Description and Operating Manual

PF-45 DS3/DS1 Analyzer

BN 9402/01
BN 9402/02 Series I...

Wandel & Goltermann

Electronic Measurement Technology

INTRODUCTION - **READ ME FIRST!**

Your PF-45 comes with the following written resources:

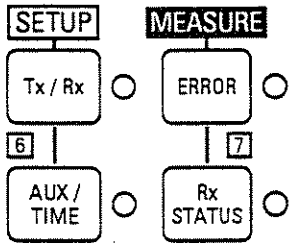
Use these to get started, and for normal use:

(this) INTRODUCTION
SHORT OPERATION MANUAL (in slide-out drawer under instrument)

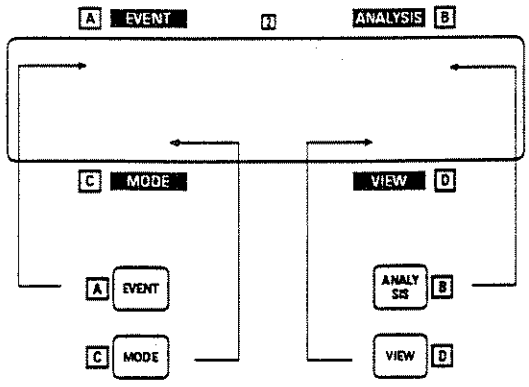
Use these for a reference, and for advanced features:

Chapter 1 - Detailed Specifications
Chapter 2 - Safety and initial turn-on
Chapter 3 - Complete operation of PF-45
Chapter 4 - Applications:
How to perform certain common measurements
Other helpful measurement hints
Overview of PF-45 features and operation
Chapter 5 - Quick functional checkout
Appendix A - Short tutorial on PCM
Appendix B - Remote control

Learn these two "secrets": and you're ready to begin operation of the PF-45 with the help of the SHORT OPERATION MANUAL



these keys control the **display category**.



these keys correspond to the **four quadrants** of the display, and are used to change the value displayed in that quadrant.

Now you are ready to start using the PF-45 with the help of the SHORT OPERATION MANUAL. Good luck!

FIGURES

1.1 OPERATION MODES

1.1.1 Test (Out-of-Service) Modes

Tx3 -> Rx3

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern/Rate . . . . . PRBS/digital word, at DS3
M13 C-bits . . . . . 7-in-18 pattern (001001001001001011...), no stuffing or destuffing
C-Parity C-bits . . . . . 1st C-bit of M-subframe 1 =1, C-bits of M-subframe 3 = parity, C-bits of M-subframe 4 = FEBE, (nominally 111), all other C-bits = 1, no stuffing or destuffing

Tx1->Rx1

Transmit rate/jack . . . . . DS1 Tx
Receive rate/jack . . . . . DS1 Rx
Pattern/Rate . . . . . PRBS/QRSS/digital word, at DS1

Tx1->Rx^3_1

Transmit rate/jack . . . . . DS1 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern/Rate . . . . . PRBS/QRSS/digital word, at DS1
Rx DS1 . . . . . dropped from Rx DS3
Select . . . . . (dropped) DS1 # 1-28
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits
DS3 Tx Jack . . . . . transmits a Tx^3_1-type "keep-alive" signal
Tx^3_1 Keep Alive . . . . . 28 copies of the Tx1 signal are muxed to DS3

Tx^3_1->Rx1

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS1 Rx
Pattern/Rate . . . . . PRBS/QRSS/digital word, at DS1, or external DS1
Tx Signal . . . . 28 identical DS1 test patterns are multiplexed to DS3 (M13/C-Parity compatible)
DS3 Stuffing . . . . . stuffed according to 7-in-18 pattern for M13, or stuck stuffing for C-Parity
DS2 Bitrate . . . . . determined by DS3 bitrate, and DS3 stuffing pattern
DS2 Stuffing . . . . . dynamic stuffing, determined by DS2 and DS1 bitrates

Tx^3_1->Rx^3_1

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern/Rate . . . . . PRBS/QRSS/digital word, at DS1, or external DS1
Tx Signal . . . . 28 identical DS1 test patterns are multiplexed to DS3 (M13/C-Parity compatible)
Rx DS1 . . . . . dropped from Rx DS3
Select . . . . . (dropped) DS1 # 1-28
DS3 Stuffing . . . . . stuffed according to 7-in-18 pattern for M13, or stuck stuffing for C-Parity
DS2 Bitrate . . . . . determined by DS3 bitrate, and DS3 stuffing pattern
DS2 Stuffing . . . . . dynamic stuffing, determined by DS2 and DS1 bitrates
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits

1.1.2 Monitor Modes

MON3

Receive rate/jack . . . . . DS3 Rx
In-service monitoring of DS3
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS3 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches monitored DS3 for selected Rx pattern
C-bits . . . . . no destuffing

MON1

Receive rate/jack . . . . . DS1 Rx
In-service monitoring of DS1
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS1 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches monitored DS1 for selected Rx pattern

MON^3_1

Receive rate/jack . . . . . DS3 Rx
In-service monitoring of DS3/DS2/DS1
Monitored DS1 . . . . . dropped from Rx DS3
Select . . . . . (dropped) DS1 # 1-28
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS1 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches monitored DS1 for selected Rx pattern
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits

(Additional MON$^3_1$ features with E1 Drop/Analysis Option)
In-service monitoring of . . DS3, dropped DS2E (CCITT G.747) and E1 (2.048Mb/s CEPT Level 1)
Select . . . . . (dropped) channel # 1-28
Identity of channel as DS1 or E1 . . . . . automatically determined upon channel selection

1.1.3 Through Modes

THRU3
Receive rate/jack . . . . . DS3 Rx
Transmit rate/jack . . . . . DS3 Tx
In-service monitoring of DS3
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS3 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches DS3 for selected Rx pattern

THRU1
Receive rate/jack . . . . . DS1 Rx
Transmit rate/jack . . . . . DS1 Tx
In-service monitoring of DS1
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS1 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches DS1 for selected Rx pattern

THRU$^3_1$
Receive rate/jack . . . . . DS3 Rx
Transmit rate/jack . . . . . DS3 Tx
In-service monitoring of DS3/DS2/DS1
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, DS1 test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches DS1 for selected Rx pattern
Monitored DS1 . . . . . dropped from Rx DS3
Select . . . . . (dropped) DS1 # 1-28
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits

1.1.4 Drop & Insert Modes

(Hitless Drop & Insert is performed, ie. no DS2s are disrupted and no DS1s other than the inserted channel are affected.)

Int $D\&I^3_1$

(Internal Drop & Insert)

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern source/sink . . . . . "Internal" PF-45 DS1 Pattern Generator/Receiver
Pattern/Rate . . . . . PRBS/QRSS/digital word, at DS1
Select . . . . . (dropped/inserted) DS1 # 1-28
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits
DS2 Stuffing . . . . . dynamic stuffing, determined by DS2 and DS1 bitrates
Rx: DS1 for analysis . . . . . Dropped DS1

Ext $D\&I^3_1$

(External Drop & Insert)

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern source . . . . . (rear panel) DS1 Insert jack
Pattern sink . . . . . (rear panel) DS1 Drop jack
Pattern rate DS1
Pattern . . . . . defaults to "Live", ie, no pattern
. . . . . however, test patterns can be selected in the Pattern Select Page
. . . . . in which case the PF-45 searches monitored DS1 for selected Rx pattern
Select . . . . . (dropped/inserted) DS1 # 1-28
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits
DS2 Stuffing . . . . . dynamic stuffing, determined by DS2 and DS1 bitrates
Rx: DS1 for analysis . . . . . Dropped DS1

INS^3_1->Rx1

(Insert DS1 into live DS3)

Transmit rate/jack . . . . . DS3 Tx
Receive rate/jack . . . . . DS3 Rx
Pattern source/sink . . . . . "Internal" PF-45 DS1 Pattern Generator/Receiver
Pattern/Rate . . . . . PRBS/QRSS/Digital Word, at DS1
Select . . . . . (inserted) DS1 # 1-28
DS3 Destuffing . . . . . according to received C-bits for M13, stuck destuffing for C-Parity
DS2 Destuffing . . . . . according to received C-bits
DS2 Stuffing . . . . . dynamic stuffing, determined by DS2 and DS1 bitrates
Rx1: (DS1 for analysis) receive rate/jack . . . . . DS1 at Rx jack [14]

1.2 MEASUREMENTS

1.2.1 Simultaneous Measurements

DS3 or DS1 Bit (Logic) Errors and BPVs (each)
Error Count
Errors Per Second/Max. Errors Per Second
Dribbling Error Count
Current Error Ratio/Max. Current Error Ratio
Average Error Ratio
Dribbling Error Ratio
Errored Seconds

	DS3	DS1
Threshold ErrSecs	<E-6	<E-5
Threshold ErrSecs	≥E-6	≥E-5
Threshold ErrSecs	≥E-5	≥E-4
Threshold ErrSecs	≥E-4	≥E-3
Threshold ErrSecs	≥E-3	≥E-2

% Error-Free Seconds

DS3, DS2 and DS1 Frame Errors* (each)
Error Count
Errors Per Second/Max. Errors Per Second
Current Error Ratio/Max. Current Error Ratio (DS3 only)
Average Error Ratio
Errored Seconds

	DS3	DS2/DS1
Threshold ErrSecs	<E-4	<E-3
Threshold ErrSecs	≥E-4	≥E-3
Threshold ErrSecs	≥E-3	≥E-2
Threshold ErrSecs	≥E-2	≥E-1

% Error-Free Seconds

* DS3 Frame Errors: F & M-bit errors
DS2 Frame Errors: F & M-bit errors
DS1 D4/SF Frame Errors: F & M-bit errors
DS1 ESF Frame Errors: F-bit errors
DS1 SLC-96/CCIS Frame Errors: F-bit errors

DS3 Parity, C-Parity and FEBE Errors (each)
Error Count
Errors Per Second/Max. Errors Per Second
Current Error Ratio/Max. Current Error Ratio (Estimated BER)
Average Error Ratio (Estimated BER)
Errored Seconds

	DS3
Threshold ErrSecs	<E-6
Threshold ErrSecs	≥E-6
Threshold ErrSecs	≥E-5
Threshold ErrSecs	≥E-4

% Error-Free Seconds

DS1 CRC-6 Errors
Error Count
Errors Per Second/Max. Errors Per Second
Current Error Ratio/Max. Current Error Ratio (Estimated BER)
Average Error Ratio (Estimated BER)
Errored Seconds
SevErrSecs: ≥320 err/sec
% Error-Free Seconds

DS3 Rx Status
No Signal Seconds
No Frame Sync Seconds
Pattern Sync Loss Seconds
AIS/Blue Seconds
X-bit Seconds
Idle Seconds

DS2 Rx Status
No Signal Seconds
No Frame Sync Seconds
AIS Seconds
X-bit Seconds

DS1 Rx Status
No Signal Seconds
No Frame Sync Seconds
Pattern Sync Loss Seconds
AIS Seconds
Yellow Alarm Seconds
Excess Zeros Seconds

PF-45 Operating Manual Errata Sheet

June 2, 1993

Description of Problem

The PF-45 may report an incorrect reading for the DS1 Peak Voltage, if you manually reset the instrument during power-up. This problem only occurs if you have the Signal Analysis option installed. You can manually reset the PF-45 to its factory default settings by holding down both Data Entry keys while the instrument is powering up. This procedure is described in section 2.3.8. of the *PF-45 Operating Manual.*

Work-around

Because the PF-45 remembers its settings when the power is switched off or interrupted and then restores the settings when the power is re-applied, it is normally not necessary to manually reset the PF-45 to its factory default settings.

If you need to perform the manual reset, you can avoid the problem described above by temporarily setting the operation mode to TX31->RX31 after the manual reset. Then you can change any of the settings without adversely affecting the DS1 Peak Voltage reading. Setting the operation mode is described in section 3.4.1. of the *PF-45 Operating Manual.*

1.10.2 Store/Recall
(Additional feature with IEEE 488/RS-232 Remote Control Option)

Setups stored 16
Storage method ..... EEPROM (no backup battery required)
Store/Recall accessed via..... [Tx/Rx] Setup Page, IEEE-488, or RS-232 Remote Control
Stored Setup values ..... Mode, Tx/Rx Level, Frm, Clk, Pattern, Cont/Timed Run, AutoPrint Selection
Write Protection ..... available via IEEE-488 or RS-232
Preview of stored values ..... via built-in printer

3.13 STORE/RECALL OPERATION
(Additional feature with IEEE 488/RS-232 Remote Control Option)

The STORE/RECALL feature is available when an IEEE 488/RS-232 Remote Control Option card is installed in a PF-45. The EEPROM on this card provides the nonvolatile memory for this function.

Front panel access of STORE/RECALL is found within the [Tx/Rx] Setup Page. Normal PF-45 Mode selection is performed by pressing the [C] key, and then "executing" the setup with the [D] key.

```
A                B
Setup:New Mode

Tx3->Rx3  Execute
C                D
```

Recall
Press [A] to bring up the Setup Recall Page seen below. The "**" after Recall is a null-location, eliminating the possibility of accidentally recalling a stored setup.

```
A                B
Setup:Recall

Recall:**
C                D
```

Press the [C] key to select the desired Recall position, 1-16. Press the [D] key to "execute" the recall. If the Recall position does not contain a stored setup, the display field associated with [D] will show "empty" after [D] is pressed.

```
A                B
Setup:Recall

Recall:01 Execute
C                D
```

Before "executing", *the recalled setup can be previewed* by pressing the [MAN PRINT] key. The PF-45 will print the stored setup. Here is an example:

```
PF45:Print Setup #01
Mode: Tx->Rx1
Code:AMI      Rx:Term
Frm1:D4/SF  Clk1:Int
Ptn:QRSS20
Error Insert:    @DS1
Aux Err:     Loopback
Test Duration: Cont.
Clock:       08:12:03
Date:        Dec01'93
AutoPrint:         Off
PF45:   End of Setup
```

Store

Press [A] to bring up the Setup Store Page seen below. The "**" after Store is a null-location, eliminating the possibility of overwriting an important stored setup accidentally.

```
 A                B
┌──────────────────┐
│Setup:Store       │
│                  │
│Store:**          │
└──────────────────┘
 C                D
```

Press the [C] key to select the desired Storage position, 1-16. Press [D] to "execute" the storage process. If the selected storage position is *write protected*, the store will be aborted, and the printer will print "Setup #xx Recall Error".

Before "executing" the store, *the existing stored setup can be reviewed* by pressing the [MAN PRINT] key. The PF-45 will print the existing stored setup. If the stored setup is *write-protected*, the first line of the setup printout will be "Protected Location".

```
 A                B
┌──────────────────┐
│Setup:Store       │
│                  │
│Store:01  Execute │
└──────────────────┘
 C                D
```

Delete

Though not shown on the front panel display, a delete (erase) function is available. Press the two [down arrow] keys simultaneously to delete the currently selected stored setup(s). If "**" is selected, all setups that are not *write-protected* will be deleted.

1.1.4 Drop & Insert Modes

Ext D&I$^3_1$

(Additional ExtD&I$^3_1$ features with E1 Drop/Analysis Option)

In-service monitoring of . . . DS3, dropped DS2E (CCITT G.747) and E1 (2.048Mb/s CEPT Level 1)

Select . . . . . (dropped) channel # 1-28

Identity of channel as DS1 or E1 . . . . . automatically determined upon channel selection

E1 Insertion . . . . . performed when dropped channel is identified as "E1",

. . . . . otherwise normal DS1 "external" insertion is performed.

E1 Source . . . . . (rear panel) E1 Insert jack [60]

THRU$^3_1$

(Additional THRU$^3_1$ features with E1 Drop/Analysis Option)

In-service monitoring of . . . DS3, dropped DS2E (CCITT G.747) and E1 (2.048Mb/s CEPT Level 1)

Select . . . . . (dropped) channel # 1-28

Identity of channel as DS1 or E1 . . . . . automatically determined upon channel selection

1.2.6 G.821 Analysis

G.821 type error analysis is performed simultaneously with all normal analysis.

Events for G.821 Analysis

	With Pattern Sync			Without Pattern Sync		
Rx3 Modes: (DS3 Frame)	M13	Unframed	CPar	M13	Unframed	CPar
	Bit3	Bit3	Bit3	Par	N/A	CPar
			FEBE			FEBE
Rx1 Modes: (DS1 Frame)	D4	Unframed	ESF	D4	Unframed	ESF
	Bit1	Bit1	Bit1	Frm1	N/A	CRC

Rx$^3_1$ Modes: (DS3 Frame) (DS1/E1 Frame)	With Pattern Sync						Without Pattern Sync					
	M13			CPar			M13			CPar		
	D4	Unframed	ESF	D4	Unframed	ESF	D4/ FAS	Unframed	ESF/ CRC	D4/ FAS	Unframed	ESF/ CRC
	Bit1	Bit1	Bit1	Bit1	Bit1	Bit1	Par	Par	Par	CPar	CPar	CPar
	Par	Par	Par	CPar	CPar	CPar	Frm1		CRC	FEBE	FEBE	FEBE
				FEBE	FEBE	FEBE				Frm1		CRC

Simultaneous Analysis types

ES (Errored Second) . . . . . any second with ≥ 1 error, or alarm

SES (Severely Errored Second)

Bit3 . . . . . any second with >44 errs, or DS3 alarm (≥1E-6)

Bit1 . . . . . any second with >1536 errs, or DS1 alarm (≥1E-3)

Par . . . . . any second with >44 errs, or DS3 alarm (≥1E-6)

CPar . . . . . any second with >44 errs, or DS3 alarm (≥1E-6)

FEBE . . . . . any second with >44 errs , or DS3 alarm (≥1E-6)

CRC (DS1) . . . . . any second with ≥320 errs, or DS1 alarm (≥1E-3)

CRC4 (E1) . . . . . any second with ≥915 errs, or E1 alarm (≥1E-3)

Frm1 (DS1) . . . . . any second with ≥8 errs (D4), or DS1 alarm (≥1E-3)

Frm1 (E1) . . . . . any second with ≥4 errs, or E1 alarm (≥1E-3)

DM (Degraded Minute)

Bit1 . . . . . 60 contiguous seconds, minus SES's and UAS's,with ≥92 errors (≥1E-6)

CRC (DS1) . . . . 60 contiguous seconds, minus SES's and UAS's,with ≥92 errors (≥1E-6)

CRC (E1) . . . . 60 contiguous seconds, minus SES's and UAS's,with ≥115 errors (≥1E-6)

UAS (Unavailable Second) . . . . . a period of unavailable time (UAS) begins when
. . . . . a Severely Errored Second (SES) occurs for ten consecutive seconds.
. . . . . These ten seconds are unavailable. The period of unavailable time
. . . . . terminates with a period of ten consecutive non Severely Errored Seconds.
. . . . . These ten seconds are Available Seconds (AS)

AS (Available Seconds) . . . . . Measurement Run seconds which are not unavailable

Operation . . . . . press Measure [Error] key to toggle between normal and G.821 results pages
. . . . . Events and Analysis are then selected as usual

Results . . . . . displayed after 10 second wait period

1.3 TEST PATTERNS

DS3 and DS1 . . . . . 2^{23}-1 (inv.), 2^{20}-1, 2^{15}-1 (inv.), 2^{11}-1, 2^{9}-1, 1111^{++}

DS3 only . . . . . 1000^{+}, 1100 (not IDLE), 1010 (not AIS), 100^{+}

DS1 only . . . . . QRSS20 (2^{20}-1 w/max. 14 zeros), QRSS11 (2^{11}-1 w/max. 7 zeros)
. . . . . 1-in-8^{*+}: [F]01000000...
. . . . . 2-in-8^{+}: [F]01000010...
. . . . . 3-in-24^{*+}: [F]010001000000000000000100...

Programmable Digital Words

Select . . . . . DigWrd1 or DigWrd2

Available in . . . . . all test modes, IntD&I, Ins$^{3}_{1}$->Rx1

Length . . . . . 2,3,4,5,6,8,10,12,16,20, or 24 bits

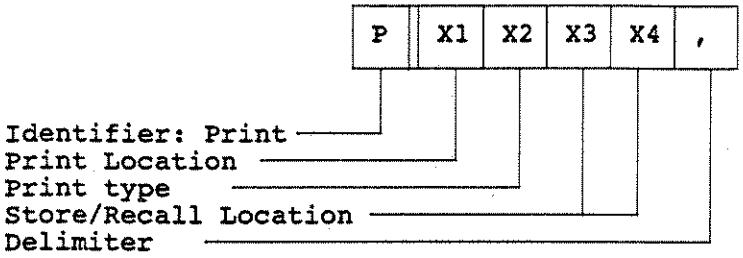
Received . . . . . as generic 16, 20, or 24-bit repeating pattern

Live . . . . . default pattern for MON, THRU, and ExtD&I modes. When selected, no "Bit" event or
. . . . . No Pattern Sync Seconds are available, and all Pattern Sync LEDs remain off.

InsDS1 . . . . . available only in Tx$^{3}_{1}$ modes, PF-45 uses externally sourced DS1 applied to
. . . . . DS1 Insert Jack [34] as the DS1 test signal. When selected, no "Bit" event or
. . . . . No Pattern Sync Seconds are available, and all Pattern Sync LEDs remain off.

[P] Printer String

The print commands select the print destination, print type, and store/recall position:

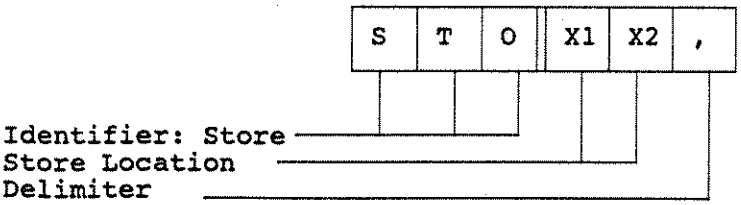



```
X1 = 0  to print to the PF-45 thermal printer
     1  to print to the IEEE/RS-232 controller

X2 = 0  for a SUMMARY PRINT
     1  for a G.821 SUMMARY PRINT
     2  for a PRINT SETUP
     3  for a Store/Recall Setup PRINT

X3 X4 = 01 - 16
```

STORE/RECALL Remote Control Commands

[STO] Store String

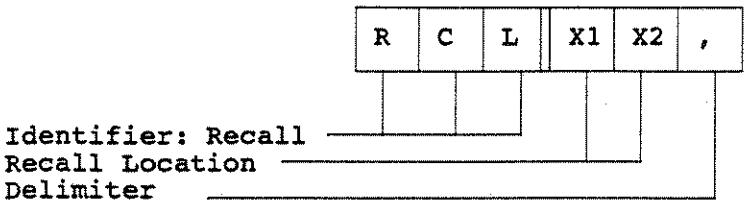
The current PF-45 setup will be stored, *write-protected,* at the designated location. Completion is indicated by a Status =1. Attempting to store to a write-protected location will give an execution error.




```
X1 X2 = 01 - 16
```

[RCL] Recall String

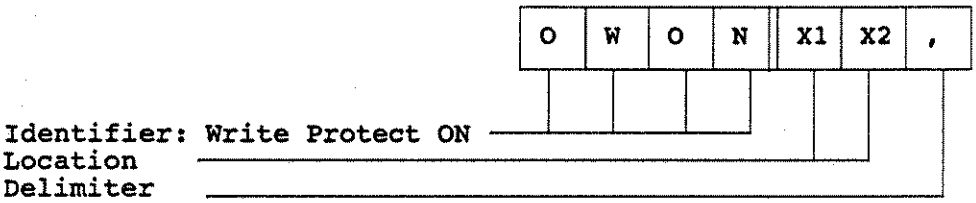
The setup stored at the designated location will be recalled . Completion is indicated by a Status =1. Recalling an empty location will give an execution error.



X1 X2 = 01 - 16

[OWON] Write Protect ON String

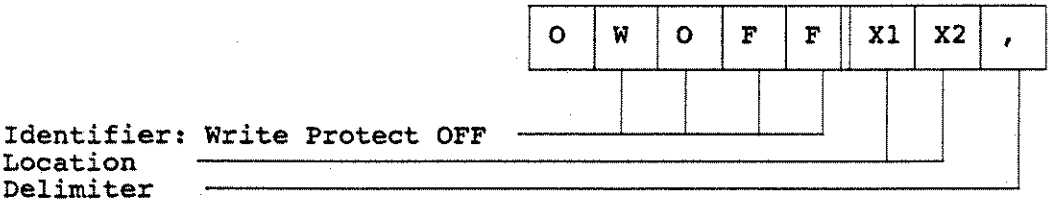
Turns ON write protection for any selected Store/Recall position. When write protected, a user cannot save a setup over the position from the keyboard or from remote control. Completion is indicated by a Status =1.



X1 X2 = 01 - 16

[OWOFF] Write Protect OFF String

Turns OFF write protection for selected Store/Recall position. Completion is indicated by a Status =1.



X1 X2 = 01 - 16

16/20/24BitWrd . . . . . available only in Mon,Thru,ExtD&I Modes,these are receive-only selections
. . . . . which allow the PF-45 to receive any 16/20/24 bit repeating patterns.

(*) Do not cause SF Yellow Alarm or Excess Zeros when framed.

(+)Received as generic 24-bit repeating pattern.

(++)Received as generic 16-bit repeating pattern.

1.4.2 Auxiliary "AUX" Insert

DS1 ESF DataLink Loopback Codes

Available in . . . . . Tx1, Tx^3_1, and IntD&I Modes when Frm1=ESF

Loopback codes . . . . . inserted in transmitted ESF DataLink

[SINGLE] . . . . . 10 repetitions of codeword

[CONTIN] . . . . . continuous transmission of codeword

[BURST] . . . . . transmission of codeword for programmed Burst length

DataLink Codewords (right-most bit transmitted first)

DL LLpUP . . . . . (DataLink) Line Loop Up: 0 000111 0 11111111

DL LLpDn . . . . . (DataLink) Line Loop Down: 0 011100 0 11111111

DL PLpUp . . . . . (DataLink) Payload Loop Up: 0 001010 0 11111111

DL PLpDn . . . . . (DataLink) Payload Loop Down: 0 011001 0 11111111

DL NLpUp . . . . . (DataLink) Network Loop Up: 0 001001 0 11111111

DL NLpDn . . . . . (DataLink) Network Loop Down: 0 010010 0 11111111

1.4.5 Error Insertion Selection

	MODE										
TYPE	Tx3	Tx1	Tx31	THRU3	THRU1	THRU31 (DS1)	THRU31 (E1)+++	IntD&I Ins31	ExtD&I (DS1)	ExtD&I (E1)+++	NOTES:
BIT	Bit3	Bit1	Bit1	Bit3	Bit1	Bit1		Bit1	Bit1	Bit1 **	Tx^3_1 MODES: Errors are inserted in the DS1 Chan # selected in "ERROR INSERT" or Tx^3_1:XX $THRU^3_1$ MODE: Errors are inserted in the dropped DS1 channel $THRU^3_1$:XX
BPV	BPV3	BPV1	BPV3	BPV3	BPV1	BPV3	BPV3	BPV3	BPV3	BPV3	
PAR/	Par *	CRC +	Par *	Par *	CRC +	Par *	Par *	Par *	Par *	Par *	
CRC	CPar *		CPar *	CPar *		CPar *	CPar *	CPar *	CPar *	CPar *	
	FEBE *		FEBE *	FEBE *		FEBE *	FEBE *	FEBE *	FEBE *	FEBE *	
			CRC +			CRC +		CRC +			
FRM	Frm3	Frm1	Frm3	Frm3	Frm1	Frm3	Frm3	Frm3	Frm3	Frm3	
			Frm2			Frm2	Frm2E++	Frm2	Frm2	Frm2E++	
			Frm1			Frm1		Frm1			
AUX	DS3Fbit	DS1Fbit	DS3Fbit	DS3Fbit	DS1Fbit	DS3Fbit	DS3Fbit	DS3Fbit	DS3Fbit	DS3Fbit	Tx^3_1 MODES: DS1/DS2 AUX error patterns and Alarms inserted in all DS1/DS2's. (Indicated by: Tx^3_1:**)
	DS3Mbit	DS1Loop	DS3Mbit	DS3Mbit	DS1Loop	DS3Mbit	DS3Mbit	DS3Mbit	DS3Mbit	DS3Mbit	
	DS3Xbit		DS3Xbit	DS3Xbit		DS3Xbit	DS3Xbit	DS3Xbit	DS3Xbit	DS3Xbit	
	DS3Cbit		DS3Cbit			DS1Loop	DS2EPar	DS1Fbit	DS1Loop	DS2EPar	
			DS2Fbit					DS1Loop			
			DS2Mbit								
			DS2Xbit								
			DS2Cbit								
			DS1Fbit								
			DS1Loop								
ALM	DS3AIS	DS1AIS	DS3AIS	DS3AIS	DS1AIS	DS3AIS	DS3AIS	DS3AIS	DS3AIS	DS3AIS	
	DS3Idle	DS1Yel	DS3Idle	DS3Idle	DS1Yel	DS3Idle	DS3Idle	DS3Idle	DS3Idle	DS3Idle	
	DS3X=00		DS3X=00	DS3X=00		DS3X=00	DS3X=00	DS3X=00	DS3X=00	DS3X=00	
			DS2X=0			DS2X=0	DS2A=1	DS2X=0	DS2X=0	DS2A=1	
			DS1AIS					DS1AIS			
			DS1Yel					DS1Yel			

Note: Due to the logical constraints of Parity and CRC, no matter how high a selected ratio:
* The maximum insertable Par, CPar, FEBE error ratio is: 1.06E-04.
+ The maximum insertable CRC error ratio is: 2.17E-04.

+++ for PF-45s equipped with E1 Option:
** All E1 bits (including overhead) are available for erroring.
++ DS2E (G.747) Frame Word Error

1.10 OPERATIONAL FEATURES

Manual Print

Display = MEASURE ERROR or RX STATUS . . . . . on-demand summary of current results
Display = SETUP . . . . . on-demand print of instrument setup
Display = G.821 MEASURE ERROR . . . . . on-demand summary of (completed) G.821 results

1.10.1 Auto Setup

During Auto Setup, the PF-45 determines the type of signal applied to the receive test jacks, and then selects the appropriate operating mode for that signal. The PF-45 then configures itself to match the frame, line-code and pattern of the incoming signal.

Operation

Auto Setup ON . . . . . Simultaneously press [AUX/TIME] & [RxSTATUS] keys
Auto Setup RESTART . . . . . upon repressing "Auto Setup" keys, or loss of line signal
Channel# . . . . DS1 (& DS0 if equipped) Chan#s can be selected while Auto Setup is active
Volume . . . . . (if equipped) DS0 volume can be set while Auto Setup is active
Display during Auto Setup:

Auto Setup OFF . . . . . Press any key
. . . . . (except [MODE]/[VIEW]/[DATAENTRY] keys for Channel & Volume Select)

Auto Mode Select

If the PF-45 was set to a Test or Mon Mode at the start of Auto Setup:
. . . . . the appropriate Monitor Mode: Mon3, Mon1, or Mon^3_1 is selected
If the PF-45 was set to a Thru or D&I Mode at the start of Auto Setup:
. . . . . the appropriate Thru Mode: Thru3, Thru1, or $Thru^3_1$ is selected

Other Setup Parameters determined during Auto Setup

. . . . . DS3/DS1 Frame Format
. . . . . DS1 Line Code
. . . . . PRBS/QRSS Pattern or 16/20/24 Bit Word

Auto Setup with E1 Option installed

If received DS3 contains either DS2s or DS2Es . . Mon^3_1/$THRU^3_1$ mode, "mixed" DS3 selected
Other Auto Setup Parameter . . . . . E1 Frame Format

1.18 SIGNAL ANALYSIS OPTION

Frequency/Bitrate Measurement

- Signals for measurement . . . . . Rx DS3, Rx DS2, Rx DS1, External TTL (Ext1)
- Accuracy . . . . . +/- 2ppm
- Resolution 1Hz
- DS3 Rx bps Range . . . . . 44736kHz +/- $1x10^{-3}$
- DS2 Rx bps Range . . . . . 6312kHz +/- $0.5x10^{-3}$
- DS1 Rx bps Range . . . . . 1544kHz +/- $1x10^{-3}$
- Ext1 Frequency Range . . . . . 1Hz to 50MHz

+/- Peak Volts

- DS3 Range . . . . . 25 mV to 1.5V
- DS3 Accuracy . . . . . +/- 4%, +/- 5mV
- DS1 Range . . . . . 150 mV to 6V
- DS1 Accuracy . . . . . +/- 4%, +/- 10mV
- Resolution . . . . . 1 mV

DS3 Delay

- Delay measurement method . . . . . X-bit pattern "1001" is sent once from transmitter, ... receiver monitors its return, and the transit time is measured
- Accuracy . . . . . +/- 0.050 micro-seconds
- Resolution . . . . . 0.02 micro-seconds
- Range . . . . . 0 to 999 mSec

DS1 Delay

- Delay measurement method . . . . . 2-out-of-6 Ft error pattern is sent once from transmitter, ... receiver monitors its return, and the transit time is measured
- Accuracy . . . . . +/- 1 micro-second
- Resolution . . . . . 1 micro-second
- Range . . . . . 0 to 999 mSec

DS1 Slips

- Reference clock . . . . . recovered from rear-panel DS1 Insert Jack [34]
- Slips counted . . . . . during measurement run
- Definitions
  - +Bit Slip . . . . . +360deg phase shift of DS1 under test compared to reference
  - -Bit Slip . . . . . -360deg phase shift of DS1 under test compared to reference
  - +Frame Slip (estimated) . . . . . each cumulative occurrence of +193 bit slips
  - -Frame Slip (estimated) . . . . . each cumulative occurrence of -193 bit slips
- Measurement Types
  - Bit Slips . . . . . current algebraic sum of bit slips
  - Peak Slips . . . . . maximum + and - bit slips counts
  - Frame Slips . . . . . counts of + and - frame slips

External Event Count

Signals for event counting . . . . . Ext Event 1 [40], Ext Event 2 [41]
Input Jack Characteristics . . . . . 75 ohms, TTL, BNC
Max. count rate 50kHz
Event Counts . . . . . total counts during measurement run
Event Seconds . . count of the number of seconds, asynchronous to the event, in which at least one event of the type selected, occurred.

Signal Analysis Selection

TYPE	MODE: Tx3-> Rx3	Tx1,Tx31 ->Rx1	Tx1-> Rx31	Tx31-> Rx31	THRU3 MON3	THRU1 MON1	THRU31,MON31 IntD&I,ExtD&I,Ins31
DS3 RxBps	x		x	x	x		x
DS2 RxBps			x	x			x
DS1 RxBps		x	x	x		x	x
DS3 +Vpeak	x		x	x	x		x
DS3 -Vpeak	x		x	x	x		x
DS1 +Vpeak		x				x	
DS1 -Vpeak		x				x	
DS3 Delay*	x			x			
DS1 Delay*		x	x	x			
DS1 BitSlp		x	x	x		x	x
DS1 PkSL		x	x	x		x	x
DS1 FrSL		x	x	x		x	x
Ext1 Freq	x	x	x	x	x	x	x
Ext1 Count	x	x	x	x	x	x	x
Ext1 Event Seconds	x	x	x	x	x	x	x
Ext2 Count	x	x	x	x	x	x	x
Ext2 Event Seconds	x	x	x	x	x	x	x

* Framed only, with Error Insertion Off,

1.19 DS0 Option

Allows user to listen to live traffic, and to perform channelized Drop & Insert via a VF test set, DDS test set, or Protocol Analyzer. The type of D&I is determined by the DS0 operating mode. ESF Data Link D&I is also supported.

For all DS0 operating modes

DS0 availability . . . . . in MON31,MON1,THRU31,THRU1,ExtD&I modes, when pattern = "Live"
DS0 channel # select . . . . . via [VIEW]/Data Entry keys, similar to DS1 chan.# selection
VF Coding/Decoding . . . . . mu-law, $7^5/_6$ coding
Speaker volume control . . . . . via Data Entry keys when Data Entry LED is off

Rx Signaling Bits . . . . . AB (D4)/ABCD (ESF) bits displayed under [RxSTATUS]
Rx 8-bit Word . . . . . displayed under [RxSTATUS]
DS0 Insertion . . . . . available in THRU modes, selected via rear-panel DIP switch [65] #1
DS0 Operating Mode selection . . . . . via rear-panel DIP switch [65] #2-5

VF Mode
VF Mode Select . . . . . set rear-panel DIP switch [65] #s 2,3,4,5 to "1000"
VF Drop . . . . . from rear-panel Bantam jack [63], 600 ohms, balanced, 0dBm = 0dBm0
VF Insert . . . . . from rear-panel Bantam jack [64], 600 ohms, balanced, 0dBm = 0dBm0
Signaling Bit Insertion
Availablity . . . . . when VF Insertion is active
Selection . . . switch [65] #8: ON=Signaling Bit Insert, OFF=Signaling Bits are passed THRU
Value . . . . . set via rear-panel DIP switch [65] #3-6 (ABCD)

DDS Mode
DDS Mode Select . . . . . set rear-panel DIP switch [65] #s 2,3,4,5 to "0100"
Drop & Insert interface . . . . . DDS test set (KS-20909/20908) compatible
DS0 Drop . . . . . from rear-panel Bantam jack [63], TTL-compatible NRZ data on connector tip
. . . . . set DDS test set receiver to FAR LOGIC
DS0 Insert . from rear-panel Bantam jack [64], will receive TTL-compatible NRZ on connector tip
. . . . . set DDS test set transmitter to FAR LOGIC
DDS Clock . . . . . TTL-level clocks provided via male DB-9 connector [66]
64kHz clock . . . . . Pin 3
8kHz clock . . . . . Pin 4
+5V DC . . . . . Pin 1
GND . . . . . Pin 2

64kb/s DS0 Mode
64kb/s Mode Select . . . . . set rear-panel DIP switch [65] #s 2,3,4,5 to "0010"
Drop & Insert interface . . . . . synchronous RS-232 (no handshaking) or TTL clock/data
RS-232/TTL selection . . . . . rear-panel DIP switch [65] #6: ON=RS-232, OFF=TTL
RS-232 Pinout using supplied DB-9/DB-25 Adaptor
Type . . . . . DCE, DB-25 female
Drop NRZ Data BB (from PF-45) . . . . . Pin 3
Drop Clock DD (from PF-45) . . . . . Pin 17
Insert NRZ Data BA (from PF-45) . . . . . Pin 2
Insert Clock DB (from PF-45) . . . . . Pin 15
TTL Pinout
Drop NRZ Data (from PF-45) . . . . . Pin 3
Drop Clock (from PF-45) . . . . . Pin 1
Insert NRZ Data (to PF-45) . . . . . Pin 5
Insert Clock (from PF-45) . . . . . Pin 4
PF-45 samples Insert TTL NRZ . . . . . on rising edge of Insert Clock

56kb/s DS0 Mode

64kb/s Mode Select . . . . . set rear-panel DIP switch [65] #s 2,3,4,5 to "0001"

Features/controls . . . . . same as 64kb/s, but bit 8 of DS1 timeslot is ignored

ESF Data Link Drop & Insert

Select . . . . . ESF/VF Mode, set DIP switch [65] #s 2,3,4,5 to "1000"

DL Drop Availability . . . . . in any PF-45 mode that receives a DS1, when Frm1=ESF

DL Originate Availability . . . . . in Tx1,Tx31,IntD&I,Ins31 modes, when Frm1=ESF

DL Insert . . . . . THRU1,THRU31 modes, when Frm1=ESF and DIP switch [65] #7 is ON

RS-232/TTL Selection and Pinout . . . . . same as for 64&56kb/s DS0 modes

PF-45 samples Originate/Insert TTL NRZ . . . . . on falling edge of Insert Clock

3.2.12 Auto Setup Operation

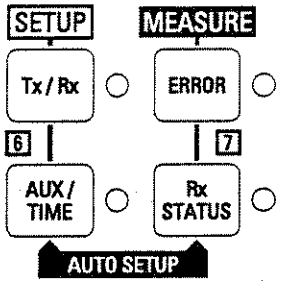
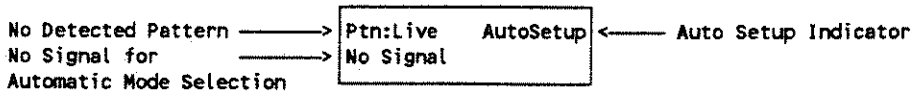


Figure 3-13a: Auto Setup Keys

In Auto Setup the PF-45 makes all the setup decisions that are normally required to do basic in-service and out-of-service monitoring of DS3s, DS1s, and DS1s embedded in DS3. For the experienced user this leads to quick setup when switching between various DS3 and DS1 systems. For the novice user this means that the most typical monitoring tasks can be performed without venturing into the normal setup pages.

To start Auto Setup, press the two "Auto Setup Keys" shown above.

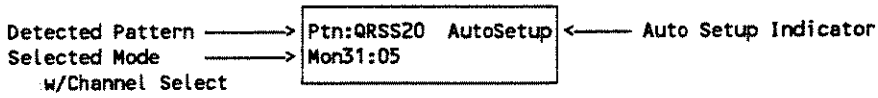
The display below appears, informing the user that Auto Setup is active, but no valid line signal has been applied to either the DS3 Rx jack [12] or the DS1 Rx jack [14].



Insert the signal to be monitored.

In the example below:

- The PF-45 determined that the input signal is a DS3.
- It determined the DS3 frame format (shown on the front panel Tx/Rx LEDs).
- Starting with the previously selected channel, it has scanned through the demultiplexed DS2s until it found one that contained DS2 framing, and it selected the first DS1 of that DS2 to monitor.
- If no framed DS2s were found, the PF-45 would have considered the DS3 "unchannelized", and so selected Mon3 mode.
- The PF-45 determined the frame format of the dropped DS1, (shown on the front panel Tx/Rx LEDs)
- It determined the PRBS or QRSS20 pattern contained within the DS1.
- If pattern sync was not detected, the PF-45 would have continued to show "Live" pattern.



If the PF-45 is in a Thru or Drop & Insert mode at the start of Auto Setup, the appropriate Thru mode is automatically selected, to maintain the through-connectivity of an existing hookup. Auto Setup remains ON while selecting channels. For $Thru^3_1$ and Mon^3_1 modes, the user can select dropped DS1 channels while Auto Setup continues.

Auto Setup can be "Restarted" either by pressing the "Auto Setup Keys" again, or by removing the line signal being tested. Most Auto Setup parameters will follow changes in the input signal, such as changes of frame format or pattern. However, the automatic mode selection and the DS1 line-code switch from AMI to B8ZS only occur once, so the process may need to be "restarted" for a new signal. In most cases, a new signal applied to the PF-45 will also cause a "No Signal" condition on the line. This will automatically restart Auto Setup. Under some conditions, such as electronic switching, or reconfiguration of a line card, a "No Signal" condition may not occur. For these and related cases, press the "Auto Setup Keys" again to restart the Auto Setup process.

To stop Auto Setup, press any key.

Any key press will turn the Auto Setup feature off. The [START] key is commonly used at this point to start a measurement run. When starting a measurement directly from Auto Setup, the Rx Status measurement page "Total ErrSecs=" is displayed. This allows the user to immediately detect the occurrence of any error counts, and also the shows the Rx Status LED history.

A Quick Measurement Scheme:

1). Start Auto Setup, by pressing the two "Auto Setup Keys"
2). [Start] the measurement run.

3). Press [MAN PRINT] key to print out results.

Select DS1/DS0 Channels while Auto Setup remains on

While Auto Setup is active, the DS1 (and E1 or DS0 if equipped) channels can be selected. This allows the user to scroll through all 28 DS1s, while the PF-45 automatically determines the frame type and pattern, if any. Since the DS0 channel select and volume controls also remain active during Auto Setup, the user can listen to channel activity for each selected DS1.

3.6.1 Set DS1 Channel Number

Channel Number selection on mode change is carried over from previous mode:

For Test, Monitor and THRU modes the channel remains as selected from the last mode. This is true for AUTO SETUP as well. This means that AUTO SETUP can be used to identify and auto configure on a particular channel, and then the desired mode, such as Test or THRU can be selected, maintaining the channel choice and other setup parameters.

For D&I modes the channel number is set to "00", ie. "no channel".

Received Channel Number is 'Live' during selection:

For all modes, the received channel number displayed is the actual channel being dropped, even while the channel number is blinking. This is true even during AUTO SETUP. This allows the user to easily scan through the received DS1s (perhaps looking for a particular frame format or pattern) using only the Up or Down Arrow Data Entry keys.

Tx^{3}_{1} Error Insert Channel Number is 'Live' during selection:

The channel number displayed for error insertion is the actual channel used, even while the channel number is blinking. This allows the user, while making a measurement run, to sequentially insert errors in each DS1 channel while monitoring a particular received channel for errors, thus showing continuity.

Received Channel cannot be changed during a Measurement Run:

The received channel is blocked during a run to protect the accumulated measurement data. Stop the run to gain access to the received channel number.

For D&I Modes the Received Channel Number is 'Live', but Insertion is Off during Selection:

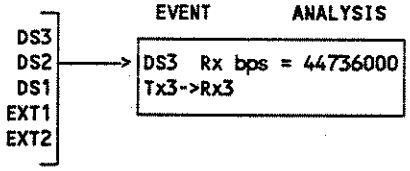
Like other modes, the user can scan through the received DS1s, looking for the desired signal. The channel insertion however is only performed after the [MODE] key is pressed to "enter" the channel and stop the selection process.

3.11 SIGNAL ANALYSIS OPTION OPERATION

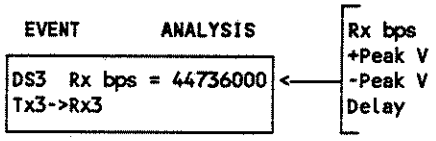
With the Signal Analysis option installed, the PF-45 has three (or four if equipped with DS0 option) pages under RxStatus:

Page 1: RxStatus Seconds
Page 2: Elapsed Time
Page 3: Signal Analysis
Page 4: DS0

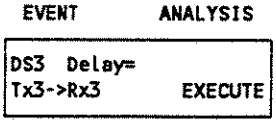
With the [RxSTATUS] key, bring up the Signal Analysis page.



DS3 Signal Analysis

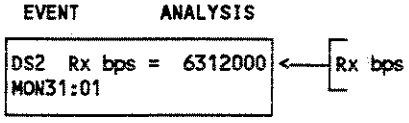


When DS3 is selected, the analyses shown above are available. Rx bps and +/-Peak Voltage measurements take a second or two, and show "counting" and "measure" respectively during this process.



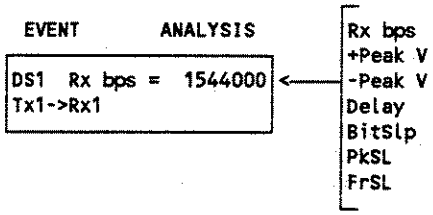
Delay measurements require the loopback of a PF-45 generated test signal, and so are only available in framed Test Modes. Press the [D] key to start the delay measurement. This sends the DS3 X-bit 1001 pattern which is used to measure the delay. If the X-bit pattern is not received within 1 second, the PF-45 will show "timed out".

DS2 Signal Analysis

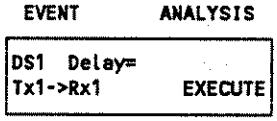


Rx bps is the only signal analysis choice for DS2, and is available in any mode which receives a channelized DS2.

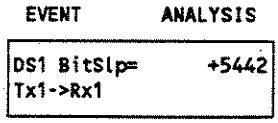
DS1 Signal Analysis



When DS1 is selected, the analyses shown above are available. Rx bps and +/-Peak Voltage measurements take a second or two, and show "counting" and "measure" respectively during this process.

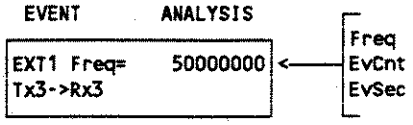


Delay measurement requires the loopback of a PF-45 generated test signal, and is only available in framed Test Modes. Press the [D] key to start the delay measurement. This sends a 2-in-6 DS1 Ft-bit error pattern which is used to measure the delay. If the error pattern is not received within 1 second, the PF-45 will show "timed out".



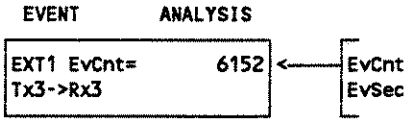
Bit Slips measurements compare the phase (frequency) of two DS1s, the DS1 under test, and the rear-panel "reference DS1". If the reference DS1, or the DS1 under test or has a NO SIGNAL condition, the measurement cannot be made, and the PF-45 will display a "NoSignal" or "NoRef" message in the results display. If a total bit slips count exceeds +/- 32767 during a measurement, or >1 frame-slip in any second, the PF-45 will display a "LostSync" message.

EXT1 Signal Analysis



When EXT1 is select, the analyses above are available. Frequency measurements up to 50MHz are provided at any time, and like Rx bps, shows "counting" during the initial gating period. Event Count (max. 50kHz) and Event Seconds are only counted during a measurement run.

EXT2 Signal Analysis



When EXT2 is selected, Event Count and Event Seconds results are available.

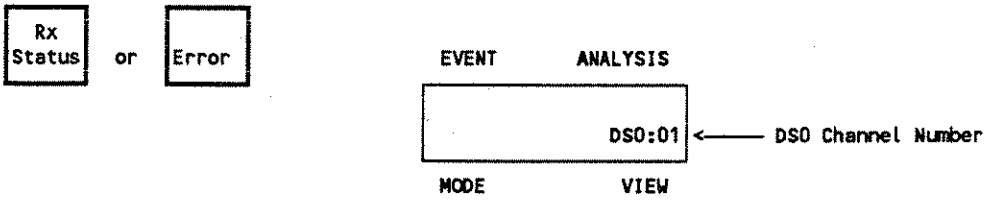
3.12 DS0 OPTION OPERATION

Use AutoSetup to activate the DS0 option:

The AutoSetup function will properly configure the PF-45 for all DS0 monitoring tasks. While AutoSetup is active, the DS1 and DS0 channels can be selected, as well as the speaker volume.

Manually activate the DS0 option:

1) Set PF-45 mode to MON31, MON1, THRU31, THRU1, or ExtD&I
2) Leave Pattern set to default value "Live"
3) DS0 Channel Number is placed in VIEW field
   whenever the display is in the Error or RxSTATUS category.



Set the DS0 Channel Number:

1) Press [VIEW] key
2) DS0 Chan. No. in display and Data Entry LED blink
3) Select desired Chan. No. with Data Entry keys
4) Press [VIEW] key again to "enter" the DS0 Chan. No.

Set the speaker volume:

Use the Data Entry keys for volume adjustment whenever the Data Entry LED is not on or blinking.

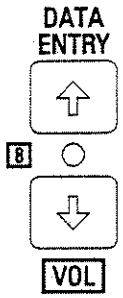
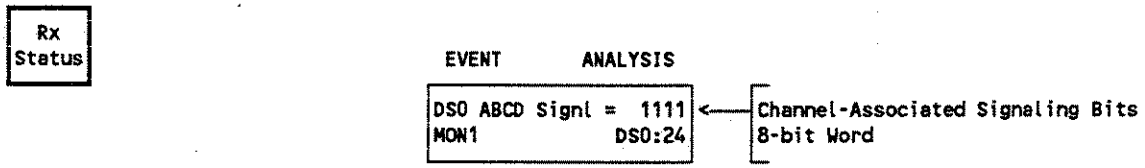


Figure 3-22: Data Entry keys for Volume Adjustment

Display the Received Signaling Bits and 8-bit Word:



With the DS0 option installed, the PF-45 has three (or four if Signal Analysis option is also installed) pages of RxStatus:

Page 1: RxStatus Seconds
Page 2: Elapsed Timed
Page 3: Signal Analysis (if installed)
Page 4: DS0 Results

Rear-Panel:

Use the control switches and jacks on the rear-panel for Drop & Insert to VF test sets, DDS test sets, and protocol analyzers. Pinouts of jack [66] change by DS0 "mode", and are given in Section 1.19.

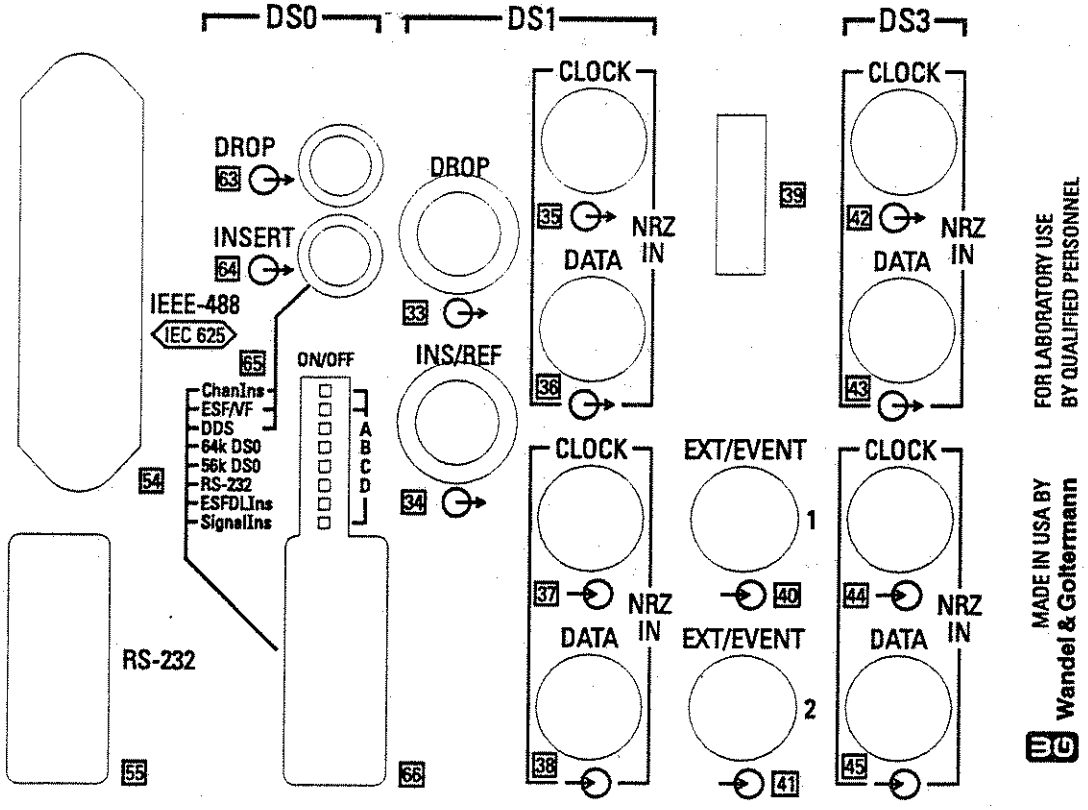


Figure 3-23: PF-45 Rear-Panel with DS0 Option Installed

VF Operation:

Set the rear-panel DIP switch [65] #s to:

ChanIns = OFF
ESF/VF = ON
DDS = OFF
64k DS0 = OFF
56k DS0 = OFF
RS-232 = OFF
ESFDLIns = OFF
SignalIns = OFF

When configured for VF operation, the DS0 option will port the decoded channel contents to the rear-panel output jack [63]. This signal is suitable for direct measurement with any standard 600 ohm balanced VF test set.

To insert a VF signal within the channel, set the PF-45 mode to ExtD&I, and set:

ChanIns = ON

When VF insertion is on, but the Signaling Insertion switch #8 is OFF, the received signaling bits are passed through the PF-45. To insert user selected signaling bits along with the VF signal, set the PF-45 mode to ExtD&I, and set: (notice that switches 3-7 are redefined as A,B,C,D when switches 1,2, & 8 are ON)

ChanIns = ON
ESF/VF = ON
A = (user selected value)
B = (user selected value)
C = (user selected value)
D = (user selected value)
ESFDLIns = OFF
SignalIns = ON

DDS Operation:

Set the rear-panel DIP switch [65] #s to:

ChanIns = OFF
ESF/VF = OFF
DDS = ON
64k DS0 = OFF
56k DS0 = OFF
RS-232 = OFF
ESFDLIns = OFF
SignalIns = OFF

When configured for DDS operation, the PF-45 will port the received DS0 data bits to the rear-panel Bantam jack [63], as a 64kbs TTL-compatible NRZ data on the connector tip. A pair of TTL-compatible clocks is provided on the male DB-9 connector [66]. These signals are compatible with KS-style DDS test set receivers, when set to FAR LOGIC.

The rear-panel insert jack [64] is compatible with DDS test set transmitters, when set to FAR LOGIC. To insert a DDS signal within the channel, set the PF-45 mode to ExtD&I, and set:

ChanIns = ON

ESF Data Link Insertion, and Signaling Insertion are unavailable during DDS operation.

64kb/s DS0 Operation:

Set the rear-panel DIP switch [65] #s to:

ChanIns = OFF
ESF/VF = OFF
DDS = OFF
64k DS0 = ON
56k DS0 = OFF
RS-232 = ON
ESFDLIns = OFF
SignalIns = OFF

When configured for 64kb/s DS0 operation, the DS0 option will port the complete channel contents to the rear-panel output jack [66]. The output levels can be set to TTL or RS-232 with switch #6. When set to RS-232, and connected via the DB-9/DB-25 connector provided with the option, this signal is suitable for direct connection with any protocol analyzer capable of working at 64kb/s with synchronous RS-232, no handshaking.

!WARNING: the supplied DB-9/DB-25 connector is a custom adaptor! IBM AT-compatible computers often are equipped with a DB-9 serial port, and come with a standard DB-9/DB-25 connector. The PF-45 connector is for synchronous RS-232, whereas the PC-AT connector is for asynchronous RS-232. They are not the same.

To insert a 64kb/s DS0 signal within the channel, set the PF-45 mode to ExtD&I, and set:

ChanIns = ON

ESF Data Link Insertion, and Signaling Insertion are unavailable during DS0 operation.

56kb/s DS0 Operation:

Set the rear-panel DIP switch [65] #s to:

ChanIns = OFF
ESF/VF = OFF
DDS = OFF
64k DS0 = OFF
56k DS0 = ON
RS-232 = ON
ESFDLIns = OFF
SignalIns = OFF

When configured for 56kb/s DS0 operation, the DS0 option will port the upper seven bits of the channel contents to the rear-panel output jack [66]. The output levels can be set to TTL or RS-232 with switch #6. When set to RS-232, and connected via the DB-9/DB-25 connector provided with the option, this signal is suitable for direct connection with any protocol analyzer capable of working at 56kb/s with synchronous RS-232, no handshaking.

To insert a 56kb/s DS0 signal within the channel, set the PF-45 mode to ExtD&I, and set:

ChanIns = ON

ESF Data Link Insertion, and Signaling Insertion are unavailable during DS0 operation.

ESF Data Link Operation:

ESF DL D&I is independent of normal DS0 functionality, other than the necessity of setting the DS0 "mode" to ESF/VF. Set the rear-panel DIP switch [65] #s to:

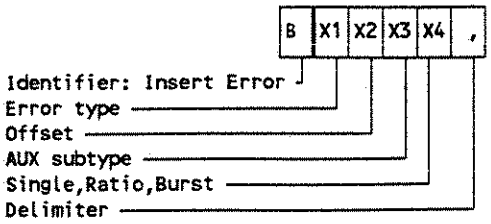
ChanIns = OFF
ESF/VF = ON
DDS = OFF
64k DS0 = OFF
56k DS0 = OFF
RS-232 = ON or OFF
ESFDLIns = OFF
SignalIns = OFF

When configured for ESF Data Link operation, the DS0 option will port the 4kbs ESF Data Link contents to the rear-panel output jack [66]. This dropped signal is present for all modes that receive a DS1, when the DS1 frame is set to ESF. The output levels can be set to TTL or RS-232 with switch #6. When set to RS-232, and connected via the DB-9/DB-25 connector provided with the option, this signal is suitable for direct connection with any protocol analyzer capable of working at 4kb/s with synchronous RS-232, no handshaking.

In all modes in which the PF-45 originates an ESF DS1 test signal (Tx1, Tx31, IntD&I, Ins31->Rx1 modes) the default transmitted Data Link value of "01111110" can be replaced by the inserted pattern. Or, in THRU1 and THRU31 modes, the external ESF Data Link can be inserted in the live signal. Set the rear-panel DIP switch [65] #s to:

ChanIns = OFF
ESF/VF = ON
DDS = OFF
64k DS0 = OFF
56k DS0 = OFF
RS-232 = ON or OFF
ESFDLIns = ON
SignalIns = OFF

[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
		X3: 4 = DL LLpUp
		X3: 5 = DL LLpDn
		X3: 6 = DL PLpUp
		X3: 7 = DL PLpDn
		X3: 8 = DL NLpUp
		X3: 9 = DL NLpDn
	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
                        X2: : = DS2E Par X3: ---

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: ---
                        X2: 6 = DS2E A-bit        X3: ---
X4: 0 = No Error
    1 = Single Error Insert
    2 = Ratio ON
    3 = Ratio OFF
    4 = Burst Error Insert
```

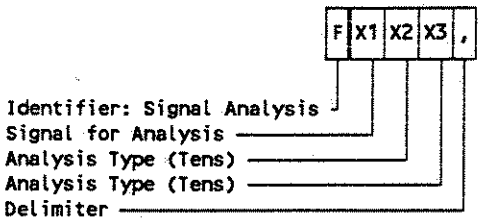
"---" means value of character is disregarded (don't care).

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

```
10 OUTPUT 701;"B5621," !This sends a single group of 2/3 DS2 M-bit errors.
```

[F] Signal Analysis 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 (OAH). 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 Signal Analysis result display.



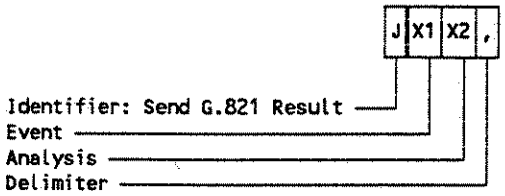
Signal for Analysis X1:	0 = DS3 1 = DS2 2 = DS1 3 = EXT1 4 = EXT2
Analysis Type X1 X2:	00 = Rx bps 01 = Peak Volt + 02 = Peak Volt - 03 = Delay 04 = Bit Slips 05 = Peak Bit Slips 06 = (Estimated) Frame Slips 11 = Frequency 12 = Event Count 13 = Event Seconds

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

```
10 OUTPUT 701;"F203,"      !This selects the RxSTATUS display category, and sets the [EVENT]
                           !to DS1, and the [ANALYSIS] to Delay, then it activates "EXECUTE".
```

[J] G.821 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.



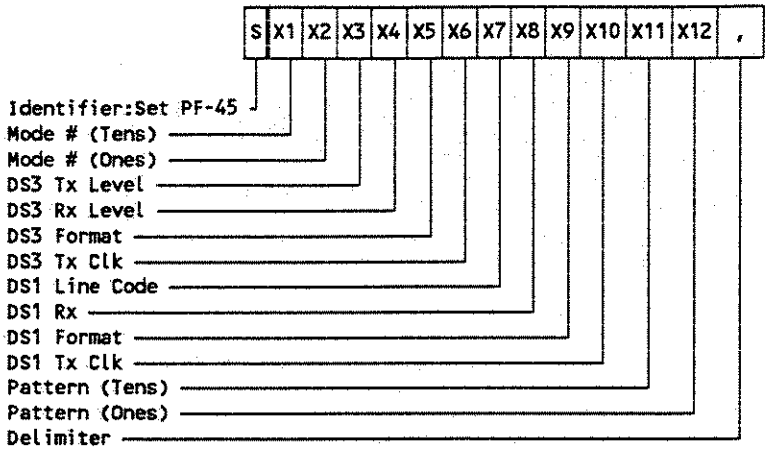

```
Event   X1:     0 = Bit
                1 = Par
                2 = C-Par
                3 = FEBE
                4 = CRC
                5 = Frm1
                6 = CRC4

Analysis X2:    0 = ES (Errored Second)
                1 = SES (Severely Errored Second)
                2 = AS (Available Second)
                3 = UAS (UnAvailable Second)
                4 = DM (Degraded Minute)
```

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

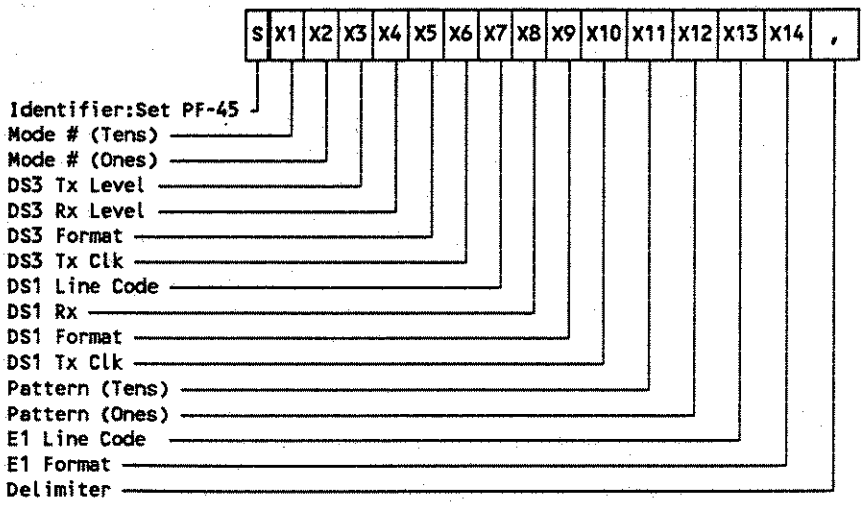
```
10 OUTPUT 701;"J01,"  !This selects the G.821 ERROR MEASUREMENT display category, and sets
                      ! the [EVENT] to Bit, and the [ANALYSIS] to Severely Errored Seconds.
```

[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

Pattern X11 X12:	DS3	DS1
	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 = DigWrd1	11 = Live
	12 = DigWrd2	12 = InsDS1
	13 = 16-bit Rx Word	13 = DigWrd1
	14 = 20-bit Rx Word	14 = DigWrd2
	15 = 24-bit Rx Word	15 = 16-bit Rx Word
		16 = 20-bit Rx Word
		17 = 24-bit Rx Word

E1 Line Code X13:

0 = CodeE1:AMI
1 = CodeE1:HDB3

E1 Format X14:

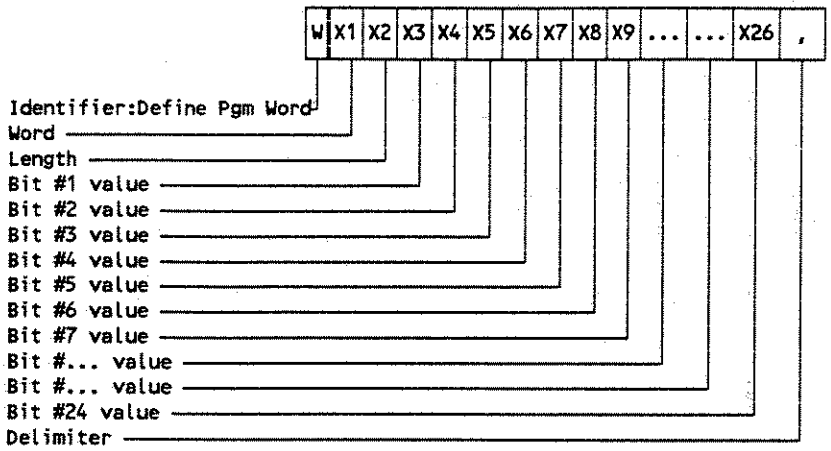
0 = FrmE1:FAS
1 = FrmE1:CRC4
2 = FrmE1:Unfrm

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.
```

[W] Programmable Word String

This command is used to setup the size and content of the selected programmable word.




```
Word X1:          1 = Programmable Word 1
                  2 = Programmable Word 2

Length X2:        0 = 2 bits
                  1 = 3 bits
                  2 = 4 bits
                  3 = 5 bits
                  4 = 6 bits
                  5 = 8 bits
                  6 = 10 bits
                  7 = 12 bits
                  8 = 15 bits
                  9 = 20 bits
                  : = 24 bits

Bit values X3-X26:        0 or 1 only
```

Notes: Actual pattern used by PF-45 must be selected using the S-string. Once the programmable word has been selected as the pattern, the W-string can be used over and over to change the pattern (the S-string does not need to be resent to activate the new word). The W-string will fill in a "too short" string with 1s.

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

```
10 OUTPUT 701;"W01100,"     !Command Error

10 OUTPUT 703;"W11100,"     !Programmable Word 1 = 3 bits long, pattern 100

10 OUTPUT 702; "W111,"      !Programmable Word 1 = 3 bits long, pattern 111
```

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									
Err/S	x	x	x	x	x	x	x	x	x	x	x	x	x
MaxES	x	x	x	x	x	x	x	x	x	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
ES	x	x			x	x	x		x	x			x
SES	x	x			x	x	x		x	x			x
AS	x	x			x	x	x		x	x			x
UAS	x	x			x	x	x		x	x			x
DM		x							x	x			

PF-45 Status
No Power Seconds
Total Errored Seconds
Total Alarm Seconds

(Additional simultaneous measurements with E1 Drop/Analysis Option)

DS2E Frame-Word Errors, E1 FAS-Word Errors (each)
Error Count
Errors Per Second/Max. Errors Per Second
Average Error Ratio
Errored Seconds
Threshold ErrSecs.....<E-3
Threshold ErrSecs.....≥E-3
Threshold ErrSecs.....≥E-2
Threshold ErrSecs.....≥E-1
% Error-Free Seconds

DS2E Parity Errors
Error Count
Errors Per Second/Max. Errors Per Second
Current Error Ratio/Max. Current Error Ratio (Estimated BER)
Average Error Ratio (Estimated BER)
Errored Seconds
Threshold ErrSecs.....<E-6
Threshold ErrSecs.....≥E-6
Threshold ErrSecs.....≥E-5
Threshold ErrSecs.....≥E-4
% Error-Free Seconds

E1 CRC-4 Errors
Error Count
Errors Per Second/Max. Errors Per Second
Current Error Ratio/Max. Current Error Ratio (Estimated BER)
Average Error Ratio (Estimated BER)
Errored Seconds
Threshold ErrSecs.....<E-5
Threshold ErrSecs.....≥E-5
Threshold ErrSecs.....≥E-4
Threshold ErrSecs.....≥E-3
% Error-Free Seconds

DS2E Rx Status (Selected DS2E embedded in DS3)
No Signal Seconds
No Frame Sync Seconds
AIS Seconds
A-bit Alarm Seconds

E1 Rx Status (Selected E1 embedded in DS3)
No Signal Seconds
No Frame Sync Seconds
AIS Seconds
Remote Alarm Seconds

1.2.2 Error Counting

Bit Error Count and No Pattern Sync Seconds Count are inhibited for the entire measurement run when pattern synchronization is not established at the start of the measurement, or when "Live" or "InsDS1" pattern is selected.

Bit Error Counter inhibited while any of the following conditions exist:
. . . . . No Signal, No Frame Sync (ignored for "UNFRAMED" setup),
. . . . . No Pattern Sync, DS3 AIS/BLUE, DS1 AIS, DS1 Yellow (SF only)

When rear-panel DIP switch # 7 is set ON:
. . . . a DS3 bit error is counted for each clock period during a DS3 No Signal condition

Parity, C-Parity, FEBE, CRC-6, and Frame Error Counters inhibited while any of the following conditions exist: . . . . . No Signal, No Frame Sync, DS1 AIS (CRC-6 only)

BPV Counters inhibited while the following condition exists . . . . . No Signal

1.2.3 Dribbling Analysis

DS3 Dribbling Error Count: . . . . . total count of errors that
. . . . . occur within seconds which have a BER less than 1E-6
DS3 Dribbling Error Ratio: . . . . . total (average) BER for those seconds
. . . . . each of which have a BER of less than 1E-6
DS1 Dribbling Error Count: . . . . . total count of errors that
. . . . . occur within seconds which have a BER less than 1E-5
DS1 Dribbling Error Ratio: . . . . . total (average) BER for those seconds
. . . . . each of which have a BER of less than 1E-5

1.2.4 Estimated BER

For DS3 Parity, C-Parity, FEBE, and DS1 ESF CRC-6 (DS2E Parity and E1 CRC with E1 Option):
Current and Average error ratios are calculated to provide an "estimated" Bit-Error-Ratio (BER). This is done by considering each parity, C-parity, FEBE, or CRC error to have been caused by a single "data-bit" error. The resulting Current or Average "data-bit" error ratio is the "estimated" BER.

1.2.5 Maximum (Peak)

MaxE/S . . . . . peak value of Errors Per Second during a measurement is displayed at end of run

MaxBER . . . peak value of Current Error Ratio during a measurement is displayed at end of run

1.3 TEST PATTERNS

DS3 and DS1 . . . . . 2^{23}-1 (inv.), 2^{20}-1, 2^{15}-1 (inv.), 2^{11}-1, 2^{9}-1, 1111^{++}

DS3 only . . . . . 1000^{+}, 1100 (not IDLE), 1010 (not AIS), 100^{+}

DS1 only . . . . . QRSS20 (2^{20}-1 w/max. 14 zeros), QRSS11 (2^{11}-1 w/max. 7 zeros)

. . . . . 1-in-8^{*+}: [F]01000000...

. . . . . 2-in-8^{+}: [F]01000010...

. . . . . 3-in-24^{*+}: [F]010001000000000000000100...

Live . . . . default pattern for MON, THRU, and ExtD&I modes. When selected, no "Bit" event or No Pattern Sync Seconds are available, and all Pattern Sync LEDs remain off.

InsDS1 . . . . available only in Tx^{3}_{1} modes, PF-45 uses externally sourced DS1 applied to DS1 Insert Jack [34] as the DS1 test signal. When selected, no "Bit" event or No Pattern Sync Seconds are available, and all Pattern Sync LEDs remain off.

(*) Do not cause SF Yellow Alarm or Excess Zeros when framed.

(+)Received as generic 24-bit repeating patterns. The PF-45 receiver will achieve pattern sync and count errors on any repeating 24-bit pattern when set to one of these patterns.

(++)Received as generic 16-bit repeating pattern.

1.3.1 Pattern Re-sync Criteria

PRBS/QRSS . . . . . BER > approx. 22% over 5000 bits

DS3 1010, 1100 . . . . . BER > approx. 22% over 5000 bits

DS3/DS1 All 1's . . . . . BER > approx. 5.5% over 5000 bits

Other Patterns . . . . . BER > approx. 2.5% over 5000 bits

Pattern Sync . . . . . requires approx. 110 (DS3) or 220 (DS1) unerrored bits

1.4 ERROR INSERTION

1.4.1 Standard Error Types* (Single, Ratio, Burst)

Bit (Tx3/THRU3 modes) . . . . . DS3 data-bit (logic) error,
. . . . (creates a parity error if an odd number of errors occurs within a DS3 multiframe)
Bit (Tx1/THRU1/IntD&I/Ins$^3_1$ modes) . . . . . DS1 data-bit (logic) error,
. . . . . (for ESF, creates a CRC-6 error for 100% of multiframes containing a single error
. . . . . and for multiframes with more errors, 98.4% will cause CRC-6 errors)
Bit (Tx$^3_1$/THRU$^3_1$ modes) . . . . . DS1 data-bit (logic) error in selected channel,
. (creates a DS3 parity error if an odd number of errors occurs within a DS3 multiframe,
. . . . . for ESF, creates a CRC-6 error for 100% of multiframes containing a single error
. . . . . and for multiframes with more errors, 98.4% will cause CRC-6 errors)
Bit (ExtD&I mode and Ins DS1 Pattern) . . . . . DS1 error in selected channel
BPV (DS3) . . . . . B0V sent instead of 00V, or vice versa, (no bit errors inserted)
BPV (DS1 B8ZS) . . . . . violation placed outside of B8ZS byte, (no bit errors inserted)
Frame (DS3) . . . . . F and M-bit errors
Frame (DS2) . . . . . F and M-bit errors
. (creates a DS3 parity error if an odd number of errors occurs within a DS3 multiframe)
Frame (DS1 D4/SF) . . . . . Ft and Fs errors, (for Tx$^3_1$ and THRU$^3_1$ modes,
. creates a DS3 parity error if an odd number of errors occurs within a DS3 multiframe)
Frame (DS1 ESF) . . . . . Ft errors, (for Tx$^3_1$ and THRU$^3_1$ modes,
. creates a DS3 parity error if an odd number of errors occurs within a DS3 multiframe)
Parity (DS3 M13 and C-Parity) . . . . . both P-bits of a single multiframe are inverted
C-Parity (DS3 C-Parity) . . . . . all 3 C-bits of m-subframe (row) 3 are inverted
FEBE (DS3 C-Parity) . . . . . all 3 C-bits of m-subframe (row) 4 are set = "0"
CRC-6 (DS1 ESF) . . . . . a single checksum bit is errored, (for Tx$^3_1$ and THRU$^3_1$ modes,
. creates a DS3 parity error if an odd number of errors occurs within a DS3 multiframe)
Error Insertion Ratios . . . . . 1.0x10^{-2} to 1.0x10^{-9} (mantissa in 1, 2, 5 steps)
Error Insertion Ratios for Parity,C-Parity,FEBE,CRC-6 . . . . . produce "estimated" BER at set ratio
Burst: (gated insertion of error ratio or alarm) . . . . . 1 ms to 6 sec (1 ms resolution)
*In Tx$^3_1$, THRU$^3_1$ and D&I modes, the errors are inserted in the selected channel only.

1.4.2 Auxiliary "AUX" Insert* (Single, Continuous, Burst)

DS1 Inband Loopback Codes . . . . . CSU Loop Up (10000...)
. . . . . CSU Loop Down (100...)
. . . . . Network Interface Loop Up (11000...)
. . . . . Network Interface Loop Down (11100...)
Single . . . . . six second burst
DS1 Frame Bits . . . . . overwrite pattern for framed operation
*In Tx$^3_1$ modes, the AUX pattern is inserted in all DS1s. In THRU$^3_1$ mode, the DS1 AUX pattern is inserted in the selected channel only.

1.4.3 Auxiliary "AUX" Error Types* (Single)

"AUX" error insertion is different in character and intent from the standard (Bit, BPV, Par/CRC, and Frm) error insertion types. The AUX error types are meant to be "single-shots" of various error patterns, each of which has unique function in testing the DS1/DS2/DS3 multiplex hierarchy. Each of these single-shots occurs with respect to the transmitted multiframe position, and lasts (with the exception of X-bit) for one multiframe. For AUX error insertion, the [SINGLE] key triggers the error insertion, while the [RATIO] selects "Ext2", which allows the user to trigger the error insertion from an external source.

DS3 frame-bit errors . . . . . 2 or 3 consecutive F-bit or M-bit, or (3-in-15) to (3-in-17) F-bit

The AUX DS3 Fbit and Mbit insertion allows the user to choose from the following list of preset error-patterns where the pattern always starts at the beginning of a multiframe. The bits shown are the F-bits or M-bits only, and the inserted errors are marked E.

```
(Unerrored F3:) 1  0  0  1    1  0  0  1    1  0  0  1    1  0  0  1    1  0  0  1   ...................
       F3:2/2  E  E  F0 F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1  remainder unerrored
       F3:2/3  E  F0 E  F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1  remainder unerrored
       F3:3/3  E  E  E  F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1    F1 F0 F0 F1  remainder unerrored
       F3:3/15 E  F0 F0 F1    F1 F0 F0 E     F1 F0 F0 F1    F1 F0 E  F1    F1 F0 F0 F1  remainder unerrored
       F3:3/16 E  F0 F0 F1    F1 F0 F0 F1    E  F0 F0 F1    F1 F0 F0 E     F1 F0 F0 F1  remainder unerrored
       F3:3/17 E  F0 F0 F1    F1 F0 F0 F1    E  F0 F0 F1    F1 F0 F0 F1    E  F0 F0 F1  remainder unerrored
(Unerrored M3:) 0  1  0
       M3:1/1  E  M1 M0
       M3:2/2  E  E  M0
       M3:2/3  E  M1 E
       M3:3/3  E  E  E
```

DS2 frame-bit errors . . . . . 2 or 3 consecutive F-bit, 1,2 or 3 consecutive M-bit

. . . . . 2-in-3 M-bit, (2-in-4) to (2-in-6) F-bit

The AUX DS2 Fbit and Mbit insertion allows the user to choose from the following list of preset error-patterns where the pattern always starts at the beginning of a multiframe. The bits shown are the F-bits or M-bits only, and the inserted errors are marked E. AUX DS2 Fbit insertion does not cause DS3 parity errors.

```
(Unerrored F2:)     1  0  1   0  1   0  1   0
          F2:2/2    E  E  F1  F0 F1  F0 F1  F0
          F2:3/3    E  E  E   F0 F1  F0 F1  F0
          F2:2/4    E  F0 F1  E  F1  F0 F1  F0
          F2:2/5    E  F0 F1  F0 E   F0 F1  F0
          F2:2/6    E  F0 F1  F0 F1  E  F1  F0
(Unerrored M2:)     0  1  1
          M2:1/1    E  M1 M1
          M3:2/2    E  E  M1
          M3:2/3    E  M1 E
          M3:3/3    E  E  E
```

DS1 frame-bit errors . . . . . (2-in-4) to (2-in-6) Ft-bit
. . . . . (2-in-4) Fs or (Ft and Fs)-bits

The AUX DS1 Fbit insertion allows the user to choose from the following list of preset error-patterns where the pattern always starts at the beginning of a multiframe. The bits shown are the F-bits only, and the inserted errors are marked E. AUX DS1 Fbit insertion does not cause DS3 parity errors.

D4 (Superframe Format)

```
(Unerrored F1:)      1  0  0  0  1  1  0  1  1  1  0  0
          Ft: 2/4   E  Fs Ft Fs Ft Fs E  Fs Ft Fs Ft Fs
          Ft: 2/5   E  Fs Ft Fs Ft Fs Ft Fs E  Fs Ft Fs
          Ft: 2/6   E  Fs Ft Fs Ft Fs Ft Fs Ft Fs E  Fs
          Fs: 2/4   Ft E  Ft Fs Ft Fs Ft E  Ft Fs Ft Fs
          Fts:2/4   E  Fs Ft E  Ft Fs Ft Fs Ft Fs Ft Fs
```

ESF (Extended Superframe Format)

```
(Unerrored F1:)      0  0  1  0  1  1
          Ft: 2/4   E  Ft Ft E  Ft Ft
          Ft: 2/5   E  Ft Ft Ft E  Ft
          Ft: 2/6   E  Ft Ft Ft Ft E
```

DS3 or DS2 C-bit errors . . . . . 1st, 2nd or 3rd C-bit of each M-subframe (row)

The AUX DS3 and DS2 Cbit insertion gives the user a single multiframe of errored C-bits in the following patterns. AUX DS3 and DS2 Cbit insertion does not cause DS3 parity errors.

```
C3:Col1   The first C-bit of each row is errored.
C3:Col2   The second C-bit of each row is errored.
C3:Col3   The third C-bit of each row is errored.
C2:Col1   The first C-bit of each row is errored.
C2:Col2   The second C-bit of each row is errored.
C2:Col3   The third C-bit of each row is errored.
```

DS3 X-bits = 01 or 10 . . . . . single occurrence of X= 01 or 10
DS3 X-bits = 00 . . . . . one second burst
DS2 X-bit = 0 . . . . . one second burst
*In Tx^3_1 modes, the DS2 and DS1 AUX errors are inserted in all DS2s and DS1s. In $THRU^3_1$ and D&I modes, the DS2 and DS1 AUX errors are inserted in the selected channel only.

1.4.4 Alarm Types* (Continuous, Burst, Single+)

DS3 AIS . . . "1010..." with "1" directly after each overhead bit, and stuck stuffing: all C-bits = 0
DS3 Idle . . . . . "1100..." with 1st "1" directly after each overhead bit, Row 3 C-bits = 000
DS3 X3=00 (Yellow) . . . . . DS3 Xbits = 00
DS2 X2=0 . . . . . DS2 Xbits = 0
DS1 AIS . . . . . unframed, all 1's
DS1 Yellow (D4/SF) . . . . . bit 2 of each channel timeslot = 0
DS1 Yellow (ESF) . . . . . DL = "1111111100000000..."
*In Tx^3_1 modes, the DS1 and DS2 Alarms are inserted in all channels.
+Single available only for X-bit insertion. Gives a one second burst.

1.4.5 Error Insertion Selection

TYPE	MODE: Tx3	Tx1	Tx^3_1	THRU3	THRU1	$THRU^3_1$	IntD&I Ins31	ExtD&I	NOTES:
BIT	Bit3	Bit1	Bit1	Bit3	Bit1	Bit1	Bit1	Bit1	Tx^3_1 MODES: Errors
BPV	BPV3	BPV1	BPV3	BPV3	BPV1	BPV3	BPV3	BPV3	are inserted in the
PAR/	Par *	CRC +	Par *	Par *	CRC +	Par *	Par *	Par *	DS1 Chan # selected
CRC	CPar *		CPar *	CPar *		CPar *	CPar *	CPar *	in "ERROR INSERT"
	FEBE *		FEBE *	FEBE *		FEBE *	FEBE *	FEBE *	or Tx^3_1:XX
			CRC +			CRC +	CRC +		$THRU^3_1$ MODE: Errors
FRM	Frm3	Frm1	Frm3	Frm3	Frm1	Frm3	Frm3	Frm3	are inserted in the
			Frm2			Frm2	Frm2	Frm2	dropped DS1 channel
			Frm1			Frm1	Frm1		$THRU^3_1$:XX
AUX	DS3Fbit	DS1Fbit	DS3Fbit	DS3Fbit	DS1Fbit	DS3Fbit	DS3Fbit	DS3Fbit	Tx^3_1 MODES: DS1/DS2
	DS3Mbit	DS1Loop	DS3Mbit	DS3Mbit	DS1Loop	DS3Mbit	DS3Mbit	DS3Mbit	AUX error patterns
	DS3Xbit		DS3Xbit	DS3Xbit		DS3Xbit	DS3Xbit	DS3Xbit	and Alarms inserted
	DS3Cbit		DS3Cbit			DS1Loop	DS1Fbit	DS1Loop	in all DS1/DS2's.
			DS2Fbit				DS1Loop		(Indicated by:
			DS2Mbit						Tx^3_1:**)
			DS2Xbit						
			DS2Cbit						
			DS1Fbit						
			DS1Loop						
ALM	DS3AIS	DS1AIS	DS3AIS	DS3AIS	DS1AIS	DS3AIS	DS3AIS	DS3AIS	
	DS3Idle	DS1Yel	DS3Idle	DS3Idle	DS1Yel	DS3Idle	DS3Idle	DS3Idle	
	DS3X=00		DS3X=00	DS3X=00		DS3X=00	DS3X=00	DS3X=00	
			DS2X=0			DS2X=0	DS2X=0	DS2X=0	
			DS1AIS				DS1AIS		
			DS1Yel				DS1Yel		

Note: Due to the logical constraints of Parity and CRC, no matter how high a selected ratio:
* The maximum insertable Par, CPar, FEBE error ratio is: 1.06E-04.
+ The maximum insertable CRC error ratio is: 2.17E-04.

1.4.6 External Error Insertion

Input Jack, Levels, Max.Speed . . . . . Ext/Event [41], 75 ohm, TTL-compatible, 6MHz typical

Selection . . . . . scroll insertion ratio to "Ins Ext 2" in VIEW field

1.5 Rx STATUS MONITORING

1.5.1 Rx Status Criteria

DS3 NO SIGNAL . . . . . 175 +/- 75 consecutive line or decoded zeros
DS2 NO SIGNAL . . . . . 175 +/-75 consecutive zeros
DS1 NO SIGNAL . . . . . 32 consecutive decoded zeros
DS3 Loss of F-bit frame-sync . . . . . 3-out-of-16 F-bits in error
DS3 Loss of M-bit frame-sync . . . . . 2-out-of-3 M-bits in error
DS2 Loss of F-bit frame-sync . . . . . 2-out-of-4 F-bits in error
DS2 Loss of M-bit frame-sync . . . . . 2-out-of-3 M-bits in error
DS1 Loss of frame-sync . . . . . 2-out-of-4 Ft-bits in error
DS3 C-Parity . . . . . 1st C-bit of m-subframe (row) 1 is always "1"
DS3 AIS/Blue . . . . . data = "1010", with "1" directly after each overhead bit
. . . . . or stuck stuffing: all C-bits = "0", or both
DS2 AIS . . . . . unframed, all 1's
DS1 AIS . . . . . unframed, all 1's
DS3 IDLE . . . . . data = "1100", with 1st "1" directly after each overhead bit
DS1 Yellow (D4/superframe format) . . . . . bit "2" of each channel set to "0"
DS1 Yellow (ESF) . . . . . repeated "1111111100000000.. " in 4kbit/s data link
DS3 X-bit . . . . . X1 X2 not equal to "11"
DS2 X-bit . . . . . X (M4) not equal to 1
DS1 Excess Zeros* (AMI) . . . . . $\geq$ 16 consecutive line zeros at DS1 Rx jack [14]
DS1 Excess Zeros* (B8ZS) . . . . . $\geq$ 8 consecutive line zeros at DS1 Rx jack [14]
PF-45 No Power . . . . . loss of instrument power during measurement
* Excess Zeros only available when DS1 for analysis is input to (bipolar) DS1 Rx Jack [14]

(Additional Rx Status Criteria with E1 Drop/Analysis Option)

DS2E NO SIGNAL . . . . . 175 consecutive zeros
E1 NO SIGNAL . . . . . 32 consecutive zeros
DS2E Loss of frame-sync . . . . . 4 consecutive frame words in error
E1 Loss of FAS frame-sync . . . . . 3 consecutive FAS words in error
DS2E AIS . . . . . unframed, all 1's
E1 AIS . . . . . unframed, all 1's
DS2E A-bit Alarm . . . . . A-bit equal to 1
E1 Remote Alarm . . . . . A-bit in 3 consecutive non-align frames equal to 1

1.5.2 Rx Status LEDs

DS3 LEDs . . . . . No Signal, No Frame Sync, C-Parity, AIS/Blue, Idle, X-bit

DS1 LEDs . . . . . No Signal, No Frame Sync, AIS, Yellow, Excess Zeros

Pattern Sync LEDs (off for "Live" and "InsDS1" patterns)

DS3 Green . . . . . DS3 Pattern Sync

DS3 Red . . . . . No DS3 Pattern Sync

DS1 Green . . . . . DS1 Pattern Sync

DS1 Red . . . . . No DS1 Pattern Sync

(Additional Rx Status LED functionality with E1 Drop/Analysis Option)

E1 LEDs: when dropped channel is E1, then E1 NoSignal, NoFrame, AIS, and Remote Alm use DS1 NoSignal, NoFrame, AIS, and Yellow LEDs, respectively.

1.5.3 Rx Status Seconds

Event Seconds . . . . .count of the number of seconds, asynchronous to the event, in which at least one event, of the type selected, occurred. (For unframed operation, the red "No Frame" LED is lit, but "No Frame" event seconds are not counted.)

Total ErrSecs . . . . .count of the number of seconds, asynchronous to the event, in which at least one error, of any type below, occurred.

DS3: Bit, BPV, Par, CPar, FEBE, Frame

DS2: Frame

DS1: Bit, BPV, CRC, Frame

DS2E: Parity, Frame (with E1 Option)

E1: CRC, Frame (with E1 Option)

Total AlmSecs. . . . . count of the number of seconds, asynchronous to the event, in which at least one alarm, of any type below, occurred.

DS3: No Signal, No Frame, No Pattern, AIS, Idle

DS2: No Signal, No Frame, AIS

DS1: No Signal, No Frame, No Pattern, AIS, Yellow

DS2E: No Signal, No Frame, AIS, A-bit Alarm (with E1 Option)

E1: No Signal, No Frame, AIS, Remote Alarm (with E1 Option)

1.6 DS3 INTERFACE

Frame format . . . . . Unframed, M13 Frame, C-Parity
Max. Avg. Frame Acquisition Time . . . . . 5.5 mSec
Jitter . . . . . meets Jitter Tolerance/Generation requirements of TR-TSY-000499
Tx Clock . . . . . 44.736 MHz,+/-20 ppm (Int),
. . . . . or external TTL clock (Ext), or Rx recovered clock (Loop)
Input/Output . . . . . 75 ohms, unbalanced
Jacks . . . . . WECO 358 compatible (or WECO 440A or BNC, selectable at factory)
Line coding B3ZS
Output levels (switchable)
DS HI . . . . . 0.909Vp +/- 0.5dB, rectangular pulse
DSX3 . . . . . HI + simulated 450 feet 728A cable
DS LO . . . . . HI - 13.8 dB
or in lieu of DS LO (selectable at factory)
DS 900 . . . . . HI + simulated 900 feet 728A cable
Outputs 3
Optional outputs (rear-panel) . . . . . 3 additional, delayed 11 bits from front panel outputs
Input levels (switchable)
HI/LO . . . . . +6 to -26 dB from nominal HI
DSX . . . . . +6 to -26 dB from nominal DSX
Input return loss . . . . . 1 to 50 MHz: >20 dB

1.7 DS1 INTERFACE

Frame format . . . . . Unframed, D4 (SF), ESF, (SLC-96/CCIS - MONITOR Mode only)
DS1 Max. Avg. Frame Acquisition Time . . . . . 9 mSec
(DS2 Max. Avg. Frame Acquisition Time . . . . . 12.5 mSec)
ESF Frame acquisition . . . . . verified with CRC-6
ESF Data Link contents . . . . . "01111110..."
Jitter . . . . . meets Jitter Tolerance/Generation requirements of TR-TSY-000499
Tx Clock . . . . . 1544 kHz,+/-20 ppm (Int,)
. . . . . or recovered clock from DS1 rear-panel bipolar Insert/Reference input (Ref),
. . . . . or external TTL clock (Ext), or from Rx recovered clock (Loop)
Input/Output . . . . . 100 ohms, balanced (Bridging provided for DS1 Rx [14])
Jacks . . . . . WECO 310 compatible (or Bantam, selectable at factory)
Output waveform, level . . . . . DSX1 compatible
Line coding . . . . . AMI or B8ZS
Input waveform, level . . . . . DSX, +6 to -26 dB
Input return loss . . . . . 0.1 to 3.5 MHz: >20dB

1.8 AUXILIARY INPUTS

DS3 Rx NRZ and Clock [45], [44] . 75 ohms, TTL, BNC (falling clock edge in center of NRZ data)
DS1 Rx NRZ and Clock [38], [37] . 75 ohms, TTL, BNC (rising clock edge in center of NRZ data)
DS3 External Tx Clock [53] . . . . . 75 ohms, TTL, BNC
DS1 External Tx Clock [37] . . . . . (same jack as DS1 Rx Clock). . . 75 ohms, TTL, BNC
DS1 Insert/Ref [34] . . . . . DSX1/Monitor-compatible jack,
. . . . . for inserting an external DS1 into DS3 in Ext D&I31 Mode and InsDS1 Pattern
. . . . . Also used for Reference input for "Clk1:Ref" DS1 Tx clock setting

1.9 AUXILIARY OUTPUTS

DS3 Tx NRZ and Clock [43], [42] . . . . . 75 ohms, TTL, BNC
DS1 Tx NRZ and Clock [36], [35] . . . . . 75 ohms, TTL, BNC
DS1 Drop [33] . . . . DSX1-compatible, containing DS1 dropped from DS3 in all applicable modes
Bit Error Event Out [22] . . . . 75 ohms, TTL, BNC, nominal pulse-width: 11nS (DS3), 324nS (DS1)

1.10 OPERATIONAL FEATURES

Measurement run
controlled with . . . . . [START/STOP] push button
Type . . . . . Timed or Continuous measurement run
Pause . . timed run can be manually STOPped, then continued by following display prompts
Duration . . . . . 1 sec. to 1000 hrs, settable in 1 sec. increments
Display . . . . . (2x20) character VFD with green filter
Internal clock/calendar . . . . . battery backed-up
Non-volatile memory . . . . . all memory, (such as current measurement run data,
. . . . . and instrument setup) is battery backed-up
Backup Battery . . . . . (3 x AAA) Nicad, charged while PF-45 is on
History LED
RxSTATUS Display Page . . . . . History LED is lit continuously and all Rx STATUS LEDs are lit
. . . . . which have a non-zero count since start of measurement or last RESET
All other Display Pages . . . . . History LED blinks if any non-zero count
. . . . . of errors or RxStatus exists since start of measurement or last RESET
RESET . . . . . Reset "History" by simultaneously pressing both Data Entry Keys
Elapsed Measurement Run Time . . . . . Elapsed Seconds or Elapsed Time (HH:MM:SS)
Built-in printer (standard feature) . . . . . 24-column thermal printer
Print modes
Manual . . . . . On-demand summary of current results
Summary . . . . Automatic summary print at: 5,15 min, 1,2,6,12,24 hr intervals, or at End of Run
Print All Events . . . . . Timestamped printout of all errors and alarms
Print All Alarms . . . . . Timestamped printout of all alarms
Print On Event . . . . . Timestamped printout of a selected event/error threshold and all alarms
Print-On-Event Squelch . . . . . printing squelched after 10 consecutive print seconds,
. . . . . squelch cleared after 10 consecutive non-print seconds
Beep on Bit Error . . . . . when rear-panel switch [39] #8 is on

1.11 DC POWER OPTION

DC Power (factory installed, in addition to standard AC supply)
. . . . . Range: 21 to 56 V DC, polarity independent
Max.Current . . . . . $\leq$ 2A

1.12 DS3 OUTPUT OPTION

DS3 Output . . . . . 3 additional rear panel bipolar Tx jacks, with 11-bit delay from 3 front
. . . . . panel jacks, and same output level as front-panel DS3 Tx jacks [11]

1.13 DATA LINK/MULTIFUNCTION OPTION

Option allows Drop & Insertion of various DS3 overhead bits, including the FEAC, DL5, DL6, DL2/7, and N_a (C12) C-Parity data links, D&I of the DS1 ESF data link, and provides auxiliary outputs for numerous live error and alarm detection signals listed below.

Multipole Connector [58]
Physical type . . . . . Rear-panel 25 pole D-type
Electrical characteristics . . . . . HCMOS compatible, Z_o = 250 ohms nom., Z_i > 5000 ohms
Function: Config. 1A . . . simultaneous DS3 C-Parity and DS1 ESF Data Link D&I, DS3 X-bit D&I
Config. 1B . simultaneous DS3 C-Parity Data Link D&I, DS3 X-bit, P-bit and FEBE D&I
Config. 2 . . . . . Parallel Auxiliary Output of the following signals:
. . . . . DS3: Parity Errors, CParity Errors, FEBE events, Frame Errors,
. . . . . DS3: No Signal, No Frame, AIS, Idle, No Pattern: (all inverted),
. . . . . DS2: Frame Errors, No Frame (inv.) and All 1s (inv.),
. . . . . DS1: CRC Errors, Frame Errors,
. . . . . DS1: No Signal, No Frame, All 1s, No Pattern: (all inverted),
. . . . . DS3 and DS1 Transmit and Receive Multiframe Sync

Output Jacks [56], [57]
Physical type . . . . . Rear-panel BNC (x2)
Electrical characteristics . . . . . capable of driving 75 ohm load to TTL-compatible level
Function . . . . . assignable output of one (each) of the following signals:
Jack [56] . . . . . DS3 Rx M-Sync, DS1 Rx M-Sync, Rx3 FEAC CLK, Rx3 DL2/7 CLK,
. . . . . Rx3 DL5 CLK, Rx3 DL6 CLK, Rx3 C12 CLK, Rx1 ESF DL CLK
Jack [57] . . . . . DS3 Tx M-Sync, DS1 Tx M-Sync, Alarm/Error Composite, 5 MHz CLK,
. . . . . Rx3 X1 Valid, DS3 Rx OH, Rx1 ESF DL, Burst time
Alarm/Error Composite . . . . . logical "OR"ing of any combination of the following signals:
. . . . . Bit Error, No Pattern Sync
. . . . . DS3: BPV, Parity, C-Parity, FEBE, or Frame Error,
. . . . . DS2 Frame Error,
. . . . . DS1: BPV, CRC, or Frame Error,
. . . . . DS3: No Signal, No Frame, AIS, Idle,
. . . . . DS1: No Signal, No Frame, AIS,
Control . . . . . via DIP switches located on option board,
. . accessible by removing PF-45 top cover (4 Allen screws) with attached wrench

1.14 E1 DROP/ANALYSIS OPTION

In Mon^3_1 mode, option allows E1 (2.048Mb/s CEPT Level 1) channels to be dropped from DS3, and simultaneous live performance monitoring is performed on the received DS3 and the dropped DS2E (CCITT G.747) and E1.

DS2E Max. Avg. Frame Acquisition Time 0.53mSec

E1 Interface

Frame Format . . . . . Unframed, FAS only, CRC-4 & FAS
E1 Max. Avg. Frame Acquisition Time . . . . . 500 uSec (+ 4 additional mSec for CRC)
Jitter tolerance/generation . . . . . CCITT G.823 (Rx), G.742 (Tx)
Input/Output impedance . . . . . 120 ohm balanced
Jacks . . . . . WECO 310 compatible (or Bantam, selectable at factory)
Output waveform, level . . . . . CCITT G.703 compatible
Line coding . . . . . AMI, or HDB3
Input waveform, level . . . . . per G.703, +6 to -26 dB
Input Return Loss . . . . . 0.1 to 3.5 MHz > 20 dB

1.15 REMOTE CONTROL OPTION

IEEE-488 . . . . . SH1,AH1,T6,TE0,L4,LE0,SR1,RL1,PP0,DC1,DT1,C0,E2
RS-232
- Connector . . . . . Rear-panel DB-9
- Pinout . . . . . DTE
- Handshake . . . . . Xon/Xoff
- Set DTR on RI . . . . . Enable/Disable
- Echo . . . . . On or Off
- Baud Rates 110, 300, 1200, 2400, 4800, 9600
- Parity/Data Bits/Stop Bits . . . . . N,8,1 / E,8,1 / O,8,1 / N,8,2 / N,7,2

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

1.16 GENERAL SPECIFICATIONS

AC Power Supply . . . . . 90-250V, 47-65Hz, 40VA max.
Operating Temperature . . . . . +5degC to +40degC
Dimensions (wxhxd) . . . . . 13.75 in. X 6.25 in. X 14 in.
. . . . . (319 mm x 159 mm x 357 mm)
Approximate Weight . . . . . 15 lbs. (6.8 kg)
Safety Class . . . . . CSA Safety Class 3631 01
. . . . . for Electronic Development and Test Equipment
. . . . . Registration No. LR 81320

1.17 ORDERING INFORMATION

PF-45 DS3/DS1 Analyzer . . . . . **BN 9402/01**
Stnd. Accessories: line cord, 5 rolls printer paper, operation manual, short operation manual, fuse
Connector Selection for BN 9402/01
DS-3 Tx/Rx WECO 358 compatible . . . . . Standard
or WECO 440A compatible option (no extra charge, factory installed) . . . . . BN 9402/00.01
or BNC option (no extra charge, factory installed) . . . . . See BN 9402/02
DS1 Tx/Rx WECO 310 . . . . . Standard
DS1/E1 Tx/Rx Bantam connectors instead of WECO 310
(no extra charge, factory installed) . . . . . BN 9402/00.03

PF-45 DS3/DS1 Analyzer (Versacon®9 version) . . . . . **BN 9402/02**
Stnd. Accessories: line cord, 5 rolls printer paper, operation manual, short operation manual, fuse
Connector Selection for BN 9402/02
DS3 Tx/Rx BNC compatible . . . . . Standard
DS1 Tx/Rx WE 310 . . . . . Standard
DS1/E1 Tx/Rx Bantam connectors instead of WECO 310
(no extra charge, factory installed) . . . . . BN 9402/00.03

For both versions:

DS 900 instead of DS Lo DS3 output levels (no extra charge, factory installed) . . . BN 9402/00.04

Options (charged extra)
DC Power Option . . . . . BN 9402/00.06
DS3 Output Option (specify only one connector type)
WECO 440A compatible . . . . . BN 9402/00.07
or WECO 358 compatible . . . . . BN 9402/00.08
or BNC . . . . . BN 9402/00.09
Data Link/Multifunction Option* . . . . . BN 9402/00.10
E1 Drop/Analysis Option* . . . . . BN 9402/00.11
IEEE 488/RS232C Remote Control . . . . . BN 9402/00.12
*Data Link and E1 Options occupy the same motherboard slot, and so are mutually exclusive.

Accessories (charged extra)
AT-53 carrying case . . . . . BN 2015/00.03
SD-930 protective covers (front and back) . . . . . BN 0960/00.01
Thermal printer paper (5 rolls) . . . . . BN 9402/00.13

Bellcore CLEI No. DMTE 4218 AA (CPR No. 574609)
PF-45 accepts 2.25 " wide SEIKO TP201-211-25C thermal printer paper or equivalent

2.1 UNPACKING THE INSTRUMENT

The PF-45 is shipped in a special packing case, which has been subject to comprehensive material strength tests at Wandel & Goltermann. This guarantees that the instrument will arrive without damage, even if subjected to rough treatment. The instrument should be lifted carefully out of the packing materials as indicated on the package. We recommend that the original packing materials be saved for possible subsequent shipment.

2.1.1 Shipping Notes

Shipping of the PF-45 without damage can be guaranteed only if correctly designed packing materials are used. We recommend saving the original carton and packing materials for this use.

2.2 IMPORTANT SAFETY INSTRUCTIONS

AC mains (line) voltage

Before switching on the equipment, make sure that it is set to the voltage of the power supply.

Protective earth conductor

Before the instrument is connected to the measuring circuit, a protective ground connection shall be made. If the protective ground conductor of the AC mains can serve for this purpose, then plug the instrument into the mains first. If the measuring circuit has its own protective ground conductor, then this should connected to the instrument casing before the rest of the test circuit is connected.

Safety procedure for damaged or malfunctioning instruments

If the instrument

- shows visible damage
- fails to perform the intended measurements
- has been subjected to damp conditions

it shall be considered a hazard, and shall be made inoperative and secured against any unintended operation.

Fuses

Only the specified fuses shall be used.

Opening the instrument

It may be necessary to remove the instrument covers to carry out repairs, maintenance and adjustments. This may expose live circuits, so the instrument shall be disconnected from all power sources before it is opened. Repair, maintenance and calibration of the opened equipment under voltage shall be carried out by a skilled person who is aware of the hazard involved.

Repairs
Repairs must be made by competent technicians. Care must be taken to ensure that the safety characteristics of the instrument are not altered. In particular, the dimensions of clearances and creepage distances and insulation must not be modified.

Spare parts
If spare parts other than those specified are used, then always ensure that the safety specifications of the instrument are retained.

Safety tests after repairs and maintenance
Protective ground conductor test:
Check the cable for visible signs of damage and poor connections. Measure the resistance of the protective ground conductor between the AC mains plug contact and the instrument casing. The resistance should be <0.5 Ω. Shake the cable during the measurement; resistance variations mean that the cable is faulty.

Insulation test:
Measure the insulation resistance between the mains conductor terminals (shorted together) and the protective conductor terminal of the instrument using a 500 V dc insulation tester. Ensure that the mains switch of the instrument is in the "ON" position. The insulation resistance must > 2 MΩ.

2.3 INSTALLING THE INSTRUMENT

2.3.1 Use as a Benchtop Unit
The instrument can be used as a benchtop unit in a horizontal position or, by folding down the handle, at a slight angle (front panel approximately 30 deg. from the vertical).

2.3.2 Use When Set on its Rear-Feet
The instrument may be placed on its rear-feet, with the front-panel facing straight up. In this position the built-in printer may bind if the paper roll diameter is too large. This can happen on standard 2.25 inch rolls which are not purchased through Wandel & Goltermann, Inc. To fix this, simply strip off a length of paper from the paper roll to decrease its diameter, thus stopping the printer from binding.

2.3.3 Operating Conditions
The operating characteristics of the PF-45 specified in section 1 "Technical Specifications" are valid only if the nominal operating conditions specified there are observed. The nominal operating temperatures are: +5degC to +40degC. The PF-45 must not be operated under conditions where condensation is likely to form. If condensation does form, e.g. when a cold instrument is brought into a warmer room, the instrument should be allowed to dry before being switched on.

2.3.4 Mains Connection and Fuses

Mains frequency and voltage

The instrument can be operated from a.c. mains supplies with frequencies between 48 and 65 Hz. The nominal mains voltage must not vary by more than +/-10%.

Setting the mains voltage

Before connecting the instrument to the a.c. mains supply, check that the mains voltage selector is set to the correct value and that the correct fuses are fitted. When the instrument leaves the factory it is set for operation from 115 V supplies, unless otherwise specified on the order form. For connection to supplies with voltages of 230 V, the mains voltage selector on the rear of the PF-45 must be set by re-positioning the small switch accessible from the rear panel.

Fuses

We specify the following fuse values and types:

115V: T 1.0 A (anti-surge)
230V: T 0.5 A (anti-surge)
DC: T 3.0 A (anti-surge)

2.3.5 Switch-On

Mains switch

The PF-45's mains-switch is at the bottom right-hand corner of the front panel. A red panel in the switch-face shows that it is in the ON position. NOTE: this switch affects AC-power operation only! See Section 3.3.1 "Power".

Functional checkout

See Chapter 5 for a quick back-to-back functional checkout.

2.3.6 Loading Printer Paper

(These instructions apply to 2.25" wide SEIKO TP201-211-25C paper)

Gently pull plastic printer housing [4] out from the PF-45 front-panel, and swing it down approx. 45 degrees. Lift the lid, exposing the print-head mechanism and the paper-roll bin. Remove the aluminum spindle. Prepare the paper-roll by removing the cardboard tube from inside the roll. Place the aluminum spindle in the paper-roll. Position the paper-roll so the paper feeds from the bottom of the roll when viewed from the front of the PF-45. (Only one side of the thermal paper can be printed on). Pull out a few inches of paper, and make a clean cut across the end if it is ragged. Place the paper-roll with spindle in the paper-roll bin. Feed the paper down into the print-head slot closest to the paper-roll until it stops. Use the line-feed key to advance the paper through the print-head mechanism. Close the printer housing lid, lift the housing back up to vertical, and gently push it back into the front panel until it is seated.

The SEIKO paper provided is sized to give maximum paper length within the printer housing. Occasionally, a roll may be slightly oversized in diameter, and may cause the printer mechanism to bind when the printer housing lid is closed, or when the PF-45 is positioned on its rear-feet. In this case, remove a few feet of paper to decrease the paper-roll diameter, and eliminate the binding.

2.3.7 Batteries for Non-Volatile Memory

The PF-45 contains (3) AAA NiCad batteries. When fully charged they will maintain PF-45 settings and results for one month. The batteries are recharged whenever the instrument is turned on, and fully charge within 14 hours of operation. If the battery voltage is too low to maintain RAM, on turn-on the PF-45 will sense this, reset the instrument to its default settings, and display:

```
PF-45 System-Reset!
Battery LOW
```

If the PF-45 detects RAM errors on turn-on, the instrument will be reset to its default settings, and display:

```
PF-45 System-Reset!
RAM Data Corrupted
```

If the batteries fail to charge, (possibly indicated by RAM errors), they may need replacement. To do this, remove the right-hand rear-panel. Remove the fourth board from the right (from the rear). Remove the battery-clip, replace the 3 NiCads, replace the battery-clip, pc-board, and rear-panel.

2.3.8 Manual System-Reset

To clear all data-results and bring PF-45 back to its default settings, hold down both Data Entry keys while powering-up the instrument. The display will then show:

```
PF-45 System-Reset!
Manual Reset
```

2.3.9 Firmware Revision and Release Date

On power-up, the PF-45 will light all the display pixels for approx. one second, then display the following for approx. one second, where "XX" is the installed firmware revision number.

```
PF-45 Analyzer
    Rev XX
```

After a PF-45 System Reset (see Sections 2.3.7 and 2.3.8 above) the real-time clock will be set to 00:00:00, and the date will be set to the firmware release date.

2.3.10 CPU Switch Settings

Occasionally, new firmware for the PF-45 will be released for updating older units. When EPROMS are changed on the CPU card (card with green pull-tab) it is possible that the switch settings on that card may be inadvertently changed. If the PF-45 fails to operate after installing new firmware, make sure that switch #9 is set OFF, and that all other switches are set ON!

2.3.11 Display Burn-In

On power up the PF-45 will first light all LEDs and display pixels for approx. one second. This allows for a checkout of the display and LEDs, and also exercises the VFD. Due to the nature of the PF-45 display messages and the Vacuum Fluorescent Display, certain pixels are rarely used, and may become dim with time. This is reversable by occasionally turning those pixels on. This is now performed at turn-on.

If a PF-45 is left on, or rarely powered up, the routine described above will not provide enough "on" time for some of the pixels. In this case, if the display appears mottled, the user may activate a steady-state "all-pixels-on" routine in the PF-45 firmware. This is done by holding down the two leftmost keys, [SINGLE] and [Down Arrow] while powering up the unit. All display pixels and front panel LEDs will now remain on until the unit is powered down again. Leave the unit on until all the displayed pixels are of the same brightness. This should take an hour or two, but no harm will come by leaving the unit in this state for a longer time. Powering up once again will bring the PF-45 back to normal operation.

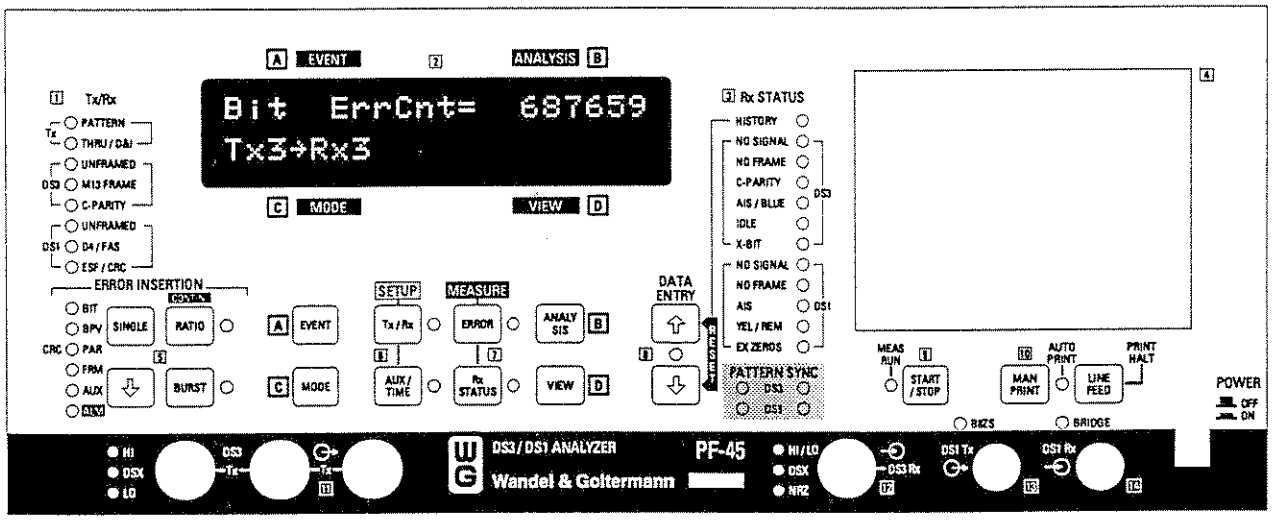


Fig. 3-1: Front View

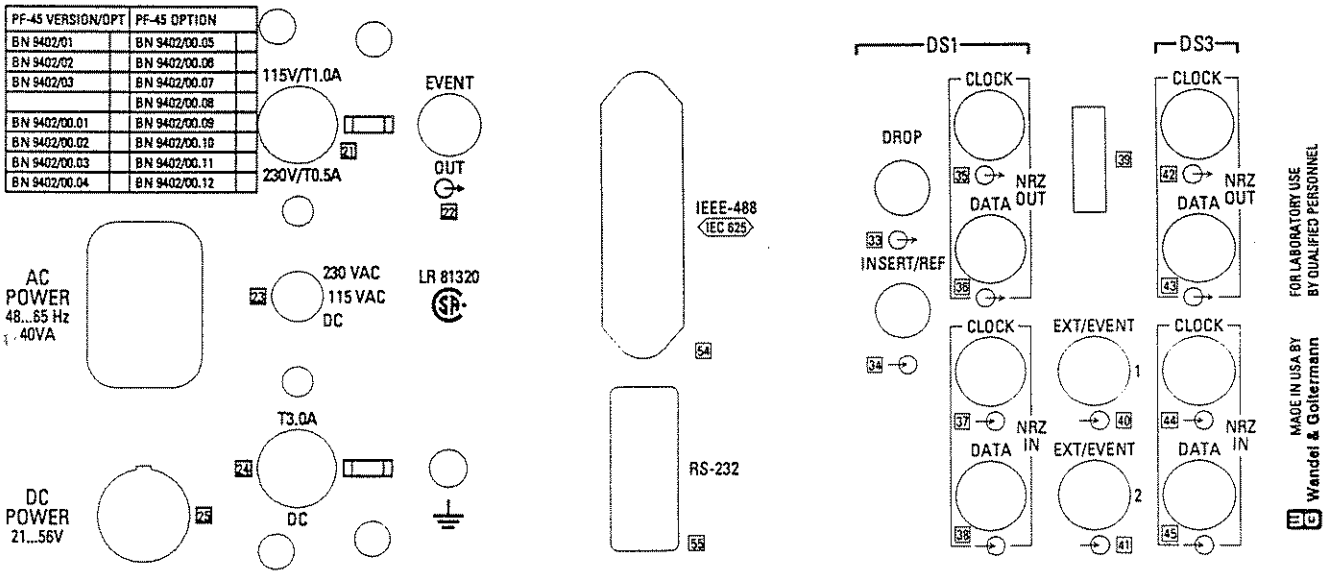


Fig. 3-2: Rear View

3.1 OVERVIEW

All important controls, displays and connectors are on the front panel of the PF-45. Other inputs and outputs are on the back panel. Refer to Figs 3.1 and 3.2 for the meaning of the code numbers used to describe the PF-45's controls, displays and connectors. All controls, displays, and connectors are described below.

3.2 CONTROLS, INDICATORS, AND CONNECTORS ON THE FRONT PANEL

The codes below correspond to the codes printed on the front panel of the PF-45.

3.2.1 Display Categories [6], [7]: See Fig 3-3.

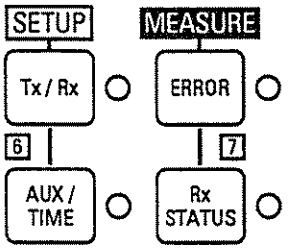


Figure 3-3: Display Category Select Keys

The display [2] is in 1 of 4 categories, indicated by the LED adjacent to one of the four display category keys [6] or [7]. Select the desired display category by pressing the appropriate key. Repeated pressing of these keys will cycle through additional pages if available. Use the two SETUP [6] keys, [Tx/Rx] and [AUX/TIME], to configure PF-45. Use the two MEASURE [7] keys, [ERROR] and [Rx STATUS], to read measurement results. The choice of display category does not affect the measurement process.

3.2.2 Softkeys [A], [B], [C], [D]: See Fig 3-4.

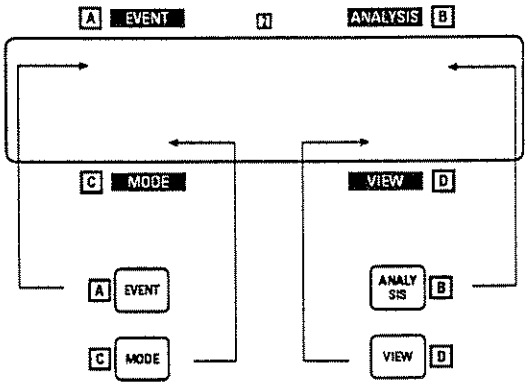


Figure 3-4: Softkeys

Each key has an associated display field, marked in blue for SETUP and gray for MEASURE. Press a softkey to change the parameter or value in its field. This will either cycle through the available choices, or enable the Data Entry keys [8].

3.2.3 Tx/Rx [1]: See Fig 3-5.

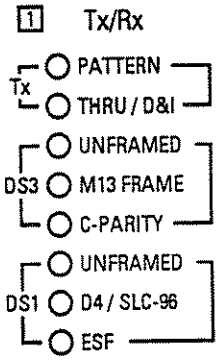


Figure 3-5: Tx/Rx LEDs

Tx: The PATTERN LED is on when the Tx signal is (or contains) an internally generated test pattern.
The THRU/D&I LED is on when the Tx signal is a live signal from receiver.
DS3: DS3 frame format, selected from [Tx/Rx] SETUP.
DS1: DS1 frame format, selected from [Tx/Rx] SETUP.

3.2.4 Rx STATUS [3]: See Fig 3-6.

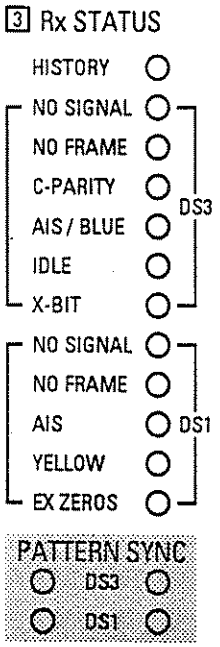


Figure 3-6: Rx STATUS LEDs

The LEDs show live DS3, DS1 and Pattern Sync status (appropriate for the selected operating mode). When the display is in any category other than [Rx Status], the History LED will blink if any event/alarm has been logged since the last History RESET, or the start of the measurement run. When the display is in the [Rx Status] category, the HISTORY LED is lit, and each LED corresponding to a status-event-second count of 1 or more since the start of the measurement or the last History RESET is lit.

3.2.5 Data Entry [8]: See Fig 3-7

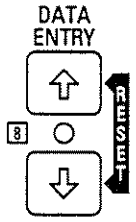


Figure 3-7: Data Entry Keys

Select the display field for change with the appropriate softkey. The changeable parameter and DATA ENTRY LED will blink, showing that the Data Entry keys are active. Press the Data Entry keys to select the desired value. (When setting the BURST time, hold down the key to quickly scroll through the available values). Then press the softkey again to "enter" the selected value, and stop the blinking.

RESET "History" by pressing the two Data Entry Keys simultaneously (see front escutcheon markings). This effects the LEDs that are lit under RxStatus, and the blinking of the History LED, but does not effect the measurement results.

3.2.6 [START/STOP] [9]: See Fig 3-8.

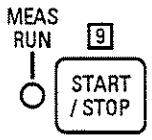


Figure 3-8 [START/STOP] Key

(Set Timed or Continuous measurement run with [AUX/TIME] SETUP).
CONTINUOUS: Press key [9] to Start/Stop measurement.
TIMED: Use key, follow display prompts.

The PF-45 performs measurements on either a continuous or timed basis. In either case, the measurement is initiated by pressing the [START/STOP] key and is stopped by again pressing the same key, or by a change of SETUP. Data accumulated during a measurement interval can be examined or printed after the measurement has been stopped, as well as during the measurement run.

For a CONTINUOUS measurement, when the [START/STOP] key is toggled ON, all stored data is erased and a new measurement is initiated. In the case of a TIMED measurement that has been stopped before the total measurement time has elapsed, the user has the opportunity to either continue the measurement after a pause, or restart the measurement from the beginning. If CONTINUE is selected, the previously stored data is retained and the elapsed measurement time re-commences from the point at which the measurement was halted.

The procedure for "pause" is as follows: if, during a timed measurement, the user wishes to interrupt a measurement and continue at a later time, [START/STOP] should be toggled OFF. When the measurement is to be continued, [START/STOP] is again toggled ON. At this point, the following display appears:

```
START        CONTINUE
"START" ERASES DATA
```

If the user desires to CONTINUE the measurement from the point at which it was halted, softkey [B] is depressed and the measurement continues after a "pause". If the intention is to abort the previous measurement and to begin anew, softkey [A] is depressed and a new timed measurement begins.

This procedure reduces the likelihood of inadvertently stopping a timed measurement and being unable to continue.

3.2.7 DS3 Tx [11]: See Fig 3-9.

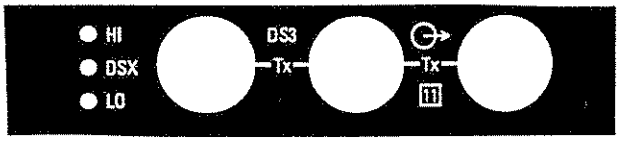


Figure 3-9: DS3 Transmit Jacks

3 in-phase DS3 transmit jacks. Select the output level with [Tx/Rx] SETUP. See Chapter 4.5.2 "Notes for DS3 DSX use" for guidance on the choice of Tx level.

3.2.8 DS3 Rx [12]: See Fig 3-10.

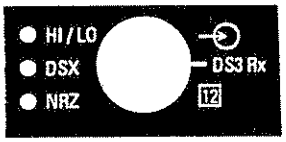


Figure 3-10: DS3 Receive Jack

DS3 receive jack. Select expected receive level with [Tx/Rx] SETUP. Automatically adjusts to MONITOR level. NRZ refers to rear-panel data and clock BNC input jacks. NRZ↑ uses the clock rising edge, while NRZ↓ uses the falling edge. See Chapter 4.5.2 "Notes for DS3 DSX use" for the proper selection of expected Rx level.

3.2.9 DS1 Tx [13] and Rx [14]: See Fig 3-11.

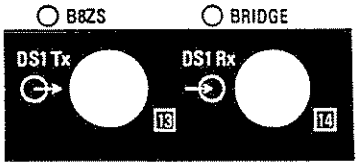


Figure 3-11: DS1 Transmit and Receive Jacks

DSX1-compatible test jacks. With [Tx/Rx] SETUP select B8ZS or AMI, and Rx Terminated or Bridged. Rx automatically adjusts to MONITOR level. NRZ refers to rear-panel data and clock BNC input jacks. NRZ↑ uses the clock rising edge, while NRZ↓ uses the falling edge.

3.2.10 Printer [4]: See Fig 3-12.

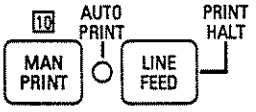


Figure 3-12: Printer Control Keys

Press [Manual Print] [10] key for an immediate printout of current measurement results, see example below. Press [LINE FEED] for a single line of paper feed, or to halt a current printout. Select AUTO PRINT with [AUX/TIME] SETUP.

3.2.11 Error Insertion [5]: See Fig 3-13.

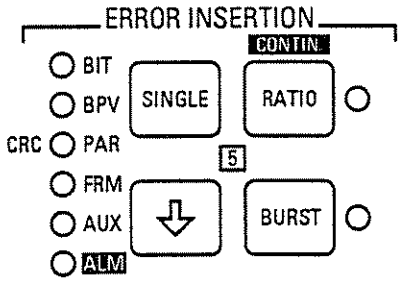


Figure 3-13: Error Insertion Keys

Set display to [ERROR] or [Rx STATUS] category. Select error type for insertion with down-arrow key. Further information on the error type is shown in VIEW field. Certain parameters in VIEW (such as inserted error ratio) may be changed by pressing [VIEW], using Data Entry keys, pressing [VIEW] again.

To preset [RATIO] or [BURST] values, press the [RATIO] or [BURST] key when no error type is currently selected. The ratio or burst time will appear in VIEW, and can be changed with [VIEW] and the DATA ENTRY keys.

BIT,BPV,PAR/CRC,FRM:

SINGLE: 1 error.
RATIO: continuous insertion of error ratio shown in [VIEW].
BURST: timed burst of error ratio.

AUX INSERT: (of DS1 In-Band Loopback Codes)

SINGLE: 6 second burst
CONTIN.: continuous loopback code insertion
BURST: timed burst of loopback code
Select loopback type using [VIEW] and the Data Entry keys.

AUX ERRORS:

SINGLE only.
Select AUX category in [Tx/Rx] SETUP.
Select error type using [VIEW] and the Data Entry keys.

ALM:

CONTIN.: continuous insertion of alarm shown and selected in [VIEW].
BURST: timed burst of alarm.

3.3 CONTROLS, INDICATORS, AND CONNECTORS ON THE REAR PANEL

3.3.1 Power

A.C. Power: Line cord jack, suitable for 48Hz to 65 Hz operation. Switch between nominal AC voltage 110VAC and 220 VAC or DC operation with switch [23]. Fuse [21] must be T1.0A for 110 VAC use, and T0.5A for 220 VAC use.

D.C. Power (Option): Use supplied cable BN 9402-8528.00 to connect to any D.C. power source 21..56 VDC. The two leads are not polarity sensitive, and are floating with respect to ground. The power switch [23] is used to switch DC Power on.

3.3.2 IEEE-488/RS-232 Connectors (Option) [54], [55]:

24-pin D-type for IEEE-488 [54]. DB9 RS-232 [55] (9-pin male jack).

3.3.3 DS1 Drop & Insert Jacks [33], [34]

Dedicated DSX1-compatible jacks for DS3 to DS1 Drop & Insert. Factory equipped 310 or Bantam (same as front-panel test jacks). Line code (AMI or B8ZS) is set the same as the front panel DS1 test jacks. No Rx Bridging (high-Z) is available. The Drop jack contains selected DS1 dropped from DS3 in any suitable operation mode. The Insert/Reference jack accepts any DSX1-compatible or DSX1-monitor signal for insertion into a DS3 in ExtD&I$^{3}_{1}$ mode. The recovered clock from this signal is also used as a network timing reference for the DS1 Tx clock when set to "Clk1:Ref".

3.3.4 DS1 NRZ Ports [35], [36], [37], [38]:

4 BNC jacks, 75 ohms: NRZ OUT Clock [35] and Data [36], NRZ IN Clock [37] and Data [38]. Whenever the PF-45 is in a mode in which it creates a DS1 test signal, NRZ OUT contains that signal and Tx clock. In any mode that analyzes a DS1 signal at DS1 (such as Rx1, THRU1, or MON1), the NRZ IN ports may be selected under [Tx/Rx] Setup (DS1 page) to replace the front panel DSX1 Rx jack. Rx1:NRZ↑ uses the rising edge of the clock, Rx1:NRZ↓ uses the falling edge. The NRZ IN Clock jack also doubles as the DS1 External Clock input, which is selectable from the same DS1 setup page as "Clk1:Ext".

3.3.5 External Event Input Jacks [40], [41]:

Ext/Event jack [41] is used for external error insertion (See Section 1.4.6). Ext/Event jack [40] is reserved for future features.

3.3.6 DS3 NRZ Ports [42], [43], [44], [45]:

4 BNC jacks, 75 ohms: NRZ OUT Clock [42] and Data [43], NRZ IN Clock [44] and Data [45]. Whenever the PF-45 is in a mode in which it creates a DS3 test signal, NRZ OUT contains that signal and Tx clock. In any mode that analyzes a DS3 signal at DS3 (such as Rx3, THRU3, or MON3), the NRZ IN ports may be selected under [Tx/Rx] Setup (DS3 page) to replace the front panel DSX3 Rx jack. Rx3:NRZ↑ uses the rising edge of the clock, Rx3:NRZ↓ uses the falling edge.

3.3.7 DS3 Additional Outputs [50], [51], [52] (Option):

3 jacks provide the identical signal as the front-panel DS3 Tx jacks [11], but delayed by 11 DS3 clock periods.

3.3.8 DS3 External Tx Clock Input [53]:

BNC jack, 75 ohms, used for DS3 Transmit clock when selected from DS3 [Tx/Rx] Setup Page: Clk3:Ext.

3.3.9 Event Out [22]:

BNC jack sends TTL-level pulses on BIT errors.

3.3.10 Rear Panel DIP Switch #7: Measuring DS3 No Signal Duration

This provides a means of measuring DS3 No Signal duration. The function is available in Tx3--Rx3, Mon3, and Thru3 modes and is invoked by setting the rear panel dip switch #7 ON (set switch to the left position). When configured in this way, the PF45 logs one bit error for each DS3 clock transition during the No Signal condition (Normally bit error counting is inhibited during DS3 No Signal).

DS3 No Signal is declared after 175+/-75 contiguous zeros and is terminated upon receipt of a one. Normal bit error counting persists during the first 175 bits of the missing signal, switching over to counting clock transitions when No Signal is declared. With cessation of No Signal, counting is inhibited until pattern synchronization is achieved. Therefore, the bit error count accumulated during No Signal is an excellent measure of the time during which the DS3 signal is absent. The greatest uncertainty lies in the number of errors counted during the 175 bits preceding declaration of No Signal. If, for example, the pattern in use is All Ones, each bit following No Signal will result in an error and the total count will accurately represent the total number of missing timeslots from the first zero to the first one. If a PRBS signal is being used, only about half of the 175 bits will be counted as errors.

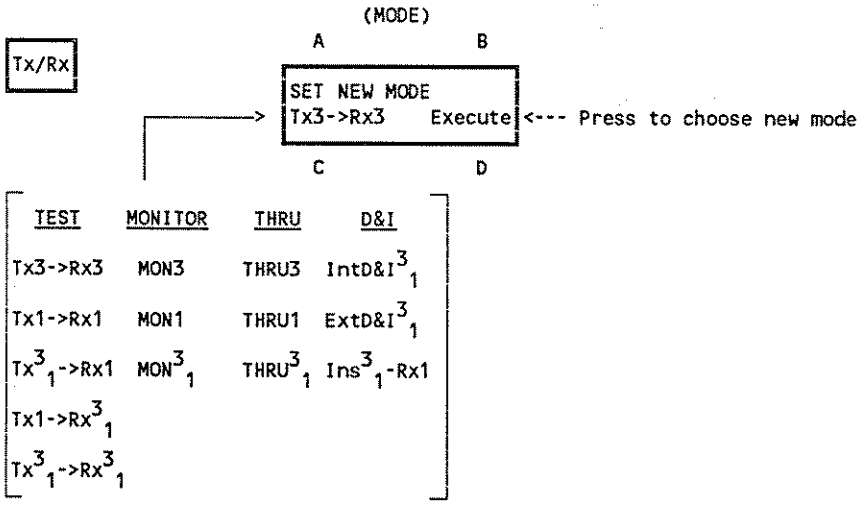
In the unframed mode, each recorded bit error will represent 1/44736000 = 22.35 nSec. In a framed mode, the PF45 measures bit errors over payload (non overhead) bits. In this case each bit error will represent 85/84(22.35) = 22.62 nSec. Taking into account the uncertainties discussed in the previous paragraph, No Signal measurement error will not exceed +75/-175 time slots or +1.7/-4.0 microseconds. The longest measurable time interval is $2.14X10^9$ time slots or about 47 seconds. This limitation results from the maximum count capacity of the PF45.

3.3.11 Rear Panel DIP Switch #8: Beep on Bit Error

Set rear-panel DIP switch #8 ON (set switch to the left position) for a single beep for each bit error. In this case, the beeps are not suppressed during No Signal, No Frame, Alarms, etc., so the beeps are a clear indication of "something wrong".

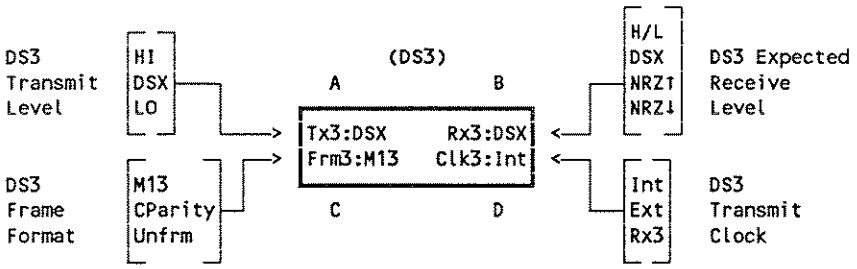
3.4 [Tx/Rx] SETUP

3.4.1 Set New Mode Page:



Press [C] to scroll through the list of operation modes. When the desired new mode has been displayed, press [D] to "EXECUTE" the mode change. The original operation mode is not changed until "EXECUTE" has been performed. When a new mode is executed the present measurement run is stopped, the previous measurement data is erased, the last-set values of the setup parameters are implemented, and the PF-45 is ready to start a new measurement run.

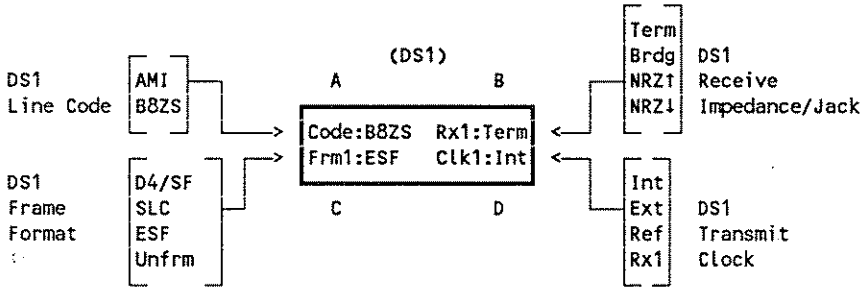
3.4.2 DS3 Setup Page:



The DS3 Setup Page appears for all operation modes which transmit or receive DS3. Each of the four display quadrants contains the present value for a particular setup parameter. Press the appropriate softkey to scroll through the list of setup choices. The displayed choice is implemented immediately. The setup page may be viewed without affecting a measurement run, however, if a setup parameter is changed while a measurement run is taking place, the measurement will STOP, and all error-insertion will be shut off. If the choice of frame format is changed, the PF-45 must change the available measurement "Events", and in the process will also erase the previous measurement results.

"Tx3" is the DS3 transmit level for the three front-panel (and three opt. rear-panel) jacks.
"Rx3" is the expected receive level for the front panel DS3 Rx jack, or selects the rear-panel DS3 NRZ IN ports (with selectable clock edges).
"Frm3" is the selected frame format for the DS3 transmitter and receiver.
"Clk3" is the selected source of the DS3 transmit clock.

3.4.3 DS1 Setup Page:



The DS1 Setup Page appears for all operation modes which transmit or receive DS1. Each of the four display quadrants contains the present value for a particular setup parameter. Press the appropriate softkey to scroll through the list of setup choices. The displayed choice is implemented immediately. The setup page may be viewed without affecting a measurement run, however, if a setup parameter is changed while a measurement run is taking place, the measurement will STOP, and all error-insertion will be shut off. If the choice of frame format is changed, the PF-45 must change the available measurement "Events", and in the process will also erase the previous measurement results.

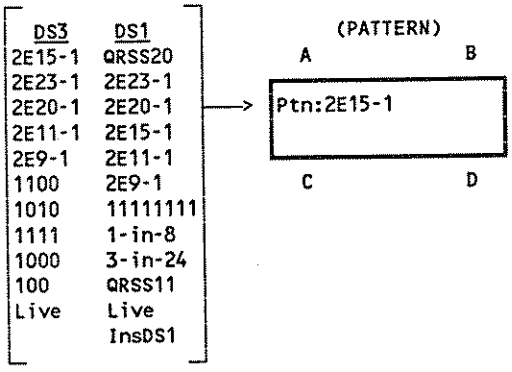
"Code" is the DS1 line code for the front-panel DS1 Tx and Rx jacks and the rear-panel Drop and Insert jacks.

"Rx1" is the selected DS1 receive-source: the front-panel DS1 Rx jack (terminated with 100 ohms or bridged) or the rear-panel DS1 NRZ IN jacks (with selectable clock-edges).

"Frm1" is the selected frame format for the DS1 transmitter and receiver.

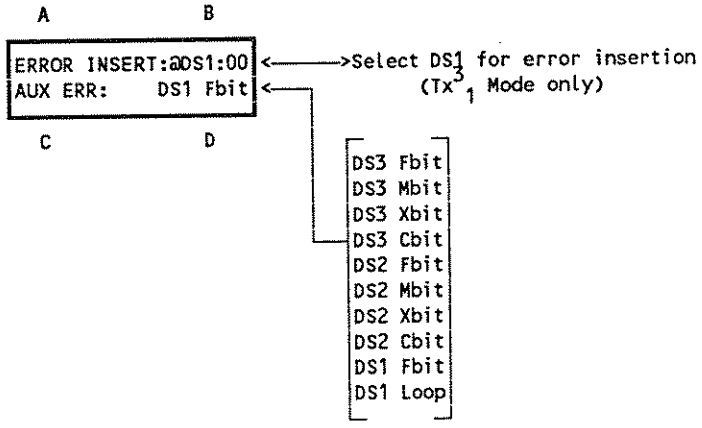
"Clk1" is the selected source of the DS1 transmitter clock.

3.4.4 Pattern Select Page:



Field [A] displays the current transmit and receive test pattern. Scroll through the available DS3 or DS1 patterns by pressing key [A]. The displayed pattern is implemented immediately. The setup page may be viewed without affecting a measurement run, however, if the test-pattern is changed while a measurement run is taking place, the measurement will STOP, and all error-insertion will be shut off.

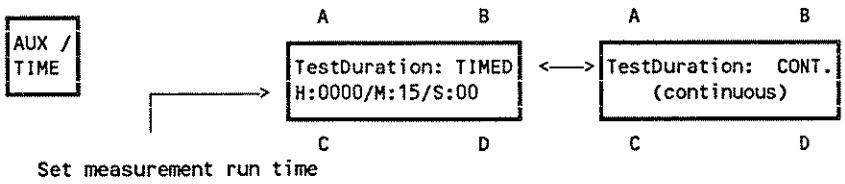
3.4.5 AUX Error Insert Select Page:



Field [D] displays the current category for AUX error insertion. Scroll through the available categories by pressing [D]. The list of error-patterns in the selected category will be found in the VIEW field when the "AUX" error insertion LED is again lit. Field [B] displays the selected DS1 (channel number) for error insertion. This is only shown when in a Tx^3_1 mode.

3.5 [AUX/TIME] SETUP

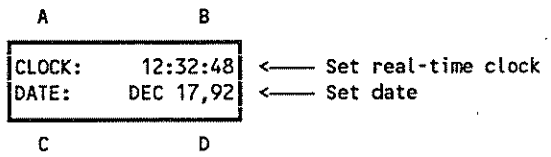
3.5.1 Test Duration Setup Page:



Field [B] displays the current status of Test Duration: Timed or Continuous measurement. If TIMED has been selected, then a measurement-run time from 1 second to 1000 hours can be set up. Pressing [C] once will cause the four "hours" digits to blink. While blinking, they can be set with the Data Entry "up/down" arrow keys (hold down the key to quickly scan to the desired value). Press [C] a second time to blink and set the test duration minutes. Press [C] a third time to set seconds. A fourth pressing of [C] completes the measurement-run-time setup.

The Test-Duration Setup Page can be viewed during a measurement run, but cannot be changed while the "Measurement-Run" LED is lit.

3.5.2 Real-Time Clock and Date Setup Page:



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 set 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 toward the right of the display, and finally off the display.

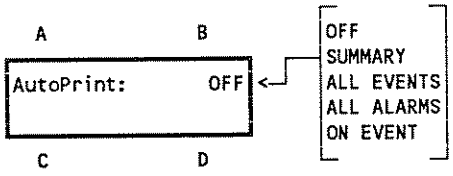
To set the date:

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

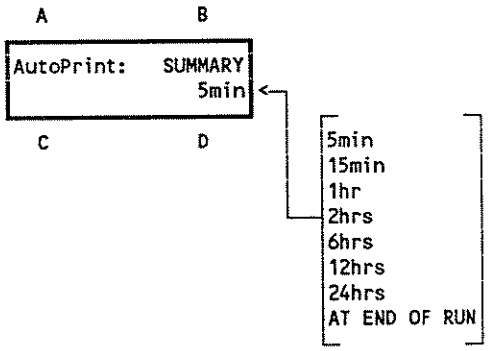
3.5.3 Printer Setup Page:

Field [B] shows the current status of Auto Print. The AUTO PRINT LED is lit for all choices except OFF. The Printer Setup Page can be viewed during a measurement run, but cannot be changed while a measurement is in progress (while the "Measurement-Run" LED is lit), or while the printer is printing.

Manual print via the [MAN PRINT] key is always available, even when Auto Print is on. However, in the Print-On-Event modes, the manual print will not start until the printer buffer is empty, and the Print-On-Event function will be disabled while the Manual print is printing.

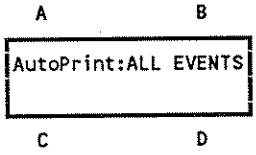


Summary Print

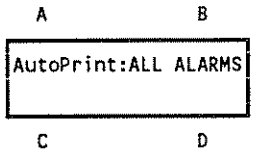


When SUMMARY is selected, the PF-45 automatically prints a summary of the current measurement results at the end of each time interval. Field [D] provides a choice of the desired time interval. Each summary print-out contains the same printed information and format as a Manual Print-out, that is, the data printed is the total (cumulative) data for the measurement run from "start" until the printout has begun. (The measurement run is NOT restarted at the beginning of each time interval.)

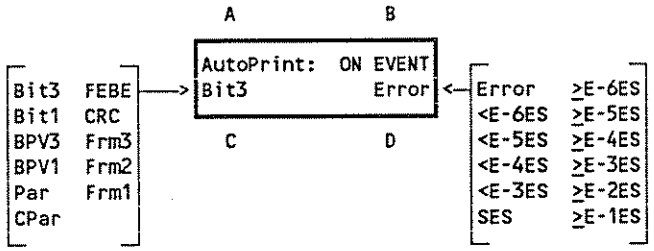
Print-On-Event



Print On All Events will cause a date and time-stamped printout for any:
Error event: Bit3, Bit1, BPV3, BPV1, Par, CPar, FEBE, CRC, Frm3, Frm2, Frm1
Alarm event: DS3: No Signal, No Frame, No Pattern Sync, AIS, Idle
DS2: No Signal, No Frame, AIS
DS1: No Signal, No Frame, No Pattern Sync, AIS, Yellow
Rx Status event: DS3 Xbit, DS2 Xbit, DS1 Excess Zeros, PF-45 No Power



Print On All Alarms will cause a date and time-stamped printout for any:
Alarm event:DS3: No Signal, No Frame, No Pattern Sync, AIS, Idle
DS2: No Signal, No Frame, AIS
DS1: No Signal, No Frame, No Pattern Sync, AIS, Yellow
Rx Status event: PF-45 No Power



Print On (Selected) Event will cause a date and time-stamped printout for:
A selected Event/Threshold second (ie: BPV3 Error, or CRC SES) and, will also print for any of the following:

Alarm event: DS3: No Signal, No Frame, No Pattern Sync, AIS, Idle
DS2: No Signal, No Frame, AIS
DS1: No Signal, No Frame, No Pattern Sync, AIS, Yellow
Rx Status event: PF-45 No Power

Print-On-Event Results

In order to eliminate redundancy in the printout, the PF-45 does not print every event possible each second, but instead prints the subset of meaningful events only.

An example may help: in an Rx^{3}_{1} mode there is a second with DS3, DS2 and DS1 No Signal, DS3, DS2 and DS1 No Frame, Loss of Pattern Sync, DS3, DS2 and DS1 Frame Errors, Par, C-Par, CRC and Bit1 Errors. The PF-45 will print only "ALARM: DS3 No Signal". This is because the remaining alarms and errors are inevitably caused by the DS3 No Signal condition, and so, the other events and alarms add no useful information about the signal condition.

Error Events will show the time, date, the event type, and the number of errors that occurred during the errored second (Err/Sec).

Print-On-Event Squelch

For Print-On-Event, the printout will be squelched after ten consecutive seconds of events to be printed. The printer will print the ten seconds of data, followed by:

(time)/(date)
Printer:SQUELCHED

After ten consecutive seconds without events to be printed, the printer will print:

(time)/(date)
Printer: ENABLED

and the Auto Print feature will continue. During the squelch period, the PF-45 will continue to log all errors and events as usual, but no events will be stored to the printer buffer, or printed.

Print Buffer Overflow

The built-in printer in the PF-45 can print approximately one line per second. Multiple events to be printed may occur during any second, and it is possible that the printer buffer may fill up and overflow in a high-error situation. For Print-On-Event, when 70 lines of print are queued in the printer buffer, the PF-45 will place a time-stamped message:

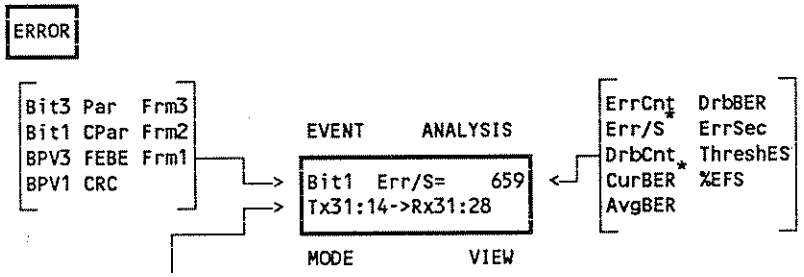
Buffer: OVERFLOW

in the buffer, and will stop loading new lines in. The printer will then print the 70 lines followed by the buffer overflow message (with the time when the buffer ceased to be loaded). The printer will then print the current time and date followed by:

Buffer: CLEARED

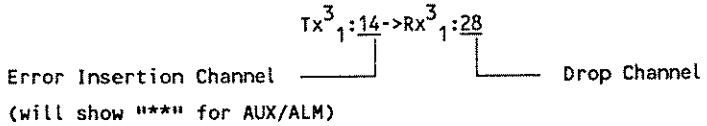
Normal operation of Print-On-Event is then resumed. As with the printer squelch, the PF-45 continues to log all errors and events as usual during the overflow time, but no events will be stored to the printer buffer, or printed.

3.6 MEASURE [ERRORS]



Set Tx (Error Insert) and Rx (Drop DS1) Channel Numbers:

1) Press [MODE] key
2) Tx^{3}_{1} Chan.No.in display & Data Entry LED blink
3) Select Channel for Error Insertion with Data Entry keys
4) Press [MODE] key again to "enter" Error Insertion Chan.No.
5) Rx^{3}_{1} Chan.No.in display & Data Entry LED blink
6) Select Drop Channel (for analysis) with Data Entry keys
7) Press [MODE] key again to "enter" Drop Channel No. and exit



* At end of measurement run, Err/S becomes MaxE/S, and CurBER becomes MaxBER.

The Error Measurement display category shows the current measurement data. While a measurement run is taking place, the displayed values are continually updated. After a measurement run is through, the displayed values are the stored, final results of that measurement. The "measurement process" is not affected by the display category selected. The [EVENT]/[ANALYSIS] selection is a matrix of measurement results, but not all analyses are applicable for every event. In these cases, the analysis will be displayed as "N/A" ie: "Not Applicable" or "Not Available".

3.6.1 Set DS1 Channel Number

When a new mode containing DS1 analysis (other than D&I) is set, the default DS1 channel number is "01".

When a D&I mode is set, the default DS1 channel number is "00", which means NO CHANNEL IS SELECTED! This allows the user to setup the mode completely, monitor the DS3 status, and then perform the Drop & Insert function by selecting a non-zero DS1 channel number. The new DS1 channel number is only activated when the [MODE] key is pressed a second time, stopping the blinking of the channel number in the display and the DATA ENTRY LEDs.

3.6.2 DS2 Channel Numbers

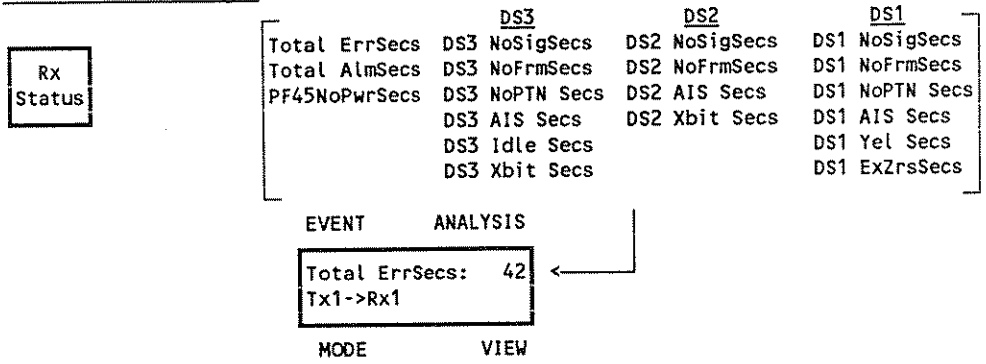
Each DS1 is multiplexed into DS3 via a DS2. Each DS1 channel therefore has a DS2 that contains it. For Tx^{3}_{1} modes, a DS1 channel number is also selectable for error insertion. The DS2 that carries the selected DS1 is also available for error insertion (see 3.4.5 "AUX Error Insert Select Page"). The DS1 channel numbers and their associated DS2 channel numbers are as follows:

DS1 #	DS2 #
1-4	1
5-8	2
9-12	3
13-16	4
17-20	5
21-24	6
25-28	7

3.7 MEASURE [Rx STATUS]

Two display pages are available by pressing the [RxSTATUS] key. The RxStatus Page provides status seconds counts of the individual status events, and of certain composite events. Pressing the [RxSTATUS] key again will toggle to the Elapsed Time Page, which provides the elapsed measurement run time in either seconds or hours/minutes/seconds.

3.7.1 RxStatus Page:



Like the [ERROR] measurement display category, the Rx STATUS page contains constantly updated values during a measurement run, and stored values for that run, when the measurement has stopped.

History LED

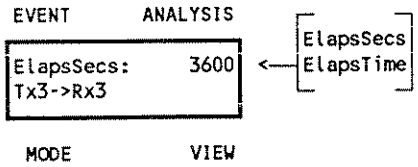
When the Rx STATUS page is selected, the History LED is continuously lit, and any LED that has been lit since the start of the measurement run, or the last History Reset, is now lit again to show the Rx Status "history".

For any display category or page other than the Rx STATUS page, the History LED will blink when a count has occured in the RxStatus Page since the start of the measurement run or the last History Reset. THE BLINKING HISTORY LED IS AN IMMEDIATE INDICATION THAT AN ERROR OR ALARM EVENT HAS OCCURRED. Since Total Errored Seconds and Total Alarm Seconds are provided, the user can quickly determine whether the History LED is blinking to show error events and/or alarm events.

Zero Count Suppression

The Total Errored Seconds and Total Alarm Seconds are always available for display. However, to simplify operation, all other alarms and events with zero-counts are suppressed from the display list. This means that, with the exception of Total ErrSecs and Total AlmSecs, when scrolling through the results with key [B], only those alarms and events which have occurred during the measurement run will be displayed along with their non-zero event-second count.

3.7.2 Elapsed Time Page:



Press key [B] to toggle between the measurement run Elapsed Seconds and Elapsed Time (in hours/minutes/seconds format).

3.8 MAKING SENSE OF MEASUREMENT RESULTS

Consequences of the Error-Count Inhibit:

The "Error-Count Inhibit Feature" (see Section 1.2.2) is a powerful tool for error analysis. Essentially, it inhibits error-counting whenever the conditions for making a particular measurement are not met.

In other, less sophisticated instruments, error-counting continues regardless of the receive signal status. So, for instance, a momentary loss-of-signal could result in millions of DS3 "bit" errors being counted. These errors can swamp the previous error-count, and for most purposes make the error-count data meaningless. The only meaningful data recorded by such an instrument is the loss-of-signal occurrence.

The PF-45 however will, in the instance of a DS3 loss-of-signal, detect the loss-of-signal and immediately inhibit the error-counter. Since the DS3 loss-of-signal is detected within 175 +/- 75 zeros, a relatively small "bit" error count will be accumulated due to it. The PF-45 waits until the signal is restored before re-enabling the counter, then continuing the measurement process. In this case, the PF-45 user has more meaningful data: the loss-of-signal occurrence, and the "bit" error count (and ratios, thresholds, etc.) that occurred while the DS3 signal was present.

Due to this difference in error-count inhibit, the PF-45 user must be aware of the following:

The error-performance of the system-under-test must be judged by a combination of the "Measure Errors" results and the "Measure Rx STATUS"!

Always look at the Rx STATUS results to validate the measurement run results. A bit error count of zero could mean that the system is error-free, OR it could mean that the signal was never present, or the receiver never achieved frame-sync or pattern-sync.

The built-in printer is very helpful for this, because it shows the entire range of error and Rx Status results.

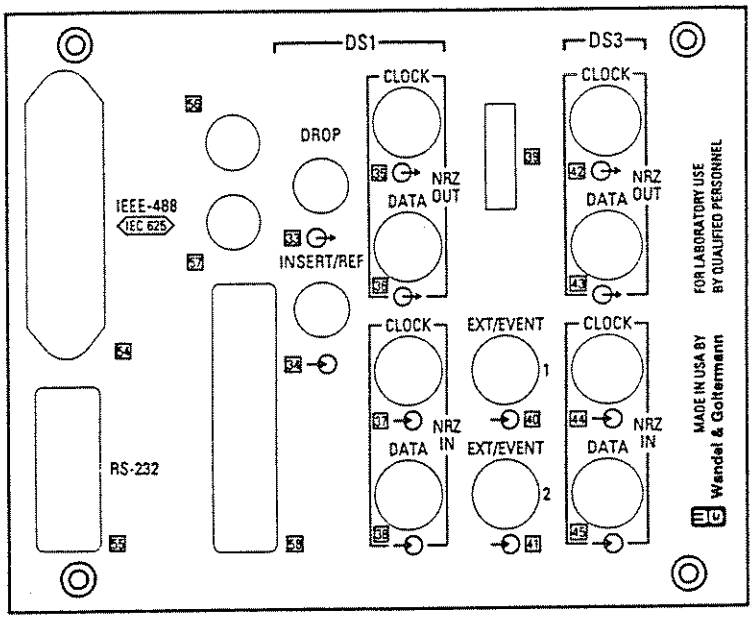


Figure 3-14: Rear View with Data Link/Multifunction Option Installed

OVERVIEW

The Data Link/Multifunction Option Card offers three distinct functions: (1) Transmit (Insert) and Receive access to several DS3 C-Parity Data Links and to the DS1 ESF Data Link. (2) Parallel output of eighteen detected errors and alarm conditions as well as DS3 and DS1 Transmit and Receive M-sync. (3) Two BNC rear panel jacks with assignable outputs.

Functions (1) and (2) share a 25 pole rear panel connector; the desired configuration is selected by the user via an internal DIP switch. The BNC outputs are also assigned via internal DIP switches (see Figure 3-17). The DIP switches are accessible from the top of the option board by removing the top cover (four Allen screws).

DATA LINK ACCESS

The Data Link Configuration provides access to the DS1 ESF Transmit and Receive Facility Data Link as well as a number of present and planned DS3 C-Parity data links. Transmit and Receive access to other selected DS3 overhead bits is also possible. The Data Link configuration is selected by DIP Sw 6 #1 = OFF.

DS3 C-Parity Data Link Drop and Insert

The option provides external access to five DS3 C-Parity data links, making it possible to drop one or more data links from the received C-Parity Formatted signal and to insert one or more data links simultaneously into the transmitted signal. Access is via the 25 pole rear panel connector [58]. The C-bit data links defined below can be accessed in C-Parity frame format:

(1) C12: N_a (9.4 kbit data link not currently assigned)
(2) C13: FEAC (9.4 kbit Far End Alarm & Control)
(3) Row 5: (DL5--28.2 kbit data link) C51,C52, & C53
(4) Row 6: (DL6--28.2 kbit data link) C61,C62, & C63
(5) Rows 2&7: (DL2/7--56.4kbit) C21,C22,C23,C71,C72, &C73

Separate Transmit and Receive "clock" signals are provided for each of the data links defined above; eg, Tx3 DL5 Clk or Rx FEAC Clk.

DS3 X-Bit Drop and Insert
Access to individual Transmit and Receive X bits is provided by means of X1 and X2 clocks, analogous to the C-data link clocks described above. Separate Transmit and Receive clock signals are provided for individual X1 and X2 bits (9.4 k-bit); eg, Tx3 X1 Clk or Rx3 X2 Clk.

DS3 FEBE Access
Access to the FEBE bits is provided by means of Transmit and Receive FEBE clocks that define the location of the three FEBE C-bits (28.2 kbit); eg, Tx3 FEBE Clk.

DS3 P-Bit Access
Access to the P-bits is provided by means of Transmit and Receive P Bit clocks that define the locations of both P bits (18.8kbit); eg, Tx3 P Clk (P1+P2).

DS3 Receive Data Link Drop
The positive transitions of each of the DS3 Receive clock signals discribed above fall in the middle of the corresponding Overhead bit of the Receive Overhead signal (Rx3 OH OUT). This permits individual data links to be extracted from the Overhead. See Figure 3-16.

DS3 Transmit Data Link Insert
Externally sourced DS3 data link and overhead bit insertion is available in the following modes: Tx3->Rx3, Tx^3_1->Rx^3_1, Tx^3_1->Rx1, THRU3, $THRU^3_1$, IntD&I, ExtD&I, and Ins^3_1->Rx1. To insert information into one or more transmitted DS3 data links, an output clock is provided for each of the possible candidates. Transmit clock signals serve two functions: The positive transitions provide a synchronous demand clock for the external data source and the positive clock state is used as the Overhead bit Insert Valid signal to the PF45. The externally sourced data and relevant clock are input to the PF45 multipole connector [58]: Tx3 EXT OH IN (pin 8) and Tx3 USER CLK IN (pin 11). If two or more external data links are to be inserted, each individual data signal must first be logically ANDed with it's clock and then combined (logical OR) with other data signals to form the input to EXT OH IN. Similarly, the individual clocks for each data link must be ORed and input to USER CLK IN. Figure 3-15 is an example of the circuitry required to simultaneously insert both DL6 and FEAC into the transmitted C-bits.

DS3 Timing

Figure 3-16 shows clock timing for the DS3 Receive and Transmit clocks. Receive clock timing is illustrated by Rx3 DL5 CLK (pin 13) relative to Rx3 OH OUT (pin 22). Transmit clock timing depicts the signals for the example shown in Figure 3-16. The maximum delay allowed between an output Tx DL Clock, say Tx DL5 CLK, and the corresponding USER CLK IN or EXT OH IN is 500 nSec.

DS3 Insert Validation

To prevent unintended overhead data insertion, the desired Transmit clocks must be enabled by internal dip switches. Any combination of nine clocks may be enabled by switching the appropriate switch ON:

DS3 Insert Validation

M13 C-bit Ins	Sw 5 #8*
FEAC	Sw 5 #7
C12	Sw 5 #6
DL5	Sw 5 #5
DL6	Sw 5 #4
DL2/7	Sw 5 #3
X1	Sw 5 #2
X2	Sw 5 #1
FEBE**	Sw 6 #8
(P1+P2)**	Sw 6 #7

*Switch 5, position #8 is normally set to OFF enabling the five Tx3 C-Bit and FEBE clocks only in the C-Parity frame format. If position #8 is closed (ON), the clocks will be enabled in M13 frame as well. This may result in erroneous DS2 demultiplexing. Sw#8 does not affect other overhead bit clocks. DS3 Overhead Insertion takes priority over the front panel Error Insertion insofar as overhead bits are concerned. For example, FEBE errors cannot be inserted on top of externally sourced FEBE bits.

**FEBE and P-Bit clocks are available on the rear connector [58] only for configuration B which excludes DS1 ESF data link access. Configuration B is selected by positioning a socketed SIP resistor pack as shown in Figure 3-18.

DS1 ESF Data Link Drop and Insert

For ESF Data Link operation, set the option board to Configuration #1A by setting DIP Switch 6 #1 OFF and placing the socketed SIP resistor pack as shown in Figure 3-18.

In Configuration #1A, any time the PF-45 is receiving and analyzing an ESF DS1 signal, that DS1's 4Kbs data link (Rx1 DL OUT) is output from pin 21 of the 25 pole rear-panel D-type connector as NRZ data. A 4kHz clock (Rx DL CLK OUT) is output from pin 23. Either clock edge can be used to sample the NRZ data, though the falling edge which lies in the nominal center of the data will provide the most robust results (the rising edge occurs nominally 650nS after the data transition). ESF Data Link insertion is activated by setting the PF-45 rear-panel DIP Switch [39] #6 ON.

Insertion of an externally-sourced data link is available in the following modes: Tx1->Rx1, Tx1->Rx^3_1, Tx^3_1->Rx1, Tx^3_1->Rx^3_1, THRU1, $THRU^3_1$, $IntD\&I^3_1$, and Ins^3_1->Rx1. (Note: in the two THRU modes, a momentary "hit" will be placed on the (selected) DS1 as the PF-45 reroutes the signal to accommodate the insertion.)

A 4kHz demand clock for the inserted data link (Tx1DL CLK OUT) is provided at pin 16 of the rear-panel connector. The data to be inserted should be input to pin 15 (Tx1 DL IN). Use the falling edge of the clock as the synchronous clock for the data link source, as the PF-45 samples the input data at approximately the same time as the rising edge of the clock.

DS1 Transmit Yellow Alarm insertion overwrites the externally sourced ESF data link insertion.

Alarm/Error output

The Alarm/Error output configuration is selected by setting DIP Sw 6 #1 ON. This configuration assigns the pins of the 25 pole connector [58] as shown for Configuration 2 below. Errors are output positive true while alarms are negative true. Thus power failure to the PF45 will cause all alarms to go active.

25 Pole Rear Connector

I/O Signals associated with the Alarm/Data Link Option make their appearance at a 25 Pole connector on the rear panel of the PF45. Interface signals are HCMOS compatible. Source resistance is approximately 250 ohms; input resistance is greater than 5000 ohms. Dip Switch 6,#1 selects either the Data Link (Configuration #1) or Alarm/Error (Configuration #2) signals to be accessed via the 25 pole connector. In the Data Link mode, one of two slightly different pin configurations may be selected, depending on the positioning of a SIP resistor network (see Figure 3-18). Configuration #1B replaces DS1 ESF data link access (#1A) with DS3 FEBE and Pbit access. The connector pinout for the different configurations is shown below:

Pin	DATA LINK MODE		ALARM/ERROR MODE	
	Config #1A	Config#1B	Config#2A	Config#2B
1	+5 volts		+5 volts	
2	Tx3 DL2/7 CLK		DS3 ParErr	
3	Tx3 FEAC CLK		DS3 CParErr	
4	Tx3 DL5 CLK		DS3 FEBE	
5	Tx3 DL6 CLK		DS3 Frm Err	
6	Rx3 X2 CLK		DS3 LOS (inv.)	
7	Tx3 X1 CLK		DS3 OOF (inv.)	
8	Tx3 EXT OH IN		DS3 AIS (inv.)	
9	Rx3 X1 CLK		DS3 IDLE (inv.)	
10	Rx3 DL2/7 CLK		DS1 CRC Err	
11	Tx3 USER CLK IN		DS1 Frm Err	
12	Rx3 DL6 CLK		DS1 LOS (inv).	
13	Rx3 DL5 CLK		DS1 OOF (inv.)	
14	RESERVED		DS1 AllOnes	
15	Tx1 DL IN	Tx3 Pbit CLK	DS1 Rx M-Sync	RESERVED
16	Tx1 DL CLK OUT	Rx3 Pbit Clk	DS3 Tx M-Sync	RESERVED
17	Rx3 FEAC CLK		DS2 OOF (inv.)	
18	Tx3 C12 CLK		DS2 AllOnes (inv.)	
19	Tx3 X2 CLK		DS1 PatLoss (inv.)	
20	Rx3 C12 CLK		DS3 PatLoss (inv.)	
21	Rx1 DL OUT	Tx3 FEBE CLK	DS3 Rx M-Sync	RESERVED
22	Rx3 OH OUT		DS2 Frm Err	
23	Rx1 DL CLKOUT	Rx3 FEBE CLK	DS1 Tx M-Sync	RESERVED
24	Ground		Ground	
25	Ground		Ground	

ASSIGNABLE REAR PANEL BNC JACKS

Regardless of the multipole [58] configuration selected, the option board also provides two TTL compatible BNC Output jacks [56] & [57], with assignable outputs and capable of driving 75 ohm loads. A number of internal signals are accessible via internal dip switches. As delivered, [56] outputs the DS3 Rx M-Sync pulse and [57] outputs DS3 Tx M-Sync. Other possibilities are:

	BNC [56]				BNC [57]		
SIGNAL	A2	A1	A0	SIGNAL	B2	B1	B0
SW1	#3	#2	#1	SW1	#7	#6	#5
DS3 Rx M-Sync	0	0	0	DS3 Tx M-Sync	0	0	0
DS1 Rx M-Sync	0	0	1	DS1 Tx M-Sync	0	0	1
Rx3 FEAC CLK	0	1	0	Alm/Err Comp*	0	1	0
Rx3 DL2/7 CLK	0	1	1	5 Mhz Clock	0	1	1
Rx3 DL5 CLK	1	0	0	Rx3 X1 Valid	1	0	0
Rx3 DL6 CLK	1	0	1	DS3 Rx OH	1	0	1
Rx3 C12 CLK	1	1	0	Rx1 ESF DL	1	1	0
Rx1 ESF DL CLK	1	1	1	Burst time	1	1	1
SW1 #4 ON=INVERT [56]				SW1 #8 ON=INVERT [57]			

*Alarm / Error Composite is a signal comprised of selected alarms and errors combined by logical OR. Any combination of eighteen signals may be selected using the internal dip switch array illustrated in Figure 3-18 and listed below:

ERRORS

SW2 #2 ON	Bit Error
SW2 #1 ON	DS3 BPV
SW3 #8 ON	DS3 Parity Error
SW3 #7 ON	DS3 C-Parity Error
SW3 #6 ON	DS3 FEBE
SW3 #5 ON	DS1 CRC6 Error
SW3 #4 ON	DS3 Frm Error
SW3 #3 ON	DS2 Frm Error
SW3 #2 ON	DS1 Frm Error
SW3 #1 ON	DS1 BPV

ALARMS

SW4 #8 ON	DS3 No Signal
SW4 #7 ON	DS3 No Frame
SW4 #6 ON	DS3 AIS
SW4 #5 ON	DS3 IDLE
SW4 #4 ON	DS1 No Signal
SW4 #3 ON	DS1 No Frame
SW4 #2 ON	DS1 AIS
SW4 #1 ON	No Pattern Sync

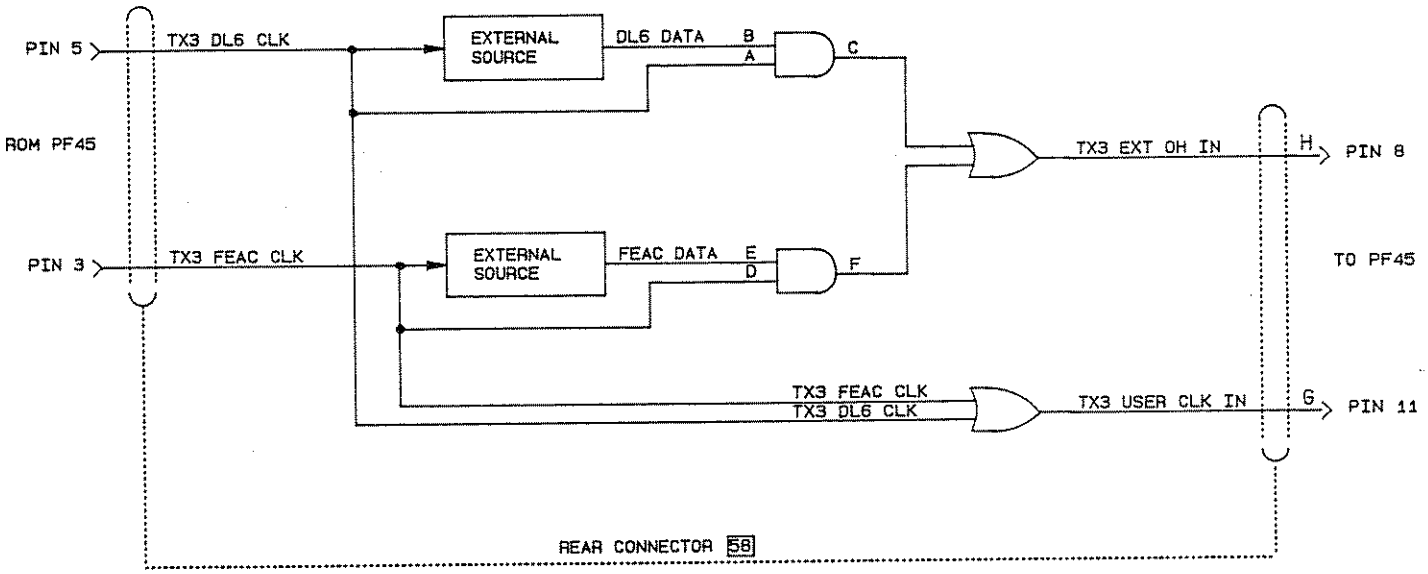


Figure 3-15: DS3 Overhead-Bit Drop & Insert (Data Link/Multifunction Option)
Example: Insert DL6 and FEAC

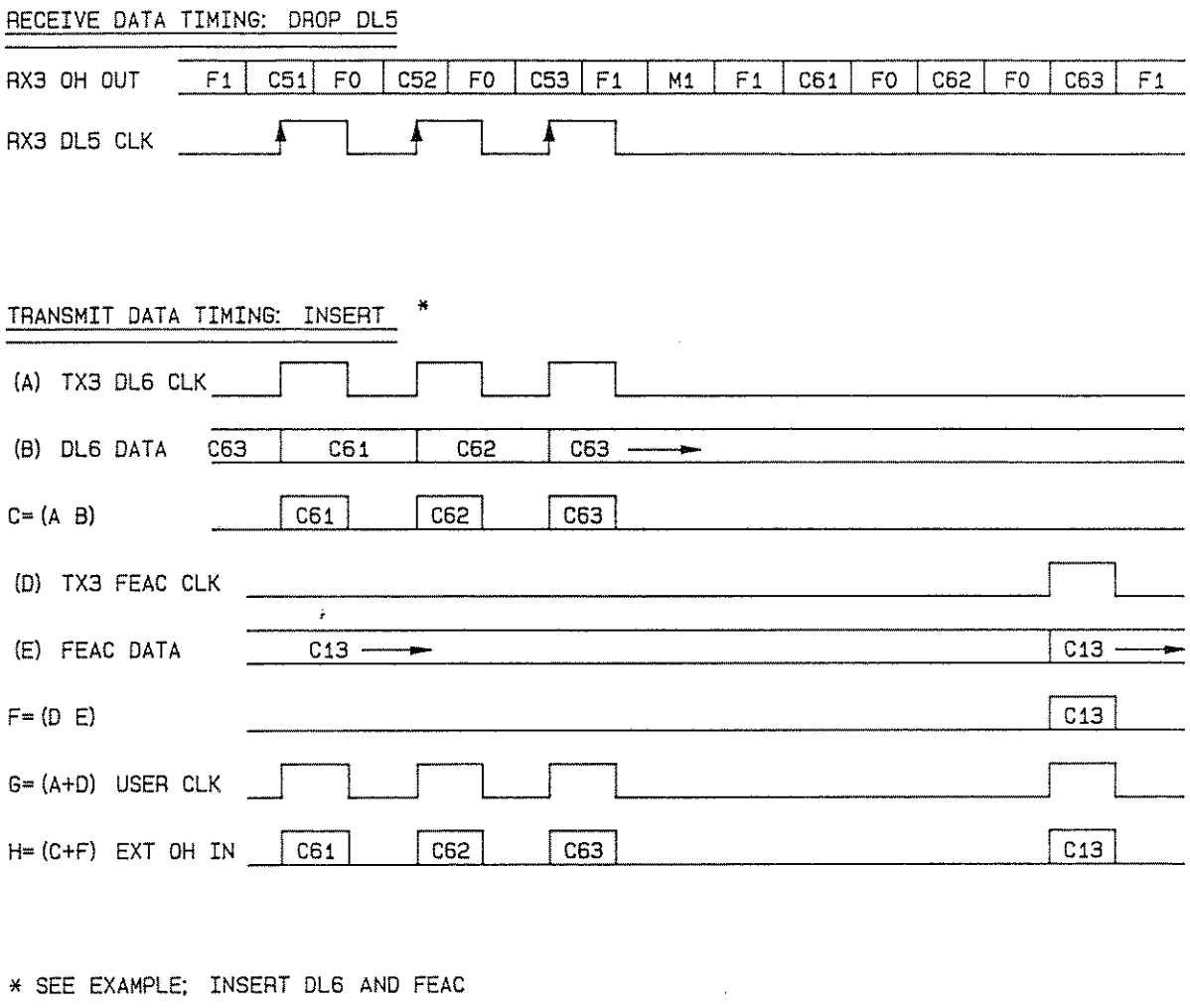


Figure 3-16: DS3 Overhead-Bit Drop & Insert (Data Link/Multifunction Option)
Rx/Tx Data Timing

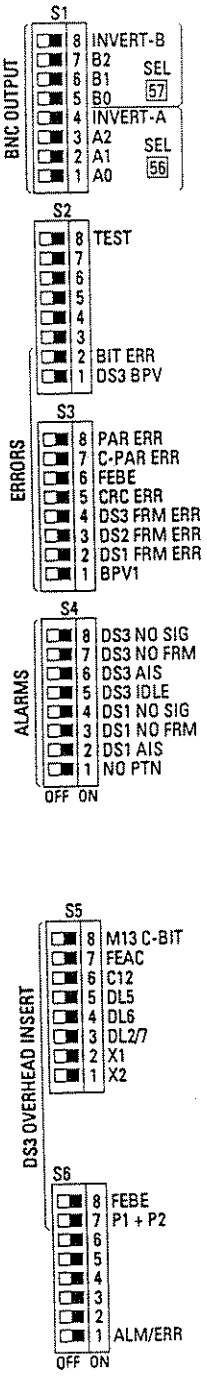


Figure 3-17: Data Link/Multifunction Option Setup Switches

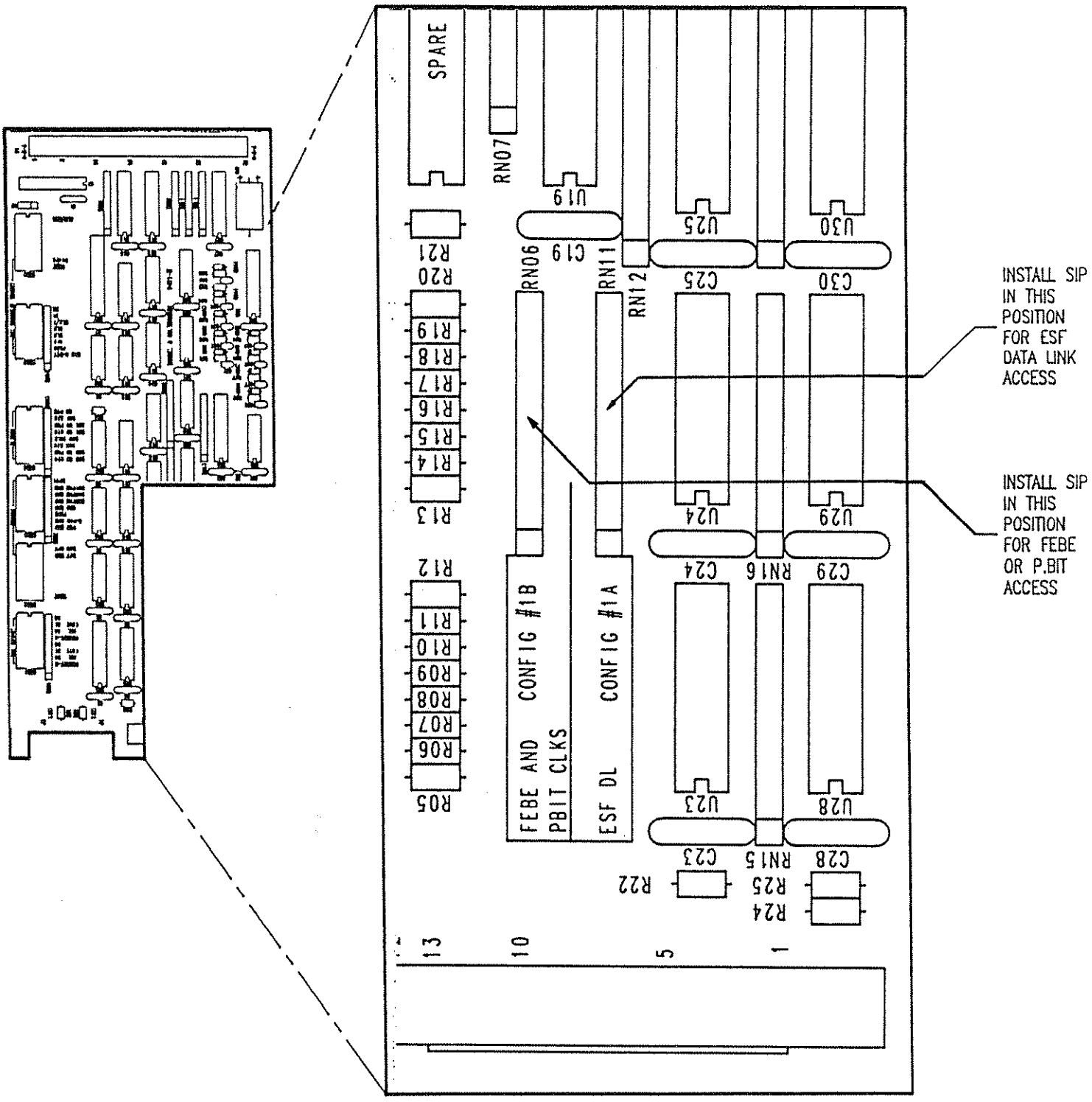


Figure 3-18: SIP Position for Configuration 1A/1B (Data Link/Multifunction Option)

3.10 E1 DROP/ANALYSIS OPTION OPERATION

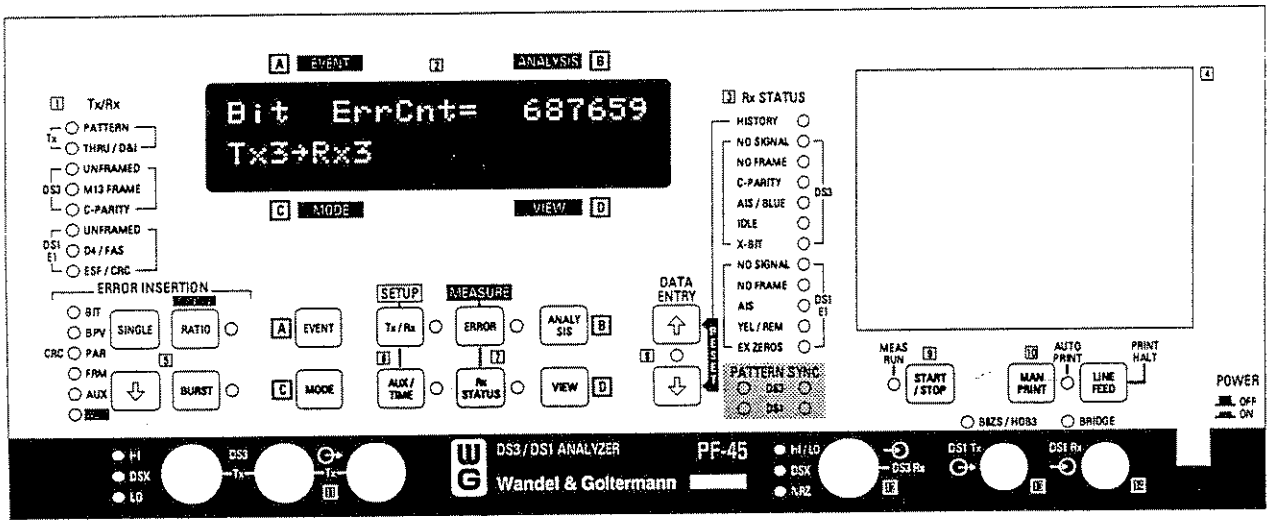


Figure 3-19: Front View with E1 Drop/Analysis Option Installed

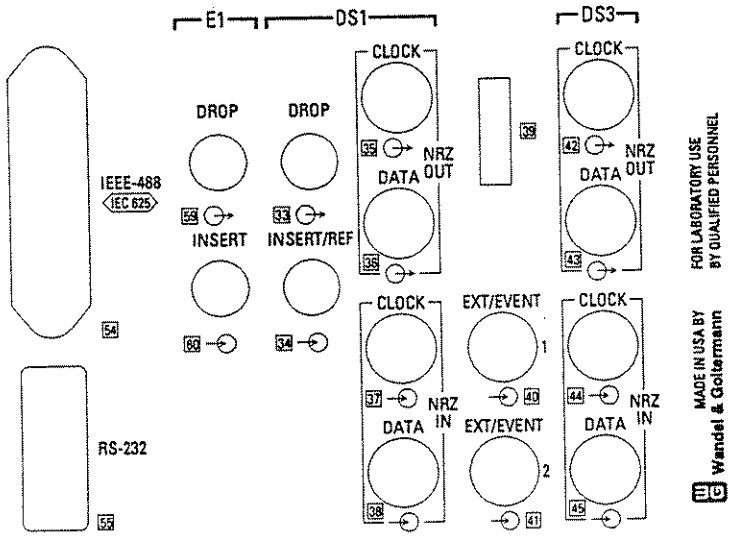
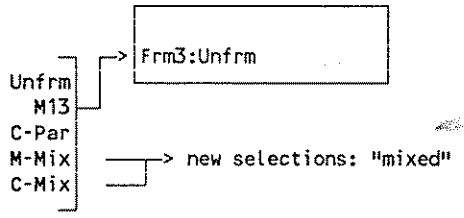
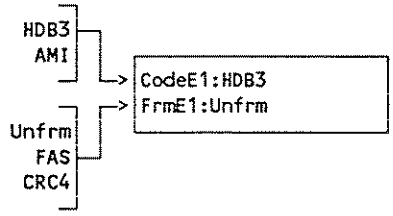


Figure 3-20: Rear View with E1 Drop/Analysis Option Installed

Mon$^3_1$ Setup:



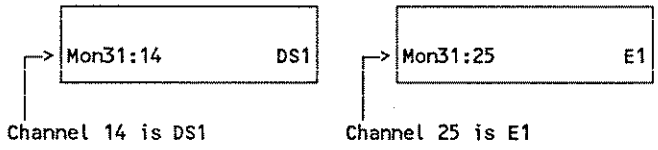
If the E1 D&I Option is installed, then the user can select a "mixed" DS3 frame format in the DS3 Setup Page. "Mixed" tells the PF-45 that the DS3 can contain both DS1's and E1's, and that the PF-45 should act accordingly. "M-Mix" is for M13 format DS3, while "C-Mix" is for C-Parity format DS3.



If a mixed format is selected, then the E1 Setup Page is now included in the Tx/Rx setup list. Select the desired E1 Line Code and E1 Frame Format in the usual way.

Channel Selection:

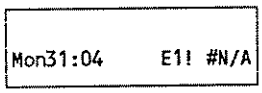
The user selects a drop (DS1/E1) channel number 00-28 from the front panel as usual. The PF-45 monitors the dropped DS2 (corresponding to the selected channel number), determines if it is a DS2 or DS2E, and respectively displays "DS1" or "E1" in the VIEW display.



The channel numbers are mapped to the DS1s and E1s as follows:

DS2/DS2E	DS1	E1	
0	00	00	(no channel selected)
1	01	01	
	02	02	
	03	03	
	04	N/A	
2	05	05	
	06	06	
	07	07	
	08	N/A	
3	09	09	
	10	10	
	11	11	
	12	N/A	
4	13	13	
	14	14	
	15	15	
	16	N/A	
5	17	17	
	18	18	
	19	19	
	20	N/A	
6	21	21	
	22	22	
	23	23	
	24	N/A	
7	25	25	
	26	26	
	27	27	
	28	N/A	

If a channel number that is not available (N/A) for E1 has been selected, and the DS2 has been determined to be a DS2E, the following message is displayed in VIEW: "E1! #N/A". Like channel "00", this is non-existent.



PF-45 E1 Operation while Measurement Run is Off:

While the Measurement Run is OFF, the PF-45 continues to evaluate the E1/DS1 status of the dropped channel, and will change according to the input signal. When the mode is originally selected, the default E1/DS1 status is E1. However, once a valid E1/DS1 status has been determined, that status will be maintained until the opposite status has been determined.

For example, if the selected receive channel is E1, and the PF-45 displays "E1" in the VIEW display, then during a subsequent period of DS3 No Signal, the PF-45 will still display "E1" as the status of the dropped channel. Only when a new signal is found and the dropped channel is determined to be DS1 will the PF-45 change its status to "DS1".

If the selected channel is DS1, then the PF-45 behaves normally. ("DS1" is displayed in the VIEW field).

If the selected channel is E1, then immediately:

- The E1 is dropped to the E1 Drop jack
- The DS1 RxStatus LEDs now apply to E1:

No Signal:	E1 No Signal
No Frame:	E1 No Frame
AIS:	E1 AIS
Yellow:	E1 Remote Alarm
Ex Zeros:	N/A (off)
PatnSync:	N/A (both off)

- The previous measurement results remain on the display, and are available for printing and/or IEEE/RS-232 access.

PF-45 E1 Operation while Measurement Run is On:

While the Measurement Run is ON, the E1/DS1 status is frozen in the state found when the run was started.

If the selected channel is DS1, then the PF-45 behaves normally. ("DS1" is displayed in the VIEW field).

If the selected channel is E1, then upon starting the new measurement run:

- DS2 error events are replaced with:

DS2E Frame Errors	"Frm2"
DS2E Parity Errors	"Par2"

- DS2 alarm events are replaced with:

DS2E No Signal Seconds	"DS2 NoSigSecs"
DS2E No Frame Seconds	"DS2 NoFrmSecs"
DS2E AIS Seconds	"DS2 AIS Secs"
DS2E A-bit Alarm Seconds	"DS2 Abit Secs"

- Bit1 error events and No Pattern Sync seconds are "N/A"
- DS1 error events are replaced with:

E1 FAS Errors (FAS or CRC format)	"Frm1"
E1 CRC4 Errs (CRC format)	"CRC4"

- DS1 alarm events are replaced with:

E1 No Signal Seconds	"E1 NoSigSecs"
E1 No Frame Seconds	"E1 NoFrmSecs"
E1 AIS Seconds	"E1 AIS Secs"
E1 Remote Alarm Seconds	"E1 R-AlmSecs"

4.1 IN-SERVICE MONITORING:

The PF-45 has three dedicated monitoring modes. [MON3] and [MON$^3_1$] modes (Fig 4-1) measure and analyze simultaneously the following DS3 parameters: DS3 BPV's, DS3 frame, parity, C-parity, and FEBE errors, as well as logging and counting as event seconds: DS3 No Signal, DS3 No Frame Sync, DS3 AIS, DS3 Idle, and DS3 X-bit. Analyses include Error Count, Current and Average Bit Error Ratio, Errored Seconds, Threshold Errored Seconds, and % Error-Free-Seconds. [MON$^3_1$] mode also drops a selected DS1 from the DS3, adding the following DS1 parameters: DS1 frame and CRC-6 errors, and logging DS1 No Signal, DS1 No Frame Sync, DS1 AIS and DS1 Yellow Alarm events. [MON1] mode monitors a DS1 line signal (Fig 4-2), and includes DS1 BPV's in the above list of DS1 parameters.

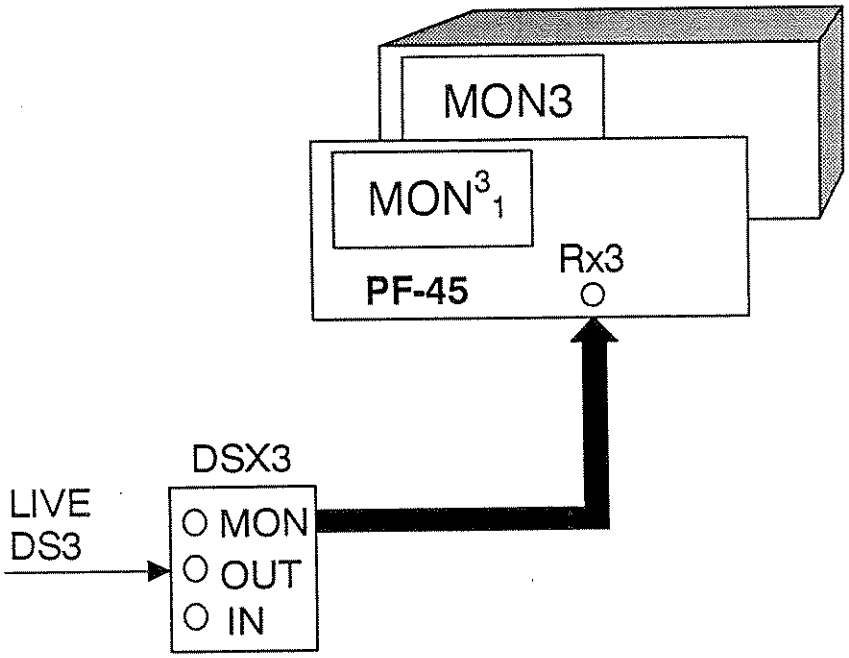


Figure 4-1: MON3 & MON$^3_1$ Modes

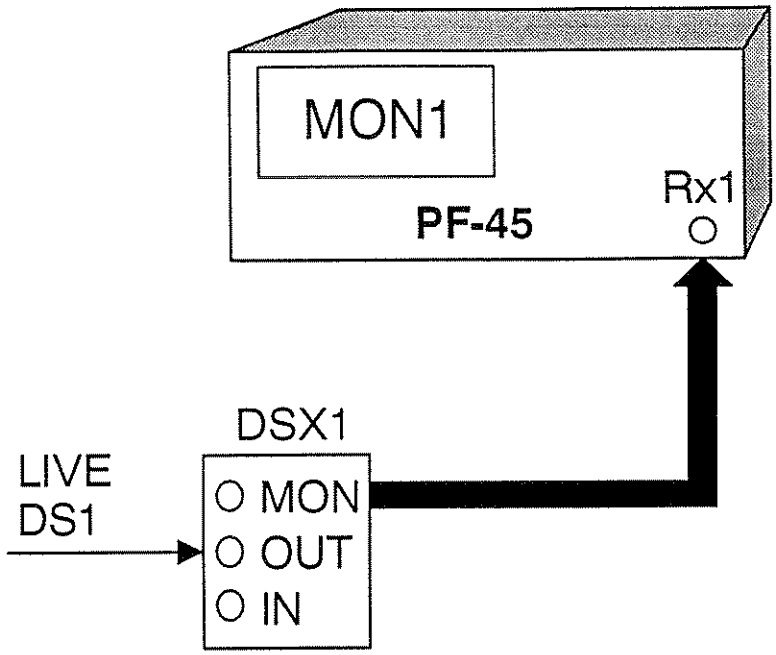


Figure 4-2: MON1 Mode

4.1.1 In-Service Monitoring of DS3

The MON3 mode monitors a DS3 signal for all DS3-related parameters, but ignores the payload, including DS2s and DS1s.

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

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "MON3" is in the lower left display quadrant as shown below.
   - "Execute" the mode change by pressing key [D] once.

```
SET NEW MODE
MON3          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 [C] until the desired DS3 frame format is selected. HINT: if the C-PARITY Rx STATUS LED is lit, then set the frame format to "CPar", otherwise set it to "M13". Watch the DS3 No Frame RxSTATUS LED. If it stays on for both "CPar" and "M13" formats, then the DS3 is unframed, and so, set the frame format to "Unfrm".

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

4. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page. The default pattern in monitor modes is "Live", ie., "no pattern". If the DS3 under test contains live traffic, leave the pattern set to "Live".
- If the DS3 under test contains a test pattern, then press key [A] until that pattern is displayed, and the green DS3 Pattern Sync LED is lit. Typically, this will be the 2E15-1 pattern, which is the most widely used DS3 test pattern.

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

5. - 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 5.
- 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)

6. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 6, 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)

7. - The PF-45 is now setup. Press the [ERROR] Measure key to bring up that display category.
- Before starting the measurement run, make a careful check of the RxSTATUS LEDs. Do we have signal? If a framed signal is expected, are we in frame sync? Is any alarm or idle signal present? If a pattern other than "Live" has been selected, 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
MON3
```

8. - 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.

4.1.2 In-Service Monitoring of DS1

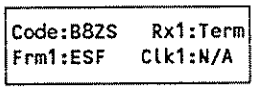
The MON1 mode monitors a DS1 signal for all DS1-related parameters, but ignores the payload, including DS0s.

1. - Connect the PF-45 DS1 receive jack [14] to the monitor jack at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-2.

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
- Press key [C] until "MON1" is in the lower left display quadrant as shown below.
- "Execute" the mode change by pressing key [D] once.

```
SET NEW MODE                (Set New Mode Page)
MON1          EXECUTE
```

3. - 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 [A] to select the DS1 line code. Try B8ZS first. If the DS1 Excess 0s LED stays OFF, and the next step of finding the proper frame format and sync works, then leave the code set to B8ZS, otherwise set AMI.
- Press key [C] until the desired DS1 frame format is selected. HINT: try both the D4/SF and the ESF frame formats. Watch the DS1 No Frame RxSTATUS LED to see which format achieves sync. If the No Frame LED stays on for both "D4/SF" and "ESF" formats, then the DS1 is unframed, and so, set the frame format to "Unfrm". If frame sync cannot be achieved, but the signal is expected to framed, try setting the alternate line code, and start this step again.

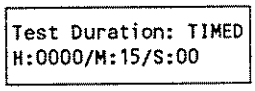


(DS1 Setup Page)

4. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page. The default pattern in monitor modes is "Live", ie., "no pattern". If the DS1 under test contains live traffic, leave the pattern set to "Live".
- If the DS1 under test contains a test pattern, then press key [A] until that pattern is displayed, and the green DS1 Pattern Sync LED is lit. Typically, this will be the QRSS20 pattern, which is the most widely used DS1 test pattern.

(Pattern Select Page)

5. - 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 5.
- 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 Page)

6. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 6, 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)

7. - The PF-45 is now setup. Press the [ERROR] Measure key to bring up that display category.
- Before starting the measurement run, make a careful check of the RxSTATUS LEDs. Do we have signal? If a framed signal is expected, are we in frame sync? Is any alarm or idle signal present? If a pattern other than "Live" has been selected, do we have Pattern Sync? Is the Excess 0s LED on when it shouldn't be?
- 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
MON1
```

8. - 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.

4.1.3 In-Service Monitoring of DS1 Embedded in DS3

The MON^3_1 mode monitors a DS3 signal for all DS3-related parameters, and monitors the payload, including a selected DS1 and the DS2 that contains it.

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

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

```
SET NEW MODE
MON31        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 [C] until the desired DS3 frame format is selected. HINT: if the C-PARITY Rx STATUS LED is lit, then set the frame format to "CPar", otherwise set it to "M13". Watch the DS3 No Frame RxSTATUS LED.

```
Tx3:OFF      Rx3:DSX
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 [C] until the desired DS1 frame format is selected. HINT: try both the D4/SF and the ESF frame formats. Watch the DS1 No Frame RxSTATUS LED to see which format achieves sync. If the No Frame LED stays on for both "D4/SF" and "ESF" formats, then the DS1 is unframed, and so, set the frame format to "Unfrm".

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

5. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page. The default pattern in monitor modes is "Live", ie., "no pattern". If the DS1 under test contains live traffic, leave the pattern set to "Live".
   - If the DS1 under test contains a test pattern, then press key [A] until that pattern is displayed, and the green DS1 Pattern Sync LED is lit. Typically, this will be the QRSS20 pattern, which is the most widely used DS1 test pattern.

```
Ptn:Live
```
(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 desired 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.
- The PF-45 is now 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? If a pattern other than "Live" has been selected, 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 <u>not</u> 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
MON31:28
```

9. - 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.

4.2 OUT-OF-SERVICE TESTING

STAND-ALONE BIT ERROR TESTING OF EVERY MAJOR DS3/DS1 SYSTEM COMPONENT:
The five test modes provide a complete test solution by transmitting and receiving the correct test signal for the network or network equipment under test (Figs 4-3 through 4-7). Other network elements must no longer be pulled out of service to create or access the test signal. Only the system under test need be in the test loop.

4.2.1 Out-Of-Service Testing of DS3

In [Tx3->Rx3] mode (Fig 4.3), a DS3 test pattern (such as 2^{23}-1,2^{20}-1,2^{15}-1,1010,1100, etc.) is transmitted, received and analyzed. The test object could be for instance, a DACS 3/3, a DS3 looped-back signal (as shown), or a straightaway test with a PF-45 at each end of a DS3 circuit.

1. - Connect the PF-45 DS3 receive jack [12] to the monitor jack of the incoming DS3 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-3.

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "Tx3->Rx3" is in the lower left display quadrant as shown below.
   - "Execute" the mode change by pressing key [D] once.

```
SET NEW MODE
Tx3->Rx3    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 [B] until Rx3:DSX is displayed as shown below.
   - Press key [C] until the desired DS3 frame format is selected.

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

4. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page.
- Press key [A] until the 2E15-1 pattern is displayed. This is the pattern most typically used for DS3 testing.

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

5. - 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 5.
- 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)

6. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 6, 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)

7. - The PF-45 is now setup. (For the sake of simplicity, the remainder of this section will deal with a looped-back DS3 out-of-service test). The loop-back must now be made and verified.
- Perform the DS3 loop-back.
- Connect the PF-45 DS3 transmit jack [11] to the input jack of the outgoing DS3 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-3.
- 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, to verify the proper connection, we will make a short measurement run, by pressing [START/STOP].
- Press the [ERROR] Measure key to bring up that display category. Select the "BIT" Event, and the "ErrCnt=..." Analysis.

- Insert a single bit error by using the Error Insertion [Down Arrow] to select "BIT", and then pressing [SINGLE].
- If the loopback has been made correctly, the Bit Error Count will = 1.
- Press [START/STOP] to stop the measurement run.

8. - The loopback has now been verified.
- 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
Tx3->Rx3
```

9. - 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.

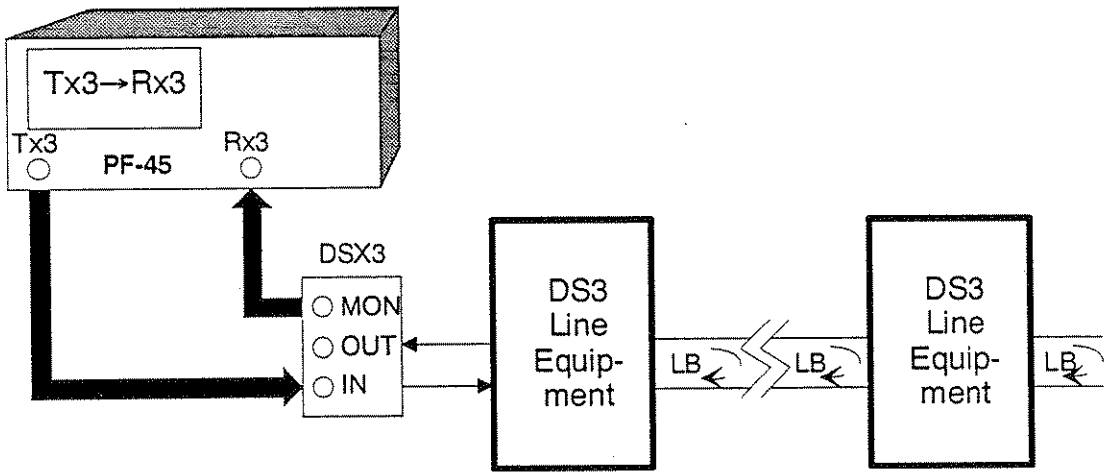


Figure 4-3: Tx3->Rx3 Mode

4.2.2 Out-Of-Service Testing of DS1

[Tx1->Rx1] mode (Fig 4-4), performs DS1 testing at DS1 line rate. The DS1 test patterns include QRSS for standard bit error testing, and digital words such as 1-in-8 and 3-in-24 for stress testing DS1 transmission equipment. The test object can be any portion of a network with DSX1 appearances, such as the CSU loopback test shown.

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

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "Tx1->Rx1" is in the lower left display quadrant as shown below.
   - "Execute" the mode change by pressing key [D] once.

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

3. - 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 [B] until Rx1:Term 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:B8ZS   Rx1:Term
Frm1:ESF    Clk1:Int
```
(DS1 Setup Page)

4. - Press the [Tx/Rx] SETUP key once again, to bring up the "Pattern" Page.
   - Press key [A] until the QRSS20 pattern is displayed. This is the most widely used "general-purpose" pattern for DS1, but a typical test sequence will also include a "stress-test" for the T1 line, usually "3-in-24" for AMI, and "1-in-8" for B8ZS systems.

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

5. - 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 5.
   - 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.

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)

6. - If an automatic Summary print at the end of the measurement run is not desired, then skip step 6, 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)

7. - The PF-45 is now setup. (For the sake of simplicity, the remainder of this section will deal with a looped-back DS1 out-of-service test). The loop-back must now be made and verified.
- Connect the PF-45 DS1 transmit jack [13] to the input jack of the outgoing DS1 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-4.
- Press the [ERROR] Measure key to bring up that display category. Select the "BIT" Event, and the "ErrCnt=..." Analysis.
- Use the Error Insertion [Down Arrow] to select "AUX".
- Press [VIEW], and use the Data Entry keys to select "CSU LpUp", then press [VIEW] a second time to complete the choice.
- Press [SINGLE] to send a six second burst of the in-band CSU Loop Up code.
- After the burst is over, the loop-back should be made, and must be verified.
- 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, otherwise try the loopback process again.
- Now to verify the loopback, make a short measurement run, by pressing [START/STOP].
- Insert a single bit error by using the Error Insertion [Down Arrow] to select "BIT", and then pressing [SINGLE].
- If the loopback has been made correctly, the Bit Error Count will = 1.
- Press [START/STOP] to stop the measurement run.

8. - The loopback has now been verified.
- 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
Tx1->Rx1
```

9. - 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.
- Remove the CSU loopback by selecting "CSU LpDn" under AUX, and sending a [SINGLE] six-second burst of the in-band loop-down code.

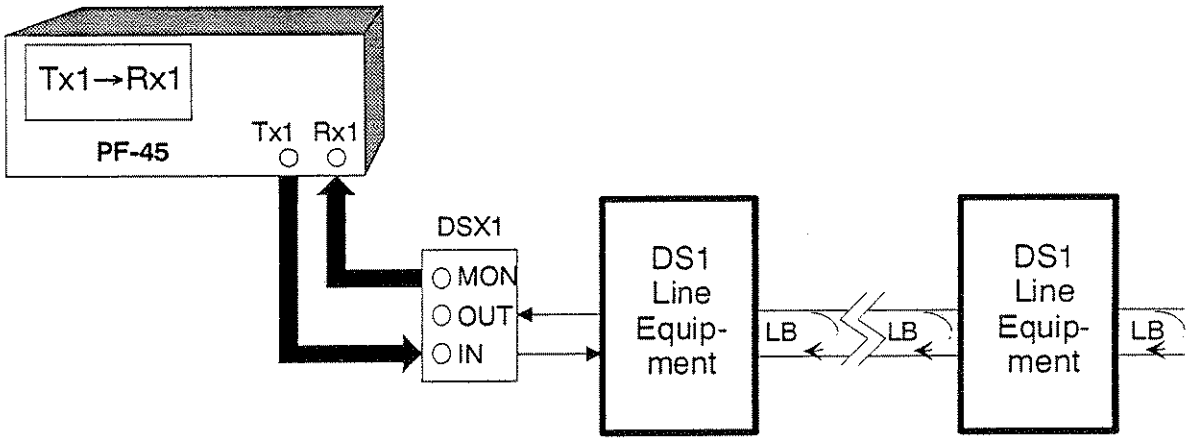


Figure 4-4: Tx1->Rx1 Mode

(The remaining modes are essentially DS1 test modes where the transmitted or receive DS1 test signal, or both, are embedded in a DS3 signal.)

4.2.3 Out-of-Service Testing of DS1 Embedded in DS3: M13 Multiplexer Testing

[Tx1->Rx^3_1] mode (Fig 4-5) shows the testing of an M13 mux, but can also be used to test any portion of a system which can input a DSX1 test signal, but can only provide the returning test signal embedded in a DS3. In this case the system under test may be an M13 mux, or simply perform that function.

1. - Connect the PF-45 DS3 receive jack [12] to the monitor jack of the incoming DS3 at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-5.

2. - Press the [Tx/Rx] SETUP key repeatedly until the "Set New Mode" Page is displayed.
   - Press key [C] until "Tx1->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
Tx1->Rx31    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 [B] until Rx3:DSX is displayed as shown below.
   - Press key [C] until the desired DS3 frame format is selected.

```
Tx3:DSX       Rx3:DSX
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 [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.
- Select the desired Rx 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.
- Connect the PF-45 DS1 transmit jack [13] to the desired DS1 input jack of the multiplexer at the DSX cross-connect panel with the appropriate cable, as shown in Figure 4-5.
- 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 proper connections have been made, 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 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
Tx1->Rx31:28
```

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.

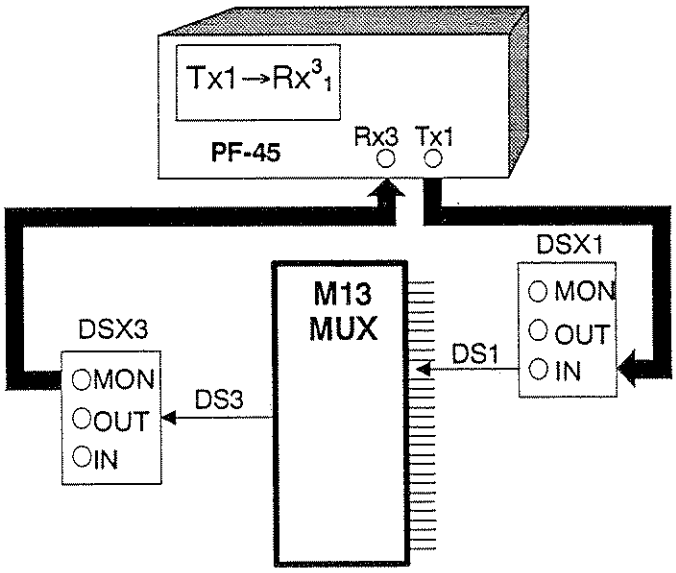


Figure 4-5: Tx1->Rx$^3_1$ Mode

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.

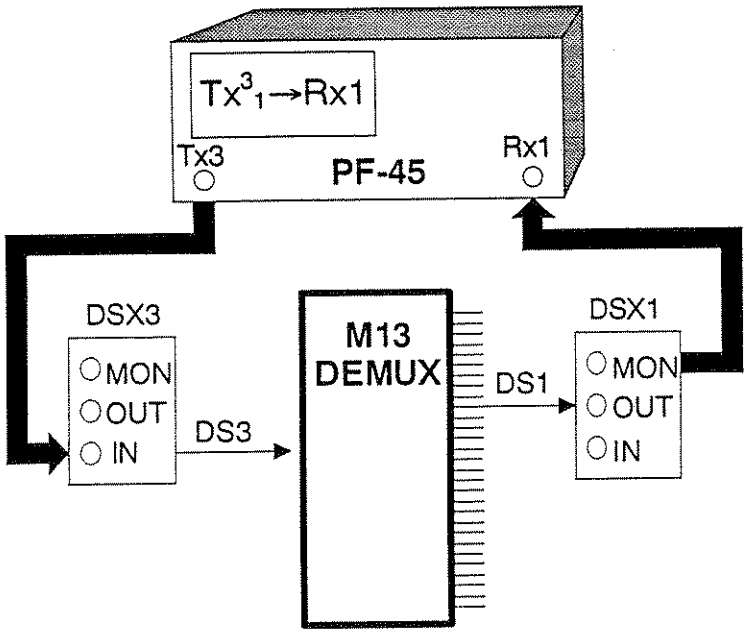


Figure 4-6: Tx^{3}_{1}->Rx1 Mode

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.

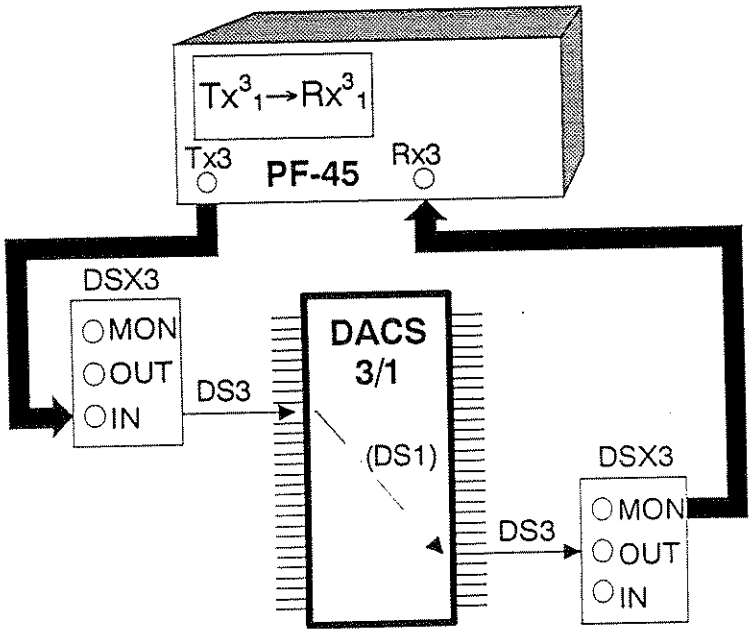


Figure 4-7: Tx^3_1->Rx^3_1 Mode

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.

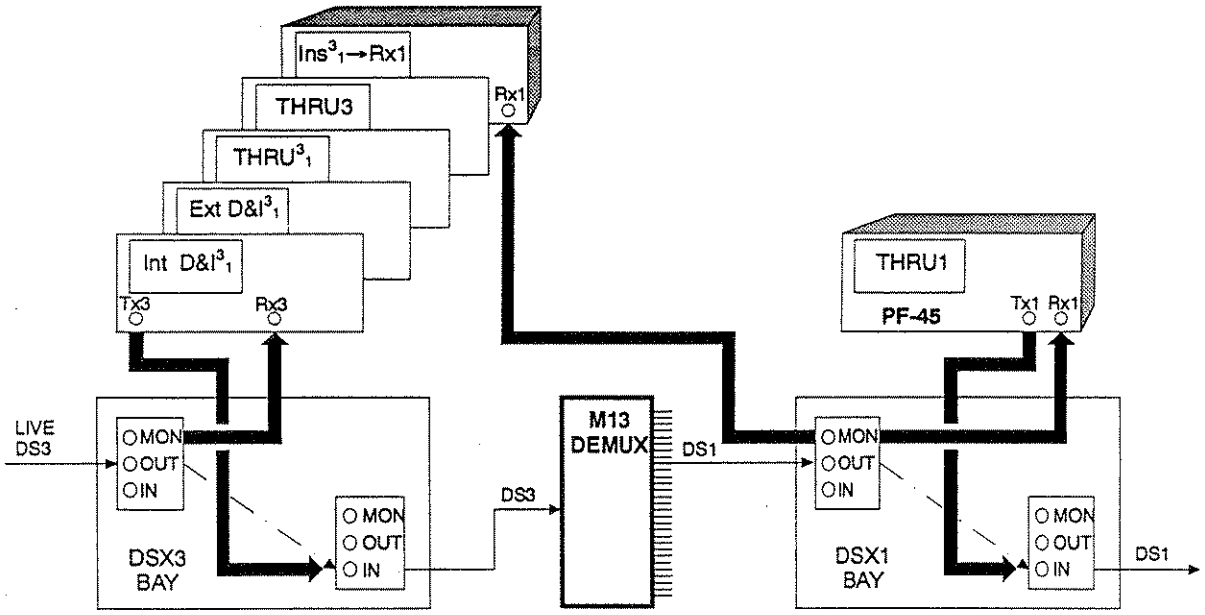


Figure 4-8: Drop & Insert/Thru Modes

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.

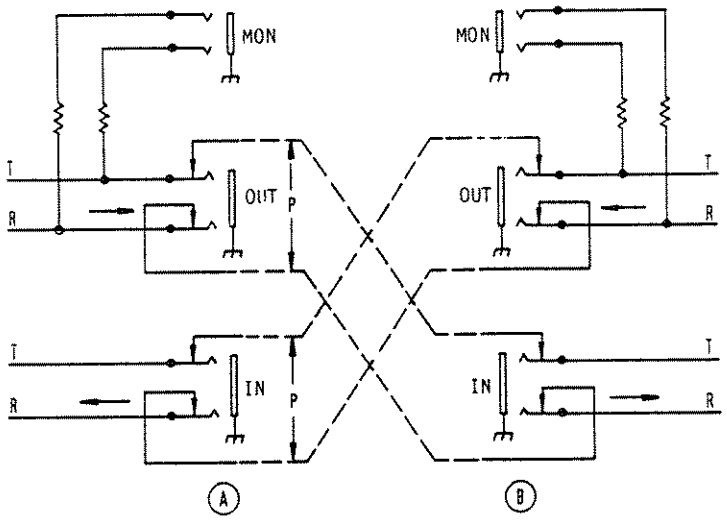


Figure 4-9: DSX Cross-Connect

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:

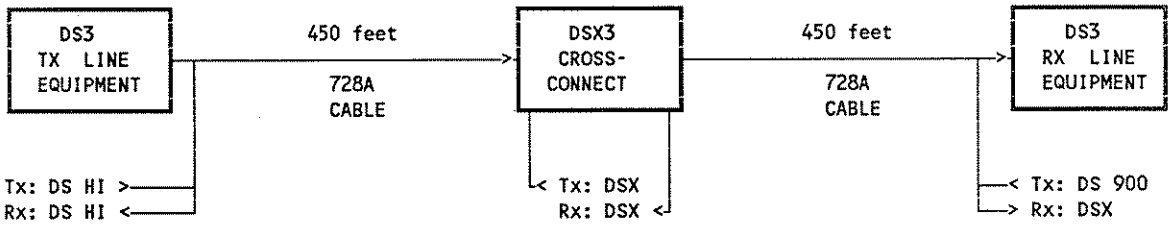


Figure 4-10: Typical DSX3 Architecture

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.

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.
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}
$\geq$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.

5.1 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          (Set New Mode Page)
Tx1->Rx1

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

Ptn:QRSS20            (Pattern Select Page)

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

[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= ".

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.

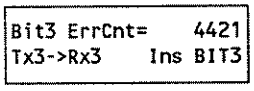
Result: Rx STATUS LEDs: DS3 NO SIGNAL, DS3 NO FRAME, and DS3 red Pattern Sync LEDs are extinguished, and the green DS3 Pattern Sync LED is lit.

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.

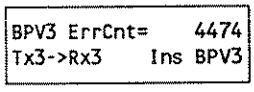
5. - Start measurement run by pressing [START/STOP] key [9].
   - Press the Error Insertion "down arrow" key [5] once to light the "BIT" LED.
   - Press [BURST] one time to insert one burst of pattern-bit errors.

   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.



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.



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.
   (continuous)
```

(Test Duration Page)

- 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)

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:

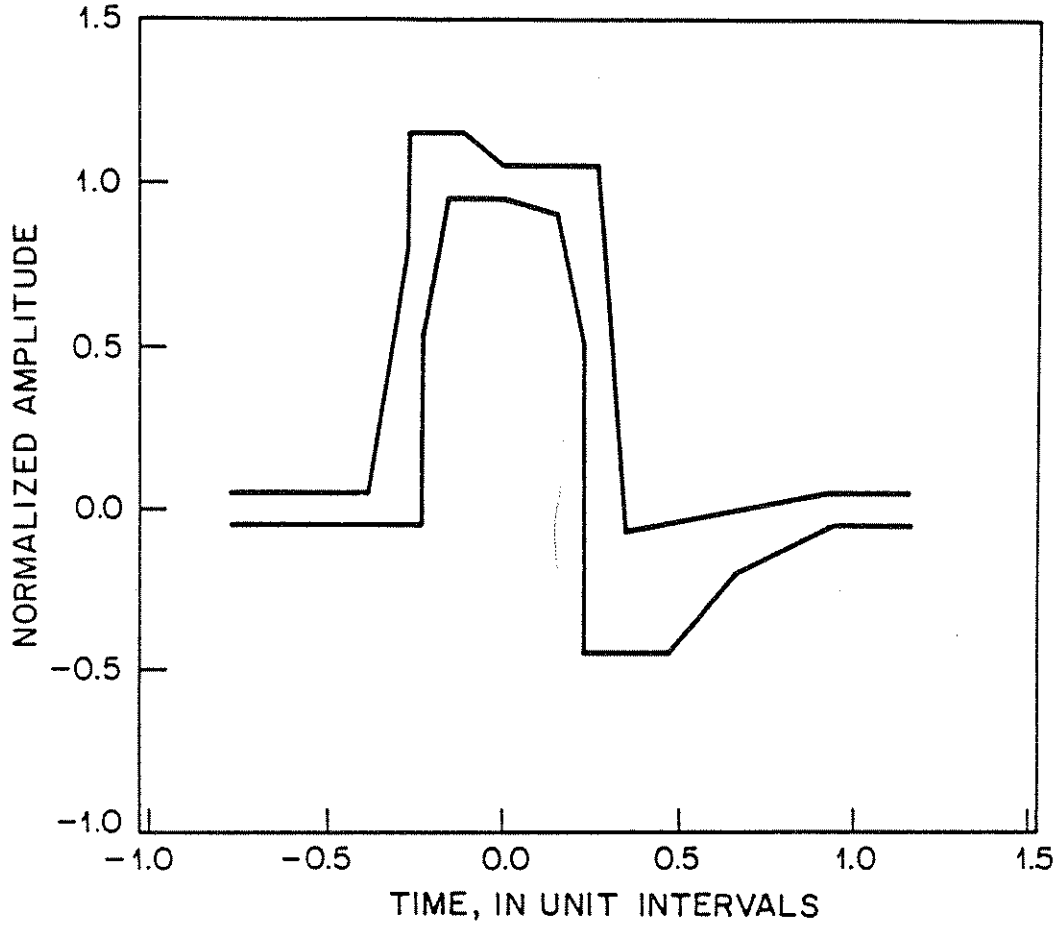
There should be < 0.5dB difference between the total power of the positive pulses and of the negative pulses.

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:

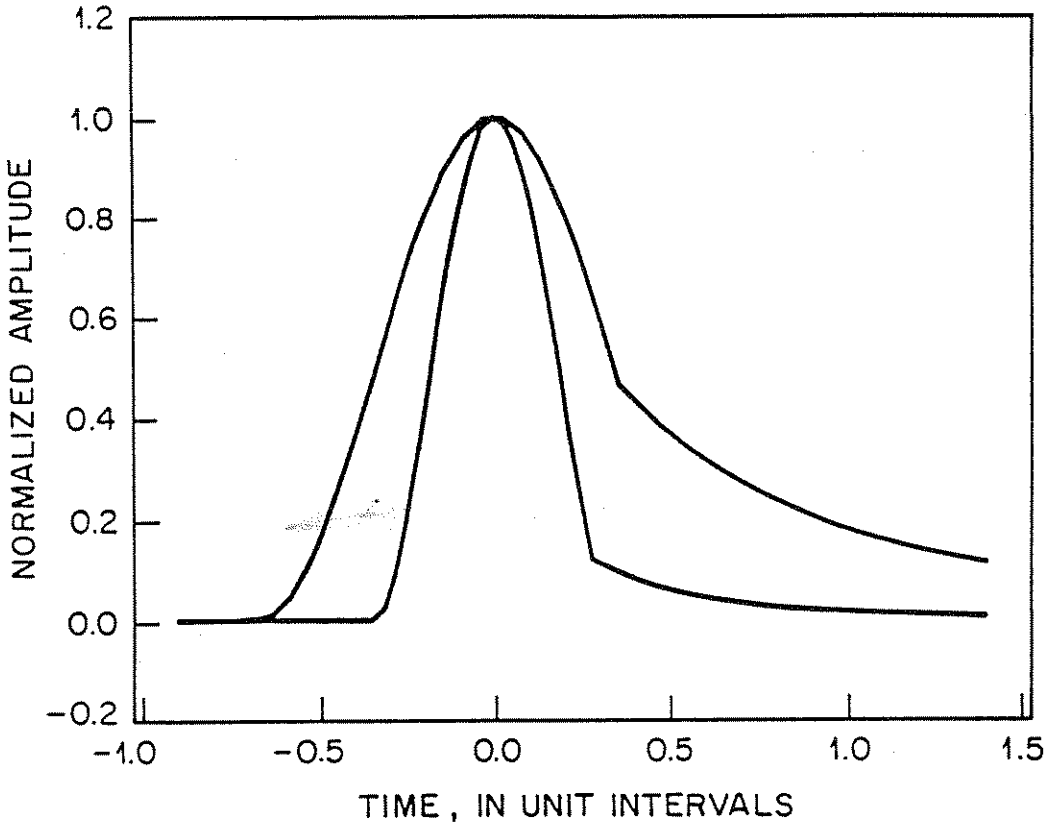
For an all ones pattern, the power in a band of $\leq$ 3kHz centered at 22.368MHz shall be between -1.8 and +5.7 dBm, and at 44.736MHz the power shall be at least 20 dB below that at 22.368MHz.

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.

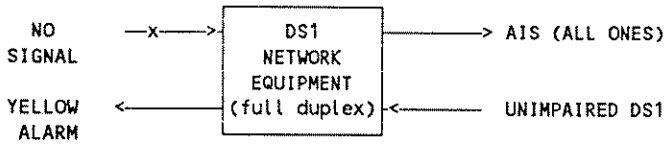
End-to-end error detection for ESF is provided via the CRC-6 cyclic redundancy check. During each superframe, the bitstream is processed to derive a six-bit checksum. This checksum is transmitted in the six C-bits in the following superframe. Identical processing takes place at the receiver, after which 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:

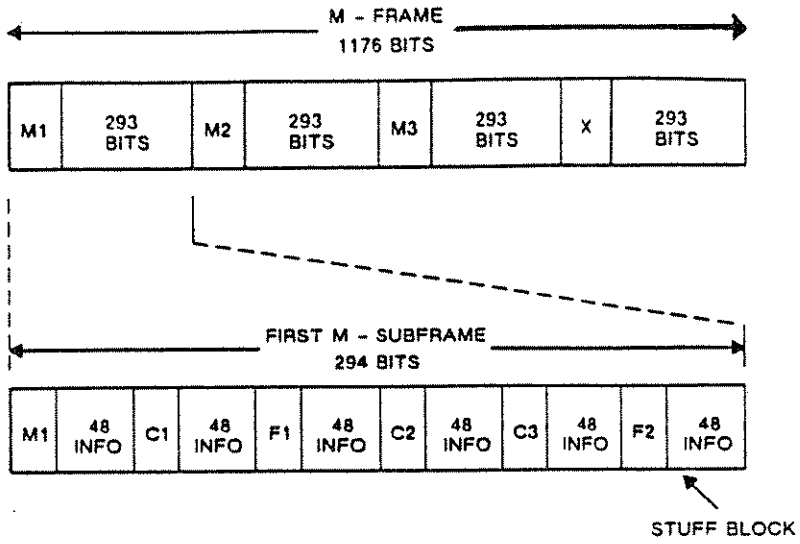


DS1 network equipment upon detection of a loss of signal, or a loss of synchronization on an incoming DS1 line, will declare a carrier failure alarm to the operating system and will insert alarms in both direction of transmission for the DS1. The figure above shows two DS1 lines that form one full-duplex 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:

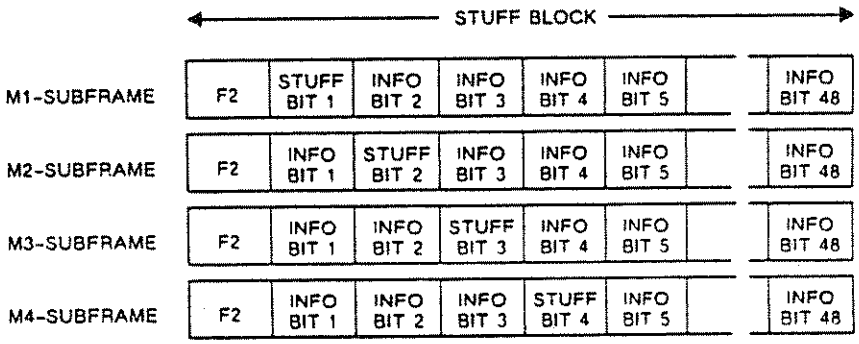
The DS2 6.312 Mbit/sec signal is formed by combining four DS1 signals, and adding control bits. The four DS1's are bit-interleaved, with the 2nd and 4th DS1's inverted. A control bit is inserted between every block of 48 bits (12 bits from each DS1). The position of all control bits is marked by the 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.



M - FRAME OVERHEAD BIT SEQUENCE
24 OVERHEAD BITS OCCUPIES SEQUENTIAL OVERHEAD BIT POSITIONS AS FOLLOWS:

M1,	C1,	F1,	C2,	C3,	F2,
M2,	C1,	F1,	C2,	C3,	F2,
M3,	C1,	F1,	C2,	C3,	F2,
X,	C1,	F1,	C2,	C3,	F2,



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.

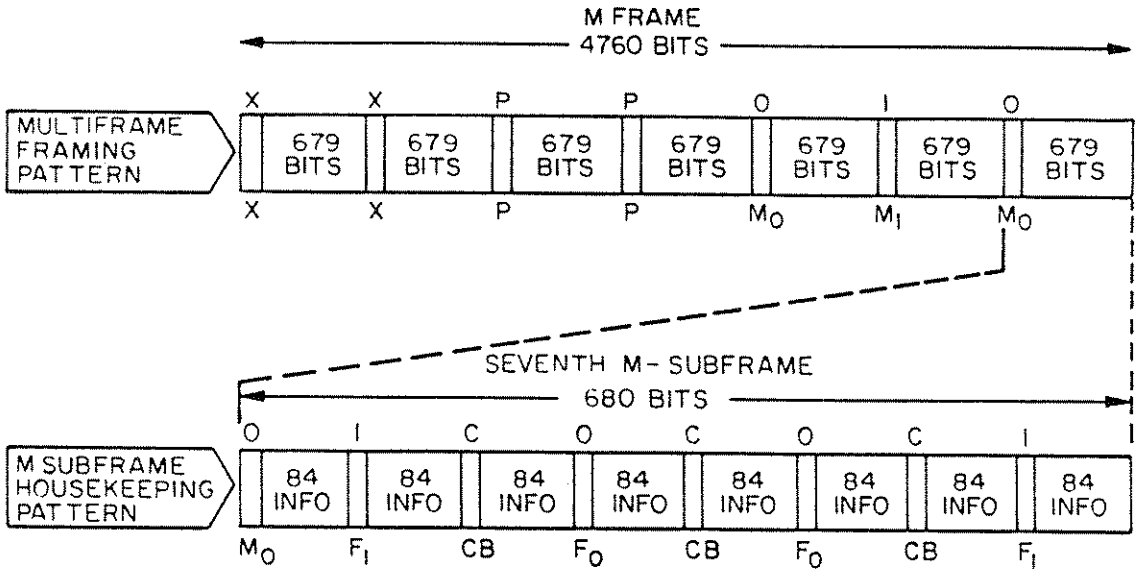
Unlike M13 format, which uses two levels of dynamic stuffing to multiplex DS1 to DS3, C-Parity format uses one level of dynamic stuffing (from DS1 to a non-standard DS2) and one level of fixed stuffing (from the non-standard DS2 to DS3). In the first step, four 1.544 Mbit/s channels are multiplexed together 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.

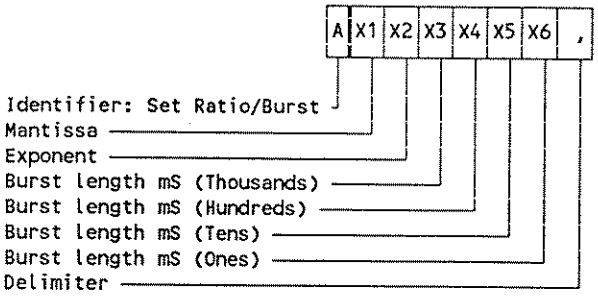
Sending a syntactically-correct string at the wrong time, such as asking for DS3 Frame Errors in MON1 mode is recognizable by the PF-45, but cannot be performed. This will cause an Execution Error in the STATUS byte, and will load "Execution Error" in the IEEE-488 output buffer. For RS-232, "Execution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



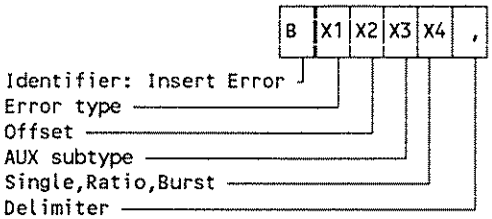
Mantissa (Ratio)	X1: 1,2 or
Exponent (Ratio)	X2: (-)2...9
Burst Length	X3 X4 X5 X6: 0001 ... 6000 (mS)

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
```

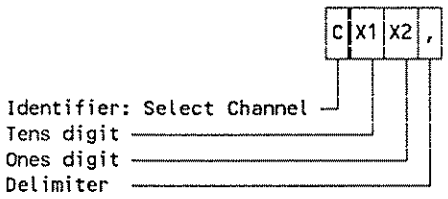
"---" means value of character is disregarded (don't care).

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,".)

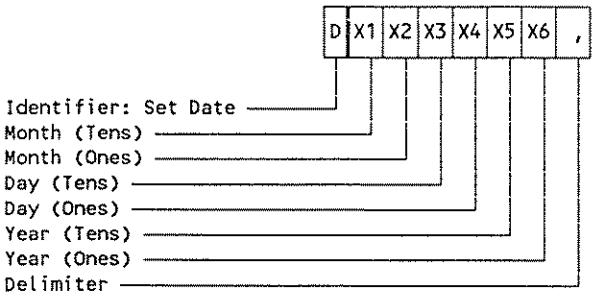


X1 X2 = 00 through 28

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

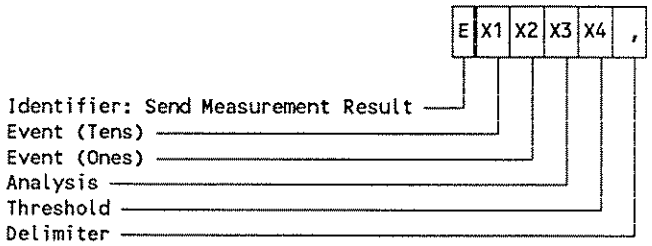


X1 X2: 01 - 12
X3 X4: 01 - 31
X5 X6: 00 - 99

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.



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

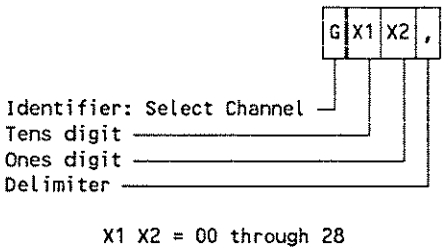
* If X1 X2 = 07 (CRC), and X3 = 6 (Threshold ErrSec), "SES" is by default the selected measurement, and the value of X4 is "don't care".

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,".)



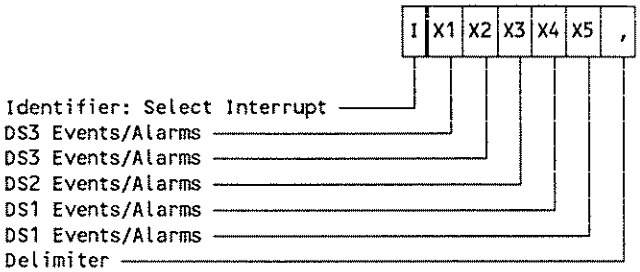
X1 X2 = 00 through 28

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).



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

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

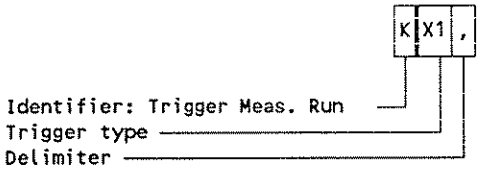
X4	DS1 Yel / E1 R-Alarm	DS1 AIS / E1 AIS	DS1 No Frame / E1 No Frame	DS1 No Signal / E1 No Signal
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
:	1	0	1	0
;	1	0	1	1
<	1	1	0	0
=	1	1	0	1
>	1	1	1	0
?	1	1	1	1

X5	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

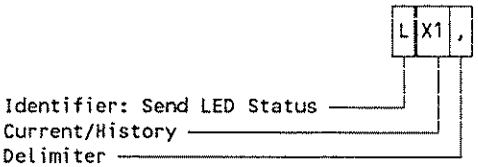
The three trigger commands perform the same function in remote mode as the START/STOP key.



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



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 / DS2E No 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

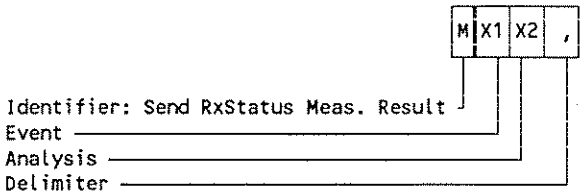
X5	DS1/E1 * Status=E1	DS1 Ptn Sync Loss	DS1 Excess Zeros
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0

* 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.



Event X1:

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

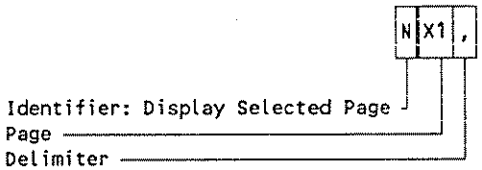
Analysis X2:

			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



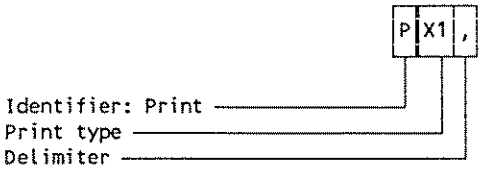
X1:
0 = Set New Mode Page
1 = DS3 Setup Page
2 = DS1 Setup Page
3 = Pattern Select Page
4 = AUX Error Insert Select Page
5 = Test Duration Setup Page
6 = Real-Time Clock and Date Setup Page
7 = Printer Setup Page
8 = Measure Errors Page
9 = Measure RxSTATUS Page

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

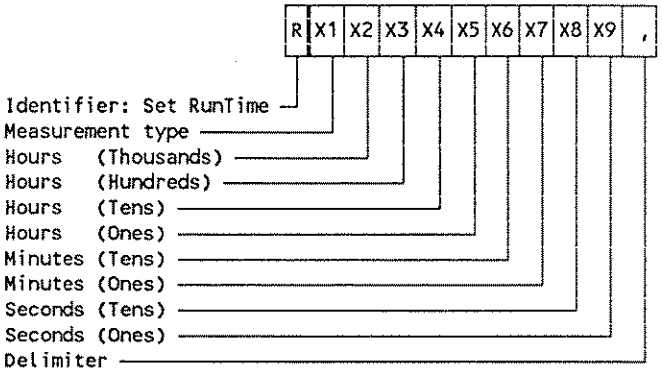
The two Print commands each ask for a "Manual Print", but to different destinations.



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



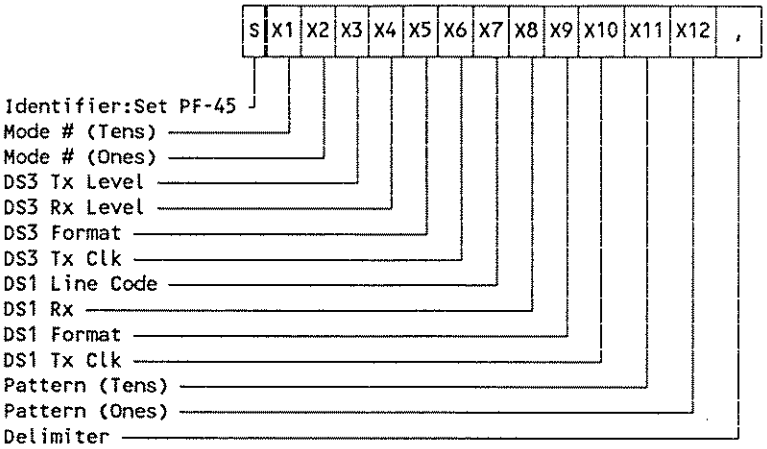
Measurement X1:	0 = Timed
	1 = Continuous
Hours X2 X3 X4 X5:	0000 - 1000
Minutes X6 X7:	00 - 59
Seconds X8 X9:	00 - 59

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

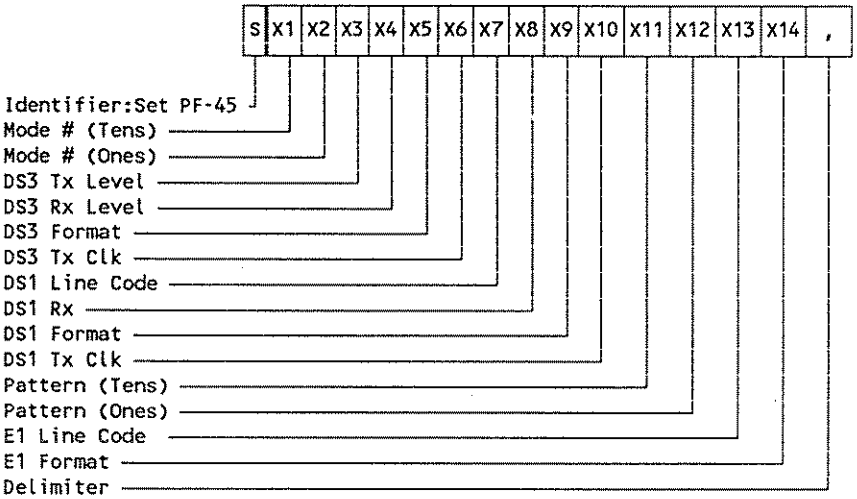
10 OUTPUT 701;"R000013000," !This sets up a Timed Measurement Run of 1 hour 30 minutes.

[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

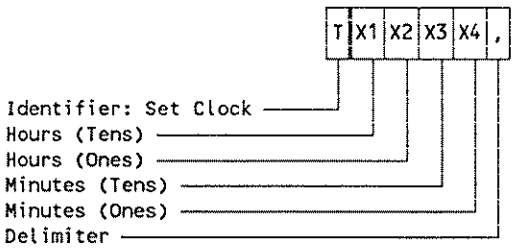
DS1 Rx X8: 0 = Rx1 Term
1 = Rx1 Brdg
2 = Rx1 NRZ Up
3 = Rx1 NRZ Down

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
```

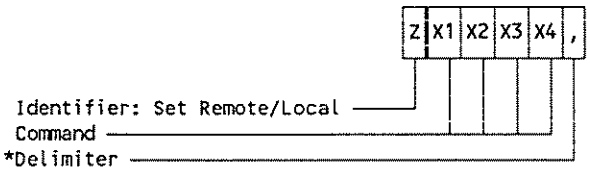
Sample IEEE command (HP-BASIC for HP-85):

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

B.4.2 RS-232 Command Extensions

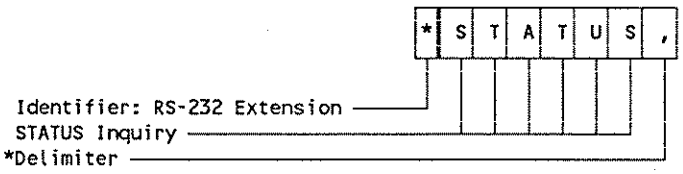
The following command extensions allow the RS-232 user to access interface functions normally only available via GPIB/IEEE-488.

[Z] Remote/Local String



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

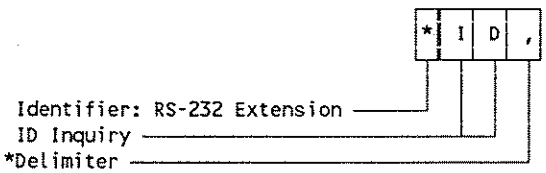
[*STATUS] String



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

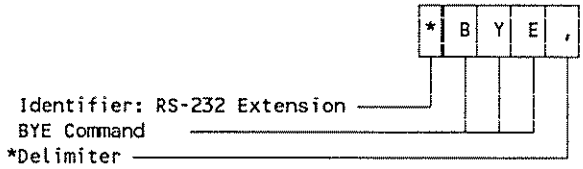


Sending this command forces the instrument to send an identifier message. Syntax as follows:

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

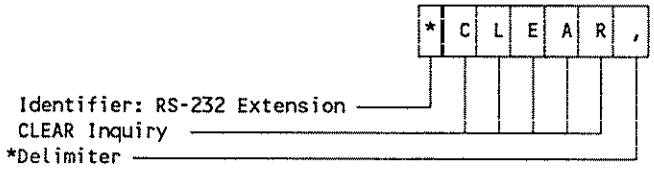
*Note: Delimiter may also be CR/LF.

[*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