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Application Series

SunSet xDSL: TDR Testing Techniques for DSL Circuits

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WHAT IS A TDR?

TDR stands for Time Domain Reflectometer. In short, it's a test instrument that works by shooting a pulse down the cable and then measuring any reflections that return. These reflections are caused by changes in impedance of the cable, which can be caused by water, split pairs, bridge taps, load coils, shorts, and opens. One main benefit of a TDR is its accuracy and ability to pinpoint the exact location of a fault. Whereas a Coil Detection feature can detect if a load coil is present, only a TDR can determine its location.

A TDR is an excellent tool for prequalifying the copper plant for DSL. DSL is affected by the traditional faults found on a cable pair like opens, shorts, and wet cable. However, it is also affected by some common elements of the local loop- namely load coils and bridge taps. Whereas load coils were beneficial for analog voice over long loops, they have the opposite effect on high-frequency digital services like DSL. A single load coil prevents DSL service. Therefore, it is critical to understand how to properly upgrade your copper plant for DSL deployment.

There are two key factors for determining the effect a bridge tap has on DSL performance. First, the length of the lateral: shorter bridge taps are more harmful than longer ones. The reflected signal encounters little attenuation over a short lateral and thus is more powerful. With long laterals, the reflection may be so attenuated that it has little effect on performance. The second factor is the distance of the bridge tap to either modem (xTU-C or xTU-R). Again, attenuation is the key here. When the noise source is closer to the receiver, there is more damage than from a distant source that has been attenuated. Based on field testing, the worst scenarios for bridge taps (for ADSL) seem to be when the bridge tap is within 1,000 feet from either modem and between 200 to 500 feet long. These results are based on internal lab and field testing; they are not part of any standardized specification.

On a TDR, a bridge tap appears as a downward spike, followed by an upward bump representing the end of the lateral. Refer to Figure 3. You can learn the location of the bridge tap by determining the location at the beginning of the downspike. Place the cursor at the beginning of the downspike; the DISTANCE reading

Fault	Appearance on TDR	Effect on DSL service	Other SunSet xDSL tests
Bridge tap	Downspike followed by upwards bump	Degraded performance	INSERTION LOSS (the "detaptor")
Load coil	Upwards bump	Prevent communication completely between modems	COIL DETECTION
Open	Upwards bump	Prevent communication completely between modems	DMM: OHM, CAP measurements
Short	Downspike	Prevent communication completely between modems	DMM: OHM, LOOP RESISTANCE measurements
Split	Downspike or upspike	Degraded performance	DMM: DCV

Figure 1 Common faults and testing tools

Bridge Taps

Bridge taps, unused and unterminated lines to customers, have proven to be one of the most performance-affecting faults on ADSL circuits. The length of the bridge tap is commonly referred to as a lateral and is any length of cable that is not in the direct path between the central office and customer. Bridge taps cause problems with high-frequency digital signals like ISDN and DSL. A lateral creates a second path for the digital signal. The signal travels down the lateral and is reflected by the open at the end. Bridge taps are harmful because the reflected signal that bounces off the end of the bridge tap creates noise back onto the real cable pair.

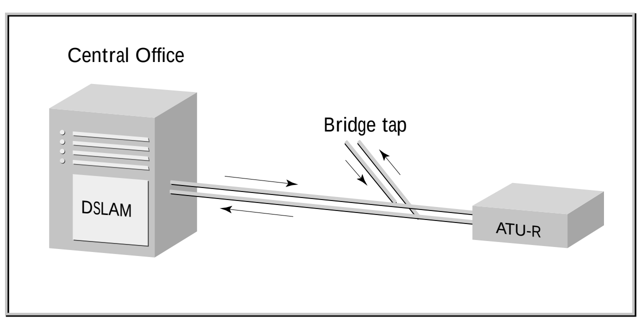

Figure 2 Bridge tap

at the top gives the location (5,491 feet in Figure 3). Since the upwards bump represents the open at the end of the lateral, you can also determine the length of the lateral by the distance between the downspike and bump. Place the MARKER (dotted line) at the beginning of the upwards bump; the MARKER reading below the graph provides the length (1,693 feet in Figure 3).

Load Coils

A single load coil prevents DSL service. Therefore, it is a good idea to first check for load coils on the pair before installation. Or, if you're trying to turn-up the link and cannot connect with the other end, check to see if there are any load coils which might be preventing service.

Load coils are used to extend a voice signal's range over long loops (greater than 18,000 feet). A load coil is an inductor, typically 88 mH. It works by boosting the transmit power level for voice frequencies (between 300 Hz and 3 kHz). However, after 3.1 kHz, the power drops below that of unloaded cable. This is ideal for voice transmission, since it is limited to the 300 Hz to 3.1 kHz bandwidth. But, what happens with ADSL or other DSL services that use the higher frequencies? They simply cannot pass through load coils. ***Therefore, it is critical to remove all load coils before deploying ADSL or other high frequency signals.***

Load coils are placed at regular intervals- a key factor for locating and removing them. The first coil appears 3,000 feet from the central office or exchange and subsequent load coils are placed every 6,000 feet after that.

On a TDR, a load coil appears as a smooth upwards bump. It will look very similar to an open on a TDR. Placing the cursor at the beginning of the upwards slope gives you the distance to the load coil (5,117 feet in Figure 4). Knowing the spacing interval is a key to identifying a load coil. For example, if this signature appears approximately 9,000 feet from the central office, chances are high it is a load coil.

A TDR can detect only the first load coil on the cable. You will need to run the TDR, remove the first load coil, and then run the TDR again to check for other load coils. This process should be repeated until there are no more load coils on the line.

Split Pairs

A split pair means that one wire of a pair is spliced onto a wire of an adjacent pair. It is generally caused by improper splicing or wire labeling. Split pairs lead to crosstalk which can impair DSL performance. Refer to Figure 5. On a TDR, a split appears as a sharp spike. In Figure 5, the spike is positive; however, depending on how the wires are connected, a split may appear as either a positive or negative spike.

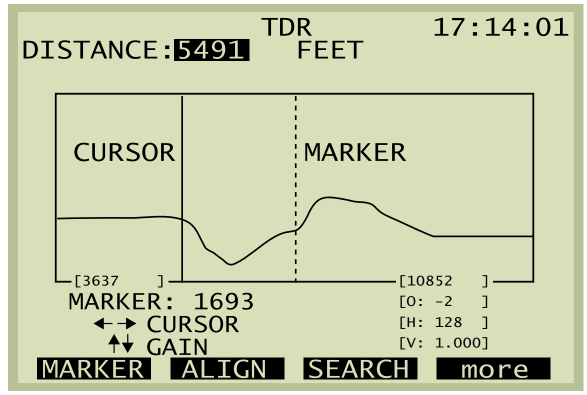

Figure 3 Test data for 14,000 ft/26 AWG

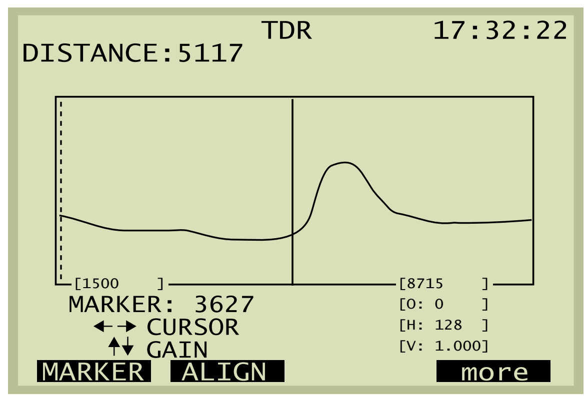

Figure 4 Sample load coil on TDR

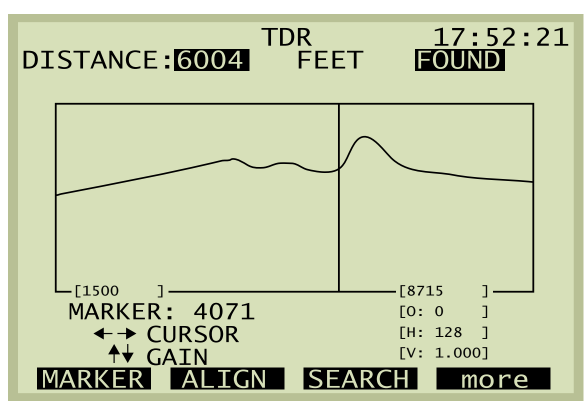

Figure 5 Sample split pair on TDR

Opens

An open is a break in the cable pair; it does not allow electrical energy to flow through. One major cause of an open is careless, or unauthorized, digging in an area. As expected, an open prevents DSL service. If the two modems at either end cannot communicate at all during installation, there could be an open in the cable between them. On a TDR, an open appears as an upwards bump. Refer to Figure 6.

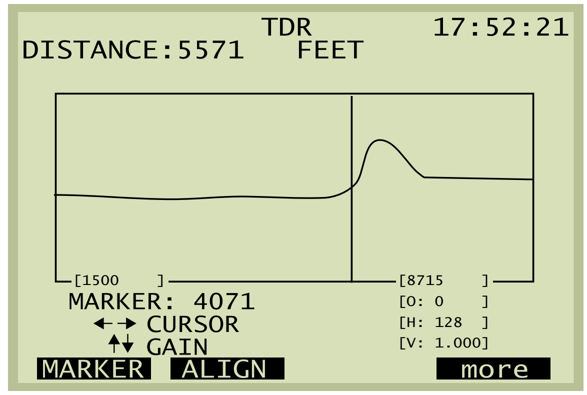

Figure 6 Sample open on TDR

Shorts

A short occurs when the tip and ring wires come in contact. A short prevents the DSL signal from passing through. Shorts can be caused by improper splicing or worn sheaths. On a TDR, a short appears as a downspike. Refer to Figure 7.

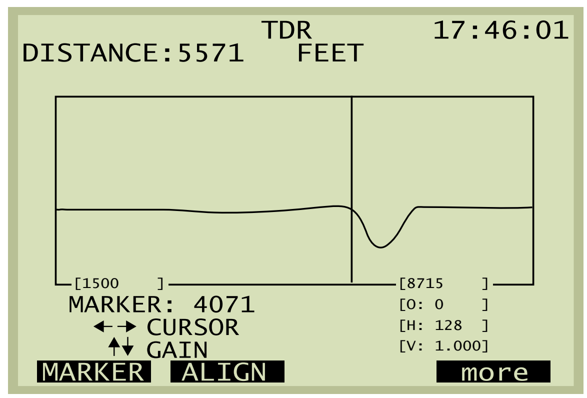

Figure 7 Sample short on TDR

OPERATING THE SUNSET XDSL TDR

Refer to this procedure for making a TDR measurement with the SunSet xDSL:

1. Press the MENU key located on the second row of the keypad.
2. Enter TDR. Note that the TDR LED lights green.
3. Configure the Setup screen. Refer to Figure 8.
   a. If you need to change the UNITS (English or metric), escape back to the main menu. Enter OTHER SETUP, then SYSTEM CONIFG. Here you can change the UNITS setting.
   b. Select the gauge value for the cable you'll be testing. An incorrect setting will result in a reduction of measurement range. If you are testing a cable span with mixed gauge values, select the highest gauge value.
   c. Select the Velocity of Propagation value. If you're uncertain of the exact value, either keep the default value (0.67) or calculate it as described below.

Velocity of Propagation

Propagation Velocity (Vp) indicates the speed that the signal travels down the cable. It is a ratio of the speed in cable to the speed of light; a value of .65 means the signal travels down that cable at 65% the speed of light.

Setting the Propagation Velocity is crucial for using a TDR. This calibrates the SunSet for the particular cable type. You should be able to find the Vp in the cable's specification sheet or from the manufacturer. If you cannot find it, take good cable of a known length and measure it with the SunSet's TDR. Change the Propagation Velocity setting until the SunSet provides an accurate distance reading.

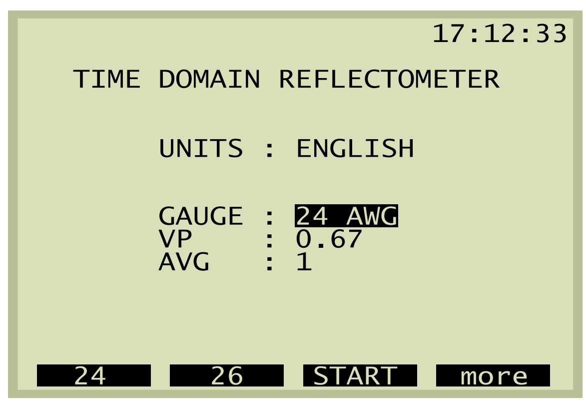

Figure 8 TDR setup screen

4. Connect to the cable pair. A common method for connecting uses an RJ-45 to alligator clip cable. Plug the RJ-45 into the jack on the right side of the SunSet (labeled DMM/TDR/LINE). Use the alligator clips to clip directly to the cable pair.
5. Press the START (F3) key when you have completed your settings and have connected to the pair.

6. Press the SEARCH (F3) key. The SunSet now begins to look for the first fault. The screen shows SEARCHING while it scans the line. Refer to Figure 9.
7. When a fault is found, it appears on the screen. FOUND is displayed at the top right. Refer to Figure 10. The cursor automatically jumps to the beginning of the fault. The DISTANCE reading at top provides the distance to the cursor's position- thus, the distance to the fault.
8. The fault found in Figure 10 represents a bridge tap. We can use the TDR to determine the length of the lateral, if necessary. To measure the length:
   a. Press MARKER (F1); you will probably need to press the more (F4) key to find this option.
   b. Use the right arrow key to move the dotted line, marker. Position the Marker at the end of the bridge tap. Refer to Figure 11.
   c. The MARKER reading on the graph shows the distance between the Cursor and Marker (1,693 feet in Figure 11).
9. To look past this bridge tap for other possible faults, either press the ZOOM_OT or PAGE-RT keys.

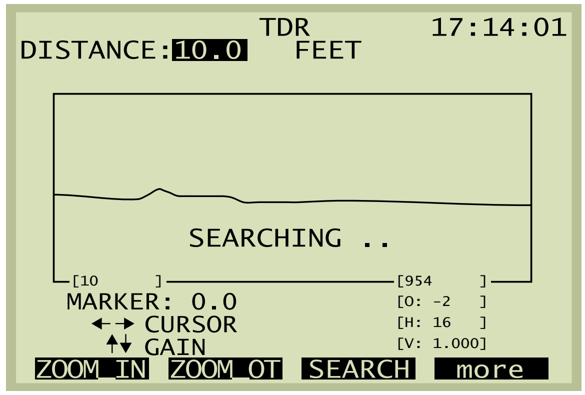

Figure 9 TDR screen, search function

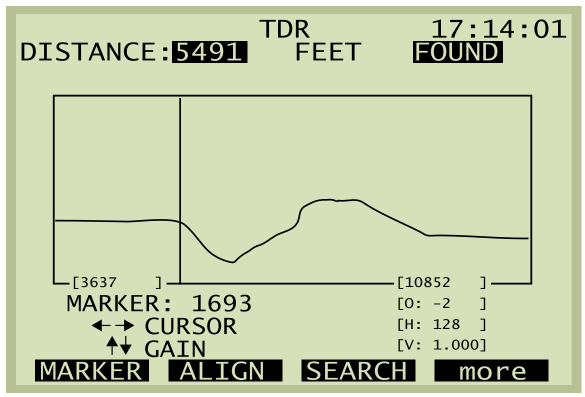

Figure 10 TDR screen, fault found

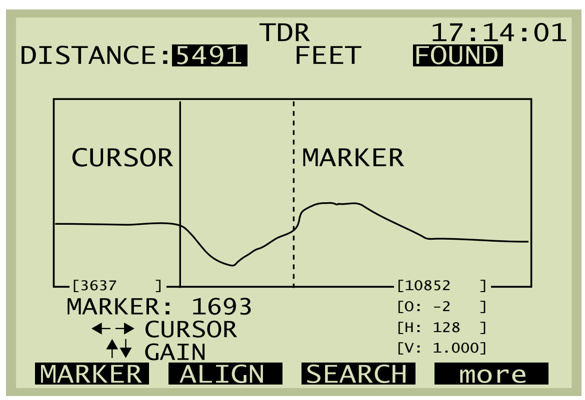

Figure 11 TDR screen, finding the length of a bridge tap

MANUALLY LOCATING FAULTS

Although the SEARCH function is an easy method for locating faults, there may be times when you want to manually control the TDR. Here are some tips for manually locating faults.

Zooming Out

You can adjust the zoom of the screen to scan the entire cable span and then focus in on a potential fault or cable segment.

Upon entering the TDR screen, you can zoom out to view the entire cable span. Press the ZOOM_OT F-key to zoom out. Note the zoom factor (H) below the graph. It ranges from 1 (nearest range) to 512 (farthest out). Zooming out to the maximum value allows you to view the entire span of the cable. The numbers in brackets below the graph represent the length of cable currently displayed on the screen.

After zooming out, scan the display for a potential fault. If you see a potential fault, press the right arrow key to move the cursor (solid line) to the beginning of the fault. Then, press the ZOOM_IN F-key to view the fault more closely. The SunSet zooms in around the cursor location, so it's important to move the cursor to the area you want to view.

Paging Right

Another method for manually locating faults is by pressing the page right F-key. Upon entering the TDR screen, view the first page. The numbers in brackets below the graph represent the length of cable currently displayed on the screen.

Press the PG_RGT F-key to view more of the cable span. You may need to press more (F4) first. Refer to the distance values below the graph. Continue pressing the PG_RGT key until you find a fault or reach the end of the cable.

This is a useful method for finding multiple faults. For example, if you discover a bridge tap on the cable, you can press the PG_RGT key to view the cable after the bridge tap. Remember, you will not be able to look past a short, open, or load coil.

FROM THEORY TO THE FIELD

Here's a recent scenario that helps illustrate the benefits of a TDR when troubleshooting ADSL service. A provider turned up ADSL service using the SunSet ATU-R module. The customer site was 14,500 feet away from the serving central office. When the link turned up, the SunSet displayed a maximum downstream rate of 1.3 Mbps. Typically, they were getting a good 2 Mbps at 15,000 feet. Clearly, there was some fault on this cable pair that was degrading performance.

The technician pressed the MENU key on his SunSet and entered TDR. He started the TDR and with one press of the SEARCH key, discovered a bridge tap about 300 feet away and 250 feet long. There were two key factors to his decision to remove the bridge tap. First, shorter laterals are more harmful than longer laterals for ADSL service. This is due to the fact that there is less attenuation to weaken the reflected signal over shorter bridge taps. Second, the closer a bridge tap is to one of the modems, the more harmful it can be. He decided to remove this bridge tap and the circuit then achieved 1.9 Mbps downstream.

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