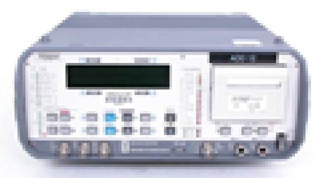
WWG PF-45

DS1 / DS3 Analyzer



4.2.4 Out-of-Service Testing of DS1 Embedded in DS3: M13 Demultiplexer Testing

[Tx^3_1->Rx1] mode (Fig 4-6), is used for DS1 testing when the test object requires the DS1 test signal be already embedded in DS3, but the returning test signal is at DS1 line rate. In this case the system under test may be an M13 demux, or simply perform that function.

1. - Connect the PF-45 DS1 receive jack [14] to the monitor jack of the outgoing DS1 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-6.

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "Tx^3_1->Rx1" is in the lower left display quadrant as shown below.
   - "Execute" the mode change by pressing key [D] once.

```
SET NEW MODE
Tx31->Rx1    EXECUTE
```
(Set New Mode Page)

3. - Press the [Tx/Rx] SETUP key once again, bringing up the "DS3 Setup Page".
   - Press key [A] until Tx3:DSX is displayed as shown below.
   - Press key [C] until the desired DS3 frame format is selected.

```
Tx3:DSX      Rx3:N/A
Frm3:M13    Clk3:N/A
```
(DS3 Setup Page)

4. - Press the [Tx/Rx] SETUP key once again, bringing up the "DS1 Setup Page".
   - Press key [B] until Rx1:Term is displayed as shown below.
   - Press key [D] until Clk1:Int is displayed as shown below.
   - Press key [A] to select the DS1 line code.
   - Press key [C] until the desired DS1 frame format is selected.

```
Code:AMI     Rx1:Term
Frm1:ESF    Clk1:Int
```
(DS1 Setup Page)

5. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page.
   - Press key [A] until the QRSS20 pattern is displayed..

```
Ptn:QRSS20
```
(Pattern Select Page)

6. - Press the [AUX/TIME] SETUP key until the "Test Duration" Page is displayed as shown below.
- If a continuous measurement run is desired, press key [B] to bring up "CONT". Skip the rest of step 6.
- If a timed measurement run (say, 15 minutes) is desired, press key [B] to bring up "TIMED".
- Press key [C] once. The four "Hours" digits blink along with the Data Entry LED. Set the hours to 0000 with the Data Entry keys.
- Press key [C] a second time. The two "Minutes" digits blink along with the Data Entry LED. Set the minutes to 15 with the Data Entry keys.
- Press key [C] a third time. The two "Seconds" digits blink along with the Data Entry LED. Set the seconds to 00 with the Data Entry keys.
- Press key [C] a fourth time. This completes the Test Duration setup.

```
Test Duration: TIMED
H:0000/M:15/S:00
```
(Test Duration Page)

7. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 7, otherwise continue.
- Press the [AUX/TIME] SETUP key to bring up the "Printer" Page.
- Press key [B] until SUMMARY is displayed as shown below.
- Press key [D] until AT END OF RUN is displayed as shown below.

```
AutoPrint:   SUMMARY
       AT END OF RUN
```
(Test Duration Page)

8. - Press the [ERROR] Measure key to bring up that display category. Select the "BIT" Event, and the "ErrCnt=..." Analysis.
- Connect the PF-45 DS3 transmit jack [11] to the DS3 input jack of the multiplexer at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-6.
- To verify the connection, we will send an error in one of the 28 transmitted DS1s.
- Select the desired Tx DS1 Channel. First, press [MODE] which will start the displayed channel number blinking along with the Data Entry LED. Use the Data Entry keys to set the desired channel number, then press [MODE] again to exit the channel selection process.
- Make a careful check of the RxSTATUS LEDs. Do we have signal? Are we in frame sync? Is any alarm or idle signal present? Do we have Pattern Sync? If the status is as expected, then continue.
- Now, make a short measurement run, by pressing [START/STOP].
- Use the Error Insertion [Down Arrow] to select "Bit".
- Press [SINGLE].
- If the connection has been made correctly, the Bit Error Count will = 1.
- Press [START/STOP] to stop the measurement run.

9. - The DS1 connectivity has now been verified, and the PF-45 is also setup.
- Before starting the measurement run, make a careful check of the RxSTATUS LEDs. Do we have DS1 signal? If a framed DS1 signal is expected, are we in frame sync? Is any alarm or signal present? Do we have Pattern Sync?
- If the status is as expected, then begin the measurement run by pressing the [START/STOP] key, lighting the "Measurement Run" LED.
- During the measurement run, the user can view the monitored values under MEASURE [ERROR] and [RxSTATUS]. This will not effect the measurement run.
- During the measurement run, do not change any values under SETUP. This will automatically stop the measurement run.
- If the PF-45 is to be left unattended, it is suggested that the [RxSTATUS] key be pressed until Rx Status "Seconds", (rather than "Elapsed" time or seconds), are displayed. Then press key [B] until "Total ErrSecs= XXXXXXXX" is displayed. The PF-45 now shows the number of "any-kind-of" errored seconds, and the RxSTATUS LEDs are in "History" mode. Leave the PF-45 set like this. When the user comes back, the display immediately shows the occurrence of any errors, and the RxSTATUS LEDs show the occurrence of any sync losses, and/or alarms.

```
Total ErrSecs=       0
Tx31:xx->Rx1
```

10. - When the measurement run has timed out, or the [START/STOP] key is pushed again, the measurement run LED will extinguish, the final values for the run are available for viewing, and if the Summary AutoPrint was set, an automatic print-out of the results will start.

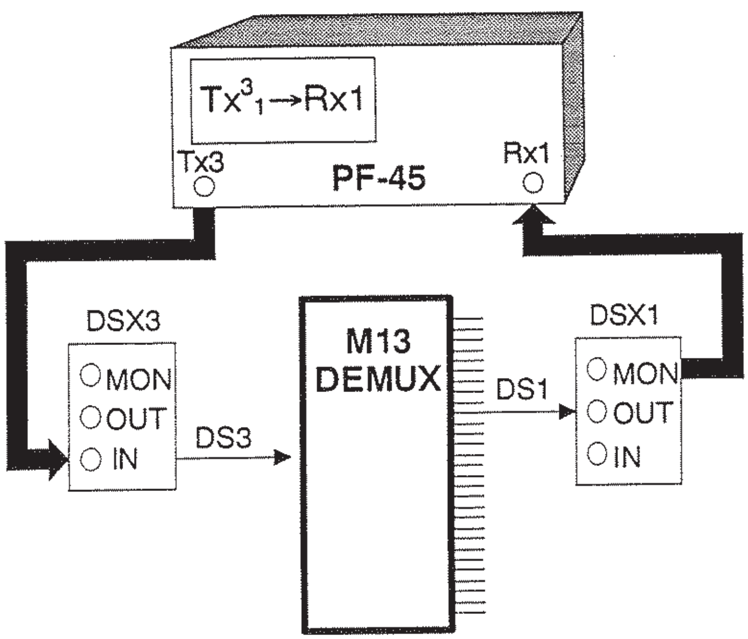


Figure 4-6: Tx^3_1->Rx1 Mode

4.2.5 Out-of-Service Testing of DS1 Embedded in DS3: 31 DACS Testing

[Tx^3_1->Rx^3_1] mode (Fig 4-7), is used for portions of a system where the Tx and Rx DS1 test signal appearances are both at DS3. This is an appropriate test mode for DACS 3/1 (as shown) or back-to-back M13's.

1. - Connect the PF-45 DS3 receive jack [12] to the monitor jack of the outgoing DS3 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-7.

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "Tx^3_1->Rx^3_1" is in the lower left display quadrant as shown below.
   - "Execute" the mode change by pressing key [D] once.

```
SET NEW MODE
Tx31->Rx31  EXECUTE
```
(Set New Mode Page)

3. - Press the [Tx/Rx] SETUP key once again, bringing up the "DS3 Setup Page".
   - Press key [B] until Rx3:DSX is displayed as shown below.
   - Press key [A] until Tx3:DSX is displayed as shown below.
   - Press key [C] until the desired DS3 frame format is selected.
   - Press key [D] until Clk3:Int is displayed as shown below.

```
Tx3:DSX      Rx3:DSX
Frm3:M13    Clk3:Int
```
(DS3 Setup Page)

4. - Press the [Tx/Rx] SETUP key once again, bringing up the "DS1 Setup Page".
   - Press key [D] until Clk1:Int is displayed as shown below.
   - Press key [A] to select the DS1 line code.
   - Press key [C] until the desired DS1 frame format is selected.

```
Code:AMI     Rx1:N/A
Frm1:ESF    Clk1:Int
```
(DS1 Setup Page)

5. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page.
   - Press key [A] until the QRSS20 pattern is displayed..

```
Ptn:QRSS20
```
(Pattern Select Page)

6. - Press the [AUX/TIME] SETUP key until the "Test Duration" Page is displayed as shown below.
   - If a continuous measurement run is desired, press key [B] to bring up "CONT". Skip the rest of step 6.
   - If a timed measurement run (say, 15 minutes) is desired, press key [B] to bring up "TIMED".

- Press key [C] once. The four "Hours" digits blink along with the Data Entry LED. Set the hours to 0000 with the Data Entry keys.
- Press key [C] a second time. The two "Minutes" digits blink along with the Data Entry LED. Set the minutes to 15 with the Data Entry keys.
- Press key [C] a third time. The two "Seconds" digits blink along with the Data Entry LED. Set the seconds to 00 with the Data Entry keys.
- Press key [C] a fourth time. This completes the Test Duration setup.

```
Test Duration: TIMED
H:0000/M:15/S:00
```
(Test Duration Page)

7. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 7, otherwise continue.
- Press the [AUX/TIME] SETUP key to bring up the "Printer" Page.
- Press key [B] until SUMMARY is displayed as shown below.
- Press key [D] until AT END OF RUN is displayed as shown below

```
AutoPrint:   SUMMARY
       AT END OF RUN
```
(Test Duration Page)

8. - Press the [ERROR] Measure key to bring up that display category. Select the "BIT" Event, and the "ErrCnt=..." Analysis.
- Connect the PF-45 DS3 transmit jack [11] to the DS3 input jack of the multiplexer at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-7.
- Verify the DS1 connectivity by inserting an error in the transmitted DS1 of interest, and monitoring the received DS1 for its occurrence.
- Select the desired Tx DS1 Channel number for error insertion. First, press [MODE] which will start the displayed Tx channel number blinking along with the Data Entry LED. Use the Data Entry keys to set the desired channel number.
- Press [MODE] again to repeat the process for the Rx dropped-DS1 Channel number.
- Make a careful check of the RxSTATUS LEDs. Do we have signal? Are we in frame sync? Is any alarm or idle signal present? Do we have Pattern Sync? If the status is as expected, then continue.
- Make a short measurement run by pressing [START/STOP].
- Use the Error Insertion [Down Arrow] to select "Bit".
- Press [SINGLE].
- If the connection has been made correctly, the Bit Error Count will = 1.
- Press [START/STOP] again to end the measurement.

9. - The DS1 connectivity has now been verified, and the PF-45 is also setup.
- Before starting the measurement run, make a careful check of the RxSTATUS LEDs. Do we have both DS3 and DS1 signal? Do we have DS3 Frame Sync? If a framed DS1 signal is expected, are we in frame sync? Is any alarm or idle signal present? Do we have Pattern Sync?

- If the status is as expected, then begin the measurement run by pressing the [START/STOP] key, lighting the "Measurement Run" LED.
- During the measurement run, the user can view the monitored values under MEASURE [ERROR] and [RxSTATUS]. This will not effect the measurement run.
- During the measurement run, do not change any values under SETUP. This will automatically stop the measurement run.
- If the PF-45 is to be left unattended, it is suggested that the [RxSTATUS] key be pressed until Rx Status "Seconds", (rather than "Elapsed" time or seconds), are displayed. Then press key [B] until "Total ErrSecs= XXXXXXXX" is displayed. The PF-45 now shows the number of "any-kind-of" errored seconds, and the RxSTATUS LEDs are in "History" mode. Leave the PF-45 set like this. When the user comes back, the display immediately shows the occurrence of any errors, and the RxSTATUS LEDs show the occurrence of any sync losses, and/or alarms.

```
Total ErrSecs=      0
Tx31:xx->Rx31:xx
```

10. - When the measurement run has timed out, or the [START/STOP] key is pushed again, the measurement run LED will extinguish, the final values for the run are available for viewing, and if the Summary AutoPrint was set, an automatic print-out of the results will start.

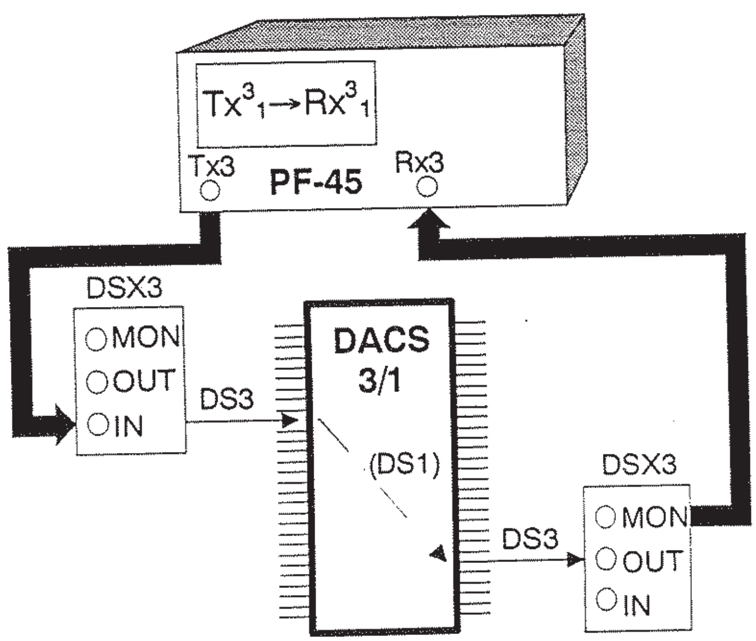


Figure 4-7: Tx^3_1->Rx^3_1 Mode

4.3 DROP & INSERT

The following two Drop & Insert modes (Fig 4-8) allow the user to replace a single DS1 within a DS3 signal for test or patch purposes, without the use of a DACS 3/1 or back-to-back M13 muxes.

[Int D&I$^3_1$] mode inserts a PF-45-generated test pattern in the selected DS1 channel, and analyzes the received DS3 and dropped DS1.

[Ins$^3_1$->Rx1] mode inserts a PF-45-generated test pattern in the selected DS1 channel, and analyzes the received DS3, but in this case the DS1 analysis is of the received bipolar DS1. This enables testing of an M13 demux (or that function) with only 1 DS1 out of 28 taken out-of-service.

[ExtD&I$^3_1$] mode inserts an externally-supplied DS1 signal inserted in the rear-panel bipolar DS1 Insert/Ref jack, and also analyzes the received DS3 and dropped DS1.

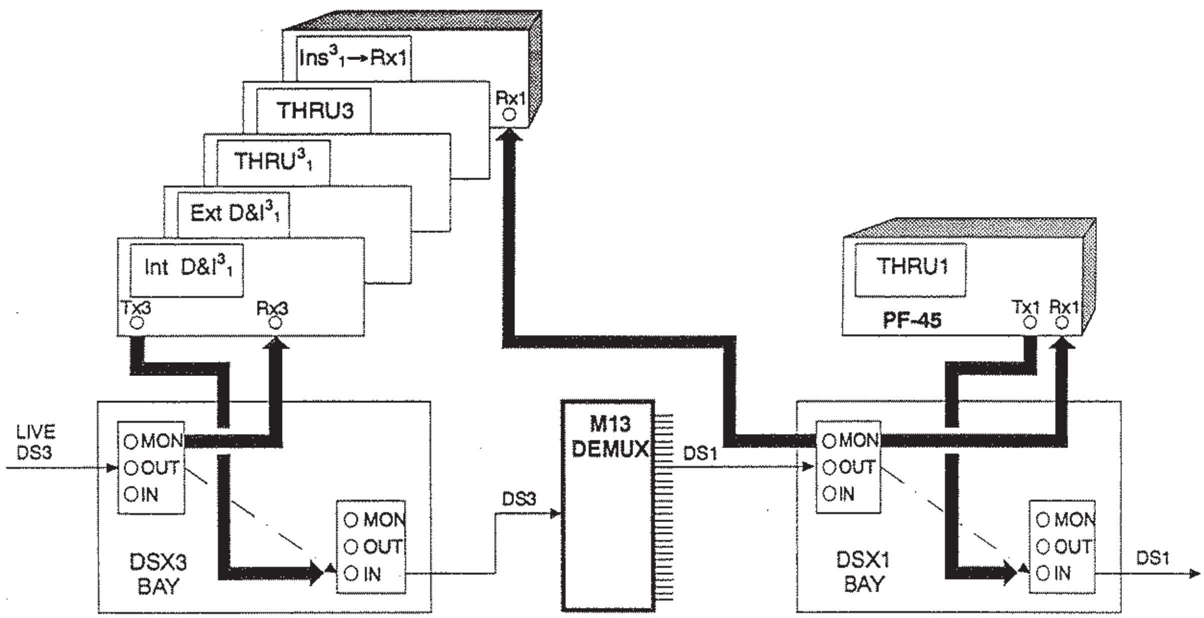


Figure 4-8: Drop & Insert/Thru Modes

4.4 ERROR INSERTION

The error-insertion feature addresses the need to test and verify circuits within DS3 and DS1 network equipment which monitor and respond to errors and alarms. A partial list follows:

DS3 transmission systems respond to parity errors, and DS1 systems respond to BPVs, frame or CRC errors for Automatic Protection Switching. DS1 intelligent CSU's respond to CRC errors. DS3 and DS1 performance monitoring network elements report parity, C-parity, F-bit and/or CRC errors and error ratios. The PF-45 can insert Bit, BPV, frame, parity/C-parity, FEBE, and CRC errors singly, at a selected ratio (1E-2,5E-3,2E-3,1E-3...1E-9), or in a timed burst of the selected ratio.

DS3 and DS1 network elements respond to network alarms. The PF-45 can insert alarms continuously or in a timed burst (1mS resolution).

4.4.1 Bit Error Insertion

Generally, "BIT" errors are inserted in the internally-generated test patterns (for TEST modes), or the data-bits (non-overhead-bits) of the THRU data stream (for THRU and D&I modes). The errors are inserted after framing, so that DS3 Parity and DS1 ESF CRC-6 errors also occur. [SINGLE] will produce one error, [RATIO] will toggle on/off error insertion at the selected ratio seen in the VIEW field, and [BURST] will produce a timed burst of the selected ratio. While the ratio may be changed during error insertion, the burst time can only be changed when all error insertion LEDs are off, and the [BURST] key is pressed. Values from 1 to 6000 milliseconds can be selected for burst time.

4.4.2 Bipolar Violation Insertion

Bipolar violations are always inserted without any bit error being produced. Like "BIT", the [SINGLE], [RATIO], and [BURST] are active.

DS3: The DS3 line-code is B3ZS. When three consecutive zeros are to be sent, they are translated into a triplet that contains at least one transition (normally a "1"), but the triplet is marked by having one of these transitions violate the "bipolar rule". This rule states that each "1" to be transmitted must be in the opposite polarity of the last. A bipolar violation then occurs when two consecutive "1"s or "marks" are of the same polarity. This makes inserting bipolar violations in DS3 awkward, because any simple insertion of a BPV will be interpreted by a receiver as a triplet, and will be decoded as "000", thus creating "bit" errors. There is however, an added sophistication for B3ZS coding, which requires that triplets be of the form "00V" or "B0V" where "0" is a zero, "V" is a bipolar violation, and "B" is a properly transmitted "1". The choice of "00V" or "B0V" is made so that each "V" is of the opposite polarity as the last "V". Typically, B3ZS decoders will disregard the "B" or "0" of the triplet as a requirement for decoding the triplet to "000". Yet, the decoder will recognize a misplaced "B" or "0" and call it a bipolar violation. The PF-45 sends DS3 bipolar violations by transmitting a "B0V" instead of an "00V", or vice-versa, when a BPV is desired. The receiving end will call this a "bipolar violation", but will properly decode it as "000". Therefore, in order to send DS3 BPV's, the data stream must have sufficient strings of three consecutive zeros.

DS1 AMI: This line-code requires only that alternate "1"s (marks) be transmitted in alternate polarity. A BPV is inserted by sending two consecutive "1"s in the same polarity.

DS1 B8ZS: This line-code is the same as AMI until an octet of consecutive zeros occurs. Then an 8-bit pattern, including two bipolar violations is sent. At the receiver, this 8-bit pattern is recognized and decoded to eight zeros. A BPV is sent, like AMI, by sending two consecutive "1"s in the same polarity, but this is never done within a B8ZS code-word, thus precluding bit-error insertion.

4.4.3 DS3 Parity/C-Parity and DS1 CRC-6 Error Insertion
Parity, C-Parity, and CRC-6 errors are inserted without data-bit errors occurring. This is done by toggling the transmitted P-bits and C-Parity bits, or one of the six CRC-6 bits, to the wrong value when a error is to be inserted. The data-stream itself is unaffected. Like "BIT", the [SINGLE], [RATIO], and [BURST] keys are active.

4.4.4 Frame Error Insertion
Frame error insertion is performed on the "frame-alignment" bits, and leaves the other overhead functions, such as DS3 Parity, C-bits, X-bits, CRC-6 bits, and ESF Data-link unaffected. The data stream is also untouched. Like "BIT", the [SINGLE], [RATIO], and [BURST] keys are active.

DS3: Both F and M bits are candidates for error insertion. This matches the PF-45 DS3 receiver, which monitors and analyzes the combined F & M bitstream.

DS1 D4/SF: Both Ft and Fs bits are candidates for error insertion. This matches the PF-45 DS1 receiver, which monitors and analyzes the combined Ft and Fs bitstreams.

DS1 ESF: The six Ft frame-alignment bits (also known as FAS, or multiframe bits) are candidates for error insertion. This matches the PF-45 DS1 receiver, which monitors and analyzes the Ft-bits.

4.4.5 AUX Error Insertion
DS3 framers respond to 3-in-n (n $\leq$ 16) F-bit errors, and DS1 framers respond to 2-in-4 or 2-in-5 F-bit errors by declaring 'loss of frame sync'. The PF-45 can send a single burst of 3-in-n (n=15,16,1-7) DS3 F-bit errors, or 2-in-n (n=4,5,6) DS1 F-bit errors to force resync.

DS3 and DS2 framers must ignore 1 out of 3 C-bit errors for proper destuffing. The PF-45 can send a single burst of DS3 or DS2 C-bit errors, erroring the 1st, 2nd, or 3rd C-bit in each row of a single multiframe to verify proper handling of C-bit errors.

4.4.6 Alarm Insertion
Network alarms are inserted via the Error Insertion block. While the "ALM" LED is lit, the [RATIO] key is now the "CONTINUOUS" key, that is, for continuous insertion of the selected alarm. [BURST] can also be used to transmit a timed burst of the alarm.

Future ANSI documents will define DS3 X=00 as a DS3 Yellow Alarm. So X-bits have been added to the list of insertable alarms. They are also available under AUX Error Insertion, but only as SINGLE which gives a predefined burst time (See D&O Section 1.4.3). Under Alarm Insertion, both Continuous and (programmable-length) Burst are available, while [SINGLE] results in a 1 second burst of these two new alarms.

4.4.7 DS1 Loopback Insertion

Remote control of loopback points is an important part of DS1 network testing. The PF-45 can send the four common in-band loop-up and loop-down codes. The CSU codes will activate the end customer's DS1 CSU loopback. The NI (Network Interface) codes activate the loopback of the Telco's "DS1 Interface Connector" which is located at the demarcation point between the Local Exchange Carrier and the Customer Installation.

Transmission of the codes is performed under AUX Error Insert. "Single" will give a 6-second burst of the code, which is one second longer than the required 5 seconds for the receiver to detect the code and make the switch. Continuous and Burst insertion are also available. Burst time for all error insertion is a maximum of 6000mSec, so bursts of loopback codes on either side of the 5 second mark may be made (in order to test CSUs and NIs).

Since new or infrequent users may not be familiar with the process of selecting the AUX category (such as DS3 F-bits, or DS2 X-bits) under Tx/Rx SETUP, the category "Loopback" has been made the default setting for all modes that can insert the loopback codes. This means that when scrolling the Error Insertion LEDs past AUX, the user is automatically provided with access to the loopback codes, unless the user has previously selected a different category while in that mode.

4.5 USING THE PF-45 AT THE DIGITAL CROSS-CONNECT (DSX):

The Digital Signal Cross-connect (DSX) frame is a centralized termination point for digital equipment at a particular digital signal level or bit-rate. A DSX frame provides rearrangeable connections between any two equipment terminations or appearances, bridged access where equipment can be connected in parallel with a digital signal path, and series access where a digital signal path can be split.

Fig. 4-9 shows a DSX Cross-connection. Each 3-jack DSX block is dedicated to a certain piece of Line Equipment. The "OUT" jack is the output of that line equipment, the "IN" jack is the input to that line equipment. The "MON" (monitor) jack is a buffered version of the "OUT" jack, approximately 20 dB lower in level. Permanent cross-connect paths between two pieces of line equipment (shown with the dotted lines) are made with jumper wires at the rear of the DSX bay. The permanent paths can be temporarily re-routed using jumper cables (of the appropriate type) from the front of the DSX bay. The DSX contains switching jacks which default to the jumper wires, but route the signal path to the jumper cables when a cable plug is inserted.

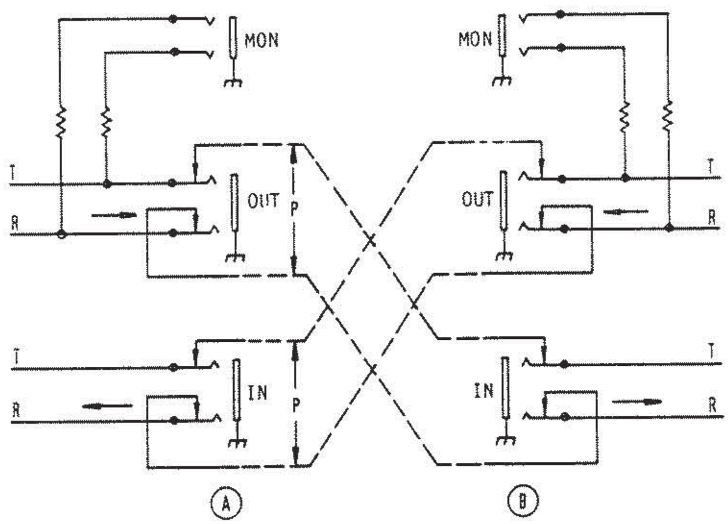


Figure 4-9: DSX Cross-Connect

To use the PF-45 as a stand-alone generator, the PF-45 output signal from jack [11] or [13] should be connected to the appropriate "IN" jack at the DSX. This is clearly an out-of-service situation, useful for initiation of service on new lines and equipment as well as maintenance and repair verification.

4.5.1 Notes for DS1 DSX use:

DSX1 Monitor Jack

At the cross-connect, a monitor point is provided. When terminated with 100 ohms, the signal level at this point is a flat 20 dB lower than the DSX1-compatible signal. The PF-45 receiver will automatically adjust for normal DSX-level or DSX-monitor level.

Not all commercially available DSX1 jack fields have resistors buffering the Monitor jacks. The PF-45 user must determine which type of configuration is under test. The accepted procedure is to use the TERM (100Ω, terminated) setting on the PF-45 when the proper series resistors are in the monitor path. For DSX's with direct bridging at the monitor jack, use the high impedance bridging setting on the PF-45. Mismatch could result in line errors.

4.5.2 Notes for DS3 DSX use:

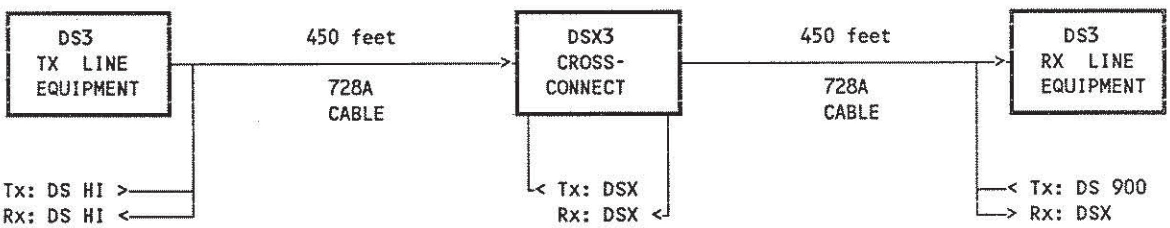


Figure 4-10: Typical DSX3 Architecture

The typical DS3 cross-connect scheme is shown above (one direction only). The "source" of the DS3 signal is the DS3 Tx Line Equipment. 450 feet of WECO 728A-compatible cable separate the transmitter from the DSX3 patch panel. At the cross-connect the signal must meet the network DSX3 pulse-shape and amplitude requirements. An additional 450 feet of cable connects the DSX3 to the DS3 Rx Line Equipment which "sinks" the signal.

At the DS3 bitrate, 450 feet of cable produces a considerable amount of loss and shaping. Therefore, the DS3 Tx Line Equipment must "source" a signal, which having traveled through this cable, will meet the DSX3 requirements. This is essentially a rectangular wave of .909 volts peak. This signal is provided by the PF-45 transmitter, and is called "DS HI". The PF-45 receiver can handle this signal when the expected receive level is set to "HI/LO".

At the DSX3 cross-connect the signal requirements are well-defined in the network specifications. The PF-45 transmitter provides this signal, which is called "DSX". The PF-45 receiver can handle this signal when the expected receive level is set to "DSX".

After the DSX3-compatible signal leaves the cross-connect, it goes through an additional 450 feet of cable, further attenuating and shaping the signal. If option 9402/00.04 (no additional charge) has been requested at initial purchase, the PF-45 transmitter will provide this signal, which is called "DS 900" (450 ft + 450 ft = 900 ft). The PF-45 receiver can handle this signal when the expected receive level is set to "DSX".

DSX3 Monitor Jack

At the cross-connect, a monitor point is provided. When terminated with 75 ohms, the signal level at this point is a flat 20 dB lower than the DSX3-compatible signal. The PF-45 receiver will automatically adjust for normal DSX-level or DSX-monitor level.

DS LO

Traditional DS3 test equipment have provided a "DS LO" transmit signal. This is a "DS HI" signal with 13.8 dB of flat loss. The PF-45 transmitter provides this level when set to "LO" (not available if equipped with "DS 900"). The PF-45 receiver will automatically adjust for this level when the expected receive level is set to "HI/LO".

4.5.3 Special Consideration when in THRU or D&I modes:

The first step for all THRU or D&I setups will be to connect the PF-45 input to the appropriate monitor jack. At this point the signal path has not been affected. When the PF-45 receiver has achieved synchronization, and the setup has been made correctly, get ready to connect the PF-45 output signal to the appropriate DSX "IN" jack.

These setups will generally be "in-service". Careful setup, and understanding of the equipment under test will produce the desired result. The connection of the PF-45 to the "IN" jack will cause a "hit" by the nature of the switches in the jacks and the signal-path delay through the PF-45. This is unavoidable. When inserting the cable plug into the "IN" jack, snap in the plug in one quick motion to minimize the "hit time". Further hits are avoidable in most cases if care is taken. Remember, when initially setting up for Drop & Insert functions, channel "00" gives the user a "neutral" starting place. Double check the settings on the PF-45. These determine line-code, framing-type, etc. any of which could interrupt transmission if improperly set. Always review the PF-45 Tx/Rx configuration before connecting to an in-service line.

-Connect PF-45 to monitor jack.
-Check PF-45 status LEDs. Do we see what we expect?
-Double-check setup.
-Review PF-45 Status and warning LEDs.
-Connect PF-45 Tx jack to "IN" jack.

NO "HITS" ON THE SELECTED DS2 OR ANY NON-SELECTED DS1'S:

In order to perform a Drop & Insert function, the DS3 signal must be looped through the PF-45. This will cause a "hit" on the entire DS3. When a Drop & Insert Mode is selected, the DS1 channel number is first set at "00" (NO DS1!), allowing the user to check the status of the looped through DS3 before performing the Drop & Insert. Selecting a DS1 channel number and "entering" it with a final press of the [MODE] key actually performs the Drop & Insert function and naturally disrupts that DS1 by switching a different signal into its timeslots. However, NO DS2'S ARE DISRUPTED AND NO DS1s OTHER THAN THE INSERTED CHANNEL ARE AFFECTED BY THE DROP & INSERT FUNCTION.

4.6 USING THE NRZ INTERFACES:

Transmit

The transmit NRZ OUT jacks are always active when an internal pattern (at DS1 or DS3) is being generated.

Receive

The receive NRZ IN jacks must be selected in the [Tx/Rx] setup pages to be active. A choice of clock edge is provided.

4.7 TEST PATTERN SELECTION

DS3

The standard (traditional) test signal for characterizing DS3 system performance is the 2^{15}-1 PRBS. Digital words are used for other uses, such as providing an isolated pulse for pulse-shape verification with the "100..." signal. Unlike other test sets which use "1010..." to create AIS, and "1100..." to create Idle, the PF-45 inserts AIS and Idle via the error/alarm-insertion function. The "1010..." and "1100..." digital words are phased so as NOT to create AIS or Idle.

DS1

The standard (traditional) test signal for characterizing DS1 system performance is the QRSS. This is a 2^{20}-1 PRBS with maximum consecutive zeros = 14. However, many DS1 transmission systems have their weakest link in the ability of the repeaters to handle low pulse-density. For this reason, two special digital words are provided: the 1-in-8 and the 3-in-24 signals. They both offer the minimum-allowed pulse density to stress repeaters, and the 3-in-24 also includes a string of the maximum allowable consecutive zeros: 15. Both signals can be sent framed or unframed, while maintaining network density/consecutive-zeros requirement, and without mimicking a yellow alarm. However, sending SF Yellow Alarm in any of the above will overwrite bit 2 of each channel time-slot with "0", creating transmitted patterns of all or mostly zeros zeros which will violate pulse-density requirements on AMI systems and possibly trigger NO SIGNAL, LOSS OF FRAME SYNC, and LOSS OF PATTERN SYNC.

The all-ones word is also available. When it is unframed, it is identical to DS1 AIS. However, by inserting errors in the pattern (up to 1 in 100: 1E-2), it is possible to characterize the "AIS threshold" of network equipment. In this way, the PF-45 user can produce a variable, "High-Density" signal.

"Live" pattern

When MON, THRU or ExtD&I modes are selected, the default pattern is "Live", which essentially means the PF-45 does not look for a pattern. No "Bit" event, or "No Pattern Seconds" occur, and the Pattern Sync LEDs are turned off. If the user should want to monitor a pattern, all the regular patterns are still available in the Set Pattern Page of SETUP.

"InsDS1" pattern

In Tx31->Rx1 and Tx31->Rx31 modes, the user can create a DS3 containing 28 copies of any DS1. By selecting "InsDS1" in the Pattern SETUP Page, the DS1 inserted in the rear-panel DS1 Insert jack [34] is used as the DS1 transmit test signal. Since the PF-45 does not know what is contained in the inserted DS1, (like "Live" pattern), no "Bit" event, or "No Pattern Seconds" occur, and the Pattern Sync LEDs are turned off.

4.8 GLOSSARY OF PF-45 TERMS AND ABBREVIATIONS

AMI — Alternate Mark Inversion. This is the traditional DS1 line code. When sent over a T1 system, no more than 15 consecutive zeros are allowed, and the pulse density must be $\geq$ 12.5%.

ALM — Alarm

AUX — Auxiliary Insert/Error Insert

AvgBER — Average Bit Error Ratio. This is the BER over the entire measurement run time.

B3ZS — Bipolar 3-Zero Substitution. This is the line code used for electrical transport of DS3. Trios of zeros are encoded to trios which contain a deliberate bipolar violation. This maintains pulse density.

B8ZS — Bipolar 8-Zero Substitution. This DS1 line code substitutes an octet containing deliberate bipolar violations in a particular pattern for each octet of zeros. This eliminates the consecutive-zeros and pulse density constraints placed on DS1s that are transported using the AMI line code.

Bit1 — DS1 Pattern-Bit

Bit3 — DS3 Pattern-Bit

BPV1 — DS1 Bipolar Violation (see Section 4.4.2)

BPV3 — DS3 Bipolar Violation (see Section 4.4.2)

Brdg — DS1 Bridging: input impedance of receive jack [14] is set high (>1000 ohms).

Clk1 — DS1 Transmit Clock

Clk3 — DS3 Transmit Clock

CPar

(Frame format) — DS3 C-Parity frame format. Has the same overhead structure as DS3 M13 format, but the DS2-to-DS3 stuffing is "stuck" on, and as a result the C-bits are freed for other functions such as "C-Par" Path Parity, FEBE, and Data Links.

(Parity) — Path Parity found in C-Parity frame format. The originating DS3 multiplexer sets both the "C-Par" Path Parity and the normal P-bit parity to the correct values. Subsequent DS3 equipment may monitor the P-bit parity and then correct it, to establish performance values on a sectional basis. The "C-Par" Path Parity is not corrected however, and so provides an end-to-end "path" performance monitoring capability.

CONT, CONTIN	Continuous
CRC	Cyclic Redundancy Check (valid for DS1 ESF format systems)
CurBER	Current Bit Error Ratio. This is the BER repeatedly calculated over a gated time period.
D4/SF	DS1 Superframe Format. Two functions are provided: location of framing bits, and location of signaling frames.
D&I	Drop & Insert (DS1 from and into DS3)
DrbBER	Dribbling Bit Error Ratio. This is the BER over the entire measurement run, but using only those seconds that do not contain error bursts.
ErrCnt	Error Count
ErrSec	Errored Seconds
ESF	DS1 Extended Superframe Format. Four functions are provided: location of framing bits, location of signaling frames, CRC-6 transmission, and an embedded data link.
Ext	External
ExtD&I	This mode allows the user to drop a DS1 from a live DS3, and to insert an externally-generated DS1 into the same channel. Performance monitoring is also done.
FEBE	Far-End-Block-Error (valid for C-Parity format DS3 systems)
Frm1	DS1 Frame-bit
Frm2	DS2 Frame-bit
Frm3	DS3 Frame-bit
Hi	High (DS3 Tx/Rx Level)
H/L	High/Low (DS3 Tx/Rx Level)
Ins	Insert
InsDS1	In Tx^3_1->Rx^3_1 and Tx^3_1->Rx1 modes, this "pattern" allows the user to create a DS3 test signal containing 28 multiplexed copies of a DS1 sent in the InsDS1 rear-panel jack.

$\text{Ins}^3{}_1$->Rx1	This mode, like IntD&I, allows the user to drop a DS1 out of a live DS3, and to simultaneously insert an internally-generated DS1 into that same channel of the live DS3. However, the DS1 to be tested is not the dropped DS1, but the DS1 applied to the DS1 Rx jack [14]. This allows easy testing of an M13 Demultiplexer, leaving 27 DS1s in-service, while 1 DS1 is taken out-of-service for testing.
Int	Internal
IntD&I	This mode allows the user to drop a DS1 out of a live DS3 and test it. Simultaneously, an internally-generated DS1 test signal is inserted into that same channel of the live DS3. Full out-of-service testing is performed on that DS1.
Lo	Low
M13	Normal DS3 frame format. Sometimes called "M23", it is the format used by traditional multiplexers. Unlike C-Parity format, M13 uses two levels of stuffing, and therefore uses both DS2 and DS3 C-bits as stuffing indicators only.
MAN	Manual
MON1	This is an in-service mode for DS1 performance monitoring at the DS1 rate.
MON3	This is an in-service mode for DS3 performance monitoring.
$\text{MON}^3{}_1$	This is an in-service mode for performance monitoring of a DS1 embedded in DS3.
N/A	Not Applicable
NRZ↑	Non-Return-To-Zero (clock rising edge)
NRZ↓	Non-Return-To-Zero (clock falling edge)
Par	DS3 P-bit Parity. The two P-bits are set to odd-parity by the originating DS3 multiplexer. DS3 section equipment may use this for performance monitoring, and typically will overwrite the P-bits with corrected parity values.
PTN	Pattern
Ref	Reference
Secs	Seconds
Term	Terminated
ThreshES	Threshold Errored Second
THRU1	This mode allows the user to insert errors, alarms, and loopback codes into a live DS1. Performance monitoring is also done.

THRU3	This mode allows the user to insert errors and alarms into a live DS3. Performance monitoring is also done.
THRU$^3_1$	This mode allows the user to insert DS3/DS2/DS1-related errors/alarms/loopbacks into a live DS3 carrying DS2s/DS1s. Performance monitoring is also done.
Tx1->Rx1	This is a test mode meant for out-of-service testing of DS1 facilities.
Tx1->Rx$^3_1$	This is a test mode meant for out-of-service testing of DS1 facilities whose input is at DS1, but whose output contains the DS1 embedded in DS3. An M13 multiplexer is an example of this.
Tx3->Rx3	This is a test mode meant for out-of-service testing of DS3 facilities.
Tx$^3_1$->Rx1	This is a test mode meant for out-of-service testing of DS1 facilities whose input is a DS1 embedded in DS3, but whose output is at DS1. An M13 demultiplexer is an example of this.
Tx$^3_1$->Rx$^3_1$	This is a test mode meant for out-of-service testing of DS1 facilities whose inputs and outputs contain DS1 embedded in DS3. A $^3_1$ DACS is an example of this.
<E-m	Errored Second with error ratio less than 1 in 10^m
≥E-n	Errored Second with error ratio greater than or equal to 1 in 10^n
Unfrm	Unframed
Y.YY E-Z	(Y.YY) X 10^{-Z}

4.9 OVERVIEW OF PF-45 FEATURES AND OPERATION

Features

* Full DS3 BERTS (Unframed, M13 frame or C-Parity frame formats)
* Full DS1 BERTS (Unframed, D4/SF, or ESF frame formats)
* 1/3 Mux (built-in)
* 3/1 Demux (built-in)
* DS1 Drop and Insert
* Extensive simultaneous measurement and analysis at DS3, DS1, and DS1/DS2 embedded in DS3
* Complete PRBS/QRSS/Digital word selection
* Comprehensive error insertion to check line equipment and monitoring facilities
* Printer (built-in)
* Portable, with rugged cast-aluminum case
* IEEE 488/RS232 Remote Control option
* -24/-48V DC Operation option
* E1 Drop/Analysis option
* Data Link/Multifunction option

The PF-45 DS3/DS1 Analyzer is a unique tool for North American DS3 and DS1 PCM systems. It combines state of the art DS3 and DS1 Bit Error Rate Test Sets (BERTS), DS1 Drop & Insert, comprehensive error insertion capabilities, and a built-in printer. This includes the ability to test directly across M13 mux and demux facilities. DSX3 and DSX1-compatible interfaces are provided for Central Office and customer premises applications, while TTL-compatible interfaces are suitable for laboratory use.

The receive portion of the PF-45 DS3/DS1 Analyzer performs comprehensive error measurement, analysis, and status monitoring of DS3 and DS1. The monitored DS1 may be a baseband bipolar line signal (Rx1 mode), or a DS1 'dropped' by the PF-45 from the received DS3 (Rx^3_1 modes). In the later case, the DS3 signal containing the selected DS1 is monitored simultaneously with the DS1 signal, and the DS1 is output to the dedicated rear-panel 'Drop DS1' jack for further testing and/or patching.

The PF-45 transmitter can output framed or unframed test patterns at DS3 (Tx3 mode) or DS1 (Tx1 mode) as well as a unique DS3 test signal containing 28 identical DS1 test patterns with proper DS2 and DS3 framing and stuffing (Tx^3_1 modes). The received DS1 or DS3 line signal can also be retransmitted with selectable error insertion (THRU1 and THRU3 modes, respectively), and the looped DS3 signal can have a DS1 test pattern or live signal inserted in a selected DS1 channel (D&I Modes).

Applications

*Network Maintenance		*DS3 Circuits
*Troubleshooting		*DS1 Circuits
*In-Service-Monitoring		*M13 Multiplexers
*Fault Isolation	OF:	*M31 Demultiplexers
*Installation		*DACS 3/3
*Acceptance Testing		*DACS 3/1
*Manufacturing		
*Development		

With the continuing growth in high density digital transmission systems, it is becoming increasingly important to provide multifunctional instruments for their installation and maintenance. The PF-45 DS3/DS1 Analyzer is ideally suited for troubleshooting, fault isolation and monitoring of network elements such as M13 Mux and M31 Demux, 3/1 and 3/3 DACS and transmission paths. Due to its unique characteristics, PF-45 is also equally suited for development, manufacturing and acceptance testing of these systems.

Characteristics

The PF-45 DS3/DS1 Analyzer performs comprehensive error measurement, analysis and status monitoring at DS3, DS1 or between the DS3 and DS1 hierarchical levels.

Because the PF-45 is capable of measuring DS1 parameters of a DS1 signal embedded within a DS3, a variety of measurement configurations are possible. The PF-45 offers a selection of 14 modes of operation depending on the measurement to be performed and the hierarchical level where test signals are to be inserted or measured.

To differentiate between the line rate at which signals are inserted or accessed and pattern rate at which the measurements are to take place, the PF-45 uses a shorthand notation for mode identification: a "3" suffix on either Tx or Rx means that both line rate and pattern rate are DS3; similarly a "1" suffix means that both line rate and pattern rate are DS1. A "3/1" suffix indicates the instrument is transmitting and/or receiving at DS3 line rate but the pattern to be measured is at DS1. In Rx^{3}_{1} Modes, parity, CRC and frame error measurements are simultaneously performed at DS3, and DS1.

Mode selection defines the remainder of the Setup Menu. For each mode the user selects the desired operating parameters from the Setup Menu corresponding to that mode. The selected mode automatically defines the relevant simultaneous measurements that will be performed.

The PF-45 simultaneously measures and analyzes the following events: bit errors (DS3 or DS1); bipolar violations (DS3 or DS1); frame and multiframe errors (DS3, and DS1); parity, C-Parity and FEBE errors (DS3); and CRC-6 errors (DS1 ESF). Alarms and status changes are also logged and counted as event seconds. Events with their associated analyses can be displayed at any time and/or printed with a time stamp on the built-in printer.

PATTERNS: 2^{23}-1, 2^{20}-1, 2^{15}-1, 2^{11}-1, 2^{9}-1, QRSS, 1111, 1000, 1100, 1010, 1-in-8, 2-in-8, 3-in-24
ERROR EVENTS: Bit, BPV, Parity, C-Parity, FEBE, CRC-6, Frame
ERROR ANALYSIS: Error Count, Errs/Sec, Dribbling Count, Current Error Ratio, Average Error Ratio, Dribbling Error Ratio, Errored Seconds, Threshold Errored Seconds, % Error-Free Seconds
STATUS EVENT SECONDS:
DS3: No Signal, No Frame Sync, No Pattern Sync, AIS, Idle, X-bit
DS2: No Signal, No Frame Sync, AIS, X-bit
DS1: No Signal, No Frame Sync, No Pattern Sync, AIS, Yellow Alarm, Excess Zeros
PF-45: No Power
INTERFACE: DSX3, DSX3-Monitor, DSX1, DSX1-Monitor, and TTL NRZ-data/Clock compatible

Modes of Operation

In the five Test (Out-of-Service) Modes, the PF-45 transmits and measures a wide selection of pseudorandom patterns and digital words at either DS3 or DS1 line rates. In Tx^3_1 Modes the selected test pattern is inserted into 28 identical DS1 signals embedded in a DS3 with correct DS3 and DS2 framing and control bits. In Rx^3_1 Modes a selected DS1 is demultiplexed from DS3 and measured.

In the MONITOR, THRU and DROP & INSERT (D&I) Modes relevant measurements are performed on the received signal (DS3 or DS1). For both THRU and D&I Modes, the received signal is retransmitted at the received clock rate from the transmitter. (Code errors are not retransmitted).

In the MONITOR$^3_1$, THRU$^3_1$ or D&I$^3_1$ Modes the PF-45 will demultiplex a selected DS1 from the received DS3 signal, outputting the dropped DS1 in DSX1 format at the dedicated rear panel DS1 DROP jack. Error analysis is performed simultaneously on the DS3, and dropped DS1 signals. In the D&I Modes the PF-45 is also capable of inserting a DS1 signal into the received DS3 without interfering with the remaining DS1s. The inserted signal may be either a test pattern originating within the instrument (IntD&I$^3_1$), or an externally sourced DS1 in DSX1 format input at the dedicated rear panel DS1 INSERT/REF jack (ExtD&I$^3_1$).

Error Insertion

The PF-45 has extensive and precise error insertion capability. Bit, BPV, frame, parity and CRC errors are inserted singly, at a selected error ratio or in a timed burst at the selected error ratio. Bit errors are accompanied by appropriate parity or CRC errors. All other error types are inserted in such a way that no other error type occurs, ie: parity or CRC errors do not cause bit errors. The AUX error position offers a wide selection of well-defined overhead error patterns that are injected as a single burst, for example, 3 of 16 contiguous DS3 frame bits or the third C-bit (stuff indicator) of each row of either a DS2 or DS3 multiframe. These well-defined error patterns are useful in testing frame synchronization circuits and multiplex equipment.

Alarms can be transmitted continuously or as timed bursts to test alarm recognition circuits.

Operation

The front panel of the PF-45 can be divided into five distinct groups of controls and displays:

* The Tx/Rx column of LEDs on the upper left [1] provides a summary of the selected pattern and frame parameters for DS3 and/or DS1.

* Directly below is the ERROR INSERTION field [5] with LEDs indicating the type of error to be inserted and a push button to scroll through the error selection. [SINGLE], [RATIO], and [BURST] push buttons activate the error insertion. The VIEW field shows additional information about the error insertion parameters, many of which can be changed with the [VIEW] and Data Entry keys.

* In the middle of the panel is the 2 by 20 character vacuum-fluorescent DISPLAY [2]. Below it are eight push buttons [A], [B], [C], [D], [6], and [7] that control the display operation; two additional DATA ENTRY push buttons [8] are used to change certain parameters.

* To the right of the display section is the Rx STATUS column of LEDs [3]. These normally display the current state of DS3 and DS1 alarms and signal status. The top LED labeled HISTORY is lit only when the [Rx STATUS] push button has been depressed. While lit, the column of LEDs indicates the history of all alarms or changes of status that have occurred since the start of the measurement.

* The printer [4] is mounted to the right of the front panel. Below it are the printer control push buttons, the [START/STOP] push button, and the measurement run LED which is lit while a measurement run is in process.

Setup

Two blue push buttons [6] appear under the SETUP category. [Tx/Rx] activates the setup display menu in which the measuring mode and the appropriate operating parameters are selected. Successive pages of the Setup Menu are displayed each time [Tx/Rx] is depressed.

Each page of the display is divided into four quadrants controlled by the [A], [B], [C] and [D] push buttons located below the display. The parameter displayed in a quadrant can be changed by depressing the associated push button.

The [AUX/TIME] push button activates auxiliary setup functions such as Date, Time, Test-duration, Auto Print, etc. The operation is similar to that described above.

Measure

Two black push buttons [7] appear under the MEASURE category. [ERROR] activates the error measurement display. This display is also divided into four quadrants. The top left quadrant displays the error type. It can be scrolled by depressing the [EVENT] push button. The top right quadrant displays the error analysis result and can be scrolled by depressing the [ANALYSIS] push button. The bottom left quadrant indicates the operating [MODE]. The bottom right quadrant contains information that is pertinent to a specific measurement operation and may be changed by depressing [VIEW].

The [Rx STATUS] push button activates the status measurement display containing status event second counts accumulated during the measurement. These are scrolled the same as described above.

5 FUNCTIONAL CHECK, MAINTENANCE, ETC.

5.1 BACK-TO-BACK FUNCTIONAL CHECKOUT

This section shows the user how to check many of the main features of the PF-45 with a simple back-to-back checkout, requiring no equipment other than the PF-45 itself and DS3 and DS1 patch cords. Refer to Section 3 "CONTROLS" or the PF-45 Short Operation Manual found in the slideout drawer under the instrument for further details on the required setups below.

5.1.1 Turn ON

1. Set real-time clock:

[AUX/TIME] SETUP:

```
Clock:      00:00:00   (Set Clock/Date Page)
Date:       Oct01'89
```

The real-time clock and date are used for time-stamping certain printer events. To view and/or change the clock/date setting, press the [AUX/TIME] setup key until the above display is brought up.

To set the real-time clock:

Press key [B]. The leftmost digit of the time will blink in conjunction with the Data Entry LED.

Select the desired number and press [B] again. The next digit now blinks, and so on.
To finish the clock setup, "walk" the blinking digit towards the right of the display, and finally off the display.

To set the date:

Press key [D], and set the date in the same way as the clock was set.

5.1.2 Tx1->Rx1

The Tx1->Rx1 mode transmits and receives an internally generated DS1 test signal. In a typical application, the DS1 system under test will be looped-back to the originating end. In this case however, the DS1 system under test is eliminated, and the PF-45 "tests" itself.

1. - Make the following setup with no DS1 patch cord:

[Tx/Rx] SETUP:

```
SET NEW MODE
Tx1->Rx1
```
(Set New Mode Page)

```
Code:AMI    Rx1:Term
Frm1:D4/SF Clk1:Int
```
(DS1 Setup Page)

```
Ptn:QRSS20
```
(Pattern Select Page)

```
ERROR INSERT:   @DS1
AUX ERR:     DS1 Fbit
```
(AUX Error Insert Select Page)

[AUX/TIME] SETUP:

```
Test Duration: CONT.
    (continuous)
```
(Test Duration Page)

- Press [ERROR] Measure.
- With [EVENT] key, bring up "Bit1".
- With [ANALYSIS] key, bring up "ErrCnt=   ".

Result: Under Tx/Rx [1], the Tx Pattern and DS1 D4/SLC-96 front-panel LEDs are lit. Under Rx STATUS [3], the DS1 NO SIGNAL, DS1 NO FRAME, EX ZEROS, and DS1 red (no) Pattern Sync LEDs are lit.

```
Bit1 ErrCnt=        0
Tx1->Rx1
```

NOTE: the Bit1 Error Count remains at 0. This is because the counter is enabled only when there is signal presence, frame sync, pattern sync, and the measurement run is ON. See Section 1.2.2 Error Counting.

2. - Connect DS1 Tx [13] to DS1 Rx [14] with the appropriate patch cord.

Result: Rx STATUS LEDs: DS1 NO SIGNAL, DS1 NO FRAME, EX ZEROS, and DS1 red Pattern Sync LEDs are extinguished, and the green DS1 Pattern Sync LED is lit.

3. - Start measurement run by pressing [START/STOP] key [9].
- Press the Error Insertion "down arrow" key [5] once to light the "BIT" LED.
- Press [SINGLE] one time to insert one pattern-bit error.

Result: "MEAS RUN" LED is lit, "BIT" LED is lit, and the error count on the display is "1".

```
Bit1 ErrCnt=        1
Tx1->Rx1      Ins BIT1
```

4. - Press Error Insertion "down arrow" key [5] again to light "BPV" LED.
- Press [EVENT] once to display "BPV1".
- Press [SINGLE] once to insert one bipolar violation.

Result: the "BPV" LED is lit, and the BPV1 error count on the display is "1".

```
BPV1 ErrCnt=        1
Tx1->Rx1      Ins BPV1
```

5. - Press Error Insertion "down arrow" key [5] again to light "FRM" LED.
- Press [EVENT] once to display "Frm1".
- Press [SINGLE] once to insert one Frame-bit error.

Result: the "FRM" LED is lit, and the Frm1 error count on the display is "1".

```
Frm1 ErrCnt=        1
Tx1->Rx1      Ins FRM1
```

6. - Press Error Insertion "down arrow" key [5] again to light the "AUX" LED. The VIEW field should show "Ft1: 2/6".
- Press [VIEW]. "Ft1:2/6" now blinks in conjunction with the Data Entry LED. Use the data entry keys to select "Ft1:2/4".
- Press [VIEW] a second time to stop the blinking, and exit the selection process.
- Press [SINGLE] once to insert a single group of two-out-of-four Ft-bit errors (which will force the DS1 Rx framer out of frame sync).

Result: the "AUX" LED is lit, and the DS1 NO FRAME LED momentarily lights. The Frm1 error is incremented by 1 or 2 counts.

```
Frm1 ErrCnt=        3
Tx1->Rx1      Ft1: 2/4
```

7. - Press Error Insertion "down arrow" key [5] again to light the "ALM" LED. The VIEW field should show "DS1 AIS".
   - Press [RATIO] (Continuous) to continuously insert DS1 AIS.

Result: The "ALM" and "RATIO" LEDs [5] are lit. Under Rx STATUS, the DS1 NO FRAME, DS1 AIS, and red DS1 Pattern Sync LEDs are lit.

```
Frm1 ErrCnt=       X
Tx1->Rx1     DS1 AIS
```

(X is "don't care")

8. - Turn off DS1 AIS insertion by pressing [RATIO] (Continuous) again, toggling off the "RATIO" LED.
   - Set the inserted alarm type to DS1 Yellow by pressing [VIEW] (DS1 AIS now flashes with DATA ENTRY)
   - Press the Data Entry "up arrow" and bringing up a flashing "DS1 YELL"
   - Press [VIEW] again to "enter" the DS1 Yellow selection (no longer flashing)
   - Press [RATIO] (Continuous) to turn on DS1 Yellow Alarm insertion.

Result: The "ALM" and "RATIO" LEDs [5] are lit. Under Rx STATUS, the DS1 YELLOW, and EX ZEROS LEDs are lit.

```
Frm1 ErrCnt=        X
Tx1->Rx1     DS1 YELL
```

5.1.3 Tx3->Rx3

The Tx3->Rx3 mode generates and receives an internally generated DS3 test signal. This test signal consists of a framed or unframed DS3-rate pattern (ie, contains no DS2's or DS1's). Like the above Tx1->Rx1 back-to-back test, the following "tests" the PF-45.

1. - Make the following setup with no DS3 patch cord:

[Tx/Rx] SETUP:

```
SET NEW MODE
Tx3->Rx3
```
(Set New Mode Page)

```
Tx3:HI      Rx3:H/L
Frm3:M13   Clk3:Int
```
(DS3 Setup Page)

```
Ptn:2E15-1
```
(Pattern Select Page)

```
ERROR INSERT:   @DS3
AUX ERR:    DS3 Fbit
```
(AUX Error Insert Select Page)

[AUX/TIME] SETUP:

```
Test Duration: CONT.
    (continuous)
```
(Test Duration Page)

- Press [ERROR] Measure.
- With [EVENT] key, bring up "Bit3".
- With [ANALYSIS] key, bring up "ErrCnt=   ".

Result: Under Tx/Rx [1], the Tx Pattern and DS3 M13 FRAME front-panel LEDs are lit. The DS3 Tx and Rx level LEDs [11], [12] show "HI" and "HI/LO" respectively. Under Rx STATUS [3], the DS3 NO SIGNAL, DS3 NO FRAME, and DS3 red (no) Pattern Sync LEDs are lit.

```
Bit3 ErrCnt=       0
Tx3->Rx3
```

2. - Connect DS3 Tx [11] to DS3 Rx [12] with the appropriate patch cord.

Result: Rx STATUS LEDs: DS3 NO SIGNAL, DS3 NO FRAME, and DS3 red Pattern Sync LEDs are extinguished, and the green DS3 Pattern Sync LED is lit.

3. Preset Error Insertion Ratio:
   - While no Error Insertion LEDs [5] are lit, press [RATIO].
   - The RATIO LED is lit, and the VIEW field shows "Ins XE-X".
   - Press [VIEW], causing the displayed ratio and the Data Entry LED to blink.
   - Use the Data Entry up/down arrow keys [8] to select the desired ratio, in this case: 1E-4
   - Press [VIEW] again to "enter" the value, and stop the blinking.
   - Press [RATIO] again to exit the setup process, and remove the "Ins 1E-4" from the display.

4. Preset Burst Length:
   - While no Error Insertion LEDs [5] are lit, press [BURST].
   - The BURST LED is lit, and the VIEW field shows "XXXXmSec".
   - Press [VIEW], causing the displayed burst length and the Data Entry LED to blink.
   - Use the Data Entry up/down arrow keys [8] to select the desired burst length, in this case: 1000mSec
   (NOTE: hold down the up or down arrow keys to accelerate the selection process.)
   - Press [VIEW] again to "enter" the value, and stop the blinking.
   - Press [BURST] again to exit the setup process, and remove the "1000mSec" from the display.

5. - Start measurement run by pressing [START/STOP] key [9].
   - Press the Error Insertion "down arrow" key [5] once to light the "BIT" LED.
   - Press [BURST] one time to insert one burst of pattern-bit errors.

Result: "MEAS RUN" LED is lit, "BIT" LED is lit, the BURST LED is lit for 1 second, and the error count on the display is "4421", +/-1.

```
Bit3 ErrCnt=    4421
Tx3->Rx3    Ins BIT3
```

6. - Press Error Insertion "down arrow" key [5] again to light "BPV" LED.
   - Press [EVENT] once to display "BPV3".
   - Press [BURST] once to insert one burst of bipolar-violations.

Result: the "BPV" LED is lit, the Burst LED is lit for 1 second, and the BPV3 error count on the display is "4474", +/-1.

```
BPV3 ErrCnt=    4474
Tx3->Rx3    Ins BPV3
```

7. - Press Error Insertion "down arrow" key [5] again to light "PAR" LED.
- Press [EVENT] once to display "Par".
- Press [BURST] once to insert one burst of parity errors.

Result: the "PAR" LED is lit, and the Par error count on the display is incremented from approximately "4474" (the value remaining from the "Bit" error insertion), to approximately "8842".

```
Par  ErrCnt=    8842
Tx3->Rx3    Ins PAR3
```

8. - Press Error Insertion "down arrow" key [5] again to light "FRM" LED.
- Press [EVENT] once to display "Frm3".
- Press [BURST] once to insert one burst of Frame-bit errors.

Result: the "FRM" LED is lit, and the Frm3 error count on the display is approximately "30".

```
Frm3 ErrCnt=      30
Tx3->Rx3    Ins FRM3
```

9. - Press Error Insertion "down arrow" key [5] again to light "AUX" LED.
- Bring up "F3: 3/16" in the VIEW field by pressing [VIEW], using the Data Entry keys to make the selection.
- Press [VIEW] again to "enter" the selection.
- Press [SINGLE] once to insert a single group of three-out-of-sixteen F-bit errors (which will force the DS3 Rx framer out of frame sync).

Result: the "AUX" LED is lit, and the DS3 NO FRAME LED momentarily lights. The Frm3 error is incremented by 3 counts.

```
Frm3 ErrCnt=      33
Tx3->Rx3    F3: 3/16
```

10. - Press Error Insertion "down arrow" key [5] again to light "ALM" LED.
- Bring up "DS3 AIS" in the VIEW field by pressing [VIEW], using the Data Entry keys.
- Press [VIEW] again to "enter" the selection.
- Press [BURST] to insert a 1-second burst of DS3 AIS.

Result: the "ALM" LED is lit, the DS3 AIS and red Pattern Sync LEDs momentarily light.

```
Frm3 ErrCnt=      33
Tx3->Rx3    DS3: AIS
```

11. - Set the inserted alarm type to DS3 Idle by pressing [VIEW] (DS3 AIS now flashes with Data Entry LED).
 - Press Data Entry "up arrow" and bring up a flashing "DS3 IDLE".
 - Press [VIEW] again to "enter" the DS3 IDLE selection (no longer flashing).
 - Press [BURST] to insert a 1-second burst of DS3 IDLE.

Result: the DS3 IDLE and red Pattern Sync LEDs momentarily light.

```
Frm3 ErrCnt=      33
Tx3->Rx3    DS3:IDLE
```

5.1.4 $Tx^3{}_1$->$Rx^3{}_1$

The $Tx^3{}_1$->$Rx^3{}_1$ mode generates and receives:

- a properly framed and stuffed DS3 signal which contains:
- seven identical properly framed and stuffed DS2's, each of which contains:
- four identical properly framed or unframed DS1's, each comprising a test pattern interleaved with frame-bits (if framed)

The receiver drops a selected DS1 by first demultiplexing and destuffing a DS2 out of the received DS3 signal, then demultiplexing and destuffing a DS1 out of that DS2. The selected DS1 and DS2 are then analyzed for errors, etc. In a typical application, one or more of the 28 transmitted DS1's will be looped back and multiplexed into the received DS3 signal for analysis. In this case, the PF-45 "tests" itself.

1. - Make the following setup with no DS3 patch cord:

[Tx/Rx] SETUP:

```
SET NEW MODE
Tx31->Rx31
```
(Set New Mode Page)

```
Tx3:DSX     Rx3:DSX
Frm3:C-Par Clk3:Int
```
(DS3 Setup Page)

```
Code:AMI     Rx1:N/A
Frm1:ESF    Clk1:Int
```
(DS1 Setup Page)

```
Ptn:3-in-24
```
(Pattern Select Page)

```
ERROR INSERT:@DS1:00
AUX ERR:    Loopback
```
(AUX Error Insert Select Page)

[AUX/TIME] SETUP:

```
Test Duration: CONT.      (Test Duration Page)
   (continuous)
```

- Press [ERROR] Measure.
- With [EVENT] key, bring up "Bit1".
- With [ANALYSIS] key, bring up "ErrCnt=   ".
- DS1 channel default is #01

Result: Under Tx/Rx [1], the Tx PATTERN, DS3 C-PARITY, and DS1 ESF LEDs are lit. Under Rx STATUS [3], the DS3 and DS1 NO SIGNAL, DS3 and DS1 NO FRAME, and the DS1 red (no) PATTERN SYNC LEDs are lit.

```
Bit1 ErrCnt=        0
Tx31:00->Rx31:01
```

2. - Connect DS3 Tx [11] to DS3 Rx [12] with the appropriate patch cord.

Result: Rx STATUS DS3 and DS1 NO SIGNAL, DS3 and DS1 NO FRAME, and DS1 red PATTERN SYNC LEDs are extinguished, and the green DS1 PATTERN SYNC LED is lit.

3. Start measurement run by pressing [START/STOP] key [9].

Result: no errors should accumulate:

```
Bit1 ErrCnt=        0
Tx31:00->Rx31:01
```

5.2 CHECKOUT WITH ADDITIONAL PF-45

5.2.1 Tx^3_1->Rx1

The Tx^3_1->Rx1 mode is used to test a 3/1 demultiplexer, or any portion of a network that provides that function. The second PF-45 acts as a 3/1 demultiplexer, by accepting a DS3 signal, and demultiplexing a DS1 from it.

1. - Make the following setups:

Unit Under Test [Tx/Rx] SETUP:

SET NEW MODE Tx31->Rx1	(Set New Mode Page)
Tx3:HI Rx3:N/A Frm3:M13 Clk3:Int	(DS3 Setup Page)
Code:AMI Rx1:Term Frm1:D4/SF Clk1:Int	(DS1 Setup Page)
Ptn:QRSS20	(Pattern Select Page)
ERROR INSERT:@DS1:00 AUX ERR: Loopback	(AUX Error Insert Select Page)

Second PF-45 [Tx/Rx] SETUP:

SET NEW MODE MON31	(Set New Mode Page)
Tx3:OFF Rx3:H/L Frm3:M13 Clk3:N/A	(DS3 Setup Page)
Code:AMI Rx1:N/A Frm1:D4/SF Clk1:N/A	(DS1 Setup Page)
Ptn:QRSS20	(Pattern Select Page)

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2. - On both units, press [ERROR] Measure.
   - With [EVENT] key, bring up "Bit1".
   - With [ANALYSIS] key, bring up "ErrCnt=   ".
   - On the second PF-45, DS1 default channel is #01

   UUT Result:

```
Bit1 ErrCnt=        0
Tx31:00->Rx1
```

3. - Connect the UUT DS3 Tx jack [11] to the 2nd PF-45's DS3 Rx [12] jack with the appropriate cable.
   - Connect the UUT DS1 Rx jack [14] to the 2nd PF-45's Drop jack [33].
   - Start measurement run by pressing [START/STOP] key.

   Result: The DS1 green Pattern-Sync LED should be lit on both units, and no errors should accumulate.

4. - Select a DS1 for error insertion from the UUT by pressing [MODE] (causing "00" to blink along with the Data Entry LED).
   - Select Channel #01 with the Data Entry keys, and press [MODE] again to "enter" the value.
   - Press Error Insertion "down arrow" key [5] to light the BIT LED.
   - Press [SINGLE] to insert a single DS1 bit error.

   Result: Since the 2nd unit is dropping out Channel #01 (the channel with the error inserted into it), both the UUTand the 2nd PF-45 should count a single error in that channel.

```
Bit1 ErrCnt=        1
Tx31:01->Rx1
```

5.2.2 Tx1->$Rx^3{}_1$

The Tx1->$Rx^3{}_1$ mode is used to test a 3/1 multiplexer, or any portion of a network that provides that function. The second PF-45 acts as a virtual 3/1 multiplexer, by accepting a DS1 signal, and providing a DS3 signal with the identical DS1 pattern multiplexed into it.

1. Make the following setups:

Unit Under Test [Tx/Rx] SETUP:

```
SET NEW MODE
Tx1->Rx31
```
(Set New Mode Page)

```
Tx3:OFF      Rx3:H/L
Frm3:M13    Clk3:N/A
```
(DS3 Setup Page)

```
Code:AMI     Rx1:N/A
Frm1:D4/SF Clk1:Int
```
(DS1 Setup Page)

```
Ptn:QRSS20
```
(Pattern Select Page)

```
ERROR INSERT:   @DS1
AUX ERR:     Loopback
```
(AUX Error Insert Select Page)

Second PF-45 [Tx/Rx] SETUP:

```
SET NEW MODE
Tx31->Rx1
```
(Set New Mode Page)

```
Tx3:HI       Rx3:N/A
Frm3:M13    Clk3:Int
```
(DS3 Setup Page)

```
Code:AMI    Rx1:Term
Frm1:D4/SF Clk1:Int
```
(DS1 Setup Page)

```
Ptn:QRSS20
```
(Pattern Select Page)

```
ERROR INSERT:@DS1:00
AUX ERR:    Loopback
```
(AUX Error Insert Select Page)

2. - On both units, press [ERROR] Measure.
   - With [EVENT] key, bring up "Bit1".
   - With [ANALYSIS] key, bring up "ErrCnt= ".
   - On the UUT, the DS1 default channel is #01.

   UUT Result:

   ```
   Bit1 ErrCnt=        0
   Tx1->Rx31:01
   ```

3. - Connect the UUT DS1 Tx jack [13] to the 2nd PF-45's DS1 Rx [14] jack with the appropriate cable.
   - Connect the UUT DS3 Rx jack [12] to the 2nd PF-45's DS3 Tx jack [11].
   - Start measurement run by pressing [START/STOP] key.

   Result: The DS1 green Pattern-Sync LED should be lit on both units, and no errors should accumulate.

4. - Press UUT Error Insertion "down arrow" key [5] to light the BIT LED.
   - Press [SINGLE] to insert a single DS1 bit error.

   Result: The 2nd PF-45 should count a single bit error.

   ```
   Bit1 ErrCnt=        1
   Tx31:00->Rx1
   ```

5.2.3 IntD&I$^3_1$

1. - Make the following setups

UUT [Tx/Rx] SETUP:

SET NEW MODE IntD&I31	(Set New Mode Page)
Tx3:HI Rx3:H/L Frm3:M13 Clk3:Loop	(DS3 Setup Page)
Code:AMI Rx1:N/A Frm1:D4/SF Clk1:Int	(DS1 Setup Page)
Ptn:2E15-1	(Pattern Select Page)
ERROR INSERT:@DS1:00 AUX ERR: Loopback	(AUX Error Insert Select Page)

Second PF-45 [Tx/Rx] SETUP:

SET NEW MODE Tx31->Rx31	(Set New Mode Page)
Tx3:HI Rx3:H/L Frm3:M13 Clk3:Int	(DS3 Setup Page)
Code:AMI Rx1:N/A Frm1:D4/SF Clk1:Int	(DS1 Setup Page)
Ptn:QRSS20	(Pattern Select Page)
ERROR INSERT:@DS1:00 AUX ERR: Loopback	(AUX Error Insert Select Page)

2. On both units:
   - Press [ERROR] Measure.
   - With [EVENT] key, bring up "Bit1".
   - With [ANALYSIS] key, bring up "ErrCnt=   ".
   - DS1 default channel is #01 on 2nd PF-45.
   - On UUT, DS1 channel is #00 (NO channel), so:
   - Select an actual DS1 channel # by pressing [MODE] (causing "00" to blink along with the Data Entry LED).
   - Select the desired drop channel #, in this case "01", with the Data Entry keys.
   - Press [MODE] again to "enter" the channel selection.

   Result:

   ```
   Bit1 ErrCnt=       0
   IntD&I31:01
   ```

3. - Connect the UUT DS3 Tx jack [11] to the 2nd PF-45's DS3 Rx [12] jack with the appropriate cable.
   - Connect the UUT DS3 Rx jack [12] to the 2nd PF-45's DS3 Tx jack [11].

   Result: The DS1 red Pattern-Sync LEDs should be lit.

4. - Change the UUT DS1 channel number to #2.

   Result: The 2nd PF-45's DS1 green Pattern-Sync LED is lit.

5. - Change the 2nd PF-45's DS1 channel number to #2.

   Result: Both unit's DS1 red Pattern-Sync LEDs are lit.

6. - Change the UUT pattern to QRSS20.

   Result: Both unit's DS1 green Pattern-Sync LEDs are lit.

5.3 Maintenance

The PF-45 is a digital instrument, and as such, requires no routine maintenance.

A.1 DS1 INTERCONNECTION SPECIFICATION (DSX1): (according to ANSI standard T1.102-1987)

Line Rate:

1.544Mbit/s +/-32ppm

Line Code:

AMI: bipolar with at least 12.5% average ones density and no more than 15 consecutive zeros.

B8ZS: bipolar with Eight Zero Substitution. In the B8ZS line code any sequence of eight consecutive zeros -0000 0000- is replaced by a 00 0VB 0VB code. Here B represents a normal bipolar pulse and V represent a pulse violating the bipolar rule (V has the same polarity as the preceding pulse).

Termination:

One balanced twisted pair shall be used for each direction of transmission. The distribution frame jack connected to a pair bringing signals to the distribution frame is an out-jack. The distribution frame jack connected to a pair carrying signals away from the distribution frame is termed the in-jack. (see Fig.4-9)

Impedance:

A test load of 100 ohms resistive +/-5% is used at the interface for the evaluation of pulse shape and the remaining electrical parameters.

Pulse Shape:

According to template below, the amplitude shall be between 2.4 and 3.6 volts measured at the center of the pulse and may be scaled by a constant factor to fit the template.

Power Level:

For new equipment, for an all ones pattern, the power in a band of $\leq$ 3kHz centered at 772kHz shall be between 12.6 and 17.9 dBm, and at 1544kHz the power shall be at least 29dB below that at 772kHz.

Pulse Imbalance:

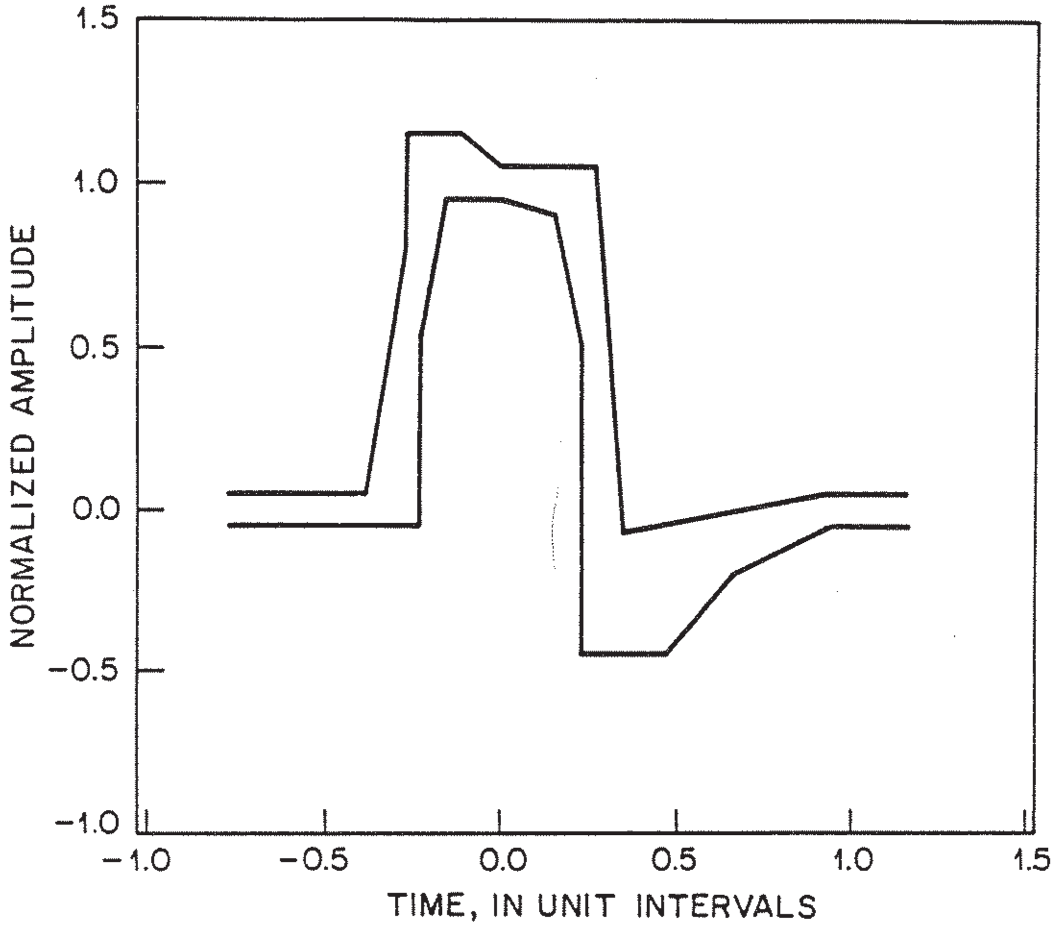
There should be < 0.5dB difference between the total power of the positive pulses and of the negative pulses.

Cable Characteristics:

Reference cable for DSX1 is 655 feet of multipair 22 AWG PIC (22 AWG ABAM) construction with overall outer shield.

Test Access:

High impedance bridging monitor access should be provided across the out-jacks of the DSX as shown in Fig.4-9. For DS1 the bridging circuit consists of 432 ohms +/- 5% resistors connected to tip and ring.



DSX-1 PULSE TEMPLATE CORNER POINTS (NEW EQUIPMENT)

MAXIMUM CURVE

TIME UNIT INTERVALS	-.77	-.39	-.27	-.27	-.12	0.0	.27	.35	.93	1.16
NORMALIZED AMPLITUDE	.05	.05	.8	1.15	1.15	1.05	1.05	-.07	.05	.05

MINIMUM CURVE

TIME UNIT INTERVALS	-.77	-.23	-.23	-.15	0.0	.15	.23	.23	.46	.66	.93	1.16
NORMALIZED AMPLITUDE	-.05	-.05	.5	.95	.95	.9	.5	-.45	-.45	-.2	-.05	-.05

Figure A-1: DSX1 Isolated Pulse Template and Corner Points

A.2 DS3 INTERCONNECTION SPECIFICATION (DSX3): (according to ANSI standard T1.102-1987)

Line Rate:

44.736Mbit/s +/-20ppm

Line Code:

B3ZS: bipolar with three-zero Substitution. In the B3ZS line code any sequence of three consecutive zeros -000- is replaced by B0V or 00V where B represents a pulse conforming with the bipolar rule and V represents a pulse violating the bipolar rule. The choice of B0V or 00V is made so that the number of B pulses between consecutive V pulses is odd.

Termination:

One coaxial line shall be used for each direction of transmission. The distribution frame jack connected to a pair bringing signals to the distribution frame is an out-jack. The distribution frame jack connected to a pair carrying signals away from the distribution frame is termed the in-jack.

Impedance:

A test load of 75 ohms resistive +/-5% is used at the interface for the evaluation of pulse shape and the remaining electrical parameters.

Pulse Shape:

According to template below, for an isolated pulse, the amplitude shall be between 0.36 and 0.85 volts peak, measured at the center of the pulse, and may be scaled by a constant factor to fit the template.

Power Level:

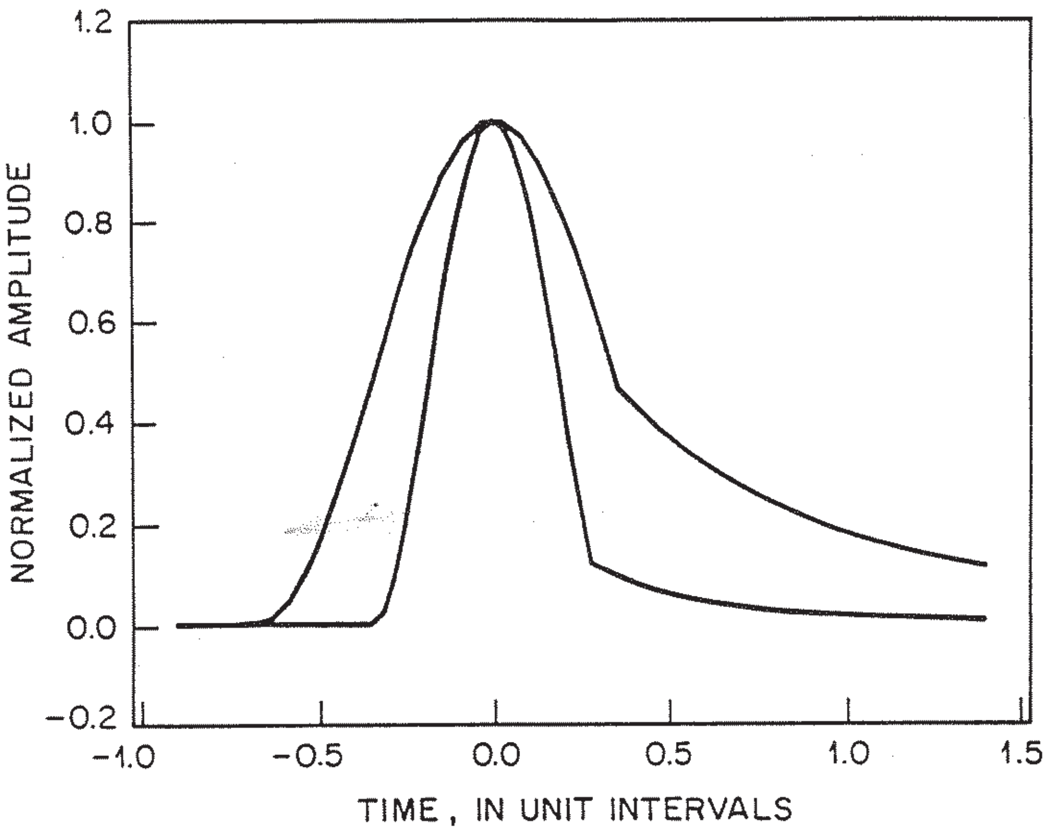
For an all ones pattern, the power in a band of $\leq$ 3kHz centered at 22.368MHz shall be between -1.8 and +5.7 dBm, and at 44.736MHz the power shall be at least 20 dB below that at 22.368MHz.

Cable Characteristics:

Reference cable for DSX3 is 450 feet of 75 ohm coaxial cable with tinned copper shield (WE Co. 728A coaxial cable).

Test Access:

Monitor access should be provided. Signal level at the monitor point shall be more than a nominal 20 dB below the main signal level at the DSX3.



DSX-3 PULSE TEMPLATE BOUNDARIES

CURVE	TIME UNIT INTERVALS	NORMALIZED AMPLITUDE
MAXIMUM CURVE	$T \leq -0.68$	0
	$-0.68 \leq T \leq 0.36$	$0.5\left[1+\sin\frac{\pi}{2}\left(1+\frac{T}{0.34}\right)\right]$
	$0.36 \leq T$	$0.05+0.407e^{-1.84(T-0.36)}$
MINIMUM CURVE	$T \leq -0.36$	0
	$-0.36 \leq T \leq 0.28$	$0.5\left[1+\sin\frac{\pi}{2}\left(1+\frac{T}{0.18}\right)\right]$
	$0.28 \leq T$	$0.11e^{-3.42(T-0.3)}$

Figure A-2: DSX3 Isolated Pulse Template and Equations

A.3 DS1 FRAME FORMAT:

DS1 is created by time-division-multiplexing (TDM) 24 64kbit/s channels into a single 1.544Mbit/s data stream. Each channel is provided with an 8-bit time-slot 8000 times per second. Channel identification (recovery) is made possible by the use of added-bit framing. Prior to the start of the first time-slot (of 24), an extra bit is added to the signal. This bit is toggled in a pattern that identifies it as the "frame bit". A frame consists of a single frame-bit followed by 24 8-bit words. [1 + (24 x 8)] = 193 bits/frame. The frame rate is 8000 frames/sec, so:

(193 bits/frame x 8000 frames/sec = 1.544 Mbit/sec).

Superframe (D4) format:

DS1 SF groups 12 frames together as a superframe in order to provide two signaling channels, A and B. Frame bits for the odd-numbered frames contain an alternating 1-0-1-0 pattern that is suitable for fast frame acquisition. Frame bits for the even-numbered frames contain a pattern that points to the sixth and twelfth frames. The pattern is made up of groups of three zeros followed by three ones. The pattern is phased so that the first occurrence of a one, after three zeros, always is the frame bit for frame 6 (channel A), and the first occurrence of a zero, after three ones, is the frame bit for frame 12 (channel B). This is summarized in the table below.

FRAME NUMBER	TERMINAL FRAMING F_T	SIGNALING FRAMING F_S	INFORMATION CODING BITS	SIGNALING BIT	SIGNALING CHANNEL
1	1	-	1-8	-	
2	-	0	1-8	-	
3	0	-	1-8	-	
4	-	0	1-8	-	
5	1	-	1-8	-	
6	-	1	1-7	8	A
7	0	-	1-8	-	
8	-	1	1-8	-	
9	1	-	1-8	-	
10	-	1	1-8	-	
11	0	-	1-8	-	
12	-	0	1-7	8	B

Figure A-3: DS1 Superframe Format

Extended Superframe format:
Improvements in integrated circuit technology have made it practical to reduce the density of framing bits that are required to quickly achieve frame/multiframe synchronization. The extended superframe format uses only 1 out of 4 overhead bits to achieve sync, and uses the remainder to provide an error-detecting checksum (CRC-6) and a 4 kbit/s data link.

End-to-end error detection for ESF is provided via the CRC-6 cyclic redundancy check. During each superframe, the bitstream is processed to derive a six-bit checksum. This checksum is transmitted in the six C-bits in the following superframe. Identical processing takes place at the receiver, after which the two checksums are compared. 100% of all superframes with single errors are detected. While overall, 98.4% of all superframes containing transmission errors will be detected.

The chart below summarizes the use of the frame bits in the ESF. Notice that its superframe consists of 24 frames versus 12 for SF and that one 6-bit pattern is used for both frame and multiframe sync. Up to four signaling bit channels are available, though their use is system-dependent.

ESF		F BITS			BIT USE IN EACH CHANNEL TIME SLOT		SIGNALING BIT USE OPTIONS			
FRAME NO.	BIT NO.	F_T	DL	CRC	TRAFFIC	SIGNALING	T	2	4	16
1	0	-	m	-	BITS 1-8					
2	193	-	-	C1	BITS 1-8					
3	386	-	m	-	BITS 1-8					
4	579	0	-	-	BITS 1-8					
5	772	-	m	-	BITS 1-8					
6	965	-	-	C2	BITS 1-7	BIT 8	-	A	A	A
7	1158	-	m	-	BITS 1-8					
8	1351	0	-	-	BITS 1-8					
9	1544	-	m	-	BITS 1-8					
10	1737	-	-	C3	BITS 1-8					
11	1930	-	m	-	BITS 1-8					
12	2123	1	-	-	BITS 1-7	BIT 8	-	A	B	B
13	2316	-	m	-	BITS 1-8					
14	2509	-	-	C4	BITS 1-8					
15	2702	-	m	-	BITS 1-8					
16	2895	0	-	-	BITS 1-8					
17	3088	-	m	-	BITS 1-8					
18	3281	-	-	C5	BITS 1-7	BIT 8	-	A	A	C
19	3474	-	m	-	BITS 1-8					
20	3667	1	-	-	BITS 1-8					
21	3860	-	m	-	BITS 1-8					
22	4053	-	-	C6	BITS 1-8					
23	4246	-	m	-	BITS 1-8					
24	4439	1	-	-	BITS 1-7	BIT 8	-	A	B	D

Figure A-4: DS1 Extended Superframe Format

DS1 Alarms:

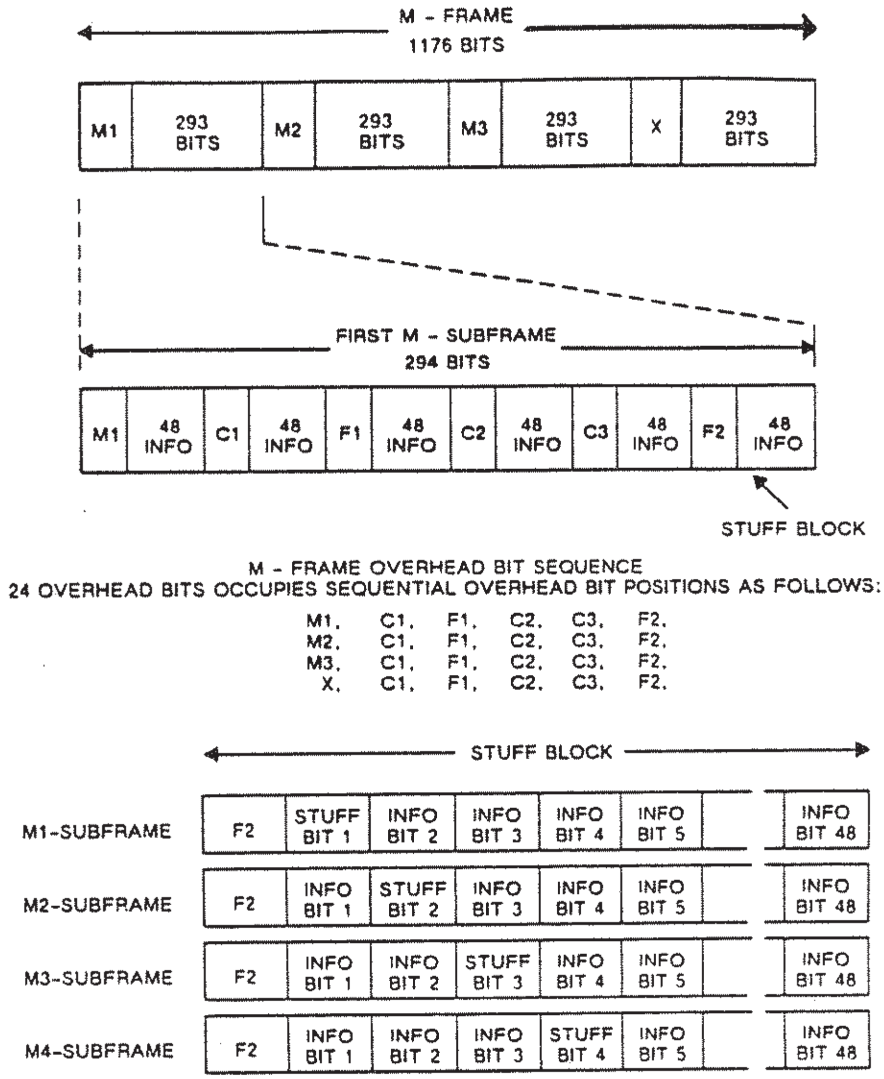
```
   NO      —x——>┌──────────────┐
 SIGNAL         │     DS1      │——————> AIS (ALL ONES)
                │   NETWORK    │
                │  EQUIPMENT   │
 YELLOW  <——————│(full duplex) │<—————— UNIMPAIRED DS1
  ALARM         └──────────────┘
```

DS1 network equipment upon detection of a loss of signal, or a loss of synchronization on an incoming DS1 line, will declare a carrier failure alarm to the operating system and will insert alarms in both direction of transmission for the DS1. The figure above shows two DS1 lines that form one full-duplex 24 channel system. The incoming line on the left side is faulty, in this case producing a loss-of-signal status at the Network Equipment. The N.E. responds to this by replacing the lost signal with the all ones AIS (or keep-alive) signal. This maintains network timing and prevents the downstream terminals from also declaring alarms. In the upstream direction from the fault, a yellow alarm (remote alarm) is sent. In SF systems this is done by setting bit 2 in each 8-bit channel time slot to "0". In ESF systems this is done by sending a repeated "eight 1's followed by eight 0's" in the 4-kbit/sec ESF data link.

A.4 DS2 FRAME FORMAT:

The DS2 6.312 Mbit/sec signal is formed by combining four DS1 signals, and adding control bits. The four DS1's are bit-interleaved, with the 2nd and 4th DS1's inverted. A control bit is inserted between every block of 48 bits (12 bits from each DS1). The position of all control bits is marked by the F-bits which have a repeated 1-0-1-0 pattern for quick identification. Further differentiation of control-bits is made by identifying the M-bits, which have a repeated 0-1-1 pattern. M4 is used as a "condition-indicator" bit, and is not used for frame synchronization.

The remaining control bits are the C-bits which are used as "stuff-indicators". Stuffing is necessary when multiplexing 4 DS1's to DS2. Since the DS1's may not be at exactly the same average bit-rates, they are all forced to an artificially-high (but equal) bit-rate by inserting "stuff-bits" in their data streams. There are four time-slots available for stuff bits in each multiframe, one time-slot for each DS1. If the slot contains a "stuff-bit" the three C-bits in that row are set to "1's", if it contains a DS1 data bit they are set to "0's". On the receive end a majority vote is taken of the three C-bits of each row to determine whether or not the "potential" stuff bit in that row was stuffed, or is a DS1 data bit.



NOTES:

1. THE M - FRAME ALIGNMENT SIGNAL IS M1 = 0, M2 = 1, AND M3 = 1.
2. THE M - SUBFRAME ALIGNMENT SIGNAL IS F1 = 0 AND F2 = 1.
3. THE C1, C2, AND C3 BIT POSITIONS ARE AVAILABLE FOR APPLICATION SPECIFIC USE.
4. IN THE M12 MULTIPLEX APPLICATION, STUFFING FOR I TH DS1 CHANNEL OCCURS IN M - SUBFRAMES I, IN THE ITH INFORMATION BIT OF THE LAST BLOCK. THE C - BITS OF THAT M - SUBFRAME ARE SET TO C1 = C2 = C3 = 1 IF STUFFING OCCURS, OR C1 = C2 = C3 = 0 INDICATING NO STUFFING.

Figure A-5: DS2 Frame Format

A.5 DS3 M13 FRAME FORMAT:

The DS3 44.736Mbit/sec signal is formed by combining seven DS2 signals, and adding control bits. The seven DS2's are bit-interleaved. A control bit is inserted between every block of 84 bits (12 bits for each DS2). The position of all control bits is marked by the F-bits which have a repeated 1-0-0-1 pattern for quick identification. Further differentiation of control-bits is made by identifying the M-bits, which have a repeated 0-1-0 pattern. The two X-bits are used as condition indicators, and in order not to mimic the M-bit pattern they, as well as the two P-bits, must always have the same value. The two P-bits are used to transmit parity from the previous multiframe. If the parity count of the information bits from the previous multiframe is odd, then the two P-bits are set to "11". If the parity count was even, they are set to "00". Using the P-bits, DS3 receivers can monitor for any multiframe containing an odd number of data-bit errors.

The remaining control bits are the C-bits which are used as "stuff-indicators". Stuffing is necessary when multiplexing 7 DS2's to DS3. Since the DS2's may not be at exactly the same average bit-rates, they are all forced to an artificially-high (but equal) bit-rate by inserting "stuff-bits" in their data streams. There are seven time-slots available for stuff bits in each multiframe, one time-slot for each DS2. If the slot is stuffed, the three C-bits in that row are set to "1's", otherwise they are set to "0's". On the receive end a majority vote is taken of the three C-bits of each row to determine whether or not the "potential" stuff bit in that row was stuffed, or is a DS2 data bit.

A.6 DS3 C-PARITY FRAME FORMAT:

The C-Parity frame format has the same overhead structure as the M13 format, which allows it to be transported over any DS3 facility. Within the frame structure however, the meaning of the C-bits is different. This in turn means that the C-Parity format can only be created by special "C-Parity" multiplexers, and can be terminated only by "C-Parity" demultiplexers. These multiplexers and demultiplexers work between DS1 and DS3, and have no DS2 appearances. This is because in C-Parity format, the "DS2" level is non-standard. Since standalone DS2 is seldom used in modern networks, this is not a problem.

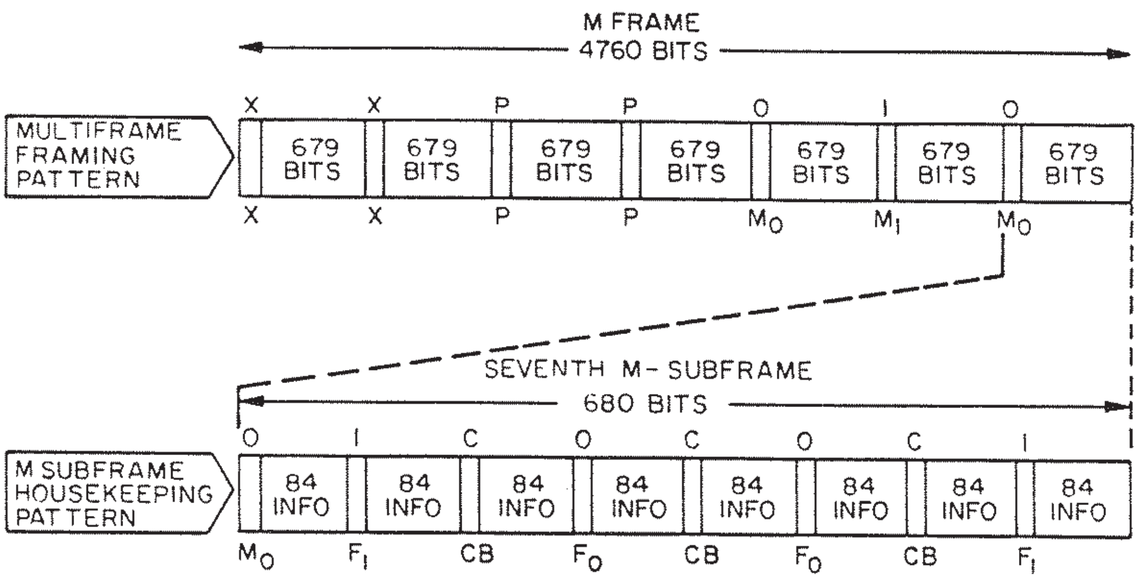
Unlike M13 format, which uses two levels of dynamic stuffing to multiplex DS1 to DS3, C-Parity format uses one level of dynamic stuffing (from DS1 to a non-standard DS2) and one level of fixed stuffing (from the non-standard DS2 to DS3). In the first step, four 1.544 Mbit/s channels are multiplexed together to form a pseudo DS2 at nominal frequency of 6.306 Mbit/s. In the second step, seven pseudo DS2 channels, each at 6.306 Mbit/s are multiplexed together to form the DS3 signal, during which, all seven stuff time-slots are stuffed at every stuffing opportunity. By using fixed stuffing from DS2 to DS3, the DS3 C-bits become free for other uses.

The primary use of the C-bits is to provide a second parity channel called "Path-Parity" or simply, "C-Parity". Typically, network equipment that monitors P-bit parity also recalculates and transmits non-errored P-bit parity, so that error performance can be determined on a section-by-section basis. A second parity channel (using the 3 C-bits of M-subframe (row) 3) is created by the originating network equipment, but is not "cleaned-up" along the path. The 3 C-bits are set to the same value as the 2 P-bits by the originating equipment, and is evaluated in the same manner. This gives the network terminating equipment the ability to monitor the DS3 error performance along the entire DS3 path.

A second use of the C-bits is to provide a transmission path for far-end performance messages. In this case, when a network terminating equipment senses a C-Parity or framing error, it transmits a Far-End-Block-Error "FEBE" back to the originating equipment using the 3 C-bits of M-subframe (row) 4. If no parity or framing error is detected on the received signal, the 3 bits are set = "111". If there is an incoming error, they are set not equal to "111". This allows both ends of the DS3 path to monitor full-duplex performance.

The first C-bit of M-subframe (row) 1 is used to indicate that the DS3 is in C-Parity format. If this bit is a constant "1", then the signal is C-Parity. For M13 format this bit toggles at the stuffing rate of DS2 #1, and for DS3 AIS, it is a constant "0".

The remaining C-bits have been reserved for network data links.



CONTROL BIT SEQUENCE - EACH CONTROL BIT OCCUPIES BIT POSITIONS

X, F1, CB, F0, CB, F0, CB, F1, X, F1, CB, F0, CB, F0, CB, F1, P, F1, CB, F0, CB, F0, CB, F1, P, F1, CB, F0, CB, F0, CB, F1,
M0, F1, CB, F0, CB, F0, CB, F1, M1, F1, CB, F0, CB, F0, CB, F1, M0, F1, CB, F0, CB, F0, CB, F1 . . .

Notes:

(1) The frame alignment signal is F0=0 and F1=1.

(2) M0 M1 M0 is the multiframe alignment signal and appears in the 5th, 6th, and 7th M subframes, M0=0 and M1=1.

(3) CB designates a bit position available for control or service bits.

Figure A-6: DS3 Frame Format

B.1 OVERVIEW

The PF-45 may be optionally equipped with a general purpose communications interface. This feature provides computer control of the PF-45 settings, and computer access of the PF-45 measurement results. The interface consists of a plug-in PC Board and supports two modes of operation: IEEE-488 (GPIB), and RS-232 C.

The VIEW field on the front panel will show "REMOTE" when the unit is under remote control (unless the field contains Error Insertion data). When the unit is under remote control the front panel indicators will be fully operational and the front panel switches will be disabled.

The interface is configured via on-board switches. See Section B.1.1.

Under Remote Control, the PF-45 behaves much like it does under manual control. Setup command strings are sent to the PF-45. These select the SETUP parameters that are desired. Measurement results are requested by sending the desired [EVENT] and [ANALYSIS] parameters.

Instrument operation, and the set of Command Strings are essentially identical for both IEEE-488 and RS-232. Some extensions have been added to the basic command set to allow "IEEE-488-like" status responses via RS-232. These differences are described in detail in section B.4.2 "RS-232 Command Extensions".

B.1.1 PC Board Configuration

The communications board has two dip switches labeled S1 and S2. These switches configure the interface for the desired operation. The functions of these switches are as follows:

CLOSED = 1
OPEN = 0

S1

1	2	3	4	5	6	7	8
IEEE ADDRS	IEEE ADDRS	IEEE ADDRS	IEEE ADDRS	SRQ 1 NONE 0	ANSWR 1 NONE 0	ERROR 1 NONE 0	RS232 1 IEEE 0

LSB 0...15 MSB

S2

1	2	3	4	5	6	7	8
BAUD RATE	BAUD RATE	BAUD RATE	STOP/ DATA	STOP/ DATA	STOP/ DATA	ECHO 1 NONE 0	UNDEF

S1 Switches 1...4: IEEE Address

1	2	3	4	Address
0	0	0	0	System Controller Only
1	0	0	0	1 Default
0	1	0	0	2
1	1	0	0	3
0	0	1	0	4
1	0	1	0	5
0	1	1	0	6
1	1	1	0	7
0	0	0	1	8
1	0	0	1	9
0	1	0	1	10
1	1	0	1	11
0	0	1	1	12
1	0	1	1	13
0	1	1	1	14
1	1	1	1	15

S1 Switch 5: SRQ

Setting this switch to 1 (Closed) allows the PF-45 to generate a service request. See section B.2.3 IEEE-488 STATUS BYTE.

S1 Switch 6: ANSWR

Setting this switch to 1 (Closed) allows the PF-45 to answer an incoming call. If a modem is connected to RS-232 port the ring indicator RI signal is monitored, when detected the instrument will set DTR and attempt to establish a communications link. Commands may now be sent, and data received. In order for the PF-45 to remain active, the operator must send commands at least every *60 seconds. Should commands fail to come in at this rate, the PF-45 will automatically disconnect. Should the operator desire to disconnect, the command *BYE should be sent.

* After a local print (Print on PF-45 printer) timeout is extended to 120 seconds.

S1 Switch 7: ERROR

The Error-Check Mode is activated when Switch S1.7 is set ON. The PF-45 then expects the incoming RS-232 strings to be in the format shown below. The transmitted results from the PF-45 are sent in the normal format.

PF-45 Receive Data Format:

BYTE	CONTENTS
1	#Bytes Total: 00H..FFH (Hex, not part of checksum)
2...X	Message (ie: "E0000,")
X+1	D7...D0 Checksum Low Byte (00H...FFH)
X+2	D15..D8 Checksum High Byte (00H...FFH)
X+3	Carriage Return (not part of checksum)
X+4	Line Feed (not part of checksum)

S1 Switch 8: IEEE/RS-232

Setting this switch to 1 (Closed) enables RS-232 mode. 0 (open) is the default mode GPIB/IEEE-488.

S2 Switches 1...3: RS-232 BAUD RATE

Desired BAUD Rate:	S2	1	2	3	
110		0	0	0	
300		1	0	0	
1200		0	1	0	
2400		1	1	0	Default
4800		0	0	1	
9600		1	0	1	
Test use only		1	1	1	

S2 Switches 4...6: STOP/DATA

N = No Parity
E = Even Parity
O = Odd Parity

Format: Parity?, #Data Bits, #Stop Bits

Selection:	S2	4	5	6	
N,8,1		0	0	0	Default
E,7,1		1	0	0	
O,7,1		0	1	0	
N,8,2		1	1	0	
N,7,2		0	0	1	
Undefined		1	0	1	
Undefined		0	1	1	
Undefined		1	1	1	

S2 Switch 7: ECHO

Setting this switch to 1 (Closed) will force the RS-232 interface to echo characters back to the sending device. This is commonly known as FULL DUPLEX mode. Default Echo.

B.2 IEEE-488 (GPIB)

B.2.1 IEEE-488 Implementation

The IEEE 488 option is a talker/listener, with no controller functions. The following functions are implemented:

SH1	Complete source handshake
AH1	Complete accepter handshake
T6	Basic talker, serial poll, unaddress if addressed to listen
TE0	No extended talker capability
L4	Basic listener, no listen only, unaddress if addressed to talk
LE0	No extended listener capability
SR1	Complete service request capability
RL1	Complete remote/local capability
PP0	No parallel poll capability
DC1	Complete device clear capability
DT1	Complete device trigger capability (equal to string "K0,")
C0	No controller capability
E2	Tri-state drivers are used on DIO lines

Device Clear: Sets PF-45 to Tx3->Rx3 mode, Tx3:HI, Rx3: H/L, Frm3:M13, Clk3:Int, Ptn:2E15-1, AUX ERR: DS3 Fbit. Puts PF-45 into Remote state.

Remote: Always use IEEE "Remote" command (or "Device Clear") to enter the remote state.

Local Lockout: When in the remote state, the PF-45 front panel pushbuttons are always disabled. Local control can be achieved using the IEEE "Local" command, or by turning the power off then on.

Power-On Status: Under IEEE control, the PF-45 powers up in the same manner as in manual. However, the PF-45 always powers up under manual (LOCAL) control. When this happens, the IEEE Status Byte is correctly set with D7 = 1, and if SRQ is enabled, a Service Request is transmitted.

Note on IEEE-488 Timeout:
The PF-45 processes and acts on setup commands as soon as they are received. While it is performing the setup it will not accept another command over the IEEE bus. In general, this process is very fast, but certain commands, such as the "S-string" which reconfigures the entire PF-45, may take upwards of 0.33 seconds. If the IEEE timeout has been set for this time or shorter, the IEEE bus-controller will timeout.

Recommendation: SET IEEE-488 TIMEOUT TO APPROXIMATELY ONE SECOND MININMUM!

B.2.2 IEEE-488 Status Byte

The PF-45 responds to a Serial Poll by sending the Status byte to the controller. The bits of the Status byte are organized as follows:

D7	Power On Reset
D6	SRQ (Service Request)
D5	Command Error
D4	End of measurement
D3	Hardware Error
D2	Execution Error
D1	Measurement Alarm
D0	Operation Complete

Each of the bits of the Status byte will be ON (1) after the designated event has occurred, and will be self-clearing. (They will return to the OFF (0) status after the Status byte is sent.)

Power On Reset (D7): indicates that a Power On Reset condition has occurred (the instrument has been powered-up) since the last Serial Poll.

SRQ (D6): indicates that the PF-45 has issued a Service Request because one or more of the following conditions has occurred. Note that a Service Request will not be issued if S1/5 = 0, ie: the Service Request is disabled.

Power On Reset	Hardware Error
Command Error	Measurement Alarm
Execution Error	Operation Complete
End of Measurement	

Command Error (D5): indicates that the PF-45 has received an unrecognizable command.

End of Measurement (D4): indicates that the PF-45 has completed a timed measurement.

Hardware Error (D3): indicates that a hardware failure has occurred in the PF-45.

Execution Error (D2): indicates that the PF-45 has received a command for an impossible combination of settings.

Measurement Alarm (D1): indicates that a condition which might effect the accuracy of the measurement has occurred. Note that any of these events will cause a Measurement Alarm only if it has been selected by the Interrupt Select command.

Operation Complete (D0): indicates that the last operation has been completed, such as data requested by a Send Measurement Result string is ready to be sent, or an Error Insertion Burst has finished.

B.3 RS-232

The RS-232 port provided on the PF-45 Option is a simple asynchronous communication interface configured as a DTE. It uses a nine pin "D" type connector. Various Baud Rates/Bit Combinations are supported. A modem may be connected for dial up applications.

Interface:	9 Pin D-Type Male Standard Bi-Directional Serial.
Pinout:	DTE
Handshake:	Xon/Xoff
Modem:	Answer (When Enabled).
Echo:	On or Off
Baud Rates:	110,300,1200,2400,4800,9600
Bits:	N,8,1/E,8,1/O,8,1/N,8,2/N,7,2
Format:	Parity, Data Bits, Stop Bits

N = No Parity
E = Even Parity
O = Odd Parity

Pin:	Signal:	
1	NC	
2	Receive Data	Required
3	TX Data	Required
4	DTR (Set after RI true).	
5	Signal Ground	Required
6	DSR (Data Set Ready).	
7	RTS (Request to Send).	
8	CTS (Clear to Send).	
9	RI (Ring Indicator).	Required (Modem answer only)

Modem use
PF-45 will support the use of a dial up modem. The signal DTR is used to take the modem off hook. If enabled (S1 POS 6) upon detection of signal RI (Ring Indicator) DTR is set true. Commands must be sent to PF-45 at least every 60 seconds for it to hold DTR. Disconnect with the command *BYE. Note: Modem should not echo characters back to PF-45.

Notes:

- All commands are acknowledged by a STATUS message
  Example: STATUS = 1
- Controller must wait for STATUS message before sending next command.
- Controller must put the PF-45 in REMOTE before sending any command.
- Since sending "E" or "M" commands will result in a STATUS message, make sure to read the STATUS message before reading the results.

B.4 PROGRAMMING

Available Functions

Under manual control, setups and measurements are selected by scrolling through the available choices shown on the PF-45 display. Only "available" choices can be made, since unavailable or inappropriate choices are not offered. The remote control Command Strings however, offer complete lists of all setups and measurements, and for any given Mode or setup configuration not all of these are valid.

Command structure

Every command starts with one of the letters (ASCII) defined in the identifier list below. It is then followed by a string of one of the following (ASCII) characters "0 1 2 3 4 5 6 7 8 9 : ; < = > ?" and is ended by a delimiter ",". Each command string must always be sent in its entirety. Send one command at a time. DO NOT CONCATENATE COMMANDS!

Delimiter

Every command must end with a comma, which is the only character recognized by the PF-45 as a proper delimiter. The Carriage Return character (OCH), the Line Feed character (OAH), and the Space character (2OH) are not recognized as delimiters, and are ignored. Therefore, "C12," and "C 1 2 ," are recognized as the same command.

Programming Errors

Syntax errors, such as command strings with the wrong number of characters, or lacking a valid "letter" prefix, or any other non-valid string, are unrecognizable by the PF-45. This will cause a Command Error in the STATUS byte, and will load "Command Error" in the IEEE-488 output buffer. For RS-232, "Command Error" is automatically returned to the controller.

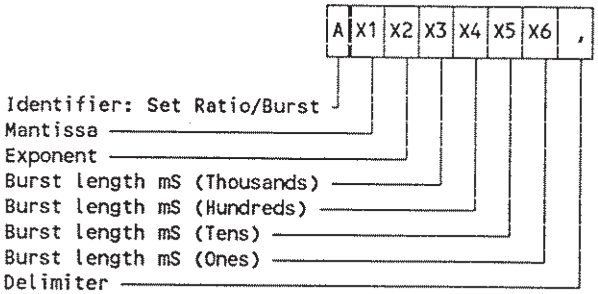
Sending a syntactically-correct string at the wrong time, such as asking for DS3 Frame Errors in MON1 mode is recognizable by the PF-45, but cannot be performed. This will cause an Execution Error in the STATUS byte, and will load "Execution Error" in the IEEE-488 output buffer. For RS-232, "Execution Error" is automatically returned to the controller.

B.4.1 Command Strings

Identifier list:

A = Ratio/Burst Length string
B = Error Insertion string
C = DS1 Dropped-Channel Select string
D = Date Setup string
E = Error Measurement string
G = DS1 Error Insert Channel Select string
I = Interrupt Select string
K = Trigger string
L = LED STATUS string
M = RxSTATUS Measurement string
N = Display string
P = Print string
R = Measurement Run Time string
S = Setup string
T = Real-time Clock string

[A] Error Insertion Ratio/Burst Length String



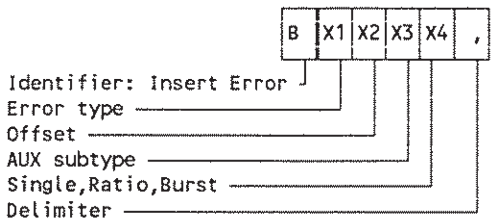
Mantissa (Ratio)	X1: 1,2 or
Exponent (Ratio)	X2: (-)2...9
Burst Length	X3 X4 X5 X6: 0001 ... 6000 (mS)

X1 X2 = 00 Selects "Ext2"

Sample IEEE command (HP-BASIC for HP-85):

10 OUTPUT 701;"A130500," !This sets the Error Insertion Ratio to 1E-3,
and the Burst Length to 500mSec.

[B] Error Insertion String



Error Type (X1)	Offset (X2)	Aux Subtype (X3)
X1: 0 = No Error	X2: ---	X3: ---
X1: 1 = BIT	X2: ---	X3: ---
X1: 2 = BPV	X2: ---	X3: ---
X1: 3 = CRC/PAR	X2: 0 = Parity	X3: ---
	X2: 1 = C-Parity	X3: ---
	X2: 2 = FEBE	X3: ---
	X2: 3 = CRC	X3: ---
X1: 4 = FRM	X2: 0 = Frm3	X3: ---
	X2: 1 = Frm2	X3: ---
	X2: 2 = Frm1	X3: ---
X1: 5 = AUX	X2: 0 = Loopback	X3: 0 = CSU Up
		X3: 1 = CSU Dn
		X3: 2 = NI Up
		X3: 3 = NI Dn
	X2: 1 = DS3 Fbit	X3: 0 = 2/2
		X3: 1 = 2/3
		X3: 2 = 3/3
		X3: 3 = 3/15
		X3: 4 = 3/16
		X3: 5 = 3/17
	X2: 2 = DS3 Mbit	X3: 0 = 1/1
		X3: 1 = 2/2
		X3: 2 = 2/3
		X3: 3 = 3/3
	X2: 3 = DS3 Xbit	X3: 0 = 00
		X3: 1 = 01
		X3: 2 = 10
	X2: 4 = DS3 Cbit	X3: 0 = Col1
		X3: 1 = Col2
		X3: 2 = Col3
	X2: 5 = DS2 Fbit	X3: 0 = 2/6
		X3: 1 = 2/5
		X3: 2 = 2/4
		X3: 3 = 3/3
		X3: 4 = 2/2
	X2: 6 = DS2 Mbit	X3: 0 = 1/1
		X3: 1 = 2/2
		X3: 2 = 2/3
		X3: 3 = 3/3
	X2: 7 = DS2 Xbit	X3: 0 = 0
	X2: 8 = DS2 Cbit	X3: 0 = Col1
		X3: 1 = Col2
		X3: 2 = Col3
	X2: 9 = DS1 Fbit	X3: 0 = Ft 2/6
		X3: 1 = Ft 2/5
		X3: 2 = Ft 2/4
		X3: 3 = Fs 2/4
		X3: 4 = Fts 2/4

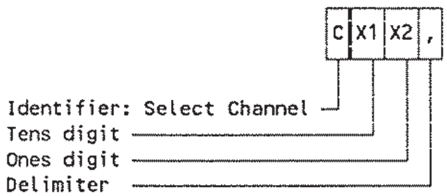
```
X1: 6 = ALM              X2: 0 = DS3 AIS        X3: ---
                         X2: 1 = DS3 IDLE       X3: ---
                         X2: 2 = DS1 AIS        X3: ---
                         X2: 3 = DS1 YELLOW     X3: ---
                         X2: 4 = DS3 X=00       X3: ---
                         X2: 5 = DS2 X=0        X3: ---
X4: 0 = No Error
    1 = Single Error Insert
    2 = Ratio ON
    3 = Ratio OFF
    4 = Burst Error Insert
```

"---" means value of character is disregarded (don't care).

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"B5621," !This sends a single group of 2/3 DS2 M-bit errors.

[C] DS1 Dropped-Channel Select String

Use this to select a dropped DS1 (channel) number. This can only be selected in Mode # 02,04,07,10,11, 12, and 13. (Be sure to send both digits since a command such as "C2," is illegal. Select Channel 2 with "C02,".)

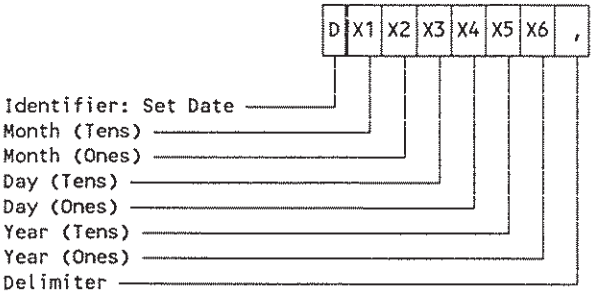


X1 X2 = 00 through 28

DS1 channel 00 will select NO dropped DS1.

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"C14," !This selects DS1 #14 for analysis.

[D] Date Setup String



X1 X2: 01 - 12
X3 X4: 01 - 31
X5 X6: 00 - 99

Sample IEEE command (HP-BASIC for HP-85):

```
10 OUTPUT 701;"D010100," !This sets the date to January 01, 2000.
```

[E] Error Measurement String

The entire 20-character top line of the display is sent. Following the last of the 20 ASCII data characters is a Line Feed character (0AH). The PF-45 also sends an EOI (End or Identify) along with the Line Feed character. Therefore, the controller can terminate data reception on either the EOI command or the Line Feed character, when reading the measurement result display.

```
                                          | E | X1 | X2 | X3 | X4 | , |
Identifier: Send Measurement Result ------+   |    |    |    |    |
Event (Tens) ---------------------------------+    |    |    |    |
Event (Ones) --------------------------------------+    |    |    |
Analysis -----------------------------------------------+    |    |
Threshold ---------------------------------------------------+    |
Delimiter --------------------------------------------------------+
```

X1 X2:	00	=	Bit3
	01	=	Bit1
	02	=	BPV3
	03	=	BPV1
	04	=	Par
	05	=	C-Par
	06	=	FEBE
	07	=	* CRC (DS1/E1)
	08	=	Frm3
	09	=	Frm2 (DS2/DS2E)
	10	=	Frm1 (DS1/E1)
	11	=	Par2 (DS2E)
X3:	0	=	ErrCnt
	1	=	DrbCnt
	2	=	CurBER/MaxBER
	3	=	AvgBER
	4	=	DrbBER
	5	=	ErrSec
	6	=	* Threshold ErrSec
	7	=	%EFS
	8	=	Err/S/MaxES
X4:	0	=	<E-6ES
	1	=	≥E-6ES
	2	=	<E-5ES
	3	=	≥E-5ES
	4	=	<E-4ES
	5	=	≥E-4ES
	6	=	<E-3ES
	7	=	≥E-3ES
	8	=	≥E-2ES
	9	=	≥E-1ES
	:	=	SES

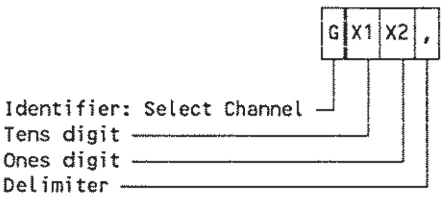
* If X1 X2 = 07 (CRC), and X3 = 6 (Threshold ErrSec), "SES" is by default the selected measurement, and the value of X4 is "don't care".

Sample IEEE command (HP-BASIC for HP-85):

```
10 OUTPUT 701;"E0868,"      !This selects the ERROR MEASUREMENT display category,
                            !and sets the [EVENT] to Frm3, and the [ANALYSIS] to
                             >E-2 Threshold Errored Seconds.
```

[G] DS1 Error Insert Channel Select String

Use this to select a DS1 (channel) number for error insertion. This can only be selected in Mode # 03 and 04. (Be sure to send both digits since a command such as "G2," is illegal. Select Channel 2 with "G02,".)



X1 X2 = 00 through 28

DS1 channel 00 will select NO DS1 for error insertion. This is the default value after sending a SETUP string, (ie, defining an operating mode).

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"G01," !This selects DS1 #1 for error insertion.

[I] Interrupt Select String

This command is used to select any combination of events and alarms which set the Measurement Alarm bit (used in the IEEE status byte).

I	X1	X2	X3	X4	X5	,

```
Identifier: Select Interrupt ── I
DS3 Events/Alarms ──────────── X1
DS3 Events/Alarms ──────────── X2
DS2 Events/Alarms ──────────── X3
DS1 Events/Alarms ──────────── X4
DS1 Events/Alarms ──────────── X5
Delimiter ──────────────────── ,
```

To enable an Alarm condition, choose a value of X1-X5 that includes a "1" in the table for the desired alarm condition. Measurement alarms are sent only during a measurement run. Selecting an individual Alarm condition has no effect on the LED status information. After receiving the Device Clear command, or an "S"-string, no alarm conditions will be selected.

X1	DS3 AIS	DS3 CPar	DS3 No Frame	DS3 No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X2	DS3 Ptn Sync Loss	DS3 X-bit	DS3 Idle
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

	DS2 AIS	DS2 Xbit	DS2 No Frame	DS2 No Signal
X3	DS2E AIS	DS2E Abit	DS2ENo Frame	DS2E No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

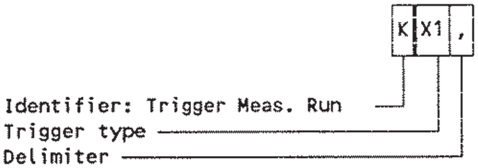
	DS1 Yel	DS1 AIS	DS1 No Frame	DS1 No Signal
X4	E1 R-Alarm	E1 AIS	E1 No Frame	E1 No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X5	Errored Second	DS1 Ptn Sync Loss	DS1 Excess Zeros
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"I30002," !This selects DS3 No Signal, DS3 No Frame, and DS1 No Patn Sync for Measurement Alarms.

[K] Trigger String

The three trigger commands perform the same function in remote mode as the START/STOP key.



X1 = 0 for START new measurement run
X1 = 1 for CONTINUE previous measurement run
(timed measurement runs only)
X1 = 2 for STOP present measurement run

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"K0," !This starts a new measurement run.

[L] LED Status String

```
                                     |L|X1|,|
                                      |  |  |
Identifier: Send LED Status ----------+  |  |
Current/History -------------------------+  |
Delimiter ----------------------------------+
```

```
      X1:          0      =      Current LED Status*
                   1      =      HISTORY of LED Status
```

A five-character string is returned which represents the RxSTATUS (1=On, 0=Off). The following tables describe the range of each character X1 through X5, and the meaning of each value.

*Use of "L0," is not recommended after an "N9," has brought up the Rx Status Page.

X1	DS3 AIS	DS3 CPar	DS3 No Frame	DS3 No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X2	DS3 Ptn Sync Loss	DS3 X-bit	DS3 Idle
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

X3	DS2 AIS / DS2E AIS	DS2 Xbit / DS2E Abit	DS2 No Frame / DS2ENo Frame	DS2 No Signal / DS2E No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X4	DS1 Yel / E1 R-Alarm	DS1 AIS / E1 AIS	DS1 No Frame / E1 No Frame	DS1 No Signal / E1 No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X5	DS1/E1 * Status=E1	DS1 Ptn Sync Loss	DS1 Excess Zeros
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0

* L0 (Current) = Current DS1/E1 Status
L1 (History) = DS1/E1 Status of last measurement run

Sample IEEE command (HP-BASIC for HP-85):
10 OUTPUT 701;"L1," !This commands the PF-45 to return the HISTORY of the RxSTATUS LEDs.

[M] RxSTATUS Measurement String

Like "Error Measurement String" the entire 20-character top line of the display is sent.

```
                                       | M | X1 | X2 | , |
Identifier: Send RxStatus Meas. Result ┘   |    |    |
Event ──────────────────────────────────────┘    |    |
Analysis ─────────────────────────────────────────┘    |
Delimiter ──────────────────────────────────────────────┘
```

Event X1:			
	0	=	DS3
	1	=	DS2/DS2E
	2	=	DS1/E1
	3	=	PF-45

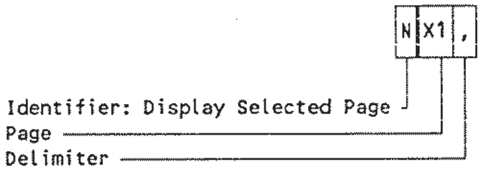
Analysis X2:

			DS3	DS2/DS2E	DS1/E1	PF-45
X2:	0	=	NoSigSecs	NoSigSecs	NoSigSecs	NoPowerSec
	1	=	NoFrmSecs	NoFrmSecs	NoFrmSecs	Total ErrSecs
	2	=	NoPTNSecs	AIS Secs	NoPTNSecs	Total AlmSecs
	3	=	AIS Secs	X/AbitSecs	AIS Secs	---
	4	=	Idle Secs	---	Yel/R-Alm Secs	---
	5	=	XbitSecs	---	ExZrsSecs	---
	6	=	---	---	---	---
	7	=	---	---	---	---

Sample IEEE command (HP-BASIC for HP-85):

10 OUTPUT 701;"M30," !This selects the RxSTATUS MEASUREMENT display category,
!and sets the [ANALYSIS] to PF-45 NoPowerSec.

[N] Display String



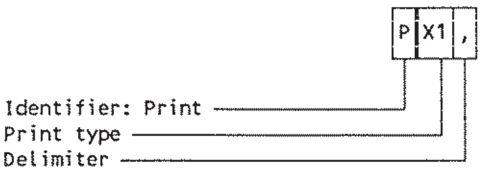

```
X1:    0 = Set New Mode Page
       1 = DS3 Setup Page
       2 = DS1 Setup Page
       3 = Pattern Select Page
       4 = AUX Error Insert Select Page
       5 = Test Duration Setup Page
       6 = Real-Time Clock and Date Setup Page
       7 = Printer Setup Page
       8 = Measure Errors Page
       9 = Measure RxSTATUS Page
```

Sample IEEE command (HP-BASIC for HP-85):

10 OUTPUT 701;"N6," !This brings up the Real-Time Clock and Date Setup Page on the front panel display.

[P] Printer String

The two Print commands each ask for a "Manual Print", but to different destinations.




```
X1 = 0  for a Manual Print on the PF-45 thermal printer.
X1 = 1  for a "Manual Print" to the IEEE controller.
```

Sample IEEE command (HP-BASIC for HP-85):

10 OUTPUT 701;"P1," !This requests a "Manual Print" to be dumped to the IEEE Controller.

[R] Measurement Run Time String

R	X1	X2	X3	X4	X5	X6	X7	X8	X9	,

```
Identifier: Set RunTime
Measurement type
Hours    (Thousands)
Hours    (Hundreds)
Hours    (Tens)
Hours    (Ones)
Minutes  (Tens)
Minutes  (Ones)
Seconds  (Tens)
Seconds  (Ones)
Delimiter
```

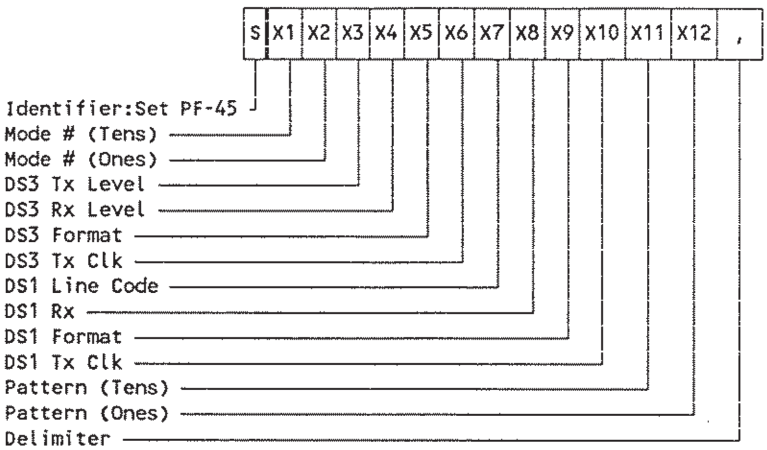
```
Measurement X1:          0 = Timed
                         1 = Continuous
Hours X2 X3 X4 X5:       0000 - 1000
Minutes X6 X7:           00 - 59
Seconds X8 X9:           00 - 59
```

Sample IEEE command (HP-BASIC for HP-85):

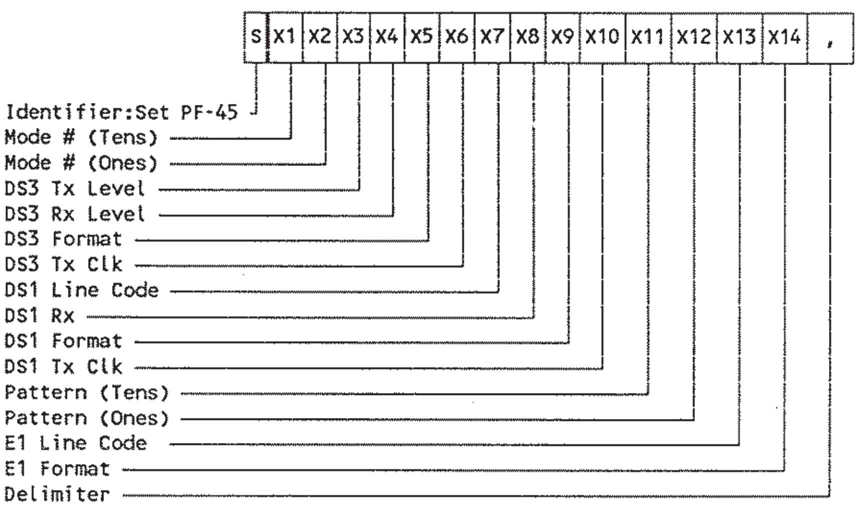
10 OUTPUT 701;"R000013000," !This sets up a Timed Measurement Run of 1 hour 30 minutes.

[S] Setup String

Use this once, initially to set the operating parameters of the instrument, and later to make subsequent changes.



Or for operation with the E1 Drop/Analysis Option:



Mode X1 X2:	00 = Tx3->Rx3
	01 = Tx1->Rx1
	02 = Tx1->Rx^3_1
	03 = Tx^3_1->Rx1
	04 = Tx^3_1->Rx^3_1
	05 = MON3
	06 = MON1
	07 = MON^3_1
	08 = THRU3
	09 = THRU1
	10 = $THRU^3_1$
	11 = $IntD\&I^3_1$
	12 = $ExtD\&I^3_1$
	13 = INS^3_1->Rx1

DS3 Tx Level X3:	0 = Tx3 HI
	1 = Tx3 DSX
	2 = Tx3 LO

DS3 Rx Level X4:	0 = Rx3 H/L
	1 = Rx3 DSX
	2 = Rx3 NRZ Up
	3 = Rx3 NRZ Down

DS3 Format X5:	0 = Frm3 M13
	1 = Frm3 C-Par
	2 = Frm3 Unfrm
	3 = Frm3 M-Mix (S-string must be 14 chars. long)
	4 = Frm3 C-Mix (S-string must be 14 chars. long)

DS3 Tx Clk X6:	0 = Clk3 Int
	1 = Clk3 Ext
	2 = Clk3 Loop

DS1 Line Code X7:	0 = Code AMI
	1 = Code B8ZS

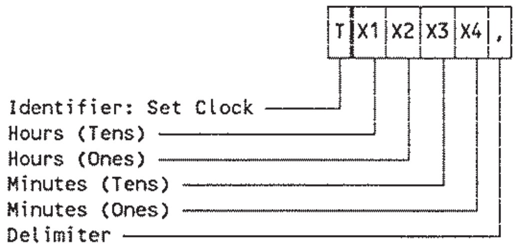
DS1 Rx X8:	0 = Rx1 Term
	1 = Rx1 Brdg
	2 = Rx1 NRZ Up
	3 = Rx1 NRZ Down

DS1 Format X9:	0 = Frm1 D4/SF	
	1 = Frm1 ESF	
	2 = Frm1 Unfrm	
	3 = Frm1 SLC	
DS1 Tx Clk X10:	0 = Clk1 Int	
	1 = Clk1 Ext	
	2 = Clk1 Ref	
	3 = Clk1 Loop	
	DS3	DS1
Pattern X11 X12:	00 = 1111	00 = QRSS20
	01 = 2E23-1	01 = 2E23-1
	02 = 2E20-1	02 = 2E20-1
	03 = 2E15-1	03 = 2E15-1
	04 = 2E11-1	04 = 2E11-1
	05 = 2E9-1	05 = 2E9-1
	06 = 1010	06 = 11111111
	07 = 1100	07 = 1-in-8
	08 = 1000	08 = 2-in-8
	09 = 100	09 = 3-in-24
	10 = Live	10 = QRSS11
		11 = Live
		12 = InsDS1
E1 Line Code X13:	0 = CodeE1:AMI	
	1 = CodeE1:HDB3	
E1 Format X14:	0 = FrmE1:FAS	
	1 = FrmE1:CRC4	
	2 = FrmE1:Unfrm	

Sample IEEE command (HP-BASIC for HP-85):

```
10 OUTPUT 701;"S041110001009,"  !This sets up Tx31->Rx31 mode, Tx3:DSX, Rx3:DSX, Frm3:CPar,
                                !Clk3:Int, Code:AMI, Frm1:ESF, Clk1:Int, Pattern:3-in-24.
```

[T] Real-Time Clock String




```
Hours    X1 X2:  00 - 23
Minutes  X3 X4:  00 - 59
```

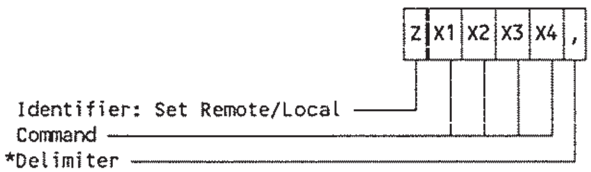
Sample IEEE command (HP-BASIC for HP-85):

10 OUTPUT 701;"T0000," !This sets the time to midnight.

B.4.2 RS-232 Command Extensions

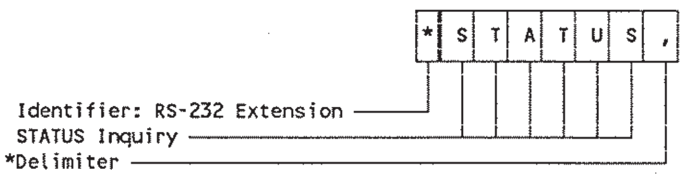
The following command extensions allow the RS-232 user to access interface functions normally only available via GPIB/IEEE-488.

[Z] Remote/Local String



X1,X2,X3,X4: 0000 = Local (Remote OFF)
1000 = Remote ON
9999 = Remote RESET

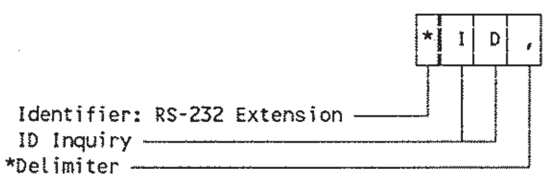
[*STATUS] String



Sending this command will instruct the interface to check and see if any of the bits in the status byte are set. Should any bits be set (or equal to 1), the instrument will send a decimal value corresponding to the status byte. Else the response will be 0.

D0 = LSB
D7 = MSB

[*ID] String

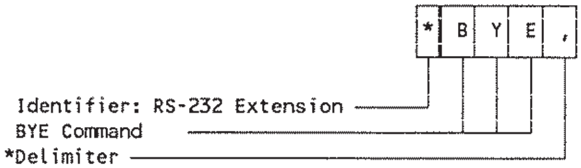


Sending this command forces the instrument to send an identifier message. Syntax as follows:

PF-45 [#X] RS-232 REMOTE
#X is a number "0" to "?".
Depends on IEEE-488 address setting.

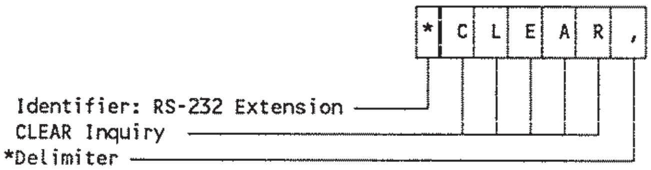
*Note: Delimiter may also be CR/LF.

[*BYE] String



This command forces the PF-45 to set DTR False. Disconnecting a modem from the line.

[*CLEAR] String



Sending this command will force the instrument to a known default setup. This corresponds to the IEEE-488 command DEVICE CLEAR. Instrument must be in remote mode first.

*Note: Delimiter may also be CR/LF.

B.4.3 IEEE-488 Programming Examples

The following examples are for the HP-85 Computer. The language is HP-BASIC with IEEE extensions. The PF-45 is set to IEEE address 01. The IEEE bus is address 7.

Putting the PF-45 into Remote State:

Always put the PF-45 into Remote State before sending other commands.

```
10 REMOTE 701           !Puts PF-45 into Remote State
or
10 CLEAR 701            !Puts PF-45 into the default configuration, including Remote State
```

Setting up the PF-45 under remote control:

```
10 RESET 7                      !Reset IEEE bus
20 REMOTE 701                   !Put PF-45 into Remote state
30 OUTPUT 701;"S040000000000,"  !Setup Tx31->Rx31 mode, Tx3:HI, Rx3:H/L, Frm3:M13, Clk3:Int,
                                !Code:AMI, Frm1:D4/SF, Clk1:Int, Pattern:QRSS20
40 OUTPUT 701;"R100000000,"     !Setup CONTINUOUS Measurement Run
50 OUTPUT 701;"K0,"             !Start Measurement Run
.
.
.
```

Getting data from the PF-45 (using Serial Poll):

```
10 DIM A$[50]                   !Dimension A$ large enough for expected data string
.
.
100 OUTPUT 701;"E0000,"         !Request Bit3 ErrCnt
110 S=SPOLL(701)                !Get Status Byte
120 IF NOT BIT(S,0) THEN 110    !If bit "0" of the Status Byte is not = 1,
                                !the measurement result is not ready yet, so get another Status Byte
130 !                           !The measurement result is ready
140 ENTER 701;A$                !Get the measurement result
150 DISP A$                     !Display the measurement result
```

Getting data from the PF-45 (using Service Request):

SRQ must be enabled (S1/5 = 1).

```
10 DIM A$[50]                          !Dimension A$
.
.
100 OUTPUT 701;"E0000,"                !Request Bit3 ErrCnt
110 ON INTR 7 GOTO 200                 !Set interrupt branch
120 ENABLE INTR 7;8                    !Enable HP-85 to be interrupted by SRQ
130 GOTO 130                           !Wait for SRQ
.
.
200 ENABLE INTR 7;0                    !SRQ has interrupted "GOTO 130" loop
                                       !Disable interrupt while it is being serviced
210 S=SPOLL(701)                       !Get Status Byte
220 IF NOT BIT(S,0) THEN 500           !SRQ was not caused by Operation Complete
                                       !Branch to a general-purpose SRQ-servicing routine
230 !                                  !The SRQ was sent because the measurement result is ready
240 ENTER 701;A$                       !Get the measurement result
250 DISP A$                            !Display the measurement result
260 GOTO 100                           !Make another measurement
.
.
500 !                                  !General-purpose SRQ-servicing routine
510 IF BIT(S,1) THEN 600               !Measurement Alarm
520 IF BIT(S,2) THEN 700               !Execution Error
530 IF BIT(S,3) THEN 800               !Hardware Error
540 IF BIT(S,4) THEN 900               !End of Measurement Run
550 IF BIT(S,5) THEN 1000              !Command Error
560 IF BIT(S,7) THEN 1100              !Power On
570 GOTO 100                           !Make another measurement
.
.
```

Getting a Print, and Displaying it on the Controller Screen:

```
10 DIM A$[3600]                        !Dimension A$ for the maximum printout length
.
.
100 OUTPUT 701;"P1,"                   !Request a print
110 S=SPOLL(701)                       !Get the Status Byte
120 IF NOT BIT(S,0) THEN 110           !Check if data is ready
130 ENTER 701 USING "#%,#%K",A$        !Get print data. Use EOI as terminator.
140 N=LEN(A$)                          !Determine length of print string
150 A=1                                !Initialize A
160 FOR I=1 TO N                       !Define loop
170 IF A$[I,I]=CHR$(13) THEN DISP A$[A,I-1] @ A=I+2
                                       !Display each line based on the position of Carriage Return
180 NEXT I                             !Continue loop
.
.
```

B.4.4 RS-232 Sample Session

Tx3->Rx3, 1 Minute Timed Run, with 1E-4 Ratio On, and Interrupt on DS3 No Signal

```
(type)       Z1000            Put PF-45 into Remote mode
(returned)   STATUS=1         Command Accepted

(type)       S000000000000    Setup
(returned)   STATUS=1         Command Accepted

(type)       A141000          Set Insert Ratio to 1E-4
```

(returned)	STATUS=1	Command Accepted
(type)	B1002	Set Bit Error Insert Ratio On
(returned)	STATUS=1	Command Accepted
(type)	R000000100	Measurement Run Time = 1 Minute
(returned)	STATUS=1	Command Accepted
(type)	I10000	Request Interrupt on DS3 No Signal
(returned)	STATUS=1	Command Accepted
(type)	K0	Start Measurement Run
(returned)	STATUS=1	Command Accepted
(type)	E0000	Request Bit Error Count while measurement is running
(returned)	Bit3 ErrCnt= 44206	Result
(returned)	STATUS=65	Result Complete

Manually, cause DS3 No Signal by pulling out the DS3 Rx cable

(returned)	STATUS=66	Measurement Alarm (DS3 No Signal) has occurred

Manually, plug DS3 Rx cable back in

(returned)	STATUS=66	Measurement Alarm (DS3 No Signal) has cleared

(wait)

(returned)	STATUS=80	1 Minute Measurement Run finished
(type)	E0000	Request final Bit Error Count
(returned)	Bit3 ErrCnt= 265259	Result
(returned)	STATUS=65	Result Complete

B.5 PF-45 FUNCTIONS (EXPLICIT LISTING)

Available Events for each Mode (DS1)

	Tx3->Rx3 MON3 THRU3			Tx1->Rx1 Tx31->Rx1 MON1 THRU1			Tx31->Rx31 Tx1-Rx31 MON31 THRU31			IntD&I31 ExtD&I31 Ins31->Rx1*			Mode
	Unf	M13	CPar				M13			CPar			DS3 Format
				Unf	D4	ESF	Unf	D4	ESF	Unf	D4	ESF	DS1 Format
Bit3	x	x	x										Events
Bit1				x	x	x	x	x	x	x	x	x	
BPV3	x	x	x				x	x	x	x	x	x	
BPV1				x	x	x	[I]	[I]	[I]	[I]	[I]	[I]	
Par		x	x				x	x	x	x	x	x	
CPar			x							x	x	x	
Febe			x							x	x	x	
CRC						x			x			x	
Frm3		x	x				x	x	x	x	x	x	
Frm2							x	x	x	x	x	x	
Frm1					x	x		x	x		x	x	

[I]: Ins31->Rx1 only!

Available Events for each Mode (E1)

	MON31						Mode
	M-Mixed			C-Mixed			DS3 Format
	Unf	FAS	CRC	Unf	FAS	CRC	E1 Format
Bit3							Events
Bit1							
BPV3	x	x	x	x	x	x	
BPV1							
Par	x	x	x	x	x	x	
CPar				x	x	x	
Febe				x	x	x	
Par2	x	x	x	x	x	x	
CRC			x			x	
Frm3	x	x	x	x	x	x	
Frm2	x	x	x	x	x	x	
Frm1		x	x		x	x	

Available Analyses for each Event

	Bit3	Bit1	BPV3	BPV1	Par	CPar	Febe	Par2 DS2E	CRC DS1	CRC4 E1	Frm3	Frm2 DS2/ DS2E	Frm1 DS1/ E1
ErrCnt	x	x	x	x	x	x	x	x	x	x	x	x	x
DrbCnt	x	x	x	x									
CurBER	x	x	x	x	x	x	x	x	x	x	x		
AvgBER	x	x	x	x	x	x	x	x	x	x	x	x	x
DrbBER	x	x	x	x									
ErrSec	x	x	x	x	x	x	x	x	x	x	x	x	x
<E-6ES	x		x		x	x	x	x		x			
<E-5ES		x		x									
<E-4ES											x		
<E-3ES												x	x
≥E-6ES	x		x		x	x	x	x		x			
≥E-5ES	x	x	x	x	x	x	x	x		x			
≥E-4ES	x	x	x	x	x	x	x	x		x	x		
≥E-3ES	x	x	x	x							x	x	x
≥E-2ES		x		x							x	x	x
≥E-1ES												x	x
SES									x				
%EFS	x	x	x	x	x	x	x	x	x	x	x	x	x

Available RxSTATUS Seconds for each Mode

		Tx3->Rx3 MON3 THRU3	Tx1-Rx1 Tx31->Rx1 MON1 THRU1	Tx31->Rx31 IntD&I31 Tx1->Rx31 ExtD&I31 MON31 Ins31->Rx1 THRU31	MON31*
DS3	NO SIGNAL	x		x	x
	NO FRAME	x		x	x
	NO PTN	x		x	x
	AIS	x		x	x
	IDLE	x		x	x
	X-bit	x		x	x
DS2	NO SIGNAL			x	
	NO FRAME			x	
	AIS			x	
	X-bit			x	
DS1	NO SIGNAL		x	x	
	NO FRAME		x	x	
	NO PTN		x	x	
	AIS		x	x	
	YELLOW		x	x	
	EX ZEROS		x	x	
DS2E	NO SIGNAL				x
	NO FRAME				x
	AIS				x
	A-bit				x
E1	NO SIGNAL				x
	NO FRAME				x
	AIS				x
	R-ALARM				x
PF45	NO POWER	x	x	x	x

* If DS1/E1 Status = E1

Available Setup Choices for each Mode

	Tx3->Rx3	Tx1->Rx1	Tx1->Rx31	Tx31->Rx1	Tx31->Rx31	MON3	MON1	MON31	THRU3	THRU1	THRU31	Int D&I31	Ext D&I31	Ins31 ->Rx1
Tx3 HI	x		x	x	x				x		x	x	x	x
DSX	x		x	x	x				x		x	x	x	x
LO	x		x	x	x	x			x		x	x	x	x
OFF								x						
Rx3 H/L	x		x		x	x		x	x		x	x	x	x
DSX	x		x		x	x		x	x		x	x	x	x
NRZ↑	x		x		x	x		x	x		x	x	x	x
NRZ↓	x		x		x	x		x	x		x	x	x	x
N/A				x										
Frm3 Unfrm	x					x			x					
M13	x		x	x	x	x		x	x		x	x	x	x
C-Par	x		x	x	x	x		x	x		x	x	x	x
M-Mix								x						
C-Mix								x						
Clk3 Int	x			x	x									
Ext	x			x	x									
Loop	x			x	x				x		x	x	x	x
N/A			x			x		x						
Code AMI		x	x	x	x		x	x		x	x	x	x	x
B8ZS		x	x	x	x		x	x		x	x	x	x	x
Rx1 Term		x		x			x			x				x
Brdg		x		x			x			x				x
NRZ↑		x		x			x			x				x
NRZ↓		x		x			x			x				x
N/A			x		x			x			x	x	x	
Frm1 Unfrm		x	x	x	x		x	x		x	x	x	x	x
D4/SF		x	x	x	x		x	x		x	x	x	x	x
ESF		x	x	x	x		x	x		x	x	x	x	x
SLC							x	x						
Clk1 Int		x	x	x	x							x		x
Ext		x	x	x	x							x		x
Ref		x	x	x	x							x		x
Loop		x	x	x	x					x		x		x
N/A							x	x			x		x	
CodeE1 AMI*								x						
HDB3*								x						
Frm1 Unfrm*								x						
FAS*								x						
CRC*								x						
ErrInsert: @DS3	x								x					
@DS1		x	x							x				
@DS1:00				x	x						x	x	x	x
N/A						x	x	x						
AUX: DS3	x			x	x				x		x	x	x	x
DS2				x	x									
DS1		x	x	x	x					x	x	x	x	x
N/A						x	x	x						

* Only for Frm3=M-Mix or Frm3=C-Mix

Available Error Insertion for each Mode: Page 1

	Tx3->Rx3			Tx1->Rx1 Tx1->Rx31			Tx31->Rx31 Tx31->Rx1*						THRU3			THRU1			THRU31					
							M13			C-Par									M13			C-Par		
	Unf	M13	CPar	Unf	D4	ESF	Unf	D4	ESF	Unf	D4	ESF	Unf	M13	CPar	Unf	D4	ESF	Unf	D4	ESF	Unf	D4	ESF
BIT: Bit3	x	x	x										x	x	x									
Bit1				x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x
BPV: BPV3	x	x	x				x	x	x	x	x	x	x	x	x				x	x	x	x	x	x
BPV1				x	x	x										x	x	x						
PAR/CRC:																								
Par		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
CPar			x							x	x	x			x							x	x	x
Febe			x							x	x	x			x							x	x	x
CRC						x			x			x						x			x			x
FRM: Frm3		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
Frm2							x	x	x	x	x	x							x	x	x	x	x	x
Frm1					x	x		x	x		x	x					x	x		x	x		x	x
AUX: DS3 Fbit		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
Mbit		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
Xbit		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
Cbit		x	x				x	x	x	x	x	x												
DS2 Fbit							x	x	x	x	x	x												
Mbit							x	x	x	x	x	x												
Xbit							x	x	x	x	x	x												
Cbit							x	x	x	x	x	x												
DS1 Fbit					x	x		x	x		x	x					x	x						
Loopback				x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x
ALM: DS3 AIS		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
Idle		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
DS3 X=00		x	x				x	x	x	x	x	x		x	x				x	x	x	x	x	x
DS2 X=0							x	x	x	x	x	x							x	x	x	x	x	x
AIS					x	x		x	x		x	x					x	x						
Yel					x	x		x	x		x	x					x	x						

*For InsDS1 Pattern, Bit1 Error Insertion occurs across entire 1.544Mbs data stream, and Frm1 and CRC errors as well as DS1 alarms are not available.

Available Error Insertion for each Mode: Page 2

	IntD&I Ins31->Rx1						ExtD&I					
	M13			C-Par			M13			C-Par		
	Unf	D4	ESF	Unf	D4	ESF	Unf	D4	ESF	Unf	D4	ESF
BIT: Bit3*												
Bit1	x	x	x	x	x	x	x	x	x	x	x	x
BPV: BPV3	x	x	x	x	x	x	x	x	x	x	x	x
BPV1												
PAR/CRC:												
Par	x	x	x	x	x	x	x	x	x	x	x	x
CPar				x	x	x				x	x	x
Febe				x	x	x				x	x	x
CRC			x			x						
FRM: Frm3	x	x	x	x	x	x	x	x	x	x	x	x
Frm2	x	x	x	x	x	x	x	x	x	x	x	x
Frm1		x	x		x	x						
AUX: DS3 Fbit	x	x	x	x	x	x	x	x	x	x	x	x
Mbit	x	x	x	x	x	x	x	x	x	x	x	x
Xbit	x	x	x	x	x	x	x	x	x	x	x	x
Cbit												
DS2 Fbit												
Mbit												
Xbit												
Cbit												
DS1 Fbit		x	x		x	x						
Loopback	x	x	x	x	x	x	x	x	x	x	x	x
ALM: DS3 AIS	x	x	x	x	x	x	x	x	x	x	x	x
Idle	x	x	x	x	x	x	x	x	x	x	x	x
DS3 X=00	x	x	x	x	x	x	x	x	x	x	x	x
DS2 X=0	x	x	x	x	x	x	x	x	x	x	x	x
AIS		x	x		x	x						
Yel		x	x		x	x						

*For ExtD&I, Bit1 error insertion occurs across entire 1.544Mbs data stream

Available Implementation of each Error Insertion Type

	SINGLE	RATIO	BURST
BIT: Bit3	x	x	x
Bit1	x	x	x
BPV: BPV3	x	x	x
BPV1	x	x	x
PAR/CRC:			
Par	x	x	x
CPar	x	x	x
Febe	x	x	x
CRC	x	x	x
FRM: Frm3	x	x	x
Frm2	x	x	x
Frm1	x	x	x
AUX: DS3 Fbit	x		
Mbit	x		
Xbit	x		
Cbit	x		
DS2 Fbit	x		
Mbit	x		
Xbit	x		
Cbit	x		
DS1 Fbit	x		
Loopback	x	CONT.	x
ALM: DS3 AIS		CONT.	x
Idle		CONT.	x
DS3 X=00	x	CONT.	x
DS2 X=0	x	CONT.	x
DS1 AIS		CONT.	x
Yel		CONT.	x