

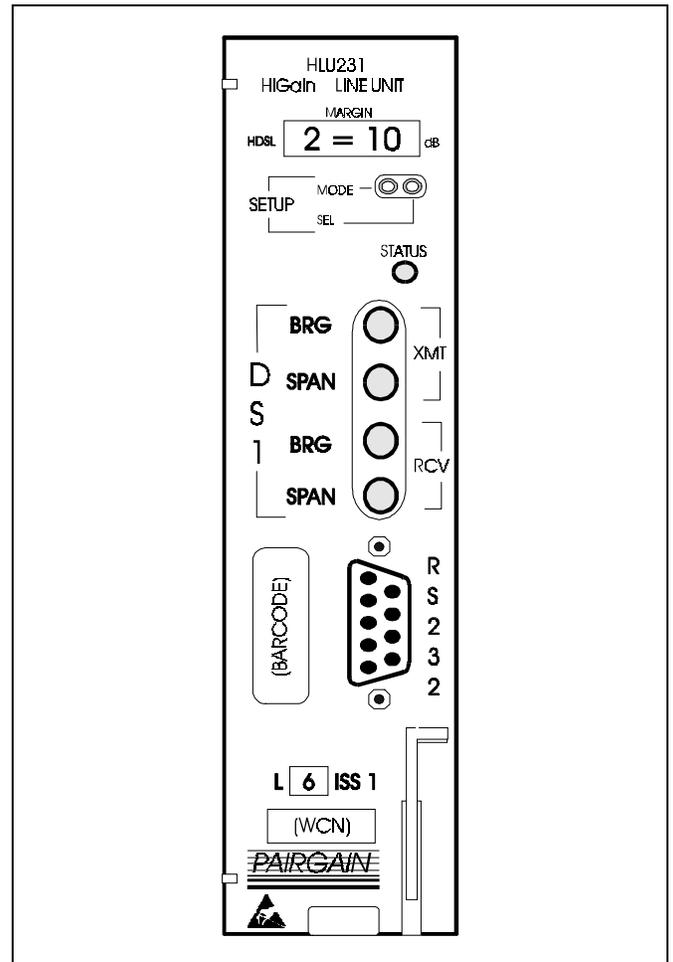
# PAIRGAIN™ TECHNOLOGIES HiGAIN™ LINE UNIT

## MODEL HLU-231 Issue 1

List 6, PairGain #150-1111-06 CLEI Code: T1LIE1N4AA

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



**Figure 1. HLU-231, List 6 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.

## **A. PRODUCT OVERVIEW**

### **1. DESCRIPTION AND FEATURES**

**1.01** PairGain's HiGain Line Unit Model HLU-231 Issue 1, List 6 (Figure 1) is the Central Office (CO) side of a repeaterless T1 transmission system. When used in conjunction with an HRU-412 HiGain Remote Unit, the system provides 1.544 Mb/s transmission on two unconditioned copper pairs over the full Carrier Serving Area (CSA) range. 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. HiGain 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 05—February 3, 1995**

- a) Changed the default setting of the DS1 line code to AMI.
- b) This change initiated by software version 1.4.

**1.03** HLU-231, List 6, Issue 1 features:

- Selectable DSX-1 Pre-equalizer
- -130 VDC Line Power for HRU-412
- Front Panel HDSL S/N Margin Display
- Selectable Loopback activation codes
- RS-232 maintenance port
- Non-volatile front-panel operator setup
- Front Panel DS1 splitting & brdg access
- Lightning and power cross protection on HDSL interfaces
- 784 kbps full-duplex 2B1Q HDSL transmission on two pairs
- Front panel status indicating LED
- On / Off front panel display power cycling
- DS1 LOS detector (125 consecutive zeros)
- Margin threshold alarm
- HAIS & SAIS options
- Easy return to factory default user settings
- New T1 transceiver chip
- Circuit ID option.

### **2. APPLICATIONS**

**2.01** HiGain 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 ohm driving and terminating impedances. 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. HiGain also provides a means of quickly deploying service in advance of fiber-optic transmission systems. With HiGain, service can be provided within hours. Fiber optic systems can be installed at a leisurely pace and cut-over from HiGain when convenient to do so. The HiGain system can then be easily removed and utilized elsewhere.

### **3. SPECIFICATIONS**

#### **HDSL Line Code**

784 kbps 2B1Q full duplex

#### **HDSL Output**

+13.5 dBm  $\pm$  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 Startup Time**

30 seconds (typical), 60 seconds (maximum)

#### **One-way DS1 Delay**

<220 microseconds

#### **DSX-1 Line Impedance**

100 ohms

#### **DSX-1 Pulse Output**

12V pk-pk for EXTERNAL equalizer or pre-equalized for 0-655 feet of ABAM

**DSX-1 Input Level**

+1.5 to -7.5 dB

**DS1 Line Rate**

1.544 Mbps  $\pm$  200 bps

**DS1 Line Format**

AMI, B8ZS or ZBTSI

**DS1 Frame Format**

ESF, SF or unframed

**Power Consumption**

14 Watts (typical), 18 Watts (maximum)

**Heat Dissipation**

6 Watts (typical), 8 Watts (maximum)

**Fusing**

Internal, connected to FUSEALARM output on pin 32

**Span Voltage**

-136Vdc  $\pm$  4 Vdc

Margin Indicator: displays span SNR margin for both spans relative to  $10^{-7}$  BER operation

**Electrical Protection**

Secondary surge protection on DS1 and HDSL ports

Power cross protection on HDSL ports

**Operating Temperature and Humidity**

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

**Mounting**

AT&T 220 type or equivalent

**Dimensions**

Height: 5.9" (15 cm)

Width: 1.4" (3.5 cm)

Depth: 10" (25.4 cm)

**4. CERTIFICATION**

**4.01** FCC compliance: The HLU-231 has been 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 harmful interference in which case the user will be required to correct the interference at his own expense.

**5. WARRANTY**

**5.01** 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 or improper use or installation.

**5.02** 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.

**5.03** 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) 638-0031**

**B. FUNCTIONAL DESCRIPTION**

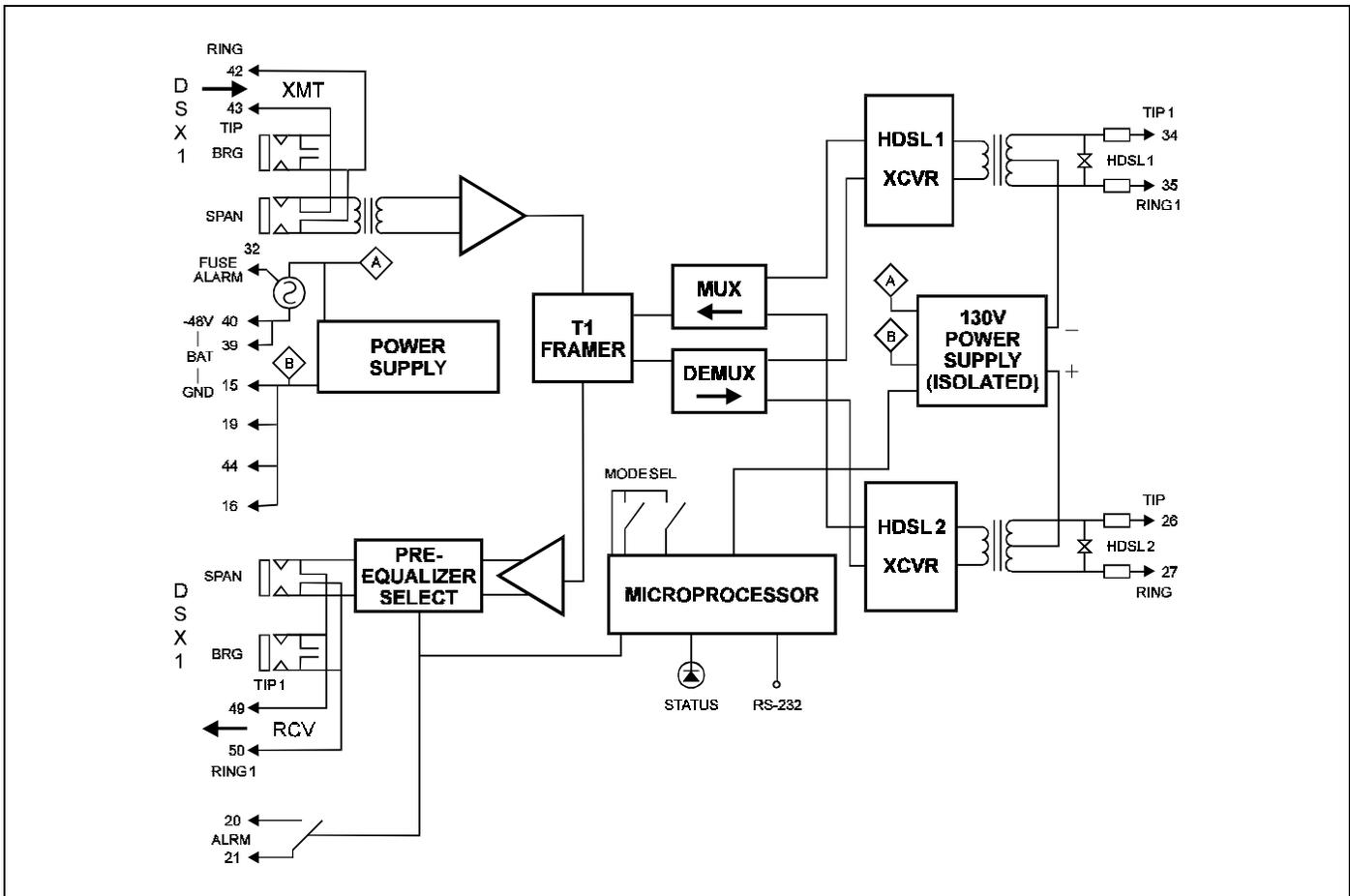
**6. OPERATIONAL CAPABILITIES**

**6.01** HiGain utilizes PairGain's 2B1Q HDSL transceiver systems to establish two full-duplex 784 kbps data channels between the HLU-231 and a remotely mounted HRU-412 HiGain Remote Unit. This provides a total capacity of 1.568 Mbps between the two units.

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

**6.03** The HLU-231 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. HDSL channel 1 contains the DS1 time slots 1 thru 12. HDSL channel 2 contains the DS1 time slots 13 thru 24. The 8 kbps frame bits of the DS1 stream are included on both HDSL channels.

**6.04** 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's echo canceler and adaptive equalizer receive the signal from the remote end in the presence of impairments and noise on the copper pairs.



**Figure 2. HRU-231, List 6 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.

**6.05** The received HDSL channels are processed by the transceiver and then passed on to the HLU-231 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 micro controller 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 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 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.

**6.06** The multiplexer removes data link messages from the HDSL channels and pass them to the micro controller. This mechanism allows operations messages and status to be exchanged between the HLU-231 and the HRU-412 remote unit.

**6.07** 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  $\pm 200$  bps of offset.

**6.08** A DSX-1 interface driver converts the DS1 channel to an AMI or B8ZS format, as determined by the T1 input data to the HLU (when in AUTO mode) or by the setting. The DSX-1 equalizer is programmable to five different lengths as determined by the distance between the HLU and the DSX-1 interface. This provides CB-119 compliant pulses at the DSX-1 interface over a range of 0-655 feet of ABAM cable.

**6.09** The HLU-231 contains two separate power converters. The main power supply converts -48V local battery to logic power for the HLU-231 circuits. The line power supply converts the -48V battery to a -130VDC feed that provides simplex power feed on the two line interfaces. The line power supply can be turned on or off by the micro controller and is automatically shut down in the presence of line short circuits or micro controller failure.

**6.10** The three most important power demands of an HLU-231 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, on a per slot and per shelf basis, are as follows:

**Maximum Power Dissipation**

- Per Slot = 8.0 Watts
- Per Shelf = 104 Watts

**Maximum Power Consumption**

- Per Slot = 18 Watts
- Per Shelf = 234 Watts

**Maximum Current Drain**

- Per Slot = 0.423 Amps
- Per Shelf = 5.5 Amps.

Note that the worse case conditions under which these parameters were measured include a 9,000 ft. #26 AWG loop, 60 mA of CPE current, a fully loaded 13-slot shelf, and a 42.5 V shelf battery voltage.

**6.11** 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.

**6.12** In Central Office (CO) 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 13-slot, 23-inch HLU-231 shelf is 7.024 sq. ft. Thus the maximum bay dissipation is limited to 840 Watts. At 104 Watts per shelf, this limits the number of fully loaded HLU-231 shelves to eight per bay. Note that this is a worse case situation in that it assumes the entire CO is subjected to the maximum power density. Conditions other than these worse case ones would permit increasing the number of shelves per bay without jeopardizing the CO's thermal integrity.

**6.13** The thermal loading limitations imposed when using the HLU-231 in CEVs or other enclosures are determined by applying the HLU-231's power parameters to the manufacturer's requirements for each specific housing.

**6.14** The Maximum Power Consumption is the total power that the HLU-231 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 remote enclosure. Use the above data to perform this analysis on a case by case basis.

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**6.15** 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 shelves are fused at 10 amps. A fully loaded shelf of 13 HLU-231s draws 5.5 amps in the worst case. This is well within the 10 amp fuse limit.

**6.16** A 9-pin RS-232 (DB-9) connector is provided on the front panel (see Figure 3). This connector provides access to HiGain's maintenance, provisioning and performance monitoring interface. A very basic interface is available via a 'dumb terminal'. Figures 6 through 13 show the menu selections that are available from the terminal. Tables 9 and 10 define the various terms used in the screen displays. An enhanced interface is available with a 'smart' PC-based interface and the HiGain Maintenance diskette that is available from PairGain. The port is configured as DCE with 8 data bits, 1 stop bit and no parity. Striking the SPACE bar several times invokes autobaud from 1200 to 9600 bps.

**6.17** The normally open alarm contacts available across pins 20 and 21 comprise the HLU-231's Minor Alarm output. These alarm contacts close for any of the following alarm conditions. 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.

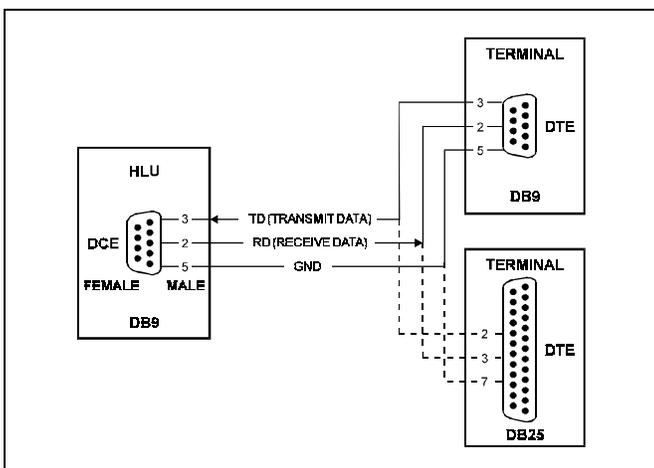
- 1) **ALRM LOSW:** Either HDSL loop loses sync.
- 2) **ALRM LLOS:** Loss of the HLU T1 input signal.
- 3) **ALRM RLOS:** Loss of HRU T1 input signal
- 4) **ALRM H1(2)ES:** HDSL Loop 1 or Loop 2 has exceeded the 24-hour user-selected Errored-Seconds CRC threshold
- 5) **ALRM DS1:** The total number of bipolar violations (BPV) at the HLU and HRU T1 inputs have exceeded the 24-hour user-selected threshold.
- 6) **ALRM MAL1(2):** The margin on HDSL Loop 1 or Loop 2 has dropped below the minimum threshold value set by the dumb terminal MARGIN ALARM THRES; as described in Section 7.

**6.18** The HLU 231's STATUS LED flashes RED for the duration of a minor alarm condition. Alarms 4 and 5 can be inhibited by selecting NONE for the ESAL system option. See Section 7 for System Settings information. The MAL(X) alarm can be disabled by setting the margin alarm threshold to 0. A minor alarm can be retired by executing the ACO option. This is accomplished by pressing the SEL button on the front panel. This turns the alarm off and replaces the ALRM message by 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.

**6.19** Note that when both HDSL loops detect a Loss of Sync Word (LOSW), a minor alarm condition exists but because the HLU 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.

**6.20** 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.

**6.21** Pin 32, FUSEALARM, is driven to -48 V and the front panel STATUS LED turns red whenever the on board fuse opens.



**Figure 3. HLU-231, List 6 DB-9 Pin-Outs.** A standard RS-232 (DB-9) connector on the front panel provides access to the menu interface feature via a dumb terminal.

**6.22** The HLU-231's 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 6.17)
- RED - FUSEALRM
- YELLOW - Self Test in process or an HLU loopback in effect (CREM or NLOC).
- FLASHING YELLOW - The HLU is in an ARMED state.

**6.23** Pressing both the MODE and SEL pushbuttons 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 loopbacks. The message, MAN LPBK, appears on the front panel display followed by the message NLO?. If the SEL button is now depressed, an NLOC loopback is executed and the message changes from NLO? to NLOC. If the MODE button is depressed instead of the SEL button, NLO? is replaced by NRE?. This now allows an NREM loopback to be executed with the SEL button.

Pressing the MODE button two more times yields the CRE? (CREM) and CLO? (CLOC) customer loopback options respectively. This interactive button procedure permits any of the four HiGain loopback to be executed. Once a loopback is executed, it can be terminated and the next loopback option presented by pressing the MODE button. If neither button is depressed for a period of 30 seconds and no loopback is active, this manual loopback session terminates and the normal margin displays reappear. If any loopback is in effect, this 30 second time-out is inhibited. The manual interactive loopback session continues and the loopback in effect remains active until it times out, in accordance with the user LBTO option setting, or another loopback is selected. Only 1 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. Note that these same four loopbacks can be initiated from RS-232 maintenance port by choosing the LOOPBACK MODE, option D, from the main menu. This displays the Loopback Menu, shown in Figure 13, from which any of the four loopbacks can be initiated.

## **7. SYSTEM OPTION SETTINGS**

**7.01** The HLU-231 contains non-volatile RAM which stores the system option settings. No dip-switches or jumpers are required to set the HLU-231 configuration. The options are set via pushbuttons on the front panel, through the RS-232 interface, or from the NMA interface and are retained if shelf power is lost or if the HLU-231 is unplugged. Table 1 lists the HLU-231 option settings. Note that only those options enclosed by quotes can be set by the front panel buttons. All 14 options can be set via the front panel RS-232 port. Figure 8 shows the Systems Settings menu used to set these options from the RS-232 port. The settings with an asterisk (\*) in the second column represent the factory default settings.

**7.02** The SETUP (MODE and SEL) momentary pushbuttons are used to set the four options shown in quotes in Table 1 from the front panel. To initiate an OPTION SETTING mode, depress the MODE button for one second and release. The message displayed on the front panel alternates between the system parameter and its current setting. Pressing the SEL button steps the display through all possible settings (one at a time) of the MODE (parameter) being displayed. After the desired setting has been chosen, depress MODE. This does two things. First it updates the current displayed mode to the setting chosen. It then selects the next configurable parameter. After the last parameter has been selected, the display shows CONF/NO. If the MODE button is now depressed, none of the changed parameters are installed. If the SEL button is depressed, a YES message is displayed and the chosen 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 depressed for 30 seconds.

**7.03** 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.

**7.04** Pressing the MODE button for 3 or more seconds causes the display to scroll through

the HLU's software version number, its List #, the type of frame pattern being received from the DSX-1, the line code setting of the HLU and all 14 option settings. See Table 8 for these additional messages. The line code is the actual DS1 line code being received by the HLU if the DS1 code is set to AUTO. Otherwise it simply mimics either of the two DS1 code settings; AMI or B8ZS.

**7.05** The following three user options must be set with a dumb or smart terminal: CIRCUIT ID, DS0 BLOCKING and MARGIN ALARM THRESHOLD.

**7.06** The CIRCUIT ID option is set by choosing the "H" option from the dumb terminal's main menu shown in Figure 6. The message "enter circuit ID # 24 characters max" follows the "H" selection. Hit the return key after entering the chosen set of alphanumeric ID characters. Then chose "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 screens as shown in Figures 6 through 13. The ID does not appear on the HRU 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.

**7.07** To set the DS0 BLOCKING option, first select the SYSTEMS SETTINGS ("C" choice) from the main menu. The menu shown in Figure 8 appears. Now enter the letter "B" shown in parenthesis of the DS0 blocking selection. The DS0 channels are blocked or unblocked by entering each channel's number. Multiple channels can be selected by inserting a space between each entry. After all the new settings have been made, enter "E" for exit and then "C" for confirm. The new choices are now installed. If DS0 blocking is invoked in a HiGain system that has an earlier HRU that does not support the blocking option, blocking will only occur at the DS1 output of the HLU. The HRU's DS1 output will not be blocked. Also, all blocked channels are opened for all HiGain loopback tests. This allows the standard full bandwidth T1 loopback tests to be performed.

**7.08** To set the MARGIN ALARM THRESHOLD select "G" from the system settings menu. Enter the desired minimum acceptable alarm threshold from the 0 to 15 dB range. This causes a minor alarm to occur (see paragraph 6.17) 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.

**7.09** The other dumb terminal system settings are set in a similar manner. Simply enter the letter in parenthesis of the parameter to be changed. Each entry of this letter scrolls the parameter to its next value. Hit the enter key after each selection is made. After all selections have been made, enter "E" and then "C" to the resulting Confirm message. This activates the new choices and returns control to the main menu.

**7.10** The new T1 transceiver chip in this HLU 231, List 6 unit and the equivalent versions of the companion HRU-412 unit allows each unit to process both B8ZS and AMI code inputs, regardless of the DS1 code setting (AMI or B8ZS). Earlier units cause input BPVs if B8ZS patterns are processed while in AMI mode. When the newer units are in AMI mode, they can receive B8ZS but can only transmit AMI. For this reason, mixed systems will respond differently in each direction for B8ZS inputs when in their AMI mode.

**7.11** 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 during these out of sync intervals, to exhibit occasional BPVs.

**7.12** The HAIS option provides two choices for the T1 transmit outputs at both the HLU & HRU for HDSL loss of sync conditions. The "1LP" choice

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 and 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 about 5 to 10 dB. Thus if the Margin alarm is set to 5 dB below the normal margin at turn-up, then when one conductor does open, a margin 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. The 12 channels from the loop that is lost are replaced by all ones.

**7.13** All user options that affect the operation in both the HLU & HRU, such as HAIS, SAIS & DS0 blocking, will not be available in older versions of the HRU that do not support these newer options.

**TABLE 1. SYSTEM OPTION SETTINGS**

<i>Mode</i>	<i>Selection</i>	<i>Description</i>
EQL	EXT*	Replaces the internal equalizer with a 12 Vp/p driver for external equalizers.
	0	Sets Equalizer to DSX-1 for 0-133 feet.
	133	Sets Equalizer to DSX-1 for 133-266 feet.
	266	Sets Equalizer to DSX-1 for 266-399 feet.
	399	Sets Equalizer to DSX-1 for 399-533 feet.
	533	Sets Equalizer to DSX-1 for 533-655 feet.
LPBK	DIS	Configures HiGain to ignore all in-band "smart-jack" loopback commands.
	ENA*	Enables HiGain to recognize all in-band "smart-jack" loopback commands.
SPLB	GNLB*	Configures HiGain to respond to the generic 3/4 in 7 in-band loopback codes.
	A1LB&A2LB	Configures HiGain to respond to the Teltrend addressable repeater in-band loopback codes.
	A3LB	Configures HiGain to respond to the Wescom addressable repeater in-band loopback codes.
	A4LB	Configures HiGain to respond to the Wescom Mod 1 addressable repeater in-band loopback codes.
	A5LB	Configures HiGain to respond to the Teltrend Mod 1 addressable repeater in-band loopback codes.
PWRF	DIS	Disables powering to the HRU.
	ENA*	Enables powering to the HRU.
ZBTS	ON	Tells HiGain that the ESF frame is operating in its ZBTSI mode.
	OFF*	Tells HiGain that the ESF frame is operating in its normal non-ZBTSI mode.
ESAL	17	Activates (closes) the ALRM output relay contacts on pins 20 & 21 and flashes the red STATUS LED when 17 Errored Seconds (ES) (17 HDSL CRC errors on either HDSL loop or a total of 17 BPVs) occur within a 24-hour period.
	170	Activates (closes) the ALRM output 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.
ALM	DIS*	Opens the relay alarm contacts, if closed, and prevents another relay alarm closure from occurring.
	ENA	Enables activation of the minor alarm relay when a minor alarm condition occurs.

*Table continued on next page*

**TABLE 1. SYSTEM OPTION SETTINGS (CONTINUED)**

<i>Mode</i>	<i>Selection</i>	<i>Description</i>
DS1	AUTO	The HLU and HRU independently monitor their incoming DS1 bit streams for the B8ZS pattern. If either unit detects this pattern, it enters its B8ZS mode. It reverts back to its AMI mode if no B8ZS patterns are received for 5 seconds.
	B8ZS	Places both the HLU & HRU into their B8ZS modes.
	AMI*	Places both the HLU & HRU into their AMI modes.
FRMG	AUTO*	Configures HiGain 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 HiGain can also process unframed data in this AUTO mode, it is recommended that the 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 HiGain to operate in an unframed mode. This mode disables the auto framing process and forces HiGain to function as a transparent bit pipe.
HAIS	2LP*	Causes HiGain to transmit the AIS signal at both the HLU & HRU T1 output ports when <b>both</b> of the HDSL loops are not in sync (LOSW).
	1LP	Causes HiGain to transmit the AIS signal at both the HLU & HRU T1 output ports when <b>either</b> of the two HDSL loops is not in sync (LOSW) or if a minor alarm occurs.
SAIS	ENA*	Causes the List 6 and 7 HRU to transmit the AIS signal towards the NI when in NREM or SMJK loopback.
	DIS	Causes the List 6 HRU to transmit the signal from the network towards the NI and the List 7 to open and terminate its NI when in its NREM or SMJK loopback states. The AIS signal is turned off.
CONF	YES	Confirms that all 12 of the above operating modes are to be updated to their current choices.
	NO*	Prevents the most recently selected operating mode choices from being updated. They remain as they were before the system option settings mode was entered.
MARG	0 to 15 dB (4*)	The Margin Alarm Threshold can only be set via the RS-232 maintenance port with a dumb terminal. See Figure 8. It determines the minimum allowable margin below which a minor alarm will occur.
DS0	BLK/NONE*	The DS0 blocking option can only be set via the RS-232 maintenance port with a dumb terminal. See Figure 8. The 4 character HLU front panel only displays the status of the blocking option. NONE indicates no channels are blocked. BLK indicates at least one channel is blocked.

\* Indicates HLU-231 factory settings. HiGain can be set to these default settings by pressing the SEL button for 6 seconds and then selecting the YES response to the resulting DFLT message.

## **8. LOOPBACK DESIGN DESCRIPTION**

**8.01** HiGain 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 five Smart-Jack in-band loopback codes and thus emulate the functions of a standard NID. This option can be enabled or disabled from either the front panel settings or the dumb terminal system settings menu.

**8.02** In addition to the Smart-Jack loopback, HiGain can be configured for one of five special in-band loopback command sequences. These are selected from the SPLB user option shown in Table 1 and Figure 8. The loopback locations are shown in Figure 4.

**8.03** GNLB is the HiGain 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 messages must be present for five seconds before HiGain responds. Table 2 list the test procedures that apply when using the GNLB mode.

**8.04** The A1LB loopback selection (Table 3) complies with that proposed for HDSL systems in the T1E1.4/92 recommendation with the following additions:

- 1) Query loopback
- 2) IOR powerdown
- 3) Three loopback time-out choices
- 4) Initiation from either end
- 5) Repeating bit error signatures
- 6) Alternate Query loopback

These additions make A1LB identical to A2LB described below. It is given a separate identity to allow future T1E1 enhancements to be added without affecting A2LB.

**8.05** A2LB through A5LB are four special addressable repeater loopback functions which are supported by the List 6 version of HiGain. These loopbacks provide HiGain with sophisticated maintenance and trouble shooting tools. Tables 4 through 7 list the details of these Special Loopback (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 customers:

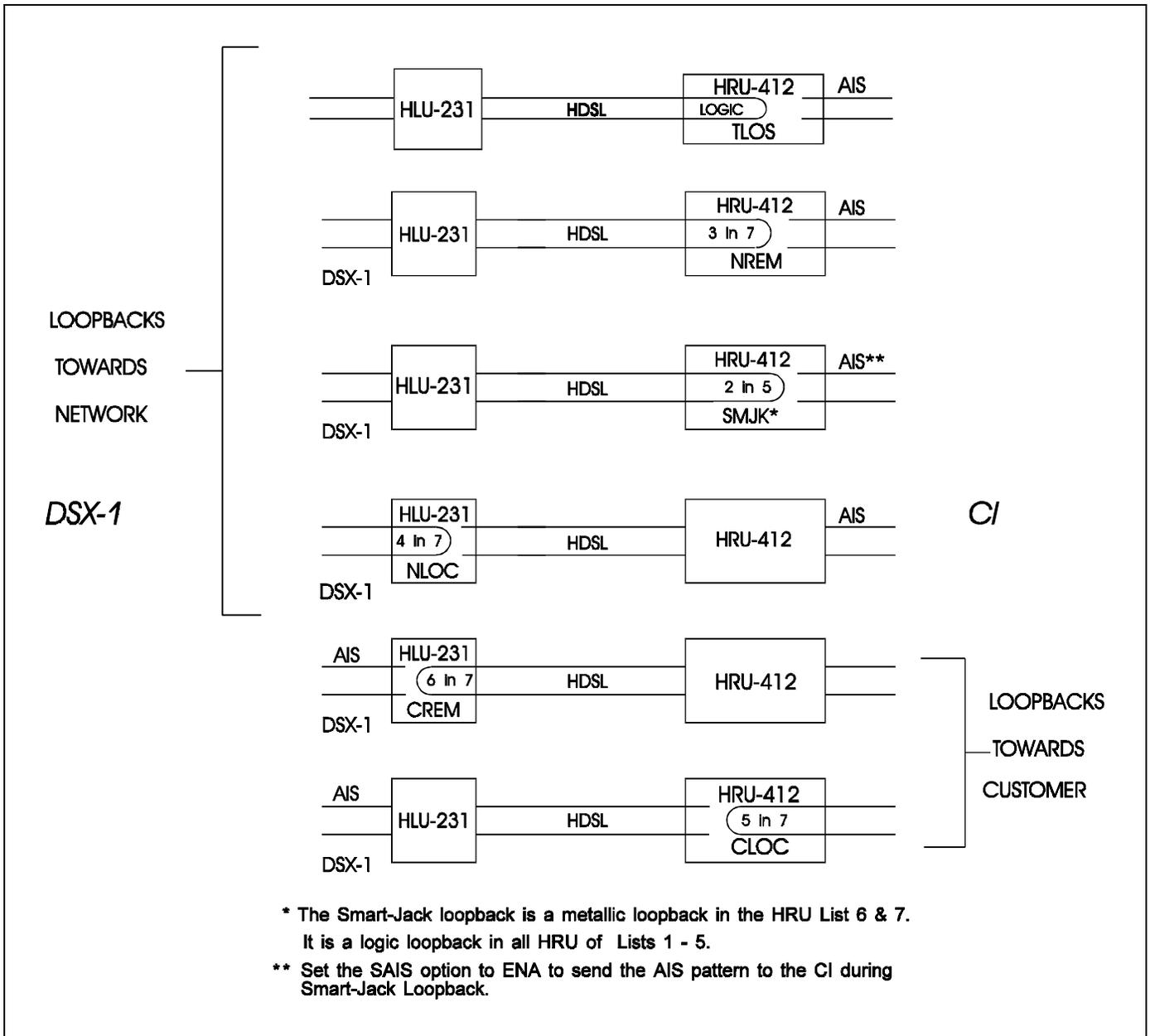
- A2LB (Teltrend) = Southwestern Bell
- A3LB (Wescom)=New England Tel.
- A4LB (Wescom Mod 1) =New York Tel.
- A5LB (Teltrend Mod 1) =Southern New England Tel. (SNET)

**8.06** A5LB differs from A2LB in that A5LB does not block the arming code from exiting the HLU 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, 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.

**8.07** The HDU-451 doubler commands are only available when using the HLU-231, List 6D line unit which supports use of HiGain in-line HDSL doublers. The simplest HiGain system includes two loopback locations: The HLU and the HRU. The most complex HiGain application includes the HLU, HRU & two in-line HDU-451 doublers. Refer to the PairGain HiGain Intelligent Repeater Application Note # 910 Part # 325-910-100 for more SPLB details.

**8.08** 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 & HRU 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 has a metallic loopback and the HLU's receive pattern's code is changed from AMI to B8ZS and then the all 0 pattern is sent into the HLU, the HLU changes to its B8ZS mode while the HRU remains in its AMI mode and thus loops all 0's. This causes the HRU to indicate a LOS condition which then causes the HLU to output the AIS pattern.

**8.09** HiGain may take longer than normal to respond to inband loopback commands when its framing mode is set to UNFR and the inband 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 HiGain to reject some sequences. This can extend the detection interval.



**Figure 4. HLU-231 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.

C. INSTALLATION AND TEST

9. INSTALLATION OPTIONS

9.01 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.

9.02 The HLU-231 is designed to mount in a 220-type ORB shelf or equivalent SXSS, Kentrox T-Term and Wescom 342-30 shelves. The HLU-231 slot pin-outs are shown in Figure 5.

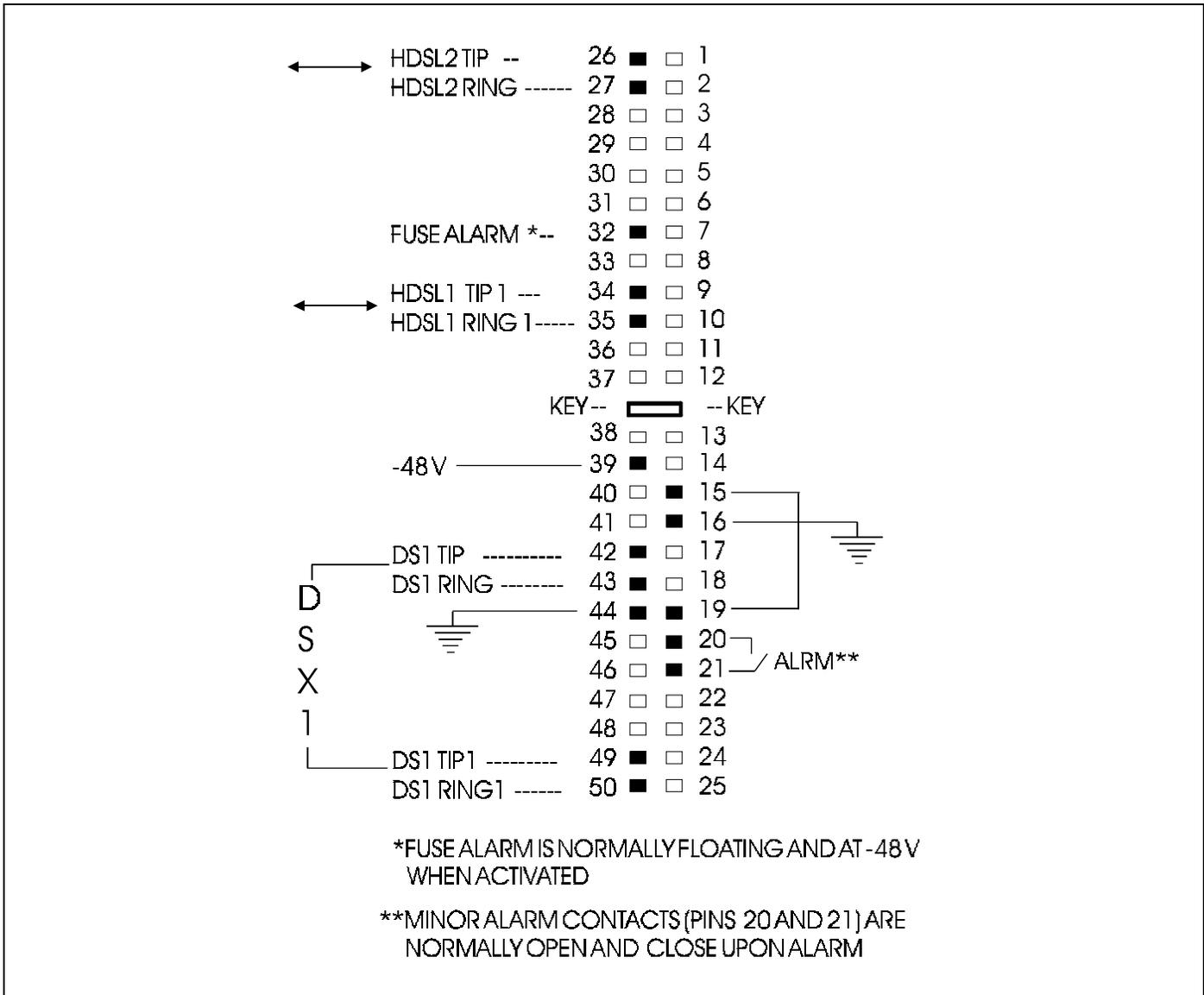


Figure 5. HLU-231, List 6 Pin-Outs. The active pins are highlighted in black in the above illustration.

## 10. TESTING PROCEDURES

**10.01** Tables 2 through 7 provide step-by-step test procedures for the HLU-231 unit as a function of the loopback option selected. These procedures allow verification of the integrity of the HDSL channels to the HRU-412 remote unit as well as the DS1 channels to the customer and the local DSX-1 interface.

**10.02** The HLU's 4 character front panel display has many useful system diagnostic messages. They are listed in Tables 8 & 9. This display turns on when power is initially applied to the 231. In order to conserve power, it only remains on for five minutes if neither the MODE nor SEL buttons are depressed. The use of either button restarts the 5-minute power-control timer.

**10.03** If trouble is encountered on the DSX-1 interface, verify that the unit is making a positive connection with the mounting assembly's connector. Also, verify that the pre-equalizer is

properly set. All installations should be set to the largest value that does not exceed the distance from the DSX-1 to the shelf.

**10.04** The transmit and receive T1 DSX-1 ports have splitting access and bridging miniature 210 jacks. Connecting one cable between the two BDG 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.

**10.05** Figure 7 shows the HLU status screen. It contains useful information on both HDSL loops and the DS1 input. Figures 10, 11 and 12 show the Performance Data and Alarm History screens. All the performance data shown in Figures 10, 11 and 12 can be cleared to zero by selecting the (C)lear option from the HLU Status Screen shown in Figure 7. Note that since the HLU is considered the master module, this clears **all** performance data screens at both the HLU & the HRU. Clearing the data from the HRU only clears performance data at the HRU, not at the HLU.

**TABLE 2. TEST PROCEDURES FOR GNLB OPTION**

<b>Step</b>	<b>Action</b>
1	Have the CO tester send the HRU (3 in 7) in-band loop-up code for 5 seconds. Observe that the HLU displays the "NREM" message indicating an HRU loopback is in effect (see Figure 4).
2	Have the CO tester transmit a T1 test signal into the HLU 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 display returns to normal.
4	Have the CO tester send the HLU (4 in 7) in-band loop-up for 5 seconds. Observe that the HLU displays the "NLOC" message indicating an HLU loopback is in effect.
5	Repeat step "2". If the test passes, the problem is in the cable pair or the HRU. 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 with the MODE and SEL pushbuttons. See Paragraph 6.23 for details.
7	The HLU can be looped-up from the remote location (CREM) by issuing the 6 in 7 command at the HRU's DS1 input port.
8	The HRU can be looped-up from the remote location (CLOC) by issuing the 5 in 7 command at the HRU's DS1 input port.

**TABLE 3. TEST PROCEDURES FOR A1LB OPTION**

<b>Step</b>	<b>Action</b>
1	Send into the HLU the inband ARMING and NIU (Network Interface Unit) LPBK code 11000 for at least 5 seconds, or at least 4 repetitions of the 16-bit ESF Data Link ARMING code 0001 0010 1111 1111.
2	Monitor the output of the HLU-231 for the return of the pattern. Return of pattern indicates that either the HRU has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NIU has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU and HRU units have been ARMED. Verify that the HLU display intermittently indicates "ARM" and also "SMJK" if the HRU is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU is armed or that it is on solid, indicating that it is both armed and in loopback.
3	<p>Once armed, the HLU can be looped back (NLOC in Figure 4) by sending IOR (Intelligent Office Repeater) LPBK activation code 1101 0011 1101 0011 for at least 5 seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> <li>• 2 seconds of AIS (all ones), followed by:</li> <li>• 5 seconds of returning data pattern, followed by:</li> <li>• 231 logic errors (including the frame bits) occur in the returned pattern (10 errors if ILR-1 were sent), followed by:</li> <li>• 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.)</li> </ul> <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 4). The display on the HLU-231 periodically shows "NLOC" (network local loop) and "ARM" (the HLU 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 is received, the "activation sequence" described 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 down is to issue the IR (Intelligent Repeater) LPDN (loopdown) code 1001 0011 1001 0011 or to issue the NIU (Network Interface Unit) LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.</p>
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 to loop-down the HiGain Line Unit. The unit remains armed however, as indicated by the "ARM" message on the HLU-231 and the flashing of the HRU-412's LOOPBACK LED.

*Table continued on next page*

**TABLE 3. TEST PROCEDURES FOR A1LB OPTION (CONTINUED)**

<b>Step</b>	<b>Action</b>		
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 4. A customer tester can activate loopbacks CLOC or CREM.		
	<b>ADDRESSABLE 1 (A1LB) REPEATER LOOPBACK COMMANDS</b>		
	ARMING or NIU LPBK (inband)	Arming code	11000 11000..
	ARMING or NIU LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)
	IR LPDN or DISARM (inband)	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 NIU 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 $10E^{-3}$ 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, HiGain 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.		
7	The NREM and NLOC loopbacks can also be initiated from the front panel of the HLU with the MODE and SEL pushbuttons. See Paragraph 6.23 for details.		

**TABLE 4. TEST PROCEDURES FOR A2LB OPTION**

<b>Step</b>	<b>Action</b>
1	Send into the HLU the inband ARMING and NIU (Network Interface Unit) LPBK code 11000 for at least 5 seconds, or at least 4 repetitions of the 16-bit ESF Data Link ARMING code 0001 0010 1111 1111.
2	Monitor the output of the HLU-231 for the return of the pattern. Return of pattern indicates that either the HRU has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NIU has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU and HRU units have been ARMED. Verify that the HLU display intermittently indicates "ARM" and also "SMJK" if the HRU is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU is armed or that it is on solid, indicating that it is both armed and in loopback.
3	<p>Once armed, the HLU can be looped back (NLOC in Figure 4) by sending IOR (Intelligent Office Repeater) LPBK activation code 1101 0011 1101 0011 for at least 5 seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> <li>• 2 seconds of AIS (all ones), followed by:</li> <li>• 5 seconds of returning data pattern, followed by:</li> <li>• 231 logic errors (including the frame bits) occur in the returned pattern (10 errors if ILR-1 were sent), followed by:</li> <li>• 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.)</li> </ul> <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 5). The display on the HLU-231 periodically shows "NLOC" (network local loop) and "ARM" (the HLU 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 is received, the "activation sequence" described 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 down is to issue the IR (Intelligent Repeater) LPDN (loopdown) code 1001 0011 1001 0011 or to issue the NIU (Network Interface Unit) LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.</p>
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 to loop-down the HiGain Line Unit. The unit remains armed however, as indicated by the "ARM" message on the HLU-231 and the flashing of the HRU-412's LOOPBACK LED.

*Table continued on next page*

**TABLE 4. TEST PROCEDURES FOR A2LB OPTION (CONTINUED)**

<b>Step</b>	<b>Action</b>																																									
5	<p>Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 4. A customer tester can activate loopbacks CLOC or CREM.</p> <p style="text-align: center;">ADDRESSABLE 2 (A2LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" data-bbox="233 428 1370 1266"> <thead> <tr> <th data-bbox="233 428 667 474">Command</th> <th data-bbox="667 428 889 474">Action</th> <th data-bbox="889 428 1370 474">Code</th> </tr> </thead> <tbody> <tr> <td data-bbox="233 474 667 520">ARMING or NIU LPBK (inband)</td> <td data-bbox="667 474 889 520">Arming code</td> <td data-bbox="889 474 1370 520">11000 11000..</td> </tr> <tr> <td data-bbox="233 520 667 567">ARMING or NIU LPBK (ESF Data Link)</td> <td data-bbox="667 520 889 567">Arming code</td> <td data-bbox="889 520 1370 567">1111(F)*1111(F)0100(4)1000(8)</td> </tr> <tr> <td data-bbox="233 567 667 613">IR LPDN or DISARM (inband)</td> <td data-bbox="667 567 889 613">Disarming code</td> <td data-bbox="889 567 1370 613">11100 11100..</td> </tr> <tr> <td data-bbox="233 613 667 659">DISARM (ESF Data Link)</td> <td data-bbox="667 613 889 659">Disarming code</td> <td data-bbox="889 613 1370 659">1111(F)1111(F)0010(2)0100(4)</td> </tr> <tr> <td data-bbox="233 659 667 705">IOR LPBK (NLOC &amp; CREM 231 errors)</td> <td data-bbox="667 659 889 705">HLU Loop up</td> <td data-bbox="889 659 1370 705">1101(D)0011(3)1101(D)0011(3)</td> </tr> <tr> <td data-bbox="233 705 667 751">ILR-2 LPBK (NREM &amp; CLOC 20 bit errors)</td> <td data-bbox="667 705 889 751">HRU Loop up</td> <td data-bbox="889 705 1370 751">1100(C)0111(7)0100(4)0010(2)</td> </tr> <tr> <td data-bbox="233 751 667 798">IR LPDN</td> <td data-bbox="667 751 889 798">Loop down (HLU or HRU)</td> <td data-bbox="889 751 1370 798">1001(9)0011(3)1001(9)0011(3)</td> </tr> <tr> <td data-bbox="233 798 667 844">IR QUERY LPBK</td> <td data-bbox="667 798 889 844">Query loopback</td> <td data-bbox="889 798 1370 844">1101(D)0101(5)1101(D)0101(5)</td> </tr> <tr> <td data-bbox="233 844 667 890">IR ALTERNATE QUERY LPBK</td> <td data-bbox="667 844 889 890">Alternate Query loopback</td> <td data-bbox="889 844 1370 890">1101(D)0101(5)1110(E)1010(A)</td> </tr> <tr> <td data-bbox="233 890 667 936">TIME-OUT OVERRIDE</td> <td data-bbox="667 890 889 936">Loopback Time-out Override</td> <td data-bbox="889 890 1370 936">1101(D)0101(5)1101(D)0110(6)</td> </tr> <tr> <td data-bbox="233 936 667 982">FAR END NIU ACTIVATE</td> <td data-bbox="667 936 889 982">Unblock AIS &amp; pass 2 in 5</td> <td data-bbox="889 936 1370 982">1100(C)0101(5)0101(5)0100(4)</td> </tr> <tr> <td data-bbox="233 982 667 1029">IOR POWER DOWN (HLU)</td> <td data-bbox="667 982 889 1029">Removes HDSL line power</td> <td data-bbox="889 982 1370 1029">0110(6)0111(7)0110(6)0111(7)</td> </tr> </tbody> </table> <p data-bbox="233 1297 1370 1423">Note: The left most bit arrives first in all sequences. The detection algorithm functions reliably with a random <math>10E^{-3}</math> 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, HiGain returns to its normal unlooped and unarmed state. *This is the HEX number for the 4 bit group.</p>			Command	Action	Code	ARMING or NIU LPBK (inband)	Arming code	11000 11000..	ARMING or NIU LPBK (ESF Data Link)	Arming code	1111(F)*1111(F)0100(4)1000(8)	IR LPDN or DISARM (inband)	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 NIU 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)
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7	<p>The NREM and NLOC loopbacks can also be initiated from the front panel of the HLU with the MODE and SEL pushbuttons. See Paragraph 6.23 for details.</p>																																									

**TABLE 5. TEST PROCEDURES FOR A3LB OPTION**

<b>Step</b>	<b>Action</b>																																	
1	<p>The HiGain Line Unit can be looped back (NLOC in Figure 4) by sending the (Addressable Office Repeater) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least 5 seconds. This causes the HLU to enter its NLOC state shown in Figure 4. The display on the HLU-231 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 loopup command before the timer expires. When this time-out override state exists, the only way to loop the HLU 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.</p>																																	
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**TABLE 6. TEST PROCEDURES FOR A4LB OPTION**

<b>Step</b>	<b>Action</b>																														
1	<p>The HiGain Line Unit can be looped back (NLOC in Figure 4) by sending the (Addressable Office Repeater) LPBK activation code 1111(F) 1111(F) 0001(1) 1110(E) for at least 5 seconds. This causes the HLU to enter its NLOC state shown in Figure 4. The display on the HLU-231 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 loopup command before the timer expires. When this time-out override state exists, the only way to loop the HLU 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.</p>																														
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3	<p>The NREM and NLOC loopbacks can also be initiated from the front panel of the HLU with the MODE and SEL pushbuttons. See Paragraph 6.23 for details.</p>																														

**TABLE 7. TEST PROCEDURES FOR A5LB OPTION**

<b>Step</b>	<b>Action</b>
1	Send into the HLU the inband ARMING and NIU (Network Interface Unit) LPBK code 11000 for at least 5 seconds, or at least 4 repetitions of the 16-bit ESF Data Link ARMING code 0001 0010 1111 1111.
2	Monitor the output of the HLU-231 for the return of the pattern. Return of pattern indicates that either the HRU has looped-up (if the SMART-JACK LOOPBACK option is ENABLED) or that an external NIU has looped up (if the SMART-JACK LOOPBACK option is DISABLED) and that the HLU and HRU units have been ARMED. Verify that the HLU display intermittently indicates "ARM" and also "SMJK" if the HRU is in loopback. Also verify, if possible, that the LOOPBACK LED of the HRU-412 is flashing, indicating that the HRU is armed or that it is on solid, indicating that it is both armed and in loopback.
3	<p>Once armed, the HLU can be looped back (NLOC in Figure 4) by sending IOR (Intelligent Office Repeater) LPBK activation code 1101 0011 1101 0011 for at least 5 seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> <li>• 2 seconds of AIS (all ones), followed by:</li> <li>• 5 seconds of returning data pattern, followed by:</li> <li>• 231 logic errors (including the frame bits) occur in the returned pattern (10 errors if ILR-1 were sent), followed by:</li> <li>• 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.)</li> </ul> <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 4). The display on the HLU-231 periodically shows "NLOC" (network local loop) and "ARM" (the HLU 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 is received, the "activation sequence" described 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 down is to issue the IR (Intelligent Repeater) LPDN (loopdown) code 1001 0011 1001 0011 or to issue the NIU (Network Interface Unit) LPDN and Disarm code 11100. The automatic time-out timer is restored during subsequent loopback sessions.</p>
4	Upon completion, the tester sends IOR LPDN code 1001 0011 1001 0011 to loop-down the HiGain Line Unit. The unit remains armed, however, as indicated by the "ARM" message on the HLU-231 and the flashing of the HRU-412's LOOPBACK LED.

*Table continued on next page*

**TABLE 7. TEST PROCEDURES FOR A5LB OPTION (CONTINUED)**

<b>Step</b>	<b>Action</b>																																			
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 4. A customer tester can activate loopbacks CLOC or CREM.																																			
<b>ADDRESSABLE 5 (A5LB) REPEATER LOOPBACK COMMANDS</b>																																				
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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.																																			
7	The NREM and NLOC loopbacks can also be initiated from the front panel of the HLU with the MODE and SEL pushbuttons. See Paragraph 6.23 for details.																																			

**TABLE 8. HLU 4-CHARACTER FRONT PANEL MESSAGES**

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
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 NI, if enabled via the HRU TLOS switch.
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 MNRALM 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 MNRALM 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 HRU.
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 PWRF option to DIS.

*Table continued on next page*

**TABLE 8. HLU 4 CHARACTER FRONT PANEL MESSAGES (CONTINUED)**

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
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.
CODE	Line Code: AMI, B8ZS	This is the line code that the HLU is set to receive and transmit at its DSX-1 interface. 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 and HRU DS1 inputs that 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.

**TABLE 9. HLU-231 STATUS MENU DEFINITIONS**

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
<b>ALARMS</b>		
NONE	No Alarms	
LLOS	Local Loss of Signal	No signal from local T1 interface.
RLOS	Remote Loss of Signal	No signal from remote T1 interface.
LOSW1(2)	Loss of Sync Word Loops 1 and 2	HDSL Loop 1 or Loop 2 has lost sync.
H1ES	HDSL Loop 1 Errored Second	Loop 1's CRC has exceeded the user-selected ES threshold.
H2ES	HDSL Loop 2 Errored Second	Loop 2's CRC has exceeded the user-selected ES threshold.
DS1	Digital Service 1	DS1 input BPVs have exceeded the user-selected ES threshold.
LAIS	Local Alarm Indicating Signal	Indicates an AIS (all 1's) pattern is being transmitted from the local T1 output port.
RAIS	Remote Alarm Indicating Signal	Indicates an AIS (all 1's) pattern is being transmitted from the remote T1 output port.
MAL1	Margin Alarm HDSL Loop 1	The margin on HDSL Loop 1 dropped below the user Margin Alarm Threshold (1 to 15). Setting the threshold to 0 (zero) inhibits the alarm.
MAL2	Margin Alarm HDSL Loop 2	The margin on HDSL Loop 2 dropped below the user Margin Alarm Threshold (1 to 15). Setting the threshold to 0 (zero) inhibits the alarm.
<b>LOOPBACKS</b>		
SMJK	Smartjack Loopback	Loopback at HRU towards network initiated by 2 in 5 in-band loopback code or out-of-band ESF data link code. See Figure 4.
NREM	Network Remote Loopback	Loopback at HRU (remote) towards network initiated by addressable line repeater code, HRU front panel push-button, HLU front panel manual loopback push-button, or maintenance terminal. See Figure 4.
NLOC	Network Local Loopback	Loopback at HLU (local) towards network initiated by addressable office repeater code, HLU front panel manual loopback push-button, or maintenance terminal. See Figure 4.
CLOC	Customer Local Loopback	Loopback at HRU (local) towards CI initiated by addressable line repeater code, HLU front panel manual loopback push-button, or maintenance terminal. See Figure 4.
CREM	Customer Remote Loopback	Loopback at HLU (remote) towards customer initiated by addressable office repeater code, HLU front panel manual loopback push-button, or maintenance terminal. See Figure 4.
ARM	Armed	HiGain has detected the addressable repeater loopback (2 in 5) arming code.
TLOS	Transmit Loss Of Signal loopback	HRU is in a logic loopback state caused by a loss of its T1 input from the NI, if enabled via SAIS option.

**TABLE 10. GLOSSARY OF HIGAIN TERMS**

<i>Term</i>	<i>Definition</i>
MARGINS	Indicates the excess signal to noise ratio, at either the HLU or HRU, 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, and NA means Not Available. 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. HiGain 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 from 1 to 32 dB.
PPM	Indicates the relative offset of the crystal oscillator in the HRU-412 from the HLU-231's crystal oscillator. Any value between -64 and +64 is adequate. Values outside this range indicate out of tolerance components or excessive temperature drift of 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 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's).
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 HiGain is set to its ZBTS mode. In either the AMI or B8ZS DS1 code mode, it displays the selected code. In the AUTO mode, it displays the code being received.
Ver VwxL	"wx" = the software version number of the HLU. "ab" = the software version number of the HRU. "y" = the list number of the HLU. "c" = the list number of the HRU.

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HI-GAIN HLU-231  MAINTENANCE TERMINAL MAIN MENU  (ver U1.3L-0006)
                  CIRCUIT ID#: TEST ID

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 6. HLU-231 Main Menu.

```

                  SPAN STATUS
( HLU/ver1.3-0006: HRU/ver1.4-0006)

TIME: 09:43:36
DATE: 01/02/00                CIRCUIT ID#: TEST ID

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:         22/21/24    22/21/23    23/21/24    22/21/24 dB
PULSE ATTN:     02         02         02         02 dB
PPM OFFSET:     00         00         36         36 ppm
24 HOUR ES:     00016     00013     00031     00026 seconds
24 HOUR UAS:    00324     00402     00235     00003 seconds

                DS1 STATUS
                HLU                                HRU
24 HOUR BPU Seconds:  00023                        00031
24 HOUR UAS Count:   00122                        00003
Frame type:          Unframed                      Unframed
Code type:           B8ZS                          B8ZS

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

```

Figure 7. HLU Span Status Display.

```

                                SYSTEM SETTINGS

TIME: 00:26:17
DATE: 10/10/94                CIRCUIT ID#:

E(Q)UALIZATION:      0
SMART-JACK (L)B:    ENABLE
(S)PECIAL LPBK:     A2LB
(P)OWER:             ENABLE
(Z)BTSI:             OFF
ES ALARM TH(R)ES:   NONE
LOOPBACK (T)IMEOUT: 120
(A)LARM:             DISABLE
(D)S1 LINE CODE:    AMI
(F)RAMING:           UNFR
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 8. System Settings Menu.

```

                                SET CLOCK

TIME: 00:28:52
DATE: 10/10/94
CIRCUIT ID#:

Format: HH:MM
        MM/DD/YY

NEW TIME:

NEW DATE:

(U)PDATE REMOTE?█

```

Figure 9. Set Clock Menu.

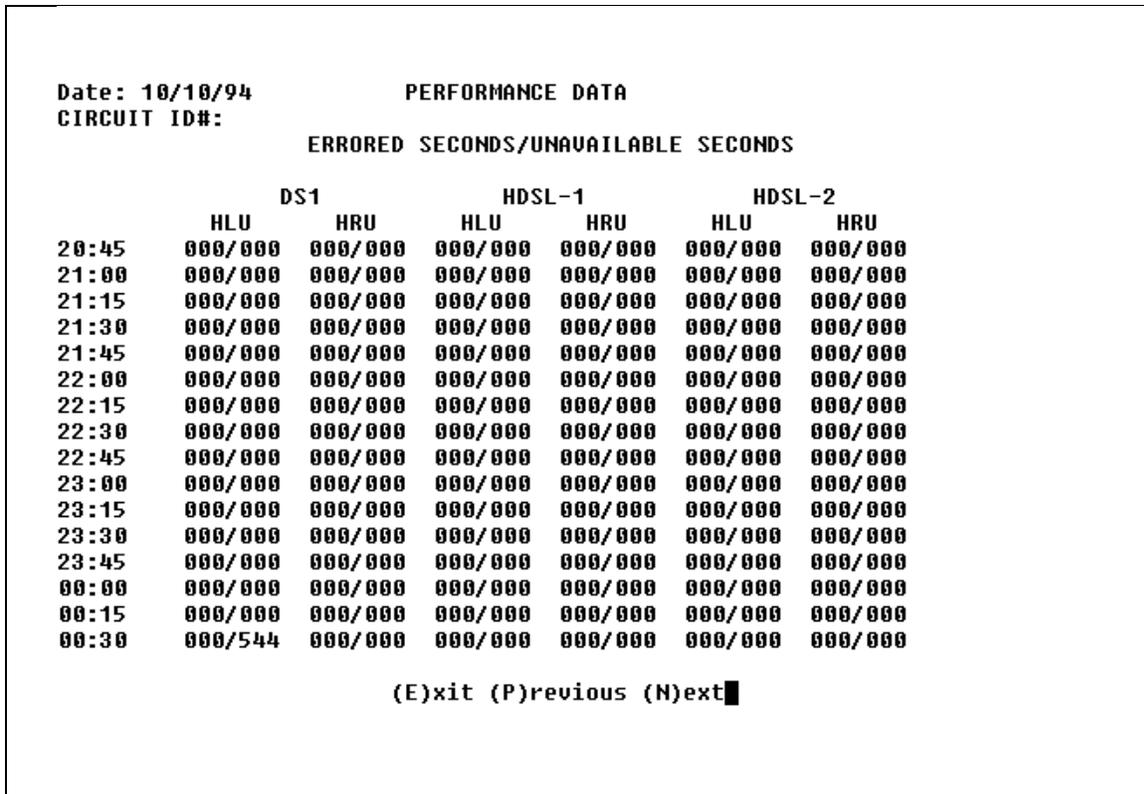


Figure 10. Performance Data.

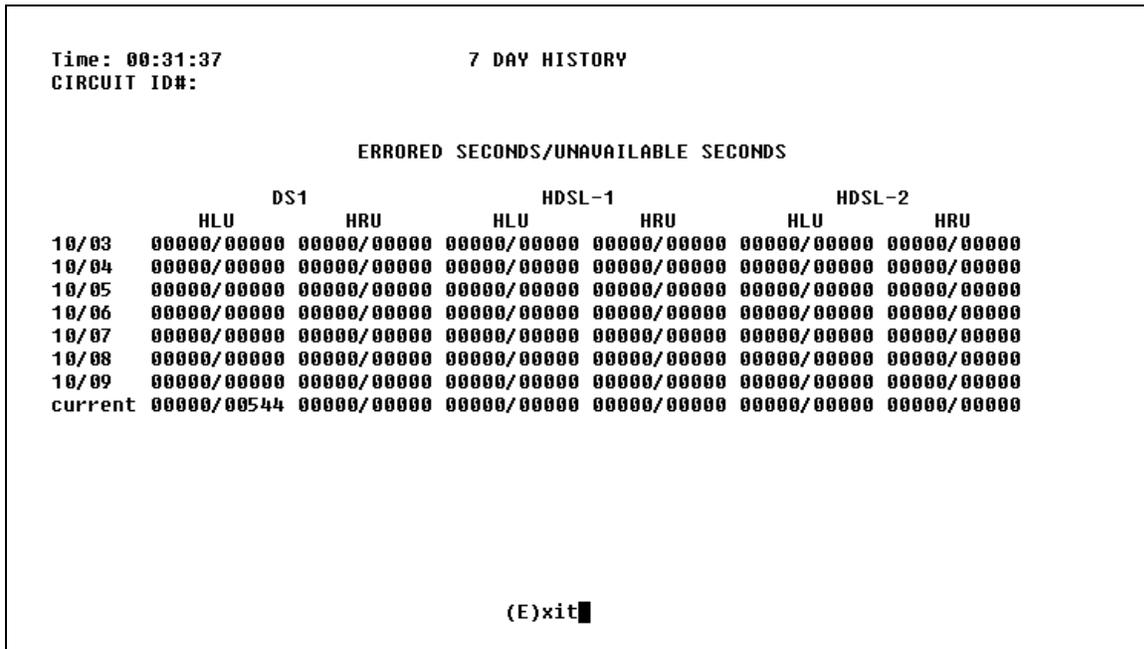


Figure 11. Performance Data History.

```
ALARM HISTORY

TIME: 00:32:50
DATE: 10/10/94
CIRCUIT ID#:

Type          First          Last          Current      Count
LOS, DS1-HLU  10/10/94-00:00  10/10/94-00:20  ALARM        003
LOS, DS1-HRU  10/10/94-00:00  10/10/94-00:00  OK           001
LOSW, HDLSL1  10/10/94-00:00  10/10/94-00:00  OK           001
LOSW, HDLSL2  10/10/94-00:00  10/10/94-00:00  OK           001
ES, HDLSL1    10/10/94-00:00  10/10/94-00:00  OK           000
ES, HDLSL2    10/10/94-00:00  10/10/94-00:00  OK           000
MARGIN L1     10/10/94-00:00  10/10/94-00:00  OK           000
MARGIN L2     10/10/94-00:00  10/10/94-00:00  OK           000
PWR-OPEN      10/10/94-00:00  10/10/94-00:00  OK           000
PWR-SHRT      10/10/94-00:00  10/10/94-00:00  OK           001

LAST CLEARED: NONE

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

Figure 12. HLU Alarm History.

```
LOOPBACK MENU

TIME: 00:33:50
DATE: 10/10/94
CIRCUIT ID#:

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 13. Loopback Menu.