

HIGAIN™ LINE UNIT MODEL HLU-232

List #	PairGain #	CLEI Code
1D	150-1246-14	T1L1GK03AA

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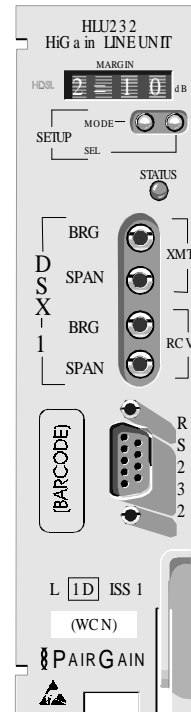


Figure 1. HLU-232, List 1D Front Panel. The PairGain HLU-232 is the local unit used in conjunction with the HRU-412 remote unit to provide a complete HiGain HDSL system with protection switching capability.

CAUTION: THIS PRODUCT INCORPORATES STATIC SENSITIVE COMPONENTS. PROPER ELECTROSTATIC DISCHARGE PROCEDURES MUST BE FOLLOWED.

Revision history:
 Revision 01-September 5, 1996
 a) Initial release.

A. GENERAL

1. DESCRIPTION AND FEATURES

1.01 PairGain's HiGain protection switch line unit Model HLU-232, List 1D is the Central Office (CO) side of a repeaterless T1 transmission system (see Figure 1). The line unit is designed for high reliability applications and is capable of providing a "hot standby" backup to a second HLU-232 unit (see Figure 2). Otherwise, the HLU-232 operates as a standard HDSL (High-bit-rate Digital Subscriber Line) line unit and retains the operational features of the HLU-231. When used in conjunction with an HRU-412 HiGain Remote Unit, 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 HiGain Doubler Units HDU-451, HDU-437, or HDU-439. 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 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 HLU-232, List 1D includes:

- ◆ Primary and secondary protection switch applications
- ◆ Selectable DSX-1 Pre-equalizer
- ◆ -130V to -200V 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 and bridging access jacks
- ◆ 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
- ◆ DS1 LOS detector (125 consecutive zeros)
- ◆ Margin threshold alarm
- ◆ HAIS & SAIS options
- ◆ Easy return to factory default system option settings
- ◆ Circuit ID option.

1.03 HLU-232, List 1D requirements for running as a protection system:

- ◆ HLU-232 List 1D (2 ea)
- ◆ HSA-232 List 1 (1 ea)
- ◆ HRU-412, List 7, or 8 (2 ea)
- ◆ HRE-422 (1 ea)
- ◆ HDU-451, List 4, HDU-437, List 1, or HDU-439, List 1 (optional)

2. APPLICATIONS

2.01 The primary application of the HLU-232 is to provide a “hot standby” backup unit when used in conjunction with another HLU-232. Both units require the use of an HSA-232 Shelf Adapter for all applications. The HSA-232 Shelf Adapter slides into a standard 220-type mechanics shelf, which provides access to the shelf card-edge connector.

2.02 The remote side of the circuit requires two HRU-412 remote units housed in an HRE-422 enclosure.

2.03 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 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

2.04 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.

2.05 In addition to all of the standard HDSL line unit features found in the HLU-231, the HLU-232 provides protection switching capability for applications where automatic switching from the primary circuit to a protection circuit is required in the event of a primary circuit failure. Switches located on the HSA-232 Shelf Adapter and the HRE-422 enclosure allow the user to enable (protection operation) or disable (non-protection operation) the automatic switchover feature.

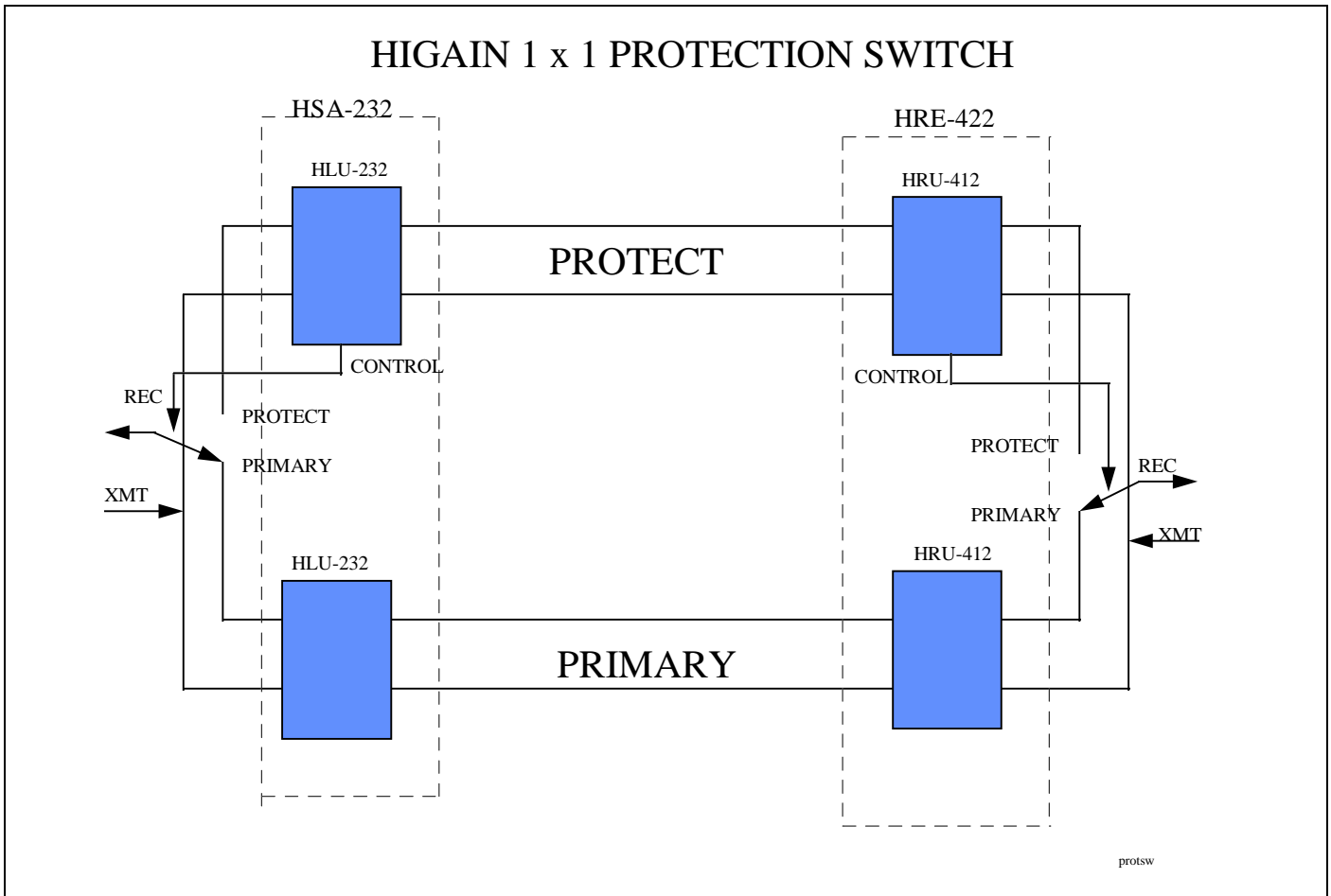


Figure 2. HiGain Protection Circuit.

3. FUNCTIONAL OPERATION

3.01 The HLU-232 is capable of operating in three modes: 1) *normal* operation as a standard HDSL line unit, 2) *primary* unit operation in a “hot standby” backup system, and 3) *protection* unit operation in a “hot standby” backup system.

3.02 In the normal mode of operation, the HLU-232 retains the operational features of the HLU-231. When configured as the primary line unit of a “hot standby” backup system, the HLU-232 provides DS1 and HDSL interfaces unless a primary unit failure occurs. When configured as the protection line unit of a “hot standby” backup system, the HLU-232 monitors the operation of the primary line unit and provides a complete backup system (HLU, HDU, HRU, and HDSL cable pairs) in case of primary unit failure.

3.03 The HiGain system with the protection switching feature provides automatic switchover to the protection circuit interface. Switchover occurs in the case of service degradation, alarm condition, and major failure of the primary circuit.

3.04 HiGain utilizes PairGain's 2B1Q HDSL transceiver systems to establish two full-duplex 784 kbps data channels between the HLU-232 and a remotely mounted HRU-412 HiGain Remote Unit. This provides a total capacity of 1.568 Mbps between the two units.

3.05 A block diagram of the HLU-232 is shown in Figure 3. The HiGain HLU-232 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-232 recognizes SF or ESF framing. When the data is unframed, the HLU-232 arbitrarily defines a frame bit.

3.06 The HLU-232 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.

3.07 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.

3.08 The received HDSL channels are processed by the transceiver and then passed on to the HLU-232 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-232 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 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-232 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.

3.09 The multiplexer removes data link messages from the HDSL channels and passes them to the micro-controller. This mechanism allows operations messages and status to be exchanged between the HLU-232 and the HRU-412 remote unit.

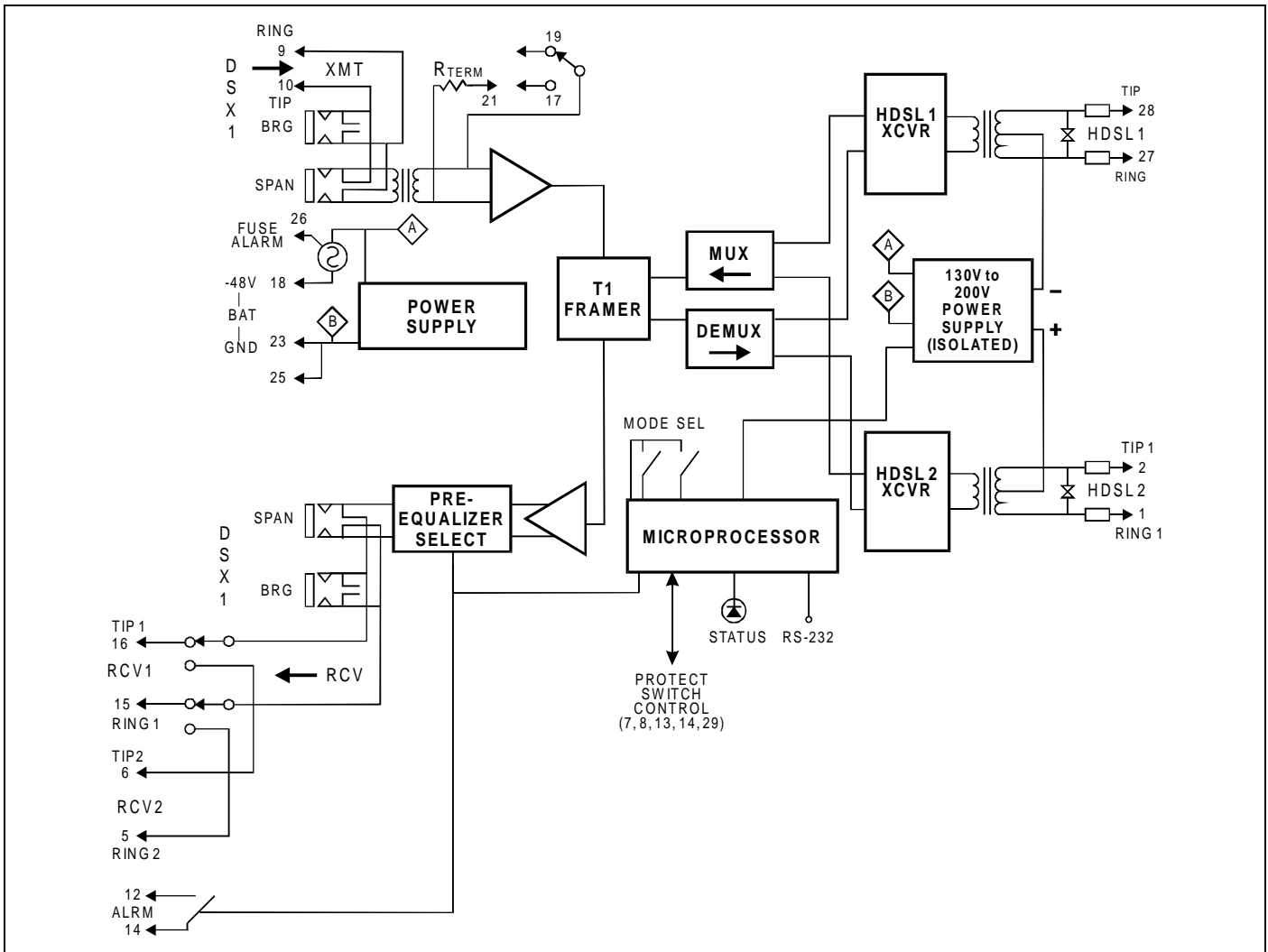


Figure 3. HLU-232, List 1D Block Diagram. PairGain's HD SL technology provides full-duplex services at standard T1 rates over copper wires between an HLU and an HRU, which comprise one HiGain system.

Note: The HLU-232 List 1D requires the use of an HSA-232 Shelf Adapter for both normal and protection applications.

3.10 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.

3.11 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 user 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. An external equalizer setting is also available for use with external equalizer hardware.

3.12 The HLU-232 contains two separate power converters. The main power supply converts -48V local battery to logic power for the HLU-232 circuits. The line power supply converts the -48V battery to a -130V dc (no doublers) to -200V dc (doubler) feed that provides simplex power feed on the two HDSL 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.

3.13 A female 9-pin RS-232 DB-9 connector is provided on the front panel of the HLU-232 (see Figure 4). 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-232 List 1D to automatically match the terminal line baud rate, from 1200 to 9600 baud. Figure 7 through Figure 18 show the menu selections available from the terminal for non-Doubler applications, and Figure 20 through Figure 42 show the menu selections available from the terminal for Doubler applications. Table 12 defines the various terms used in the non-Doubler System Status Screen, and Table 24 defines the same terms for the Doubler System Status Screens.

4. ALARMS

4.01 The normally open alarm contacts available across pins 12 and 14 (Figure 3) comprise the HLU-232's Minor Alarm output and are available at the 220 shelf back plane across pins 20 and 21 respectively (Figure 5). These alarm contacts close for any of the following alarm conditions, and the alarm type is shown on the HLU-232 List 1D front panel display. If multiple alarm conditions exist, only the highest priority alarm type is shown. The following alarms are listed from highest to lowest priority.

TYPE	REASON
ALRM LOSW:	Either HDSL loop loses sync.
ALRM LLOS:	Loss of the HLU DS1 input signal.
ALRM RLOS:	Loss of HRU DS1 input signal.
ALRM TLOS:	The DS1 input to the HRU, whose TLOS switch option has been enabled, is not present (LOS).
ALRM H1(2)ES:	HDSL Loop 1 or Loop 2 has exceeded the 24-hour user-selected Errored-Seconds CRC threshold.
ALRM DS1:	The total number of bipolar violations (BPV) at the HLU or HRU DS1 inputs have exceeded the 24-hour user-selected threshold.
ALRM MAL1(2):	The margin on HDSL Loop 1 or Loop 2 has dropped below the minimum threshold value set by the ASCII terminal MARGIN ALARM THRES option; as described in Section 8.

The following alarms can only occur if the system is configured for Protection Switching capability:

TYPE	REASON
ALRM PROT	The system is operating on the Protection circuit due to a failure of the Primary circuit
ALRM HBER	The user selectable HDSL bit error rate has been exceeded
ALRM PROR	The HRU is not responding to HLU Protection commands

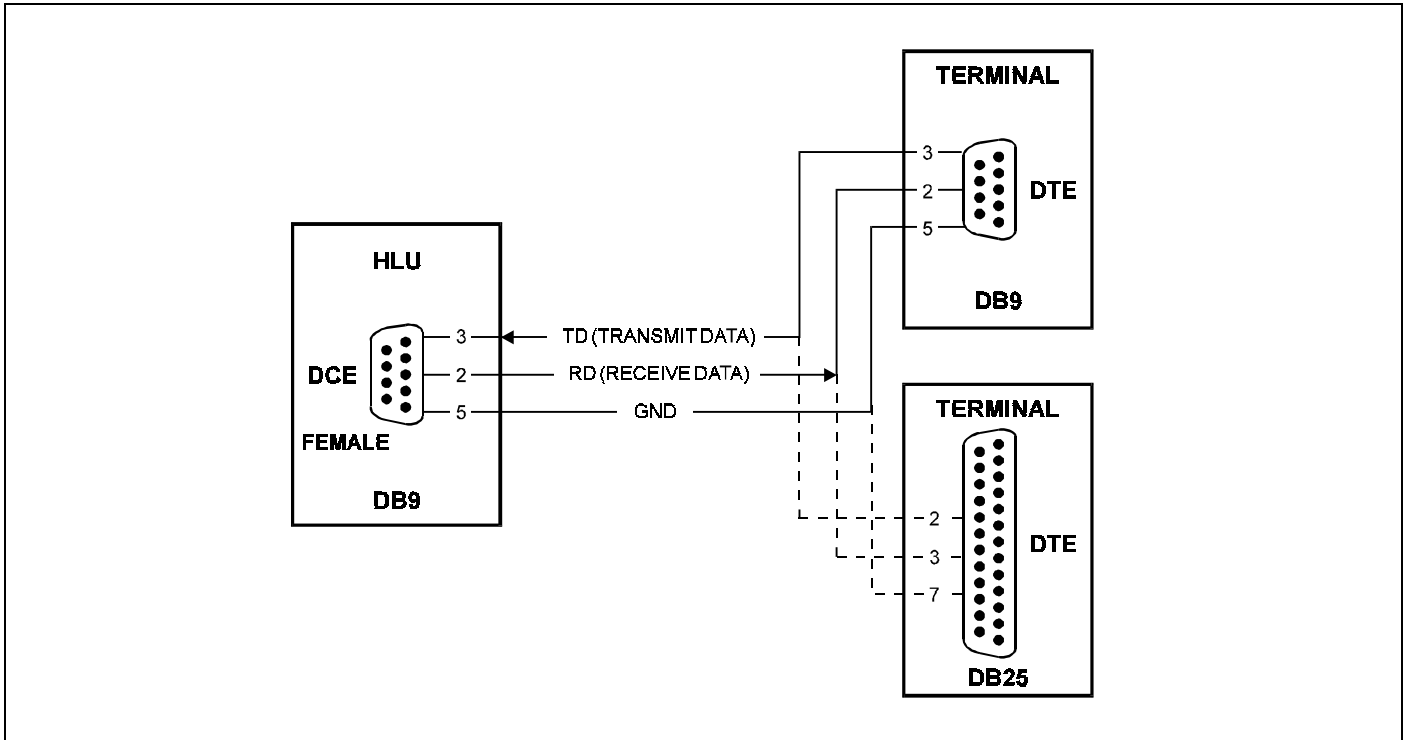


Figure 4. HLU-232, List 1D DB-9 Pin-Outs. A standard RS-232 DB-9, female connector on the front panel provides access to the menu interface feature via a dumb terminal.

4.02 The HLU 232's STATUS LED flashes RED for the duration of a minor alarm condition. The H1(2)ES and DS1 alarms can be inhibited by selecting NONE for the ESAL system option. See Section 8 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 when an alarm is active. 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 detect a Loss of Sync Word (LOSW), a minor alarm condition exists but because the HLU enters a self test 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 on the HSA-232, FUSEALARM (Figure 5), is driven to -48 V and the front panel STATUS LED turns red whenever the on-board fuse installed on the HLU-232 opens.

4.06 The HLU-232’s front panel tri-color STATUS LED has the following states:

NORMAL OPERATION:	
INDICATOR	STATUS
GREEN	Normal Operation
FLASHING GREEN	HDSL Acquisition
YELLOW	HLU loopback in effect (CREM or NLOC)
FLASHING YELLOW	The HiGain system is in an ARMED state
RED	Fuse Alarm or Fault
FLASHING RED	minor alarm (see paragraph 4.01)
SELF TEST OPERATION:	
GREEN	Self test OK, hold for 1 second
YELLOW	Self test in process
RED	Self test Failed

5. NORMAL SYSTEM OPTIONS SETTINGS

5.01 When the two HLU-232 plugs are to be used as normal, stand-alone line units, the configuration switch on the HSA-232 Shelf Adapter must be set to NORMAL. For more details, refer to the HSA-232 Technical Practice #100-232-100. The configuration switch on the HRE-422 (if used) must also be set to NORMAL. For more details, refer to the HRE-422 Technical Practice #100-422-100.

5.02 The HLU-232 contains non-volatile RAM which stores the system option and Protection function settings. No dip-switches or jumpers are required to set the HLU-232 configurations. The options are set from the buttons on the front panel, or through the RS-232 interface, and are retained if shelf power is lost or if the HLU-232 is unplugged. Table 2 lists the HLU-232 system option settings and Table 3 lists the protection system function settings. The settings with an asterisk (*) represent the factory (default) settings. Not all options or functions can be set via the front panel buttons. However, all options and functions can be set via the front panel RS-232 port. Figure 10 shows the Systems Settings menu, and Figure 16 shows the Protection System Configuration menu.

5.03 The SETUP (**MODE** and **SEL**) momentary buttons are used to set the options from the HLU-232 front panel. To initiate an OPTION SETTING mode, press the **MODE** button for at least 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 parameter settings, one at a time. 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.

5.04 All 14 user system options and 7 Protection functions 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.

5.05 When the HLU is installed in the "Primary" slot (left slot of the HSA-232), 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, all 14 option settings and the protection BER settings. When the HLU is installed in the "Protect" slot (right slot of the HSA-232), the "Protection Mode" setting is also displayed. The line code is the actual DS1 line code being received by the HLU if the DS1 code pattern is set to AUTO. Otherwise the line code parameter displayed is the user selected choice of either AMI or B8ZS.

5.06 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 and may be either AMI or 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. 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.

5.07 The following three user options can only be set using an ASCII terminal: CIRCUIT ID, DS0 BLOCKING and MARGIN ALARM THRESHOLD.

5.08 The CIRCUIT ID option is set by selecting the “H” option from the terminal’s main menu shown in Figure 7. The message “enter circuit ID # (24 characters max):” follows the “H” selection. Press **ENTER** after entering the chosen set of alpha-numeric ID characters, then 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 screens as shown in Figures 7 through 16. 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.

5.09 To set the DS0 BLOCKING option, first select the SYSTEM SETTINGS (“C” option) from the main menu. The menu shown in Figure 10 appears. Now press the letter “B” (shown in parenthesis) to select the DS0 blocking function. The DS0 channels are blocked or unblocked by entering each channel’s number. Multiple channels can be selected by inserting a single space between each entry. After all the new settings have been made press “E” for “Enter”, then press “E” for Exit, then press “C” for Confirm. The new selections are now installed. If DS0 blocking is invoked in a HiGain system that has an earlier version 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 temporarily “unblocked” for all HiGain system loopback tests. This allows the standard full bandwidth T1 loopback tests to be performed.

5.10 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 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 disables the margin alarm function.

5.11 The HAIS option provides two choices for the DS1 transmit outputs at both the HLU and HRU for HDSL loss of sync conditions. The “1LP” choice causes the AIS pattern to be transmitted at both DS1 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 all 24 channels are replaced by the AIS pattern. However it does allow both downstream 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 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.

5.12 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.

5.13 The other system settings are set using an ASCII terminal 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. After all selections have been made, enter “E” and then “C” to the resulting Confirm message. This activates the new selections and returns control to the main menu.

5.14 The new T1 transceiver chip in this HLU-232 List 1D unit and the equivalent versions of the companion HRU-412 List 7 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.

5.15 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 on the HLU DS1 output.

5.16 The PairGain HCS-417 and -418 shelves and some 220-configuration shelves deployed in remote cabinets do not have external equalizers. Therefore, the "EXT" setting of the EQL option is never used in these applications.

TABLE 2. 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 line powering to the HRU.
	ENA*	Enables line 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 minor alarm relay contacts on pins 12 & 14 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 minor alarm relay contacts on pins 12 & 14 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. (Note: this is the recommended setting for protection switching applications.)
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 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 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.

Table continued on next page

TABLE 2. SYSTEM OPTION SETTINGS (CONTINUED)

<i>Mode</i>	<i>Selection</i>	<i>Description</i>
FRMG	AUTO*	Configures HiGain to operate in an auto-framing (AUTO) mode in which it continuously searches the input DS1 bit stream for a valid SF or ESF frame pattern. This feature is required for fractional DS1 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 DS1 output ports when both of the HDSL loops are not in sync (LOSW).
	1LP	Causes HiGain to transmit the AIS signal at both the HLU & HRU DS1 output ports when either of the two HDSL loops is not in sync (LOSW) or if a minor alarm occurs.
SAIS	ENA*	Causes the HRU to transmit the AIS signal towards the Customer Interface (CI) when in NREM or SMJK loopback.
	DIS	Causes the List 6 HRU to transmit the signal from the network towards the CI and the List 7 to open and terminate the NI when in the NREM or SMJK loopback state. The AIS signal towards the CI is turned off.
CONF	YES	Confirms that all 12 of the above operating modes are to be updated to their current selections.
	NO*	Prevents the most recently selected operating mode selections 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 an ASCII terminal. See Figure 10. It determines the minimum allowable margin below which a minor alarm will occur.
DS0	BLK	The DS0 blocking option can only be set via the RS-232 maintenance port with a dumb terminal. See Figure 10. The 4-character HLU 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-232 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.

6. PROTECTION SYSTEM OPTION SETTINGS

6.01 When the two HLU-232 plugs are to be used for the Protection function, the configuration switch on the HSA-232 Shelf Adapter must be set to PROTECT. For more details, refer to the HSA-232 Technical Practice #100-232-100. The configuration switch on the HRE-422 must also be set to PROTECT. For more details, refer to the HRE-422 Technical Practice #100-422-100.

6.02 Table 3 lists the user option settings that are unique to the Protection System mode of operation. All of these options are settable on the HLU-232 being used for the protection circuit. Only the BER Threshold and BER Interval are settable on the HLU-232 being used for the primary circuit. The Protection Mode can be set by the front panel **MODE** and **SEL** buttons. The rest of the options can only be set using an ASCII terminal connected to the front panel RS-232 maintenance port.

6.03 Auto Protect (APRO) is the default mode of the Protection configuration. In this mode the protect HLU-232 monitors the performance of the Primary circuit and automatically forces a switchover from the Primary system to the Protect system if any of the following events occur:

1. A minor alarm occurs in the primary system. These include a LOSW, H1(2)ES or MAL1(2). Since both the Primary & Protect circuits use the same T1 input, an LLOS or RLOS condition usually affects both circuits. This prevents a switchover from occurring because the Protect circuit is affected by the same problem as the Primary. An LLOS or RLOS will only cause a switchover in the rare event that the condition is only detected in the Primary and not the Protect circuit.
2. The user defined BER threshold is exceeded in the Primary system. The BER switching threshold can be set to one of the four values shown in Table 3. A BER bit error is defined as either an HDSL CRC or FEBE (far end bit error) in either of the two HDSL loops. An HDSL CRC error occurs when the bit pattern of the received HDSL frame is different from that of the transmitted frame. A FEBE means that a CRC error occurred in the HDSL receiver at the other end of the loop. A CRC error implies at least one or more HDSL bit errors. Since each HDSL loop transmits 784 kbps, a BER of 10^{-4} implies at least 4704 CRC errors per minute. The BER threshold is satisfied only when the selected threshold is exceeded for the BER measurement interval, which can also be selected by the user. Since fewer errors are required to exceed the lower BER rates, more time is required to compute an accurate BER at these lower rates. The three possible intervals are 5, 10 & 15 minutes. The default measurement intervals for each BER threshold and the number of CRC errors required in each interval is:
 - 10^{-4} : 5 minutes (23,520 CRC errors)
 - 10^{-5} : 5 minutes (2352 CRC errors)
 - 10^{-6} : 10 minutes (470 CRC errors)
 - 10^{-7} : 15 minutes (70 CRC errors)

6.04 Switchover causes a minor alarm in the Protect circuit which is displayed as ALRM PROT on its front panel display. Once switchover has occurred, the Protect line unit continues to monitor the integrity of the failed Primary circuit. It will revert back to the Primary circuit when all of the following conditions are satisfied:

1. The user selected Minimum Hold-in Time has expired.
2. The Primary circuit has 10 contiguous seconds of error free HDSL operation.
3. The Primary circuit has a BER performance at least 10 times better (lower) than the selected threshold, up to a limit of 10^{-7}
4. The Primary circuit margin is at least 3 dB greater than the programmed threshold, up to a limit of 15 dB.
5. The user-selected Lock-In thresholds (maximum switchovers, switch interval, lock-in hours), if exceeded, have also been satisfied.

The Lock-In thresholds provide a mechanism to prevent repetitive switchover/reverts in the event of recurring intermittent fault conditions. These thresholds are set by the G, H & I options in the Protection Switch Configuration menu shown in Figure 16. After G switchovers in H minutes, the switchover to the protect circuit remains (does not revert) for I hours. The ranges and (default) settings for these three parameters are:

- G:** 1 to 9 minutes (4)
- H:** 1 to 99 minutes (10)
- I:** 1 to 99 hours (24)

6.05 A minor alarm HBER (high BER) is generated in either the Primary or Protect HLU whenever that HLU determines that its current BER exceeds the user-selected threshold. Note that an HBER or any other alarm condition in the Protect circuit will inhibit a switchover. When such a condition exists the message SWITCHOVER LOCKED OUT appears in the PROTECTION SYSTEM STATUS field of the Protection System Configuration Menu shown in Figure 16. A minor alarm PROR is displayed on the Protect HLU whenever the Protect HLU does not receive positive confirmation that the Protect HRU has switched or reverted when requested. These events are accumulated in the Switchover Event History shown in Figure 18.

6.06 Error free transmission is hindered for a maximum of 100 milliseconds during either a switchover or revert event. This is a result of the need to switch the T1 Receive output from the off-line to the on-line circuit as shown in Figure 2. The transmit (input) circuits can also be affected during switchover but to a lesser degree. The single T1 input is connected to both T1 inputs of the two units (HLU & HRU) at each end of the circuit. At the HLU the input 100 ohm input impedance switches with the on-line unit. This prevents any service errors when the defective HLU is replaced. However, BPV and LOS conditions can occur at the HLU end during switchover. At the HRU end the two T1 inputs are hard wire connected by a 6 db power splitter which does not change during a switchover. However removal of the defective HRU causes the input impedance to increase which could cause some BPVs in the on-line circuit.

6.07 AHLD is the AUTO HOLD mode. It operates exactly like the APRO mode except it is non-reverting. If switchover occurs, the Protect circuit is locked on-line until the operator forces it out by changing to another protect mode. The Protect HLU displays the AHLD message when in this mode.

6.08 MPRO is the MANUAL PROTECT mode. It forces the system to the Protect circuit where it remains until the mode is changed. The Protect HLU displays the MPRO message when in this mode.

6.09 MDIS is the MANUAL DISABLE mode. It overrides and resets any automatic or manually activated Protect mode and forces the system to the Primary circuit where it remains until the mode is changed. The Protect HLU displays the MDIS message when in this mode.

6.10 For Protection Switching applications, ESAL (Errored Seconds Alarm) should be disabled.

6.11 It is recommended that the same BER threshold and BER measurement interval settings be used on both the Primary and Protect line units.

6.12 It is recommended to have a Protect line unit installed while operating in MPRO (Manual Protect) mode. Change the Protection Mode setting to another value before removing the card.

TABLE 3. PROTECTION SYSTEM OPTION SETTINGS

Mode	Selection	Description
Protection Mode	MDIS	Invokes the Manual Disable mode. This keeps the Primary circuit on-line and inhibits switch-over to the Protection circuit.
	MPRO	Invokes the Manual Protect mode to switch to the Protection circuit and locks the Protection circuit on-line.
	APRO*	Invokes the Auto Protect mode in which the Protection line unit monitors the health of the Primary circuit and forces a switchover to the Protection circuit when the Primary circuit's health degrades. System reverts back to the Primary circuit when the Primary circuits health improves.
	AHLD	Invokes the Auto Hold mode. Same as APRO (above) except switchover is non-reverting.
Minimum Hold-in Time (SHLD)	Hold-in minutes (1-99) (3*)	Sets the minimum time the system shall be switched over to the Protection circuit before attempting to switch back to the Primary circuit.
BER (CRC) Threshold (BERT)	1E-4*	Sets the BER threshold to 10 ⁻⁴ : 4704 CRC and/or FEBE errors within 1 minute.
	1E-5	Sets the BER threshold to 10 ⁻⁵ : 470 CRC and/or FEBE errors within 1 minute.
	1E-6	Sets the BER threshold to 10 ⁻⁶ : 47 CRC and/or FEBE errors within 1 minute.
	1E-7	Sets the BER threshold to 10 ⁻⁷ : 4.7 CRC and/or FEBE errors within 1 minute.
BER Measurement Interval (BERI)	5*	Sets the BER measurement interval to 5 minutes.
	10	Sets the BER measurement interval to 10 minutes.
	15	Sets the BER measurement interval to 15 minutes.
Maximum Switchovers (SCNT) Switch Interval (SLIM) Lock-in Hours (SLCK)	1-9 (4*) 1-99 min. (10 min.*) 0-99 hrs. (24 hrs.*)	These three functions are used together to define the switchover operation. Maximum switchovers is set to the number of switchovers to occur within the switch interval time period before the system remains switched for the lock-in period. (If Lock-in hours is set to 0, the Lock-in mechanism is disabled.)

* Indicates HLU-232 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.

BER Threshold and BER Measurement Interval are settable on both the Primary and the Protect line units. All other settings apply only to the Protect line unit. Only the Protection Mode can be set from the front panel buttons on the Protect line unit. All other Protect line unit settings must be made using an ASCII terminal connected to the front panel maintenance port.

7. INSTALLATION

7.01 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.

7.02 The HLU-232 mounts into a PairGain HSA-232 Shelf Adapter. This combined assembly is then installed into a 220-configuration Office Repeater Bay (ORB) shelf or equivalent Small Cross Section Shelf (SXSS), Kentrox T-Term, Wescom 342-30 shelves, or PairGain HCS-418 (19") or HCS-417 (23") shelves. The HLU-232 slot pin-outs are shown in Figure 5.

7.03 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.

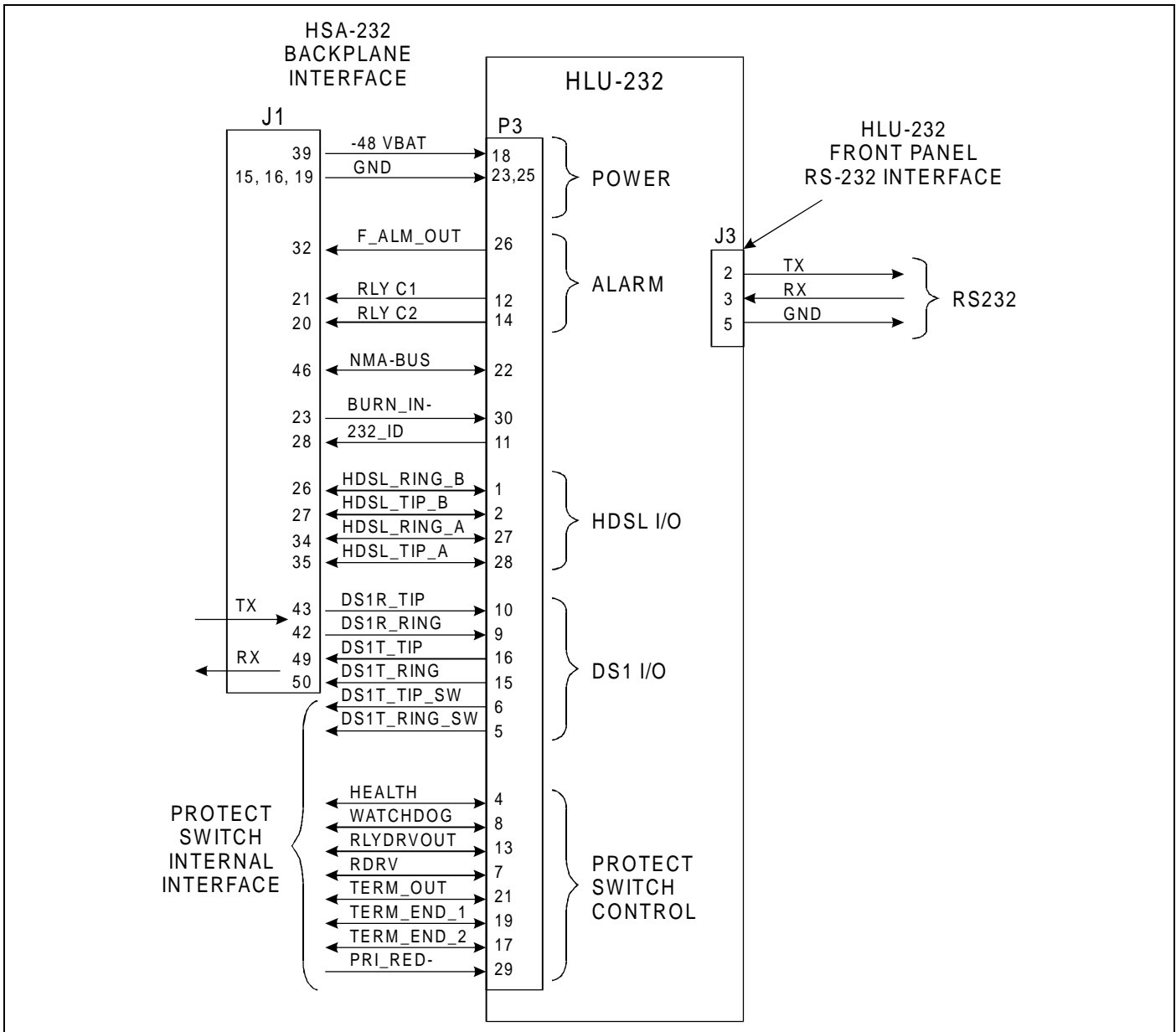


Figure 5. HLU-232, List 1D Pin-Outs. HLU-232 I/O pins and associated 220 shelf back plane pins.

8. SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

HDSL Line Code	784 kbps 2B1Q full duplex
HDSL Output	+13.5 dBm ± 0.5 dBm at 135 ohms
HDSL Line Impedance	135 ohms
Maximum Provisioning Loss	35 dBm at 196 kHz, 135 ohms
Line Clock rate	Internal Stratum 4 clock
HDSL Startup 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	12V pk-pk for EXTERNAL equalizer or pre-equalized for 0-655 feet of ABAM cable
DSX-1 Input Level	+1.5 dBm to -7.5 dBm
DS1 Line Rate	1.544 Mbps ± 200 bps
DS1 Line Format	AMI, B8ZS or ZBTISI
DS1 Frame Format	SF, ESF, or unframed
Maximum Power Consumption	18 Watts without Doubler, 34 Watts with Doubler
Maximum Heat Dissipation	7 Watts without Doubler, 9 Watts with Doubler
Fusing	Internal, connected to FUSEALARM output, pin 26 (connected to 220 Shelf pin 32 by the HSA-232 Adapter)
HDSL Span Voltage	-130V dc to -200V dc
Margin Indicator	Displays span SNR margin for both spans relative to 10 ⁻⁷ BER operation
Electrical Protection	<ul style="list-style-type: none">• 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	HSA-232 Shelf Adapter

PHYSICAL SPECIFICATIONS

Dimensions	
Height:	5.9 in. (15 cm)
Width:	1.4 in. (3.5 cm)
Depth:	8.4 in. (21.33 cm)

9. CERTIFICATION

9.01 FCC compliance: The HLU-232, List 1D 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 this Technical Practice, 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.

10. WARRANTY

10.01 PairGain Technologies warrants this product to be free of defects and to be fully functional for a period of 60 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 improper installation.

10.02 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.

10.03 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 92780

ATTN: Repair and Return Dept.

(714) 832-9922

(800) 638-0031

11. TECHNICAL ASSISTANCE

11.01 PairGain Technical Assistance is available 24-hours-a-day, 7-days-a-week by contacting PairGain's Customer Service Engineering group at one of the following numbers:

Telephone: (800) 638-0031
(714) 832-9922

Fax: (714) 832-9924
BBS: (714) 730-3299

During normal business hours (8:00 AM to 5:00 PM, Pacific Time, Monday - Friday, excluding holidays), technical assistance calls are answered directly by a Customer Service Engineer. At other times, a request for technical assistance is handled by an on-duty Customer Service Engineer through a callback process. This process results in a callback within 30 minutes of initiating the request.

In addition, PairGain maintains a computer bulletin board system for obtaining current information on PairGain products, product troubleshooting tips and aids, accessing helpful utilities, and for posting requests or questions. This system is available 24-hours-a-day. Transmission speeds up to 28.8 kbps are supported with a character format of 8-N-1.

B. APPLICATIONS WITHOUT USING HIGAIN DOUBLERS

1. GENERAL

1.01 This section addresses HLU-232 List 1D operation when used without doublers. For applications without Doublers, the HLU-232 List 1D is directly connected to the HRU-412 by the two HDSL cable pairs.

2. POWER CONSUMPTION

2.01 The three most important power demands of an HLU-232 List 1D 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-232 List 1D, on a per slot and per shelf basis (assuming 12 HLU-232's per shelf), are as follows:

Maximum Power Dissipation:

- Per Slot = 7.0 Watts
- Per Shelf = 84 Watts

Maximum Power Consumption:

- Per Slot = 18 Watts
- Per Shelf = 216 Watts

Maximum Current Drain:

- Per Slot = 0.4 Amps
- Per Shelf = 4.8 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 Premise Equipment (CPE) current, a fully loaded 13 slot shelf, and a -42.5 V shelf battery voltage with HLU-232 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 (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 standard 13 slot 23" HLU-232 List 1D shelf is 7.024 sq. ft. Thus the maximum bay dissipation is limited to 840 Watts. At 84 Watts per shelf, this limits the number of fully loaded HLU-232 List 1D 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-232 List 1D in Controlled Environment Vault (CEV) or other enclosures are determined by applying the HLU-232 List 1D'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-232 List 1D consumes or draws from its -48 V shelf power source. This parameter is needed when the 232 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-232 List 1D shelves are fused at 10 A. A fully loaded shelf of 12 HLU-232s draws 4.8 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 16 (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” option 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. All the in-band loop codes must be present for at least 5 seconds before the HiGain system responds. Table 4 lists the test procedures that apply when using the “GNLB” mode.

3.04 The A1LB loopback selection, Table 5, 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
- ◆ Repeater bit error signatures
- ◆ Alternate query loopback

These additions make A1LB identical to A2LB described on the following page. 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 addressable repeater loopback functions which are supported by the HiGain System. These loopbacks provide the HiGain system with sophisticated maintenance and trouble shooting tools. Table 6 through Table 9 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. The following 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-232 List 1D 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-232 List 1D, 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-232 List 1D & 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-232 List 1D receive pattern code is changed from AMI to B8ZS and then the all "0" pattern is sent into the HLU-232 List 1D, the HLU-232 List 1D 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-232 List 1D 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** 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** 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** 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) loopback options in the sequence listed. This interactive button procedure permits any of the four HiGain loopbacks to be executed/activated. The next loopback option can be presented by pressing the **MODE** button however, the previously executed loopback will remain active until the **SEL** 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 11), from which any of the loopbacks can be initiated/terminated.

4. TESTING

4.01 Table 4 through Table 9 provide step-by-step test procedures for the HLU-232 List 1D 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-232 List 1D 4-character front panel display has many useful system diagnostic messages. They are listed in Table 10. This display turns on when power is initially applied to the HLU-232 List 1D. To conserve power, the display only remains on for four minutes if neither the **MODE** nor **SEL** buttons are pressed. The use of either button activates the 4-character display and restarts the 4-minute power-control timer.

4.03 If trouble is encountered on the HLU-232 List 1D DSX-1 interface, verify that the HLU-232 is properly seated in the HSA-232 adapter, and the HSA-232 is properly seated in the 220 shelf. Also, verify that the HLU-232 List 1D internal equalizer is set to EXT for driving the external equalizer or to the correct distance range per Table 2 for internal 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 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-232 List 1D. If plugs are inserted into both SPAN jacks, the BRG jacks can be used to send and receive test patterns towards the DSX-1.

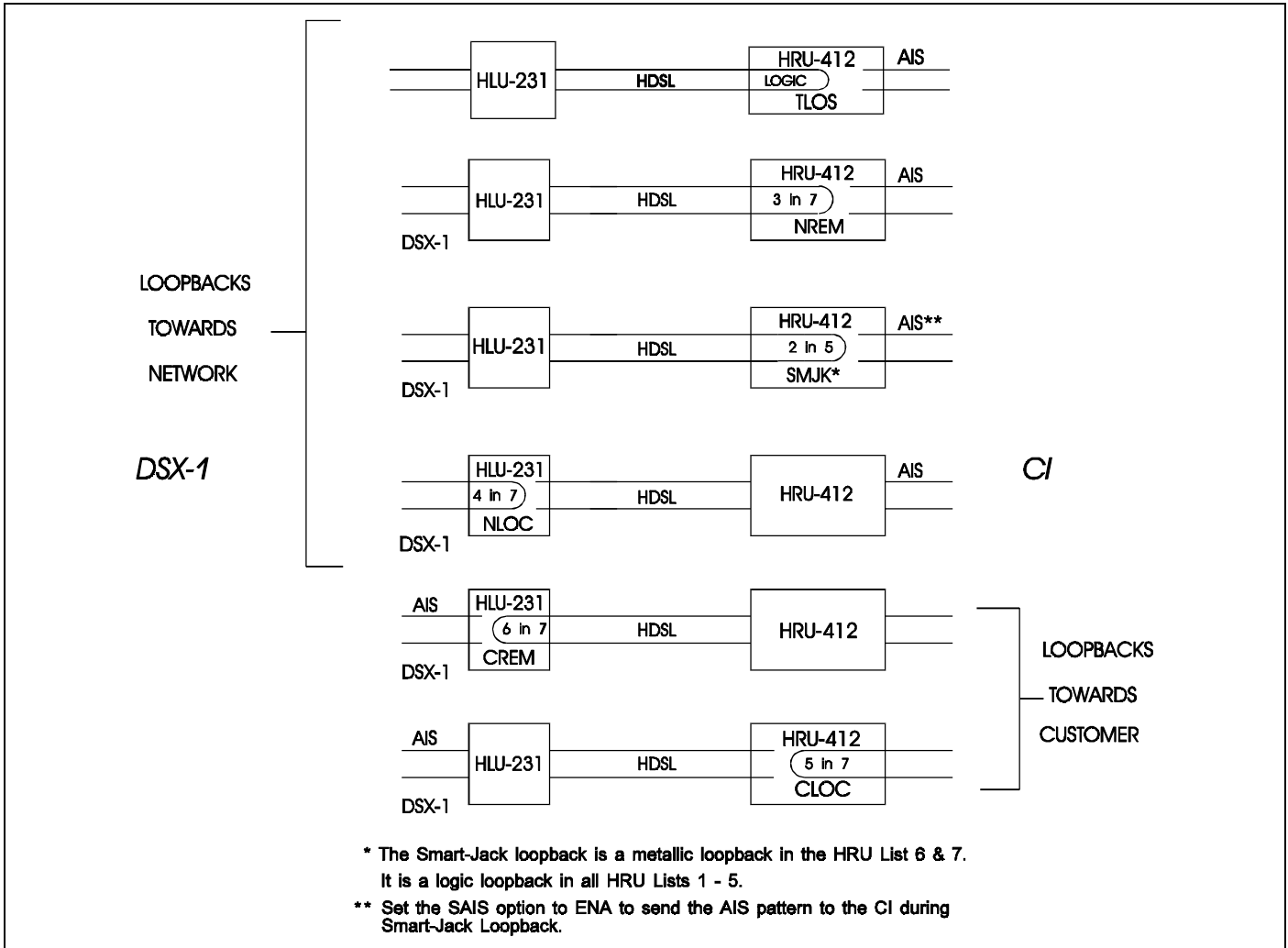


Figure 6. HLU-232 non-Doubler Loopback Configurations. The most important of the HiGain family of loopback options is the Smart-Jack loopback, which emulates the functions of a standard NID.

TABLE 4. HLU-232 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-232 List 1D displays the "NREM" message indicating an HRU loopback is in effect.
2	Have the CO tester transmit a T1 test signal into the HLU-232 List 1D 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-232 List 1D display returns to normal.
4	Have the CO tester send the HLU-232 List 1D (4 in 7) in-band loop-up code for five seconds. Observe that the HLU-232 List 1D displays the "NLOC" message indicating an HLU-232 List 1D 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-232 List 1D with the MODE and SEL buttons (Section B Paragraph 3.09).
7	The HLU-232 List 1D can be looped-up from the remote location (CREM) by issuing the (6 in 7) in-band loop-up code 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) in-band loop-up code 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-232 List 1D receive pattern code is changed from AMI to B8ZS and then the all "0" pattern is sent into the HLU-232 List 1D, 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-232 List 1D 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 5. HLU-232 A1LB TEST PROCEDURES

<i>Step</i>	<i>Action</i>
1	Send into the HLU-232 List 1D 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-232 List 1D for 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates “ARM” and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 6) by sending the Intelligent Office Repeater (IOR) LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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 IOR, Time-Out Override and Query commands. <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-232 List 1D periodically shows NLOC (network local loop) and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 List 1D 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 5. HLU-232 A1LB TEST PROCEDURES (CONTINUED)

Step	Action																																				
5	<p>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.</p> <p style="text-align: center;">ADDRESSABLE 1 (A1LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 40%;">ARMING or NI LPBK (in-band)</td> <td style="width: 30%;">Arming code</td> <td style="width: 30%;">11000 11000 ...</td> </tr> <tr> <td>ARMING or NI LPBK (ESF Data Link)</td> <td>Arming code</td> <td>1111(F)*1111(F)0100(4)1000(8)</td> </tr> <tr> <td>IR LPDN or DISARM (in-band)</td> <td>Disarming code</td> <td>11100 11100 ...</td> </tr> <tr> <td>DISARM (ESF Data Link)</td> <td>Disarming code</td> <td>1111(F)1111(F)0010(2)0100(4)</td> </tr> <tr> <td>IOR LPBK (NLOC & CREM 231 errors)</td> <td>HLU Loop up</td> <td>1101(D)0011(3)1101(D)0011(3)</td> </tr> <tr> <td>ILR-2 LPBK (NREM & CLOC 20 bit errors)</td> <td>HRU Loop up</td> <td>1100(C)0111(7)0100(4)0010(2)</td> </tr> <tr> <td>IR LPDN</td> <td>Loop down (HLU or HRU)</td> <td>1001(9)0011(3)1001(9)0011(3)</td> </tr> <tr> <td>IR QUERY LPBK</td> <td>Query loopback</td> <td>1101(D)0101(5)1101(D)0101(5)</td> </tr> <tr> <td>IR ALTERNATE QUERY LPBK</td> <td>Alternate Query loopback</td> <td>1101(D)0101(5)1110(E)1010(A)</td> </tr> <tr> <td>TIME-OUT OVERRIDE</td> <td>Loopback Time- out Override</td> <td>1101(D)0101(5)1101(D)0110(6)</td> </tr> <tr> <td>FAR END NI ACTIVATE</td> <td>Unblock AIS & pass 2 in 5</td> <td>1100(C)0101(5)0101(5)0100(4)</td> </tr> <tr> <td>IOR POWER DOWN (HLU)</td> <td>Removes HDSL line power</td> <td>0110(6)0111(7)0110(6)0111(7)</td> </tr> </table> <p>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 16-bit binary code.</p>	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)
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)																																			
6	<p>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.</p>																																				
7	<p>All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section B Paragraph 3.09).</p>																																				

TABLE 6. HLU-232 A2LB TEST PROCEDURES

Step	Action
1	Send into the HLU-232 List 1D 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-232 List 1D for 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates “ARM” and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 6) by sending the IOR LPBK activation code 1101 0011 1101 0011(D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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 IOR, Time-Out Override and Query commands. <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-232 List 1D periodically shows NLOC (network local loop) and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 List 1D 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 6. HLU-232 A2LB TEST PROCEDURES (CONTINUED)

<i>Step</i>	<i>Action</i>		
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 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-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 16-bit binary code.		
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	All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section B Paragraph 3.09).		

TABLE 7. HLU-232 A3LB TEST PROCEDURES

Step	Action																																	
1	<p>The HiGain Line Unit can be looped back (NLOC in Figure 6) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111 1111 0001 1110 (FF1E) for at least five seconds. This causes the HLU-232 List 1D to enter its NLOC state shown in Figure 6. The display on the HLU-232 List 1D 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-232 List 1D 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>																																	
2	<p>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.</p> <p style="text-align: center;">ABBREVIATIONS USED BELOW:</p> <p style="margin-left: 40px;">LU = LoopUp LD = LoopDown NI = Network Interface CI = Customer Interface ESF-DL = Extended Super Frame Data Link</p> <p style="text-align: center;">ADDRESSABLE 3 (A3LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th data-bbox="180 894 751 930"><i>Position</i></th> <th data-bbox="751 894 979 930"><i>Name</i></th> <th data-bbox="979 894 1463 930"><i>Code</i></th> </tr> </thead> <tbody> <tr> <td data-bbox="180 936 751 968">HLU-232 LU FROM NI</td> <td data-bbox="751 936 979 968">NLOC</td> <td data-bbox="979 936 1463 968">1111(F)*1111(F)0001(1)1110(E)</td> </tr> <tr> <td data-bbox="180 974 751 1005">HLU-232 LU FROM CI</td> <td data-bbox="751 974 979 1005">CREM</td> <td data-bbox="979 974 1463 1005">0011(3)1111(F)0001(1)1110(E)</td> </tr> <tr> <td data-bbox="180 1012 751 1043">HRU-412 LU FROM NI</td> <td data-bbox="751 1012 979 1043">NREM</td> <td data-bbox="979 1012 1463 1043">1111(F)1111(F)0000(0)0010(2)</td> </tr> <tr> <td data-bbox="180 1050 751 1081">HRU-412 LU FROM CI</td> <td data-bbox="751 1050 979 1081">CLOC</td> <td data-bbox="979 1050 1463 1081">0011(3)1111(F)0000(0)0010(2)</td> </tr> <tr> <td data-bbox="180 1087 751 1119">HRU-412 LU FROM NI</td> <td data-bbox="751 1087 979 1119">SMJK</td> <td data-bbox="979 1087 1463 1119">11000 11000 11000 ...</td> </tr> <tr> <td data-bbox="180 1125 751 1157">HRU-412 LU FROM NI</td> <td data-bbox="751 1125 979 1157">SMJK</td> <td data-bbox="979 1125 1463 1157">100000 100000 100000 ...</td> </tr> <tr> <td data-bbox="180 1163 751 1194">HRU-412 LU FROM NI (ESF-DL)</td> <td data-bbox="751 1163 979 1194">SMJK</td> <td data-bbox="979 1163 1463 1194">1111(F)1111(F)0100(4)1000(8)</td> </tr> <tr> <td data-bbox="180 1201 751 1232">HLU & HRU LD FROM NI OR CI</td> <td data-bbox="751 1201 979 1232"></td> <td data-bbox="979 1201 1463 1232">11100 11100 11100 ...</td> </tr> <tr> <td data-bbox="180 1239 751 1270">HLU & HRU LD FROM NI OR CI</td> <td data-bbox="751 1239 979 1270"></td> <td data-bbox="979 1239 1463 1270">100 100 100 ...</td> </tr> <tr> <td data-bbox="180 1276 751 1308">HLU & HRU LD FROM NI OR CI (ESF-DL)</td> <td data-bbox="751 1276 979 1308"></td> <td data-bbox="979 1276 1463 1308">1111(F)1111(F)0010(2)0100(4)</td> </tr> </tbody> </table> <p>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 16-bit binary code.</p>	<i>Position</i>	<i>Name</i>	<i>Code</i>	HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)	HLU-232 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)
<i>Position</i>	<i>Name</i>	<i>Code</i>																																
HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)																																
HLU-232 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)																																
3	<p>All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section B Paragraph 3.09).</p>																																	

TABLE 8. HLU-232 A4LB TEST PROCEDURES

Step	Action																														
1	<p>The HiGain Line Unit can be looped back (NLOC in Figure 6) by sending the Addressable Office Repeater (AOR) LPBK activation code 1111 1111 0001 1110 (FF1E) for at least five seconds. This causes the HLU-232 List 1D to enter its NLOC state shown in Figure 6. The display on the HLU-232 List 1D 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 1D 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.</p>																														
2	<p>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.</p> <p style="text-align: center;">ABBREVIATIONS USED BELOW:</p> <p style="text-align: center;">LU = LoopUp LD = LoopDown NI = Network Interface CI = Customer Interface ESF-DL = Extended Super Frame Data Link</p> <p style="text-align: center;">ADDRESSABLE 4 (A4LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Position</i></th> <th style="text-align: center;"><i>Name</i></th> <th style="text-align: center;"><i>Code</i></th> </tr> </thead> <tbody> <tr> <td>HLU-232 LU FROM NI</td> <td>NLOC</td> <td>1111(F)*1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HLU-232 LU FROM CI</td> <td>CREM</td> <td>0011(3)1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>NREM</td> <td>1111(F)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM CI</td> <td>CLOC</td> <td>0011(3)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>SMJK</td> <td>11000 11000 11000 ...</td> </tr> <tr> <td>HRU-412 LU FROM NI (ESF-DL)</td> <td>SMJK</td> <td>1111(F)1111(F)0100(4)1000(8)</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>11100 11100 11100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>100 100 100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI (ESF-DL)</td> <td></td> <td>1111(F)1111(F)0010(2)0100(4)</td> </tr> </tbody> </table> <p>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 16-bit binary code.</p>	<i>Position</i>	<i>Name</i>	<i>Code</i>	HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)	HLU-232 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)
<i>Position</i>	<i>Name</i>	<i>Code</i>																													
HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)																													
HLU-232 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)																													
3	<p>All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section B Paragraph 3.09).</p>																														

TABLE 9. HLU-232 A5LB TEST PROCEDURES

Step	Action
1	Send into the HLU-232 List 1D 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-232 List 1D 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates “ARM” and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 6) by sending the IOR (Intelligent Office Repeater) LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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 (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 IOR, Time-Out Override and Query commands.) <p>The HiGain Line Unit is now in Logic Loopback (NLOC of Figure 6). The display on the HLU-232 List 1D periodically shows NLOC and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 9. HLU-232 A5LB TEST PROCEDURES (CONTINUED)

<i>Step</i>	<i>Action</i>		
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 16-bit binary code.		
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	All of the above loopbacks can also be initiated from the front panel of the HLU with the MODE and SEL buttons (Section B Paragraph 3.09).		

TABLE 10. HLU-232, LIST 1D 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-232.
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	DSX signal is looped back to DSX 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-232.
SIG1 or SIG2	Signal 1 or Signal 2	The HLU & HRU transceivers are trying to establish contact with each other.
ACQ1 or ACQ2	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	Self Test	The HLU is in 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 10. HLU-232, LIST 1D 4-CHARACTER FRONT PANEL MESSAGES (CONTINUED)

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
PWR FEED OPEN	Power Feed Open	Indicates an open circuit in the T&R of either HDSL pair.
POFF	Power Feed Off	HDSL span power has been turned off by setting the PWRF option to DIS.
PWR OFF	Power Feed Off	HDSL span power has been turned off from the use of the A1LB/A2LB/A5LB Intelligent Office Repeater (IOR) power down code (see Tables 5, 6, and 9).
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 ####	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 the HLU-232 List 1D 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 and/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 MAL2	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 11. ADDITIONAL HLU 4-CHARACTER FRONT PANEL MESSAGES FOR PROTECTION OPERATION

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
PROT	Switched State	Displayed on Protection HLU only. This minor alarm indicates that the protection line unit has switched states and the DS1 data is transported over the protection circuit.
PROR	Protection Remote	Displayed on Protection HLU only. This minor alarm is generated whenever the protection line unit does not receive positive confirmation that the HRU has switched or reverted when requested.
HBER	Excessive HDSL Bit Error Rate	This minor alarm is generated on either the Primary or Protection HLU whenever the HLU determines that its current BER exceeded the minimum BER threshold set by the user.
MPRO	Manual Protect Mode	Displayed on Protection HLU only. Indicates that the Manual Protect mode has been activated either from a dumb terminal or from the front panel.
MDIS	Manual Disable Mode	Displayed on Protection HLU only. Indicates that the Manual Disable mode has been activated either from a dumb terminal or from the front panel.
APRO	Auto Protect Mode	Displayed on Protection HLU only. Indicates that Auto Protect mode has been activated from either an ASCII terminal or from the front panel. This mode enables the HLU to execute the "monitor" and "switched" state functions.
AHLD	Auto Hold Mode	Displayed on Protection HLU only. Same as APRO mode (above) except that PROTECT circuit remains on-line (non-reverting) once switchover occurs.
NORM	Normal Mode	Displayed on Protection HLU only. Indicates the Protection system capability is disabled and the HiGain units are operating as two separate "Normal" unprotected units.

5. SYSTEM MAINTENANCE MENU SCREENS

5.01 Figure 7 is the Maintenance Terminal MAIN MENU Screen. Its ten sub-menus provide many useful provisioning, test and monitoring tools. Figure 8 shows the HLU-232 List 1D 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-232 List 1D 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 normal user options can be set from this screen. To change any option, press 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-232 List 1D SPAN STATUS Screen shown in Figure 8. Note that since the HLU-232 List 1D is considered the master module, this clears *all* performance data screens at both the HLU-232 List 1D & 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-232 List 1D SPAN STATUS Screen (Figure 8). Note that since the HLU-232 List 1D is considered the master module, this clears *all* performance data screens at both the HLU-232 List 1D & 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" and "Last" columns contain the time and date stamp of the first and 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 RS-232 terminal interface at the HRU-412 does not allow the data to be cleared.

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.

5.09 Selections I and J on the Primary Line Unit's Main Menu (Figure 7) allow setting BER Threshold and BER Measurement Interval as described in Section A, subsection 6.

5.10 Selection I of the Protection Line Unit's Main Menu (Figure 15) causes the Protection Switching Function Menu (Figure 16) to be displayed. From this menu, the Protection Mode, Minimum Hold-In Time, BER Threshold, BER Interval, and Lock-In parameters can be set, as described in Section A, subsection 6. Select A, to view the Protection Mode Menu (Figure 17).

5.11 Selection J on the Protection Line Unit's Main Menu (Figure 15) provides a switchover event history (Figure 18), lists each Protection Switch event type, the date and time of both the oldest and the most recent event, the total number of occurrences and reason for last switchover.

5.12 For Protection Switching applications, ESAL (Errored Seconds Alarm) should be disabled.

TABLE 12. HLU-232 LIST 1D STATUS MENU MESSAGES

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
<i>ALARMS:</i>		
NONE	No Alarms	
LLOS	Local Loss of Signal	No signal from HLU-232 List 1D local T1 interface.
RLOS	Remote Loss of Signal	No signal from HRU-412 remote T1 interface.
LOSW1 LOSW2	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 BPVs for either the HLU-232 List 1D or HRU-412 have exceeded the user selected ES threshold.
RAIS LAIS	Remote (Local) Alarm Indicating Signal	Indicates an AIS (all "1s") 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.
ARM	Armed	The HiGain system detected the IR loopback (2 in 5) arming code.
PROT	Switched State	This minor alarm indicates that the Protect line unit has switched states and the T1 data is transported over the Protection circuit.
PROR	Protection Remote	This minor alarm is generated whenever the Protection HLU does not receive positive confirmation that the HRU has switched or reverted when requested.

Table continued on next page

TABLE 12. HLU-232 LIST 1D STATUS MENU MESSAGES (CONTINUED)

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
HBER	Excessive HDSL Bit Error Rate	This minor alarm is generated on either the Primary or Protection line unit whenever the line unit determines that its current BER has exceeded the minimum BER threshold set by the user.
<i>LOOPBACKS:</i>		
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, in-band loop code, HLU-232 front panel MANUAL LOOPBACK buttons, HRU-412 front panel button, or maintenance terminal (Figure 6).
NLOC	Network Local Loopback	Loopback at HLU-232 List 1D (local) towards network initiated from CO (network) by IOR code, in-band loop code, HLU front panel MANUAL LOOPBACK 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, in-band loop code, HLU-232 front panel MANUAL LOOPBACK buttons, or maintenance terminal (Figure 6).
CREM	Customer Remote Loopback	Loopback at HLU-232 List 1D (remote) towards customer initiated from CPE (customer) by IOR code, in-band loop code, HLU-232 front panel MANUAL LOOPBACK buttons, or maintenance terminal (Figure 6).
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.

TABLE 13. GLOSSARY OF HIGAIN TERMS

<i>Term</i>	<i>Definition</i>
MARGIN	Indicates the excess signal to noise ratio, at either the HRU-412 or HLU-232 List 1D 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 28 dB.
PPM OFFSET	Indicates the relative offset of the crystal oscillator in the HRU-412 from the HLU-232 List 1D crystal oscillator. Any value between -100 and +100 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 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 zeros).
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-yyyy	"w.x" = software version number of the HLU-232 List 1D. "yyyy" = list # of HLU-232 List 1D.
HRU/Ver a.b-cccc	"a.b" = software version number of the HRU-412. "cccc" = list # of HRU-412.

```

HI-GAIN HLU-232      MAINTENANCE TERMINAL MAIN MENU   (ver U2.3L-001D)
                      CIRCUIT 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 #
I. SET BER THRESHOLD
J. SET BER MEASUREMENT INTERVAL
    
```

Figure 7. HLU-232 List 1D Main Menu for the Primary Line Unit.

```

                                SPAN STATUS
                                ( HLU/ver2.3-001D: HRU/ver1.6-0007)

TIME: 00:42:03
DATE: 06/17/96                                CIRCUIT ID#:

ALARMS: NONE
LOOPBACK: OFF

                                HLU                                HRU
                                HDSL-1    HDSL-2    HDSL-1    HDSL-2
MARGIN:          cur/min/max  cur/min/max  cur/min/max  cur/min/max  dB
PULSE ATTN:      34           33           34           32           dB
PPM OFFSET:      00           00           -21          -20          ppm
24 HOUR ES:      00000       00001       00002       00002       seconds
24 HOUR UAS:     00018       00019       00001       00000       seconds

                                DS1 STATUS
                                HLU                                HRU
24 HOUR BPU Seconds:  00002                                00003
24 HOUR UAS Count:   00001                                00003
Frame type:          ESF                                ESF
Code type:           AMI                                AMI

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

Figure 8. HLU-232 List 1D non-Doubler Span Status.

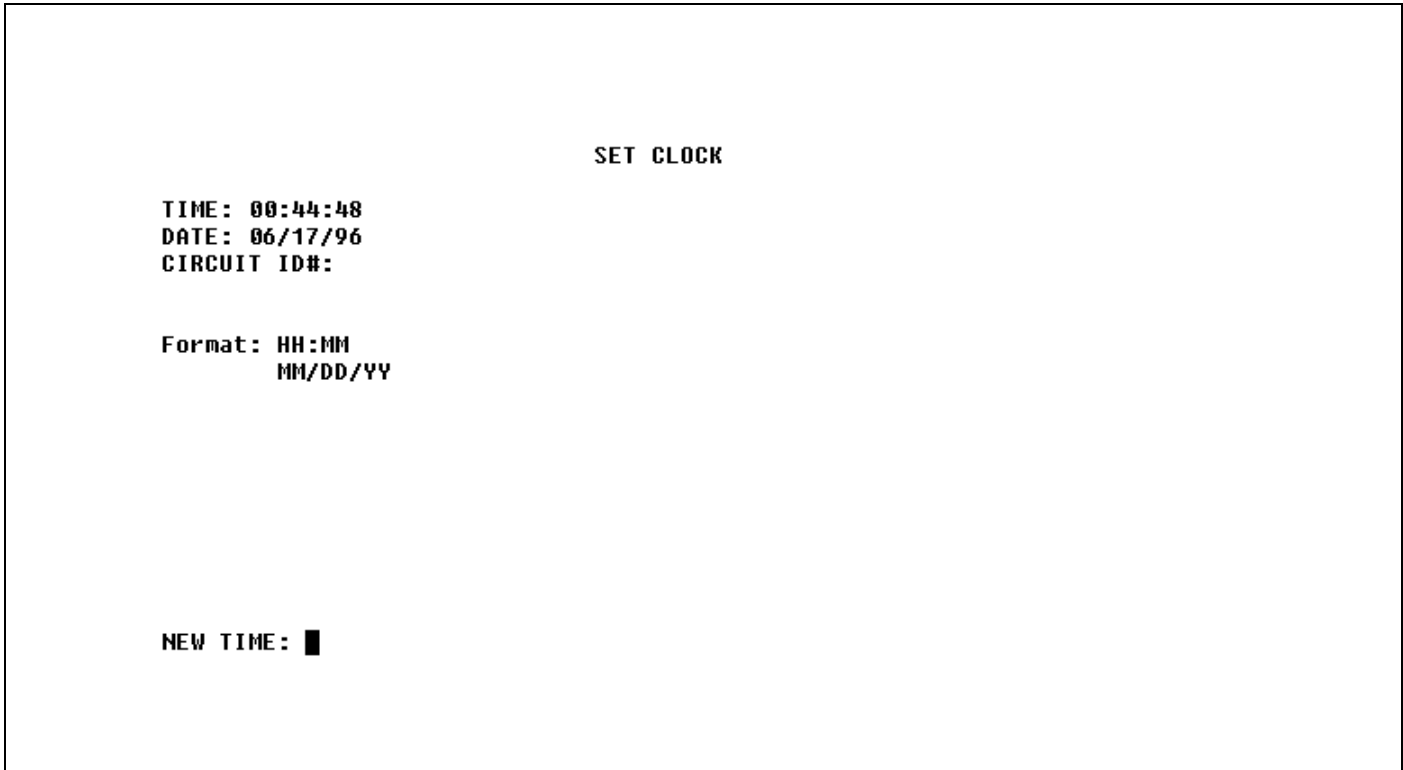


Figure 9. Set Clock Menu.

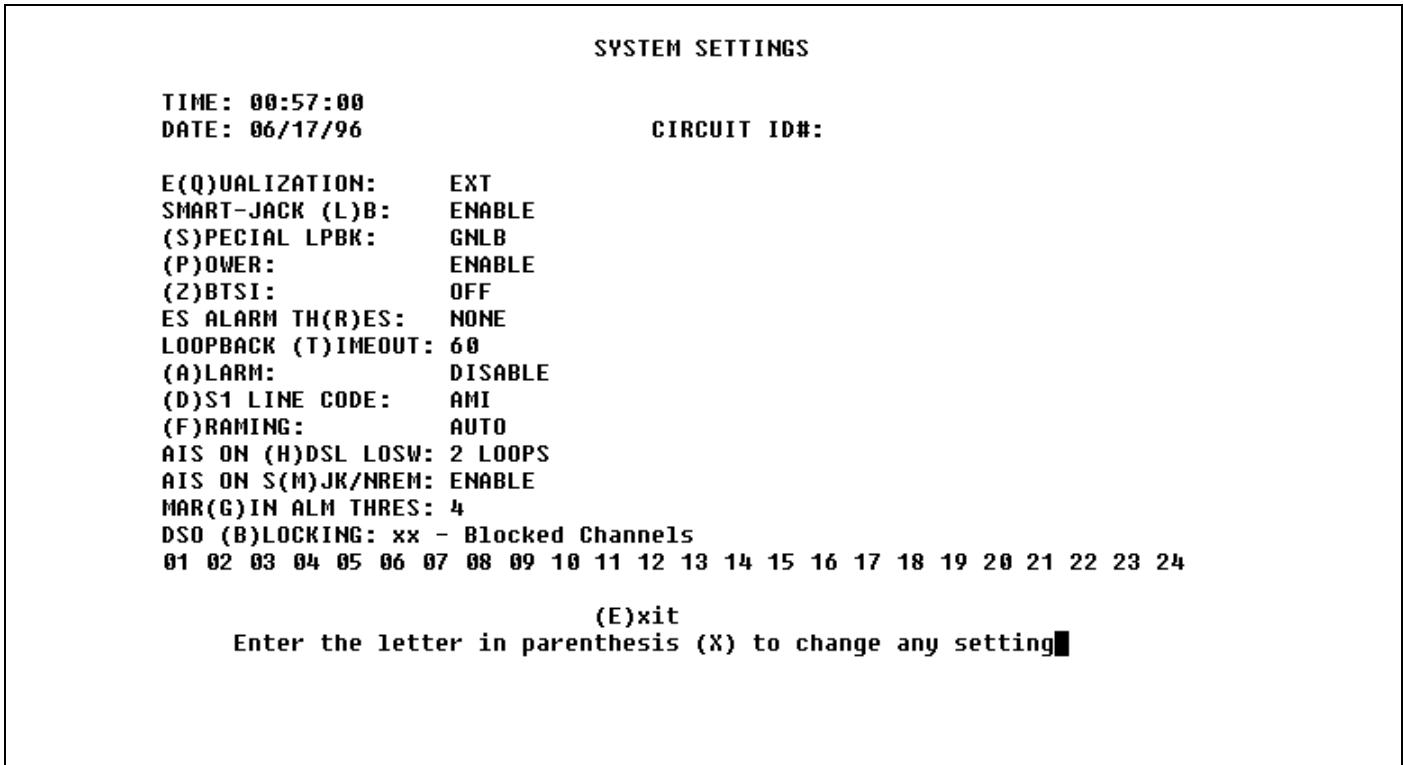


Figure 10. HLU-232 List 1D System Settings Main Menu.

```

                                LOOPBACK MENU

TIME: 00:59:36
DATE: 06/17/96
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 11. HLU-232 List 1D non-Doubler Loopback Menu.

```

Date: 06/17/96           PERFORMANCE DATA
CIRCUIT ID#:

                                ERRORED SECONDS/UNAVAILABLE SECONDS

                                DS1                HDSSL-1        HDSSL-2
                                HLU    HRU    HLU    HRU    HLU    HRU
21:15    000/000    000/000    000/000    000/000    000/000    000/000
21:30    000/000    000/000    000/000    000/000    000/000    000/000
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    002/001    003/003    000/018    002/001    001/019    002/000
00:30    000/000    000/000    000/000    000/000    000/000    000/000
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

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

Figure 12. HLU-232 List 1D non-Doubler Performance Data.

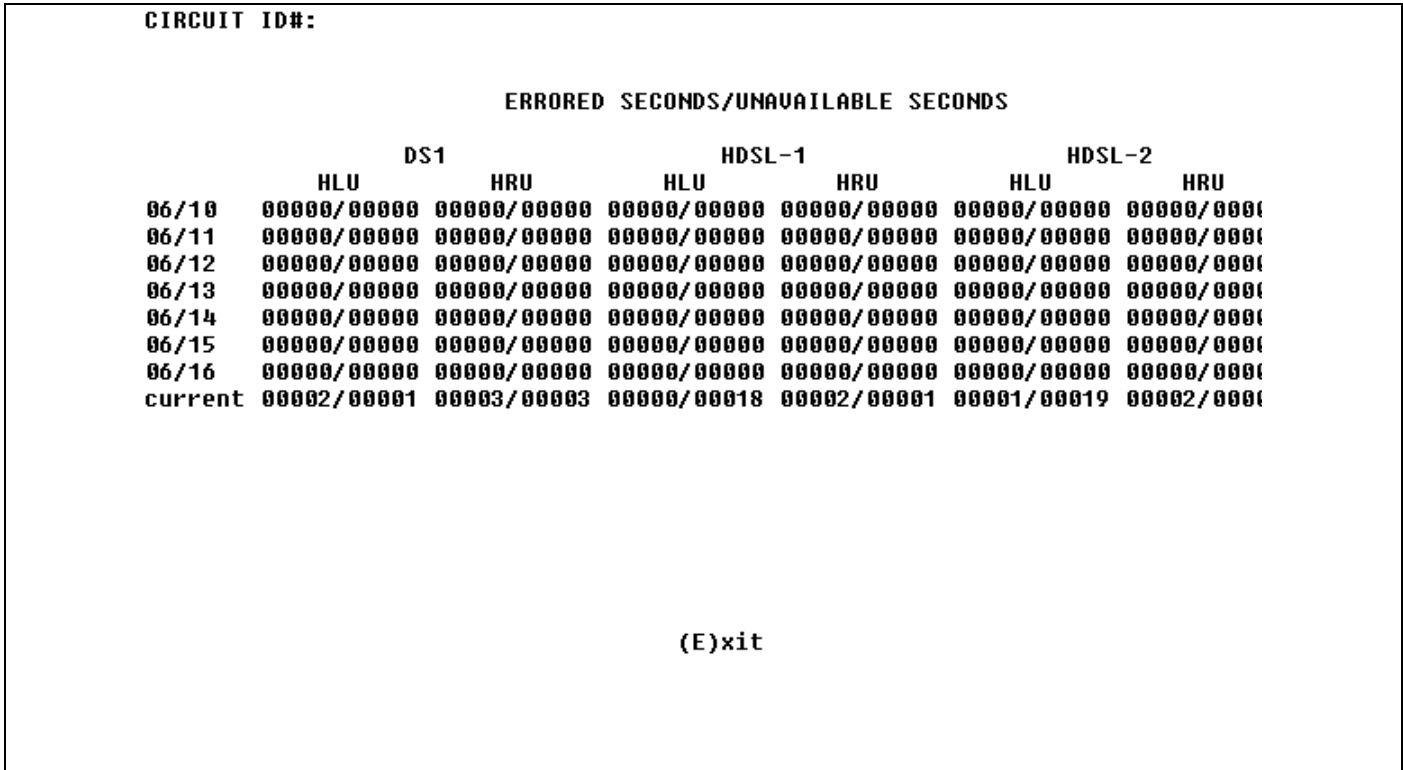


Figure 13. HLU-232 List 1D non-Doubler Performance Data History.

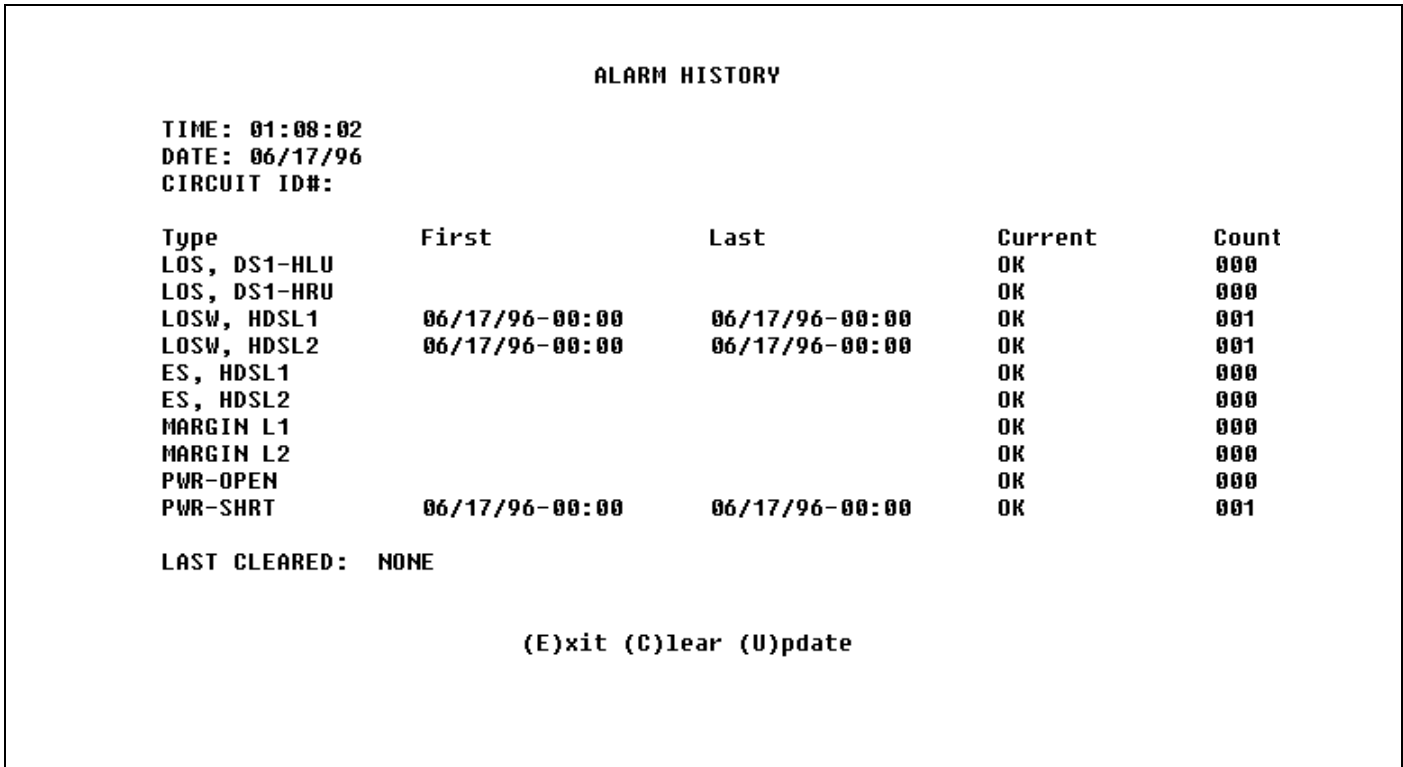


Figure 14. HLU-232 List 1D non-Doubler Alarm History.

```

HI-GAIN HLU-232      MAINTENANCE TERMINAL MAIN MENU   (ver U2.3L-001D)
                      CIRCUIT 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 #
                      I. SWITCHOVER STATUS AND CONFIG
                      J. VIEW SWITCHOVER HISTORY

█
    
```

Figure 15. HLU-232 List 1D Main Menu for the Protection Line Unit.

```

                                PROTECTION SWITCH FUNCTIONS
TIME/DATE: 01:33:42 06-17-96      CIRCUIT ID:
PROTECTION SYSTEM STATUS
  System state: SWITCHOVER LOCKED OUT

Switchover History:           First           Last           Count
                                000

PROTECTION SYSTEM CONFIGURATION
  A. Protection Mode           Auto Protect
  B. Minimum Hold-in Time      3 minutes
  D. BER (CRC) Threshold        1E-4
  F. BER Measurement Interval   5 minutes

If 04 switchovers occur within 10 minutes, lock-in for 24 hours
  G.---|
  H.-----|
  I.-----|

Enter the menu item letter to change any setting,
or select (U)pdate, (E)xit
    
```

Figure 16. Protection Switch Configuration Menu for the Protection Line Unit.

```
Protection Mode: Auto Protect

Enter item letter to change selection, or (E)xit

A. Manual Disable
B. Manual Protect
C. Auto Protect
D. Auto Hold

Choose new selection:
```

Figure 17. Protection Mode Menu for the Protection Line Unit

Switchover Event History

Type	First	Last	Count
Switchovers			000
Reversions			000
Switch Failures			000
Switch Lockouts	06/17/96-00:00	06/17/96-00:00	001

(E)xit (C)lear (U)pdate█

Figure 18. View Switchover History for the Protection Line Unit.

C. APPLICATIONS USING HIGAIN DOUBLERS

1. GENERAL

1.01 One or two HDU-451, HDU-439, or HDU-437 Doublers may be used to extend the distance between the HLU-232 Line Unit and the HRU-412 Remote Unit. Note that older List 1, 2, and 3 versions of the HDU-451 do not support protection switching.

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-232 List 1D 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-232 List 1D 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 14.

2.02 The maximum shelf current drain allowed is a function of the shelf -48 VDC fuse. Table 15 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 15 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-232 List 1D 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-232 List 1D 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.

2.05 The thermal loading limitations imposed when using the HLU-232 List 1D in Controlled Environment Vaults (CEV) or other enclosures are determined by applying the HLU-232 List 1D power parameters to the manufacturer requirements for each specific housing.

2.06 The power consumption listed in Table 14 is the total power that the HLU-232 List 1D consumes or draws from its -48 VDC shelf power source. This parameter is needed when the HLU-232 List 1D 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.

TABLE 14. HLU-232 LIST 1D DOUBLER POWER PARAMETERS

60 mA CPE Current	CO Voltage Volts	CO Current Amps HDU-451 List 1, 2	CO Current Amps HDU-451 List 3, 4 HDU-439/437	Power Consumption Watts HDU-451 List 1, 2	Power Consumption Watts HDU-451 List 3, 4, HDU-439/437	HLU Power Dissipation Watts HDU-451 List 1, 2	HLU Power Dissipation Watts HDU-451 List 3, 4, HDU-439/437i
OFF	42.5	0.65	0.50	28	22	8.5	8.25
OFF	48.0	0.59	0.41	28	22	8.5	8.25
OFF	56.0	0.50	0.38	28	22	8.5	8.25
ON	42.5	0.80	0.58	34	25	9.0	8.5
ON	48.0	0.70	0.52	34	25	9.0	8.5
ON	56.0	0.60	0.43	34	25	9.0	8.5

TABLE 15. HLU-232 LIST 1D/ HDU-451
LIST 1, 2, 3, and 4 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

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 2. The loopback locations are shown in Figure 27.

3.03 "GNLB" is the HiGain system Generic loopback code. The "GNLB" option 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 in-band loop codes must be present for at least five seconds before the HiGain system will respond. Table 16 lists the test procedures that apply when using the "GNLB" mode.

3.04 The A1LB loopback selection (Table 17) 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
- ◆ Repeater 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 addressable repeater loopback functions which are supported by the HLU-232 List 1D HiGain system. These loopbacks provide the HiGain system with sophisticated maintenance and trouble shooting tools. Table 16 through Table 21 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. The following 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-232 List 1D 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-232 List 1D, 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 doubler that is used. 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 17, 18, and 19 respectively. NDU1 and NDU2, along with the rest of the loopbacks towards the network, can be issued from the Loopback Menu shown in Figure 27. See Section C paragraph 3.10 below for Front Panel-initiated loopbacks. The simplest HiGain system includes two loopback locations: The HLU-232 List 1D and the HRU-412. The most complex HiGain system application includes the HLU-232 List 1D, HRU-412 & two in-line 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-232 List 1D & 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-232 List 1D receive pattern code is first changed from AMI to B8ZS, and second, the all "0" pattern is sent into the HLU-232 List 1D, the HLU-232 List 1D 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-232 List 1D 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** 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 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** button, "NLO?" is replaced by "ND1?". This now allows an "NDU1" loopback to be executed (if it is a Doubler application) with the **SEL** 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. This interactive button procedure permits any of the eight HiGain loopbacks to be executed/activated. The next loopback option can be presented by pressing the **MODE** button however, the previously executed loopback will remain active until the **SEL** 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 27), from which any of the eight loopbacks can be initiated/terminated.

4. TESTING

4.01 Table 16 through Table 21 provide step-by-step test procedures for the HLU-232 List 1D 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-232 List 1D 4-character front panel display has many useful system diagnostic messages; which are listed in Table 22. The display turns on when power is initially applied to the HLU-232 List 1D. In order to conserve power, it only remains on for four minutes if neither the **MODE** nor **SEL** buttons are pressed. The use of either button activates the 4-character display and restarts the 4-minute power-control timer.

4.03 If trouble is encountered on the HLU-232 List 1D DSX-1 interface, verify that the HLU-232 List 1D is properly seated in the HSA-232 adapter, and the HSA-232 is properly seated in the 220-shelf. Also, verify that the HLU-232 List 1D internal equalizer is set to EXT for driving external equalizers or to the correct distance range per 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-232 List 1D. If plugs are inserted into both SPAN jacks, the BRG jacks can be used to send and receive test patterns towards the DSX-1.

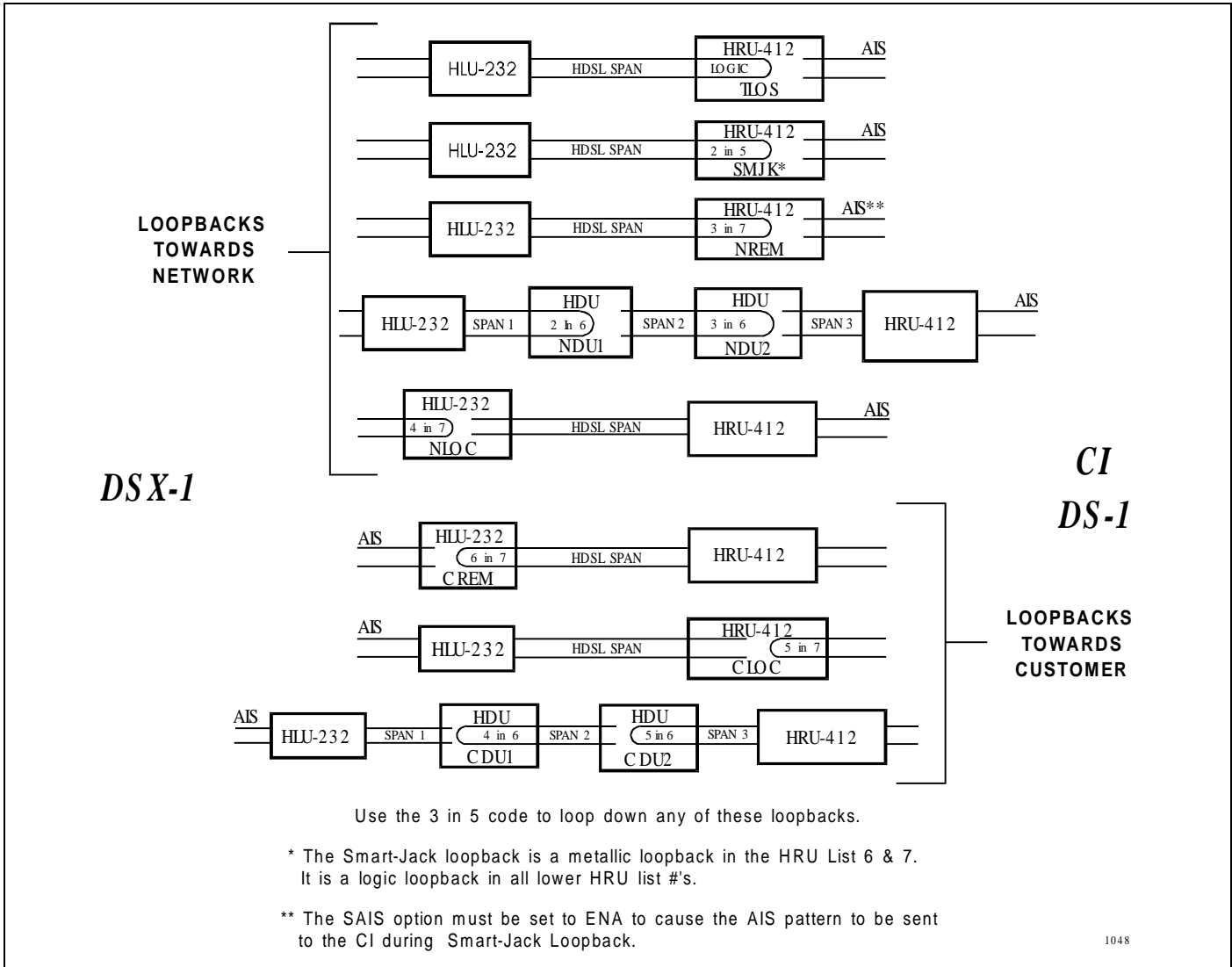


Figure 19. HLU-232 Doubler Loopback Configurations. The most important of the HiGain family of loopback options is the Smart-Jack loopback, which emulates the functions of a standard NID.

TABLE 16. HLU-232 GNLB TEST PROCEDURES

<i>Step</i>	<i>Action</i>
1	Have the CO tester send the HRU-412 (3 in 7) in-band loop-up code for five seconds. Observe that the HLU-232 List 1D displays the "NREM" message indicating an HRU-412 loopback is in effect (Figure 19).
2	Have the CO tester transmit a T1 test signal into the HLU-232 List 1D 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-232 List 1D display returns to normal.
4	Have the CO tester send the HLU-232 List 1D (4 in 7) in-band loop-up code for five seconds. Observe that the HLU-232 List 1D displays the "NLOC" message indicating an HLU-232 List 1D 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-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10).
7	The HLU-232 List 1D can be looped-up from the remote location (CREM) by issuing the (6 in 7) in-band loop-up code 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) in-band loop-up code 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 in-band loop-up code 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 in-band loop-up code at the HLU-232 List 1D DS1 input port.
11	Doubler #2 can engage loopback from the remote location (CDU2) by issuing the (5 in 6) loopback in-band loop-up code 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 in-band loop-up code at the HLU-232 List 1D 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-232 List 1D receive pattern's code is changed from AMI to B8ZS and the all "0" pattern is sent into the HLU-232 List 1D, 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-232 List 1D 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 17. HLU-232 A1LB TEST PROCEDURES

<i>Step</i>	<i>Action</i>
1	Send into the HLU-232 List 1D 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-232 List 1D for 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates “ARM” and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 19) by sending the IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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, 20 errors if ILR-2, 200 errors if ILR-20), 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 IOR, Time-Out Override and Query commands. <p>The HLU-232 List 1D is now in Logic Loopback (NLOC of Figure 19). The display on the HLU-232 List 1D periodically shows NLOC and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 List 1D 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 17. HLU-232 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 19. A customer tester can activate loopbacks CLOC or CREM.		
	ADDRESSABLE 1 (A1LB) 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 16-bit binary code.		
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	All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10).		

TABLE 18. HLU-232 A2LB TEST PROCEDURES

Step	Action
1	Send into the HLU-232 List 1D 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-232 List 1D for 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates “ARM” and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 19) by sending the IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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, 20 errors if ILR-2, 200 errors if ILR-20), 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 IOR, Time-Out Override and Query commands. <p>The HLU-232 List 1D is now in Logic Loopback (NLOC of Figure 19). The display on the HLU-232 List 1D periodically shows NLOC and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 List 1D 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 18. HLU-232 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 19. 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 16-bit binary code.		
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	All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10).		

TABLE 19. HLU-232 A3LB TEST PROCEDURES

Step	Action																																													
1	<p>The HLU-232 List 1D can be looped back by sending the Addressable Office Repeater (AOR) LPBK activation code 1111 1111 0001 1110 (FF1E) for at least five seconds. This causes the HLU-232 List 1D to enter its NLOC state shown in Figure 19. The display on the HLU-232 List 1D 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-232 List 1D 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.</p>																																													
2	<p>The following list summarizes the codes required to execute all the HiGain system loopbacks shown in Figure 19. Note that all code sequences must be present for at least five seconds.</p> <p style="text-align: center;">ABBREVIATIONS USED BELOW:</p> <p style="margin-left: 40px;">LU = LoopUp LD = LoopDown NI = Network Interface CI = Customer Interface ESF-DL = Extended Super Frame Data Link</p> <p style="text-align: center;">ADDRESSABLE 3 (A3LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Position</i></th> <th style="text-align: center;"><i>Name</i></th> <th style="text-align: center;"><i>Code</i></th> </tr> </thead> <tbody> <tr> <td>HLU-232 LU FROM NI</td> <td>NLOC</td> <td>1111(F)*1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HLU-232 LU FROM CI</td> <td>CREM</td> <td>0011(3)1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HDU-451 DOUBLER 1 FROM NI</td> <td>NDU1</td> <td>1111(F)*1111(F)0000(0)0100(4)</td> </tr> <tr> <td>HDU-451 DOUBLER 1 FROM CI</td> <td>CDU1</td> <td>0011(3)*1111(F)0000(0)0100(4)</td> </tr> <tr> <td>HDU-451 DOUBLER 2 FROM NI</td> <td>NDU2</td> <td>1111(F)*1111(F)0000(0)0101(6)</td> </tr> <tr> <td>HDU-451 DOUBLER 2 FROM CI</td> <td>CDU2</td> <td>0011(3)*1111(F)0000(0)0101(6)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>NREM</td> <td>1111(F)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM CI</td> <td>CLOC</td> <td>0011(3)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>SMJK</td> <td>11000 11000 11000 ...</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>SMJK</td> <td>100000 100000 100000 ...</td> </tr> <tr> <td>HRU-412 LU FROM NI (ESF-DL)</td> <td>SMJK</td> <td>1111(F)1111(F)0100(4)1000(8)</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>11100 11100 11100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>100 100 100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI (ESF-DL)</td> <td></td> <td>1111(F)1111(F)0010(2)0100(4)</td> </tr> </tbody> </table> <p>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 16-bit binary code.</p>	<i>Position</i>	<i>Name</i>	<i>Code</i>	HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)	HLU-232 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)
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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)																																												
3	<p>All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10).</p>																																													

TABLE 20. HLU-232 A4LB TEST PROCEDURES

<i>Step</i>	<i>Action</i>																																										
1	The HLU-232 List 1D can be looped back by sending the Addressable Office Repeater (AOR) LPBK activation code 1111 1111 0001 1110 (FF1E) for at least five seconds. This causes the HLU-232 List 1D to enter its NLOC state shown in Figure 19. The display on the HLU-232 List 1D 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-232 List 1D 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	<p>The following list summarizes the codes required to execute all the HiGain system loopbacks shown in Figure 19. Note that all code sequences must be present for at least five seconds.</p> <p style="text-align: center;">ABBREVIATIONS USED BELOW:</p> <p style="text-align: center;">LU = LoopUp LD = LoopDown NI = Network Interface CI = Customer Interface ESF-DL = Extended Super Frame Data Link</p> <p style="text-align: center;">ADDRESSABLE 4 (A4LB) REPEATER LOOPBACK COMMANDS</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Position</i></th> <th style="text-align: center;"><i>Name</i></th> <th style="text-align: center;"><i>Code</i></th> </tr> </thead> <tbody> <tr> <td>HLU-232 LU FROM NI</td> <td>NLOC</td> <td>1111(F)*1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HLU-232 LU FROM CI</td> <td>CREM</td> <td>0011(3)1111(F)0001(1)1110(E)</td> </tr> <tr> <td>HDU-451 DOUBLER 1 FROM NI</td> <td>NDU1</td> <td>1111(F)*1111(F)0000(0)0100(4)</td> </tr> <tr> <td>HDU-451 DOUBLER 1 FROM CI</td> <td>CDU1</td> <td>0011(3)*1111(F)0000(0)0100(4)</td> </tr> <tr> <td>HDU-451 DOUBLER 2 FROM NI</td> <td>NDU2</td> <td>1111(F)*1111(F)0000(0)0101(6)</td> </tr> <tr> <td>HDU-451 DOUBLER 2 FROM CI</td> <td>CDU2</td> <td>0011(3)*1111(F)0000(0)0101(6)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>NREM</td> <td>1111(F)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM CI</td> <td>CLOC</td> <td>0011(3)1111(F)0000(0)0010(2)</td> </tr> <tr> <td>HRU-412 LU FROM NI</td> <td>SMJK</td> <td>11000 11000 11000 ...</td> </tr> <tr> <td>HRU-412 LU FROM NI (ESF-DL)</td> <td>SMJK</td> <td>1111(F)1111(F)0100(4)1000(8)</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>11100 11100 11100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI</td> <td></td> <td>100 100 100 ...</td> </tr> <tr> <td>HLU & HRU LD FROM NI OR CI (ESF-DL)</td> <td></td> <td>1111(F)1111(F)0010(2)0100(4)</td> </tr> </tbody> </table> <p>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 16-bit binary code.</p>	<i>Position</i>	<i>Name</i>	<i>Code</i>	HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)	HLU-232 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)
<i>Position</i>	<i>Name</i>	<i>Code</i>																																									
HLU-232 LU FROM NI	NLOC	1111(F)*1111(F)0001(1)1110(E)																																									
HLU-232 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 ...																																									
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HLU & HRU LD FROM NI OR CI (ESF-DL)		1111(F)1111(F)0010(2)0100(4)																																									
3	All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10.)																																										

TABLE 21. HLU-232 A5LB TEST PROCEDURES

Step	Action
1	Send into the HLU-232 List 1D 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-232 List 1D 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-232 List 1D and HRU-412 units have been ARMED. Verify that the HLU-232 List 1D display intermittently indicates "ARM" and the STATUS LED is flashing yellow at a rate of 4 times per second 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 is illuminated steadily, indicating that it is both armed and in loopback.
3	<p>Once armed the HLU-232 List 1D can be looped back (NLOC in Figure 19) by sending the IOR LPBK activation code 1101 0011 1101 0011 (D3D3) for at least five seconds. The tester observes the following activation response:</p> <ul style="list-style-type: none"> • 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, 20 errors if ILR-2, 200 errors if ILR-20), 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 IOR, Time-Out Override and Query commands. <p>The HLU-232 List 1D is now in Logic Loopback (NLOC of Figure 19). The display on the HLU-232 List 1D periodically shows NLOC and ARM (the HLU-232 List 1D is still armed) in addition to the margin displays and the STATUS LED is illuminated a steady yellow. 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-232 List 1D 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.</p>
4	Upon completion, the tester sends IR LPDN code 1001 0011 1001 0011 (9393) to loop-down the HLU-232 List 1D. The unit remains armed however, as indicated by the ARM message and flashing yellow STATUS LED on the HLU-232 List 1D and the flashing of the HRU-412 LOOPBACK LED.

Table continued on next page

TABLE 21. HLU-232 A5LB TEST PROCEDURES (CONTINUED)

<i>Step</i>	<i>Action</i>		
5	Using the following codes, a network tester can activate loopbacks NLOC or NREM or SMJK (if enabled) shown in Figure 19. A customer tester can activate loopbacks CLOC or CREM.		
	ADDRESSABLE 5 (A5LB) 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)
	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-232 List 1D returns to its normal unlooped and unarmed state. *This is the HEX number for the 16-bit binary code.		
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	All of the above loopbacks can also be initiated from the front panel of the HLU-232 List 1D with the MODE and SEL buttons (Section C Paragraph 3.10).		

TABLE 22. HLU-232, LIST 1D 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-232.
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	DSX signal is looped back to DSX 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-232.
SIG1 SIG2	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 S2L2	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 S3L2	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.
ACQ1 ACQ2	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 A2L2	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 A3L2	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.
SELF TEST	Self Test	The HLU is in 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.

Table continued on next page

TABLE 22. HLU-232, LIST 1D 4-CHARACTER FRONT PANEL MESSAGES (CONTINUED)

Message	Full Name	Description
POFF	Power Feed Off	HDSL span power has been turned off by setting the PWRF option to DIS.
PWR OFF	Power Feed Off	HDSL span power has been turned off from the use of the A1LB/A2LB/A5LB Intelligent Office Repeater (IOR) power down code (see Tables 17, 18, and 21).
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 ####	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-232 List 1D 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 and/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 MAL2	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 23. ADDITIONAL HLU 4-CHARACTER FRONT PANEL MESSAGES FOR PROTECTION OPERATION

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
PROT	Switched State	Displayed on Protection HLU only. This minor alarm indicates that the protection line unit has switched states and the DS1 data is transported over the protection circuit.
PROR	Protection Remote	Displayed on Protection HLU only. This minor alarm is generated whenever the protection line unit does not receive positive confirmation that the HRU has switched or reverted when requested.
HBER	Excessive HDSL Bit Error Rate	This minor alarm is generated on either the Primary or Protection HLU whenever the HLU determines that its current BER exceeded the minimum BER threshold set by the user.
MPRO	Manual Protect Mode	Displayed on Protection HLU only. Indicates that the Manual Protect mode has been activated either from a dumb terminal or from the front panel.
MDIS	Manual Disable Mode	Displayed on Protection HLU only. Indicates that the Manual Disable mode has been activated either from a dumb terminal or from the front panel.
APRO	Auto Protect Mode	Displayed on Protection HLU only. Indicates that Auto Protect mode has been activated from either an ASCII terminal or from the front panel. This mode enables the HLU to execute the “monitor” and “switched” state functions.
AHLD	Auto Hold Mode	Displayed on Protection HLU only. Same as APRO mode (above) except that PROTECT circuit remains on-line (non-reverting) once switchover occurs.
NORM	Normal Mode	Displayed on Protection HLU only. Indicates the Protection system capability is disabled and the HiGain units are operating as two separate “Normal” unprotected units.

5. SYSTEM MAINTENANCE MENU SCREENS

5.01 Figure 20 is the Maintenance Terminal MAIN MENU Screen. Its ten sub-menus provide many useful provisioning, test and monitoring tools.

5.02 Figure 21 through Figure 24 show the HLU-232 List 1D SPAN STATUS screens for single and dual Doubler applications. The SPAN 1 Screen contains data on the two HDSL loops between the HLU-232 List 1D 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.

5.03 Figure 25 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-232 List 1D 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.

5.04 Figure 26 shows the SYSTEM SETTINGS Menu Screen. All 14 user options can be set from this screen. To change any option, press 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.

5.05 Figure 27 shows the LOOPBACK MENU Screen for a single doubler system. Each of the three HiGain Units can be looped back towards the network or the customer from this screen.

5.06 Figure 28 through Figure 31 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-232 List 1D 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-232 List 1D SPAN STATUS Screen shown in Figure 21 through Figure 24. Note that since the HLU-232 List 1D is considered the master module, this clears *all* performance data screens at both the HLU-232 List 1D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared.

5.07 Figure 32 through Figure 35 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-232 List 1D 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-232 List 1D SPAN STATUS Screen. Note that since the HLU-232 List 1D is considered the master module, this clears *all* performance data screens at both the HLU-232 List 1D & the HRU-412. The RS-232 terminal interface at the HRU-412 does not allow the counters to be cleared.

5.08 Figure 36 through Figure 38 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-232 List1D. PWR alarm conditions apply only to SPAN 1 eventhough they are displayed on the other spans. In Figure 36 through Figure 38, 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-232 List 1D 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. The RS-232 terminal interface at the HRU-412 does not allow the data to be cleared.

5.09 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.

5.10 Selection I of the Protection Line Unit’s Main Menu (Figure 39) causes the Protection Switching Functions Menu (Figure 40) to be displayed. From this menu, the Protection Mode, Minimum Hold-In Time, BER Threshold, BER Interval, and Lock-In parameters can be set, as described in Section A, subsection 6. Select A to view the Protection Mode Menu (Figure 41).

5.11 Selection J on the Protection Line Unit’s Main Menu (Figure 39) provides a switchover event history, (Figure 42) lists each Protection Switch event type, the date and time of both the oldest and the most recent event, along with a total number of occurrences and reason for last switchover.

5.12 For Protection Switching applications, ESAL (Errored Seconds Alarm) should be disabled.

TABLE 24. HLU-232 LIST 1D STATUS MENU MESSAGES

<i>Message</i>	<i>Full Name</i>	<i>Description</i>
ALARMS:		
LLOS	Local Loss of Signal	No signal from HLU-232 List 1D local T1 interface.
RLOS	Remote Loss of Signal	No signal from HRU-412 remote T1 interface.
LOSW1 LOSW2	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	DS1 input BPVs either the HLU-232 List 1D or HRU-412 DS1 input have exceeded the user selected ES threshold.
RAIS LAIS	Remote (Local) Alarm Indicating Signal	Indicates an AIS (all "1's") 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.
ARM	Armed	The HiGain system has detected the IR loopback (2 in 5) arming code.
PROT	Switched State	This minor alarm indicates that the Protect line unit has switched states and the T1 data is transported over the Protection circuit.
PROR	Protection Remote	This minor alarm is generated whenever the Protection HLU does not receive positive confirmation that the HRU has switched or reverted when requested.

Table continued on next page

TABLE 24. HLU-232 LIST 1D STATUS MENU MESSAGES (CONTINUED)

Message	Full Name	Description
HBER	Excessive HDSL Bit Error Rate	This minor alarm is generated on either the Primary or Protection line unit whenever the line unit determines that its current BER has exceeded the minimum BER threshold set by the user.
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 19).
NREM	Network Remote Loopback	Loopback at HRU-412 (remote) towards network initiated from CO (network) by Intelligent Line Repeater (ILR) #2 code, in-band loop code HLU-232 front panel MANUAL LOOPBACK buttons, HRU-412 front panel button, or maintenance terminal (Figure 19).
NLOC	Network Local Loopback	Loopback at HLU-232 List 1D (local) towards network initiated from CO by IOR code, in-band loop code HLU-232 front panel MANUAL LOOPBACK buttons or maintenance terminal (Figure 19).
HDU1	Network Doubler 1 Loopback	Loopback at Doubler #1 towards network initiated by IOR code, in-band loop code, or HLU-232 front panel MANUAL LOOPBACK buttons or maintenance terminal (Figure 19).
HDU2	Network Doubler 2 Loopback	Loopback at Doubler #2 towards network initiated by IOR code, in-band loop code, or HLU-232 front panel MANUAL LOOPBACK buttons or maintenance terminal (Figure 19).
CLOC	Customer Local Loopback	Loopback at HRU-412 (local) towards CI initiated from CPE by ILR code, in-band loop code, or HLU-232 front panel MANUAL LOOPBACK buttons or maintenance terminal (Figure 19).
CREM	Customer Remote Loopback	Loopback at HLU-232 List 1D (remote) towards customer initiated by IOR code, in-band loop code, or HLU front panel MANUAL LOOPBACK buttons, or maintenance terminal (Figure 19).
CDU 1	Customer Doubler 1 Loopback	Loopback at Doubler 1 towards CI initiated by ILR code, HLU-232 front panel MANUAL LOOPBACK buttons, or maintenance terminal (Figure 19).
CDU 2	Customer Doubler 2 Loopback	Loopback at Doubler 2 towards CI initiated by ILR code, in-band loop code, HLU-232 front panel MANUAL LOOPBACK buttons, or maintenance terminal (Figure 19).
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.

TABLE 25. GLOSSARY OF HIGAIN TERMS

<i>Term</i>	<i>Definition</i>
MARGIN	Indicates the excess signal to noise ratio, at the HRU-412, HDU-451, or HLU-232 List 1D 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 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 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-232 List 1D crystal oscillator. Any value between -100 and +100 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 zero).
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-yyyy	"w.x" = software version number of the HLU-232 List 1D. "yyyy" = list # of HLU-232 List 1D.
HRU/Ver a.b-cccc	"a.b" = software version number of the HRU-412. "cccc" = list # of HRU-412.
HDU1/Ver s.t-uuuu	"s.t" = the software version number of the HDU-451 #1. "uuuu" = List number of the HDU-451 #1.
HDU2/Ver f.g-hhhh	"f.g" = the software version number of the HDU-451 #2. "hhhh" = List number of the HDU-451 #2.

```

HI-GAIN HLU-232      MAINTENANCE TERMINAL MAIN MENU  (ver U2.3L-001D)
                      CIRCUIT 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 #
I. SET BER THRESHOLD
J. SET BER MEASUREMENT INTERVAL
    
```

Figure 20. HLU-232 List 1D Main Menu for the Primary Line Unit.

```

                      SPAN 1 STATUS
                ( HLU/ver2.3-001D:HDU1/ver2.6-0003)

TIME: 00:08:43
DATE: 06/17/96                      CIRCUIT ID#:

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:         08/08/09      09/08/10      07/00/08      08/00/09 dB
PULSE ATTN:     34             33             34             32 dB
PPM OFFSET:     00             00             -01            -01 ppm
24 HOUR ES:     00000         00000         00000         00000 seconds
24 HOUR UAS:    00013         00014         00005         00006 seconds

                      DS1 STATUS

24 HOUR BPU Seconds:   HLU      HRU
24 HOUR UAS Count:    00002    00004
Frame type:           ESF      ESF
Code type:            AMI      AMI

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

Figure 21. HLU-232 List 1D Status Display - Span 1 (1 or 2 Doublers).


```

                SPAN 2 STATUS
                (HDU1/ver2.6-0003: HRU/ver1.6-0007)

TIME: 00:23:05
DATE: 06/17/96                                CIRCUIT ID#:

ALARMS:  NONE
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:        12/00/12    11/00/11    08/08/09    09/09/10 dB
PULSE ATTN:    30         30         30         30 dB
PPM OFFSET:    00         00         -19        -19 ppm
24 HOUR ES:    00000     00000     00005     00002 seconds
24 HOUR UAS:   00004     00003     00001     00000 seconds

                DS1 STATUS

24 HOUR BPU Seconds:    HLU        HRU
                        00002        00004
24 HOUR UAS Count:     00001        00005
Frame type:             ESF         ESF
Code type:              AMI         AMI

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

```

Figure 22. HLU-232 List 1D Status Display - Span 2 (1 Doubler).

```

                SPAN 2 STATUS
                (HDU1/ver2.6-0003:HDU2/ver2.6-0003)

TIME: 00:54:58
DATE: 06/17/96                                CIRCUIT ID#:

ALARMS:  CHREV
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:        11/00/12    11/00/12    11/00/11    12/00/12 dB
PULSE ATTN:    30         30         30         30 dB
PPM OFFSET:    00         00         -07        -07 ppm
24 HOUR ES:    00001     00004     00000     00001 seconds
24 HOUR UAS:   00029     00022     00004     00010 seconds

                DS1 STATUS

24 HOUR BPU Seconds:    HLU        HRU
                        00006        00028
24 HOUR UAS Count:     00002        00028
Frame type:             ESF         ESF
Code type:              AMI         AMI

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

```

Figure 23. HLU-232 List 1D Status Display - Span 2 (2 Doublers).

```

                SPAN 3 STATUS
          (HDU2/ver2.6-0003: HRU/ver1.6-0007)

TIME: 00:57:03
DATE: 06/17/96                CIRCUIT ID#:

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:          11/00/11    11/00/11    08/08/09    08/00/09 dB
PULSE ATTN:          30          31          31          31 dB
PPM OFFSET:          00          00          -11         -11 ppm
24 HOUR ES:          00003      00002      00025      00016 seconds
24 HOUR UAS:          00015      00008      00031      00005 seconds

                DS1 STATUS
          HLU                      HRU
24 HOUR BPU Seconds:    00007      00029
24 HOUR UAS Count:     00003      00029
Frame type:             ESF          ESF
Code type:              AMI          AMI

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

```

Figure 24. HLU-232 List 1D Status Display - Span 3 (2 Doublers).

```

TIME: 00:10:04
DATE: 06/17/96
CIRCUIT ID#:

Format: HH:MM
       MM/DD/YY

NEW TIME:
NEW DATE:

(U)PDATE REMOTE?

```

Figure 25. HLU-232 List 1D Set Clock Menu.

```

                                SYSTEM SETTINGS

TIME: 00:11:25
DATE: 06/17/96                                CIRCUIT ID#:

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 26. HLU-232 List 1D Systems Settings Menu.

```

                                LOOPBACK MENU

TIME: 00:12:36
DATE: 06/17/96
CIRCUIT ID#:

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

                                (E)xit

```

Figure 27. HLU-232 List 1D Doubler Loopback Menu.

```

Date: 06/17/96          SPAN 1 PERFORMANCE DATA
CIRCUIT ID#:
      ERRORED SECONDS/UNAVAILABLE SECONDS

      DS1              HDSL-1              HDSL-2
      HLU      HRU      HLU      HDU1      HLU      HDU1
20:15  000/000  000/000  000/000  000/000  000/000  000/000
20:30  000/000  000/000  000/000  000/000  000/000  000/000
20:45  000/000  000/000  000/000  000/000  000/000  000/000
21:00  000/000  000/000  000/000  000/000  000/000  000/000
21:15  000/000  000/000  000/000  000/000  000/000  000/000
21:30  000/000  000/000  000/000  000/000  000/000  000/000
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

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

Figure 28. HLU-232 List 1D Performance Data - Span 1 (1 or 2 Doublers).

```

Date: 06/17/96          SPAN 2 PERFORMANCE DATA
CIRCUIT ID#:
      ERRORED SECONDS/UNAVAILABLE SECONDS

      DS1              HDSL-1              HDSL-2
      HLU      HRU      HDU1      HRU      HDU1      HRU
20:45  000/000  000/000  000/000  000/000  000/000  000/000
21:00  000/000  000/000  000/000  000/000  000/000  000/000
21:15  000/000  000/000  000/000  000/000  000/000  000/000
21:30  000/000  000/000  000/000  000/000  000/000  000/000
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  002/001  004/005  000/004  005/001  000/003  002/000
00:30  000/000  000/000  000/000  001/000  000/000  000/000

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

Figure 29. HLU-232 List 1D Performance Data - Span 2 (1 Doubler).

```

Date: 06/17/96          SPAN 2 PERFORMANCE DATA
CIRCUIT ID#:
ERRORED SECONDS/UNAVAILABLE SECONDS

          DS1                HDSSL-1                HDSSL-2
          HLU                HRU                HDU1                HDU2                HDU1                HDU2
21:00    000/000    000/000    000/000    000/000    000/000    000/000
21:15    000/000    000/000    000/000    000/000    000/000    000/000
21:30    000/000    000/000    000/000    000/000    000/000    000/000
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    002/001    004/005    000/004    000/000    000/003    000/000
00:30    000/000    000/000    000/000    000/000    000/000    000/000
00:45    000/000    000/000    000/000    000/000    000/000    000/000

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

```

Figure 30. HLU-232 List 1D Performance Data - Span 2 (2 Doublers).

```

Date: 06/17/96          SPAN 3 PERFORMANCE DATA
CIRCUIT ID#:
ERRORED SECONDS/UNAVAILABLE SECONDS

          DS1                HDSSL-1                HDSSL-2
          HLU                HRU                HDU2                HRU                HDU2                HRU
21:00    000/000    000/000    000/000    000/000    000/000    000/000
21:15    000/000    000/000    000/000    000/000    000/000    000/000
21:30    000/000    000/000    000/000    000/000    000/000    000/000
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    002/001    004/005    000/000    005/001    000/000    002/000
00:30    000/000    000/000    000/000    001/000    000/000    000/000
00:45    000/000    000/000    000/000    006/000    000/000    000/000

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

```

Figure 31. HLU-232 List 1D Performance Data - Span 3 (2 Doublers).

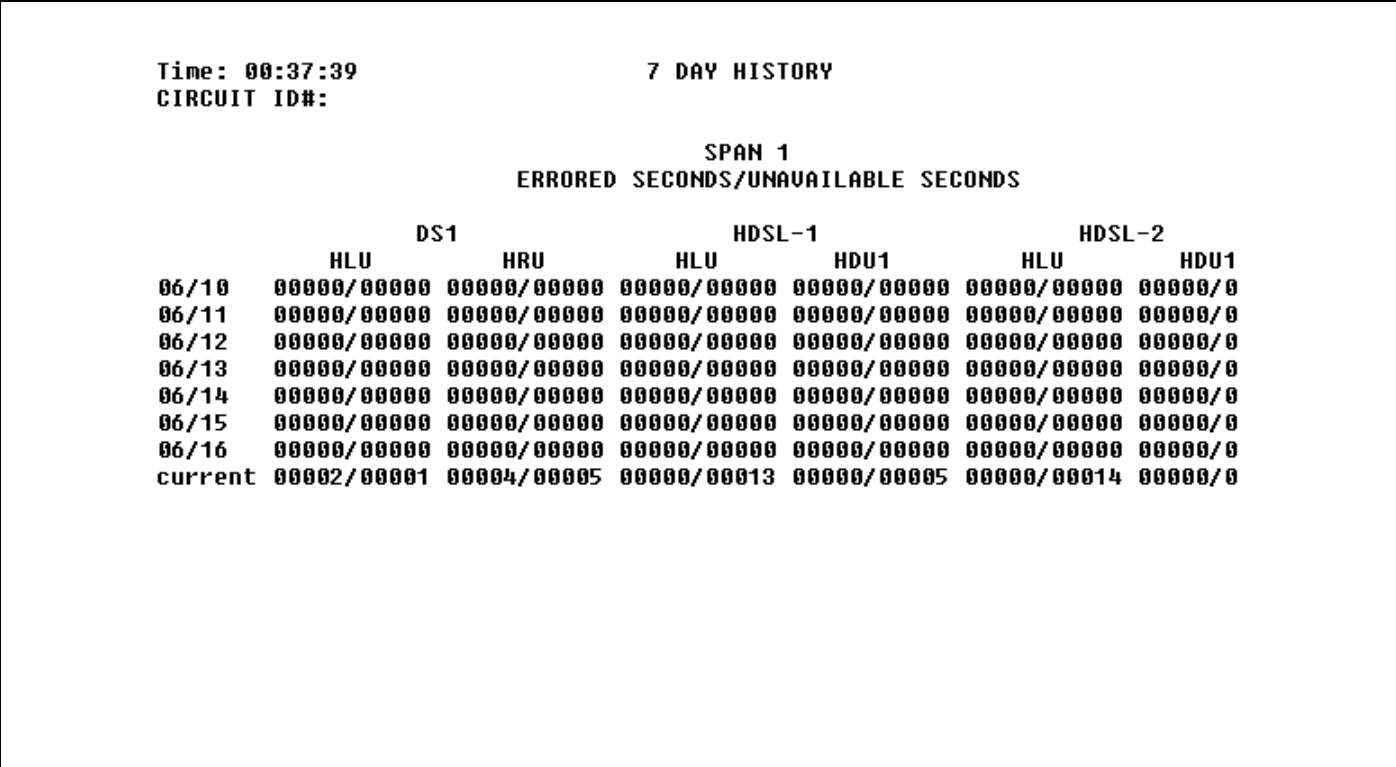


Figure 32. HLU-232 List 1D Performance Data History - Span 1 (1 or 2 Doublers).

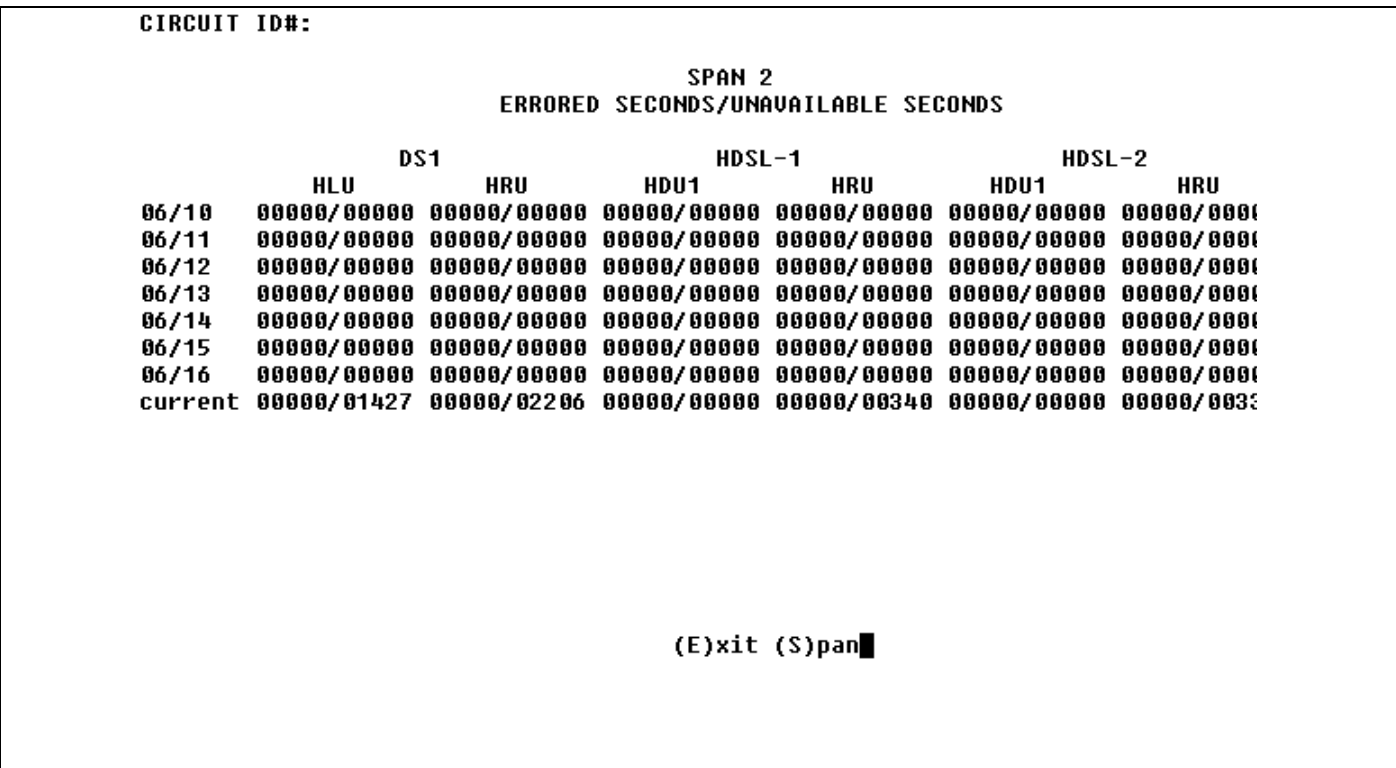


Figure 33. HLU-232 List 1D Performance Data History - Span 2 (1 Doubler).

```

Time: 01:02:51                7 DAY HISTORY
CIRCUIT ID#:

                                SPAN 2
                                ERRORED SECONDS/UNAVAILABLE SECONDS

                                DS1
                                HLU      HRU
                                HDU1     HDU2     HDU1     HDU2
06/10  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/11  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/12  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/13  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/14  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/15  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/16  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
current 00007/00003  00029/00029  00001/00029  00000/00004  00004/00022  00001/00001

                                (E)xit (S)pan

```

Figure 34. HLU-232 List 1D Performance Data History - Span 2 (2 Doublers).

```

Time: 01:04:19                7 DAY HISTORY
CIRCUIT ID#:

                                SPAN 3
                                ERRORED SECONDS/UNAVAILABLE SECONDS

                                DS1
                                HLU      HRU
                                HDU2     HRU      HDU2     HRU
06/10  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/11  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/12  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/13  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/14  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/15  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
06/16  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
current 00007/00003  00029/00029  00003/00015  00025/00031  00002/00008  00016/00001

                                (E)xit (S)pan

```

Figure 35. HLU-232 List 1D Performance Data History - Span 3 (2 Doublers).

ALARM HISTORY				
TIME: 00:41:52				
DATE: 06/17/96				
CIRCUIT ID#:				
Type	First	Last	Current	Count
LOS, DS1-HLU			OK	000
LOS, DS1-HRU			OK	000
SPAN1 LOSW, HDSL1	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN1 LOSW, HDSL2	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN1 ES, HDSL1			OK	000
SPAN1 ES, HDSL2			OK	000
SPAN1 MARGIN L1	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN1 MARGIN L2	06/17/96-00:00	06/17/96-00:00	OK	001
PWR-OPEN			OK	000
PWR-SHRT	06/17/96-00:00	06/17/96-00:00	OK	001
LAST CLEARED: NONE				
(E)xit (C)lear (U)pdate (S)pan				

Figure 36. HLU-232 List 1D Alarm History - Span 1 (1 or 2 Doublers).

ALARM HISTORY				
TIME: 00:43:06				
DATE: 06/17/96				
CIRCUIT ID#:				
Type	First	Last	Current	Count
LOS, DS1-HLU			OK	000
LOS, DS1-HRU			OK	000
SPAN2 LOSW, HDSL1	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN2 LOSW, HDSL2	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN2 ES, HDSL1			OK	000
SPAN2 ES, HDSL2			OK	000
SPAN2 MARGIN L1	06/17/96-00:00	06/17/96-00:00	OK	001
SPAN2 MARGIN L2	06/17/96-00:00	06/17/96-00:00	OK	001
PWR-OPEN			OK	000
PWR-SHRT	06/17/96-00:00	06/17/96-00:00	OK	001
LAST CLEARED: NONE				
(E)xit (C)lear (U)pdate (S)pan				

Figure 37. HLU-232 List 1D Alarm History - Span 2 (1 or 2 Doublers).

ALARM HISTORY

TIME: 01:06:01
DATE: 06/17/96
CIRCUIT ID#:

Type	First	Last	Current	Count
LOS, DS1-HLU			OK	000
LOS, DS1-HRU	06/17/96-00:54	06/17/96-00:54	OK	001
SPAN3 LOSW, HDL1	06/17/96-00:54	06/17/96-00:54	OK	002
SPAN3 LOSW, HDL2	06/17/96-00:54	06/17/96-00:54	OK	001
SPAN3 ES, HDL1			OK	000
SPAN3 ES, HDL2			OK	000
SPAN3 MARGIN L1	06/17/96-00:54	06/17/96-00:54	OK	001
SPAN3 MARGIN L2	06/17/96-00:54	06/17/96-00:54	OK	001
PWR-OPEN	06/17/96-00:50	06/17/96-00:53	OK	003
PWR-SHRT	06/17/96-00:00	06/17/96-00:00	OK	001

LAST CLEARED: NONE

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

Figure 38. HLU-232 List 1D Alarm History - Span 3 (2 Doublers).

HI-GAIN HLU-232 MAINTENANCE TERMINAL MAIN MENU (ver U2.3L-001D)
CIRCUIT 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 #
- I. SWITCHOVER STATUS AND CONFIG
- J. VIEW SWITCHOVER HISTORY

█

Figure 39. HLU-232 List 1D Main Menu for the Protection Line Unit.

```
                                PROTECTION SWITCH FUNCTIONS
TIME/DATE: 01:33:42  06-17-96          CIRCUIT ID:
PROTECTION SYSTEM STATUS
    System state: SWITCHOVER LOCKED OUT

                                First            Last            Count
Switchover History:
                                000

PROTECTION SYSTEM CONFIGURATION
A. Protection Mode             Auto Protect
B. Minimum Hold-in Time       3 minutes
D. BER (CRC) Threshold         1E-4
F. BER Measurement Interval    5 minutes

If 04 switchovers occur within 10 minutes, lock-in for 24 hours
G.-----|-----|-----|
H.-----|-----|-----|
I.-----|-----|-----|

Enter the menu item letter to change any setting,
or select (U)pdate, (E)xit
```

Figure 40. Protection Switch Configuration Menu

```
Protection Mode: Auto Protect

Enter item letter to change selection, or (E)xit

A. Manual Disable
B. Manual Protect
C. Auto Protect
D. Auto Hold

Choose new selection:
```

Figure 41. Protection Mode Menu

Switchover Event History			
Type	First	Last	Count
Switchovers			000
Reversions			000
Switch Failures			000
Switch Lockouts	06/17/96-00:00	06/17/96-00:00	001

(E)xit (C)lear (U)pdate█

Figure 42. View Switchover History