

# How to Qualify a Copper Pair for SHDSL Service

Alfonso Domesi, Regional Product Line Manager, Access Business Unit

A symmetrical high-speed digital subscriber line or SHDSL (ITU Rec. G.991.2) is a group of symmetrical DSL technologies combined into a single industry standard providing rate adaptation, greater reach, spectral compatibility, lower power, and application flexibility. SHDSL is quite commonly chosen as the preferred access technology of service providers providing high-speed, symmetric service offerings to businesses and small-office home-office (SOHO) customers. It can be used as a T1 or a 2 Mbit/s (E1) replacement technology.

SHDSL operates over a single pair of wires but can be provisioned to use up to 4 pairs, depending upon the application. For single-pair operation, SHDSL offers data rates from 192 kbit/s to 2.3 Mbit/s in a symmetrical fashion, while two-pair operation offers data rates ranging from 384 kbit/s to 4.72 Mbit/s. The new SHDSL.bis version offers even higher rates, such as 5.7 Mbit/s for a single pair.

The amount of usable bandwidth available over a loop is dependent upon a number of factors including loop length, impedance, signal power, frequency and line coding techniques. The higher the frequency, the greater the attenuation and the smaller the signal becomes when it is received at the far end.

SHDSL has been developed to be spectrally compatible with other technologies within bundles of local loops and to adapt well to the above typical characteristics of a copper pair. SHDSL owes this compatibility to the trellis-coded pulse amplitude modulation (TC-PAM) line coding. This coding technique maximizes the use of the lower frequencies of available loop bandwidth, thus avoiding higher frequencies where signals are more susceptible to crosstalk and attenuation (loss). It requires approximately 1 MHz of bandwidth in order to operate and it uses 135 Ohm termination.

## REQUIREMENTS TO QUALIFY A COPPER PAIR FOR SHDSL

When an operator needs to evaluate a circuit's capability to support an SHDSL service, a set of analog measurements can be run in order to analyze the response of the pair at DC, and low- and high-frequency ranges, and compare them with specific thresholds based on SHDSL requirements.

Voltage	<1 VDC, <3 VAC	Longitudinal balance	≥40 dB
Isolation resistance	≥5 MOhms	Return loss (at 135 Ohms)	≥13 dB
Capacitance balance	±5 nF or >90%	RMS WB noise	≤34 dBm
Resistance balance	±5 Ohms or >90%	NEXT	≥65 dB

Table 1. SHDSL test and threshold limits

Table 1 above provides an example of tests and threshold limits that can be run over an unpowered inactive copper pair to verify that the line is free of impairment and the in-frequency characteristics are within SHDSL requirements. Equally important is the TDR measurement to verify that the length of the pair is within the maximum allowed for the service.

SHDSL technology enables the use of a repeater on the line in order to extend the maximum reach of the service. In this case, tests must be executed for each single piece of cable between each section. For the isolation resistance test, it is best to use a voltage test close to the real one used to feed power to the repeater. This guarantees that the pair has a good isolation to support high voltage on the line.



EXFO's [MaxTester 610 \(MAX-610\)](#) handheld tester is capable of performing single-ended automatic testing on a copper telco cable for ADSL2+, SHDSL and VDSL2 pre-qualification, installation and maintenance. Wideband frequency response, time-domain reflectometry, digital multimeter with high-voltage isolation test capability, power spectral density and impulse noise tests are examples of single-ended tests available

with the MAX-610. Packed with these and other powerful features, the MAX-610 can perform a service acceptance close-out test, eliminating the need for additional test sets to perform end-to-end testing. EXFO's [MaxTester 635](#) model offers the same features as the MAX-610, but bundles a complete ADSL/VDSL2 modem emulation for sync and triple-play testing.

The MAX-610 integrates a powerful profile management system that enables the creation of pre-defined profiles (see figure 1) with the control of all test parameters and acceptance thresholds based on the requested service.

Profile Name	Modification Date
ADSL	09-09-2015 14:18
ADSL2+	09-09-2015 14:20
ADSL2+ (FED)	09-09-2015 14:20
Default	15-10-2015 09:43
HDSL	09-09-2015 14:22
ISDN	09-09-2015 14:22
<b>SHDSL</b>	<b>09-09-2015 14:23</b>
SHDSL (FED)	09-09-2015 14:23
VDSL2-12	09-09-2015 14:24
VDSL2-17	09-09-2015 14:25
VDSL2-8	09-09-2015 14:24

Figure 1. Profile management is very flexible

With the MAX-610 and the [EXFO Connect](#) cloud service, operators can create a set of profiles then share those profiles directly with test sets in the field using a standard Internet connection. This eliminates uncertainty caused by an incorrect profile, and increases the accuracy of results, thanks to the ability to automatically update profiles when required.

Using these pre-defined profiles, it is possible to run a very easy single-button automatic closeout test to qualify a circuit for SHDSL featuring a range of different tests comparing measured results against stored thresholds for pass/fail results.

With the MAX-610, it is simple to perform a quick and powerful evaluation of a cable to see if it is acceptable for SHDSL service:

- › Step 1: Create and select a pre-defined profile for SHDSL.
- › Step 2: Connect the test leads to the pair under test.
- › Step 3: Press the User Auto-Test button.

At the conclusion of the AUTO test, the MAX-610 will report a clear PASSED if all the user defined thresholds are not compromised. Otherwise it will report FAILED. The details of the results are provided in both textual and graphical formats.

Result:	Test	Test Status	P/F
	Voltage	Completed	✓
	Resistance	Completed	✓
	Resistive Balance	Completed	✓
	Isolation	Completed	✓
	Capacitance	Completed	✓
	WB PSD Noise	Completed	✓
	AC Balance (Active)	Completed	✓
	WB Balance	Completed	✓
	WB Attenuation	Completed	✓
	TDR Test	Completed	✓
	Return Loss	Completed	✗

Figure 2. User AUTO test sequence with clear PASS/FAIL flag.

For important tests like attenuation, return loss and longitudinal balance, the MAX-610 features integrated, specific threshold masks with green or red areas that the technician can refer to for an easy and immediate visualization of the result.

The MAX-610 provides the possibility to execute all the measurements during the AUTO sequence in full Manual mode. In the case of troubleshooting or for an in-depth analysis, the technician can select the requested test from a complete toolbox and run it. Examples of available tests are listed in the appendix of this application note.

At the end of a test, it is possible to save the results and create a report including all the overhead information such as job ID, contractor name, test to/from location and comment.

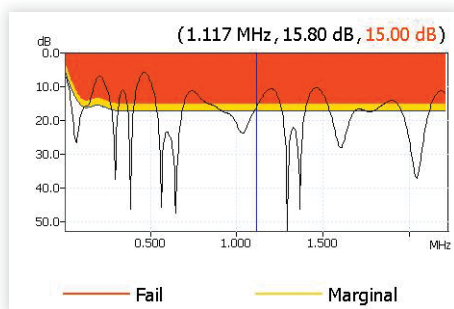


Figure 3. Threshold mask overlay

If requested, the technician can easily export reports on a USB memory stick or directly to a smartphone (for details, please refer to the [EXFO Sync](#) app) with a GPS tagging feature for final upload to a remote FTP server.

In this mode, it is possible to offer an off-line analysis without losing time searching for the right result which would delay the closing of the job.

For more information concerning the MAX-610, MAX-635 or EXFO Connect, please visit [EXFO.com](#) or ask an EXFO representative for a live demonstration.

FEATURE	APPLICATION
<b>Digital multimeter (DMM)</b>	
<b>Performs basic measurements such as resistance and voltage, to determine the physical characteristics of the copper loop and to determine if basic copper faults are causing service problems.</b>	
 Voltage	Measures the presence of voltage on the pair. During the qualification and troubleshooting job, the pair under test must be disconnected on both sides, so there should not be any voltage present on the line. If voltage is present, it means there is a low isolation contact with another live pair.
 Capacitance	Measures the capacitance value (in nF or uF) and calculates the cable length of the line under test. It needs an open state at the far end. The test also provides a capacitance balance measurement that may provide important information on possible split, bridge tap or bad grounding impairments.
 Isolation resistance (stress/leakage)	Applies high voltage to the A/Tip and B/Ring and to earth/ground and measures the resistive isolation between the wires and to ground. It needs an open state at the far end. Problems in the cable can be determined by observing if the resistive value rises or falls under high voltage.
<b>Noise tests</b>	
<b>The purpose of the noise tests is to perform wide band (WB) noise measurement.</b>	
 WB power spectral density (PSD) noise	Allows the technician to check the ambient noise on a circuit prior to provisioning to ensure it will support the rate requested by the customer. Helps avoid providing service that will be unreliable and cause further technician visits. Crosstalk noise is a typical problem that can cause incompatibility between different services on the same cable bundle.
 NEXT	Measures the near end cross talk (NEXT) attenuation between two pairs. In good conditions, the two pairs should have a big attenuation of the crosstalk, but in cases of unbalance, split pairs or low isolation, there could be strong injection of noise from one pair to the other. Connect the two pairs being qualified to the tester and leave the far end open.
<b>Frequency tests</b>	
<b>Set of tests used to measure the characteristics of the pair under test in the frequency domain.</b>	
 Load coil detection	Measures the presence of up to 5 load coils on the copper pair. Good measurement for making sure a cable is loaded properly, or for pre-qualifying DSL loops by making sure all load coils are removed from service. Load coils were used in the past to extend the reach of normal voice (POTS) line.
 Single-ended attenuation	Allows loss of a circuit for all frequencies to be measured from one end without the use of a FED or second technician. Special sending & receiving tones measurement is made on one side of the copper pair. Leave an open state at the far end.
 WB longitudinal balance	Single-ended WB longitudinal balance measures the ability of a circuit to reject noise across wideband frequencies. Useful for determining conditions of grounds, or conditions such as poor splices or insulation breakdown.
 WB return loss	WB return loss test measures the mismatching of the line impedance with respect to the ideal impedance across the frequency band. The difference may be created by pair impairment and it can create problems for technologies relying to echo cancellation systems like ISDN or SHDSL.

EXFO Headquarters > Tel.: +1 418 683-0211 | Toll-free: +1 800 663-3936 (USA and Canada) | Fax: +1 418 683-2170 | info@EXFO.com | [www.EXFO.com](http://www.EXFO.com)

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