PAIRGAIN TECHNOLOGIES
Technical Practice
Engineering - PLANT Series

Section 150-231-174
Revision 02
August 5, 1996

PAIRGAIN™ TECHNOLOGIES HIGAIN™ LINE UNIT
MODEL HLU-231
List 7D, PairGain #150-1111-74, CLEI Code: T1LI4144AA

Figure 1. HLU-231, List 7D Front Panel. The PairGain HLU-231 is the local unit used in conjunction with the HRU-412 remote unit to provide a complete HiGain HDSL system.

CAUTION
This product incorporates static sensitive components. Proper electrostatic discharge procedures must be followed.

A. GENERAL

1. INTRODUCTION

1.01 The PairGain HiGain Line Unit Model HLU-231 Issue 1, List 7D (Figure 1), is the Central Office (CO) side of a repeater-less T1 transmission system. When used in conjunction with a HiGain Remote Unit Model HRU-412, the system provides 1.544 Mbps transmission on two unconditioned copper pairs over the full Carrier Serving Area (CSA) range. The "D" designation in the list number indicates that this line unit can be used in applications with or without the HiGain Doubler Unit (HDU-451). The CSA includes loops up to 12000 feet of AWG 24 or 9000 feet of AWG 26 wire, including bridged taps. The HiGain system uses HDSL (High-bit-rate Digital Subscriber Line) transmission technology as recommended by Bellcore TA-TSY-001210. The HiGain system complies with TR-TSY-000063 (Network Equipment Building System (NEBS) Generic Equipment requirements) and TR-TSY-000499 (Transport System Generic Requirements - TSGR) common requirements.

1.02 Revision History of this practice.

Revision 02—**August 5, 1996**

a) Corrected CLEI Code number.

b) Added 3 Span Line powering information.

c) Added paragraph 8.04.

d) Added reference to the HDU 437/439 "mini" doubler in Section C.

1.03 HLU-231, List 7D features:

- Selectable DSX-1 Pre-equalizer
- -130 V to -200 V self-adjusting line voltage for HRU-412 and HDU-451 applications
- Front Panel HDSL S/N Margin Display
- Selectable Loopback activation codes
- RS-232 maintenance port
- Front-panel user option setup
- Front Panel DS1 splitting & bridging access
- Lightning and power cross protection on HDSL interfaces
- 784 kbps full-duplex 2B1Q HDSL Transmission on two pairs
- Front panel status indicating LED
- Automatic front-panel display blanking
- Margin threshold alarm
- HAIS & SAIS options
- Easy default setting of user options
- New T1 transceiver chip
- Circuit ID option
- Network management ready
- Single board design

- HDSL Unipolar (0, -200V), Bipolar (±100V) switch
- Can line power 3 spans (2 doublers and 1 remote).

2. APPLICATIONS

2.01 The HiGain system provides a cost-effective, easy to deploy method for delivering T1 High Capacity Digital Service (HCDS) over metallic pairs. The fiber-like quality service is deployed over two unconditioned, non-loaded copper pairs. Conventional in-line T1 repeaters are not required. Cable pair conditioning, pair separation and bridged tap removal, are not required.

2.02 The general guidelines require that each loop have less than 35 dB of loss at 196 kHz, with 135 ohms driving and terminating impedances. Table 1 (below) provides a guide for the loss of various cable gauges at 196 kHz and 135 ohms. The table applies to the HDSL cable pairs between the HLU, HRU and HDU modules. Without specific insertion loss measurement data, add 3 dB for each bridged tap and 1 dB for each cable gauge change.

TABLE 1. HDSL LOSS OVER CABLES

Cable Gauge	Loss at 196 kHz (db/kft)	Ohms per kft
26/0.4mm	3.88	83
24/0.51mm	2.84	52
22/0.61mm	2.18	32
19/0.91mm	1.54	16

2.03 The HiGain system operates with any number of other T1, POTS, Digital Data Service (DDS) or other HiGain systems sharing the same cable binder group. HiGain systems can be used with customers requiring DS1 service on a temporary or permanent basis. The HiGain system also provides a means of quickly deploying service in advance of fiber-optic transmission systems. With the HiGain system, service can be provided within hours. Fiber optic systems can be installed at a leisurely pace and cut-over from the installed HiGain system when convenient to do so. The installed HiGain system can then be easily removed and utilized elsewhere.

3. FUNCTIONAL OPERATION

3.01 The HiGain system uses PairGain 2-Bit 1-Quartenary (2B1Q) HDSL transceiver systems to establish two full-duplex 784 kbps data channels between the HLU-231 List 7D and a remotely mounted HRU-412 HiGain Remote Unit. This provides a total capacity of 1.568 Mbps between the two units.

3.02 A block diagram of the HLU-231 List 7D is shown in Figure 2. The HiGain HLU-231 List 7D receives a 1.544 Mbps DS1 data stream from the DSX-1 digital cross connect interface. The HLU-231 List 7D contains a DS1 frame synchronizer controlled by an 8-bit microprocessor that determines the type of framing on the DS1 stream and synchronizes to it. The HLU-231 List 7D recognizes Super Frame (SF) (including D4) or Extended Super Frame (ESF) framing. When the data is unframed, the HLU-231 List 7D arbitrarily defines a frame bit.

3.03 The HLU-231 List 7D contains a demultiplexer that generates two parallel 784 kbps data streams. The data streams contain HDSL frames that are nominally 4704 bits (6 milliseconds) in length. The HDSL frames contain a 14 bit Frame Sync Word (FSW), 6 bit Cyclic Redundancy Check (CRC), 21 bit operations channel and DS1 payload. The DS1 stream is separated into two parallel streams that comprise the payloads of the HDSL channels. The HLU-231, List 7D, allocates the DSO time slots according to the version of HRU-412 to which it is connected. Older version HRUs require the odd DSO time slots allocated to channel 1 and the even DSO time slots to channel 2. Newer versions allocated DSO time slots 1 through 12 to channel 1, and time slots 13 through 24 to channel 2. The 8 kbps frame bits of the DS1 stream are included on both HDSL channels. The two formatted HDSL channels are passed to the HDSL transceivers which convert them to 2B1Q format on the HDSL lines. The 2B1Q line code is designed to operate in a full-duplex mode on unconditioned pairs. The transceiver echo canceler and adaptive equalizer receive the signal from the remote end in the presence of impairments and noise on the copper pairs.

3.04 The received HDSL channels are processed by the transceiver and then passed on to the HLU-231 List 7D multiplexer module. The multiplexer provides frame synchronization for each of the two HDSL channels. The multiplexer and HDSL transceivers work under control of the HLU-231 List 7D microprocessor and compensate for data inversions caused by tip-ring reversals and for channel swaps caused by pair reversals. The HiGain system allows for tip-ring or pair reversals, but does not tolerate split pairs. By synchronizing to the Frame Sync Word (FSW) of

each channel, the multiplexer can reconstruct the original 1.544 Mbps DS1 stream from the payloads of the two HDSL channels. The CRC fields on the HDSL streams allow the HLU-231 List 7D to determine if errors are present on the channel due to excessive impairments on the HDSL pairs, or due to excessive impulse or crosstalk noise.

3.05 The multiplexer removes data link messages from the HDSL channels and passes them to the microprocessor. This mechanism allows operations messages and status to be exchanged between the HLU-231 List 7D and the HRU-412 remote unit.

3.06 The reconstructed HDSL data channel is buffered in a first-in-first-out buffer (FIFO) within the multiplexer. A frequency synthesizer in conjunction with the FIFO regulates the output bit rate and reconstructs the DS1 clock at the exact rate received from the remote end. The HiGain system operates at DS1 rates of 1.544 Mbps with up to ±200 bps of offset.

3.07 A DSX-1 interface driver converts the DS1 channel to an Alternate Mark Inversion (AMI) or Binary Eight Zero Substitution (B8ZS) format. The DSX-1 equalizer is programmable to five different lengths as determined by the distance between the HLU-231 List 7D and the DSX-1 interface. This provides CB-119 specification-compliant pulses at the DSX-1 interface over a range of 0-655 feet of ABAM-specification cable.

3.08 The HLU-231 List 7D contains two separate power converters. The main power supply converts -48 VDC local battery to logic power for the HLU-231 List 7D circuits. The line power supply converts the -48 VDC battery to an HDSL variable power supply that provides simplex power feed on the two HDSL cable loops. The output voltage adjusts itself as a function of the demands made on it by short loops without doublers (low voltage) or long loops with doublers (high voltage). The line power supply can be turned on or off by the microprocessor and is automatically shut down in the presence of line short circuits or microprocessor failure. A user switch option S2 allows the line voltage to be set to a unipolar (0,-V) or a bipolar (±V/2) mode.

3.09 A female 9-pin (RS-232) DB-9), is provided on the front panel connector (see Figure 3). This connector provides asynchronous access to the HiGain system maintenance, provisioning and performance monitoring firmware. The port is configured as DCE with 8 data bits, 1 stop bit and no parity. Operator interaction with the firmware is via an ASCII terminal or a Personal Computer with asynchronous communication software. Striking the SPACE bar several times enables the HLU-231 List 7D to automatically match the terminal line baud rate, from 1200 to 9600 baud. Figure 7 through Figure

14 show the menu selections available from the terminal for non-Doubler applications, and Figure 16 through Figure 34 show the menu selections available from the terminal for Doubler applications.

Table 9 defines the various terms used in the non-Doubler System Status Screen, and Table 18 defines the same terms for the Doubler System Status Screens.
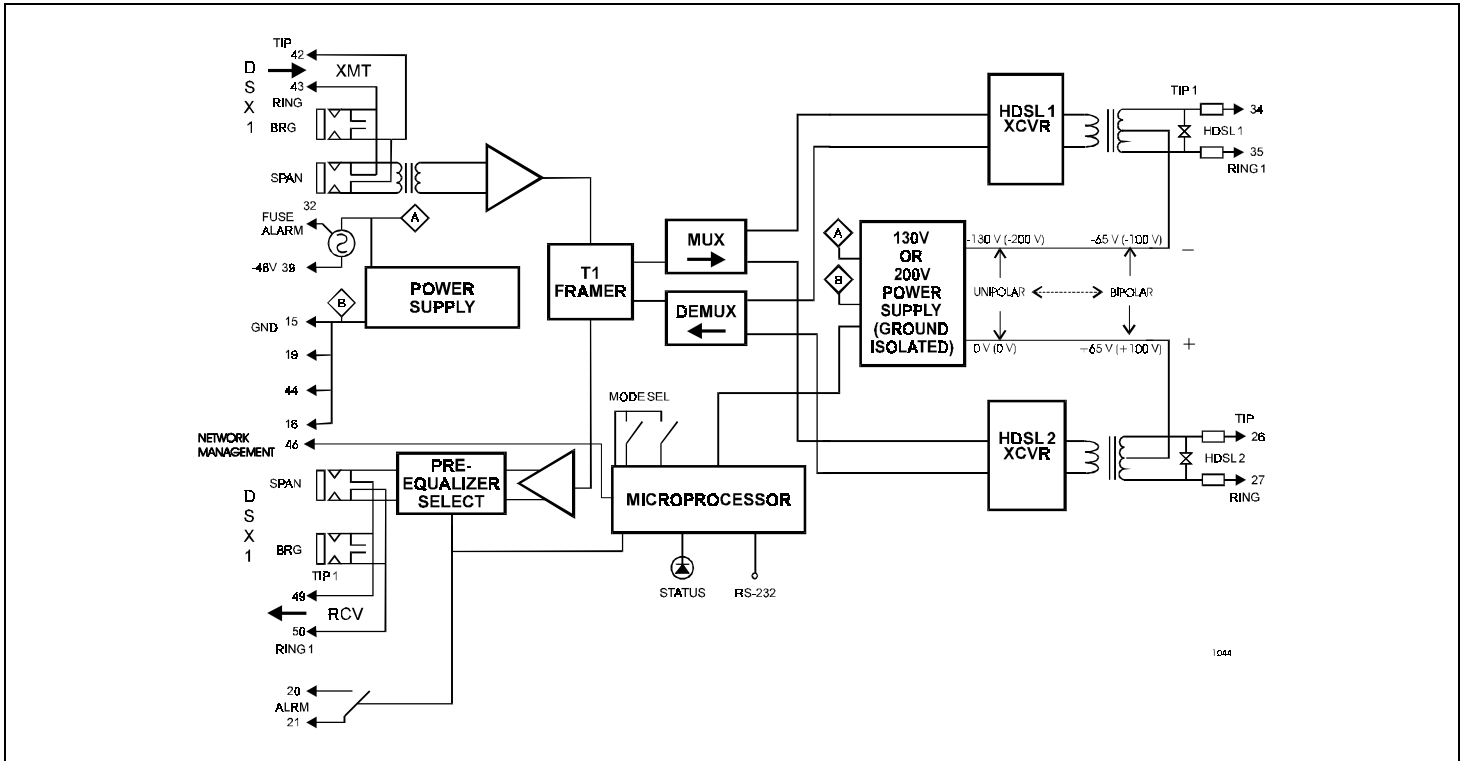
Figure 2. HLU-231, List 7D Block Diagram. PairGain's HDSL technology provides full-duplex services at standard T-1 rates over copper wires between an HLU and an HRU, which comprise one HiGain system.
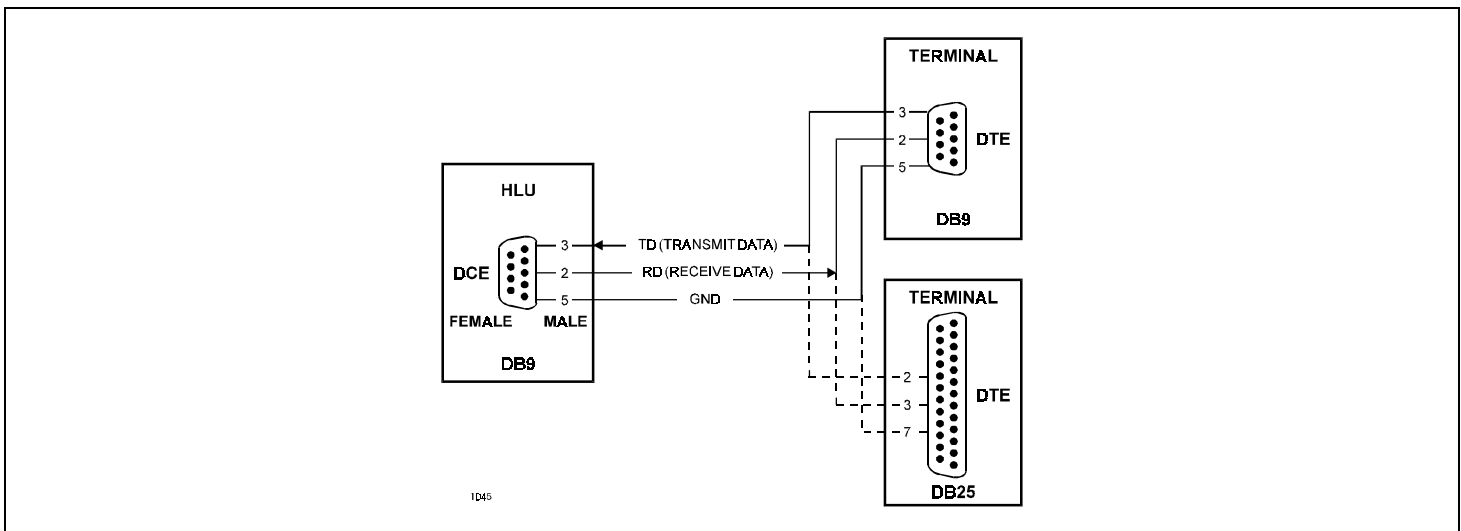
Figure 3. DB-9 RS-232 I/O Pin-Outs. A standard RS-232 (DB-9, female) connector on the front panel provides access to the menu interface feature via a dumb terminal.

4. ALARMS

4.01   The normally open alarm contacts available across pins 20 & 21 (Figure 4) comprise the HLU-231 List 7D Minor Alarm output. These alarm contacts close for any of the alarm conditions listed below. Since more than one alarm condition can exist at any given time but only one message can be displayed, the alarms are listed as follows in their order of priorities. Only the highest priority alarm is displayed if more than one alarm condition exists. The ALRM message precedes every specific alarm condition display.

1)   **ALRM LOSW:** Either HDSL loop loses sync.

2)   **ALRM LLOS:** Loss of the HLU-231 List 7D DS1 input signal.

3)   **ALRM RLOS:** Loss of HRU-412 DS1 input signal.

4)   **ALRM TLOS:** The DS1 input to a List 6 or 7 HRU-412, whose TLOS switch option has been enabled, is not present (LOS).

5)   **ALRM H1(2)ES:** HDSL Loop 1 or Loop 2 has exceeded the 24 hour user-selected Errored-Seconds Cyclic Redundancy Check (CRC) threshold.

6)   **ALRM DS1:** The total number of Bipolar Violations (BPV) at the HLU-231 List 7D or HRU-412 T1 inputs have exceeded the 24-hour user-selected threshold.

7)   **ALRM MAL 1 (2):** The margin on HDSL Loop 1 or Loop 2 has dropped below the minimum threshold value set by the terminal MARGIN ALARM THRES; as described in Section 5.

Figure 4. HLU-231, Card-Edge Connectors. The active pins are highlighted in black in the above illustration.

4.02   The HLU-231 List 7D STATUS LED flashes RED for the duration of a minor alarm condition. Alarms 5 & 6 can be inhibited by selecting NONE for the Errored Seconds Alarm (ESAL) system option. See Section B Paragraph 5, and Section C Paragraph 5 for System Settings information. The MAL1(2) alarm can be disabled by setting the margin alarm threshold to 0. A Minor Alarm can be retired by executing the Alarm Cut Off (ACO) option. This is accomplished by pressing the **SEL** button on the front panel. This turns the alarm off and replaces the "ALRM" message with the "ACO" message. The second part of the "ALRM" message, which defines the cause of the alarm, remains. Both messages remain until the alarm condition clears or another alarm occurs.

4.03   Note that when both HDSL loops lose sync word (LOSW), a minor alarm condition exists but because the HLU-231 List 7D enters a self test cycling mode, the front panel LED lights yellow instead of red and the "SELF TEST" message is displayed instead of the "ALRM" message.

4.04   Setting the ALM option to DIS only prevents the alarm relay from operating on a minor alarm event. The STATUS LED still flashes red and the "ALRM" message is still displayed.

4.05   Pin 32, FUSEALARM, is driven to -48 V through a 1000 ohm resistor and the front panel STATUS LED turns red whenever the on board fuse opens.

4.06   The HLU-231 List 7D front panel tri-color STATUS LED has the following states:

- GREEN - Normal Operation.

- FLASHING GREEN - HDSL Acquisition.

- FLASHING RED - Minor Alarm (For conditions see Paragraph 4.02).

- RED - FUSEALRM.

- YELLOW - Self Test in process or an HLU-231 List 7D loopback in effect (CREM) or (NLOC) (Sections B Paragraph 3, and Section C Paragraph 3).

- FLASHING YELLOW - The HLU-231 List 7D is in an ARMED state.

5. OPTIONS

5.01   The HLU-231 List 7D contains a non-volatile RAM (NVRAM) which stores the system option settings. No dip-switches or jumpers are required to configure the HLU-231 List 7D. The options are set via push-buttons on the front panel, or through the RS-232 interface. They are retained if shelf power is lost or if the HLU-231 List 7D is unplugged. Table 2 lists the HLU-231 List 7D option settings. Figure 9 and Figure 21 illustrate the same options on the HLU-231 List 7D non-Doubler and Doubler System Settings Menu Screens, respectively. In the System Settings menu (which is identical for both non-Doubler and Doubler applications) the settings shown represent the factory default settings.

5.02   The SETUP (**MODE** and **SEL**) momentary push-buttons are used to set the options from the HLU-231 List 7D Front Panel. To initiate the OPTION SETTING mode, press the **MODE** button at least for one second, but less than three seconds, and release. The message displayed on the front panel alternates between the first system parameter and its current setting. Pressing the **SEL** button steps the display through all possible settings (one at a time) of the parameter being displayed. After the desired setting has been selected, press the **MODE** button. This updates the current displayed mode to the setting selected, then selects the next configurable parameter. After the last parameter has been selected, the display shows "CONF NO" (Confirm? (Yes/No)). If the **MODE** button is now pressed, none of the changed parameters are installed. If the **SEL** button is pressed, a "YES" message is displayed and the selected changes are installed. In either case the display returns to its normal mode. The display also returns to its normal mode, without installing any new changes, if neither button is pressed for 30 seconds.

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TABLE 2. HLU-231 LIST 7D SYSTEM OPTIONS

Mode	Selection	Description
EQL	EXT*	Replaces the internal equalizer with a 12 V_{pk-pk} drive source for an external equalizer.
	0	Sets the Equalizer to DSX-1 for 0-133 feet.
	133	Sets the Equalizer to DSX-1 for 133-266 feet.
	266	Sets the Equalizer to DSX-1 for 266-399 feet.
	399	Sets the Equalizer to DSX-1 for 399-533 feet.
	533	Sets the Equalizer to DSX-1 for 533-655 feet.
LBPK	DIS	Configures the HiGain system to ignore all in-band Smart-Jack loopback commands.
	ENA*	Enables the HiGain system to recognize all in-band Smart-Jack loopback commands.
SPLB	GNLB*	Configures the HiGain system to respond to the generic (3/4 in 7) in-band loopback codes.
	A1LB & A2LB	Configures the HiGain system to respond to the Teltrend addressable repeater in-band loopback codes.
	A3LB	Configures the HiGain system to respond to the Wescom addressable repeater in-band loopback codes.
	A4LB	Configures the HiGain system to respond to the Wescom Mod 1 addressable repeater in-band loopback codes.
	A5LB	Configures the HiGain system to respond to the Teltrend Mod 1 addressable repeater in-band loopback codes.
PWRF	DIS	Disables powering to the HRU-412.
	ENA*	Enables powering to the HRU-412.
ZBTS	ON	Tells the HiGain system that the ESF frame is operating in its Zero Byte Time Slot Interface (ZBTSI) mode.
	OFF*	Tells the HiGain system that the ESF frame is operating in its normal non-ZBTSI mode.
ESAL	17	Activates (closes) the minor alarm relay contacts on pins 20 & 21 and flashes the red STATUS LED when 17 Errored Seconds (ES) (17 HDSL cyclic redundancy check (CRC) errors on either HDSL loop or a total of 17 BPVs) occur within a 24-hour period.
	170	Activates (closes) the minor alarm relay contacts on pins 20 & 21 and flashes the red STATUS LED when 170 ES (170 HDSL CRC errors on either HDSL loop or a total of 170 BPVs) occur within a 24-hour period.
	NONE*	Prevents generation of a minor alarm due to excessive Errored Seconds.
LBTO	NONE	Disables automatic time-out cancellation of all loopbacks.
	20	Sets automatic cancellation of all loopbacks to 20 minutes after initiation.
	60*	Sets automatic cancellation of all loopbacks to 60 minutes after initiation.
	120	Sets automatic cancellation of all loopbacks to 120 minutes after initiation.

Table continued on next page

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TABLE 2. HLU-231 LIST 7D SYSTEM OPTIONS (CONTINUED)

Mode	Selection	Description
ALM	DIS*	Opens the minor alarm relay contacts if closed, and disables activation of the minor alarm relay when a minor alarm condition occurs.
	ENA	Enables activation of the minor alarm relay when a minor alarm condition occurs.
DS1	AUTO	The HLU-231 List 7D & HRU-412 independently monitor their incoming DS1 bit streams for the Binary Eight Zero Substitution (B8ZS) pattern. If either unit detects this pattern, it enters its B8ZS mode. It reverts back to its Alternate Mark Inversion (AMI) mode if no B8ZS patterns are received for five seconds.
	B8ZS	Places both the HLU-231 List 7D & HRU-412 into their B8ZS modes.
	AMI*	Places both the HLU-231 List 7D & HRU-412 into their AMI modes.
FRMG	AUTO*	Configures the HiGain system to operate in an auto-framing (AUTO) mode in which it continuously searches the input T1 bit stream for a valid SF or ESF frame pattern. This feature is required for fractional T1 applications (DS0 blocking) where it insures proper channel time slot alignment. While the HiGain system can also process unframed data in this AUTO mode, it is recommended that the unframed (UNFR) mode be used for all unframed applications. Using the AUTO mode for unframed applications runs the risk of detecting "pseudo-valid" frame sequences, which can affect the data integrity.
	UNFR	Configures the HiGain system to operate in an unframed mode. This mode disables the auto framing process and forces the HiGain system to function as a transparent bit pipe.
HAIS	2LP*	Causes the HiGain system to transmit the AIS signal at both the HLU-231 List 7D & HRU-412 T1 output ports when both of the HDSL loops are not in sync (LOSW).
	1LP	Causes the HiGain system to transmit the AIS signal at both the HLU-231 List 7D & HRU-412 T1 output ports when either of the two HDSL loops is not in sync (LOSW) or if a MARGin alarm occurs.
SAIS	ENA*	Causes the List 6 & 7 HRU-412 to transmit the AIS signal towards the Customer Interface (CI) when in NREM or Smart-Jack loopback (see Figure 6).
	DIS	Causes the List 6 HRU-412 to transmit the signal from the network towards the CI & the List 7 HRU-412 to open & terminate its RCV CI port when an HRU NREM or Smart-Jack loopback is executed. The AIS signal is disabled (towards the NI) and the network signal is transmitted back to the network.
CONF	YES	Confirms that all twelve operating modes (listed above) are to be updated to their current selections.
	NO*	Prevents the most recently selected operating mode selections form being updated. They remain as they were before the system option settings mode was entered.
MARG	0 to 15 dB	The Margin Alarm Threshold can only be set via the RS-232 maintenance port with a terminal (Figure 10 (non-Doubler) and Figure 22 (Doubler)). It determines the minimum allowable margin below which a minor alarm can occur.
	4 dB*	(Default value)

TABLE 2. HLU-231 LIST 7D SYSTEM OPTIONS (CONTINUED)

Mode	Selection	Description
DS0	BLK	The DS0 blocking option can only be set via the RS-232 maintenance port with a terminal (Figure 10 (non-Doubler) and Figure 22 (Doubler)). The 4-Character HLU-231 List 7D front panel LED readout only displays the status of the blocking option. BLK indicates at least one channel is blocked.
	NONE*	NONE indicates no channels are blocked.

*Indicates HLU-231 List 7D factory (default) settings.

5.03   All 14 user options can be set to the factory default values by pressing the SEL button for six seconds until the message: "DFLT NO" appears. To set the default values press the SEL button while the "DFLT NO" message is displayed. "DFLT YES" will be displayed indicating the factory default values are now in effect. To terminate the DFLT mode without setting the factory default values, press the MODE button or do nothing for 30 seconds. The latter returns the display to its normal state.

5.04   Pressing the **MODE** button for three or more seconds causes the display to scroll through the HLU-231 List 7D software version number, its List #, the type of frame pattern being received from the DSX-1, and the line code setting of the HLU-231 List 7D, and all 14 option settings. The line code parameter is the actual DS1 line code being received by the HLU-231 List 7D if the DS1 code pattern is set to AUTO. Otherwise the line code parameter mimics either of the other two line code settings, AMI or B8ZS.

5.05   The DS1 line code option should always be set to conform to the type of DS1 service, AMI or B8ZS, being provided by the HiGain system. The AUTO mode, which can adapt to either AMI or B8ZS, should only be used in applications that require it (such as when HiGain acts as a standby circuit to DS1 circuits whose line codes are not known or may be both AMI and B8ZS) since it has the following two limitations. The AUTO mode will induce one BPV in the DS1 bit stream whenever it switches from AMI to B8ZS. The AUTO mode allows each HiGain end, HLU and HRU, to set its DS1 mode to the code it is receiving at its local DS1 input port. This makes each unit's code independent of the DS1 code being received at the distant DS1 input port. Thus if the line codes being received by HiGain are different in each of the two DS1 directions, the HiGain DS1 output codes will not match their respective DS1 input codes at the other end. This could cause the customer's received data to be AMI instead of B8ZS and thus violate the one's density rules by having excessive zeroes.

5.06   The following three user options cannot only be set using a terminal: CIRCUIT ID, DS0 BLOCKING and MARGIN ALARM THRESHOLD.

5.07   The CIRCUIT ID option is set by choosing the "H" option from the terminal MAIN MENU Screen shown in Figure 6 for non-Doubler applications and Figure 16 for Doubler applications. The message "enter circuit ID # (24 characters max):" follows the "H" selection. Press **Enter** after entering the chosen set of alpha-numeric ID characters; choose **C** to confirm. Note if more than 24 characters are entered, a "Beep" is emitted and only the first 24 characters are accepted. The ID appears in all HLU-231 List 7D screens as shown in Figures 8 - 14 for non-Doubler applications, and Figures 16 - 34 for Doubler applications. The ID does not appear on the HRU-412 screens when the maintenance port is accessed at the remote unit. Note that the Circuit ID is not set to its default (all blanks) setting when the DFLT setting option is utilized (see paragraph 5.03).

5.08   From the MAIN MENU Screen, to set the DS0 BLOCKING option, first press **C** to select the SYSTEMS SETTINGS MAIN MENU Screen. The menu shown in Figure 9 (for non-Doubler applications) and Figure 22 (for Doubler applications) appears. Press **B** as shown in parenthesis of the DS0 blocking selection. The DS0 channels are blocked or unblocked by entering each channel number. Multiple channels can be selected by inserting a space between each entry. After all the new settings have been made, press **E** for ("Exit") and **C** ("Confirm"). The new choices are now installed. If DS0 blocking is invoked in a HiGain system that has an earlier version HRU-412 that does not support the blocking option, blocking will only occur at the DS1 output of the HLU-231 List 7D. The HRU-412 DS1 output will not be blocked. Also, all blocked channels are temporarily "unblocked" for all HiGain system loopback tests. This allows the standard full bandwidth T1 loopback tests to be performed.

5.09   To set the MARGIN ALARM THRESHOLD select "G" from the SYSTEM SETTINGS MAIN MENU Screen. Enter the desired minimum acceptable alarm threshold from the 0 to 15 dB range. This causes a minor alarm to occur (Section 4) if either the margin on HDSL loop 1 (MAL1) or loop 2 (MAL2) drops *below* the selected threshold value. Since the margin can never drop below 0, choosing "0" for the margin threshold turns the margin alarm off.

5.10   Other system settings are set using a terminal in a similar manner. Enter the key represented by the letter in parenthesis of the parameter to be changed. Each entry of this letter scrolls the parameter to its next value. After all selections have been made, press **E** to "Exit" and **C** to "Confirm" the changes. This activates the new choices and returns control to the MAIN MENU Screen.

5.11   The new T1 transceiver chip in the List 7D allows the unit to process both B8ZS and AMI code inputs, regardless of the DS1 code setting (AMI or B8ZS). Earlier units caused input BPV, if B8ZS patterns were processed while in the AMI mode. When the newer units are in the AMI mode, they can receive B8ZS but can only transmit AMI. For this reason, mixed systems (those consisting of both List 7D and older List 1, 2, 3, 3A & 4) units will respond differently in each direction for B8ZS inputs when in their AMI modes.

5.12   The SELF-TEST mode that occurs when both HDSL loops are not in sync has been enhanced to include the input DS1 transceiver chip in the self test procedure. This process can cause the AIS pattern, that is normally transmitted from the HLU-231 List 7D during these out of sync intervals, to exhibit occasional BPVs.

5.13   The HAIS option provides two selections for the T1 transmit outputs at both the HLU-231 List 7D & HRU-412 for HDSL loss of sync conditions. The "1LP" selection causes the AIS pattern to be transmitted at both T1 outputs when either of the two HDSL loops experience an out of sync (LOSW) condition or when a margin alarm occurs. This choice causes the 12 channels on the surviving loop to be lost as they are replaced by the AIS pattern. However it does allow both down & upstream equipment to be made aware of the loss of one HDSL loop or a loop with low margin. This is the preferred setting to be able to initiate an AIS state with just one conductor open in either of the HDSL pairs.

Short loops, below about 16 dB of loss at 200 kHz, can remain in sync with one conductor open. Since the loop is still in sync, no LOSW condition occurs. However, the margin on a one conductor loop drops from 5 to 10 dB. Thus if the Margin alarm is set to 5 dB below the normal margin at turn-up, when one conductor does open, a minor alarm occurs and causes the AIS condition. This alerts the maintenance personnel of the problem. The "2LP" choice requires both HDSL loops to be out of sync (LOSW) before the AIS signal is transmitted. This choice preserves the integrity of the 12 surviving channels when just one loop is lost.

5.14   All user options that affect the operation in both the HLU-231 List 7D & HRU-412, such as HAIS, SAIS & DS0 blocking, are not available in older versions of the HRU-412, List 1, 2, 3, 3A and 4, that do not support these newer options.

5.15   The PairGain HCS-417 & 418 shelves and some 220-configuration shelves deployed in remote cabinets do not have external equalizers. Therefore, the EXT EQL option may not be used in these applications.
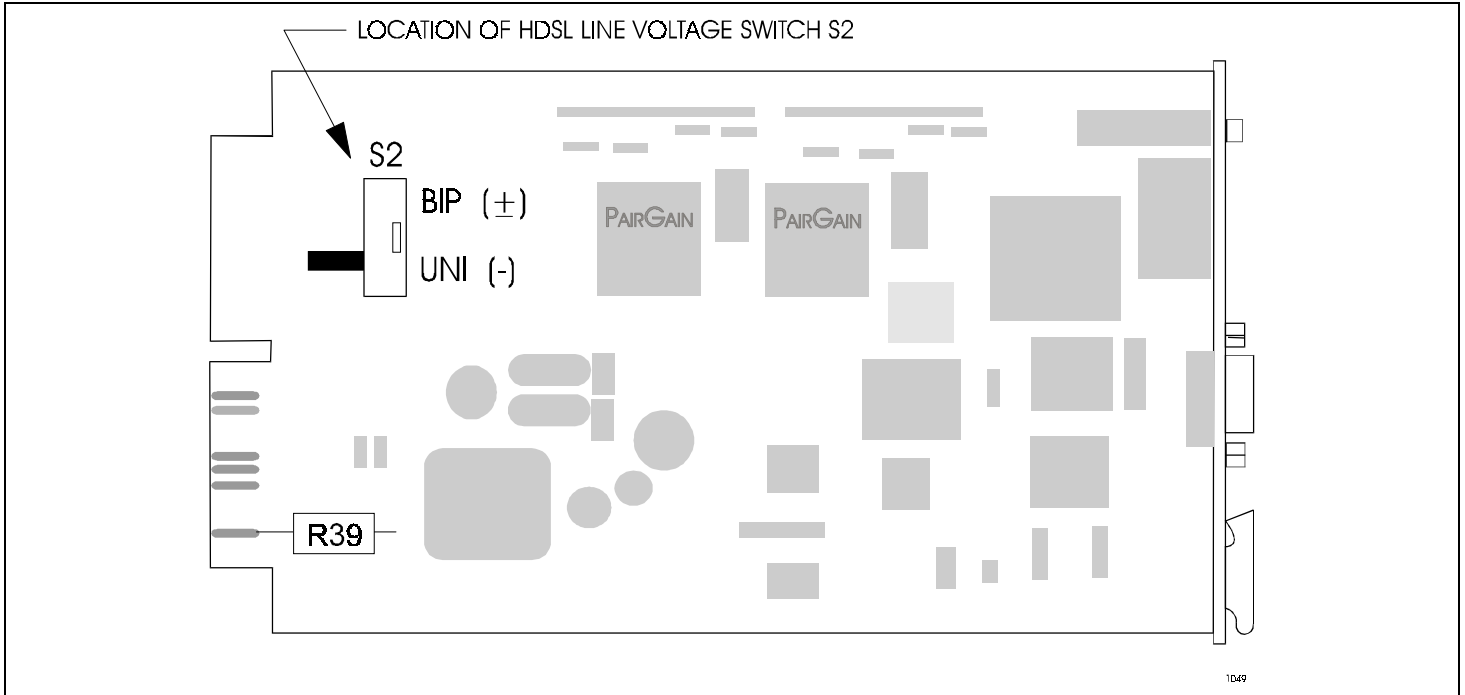
Figure 5. HDSL Line Voltage Switch S2.

6. HDSL LINE VOLTAGE OPTION

6.01   The symmetry of the HDSL line powering voltage can be set by the S2 switch, located on the printed circuit board, as shown in Figure 5.

6.02   The factory default setting is Unipolar (-). It sets the HDSL line voltage to 0 V on loop 2 and to either -130 V (for non-doubler applications) or -200 V (for doubler applications) on loop 1. This setting keeps the HDSL cable pair voltage at or below ground potential, thereby avoiding corrosion problems caused by cable voltages more positive than ground.

6.03   The bipolar selection sets the HDSL line voltage to +65 V on loop 2 and -65 V on loop 1, for non-doubler applications. Doubler applications will have +100 V on loop 2 and -100 V on loop 1. This setting reduces the maximum ground referenced voltage to 100 V, but applies positive voltage to the cable pairs, which could accelerate corrosion on the cable pairs.

6.04   The line voltage power supply, used for both options, is ground referenced, but also ground isolated by 200 kohms. This ground isolation reduces problems due to induced noise currents and large surge voltages, which are ground referenced. It also reduces ground fault currents, which improves the product's safety. The safety issue thus depends solely on the differential voltage across loop 1 and loop 2, and is independent of S2's setting.

7. NETWORK MANAGEMENT

7.01   The HLU-231, List 7D has a Network Management Control Bus available on pin 46. This allows the 7D to be managed by various PairGain Management System protocals through the HMU-319 common control card.

8. INSTALLATION

8.01   Upon receipt of the equipment, visually inspect it for signs of damage. If the equipment has been damaged in transit, immediately report the extent of damage to the transportation company and to PairGain Technologies.

8.02   The HLU-231 List 7D is designed to mount in a 220-configuration Office Repeater Bay (ORB) shelf or equivalent Small Cross Section Shelf (SXSS), Kentrox T-Term, Wescom 342-30 shelves, or PairGain HLS-410 (19") or HLS-419 (23"). The HLU-231 List 7D slot pin-outs are shown in Figure 4.

8.03   The ALM option must be disabled (DIS) when using the Kentrox 220 T-Term shelf. This is required to resolve a conflict between the HLU alarm relay output and the Kentrox external equalizer output. Both use the same pins, 20 and 21.

8.04   If the burn-in pin #23 is used by the backplane of the users shelf, R39, shown in Figure 5, can be removed to disconnect the burn-in circuit from this backplane pin.

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9. SPECIFICATIONS

HDSL Line Code

784 kbps 2B1Q.

HDSL Output

+13.5 dBm ±0.5 dB at 135 ohms.

HDSL Line Impedance

135 ohms.

Maximum Provisioning Loss

35 dB at 196 kHz,135 ohms.

Line Clock rate

Internal "Stratum 4" clock.

HDSL Start-up Time

30 seconds (typical), 60 seconds (maximum) per span.

One-way DS1 Delay

<220 microseconds per span.

DSX-1 Line Impedance

100 ohms.

DSX-1 Pulse Output

12 V $_{pk-pk}$ for EXTERNAL equalizer or pre-equalized for 0-655 feet of ABAM-specification cable.

DSX-1 Input Level

+1.5 to -7.5 dBDSX.

DS1 Line Rate

1.544 Mbps ±200 bps.

DS1 Line Format

AMI, B8ZS or ZBTSI.

DS1 Frame Format

ESF, SF or UNFR.

Maximum Power Consumption

18 Watts (without Doubler); 35 Watts (with Doubler).

Maximum Heat Dissipation

8 Watts (without Doubler); 12.5 Watts (with Doubler).

Fusing

Internal; connected to "FUSE-ALARM" output on pin 32.

HDSL Span Voltage

-130 to -210 VDC.

Margin Indicator

Displays HDSL span SNR margin for both HDSL spans relative to 10^{-7} BER operation.

Electrical Protection

Secondary surge protection on DS1 & HDSL ports. Power cross protection on HDSL ports.

Operating Temperature & Humidity

-40° to +65° Celsius, 5 to 95% (non-condensing)

Mounting

AT&T 220-configuration or equivalent.

Dimensions

Height: 5.9" (15 cm)
Width: 1.4" (3.5 cm)
Depth: 10" (25.4 cm)
Weight   1 lb. 14 oz.

10. CERTIFICATION

10.01   FCC compliance: The HLU-231 List 7D was tested and found to comply with the limits for Class A digital devices, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause electrical interference in which case the user will be required to correct the interference at his own expense.

11. WARRANTY

11.01   PairGain Technologies warrants this product to be free of defects and to be fully functional for a period of 24 months from the date of original shipment, given proper installation. PairGain will repair or replace any unit without cost during this period if the unit is found to be defective for any reason other than abuse, improper use, or installation.

11.02   This module should not be field repaired. If it fails, replace it with another unit and return the faulty unit to PairGain for repair. Any modifications of the unit by anyone other than an authorized PairGain representative voids the warranty.

11.03   If a unit needs repair, call PairGain for a Return Material Authorization (RMA) number and return the defective unit, freight prepaid, along with a brief description of the problem, to:

PairGain Technologies, Inc.
14402 Franklin Avenue
Tustin, CA 92680
ATTN.: Repair and Return Dept.
(714) 832-9922
(800) 638-0031

B. APPLICATIONS WITHOUT USING HIGAIN DOUBLER HDU-451

1. GENERAL

1.04 This section addresses HLU-231 List 7D operation when used without doublers. For applications without Doublers, the HLU-231 List 7D is directly connected to the HRU-412 by the two cable pairs.

2. POWER CONSUMPTION

2.01 The three most important power demands of an HLU-231 List 7D on the shelf power supply are its maximum power consumption, its maximum power dissipation and its maximum current drain. These three parameters for the HLU-231 List 7D, on a per slot and per shelf basis, are as follows:

Maximum Power Dissipation:

- Per Slot = 7.0 Watts
- Per Shelf = 91 Watts

Maximum Power Consumption:

- Per Slot = 16 Watts
- Per Shelf = 208 Watts

Maximum Current Drain:

- Per Slot = 0.4 Amps
- Per Shelf = 5.2 Amps

Note that the worst case conditions under which these parameters were measured include a 9,000 ft., AWG 26 loop, 60 mA of Customer Premier Equipment (CPE) current, a fully loaded 13 slot shelf, and a -42.5 V shelf battery voltage with HLU-231, 4-character display "OFF".

2.02 The Maximum Power Dissipation measures the power that is converted into heat build up within the unit. It contributes to the total heat generated in the space around the unit. It is used to determine the maximum number of fully loaded shelves per bay that does not exceed the maximum allowable power dissipation density in Watts/sq. ft.

2.03 In Central Office locations, the maximum power dissipation for open faced, natural convection cooled mountings is limited to 120 Watts/sq. ft. per Section 4.2.3 of the NEBS standard TR-NWT-000063. The footprint of a standard 13 slot 23" HLU-231 List 7D shelf is 7.024 sq. ft. Thus the maximum bay dissipation is limited to 840 Watts. At 91 Watts per shelf, this limits the number of fully loaded HLU-231 List 7D shelves to 9 per bay. Note that this is a worst case situation in that it assumes the entire Central Office is subjected to the maximum power density. Conditions other than these worst case ones would permit increasing the number of shelves per bay without jeopardizing the CO thermal integrity.

2.04 The thermal loading limitations imposed when using the HLU-231 List 7D in Controlled Environmental Vault (CEV) or other enclosures are determined by applying the HLU-231 List 7D's power parameters to the manufacturer's requirements for each specific housing.

2.05 The Maximum Power Consumption is the total power that the HLU-231 List 7D consumes or draws from its -48 V shelf power source. This parameter is needed when the 231 is located remote to its serving CO. It determines the battery capacity required to maintain an 8 hour stand-by battery reserve for emergency situations. It thus limits the maximum number of plugs per line units remote enclosure. Use the above data to perform this analysis on a case by case basis.

2.06 The Maximum Current Drain is the maximum current drawn from the shelf power supply when it is at its minimum voltage (-42.5 V). This determines the shelf fusing requirements. HLU-231 List 7D shelves are fused at 10 A. A fully loaded shelf of 13 HLU-231s draws 5.2 A in the worst case. This is well within the 10 A fuse limit.

3. LOOPBACK OPERATION

3.01 The HiGain system has a family of loopback options. The most important of these is the "Smart-Jack" loopback which enables the HRU-412 to respond to the standard (2/3 in 5) Smart-Jack in-band loopback codes and thus emulate the functions of a standard Network Interface Device (NID). This option can be enabled or disabled from either the front panel buttons or the terminal SYSTEM SETTINGS MENU.

3.02 In addition to the Smart-Jack loopback, the HiGain system can be configured for one of five special in-band loopback ("SPLB") command sequences. These are selected from the SPLB user option shown in Table 2 and Figure 11 (non-Doubler applications). The non-Doubler loopback locations are shown in Figure 6.

3.03 "GNLB" is the HiGain system Generic loopback code. The GNLB allows in-band codes to loop-up either the HLU/NLOC (4 in 7) or HRU/NREM (3 in 7) towards the network. In addition, it allows in-band codes to loop-up the HLU/CREM (6 in 7) or HRU/CLOC (5 in 7) towards the customer. Either loop-up condition is terminated (looped-down) with the 3 in 5 loop-down code. Both in-band codes must be present for 5 seconds before the HiGain system responds. Table 3

lists the test procedures that apply when using the GNLB mode.

3.04 The A1LB loopback selection, Table 4, complies with that proposed for HDSL systems in the T1E1.4/92 recommendation with the following additions:

- Query loopback
- IOR (Intelligent Office Repeater) power-down
- Three loopback time-out choices
- Initiation from either end
- Repeating bit error signatures
- Alternate query loopback

These additions make A1LB identical to A2LB described below. It is given a separate identity to allow future T1/E1 enhancements to be added without affecting A2LB.

3.05 A2LB through A5LB are four special address-able repeater loopback functions which are supported by the List 7D version of the HiGain system. These loopbacks provide the HiGain system with sophisticated maintenance and trouble shooting tools. Table 5 through Table 8 list the details of these SPLB functions. A2LB & A5LB are patterned after the Teltrend addressable T1 repeater loopbacks. A3LB & A4LB are patterned after the Wescom addressable T1 repeater loopbacks. All four SPLBs have been enhanced to handle the specific requirements of the following HiGain system customers:

- A2LB (Teltrend) = Southwestern Bell
- A3LB (Wescom) = New England Telephone
- A4LB (Wescom Mod 1) = New York Telephone
- A5LB (Teltrend Mod 1) = Southern New England Telephone (SNET)

3.06 A5LB differs from A2LB in that A5LB does not block the arming code from exiting the HLU-231 List 7D into the network. A2LB can be configured to either block this arming code after two seconds, and replace it with the AIS code, or to unblock it by executing the FAR-END ACTIVATE code. Since A5LB never blocks the arming code from exiting the HLU-231 List 7D, it does not need this FAR-END ACTIVATE code. A3LB differs from A4LB in that A3LB supports the additional (1 in 6) Smart-Jack loopback command.

3.07 When T1 loopback tests are performed on the HiGain system with metallic loopback connections at either end, the DS1 code that exists at the metallic loopback interface may be different from the DS1 code being received at the opposite end when the DS1 user code is set to AUTO. This is caused by the fact that in the AUTO DS1 code mode, the HLU-231 List 7D & HRU-412 set their own code independent of each

other. Each end sets its transmit code to match its receive code. Thus if one end is receiving AMI and the other B8ZS, their codes are different. For example, if the HRU-412 has a metallic loopback and the HLU-231 List 7D receive pattern code is changed from AMI to B8ZS and then the all "0" pattern is sent into the HLU-231 List 7D, the HLU-231 List 7D changes to its B8ZS mode while the HRU-412 remains in its AMI mode and thus loops all "0". This causes the HRU-412 to indicate a LOS condition which causes the HLU-231 List 7D to output the AIS pattern.

3.08 The HiGain system may take longer than normal to respond to in-band loopback commands when its framing mode is set to UNFR and the in-band commands are sent in either an SF or ESF mode. The frame bits override the command bits and cause errors in the command sequence. These errors cause the HiGain system to reject some sequences. This can extend the detection interval.

3.09 Pressing both the **MODE** and **SEL** push-buttons on the front panel for at least three seconds initiates a MANUAL loopback session. This session allows the user to **SEL** one of four HiGain system loopbacks. The message, "MAN LPBK", appears on the front panel display followed by the message "NLO?". If the **SEL** push-button is now pressed, an "NLOC" loopback is executed and the message changes from "NLO?" to "NLOC". If the **MODE** button is pressed instead of the **SEL** push-button, "NLO?" is replaced by "NRE?". This now allows an 'NREM' loopback to be executed with the **SEL** push-button. Pressing the MODE push-button two more times yields the CRE and CLO loopback options in the sequence listed. This interactive push-button procedure permits any of the four HiGain loopbacks to be executed/activated. The next loopback option can be presented by pressing the MODE push-button however, the previously executed loopback will remain active until the SEL push-button is pressed and a different loopback is activated. If neither push-button is pressed for a period of 30 seconds and no loopback is in effect, the manual loopback session terminates and the normal margin displays reappear. If any loopback is in effect, the 30-second time-out is inhibited. The active loopback and the manual loopback session continue until the loopback times out in accordance with the user selected LBTO setting. Only one loopback can exist at any given time. Pressing both push-buttons, again for three seconds, terminates any active loopback, ends the MANUAL loopback session and returns the display to normal mode. Note that these same loopbacks can be initiated from the RS-232 maintenance port by choosing the LOOPBACK MODE, option D, from the MAIN MENU. This displays the Loopback Menu (Figure 10),

from which any of the loopbacks can be initiated/terminated.

4. TESTING

4.01	Table 3 through Table 8 provide step-by-step test procedures for the HLU-231 List 7D as a function of the loopback option selected. These procedures allow verification of the integrity of the HDSL channels at every module location as well as the DS1 channels to the customer and the local DSX-1 interface.

4.02	The HLU-231 List 7D 4-character front panel display has many useful system diagnostic messages. They are listed in Table 9. This display turns on when power is initially applied to the HLU-231 List 7D. To conserve power, the display only remains on for five minutes if neither the **MODE** or **SEL** buttons are pressed. The use of either button activates the 4-character display and restarts the 5-minute power-control timer.

4.03	If trouble is encountered on the HLU-231 List 7D DSX-1 interface, verify that the HLU-231 List 7D is making a positive connection with its mounting assembly (shelf) connector. Also, verify that the HLU-231 List 7D internal equalizer is set to TEXT for driving the external equalizer or to the correct distance range per Table 2 for external equalization. All installations should be set to the largest distance range value that does not exceed the distance from the DSX-1 to the shelf.

4.04	The transmit and receive T1 DSX-1 ports have splitting access and bridging miniature 210-series jacks as shown in Figure 2. Connecting one cable between the two bridging jacks and another between the two SPAN jacks splits the XMT and RCV and creates metallic loopbacks towards both the DSX-1 and the HLU-231 List 7D. If plugs are inserted into both SPAN jacks, the BRG jacks can be used to send and receive test patterns towards the DSX-1.
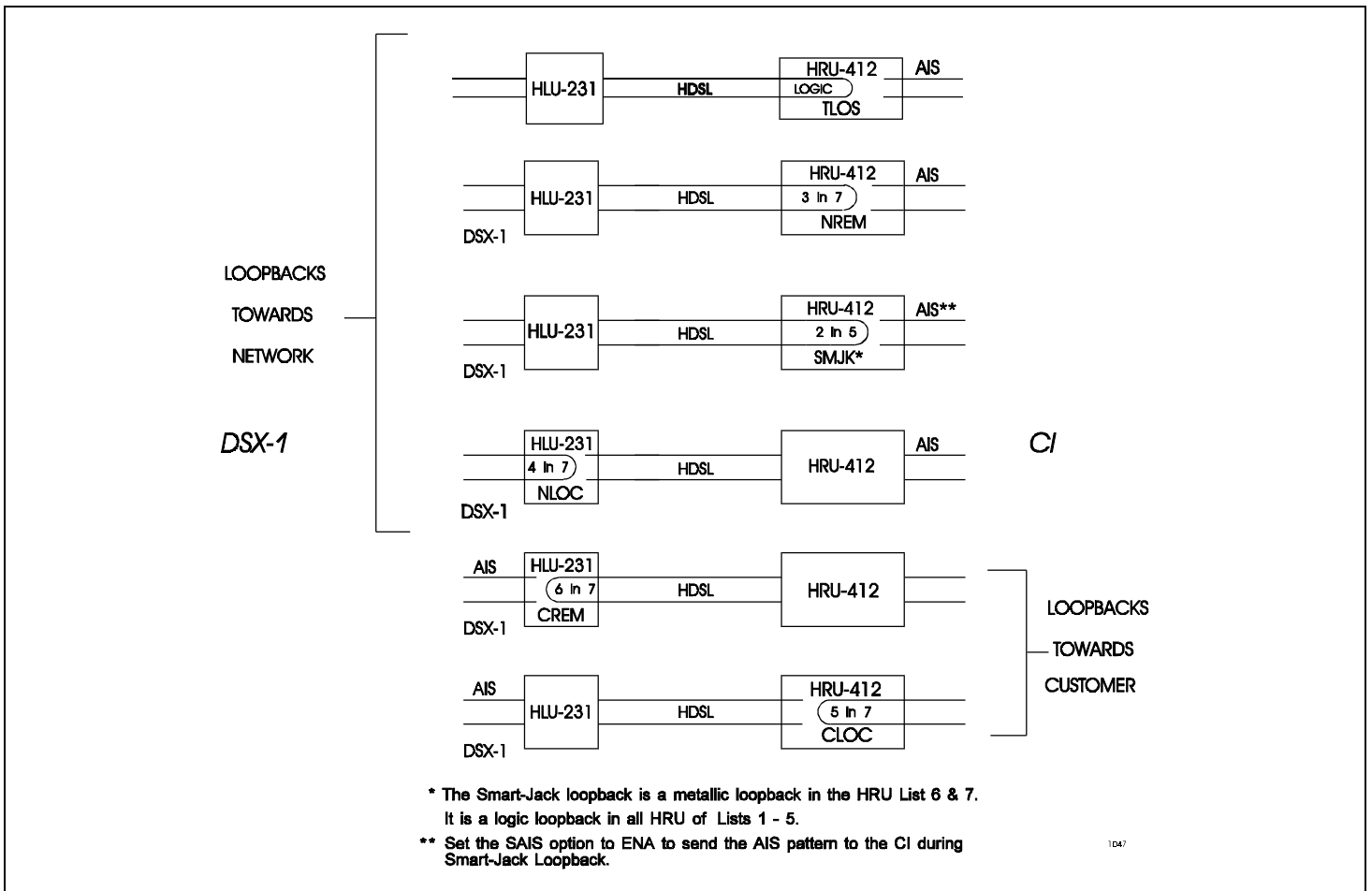
Figure 6. HLU-231 non-Doubler Loopback Configurations. The most important of the HiGain family of loopback options is the Smart-Jack loopback, which emulates the functions of a standard NID.

TABLE 3. HLU-231 GNLB TEST PROCEDURES

Step	Action
1	Have the CO tester send the HRU-412 (3 in 7) in-band loop-up code for five seconds. Observe that the HLU-231 List 7D displays the "NREM" message indicating an HRU loopback is in effect (Figure 5).
2	Have the CO tester transmit a T1 test signal into the HLU-231 List 7D and verify that the returned (looped) signal is error free.
3	If the above test fails, have the CO tester transmit the (3 in 5) in-band loop-down code. Verify that the HLU-231 List 7D display returns to normal.
4	Have the CO tester send the HLU-231 List 7D (4 in 7) in-band loop-up for five seconds. Observe that the HLU-231 List 7D displays the "NLOC" message indicating an HLU-231 List 7D loopback is in effect.
5	Repeat Step 2. If the test passes, the problem is in the cable pair or the HRU-412. If it fails, the problem is in the CO equipment.
6	The **NREM, NLOC, CREM and CLOC** loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section B Paragraph 3.09).
7	The HLU-231 List 7D can be looped-up from the remote location (CREM) by issuing the (6 in 7) command at the HRU-412 DS1 input port.
8	The HRU-412 can be looped-up from the remote location (CLOC) by issuing the (5 in 7) command at the HRU-412 DS1 input port.

Note 1
When T1 loopback tests are performed on the HiGain system with metallic loopback connections at either end, the DS1 code that occurs at the metallic loopback interface may be different from the DS1 code being received at the opposite end when the DS1 user code is set to AUTO. For example, if the HRU-412 has a metallic loopback and the HLU-231 List 7D receive pattern code is changed from AMI to B8ZS and then the all "0" pattern is sent into the HLU-231 List 7D, the HRU-412 remains in its AMI mode and thus loops all "0". This causes the HRU-412 to indicate a LOS condition which then causes the HLU-231 List 7D to output the AIS pattern.

Note 2
The HiGain system may take longer than normal to respond to in-band commands when its framing mode is set to UNFR and the in-band commands are sent in either an SF or ESF mode. The frame bits override the command bits and cause errors in the command sequence. These errors cause the HiGain system to reject some sequences. This can extend the detection interval.

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TABLE 4. HLU-231 A1LB TEST PROCEDURES

Step	*Action*
1	Send into the HLU-231 List 7D the in-band ARMING and NI LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrives first)
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 6) by sending Intelligent Office Repeater (IOR) LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bit) occur in the returned pattern (20 errors if ILR-2 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands. The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-231 List 7D periodically shows NLOC (network local loop) and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 List 7D down is to issue the IR (Intelligent Repeater) LPDN (loop-down) code 1001 0011 1001 0011 (9393) or to issue the NI LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 4. TEST PROCEDURES FOR A1LB OPTION (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 6. A customer tester can activate loopbacks CLOC or CREM.

<div align="center">

ADDRESSABLE 1 (A1LB) REPEATER LOOPBACK COMMANDS

</div>

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
FAR END NI ACTIVATE	Unblock AIS & pass 2 in 5	1100(C)0101(5)0101(5)0100(4)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HiGain system returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section B Paragraph 3.09).

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TABLE 5. HLU-231 A2LB TEST PROCEDURES

Step	Action
1	Send into the HLU-231 List 7D the in-band ARMING and NI LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrive first)
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 6) by sending IOR LPBK activation code 1101 0011 1101 0011(D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bit) occur in the returned pattern (10 errors if ILR-1 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands. The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-231 List 7D periodically shows NLOC (network local loop) and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 List 7D down is to issue the IR (Intelligent Repeater) LPDN (loop-down) code 1001 0011 1001 0011 (9393) or to issue the NI LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

TABLE 5. HLU-231 A2LB TEST PROCEDURES (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 6. A customer tester can activate loopbacks CLOC or CREM.

<div align="center">

ADDRESSABLE 2 (A2LB) REPEATER LOOPBACK COMMANDS

</div>

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
FAR END NI ACTIVATE	Unblock AIS & pass 2 in 5	1100(C)0101(5)0101(5)0100(4)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HiGain system returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section B Paragraph 3.09).

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TABLE 6. HLU-231 A3LB TEST PROCEDURES

Step	Action
1	The HiGain Line Unit can be looped back (NLOC in Figure 6) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least five seconds. This causes the HLU-231 List 7D to enter its NLOC state shown in Figure 6. The display on the HLU-231 List 7D alternates between NLOC (network local loop) and the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the reception of a second identical 16-bit loop-up command before the timer expires. When this time-out override state exists, the only way to loop the HLU-231 List 7D down is to issue one of the three loopdown commands listed in Step 2. The automatic time-out mode is restored during subsequent loopback sessions.
2	The following list summarizes the codes required to execute all the HiGain loopbacks shown in Figure 6. Note that all code sequences must be present for at least five seconds.

<div align="center">

ABBREVIATIONS USED BELOW:
LU = LoopUp
LD = LoopDown
NI = Network Interface
CI = Customer Interface
ESF-DL = Extended Super Frame Data Link

</div>

ADDRESSABLE 3 (A3LB) REPEATER LOOPBACK COMMANDS

Position	Name	Code
HLU-231 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)
HLU-231 LU FROM CI	CREM	0011(3)1111(F)0001(1)1110(E)
HRU-412 LU FROM NI	NREM	1111(F)1111(F)0000(0)0010(2)
HRU-412 LU FROM CI	CLOC	0011(3)1111(F)0000(0)0010(2)
HRU-412 LU FROM NI	SMJK	11000 11000 11000 ...
HRU-412 LU FROM NI	SMJK	100000 100000 100000 ...
HRU-412 LU FROM NI (ESF-DL)	SMJK	1111(F)1111(F)0100(4)1000(8)
HLU & HRU LD FROM NI OR CI		11100 11100 11100 ...
HLU & HRU LD FROM NI OR CI		100 100 100 ...
HLU & HRU LD FROM NI OR CI (ESF-DL)		1111(F)1111(F)0010(2)0100(4)

Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. This is the HEX number for the 4-bit group.

Step	Action
3	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section B Paragraph 3.09).

TABLE 7. HLU-231 A4LB TEST PROCEDURES

Step	Action
1	The HiGain Line Unit can be looped back (NLOC in Figure 6) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least five seconds. This causes the HLU-231 List 7D to enter its NLOC state shown in Figure 6. The display on the HLU-231 List 7D alternates between NLOC (network local loop) and the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the reception of a second identical 16-bit loop-up command before the timer expires. When this time-out override state exists, the only way to loop the HLU List 7D down is to issue one of the three loop-down commands listed in Step 2. The automatic time-out mode is restored during subsequent loopback sessions.
2	The following list summarizes the codes required to execute all the HiGain system loopbacks shown in Figure 6. Note that all code sequences must be present for at least five seconds. ABBREVIATIONS USED BELOW: LU = LoopUp LD = LoopDown NI = Network Interface CI = Customer Interface ESF-DL = Extended Super Frame Data Link

ADDRESSABLE 4 (A4LB) REPEATER LOOPBACK COMMANDS

Position	Name	Code
HLU-231 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)
HLU-231 LU FROM CI	CREM	0011(3)1111(F)0001(1)1110(E)
HRU-412 LU FROM NI	NREM	1111(F)1111(F)0000(0)0010(2)
HRU-412 LU FROM CI	CLOC	0011(3)1111(F)0000(0)0010(2)
HRU-412 LU FROM NI	SMJK	11000 11000 11000 ...
HRU-412 LU FROM NI (ESF-DL)	SMJK	1111(F)1111(F)0100(4)1000(8)
HLU & HRU LD FROM NI OR CI		11100 11100 11100 ...
HLU & HRU LD FROM NI OR CI		100 100 100 ...
HLU & HRU LD FROM NI OR CI (ESF-DL)		1111(F)1111(F)0010(2)0100(4)

Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. This is the HEX number for the 4-bit group.

Step	Action
3	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section B Paragraph 3.09).

TABLE 8. HLU-231 A5LB TEST PROCEDURES

Step	Action
1	Send into the HLU-231 List 7D the in-band ARMING and NI (Network Interface) LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrive first)
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 6) by sending IOR (Intelligent Office Repeater) LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bits) occur in the returned pattern (10 errors if ILR-1 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands.) The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-231 List 7D periodically shows NLOC and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 down is to issue the IR (Intelligent Repeater) LPDN (loopdown) code 1001 0011 1001 0011 (9393) or to issue the NI (Network Interface) LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 8. HLU-231 A5LB TEST PROCEDURES (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 6. A customer tester can activate loopbacks CLOC or CREM.

ADDRESSABLE 5 (A5LB) REPEATER LOOPBACK S

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HiGain system returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU with the **MODE** and **SEL** pushbuttons (Section B Paragraph 3.09).

TABLE 9. HLU-231 LIST 7D STATUS MENU MESSAGES

Message	Full Name	Description
ALARMS:		
NONE	No Alarms	
LLOS	Local Loss of Signal	No signal from HLU-231 List 7D local T1 interface.
RLOS	Remote Loss of Signal	No signal from HRU-412 remote T1 interface.
LOSW1(2)	Loss of Sync Word 1 or 2	HDSL loop 1 or 2 has lost sync.
H1ES	HDSL Loop 1 Errored Second	Loop 1 CRC's have exceeded the user selected ES threshold.
H2ES	HDSL Loop 2 Errored Second	Loop 2 CRC's have exceeded the user selected ES threshold.
DS1	Digital Service 1	DS1 input BVDs for either the HLU-231 List 7D or HRU-412 have exceeded the user selected ES threshold.
R(L)AIS	Remote (Local) Alarm Indicating Signal	Indicates an AIS (all "1") pattern is being transmitted from the remote or (local) T1 output port.
MAL1	Margin Alarm 1	The margin on HDSL loop 1 has dropped below the threshold (1 to 15 dB) set by the user.
MAL2	Margin Alarm 2	The margin on HDSL loop 2 has dropped below the threshold (1 to 15 dB) set by the user.
CHREV	Channels Reversed	The Loop 1 & 2 HDSL pairs are reversed at the HRU-412 input port. Loop 1 is specified to carry the (-) simplex DC voltage, and Loop 2 is specified to carry the (+) simplex DC voltage.
LOOPBACKS:		
SMJK	Smart-Jack Loopback	Loopback at HRU-412 (remote) towards network initiated by (2 in 5) in-band loopback code or out-of-band ESF data link code (Figure 6).
NREM	Network Remote Loopback	Loopback at HRU-412 (remote) towards network initiated from CO (network) by Intelligent Line Repeater (ILR) #2 code, HLU-231 front panel MANUAL LOOPBACK push-buttons, HRU-412 front panel push-button, or maintenance terminal (Figure 6).
NLOC	Network Local Loopback	Loopback at HLU-231 List 7D (local) towards network initiated from CO (network) by IOR code, HLU front panel MANUAL LOOPBACK push-buttons, or maintenance terminal (Figure 6).
CLOC	Customer Local Loopback	Loopback at HRU-412 (local) towards CI initiated from CPE (customer) by ILR #2 code, HLU-231 front panel MANUAL LOOPBACK push-button, or maintenance terminal (Figure 6).

Table continued on next page

TABLE 9. HLU-231 LIST 7D STATUS MENU MESSAGES (CONTINUED)

Message	Full Name	Description
LOOPBACKS:		
CREM	Customer Remote Loopback	Loopback at HLU-231 List 7D (remote) towards customer initiated from CPE (customer) by IOR code, HLU-231 front panel MANUAL LOOPBACK push-button, or maintenance terminal (Figure 6).
ARM	Armed	The HiGain system detected the IR loopback (2 in 5) arming code.
TLOS	Transmit Loss of Signal (Loopback)	HRU-412 is in a logic loopback state caused by a loss of its T1 input from the CI, if enabled at the HRU-412 via its TLOS switch option.

5. SYSTEM MAINTENANCE MENU SCREENS

5.01   Figure 7 is the Maintenance Terminal MAIN MENU Screen. Its eight sub-menus provide many useful provisioning, test and monitoring tools. Figure 8 shows the HLU-231 List 7D SPAN STATUS Screen.

5.02   Figure 9 shows the SET CLOCK menu. Both the Time and Date are set with this menu. Set the hours and minutes, using the military (24-hour) convention. Setting the seconds is optional. Enter the date in the sequence and format shown. List 1 HRU-412 units having software versions 6.4 and above, and all List 6, List 7 HRU-412 units can also be set to the same time and date as the HLU-231 List 7D by entering a **U** to the "Update Remote" query. All time information is lost when power is removed. The last date, however, is retained in NVRAM and reappears when power is restored.

5.03   Figure 10 shows the SYSTEM SETTINGS Screen. All 14 user options can be set from this screen. To change any option, enter its character key which is shown inside the parenthesis within each parameter description. This causes the screen to refresh with the new parameter. After all parameters have been selected, press **E** (Exit) then **C** (Confirm). The newly selected parameters are now activated.

5.04   Figure 11 shows the LOOPBACK MENU Screen for non-Doubler applications. Loopbacks NLOC, NREM, CLOC & CREM are available.

5.05   Figure 12 shows the PERFORMANCE DATA screen for non-Doubler applications. Both the Errored and Unavailable Seconds for both HDSL loops and each T1 input are listed at 15-minute intervals over a four hour time interval. Earlier & later data, in four-hour chunks on six different screens, can be accessed

by pressing **P** (Previous) or **N** (Next) respectively. All of the counters can be set to zero by pressing **C** (Clear) from the HLU-231 List 7D SPAN STATUS Screen shown in Figure 7. Note that since the HLU-231 List 7D is considered the master module, this clears *all* performance data screens at both the HLU-231 List 7D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared

5.06   Figure 13 shows the 7-DAY PERFORMANCE HISTORY Screen. The "Errored Seconds" and "Unavailable Seconds" for both HDSL loops and each of the two DS1 inputs are listed for the current and previous seven days. All of the counters can be set to zero by pressing **C** (Clear) on the HLU-231 List 7D SPAN STATUS Screen (Figure 7). Note that since the HLU-231 List 7D is considered the master module, this clears *all* performance data screens at both the HLU-231 List 7D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared.

5.07   Figure 14 shows the ALARM HISTORY Screen for non-Doubler applications. The alarms are defined in Section A Paragraph 4.01. The "First" & "Last" columns contain the time & date stamp of the first & last occurrence of each alarm. The "Current" column shows the status of each alarm. The "Count" column lists the number of times each alarm occurred. All the data can be cleared by pressing **C** (Clear). The maximum non-overflowing count is 999.

5.08   Selection "H" from the main menu allows the Circuit ID # to be set. It is limited to 24 alpha-numeric characters. It, like the system settings, is stored in NVRAM and thus remains when power is lost. Note that the Circuit ID # is not available at the HRU-412 Maintenance Port.

TABLE 10. GLOSSARY OF HIGAIN TERMS

Term	Definition
MARGIN	Indicates the excess signal to noise ratio, at either the HRU-412 or HLU 231 List 7D HDSL ports, relative to a 10^{-7} Bit Error Rate. 1st value is current margin, 2nd value is minimum margin since (C)leared last, 3rd value is maximum value since cleared. NA means Not Available (loop is not in sync). The normal range of a typical margin is from 22 to 6 dB.
PULSE ATTN	Indicates the attenuation of the 2B1Q pulse from the distant end. The HiGain system operates with pulse attenuations in excess of 30 dB. This value is related to the cable pairs' 196 kHz loss. The pulse attenuation is a more direct indication of the loop attenuation to the 2B1Q signal than the 196 kHz loss. The normal range of pulse attenuation is from 1 to 32 dB.
PPM OFFSET	Indicates the relative offset of the crystal oscillator in the HRU-412 from the HLU-231 List 7D crystal oscillator. Any value between -64 and +64 is adequate. Values outside this range indicate out of tolerance components or excessive temperature drift in critical components.
INS LOSS	This is the approximate insertion loss of the various loops at the HDSL line rate of 196 KHZ. It is generated by multiplying the PULSE ATTN by 1.25.
HDSL 24 Hour ES (Errored Seconds)	The number of 1 second intervals that contained at least 1 CRC error. This value is a running total of the last 24 Hours.
HDSL 24 Hour UAS (Unavailable Seconds)	The number of seconds the HDSL loop was out of sync.
DS1 BPV Seconds (ES)	The number of seconds in which at least 1 bipolar violation was detected on the DS1 input.
DS1 UAS Count	The number of seconds during which the DS1 input signal was absent (125 or more consecutive "0").
Frame type	Type of DS1 framing used on the input stream (SF, ESF, Unframed or No Activity).
Code type	Type of DS1 line coding used (AMI, B8ZS, AMI : ZBTSI or B8ZS : ZBTSI). The latter two conditions indicate the code type that is being received when the HiGain system is set to its ZBTS mode. In either the AMI or B8ZS DS1 code mode, the Code type displays the selected code as opposed to the code type that is actually being received, which is what is displayed when set to AUTO code mode.
HLU/Ver w.x-y	"w.x" = software version number of the HLU-231 List 7D. "y" = list # of HLU-231 List 7D.
HRU/Ver a.b-c	"a.b" = software version number of the HRU-412. "c" = list # of HRU-412.

TABLE 11. HLU-231, LIST 7D 4-CHARACTER FRONT PANEL MESSAGES

Message	Full Name	Description
CREM	Customer Remote Loopback	Signal from customer is looped back to customer at HLU-231.
NLOC	Network Local Loopback	DSX signal is looped back to DSX at HLU.
CLOC	Customer Local Loopback	Signal from Customer is looped back to customer at HRU-412.
NREM	Network Remote Loopback	DSX signal is looped back to DSX at HRU.
SMJK	Remote Smartjack Loopback	Signal from DSX is looped back at HRU by the HRU smartjack module.
TLOS	Transmit Loss Of Signal	HRU is in a logic loopback state caused by a loss of its T1 input from the CI, if enabled at the HRU via its TLOS switch option.
FERR	Framing Bit Error Occurred	Framing bit error occurred at HLU T1 input.
LBPV	Local Bipolar Violation	A bipolar violation has been received at the T1 input to the HLU-231.
SIG 1 or 2	Signal 1 or Signal 2	The HLU & HRU transceivers are trying to establish contact with each other.
ACQ 1 or 2	Acquisition 1 or Acquisition 2	The HLU & HRU multiplexers are trying to establish synchronization over each loop.
H1ES	HDSL CRC Error Channel 1	HLU HDSL Loop 1 CRC error.
H2ES	HDSL CRC Error Channel 2	HLU HDSL Loop 2 CRC error.
ARM	HiGain System ARMED	Armed to respond to Intelligent Repeater Loop Codes.
ACO	Alarm CutOff	A minor alarm has occurred, and been retired to an ACO condition, by pressing the **SEL** button on the HLU front panel.
SELF TEST		The HLU is in a self test mode. This occurs every power ON/OFF cycle.
ALRM	Alarm Condition Exists	A minor alarm condition is in effect.
1=xx or 2=yy	HDSL Loop Margins	Indicates the power of the received HDSL signal on each Loop relative to noise. Any value of '06' or greater is adequate for reliable system operation.
PWR FEED SHRT	Power Feed Short	Indicates a short between the 2 HDSL pairs. This same message can occur with an HRU that is drawing the correct amount of power over good cable pairs but cannot communicate with the HLU.

Table continued on next page

TABLE 11. HLU-231, LIST 7D 4-CHARACTER FRONT PANEL MESSAGES (CONTINUED)

Message	Full Name	Description
PWR FEED OPEN	Power Feed Open	Indicates an open circuit in the T&R of either HDSL pair.
PWR FEED OFF	Power Feed Off	HDSL span power has been turned off by setting the PWFD option to DIS.
BAD RT?	No response from HRU	The HLU does not receive any response from the HRU. Thus, the HRU's integrity is questionable.
VER	HLU Software Version #	This is displayed during the System Settings review mode. Depress the **MODE** button for 3 seconds.
LIST 0xL	HLU's List #	Displayed during System Settings review mode defined above.
FRM	Frame:SF,ESF,UNFR,NONE	Defines the type of frame pattern being received from the DSX-1. Displayed during System Settings review mode defined above.
CODE	Line Code: AMI, B8ZS	This is the line code that HLU-231 List 7D is receiving at its DSX-1 interface. Displayed during System Setting review mode defined above.
LOSW	Loss of Sync Word	Indicates that 1 of the HDSL loops has lost sync. Causes a minor alarm.
LLOS	Local Loss of Signal	Indicates that no signal is detected at the T1 input to the HLU. Causes a minor alarm.
RLOS	Remote Loss of Signal	Indicates that no signal is detected at the T1 input to the HRU. Causes a minor alarm.
DS1	DS1 BPV errors	Indicates that the number of BPVs at the HLU or HRU DS1 inputs have exceeded the 24 hour ES threshold. Causes a minor alarm.
DS0	DS0 Blocked Channels	Indicates status of DS0 blocked channels. NONE indicates no channels are blocked. BLK indicates some channels are blocked.
MAL1(2)	Margin Alarm Loop 1 or 2	The margin on HDSL loop 1 (2) has dropped below the threshold (1 to 15 dB) set by the user.

```
    HI-GAIN HLU-231    MAINTENANCE TERMINAL MAIN MENU    (ver V2.2L-007D)
                            CIRCUIT ID#: Pasadena Lab

                      A. VIEW SPAN STATUS
                      B. SET CLOCK
                      C. SYSTEM SETTINGS
                      D. LOOPBACK MODE:  NONE
                      E. VIEW PERFORMANCE DATA
                      F. VIEW PERFORMANCE HISTORY
                      G. VIEW ALARM HISTORY
                      H. ENTER CIRCUIT ID #
```

Figure 7. HLU-231 List 7D Main Menu.

```
                            SPAN STATUS
                  ( HLU/ver2.2-007D: HRU/ver2.5-0008)
        TIME: 00:04:31
        DATE: 03/21/96              CIRCUIT ID#: Pasadena Lab
        ALARMS:   NONE
        LOOPBACK: OFF

                        HLU                        HRU
                  HDSL-1      HDSL-2         HDSL-1      HDSL-2
                cur/min/max  cur/min/max   cur/min/max  cur/min/max
        MARGIN:     21/19/22     21/18/22      22/19/23     22/19/23 dB
        PULSE ATTN:    00           01            01           01    dB
        INS LOSS:      00           00            01           01    dB
        PPM OFFSET:    00           00           -06          -06    ppm
        24 HOUR ES:   00001        00001         00002        00002  seconds
        24 HOUR UAS:  00015        00013         00002        00000  seconds

                            DS1 STATUS
                           HLU                HRU
        24 HOUR BPV Seconds:    00003             00003
        24 HOUR UAS Count:      00092             00101
        Frame type:           Unframed          Unframed
        Code type:              AMI               AMI

                    (E)xit (C)lear (U)pdate█
```

Figure 8. HLU-231 List 7D non-Doubler Status.

```
                          SET CLOCK

      TIME: 03:09:09
      DATE: 10/10/94
      CIRCUIT ID#: Pasadena Lab


      Format: HH:MM
              MM/DD/YY





      NEW TIME:

      NEW DATE:


      (U)PDATE REMOTE?█
```

Figure 9. Set Clock Menu.

```
                        SYSTEM SETTINGS

      TIME: 03:10:52
      DATE: 10/10/94                    CIRCUIT ID#: Pasadena Lab

      E(Q)UALIZATION:      EXT
      SMART-JACK (L)B:     ENABLE
      (S)PECIAL LPBK:      GNLB
      (P)OWER:             ENABLE
      (Z)BTSI:             OFF
      ES ALARM TH(R)ES:    NONE
      LOOPBACK (T)IMEOUT: 60
      (A)LARM:             DISABLE
      (D)S1 LINE CODE:     AMI
      (F)RAMING:           AUTO
      AIS ON (H)DSL LOSW: 2 LOOPS
      AIS ON S(M)JK/NREM: ENABLE
      MAR(G)IN ALM THRES: 4
      DSO (B)LOCKING: xx - Blocked Channels
      01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

                             (E)xit
           Enter the letter in parenthesis (X) to change any setting█
```

Figure 10. HLU-231 List 7D System Settings Main Menu.

```
                         LOOPBACK MENU

        TIME: 03:12:28
        DATE: 10/10/94
        CIRCUIT ID#: Pasadena Lab


                    A. DISABLE LOOPBACKS
                    B. NETWORK LOOP HLU            (NLOC)
                    C. NETWORK LOOP HRU            (NREM)
                    G. CUSTOMER LOOP HLU           (CREM)
                    H. CUSTOMER LOOP HRU           (CLOC)




                            (E)xit█
```

Figure 11. HLU-231 List 7D non-Doubler Loopback Menu.

```
        Date: 10/10/94          PERFORMANCE DATA
        CIRCUIT ID#: Pasadena Lab
                        ERRORED SECONDS/UNAVAILABLE SECONDS

                    DS1              HDSL-1            HDSL-2
                HLU      HRU      HLU      HRU      HLU      HRU
        23:30  000/000  000/000  000/000  000/000  000/000  000/000
        23:45  000/000  000/000  000/000  000/000  000/000  000/000
        00:00  000/000  000/000  000/000  000/000  000/000  000/000
        00:15  002/000  007/006  004/042  005/008  002/708  004/000
        00:30  003/000  006/006  004/027  004/009  000/553  003/000
        00:45  000/000  000/000  000/000  000/000  000/000  000/000
        01:00  000/000  000/000  000/000  000/000  000/000  000/000
        01:15  000/000  000/000  000/000  000/000  000/000  000/000
        01:30  000/000  000/000  000/000  000/000  000/000  000/000
        01:45  000/000  000/000  000/000  000/000  000/000  000/000
        02:00  000/000  000/000  000/000  000/000  000/000  000/000
        02:15  002/000  000/000  001/381  001/002  001/381  001/000
        02:30  000/000  000/000  000/900  000/000  000/900  000/000
        02:45  002/000  007/006  000/849  003/004  001/849  003/000
        03:00  000/000  000/000  000/000  000/000  000/000  000/000
        03:15  001/000  002/002  001/031  003/006  002/032  003/000

                    (E)xit (P)revious (N)ext█
```

Figure 12. HLU-231 List 7D non-Doubler Performance Data.

```
Time: 03:16:55                    7 DAY HISTORY
CIRCUIT ID#: Pasadena Lab


                  ERRORED SECONDS/UNAVAILABLE SECONDS

                 DS1                    HDSL-1                    HDSL-2
           HLU          HRU         HLU          HRU         HLU          HRU
10/03   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/04   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/05   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/06   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/07   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/08   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
10/09   00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
current 00010/00000  00022/00020  00010/02230  00016/00029  00006/03423  00014/00000






                             (E)xit█
```

Figure 13. HLU-231 List 7D non-Doubler Performance Data History.

```
                          ALARM HISTORY

        TIME: 03:18:36
        DATE: 10/10/94
        CIRCUIT ID#: Pasadena Lab

        Type            First            Last            Current       Count
        LOS, DS1-HLU                                     OK            000
        LOS, DS1-HRU                                     OK            000
        LOSW, HDSL1     10/10/94-00:00   10/10/94-03:02  OK            005
        LOSW, HDSL2     10/10/94-00:00   10/10/94-03:02  OK            004
        ES, HDSL1                                        OK            000
        ES, HDSL2                                        OK            000
        MARGIN L1       10/10/94-00:00   10/10/94-02:44  OK            005
        MARGIN L2       10/10/94-00:00   10/10/94-03:02  OK            007
        PWR-OPEN        10/10/94-00:03   10/10/94-03:02  OK            005
        PWR-SHRT        10/10/94-00:00   10/10/94-00:00  OK            001

        LAST CLEARED:  NONE


                      (E)xit (C)lear (U)pdate█
```

Figure 14. HLU-231 List 7D non-Doubler Alarm History.

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C. APPLICATIONS USING HIGAIN DOUBLER HDU-451

1. GENERAL

1.01   For Doubler applications, one or two Doublers may be used in the HDSL loops between the HLU-231 List 7D and the HRU-412. *The HLU-231, List 7D has been enhanced over the older HiGain line units so that it can line power 2 doublers and the remote unit (3 spans.)* This feature is only available when using the HDU-439, 437 List 1 "mini" doublers and the HRU-412 List 8 remote unit in HDU-231, List 7D circuits. For additional information on the "mini" doublers please refer to its technical practice #150-439-100-01. This section addresses HLU-231 List 7D operation with the HDU-451 List 1, 2, 3, & 4 or the HDU-439, 437 "mini" doublers. The List 1 and 2 doublers have identical power consumptions. The List 3 and 4 units are low power doublers which consumes 40% less power than either List 1 or 2. The Power Consumption section addresses both the high and low power doubler versions.

2. POWER CONSUMPTION

2.01   The maximum current drain is the current drawn from the shelf power supply when it is at minimum voltage (-42.5 VDC) under a worst case application. The worst case application for the HLU-231 List 7D occurs on a loop with one HDU doubler, four 9000 ft, #26 AWG spans, and an HRU-412 that is providing 60 mA of CPE current. Under these conditions the HLU-231 List 7D current drain from the -42.5 VDC battery is 0.80 A for the List 1 and 2, and 0.58 A for the List 3 and 4 doublers. This CO current and other related power parameters for this doubler application are listed in Table 12. The worst case loop conditions assumed for the 3 span line powering applications listed in Tables 12 and 13 are a 2000 ohm total loop consisting of 9000 ft, #26 AWG for span 1 and 2, and 6000 ft, #26 AWG for span 3.

2.02   The maximum shelf current drain allowed is a function of the shelf -48 VDC fuse. Table 13 lists the doubler shelf deployment guidelines, as a function of the shelf fuse, for the more popular Type 220 configuration shelves. These guidelines limit the maximum fuse load to 85% of shelf rated capacity. Use Table 13 when selecting the appropriate load fuses for the Building Distribution Fuse Bus (BDFB) when deploying the HiGain system equipment in COs.

2.03   The maximum HLU-231 List 7D power dissipation is the power that is converted into heat within the unit. It contributes to the total heat generated and is used to determine the maximum number of shelves per bay that do not exceed the maximum power dissipation density in Watts/sq. ft.

2.04   In CO locations, the maximum power dissipation for open faced, natural convection cooled mountings is 120 Watts/sq. ft. as stated in NEBS standard TR-NWT-000063 section 4.2.3. The footprint of a 13 slot 23" SXSS shelf is 7.024 sq. ft. Thus the maximum allowable dissipation is 840 W. This limits the number of HLU-231 List 7D units per bay to 80 when powering the List 1 or List 2 doubler, and to 93 when powering the List 3 or List 4 doubler. Note that this is a worst case situation since it assumes the entire CO is subjected to the maximum power density. More favorable conditions would permit increasing the number of shelves per bay without jeopardizing the CO thermal integrity.

TABLE 12. HLU-231 LIST 7D POWER PARAMETERS WITH HDU DOUBLERS, LIST 1, 2, 3 & 4, and MINI

60 mA CPE Current	CO Voltage Volts	CO Current Amps List 1, 2	CO Current Amps List 3, 4	CO Current Amps 3 Span Line Powering	Power Consumption Watts List 1, 2	Power Consumption Watts List 3, 4, Mini	Power Consumption Watts 3 Span Line Powering	HLU Power Dissipation Watts List 1, 2	HLU Power Dissipation Watts List 3, 4, Mini	HLU Power Dissipation Watts 3 Span Line Powering
OFF	42.5	0.65	0.50	0.8	28	22	34	8.5	8.25	9.0
OFF	48.0	0.59	0.41	0.7	28	22	34	8.5	8.25	9.0
OFF	56.0	0.50	0.38	0.6	28	22	34	8.5	8.25	9.0
ON	42.5	0.80	0.58	n/a	34	25	n/a	9.0	8.5	n/a
ON	48.0	0.70	0.52	n/a	34	25	n/a	9.0	8.5	n/a
ON	56.0	0.60	0.43	n/a	34	25	n/a	9.0	8.5	n/a

TABLE 13. HLU-231 LIST 7D/ HDU-451 LIST 1, 2, & 3 DEPLOYMENT GUIDELINES

Shelf Type	Shelf Fuse Amps	Max Number of Doubler Systems Per Shelf (60 mA CPE Current ON) List 1, 2	Max Number of Doubler Systems Per Shelf (60 mA CPE Current ON) List 3, 4, Mini	Max Number of Doubler Systems Per Shelf (60 mA CPE Current OFF) List 1, 2, and 3 Span Line Powering	Max Number of Doubler Systems Per Shelf (60 mA CPE Current OFF) List 3, 4, Mini
-48 V New Bays (J98725P, J98725P, J98725P)	20	13	13	13	13
SXSS (CO) (J98725CA)	10	10	13	13	13
Original 220 Bays (J98725A, B, C, D, E, F)	3.43	4	5	5	6
Upgraded 220 Bays (J98725A, B, C, D, E, F)	20	13	13	13	13
SXSS (80D Cabinet)	5	5	7	6	8
Kentrox T-Term 220	10	10	13	13	13
PairGain HCS-417	20	14	14	14	14

2.05 The thermal loading limitations imposed when using the HLU-231 List 7D in Controlled Environmental Vaults (CEV) or other enclosures are determined by applying the HLU-231 List 7D power parameters to the manufacturer requirements for each specific housing.

2.06 The power consumption listed in Table 12 is the total power that the HLU-231 List 7D consumes or draws from its -48 VDC shelf power source. This parameter is needed when the HLU-231 List 7D is located remote to its serving CO. It determines the battery capacity required to maintain an 8-hour stand-by battery reserve for emergency situations. It thus limits the maximum number of plugs per remote enclosure. Use this data to perform this analysis on a case by case basis.

3. LOOPBACK OPERATION

3.01 The HiGain system has a family of loopback options. The most important of these is the Smart-Jack loopback which enables the HRU-412 to respond to the standard (2/3 in 5) Smart-Jack in-band loopback codes. This option can be enabled or disabled from either the front panel settings or the terminal SYSTEM SETTINGS Menu Screen.

3.02 In addition to the Smart-Jack loopback, the HiGain system can be configured for one of five special in-band loopback (SPLB) command sequences. These are selected from the SPLB user options shown in Table 1. The loopback locations are shown in Figure 15.

3.03 "GNLB" is the HiGain system Generic loopback code. The GNLB allows in-band codes from the network to loop-up either the HLU/NLOC (4 in 7) or HRU/ NREM (3 in 7) towards the network. In addition, it allows in-band codes from the Network Interface (NI) to loop-up the HLU/CREM (6 in 7) or HRU/CLOC (5 in 7) towards the customer. For Doubler applications it permits looping Doubler #1 towards the network NDU1 (2 in 6) or towards the customer CDU1 (4 in 6). Doubler #2 is looped towards the network with NDU2 (3 in 6) or towards the customer with CDU2 (5 in 6). Either loop-up condition is terminated (looped-down) with the (3 in 5) loop-down code. All messages must be present for five seconds before the HiGain system will respond. Table 14 lists the test procedures that apply when using the GNLB mode.

3.04 The A1LB loopback selection (Table 15) complies with that proposed for HDSL systems in the T1/E-1.4/92 recommendation with the following additions:

- Query loopback
- IOR power-down
- Three loopback time-out choices
- Initiation from either end
- Repeating bit error signatures
- Alternate query loopback.

These additions make A1LB identical to the A2LB described below. It is given a separate identity to allow future T1/E1 enhancements to be added without affecting A2LB.

3.05 A2LB through A5LB are four special address -able repeater loopback functions which are supported by the HLU-231 List 7D HiGain system. These loopbacks provide the HiGain system with sophisticated maintenance and trouble shooting tools. Table 16 through Table 19 list the details of these SPLB functions. A2LB & A5LB are patterned after the Teltrend addressable T1 repeater loopbacks. A3LB & A4LB are patterned after the Wescom addressable T1 repeater loopbacks. All four SPLBs have been enhanced to handle the specific requirements of the following HiGain System customers:

- A2LB (Teltrend) = Southwestern Bell
- A3LB (Wescom) = New England Telephone
- A4LB (Wescom Mod 1) = New York Telephone
- A5LB (Teltrend Mod 1) = Southern New England Telephone (SNET)

3.06 A5LB differs from A2LB in that A5LB does not block the arming code from exiting the HLU-231 List 7D into the network. A2LB can be configured to either block this arming code after two seconds, and replace it with the AIS code, or to unblock it by executing the FAR-END ACTIVATE code. Since A5LB never blocks the arming code from exiting the HLU-231 List 7D, it does not need this FAR-END ACTIVATE code. A3LB differs from A4LB in that A3LB supports the additional (1 in 6) Smart-Jack loopback command.

3.07   Two additional loopback points are added for each HDU-451 doubler that is used as shown in Figure 14. NDU1 and NDU2 are executed towards the network. CDU1 and CDU2 are towards the customer. All four loopbacks can be initiated by the 16 bit in-band commands in SPLB states A1LB, A2LB & A3LB as described in Tables: Table 15, Table 16, & Table 17 respectively. NDU1 and NDU2, along with the rest of the loopbacks towards the network, can be issued from the Loopback Menu shown in Figure 23. See Section C paragraph 3.10 below for Front Panel-initiated loopbacks. The simplest HiGain system includes two loopback locations: The HLU-231 List 7D and the HRU-412. The most complex HiGain system application includes the HLU-231 List 7D, HRU-412 & two in-line HDU-451 Doublers. Refer to the PairGain HiGain Intelligent Repeater Application Note # 910, Part # 325-910-100, for more SPLB details.

3.08   When T1 loopback tests are performed on the HiGain system with metallic loopback connections at either end, the DS1 code that exists at the metallic loopback interface may be different from the DS1 code being received at the opposite end when the DS1 user code is set to AUTO. This is caused by the fact that in the AUTO DS1 code mode, the HLU-231 List 7D & HRU-412 set their own code independent of each other. Each end sets its transmit code to match its receive code. Thus if one end is receiving AMI and the other B8ZS, their codes are different. For example, if the HRU-412 has a metallic loopback and the HLU-231 List 7D receive pattern code is first changed from AMI to B8ZS, and second, the all "0" pattern is sent into the HLU-231 List 7D, the HLU-231 List 7D changes to its B8ZS mode while the HRU-412 remains in its AMI mode, and thus loops-back the all "0" pattern. This causes the HRU-412 to indicate a LOS condition, which then causes the HLU-231 List 7D to output the AIS pattern.

3.09   The HiGain system may take longer than normal to respond to in-band loopback commands when its framing mode is set to UNFR and the in-band commands are sent in either an SF or ESF mode. The frame bits override the command bits and cause errors in the command sequence. These errors cause the HiGain system to reject some sequences. This can extend the detection interval.

3.10   Depressing both the **MODE** and **SEL** push-buttons on the front panel for at least three seconds initiates a MANUAL loopback session. This session allows the user to **SEL** one of eight HiGain system loopbacks. The message, "MAN LPBK", appears on the front panel display followed by the message "NLO?". If the SEL push-button is now pressed, an "NLOC" loopback is executed and the message changes from "NLO?" to "NLOC". If the **MODE** button is pressed instead of the **SEL** push-button, "NLO?" is replaced by "ND1?". This now allows an 'NDU1' loopback to be executed (if it is a Doubler application) with the **SEL** push-button. If this same routine is followed, all eight loopbacks (NLOC, NDU1, NDU2, NREM, CLOC, CDU2, CDU1 & CREM) are presented and can be initiated in the sequence listed. Pressing the MODE push-button two more times yields the CRE and CLO loopback options in the sequence listed. This interactive push-button procedure permits any of the four HiGain loopbacks to be executed/activated.

The next loopback option can be presented by pressing the MODE push-button however, the previously executed loopback will remain active until the SEL push-button is pressed and a different loopback is activated. If neither button is pressed for a period of 30 seconds and no loopback is in effect, the manual loopback session terminates and the normal margin displays reappear. If any loopback is in effect, the 30-second time-out is inhibited. The active loopback and the manual loopback session continue until the loopback times out in accordance with the user selected LBTO setting. Only one loopback can exist at any given time. Pressing both buttons again for three seconds, terminates any active loopback, ends the MANUAL loopback session and returns the display to normal mode. Note that these same loopbacks can be initiated from the RS-232 maintenance port by choosing the LOOPBACK MODE, option D, from the MAIN MENU. This displays the Loopback Menu (Figure 23), from which any of the eight loopbacks can be initiated/terminated.

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4. TESTING

4.01   Table 14 through Table 19 provide step-by-step test procedures for the HLU-231 List 7D as a function of the loopback option selected. These procedures allow verification of the integrity of the HDSL channels at every module location as well as the DS1 channels to the customer and the local DSX-1 interface.

4.02   The HLU-231 List 7D 4-character front panel display has many useful system diagnostic messages; which are listed in Table 20. The display turns on when power is initially applied to the HLU-231 List 7D. In order to conserve power, it only remains on for five minutes if neither the **MODE** or **SEL** buttons are pressed. The use of either button activates the 4-character display and restarts the 5-minute power-control timer.

4.03   If trouble is encountered on the HLU-231 List 7D DSX-1 interface, verify that the HLU-231 List 7D (Table 2) is making a positive connection with the mounting assembly's connector. Also, verify that the equalizer is set to EXT for driving external equalizers or per the equalization settings of Table 2 for internal equalization. All installations should be set to the largest value that does not exceed the distance from the DSX-1 to the shelf.

4.04   The transmit and receive T1 DSX-1 ports have splitting access and bridging miniature 210-series jacks as shown in Figure 3. Connecting one cable between the two bridging jacks and another between the two SPAN jacks splits the XMT and RCV and creates metallic loopbacks towards both the DSX-1 and the HLU-231 List 7D. If plugs are inserted into both SPAN jacks, the BRG jacks can be used to send and receive test patterns towards the DSX-1.
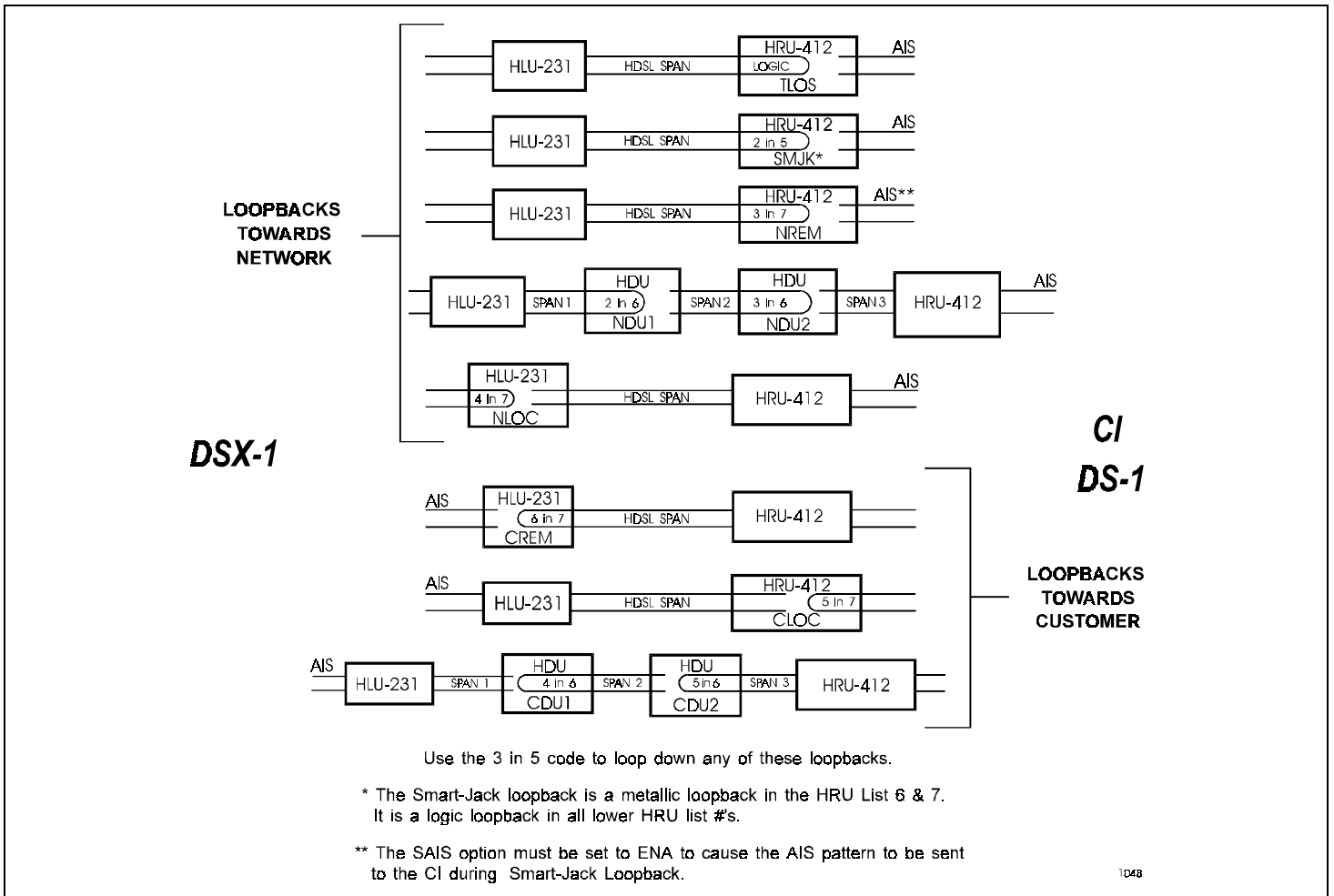
Figure 15. HLU-231 Doubler Loopback Configurations. The most important of the HiGain family of loopback options is the Smart-Jack loopback, which emulates the functions of a standard NID.

TABLE 14. HLU-231 GNLB TEST PROCEDURES

Step	Action
1	Have the CO tester send the HRU-412 (3 in 7) in-band loop-up code for five seconds. Observe that the HLU-231 List 7D displays the "NREM" message indicating an HRU-412 loopback is in effect (Figure 15).
2	Have the CO tester transmit a T1 test signal into the HLU-231 List 7D and verify that the returned (looped) signal is error free.
3	If the above test fails, have the CO tester transmit the (3 in 5) in-band loop-down code. Verify that the HLU-231 List 7D display returns to normal.
4	Have the CO tester send the HLU-231 List 7D (4 in 7) in-band loop-up for five seconds. Observe that the HLU-231 List 7D displays the "NLOC" message indicating an HLU-231 List 7D loopback is in effect.
5	Repeat Step 2. If the test passes, the problem is in the cable pair or the HRU-412. If it fails, the problem is in the CO equipment.
6	The NREM and NLOC loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10).
7	The HLU-231 List 7D can be looped-up from the remote location (CREM) by issuing the (6 in 7) command at the HRU-412 DS1 input port.
8	The HRU-412 can be looped-up from the remote location (CLOC) by issuing the (5 in 7) command at the HRU-412 DS1 input port.
9	Doubler #1 can engage loopback from the remote location (CDU1) by issuing the (4 in 6) loopback command at the HRU-412 DS1 input port.
10	Doubler #1 can engage loopback from the local location (NDU1) by issuing the (2 in 6) loopback command at the HLU-231 List 7D DS1 input port.
11	Doubler #2 can engage loopback from the remote location (CDU2) by issuing the (5 in 6) loopback command at the HRU-412 DS1 input port.
12	Doubler #2 can engage loopback from the local location (NDU2) by issuing the (3 in 6) loopback command at the HLU-231 List 7D DS1 input port.

Note 1

When T1 loopback tests are performed on the HiGain system with metallic loopback connections at either end, the DS1 code that occurs at the metallic loopback interface may be different from the DS1 code being received at the opposite end when the DS1 user code is set to AUTO. For example, if the HRU-412 has a metallic loopback and the HLU-231 List 7D receive pattern's code is changed from AMI to B8ZS and the all "0" pattern is sent into the HLU-231 List 7D, the HRU-412 remains in its AMI mode and thus loops all "0". This causes the HRU-412 to indicate a LOS condition which then causes the HLU-231 List 7D to output the AIS pattern.

Note 2

The HiGain system may take longer than normal to respond to in-band commands when its framing mode is set to UNFR and the in-band commands are sent in either an SF or ESF mode. The frame bits override the command bits and cause errors in the command sequence. These errors cause the HiGain system to reject some sequences. This can extend the detection interval.

TABLE 15. HLU-231 A1LB TEST PROCEDURES

Step	Action
1	Send into the HLU-231 List 7D the in-band ARMING and NI LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrives first)
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 15) by sending IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bit) occur in the returned pattern (10 errors if ILR-1 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands. The HLU-231 List 7D is now in Logic Loopback (NLOC of Figure 15). The display on the HLU-231 List 7D periodically shows NLOC and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 List 7D down is to issue the IR LPDN (loop-down) code 1001 0011 1001 0011 (9393) or to issue the NI LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 15. HLU-231 A1LB TEST PROCEDURES (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 15. A customer tester can activate loopbacks CLOC or CREM.

<div align="center">

ADDRESSABLE 1 (A1LB) REPEATER LOOPBACK COMMANDS

</div>

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-1 LPBK (NDU1 & CDU1 10 bit errors)	DOUBLER-1 Loop up	1100(C)0111(7)0100(4)0001(1)
ILR-20 LPBK (NDU2 & CDU2 200 bit errors)	DOUBLER-2 Loop up	1100(C)0111(7)0101(5)0100(4)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
FAR END NI ACTIVATE	Unblock AIS & pass 2 in 5	1101(C)0101(5)0101(5)0100(4)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HiGain system returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10).

TABLE 16. HLU-231 A2LB TEST PROCEDURES

Step	Action
1	Send into the HLU-231 List 7D the in-band ARMING and NI LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrives first)
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 15) by sending IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bit) occur in the returned pattern (10 errors if ILR-1 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands. The HLU-231 List 7D is now in Logic Loopback (NLOC of Figure 15). The display on the HLU-231 List 7D periodically shows NLOC and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 List 7D down is to issue the IR LPDN (loop-down) code 1001 0011 1001 0011 (9393) or to issue the NI LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 16. HLU-231 A2LB TEST PROCEDURES (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 15. A customer tester can activate loopbacks CLOC or CREM.

ADDRESSABLE 2 (A2LB) REPEATER LOOPBACK COMMANDS

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-1 LPBK (NDU1 & CDU1 10 bit errors)	DOUBLER-1 Loop up	1100(C)0111(7)0100(4)0001(1)
ILR-20 LPBK (NDU2 & CDU2 200 bit errors)	DOUBLER-2 Loop up	1100(C)0111(7)0101(5)0100(4)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
FAR END NI ACTIVATE	Unblock AIS & pass 2 in 5	1101(C)0101(5)0101(5)0100(4)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HiGain system returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10).

TABLE 17. HLU-231 A3LB TEST PROCEDURES

Step	Action
1	The HLU-231 List 7D can be looped back (NLOC in Figure 14) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least five seconds. This causes the HLU-231 List 7D to enter its NLOC state shown in Figure 15. The display on the HLU-231 List 7D alternates between NLOC (network local loop) and the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the reception of a second identical 16-bit loop-up command before the timer expires. When this time-out override state exists, the only way to loop the HLU-231 List 7D down is to issue one of the three loop-down commands listed in Step 2. The automatic time-out mode is restored during subsequent loopback sessions.
2	The following list summarizes the codes required to execute all the HiGain system loopbacks shown in Figure 15. Note that all code sequences must be present for at least five seconds.

ABBREVIATIONS USED BELOW:
LU = LoopUp
LD = LoopDown
NI = Network Interface
CI = Customer Interface
ESF-DL = Extended Super Frame Data Link

ADDRESSABLE 3 (A3LB) REPEATER LOOPBACK COMMANDS

Position	Name	Code
HLU-231 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)
HLU-231 LU FROM CI	CREM	0011(3)1111(F)0001(1)1110(E)
HDU-451 DOUBLER 1 FROM NI	NDU1	1111(F)*1111(F)0000(0)0100(4)
HDU-451 DOUBLER 1 FROM CI	CDU1	0011(3)*1111(F)0000(0)0100(4)
HDU-451 DOUBLER 2 FROM NI	NDU2	1111(F)*1111(F)0000(0)0101(6)
HDU-451 DOUBLER 2 FROM CI	CDU2	0011(3)*1111(F)0000(0)0101(6)
HRU-412 LU FROM NI	NREM	1111(F)1111(F)0000(0)0010(2)
HRU-412 LU FROM CI	CLOC	0011(3)1111(F)0000(0)0010(2)
HRU-412 LU FROM NI	SMJK	11000 11000 11000 ...
HRU-412 LU FROM NI	SMJK	100000 100000 100000 ...
HRU-412 LU FROM NI (ESF-DL)	SMJK	1111(F)1111(F)0100(4)1000(8)
HLU & HRU LD FROM NI OR CI		11100 11100 11100 ...
HLU & HRU LD FROM NI OR CI		100 100 100 ...
HLU & HRU LD FROM NI OR CI (ESF-DL)		1111(F)1111(F)0010(2)0100(4)

Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. This is the HEX number for the 4-bit group.

Step	Action
3	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10).

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TABLE 18. HLU-231 A4LB TEST PROCEDURES

Step	Action
1	The HLU-231 List 7D can be looped back (NLOC in Figure 14) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least five seconds. This causes the HLU-231 List 7D to enter its NLOC state shown in Figure 15. The display on the HLU-231 List 7D alternates between NLOC (network local loop) and the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the reception of a second identical 16-bit loop-up command before the timer expires. When this time-out override state exists, the only way to loop the HLU-231 List 7D down is to issue one of the three loop-down commands listed in Step 2. The automatic time-out mode is restored during subsequent loopback sessions.
2	The following list summarizes the codes required to execute all the HiGain system loopbacks shown in Figure 15. Note that all code sequences must be present for at least five seconds.

<div align="center">

ABBREVIATIONS USED BELOW:
LU = LoopUp
LD = LoopDown
NI = Network Interface
CI = Customer Interface
ESF-DL = Extended Super Frame Data Link

</div>

ADDRESSABLE 4 (A4LB) REPEATER LOOPBACK COMMANDS

Position	Name	Code
HLU-231 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)
HLU-231 LU FROM CI	CREM	0011(3)1111(F)0001(1)1110(E)
HDU-451 DOUBLER 1 FROM NI	NDU1	1111(F)*1111(F)0000(0)0100(4)
HDU-451 DOUBLER 1 FROM CI	CDU1	0011(3)*1111(F)0000(0)0100(4)
HDU-451 DOUBLER 2 FROM NI	NDU2	1111(F)*1111(F)0000(0)0101(6)
HDU-451 DOUBLER 2 FROM CI	CDU2	0011(3)*1111(F)0000(0)0101(6)
HRU-412 LU FROM NI	NREM	1111(F)1111(F)0000(0)0010(2)
HRU-412 LU FROM CI	CLOC	0011(3)1111(F)0000(0)0010(2)
HRU-412 LU FROM NI	SMJK	11000 11000 11000 ...
HRU-412 LU FROM NI (ESF-DL)	SMJK	1111(F)1111(F)0100(4)1000(8)
HLU & HRU LD FROM NI OR CI		11100 11100 11100 ...
HLU & HRU LD FROM NI OR CI		100 100 100 ...
HLU & HRU LD FROM NI OR CI (ESF-DL)		1111(F)1111(F)0010(2)0100(4)

Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility.). This is the HEX number for the 4-bit group.

| 3 | All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10 |

TABLE 19. HLU-231 A5LB TEST PROCEDURES

Step	Action
1	Send into the HLU-231 List 7D the in-band ARMING and NI LPBK code 11000 for at least five seconds, or at least four repetitions of the 16-bit ESF Data Link ARMING code 1111 1111 0100 1000 (FF48). (Left bit arrives first).
2	Monitor the output of the HLU-231 List 7D for the return of the pattern. Return of pattern indicates that either the HRU-412 has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NI has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU-231 List 7D and HRU-412 units have been ARMED. Verify that the HLU-231 List 7D display intermittently indicates "ARM" and also "SMJK" if the HRU-412 is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU-412 is armed or that it lights steadily, indicating that it is both armed and in loopback.
3	Once armed the HLU-231 List 7D can be looped back (NLOC in Figure 15) by sending IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response: • Two seconds of AIS (all ones), followed by: • Five seconds of returning data pattern, followed by: • 231 logic errors (including the frame bit) occur in the returned pattern (10 errors if ILR-1 were sent), followed by: • Normal looped data. Note that this error pattern will repeat every 20 seconds as long as the IOR loopback pattern is being sent. This same 20 second repeat scenario also applies to ILR, Time-Out Override and Query commands. The HLU-231 List 7D is now in Logic Loopback (NLOC of Figure 15). The display on the HLU-231 List 7D periodically shows NLOC and ARM (the HLU-231 List 7D is still armed) in addition to the margin displays. The Loopback Time-out option, which is user settable to NONE, 20, 60 or 120 minutes, determines the duration of this loopback unless it is overridden by the TIME-OUT OVERRIDE command or a loop down command is sent. If the Time-out Override code 1101 0101 1101 0110 (D5D6) is received, the "activation sequence" described in "3" above is repeated and the automatic timed expiration of the loopback is inhibited. If this Time-out Override is sent, then the only way to loop the HLU-231 List 7D down is to issue the IR (Intelligent Repeater) LPDN (loop-down) code 1001 0011 1001 0011 (9393) or to issue the NI LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-231 List 7D. The unit remains armed however, as indicated by the ARM message on the HLU-231 List 7D and the flashing of the HRU-412 LOOPBACK LED.

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TABLE 19. HLU-231 A5LB TEST PROCEDURES (CONTINUED)

Step	Action
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 15. A customer tester can activate loopbacks CLOC or CREM.

<div align="center">

ADDRESSABLE 5 (A5LB) REPEATER LOOPBACK COMMANDS

</div>

ARMING or NI LPBK (in-band)	Arming code	11000 11000 ...
ARMING or NI LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
IR LPDN or DISARM (in-band)	Disarming code	11100 11100 ...
DISARM (ESF Data Link)	Disarming code	1111(F)1111(F)0010(2)0100(4)
IOR LPBK (NLOC & CREM 231 errors)	HLU Loop up	1101(D)0011(3)1101(D)0011(3)
ILR-1 LPBK (NDU1 & CDU1 10 bit errors)	DOUBLER-1 Loop up	1100(C)0111(7)0100(4)0001(1)
ILR-20 LPBK (NDU2 & CDU2 200 bit errors)	DOUBLER-2 Loop up	1100(C)0111(7)0101(5)0100(4)
ILR-2 LPBK (NREM & CLOC 20 bit errors)	HRU Loop up	1100(C)0111(7)0100(4)0010(2)
IR LPDN	Loop down (HLU or HRU)	1001(9)0011(3)1001(9)0011(3)
IR QUERY LPBK	Query loopback	1101(D)0101(5)1101(D)0101(5)
IR ALTERNATE QUERY LPBK	Alternate Query loopback	1101(D)0101(5)1110(E)1010(A)
TIME-OUT OVERRIDE	Loopback Time-out Override	1101(D)0101(5)1101(D)0110(6)
IOR POWER DOWN (HLU)	Removes HDSL line power	0110(6)0111(7)0110(6)0111(7)

	Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random 10^{-3} Bit Error Ratio (BER) on the facility. The IOR POWER DOWN code must remain present for the duration of the power down mode. When this code is removed, the HLU-231 List 7D returns to its normal unlooped and unarmed state. This is the HEX number for the 4-bit group.
6	After testing is complete, send the universal loopdown [IR (Intelligent Repeater) LPDN] code if the system is to loopdown but remain ARMED. Send the disarm code 11100 if all the equipment is to be looped down, disarmed and returned to normal operation. Note that the ARMED mode has an automatic time-out of 120 minutes but this timer is reset to 120 for any of the following events: a) Loopback terminates (manually or time-out), b) Query, c) Alternate query, d) Far end activate, and e) Another ARM command.
7	All of the above loopbacks can also be initiated from the front panel of the HLU-231 List 7D with the **MODE** and **SEL** push-buttons (Section C Paragraph 3.10).

5. SYSTEM MAINTENANCE MENU SCREENS

5.01 Figure 16 is the Maintenance Terminal MAIN MENU Screen. Its eight sub-menus provide many useful provisioning, test and monitoring tools.

5.02 Selection "H" from the MAIN MENU Screen allows the Circuit ID# to be set. It is limited to 24 alphanumeric characters. It, like the system settings, is stored in NVRAM and thus remains when power is lost. Note that the Circuit ID# is not available at the HRU-412 Maintenance Port.

5.03 Figure 17 through Figure 20 show the HLU-231 List 7D SPAN STATUS screens for Twin Doubler applications. The SPAN 1 Screen contains data on the two HDSL loops between the HLU-231 List 7D and the first Doubler. The SPAN 2 Screen refers to the loops between the first Doubler and the HRU-412 for single-Doubler circuits or between the first and second Doublers for two-Doubler circuits. The SPAN 3 screen refers to the loops between the second Doubler and the HRU-412 for two-Doubler circuits. All status screens contain the same DS1 interface information.

Note that the HDU-439, 437 "mini" doublers are distinguished from the HDU-451 doublers by their version numbers displayed in the SPAN screen. The two mini-doublers have "ver 7.0" and above. The HDU-451 version numbers range from 1.0 to 6.9.

5.04 Figure 21 shows the SET CLOCK Menu Screen. Both the Time and Date are set with this menu. Set the hours and minutes, using the military (24-hour) convention. Setting the seconds is optional. Enter the date in the sequence and format shown. List 1 HRU-412 units having software versions 6.4 and above, and all List 6, List 7 HRU-412 units can also be set to the same time and date as the HLU-231 List 7D by entering a **U** to the "Update Remote" query. All time information is lost when power is removed. The last date, however, is retained in NVRAM and reappears when power is restored.

5.05 Figure 22 shows the SYSTEM SETTINGS Menu Screen. All 14 user options can be set from this screen. To change any option, enter its character key which is shown inside the parenthesis within each parameter description. This causes the screen to refresh with the new. After all parameters have been selected, press **E** (Exit) then **C** (Confirm). The newly selected parameters are now activated.

5.06 Figure 23 shows the LOOPBACK MENU Screen for a two-Doubler system. Each of the four modules can be looped back towards the network or the customer from this screen. NDU2 & CDU2 are not available for single Doubler applications and only NLOC, NREM, CLOC & CREM are available for non-Doubler applications.

5.07 Figure 24 through Figure 27 show the PERFORMANCE DATA screens for Doubler applications. Both the Errored and Unavailable Seconds for both HDSL loops and each T1 input are listed at 15-minute intervals over a four hour time interval. The SPAN 1 Screen contains data on the two HDSL loops between the HLU-231 List 7D and the first Doubler (HDU1). The SPAN 2 Screen refers to the loops between the first Doubler (HDU1) and the HRU-412 for one Doubler circuits or between the first and second Doublers (HDU1 & HDU2) for two-Doubler circuits. The SPAN 3 Screen refers to the loops between the second Doubler and the HRU-412 for two-Doubler circuits. All status screens contain the same DS1 interface errors. Earlier & later data, in four-hour chunks on six different screens per span, can be accessed by pressing **P** (Previous) or **N** (Next) respectively. Performance data from the different spans can be accessed by entering **S** (Span). All of the counters can be set to "0" by pressing **C** (Clear) from the HLU-231 List 7D SPAN STATUS Screen shown in Figure 17 through Figure 20. Note that since the HLU-231 List 7D is considered the master module, this clears *all* performance data screens at both the HLU-231 List 7D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared.

5.08 Figure 28 through Figure 31 show the 7-DAY PERFORMANCE HISTORY screens for Doubler applications. The "Errored Seconds" and "Unavailable Seconds" for both HDSL loops and each of the two DS1 inputs are listed for the current and previous seven days. The SPAN 1 Screen contains data on the two HDSL loops between the HLU-231 List 7D and the first Doubler (HDU1). The SPAN 2 Screen refers to the loops between the first Doubler (HDU1) and the HRU-412 for one-Doubler circuits or between the first and second Doublers (HDU1 & HDU2) for two-Doubler circuits. The SPAN 3 Screen refers to the loops between the second Doubler and the HRU-412 for two-Doubler circuits. All status screens contain the same DS-1 interface errors. All of the counters can be set to "0" by pressing **C** (Clear) on the HLU-231 List 7D SPAN STATUS Screen (Figure 17 through Figure 20). Note that since the HLU-231 List 7D is considered the master module, this clears *all* performance data screens at both the HLU-231 List 7D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared.

5.09 Figure 32 through Figure 34 show the ALARM HISTORY screens for Doubler applications. The alarms are defined in Section A Paragraph 4.01. The LOS and PWR system alarms are common to all spans. Only the LOSW, ES & MARGIN are span specific alarms. The PWR-OPEN and PWR-SHRT alarms indicate alarm conditions on the HLU-231 List. Neither PWR alarm is available on the other spans. In Figure 32 through Figure 34, the "First" & "Last" columns contain the time & date stamp of the first & last occurrence of each alarm.

The "Current" column shows the status of each alarm. The "Count" column lists the number of times each alarm occurred. All the data can be cleared by pressing **C** (Clear). The maximum non-overflowing count is 999. The SPAN 1 Screen concerns alarms that occurred on the two HDSL loops between the HLU-231 List 7D and the first Doubler (HDU1). The SPAN 2 Screen refers to the loops between the first Doubler (HDU1) and the HRU-412 for one-Doubler circuits or between the first and second Doublers (HDU1 & HDU2) for two-Doubler circuits. The SPAN 3 Screen refers to the loops between the second Doubler and the HRU-412 for two-Doubler circuits.

TABLE 20. HLU-231 LIST 7D STATUS MENU MESSAGES

Message	Full Name	Description
ALARMS:		
NONE	No Alarms	
LLOS	Local Loss of Signal	No signal from HLU-231 List 7D local T1 interface.
RLOS	Remote Loss of Signal	No signal from HRU-412 remote T1 interface.
LOSW1(2)	Loss of Sync Word 1(2)	HDSL loop 1 or 2 has lost sync.
H1ES	HDSL Loop 1 Errored Second	Loop 1 CRC have exceeded the ES threshold.
H2ES	HDSL Loop 2 Errored Second	Loop 2 CRC have exceeded the ES threshold.
DS1	Digital Service 1	BPVs for either the HLU-231 List 7D or HRU-412 DS1 input have exceeded the user selected ES threshold.
R(L)AIS	Remote (Local) Alarm Indicating Signal	Indicates an AIS (all "1") pattern is being transmitted from the remote (local) T1 output port.
MAL1	Margin Alarm 1	The margin on HDSL loop 1 has dropped below the threshold (1 to 15 dB) set by the user. Setting the threshold to 0 inhibits the margin alarm.
MAL2	Margin Alarm 2	The margin on HDSL loop 2 has dropped below the threshold (1 to 15 dB) set by the user. Setting the threshold to 0 inhibits the margin alarm.
CHREV	Channels Reversed	The Loop 1 and Loop 2 HDSL pairs are reversed at the HDU-451 or HRU-412 line input ports. Loop 1 is specified to carry the (-) simplex DC voltage, and Loop 2 is specified to carry (+) simplex DC voltage.

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TABLE 20. HLU-231 LIST 7D STATUS MENU MESSAGES (CONTINUED)

Message	Full Name	Description
LOOPBACKS:		
SMJK	Smart-Jack Loopback	Loopback at HRU-412 remote towards network initiated by (2 in 5) in-band loopback code or out-of-band ESF data link code (Figure 15).
NREM	Network Remote Loopback	Loopback at HRU-412 (remote) towards network initiated from CO (network) by Intelligent Line Repeater (ILR) #2 code, HLU-231 front panel MANUAL LOOPBACK push-buttons, HRU-412 front panel push-button, or maintenance terminal (Figure 15).
NLOC	Network Local Loopback	Loopback at HLU-231 List 7D (local) towards network initiated from C0 by IOR code, HLU-231 front panel MANUAL LOOPBACK push-buttons or maintenance terminal (Figure 15).
HDU1	Network Doubler 1 Loopback	Loopback at Doubler #1 towards network initiated by IOR code or HLU-231 front panel MANUAL LOOPBACK push-buttons or maintenance terminal (Figure 15).
HDU2	Network Doubler 2 Loopback	Loopback at Doubler #2 towards network initiated by IOR code or HLU-231 front panel MANUAL LOOPBACK push-buttons or maintenance terminal (Figure 15).
CLOC	Customer Local Loopback	Loopback at HRU-412 (local) towards CI initiated from CPE by ILR code or HLU-231 front panel MANUAL LOOPBACK push-button or maintenance terminal (Figure 15).
CREM	Customer Remote Loopback	Loopback at HLU-231 List 7D (remote) towards customer initiated by IOR code or HLU front panel MANUAL LOOPBACK push-buttons, or maintenance terminal (Figure 15).
CDU 1	Customer Doubler 1 Loopback	Loopback at Doubler 1 towards CI initiated by ILR code, HLU-231 front panel MANUAL LOOPBACK push-buttons, or maintenance terminal (Figure 15).
CDU 2	Customer Doubler 2 Loopback	Loopback at Doubler 2 towards CI initiated by ILR code, HLU-231 front panel MANUAL LOOPBACK push-buttons, or maintenance terminal (Figure 15).
ARM	Armed	The HiGain system has detected the IR loopback (2 in 5) arming code.
TLOS	Transmit Loss of Signal Loopback	HRU-412 is in a logic loopback state caused by a loss of its T1 input from the CI, if enabled at the HRU-412 via its TLOS switch option.

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TABLE 21. GLOSSARY OF HIGAIN TERMS

Term	*Definition*
MARGINS	Indicates the excess signal to noise ratio, at the HRU-412, HDU-451, or HLU-231 List 7D HDSL ports, relative to a 10^{-7} BER. 1st value is current margin, 2nd value is minimum margin since (C)leared last, 3rd value is maximum value since cleared. NA means Not Available (loop is not in sync). The normal range of a typical margin is from 22 to 6 dB.
PULSE ATTENUATION	Indicates the attenuation of the 2B1Q pulse from the distant end. The HiGain system operates with pulse attenuations in excess of 30 dB. This value is related to the cable pair's 196 kHz loss. The pulse attenuation is a more direct indication of the loop attenuation to the 2B1Q signal than the 196 kHz loss. The normal range of pulse attenuation is from 1 to 32 dB.
PPM	Indicates the relative offset of the crystal oscillator in the HRU-412 from the HLU-231 List 7D crystal oscillator. Any value between -64 and +64 is adequate. Values outside this range indicate out of tolerance components or excessive temperature drift in critical components.
HDSL 24 Hour ES (Errored Seconds)	The number of 1 second intervals that contained at least 1 CRC error. This value is a running total of the last 24 Hours.
HDSL 24 Hour UAS (Unavailable Seconds)	The number of seconds the HDSL loop was out of sync.
DS1 BPV Seconds (ES)	The number of seconds in which at least 1 BPV was detected on the DS1 input.
DS1 UAS Count	The number of seconds during which the DS1 input signal was absent (125 or more consecutive "0").
Frame type	Type of DS1 framing used on the input stream (SF, ESF, Unframed or No Activity).
Code type	Type of DS1 line coding used (AMI, B8ZS, AMI : ZBTSI or B8ZS : ZBTSI). The latter two conditions indicate the code type that is being received when the HiGain system is set to its ZBTS mode. In either the AMI or B8ZS DS1 code mode, the Code type displays the selected code as opposed to the code type that is actually being received, which is what is displayed when set to AUTO code mode.
HLU/Ver w.x-y	"w.x" = software version number of the HLU-231 List 7D. "y" = list # of HLU-231 List 7D.
HRU/Ver a.b-c	"a.b" = software version number of the HRU-412. "c" = list # of HRU-412.
HDU1/Ver s.t-u	"s.t." = the software version number of the HD-451 #1. "u" = List number of the HD-451 #1.
HDU2/Ver f.g-h	"f.g." = the software version number of the HD-451 #2. "h" = List number of the HD-451 #2.

TABLE 22. HLU-231, LIST 7D 4-CHARACTER FRONT PANEL MESSAGES

Message	Full Name	Description
CREM	Customer Remote Loopback	Signal from customer is looped back to customer at HLU-231.
NLOC	Network Local Loopback	DSX signal is looped back to DSX at HLU.
CLOC	Customer Local Loopback	Signal from Customer is looped back to customer at HRU-412.
NREM	Network Remote Loopback	DSX signal is looped back to DSX at HRU.
SMJK	Remote Smartjack Loopback	Signal from DSX is looped back at HRU by the HRU smartjack module.
TLOS	Transmit Loss Of Signal	HRU is in a logic loopback state caused by a loss of its T1 input from the CI, if enabled at the HRU via its TLOS switch option.
FERR	Framing Bit Error Occurred	Framing bit error occurred at HLU T1 input.
LBPV	Local Bipolar Violation	A bipolar violation has been received at the T1 input to the HLU-231.
SIG 1 or 2	Signal 1 or Signal 2	The HLU & HRU or 1st Doubler transceivers are trying to establish contact with each other on Loops 1 or 2 of span 1.
S2L1 or 2	Signal 2 Loop 1 or Loop 2	The 1st Doubler and either HRU or 2nd Doubler transceivers are trying to establish contact with each other on loops 1 or 2 of span 2.
S3L1 or 2	Signal 3 Loop 1 or Loop 2	The 2nd Doubler and HRU transceivers are trying to establish contact with each other on loops 1 or 2 of span 3.
ACQ 1 or 2	Acquisition 1 or Acquisition 2	The HLU & HRU or 1st Doubler multiplexers are trying to establish synchronization over each of Loops 1 or 2 of span 1
A2L1 or 2	Acquisition 2 Loop 1 or Loop 2	The 1st Doubler and either HRU or 2nd Doubler multiplexers are trying to establish synchronization with each other on loops 1 or 2 of span 2.
A3L1 or 2	Acquisition 3 Loop 1 or Loop 2	The 2nd Doubler and HRU multiplexers are trying to establish synchronization with each other on loops 1 or 2 of span 3.
H1ES	HDSL CRC Error Channel 1	HLU HDSL Loop 1 CRC error.
H2ES	HDSL CRC Error Channel 2	HLU HDSL Loop 2 CRC error.
ARM	HiGain System ARMED	Armed to respond to Intelligent Repeater Loop Codes.
ACO	Alarm CutOff	A minor alarm has occurred, and been retired to an ACO condition, by pressing the **SEL** button on the HLU front panel.

Table continued on next page

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TABLE 22. HLU-231, LIST 7D 4-CHARACTER FRONT PANEL MESSAGES (CONTINUED)

Message	Full Name	Description
SELF TEST		The HLU is in a self test mode. This occurs every power ON/OFF cycle.
ALRM	Alarm Condition Exists	A minor alarm condition is in effect.
1=xx or 2=yy	HDSL Loop Margins	Indicates the power of the received HDSL signal on each Loop relative to noise. Any value of '06' or greater is adequate for reliable system operation.
PWR FEED SHRT	Power Feed Short	Indicates a short between the 2 HDSL pairs in Span 1. This same message can occur with an HRU that is drawing the correct amount of power over good cable pairs but cannot communicate with the HLU.
PWR FEED OPEN	Power Feed Open	Indicates an open circuit in the T&R of either HDSL pair in Span 1.
PWR FEED OFF	Power Feed Off	HDSL span power has been turned off by setting the PWFD option to DIS.
BAD RT?	No response from HRU	The HLU does not receive any response from the HRU. Thus, the HRU's integrity is questionable.
VER	HLU Software Version #	This is displayed during the System Settings review mode. Depress the **MODE** button for 3 seconds.
LIST 0xL	HLU's List #	Displayed during System Settings review mode defined above.
FRM	Frame:SF,ESF,UNFR,NONE	Defines the type of frame pattern being received from the DSX-1. Displayed during System Settings mode defined above.
LOSW	Loss of Sync Word	Indicates that 1 of the HDSL loops has lost sync. Causes a minor alarm.
LLOS	Local Loss of Signal	Indicates that no signal is detected at the T1 input to the HLU. Causes a minor alarm.
RLOS	Remote Loss of Signal	Indicates that no signal is detected at the T1 input to the HRU. Causes a minor alarm.
DS1	DS1 BPV errors	Indicates that the number of BPVs at the HLU or HRU DS1 inputs have exceeded the 24 hour ES threshold. Causes a minor alarm.
DS0	DS0 Blocked Channels	Indicates status of DS0 blocked channels. NONE indicates no channels are blocked. BLK indicates some channels are blocked.
MAL1(2)	Margin Alarm Loop 1 or 2	The margin on HDSL loop 1 (2) has dropped below the threshold (1 to 15 dB) set by the user.

```
HI-GAIN HLU-231    MAINTENANCE TERMINAL MAIN MENU    (ver V2.2L-007D)
                        CIRCUIT ID#: Pasadena Lab

                    A. VIEW SPAN STATUS
                    B. SET CLOCK
                    C. SYSTEM SETTINGS
                    D. LOOPBACK MODE:  NONE
                    E. VIEW PERFORMANCE DATA
                    F. VIEW PERFORMANCE HISTORY
                    G. VIEW ALARM HISTORY
                    H. ENTER CIRCUIT ID #
```

Figure 16. HLU-231 List 7D Main Menu.

```
                            SPAN 1 STATUS
                    ( HLU/ver2.2-007D:HDU1/ver1.7-00FF)
        TIME: 00:26:21
        DATE: 03/21/96                CIRCUIT ID#: Pasadena Lab
        ALARMS:   NONE
        LOOPBACK: OFF
                            HLU                     HDU1
                    HDSL-1      HDSL-2       HDSL-1      HDSL-2
                    cur/min/max cur/min/max  cur/min/max cur/min/max
        MARGIN:     13/12/14    13/11/14     13/00/14    15/00/15 dB
        PULSE ATTN:    29          29           28          28    dB
        INS LOSS:      36          36           35          35    dB
        PPM OFFSET:    00          00          -11         -11    ppm
        24 HOUR ES:   00003       00004        00003       00003  seconds
        24 HOUR UAS:  00224       00228        00005       00009  seconds

                            DS1 STATUS
                            HLU                     HRU
        24 HOUR BPV Seconds:    00016               00007
        24 HOUR UAS Count:      00000               00006
        Frame type:             ESF                 ESF
        Code type:              AMI                 AMI

                    (E)xit (C)lear (U)pdate (S)pan█
```

Figure 17. HLU-231 List 7D Status Display - Span 1 (1 or 2 Doublers).

```
                         SPAN 2 STATUS
                 (HDU1/ver1.2-00FF: HRU/ver1.6-0006)
   TIME: 01:37:46
   DATE: 03/21/96                    CIRCUIT ID#: Pasadena Lab
   ALARMS:   CHREV LAIS RAIS LLOS RLOS
   LOOPBACK: OFF
                        HDU1                        HRU
                 HDSL-1       HDSL-2         HDSL-1       HDSL-2
                cur/min/max  cur/min/max    cur/min/max  cur/min/max
   MARGIN:       22/00/23     22/00/23       22/20/22     22/20/22  dB
   PULSE ATTN:     00           01             00           01      dB
   INS LOSS:       00           01             00           01      dB
   PPM OFFSET:     00           00             21           22      ppm
   24 HOUR ES:    00002        00002          00008        00010    seconds
   24 HOUR UAS:   00043        00041          00026        00006    seconds

                            DS1 STATUS
                          HLU              HRU
   24 HOUR BPV Seconds:   00000            00008
   24 HOUR UAS Count:     05851            05597
   Frame type:         No Activity      No Activity
   Code type:             AMI              AMI

                (E)xit (C)lear (U)pdate (S)pan
```

Figure 18. HLU-231 List 7D Status Display - Span 2 (1 Doubler).

```
                         SPAN 2 STATUS
                 (HDU1/ver1.2-00FF:HDU2/ver1.4-0003)
   TIME: 01:41:44
   DATE: 10/10/94                    CIRCUIT ID#: Pasadena Lab

   ALARMS:   NONE
   LOOPBACK: OFF
                        HDU1                        HDU2
                 HDSL-1       HDSL-2         HDSL-1       HDSL-2
                cur/min/max  cur/min/max    cur/min/max  cur/min/max
   MARGIN:       22/00/23     22/00/23       22/00/23     21/00/22  dB
   PULSE ATTN:     00           01             01           01      dB
   PPM OFFSET:     00           00             01           00      ppm
   24 HOUR ES:    00000        00002          00001        00000    seconds
   24 HOUR UAS:   00009        00013          00009        00013    seconds

                            DS1 STATUS
                          HLU              HRU
   24 HOUR BPV Seconds:   00005            00013
   24 HOUR UAS Count:     00000            00012
   Frame type:         Unframed         Unframed
   Code type:             AMI              AMI

                (E)xit (C)lear (U)pdate (S)pan█
```

Figure 19. HLU-231 List 7D Status Display - Span 2 (2 Doublers).

```
                        SPAN 3 STATUS
                (HDU2/ver1.4-0003: HRU/ver1.6-0007)
     TIME: 01:43:09
     DATE: 10/10/94                    CIRCUIT ID#: Pasadena Lab

     ALARMS:   CHREV
     LOOPBACK: OFF
                      HDU2                        HRU
                HDSL-1       HDSL-2        HDSL-1       HDSL-2
              cur/min/max  cur/min/max   cur/min/max  cur/min/max
     MARGIN:    21/00/22     21/00/22      21/19/22     20/19/22 dB
     PULSE ATTN:   00           00            00           00    dB
     PPM OFFSET:   00           00            01           01    ppm
     24 HOUR ES:  00000        00001         00009        00007  seconds
     24 HOUR UAS: 00005        00014         00017        00000  seconds

                           DS1 STATUS
                        HLU              HRU
     24 HOUR BPV Seconds:  00005            00013
     24 HOUR UAS Count:    00000            00012
     Frame type:        Unframed         Unframed
     Code type:           AMI              AMI

                 (E)xit (C)lear (U)pdate (S)pan█
```

Figure 20. HLU-231 List 7D Status Display - Span 3 (2 Doublers).

```
                        SET CLOCK

     TIME: 01:44:56
     DATE: 10/10/94
     CIRCUIT ID#: Pasadena Lab



     Format: HH:MM
             MM/DD/YY













     NEW TIME:


     NEW DATE:




     (U)PDATE REMOTE?█
```

Figure 21. HLU-231 List 7D Set Clock Menu.

```
                        SYSTEM SETTINGS

   TIME: 01:20:40
   DATE: 10/10/94                    CIRCUIT ID#: Pasadena Lab

   E(Q)UALIZATION:      EXT
   SMART-JACK (L)B:     ENABLE
   (S)PECIAL LPBK:      GNLB
   (P)OWER:             ENABLE
   (Z)BTSI:             OFF
   ES ALARM TH(R)ES:    NONE
   LOOPBACK (T)IMEOUT:  60
   (A)LARM:             DISABLE
   (D)S1 LINE CODE:     AMI
   (F)RAMING:           AUTO
   AIS ON (H)DSL LOSW:  2 LOOPS
   AIS ON S(M)JK/NREM:  ENABLE
   MAR(G)IN ALM THRES:  4
   DSO (B)LOCKING: xx - Blocked Channels
   01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

                            (E)xit
         Enter the letter in parenthesis (X) to change any setting█
```

Figure 22. HLU-231 List 7D Systems Settings Menu.

```
                        LOOPBACK MENU

   TIME: 01:22:54
   DATE: 10/10/94
   CIRCUIT ID#: Pasadena Lab


                A. DISABLE LOOPBACKS
                B. NETWORK LOOP HLU           (NLOC)
                C. NETWORK LOOP HRU           (NREM)
                D. NETWORK LOOP DOUBLER 1     (NDU1)
                F. NETWORK LOOP DOUBLER 2     (NDU2)
                G. CUSTOMER LOOP HLU          (CREM)
                H. CUSTOMER LOOP HRU          (CLOC)
                I. CUSTOMER LOOP DOUBLER 1    (CDU1)
                J. CUSTOMER LOOP DOUBLER 2    (CDU2)




                            (E)xit█
```

Figure 23. HLU-231 List 7D Doubler Loopback Menu.

```
Date: 10/10/94          SPAN 1 PERFORMANCE DATA
CIRCUIT ID#: Pasadena Lab
                   ERRORED SECONDS/UNAVAILABLE SECONDS

                DS1                HDSL-1              HDSL-2
           HLU       HRU       HLU       HDU1      HLU       HDU1
22:00   000/000   000/000   000/000   000/000   000/000   000/000
22:15   000/000   000/000   000/000   000/000   000/000   000/000
22:30   000/000   000/000   000/000   000/000   000/000   000/000
22:45   000/000   000/000   000/000   000/000   000/000   000/000
23:00   000/000   000/000   000/000   000/000   000/000   000/000
23:15   000/000   000/000   000/000   000/000   000/000   000/000
23:30   000/000   000/000   000/000   000/000   000/000   000/000
23:45   000/000   000/000   000/000   000/000   000/000   000/000
00:00   000/000   000/000   000/000   000/000   000/000   000/000
00:15   002/000   007/006   004/042   516/009   002/708   000/675
00:30   003/000   006/006   004/027   415/005   000/553   001/529
00:45   000/000   000/000   000/000   000/000   000/000   000/000
01:00   000/000   000/000   000/000   000/000   000/000   000/000
01:15   000/000   000/000   000/000   000/000   000/000   000/000
01:30   000/000   000/000   000/000   000/000   000/000   000/000
01:45   000/000   000/000   000/000   000/000   000/000   000/000

                   (E)xit (P)revious (N)ext (S)pan█
```

Figure 24. HLU-231 List 7D Performance Data - Span 1 (1 or 2 Doublers).

```
Date: 03/21/96          SPAN 2 PERFORMANCE DATA
CIRCUIT ID#: Pasadena Lab
                   ERRORED SECONDS/UNAVAILABLE SECONDS

                DS1                HDSL-1              HDSL-2
           HLU       HRU       HDU1      HRU       HDU1      HRU
21:45   000/000   000/000   000/000   000/000   000/000   000/000
22:00   000/000   000/000   000/000   000/000   000/000   000/000
22:15   000/000   000/000   000/000   000/000   000/000   000/000
22:30   000/000   000/000   000/000   000/000   000/000   000/000
22:45   000/000   000/000   000/000   000/000   000/000   000/000
23:00   000/000   000/000   000/000   000/000   000/000   000/000
23:15   000/000   000/000   000/000   000/000   000/000   000/000
23:30   000/000   000/000   000/000   000/000   000/000   000/000
23:45   000/000   000/000   000/000   000/000   000/000   000/000
00:00   000/000   000/000   000/000   000/000   000/000   000/000
00:15   000/898   003/820   001/005   002/000   001/005   003/000
00:30   000/900   000/900   000/000   000/000   000/000   000/000
00:45   000/900   000/900   000/000   000/000   000/000   000/000
01:00   000/900   000/900   000/000   000/000   000/000   000/000
01:15   000/900   000/900   000/000   000/000   000/000   000/000
01:30   000/900   000/900   000/000   000/000   000/000   000/000

                   (E)xit (P)revious (N)ext (S)pan█
```

Figure 25. HLU-231 List 7D Performance Data - Span 2 (1 Doubler).

```
Date: 10/10/94          SPAN 2 PERFORMANCE DATA
CIRCUIT ID#: Pasadena Lab
                    ERRORED SECONDS/UNAVAILABLE SECONDS

              DS1              HDSL-1            HDSL-2
         HLU      HRU      HDU1     HDU2     HDU1     HDU2
22:00  000/000  000/000  000/000  000/000  000/000  000/000
22:15  000/000  000/000  000/000  000/000  000/000  000/000
22:30  000/000  000/000  000/000  000/000  000/000  000/000
22:45  000/000  000/000  000/000  000/000  000/000  000/000
23:00  000/000  000/000  000/000  000/000  000/000  000/000
23:15  000/000  000/000  000/000  000/000  000/000  000/000
23:30  000/000  000/000  000/000  000/000  000/000  000/000
23:45  000/000  000/000  000/000  000/000  000/000  000/000
00:00  000/000  000/000  000/000  000/000  000/000  000/000
00:15  002/000  007/006  000/006  001/005  001/005  000/004
00:30  003/000  006/006  000/003  000/004  001/008  000/009
00:45  000/000  000/000  000/000  000/000  000/000  000/000
01:00  000/000  000/000  000/000  000/000  000/000  000/000
01:15  000/000  000/000  000/000  000/000  000/000  000/000
01:30  000/000  000/000  000/000  000/000  000/000  000/000
01:45  000/000  000/000  000/000  000/000  000/000  000/000

              (E)xit (P)revious (N)ext (S)pan
```

Figure 26. HLU-231 List 7D Performance Data - Span 2 (2 Doublers).

```
Date: 10/10/94          SPAN 3 PERFORMANCE DATA
CIRCUIT ID#: Pasadena Lab
                    ERRORED SECONDS/UNAVAILABLE SECONDS

              DS1              HDSL-1            HDSL-2
         HLU      HRU      HDU2     HRU      HDU2     HRU
22:00  000/000  000/000  000/000  000/000  000/000  000/000
22:15  000/000  000/000  000/000  000/000  000/000  000/000
22:30  000/000  000/000  000/000  000/000  000/000  000/000
22:45  000/000  000/000  000/000  000/000  000/000  000/000
23:00  000/000  000/000  000/000  000/000  000/000  000/000
23:15  000/000  000/000  000/000  000/000  000/000  000/000
23:30  000/000  000/000  000/000  000/000  000/000  000/000
23:45  000/000  000/000  000/000  000/000  000/000  000/000
00:00  000/000  000/000  000/000  000/000  000/000  000/000
00:15  002/000  007/006  000/003  005/008  000/007  004/000
00:30  003/000  006/006  000/002  004/009  001/007  003/000
00:45  000/000  000/000  000/000  000/000  000/000  000/000
01:00  000/000  000/000  000/000  000/000  000/000  000/000
01:15  000/000  000/000  000/000  000/000  000/000  000/000
01:30  000/000  000/000  000/000  000/000  000/000  000/000
01:45  000/000  000/000  000/000  000/000  000/000  000/000

              (E)xit (P)revious (N)ext (S)pan
```

Figure 27. HLU-231 List 7D Performance Data - Span 3 (2 Doublers).

```
Time: 02:51:33                    7 DAY HISTORY
CIRCUIT ID#: Pasadena Lab


                              SPAN 1
                   ERRORED SECONDS/UNAVAILABLE SECONDS


              DS1                  HDSL-1                  HDSL-2
         HLU         HRU         HLU         HDU1        HLU         HDU1
10/03  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/04  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/05  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/06  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/07  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/08  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/09  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
current 00009/00000 00020/00018 00009/02199 00931/00018 00004/03391 00001/01208








                         (E)xit (S)pan█
```

Figure 28. HLU-231 List 7D Performance Data History - Span 1 (1 or 2 Doublers).

```
  CIRCUIT ID#: Pasadena Lab


                              SPAN 2
                   ERRORED SECONDS/UNAVAILABLE SECONDS


              DS1                  HDSL-1                  HDSL-2
         HLU         HRU         HDU1        HRU         HDU1        HRU
03/14  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/15  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/16  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/17  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/18  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/19  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
03/20  00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/0000
current 00000/06282 00008/06028 00002/00043 00008/00026 00002/00041 00010/0000








                         (E)xit (S)pan█
```

Figure 29. HLU-231 List 7D Performance Data History - Span 2 (1 Doubler).

```
Time: 02:54:49                      7 DAY HISTORY
CIRCUIT ID#: Pasadena Lab


                                SPAN 2
                    ERRORED SECONDS/UNAVAILABLE SECONDS


                DS1                    HDSL-1                    HDSL-2
          HLU          HRU        HDU1         HDU2        HDU1         HDU2
10/03   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/04   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/05   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/06   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/07   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/08   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/09   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
current 00009/00000 00020/00018 00000/00014 00001/00014 00003/00017 00001/00017








                         (E)xit (S)pan█
```

Figure 30. HLU-231 List 7D Performance Data History - Span 2 (2 Doublers).

```
Time: 02:57:23                      7 DAY HISTORY
CIRCUIT ID#: Pasadena Lab


                                SPAN 3
                    ERRORED SECONDS/UNAVAILABLE SECONDS


                DS1                    HDSL-1                    HDSL-2
          HLU          HRU        HDU2         HRU         HDU2         HRU
10/03   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/04   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/05   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/06   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/07   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/08   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
10/09   00000/00000 00000/00000 00000/00000 00000/00000 00000/00000 00000/00000
current 00009/00000 00020/00018 00001/00011 00013/00023 00001/00020 00011/00000








                         (E)xit (S)pan█
```

Figure 31. HLU-231 List 7D Performance Data History - Span 3 (2 Doublers).
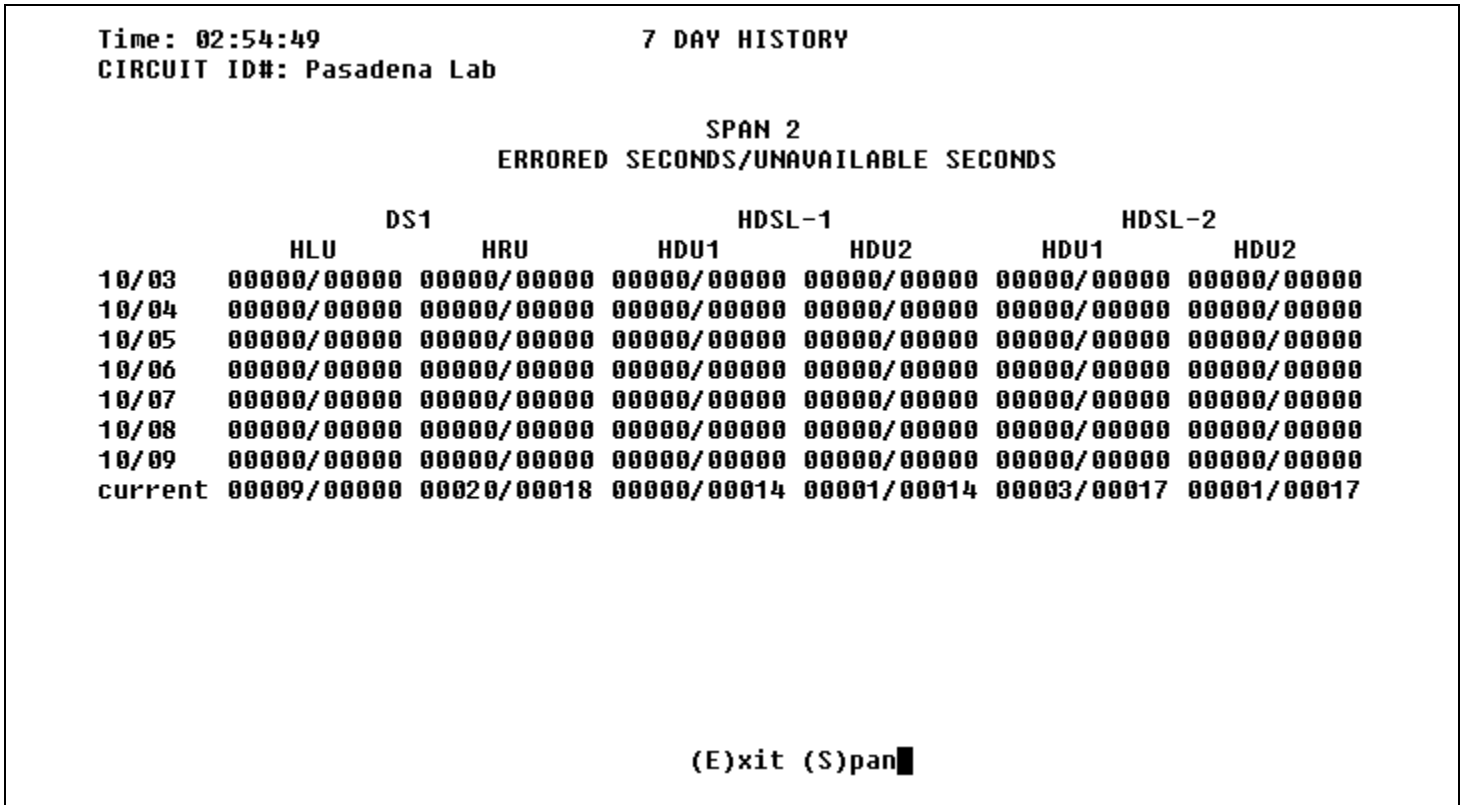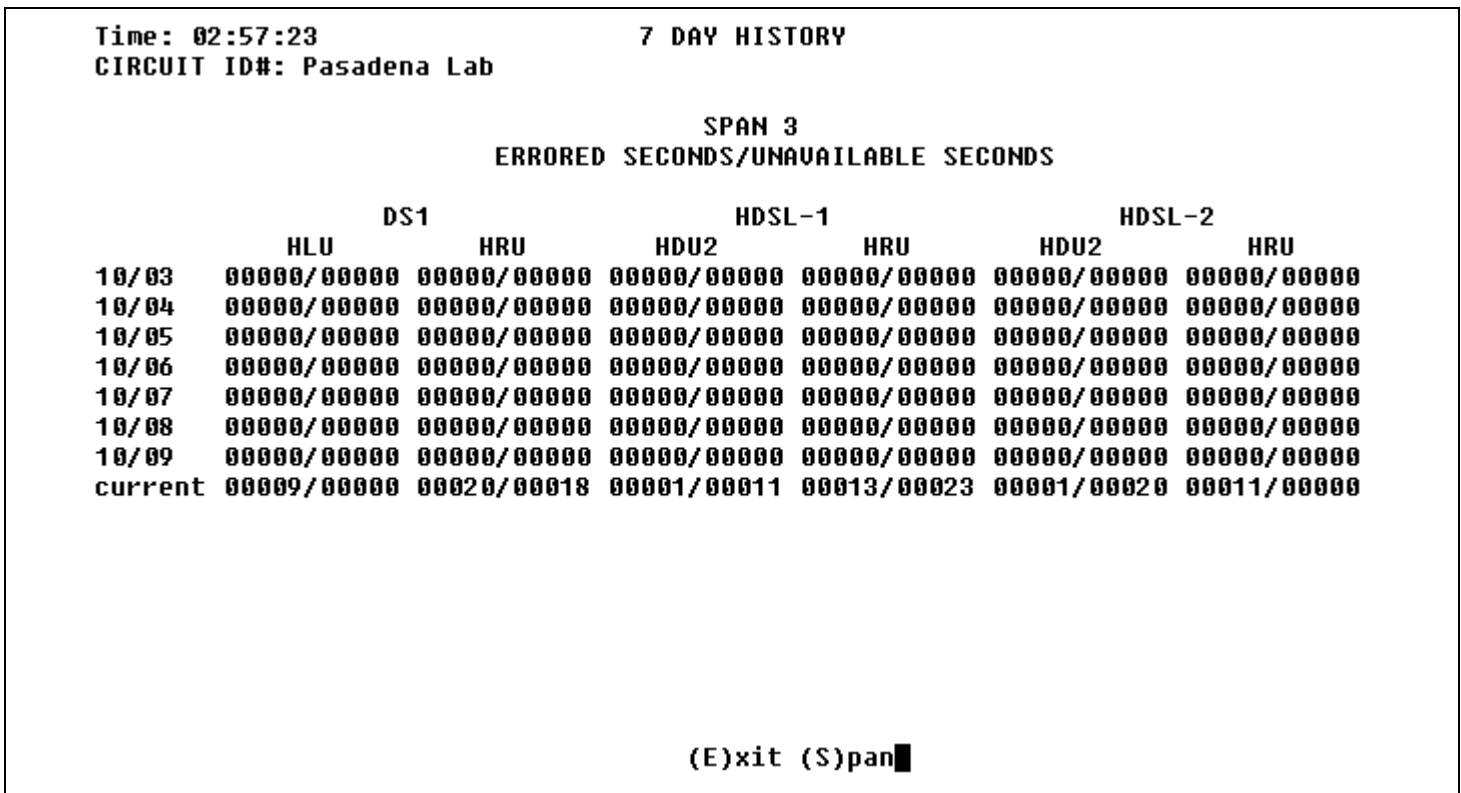
```
                         ALARM HISTORY

      TIME: 02:01:55
      DATE: 10/10/94
      CIRCUIT ID#: Pasadena Lab

      Type              First              Last              Current      Count
      LOS, DS1-HLU                                           OK           000
      LOS, DS1-HRU                                           OK           000
      SPAN1 LOSW, HDSL1 10/10/94-00:00     10/10/94-00:23    OK           003
      SPAN1 LOSW, HDSL2 10/10/94-00:00     10/10/94-00:03    OK           002
      SPAN1 ES, HDSL1                                        OK           000
      SPAN1 ES, HDSL2                                        OK           000
      SPAN1 MARGIN L1   10/10/94-00:00     10/10/94-00:24    OK           003
      SPAN1 MARGIN L2   10/10/94-00:00     10/10/94-00:24    OK           004
      PWR-OPEN          10/10/94-00:03     10/10/94-00:23    OK           002
      PWR-SHRT          10/10/94-00:00     10/10/94-00:00    OK           001

      LAST CLEARED:  NONE


                        (E)xit (C)lear (U)pdate (S)pan█
```

Figure 32. HLU-231 List 7D Alarm History - Span 1 (1 or 2 Doublers).

```
                         ALARM HISTORY

      TIME: 02:04:16
      DATE: 10/10/94
      CIRCUIT ID#: Pasadena Lab

      Type              First              Last              Current      Count
      LOS, DS1-HLU                                           OK           000
      LOS, DS1-HRU                                           OK           000
      SPAN2 LOSW, HDSL1 10/10/94-00:00     10/10/94-00:03    OK           002
      SPAN2 LOSW, HDSL2 10/10/94-00:00     10/10/94-00:03    OK           002
      SPAN2 ES, HDSL1                                        OK           000
      SPAN2 ES, HDSL2                                        OK           000
      SPAN2 MARGIN L1   10/10/94-00:00     10/10/94-00:24    OK           003
      SPAN2 MARGIN L2   10/10/94-00:00     10/10/94-00:24    OK           003
      PWR-OPEN          10/10/94-00:03     10/10/94-00:23    OK           002
      PWR-SHRT          10/10/94-00:00     10/10/94-00:00    OK           001

      LAST CLEARED:  NONE


                        (E)xit (C)lear (U)pdate (S)pan█
```

Figure 33. HLU-231 List 7D Alarm History - Span 2 (1 or 2 Doublers).

```
                         ALARM HISTORY

     TIME: 02:06:37
     DATE: 10/10/94
     CIRCUIT ID#: Pasadena Lab

     Type              First              Last              Current      Count
     LOS, DS1-HLU                                           OK           000
     LOS, DS1-HRU                                           OK           000
     SPAN3 LOSW, HDSL1 10/10/94-00:00     10/10/94-00:03    OK           002
     SPAN3 LOSW, HDSL2 10/10/94-00:00     10/10/94-00:03    OK           002
     SPAN3 ES, HDSL1                                        OK           000
     SPAN3 ES, HDSL2                                        OK           000
     SPAN3 MARGIN L1   10/10/94-00:00     10/10/94-00:25    OK           002
     SPAN3 MARGIN L2   10/10/94-00:00     10/10/94-00:00    OK           001
     PWR-OPEN          10/10/94-00:03     10/10/94-00:23    OK           002
     PWR-SHRT          10/10/94-00:00     10/10/94-00:00    OK           001

     LAST CLEARED:  NONE


                      (E)xit (C)lear (U)pdate (S)pan█
```

Figure 34. HLU-231 List 7D Alarm History - Span 3 (2 Doublers).