

Detecting Bridged Tap and Noise Interference in VDSL2 Access Networks using the JDSU SmartClass™ TPS



The JDSU SmartClass TPS tester is the ideal tool for technicians who install, troubleshoot, and maintain Triple-Play services.

Test Challenge

Very high-speed digital subscriber line 2 (VDSL2) provides data rates and quality of service (QoS) required for consumer broadband access and video services. It can be used on existing Access infrastructure and is a complementary technology for fiber-to-the-home (FTTH) deployments. However, upgrading the Access network from asymmetrical digital subscriber line 2+ (ADSL2+) to VDSL2 might be a more significant task in order to benefit from full VDSL2 data throughput performance and service stability. VDSL2 uses a significantly higher frequency spectrum than ADSL2+ and frequency-related issues can occur that were not present before on ADSL2+ using the same cable pair.

Here are some copper-pair-related faults and issues that can impact VDSL2 performance:

Copper Fault	Impact to DSL Service
Bridged taps	A bridged tap is every piece of wire not belonging to the main cable between the DSLAM and the customer premises equipment (CPE) modem. Bridged taps cause undesirable reflections at the splice point and at the end of the tap. The reflected signal becomes noise in the circuit that degrades DSL performance. Further, bridged taps can act as antennas and pick up external noise along the tap.
Poor pair balance	Twisted copper pair can cancel out some of the external noise caused by other DSL lines or short, intermittent impulse noise that electrical devices cause in the Home Network. However, if the pair is unbalanced, noise will bleed into the copper pair and degrade DSL performance.
Corroded contacts	Corroded contacts act as capacitive faults that especially impact the lower part of the frequency spectrum resulting in degraded DSL performance.

Additional copper faults can impact DSL, such as shorted pairs, crossed pairs, open pairs; however, real-world deployments indicate that bridged taps very often occur in the Access Network that negatively impact DSL data rates.

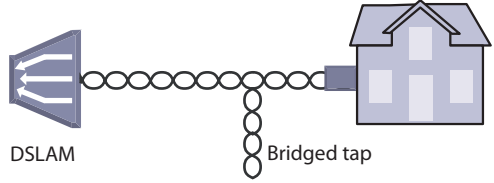


Figure 1. Bridged taps can impact DSL performance.

Bridged taps will not affect all tones equally. A given bridged tap may impact some frequencies more than others. Table 1 shows the critical bridged tap length for a specific discrete multitone (DMT) tone that will impact DSL service.

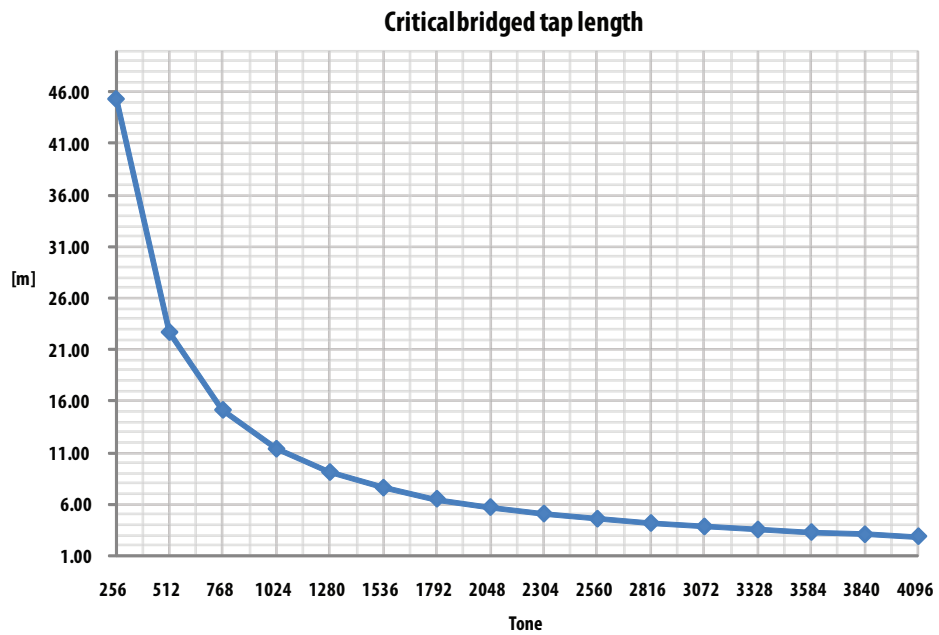


Table 1. Critical bridged tap lengths for a selection of transmission channels. *

The presence of bridged taps can be identified using the $H_{log}(f)$ data defined in ITU-T G.992.3 as the frequency response per channel with characteristic “valleys/dips” at tones that correspond to the bridged tap length shown in Table 1. This DELT-type measurement requires that the Digital Subscriber Line Access Multiplexer (DSLAM) and CPE modem be connected at both ends. As a simple illustration, the H_{log} typically represents the attenuation per power spectral density (PSD) carrier.

*All examples are calculated with an assumed velocity of propagation (VoP) = 200,000 km/s.

Figure 2 shows an example of a dip on the Hlog graph at tone 1400 caused by a bridged tap. Figure 3 shows the Hlog graph after removing the approximately 8 m long bridged tap. A bridged tap similar to this one can easily degrade VDSL2 service by more than 2 Mbps.

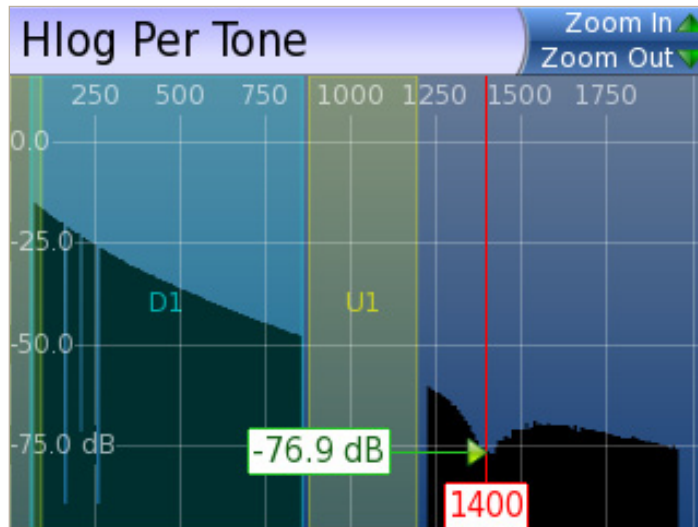


Figure 2. A bridged tap caused a "dip" on the Hlog frequency response curve. The example shows a bridged tap length of approximately 8 m.

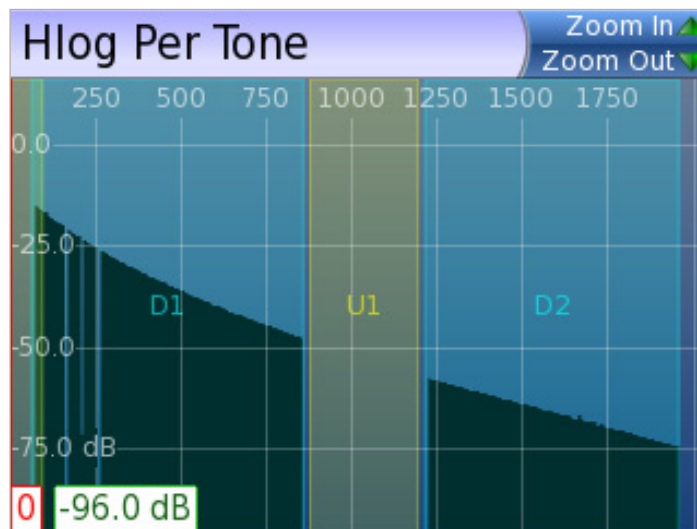


Figure 3. "Clean" frequency response after removing the bridged tap.

Addressing the Challenge with SmartClass TPS

All DSL testing associated with installation and repair must start by connecting the SmartClass TPS to the line and verifying the DSL performance parameters against the provisioned Connection Rates, as shown in Figures 4 and 5.

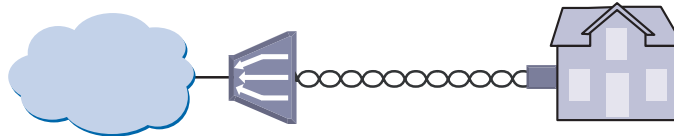


Figure 4. The first step in installation and repair DSL testing is verifying the current Connection Rates end to end.

DSL Summary		
		12:18 AM
Showtime		VDSL2 17a
	Up	Down
Conn. Rate	3.54 Mbps	19.8 Mbps
Max. Rate	4.08 Mbps	21.2 Mbps
Capacity	86%	93%
Margin	6.5 dB	6.0 dB
Atten.	0.0 dB	0.0 dB

At the bottom of the screen are two buttons: a purple button with an asterisk labeled "Setup" and a purple button with a hash symbol labeled "Results".

Figure 5. DSL Summary Results using the SmartClass TPS.

In the second step, technicians should review the bits per tone data, as shown in Figure 6, which concentrates the analysis on issues impacting the actual DSL line profile. A maximum of 15 bits can be carried over one tone. Similar to Figure 6, the bits-per-tone (BPT) graph can identify noise interference with a degraded bit load.

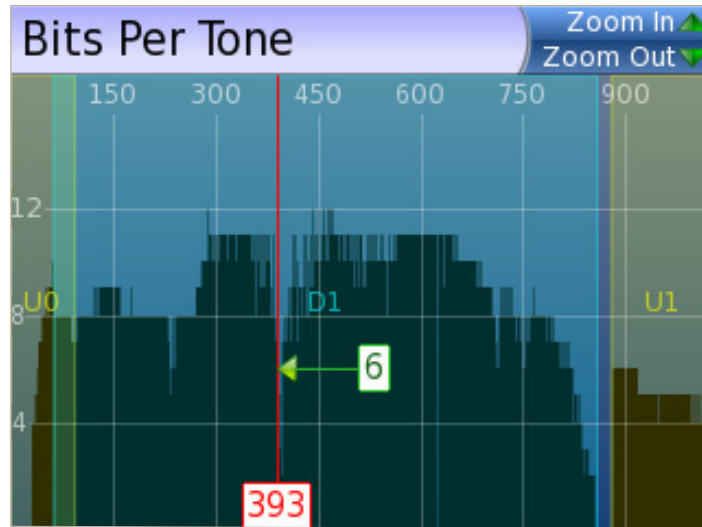


Figure 6. BPT analysis with degraded bit load around tone 393 due to possible noise interference.

The next step is investigating the signal-to-noise ratio (SNR) per tone graph, as Figure 7 shows. This test can confirm possible noise interferers and may show that a possible bridged tap is causing the up and down patterns.



Figure 7. SNR per tone graph.

In order to differentiate between noise and bridged-tap-related impacts to the SNR and, therefore, the BPT load, technicians must review the Quiet Line Noise data that the SmartClass TPS provides, which is illustrated in Figure 8. Areas that show a sharply degraded BPT and SNR graph with an increased Quiet Line Noise value indicates noise interference issues. Figure 8 provides an example of a noise spike where the tones are around 397 and the lower part of the D1 band up to tone 290 as well the upper part of the D1 band around tone 800.

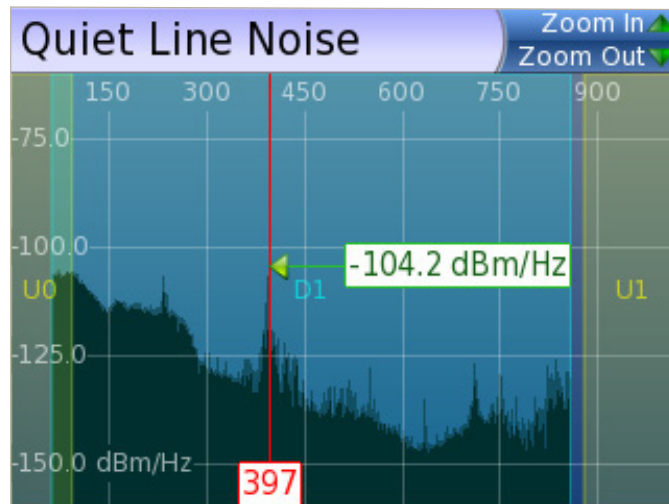


Figure 8. Quiet line noise that spikes at tone 397 and has a fairly high noise floor up to tone 290 and in the upper part of the D1 band.**

While Figure 7 showed regular ups and downs indicating the possible presence of a bridged tap, Figure 9 confirms the presence of a bridged tap as the Hlog per tone graph indicates. Either method can identify the first dip; refer to Table 1 to see the associated bridged tap length. Occasionally this is too difficult, see Figure 9 which uses Table 2. The Table 2 method takes two dips and counts the sub-dips to identify the bridged tap length. For Figures 9 and 10, the tone delta is 310 tones with one sub-dip in between and using Table 2 provides an approximate bridged tap length of 150 m. This bridged tap can be identified and removed, thus showing an Hlog response similar to the one shown in Figure 3. Figure 11 shows that the DSL Maximum Rate improved by approximately 8 Mbps and the Connection Rate is back to the contract planned 25 Mbps service.

**The presence of a bridged tap might gain the noise interference as the bridged tap acts like an antenna.

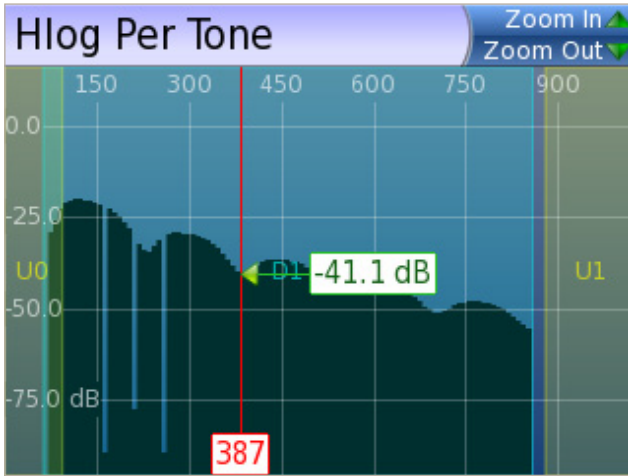


Figure 9. Hlog per tone graph, cursor at tone 387.

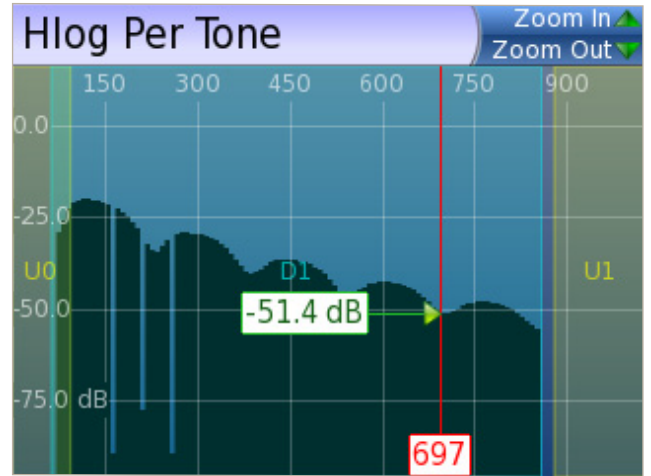


Figure 10. Hlog per tone graph, cursor at tone 697.

Bridged tap length in [m] for a given tone delta between two dips and number of sub-dips

Tone delta	Sub-dips			
	0	1	2	3
100	231.9	463.8	695.7	927.5
150	154.6	309.2	463.8	618.4
200	115.9	231.9	347.8	463.8
250	92.8	185.5	278.3	371.0
300	77.3	154.6	231.9	309.2
350	66.3	132.5	198.8	265.0
400	58.0	115.9	173.9	231.9
450	51.5	103.1	154.6	206.1
500	46.4	92.8	139.1	185.5
550	42.2	84.3	126.5	168.6
600	38.6	77.3	115.9	154.6
650	35.7	71.3	107.0	142.7
700	33.1	66.3	99.4	132.5
750	30.9	61.8	92.8	123.7
800	29.0	58.0	87.0	115.9
850	27.3	54.6	81.8	109.1

Table 2. Bridged tap length in [m] using two “dips” and a defined number of “sub-dips”.

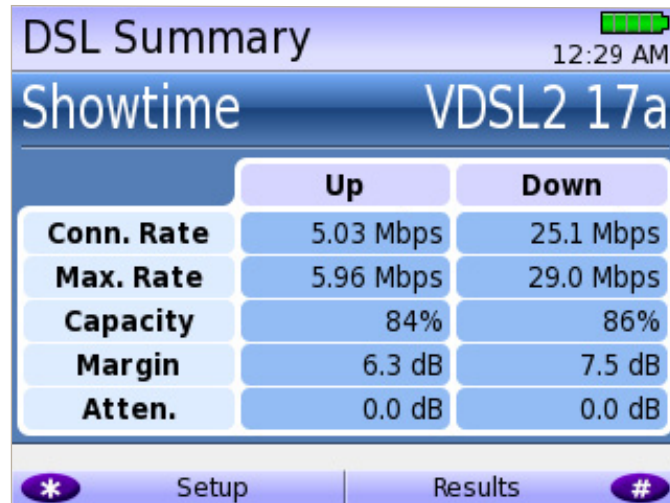


Figure 11. DSL Connection and Maximum Rates without the bridged tap.

Conclusion

Data rates associated with VDSL2 provide great market opportunities for operators and service providers, but they also increase scrutiny on the converged service when deployed incorrectly because the customer may be the first to notice diminished QoE. While VDSL2 provides significantly more bandwidth than ADSL2+, it also challenges the copper loop more because it uses a higher frequency spectrum. Copper loops that performed well for ADSL2+ may fail dramatically with full VDSL2 performance. Especially short bridged taps (between 2–50 m) can degrade VDSL2 data rates significantly.

The graphical BPT, SNR, Hlog, and QLN diagnostic modes on the SmartClass TPS allow deeper analysis of questionable DSL data throughput performance. It enables the detection of the presence of bridged taps, including their approximate length, frequency areas of noise interference, or capacitive faults due to corroded contacts. Removing the root cause of these faults enables operators to provide a more reliable DSL line with higher data rates.

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