitored for cell rate, congestion, errors, and cell delay. Meanwhile, the test set monitors the physical layer for defects.

1. Configure the test set for the appropriate data rate. Here is a sample configuration:

   TEST MODE: ATM
   TEST INTERFACE: Enter the appropriate rate
   TEST PAYLOAD: Based on the interface rate, e.g. 155M O, VC4BULK or 622M O, CONCAT

   *155M O sample*
   INTERFACE: 155M O
   PAYLOAD: VC4BULK
   TxSRC: PATRN, if using a splitter or monitoring jack, or THRU, if passing the signal through the test set.
   TxCLK: LOOP

2. ATM Configuration

   INTERFACE: UNI or NNI, as appropriate
   DISPLAY: As preferred
   SCRAMBLING: Match the circuit; usually, ON

3. Connect to the network.

   **Monitor Jack**: When monitoring a live circuit, use a monitor jack. Optical networks should have a splitter, such as 90/10, that passes 90% of the signal through to the network and allows a test set to access the 10% signal non-intrusively. When using a splitter or monitor jack, do not connect the transmit jack of the test set.

   Before connecting the test set's optical receiver, check the optical power level. If there are no indications on the output jack, use the OPTICAL POWER function in RESULTS. It may be necessary to use an attenuator to avoid saturating the receiver. Conversely, when connecting the test set's optical transmitter to a multimode network, it may be necessary to add an attenuator as not to saturate the multimode receiver.

   **THRU Mode**: In this mode, leave the transmitter turned on, sending the test pattern. Connect the Tx and Rx ports in normal fashion.

4. Verify that the test set detects a valid signal with proper framing with no errors.

- Verify that the FRAME LED is green, and that NO ERR is displayed on STATUS RESULTS.
- The three major defects to look for are LOS, LOF, LOP. If these or other errors, such as frame errors, parity errors, or SDH pointer errors are occurring, rectify these issues before continuing.
- If the test set measures LOS or LOF, verify the quality of the test cables. Saturating an optical receiver can also cause LOS or LOF, so adding an attenuator can sometimes solve this.
- Verify that the network is carrying ATM cells. Next, verify the test set payload setting is correct. If monitoring a 45M circuit, make sure to use the correct mapping type: PLCP or HEC.

5. Conduct a VCC SCAN and observe the headers and bandwidth utilization.

- Header values are sorted by when they were detected. A change in GFC, PTI, or CLP bits for a particular VCC will result in two or more entries.
- If no traffic appears in the scan, set VPI CAPTURE in the VCC SCAN CONFIGURATION screen to ALL. The circuit may be filled with idle or unassigned cells.
- Use the SAVEVCC F-key in order to save a specific VCC.

6. Enter VCC STATISTICS to get further information on the active VCC. If needed, use the DETAIL screen.

### 3.3.2 Traffic Generation

Use these procedures to insert traffic at a switch, through a free port. Assuming bandwidth is available, the test cells will not disrupt network traffic. Traffic generation is also required for out-of-service testing, such as during an equipment installation. The test set requires a PVC to be established between the two end points to be effective.

The test set will generate a specific traffic pattern using O.191 test cells or user cells carrying a test pattern over a specified AAL (adaptation layer). Designate very high peak and sustained cell rates for stress-testing the network. The test set can emulate user traffic, including contracted cell rates and AAL to troubleshoot customer-specific problems.

OAM cell generation is required for testing the ability of network elements to recognize and respond to such things as AIS alarms, RDIs, and APS messages and requests. The test set can insert OAM loopback cells to test connectivity to an ATM switch, or even a specific switch if the location id is known.

**Quality of Service**

- Measure up to 8 VCCs simultaneously
  - Timed or continuous
  - Start time, Date, Duration
- VCC Measurements
  - Cell count, rate, and bandwidth
  - Congested cell count and bandwidth
  - Transmitted cells and Cell loss ratio
  - Bit Errors, Bit Error Rate
- Global Measurements
  - Total cells, Idle cells, Discarded cells
  - Non-Correctable HEC errors and NC-HEC rate
- Traffic Measurements
  - Cell delay variation time
  - Cell delay time
- OAM Measurements
  - Cell count, Event time, Event count

#### 3.3.2.1 Quality of Service Test

When a VCC is created, the quality of service for the connection is specified within strict bounds. This procedure describes how to test and verify the VCC meets those QoS requirements.

1. VCC Setup: Set up VCC #1. Here is a sample configuration:

   PAYLOAD: TESTCEL
   TRAFFIC: CBR
   PCR: As appropriate

2. VCC Statistics

- Verify the CTD and CDV are within the specified parameters for the particular VCC.
- Verify CER, CLR, and CMR fall within the specified parameters for the particular VCC.

3. Inject HEC Errors

- Set HEC or NC-HEC as the error TYPE in ATM ERROR INJECTION, then press ERR INJ to inject the errors.
- Injecting a correctable HEC error should not produce any defects.
- Injecting a noncorrectable HEC error should produce a Lost-Cell.

#### 3.3.2.2 BERT

The purpose of this test is to verify the data transverses the ATM network free of errors.

1. VCC Setup. Here is a sample configuration:

   Payload: USER
   Pattern: 2e23, 2e20, or 2e15
   Traffic: CBR
   PCR: As appropriate

2. Verify PAT SYNC the LED is green, and that NO ERR is displayed in STATUS RESULTS.
3. VCC Statistics

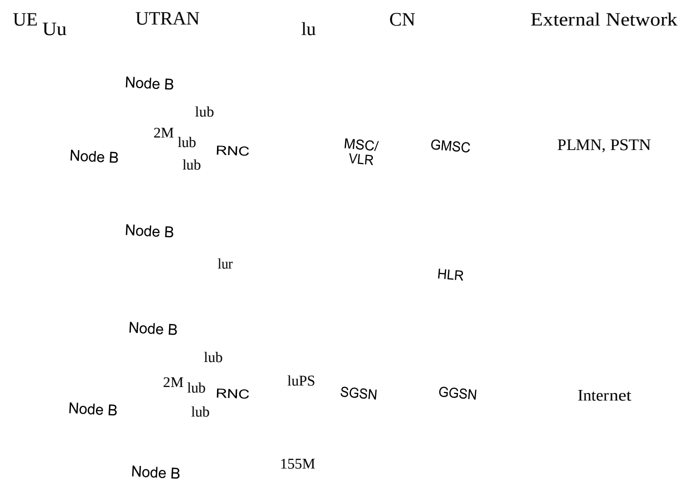
- Monitor bit errors and BER.
- Press ERR INJ to inject bit errors and verify those errors on the specified VCC.
- Inject a specific BER, such as $1x10^{-6}$, then verify receiving the same BER on the specified VCC, with no added bit errors.

1. Setup VCC#1 as described in *Section 3.3.2.1 or 3.3.2.2*.
2. Select OAM cells via ATM ALARM GENERATION, press ERR INJ and verify that the ATM switch responds appropriately to the OAM cell. See *Section 4.3.6-ATM Technology* for an explanation of OAM functionality.

   **CAUTION!**: Sending OAM cells may affect network traffic.
3. View the contents of a cell by selecting CELL CAPTURE. To avoid capturing user cells, set the cell type to OAM in CONFIGURATION. The test set will decode the header and OAM fields, as applicable, of the captured cells by selecting Header or OAM.

### 3.3.2.4 CLIP over ATM

The ability to send an InARP request/response with IP/ATM PING, i.e. over the Iub–RNC (Radio Network Controller) to NODE B (ATM switch ports)–interface, is used quite often in order to verify the network layer of ATM 3G.UMTS (Universal Mobile Telecommunications System) network for connectivity issues.




**Key**
**UE**: User Equipment
**CN**: Core Network
**SGSN**: Serving GPRS Support Node
**HLR**: Home Location Register
**GGSN**: Gateway GPRS Serving Node
**PSTN**: Public Switching Telephone Network
**Iu**: RNC to GSM Phase 2+ Core Network Interface
**MSC/VLR**: Mobile Service Switching Center/Visitor Location Register
**UTRAN**: UMTS Radio Access Network
**Uu**: User equipment to Node B Interface
**Iub**: RNC to Node B Interface
**GMSC**: Gateway MSC
**PLMN**: Public Land Mobile Network

**Figure 118 3G/UMTS Interface**

Here is a sample configuration:

TEST MODE: ATM
TEST INTERFACE: 2 or 155 Mbps.
TEST PAYLOAD: As required
VC4BULK, 622M O, or CONCAT.

Configure the ATM SETUP.

INTERFACE: UNI or NNI, as appropriate.
DISPLAY: As preferred.
SCRAMBLING: Match the circuit; usually, ON.

Connect the test set to either the Node B or RNC, and perform the following tests:

**Physical Layer Testing**

The first step to installing or monitoring any ATM network is verifying that the physical layer is free of problems. These are a major cause of problems that affect ATM traffic. When the test set is connected, the LEDs for the selected interface and framing should be green. If they are, but FRAME is not, verify that the connected interface matches the setting in SETUP.

ATM cells should be detected by the test set. If not, the test set has not been configured for ATM testing (TEST MODE).

Once satisfied that the LEDs indicate no errors or alarms, restart the measurement to clear away any errors that were detected during setup. After green LEDs are presented, select RESULTS to start the measurement. NO ERR should appear in STATUS.

**ATM InARP Testing**

1. From ATM FEATURES, select ATM IP TESTING and set MODE to CLIPOA.
2. As required, set values for # PINGS, PING LEN, PING/SEC, VPI, and VCI values.
3. Set the LOCAL IP (i.e. Node B address as client mode) and DESTINATION IP (i.e. RNC address as client mode).
4. When ready, press F3 to start and the PING TEST screen will appear, showing the PING status.
5. Press InARP (F2) to view a screen similar to Figure 119.
6. Based on RFC 2225, Classical IP and ARP over ATM, verify that an InARP_REQUEST (i.e. InARP_REQ SENT to far end and InARP_REQ SENT) has been sent and that the test set receives an InARP_REPLY (i.e. InARP_RSP RECV'D) accordingly.

- The test set will send up to 13 InARP Requests to the far end before timing out (i.e. no InARP_RSP RECV'D).
- The IP address from the responding far end equipment will be displayed.
- Verify any received InARP request from the far end and the IP address.

PINGs sent, received, unreached, and missing with current, average, max, and min roundtrip time.

```
                                 ⧫1310


ST:11:50:45         ET:000:00:45
LOCAL IP:000.000.000.000
DEST  IP:002.003.004.005
            InARP TEST
InARP_REQ to far end: RECV’D
InARP_REQ SENT  :       1
InARP_RSP RECV’D:.58.012.008.007

InARP_REQ RECV’D:  2
InARP_RSP SENT  :  2
InARP_REQ from  :.58.012.008.007

                           PING
```

**Figure 119 InARP Test Screen**

8. To view incoming PINGs from the far end, press ECHO (F1) in the STATS screen.
9. A general overview of the ATM/InARP process for RNC and Node B devices is shown in the following figure:

lub

Node B

RNC

**Figure 120 Node B and RNC in 3G/UMTS Networks**

## ATM ARP Node B Client Mode Overview

Test Set in Node B Client Mode

lub

RNC

InARP Request to far end

InARP Response

PING

Echo PING

InARP request from RNC

InARP Response

PING from RNC

Echo PING

**Figure 121 InARP Process with Test Set as Node B**

Before the test set generates an IP PING to the RNC or ATM device at far end site in a Node B client mode, the test set will generate an ATM In-ARP Request to the RNC or ATM IP far end device.

As soon as the RNC or far end ATM device responds to the In-ARP Response, an IP ping/echo request will be sent to the ATM IP far end device with the test set waiting for an IP ping/echo reply to count.

**No IP Ping Generation Overview**

When there is no IP PING generation involved, the test set will still be able to generate an ATM InARP request to the far end ATM device automatically upon completion of the physical and ATM layer linking up and record the IP address from the ATM far end device.

**ATM ARP Server Mode Overview**

When the test set acts in an RNC ATM ARP Server mode, the test set will respond to InARP Request (0008 in Hex) from the ATM ARP client using In-Arp Response (0009 in Hex).

Test Set as RNC

lub

Node
B

InARP Request to far end

PING

InARP Response

Echo PING

InARP Response

Echo PING

InARP request from RNC

PING from RNC

**Figure 122 InARP Process with Test Set as RNC**

### 3.3.3 ATM Testing Hints

Here are some things to look for if having difficulties with ATM testing.

- Check ATM Scrambling in ATM SETUP. Most switches enable scrambling by default. If you can receive cells but can't make a QoS or BER measurement, confirm the scrambling setting on the equipment under test and the test set.
- If testing at 45M, check ATM mapping. If the equipment and mapping do not match, the test set will not cells. Check the Mapping setting in ATM SETUP.
- If the switch is receiving a PLM (Payload Mismatch Alarm), change the C2 byte (payload label) in ATM SETUP.
- Some switches use only a subset of the available VPI and VCI values. Using a VPI of 255 or less and a VCC of 1023 or less is recommended.
- VCI values 0–31 are reserved. For user traffic, use a VCI value of 32 or higher.

# 4 Reference

This section provides additional useful information. Included are common abbreviations and a technology overview.

## 4.1 Abbreviations

**A**

ADM: Add/Drop Multiplex
AFBER: Average Framing Bit Error Rate
AIS: Alarm Indication Signal
AISS: Alarm Indication Signal Seconds
AISS-L: Alarm Indication Signal Seconds-Line
AMI: Alternate Mark Inversion
APS: Automatic Switching Protection
ARM-INB: Arm Inband
ARQ: Automatic Repeat Request
AS: Available Second
ASCII: American Standard Code for Information Interchange
AU: Administrative Unit
AUG: Administrative Unit Group
AVBER: Average Bit Error Rate
AVCER: Average CRC-6 block Error Rate

**B**

B1: B1 BIP-8 Parity Errors
B2: B2 BIP-8 Parity Errors
B3: B3 BIP-8 Parity Errors
B8ZS: Bipolar 8-Zero Substitution
BER: Bit Error Rate
BPV: Bipolar Violation
BPVR: Bipolar Violation Rate
BTSLP: Bit Slip

**C**

CAS: Channel Associated Signaling
Cbit: C-bit Parity Error Count
CER: CRC-6 Error Rate
CLKSLIP: Clock Slip
CMI: Coded Mark Inversion; E4 line coding
COFA: Change of Frame Alignment
CRC: Cyclic Redundancy Check
CRC-4: Cyclic Redundancy Check Code-4
CRC-6: Cyclic Redundancy Check Code-6
CSU: Customer Service Unit
CTL: Control

**D**

dB: Decibel
dBm: Decibel ratio of watts to one milliwatt (output power)
dBdsx: Decibel referenced to dsx power level
DCS: Digital Cross-connect System
DGRM: Degraded Minute
DLC: Digital Loop Carrier
DLCI: Data Link Connection Identifier
DLF: Data Link Frame
DS1: Digital Signal 1
DSX: Digital Signal Cross-connect
DSXMON: DSX Monitor signal

**E**

E1: 2.048 Mbps signal
EBER: E-bit Error Rate
EBIT: B-bit
ERR INJ: Error Injection
ES: Errored Second
ESF: Extended Super Frame
ET: Elapsed Time
EXZS: Excess Zeros Seconds

**F**

FAS: Frame Alignment Signal
FASE: Frame Alignment Signal Error
FBE: Framing Bit Error
FBER: Framing Bit Error Rate
FDL: Facility Data Link
FEAC: Far End Alarm and Control Channel
FEBE: Far end Block Error
FELP: Far End Loop
FERF: Far End Receive Failure
FERFS: Far End Receive Failure Seconds
FRAI: Frame Remote Alarm Indication
FSBEE: Frame Synchronization Bit Error Event
FSLIP: Frame Slip
FT1: Fractional T1

**G**

Gb/s: Gigabits per second

**H**

HDB3: High Density Bipolar Three
HEX: Hexadecimal
HO: High Order (as in High Path)
HP: High Path

**I**
ISDN: Integrated Services Digital Network

**K**
kbps: Kilobits Per Second

**L**
LAP-B: Link Access Protocol-Balanced
LBO: Line Build Out
LDNS: Low Density Seconds
LLPBK: Line Loopback
LO: Low Order (as in Low Path)
LOCS: Loss of Clock Seconds
LOF: Loss of Frame
LOFS: Loss of Frame Second
LOM: Loss of Multiframe
LOP: Loss of Pointer
LOPS: Loss of Pointer Seconds
LOS: Loss of Signal
LOSS: Loss of Signal Second
LP: Low Path
LPBK: Loopback
LPBKQRY: Loopback Query
Lpp: Level peak-to-peak

**M**
Mbps: Megabits per second
MF: Multi-Frequency
MFAS: MultiFrame Alignment Signal
MFAS-RAI: MultiFrame Alignment Signal Remote Alarm Indication
m-law : voice companding law
MS: Multisection
MUX: Multiplex
mW: milliwatt

**N**
NDF: New Data Flag
NI: Network Interface
NIU: Network Interface Unit
NOTE: Network Office Terminating Equipment

**O**
OC: Optical Carrier
OH: Overhead
OOF: Out Of Frame
OOFS: Out Of Frame Seconds

**P**

PAISS: Path Alarm Indication Signal Seconds
PCM: Pulse Code Modulation
PCM-30(31)/C: PCM with CRC-4 checking enabled
PDH: Plesiochronous Digital Hierarchy
PJ: Pointer Justification
PLM: Payload Label Mismatch
PLPBK: Payload Loopback
POH: Path OverHead
PRBS: Pseudo Random Bit Sequence
PWCUTTH: Power Cut Through
PWRLPQRY: Power Loop Query

**Q**

QRS: Quasi Random Signal

**R**

RAI: Remote Alarm Indication
RDI: Remote Defect Indication
REI: Remote Error Indication
RFI: Remote Failure Indication
RS: Regenerator Section
Rx: Receive

**S**

SES: Severely Errored Second
SEFE: Severely Errored Framing Event
SF: Super Frame
SHLF: Shelf
SLC-96: Subscriber Loop Carrier-96 channel
SMPX: Simplex
SOH: Section OverHead
SONET: Synchronous Optical Network
SPE: Synchronous Payload Envelope
STM: Synchronous Transport Mode
STS: Synchronous Transport Signal
SYLS: Synchronization Lost Seconds

**T**

T1: 1.544 Mbps transmission rate
T1DM: T1 Data Multiplexer
TE : Terminal Equipment
TERM: Terminated
TM: Terminal Multiplexer
TOH: Transport Overhead
TOUT: Time Out
TOUTDIS: Timeout Disable

T/S: Time Slot
TU: Tributary Unit

**U**

UAS: Unavailable Second
UI: Unit Interval
UNIVLDN: Universal Loopdown
uS: Microsecond

**V**

VF: Voice Frequency
VT: Virtual Tributary

**W**

WDR: Wander

**Y**

YEL ALM: Yellow Alarm
YELS: Yellow Alarm Second
YELS-P: Path Yellow Alarm Seconds

## 4.2 Standard Test Patterns

This section defines the patterns transmitted and recognized by the test set. The long patterns are written in hexadecimal notation, also known as 'hex'. A pattern is written in hex when it has pairs of numbers separated by commas. Hex is a 16-digit number system consisting of the digits 0–9, A _F. The hex pattern 15 FA translates to the binary pattern 0001 0101 1111 1010, where the left-most bit is transmitted first.

**2e31**: The industry-standard $2e^{31}$-1 pseudorandom bit sequence. This signal is formed from a 23-stage shift register and is not zero-constrained. This pattern contains up to 30 zeros in a row when it is inverted.

**2e23**: The industry-standard $2e^{23}$-1 pseudorandom bit sequence. This signal is formed from a 23-stage shift register and is not zero-constrained. This pattern contains up to 22 zeros in a row and violates standards for consecutive zeros in AMI-coded transmission.

**2e20**: The $2e^{20}$-1 pseudorandom bit sequence. This signal is formed from a 20-stage shift register and is not zero-constrained. This pattern contains up to 19 zeros in a row and violates standards for consecutive zeros in AMI-coded transmission. QRS is derived from this pattern.

**2e15**: The $2e^{15}$-1 pseudorandom bit sequence. This signal is formed from a 15-stage shift register and is not zero-constrained. This pattern contains up to 14 zeros in a row and does not violate standards for consecutive zeros in AMI-coded transmission.

**2e11**: This is the pseudorandom 2047 bit code. The pattern conforms to the ITU O.152 technical standard.

**ALL1**: The all 1s pattern is used for stress testing T1 AMI and B8ZS lines. If the pattern is sent unframed, it will be interpreted as an AIS (Alarm Indication Signal).

**ALL0**: The all zeros pattern. This pattern is often used to make sure that clear-channel lines have been properly provisioned for B8ZS during circuit turn-up. If a portion of the circuit is AMI, then pattern synch and/or signal will be lost.

**1010**: The alternating ones and zeros pattern. The pattern is frame aligned with "f" showing the location of the framing bit. The pattern is: f 0101 0101

**1-8**: The 1 in 8 pattern is used for stress testing AMI and B8ZS lines. The pattern is also called 1:7 in older literature. The pattern is frame aligned as shown in its binary form: f 0100 0000

**1-4**: The 1 in 4 pattern is used for stress testing circuits.

## 4.3 Technology Overview

This is an introductory guide to the SONET (Synchronous Optical Network) and Synchronous Digital Hierarchy (SDH) technology. It also presents an overview of the associated applications. Additionally, there are sections on PDH (Plesiochronous Digital Hierarchy international 2M-based) and T1-Carrier technology.

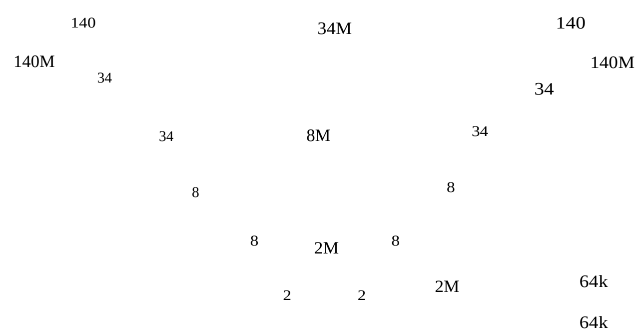



**Figure 123 PDH Drop and Insert**

SDH is based on the American SONET standard and was introduced to the telecommunications network in 1994. It was designed to transport CEPT asynchronous transmission rates. In the SDH world, PDH rates (based on the 2 Mbit/s E1 rate) are multiplexed to create the SDH rates.

SDH defines STM (Synchronous Transport Mode) levels and electrically equivalent synchronous transport signals for the fiber-optic based transmission hierarchy. STM-1 is at the 155,520 kbit/s rate. This comprehensive, synchronous transport system provides a simple, common, and flexible telecommunications infrastructure.

SONET was formulated by the ECSA (Exchange Carriers Standards Association) for ANSI. SONET defines OC (Optical Carrier) levels and electrically equivalent STS (Synchronous Transport Signals) for the fiber-optic based transmission hierarchy.

The optical standard provides many advantages. Generic standards allow products from different manufacturers to connect, and allows for greater flexibility in the future. Less equipment is required than in older systems, so fewer breakdowns occur. SDH and SONET overhead bytes allow for easy fault sectionalization. A synchronous multiplexing format defines how lower-level digital signals may be structured in an SDH/SONET signal, which simplifies the multiplexer and switch interfaces.

SDH and SONET employ a system called 'Direct Synchronous Multiplexing'. It is no longer necessary to demultiplex tributary channels before switching–a requirement with the existing PDH networks. In the existing networks, simple point-to-point transmission technology is used to link the network switches or customer locations. A fractional 2M or 1.5M signal from a phone call must be multiplexed up to a 1.5M/2M signal, then the 1.5M/2M signal must be multiplexed up to 34M.

To switch the fractional signal, the full 34M signal must be demultiplexed. This requires a full set of muxes at each end of a 34M transmission link, when in actuality it is only some of the low-order signals which need switching. See Figure 123 for a depiction.

With SONET and SDH, the low-speed signals may be extracted without demultiplexing the entire signal through multiple stages.

### 4.3.1 The SDH Network

#### 4.3.1.1 Architecture and Devices

The lowest level SDH signal is the STM-0 (Synchronous Transfer Mode-0). This signal has a rate of 51.84 Mbit/s. The higher level signals are obtained by the byte-interleaved multiplexing of lower level signals. Basically, the bytes are interleaved in such a format where the low-speed signals are still visible.

There is no additional signal processing except the direct conversion from electrical to optical form. The available SDH rates are STM-0 (51.840 Mbit/s), -1 (155.520 Mbit/s), -4 (622.08 Mbit/s), -16 (2.5 Gbit/s) and -64 (9.953 Gbit/s). Table 8 displays some SONET line rates and the SDH equivalent formats.

| **CCITT SDH** | | **Bellcore SONET** | |
|---|---|---|---|
| STM-0 | 51 Mbps | OC/STS-1 | 51 Mbps |
| STM-1 | 155 Mbps | OC/STS-3 | 155 Mbps |
| | | OC/STS-9 | 466 Mbps |
| STM-4 | 622 Mbps | OC/STS-12 | 622 Mbps |
| | | OC/STS-18 | 933 Mbps |
| STM-8 | 1.244 Mbps | OC/STS-24 | 1.244 Mbps |
| STM-12 | 1.886 Mbps | OC/STS-36 | 1.866 Mbps |
| STM-16 | 2.488 Mbps | OC/STS-48 | 2.488 Mbps |

**Table 8 Synchronous Technology Signal Line Rates**

The STM-1 rate is where the various rate systems meet; SONET's STS-3/OC-3 is equivalent to the STM-1. The rate is 155.52 Mbit/s. Higher STM standards also exist. A converter makes the transformation from electrical to optical formatting.

STM-4
STM-1
140 Mbps
45 Mbps
34 Mbps
6 Mbps
2 Mbps
1.5 Mbps
LAN
FDDI
ATM
MAN
ISDN
ISDN-B
Any Speed (TJ-*n*)

Synch Optical Interface
1+1 Protection

STM-1
STM-4
STM-16
STM-64

**Figure 124 SDH One-Step Multiplexing**

SDH
Terminal
MUX

X
Digital
Cross

or

SDH
Terminal
MUX

Regeneration
Section

Regeneration
Section

Multiplexer
Section

Multiplexer
Section

Path

Multiplexer Section: Between transport nodes.
Regenerator Section: Between regenerators or regenerators to transport mode.
Path: Between the places that a VC is assembled and disassembled.

**Figure 125 SDH Equipment and Sections**

The following is a listing of SDH network equipment:

**Terminal Multiplexer**: The PTE (Path Terminating Element) multiplexes tributary signals at the entry level. The simplest SDH link would consist of two terminal multiplexers, and optionally a regenerator, linked by a fiber.

**Regenerators**: Required when the signal goes over 100 km, as amplitude and time may cause distortion of the signal. Unlike PDH (plesiochronous) repeaters, SDH regenerators must synchronize to a framing signal. Regenerators also perform fault monitoring. Regenerators take their clocking from the received signal. They replace the Regenerator Section Overhead bytes before retransmission occurs.

**Synchronous Multiplexers**: S-MUXs map the PDH 2M signals into virtual containers. The higher rates are achieved in one step (STM-1, -4, or -16). The signal is scrambled when NRZ line coding (optical) is used, allowing the other end to achieve permanent synchronization, even though long strings of consecutive identical digits are sent. Multiplexer Section Overhead performs fault monitoring. The broadband cross-connecting muxes deal with STM or other high bandwidth signals, consolidating or segregating them as required. Wideband DCSs terminate SDH and 34M signals, switching at the VC level. Broadband DCSs do the same, switching at the STM-n level. SDH multiplexers may be installed at the customer premises.

**ADM**: Add/Drop Multiplexers multiplex/demultiplex an individual tributary. They have an optical interface and PDH interfaces. They provide interfaces between the varying network and SDH signals. They align the payload signal with the STM-1 frame.

**DCC**: Digital Cross-connection allows electronic cross-connecting at both the lower-rate tributary levels and the SDH high-rate.

#### 4.3.1.2 STM-n Framing

STM-1 has a bit rate of 155.52 Mbit/s. The smallest unit is the 8-bit byte; the frame contains 2430 bytes (270 columns by 9 rows), and has a duration of 125 microseconds. It has SOH (Section Overhead), AU (Administrative Unit) pointer, and payload areas as shown in Figure 126.

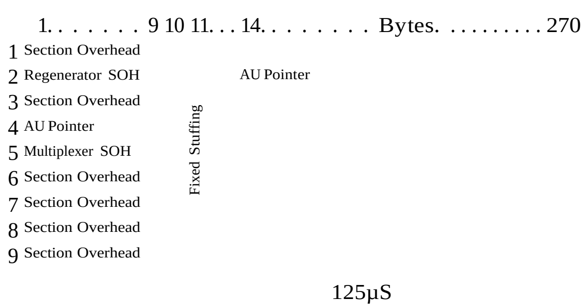



**Figure 126 STM-1 Frame**

One byte in an STM-1 frame can carry 64 kbit/s of data:

$$1 \text{ byte } \times 8000 \text{ frames/s} = 64 \text{ kbit/s}$$

Higher rates are formed by multiplying the basic 155.52 Mbit/s rate N times. The defined rates are STM-4 (622.08 Mbit/s), STM-16 (2488.32 Mbit/s) and STM-64 (9953.28 Mbit/s). Each STM-n contains NxAUGs along with the SOH. The entire SDH frame is scrambled, except for the first row of the SOH.

An STM-n frame may be built, or mapped, along a variety of paths. In Figure 127, the lines indicate different multiplexing paths. See the next section for a description of the overhead bytes.

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.5G | | AU4-16c | VC4-16c | | | BULK |
| 622M | | AU-4c | VC4-4c | | | BULK |
| 155M | AUG | AU4 | VC4 | | | BULK |
| | | | | TUG | 3VC3 | BULK |
| 52M | | AU3 | VC3 | | | 45M |
| | | | | | | 34M |
| | | | | TUG2 | | |
| | | | | TU12 | VC12 | BULK |
| | | | | | | 2M |
| | | | | TU11 | VC11 | BULK |
| | | | | | | 1.5M |

**Figure 127 Building an STM-n Frame**

### 4.3.1.3 SDH Overhead

Overhead provides management and maintenance facilities for each path and section of the SDH link. This functionality makes for quick troubleshooting of SDH circuits.

**SDH SOH (Section Overhead)**

| | | | | | | |
|---|---|---|---|---|---|---|
| A1 | A1 | A1 | A2 | A2 | A2 | J0 |
| B1 | | | E1 | | | F1 |
| D1 | | | D2 | | | D3 |
| Administration Unit Pointer | | | | | | |
| B2 | B2 | B2 | K1 | | | K2 |
| D4 | | | D5 | | | D6 |
| D10 | | | D11 | | | D12 |
| S1 | Z1 | Z1 | Z2 | Z2 | M1 | E2 |

**Figure 128 STM Section Overhead**

SOH is added to the information payload to create an STM-n. It includes block framing, maintenance, performance monitoring, and other operation function information. SOH is broken down into Regenerator SOH, terminated at regenerator functions, and Multiples SOH, which passes through regenerators and is terminated where the AUGs are assembled and disassembled.

Figure 128 shows the layout of SOH in an STM frame. SOH is contained in rows 1–3 and 5–9 of columns 1-9xN of the STM-n. Note the AU pointer, it indicates the start of the data.

**RSOH**: The first 3 rows of SOH are Regenerator SOH.

A1, A2: Frame Alignment Pattern (1111 0110, 0010 1000); indicate the start of the STM-1 frame. B1: Parity check, used for regenerator section error monitoring (BIP-8).

JO: Regenerator Section Trace; verifies continued connection to intended transmitter.

D1–D3: Data Communication Channels (NMS); 192 kbit/s channel.

E1: Orderwire; for voice communication.

F1: Users Channel.

S1-S2: Spare bytes; called Z0.

**MSOH**: Rows 5–9 of SOH pertain to Multiplexer SOH.

B2: Parity Check, error monitoring for the previous frame (BIP-24).

D4–D12: Data Communication Channel; 576 kbit/s channel.

E2: Orderwire; for voice communication.

K1, K2 (bits 1–5): Automatic Protection Switch (APS).

K2 (bits 6–8): MS-RDI; returns indication to transmit end when received end has detected an incoming section defect or is receiving MS-AIS.

M1: MS-REI; multiplex section REI; conveys count of inter-leaved bit blocks that have been detected in error by B2.

S1: Synchronization status messages; bits 5-8 used.

Z1, Z2: These are undefined.

**SDH Path Overhead (POH)**

**VC-3, 4 Path Overhead (Higher Order)**

J1: Path Trace Message; allows path receiving terminal to verify its connection to the intended transmitter.

B3: Path Parity Check (BIP-8).

C2: Virtual Container Structure; indicates composition or maintenance status of the VC.

G1: Path Status & Alarm Performance Information (error count and VC-4 RDI).

F2, F3: User Channel between path elements.

H4: Payload position indicator.

K3: Spare for future use.

N1: Network operator byte; may be used for path protection switching (Tandem Connection Monitoring).

**VC-11, 12, 2 POH (Lower Order)**

V5: Error checking and path status; with BIP-2 parity check.

J2: Lower order path trace; allows path receiving terminal to verify its connection to the intended transmitter.

N2: Tandem Connection Monitoring functions.

K4 (bits 1-4): Path APS.

K4 (bits 7-7): Reserved for optional use.

K4 (bit 8): Spare for future use.

### 4.3.1.4 SDH Multiplexing Elements

### Virtual Containers

Pointer

**VC POH**
**V5:** Errors, see V5 Byte
**J2:** Path Trace
**N2:** Tandem Monitor
**K4:** Spare

POH Data Transport Unit-*n*

POH Data Virtual Container-*n*

Data Container-*n*

| BIP-2 | | REI | SPARE | SIGNAL LABEL | | | RDI |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

V5 Path Overhead Byte

**BIP-2:** Byte Interleave Parity
**REI:** Remote Error Indication
**SIGNAL LABEL:** Identifies Payload
**RDI:** Remote Defect Indication

VC11 = 1.554 Mbps
VC12 = 2.048 Mbps
VC11 = 6.312 Mbps

**Figure 129 VC-1, -2, -11, -12**

Pointer Transport Unit (TU-*n*)

VC-3 = 34.368 Mbps
= 44.736 Mbps
VC-4 = 139.264 Mbps

J1
B3
C2
G1
F2
H4
Z3
Z4
Z5

**Path Overhead Bytes**
J1: Path Trace
B3: Path BIP-8
C2: Signal Label
G1: Path Status
F2: Path User Channel
H4: Position Indicator
F3: Path User Channel
K3: APS Channel, spare
N1: Network Operator Byte

Path Overhead

Virtual Container (VC-*n*)

J1
B3
C2
G1
F2
H4
F3
K3
N1

Not in VC-3-1

Byte

**Figure 130 VC-3 and VC-4**

VCs (Virtual Container) carry information between two Path access points. A pointer in the STM-1 frame indicates the first byte of each VC, allowing the VCs to float within the payload, for easy multiplexing and demultiplexing. The VC supports path layer connections in the SDH. VCs contain supervision and maintenance (Path Overhead) functionality. The information payload and POH are organized in a block frame structure repeating every 125 or 500 microseconds.

Figures 129 and 130 indicate how the VCs are constructed, and define the POH. Note that VC-11 carries a standard 1.5M signal. VC-12 carries a 2M. A VC3 may have a rate of 34M or 45M, depending on the mapping.

A lower order VC consists of a single container (VC-1 or -2) and the appropriate POH. A higher order VC consists of either a single container (VC-3 or -4) or an assembly of TUGs along with the appropriate POH.

**TU (Tributary Unit)**

TUs are how lower rate signals (such as 2.048 Mbit/s) are placed into a VC. TUs may be fixed (locked into position, no pointer required) or floating (requires a pointer). TUs are the information structure providing adaptation between the lower order path layer and the higher order path layer. Bit synchronous mapping is used for non-channelized 2.048 Mbit/s signals. Byte synchronous mapping is used for channelized 2.048 Mbit/s.

TUs consist of the information payload (lower order VC) and a pointer. The TU pointer indicates where each TU within the VC frame begins. A TUG (TU Group) consists on one or more TUs occupying a fixed position in a higher order VC payload. A TUG-2 is a group of identical TU-1s or a TU-2. A TUG-3 is a group of TUG-2s or a TU-3.

If there is a change in the payload, a NDF (New Data Flag) is sent, and the accompanying pointer value becomes the new AU pointer value. The pointer can also be incremented or decremented to accommodate frequency offsets between the VC and the multiframe.

**Administrative Units**

An STM-n consists of n AUGs (Administrative Unit Group) together with SOH. The AU provides adaptation between the higher order path layer and the multiplex section layer. It consists of the higher order VC (information payload) and the AU pointer. An AU-4 is a VC-4 plus an AU pointer. An AU-3 is a VC-3 plus an AU pointer.

The AU pointer indicates where each VC within the AU frame begins. It is contained in bytes H1, H2, and H3. If there is a change in the payload, a NDF is sent, and the accompanying pointer value becomes the new AU pointer value. The pointer can also be incremented or decremented to accommodate frequency offsets between the VC and the SOH.

## APS

APS (Automatic Protection Switching) keeps the network working even if a network element or link fails. When a failure is detected by one or more network elements, the network proceeds through a coordinated, predefined sequence of steps to transfer (switchover) live traffic to the backup facility (protection facility). See Figure 131 for the architecture.This is done very quickly to minimize lost traffic. Traffic remains on the protection facility until the primary facility (working facility) fault is cleared, at which time the traffic reverts to the working facility.

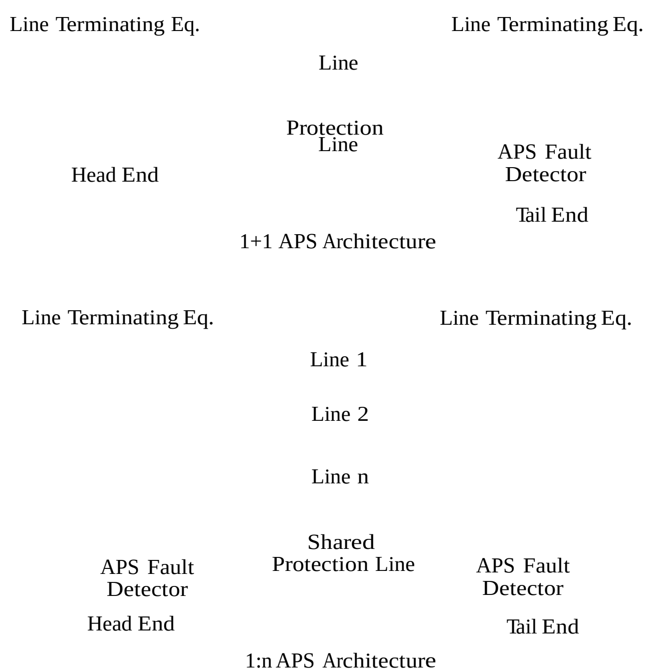



**Figure 131 1+1 APS Architecture**

In a SONET or SDH network, K1 and K2 line overhead bytes (APS channel) are used by the Network Elements to exchange request and acknowledgments for protection switch actions.

During a protection switchover, network elements signal an APS by sending AIS through the network. AIS is also present at the ADM drop points. The AIS may come and go as the network elements switch traffic to the protection circuit.

What causes the network to initiate an automatic protection switch-over? The three most common causes are: detection of AIS, detection of excessive B2 errors, and initiation through a network management terminal. According to GR-253 and G.841, a network element is required to detect AIS and initiate an APS within 10 ms. B2 errors should be detected according to a defined algorithm, and more than 10 ms is allowed. This means that the entire time for both failure detection and traffic restoration may be 60 ms or more (10 ms or more detect time plus 50 ms switch time).

To take an APS measurement, connect the test set to the location of concern within the network. For many applications, this will be a drop point of an ADM. For others it will be a monitoring point in the ring. Examples of both are shown in Figure 132.

MS-AIS measured
Point of Failure
2M Loopback
To start an APS,
insert MS-ASI.
ADM
45M
SDH
Ring
ADM
ADM
Protection Circuit
To start an APS,
insert MS-ASI.
Working Circuit
ADM
VC-12 Mapping
(2M Payload)
In-Service Test
TU-AIS measured
Out-of-Service Test
2M AIS Measured

**Figure 132 APS Measurement Points**

### 4.3.1.5 SDH Performance Monitoring

SDH has excellent operations and maintenance facilities built in. One SDH link reaches all of the network elements in its architecture setup, and all of the elements monitor for faults. Simple loopbacks are also available for basic testing. SDH's ample overhead provides for quick detection and reporting on failures, and easy troubleshooting, as the location of the error (section of it occurs in) is inherent in the error report. See Figure 133.

**Alarm Indications**

**LOS**: Received amplitude is below predefined level.

**OOF**: Five consecutive frames with FAS errors; position of frame alignment bytes unknown.

**LOF**: Once an OOF occurs, if three msec occur without two consecutive unerrored frames, LOF is declared.

**LOP**: 10 consecutive invalid pointers; pointer value unknown.

**Path AIS**: All 1s in the TU or AU pointer. SOH is ok.

**AIS**: Sent from the error, as 'keep-alive' signal (all 1s).

**MS-AIS**: Valid RSOH; all 1s for rest of the signal.

**RDI**: Signal has Section defect or receiving MS-AIS.

**RFI**: Signal failure.

**REI**: One or more errors detected by a parity check.

REI: Remote Error Indication when BIP fails

REI

A B

BIP Error

RDI: Remote Defect Indication indicates serious network failure, LOSS, LOF, LOP, etc.

RDI

A B AIS

Frame Error

AIS: Alarm Indication Signal NNS:Next Naming System

**Figure 133 SDH Errors: REI, RDI, AIS**

The following table provides additional detail:

| | |
|---|---|
| LOS | Loss of Signal; formerly NO-SIG |
| TSE | Test Sequence Error, Bit error in the test pattern |
| LSS | Loss of Sequence Synchronization |
| LTI | Loss of incoming Timing Intervals |
| **Regenerator Section** | |
| OOF | Out Of Frame |
| LOF | Loss Of Frame |
| B1 (8 bits) | Regenerator section error monitoring |
| **Multiplex Section** | |
| B2 (n x 24 bits) | MS error monitoring |
| MS-AIS | MS Alarm Indication Signal |
| MS-RDI | MS Remote Defect Indication |
| MS-REI | MS Remote Error Indication |
| **Administrative Unit** | |
| AU-LOP | AU Loss Of AU Pointer |
| AU-NDF | AU Pointer New Data Flag |
| AU-AIS | AU Alarm Indication Signal |
| AU-PJE | AU Pointer Justification Event |
| **HO Path** | |
| B3 (8 bits) | HO Path error monitoring (VC-3/4) |
| HP-UNEQ | HO Path Unequipped |
| HP-RDI | HO Path Remote Defect Indication; |
| HPRDIEP | HO Path RDI Payload Defect |
| HPRDIES | HO Path RDI Server Defect |
| HPRDIEC | HO Path RDI Connectivity Defect |
| HP-REI | HO Path Remote Error Indication |
| HP-TIM | HO Path Trace Identifier Mismatch |
| HP-PLM | HO Path Payload Label Mismatch |
| **Tributary Unit** | |
| TU-LOP | TU Loss of Pointer |
| TU-NDF | TU pointer New Data Flag |
| TU-AIS | TU Alarm Indication Signal |
| TU-LOM | TU Loss Of Multiframe (H4) |
| **LO Path** | |
| BIP-2 | LO Path error monitoring (VC-11/12) |
| B3 ( 8 bits) | LO Path error monitoring (VC-3) |
| LP-UNEQ | LO Path Unequipped |
| LP-RDI | LO Path Remote Defect Indication |
| LPRDIEP | LO Path RDI Payload Defect |
| LPRDIES | LO Path RDI Server Defect |
| LPRDIEC | LO Path RDI Connectivity Defect |
| LP-REI | LO Path Remote Error Indication |
| LP-RFI | LO Path Remote Failure Indication |
| LP-TIM | LO Path Trace Identifier Mismatch |
| LP-PLM | LO Path Payload Mismatch |

**Table 9 SDH Defects to ITU-T G.707 and G.783**

### 4.3.2 SONET Network

#### 4.3.2.1 Overview

The lowest level SONET is termed STS-1 (Synchronous Transport Signal Level-1); this signal has a rate of 51.84 Mbit/s. Its optical equivalent, as obtained by a direct electrical conversion of the STS-1 signal, is the OC-1 (Optical Carrier Level-1). The higher level signals are obtained by the byte-interleaved mapping of lower level signals. Basically, the bytes are interleaved in such a format where the low-speed signals are still visible.

There is no additional signal processing except the direct conversion from electrical (STS) to optical (OC) form. These higher signal levels are denoted by STS-N and OC-N. According to SONET standards, n can equal 1, 3, 12, 48, and 19, etc. Table 10 displays some SONET line rates and the SDH equivalent formats.

| Line Rate | SONET | SDH | SONET Capacity | SDH Capacity |
|---|---|---|---|---|
| 51.840 Mbit/s | OC-1<br>STS-1 | STM-0 | 28 DS1s or<br>1 DS3 | _ |
| 155.520 Mbit/s | OC-3 | STM-1 | 84 DS1s or<br>3 DS3s | 63 E1s or<br>1 E4 |
| 622.080 Mbit/s | OC-12 | STM-4 | 336 DS1s or<br>12 DS3s | 252 E1s or<br>4 E4s |
| 2.488 Gbit/s | OC-48 | STM-16 | 1344 DS1s or<br>48 DS3s | 1008 E1s or<br>16 E4s |
| 9.952 Gbit/s | OC-192 | STM-64 | 5376 DS1s or<br>192 DS3s | 4032 E1s or<br>64 E4s |

**Table 10 Synchronous Technology Rate Equivalencies**

The OC-3 (Optical Carrier-3) rate is where the various rate systems meet; STS-3 it is equivalent to the STM-1 (Synchronous Transport Mode-1), in the SDH standard. The rate is 155.52 Mbit/s. OC-12 is equivalent to STS-4, at 622.08 Mbit/s, etc. STS-n frames consist of a number of STS frames multiplexed together. The high rate frame is made by interleaving the STS-n's byte by byte (for example, by multiplexing three STS-1s together to make a STS-3). By multiplexing in this manner, the columns of each lower rate STS are also interleaved. As each of the first three columns of each STS are overhead, the resulting STS-3's first nine columns are overhead. Since error checking is usually done once for the entire frame, only the overhead in the first STS is actually used. The remaining overhead is left as undefined. The STS-1s are still accessible in a higher STS-n rate.

Concatenated payloads, designated STS-Nc or OC-Nc, are not divided into individual STS-1 channels. Rather, the entire SPE is used for a single payload. For example, an OC-3 is usually divided into three 52 Mb STS-1 channels, each with its own pointer and path overhead. An OC-3c is a single 155 Mb channel with a single pointer and path overhead. Concatenation is used for data-based networks such as ATM and Packet Over SONET. OC-3cs are often used for transporting ATM cells.

Figure 134 depicts the multiplexing process. In this, 3 STS-1s are multiplexed to form 1 STS-3. A1, A2, A3, B1, B2, etc., represent the overhead bytes for each STS-1 signal. Overhead bytes are discussed in *Section 4.3.2.3*. SPE A, B, C represent the synchronized payload envelopes for the three STS-1 signals.

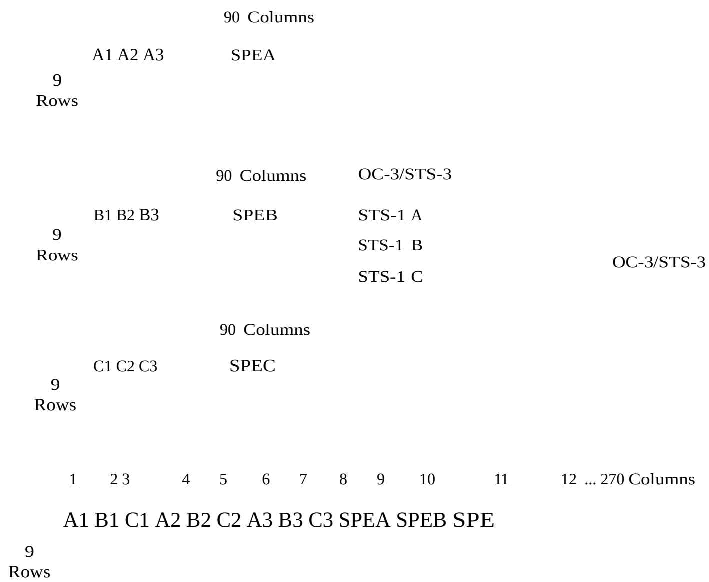



**Figure 134 Bit-Interleaving Multiplexing**

**Virtual Tributaries**

SONET also defines synchronous formats at sub-STS-1 levels. The STS-1 payload is subdivided into VTs (Virtual Tributary); synchronous signals used to transport lower-speed transmissions.

- STS-1 SPE has a channel capacity of 50.11 Mbit/s; designed to transport a DS3 tributary signal.
- The VT frame structure transports a lower rate signal (DS1).

There are three common sizes of VTs; VT 1.5, VT-2, and VT-6.

- A VT 1.5 frame consists of 27 bytes (3 columns of 9 bytes). These bytes provide a transport capacity of 1.728 Mbit/s, and thus, can accommodate the transport of a DS1 signal. 28 VT 1.5s may be multiplexed into the STS-1 SPE.
- A VT-2 frame consists of 36 bytes (4 columns of 9 bytes).

These bytes provide a transport capacity of 2.304 Mbit/s, and can accommodate the transport 1 E1 signal. 21 VT-2s may be multiplexed into the STS-1 SPE.

- A VT-6 frame consists of 108 bytes (12 columns of 9 bytes). These bytes provide a transport capacity of 6.912 Mbit/s and will accommodate the mapping of a DS2 signal. 7 VT-6s may be multiplexed into the STS-1 SPE.
- Different types of VT groups may be mixed into a STS-1 SPE.

Figure 135 shows the overall SONET multiplexing structure.

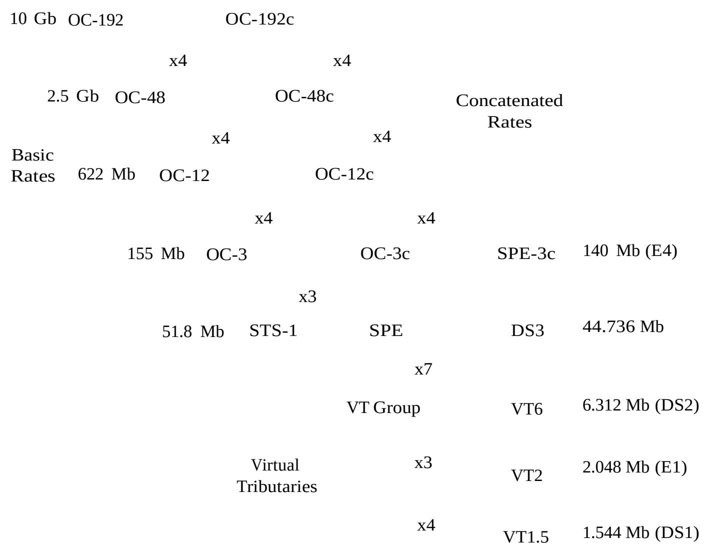



**Figure 135 SONET Multiplexing Hierarchy**

The basic devices shown in Figure 136 are defined as follows:

**Digital Loop Carrier systems (DLC)**: These are specialized SONET back-to-back mux systems providing circuit concentration in the local loop market. These elements are similar to the Terminal Mux, but transmission speed is normally limited to 155 Mbit/s.

**Terminal Mux**: This performs the simple multiplexing of SONET and standards DS1/DS3 channels onto a single SONET bearer.

**Add/Drop Mux**: This is a terminal multiplexer with the ability to operate in through mode (ADM) and add and drop channels to the through signal. This may be used to add, drop, or cross-connect tributary channels. They may operate at any SONET rate. At an add/drop site, only those signals that need to be accessed are dropped and inserted. The remaining traffic continues through the network element without requiring signal processing.

**SONET DCS (Cross Connect)**: This cross-connect accepts various SONET rates, accesses the STS-1 signals, and switches at this level. The major difference between a cross-connect and an add/drop multiplex is that a cross-connect may be used to interconnect a much larger number of STS-1s. It is ideally used at a SONET hub.

**Regenerator**: These are required for SONET and transmission over 35 miles. They are not just simple signal reconstituters, but have alarm and error checking capability.

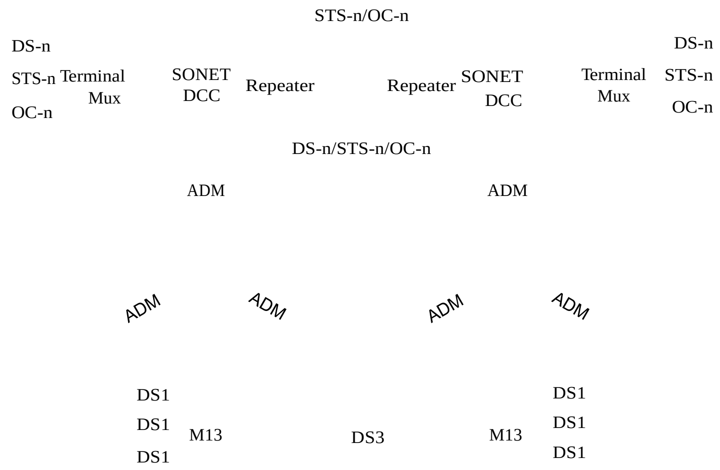



**Figure 136 SONET Architecture & Devices**

### 4.3.2.2 Frame Formats

Figures 137 and 138 show the frame formats of the STS-1 signal. The STS-1 frame format is usually depicted as a matrix of 9 rows of 90 bytes. The signal bits are transmitted starting with those on the top left hand byte in row 1, until all the bits in the 90th (last) byte in row 2 are transmitted. This process continues until the 90th byte of the 9th row is transmitted. The entire frame is transmitted in 125 microseconds.

The frame is comprised of two main areas: TOH (Transport Overhead) and the SPE (Synchronous Payload Envelope). The TOH and SPE are two distinct and readily accessible parts within the frame structure. The POH (Path Overhead) is contained in the SPE.

SPE is a defined area within an STS-n that carries data for customer services. SPE is designed to traverse the network from end to end. Once the payload is multiplexed into the SPE, it can be transported and switched without having to be examined or demultiplexed at intermediate nodes. For this reason, SONET is called service independent and transparent. SPE is shown in Figure 137.

• • •

STS-1 Synchronous Payload Envelope: 87 columns
Path Overhead (POH): 1 column
Transport Overhead (TOH): 3 columns
90 columns X 9 rows = 810 total bytes per frame
86 columns X 9 rows = 774 data bytes per frame

**Figure 137 SPE Frame Format**

TOH provides the facilities required to support and maintain the SPE between nodes in a synchronous network (i.e. alarm monitoring, bit-error monitoring, and data communications channels). The STS-1 payload can transport up to 28 DS1s or 1 DS3.

A1 A1 A1 ... A2 A2 A2 ... J0 Z0 Z0 ...
B1 E1 F1
D1 D2 D3
H1 H1 H1 ... H2 H2 H2 ... H3 H3 H3 ... B2 B2 B2 ...
K1 K2 1 2 ... N 1 2 ... N ... 1 2 ... N
D4 D5 D6
D7 D8 D9
D10 D11 D12
S1 Z1 Z1 Z1 Z2 Z2 M1 ... E2

3 X N Columns of TOH 87 X N Columns of STS-N Envelope Capacity

**Figure 138 STS-n Frame Format**

Figures 137 and 138 show different ways of looking at the frames. The first gives an overview, the second shows the specifics of the overhead and the interleaved payload.

- N STS-1 frames are interleaved to create an STS-n signal
  - Typical values for N are 3, 12, 48, 192, etc.
- Transport overhead bytes are frame-aligned.
- Individual SPEs are completely independent.
  - Each STS-1 has its own pointer.
- Gaps indicate undefined TOH bytes.

#### 4.3.2.3 STS-1 Overhead

The SONET network may be described in terms of three different network spans, which allow for fault sectionalization.

- PATH: Allows network performance to be maintained from a customer service end-to-end perspective.
- LINE: Allows network performance to be maintained between transport nodes. This provides the majority of network management reporting.
- SECTION: Allows network performance to be maintained between line regenerators (repeaters) or between a line regenerator and a SONET network element.

Figure 139 illustrates a representation of these network spans.

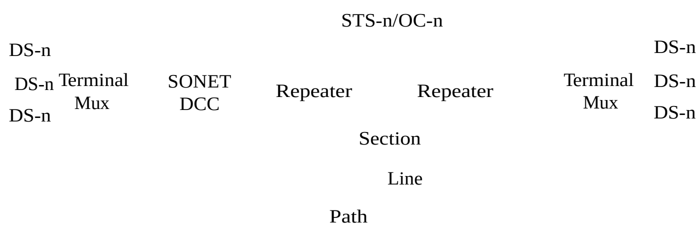



**Figure 139 DS1 Network Spans**

The embedded overhead in the SONET signal supports network maintenance at each level of these network spans. Thus, the Path, Line, and Section Overhead are distinct.

**SOH (Section Overhead)**

- Framing
- Performance monitoring
- Local orderwire
- Data communications channel (132 kb)

**LOH (Line Overhead)**

- Pointer to the start of the synchronous payload envelope
- Performance monitoring of the individual STS-1s
- Express orderwire
- Protection switching information
- Line AIS (Alarm Indication Signal)
- RDI-L (Remote Defect Indication-Line) indication

**STS POH (Path Overhead)**

- Performance monitoring of the STS SPE
- Signal label
- Path trace

The high level of network management possible with SONET depends on the information provided by the overhead within the STS frame. Basically, POH provides the facilities needed to support and maintain the transportation of the SPE between path terminating locations where the SPE is assembled and disassembled. LOH and SOH provide the facilities to support and maintain the transportation of the SPE between the adjacent nodes in the SONET network.

In higher OC rates, generally only LOH and SOH in the first STS is utilized. The rest is ignored. Each SPE within the OC-N signal has independent Path overhead. Figure 140 shows overhead labels.

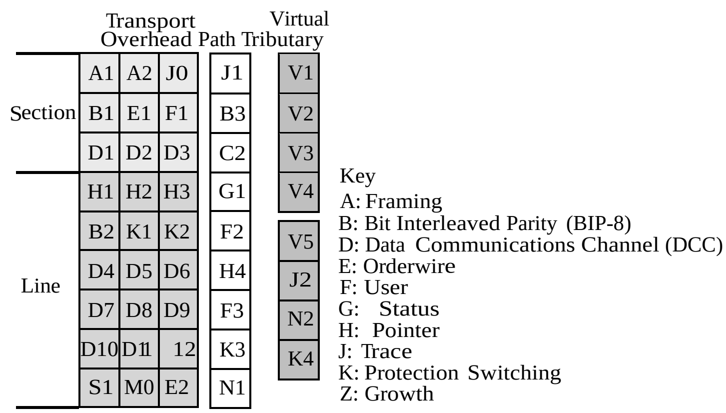



**Figure 140 SONET Overhead Bytes**

### Section Overhead Definitions

- Framing bytes, A1 and A2, provide a frame alignment pattern (11110110 00101000, binary, F6 28 hex).
- B1 parity check byte, provides section error monitoring. It uses a bit-interleaved parity 8 code (BIP-8), with even parity.
- E1 section orderwire byte provides for voice communications among regenerators, hubs, and remote terminal locations.
- F1 byte is the Section User Channel, for user's purposes. It is terminated at all section level equipment.
- The last three section OH bytes, D1-D3, prove a data communications channel for Operations, Administration, Maintenance and Provisioning (OAM&P).

### LOH (Line Overhead)

The three bytes H1-H3 facilitate the operation of the STS-1 payload pointer. The payload pointer is involved with synchronization of SONET. Ideally, all synchronous network elements should derive their timing signal from the same master network clock. However, current synchronized network timing schemes allow for the existence of more than one master clock.

SONET uses pointers to compensate for frequency phase variations caused by multiple timing sources. Pointers enable the transparent transport of synchronous payload envelopes across pleisochronous boundaries (between nodes with separate network clocks having almost the same timing). This means the SPE can be switched and transported through SONET without having to be examined and demultiplexed at intermediate nodes.

The use of pointers avoids the delays and loss of data associated with the use of large (125 µs frame) slip buffers for synchronization. This permits the ease of dropping, inserting, and cross-connecting these payloads in the network. The pointer is simply an offset value that points to where the SPE begins. Figure 141 shows the H1-H2 pointers.

| H1 | | | | | | | | H2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | N | N | N | S | S | I | D | I | D | I | D | I | D | I | D |

New Data Flag SS Bits Pointer Value: 0 through 782

**Notes**

**New Data Flag**: 0110 = Normal, 1001 = New Data Flag (NDF), other values use the '3 of 4' rule.

**SS Bits**: 00 = SONET, 10 + SDH, 01 and 11 are undefined.

**Concatenation**: In an STS-Nc signal, the first H1/H2 bytes are set normally. Subsequent H1/H2 bytes are set to 1001ss1111111111 to indicate concatenation.

**Figure 141 H1-H2 Pointers**

Here are the H bytes:

- H1-H2: Pointer; values range from 0 to 782.
- H3: Pointer Activity (Byte stuffing).
- The B2 byte provides a BIP-8 line error monitoring function.
- The two bytes K1 and K2 provide Automatic Switching Protection (APS) signaling between line terminating equipment.
- The nine bytes D4-D12 provide a data communications channel at 576k for message-based administrative, monitor, maintenance, alarm, and other communications needs.
- The S1 byte provides synchronization status, reporting on the signal clock source and quality.
- The E2 byte provides an express orderwire channel for voice communications between line terminating equipment.
- M0 is used for Remote Error Indication (REI-L). This provides a count of the far end line B2 errors. In STS-3 and higher signals, M0 is replaced by M1, which serves the same purpose. See Figure 140 for the position of M0.

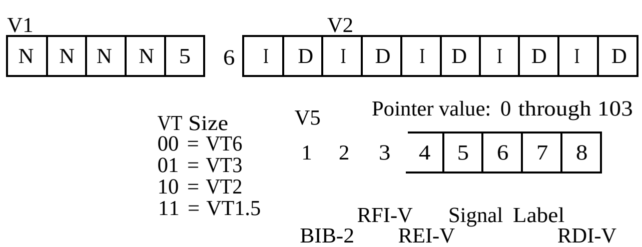
**Path Overhead**

Figure 140 shows the Path Overhead bytes.

- Byte J1 makes up a 64-byte fixed-length string, which is transmitted one byte per SPE frame. It can contain any alphanumeric message. The continuity of connection to the source of the path can be verified at any receiving terminal by checking this message string.
- Byte B3 provides a BIP-8 path error monitoring function.
- Byte C2 indicates the construction of the STS SPE.
- Byte G1 provides alarm and performance information. It conveys this information back to the originating STS Path Termination equipment. This byte allows the monitoring of a two-way path at either end, or at any point along the way.
- Byte F2 is the path user's channel; it is provided for proprietary network operator communications between Path Termination equipment.
- Byte H4 is the VT multiframe indicator. Currently, it is used only for VT multiframe carried by that particular SPE.
- Bytes Z3 and Z4 are reserved for future use.
- Byte Z5 provides tandem path connection monitoring information, which is an important feature for customers with multiple service providers.

**VT Overhead**

The first byte in the VT SPE is the V5 VT Overhead byte as shown in Figure 142.




V1-V2 VT Payload Pointer (analogous to H1-H2)
V3 Pointer Action (analogous to H3)
V4 Undefined
V5 Signal Label and Error Monitoring (analogous to B3, C2, and G1)
Signal Label
000 = Unequipped
001 = Equipped — Nonspecific payload
010 = Asynchronous mapping
011 = Bit synchronous mapping (obsolete)
100 = Byte synchronous mapping
J2 VT signal trace (16 ASCII characters)
N2 Tandem connection monitoring
K4 Protection switching and enhanced RDI-V

**Figure 142 VT Overhead**

### 4.3.2.4 Performance Monitoring

Some overhead bytes contain special functions, like Path Overhead byte G1's alarm and performance information. These bytes make effective in-service testing possible within a SONET network. LOS (Loss of Signal), LOF (Loss of Frame), and LOP (Loss of Pointer) cause an AIS to be transmitted downstream.

The AIS signals vary depending on the level of maintenance hierarchy affected. Maintenance signals, in response to AIS, are sent upstream to warn of the trouble downstream. See *Section 4.3.1.4-APS* for information on protection switching.

**Nomenclature**

Defects are identified by their location in the network: section, line, path, or virtual tributary path. The abbreviations -S, -L, -P, and -V are used to distinguish between these. Sometimes an AIS-P is written as P-AIS, but they mean the same; a path-level AIS defect.

There are 2 classes of defects: near and far end. Near end defects are any defects detected on the line being tested. Far end defects are always a response to a near end defect. In SONET, far end defects always have 'remote' somewhere in the name, like RDI (Remote Defect Indication), which is a far end response to an AIS defect.

### 4.3.2.5 Defects

**LOS**: Loss of signal occurs when the data is all zeros for 2.3 to 100 microseconds (less than a frame).

**LOF**: Loss of Framing occurs when there is no valid framing pattern for 3 ms (24 frames).

- LOS and LOF defects can be caused by optical power that is either too low or too high. In many cases when a LOF occurs, it is due to the optical receiver being saturated. Inserting an attenuator clears up the problem. This happens when interfacing between single mode and multimode equipment.
- LOS and LOF are cleared with 2 consecutive valid frames.

**LOP**: Loss of Pointer occurs for path or virtual tributaries when there is no valid pointer for 8 to 10 frames. LOP is cleared when a valid pointer appears for 3 consecutive frames.

**PLM**: Payload Label Mismatch occurs when the value of the C2 byte does not match the expected value, indicating that two network elements are not configured for the same payload.

**UNEQ**: Unequipped is used for paths and virtual tributaries that have not been provisioned. It serves the same role as an idle code. **TIM**: Trace Identifier Mismatch occurs when the expected path or virtual tributary trace (J1 or J2 byte, respectively) does not match the expected value, alerting to a potential provisioning problem. The TIM measurement is optional.

**AIS**: Alarm Indication Signal comes in three varieties depending on whether the originating defect occurred in the Line, Path, or Virtual Tributary Path. There is no Section AIS.

- Line AIS is triggered on a LOS or LOF. The AIS signal is given valid section overhead (framing), but the remainder of the signal is given an all ones (scrambled). AIS-L is detected when bits 6-8 of the K2 byte are 111 for five consecutive frames.
- Path AIS is triggered by a Line AIS or a LOP. The AIS-P sets the H1-H3 bytes to all ones. AIS-P is detected when H1-H2 are all ones for three consecutive frames.
- VT AIS is triggered by an AIS-P, LOP-P, UNEQ-P, TIM-P, PLM- P, or LOP-V. AIS-V are also triggered by a DS1 LOS, OOF, or AIS. The AIS-V sets the entire VT to all-ones, including the VT overhead. AIS-V is detected when V1-V2 are all ones for three consecutive frames.

**RDI**: Remote Defect Indication is a far end response to a major fault, such as a LOS or AIS. The network element that detects the defect generates an RDI in the overhead of the signal heading toward the origin of the problem.

SONET RDI, like AIS, comes in three varieties. Older specifications use FERF instead of RDI. An RDI that lasts for 2.5 ± 0.5 seconds becomes an RFI (Remote Failure Indication).

- Line RDI is triggered by AIS-L, LOS, or LOF. RDI-L is indicated by setting bits 6-8 of the K2 byte to 110. RDI-L is detected when this code is seen for 5 to 10 consecutive frames. Path RDI is indicated by bit 5 of the G1 byte. RDI-P is detected if this bit is set to 1 for 10 consecutive frames.
- VT RDI is indicated by bit 8 of the V5 byte. RDI-V is detected if this bit is set to 1 for 10 consecutive subframes (the V5 byte is only sent once every four SONET frames).
- Path RDI and VT RDI has changed considerably over the years. The RDI-P/V mentioned above are called one-bit RDI defects. The current specifications include an enhanced RDI, called ERDI-P/V. These indicate the presence of more types of defects besides AIS. The details on ERDI-P/V follow.

### 4.3.2.6 Enhanced RDI

Traditional RDIs do not indicate Unequipped, Payload Label Mismatch, and other serious defects. ERDIs allow for more specific designation of what caused the defect: server, connectivity, or payload defects. Payload defects would not trigger an RDI in older systems, since these systems do not include PLM or LCD (Loss of Cell Delineation–an ATM defect) in their definitions.

| | G1 Bits 5-7 | ERDI-P Priority | Trigger | Interpretation |
|---|---|---|---|---|
| RDI-P | 0xx | N/A | No defects | No RDI-P defect |
| | 1xx | N/A | AIS-P, LOP-P | One-bit RDI-P defect |
| ERDI-P | 101 | 1 | AIS-P, LOP-P | ERDI-P server defect |
| | 110 | 2 | UNEQ-P, TIM-P | ERDI-P connectivity defect |
| | 010 | 3 | PLM-P, LCD-P | ERDI-P payload defect |
| | 001 | 4 | No defects | No RDI-V defect |

**Table 11 Path ERDI**

| | Z7 Bits 5-7 | V5 Bit 8 | ERDI-P Priority | Trigger | Interpretation |
|---|---|---|---|---|---|
| RDI-V | yxx | 0 | N/A | No defects | No RDI-V defect |
| | yxx | 1 | N/A | AIS-V, LOP-V | One-bit RDI-V defect |
| ERDI-V | 101 | 0 | 1 | AIS-V, LOP-V | ERDI-V server defect |
| | 110 | 0 | 2 | UNEQ-V, TIM-V | ERDI-V connectivity defect |
| | 010 | 1 | 3 | PLM-V | ERDI-V payload defect |
| | 001 | 1 | 4 | No defects | No RDI-V defect |

**Table 12 VT ERDI**

Backwards compatibility is ensured by the tables above. If ERDI-P is not supported, the equipment only looks at G1 bit 5, ignoring bits 6 and 7. If ERDI-V is not supported, the equipment only looks at V5 bit 8, ignoring Z7.

ERDI-P and ERDI-V are detected if the appropriate bit code persists for 5 to 10 consecutive frames. The ERDI-V specification has gone through many revisions and may behave very differently on different network equipment and test sets.

**Parity**: Used to detect bit errors on live data. It is calculated after scrambling, and placed into the parity byte of the next frame (before scrambling). For example, the B1 byte of a given frame is based on the previous frame. Because the parity is calculated over 8 bits, this is called BIP-8. VT1.5 uses BIP-2 since it only looks at even/odd numbered bits.

- Section parity (B1) is calculated once over the entire SONET frame. For OC-N signals, there is still only a single B1 byte.
- Line parity (B2) is calculated over the entire frame, except the section overhead. An OC-N signal has N B2 bytes. Essentially,

each STS-1 within the OC-N is calculated separately. For concatenated signals, the parity just pretends the payload is split into N STS-1 signals. Line parity is sometimes called BIP-Nx8 parity, so that an OC-12 would use BIP-96.

- Path parity (B3) is calculated once over the payload (SPE). For OC-N signals, there are N B3 bytes–one for each STS-1 payload. For concatenated signals, there is only one B3 byte.

By calculating parity separately for section, line, path, and virtual tributaries, the source of the errors can be isolated quickly. For example, if the test set detects a B2 (Line) error, but not a B1 (Section) error, the problem originates before the last regenerator. If multiple types of parity errors occur simultaneously, they are probably caused by the same fault and you should focus on the closest one. For example, if both a B2 (Line) and B3 (Path) error are detected, there is a problem between the test set and the last line network element; the B3 error can be ignored until the B2 error is resolved.

Parity errors are also called Code Violations (not to be confused with bipolar violations) and designated CV-S, CV-L, CV-P, and CV-V.

**REI**: Remote Error Indication is a far end response to parity errors. When a network element detects one or more parity errors, it sends an REI in the overhead of the signal back in the direction the parity error originated. The REI provides an indication of the number of parity errors detected. There is no REI for section layer.

- REI-L appears in the M0 and M1 bytes. The value of the byte indicates the number of B2 errors: 0-8 for M0 (STS/OC-1 signals) and 0-255 for M1 (STS/OC-3 and higher signals).
- REI-P appears in bits 1-4 of the G1 byte, giving a number from 0-8 B3 errors.
- REI-V appears in bit 3 of the V5 byte and only gives a simple indication whether BIP-2 errors were present, not a number.

### 4.3.2.7 Performance Monitoring Parameters

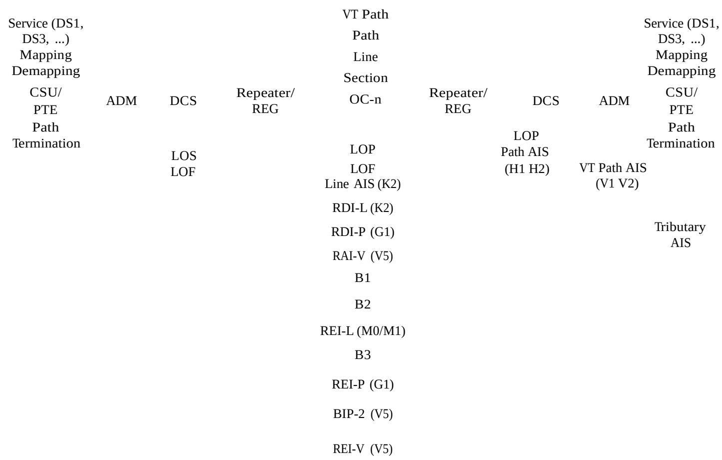



**Figure 143 DS1 Alarm Signal Flow**

The following parameters are calculated separately over section, line, path, and virtual tributary path for both near and far ends.

**SEFS**: Severely Errored Frame Second (Section only) occurs when the framing pattern has an error for 4 or more consecutive frames.

**CV**: Code Violations is a count of B1/B2/B3/BIP-2 errors (near end) or REI-L/P/V errors (far end).

**ES**: Errored Seconds is any second with one or more errors. For example, if there are 5 B1 errors within 1 second, there would be 5 CV-S and 1 ES-S. If there is 1 B1 error a second for 5 seconds, there would be 5 CV-S and 5 ES-S.

**SES**: Severely Errored Second is any second that exceeds a specified threshold of errors or AIS/RDI. It is counted for LOS and SEF. The threshold depends on the line rate and type of error. For example, SES-L triggers on 615 B2 errors at OC-12 but 2,459 at OC-48. An AIS-L triggers a SES-L at any rate.

**UAS**: Unavailable Seconds starts after 10 seconds of SES and clears after 10 seconds without an SES.

**FC**: Failure Count is a defect (AIS, RDI, etc.) that persists for 2.5 ± 0.5 seconds. FCs are not counted for Section. Failures can help distinguish between isolated events and a single persistent event. For example, an AIS-L that last 15 seconds would be 1 failure, but 3 AIS-L occurrences that last 5 seconds each would be 3 failures. In both cases, 15 UASs would be recorded.

**AS**: Available Seconds is the elapsed time minus UAS. This is a nonstandard PM parameter.

DS1 alarm flows are illustrated in Figure 143. Table 13 decrypts the SONET acronyms.

| | |
|---|---|
| **Section (S)** | |
| LOS | Loss of Signal |
| OOF | Out Of Frame |
| LOF | Loss Of Frame |
| B1 (8 bits) | Section error monitoring |
| **Line (L)** | |
| B2 (n x 8 bits) | Line error monitoring |
| AIS-L | Line Alarm Indication Signal |
| RDI-L | Line Remote Defect Indication |
| REI-L | Line Remote Error Indication |
| **STS Path (SP)** | |
| LOP-P | Path Loss of Pointer |
| NDF-P | Path New Data Flag |
| AIS-P | Path Alarm Indication Signal |
| B3 (8 bits) | Path Error Monitoring |
| UNEQ-P | Path Unequipped |
| RDI-P | Path Remote Defect Indication |
| ERDI-P PAY | Path Payload Defect Remote Defect Indication |
| ERDI-P SER | Path Server Defect Remote Defect Indication |
| ERDI-P CON | Path Connectivity Defect Remote Defect Indication |
| REI-P | Path SP Remote Error Indication |
| PDI-P | Path Payload Defect Indication |
| TIM-P | Path Trace Identifier Mismatch |
| PLM-P | Path Label Mismatch |
| **Virtual Tributary (VT)** | |
| LOP-V | Virtual Tributary Loss of Pointer |
| NDF-V | Virtual Tributary New Data Flag |
| AIS-V | Virtual Tributary Alarm Indication Signal |
| LOM | Loss of Multiframe |
| BIP-V | Virtual Tributary error monitoring |
| UNEQ-V | Virtual Tributary Unequipped |
| RDI-V | Virtual Tributary Remote Defect Indication |
| ERDI-V PAY | Virtual Tributary RDI Payload Defect |
| ERDI-V SER | Virtual Tributary RDI Server Defect |
| ERDI-V CON | Virtual Tributary RDI Connectivity Defect |
| REI-V | Virtual Tributary Remote Error Indication |
| RFI-V | Virtual Tributary Remote Failure Indication |
| PDI-V | Virtual Tributary Payload Defect Indication |
| TIM-V | Virtual Tributary Trace Identifier Mismatch |
| PLM-V | Virtual Tributary Path Label Mismatch |

**Table 13 SONET Defects ANSI T1.105 & Bellcore GR-253**

### 4.3.3 45M Transmission

#### 4.3.3.1 Introduction

45M DS3s (T3) are widely embedded in the network transport architecture as a convenient means of carrying 672 voice channels in one circuit. A 45M signal consists of digital data transmitted at 44.736 Mbit/s, ± 20 ppm. 45M applications include the transport of broadcast-quality video, ATM (Asynchronous Transfer Mode) physical layer connections, and supercomputer direct links.

#### 4.3.3.2 45M Network Elements

Many types of network elements (equipment) have DS3 interfaces. An M13 mux multiplexes 28 DS1s into a single DS3. A fiber mux may have one or more 45M low speed tributaries and has a high speed (STM-n) output.

A 3x1 DCS (Digital Cross connect System) has many 45Ms as inputs and cross-connects the 1.4Ms inside the 45Ms. Figure 144 is an example of a typical 45M circuit.


**Figure 144 Typical 45M Circuit**

#### 4.3.3.3 Framing and Alarms

Framing allows the two terminals of a 45M line to synchronize on the signal and demultiplex subchannels in a pre determined order. It also allows a variety of maintenance and operational benefits.

**M13 and C-bit Parity Framing**

There are two common types of DS3 framing, the original M23 multiplex framing and the newer C-bit parity framing.

In the M23 multiplex framing application, 7 DS2s are multiplexed into a single DS3. Each DS2 is itself created from 4 multiplexed DS1s. The 28 DS1s, 7 DS2s, and 1 DS3 are all plesiochronous, that is, they are not frequency-locked with respect to each other. As a result, a bit-stuffing algorithm is provided within the M12 and M23 frame formats to allow the minor frequency variations to occur without causing any bit errors in the transmitted data.

M-Frame, 4760 Bits Long

| | | | | | | |
|---|---|---|---|---|---|---|
| 679 | 679 | 679 | 679 | 679 | 679 | 679 |
| X1 Bits X2 | Bits P1 | Bits P2 | Bits M1 | Bits M2 | Bits M3 | Bits |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 |

X1 Bits F1 Bits C1 Bits F2 Bits C2 Bits F3 Bits C3 Bits F4 Bits

First M-Subframe, 680 Bits Long

M-Frame Overhead Bit Sequence

56 overhead bits occupy sequential overhead bit positions as follows:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M-SUBFRAME 1- | X1 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 2- | X2 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 3- | P1 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 4- | P2 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 5- | M1 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 6- | M2 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |
| M-SUBFRAME 7- | M3 | F1 | C1 | F2 | C2 | F3 | C3 | F4 |

**Notes**:

- The M-Frame alignment signal is M1=0, M2=1, M3=0.
- The M-Subframe alignment signal is F1=1, F2=0, F3=0, F4=1.
- An M-Subframe consists of 8 pairs of 1 framing bit & 84 information bits, 85 bits in each pair, 680 bits in the M-subframe. 7 M-subframes equals one m-frame (multi frame, 4760 bits).
- M23 Framing: C-Bits used for bit stuffing to allow for non-locked frequencies of 7 multiplexed DS2 signals with respect to the DS3. All three C-Bits in a M-Subframe are either 1 or 0 depending on whether a stuff takes place. Individual DS2 can be looped back by inverting DS2 C3. Also, DS1 can be looped back by inverting DS1 C3 inside the M12 framing. M12 framing, not diagramed here, is used to MUX 4 DS1s into a DS2.
- M23 Framing and C-bit parity framing: both frames follow 1, 2, 3. idle signal is valid M-Frame alignment, P-bit parity with payload (information bits) = 1100. AIS is valid M-Frame alignment, F Subframe alignment, parity, with payload = 1010. Far end alarm is X-BIts set to 0. Parity is both P-Bits are set to 0 or 1 depending on parity of payload in preceed- ing M-Frame.
- C-bit parity framing only: C-bit 1 in M-Subframe 1 = ALL 1. C-Bits not needed for stuffing because DS2 frequency locked to DS3 frequency. CP-Bit path parity on M Subframe 3 C-Bits. FEBE (Far End Block Error) errors reported on M-Subframe 4 C Bits when CP-Bit Path Parity Error is received. FEAC (Far End Alarm Control Channel) is the THIRD C-bit in M-Subframe 1. M-Subframe 5 C-Bits for terminal-to-terminal data link.

**Figure 145 DS3 Framing: C-bit Parity & M23**

C-bit parity framing was created because DS2s typically do not need to exist independently with varying frequencies. Instead, most commercial multiplex equipment operates in an M13 mode, multiplexing 28 DS1s directly into a DS3. DS2 signals are still multiplexed within the DS3, but the DS2s' timing is frequency-locked to the DS3 which frees up the M23 stuff bits to be used for other purposes, providing additional benefits to users.

Figure 145 shows the basic DS3 framing format used by both the M23 and C-bit parity framing methods.

**AIS**: Alarm Indication Signal, is used to indicate a transmis- sion failure within the network. When any intermediate network element receives a loss of signal on its input, it is supposed to propagate an AIS on its output. The AIS signal is a valid framed signal with payload containing a repeating 1010 pattern.

A 45M circuit passes through an intermediate network element. In comparison, a terminal network element terminates the 45M circuit so that no form of DS3 passes through to the other side of the element. An M13 multiplex is an example of a terminating network element where the 45M stops and the 1.5Ms continue on.

DS3 DS3

Loss of Signal | Fiber MUX | Channelized AIS | Fiber MUX | AIS

**Figure 146 DS3 AIS Generation**

**RAI:** Remote Alarm Indication, also known as a yellow or far end alarm, is transmitted on a DS3 circuit when the terminating element such as an M13 multiplex loses framing on its received 45M signal or receives an AIS signal.

If the terminating element is an M13 multiplex, it also transmits AIS on the DS1s. This is shown in Figure 147. The yellow alarm lets the M13 multiplex at the other end know that there is a service outage on the circuit. The yellow alarm is transmitted by setting the X bits to 0.

DS1 DS3

AIS | M13 | RAI | Loss of Frame or AIS

**Figure 147 DS3 RAI Generation**

**PLCP Framing**

For ATM mapping, 45M signals often use the Physical Layer Convergence Procedure (Protocol) framing. This makes use of the DS3 multiframe format with its C-bit parity application.

The DS3 rate of 44,736 kbit/s is sectioned into multiframes of 4760 bits each. The M (multi-) frames are divided into subframes, each having 680 bits. Each subframe consists of 8 blocks of 85 bits; 84 of the bits are used for payload; the remaining bit is used for frame overhead. These overhead bits total 56 bits per multiframe. They are divided into:

- M frame alignment channels: M1- M3
- M subframe channels: F1-F4
- P-bit channel: P1, P2
- X-bit channel: X1, X2
- C-bit channel: Cxy bits

The PLCP frame is a 126 microsecond frame anywhere within the DS3 payload. Nibble (four-bit) stuffing fills out the PLCP frame. See Figure 160 for the frame structure.

### 4.3.4 1.5M Transmission

#### 4.3.4.1 Introduction

1.5M lines are widely embedded in the network distribution architecture as a convenient means of reducing cable pair counts by carrying 24 voice channels in one 4 wire circuit. End users have migrated their private networks onto leased 1.5Ms as a means of reducing their network operation costs. DS1 is a universal digital access point to traditional digital networks and fiber optic synchronous networks.

#### 4.3.4.2 1.5M Framing

1.5M framing is simpler than 45M framing. In 1.5M (also known as DS1 and T1), there are 192 data bits and one framing bit. With framing, you can tell where the first bit of the frame is.

Most T1s are arranged with 24 channels of data, with one byte (8 bits) transmitted per channel per frame. As shown in Figure 148, channel 1 is the first 8 bits after the frame bit, channel 2 is the second 8 bits after the framing bit and so on. 8000 frames are transmitted per second. Each channel provides 64 kbit/s bandwidth.

Ch. 1, 8 Bits/Ch. Chs. 2-23 Ch. 24
Frame Bit
Frame 1
Bit 1
Frame 2
Frames 3-11 or 3-23
Last Frame : SF= 12 or ESF = 24

**Figure 148 T1 Frame Structure**

There are 3 kinds of standardized DS1 framing in use today, SF, ESF, and SLC-96 (SLC is a registered trademark of AT&T).

The simplest is SF framing. Twelve frames are grouped together as a SF (Super Frame). The 12 framing bits are transmitted in a recognizable pattern such that the super frame is organized into frame number 1, frame number 2, and so on.

ESF (Extended Super Frame) groups 24 frames together. Of the 24 framing bits, only 6 are used to establish the frame position, i.e. which frame is number 1, which frame is number 2, and so on. Another 6 are used for a CRC-6 (Cyclic Redundancy Check code-6), and 12 are used for the ESF FDL (Facility Data Link).

The CRC-6 bits are the remainder from a division of the bits of the previous frame by a sixth-order polynomial. Any monitoring device along the line can do the same division process and compare its remainder to the CRC-6 bits. If the two figures are not identical, then the monitoring device can assume that a transmission error has occurred somewhere between the measurement point and the origin of the ESF-framed signal.

The facility data link is a 4 kbit/s channel that allows terminal to terminal communications on an in-service circuit. One example of in-service communication is the Performance Report Message that is broadcast once per second on an in-service circuit.

The facility data link also provides a secure communication channel that the customer cannot influence. For instance, ESF NIU loopback commands are transmitted on the data link so that there is zero chance that the customer's own payload data will accidentally loop up the NIU.

SLC-96 is a framing format introduced by AT&T, and later standardized by Bellcore in TR-TSY-000008, Digital Interface between the SLC 96 Digital Loop Carrier System and a Local Digital Switch. The framing is used on AT&T's old SLC-96 product line. The framing supports a broad variety of maintenance functions such as alarm transmission, automatic switching to protection line, and far end loop back. SLC-96 framing is used on the DS1 link in between the central office terminal and the remote terminal.

### 4.3.4.3 Performance

**AIS and Yellow Alarms**

For 1.5M, AIS and yellow alarms work just like they do in 45M. An intermediate network element such as an M13 multiplex, 1x1 DCS, or SONET/SDH mux, is supposed to transmit AIS downstream when it receives a loss of signal.

Terminating elements also need to properly condition the DS0s that the DS1 carries when the frame is lost. For instance, a D4 channel bank is supposed to condition its channel cards to take them out of service and transmit an appropriate out-of-service signal to the low speed equipment which is attached. Figure 149 shows how AIS and yellow alarms are transmitted.

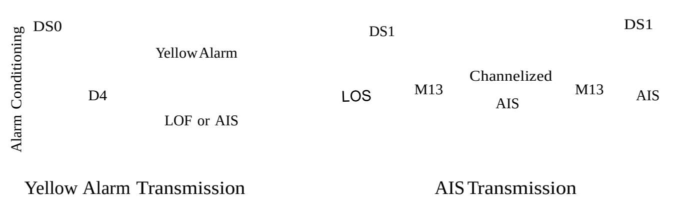



**Figure 149 DS1 AIS & Yellow Alarms**

### 4.3.5 PDH Technology

PDH (Plesiochronous Digital Hierarchy) is an almost-synchronous international transmission network. Numerous signals, almost in synch, are received at a mux, where they are multiplexed into a single signal. The entire signal must be demultiplexed in order to switch one lower-order signal. Here is a list of the standard rates, or CEPTs, and how they are multiplexed up:

- CEPT1/E1: 2.048 Mbit/s – 32 64 kbit/s streams
- CEPT2/E2: 8.448 Mbit/s – 4 2.048 Mbit/s tributaries
- CEPT3/E3: 34.368 Mbit/s – 4 8.448 Mbit/s tributaries
- CEPT3/E4: 139.264 Mbit/s – 4 34.368 tributaries

In PDH, no standards exist for optical transmission equipment. This means, different manufacturers make equipment to different standards, so the equipment may therefore not interface.

**Technical Standards**

Standards ensure that various pieces of equipment are compatible, and that networks operate in a predictable, reliable manner. The following standards cover many of the important aspects of PDH technology.

**ITU-T G.703**: Physical and Electrical characteristics of interface.

**ITU-T G.704**: Synchronous frame structures.

**ITU-T G.706**: Frame alignment and CRC procedures.

**ITU-T G.732**: Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s.

**ITU-T G.742**: Second order digital multiplex equipment operating at 8448 kbit/s and using positive justification.

**ITU-T G.751**: Digital multiplex equipment operating at the third order bit rate of 34368 kbit/s and the fourth order bit rate of 139264 kbit/s and using positive justification.

**ITU-T G.775**: LOS and AIS defect detection clearance criteria at equipment interfaces described in Rec. G.703 and operating at bit rates described in Rec. G.702.

**ITU-T G.821**: Error performance of an international connection forming part of an integrated services network.

**ITU-T G.826**: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate.

**ITU-T M.2100**: Performance limits for bringing into service and maintenance of international PDH, section and transmission paths.

**ITU-T O.151**: Error performance measuring equipment for digital systems at the primary bit rate or above.

**ITU-T O.152**: Error performance measuring equipment for 64 kbit/s paths.

**ITU-T O.153**: Basic parameters for the measurement of error performance at bit rates below the primary rate.

### 4.3.5.1 2M –139M Technology

**Lower Rate Multiplexing**

**2.048 Mbit/s Data Rate**

The E1 signal (bitstream) is transmitted at a rate of 2.048 Mbit/s (2 048 000 bits per second). This transmission rate is achieved by multiplexing 32 individual 64 kbit/s bitstreams:

64 kbit/s/Channel x 32 Channels = 2048 kbit/s or 2.048 Mbit/s

**Higher Rate Multiplexing**

2M signals may be multiplexed together at a mux. Four 2M (or E1) tributaries may be multiplexed together to create a 8.448 Mbit/s signal. An E3, with a rate of 34.368 Mbit/s, is created by multiplexing four 8.448 Mbit/s signals, and an E4, with a rate of 139.264 Mbit/s, consists of four multiplexed E3s.

The lower rate signals (called tributaries at this point) are bit interleaved to higher rates in multiplexers, in the tributary numbering order.

The tributaries have different clock sources. Each multiplexer and demultiplexer has its own internal clock source. The mux uses its internal clock to generate one higher rate signal, using bit stuffing as necessary to achieve synchronization. In demul- tiplexing, the mux reverses the process, having locked onto the frame alignment signal, and onto the clocking of the received data signal. It removes the justification stuff bits, then reclocks the signals for transmission. Hence, the variations in clocking between multiplexers don't matter.

### 4.3.5.2 Framing

**2M Framing**

2M transmission utilizes FAS (Frame Alignment Signal) and MFAS (MultiFrame Alignment Signal). Framing is necessary in order for any equipment receiving the E1 signal to be able to identify and extract the individual channels. PCM-30 transmission systems use MFAS framing along with the FAS framing. PCM-31 transmission systems use only FAS framing. The higher level signals interleave their frames to create a larger frame, using a specific frame alignment signal to indicate the start of each frame.

**Frame Alignment Signal (FAS)**

The 2.048 Mbit/s frame consists of 32 individual time slots (numbered 0-31). Each time slot consists of an individual 64 kbit/s channel of data.

In the FAS format shown in Figure 150, time slot 0 of every other frame is reserved for the frame alignment signal (FAS) pattern. Alternate frames contain the FAS Distant Alarm indication bit and other bits reserved for National and International use. Hence, there are 31 time slots into which data may be placed.

| One 2.048 Mbit/s Frame | | | |
|---|---|---|---|
| Time Slot 0 | 1 | ... | 31 |

| BITS | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| E | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| E | 1 | A | Sa | Sa | Sa | Sa | Sa |

**Notes:**

- 8 bits per timeslot x 8000 frames per second = 2.048 Mbit/s
- Even Frame: Contains Frame Alignment Signal (FAS).
- Odd Frame: No Frame Alignment Signal (NFAS).
- Sa: This bit is reserved for National Use.
- E: This is the error indication bit.
- A: This is remote alarm indication bit (FAS).
- 0011011: Frame Alignment Signal

**Figure 150 FAS Framing Format**

**MultiFrame Alignment Signal (MFAS)**

| | | | | | |
|---|---|---|---|---|---|
| FRM 0 | FRM 1 | FRM 2 | FRM 3 | ........... | FRM 15 |

TS 0 ........ TS 16 ........ TS 31

| BITS | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 0 | 0 | 0 | 0 | X | Y | X | X |

Notes:

- Frames 1-15, timeslot 16:
  (4 signalling bits/Ch)(30 Ch)
  (8 signalling bits/frame timeslot 16)
  = 15 frames of timeslot 16 signalling
- Frame 0, timeslot 16: 8-bit MFAS signal
- Frame 0 TS 16 bits: MFAS=0000
- Timeslot 16 (TS16) contains A/B/C/D bits for signalling (CAS).
- MFAS multiframe consists of 16 frames
- NMFAS=XYXX
  X=spare bits (=1 if not used)
  Y=MFAS remote alarm (= 1 if MFAS synchronization is lost)
- Frames are transmitted with 30 voice channels in timeslots 1-15 and 17-31.

TS 0 ........ TS 16 ........ TS 31

BITS

1 2 3 4 5 6 7 8

A B C D A B C D

Ch 1 (TS-1) Ch 16 (TS-17)

| | | | | |
|---|---|---|---|---|
| TS 0 | ........ | TS 16 | ........ | TS 31 |

| BITS | |
|---|---|
| 1 2 3 4 | 5 6 7 8 |
| A B C D Ch 15 (TS-15) | A B C D Ch 30 (TS-31) |

**Figure 151 MFAS Framing Format**

MFAS (MultiFrame Alignment Signal) framing uses CAS (Channel Associated Signaling) to transmit A/B/C/D bit signaling information for each of 30 channels. This method uses the 32 timeslot frame format with timeslot 0 for the FAS and timeslot 16 for the MFAS and the CAS. As shown below, it takes 16 frames to make up a MultiFrame.

When an MFAS multiframe is transmitted, 16 FAS frames are assembled together, timeslot 16 of the first frame is dedicated to MFAS/NMFAS bits, and timeslot 16 of the remaining 15 frames is dedicated to A/B/C/D bits as shown in Figure 151.

**Higher Rate FAS**

A frame alignment signal is used to align tributaries within higher rate CEPTs. Table 14 shows FAS and the basics of multiplex framing for the various CEPTs. Justification bits may be added to each frame to aid proper alignment. A justification control signal is distributed via $C_{jn}$ bits to indicate the tributary information has been added to the higher rate frame.

If four consecutive frame alignment signals have been incorrectly received, framing is considered lost, an alarm is sent back up the line. Frame alignment is considered found again when 3 consecutive FAS have arrived as predicted. Alarms may also be generated for such faults as LOS, at both the tributary and full rate levels. The AIS signal is all 1s.

| Rate (kbit/s) | Tributary Rate (kbit/s) | Number of Tributaries | FAS | Frame Length (bits) | Bits per Tributary |
|---|---|---|---|---|---|
| 8,448 | 2,048 | 4 | 1111010000 | 848 | 206 |
| 34,368 | 8,448 | 4 | 1111010000 | 1,536 | 378 |
| 139,264 | 34,368 | 4 | 111110100000 | 2,928 | 723 |

**Table 14 Multiplexing Frame Structure**

**CRC Error Checking**

A CRC-4 (Cyclic Redundancy Check-4) is often used in E1 transmission to identify possible bit errors. CRC-4 allows us to detect errors within the 2.048 Mbit/s signal while it is in service.

The equipment which originates the 2M data calculates the CRC-4 bits for one sub-multiframe. Then it inserts the CRC-4 bits in the CRC-4 positions in the next sub-multiframe. The receiving equipment performs the reverse mathematical computation on the sub-multiframe. It examines the CRC-4 bits which were transmitted in the next sub-multiframe, then it compares the transmitted CRC-4 bits to the calculated value. If there is a discrepancy in the two values, a CRC-4 error is reported.

There is one major disadvantage of relying on CRC-4 errors to determine the performance of an E1 circuit; each individual

CRC-4 error does not necessarily correspond to a single bit error. Multiple bit errors within the same sub-multiframe will lead to only one CRC-4 error for the block. Also, it is possible that errors could occur such that the new CRC-4 bits are calculated to be the same as the original CRC-4 bits.

| M-FRM | SM-FRM | FRM | Time Slot 0 Bit 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 0 | c1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 1 | 0 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 2 | c2 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 3 | 0 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 4 | c3 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 5 | 1 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 6 | c4 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 7 | 0 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | 2 | 8 | c1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 9 | 1 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 10 | c2 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 11 | 1 | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 12 | c3 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 13 | E | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |
| | | 14 | c4 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | | 15 | E | 1 | A | Sa4 | Sa5 | Sa6 | Sa7 | Sa8 |

**Notes**:
- SM-FRM+1: Sub-Multiframe #1
- Sa: Spare bit reserved for National Use
- A: Remote Alarm (FAS Remote Alarm Indication)
- Frame Alignment Signal Pattern: 0011011
- CRC-4 Frame Alignment Signal: 001011
- CRC multiframe is not aligned with MFAS timeslot 16 multiframe
- SM-FRM 2: Sub-Multiframe #2
- E: E-bit Errors
- c1, c2, c3, c4: CRC bits

**Figure 152 CRC-4 Multiframe Format**

Thus, CRC-4 error checking provides a most convenient method of identifying bit errors within an in-service system, but provides only an approximate measure of the circuit's true performance. Consider the MFAS framing, shown in Figure 152. Each MFAS frame can be divided into sub-multiframes. These are labeled SMF#1 and SMF#2 and consist of 8 frames apiece. Four bits of CRC information are associated with each sub-multiframe.

The CRC-4 bits are calculated for each sub-multiframe, buffered, then inserted into the following sub-multiframe to be transmitted.

### E-bit Performance Monitoring

When the terminal equipment of a 2.048M circuit is optioned for CRC-4 transmission, E-bit transmission may also be enabled. E-bit performance monitoring of the circuit is now possible. The terminating equipment transmits an E-bit error on the 2.048 Mbit/s line, when it receives a CRC-4 error. However, E-bit error transmission is a relatively new feature in 2.048 transmission. Therefore, it is likely that the embedded equipment does not transmit the E-bit error information correctly. If in doubt, check the specifications of the network.

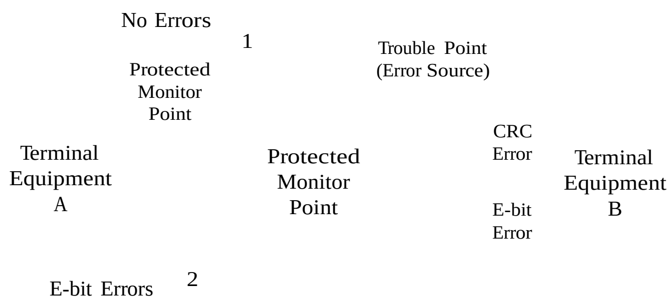



**Figure 153 In-service E-bit Performance Monitoring**

When this type of terminal equipment detects an incoming CRC-4 error, it will respond by transmitting an E-bit error toward the other terminal. Test set 2, shown in Figure 153, will be able to see the E-bit errors by plugging into a protected monitoring point. Note that the test set can not see the actual code errors, framing bit errors, and CRC errors introduced at the trouble point. The test set can see only the E-bit errors transmitted by Terminal B. Thus, E-bit error transmission allows a 2.048 Mbit/s in-service circuit to be reliably monitored for transmission performance from any point on the circuit.

Without E-bit error transmission, only a complete circuit failure can be reliably determined at any point on the circuit. With a complete circuit failure, the test set will see either loss of signal, alarm indication signal, or remote alarm indication.

### 4.3.6 ATM Technology

**Introduction**

ATM, or Asynchronous Transfer Mode, is part of the ITU-T Broadband ISDN (B-ISDN) specifications. Sometimes called cell relay, ATM uses short, fixed-length cells to transport data across the network. Unlike traditional time domain multiplexing (TDM) networks, ATM cells are not synchronized with a fixed timeslot. Idle cells fill any unused bandwidth.

As a connection-oriented technology, ATM relies on predefined connections designated by virtual paths (VP) and virtual channels (VC). The quality of service (QoS) of the connection is defined when the circuit is created. Verifying the QoS of an ATM connection is a vital element of testing ATM networks.

#### 4.3.6.1 Network Interfaces

An ATM network is built on a backbone of switches. Between switches, a network-to-network interface (NNI) is used. At the edge, a user-to-network interface (UNI) defines the connection between a user device and the ATM switch. For basic ATM applications, the differences between NNI and UNI are negligible; the latter adds an extra flow control field while sacrificing the total number of cell header values available.

**Figure 154 ATM Network over SDH**

### 4.3.6.2 ATM Adaptation Layer

ATM is designed to carry a wide variety of data types. An ATM Adaptation Layer (AAL) maps the data, such as TDM frames or IP packets, into ATM, even if the data packet spans multiple cells. AAL 1 is commonly used for constant bit rate (CBR) connections emulating TDM circuits. AAL 2 is most appropriate for variable bit rate (VBR) data. AAL 5 is the workhorse for IP over ATM. AAL 3/4 is being phased out in favor of AAL 5. AAL 0 refers to the case when no AAL is present.

### 4.3.6.3 Virtual Connections

ATM is connection-oriented. Before payloads are transmitted, the network must establish VCs (Virtual Channels). The VC address consists of a VPI (Virtual Path Identifier) and VCI (Virtual Channel Identifier). VPIs and VCIs have only local significance. They are remapped as necessary by the switch.

VCs that share a common VPI belong to the same VP (Virtual Path). A VP functions as a pipe; all cells sharing the same VPI are routed to the same port. VPs are switched transparently across the ATM network; as long as all the links have the same VPI, the switch does not look at or alter the VCI. A VCC (Virtual Channel Connection) consists of a chain of VCs across the network. VCCs can be point-to-point or point-to-multipoint. When a VCC is established, the user is given a certain QoS (Quality of Service), which specifies such details as cell loss ratio and cell delay variation.

A VPC (Virtual Path Connection) consists of a chain of VPs across the network. While the VPI values may be reassigned at each switch along the network, the VCI values remain intact between the two ends of the VPC. As with VCCs, VPCs are assigned a QoS. In Figure 155, note how each VC has VPI and a VCI in the VCC, but only a VPI in the VPC connection.

**Figure 155 VCC and VPC Connections**

A VP functions as a pipe; as long as all of the links have the same VPI (e.g. in a PVC), the VCI isn't looked at by the switch, since the path is already laid out.

VCI
VP VCs
Physical Layer Connection
VCI
VP VCs

**Figure 156 ATM Connections**

A VCC is a single connection between two (or more, if multipoint) ATM VCC endpoints. It consists of a bundle of concatenated VCs. The VCC endpoint is where the cell information field is exchanged between the ATM layer and the ATM user layer. At each switch, both the VCI and VPI are examined, so the link can be properly transferred.

VCCs are used for information transfer, between user-user, user-network, or network-network. The user is given a QoS, which specifies such details as cell loss ratio and cell delay variation. VCCs can be provided on PVCs or SVCs; hence they may be established and released with or without signaling, depending on the switching service. A signaling VCC may be used to establish the link for a VCC. Individual VCs may need to be established or released at the NNI as a result of the establishment/release of a VCC by the UNI.

A VPC consists of a bundle of VCCs carried transparently between two VPC endpoints. The VPC endpoint is where the VCIs are originated, translated, or terminated. They share a VPI and have the same endpoints. VP links are concatenated to form a VP Connection. VPCs are also assigned a QoS. Cell sequence integrity is preserved within a VPC. In order to switch VCs, the VPC supporting those links must be terminated, and a new outgoing VPC created. Cell integrity is preserved for each VC link in the VPC.

There are two types of VCCs: PVC (Permanent Virtual Connection) and SVC (Switched Virtual Connection). In a PVC, the VCC is defined by a series of routing tables created manually. PVCs are hard-coded into the network and remain intact until manually altered. Cells travelling through a PVC always take the exact same route. In a SVC, the VCC is created by the network only for the duration it is needed. The ATM network uses signaling to request, assign, and disconnect the SVC. The path dedicated for the SVC can be different each time the SVC is created.

### 4.3.6.4 Cell Structure

ATM cells consist of 53 octets (or bytes): 5 header bytes followed by 48 bytes of payload. The cell header differs slightly in UNI versus NNI. Cell payloads are often scrambled, to avoid problems such as long strings of zeros. For DS3, ATM cells are sometimes delineated upon PLCP framing.

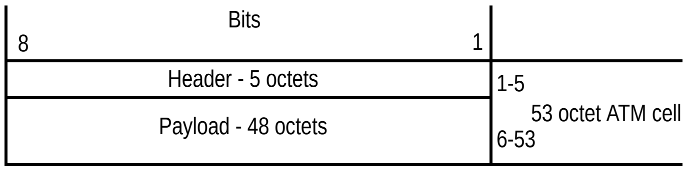



**Figure 157 ATM Cell Structure**

NNI Header

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit / Octet |
|---|---|---|---|---|---|---|---|---|
| VPI | | | | | | | | 1 |
| VPI | | | | VCI | | | | 2 |
| VCI | | | | | | | | 3 |
| VCI | | | | PT | | | CLP | 4 |
| HEC | | | | | | | | 5 |

UNI Header

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit / Octet |
|---|---|---|---|---|---|---|---|---|
| GFC | | | | VPI | | | | 1 |
| VPI | | | | VCI | | | | 2 |
| VCI | | | | | | | | 3 |
| VCI | | | | PT | | | CLP | 4 |
| HEC | | | | | | | | 5 |

CLP: Cell Loss Priority
GFC: Generic Flow Control
HEC: Header Error Control
PT: Payload Type
VCI: Virtual Channel Identifier
VPI: Virtual Path Identifier

**Figure 158 ATM Cell Headers**

The first four octets of each header are used to differentiate cells for the use of the ATM layer from those for the use of the physical layer. They also denote idle cells and physical OAM cells. The remaining values are used by the ATM layer.

### 4.3.6.5 GFC: Generic Flow Control

These 4-bits present only in UNI, assist in the control of the flow of traffic between an edge device and the network. GFC is primarily used to ease short-term overload conditions, but is not widely utilized. The default value of 0 is recommended for most ATM testing applications.

| Bit Values | Interpretation |
|---|---|
| 0000 | NO_HALT, NULL |
| 1000 | HALT, NULL_A, NULL_B |
| 0100 | NO_HALT, SET_A, NULL_B |
| 1100 | HALT, SET_A, NULL_B |
| 0010 | NO_HALT, NULL_A, SET_B |
| 1010 | HALT, NULL_A, SET_B |
| 0110 | NO_HALT, SET_A, SET_B |
| 1110 | HALT, SET_A, SET_B |
| All other values ignored | |

**Table 15 GFC to Controlled Equipment**

| Bit Values | Interpretation |
|---|---|
| 0000 | Terminal uncontrolled. Cell is assigned or on an uncontrolled ATM connection. |
| 0001 | Terminal controlled. Cell is unassigned or on an uncontrolled ATM connection. |
| 0101 | Terminal controlled.Cell is on a controlled ATM connection. Group A. |
| 0011 | Terminal controlled.Cell is on a controlled ATM connection. Group B. |
| All other values ignored | |

**Table 16 GFC to Controlling Equipment**

### 4.3.6.6 VPI and VCI

**VPI: Virtual Path Identifier**

In UNI, the VPI is 8 bits, accommodating 256 distinct paths. In NNI, the VPI is 12 bits accommodating 4096 distinct paths.

When testing an ATM connection, it is best to use the VPI value corresponding to the VCC being brought on-line.

**VCI: Virtual Channel Identifier**

The 16 VCI bits accommodate 65536 values, but the first 32 values (0–31) are reserved and some switches may not allow the full range for VCI.

When testing an ATM connection, it is best to use the VCI value corresponding to the VCC being brought on-line. Do not use the values reserved for user traffic. Unless specified otherwise, use VCI values from 32 to 1023.

| Use | VPI | VCI |
|---|---|---|
| Unassigned Cell | 00000000 | 00000000 00000000 |
| Invalid | Any VPI value except 0 | 00000000 00000000 |
| Meta Signaling | XXXXXXXX | 00000000 00000001 |
| General Broadcast | XXXXXXXX | 00000000 00000010 |
| Pt-to-Pt Signaling | XXXXXXXX | 00000000 00000101 |
| Segment OAM F4 Cell | Any Value | 00000000 00000011 |
| End-to-end OAM F4 Cell | Any Value | 00000000 00000100 |
| VP Resource Management | Any Value | 00000000 00000110 |
| Reserved For Future VP Functions | Any Value | 00000000 00000111 |
| Reserved For Future VP Functions | Any Value | 00000000 000SSSSS* |
| Reserved For Future VP Functions | Any Value | 00000000 000TTTTT** |
| Segment OAM F5 Cell | Any Value | Any value other than:<br>00000000 00000000<br>00000000 00000011<br>00000000 00000110<br>00000000 00000111 |
| End-to-end OAM F5 Cell | Any Value | Any value other than:<br>00000000 00000000<br>00000000 00000011<br>00000000 00000100<br>00000000 00000110<br>00000000 00000111 |
| **Notes** | | |
| * Any value from 01000 to 01111 | ** Any value from 10000 to 11111 | |

**Table 17 UNI VPI and VCI Values**

| Use | VPI | VCI |
|---|---|---|
| Unassigned Cell | 00000000 | 00000000 00000000 |
| Invalid | Any VPI value except 0 | 00000000 00000000 |
| NNI Signaling | Any value | 00000000 00000101 |
| Segment OAM F4 cell | Any value | 00000000 00000011 |
| End-to-end OAM F4 cell | Any value | 00000000 00000100 |
| VP Resource management | Any value | 00000000 00000110 |
| Reserved for future VP functions | Any value | 00000000 00000111 |
| Reserved for future VP functions | Any value | 00000000 000SSSSS* |
| Reserved for future VP functions | Any value | 00000000 000TTTTT** |
| Segment OAM F5 cell | Any value | Any value other than 00000000 00000000 |
| End-to-end OAM F5 cell | Any value | Any value other than 00000000 00000000 |
| VC Resource management | Any value | Any value other than 0000000 00000000, 0000000 00000110 |
| Reserved for future VC functions | Any value | Any value other than 00000000 00000000 |
| **Notes** | | |
| * Any value from 01000 to 01111 | ** Any value from 10000 to 11111 | |

**Table 18 NNI VPI and VCI Values**

### 4.3.6.7 CLP: Cell Loss Priority

Cells with this single bit set to 1 are subject to discard before cells with a CLP of 0. Typically, the CLP is set to 1 when a switch identifies the cell traffic is in violation of agreed parameters.

For most ATM testing applications, the CLP should be 0. For thorough quality of service testing, the Cell Loss Ratio (CLR) of a connection should be tested for CLP values of 0 and 1.

### 4.3.6.8 HEC: Header Error Control

The HEC field contains an 8-bit sequence derived from the previous 4 header bytes. The HEC allows an ATM switch to detect and correct a single bit error within the cell header. These are known as correctable HEC errors. Cells with two-or-more bit errors in the header result in non-correctable HEC error; the cell will be dropped. The HEC also provides cell delineation.

### 4.3.6.9 PTI: Payload Type Indicator

These three bits distinguish between user and network-use cells and indicate the presence of network congestion. When generating ATM user traffic, a PTI of 000 is recommended.

| PTI Coding Bits 432 | Interpretation |
|---|---|
| 000 | User data cell, congestion not experienced<br>ATM user-to-user indication = 0 |
| 001 | User data cell, congestion not experienced<br>ATM user-to-user indication = 1 |
| 010 | User data cell, congestion experienced<br>ATM user-to-user indication = 0 |
| 011 | User data cell, congestion experienced<br>ATM user-to-user indication = 1 |
| 100 | OAM F5 segment associated cell |
| 101 | OAM F5 end-to-end associated cell |
| 110 | UNI - Resource management cell<br>NNI - VC resource management cell |
| 111 | Reserved for future VC functions |
| *After Rec. I.361, Sec. 2.2.4 and 2.3.3* | |

**Table 19 PTI Decodes**

### 4.3.6.10 Cell Delineation

In most physical interfaces, ATM cells are placed end-to-end as shown in Figure 159.

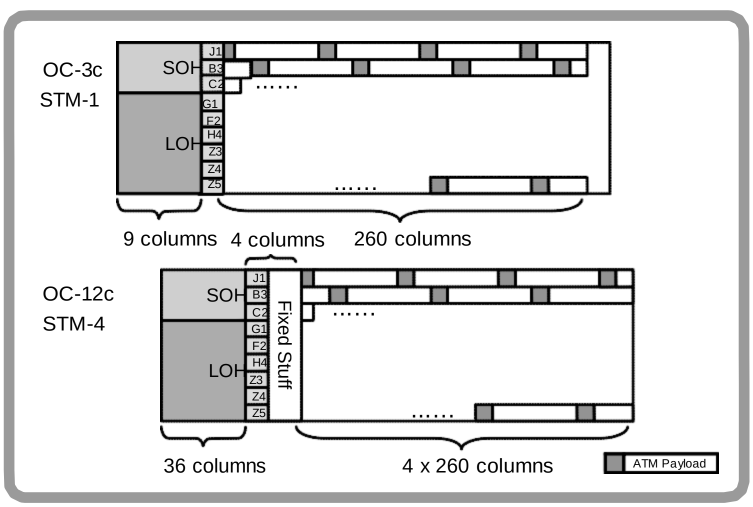



**Figure 159 ATM Cell Mapping**

When hunting for delineation, the ATM equipment looks at four consecutive bytes then checks for a valid HEC value in the following byte. This is done bit-by-bit until a valid HEC is found. Delineation is then confirmed over a number of cells. This style of delineation is known as HEC-based.

Older 45M equipment uses a delineation scheme known as Physical Layer Convergence Protocol (PLCP). The PLCP frame, with stuffing, is placed inside the DS3 frame.

| | | | | | |
|---|---|---|---|---|---|
| A1 | A2 | P11 | Z6 | 1st ATM Cell | |
| A1 | A2 | P10 | Z5 | ATM Cell | |
| A1 | A2 | P09 | Z4 | ATM Cell | |
| A1 | A2 | P08 | Z3 | ATM Cell | |
| A1 | A2 | P07 | Z2 | ATM Cell | |
| A1 | A2 | P06 | Z1 | ATM Cell | |
| A1 | A2 | P05 | X | ATM Cell | |
| A1 | A2 | P04 | B1 | ATM Cell | |
| A1 | A2 | P03 | G1 | ATM Cell | |
| A1 | A2 | P02 | X | ATM Cell | |
| A1 | A2 | P01 | X | ATM Cell | |
| A1 | A2 | P00 | C1 | 12th ATM Cell | Trailer |
| 4 Bytes | | | | 53 Bytes | 13 or 14 Nibbles |

**Key**

- **A1/A2**: Frame alignment
- **C1**: Cycle/Stuff counter
- **Pxx**: Path overhead identifier
- **B1**: PLCP path error monitoring (BIP-8)
- **G1**: PLCP path status (FEBE and RAI)
- **Zx**: Growth bytes

**Figure 160 PLCP Framing**

### 4.3.6.11 ATM Scrambling

Most ATM networks use scrambling as the default. ATM scrambling only applies to the 48-byte payload; the header is never scrambled. In SONET/SDH systems, ATM scrambling provides protection from data that might duplicate the SONET/SDH framing bytes.

### 4.3.6.12 Operations and Maintenance Fault Management

ATM fault management and network messaging is handled in-band with Operation, Administration, and Maintenance (OAM) cells. ATM builds upon the Section-Line-Path model of SONET and adds two more flows: virtual path (F4) and virtual channel (F5). Furthermore, OAM cells are designated as segment, applying to a single VPC or VCC link, or end-to-end.

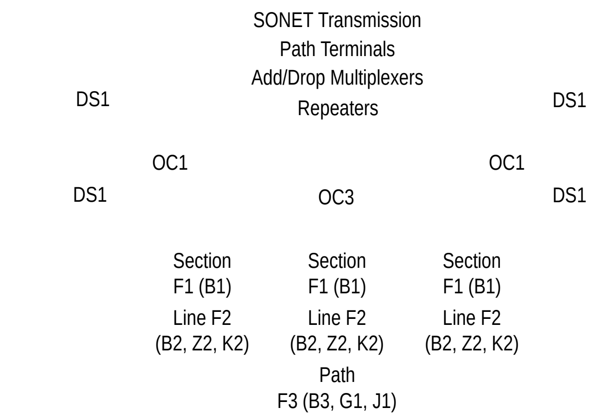



**Figure 161 OAM Flows**

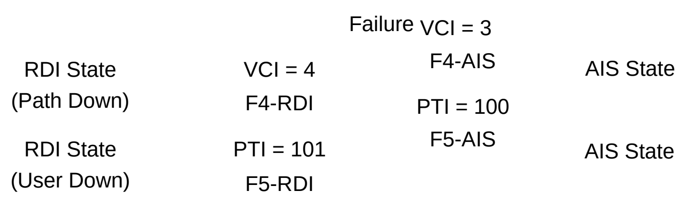



**Figure 162 F4 and F5 Flows**

F4 or VP OAM cells apply to all cells within the VP. The VPI of the OAM cell signifies the virtual path, but the VCI is set to 3 or 4. F5 ATM 83 or VC OAM cells only apply to a specific VC, so both the VPI and VCI are kept intact. The PTI is then set to 100 or 101 to signify an F4 OAM cell. The OAM cell payload contains function-specific information as shown in Figure 163.

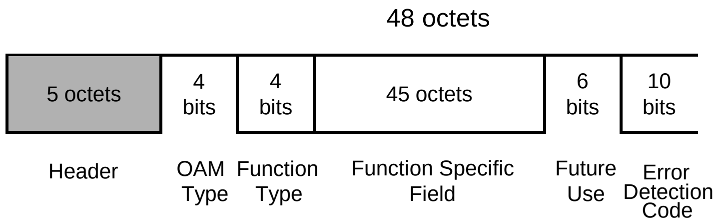



**Figure 163 OAM Cell**

Fault management cells come in four types: Alarm Indication Signal (AIS), Remote Defect Indication (RDI), Continuity Check (CC), and Loopback cells.

VP-AIS cells are sent downstream when a switch detects a Path AIS or a loss of continuity at the VP layer. When a switch detects a VP-AIS or Loss of Cell Delineation (LCD), it sends VP-RDI cells upstream. Similarly, a switch will send a VC-AIS cell downstream upon detecting a VP-AIS and send a VC-RDI upstream upon detecting a VC-AIS. AIS and RDI cells are sent once per second until the defect is cleared.

To verify continuity along a VP or VC, switches will send continuity check cells either once per second, bandwidth permitting, or when a user cell has not been detected for one second. When continuity check cells are not detected, a Loss of Continuity (LOC) defect may be declared.

Loopback cells provide dual-ended continuity. When a switch receives a loopback cell, it sends the cell back on the return path and toggles a loopback indication bit within the cell. Some switches send loopback cells like continuity cells and may go into alarm if they do not receive loopback cells.

Performance monitoring cells carry network performance and defect information in both the upstream and downstream directions. Typically, they are sent after a designated number of cells and should this not occur, a loss of forward monitoring flow (VP/VC-LFMF) may be declared.

Activation/Deactivation cells turn on/off the continuity check and performance monitoring functions. Automatic Protection Switching (APS) cells provide circuit protection at the ATM layer. System management cells are reserved for network use.

#### 4.3.6.13 Alarms and Errors

**LOS**: Loss of Signal is declared within 100 ms of the onset of an all-zeros pattern lasting 2.3 ms or longer (no light pulses for optical, no voltage for electrical). LOS is cleared with 2 consecutive valid frames.

**LOF**: Loss of Frame occurs when Out of Frame on the incoming signal persists for 3 milliseconds; OOF is declared when four or more consecutive errored framing patterns have been received. LOF is cleared with 2 consecutive valid frames.

**LOP**: Loss of Pointer (on the Path or VT) is declared when a valid AU pointer cannot be obtained; or if valid pointer is not found in 8, 9, or 10 consecutive frames, or if 8, 9, or 10 consecutive NDF are detected (bits 1-4 of pointer words; H1-H2 bytes carry the NDF. Cleared with valid pointers in 3 consecutive frames.

**LCD**: Loss of Cell Delineation occurs when HEC coding ruled is incorrect seven consecutive times on the incoming signal.

**VP/VC RDI**: Virtual Path/Virtual Container RDI (Remote Defect Indication) alerts upstream equipment that downstream failure has been detected in the path or container. VP RDI is generated within 250 microseconds by STS PTE upon entering LOS, LOF, LOP, LOC state, or on detecting Line or Path AIS. Cells are sent once per second until the defect is cleared. RDI is released when no RDI cells are received for 2.5 +/- 0.5 seconds.

**VP/VC AIS**: Virtual Path AIS (Alarm Indication Signal) is sent downstream when a switch detects a Path or Container AIS or a loss of continuity at the VP/VC layer. Cells are sent once per second until the defect is cleared. AIS is released when User or Continuity Cell Received.

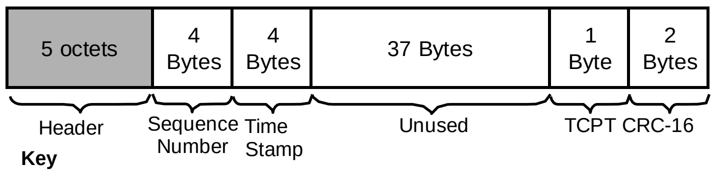
**VP/VC LFMF**: Loss of Forward Monitoring Flow alarm on the Virtual Path or Virtual Container. Too few Forward PM cells. Released with valid Forward PM cell.

**VP/VC LOC**: Loss of Continuity alarm on the Virtual Path or Virtual Container; switches will send continuity check cells either once per second, bandwidth permitting, or when a user cell has not been detected for one second.

**HEC**: Header Error Control check; calculates a checksum on the header itself only. A cell is discarded if its header is declared invalid, or if the header is valid but the resulting header impermissible.

### 4.3.6.14 Test Cells

ITU-T O.191 defines a standard test cell for measuring QoS.




**Key**

**Sequence Number**: Identifying lost, misinserted, and out of sequence cells.

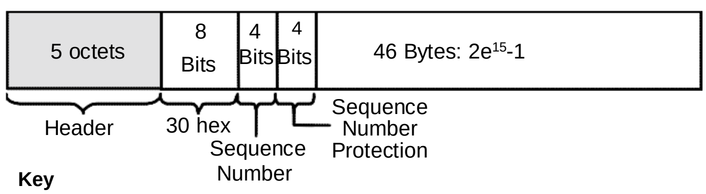
**Time Stamp**: Used for cell delay variation measurements. If no time stamp, cell delay measurements are not possible.

**TCPT**: Test Cell Payload Type; there is only one type at this time.

**CRC**: Two bytes used for CRC-16 error detection.

**Figure 164 O.191 Test Cell**

The NTT devised the OAM-B test cell to measure QoS before the O.191 test cell was defined.




**Key**

**Sequence Number**: Identifying lost, misinserted, and out of sequence cells. The relationship between the Sequence Number and Sequence Number Protection is as follows:

SN: 0 1 2 3 4 5 6 7 8 9 A B C D E F

SNP: 0 7 D A E 9 3 4 B C 6 1 5 2 8 F

**Test Pattern**: Error detection. Bit errors are used to count bit errors, BER, and the Cell Error Ratio.

**Figure 165 OAM-B Test Cell**

### 4.3.7 IP

Internet Protocol is a higher-level protocol that is transported commonly over ATM, via Adaptation Layer 5. This is illustrated in the figure to the right. The RFC 1557 standard resolves addressing issues between IP and ATM. An ATM endpoint can be a member of several IP subnets (an IP network reached through a single IP address), since ATM is connection based.

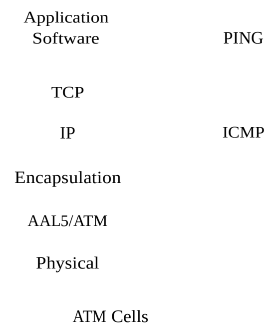



**Figure 166 TCP/IP over ATM**

#### 4.3.7.1 IP Technology

The name PING is derived from the SONAR world where one pings an object in the water and listens for its echo. This con- cept applies to the Internet world, where one pings an address and waits for its echo (reply). This verifies that the end device is present and that the connection is active.

The PING message is an ICMP (Internet Control Message Protocol) message. Both devices must be using TCP/IP protocol. However, IP can be encapsulated onto the ADSL physical layer in several ways. Figure 167 provides a summary of the different implementation schemes for IP over ADSL.

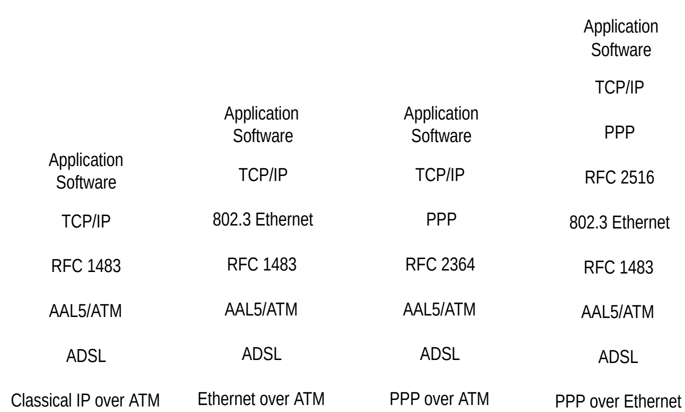



**Figure 167 Encapsulation Technologies for IP over ADSL**

#### 4.3.7.2 Classical IP over ATM (CLIPoA)

Classical IP over ATM is an IETF protocol which uses ATM's high speed ability in the Local Area Network. It uses the ATMF (ATM25.6) physical interface over Twisted Pair Cable (per ATM Forum) to interconnect in the LAN at the speed of 25.6 Mbps.

Classical IP over ATM reduces overhead by having IP and ARP datagrams encapsulated in AAL5 using IETF RFC1483 LLC/SNAP encapsulation.

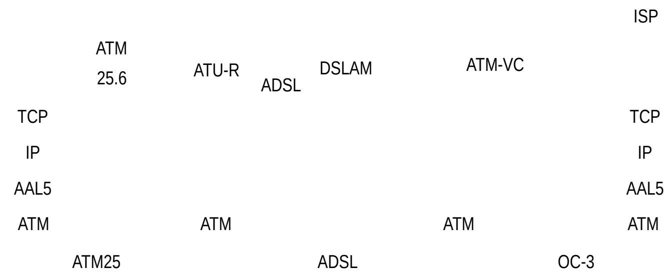



**Figure 168 Classical IP over ATM**

#### 4.3.7.3 Ethernet Frames over ATM (EoA)

In this case, Ethernet frames are encapsulated into the ATM Adaptation Layer 5 (AAL5) using RFC 1483. The encapsulation supports both routing and bridged. This is based on the standard RFC 1483–Multi protocol Encapsulation over AAL 5.

Figure 169 shows a sample configuration of Ethernet over ATM used in the field. In this case, IP address management can be static with RFC 1483 Bridge encapsulation, dynamic with the use of DHCP session management or it can use RFC 1483 Routed.

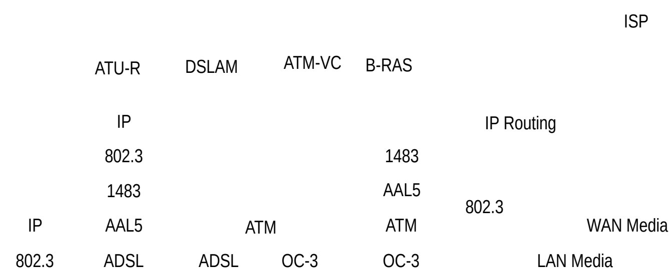



**Figure 169 Ethernet over ATM**

### 4.3.7.4 PPP over Ethernet (PPPoE) over ATM

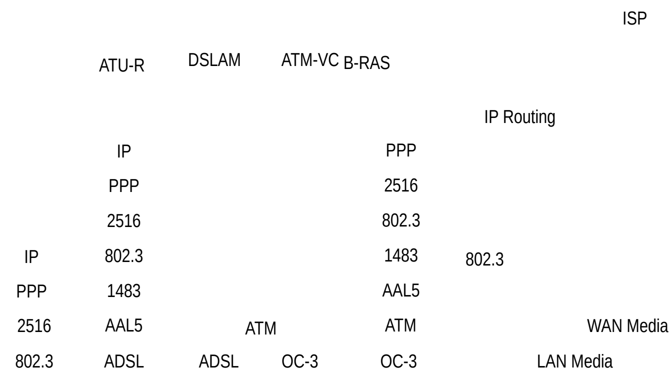



**Figure 170 PPP over Ethernet (PPPoE)**

PPPoE uses Ethernet networking with PPP in an encapsulation scheme designed for multi-PC homes and small businesses. PPPoE enables multiple PCs to connect to multiple destinations through a single, shared CPE using one PVC. This is based on the standard RFC 2516–PPP over Ethernet.

### 4.3.7.5 PPP over ATM (PPPoA)

PPPoA has a great advantage in reducing the overhead required in PPPoE. It is based on the standard RFC 2364–PPP over AAL 5.

For PPP (PPPoE and PPPoA), IP address management will most likely be dynamic. However, static IP address management can exist. Found in PPPoA are the following implementations of IP management.

- Static IP address management over PPP.
- Dynamic IP address management over PPP. In this case, the IP address is requested and assigned at the time of the connection.

Authentication is commonly used since it provides security for the connection. In the case of PPP, identification is controlled with a user name and password. These will be required in order to open a link with the ISP. Identification can use either the PAP or the CHAP authentication mechanisms. The PPP session is opened with the Broadband-Remote Access Server (B-RAS). The LCP session is handled between the B-RAS and the PC (CPE) to manage the authentication of the user name and password.

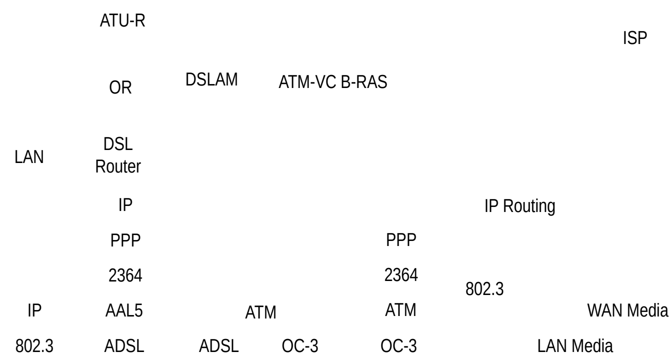



**Figure 171 PPP over ATM (PPPoA)**

### 4.3.7.6 IP Acronyms

Here are some of the acronyms and abbreviations you will commonly encounter.

**CHAP**: Challenge Handshake Authentication Protocol

**CLIPoA**: Classical IP over ATM

**DHCP**: Dynamic Host Configuration Protocol

**LCP**: Link Control Protocol

**LLC**: Logical Link Control

**PAP**: Password Authentication Protocol

**PPP**: Point-to-Point Protocol

**PPPoA**: Point-to-Point over ATM

**PPPoE**: Point-to-Point over Ethernet

**PVC**: Permanent Virtual Circuit

**VCI**: Virtual Channel Identifier

**VPI**: Virtual Path Identifier

# 5 General Information

## 5.1 Testing and Calibration Statement

VeEX Inc certifies that this product was manufactured, tested, and verified according to the applicable VeEX Inc Incorporated manufacturing and test procedure(s). These formal procedures are designed to assure that the product meets its required specifications.

This product has no user-adjustable settings. During normal usage, periodic calibration is not a requirement. However, if the product fails during the self-verification test, during power up, the product can be returned to the manufacturer for evaluation and repair.

## 5.2 Express Limited Warranty

A. Hardware Coverage. COMPANY warrants hardware products against defects in materials and workmanship. During the warranty period COMPANY will, at its sole option, either (i) refund of CUSTOMER'S purchase price without interest, (ii) repair said products, or (iii) replace hardware products which prove to be defective; provided, however, that such products which COMPANY elects to replace must be returned to COMPANY by CUSTOMER, along with acceptable evidence of purchase, within twenty (20) days of request by COMPANY, freight prepaid.

B. Software and Firmware Coverage. COMPANY warrants software media and firmware materials against defects in materials and workmanship. During the warranty period COMPANY will, at its sole option, either (i) refund of CUSTOMER'S purchase price without interest, (ii) repair said products, or (iii) replace software or firmware products which prove to be defective; provided, however, that such products which COMPANY elects to replace must be returned to COMPANY by CUSTOMER, along with acceptable evidence of purchase, within twenty (20) days of request by COMPANY, freight prepaid. In addition, during the warranty period, COMPANY will provide, without charge to CUSTOMER, all fixes and patches to the original product specifications sold which COMPANY issues during the warranty period. COMPANY does not warrant or represent that all software defects will be corrected. In any case where COMPANY has licensed a software product "AS-IS," COMPANY'S obligation will be limited to replacing an inaccurate copy of the original material. This warranty does not cover upgrade or enhancements to product software and firmware.

C. Period. The warranty period for Hardware, Software and Firmware will be One (1) Year from date of shipment to CUSTOMER.

The COMPANY may also sell warranty extensions or provide a warranty term of three years with the original sale, which pro- vide a longer coverage period for the test set chassis, software and firmware, in which case the terms of the express limited warranty will apply to said specified warranty term.

D. Only for CUSTOMER. COMPANY makes this warranty only for the benefit of CUSTOMER and not for the benefit of any subsequent purchaser or licensee of any merchandise.

E. LIMITATION ON WARRANTY. THIS CONSTITUTES THE SOLE AND EXCLUSIVE WARRANTY MADE BY COMPANY WITH RESPECT TO HARDWARE, SOFTWARE AND FIRMWARE. THERE ARE NO OTHER WARRANTIES, EXPRESS OR IM- PLIED. COMPANY SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. COMPANY'S LIABILITY UNDER THIS AGREEMENT WITH RESPECT TO A PRODUCT, INCLUD- ING COMPANY'S LIABILITY FOR FAILURE AFTER REPEATED EFFORTS TO INSTALL EQUIPMENT IN GOOD WORKING ORDER OR TO REPAIR OR REPLACE EQUIPMENT, SHALL IN NO EVENT EXCEED THE PURCHASE PRICE OR LICENSE FEE FOR THAT PRODUCT, NOR SHALL COMPANY IN ANY EVENT BE LIABLE FOR ANY INCIDENTAL, CONSEQUEN- TIAL, INDIRECT, OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, ARISING FROM OR RELATED TO THE SALE OF THE MERCHANDISE HEREUNDER, INCLUD- ING BUT NOT LIMITED TO DAMAGES ARISING FROM OR RELATED TO LOSS OF BUSINESS, LOSS OF PROFIT, LOSS OF GOODWILL, INJURY TO REPUTATION, OVERHEAD, DOWNTIME, REPAIR OR REPLACEMENT, OR CHARGE-BACKS OR OTHER DEBITS FROM CUSTOMER OR ANY CUSTOMER OF CUSTOMER.

F. No Guaranty, Nonapplication of Warranty. COMPANY does not guaranty or warrant that the operation of hardware, soft- ware, or firmware will be uninterrupted or error-free. Further, the warranty shall not apply to defects resulting from:

(1) Improper or inadequate maintenance by CUSTOMER; (2) CUSTOMER-supplied software or interfacing;
(3) Unauthorized modification or misuse;
(4) Operation outside of the environmental specifications for the product;
(5) Improper site preparation or maintenance; or
(6) Improper installation by CUSTOMER.