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High Bit Rate Digital Subscriber Line (HDSL) Testing and Maintenance Practice

Produced by Project 422241, Digital Network Transition Engineering - Transmission, part of the End-to-End Transmission, Synchronization, and Performance Product.

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1. General

1.1 This practice provides the testing and maintenance guidelines applicable to High-bit-rate Digital Subscriber Line (HDSL) deployments. HDSL is used to providing high-capacity digital service at DS1 line rates. This practice is intended primarily for use by testing and maintenance craft. The corresponding engineering design and implementation procedures are covered in BR 880-601-200[3]

1.2 The remainder of this section provides a general description of an HDSL system.

1.3 HDSL is a transport technology that uses two copper pairs to provide point-to-point, full-duplex transmission of digital data at the DS1 payload rate of 1.536 Mb/s. The HDSL loop architecture is composed of two pair of full-duplex (bi-directional) loops. Each pair operates bi-directionally at a rate of 784 Kbps using 2B1Q line coding. This 784 Kbps data stream on each pair is composed of 768 Kbps payload (12 DS0 channels), 8 Kbps DS1 framing and 8 Kbps of HDSL overhead.

1.4 HDSL is intended to transport a DS1 service at a range of up to 12 kft[1] over two pairs of wire without the need for intermediate repeaters, loop conditioning, or pair separation. Several bridged taps are allowed as long as the total length of bridged tap does not exceed 2.5 Kft, and no single bridged tap exceeds 2 Kft. The HDSL multi-level signal coding, echo cancellation, and full-duplex transmission allows HDSL systems to tolerate existing bridged taps and to operate on any loop designed to Carrier Serving Area (CSA) criteria. HDSL technology can be used to extend DS1 services out of a loop fiber hub to any point within the subtending CSA. Since existing cable is used, there is no need to build T1 spans or fiber facilities to sites that presently lack them.

1.5 HDSL may be used to transport all services requiring digital capacities up to the DS1 rate. Such services include:

1. Transport for Private DS1 lines
2. Transport for DS1 switched service or ISDN Primary Rate Access (PRA)
3. Transport for Digital Loop Carrier (DLC) trunks
4. Transport for High Bit Rate Universal Digital Channel (UDC)
5. Transport for Video services that are compressed into a 1.536 Mbps bandwidth
6. Provide access for Local Area Network (LAN) interconnections
7. Provide Access for Switched Multi-megabit Data Service (SMDS)
8. Provide Access for Switched Fractional DS1 (SWF-DS1), a dialable, public, circuit switched service that provides digital connections from 128 kbps to 1.536 Mbps in 64 kbps increments.

1.1 System Components

1.6 An HDSL system consists of two transceivers, an HDSL central office transmission unit (HTU-C), an HDSL remote termination transmission unit (HTU-R), and the metallic pairs used to connect

1. The 12 Kft range requires the use of 24 gauge pairs. If 26 gauge pairs are used, the limit is 9 Kft. Non-loaded loops of up to 24 Kft may be used for HDSL when HDSL repeaters become available.

the transceivers. These components are illustrated in Figure 1.1, and described below.

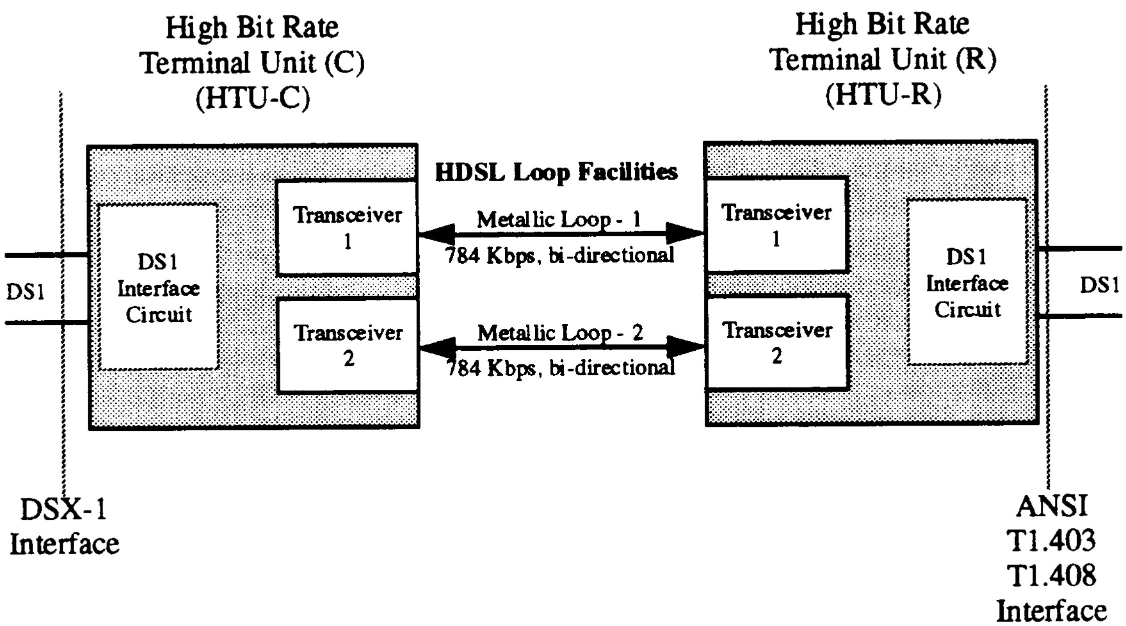

Figure 1.1 High Bit Rate Digital Subscriber Line (HDSL) System

- HTU-C
  This terminal unit is located at the Central Office (CO) end of the HDSL system and is connected to the HTU-R via two metallic pairs on the distribution (field) side of the HTU-C. On the network (switch) side, the HTU-C is connected to the internal CO network at a standard Digital Signal Cross-connect 1 (DSX-1) frame.
- HTU-R
  This terminal unit is located at the customer end of the HDSL system and is connected to the HTU-C via two metallic pairs on its CO or network side. On its customer side, the HTU-R provides interfaces that comply with ANSI T1.403-1989, ANSI T1.408-1990 and TR-TSY-000754. The HTU-R can be optioned to provide either (1) Internal Network Interface Unit (NIU, also known as a smartjack) functionality, or (2) an output that connects to an external NIU.

- HDSL Loop Facility
The HTU-C and HTU-R are connected by a pair of non-loaded twisted wire pairs. These pairs conform to the Carrier Serving Area (CSA) design guidelines (additional information on CSA guidelines is contained in IL 85/08-067[5] and in BR 880-601-200[3]) and can transport customer data at rates up to 1.536 Mbps. This requires a transmission rate of 768 kbps in each direction, on each pair[2]. With additional overhead needed for signaling and control of the HDSL system the transmission rate on each pair will be 784 kbps.HDSL equipment can automatically compensate for tip-ring polarity reversal and reversal of the dual-duplex pairs.

2. Testing and Maintenance

2.1 Many of the testing and maintenance functions for an HDSL system are controlled via a craft terminal attached to a serial port at the HTU-C. It is important that all maintenance personnel dispatched to handle HDSL troubles be provided with such a terminal. If this is not done they may be unable to perform many of the testing and maintenance procedures necessary to diagnose HDSL troubles.

2.2 Typical terminal setup characteristics are 1200-9600 baud, 8 data bits, 1 stop bit and no parity. The terminal should be attached and the SPACE bar or RETURN key should be hit several times until a connection is made. 'Dumb' terminal software may be used to communicate with the HTU-C, although supplier-provided terminal software may provide additional useful capabilities.

2.1 Installation Troubleshooting

2.3 When an HDSL systems first receives power, or when it fails to receive a valid HDSL signal, the system will enter a self-test mode. Results of these tests can be obtained using an attached craft maintenance terminal, see Section 2. On some suppliers' systems the results can be displayed via indicators on the HTU-C and HTU-R.

2.4 HDSL self-test result codes remain supplier-specific. A supplier-provided information sheet detailing the meanings of these codes must be available for interpretations of these codes.

2.2 HTU-C

2.5 The remainder of Section 2.2 contains information on troubleshooting and performing diagnostics at the HTU-C.

2.2.1 Setting Parameters at the HTU-C

2.6 A number of configuration parameters must be provisioned at the HTU-C in order for the HDSL system to function properly. These parameters may be set using an attached terminal, see Section 2, or on some units they may be set using supplier-identified dip switches or push buttons.

2.7 The HTU-C and HTU-R may contain non-volatile RAM to store system options settings.

2. This differs from repeatered T1 transmission, which uses separate transmit and receive pairs to send 1.536 Mbps in one direction on each of the pairs.

Therefore, factory 'defaults' will not be reset by unplugging the card from the shelf. To reset factory defaults, or to reconfigure the HTU-C and HTU-R, a terminal should be used.

2.8 Work order documentation for installation and maintenance should clearly indicate all configuration parameters that must be set for a particular HTU-C installation. Typical parameters that must be set are shown in Table 2.1.

Table 2.1: HTU-C Options to be Provisioned at Installation Time .

Setting	Function
Smart Jack Loopback Mode	Allows enabling or disabling NIU (smart jack) loop back codes "11000" and "11100". These codes should be disabled if an external NIU is used.
HTU-R powering	Determines whether the HTU-C will provide power to the HTU-R. Power is disabled if the HTU-R is locally powered, or power may be disabled to safely perform maintenance of the HDSL pairs.
ESF ZBTSI Setting	When ESF framing is used, this tells the HDSL system whether it is operating in ZBTSI mode or not.
Errored Seconds Alarm Closure	Set to determine the number of errored seconds that must occur in a 24-hour period before an alarm closure is activated due to excessive errors.
Loopback Time-out	Causes the HDSL system to return to a non-loopback state after a specified period of time.
Alarm Disabling	Can be set to allow disabling or retiring of an existing alarm condition, and prevents other alarms from occurring.
Line coding	May be set to B8ZS, AMI, or automatic detection of the line coding being used.
Framing Mode	Can be set to allow automatic detection of either SF or ESF framing or may be set to unframed mode.
Equalization	If the mounting shelf used is equipped with plug-in or rear-mount pre-equalizers the equalization setting of the HTU-C should be set to external. Otherwise the equalization setting is set according to the distance between the HTU-C and the DSX-1. HDSL systems typically have equalization settings that cover distance ranges of up to 655 feet.

2.2.2 Problems Observed at the HTU-C

2.9 This section discusses HDSL power and synchronization problems that may be observed at the HTU-C.

2.2.2.1 No Power Observed at the HTU-C

2.10 The following steps should be followed if no power is observed at the HTU-C:

1. Verify that the shelf has -48 v power connected to it.
2. Verify that the HTU-C does not have a blown fuse.
3. Insert the HTU-C into another shelf slot and test for proper power response.
4. The HTU-C may be bad. Test using another HTU-C.

2.2.2.2 Power O.K. But HTU-C indicates Power Feed is Open

2.11 The following apply when the HTU-C provides an indication that the power feed to the HTU-R is open:

1. The HTU-R may not be connected. Test for the presence of the HTU-R by measuring the DC resistance across each of the HDSL pairs connected to the HTU-R. Inputs to the HTU-R have a resistance of approximately 180 KΩ
2. Verify that neither of the HDSL cable pairs are open by performing a resistance test across the two wires of a pair. If Resistance is much greater than 180 KΩ, than the pairs may be open.
3. The HTU-C may be bad, test using another HTU-C.

2.2.2.3 HTU-C Power is O.K., but HTU-C indicates that HTU-R Power Feed is Off

2.12 If the HTU-C provides this indication, the following applies:

1. Possible short between cable pairs, verify that no short is present. This may be done by performing a resistance test across the wires of each pair. The measured resistance should be approximately 180 KΩ

2.2.2.4 Power is O.K. but Synchronization is Not Achieved

2.13 If the HTU-C indicates that the power feed to the HTU-R is operating properly (i.e., the remote unit is present and is drawing the correct amount of current, but synchronization of the HDSL system is not achieved, the following applies:

1. Split Pairs - Verify that the voltage measured from T1 to R1 and from T2 to R2 of the two HDSL pairs at the HTU-R HDSL interface is zero[3]. Presence of voltage across the pairs indicates that the pairs are split (although tip/ring of a pair may be interchanged, they can not be interchanged across pairs).
2. Loop Too Long - Verify that the loop complies to the CSA guidelines. If possible, measure the loop loss and verify that it does not exceed the maximum allowable insertion loss of 35 dB at 196 kHz with a 135 Ω termination. If provided by the HDSL system, an Insertion Loss Measurement Test (ILMT) can be used to confirm that the loop parameters conform to CSA guidelines, See Section 2.4.2 for additional information in the ILMT.

3. Power is carried to the HTU-R across the HDSL pairs by placing a negative potential across both wires of one of the loops, and a ground potential across both wires of the other loop. Therefore, there should be no measurable voltage across the T (tip) and R (ring) wires of a given loop.

3. Loop Too Noisy - Verify that the noise levels on both HDSL loops are within normal limits for voice frequency circuits.
4. Loops are Unbalanced - Verify that both HDSL loops are properly balanced to ground.
5. Insufficient Line Power - Confirm that the HDSL DC span voltages and currents are within the limits stated in Table 2.2, "HDSL Loop Voltage- and Current Measurements," on page 12.
6. The HTU-C may be bad, test using another HTU-C.

2.3 HTU-R

2.14 This section discusses HDSL power and synchronization problems that may be observed at the HTU-R.

2.3.1 Problems Observed at the HTU-R

2.3.1.1 No Power Observed at the HTU-R

2.15 If the HTU-R is not receiving power, the following steps apply:

1. Check that the HTU-C is connected. When connected, the HTU-C will apply a 130 volt D.C. pulse across the HDSL pairs every 15 second until an HTU-R is detected. Confirm that the HTU-C is connected by checking for the presence of this voltage pulse. The measurement should be made with the (+) lead of the voltmeter connected to HDSL Loop 1 and the (-) lead connected to HDSL Loop 2. Note that HDSL pairs are T & R reversible, and that HTU-C Loop 1 may also be connected to HTU-R Loop 2 and vice versa.
2. HDSL system may be configured to only power the HTU-R from the remote site; if so, ensure that the remote site power supply is functioning, or reconfigure the HDSL system so that the HTU-C provides simplexed power to the HTU-R.
3. The wiring of the HTU-R mount may be bad. To test for this, repeat step #1 at the HTU-R card edge connector.
4. HTU-R may be bad, swap HTU-R for another unit and re-test the HDSL system.

2.3.1.2 Power OK at HTU-R, But the HTU-R does not obtain synchronization.

1. Ensure that the pairs are not split. To power the HTU-R, the HTU-C places ground potential on T&R of one loop, and negative potential on T&R of the other loop. The powering voltage should only be measurable from one pair to another, i.e.; the voltage should be measurable from T1 to T2 and from T1 to R2, but not from T1 to R1. If there is a measurable voltage (approximately 130 volts) from T1 to R1, or from T2 to R2, then the pairs are split.
2. Loop length may be exceeded. Verify that the loop complies to the CSA guidelines. If possible measure the loop loss at 196 kHz and verify that it does not exceed the nominal maximum allowable loop loss of 35 dB

3. Loop may be too noisy. Verify that the noise levels on both HDSL loops are within normal limits for voice frequency circuits
4. Loops may be unbalanced. Verify that both HDSL loops are properly balanced to ground
5. HTU-R may be bad, swap HTU-R for another unit and re-test the HDSL system.

2.3.1.3 Inadequate (low) Simplex Current to external NIU

1. Reconfigure the NIU for "Loop Power" instead of "Thru-Power" powering. Consult the NIU supplier's practice for details on how to reconfigure the NIU.

2.4 HDSL Loop (Metallic Line) Testing

2.16 The electrical signals sent over the HDSL pairs are different than those used for transmission for traditional T1 systems. Because of this, T1 fault location procedures and test equipment designed to locate T1 repeater faults can not be used for HDSL systems.

2.17 HDSL equipment can automatically compensate for tip-ring polarity reversal and reversal of the dual-duplex pairs. However, as discussed above, pairs can not be "split".

2.18 For metallic testing, the HTU-R should be in "Quiet Mode". Quite Mode prevents the HTU-R from attempting start-up and transmission.

2.19 Each HDSL loop should have less than 35 dB of loss at 196 kHz, with 135 ohm driving and terminating impedances.

2.20 The DC cable resistance is used to determine the simplex powering resistance path of the loops. Check suppliers' literature for maximum number of ohms of power loop D.C. resistance.

2.21 Loss from HTU-R to the Channel Service Unit (CSU) can be up to 22.5 dB at 772 kHz, with 130 ohm driving and terminating impedances. Note that T1 design conditions apply between the HTU-R and the CSU.

2.22 If the above loop characteristics change significantly, there can be a long time delay for units to re-acquire synchronization and to re-set margins[4]. CAUTION: significant differences in the ability of the units to re-acquire sync and adjust for changed loop characteristics have been observed even between units from the same supplier.

2.23 A display of the near-end cross-talk (NEXT) may be available at the HTU-C, or via the supplier-provided craft terminal. This value should indicate at least a 6 dB margin on each loop. If the margin is less than 6 dB it indicates that the loop is too long or that bridged tap or crosstalk impairments are too severe for long term reliable operation. CAUTION: Users have reported chronic bit-error conditions at the DS-1 rate on loops with NEXT margins of less than 10 dB. Therefore, for long-term reliable operation, it is recommended that the NEXT margin be at least 10 dB. Loops with margins between 6 dB and 10 dB should be avoided, and those with margins below 6dB must be avoided.

4. Delays of up to 5 minutes have been observed during testing of some HDSL systems.

2.4.1 Testing of Loop Voltages and Current

2.24 Test jacks may be provided at the HTU-C to allow monitor access to the voltage and current simplexed to the HTU-R. Table 2.2 indicates accessible measurements and acceptable values for those measurements[5].

Table 2.2: HDSL Loop Voltage- and Current Measurements

Measurement	Value
+V	Voltage measurement from +V to GND should be between 0 and -1 volts.
-V	Voltage measurement from -V to GND Should be between -120 V and -135 volts.
Bal	Voltage measurement from Bal to GND should be between 0 and -1 volts. A reading more (+) or less (-) may indicate leakage from either loop to voltages above and below ground respectively.
I	Some HDSL systems may allow current to be measured. Measurement is taken as a voltage reading from I to +V. The voltage measured (in mV) indicates the current being supplied to the HTU-R (in mA).
GND	Ground point used for measuring voltages from +V,-V, and Bal

2.25 Test access may also be provided at the HTU-R to monitor the line power supplied by the HTU-C. Typical values measured from the +V to the -V jack will be in the range of 90 to 130 volts.

2.26 The HTU-R may provide jacks to monitor the current towards the CPE. The value of this current is typically 0 or 60 mA depending on whether the HTU-R has been provisioned to provide power to the CSU or not.

2.27 If the HTU-R is not connected to the HDSL loops, then a voltage measurement made on the HDSL loops will show a pulsed voltage of approximately 130 volts repeating at approximately 15 second intervals.

2.4.2 Insertion Loss Measurement Testing

2.28 Some HDSL systems may support an Insertion Loss Measurement Test (ILMT) to help determine if the cable facilities can support HDSL transmission.

2.29 The ILMT is activated using the supplier's maintenance and provisioning terminal and software.

2.30 When the ILMT is activated, a known test signal is generated by an HTU-R, and the receive strength of that signal is measured and reported by the HTU-C.

2.31 The results of the ILMT should be compared to the limits indicated by the HDSL supplier for that supplier's particular system.

2.32 Loss of synchronization on both HDSL Loop #1 and Loop #2 will occur during the ILMT. In

5. Note that this table assumes that the HTU-C is providing 130 Volts of line-power to power the HTU-R. Suppliers' documentation should be consulted to ensure that the HTU-R is being powered in this manner.

addition, the embedded operations channel (eoc) will lose communications until synchronization is restored at the end of the test.

3. Loopback Testing

3.1 Loopback testing may be used to help isolate faults to the HTU-C, HTU-R, HDSL copper loops, or the wiring to or from the HTU-R and HTU-C. All HDSL systems provide loopback capabilities from the HTU-R to the Central Office (CO) as specified in TA-NWT-1210[10]. Most HDSL equipment provides additional loopbacks to the CO and to the Customer Interface (CI). These additional loopbacks may be activated using a supplier's craft terminal, by using supplier-proprietary protocols, or they may be manually activated via switches on the HTU-R or HTU-C. Check the supplier-provided literature to determine the additional loopbacks supported and their specific activation methods.

3.2 Loop-back testing uses bit-error measurements to help determine where the source of errors is located. The basic procedure is as follows:

1. Insert a test signal on one end using a pattern generator.
2. Loop back the circuit at a selected remote point.
3. Monitor the returned signal for errors.
4. Based on the presence or absence of errors between the testing end and the active loopback location, narrow down the potential source of the errors.

3.3 The following are the four types of loopbacks typically supported:

- HTU-R Toward the central office.
- HTU-C Toward the central office.
- HTU-R Toward the customer interface.
- HTU-C Toward the customer interface.

3.4 HDSL loopback features are presumed to be maximally compatible with DS1 transport facility maintenance practices. T1 line fault location procedures do not apply, but almost all other techniques should work. HDSL should be transparent to bit-error ratio (BER) tests or stress patterns.

3.5 When a loopback is activated, there may be a delay of up to 90 seconds before re-synchronization of the loops is established (the amount of time needed will depend on the specific loop conditions and the specific HDSL system used).

3.1 Activation of Loopbacks

3.6 Activation of a supplier's extended loopbacks (i.e., those other than the 'standard' smart jack loopbacks) can be done via test equipment capable of generating 16-bit extended super-frame (ESF) loop control codes, or from a supplier's craft terminal. Some suppliers' equipment will also respond to "3 in 7" in-band super-frame (SF) codes to allow loopback from the HTU-C, HTU-R and NIU toward the CO. The ability to access a supplier's extended loopbacks using a centralized analysis system will depend on both the analysis system and the HDSL equipment that is being used.

3.7 Loopbacks from the HTU-C and the HTU-R toward the CO may be used to help determine if a fault is located in the HTU-C or on the customer premises. However, a dispatch to the customer site will be necessary to use the loopbacks from the HTU-C and HTU-R toward the Customer Interface.

3.2 Loopback Testing Procedures

3.8 This section gives a detailed description of the four loopbacks which may be supported by an HDSL system. Additional information on loopback capabilities can be obtained from supplier-provided literature.

3.2.1 Loopback from the HTU-R toward the CO

3.9 The HTU-R to CO loopback configuration is shown in Figure 3.1[6]. The results of this test provide the following information:

- If this test "passes", it indicates that the HTU-C and HDSL pairs are functioning properly, thus the likely source of a fault is on the customer premises[7].
- If the test "fails", it indicates that the error is in some component of the HDSL system and is not on the customer premises.

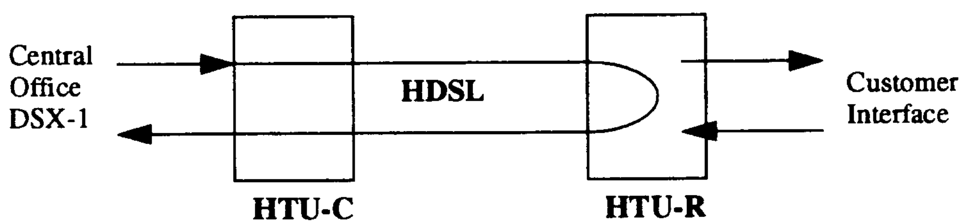

Figure 3.1 Loopback from HTU-R Toward the CO

3.10 The following steps are followed to perform this test:

6. Note this illustration assumes that an external NIU (smart jack) is not being used. If an external NIU was used, the loopback would occur at the NIU, not the HTU-R
7. There is also a small likelihood that the source of errors is at the HTU-R. This could be the case where the loopback circuitry in the HTU-R functions properly, but when the received signal at the HTU-R is passed to the customer (i.e., the HTU-R is not in loopback mode) other circuitry in the HTU-R causes errors.

1. Loopback at the HTU-R can be activated via the smart-jack loopback functions described in TR-TSY-000312[9]. This activation method may consist of an in-band loopback activation pattern (the "2 in 5" bit pattern of "11000" is sent in super-frame (SF) format), loopbacks may also be activated using out-of-band loopback codes (ESF format), or (if supported by the supplier) loopbacks may be activated via a supplier-provided craft interface terminal at the HTU-C.
2. Once the loopback has been activated, a tester at the CO sends a T1 test signal into the HTU-C and measures the signal looped-back from the HTU-R to determine if errors are present.
3. Using the results of this test, the source of errors is narrowed down as described above.
4. De-activate the HTU-R to CO loopback.

3.2.2 Loopback from the HTU-C toward the CO

3.11 The HTU-C to CO loopback configuration is shown in Figure 3.2. The results of this test provide the following information:

- If this test "passes", additional testing is needed to help determine the source of errors.
- If this test "fails", it indicates that the source of errors may be a defective HTU-C, or a defective HTU-C slot in a 220 ORB shelf, or a defective DSX-1 jack or loose wire connection at the DSX-1.

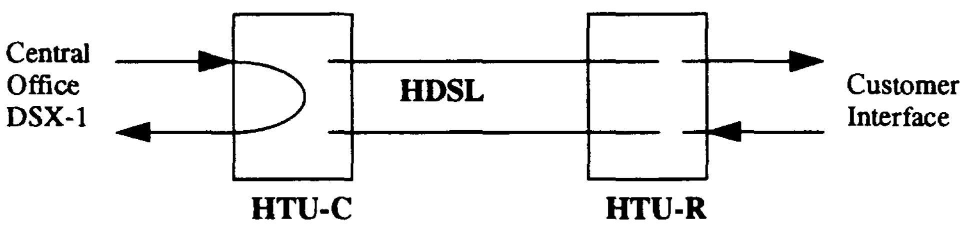

Figure 3.2 Loopback from HTU-C Toward the CO

3.12 The following steps are followed to perform this test:

1. Activate the loopback from the HTU-C to the CO[8].
2. Once the loopback has been activated, a tester at the CO sends a T1 test signal into the HTU-C and measures the looped-back signal to determine if errors are present.
3. Using the results of this test, the source of errors is narrowed down as described above.

8. Bellcore TA-NWT-1210[10] does not contain requirements for this loopback. Where supported, this loopbacks is typically activated via a manual switch at the HTU-C, or via a craft terminal attached to the HTU-C.

4. De-activate the HTU-C to CO loopback.

3.2.3 Loopback from the HTU-R Toward the Customer Interface (CI)

3.13 The HTU-R to CI loopback configuration is shown in Figure 3.3. The results of this test provide the following information:

- If this test "passes", additional testing is needed to help determine the source of errors.
- If this test "fails", it indicates that the likely source of error is the HTU-R or a defective 8 pin RJ48C/X at the HTU-R mounting,

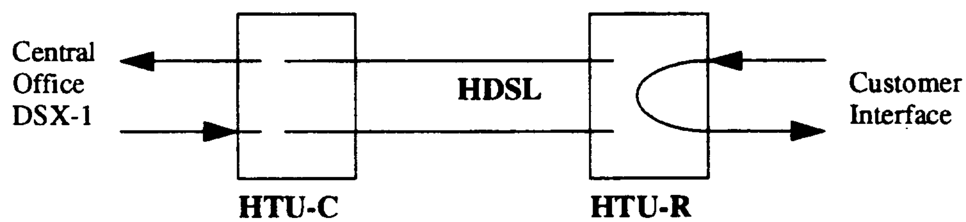

Figure 3.3 Loopback from HTU-R to the Customer Interface

3.14 The following steps are followed to perform this test:

1. Activate the loopback from the HTU-R to the CI[9].
2. Once the loopback has been activated, a tester at the CI sends a T1 test signal into the HTU-R and measures the looped-back signal to determine if errors are present.
3. Using the results of this test, the source of errors is narrowed down as described above.
4. De-activate the HTU-R to CI loopback.

3.2.4 Loopback from HTU-C Toward the Customer Interface

3.15 The HTU-C to CI loopback configuration is shown in Figure 3.4. The results of this test provide the following information:

- If this test "passes", it indicates that the HTU-R is functioning properly and the HDSL pairs are intact, the error may be in the CO wiring[10], the HTU-C, or on the customer premises.
- If this test "fails", it indicates that the CO wiring and customer premises are not the source of

9. Bellcore TA-NWT-1210[10] does not contain requirements for this loopback. Where supported, this loopbacks is typically activated via a manual switch at the HTU-R, or remotely via a craft terminal attached to the HTU-C.
10. This wiring may include frame wiring, High Frequency wiring and wiring at the DSX-1 frames.

error, and the likely source of the error either the HTU-C, the HDSL pairs, or the HTU-R.

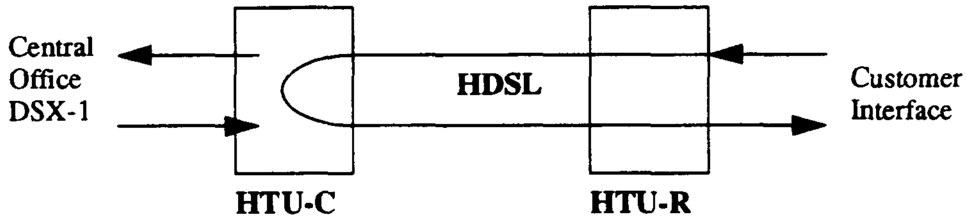

Figure 3.4 Loopback from HTU-C to the Customer Interface

3.16 The following steps are followed to perform this test:

1. Activate the loopback from the HTU-C to the CI[11].
2. Once the loopback has been activated, a tester at the CI sends a T1 test signal into the HTU-R and measures the looped-back signal to determine if errors are present.
3. Using the results of this test, the source of errors is narrowed down as described above.
4. De-activate the HTU-C to CI loopback.

3.3 Using a Combination of Loopback Tests to determine Error Sources.

3.17 The flowchart Figure 3.5 illustrates how to use a combination of these four loopback tests to determine the source of an HDSL fault. Note that if a supplier's HDSL system does not support all four of the loopback tests that have been described, additional supplier-specific testing procedures may be necessary to determine the source of the fault.

11. Bellcore TA-NWT-1210[10] does not contain requirements for this loopback. Where supported, this loopback is typically activated via a craft terminal attached to the HTU-C.

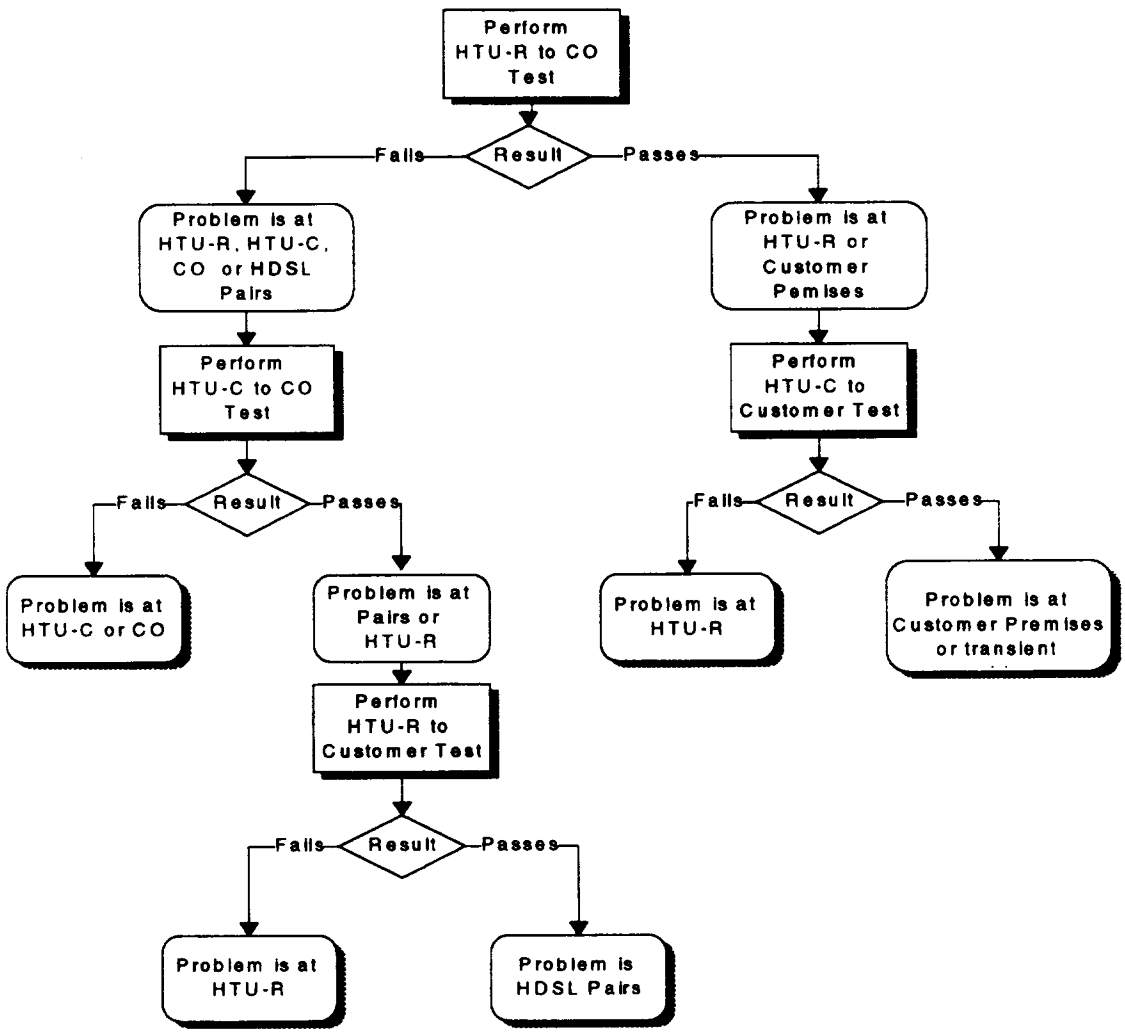

Figure 3.5 Using Loopbacks to Isolate HDSL Problems

4. Acknowledgments

The authors would like to thank Mike Behr of Bell Atlantic, Bob Enzi and John Ulanskas of U S WEST, Gordan Sodetani of Pacific Bell, and Kenny Thompson and Joel Warren of BellSouth for their substantive inputs to and comments on this Bellcore practice.

5. Acronyms

Table 5.1: Acronyms

Acronym	Meaning
ABAM	A type of wiring cable
AMI	Alternate Mark Inversion
B8ZS	Bipolar Eight Zero Substitution
CO	Central Office
CI	Customer Interface
CSA	Carrier Serving Area
CSU	Channel Service Unit
DLC	Digital Loop Carrier
DS1	Digital Signal level 1 (1.544 Mb/s).
DSX-1	Digital Cross Connect frame
ESF	Extended Superframe (DS1)
EOC	Embedded Operations Channel
Full-Duplex	A method of operating a communications circuit so that each end can simultaneously transmit and receive.
HDSL	High bit-rate Digital Subscriber Line
HTU-C	HDSL central office transmission unit
HTU-R	HDSL remote termination transmission unit
ILMT	Insertion Loss Measurement Test
LAN	Local Area Network
NIU	Network Interface Unit, commonly referred to as a smart jack
SF	Super-Frame
T&R	Refers to the Tip and Ring wires of a loop
TBOS	Telemetry Byte Oriented Serial
TL/1	Transaction Language One

6. References

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