Section 61245024L1-5A
Issue 1, March 1999
CLEI Code #T1L2C8JB _ _

T400 Low Voltage HTU-R
High-bit-rate Digital Subscriber Line Remote Unit
Installation and Maintenance

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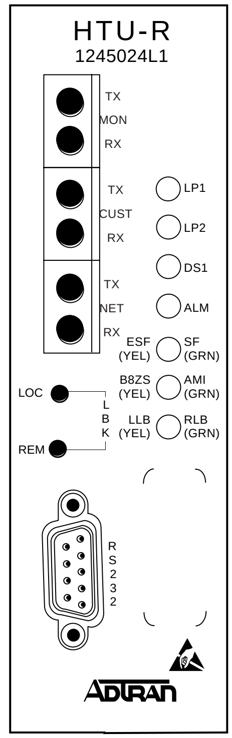


Figure 1. ADTRAN T400 Low Voltage HTU-R

1. GENERAL

The ADTRAN T400 Low Voltage HDSL Transceiver Unit for the Remote end (HTU-R) (ADTRAN part number 1245024L1) is a network terminating unit used to deploy an HDSL T1 circuit using 4-wire metallic facilities. The HTU-R is a T400 mechanics card which will fit T400 mechanics enclosures. The HTU-R can be housed in the ADTRAN standalone metal enclosure (P/N 1242034L2). Refer to the appropriate ADTRAN practice for more information. The T400 Low Voltage HTU-R card can also plug into the ADTRAN HR12 HDSL remote shelf (P/N 1242007L1), or the ADTRAN HR4 HDSL remote shelf (P/N 1242008L1).

This version of the HTU-R works with multiple list versions of the HDSL transceiver unit for the central office (HTU-C), and HDSL Range Extenders (HREs) as listed below.

Part Number	Description
1242002LX	220/E220 HTU-C
1242016LX	3192 HTU-C
1242023LX	DDM Plus HTU-C
1244001LX	Low Voltage E220 HTU-C
1244041LX	Low Voltage T400 HRE
1244042LX	Low Voltage 819A HRE
1244044L1	Low Voltage 439 HRE
1245002LX	Litespan HTU-C
1245001LX	Low Voltage E220 HTU-C
1245003LX	Low Voltage DDM+ HTU-C
1245004LX	Low Voltage 3192 HTU-C
1245045LX	239 HRE
1245041LX	T200 HRE

The Low Voltage HTU-R can be deployed in circuits using one HTU-C and one HTU-R. The Low Voltage HTU-R can also be deployed with one HTU-C M and up to two Low Voltage HREs in circuits requiring reach beyond standard CSA requirements. The Low Voltage HTU-R will power an external T1 NIU using a 60 *m*A constant current source.

The HTU-R terminates local loop HDSL signals originating from the Central Office (CO) unit and transforms the HDSL signal into traditional DS1 signals to be delivered to the customer.

The HDSL local loop operates as two independent subsystems each operating over a single twisted pair. The HTU-R communicates over these two twisted pairs to the HTU-C located at the CO. Each subsystem carries half of the total bandwidth along with a small amount of overhead used for maintenance and performance monitoring related functions. The unit is span powered by the HTU-C.

The effective range of an ADTRAN HDSL-based T1 circuit can be extended using the ADTRAN HDSL Range Extender (HRE). The HRE can double the deployment range of standard HDSL and extend the digital subscriber loop serving range up to 36 kFt on 24-gauge twisted pair wire using two HREs.

For more information on the HRE, refer to ADTRAN practices 61244041L2-5, 61244044L1-5, 61244042L1-5, 61245041L1-5, or 61245045L1-5.

The Low Voltage HTU-R (P/N 1245024L1) can be used with any Low Voltage HRE and any HTU-C to provide a fully span-powered extended range HDSL circuit. Span power is provided from the HTU-C. Span powering meets all requirements of Class A2 voltages as specified by Bellcore GR-1089-CORE. In addition, the Low Voltage T400 HTU-R can be locally powered using a -48 VDC power supply. If local power is present at the HTU-R, then span power is not used.

Revision History

This is the first issue of this practice. In subsequent issues, revisions will be summarized in this paragraph.

2. INSTALLATION

CAUTION!

SUBJECT TO ELECTROSTATIC DAMAGE
OR DECREASE IN RELIABILITY.

HANDLING PRECAUTIONS REQUIRED.

After unpacking the unit, immediately inspect it for possible shipping damage. If damage is discovered, file a claim immediately with the carrier, then contact ADTRAN customer service (see subsection 10 of this practice).

The settings on the HTU-C are encoded and transmitted to the HTU-R once the circuit has achieved synchronization. The NIU features of the HTU-R are selected using a Dipswitch on the HTU-R. See Tables A and B for details.

Table A. SW1 Option Settings

Function [1]	Description
SPRM	Enables SPRM functionality
NPRM	Enables NPRM functionality.
None	**Disables SPRM and NPRM functionality.**

NOTE: If the unit is used in a circuit that contains a second- or fourth-generation HTU-C, then the DS1 (Tx) output level is provisioned by the HTU-C. Second- or fourth-generation products are identified by a "2" or a "4" in the fourth-digit place of the product number.

Remote Provisioning

This HTU-R can be used to provision the entire HDSL circuit via the craft interface. This capability is only available when using List 4 or List 8 fifth-generation HTU-Cs.

Electrical Code Compliance

Table C shows the UL/CUL Telecommunications Codes for the DDM Plus HTU-C. The DDM Plus HTU-C complies with the requirements covered under UL 1459 third edition and is intended to be installed in an enclosure with an Installation Code (IC) of "B" or "E."

NOTE

- **This product is intended for installation in RESTRICTED ACCESS LOCATIONS only.**
- **Input current at maximum load is 1 A at -48VDC.**
- **Maximum output at overcurrent condition is 160 mA at -188 VDC.**

Table C. UL/CUL Telecommunications Codes

Code	Input	Output
IC	A	-
TC	X	-
PC	F	C

C UL US LISTED
Custom Telecom
E190349

Table B. SW4 Option Settings

Switch	Function	Description
SW4-1	Transmit Level	
	0dB	**This setting enables the DS1 (Tx) output level to be 0dB.**
	-15dB	This setting enables the DS1 (Tx) output level to be -15dB.
SW4-2	DS1 Current Setting	
	Off	**Disables the constant current source for the DS1.**
	60mA	Enables the 60mA constant current source for the DS1.
SW4-3	NIU Smartjack	
	Enable	**Allows the HTU-R to respond to NIU Smartjack loopback codes.**
	Disable	Disables the response to Smartjack loopback codes.

[1] Supplementary Performance Reporting Messages (SPRM) and Network Performance Reporting Message (NPRMs) are supported as described in ANSI T1.403, Draft 1997, Annex E and F. For a complete description of this feature, refer to ANSI T1.403, Draft 1997.

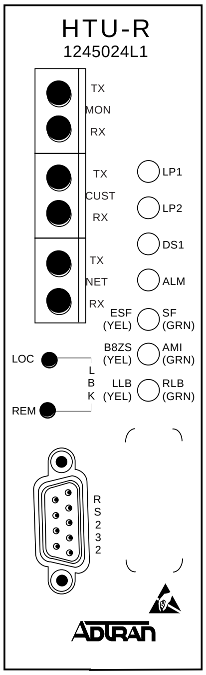
Front Panel Indicators

There are seven front panel mounted status indicators. Each indicator is described in Table D.

Front Panel Switch

Two loopback (LBK) switches are accessible from the front panel. The REM loopback switch controls a loopback to the customer at the HTU-C. The LOC loopback switch controls a loopback to the customer at the HTU-R. See Table E for details.

Table D. Front Panel Indicators



Indicator	Description
LP1	Indicates HDSL signal quality on Loop 1 is in one of the following five states: *Off* .... No synchronization of HTU-C and HTU-R on Loop 1. *Red* .... Poor signal quality on Loop 1 ($\geq 10^{-7}$ BER). *Yellow* .... Marginal signal quality on Loop 1 ($\leq$ 2 dB margin above 10^{-7} BER). *Green* .... Good signal quality on Loop 1 (> 2 dB margin above 10^{-7} BER). *Blinking* .... Detected error on either end of Loop 1.
LP2	Indicates HDSL signal quality on Loop 2 is in one of the following five states: *Off* .... No synchronization of HTU-C and HTU-R on Loop 2 *Red* .... Poor signal quality on Loop 2 ($\geq 10^{-7}$ BER) *Yellow* .... Marginal signal quality on Loop 2 ($\leq$ 2 dB margin above 10^{-7} BER) *Green* .... Good signal quality on Loop 2 (> 2 dB margin above 10^{-7} BER) *Blinking* .... Detected error on either end of Loop 2
DS1	*Off* .... Customer-side DS1 signal is absent or is of a format that does not match the HDSL circuit provisioning *Blinking* .... Detected error on the DS1 interface *On Solid* .... Customer-side DS1 signal is present and synchronized
ALM	This LED indicates three possible alarm conditions: *Off* .... No alarm condition detected *Red* .... Detected local alarm condition (HTU-R) *Yellow* .... Detected remote alarm condition (HTU-C)
ESF/SF/Unframed	This LED indicates three possible framing modes: *Yellow* .... Indicates DS1 is provisioned for ESF framing mode *Green* .... Indicates DS1 is provisioned for SF framing mode *Off* .... Indicates DS1 is provisioned for Unframed operation
B8ZS/AMI	This LED indicates two possible line codes: *Yellow* .... Indicates DS1 is provisioned for B8ZS coding *Green* .... Indicates DS1 is provisioned for AMI coding
LLB/RLB	This LED indicates three possible loopback conditions: *Off* .... Unit is not in loopback or armed state *Yellow* .... Active local loopback from the HTU-R toward the customer. *Green* .... Active remote loopback from the HTU-C toward the customer.

Table E. Front Panel Loopback Switches

Switch Label	Function
REM	Pressing this switch changes the HTU-C to customer loopback state as follows: • If the HTU-C *is not* in loopback, pressing this switch will activate a loopback toward the HTU-R. • If the HTU-C *is* in loopback, pressing this switch will deactivate the loopback toward the HTU-R.
LOC	Pressing this switch changes the HTU-C customer loopback state as follows: • If the HTU-R is not in loopback, pressing this switch will activate the bidirectional loopback. • If the HTU-R is in loopback, pressing this switch will deactivate

Option Settings

One three-position slide switch (SW1) and a three-position Dipswitch pack (SW4) are used to configure settings on the unit. Figure 2 shows the location of these switches.

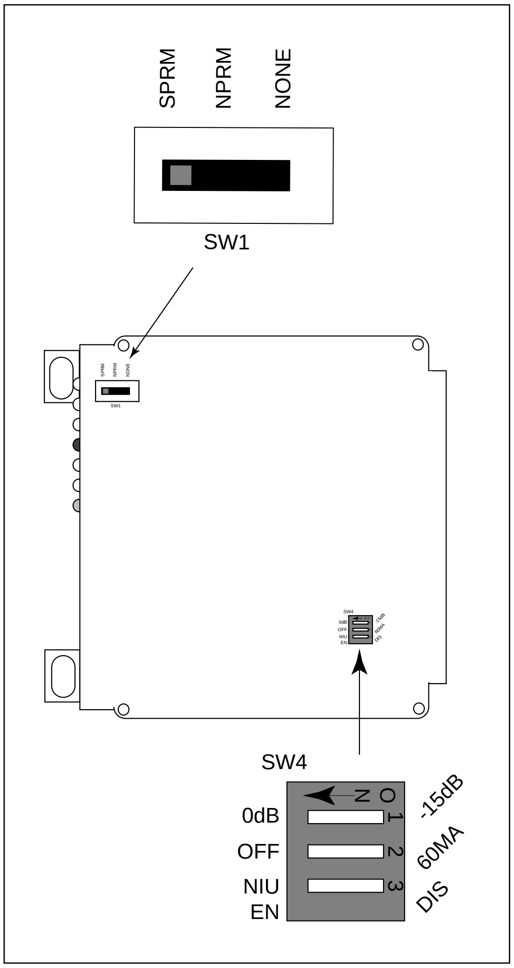


Figure 2. Switch Locations

NOTE: Some HTU-C units (Central Office) also have an option setting for NIU Enable/ Disable. If this HTU-R (P/N 1245024L1) is used in a circuit, then its NIU EN/DIS setting takes precedence.

A definition of each switch is shown in Tables C and D. Configuration may be performed by manually selecting each option switch.

3. CONNECTIONS

All connections of the HTU-R are made through card edge connectors. Table F gives the card edge pin assignments for the HTU-R circuit pack. The circuit pack operates in either of the previously mentioned stand alone chassis, the ADTRAN HR4 HDSL shelf (P/N 1242008L1), or the ADTRAN HR12 HDSL shelf (P/N 1242007L1).

When the circuit pack is installed in any of the HTU-R enclosures, all connections are made through the enclosure backplanes. See the following ADTRAN documents for more information:

Part Number	Description
61242007L1-5	HR12 Installation/ Maintenance
61242008L1-5	HR4 Installation/ Maintenance
61242034L2-5	T400 Single Mount Installation/ Maintenance (removable RJ-48 jacks)

NOTE: Ensure chassis ground is properly connected for either stand-alone or shelf-mounted applications.

Table F. Card Edge Pin Assignments

Pin	Designation	Description
1	CH GND	Chassis ground
5	DS1-T1	DS1 receive out tip (to customer interface)
7	H1-T	HDSL Loop 1 tip (facility)
11	CH GND	Chassis ground
12	GND	Ground for protection switching
13	H1-R	HDSL Loop 1 ring (facility)
15	DS1-R1	DS1 receive out ring (to customer interface)
17	-48 VR	Local power return voltage
20	VCC	+5VDC for protection switching
27	CH GND	Chassis ground
32	PROT-4	Control line for protection switching
34	PROT-3	Control line for protection switching
35	-48 V	Local power -48 VDC
38	PROT-2	Control line for protection switching
40	PROT-1	Control line for protection switching
41	H2-T	HDSL Loop 2 tip (facility)
47	H2-R	HDSL Loop 2 ring (facility)
49	DS1-R	DS1 transmit in ring (from customer interface)
55	DS1-T	DS1 transmit in tip (from customer interface)

4. HDSL SYSTEM TESTING

The T400 HTU-R provides diagnostic, loopback, and signal monitoring capabilities.

The seven front panel LEDs provide diagnostics for HDSL loops, DS1 signals, alarms, provisioning, and loopbacks. See subsection 2 for details.

The HTU-R provides local and remote loopback capabilities via the loopback switches on the front panel.

Bantam Jack Description

The front panel of the HTU-R contains monitoring and metallic splitting Bantam jacks. In general, the monitoring jacks provide a non-intrusive tap onto a signal line that permits the connection of test equipment to monitor the characteristics of that signal. For example, the DS1 MON jack on the HTU-R could be used to connect to a bit error rate tester to monitor for synchronization, test patterns, etc. The metallic splitting jacks provide an intrusive, signal interrupting access to the line. It is very important to know the direction of the access provided by a metallic splitting jack. Figures 3, 4, and 5 are illustrations of specific jack detail.

DS1 MON, DS1 CUST, and DS1 NET Bantam Jacks

The first jack, labeled MON, provides a non-intrusive access point for monitoring the transmit and receive signals at the DS1 interface point.

NOTE: For the MON jacks, the Rx and Tx indications relate to the direction of the signal to/from the HTU-R, respectively.

The second jack, labeled CUST, provides a metallic splitting of the DS1 lines for connecting test equipment to transmit and receive signals with the customer-provided equipment.

The third jack, labeled NET, provides a metallic splitting of the DS1 lines for connecting test equipment to transmit and receive signals with the HTU-R and network.

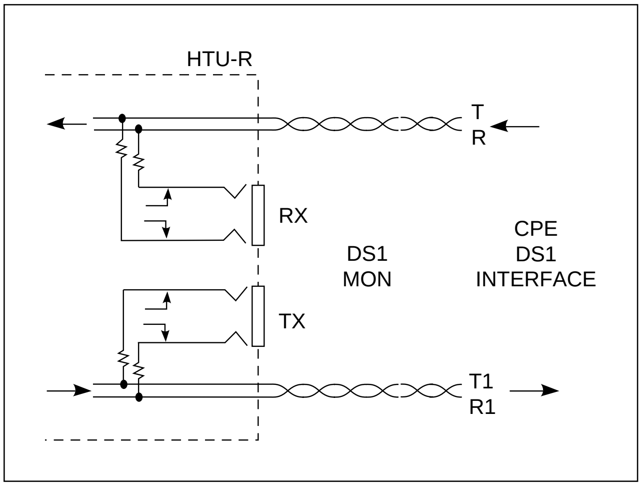


Figure 3. HTU-R MON Diagram

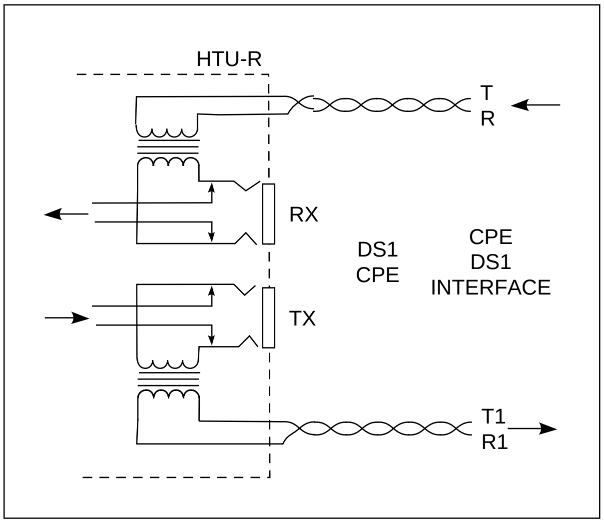


Figure 4. HTU-R NET Diagram

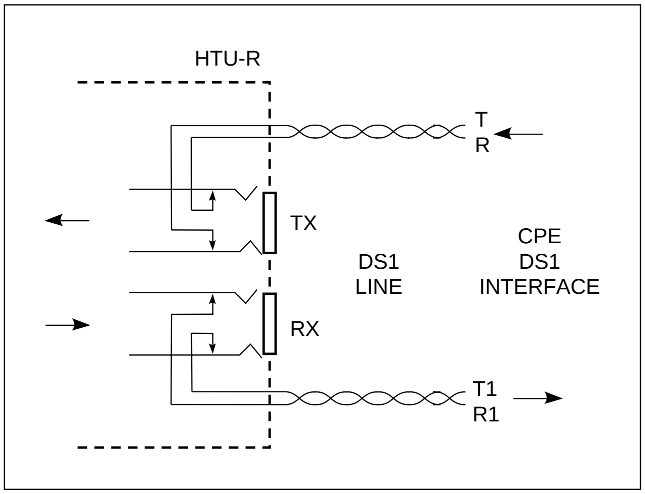


Figure 5. HTU-R CUST Diagram

HTU-R Network Loopbacks

The HTU-R responds to multiple loopback activation processes. The loopback position is a logic loopback located within the HTU-R internal HDSL transceiver. See Figure 6.

First, loopback activation may be accomplished using the control port of the HTU-C or HTU-R. Refer to the ADTRAN HTU-C Installation/Maintenance practice, Section 61245001L1-5 or other HTU-C practices for more information.

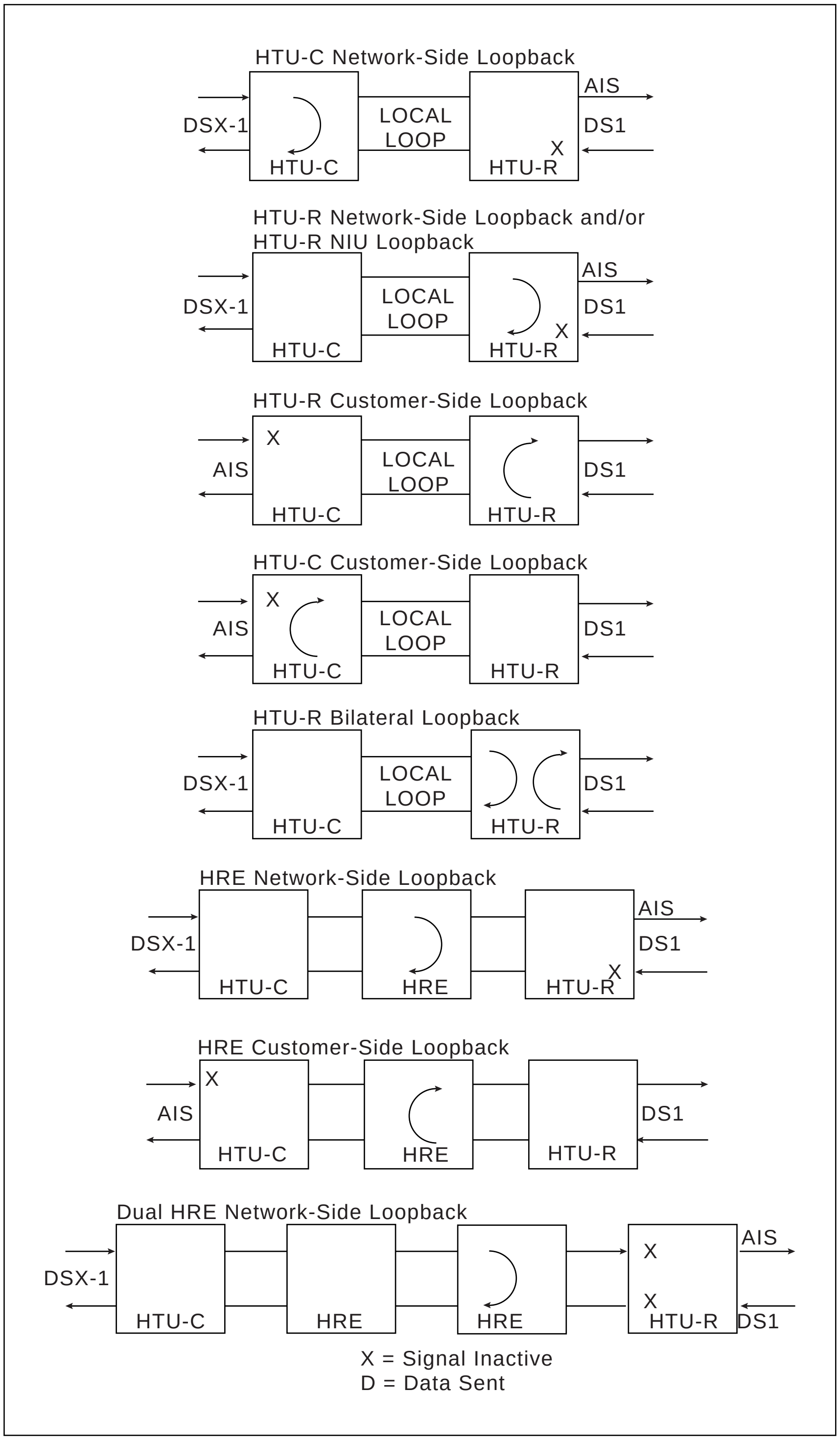


Figure 6. HDSL Loopbacks

Second, the HTU-R will respond to the industry defacto HDSL loopback codes as designated in the ANSI document T1E1.4/92. A synopsis of the method described by ANSI is presented in Appendix A.

Third, the HTU-R responds to T1 Network Interface Unit (NIU) loopback codes as described in Bellcore TR-TSY-000312 if the HTU-R is optioned for NIU loopbacks. The NIU loopback codes are as follows:

In-band Codes:	Loop-up	11000
	Loop down.......	11100
ESF Codes:	Loop-up	0001 0010 1111 1111
	Loop-down	0010 0100 1111 1111

This unit contains smartloop technology. That is, if the unit is optioned to operate in auto frame mode, it constantly monitors the DSX-1 for a framing pattern. In auto frame mode, the unit will initiate the proper loopback regardless of how the loopback control sequence is sent (framed or unframed). With the framing mode set to ESF, SF, or Unframed, the loopback control code must match the framing format.

Receiving the in-band codes for more than five seconds or the ESF codes four consecutive times will cause the appopriate loopback action.

The Low Voltage HTU-R will respond to the loop-up codes by activating the NIU loopback from either the disarmed or armed state. The loop-down codes will return the HTU-R to the state from the armed or loop-up state.

Refer to Appendix A for more details on loopbacks and loopback arming sequences.

Customer Loopbacks

In addition to the loopbacks in the direction of the network, the HTU-R may also be looped back in the direction of the customer using the terminal control port of either the HTU-C, the HTU-R or the LOC LBK switch on the front panel of the HTU-R. The HTU-C can be looped to the customer using the REM LBK switch on the front panel of the HTU-R. The HTU-C and HTU-R Customer Side Loopbacks are illustrated in Figure 6.

NOTE: Network and customer loopbacks are governed by the loopback timeout option configured on the HTU-C.

5. CONTROL PORT OPERATION

The HTU-C provides a faceplate-mounted DB9 connector that supplies an RS-232 interface for connection to a controlling terminal. The pinout of the DB9 is illustrated in Figure 7.

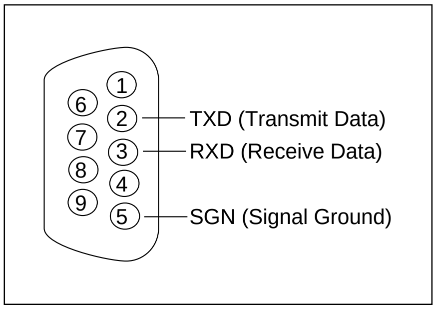


Figure 7. RS-232 (DB9) Pin Assignments

The terminal interface operates at data rates from 1.2 kbps to 19.2 kbps. The asynchronous data format is fixed at 8 data bits, no parity, and 1 stop bit. The supported terminal type is VT-100 or compatible.

NOTES: 1. If you are using a personal computer (PC) with terminal emulation capability, be sure to disable any power saving programs. Otherwise, communication between the PC and the HDSL unit may be disrupted, resulting in misplaced characters or screen timeouts. 2. If you are using HyperTerminal as a terminal emulation package with Windows 95, upgrade to HyperTerminal Private Edition, available free on-line at www.hilgraeve.com.

Operation

For abbreviations used in the screen diagrams, see Table G.

Table G. Screen Abbreviations

Abbreviation	Definition	
ES	Errored Seconds	
	DSX/DS1	SF: Second in which a BPV or frame bit error occurs
		ESF: Second in which a BPV or CRC error occurs
	HDSL	Second in which a CRC error occurs
SES	Severely errored seconds	
	DSX/DS1	SF: Second in which 1544 BPVs or 8 frame bit errors occurs
		ESF: Second in which 1544 BPVs or 320 CRC errors occur
	HDSL	Second in which 165 CRC errors occurs
UAS	Unavailable seconds	
	DSX/DS1	Second in which there is a loss of signal or sync
	HDSL	Second in which there is a loss of signal or sync
SF	Superframe format	
ESF	Extended superframe format	
B8ZS	Bipolar with 8-zero substitution	
AMI	Alternate mark inversion	
LBO	Line build-out	
BPV	Bipolar violation	
	DSX/DS1	Second in which a bipolar violation occurs
NIU	T1 Network Interface Unit	
S/N	Serial number	
15M	Fifteen-minute period	
24H	Twenty-four-hour period	

The screens illustrated in Figures 8 through 16 are for an HDSL circuit deployed with ADTRAN's Low Voltage HDSL technology. The circuit includes an HTU-C, HTU-R, and HRE. This scenario was chosen for inclusiveness of functionality. However, other configurations are possible and their displays will vary slightly from those shown in this section.

A terminal session is initiated by entering multiple space bar characters, which are used by the HTU-C to determine the speed of the terminal. Once the speed has been determined, an Introductory Menu is presented, as illustrated in Figure 8.

From the Introductory Menu, the Main Menu may be selected by pressing the letter "M". The Main Menu provides access to detailed performance and configuration information, as illustrated in Figure 9, HDSL Main Menu Screen.

From the Main Menu, the following screens can be accessed.

1. Current System Status
2. Performance History
3. ADTRAN Information
4. Loopback Options
5. Self-Test
6. Provisioning
7. Troubleshooting
8. Set Time/Date/Circuit ID

The Current System Status screen illustrated in Figure 10 provides quick access to status information for both the HTU-C and HTU-R. Type "H" to view the Current System Status screen for the HRE. See Figure 10A for the HRE Current System Status screen.

At each 15-minute interval, the performance information is transferred to the 15-minute performance data register accessed from the Performance History screen. This unit displays performance information in 15-minute increments for the last 24-hour period. At each 24-hour interval, the performance data is transferred into the 24-hour performance data register also accessed using the Performance History screen. The Performance History screen is shown in Figure 11. Type "H" to view the Performance History screen for the HRE. See Figure 11A for the HRE Performance History screen.

At the Current System Status screen, type "Z" to reset the current performance registers to zero on the Current System Status screen and Performance History screen.

Figures 10 and 10A consolidate current information for the HDSL, DSX-1, and DS1 interfaces. A key to the information provided is found in the center of the screen. Arrows indicate the key applies to both the HTU-C and HTU-R.

LOSS	Pulse Attenuation Measurement [2]
SYNC	HDSL Loop 1 and Loop 2 Sync Status
ES 15M/24H	Errored Seconds [3]
SES 15M/24H	Severely Errored Seconds [3]
UAS 15M/24H	Unavailable Seconds [3]

An indication of Pair Reversal (if present) is given at the bottom of the first key column. Status and configuration information for the DS1 and DSX-1 signals is located in the center of the screen near the bottom.

FRAME	T1 Framing Format selected
CODE	T1 Line Code selected
LBO	Line Build-Out selected (for DSX-1); Customer Signal of 0 or -15 dB (for DS1)
NIU	Network Interface Unit enabled
BPV	Bipolar Violations detected (DSX-1 and DS1)
ES	Errored Seconds (DSX-1 and DS1)
SES	Severely Errored Seconds (DSX-1 and DS1)
UAS	Unavailable Seconds (DSX-1 and DS1)
Alarms	Lists current alarm condition status

[2] LOSS is typically several dB less than the insertion loss measured at 200 kHz. The LOSS measurement is a better indication of the loop's attenuation of the 2B1Q signal than the insertion loss measured at a single frequency. Adtran HDSL can operate on cables with an excess of 30 dB LOSS.

[3] The first number is for the current 15-minute period and the second is the current 24-hour period (Loop 1 and Loop 2 numbers are displayed).

A measure of signal quality (current/minimum/ maximum) for each HDSL loop is displayed on the Current System Status screen. The noise margin is the measure in dB above the 10^{-7} BER. A noise margin of 1 to 2 is considered marginal signal quality. Good signal quality is considered to be anything above 2.

Figures 12 and 13 depict the HDSL Loopback and Self-Test Option screens. Loopbacks and Self-Test may be evoked or terminated using these screens. A status of current loopback conditions is also provided.

The Provisioning Screen, illustrated in Figure 14, displays current provisioning option settings when the T400 HTU-R is used in a circuit with fifth-generation List 4 or List 8. Settings can be changed for system configuration by selecting the letter corresponding to the desired option (i.e., “A” for DSX-1 Line Buildout). Provisioning changes are also allowed at the CO end of the circuit. Provisioning from this terminal is not supported when used with earlier-generation equipment or other fifth-generation list units. (The generation of the product is identified in the fourth digit of the product number.)

The Troubleshooting Display, shown in Figure 15, graphically presents an HDSL circuit. The unit reviews red, yellow, and blue alarm conditions in the circuit to automatically predict where a fault is located. Once a fault location is suspected, the corresponding portion of the circuit on the screen is highlighted and a message describing the failure will appear.

The Set Time/Date/Circuit ID menu screen, illustrated in Figure 16, provides additional provisioning options. Enter the Time parameters as military time (for example, enter 3:15 p.m. as “15:15:00”). Enter the Date parameters as mm/dd/yy (for example, enter January 1, 1999 as “01/01/99”). Enter the Circuit ID as a 25-character alphanumeric string.

```
CIRCUIT ID: XXX                                    01/02/98  18:35:28

                                    ADTRAN
                            901 Explorer Boulevard
                        Huntsville, Alabama 35806-2807

      --------------- For Information or Technical Support ---------------
       Support Hours ( Normal 7am - 7pm CST, Emergency 7 days x 24 hours )
Phone: 800.726.8663 / 888.873.HDSL  Fax: 256.963.6217  Internet: www.adtran.com
------------------------------------------------------------------------------
HTU-C INFORMATION                         HTU-R INFORMATION
-----------------                         -----------------
S/N : B12345678                           S/N :
CLEI: T1L2BFCBAA                          CLEI:
MANF: 06/98                               MANF:   /

HRE #1 INFORMATION
------------------
S/N : A746C6660
CLEI: T1R5FPYDAA
MANF: 01/98


                         Press “M” to view Main Menu.
```

Figure 8. Introductory Menu Screen

```
CIRCUIT ID: XXX                                    01/02/98  18:40:07



                            ADTRAN HDSL MAIN MENU


                           1) CURRENT SYSTEM STATUS
                           2) PERFORMANCE HISTORY
                           3) ADTRAN INFORMATION
                           4) LOOPBACK OPTIONS
                           5) SELF-TEST
                           6) PROVISIONING
                           7) TROUBLESHOOTING
                           8) SET TIME/DATE/CIRCUIT ID



             Choose a screen by pressing the corresponding number.
```

Figure 9. HDSL Main Menu Screen

```
CIRCUIT ID: xxxx                                         02/01/99  11:17:34
LOOP #1 <NETWORK> LOOP #2    CURRENT SYSTEM STATUS    LOOP #1 <CUSTOMER>LOOP #2
----------HTU-C----------                             -----------HTU-R---------
01(01) dB       01(01) dB    <-  LOSS  CUR(MAX) ->    02(02) dB       02(02) dB
   YES             YES       <-  SYNC           ->       YES             YES
000/00000       000/00000    <-  ES    15M/24H  ->    000/00000       000/00000
000/00000       000/00000    <-  SES   15M/24H  ->    000/00000       000/00000
839/00839       865/00865    <-  UAS   15M/24H  ->    838/00838       865/00865
    LOOPBACKS INACTIVE                                    LOOPBACKS INACTIVE

                          DSX-1                    DS1
  HTU-C MARGIN (dB)      -------------------------------  HTU-R MARGIN (dB)
       CUR/MIN/MAX        ESF     <-  FRAME ->     ESF            CUR/MIN/MAX
                          B8ZS    <-  CODE  ->    B8ZS
    LP1   >9/>9/>9        EXT     <-  LBO   ->    0 dB      LP1   20/20/20
    LP2   >9/>9/>9        N/A     <-  NIU   ->      NO      LP2   20/20/20
                          00002   <-  BPV   ->   00000
                          00002   <-  ES    ->   00000
                          00000   <-  SES   ->   00000
                          00096   <-  UAS   ->   00931
                          NONE    <- ALARMS ->    NONE

     Press “Z” to zero registers, “X” to restart MIN/MAX, “M” for Main Menu
                   “H” for HDSL Range Extender #1 (HRE) View.
```

Figure 10. Current System Status Screen

```
CIRCUIT ID: xxxx                                         02/01/99  11:18:31
LOOP #1 <NETWORK> LOOP #2    CURRENT SYSTEM STATUS    LOOP #1 <CUSTOMER>LOOP #2
-----------HRE  #1-------                             ----------HRE  #1--------
03(03) dB       03(03) dB    <-  LOSS  CUR(MAX) ->    03(03) dB       03(03) dB
   YES             YES       <-  SYNC           ->       YES             YES
000/00000       000/00000    <-  ES    15M/24H  ->    000/00001       000/00000
000/00000       000/00000    <-  SES   15M/24H  ->    000/00000       000/00000
852/00852       865/00865    <-  UAS   15M/24H  ->    852/00852       865/00865
    LOOPBACK  INACTIVE       HRE CUST PAIRS REVERSED

                          N = NETWORK SIDE RECEIVER
  HRE1 NET MARGIN (dB)    C = CUSTOMER SIDE RECEIVER       HRE1 CST MARGIN (dB)
       CUR/MIN/MAX                                                CUR/MIN/MAX
                      ____        ____           ____
    LP1   >9/>9/>9   |HTUC|  LOOP1  |HRE1|   LOOP1 |HTUR|    LP1   >9/>9/>9
    LP2   >9/>9/>9   |    |========N|    |C========|    |    LP2   >9/>9/>9
                     |    |         |    |         |    |
                     |    |========N|    |C========|    |
                     |____|  LOOP2  |____|   LOOP2 |____|



     Press “Z” to zero registers, “X” to restart MIN/MAX, “M” for Main Menu
                             “P” for previous view.
```

Figure 10A. Current System Status Screen - HRE

```
CIRCUIT ID: xxxx                                           02/01/99  11:19:08
      24 HOUR REGISTERS     PERFORMANCE HISTORY     15 MINUTE REGISTERS
     ---ES---SES--                                --ES-SES-----------ES-SES-
      00002 00000        <---CURRENT--->        000 000
01/31 ----- -----        <--          -->  11:15 002 000      07:15 --- ---
01/30 ----- -----          |          |    11:00 --- ---      07:00 --- ---
01/29 ----- -----          |          |    10:45 --- ---      06:45 --- ---
01/28 ----- -----          |          |    10:30 --- ---      06:30 --- ---
01/27 ----- -----          |PREVIOUS  |    10:15 --- ---      06:15 --- ---
01/26 ----- -----          |          |    10:00 --- ---      06:00 --- ---
01/25 ----- -----        <--          |    09:45 --- ---      05:45 --- ---
                                      |    09:30 --- ---      05:30 --- ---
VIEW 1 : HTU-C DSX-1                  |    09:15 --- ---      05:15 --- ---
                                      |    09:00 --- ---      05:00 --- ---
1->|H|<-3---   |R|         |T|        |    08:30 --- ---      04:30 --- ---
   |U|         |E|         |U|        |    08:15 --- ---      04:15 --- ---
<--|C|<-5---   |1|---6->   |R|<-2     |    08:00 --- ---      04:00 --- ---
                                      |    07:45 --- ---      03:45 --- ---
Press view number to select view      -->  07:30 --- ---      03:30 --- ---
Press “H” to view HRE #1 history
                              Press “B” to go back 8 hours

                          Press “M” to return to the Main Menu
```

Figure 11. Performance History Screen

```
CIRCUIT ID: xxxx                                           02/01/99  11:19:43
      24 HOUR REGISTERS     PERFORMANCE HISTORY     15 MINUTE REGISTERS
     ---ES---SES--                                 --ES-SES--------ES-SES-
      00000 00000        <---CURRENT--->        000 000
01/31 ----- -----        <--          -->  11:15 000 000      07:15 --- ---
01/30 ----- -----          |          |    11:00 --- ---      07:00 --- ---
01/29 ----- -----          |          |    10:45 --- ---      06:45 --- ---
01/28 ----- -----          |          |    10:30 --- ---      06:30 --- ---
01/27 ----- -----          |PREVIOUS  |    10:15 --- ---      06:15 --- ---
01/26 ----- -----          |          |    10:00 --- ---      06:00 --- ---
01/25 ----- -----        <--          |    09:45 --- ---      05:45 --- ---
                                      |    09:30 --- ---      05:30 --- ---
VIEW 1 : HRE NETWORK LP1              |    09:15 --- ---      05:15 --- ---
                                      |    09:00 --- ---      05:00 --- ---
-->|H|<--1->   |H|<-2-->   |H|-       |    08:45 --- ---      04:45 --- ---
   |T|         |R|         |T|        |    08:30 --- ---      04:30 --- ---
   |U|         |E|         |U|        |    08:15 --- ---      04:15 --- ---
<--|C|<--3->   |1|<-4-->   |R|<-      |    08:00 --- ---      04:00 --- ---
                                      |    07:45 --- ---      03:45 --- ---
Press view number to select view      -->  07:30 --- ---      03:30 --- ---
Press “P” for previous view
Press “B” to go back 8 hours

                          Press “M” to return to the Main Menu
```

Figure 11A. Performance History Screen - HRE

```
CIRCUIT ID: xxxx                                          02/01/99  11:20:31
                                LOOPBACK OPTIONS
                 _____            _____            _____
                |HTU-C|          |HRE 1|          |HTU-R|
                |     |    LP1   |     |    LP1   |     |
             --->|-----|<===========>|-----|<===========>|-----|<--
                |     |          |     |          |     |
            NET |     |          |     |          |     | CUST
                |     |    LP2   |     |    LP2   |     |
             <---|-----|<===========>|-----|<===========>|-----|-->
                |     |          |     |          |     |
                |_____|          |_____|          |_____|

                  1) LOOPBACK TO NETWORK  AT HTU-C = INACTIVE
                  2) LOOPBACK TO CUSTOMER AT HTU-C = INACTIVE
                  3) LOOPBACK TO NETWORK  AT HTU-R = INACTIVE
                  4) LOOPBACK TO CUSTOMER AT HTU-R = INACTIVE
                  5) LOOPBACK TO NETWORK  AT HRE-1 = UNAVAILABLE
                  6) LOOPBACK TO CUSTOMER AT HRE-1 = UNAVAILABLE


              Press corresponding number to toggle loopback option.
                      Press "M" to return to the Main Menu
```

Figure 12. Loopback Options Screen

```
CIRCUIT ID: XXX                                    01/02/98  18:42:12

                               SELF-TEST



              Press "S" to initiate HTU-C and HTU-R self-tests.

                     Press "M" to return to the Main Menu.
```

Figure 13. Self-Test Options Screen

```
CIRCUIT ID: xxxx                                             02/01/99
                                                             00:05:56
                                   PROVISIONING

              A.  DSX-1 LINE BUILDOUT    =  0-133 FEET
      B.  DSX-1/DS1 LINE CODE    =  B8ZS
      C.  DSX-1/DS1 FRAMING      =  AUTO
      *   NIU LOOPBACK           =  DISABLED
      D.  NEW ENGLAND 1:6 LPBK   =  DISABLED
      E.  LOOPBACK TIMEOUT       =  120 MIN
      F.  CUSTOMER LOSS RESPONSE =  AIS
      G.  LATCHING LOOPBACK MODE =  T1
      *   PRM MODE               =  NONE
      *   DS1 TX LEVEL           =  0 dB




             * Option not configurable from this terminal

     Press:  Option letter - to change option setting
             Enter - to implement and save current setting changes
             “M”   - to return to the main menu
```

Figure 14. Provisioning Screen

```
CIRCUIT ID: xxxx                                             02/01/99
                                                             11:25:05
                             TROUBLESHOOTING DISPLAY
                   _____             _____             _____
                  |HTU-C|           |HRE 1|           |HTU-R|
                  |     |           |     |           |     |
                  |     |           |     |           |     |
              --->|     |<=========>|     |<=========>|     |<---
                  |     |           |     |           |     |
              NET |     |           |     |           |     | CUST
                  |     |           |     |           |     |
              <---|     |<=========>|     |<=========>|     |--->
                  |     |           |     |           |     |
                  |     |           |     |           |     |
                  |_____|           |_____|           |_____|

                               NO ALARM CONDITIONS




                        Press “M” to return to the Main Menu
```

Figure 15. Troubleshooting Display

```
CIRCUIT ID: Circuit XXXXX                                     02/01/99  11:12:52

                              SET TIME/DATE/CIRCUIT ID

                             1) SET TIME
                             2) SET DATE
                             3) SET CIRCUIT ID

               Choose an option by pressing the corresponding number.
                          Press “M” to return to Main Menu.
```

Figure 16. Set Time/Date/Circuit ID Screen

6. HDSL DEPLOYMENT GUIDELINES

The ADTRAN HDSL system is designed to provide DS1-based services over loops designed to comply with Carrier Service Area (CSA) guidelines. CSA deployment guidelines are given below.

1. All loops are non-loaded only.
2. For loops with 26-AWG cable, the maximum loop length including bridged tap lengths is 9 kFt.
3. For loops with 24-AWG cable, the maximum loop length including bridged tap lengths is 12 kFt.
4. Any single bridged tap is limited to 2 kFt.
5. Total bridged tap length is limited to 2.5 kFt.
6. The total length of multi-gauge cable containing 26-AWG cable must not exceed

   $12 - \{(3*L^{26})/9\} - L^{BTAP}$ (in kFt)

   L^{26} = Total length of 26-AWG cable excluding bridged taps (in kFt)

   L^{BTAP} = Total length of all bridged taps (in kFt)

This deployment criteria is summarized in the chart shown in Figure 17.

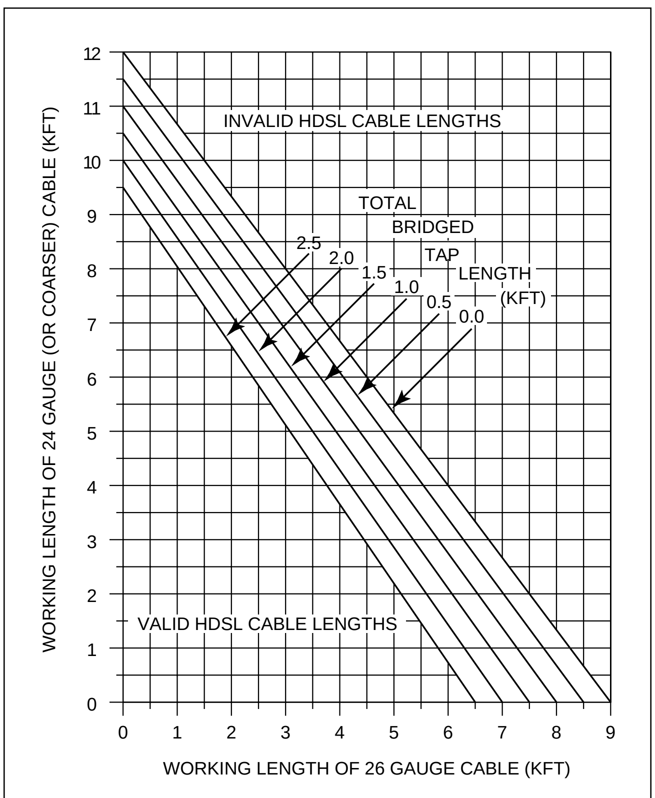


Figure 17. HDSL Deployment Guidelines

Loop loss per kFt for other wire is summarized in Table H.

Table H. HDSL Loss Values

(200 kHz cable loss in dB/Kft at 135Ω)

Cable Gauge	Cable Type	Temperature: 68°	90°	120°
26	PIC	3.902	4.051	4.253
26	Pulp	4.030	4.179	4.381
24	PIC	2.863	2.957	3.083
24	Pulp	3.159	3.257	3.391
22	PIC	2.198	2.255	2.333
22	Pulp	2.483	2.45	2.629
19	PIC	1.551	1.587	1.634
19	Pulp	1.817	1.856	1.909

Recommended maximum local loop loss information for PIC cable at 70°F, 135 Ω, resistive termination is provided in Table I.

Table I. Loop Insertion Loss Data

Frequency (Hz)	Maximum Loss (dB)
3,000	12.0
10,000	15.0
50,000	25.5
100,000	30.0
150,000	32.75
200,000	35.25

An approximation for the maximum amount of wideband noise on an HDSL local loop as measured by a 50 kbps filter is ≤ 31 dBrn.

An approximation for the maximum level of impulse noise as measured using a 50 kbps filter on an HDSL loop is ≤ 50 dBrn.

NOTE: These approximations are to be used as guidelines only and may vary slightly on different loops. Adhering to the guidelines should produce performance in excess of 10^{-7} BER.

7. TROUBLESHOOTING PROCEDURES

Use Table J to troubleshoot the ADTRAN HTU-R.

8. MAINTENANCE

The ADTRAN HTU-R requires no routine maintenance. In case of equipment malfunction, use the faceplate Bantam jack connector to help locate the source of the problem.

ADTRAN does not recommend that repairs be performed in the field. Repair services may be obtained by returning the defective unit to the ADTRAN Customer Service RMA Department.

9. PRODUCT SPECIFICATIONS

Table K lists the HTU-R specifications.

10. WARRANTY AND CUSTOMER SERVICE

ADTRAN will replace or repair this product within ten years from the date of shipment if it does not meet its published specifications or fails while in service.

For detailed warranty, repair, and return information refer to the ADTRAN Equipment Warranty, Repair, and Return Policy and Procedure.

Return Material Authorization is required prior to returning equipment to ADTRAN.

For service, RMA requests, or further information, contact one of the following numbers:

ADTRAN Customer Service

ADTRAN Telco Technical Support. (800) 726-8663
Standard support hours .... Monday-Friday
7 a.m. - 7 p.m. CST
Emergency support: .... 7 days/week, 24 hours/day

Sales .... (800) 827-0807

Customer and Product Support
(CAPS) .... (256) 963-8722

Repair and Return Address

ADTRAN, Inc.
Customer and Product Support (CAPS)
901 Explorer Boulevard
Huntsville, Alabama 35806-2807

Table J. Troubleshooting Guide

Condition	Solution
All front panel indicators are *Off*.	1. Make sure the HTU-R is properly seated in the housing. 2. Verify that the HTU-C is delivering sufficient simplex voltage to the loops, if line powered. The HTU-C should apply approximately -130 VDC between loops on point-to-point circuits or with only one HRE. Circuits with two HREs will apply a voltage of approximately -190 VDC between the loops. A minimum of approximately 65 V should be present between the HDSL loops at the HTU-R. 3. If steps 1 and 2 pass, replace the HTU-R.
Power is present and adequate, but loop sync is not available (LP1 and/or LP2 LEDs are *Off*).	1. Verify that the loop conforms with CSA guidelines (not too long, etc.). 2. Verify that the tip and ring of each HDSL loop belong to the same twisted pair. 3. Verify that loop loss at 200 kHz is not greater than 35.25 dB. 4. Verify that noise on both HDSL loops is within acceptable limits (see subsection 5). 5. If steps 1 through 4 pass and loop sync is still not available, replace the unit with one known to be in proper working condition.

Table K. ADTRAN T400 Low Voltage HTU-R Specifications

Loop Interface

Modulation Type	2B1Q
Mode	Full Duplex, Echo Cancelling
Number of Pairs	Two
Bit Rate	784 kbps per pair
Baud Rate	392K baud per pair
Service Range	Defined by Carrier Service Area Guidelines
Loop Loss	36 dB maximum @ 200 kHz
Bridged Taps	Single Taps < 2 kFt, Total Taps < 2.5 kFt
Performance	Compliant with Bellcore TA-NWT-001210
Return Loss	20 dB (40 kHz to 200 kHz)
HDSL Tx Signal Level	13.5 dBm
Input Impedance	135 Ω
DS1 Channelization	Channels 1-12 on HDSL Loop 1, Channels 13-24 on HDSL Loop 2

Customer Interface

4-wire DS1 (T1.403-compatible) (ITU-T I.431 compliant)

DS1 Signal Output Level	0 or -15 dB
DS1 Input Signal Level	0 to -22.5 dB
DS1 Line Coding	AMI, B8ZS
DS1 Framing Format	SF, ESF, Unframed

Power

Span-powered by HTU-C or locally powered via -48 VDC

Clock Sources

Clock Sources	Internal, HDSL Loop Derived
Internal Clock Accuracy	± 25 ppm (exceeds Stratum 4). Meets T1.101 timing requirements.

Tests

Diagnostics	Loopback (HTU-R), initiated with HDSL in-band codes, initiated with T1 NIU in-band codes, initiated with HTU-C command, initiated manually, HTU-R control port. Self-Test.

Physical

Dimensions	1.4" High, 5.5" Wide, 6.0" Deep
Weight	< 1 pound

Environment

Temperature	Operating (Standard)	-40°C to +70°C
	Storage	-40°C to +85°C
Relative Humidity	Up to 95% non-condensing	

Part Number

HTU-R T400 Circuit Pack	1245024L1

Appendix A
HDSL LOOPBACKS

This Appendix describes the use and operation of loopback control code sequences used in ADTRAN's HDSL system. Loopback control codes are governed by the HTU-C (and HRE[s] if deployed). Two types of HTU-Cs exist which enable two different sets of loopback codes -- Standard or Enhanced loopbacks. The Standard loopbacks are those that have been contained in ADTRAN's HDSL product family beginning with 2nd Generation products. The Enhanced loopbacks are contained in selected ADTRAN HTU-C units. The following denotes whether the HTU-C (part number) contains Standard or Enhanced loopback capabilities.

Standard Loopback

Part Number	Description
1242002LX	220/E220 HTU-C
1242016L1	3192 HTU-C
1242023L1	DDM+ HTU-C
1244001L1	E220/220 Low Voltage T1 HTU-C
1244002L1 - L3	Litespan AHDSL
1244002L4 - L6	Litespan AHT1U
1245001L1	E220/220 Low Voltage 5th GEN HTU-C
1245001L2	E220/220 HTU-C M
1245003L1	DDM+ 5th GEN HTU-C
1245004L1	3192 5th GEN HTU-C

Enhanced Loopback

Part Number	Description
1245001L6-L8	E220/220 HTU-C M R
1245003L6-L8	DDM+ HTU-C M R
1245004L7-L8	3192 HTU-C M R
1245002L2-L8	Litespan HTU-C

The loopback capabilities of both the HRE and HTU-R are controlled from the central office unit (HTU-C).

NOTE: If the HTU-C on a circuit contains Standard loopbacks, then refer to subsection 1 of this Appendix to determine its capabilities. If the HTU-C on a circuit contains Enhanced loopbacks, then refer to subsection 2 of this Appendix to determine its loopback capabilities.

---

1. STANDARD LOOPBACKS

This subsection describes operation of the HDSL system in detection of in-band and ESF facility data link loopback codes. The operation of the loopback commands in the ADTRAN HDSL system is compliant with the recommendation to ANSI recorded in T1E1.4/92. The HDSL network loopback points described below are illustrated in Figures A-1 and A-2.

HTU-C loopback is a regenerative loopback of the DSX-1 signal toward the network.

HTU-R loopback is a regenerative loopback of the DS1 signal toward the network. This loopback is in addition to a separate Smartjack loopback. Separate activation sequences are provided for the HTU-R and the Smartjack loopback initiation. The HDSL loopbacks are implemented such that the downstream HDSL elements (toward the customer) remain synchronized.

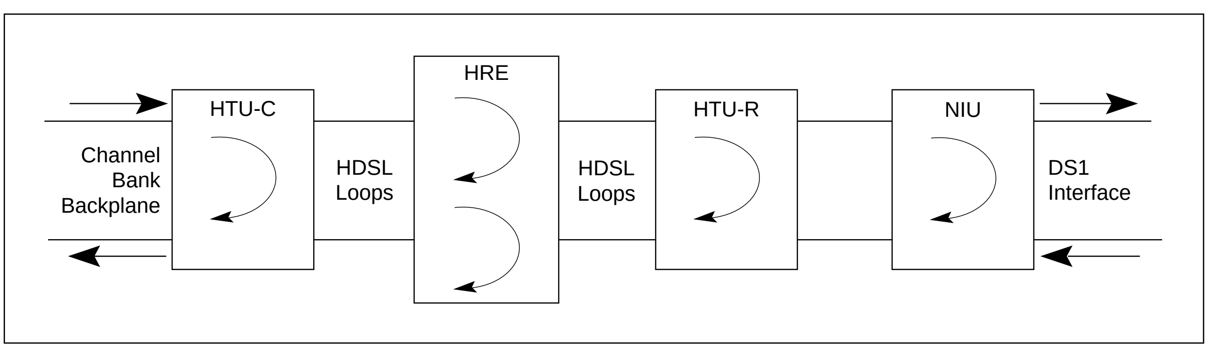


Figure A-1. HDSL Loopback Points

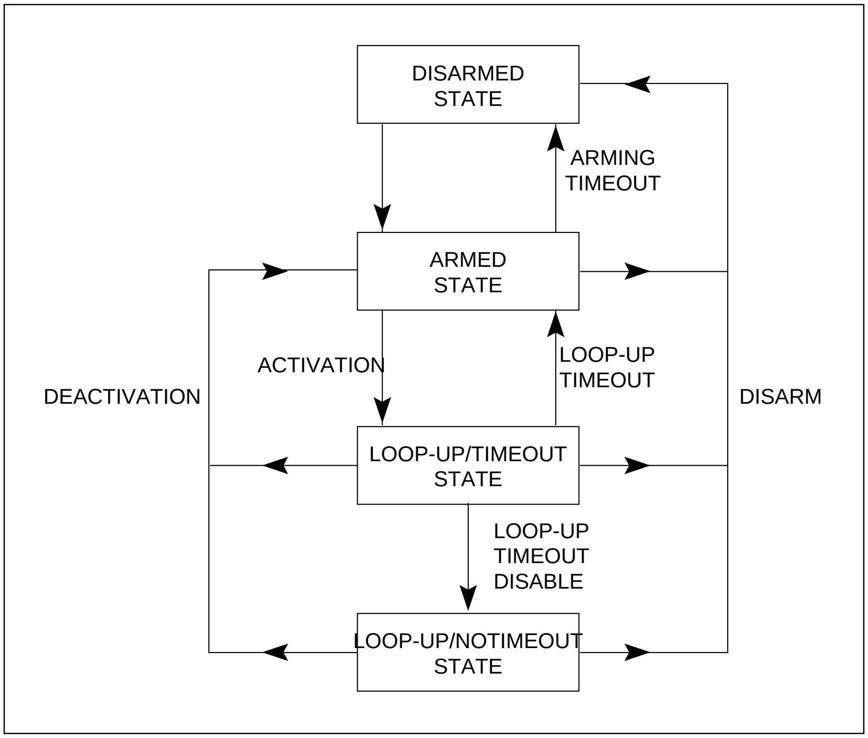


Figure A-2. HDSL Element State Diagram

Upon deactivation of a loopback, the HDSL system will synchronize automatically. It should be noted that the synchronization process of the HDSL system upon deactivation of the HRE loopback, could take up to 15 seconds to ensure all system elements are synchronized.

Loopback Process

In general, the loopback process for the HDSL system elements is modeled on the corresponding DS1 system process. Specifically, the HTU-C loopback is similar to an intelligent office repeater loopback and the HTU-R loopbacks are similar to an inline T1 repeater loopback.

Each HDSL system element is independently described by the state diagram shown in Figure A-2. The four states are disarmed, loop-up, armed, and loop-up/timeout-disable.

State transitions result from in-band, ESF data link sequences, and timeout operations. The sequences and timeouts are as follows:

- Arming (in-band and ESF)
- Activation
- Deactivation
- Disarming (in-band and ESF)
- Loop-up Timeout
- Arming Timeout

A summary of timeout and control sequences is given in Table A-2.

In-band control code sequences are transmitted over the DS1 link by either the unframed or overwrite method. The HDSL elements respond to either method.

The unframed method produces periodic control sequences, and the normal DS1 framing bit is omitted.

The overwrite method produces periodic control sequences. However, once per frame, the framing bit overwrites one of the bits in the control sequence.

The unit can detect the loopback activation or deactivation code sequence *only* if an error rate of $1E^{-03}$ or better is present.

NOTE: In all control code sequences presented, the in-band codes are shown leftmost bit transmitted first, and the ESF data link codes with rightmost bit transmitted first.

Table A-1. HDSL Standard Loopback Control Codes

Name	Code	Detection Time	Comments
Arming (In-band) Arming (ESF)	11000 0001 0010 1111 1111	5 Seconds 4 Repetitions	Signal sent in-band or over ESF data link. HDSL elements in disarmed state make transition to armed state. Detection of either code results in Smartjack loop-up, if NIU loopback is enabled.
Activation (HTU-C) Activation (HRE) Activation (HTU-R)	1101 0011 1101 0011 1100 0111 0100 0001 1100 0111 0100 0010	> 4 Seconds > 4 Seconds > 4 Seconds	Signal sent in-band. HDSL elements in armed state make transition to loop-up state. Loop-up state timeout is programmable from the HTU-C.
Deactivation (all HDSL elements)	1001 0011 1001 0011	> 5 Seconds	Signal sent in-band. HDSL element in loop-up state makes transition to armed state.
Disarming (In-band) Disarming (ESF)	11100 0010 0100 1111 1111	5 Seconds 4 Repetitions	Signal sent in-band or over ESF data link. HDSL elements in any state make transition.
Arming Timeout	N/A	2 Hours	HDSL elements in armed state make transition to disarmed state.
Loop-up Timeout	N/A	Programmable from HTU-C: None, 20, 60, or 120 minutes	HDSL element in loop-up makes transition to armed state.

Disarmed State

The disarmed state is the normal mode of operation. Each HDSL element is transparent to the data flow. However, the in-band data flow and the ESF data link are monitored for the arming sequence.

The in-band control code sequence used to simultaneously arm the loopback capability of all HDSL elements is the standard 5-bit in-band sequence used for NIU Smartjack loop-up. Each HDSL element arms after receiving the following code for five seconds:

ARM SEQUENCE .... 11000 for five seconds

The arming process ensures unambiguous race-free operation of HDSL element arming and Smartjack loop-up. The HDSL unit can detect the sequence without interfering with the detection by the Smartjack. Presently, the Smartjack loop-up response requires a duration of at least five seconds. The objective of the HDSL detection scheme is to arm the HDSL elements without interfering with the Smartjack loop-up.

The requirement imposed on the arm sequence is that the Smartjack should loop-up and all HDSL elements make a transition from the disarmed state into the armed state. All other control code sequences are ignored in the disarmed state.

The ESF data link sequence used to simultaneously arm the loopback capability of all HDSL elements is the standard 16-bit ESF data link sequence used for NIU Smartjack loop-up.

ESF ARM SEQUENCE . 0001 0010 1111 1111
for four repetitions

Race-free operations of the HDSL element arming and Smartjack loop-up is accomplished as described for the in-band code. For example, the ESF arm sequence causes the Smartjack to loop-up and all of the HDSL elements to move from the disarmed state into the armed state. All other ESF data link control code sequences are ignored in the disarmed sate.

Armed State

In the armed state, the HDSL system element continues to be transparent to data flow. However, the in-band data flow is monitored for the activation and disarming sequences. The ESF data link is monitored for the disarming sequence.

All other in-band and ESF data link control code sequences are ignored in the armed state. An arming timeout value causes automatic return to the disarmed state.

Transition from armed to loop-up state: An in-band control code sequence is used to command a specific HDSL element to move from the armed state into the loop-up state. Each HDSL element has a unique 16-bit activation control code sequence as shown in the following example:

HTU-C ACTIVATION
SEQUENCE 101 0011 1101 0011

HTU-R ACTIVATION
SEQUENCE 1100 0111 0100 0010

The designated HDSL element will loop-up after receiving the proper activation sequence.

Transition from armed to disarmed state: All HDSL elements can be commanded to move from the armed state into the disarmed state by the standard 5-bit in-band disarming sequence used for NIU Smartjack loop-down. Each HDSL element must disarm after receiving the following code for five seconds:

DISARM SEQUENCE ... 11100

The disarming process ensures race-free operation of HDSL element disarming and Smartjack loop-down. Duration of the disarm sequence may need to exceed 24 seconds to allow detection and loop-down of up to three HDSL elements and the Smartjack.

All HDSL elements can be commanded to move from the armed state into the disarmed state by the ESF DATA LINK disarming sequence used for NIU Smartjack loop-down as follows:

ESF DISARM
SEQUENCE ...... 0010 0100 1111 1111 for four repetitions per element in loopback

The disarming process ensures race-free operation of HDSL element disarming and Smartjack loop-down. Duration of the disarm sequence may need to exceed 16 repetitions to allow detections and loop-down of up to three HDSL elements and the Smartjack. This sequence will loop-down the Smartjack and the HDSL element.

All HDSL elements will automatically move from the armed state into the disarmed state when a default timeout value of two hours is reached.

ARMING TIMEOUT ....2 Hours

Loop-up State

In the loop-up state, the selected HDSL element provides continuous loop-up of the DS1 signal. However, the data flow is monitored for the in-band deactivation sequence, the in-band disarming sequence, and the ESF data link disarming sequence. Also, a loop-up timeout value causes automatic return to the armed state. All other control code sequences are ignored in the loop-up state.

Transition from loop-up to armed state: Any HDSL element can be commanded to move from the loop-up state into the armed state by a single in-band 16-bit deactivate control code sequence. The same deactivation sequence as shown is used for all HDSL elements.

DEACTIVATION AFTER RECEIVING
SEQUENCE .... for > 5 seconds

Duration of the deactivation sequence may need to exceed 18 seconds to allow detection and loop-down of up to three HDSL elements. The deactivation sequence does not disarm the HDSL elements. They can still respond to activation sequence control codes. All HDSL elements automatically move from the loop-up state into the armed state when the selected loop-up timeout value is reached.

LOOP-UP TIMEOUT programmable from HTU-C at None, 20, 60, or 120 minutes

Transition from loop-up to disarmed state: All HDSL elements can be simultaneously commanded to move from the loop-up state into the disarmed state by either the standard 5-bit in-band disarming sequence used for NIU Smartjack loop-down, or by the ESF DATA LINK command, as previously described.

2. ENHANCED LOOPBACKS

HDSL Maintenance Modes

This subsection describes operation of the HDSL system with regard to detection of in-band and ESF facility data link loopback codes.

Upon deactivation of a loopback, the HDSL system will synchronize automatically. Note that the synchronization process of the HDSL system upon deactivation of the HRE loopback could take up to 15 seconds, ensuring all system elements are synchronized.

Loopback Process Description

In general, the loopback process for the HDSL system elements is modeled on the corresponding DS1 system process. Specifically, the HTU-C loopback is similar to an Intelligent Office Repeater loopback and the HTU-R loopbacks are similar to an in-line T1 Repeater loopback.

In-band control code sequences are transmitted over the DS1 link by either the *unframed* or *overwrite* method. The HDSL elements respond to either method.

The unframed method produces periodic control sequences and the normal DS1 framing bit is omitted.

The overwrite method produces periodic control sequences. However, once per frame, the framing bit overwrites one of the bits in the control sequence.

The unit can detect the loopback activation or deactivation code sequence *only* if an error rate of $1E^{-03}$ or better is present.

DDS Latching Loopback Operation

If the unit is optioned for FT1 mode, then DDS Latching Loopback operation is supported as described in Bellcore TA-TSY-000077, Issue 3, Section 5.1.3. The HTU-C and any HRE units which are in the HDSL circuit are treated as Identical Tandem Dataports and the HTU-R is treated as a Different Tandem Dataport. For a complete description of the DDS Latching Loopback codes, refer to Bellcore TA-TSY-000077, Issue 3, Section 5.1.3.

Loopback Control Codes

A summary of control sequences is given in Tables A-2 and A-3.

NOTE: In all control code sequences presented, the in-band codes are shown left-most bit transmitted first, and the ESF data link codes with right-most bit transmitted first.

Table A-2. HDSL Loopback Control Codes

Type	Source	Code	Name
Abbreviated	(N)	3in7 (1110000)	Loopback data from network toward network in the HTUR.
	(N)	4in7 (1111000)	Loopback data from network toward network in the HTUC.
	(N)	2in6 (110000)	Loopback data from network toward network in first HRE.
	(N)	3in6 (111000)	Loopback data from network toward network in second HRE.
	(C)	6in7 (1111110)	Loopback data from customer toward customer in HTUC.
	(C)	5in7 (1111100)	Loopback data from customer toward customer in HTUR.
	(C)	4in6 (111100)	Loopback data from customer toward customer in first HRE.
	(C)	5in6 (111110)	Loopback data from customer toward customer in second HRE.
	(N)	FF1E	Loopback data from network toward network at HTUC.
Wescom	(C)	3F1E	Loopback data from customer toward customer at HTUC.
	(N)	FF04	Loopback data from network toward network at HRE1.
	(N)	FF06	Loopback data from network toward network at HRE2.
	(C)	3F04	Loopback data from customer toward customer at HRE1.
	(C)	3F06	Loopback data from customer toward customer at HRE2.
	(N)	FF02	Loopback data from network toward network at HTUR.
	(C)	3F02	Loopback data from customer toward customer at HTUR
	(N)	1in6 (100000)	Loopback data from network toward network at HTUR.
	(N)	FF48 (ESF-DL)	Loopback data from network toward network at HTUR.
	(N/C)	1in3 (100)	Loopdown everything.
	(N/C)	FF24 (ESF-DL)	Loopdown everything.

The Source column indicates which side of the interface the control codes are sent from. For example, an (N) indicates a network sourced code while a (C) indicates a customer sourced code.
All codes are inband unless labeled ESF-DL
All codes listed above must be sent for a minimum of 5 seconds in order for them to be detected and acted upon.

Table A-3. Inband Addressable Loopback Codes

Function	Code and Response
Arm	11000 (also known as a 2-in-5 pattern) The HTU-R will loop up towards the network. No AIS or errors will be sent as a result of this loopback. The HTU-C and HRE will arm.
Disarm	11100 (also known as a 3-in-5 pattern) The HTU-C and HRE are removed from the armed state. If any of the units are in loopback when the 11100 pattern is received, they will loop down. The LBK LEDs will turn *off* on all units.
HTU-C Network Loop-up	D3D3 (1101 0011 1101 0011) If the units have been armed and no units are in loopback*, the HTU-C will loopup towards the network, 2 seconds of AIS (all 1s) will be sent, 5 seconds of data will pass, and 231 bit errors will be injected into the DSX-1 signal. As long as the pattern continues to be sent, 231 errors will be injected every 20 seconds. When the pattern is removed, the unit will remain in loopback. If the pattern is reinstated, the injection of 231 bit errors will resume at 20-second intervals.
HRE Network Loop-up	C741 (1100 0111 0100 0001) If an HRE is present, the units have been armed, the HRE will loopup towards the network, 2 seconds of AIS (all 1s) will be sent, 5 seconds of data will pass, and 10 bit errors will be injected into the DSX-1 signal. As long as the pattern continues to be sent, 10 errors will be injected every 20 seconds. When the pattern is removed, the unit will remain in loopback. If the pattern is reinstated, the injection of 10 bit errors will resume at 20-second intervals.
HRE2 Network Loop-up	C754 (1100 0111 0101 0100) If a second HRE is present, the units have been armed, the HRE will loop up towards the network, 2 seconds of AIS (all 1s) will be sent, 5 seconds of data will pass, and 200 bit errors will be injected into the DSX-1 signal. As long as the pattern continues to be sent, 200 errors will be injected every 20 seconds. When the pattern is removed, the unit will remain in loopback. If the pattern is reinstated, the injection of 200 bit errors will resume at 20-second intervals.
Loopdown	9393 (1001 0011 1001 0011) Any HTU-C and HRE units currently in loopback towards the network will loopdown and will retain the armed state.
Query Loopback	D5D5 (1101 0101 1101 0101) If the units are armed and the HTU-C, HRE, or HTU-R are in network loopback, errors are injected into the DSX-1 signal upon detection of the query loopback pattern. As long as the pattern continues to be sent, errors are injected again every 20 seconds. The number of errors injected each time depends on which unit is in loopback. If the HTU-C is in network loopback, 231 errors are injected, 20 at a time if the HTU-R is in network loopback, 10 at a time if HRE #1 is in network loopback, and 200 at a time if HRE #2 is in network loopback.
Loopback Timeout Override	D5D6 (1101 0101 1101 0110) If the units are armed and this pattern is sent, the loopback timeout will be disabled. The timeout option will be updated on the Provisioning menu of the HTU-R (viewable through the RS-232 port) to None. As long as the units remain armed, the timeout will remain disabled. When the units are disarmed, the loopback timeout will return to the value it had before the D5D6 code was sent.
Span Power Disable	6767 (0110 0111 0110 0111) If the units are armed and this pattern is sent, the HTU-C will deactivate its span power supply, turning off the HTU-R and HRE (if present). As long as the pattern continues to be sent, the span power supply will remain disabled. When the pattern is no longer being sent, the HTU-C will reactivate its span power supply, turning the remote unit(s) on. All units will retrain and return to the disarmed and unlooped state.

Note: All codes listed above must be sent for a minimum of 5 seconds in order for them to be detected and acted upon.
* If NIU is enabled, then the HTU-R can be in network loopback when the HTU-C or HRE loopup codes are sent.