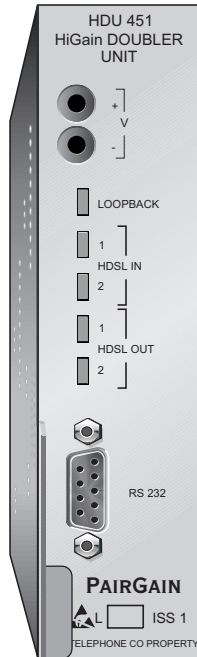


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# HIGAIN DOUBLER UNIT

| Model   | List Number | Part Number | CLEI Code  |
|---------|-------------|-------------|------------|
| HDU-451 | 4B          | 150-1143-42 | T1R5A5HEAA |



**PAIRGAIN TECHNOLOGIES, INC.**  
**ENGINEERING SERVICES TECHNICAL PRACTICE**



**SECTION 150-451-142-04**

## Revision History of This Practice

| Revision | Release Date       | Revisions Made           |
|----------|--------------------|--------------------------|
| 01       | October 3, 1997    | Initial release          |
| 02       | November 11, 1997  | Minor modifications      |
| 03       | September 15, 1998 | Reformat                 |
| 04       | October 8, 1998    | Modify cover information |

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## USING THIS MANUAL

Two types of messages, identified by icons, appear in the text.



**Notes contain information about special circumstances.**



**Cautions indicate the possibility of equipment damage or the possibility of personal injury.**

See [“Abbreviations” on page 32](#) for a list of abbreviations used throughout this technical practice.



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# PRODUCT OVERVIEW

PairGain's HiGain Model HDU-451 List 4B low power Doubler Unit (Figure 3 on page 8) extends the range of the HiGain repeaterless T1 transmission system. When installed between a HiGain Line Unit with doubler-powering capability, and an HRU-412 HiGain Remote Unit, the HDU-451 enables 1.544 Mbps transmission over an extended Carrier Serving Area (CSA) range of approximately 24,000 feet of 24 AWG or 18,000 feet of 26 AWG wire. Customers can use two doublers in series to triple the normal CSA range (36,000 feet on 24 AWG).

The HDU-451 mounts in a single slot of any industry standard 400 mechanics shelf or in equivalent enclosures manufactured by PairGain Technologies. All HiGain modules comply with the applicable requirements of TR-TSY-000063 (Network Equipment Building System (NEBS) Generic Equipment requirements) and TR-TSY-000499 (Transport System Generic Requirements - TSGR).

## DESCRIPTION AND FEATURES

HDU-451 List 4B, HiGain Doubler Unit features:

- Powered by the HLU List 6D - no local power required
- Front Panel HDSL Status Display
- Front panel jacks for test access
- Lightning and power cross protection on the HDSL interfaces (both sides)
- Front Panel Doubler loopback LED indicator
- Low power dissipation

The HDU-451 List 4B unit is compatible with any HiGain Line Unit that supports doublers.

The HDU-451 List 4B is identical to the List 3B, except that it is compatible with both metallic sealing currents and the simplexed sealing currents that are found in HiGain remote units.

In line with PairGain's continuing efforts to provide equipment that fully complies with new industry standards, the List 4B doubler has been enhanced with a special ground fault-detecting circuit described in Paragraph R7-1, Section 7.2.1 of GR-1089-CORE, Issue 1, Revision 1, December, 1996.

When used with HiGain line units, ground faults occurring at any point along any span on any wire are immediately detected. This condition shuts down the HiGain circuit. The line unit will periodically try to apply power to the first span to determine whether the fault condition is still present. As long as the fault condition exists, the power cycling and ground fault protection continues.

Circuits containing both the new List B and older doublers also support this new ground fault detecting feature, provided the doubler nearest the HLU is a List B unit. The presence of this new circuit causes the HDSL span-powering voltage levels to be shifted up to 100 volts more positive than what they are in non-List B doubler circuits. The actual shift depends on loop length, number of doublers, HRU powering option, and the setting of the HLU Bipolar/Unipolar Switch. The List B doublers are backward-compatible with all versions of HiGain line units.



**The operation of the ground fault circuit requires that the doubler enclosure be connected to earth ground.**

## APPLICATIONS

The primary application of the HDU-451 HiGain Doubler is to extend the delivery of T1 High Capacity Digital Service (HCDS) to customers over metallic cable pairs, up to 24,000 or 36,000 feet (24 AWG). A doubler application is shown in [Figure 1 on page 3](#). A maximum of two HDU-451 units can be used in tandem on the same circuit.

[Table 1 on page 3](#) 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 and the HDU-451 as well as between the HDU-451 and a second HDU-451 or the HRU-412. Add 3 dB for each bridged tap and 1 dB for each cable gauge change.

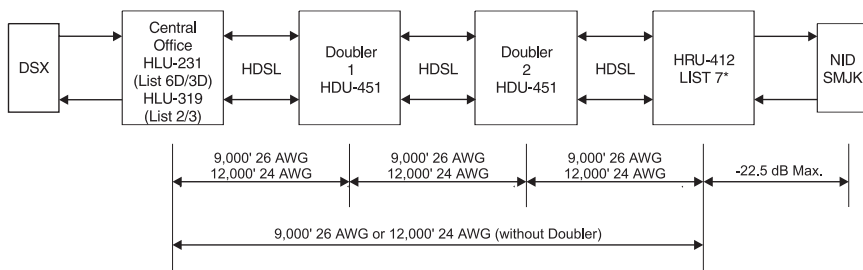
The HiGain system operates with any number of other T1, POTS, Digital Data Service (DDS) or other HiGain Systems sharing the same cable binder group.

In order to achieve optimum performance, the electrical length (196 kHz loss) of all doubler spans should be as close as possible to being equal. This arrangement usually results in the highest operating loop margins.

Use [Table 1](#) when calculating the electrical length of each span. If it is not possible to make all spans equal, then choose the span lengths to reduce the total power consumption of the HLU that powers the doublers. This is done by minimizing the length of Span 1 and maximizing the length of Span 3.

**Table 1. HDSL Loss Over Cables**

| Cable Gauge | Loss @ 196 kHz(dB/ft) | Ohms per kft |
|-------------|-----------------------|--------------|
| 26/0.4mm    | 3.880                 | 83.3         |
| 24/0.51mm   | 2.841                 | 51.9         |
| 22/0.61mm   | 2.177                 | 32.4         |
| 19/0.91mm   | 1.535                 | 16.1         |



**Figure 1. HiGain Installation with Two Doublers.**

# FUNCTIONAL DESCRIPTION

HiGain utilizes PairGain's Two-Bits, One-Quaternary (2B1Q) HDSL transceiver systems to establish two full-duplex 784 kbps data channels (total of 1.568 Mbps) between the HLU and a remotely mounted HRU-412 HiGain Remote Unit. Each HDU-451 increases the total span of the CSA by approximately 12,000 feet (24 AWG) or 9,000 feet (26 AWG).

A block diagram of the HDU-451 is shown in [Figure 2 on page 5](#). The HDU-451 power supply uses the 100 to 200 Vdc power feed voltage received on the simplex pairs to produce +5V and -5 Vdc required by the HDU-451 circuitry. The power feed is passed to the HDSL output, via the Output Span Voltage Control relay, to power one other HiGain module, either a second HDU-451 or the remote HRU-412. If two doublers are used, the remote module must be a locally powered HRU-412 List 7 or List 8 unit.

The maximum power dissipation of the HDU-451 is 6 watts.

## OUTSIDE ENCLOSURE DEPLOYMENT RULES

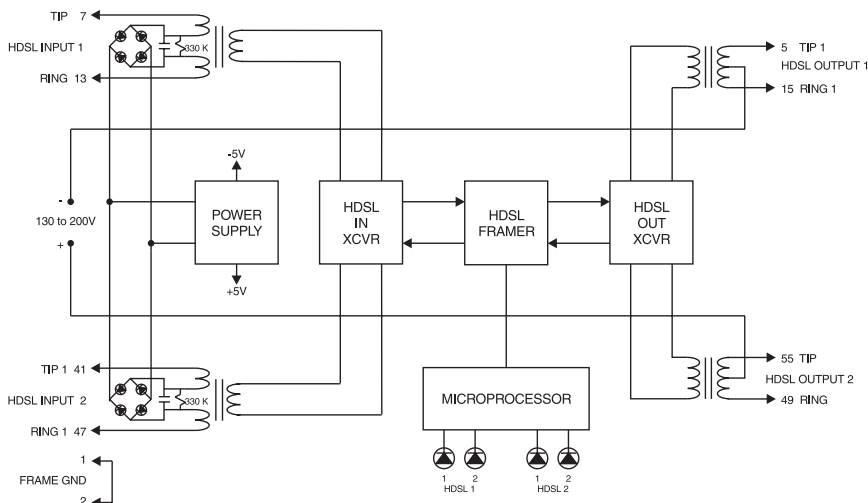
Take care when deploying the HDU-451 in sealed multislot outside enclosures, such as the PairGain 3-slot HRE-423 or 4-slot HRE-454 enclosures. To avoid excessive heat build up, follow the deployment rules shown in [Table 2 on page 6](#) (HRE-423 and HRE-450) or [Table 3 on page 7](#) (HRE-454). These tables limit the number of doublers that can be housed reliably in either the HRE-423 or HRE-454 enclosures. In the tables:

- the maximum ambient temperature column refers to the outside air temperature
- the occupied slots column designates which slots (1, 2, 3, or 4) can be occupied for each condition

For example, if the occupied slots for the HRE-423 are 1 and 3, the doublers are located in slots 1 and 3 with slot 2 empty. If the occupied slots for the HRE-454 are 2 and 4, the doublers are located in slot 2 and 4 with slots 1 and 3 empty. If other than the specific slot arrangements are used, then the next lower temperature deployment rule must be used.

For example, if slots 1 and 2 or 3 and 4 are used in the HRE-454, instead of slots 2 and 4, then use the deployment rules that apply when slots 1, 2, and 4 are occupied. All of the applications in [Table 2](#) and [Table 3](#) that exceed 115°F meet the requirements of Section 10.2.1.3 of TA-NWT-001210. This Section requires that HDSL equipment deployed in outside enclosures shall operate in a temperature, ambient outside the housing, of -40°F with no solar load, to +115°F with maximum solar load and maximum power dissipation.

The doubler may also be enclosed in the PairGain single-slot HRE-450 outdoor enclosure. Its thermal limits are also shown in [Table 2](#).



**Figure 2.** HDU-451 Block Diagram.

**Table 2.** Deployment Rules for the HRE-423 and HRE-450 Enclosures

| <b>Orientation</b> | <b>Occupied Slots</b> | <b>Solar Load<sup>a</sup></b> | <b>Max Ambient Temp</b> |
|--------------------|-----------------------|-------------------------------|-------------------------|
| HRE-423            |                       |                               |                         |
| Vertical           | 1, 2, 3               | Full                          | 120°F                   |
| Vertical           | 1, 2, 3               | None                          | 130°F                   |
| Vertical           | 1, 2                  | Full                          | 130°F                   |
| Vertical           | 1, 2                  | None                          | 140°F                   |
| Vertical           | 2                     | Full                          | 140°F                   |
| Vertical           | 2                     | None                          | 150°F                   |
| Horizontal         | 1, 2, 3               | Full                          | 110°F                   |
| Horizontal         | 1, 2, 3               | None                          | 120°F                   |
| Horizontal         | 1, 2                  | Full                          | 120°F                   |
| Horizontal         | 1, 2                  | None                          | 130°F                   |
| Horizontal         | 2                     | Full                          | 130°F                   |
| Horizontal         | 2                     | None                          | 140°F                   |
| HRE-450            |                       |                               |                         |
| Either             | 1                     | Full                          | 150°F                   |
| Either             | 1                     | None                          | 160°F                   |

a. Full Solar Load = Maximum sunlight exposure per TR-TSY-000057.  
None = Inside, underground or fully shaded.

**Table 3.** Deployment Rules for the HRE-454 Enclosure

| <b>Orientation</b> | <b>Occupied Slots</b> | <b>Solar Load<sup>a</sup></b> | <b>Max Ambient Temp</b> |
|--------------------|-----------------------|-------------------------------|-------------------------|
| Vertical           | 1, 2, 3, 4            | Full                          | 115°F                   |
| Vertical           | 1, 2, 3, 4            | None                          | 125°F                   |
| Vertical           | 1, 2, 4               | Full                          | 125°F                   |
| Vertical           | 1, 2, 4               | None                          | 135°F                   |
| Vertical           | 2, 4                  | Full                          | 135°F                   |
| Vertical           | 2, 4                  | None                          | 145°F                   |
| Vertical           | 2                     | Full                          | 145°F                   |
| Vertical           | 2                     | None                          | 155°F                   |
| Horizontal         | 1, 2, 3, 4            | Full                          | 105°F                   |
| Horizontal         | 1, 2, 3, 4            | None                          | 115°F                   |
| Horizontal         | 1, 2, 4               | Full                          | 115°F                   |
| Horizontal         | 1, 2, 4               | None                          | 125°F                   |
| Horizontal         | 2, 4                  | Full                          | 125°F                   |
| Horizontal         | 2, 4                  | None                          | 135°F                   |
| Horizontal         | 2                     | Full                          | 135°F                   |
| Horizontal         | 2                     | None                          | 145°F                   |

a. Full Solar Load = Maximum sunlight exposure per TR-TSY-000057. None = Inside, underground or fully shaded.

# FRONT PANEL

Figure 3 shows the front panel of the HDU-451 List 4B and Table 4 describes its features.

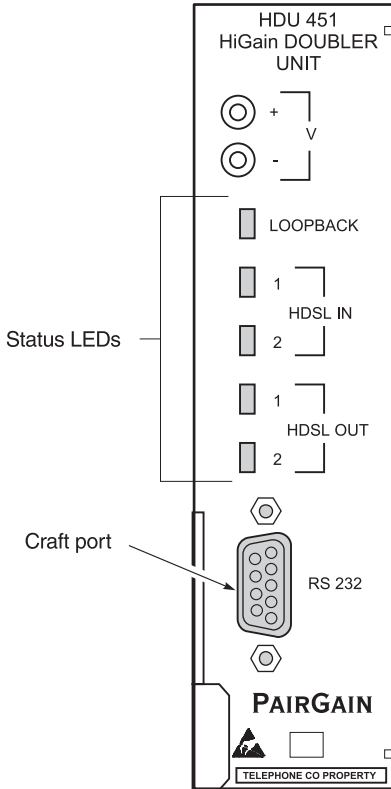


Figure 3. The HDU-451 List 4B Front Panel



**Table 4.** *The Features of the HDU-451 Front Panel*

| <b>Feature</b>      | <b>Function</b>   |
|---------------------|---|
| +/- V Jacks         | These two test jacks enable you to monitor the input voltage feed on the HDSL line. Typical values range from 130V to 200V, based on the distance from the HLU or first HDU-451.  |
| Loopback LED        | Shows the current loopback status. The LED has the following states: <ul style="list-style-type: none"> <li>• Green indicates loopback NDU1 or NDU2 is active.</li> <li>• Yellow indicates loopback CDU1 or CDU2 is active.</li> <li>• Flashing Yellow indicates the doubler is in an armed state ready to accept a 16-bit intelligent loopback command issued at the HLU or HRU-412 DS1 inputs.</li> </ul>   |
| HDSL IN LEDs        | Two LEDs indicate the status of the two HDSL input line pairs: HDSL IN 1 and HDSL IN 2. These indicators have the following states:<br>Flashing Green indicates synchronization is being attempted with the HLU.<br>Green indicates HDSL frame synchronization between the HLU and HDSL input.<br>Flashing Red indicates an HDSL error<br>Yellow indicates a Margin alarm at this HDSL port.  |
| HDSL OUT LEDs       | Two LEDs indicate the status of the two HDSL output line pairs: HDSL OUT 1 and HDSL OUT 2. These indicators have the following states:<br>Flashing Green indicates synchronization is being attempted with the HRU-412 or a second HDU-451.<br>Green indicates HDSL frame synchronization between the HDSL output and the HRU-412 or a second HDU-451.<br>Flashing Red indicates an HDSL Error.<br>Yellow indicates a Margin alarm at this HDSL port. |
| Craft (RS-232) port | Provides bidirectional communication between the unit and an external terminal to allow performance monitoring through the maintenance terminal screens.  |

# LOOPBACK DESIGN DESCRIPTION

Figure 4 shows the complete family of loopbacks that a HiGain system can execute. Four of these loopbacks (NDU1, NDU2, CDU1, and CDU2) occur in the doubler. These loopbacks can be initiated from the HLU maintenance port, the HLU front panel push-button, and from a family of Special Loopback (SPLP) in-band loopback commands. Figure 4 lists the Generic, SPLP, in-band loop-up command set for the four doubler loopbacks: 110000 (2 in 6) for NDU1, 111000 (3 in 6) for NDU2, 111100 (4 in 6) for CDU1 and 111110 (5 in 6) for CDU2. Refer to the appropriate HLU practice for more details regarding the other doubler loopback commands.

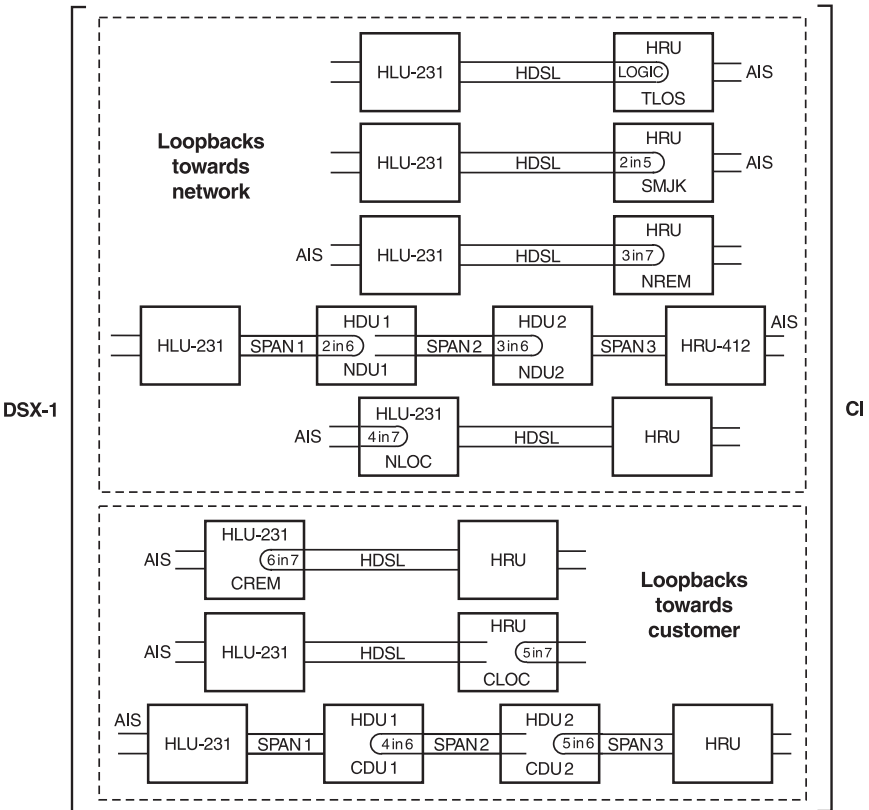


Figure 4. HiGain Loopbacks.

# INSTALLATION

This section describes the installation process for the HDU-451 List 4B.

## INSPECTING YOUR SHIPMENT

When you receive the equipment, inspect it for signs of damage. If damage has occurred, immediately report the extent of damage to the transportation company and to PairGain Technologies, Inc. (see [“Product Support”](#) on [page 35](#) for more information).

## INSTALLING THE HDU-451 LIST 4B

The HDU-451 mounts in the following PairGain Remote Enclosures:

- HRE-423 (three-slot, double-width, outdoor, above or below ground)
- HRE-454 (four slot, outdoor, above or below ground)
- HRE-450 (single-slot, outdoor, above ground)
- HRE-420 (single-slot, indoor)
- HRE-422 (two slot, single width, indoor)

The HDU-451 also mounts in any industry-standard 400-type multi-mount shelves. Pin-outs used by the HiGain Doubler Unit are shown in [Figure 12](#) on [page 31](#).

The number of HDU-451 List 4B units that you can deploy in a doubler enclosure is determined by the ambient temperature and the solar loading. See [“Outside Enclosure Deployment Rules”](#) on [page 4](#) for further information.

To install the HDU-451 List 4B:

- 1 Mount and cable the HiGain Remote Enclosure as described in the appropriate enclosure document.
- 2 Slide the doubler unit into the card guides for the desired slot, then push the unit into the enclosure until it is seated in the card edge connector.

- 3 Push the unit into the card edge connector until it is entirely within the card guide. The unit should snap into place, indicating that the unit is properly seated.
- 4 Check the indicator lights on the front panel:
  - If the HLU List xD in the CO is operational, the HDSL IN LED indicators light within 30 seconds.
  - If the HRU-412 at the customer site is installed and operational, the HDSL OUT LED indicators light and remain lit within 1 minute.

If the LEDs do not light properly, continue with the “[Troubleshooting](#)” section for possible problems and solutions.

## TROUBLESHOOTING

This section provides step by step troubleshooting procedures for common problems.

The four-character front panel display on the line unit that powers the doubler provides additional information that may be useful in solving a problem. [Table 5 on page 14](#) shows the messages that can appear on the line unit front panel display.

### Isolating a Problem

The front panel HDSL IN (loop) 1 and (loop) 2 LEDs identify the cable pairs coming into the doubler from the upstream location. The pairs are identified by the polarity of the simplex voltage that is applied to them by the upstream unit, the HLU or the HDU-451. Loop 1 has the - simplex voltage. Loop 2 has the + simplex voltage.

To isolate the source of a problem, swap the input pairs. In this case, the HDU-451 continues to identify loop 1 as the - pair and loop 2 as the + pair. If the problem remains with the same pair, as identified by the HDU, before and after the pairs are swapped, the problem is upstream or towards the pair.

For example, assume the HDSL IN 1 LED is flashing red, indicating errors on loop 1. If the pairs are swapped and the HDSL IN 1 LED continues to flash the indicated problem is towards the upstream cable pair or attached equipment. If the HDSL 2 IN LED begins flashing, the problem lies towards the HDU-451 unit itself.

## Solutions to Common Problems

This section lists several common problems and describes possible solutions.

If the LEDs do not light:

- Verify the HLU is installed and operational in the central office. Verify proper cabling between the Doubler Enclosure and the central office.
- Measure 100 to 200V dc at the HDU-451 front panel jacks (+/-V). This voltage peaks every 15 seconds as the HLU powers up. If less than 130V dc is present, suspect cabling or the HLU. Only the line units equipped with a high voltage power supply can work with doublers. All such line units have list numbers that end with a "D" such as the HLU-23I List 6D. Other HLU versions may sync with the HDU but may not provide reliable operation and should not be used.

If the HDSL OUT LEDs do not light:

- Verify that the HRU-412 at the customer site is installed and operational in the central office. All HRU-412 Remote Units, except List 8, have an HDSL input signature resistance of 180 kOhms between the Tip and Ring on each loop. The HDSL input part resistance for the List 8 HRU-4Ds is 10 Ohms.
- Verify that the central office HLU complies with the second bullet in the previous problem description.

If the HDSL LEDs flash green continuously:

- If the OUT LEDs are flashing, verify that the HRU-412 is operational and the cables between the HDU-451 and HRU-412 are intact.
- If the IN LEDs are flashing, verify that the HLU is operational and the cables between the HLU and HDU-451 are intact.

If the HDSL IN LEDs light when the HDSL OUT LEDs flash:

- No HRU-412 at the remote end. Measure the input resistance of the HDSL path of the HRU at the HDU-451. The HRU-412 HDSL input has a signature resistance of 180 kOhms or 10 Ohms between the Tip and Ring on each loop.
- Loop resistance or attenuation is out of specification. The loop resistance should be less than 800 ohms, attenuation should be less than or equal to 35 dB.

If the HDU-451 loses power, the HLU at the central is not present. Measure the resistance of the HDSL input loop. Resistance should be normal loop resistance plus the 25-Ohm signature of the HLU List xD.

## Line Unit Status Menu Messages

Table 5 shows the messages that can appear on the line unit four-character front panel display.

*Table 5. HLU-451 Status Menu Messages*

| Message   | Full Name                     | Description  |
|-----------|-------------------------------|--|
| ALARMS    |                               |  |
| NONE      | No Alarms                     |  |
| LLOS      | Local Loss of Signal          | No signal from local T1 interface.   |
| RLOS      | Remote Loss of Signal         | No signal from remote T1 interface.  |
| MNR       | Minor Alarm                   | A Minor Alarm condition is in effect.  |
| LOSW      | Loss of Sync Word             | One of the HDSL loops has lost synchronization.  |
| H1ES      | HDSL Loop 1 Errored Second    | Loop 1's CRC has exceeded the user-selected Errored Seconds threshold.                   |
| H2ES      | HDSL Loop 2 Errored Second    | Loop 2's CRC has exceeded the user-selected Errored Seconds threshold.                   |
| DS1       | Digital Service 1             | DS1 input BPVs have exceeded the user-selected Errored Seconds threshold.                |
| ACO       | Alarm Cut Off                 | An Alarm Cut Off is in effect.   |
| LAIS      | Local Alarm Indicating Signal | Indicates an AIS (all 1s) pattern is being transmitted from the local T1 output port.    |
| RAIS      | Remote AIS                    | Indicates an AIS (all 1s) pattern is being transmitted from the local T1 output port.    |
| HDSL-1(2) | HDSL Loop 1(2)                | Defines HDSL loop 1(2) in any given span.  |
| MAL 1(2)  | Margin Alarm 1 (2)            | The Margin on HDSL loop 1 (2) has dropped below the threshold (1 to 15) set by the user. |

**Table 5. HLU-451 Status Menu Messages (Cont.)**

| <b>Message</b> | <b>Full Name</b>           | <b>Description</b>   |
|----------------|----------------------------|--|
| LOOPBACKS      |                            |  |
| SMJK           | SmartJack Loopback         | Loopback at HRU-412 towards network initiated by 2 in 5 in-band loopback code or out-of-band ESF data link code. See <a href="#">Figure 4 on page 10</a> .   |
| NREM           | Network Remote Loopback    | Loopback at HRU-412 (remote) towards network initiated from a family of special loopbacks (SPLP), HRU-412 front panel push-button or maintenance terminal. See <a href="#">Figure 12 on page 31</a> .  |
| NLOC           | Network Local Loopback     | Loopback at HLU (local) towards network initiated from a family of special loopbacks (SPLP) or by depressing both the MODE and SEL HLU-231 front panel push-buttons or maintenance terminal. See <a href="#">Figure 4 on page 10</a> .   |
| NDU1           | Network Doubler 1 Loopback | Loopback at Doubler 1 towards network initiated from CO (network) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> and <a href="#">“Loopback Design Description” on page 10</a> . |
| NDU2           | Network Doubler 2 Loopback | Loopback at Doubler 2 towards network initiated from CO (network) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> and <a href="#">“Loopback Design Description” on page 10</a> . |
| CLOC           | Customer Local Loopback    | Loopback at HRU-412 (local) towards CI initiated from CPE (customer) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> .   |

**Table 5. HLU-451 Status Menu Messages (Cont.)**

| <b>Message</b> | <b>Full Name</b>                 | <b>Description</b>  |
|----------------|----------------------------------|---|
| CREM           | Customer Remote Loopback         | Loopback at HLU (remote) towards customer initiated from CPE (customer) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> . |
| CDU1           | Customer Doubler 1 Loopback      | Loopback a Doubler 1 towards CI initiated from CPE (customer) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> .           |
| CDU2           | Customer Doubler 1 Loopback      | Loopback a Doubler 1 towards CI initiated from CPE (customer) by a family of special loopbacks (SPLP) or from maintenance terminal or by depressing both the MODE and SEL HLU front panel push-buttons. See <a href="#">Figure 4 on page 10</a> .           |
| ARM            | Armed                            | HiGain has detected the intelligent repeater loopback (2 in 5) arming code.   |
| TLOS           | Transmit Loss Of Signal loopback | HRU-412 is in a logic loopback state caused by a loss of its T1 input from the NI, if enabled via the TLOS option switch in the HRU.  |

## MONITORING THE HDSL SYSTEM

The 9-pin Craft port on the front panel of the HDU-451 List 4B provides access, through an RS-232 cable, to a dumb terminal or PC running a terminal emulation program. The terminal provides access to a full set of maintenance and status information.



## CONNECTING TO THE TERMINAL

To connect a dumb terminal:

- 1 Connect a standard 9-pin serial terminal cable to the Craft port on the HDU-451. [Figure 13 on page 32](#) shows the pinouts for the Craft port.
- 2 Connect the other end of the cable to the 9-pin COM port of the dumb terminal or PC. The terminal is configured as Data Circuit-Terminating Equipment (DCE).
- 3 Configure the terminal to the following settings:
  - 1200 to 9600 baud (9600 is recommended)
  - No parity
  - 8 data bits
  - 1 stop bit
  - Hardware Flow Control set to None
  - VT Terminal Emulation



**If you are using the Microsoft Windows terminal emulation program, from the Settings, Terminal Preference menu, you must deselect *Show Scroll Bars* and *Use Function, Arrow, and Ctrl Keys for Windows*.**

## LOGGING ON AND USING THE TERMINAL MENUS

When you log on to the terminal menus, the terminal is actually logged on to the HLU line unit connected to the HDU-451. All system status information comes from the HLU, eliminating the need to store redundant information at each doubler in a HiGain system. Because of this, only one doubler can be logged on to the HLU at any time. The HDU-451 automatically logs off of the terminal after five minutes of inactivity (no keyboard input).



**Table 6.** Terminal Navigational Keys

| Key          | Function   |
|--------------|--|
| <b>ENTER</b> | Logs onto the Remote Terminal menus                |
| <b>E</b>     | Exits the current menu                             |
| <b>U</b>     | Updates a report                                   |
| <b>S</b>     | Displays the next Span Status screen               |
| <b>P</b>     | Displays the previous page of a report             |
| <b>N</b>     | Displays the next page of a report                 |
| <b>C</b>     | Clears the current values and returns them to zero |

## THE MAIN MENU

The Remote Terminal Main Menu provides access to the maintenance and status screens available through the dumb terminal.

```

HI-GAIN HLU-231D      REMOTE TERMINAL MAIN MENU   (ver V1.1L-006D
                      CIRCUIT ID#: -- P --
A. VIEW SPAN STATUS
C. SYSTEM SETTINGS
E. VIEW PERFORMANCE DATA
F. VIEW PERFORMANCE HISTORY
G. VIEW ALARM HISTORY
H. REMOTE LOGOFF

```

**Figure 6.** HDU-451 Main Menu.

**Table 7** lists the options available through the Main Menu. To access any of the Main Menu options, type the letter of the option, then press **ENTER**.

**Table 7. Main Menu Options**

| <b>Option</b>               | <b>Function</b>   | <b>Go to</b>  |
|-----------------------------|---|---|
| A. View Span Status         | Provides access to status information about the HDSL line between the HLU, HDU-451, and the HRU.  | <a href="#">“View Span Status” on page 21</a>         |
| C. System Settings          | Displays all system settings.   | <a href="#">“View System Settings” on page 23</a>     |
| E. View Performance Data    | Provides access to screens displaying the Errored Seconds (ES) and Unavailable Seconds (UAS) for each span in 15-minute increments over a four-hour period. | <a href="#">“View Performance Data” on page 26</a>    |
| F. View Performance History | Provides access to screens that show the ES and UAS for each span in 24-hour increments over a seven-day period.  | <a href="#">“View Performance History” on page 27</a> |
| G. View Alarm History       | Provides access to screens that show alarm conditions for each span.  | <a href="#">“View Alarm History” on page 28</a>       |
| H. Remote Logoff            | Logs off of the terminal.   |   |

## VIEW SPAN STATUS

The Span Status screens provide system status information for each span between the HLU and the HRU. The screens show information about:

- HDSL Loops 1 and 2
- DS1 interface
- Loopbacks
- Current alarms
- Time and Date

From the Main Menu, type **A**, then press **ENTER**. The Span 1 Status screen displays.

```

                SPAN 1 STATUS
          ( HLU/ver1.6-006D:HDUL/ver2.5-0004)
TIME: 00:30:50
DATE: 01/07/97                CIRCUIT ID#: -- P --

ALARMS:  NONE
LOOPBACK: OFF

                HDSL-1      HDSL-2      HDSL-1      HDSL-2
                cur/min/max  cur/min/max  cur/min/max  cur/min/max
MARGIN:         12/12/13     12/11/13     11/11/12     11/11/11 dB
PULSE ATTN:     26           28           27           28 dB
PPM OFFSET:     00           00           06           06 ppm
24 HOUR ES:     00000       00000       00000       00000 seconds
24 HOUR UAS:    00000       00000       00000       00000 seconds

                DS1 STATUS
                HLU           HRU
24 HOUR BPV Seconds: 00000       00000
24 HOUR UAS Count:   00000       00000
Frame type:          ESF           ESF
Code type:           B8ZS         B8ZS

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

```

**Figure 7.** Span 1 Status screen.

At this screen you have the following options:

- Type **E**, then press **ENTER** to exit and return to the Main Menu.
- Type **U**, then press **ENTER** to update the information displayed on the screen.
- Type **S**, then press **ENTER** to view information for the next available span.

Table 8 describes the fields of the Span Status screen.

*Table 8. Span Status Screen Fields*

| <b>Field</b>        | <b>Description</b>  |
|---------------------|---|
| Time                | Time of day when the Span Status was last updated.  |
| Date                | Date then the Span Status was last updated.   |
| Alarms              | Lists any current alarms. See <a href="#">“View Alarm History” on page 28.</a>  |
| Loopback            | Indicates Off or identifies active loopback condition.  |
| Margin              | Indicates the excess signal to noise ratio at all HDSL ports, relative to a Bit Error Rate (BER) of 10 <sup>-7</sup> : <ul style="list-style-type: none"> <li>• the first value is the current margin</li> <li>• the second is the minimum margin since last cleared</li> <li>• the third is the maximum margin since last cleared</li> </ul> |
| Pulse ATTN          | Indicates the attenuation of the 2B1Q pulse from the distant end. HiGain operates with pules attenuations up to 28 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.  |
| PPM Offset          | Indicates the relative offset of the crystal oscillator in the HDU-451 from the HLU crystal oscillator. Any value between ±100 is adequate.   |
| 24 Hour ES          | The number of one second intervals that contained at least one HDSL CRC error. This value is a running total from the last 24 hours.  |
| 24 Hour UAS         | The number of seconds the HDSL loop was out of synchronization in the last 24 hours.  |
| 24 Hour BPV Seconds | The number of seconds in which at least one bipolar violation was detected on the DS1 input.  |

**Table 8.** *Span Status Screen Fields (Cont.)*

| <b>Field</b>      | <b>Description</b>   |
|-------------------|--|
| 24 Hour UAS Count | The number of seconds during which the DS1 input signal was absent (125 or more consecutive 0s).   |
| Frame Type        | Type of DS1 framing used on the input stream (SF, ESF, Unframed or No Activity).   |
| Code Type         | Type of DS1 line coding used (AMI, B8ZS, AMI: ZBTSI, or B8ZS: ZBTSI). The latter two conditions indicate the code type that is being received when HiGain is set to its ZBTSI mode. In either the AMI or B8ZS DS1 code mode, it displays the selected code as opposed to the code type that is actually being received, which it displays when the DS1 CODE option is set to AUTO. |

## VIEW SYSTEM SETTINGS

The System Settings screen allows you to analyze and view configurable parameters set at the HLU. The information on this screen is for reference only and cannot be altered. The system setting can only be set at the HLU.

From the Main Menu, type **C**, then press **ENTER**. The System Settings screen displays.

```

                                SYSTEM SETTINGS

TIME: 00:30:50
DATE: 01/07/97                                CIRCUIT ID#: -- P --

EQUALIZATION:      EX1
SMART-JACK LB:    ENABLE
SPECIAL LPBK:     GNLB
POWER:            ENABLE
ZBTSI:           OFF
ES ALARM THRES:   NONE
LOOPBACK TIMEOUT: 60
ALARM:            DISABLE
DS1 CODE:        AUTO
FRAMING:         AUTO
AIS ON HDSL LOSW: 2 LOOPS
AIS ON SMJK/NREM: ENABLE
MARGIN ALM THRES: 4
DS0 BLOCKING: 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

```

**Figure 8.** System Settings Screen

To exit this screen and return to the Main Menu, type **E**, then press **ENTER**.

[Table 9](#) describes the fields of the System Settings screen.

**Table 9.** System Settings Screen Fields

| Field         | Description  |
|---------------|--|
| Time          | Time of day when System Settings were checked.   |
| Date          | Date when System Settings were checked.  |
| Equalization  | Indicates settings for equalizer of either EX1, 0 (DSX-1 for 0-133 ft), 133 (DSX-1 for 133-266 ft), 266 (DSX-1 for 266-399 ft), 399 (DSX-1 399-533 ft), 533 DSX-1 for 533-655 ft).         |
| Smart-Jack LB | Indicates settings of either <i>ENA</i> or <i>DIS</i> for SmartJack loopback: where signal from DS1 is looped back at the HRU to the DSX-1.  |
| Special LBPK  | Indicates the special loopback settings of either: Generic loopback (GNLB), where the HiGain system responds to the generic in-band loopback codes, or A1LB and A2LB, A3LB, A4LB, or A5LB. |
| Power         | Indicates whether power feed to the HRU-402 from the HLU is either OFF, AUTO, HIGH, or LOW.  |



**Table 9.** System Settings Screen Fields (Cont.)

| <b>Field</b>                         | <b>Description</b>   |
|--------------------------------------|--|
| ZBTSI                                | Indicates whether ZBTS is either <i>On</i> or <i>Off</i> . An <i>On</i> setting tells the system that the ESF frame is operating in its Zero Byte Time Slot Interface (ZBTSI) mode. An <i>Off</i> setting tells the system that the ESF frame is operating in its normal non-ZBTSI mode. |
| ES Alarm Thresh                      | Indicates the current setting of the errored seconds alarm, or if the alarm is disabled  |
| Loopback Timeout                     | Indicates one of four settings: None (DIS automatic time-out cancellation of all loopbacks) or a choice of either 20, 60, or 120, which sets automatic cancellation (timeout) of all loopbacks to either 20, 60 or 120 minutes after initiation.   |
| Alarm                                | Indicates whether alarms are enabled or DIS.   |
| DS1 Code                             | Indicates one of three settings: Auto, B8ZS, or AMI.   |
| Framing                              | Indicates whether framing is either Auto or UNFR (unframed).   |
| AIS on HDSL LOSW                     | Indicates the settings for alarm indication signals on HDSL LOSW on the HDSL loops.  |
| AIS on SMJK/NREM                     | Indicates settings of either ENA or DIS for alarm indication signals for the SmartJack Network Remote Loopback (NREM).   |
| Margin Alarm (ALM) Threshold (THRES) | Indicates the settings for the margin alarm thresholds.  |
| DS0 Blocking                         | Indicates status of DS0 blocked channels and identifies the channels that have been blocked (using "xx" symbols underneath each blocked channel). A <i>None</i> setting indicates no channels are blocked. A <i>BLK</i> setting indicates some channels are blocked.                     |

## VIEW PERFORMANCE DATA

From the Main Menu, type **E**, then press **ENTER**. The Span 1 Performance Data screen displays.

```

Date: 05/10/05          SPAN 1 PERFORMANCE DATA
CIRCUIT ID: -- P --
                ERRORED SECONDS/UNAVAILABLE SECONDS

                DS1          HDSL-1          HDSL-2
                HLU    HRU    HLU    HDU1    HLU    HDU1
23:00    000/000    000/000    000/000    000/000    000/000    000/000
23:15    000/000    000/000    000/000    000/000    000/000    000/000
23:30    000/000    000/000    000/000    000/000    000/000    000/000
23:45    000/000    000/000    000/000    000/000    000/000    000/000
00:00    000/000    000/000    000/000    000/000    000/000    000/000
00:15    000/688    008/562    004/222    001/013    003/241    002/031
00:30    000/900    000/900    000/000    000/000    000/000    000/000
00:45    000/900    000/900    000/000    000/000    000/000    000/000
01:00    000/900    000/900    000/000    000/000    000/000    000/000
01:15    000/883    000/861    001/025    000/004    002/025    001/004
01:30    000/900    000/900    000/000    002/012    000/000    000/000
01:45    000/852    012/631    004/075    000/000    004/074    002/013
02:00    000/900    000/000    000/000    000/000    000/000    000/000
02:15    000/900    000/000    000/000    000/000    000/000    000/000
02:30    000/673    004/439    002/220    000/005    001/221    000/007
02:45    000/820    009/782    004/099    000/012    003/096    001/009

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

**Figure 9.** Performance Data Span 1 (1 or 2 Doublers)

At this screen you have the following options:

- Type **E**, then press **ENTER** to exit and return to the Main Menu.
- Type **P**, then press **ENTER** to view the previous screen.
- Type **N**, then press **ENTER** to view the next screen.
- Type **S**, then press **ENTER** to view information for the next available span.

## VIEW PERFORMANCE HISTORY

From the Main Menu, type **F**, then press **ENTER**. The 7 Day History screen for Span 1 displays.

```

Time: 02:51:24          7 DAY HISTORY
CIRCUIT ID#: -- P --

                SPAN 1
      ERRORED SECONDS/UNAVAILABLE SECONDS

      DS1          HDSL-1          HDSL-2
      HLU          HRU          HLU          HDU1          HLU          HDU1
05/03  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/04  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/05  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/06  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/07  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/08  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
05/09  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000  00000/00000
current 00000/09316  00037/06875  00015/00641  00003/00046  00013/00657  00006/00064

                (E)xit (S)pan
  
```

**Figure 10.** Performance Data History Span 1 (1 or 2 Doublers)

At this screen you have the following options:

- Type **E**, then press **ENTER** to exit and return to the Main Menu.
- Type **S**, then press **ENTER** to view information for the next available span.

## VIEW ALARM HISTORY

From the Main Menu, type **G**, then press **ENTER**. The Alarm History screen displays.

```

                                ALARM HISTORY

TIME: 02:57:36
DATE: 05/10/05
CIRCUIT ID#: -- P --

Type           First           Last           Current       Count
LOS, DS1-HLU   05/10/05-00:00   05/10/05-02:41   ALARM         001
LOS, DS1-HRU   05/10/05-00:00   05/10/05-02:40   ALARM         011
SPAN1 LOSW, HDSL1 05/10/05-00:00   05/10/05-02:40   OK            010
SPAN1 LOSW, HDSL2 05/10/05-00:00   05/10/05-02:40   OK            010
SPAN1 ES, HDSL1   05/10/05-00:00   05/10/05-02:41   OK            000
SPAN1 ES, HDSL2   05/10/05-00:00   05/10/05-02:41   OK            000
SPAN1 MARGIN L1  05/10/05-00:00   05/10/05-02:41   OK            017
SPAN1 MARGIN L2  05/10/05-00:00   05/10/05-02:41   OK            021
PWR-OPEN        05/10/05-00:00   05/10/05-02:40   OK            036
PWR-SHRT        05/10/05-00:00   05/10/05-02:23   OK            004

LAST CLEARED: NONE

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

```

**Figure 11.** HLU Alarm History Span 1 (1 or 2 Doublers)

At this screen you have the following options:

- Type **E**, then press **ENTER** to exit and return to the Main Menu.
- Type **U**, then press **ENTER** to update the information displayed on the screen.
- Type **S**, then press **ENTER** to view information for the next available span.

**Table 10** describes the fields of the Alarm History screen.

**Table 10.** Alarm History Fields

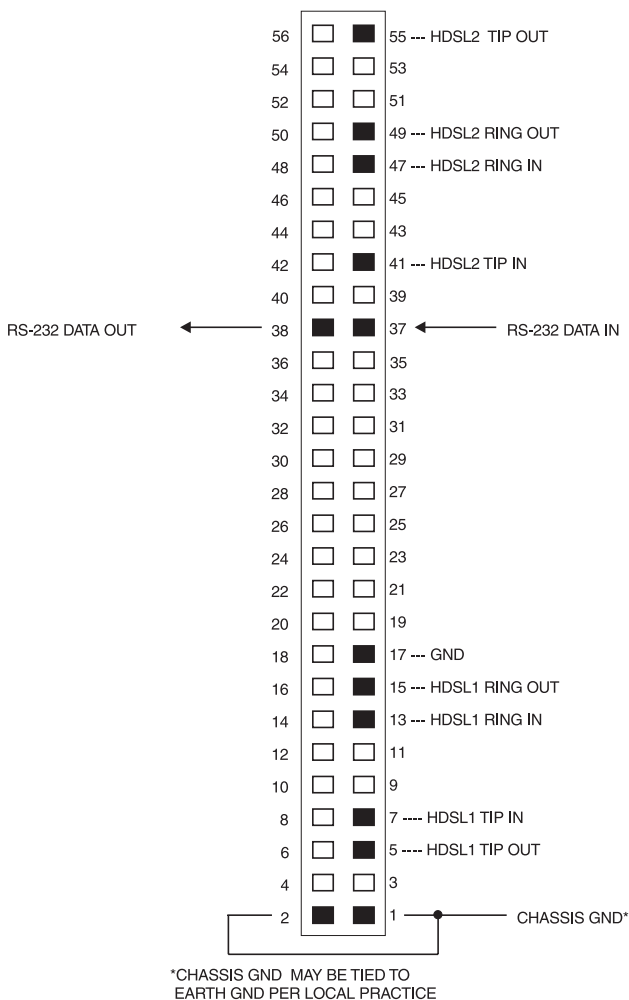
| <b>Field</b>      | <b>Description</b>  |
|-------------------|---|
| Type              | Identifies the type of alarm  |
| LOS, DS1-HLU      | First and last instance of LOS at the HLU; Current condition, number of alarms            |
| LOS, DS1-HRU      | First and last instance of LOS at the HRU; Current condition, number of alarms            |
| Span1 LOSW, HDSL1 | First and last instance of LOSW on HDSL1; Current condition, number of alarms             |
| Span1 LOSW, HDSL2 | First and last instance of LOSW on HDSL2; Current condition, number of alarms             |
| Span1 ES, HDSL1   | First and last instance of ES on HDSL1; Current condition, number of alarms               |
| Span1 ES, HDSL2   | First and last instance of ES on HDSL2; Current condition, number of alarms               |
| Span1 Margin L1   | First and last instance of exceeded margin on Loop 1; Current condition, number of alarms |
| Span1 Margin L2   | First and last instance of exceeded margin on Loop 2; Current condition, number of alarms |
| PWR Open          | Power condition: Open or Closed   |
| PWR SHRT          | Power short condition   |
| Last Cleared      | Last time Alarm History cleared   |

# TECHNICAL SPECIFICATIONS

|   |   |
|---|---|
| HDSL Line Code                                      | 784 kbps, 2B1Q full duplex  |
| HDSL Output   | +13 dBm $\pm$ 0.5 dB @ 135 ohms   |
| HDSL Line Impedance                                 | 135 ohms  |
| HDSL Line Input DC resistive signature              | 330 kilohms   |
| HDSL Line Output DC resistive signature             | 25 ohms   |
| Maximum Provisioning Loss                           | 35 dB @ 196 kHz, 135 ohms   |
| Line Clock Rate                                     | Internal Stratum 4 clock  |
| HDSL Startup Time                                   | 15 seconds (typical), 30 seconds (maximum)  |
| Power Consumption                                   | 6 watts (maximum)   |
| Electrical Protection                               | Secondary surge and power cross protection on all HDSL ports.   |
| Operating Temperature and Humidity (non-condensing) | -40° to +149° F (-40° to + 65° Celsius),<br>5 to 95%  |
| Operating Temperature in Outside Enclosures         | Complies with Section 10.2.1.3 of TA-NWT-001210. (See <a href="#">“Outside Enclosure Deployment Rules”</a> on page 4) |
| Operating Elevation                                 | 200 feet below sea level to 13,000 feet above sea level.  |
| Mounting  | Single-width, 400-type mechanics.   |
| Dimensions  | Height: 5.6 in (14.22 cm)<br>Width: 1.4 in (3.5 cm)<br>Depth: 5.6 in (14.22 cm)                                       |
| Weight  | 0.81 lb. (0.37 kg)  |

# PINOUTS

The figures in this section show the pinouts for the HDU-451 List 4B. [Figure 12 on page 31](#) shows the pinouts for the HDU-451 connector. [Figure 13 on page 32](#) shows the pinouts for the HDU-451 Craft port.



**Figure 12.** HDU-451 List 4B Pin-Outs (active pins are black).

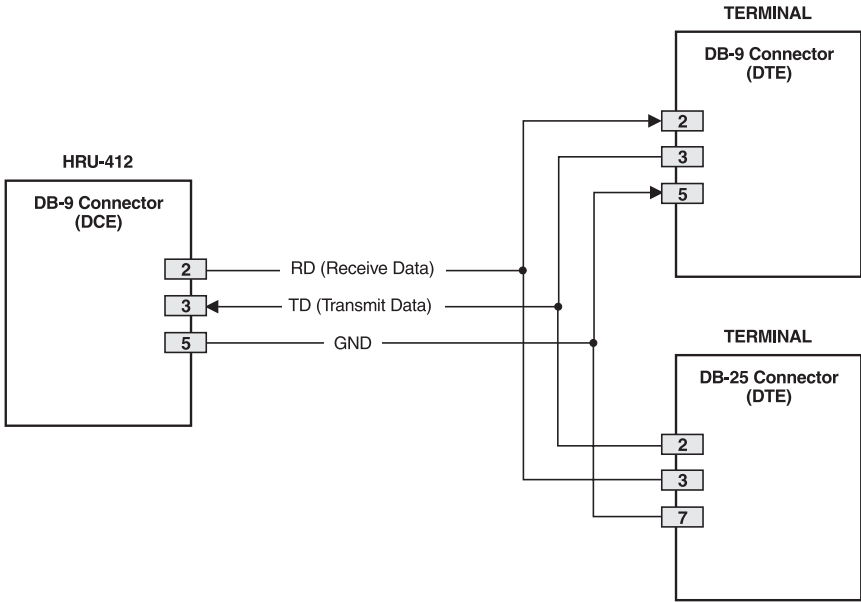


Figure 13. HDU-451 DB-9 Pin Outs.

# ABBREVIATIONS

- 2B1Q**      2Binary1Quaternary
- AIS**      Alarm Indication Signal
- ALM**      Alarm
- ALMP**     Alarm Pattern Option
- AMI**      Alternate Mark Inversion
- AWG**      American Wire Gauge
- B8ZS**     Bi-directional 8-zero Substitution
- BDG**      Bridged



---

|               |                                       |
|---------------|---------------------------------------|
| <b>BER</b>    | Bit Error Rate                        |
| <b>BERT</b>   | BIT Error Rate Threshold              |
| <b>BPV</b>    | Bipolar Violation                     |
| <b>BPVT</b>   | Bi-polar Violation Transparency       |
| <b>CI</b>     | Customer Interface                    |
| <b>CO</b>     | Central Office                        |
| <b>CLOC</b>   | Customer Local Loopback               |
| <b>CPE</b>    | Customer Premises Equipment           |
| <b>CRC</b>    | Cyclic Redundancy Check               |
| <b>CSA</b>    | Carrier Service Area                  |
| <b>CSU</b>    | Channel Service Unit                  |
| <b>dB</b>     | Decibel                               |
| <b>DCE</b>    | Data Circuit-Terminating Equipment    |
| <b>DIS</b>    | Disable                               |
| <b>DL</b>     | Data Link                             |
| <b>DLC</b>    | Data Link Control                     |
| <b>DS1</b>    | Digital Service, Level 1              |
| <b>DSX-1</b>  | Digital System Cross-Connect frame    |
| <b>EN</b>     | Enable                                |
| <b>ES</b>     | Errored Seconds                       |
| <b>ESF</b>    | Extended Super Frame                  |
| <b>ESF DL</b> | Extended Super Frame Data Link        |
| <b>FRN</b>    | Frame                                 |
| <b>HCDS</b>   | High Capacity Digital Service         |
| <b>HDSL</b>   | High-bit-rate Digital Subscriber Line |

|              |                                       |
|--------------|---------------------------------------|
| <b>HDU</b>   | HiGain Doubler Unit                   |
| <b>HLU</b>   | HiGain Line Unit                      |
| <b>HRE</b>   | HiGain Remote Enclosure               |
| <b>HRU</b>   | HiGain Remote Unit                    |
| <b>I-CPE</b> | Interface-Customer Premises Equipment |
| <b>LBK</b>   | Loopback                              |
| <b>LCD</b>   | Liquid Crystal Display                |
| <b>LED</b>   | Light Emitting Diode                  |
| <b>LOS</b>   | Loss of Signal                        |
| <b>LOSW</b>  | Loss of Sync Word                     |
| <b>LPWR</b>  | Local Power                           |
| <b>LVL</b>   | Level                                 |
| <b>NEBS</b>  | Network Equipment Building System     |
| <b>NET</b>   | Network                               |
| <b>NI</b>    | Network Interface                     |
| <b>NID</b>   | Network Interface Device              |
| <b>NIU</b>   | Network Interface Unit                |
| <b>NREM</b>  | Network Remote Loopback               |
| <b>NVRAM</b> | Non-volatile Random Access Memory     |
| <b>POTS</b>  | Plain Old Telephone Service           |
| <b>RCV</b>   | Receive                               |
| <b>RDA</b>   | Remote DS1 Alarm                      |
| <b>RLEV</b>  | Receive Level                         |
| <b>RLOS</b>  | Receive Loss of Signal                |
| <b>SAIS</b>  | SmartJack AIS                         |

|                |                                       |
|----------------|---------------------------------------|
| <b>SCURR</b>   | Sealing Current                       |
| <b>SF</b>      | Super Frame                           |
| <b>S/N</b>     | Signal-to-Noise                       |
| <b>SPLB</b>    | Special Loopback                      |
| <b>TEC</b>     | Total Error Count                     |
| <b>TLOS-LB</b> | Transmit Loss of Signal-Loopback      |
| <b>TSEC</b>    | Total System Error Count              |
| <b>TSGR</b>    | Transport System Generic Requirements |
| <b>UAS</b>     | Unavailable Seconds                   |
| <b>UL</b>      | Underwriters Laboratory               |
| <b>W</b>       | Watts                                 |
| <b>XMT</b>     | Transmit                              |
| <b>ZBTSI</b>   | Zero Byte Time Slot Interface         |

## PRODUCT SUPPORT

This section contains product support and warranty information.

## TECHNICAL SUPPORT

PairGain Technical Assistance is available 24 hours a day, 7 days a week by contacting PairGain Customer Service Engineering group at:

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

**Fax:** (714) 832-9924

During normal business hours (8:00 AM to 5:00 PM, Pacific Time, Monday through Friday, excluding holidays), technical assistance calls are normally 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 normally 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 by calling (714) 730-2800. Transmission speeds up to 28.8 kbps are supported with a character format of 8-N-1.

## **WARRANTY**

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 correct customer installation and regular maintenance. PairGain will repair or replace any unit without cost during this period if the unit is found to be defective for any reason other than abuse or incorrect use or installation.

Do not try to repair the unit. 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.

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.  
14352 Franklin Avenue  
Tustin, CA 92780  
ATTN: Repair and Return Dept.  
(800) 638-0031

PairGain continues to repair faulty modules beyond the warranty program at a nominal charge. Contact your PairGain sales representative for details and pricing.

## FCC COMPLIANCE

This unit complies with the limits for Class A digital devices pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, can 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.

Refer to the installation section of the appropriate instruction manual for the unit you are installing to get information on:

- Cabling
- Correct connections
- Grounding
- Line vs. local power

All wiring external to the product(s) should follow the provisions of the current edition of the National Electrical Code.

## MODIFICATIONS

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by PairGain Technologies, Inc. may void the user's authority to operate the equipment.

All wiring external to the products should follow the provisions of the current edition of the National Electrical Code.

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