Application Series

SunSet xDSL: Prequalifying the Copper Plant for DSL – Physical Layer Testing

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INTRODUCTION

As telecom and cable providers race to solve the last mile bottleneck and offer high speeds to the band-width-hungry subscriber, the pressure heightens to deploy service- and deploy it quickly. The best weapon for successful deployment is a complete understanding of the challenges and requirements needed for upgrading the copper plant for DSL. Using a logistical approach and the right test equipment allows technicians to identify all the factors on a dry pair that may hinder DSL service.

Prequalification determines if the copper plant is suitable to support the expected DSL service. The local loop has been optimized for analog voice, not for high-frequency digital signals like DSL. Load coils extend the range of voice, but seriously limit DSL. Bridge taps are commonly used to add new customers, but the signal reflections create noise and degrade DSL performance. New cable and testing requirements are necessary when upgrading the copper plant to a high-frequency signal like DSL.

VERIFY METALLIC CRITERIA

The first step is to run digital multimeter measurements to check for any serious faults on the cable pair. This combination of tests can detect shorts, grounds, splits, and cuts; it can also determine loop length to the end of the cable. See figure below.

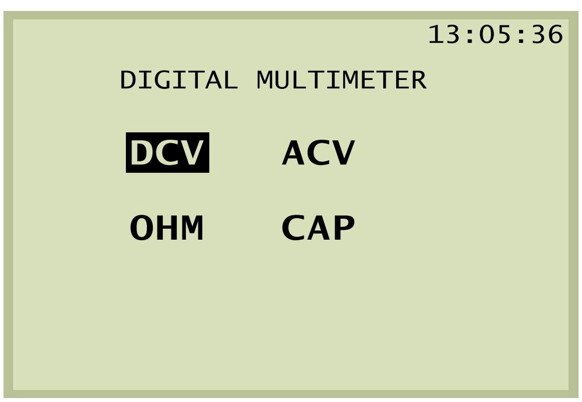

Figure 1 Digital Multimeter screen

Resistance

Measure the resistance (OHM) for all three measurement types (tip-ring, tip-ground, ring-ground). The values for all three should be greater than 5 MOHM.

If tip-ring is less then 5 MOHM, this indicates a short. Run a loop resistance test for tip-ring (found in LINE, CONTROLLER). The distance provided here is the location of the short. If you want to double-check this, run a TDR to look for a short.

Capacitance

Next measure the capacitance (CAP). This verifies that the cable is open and that you do not have any shorts on the pair.

If the CAP reading shows >2mF, there is a short on the pair. Use the OHM measurement to verify (tip-ring greater than 5 MOHM). Then, use a TDR to locate the short.

The capacitance measurement can give you the distance to the open on the cable pair. It uses a conversion factor of 83 nF= 1 mile (51 nF= 1 km). If the distance value is shorter or longer than expected, this could indicate a break in the cable. For example, if the cable records show the pair is supposed to be 10,000 feet long, but you find the capacitance reading corresponding to 8,000, there could be an open 8,000 feet away. Likewise, if the MLT measurement performed from the central office says the distance value is 2,000 feet, but the CAP measurement from the field shows 8,000 feet, there could be an open 2,000 feet from the central office.

Another factor to consider is that the capacitance measurement adds in the length of any bridge taps in its distance calculation. For example, if the cable pair is only 5,000 feet long and there is a bridge tap 1,000 feet long, a capacitance reading will give a distance of 6,000 feet.

What should you make of all these different possibilities? The best strategy is to run a TDR measurement if you see any conflicting results between the CAP distance and expected distance or between the distance measured by capacitance and distance measured by loop resistance. A TDR can locate a bridge tap or open on the pair. Using a combination of capacitance, TDR, and loop resistance measurements can provide valuable insight on the cable conditions.

DCV

Next, measure DCV. This test can indicate a crossed pair. For example, if you are testing a pair with an open at the end and see the following values, tip-ring=-48V, ring-ground= +48V, and tip-ground=0V, this indicates the ring lead is crossed with another ring. If you detect a crossed pair, run a TDR measurement to locate it.

During installation, a DC voltmeter can be used to verify proper POTS voltage.

ACV

Next, measure the AC voltage on the pair. This test checks for any unwanted power influence. All values should be minimal (less than 5 ACV recommended).

Loop Resistance

Verify that the circuit shows acceptable loop resistance values (tip-ring with a short at the far end). The required values are:

- HDSL: 900 ohm max
- ADSL/IDSL: 1300 ohm max

You can also use a loop resistance measurement to provide an estimated distance. This test must be performed with a short at the far end.

CHECK FOR LOAD COILS

The next thing to do is check for any load coils on the pair. Circuit records are not always accurate and it is better to verify that there aren't any load coils. Load coils are essentially low-pass filters that are used in some countries to extend the range of analog voice. However, they severely attenuate the DMT spectrum and will prevent DSL service from running. Therefore, it is critical to remove all load coils before trying to implement DSL, or other high-frequency services.

The easiest method to check for load coils is the COIL DETECTION feature. This quickly tells you if any load coils are on the circuit and how many. Refer to Figure 2. If any load coils are shown, you will need to run a TDR to locate the load coils. If the COIL DETECTION screen shows multiple load coils, you will need to run a TDR and find and remove the first load coil. Then, run the TDR again to find the next load coil on the pair. You will need to continue this procedure until all load coils have been removed.

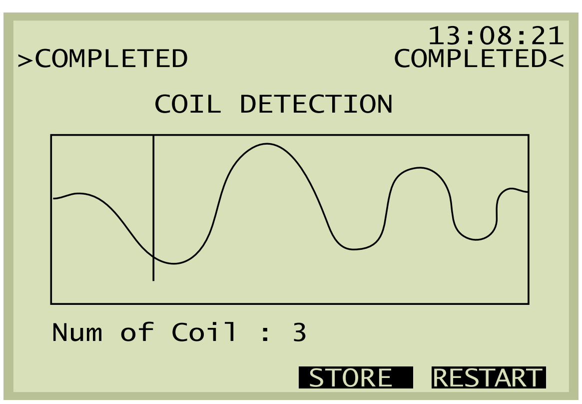

Figure 2 Coil Detection screen

DETECTING BRIDGE TAPS USING A TDR

Bridge taps are common elements in the local loop as they have been used for years to add/remove additional lines from the main distribution pair. A bridge tap is any section of cable that is not in the direct path between the central office and the subscriber.

Bridge taps can be extremely harmful to digital signals. They create a second path for the digital signal. When the signal travels down the lateral, it is reflected by the open at the end creating noise back on the main cable pair. A bridge tap can greatly reduce the rate DSL can support and in severe cases, prevent the link from turning up.

The closer a bridge tap is to a modem, the more harmful its effect. **It is recommended that no bridge taps be within 1000 feet of either modem.**

A TDR is the best tool for identifying bridge taps. Figure 3 shows a bridge tap found in the xDSL's TDR screen. It appears as a downspike followed by an upward bump. The xDSL's search function can automatically detect a bridge tap on the pair.

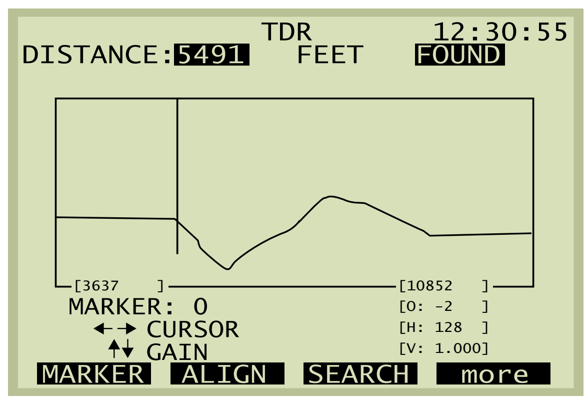

Figure 3 TDR screen showing a bridge tap

The Insertion Loss measurement can also be used to detect bridge taps. This is a dual ended test requiring test equipment at either end of the cable pair. Insertion loss can detect if bridge taps are present on the cable. However, a TDR is still needed to find the location.

In addition to identifying any bridge taps on the cable pair, a TDR is also useful for detecting any cable faults that may have been missed in the previous tests. It also provides a distance reading to the open at the end of the cable. This information can be compared to the distance readings from either loop resistance or capacitance measurements.

CHECK SPECTRAL COMPATIBILITY

Another aspect of prequalification involves checking the spectral compatibility of all the digital services in adjacent binder groups. These services can crosstalk at common frequencies. Since ADSL uses such a wide frequency spectrum (140 to 1100 kHz for DMT), it is particularly susceptible to interference from outside sources.

A power spectral density (PSD) measurement is an effective tool to identify potential interfering sources. The xDSL PSD measurement tests the full ADSL spectrum from 22 kHz to 1.6 MHz. Depending on its strength, interference could limit the achievable bit rate and noise margin or prevent service completely.

Templates can be used to identify what type of service is causing the interference. In Figure 4, the noise shape resembles the template for 24 T1 signals in an adjacent binder group.

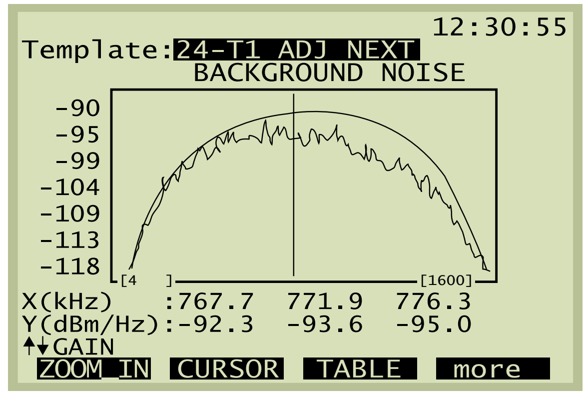

Figure 4 PSD test showing interference from 24 T1 signals in an adjacent binder group

SUMMARY

	ADSL	HDSL	IDSL	SDSL	TOOLS
Loop length	< 18,000 ft	< 12,000 ft	< 18,000 ft	< 12,000 ft	Capacitance, Loop resistance, TDR
Loop resistance	1300 ohm max	900 ohm max	1300 ohm max	900 ohm max	Loop resistance
Load coils	0	0	0	0	Coil Detection, TDR
Bridge taps (distance from modem)	> 1,000 ft	> 1,000 ft	> 1,000 ft	> 1,000 ft	TDR, Detaphor (Insertion Loss)

Figure 5 Summary of loop requirements for DSL service

Figure 5 summarizes the various loop requirements for DSL service as outlined in this application note. Additional application notes in this series are dedicated to each particular test method. The following application notes are available for DSL physical layer testing:

"Traditional DMM Tests for Prequalifying & Troubleshooting DSL Circuits"
"Detecting Load Coils"
"TDR Testing Techniques for DSL Circuits"
"Inserti on Loss Testing for ADSL DMT"
"Wideband Power Spectral Density Measurements for DSL"