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A P P L I C A T I O N N O T E

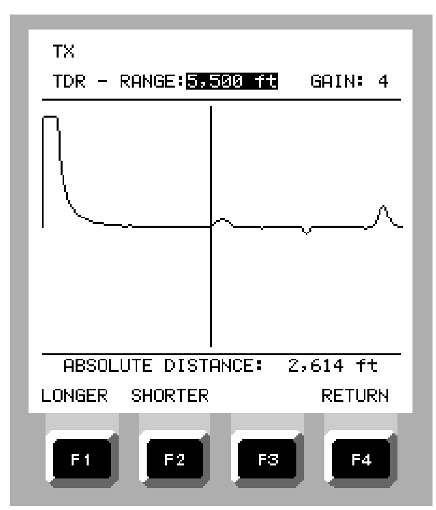
Practical Tips for Using Metalic Time Domain Reflectometers

(The EZ Way)

What is a Time Domain Reflectometer ?

Option 40 for the EZ-TESTER Series includes a metalic time domain reflectometer (TDR) used for locating faults on two-conductor transmission lines. It includes a transmitter that emits a pulse of energy down the cable being tested, and a receiver that detects energy reflected by a fault located somewhere along the signal path. The TDR determines the distance from the testing point to a fault by measuring the time delay between the launching of the pulse and the detection of the reflection. The reflection of energy from the pulse is caused by any changes in the impedance of the cable such as those caused by splices and connectors in the path, shorts between conductors, splits in cable pairs, load coils, water intrusion, and any type of damage that affects the impedance of the line.

The EZ-TESTER Series TDRs display the distance to potential faults with a graphical display, using a horizontal line representing the distance along the cable being tested. Cables without flaws generate a flat trace. When faults are detected, a bump on the trace represents an increase in impedance, and a dip represents a decrease in impedance with the leading edge of the bump or dip representing the relative distance along the line to the fault. The open end of a cable being tested shows up as a large bump on the trace. A dead short in a cable shows up as a large dip on the trace. Faults of lesser degree generate traces with smaller bumps and dips. In many cases, the nature of the fault may be distinguished by subtle differences in the shape of the bumps and dips.

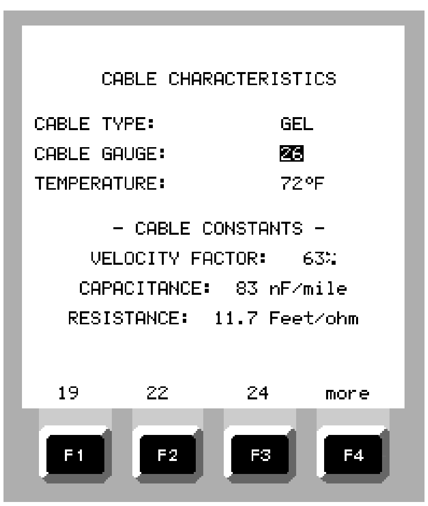


Typical TDR Display

Factors Affecting Accurate Measurements

Factors that affect the accuracy of a TDR measurement include the type of dielectric used in the cable, the gauge of the conductors, the temperature of the cable, the length and shape of the electrical pulse being transmitted by the test set, and the distance the pulse travels. The accuracy of information provided to the test set during setup directly affects the accuracy of the measured distance.

The distance between the TDR and a potential fault is computed by measuring the time delay between the transmission of a pulse and the return of reflected energy. The speed at which the pulse passes down and back along the cable is primarily determined by the manufactured characteristics of the cable and is called the Velocity of Propagation (VOP). The computed VOP uses the speed of light as the reference, with the speed of light being 1 or 100%. A cable with a VOP of .75 can transmit a pulse at at a speed of 75% of the speed of light. Different cables are manufactured with varying electrical characteristics caused by differences in gauge, insulating materials (dielectric), and spacing between the conductors. Each variation affects the cable's electrical impedance which, in turn affects the VOP for that cable. External factors at the time of measurement, such as the temperature of the cable, also affect the VOP and must be taken into account when a TDR measurement is made. The test set provides a setup screen to enable the user to enter this information.

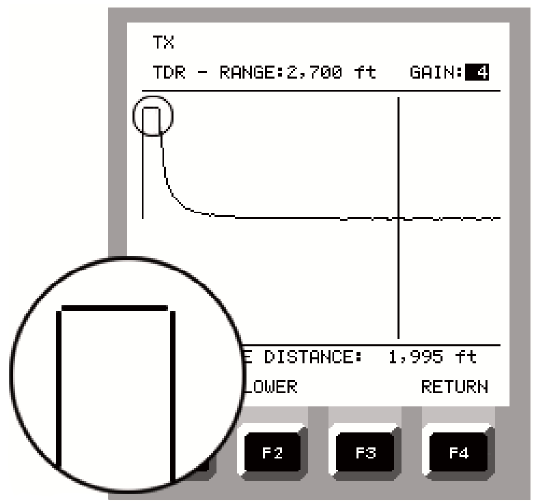


Cable Characteristics Setup Screen

The accuracy of TDR measurements depends on the accuracy of information entered into the test set during setup. The percentage of error in the VOP entry will result in an equal percentage of error in the computed distance between the test set and the fault. To assist the user in making an accurate measurement with the TDR, the test set automatically computes the VOP as the user selects the appropriate cable characteristics on the setup screen.

Range and Resolution

During the period of time that each pulse is being transmitted by the TDR, the receive section of the test set is blind to reflected energy. The blind zone is represented by the flat top of the trace on the left side of the TDR screen as shown in the circled enlargment of the trace below. Following the flat section, the trace drops and curves to the right as the transmitted pulse charges the line.



TDR Blind Zone

The pulse width is designed to be as short as possible for each range setting to minimize the blind zone, however, as the range setting is increased to cover a longer distance along the cable, a wider pulse is necessary to be sure there is enough energy to allow the reflection to return to the test set. The longer range setting also results in a longer blind zone. In the EZ-TESTER Series, the shortest range setting is 750 feet with a blind zone of about 40 feet. The maximum range of the test set is 32,000 feet with a blind zone of about 850 feet.

After the test set has displayed a trace, the user must mark the leading edge of a bump or dip with a movable cursor, represented by a vertical line. The test set determines the distance to the fault by measuring the position of the cursor. The ability of the test set to clearly display the leading edge of the bump or dip is referred to as the resolution. The shorter the pulse, the better the resolution. The longer distance the pulse must travel, the greater the distortion of the pulse. Therefore, the best resolution of the display is obtained, by using the lowest range setting possible. In circumstances when long distance tests are necessary, diminished resolution may prevent the test set from detecting two faults that are close together. When a fault exists on the line, some of the energy from the pulse will be reflected back to the test set and some of the energy will continue farther down the line, possibly allowing the test set to detect and display a second fault. Depending on the severity of the first fault, so much energy may be reflected that the second fault will not be detected.

Tips for Using a TDR

1. Whenever possible, always obtain the manufacturer's specifications for the cable being tested before departing the shop for the test site. Accurate information is essential to accurate distance measurements. Cable conductor gauge and VOP are available from the manufacturer and can often be found on cable spools. Refer to local documentation for cable length so that the far end bump isn't mistaken for a fault.

2. Determine the velocity of propagation (VOP) as accurately as possible before performing the CABLE CHARACTERISTICS setup. If the VOP is not known, test a known length of an identical cable type. Experiment with the VOP setting and perform TDR measurements on the sample cable until the test result matches the known length of the cable, then use the VOP setting on the actual cable being tested.

3. Temperature of the cable being tested affects the VOP. During the CABLE CHARACTERISTICS setup, be sure to include as accurate a temperature value as is practical to improve measurement accuracy.

4. Always break the cable into individual sections wherever possible and test each section separately. Measurements on short sections are often more accurate than measurements made on long sections.

5. Regardless of the length of each section, always start testing with the shortest range setting to improve detection of small faults close to the testing point. The shorter pulse widths have the shortest blind zone and allow detection of close-in faults that may be missed at a higher range setting. When the short range tests indicate no potential problems, increase the range settings one at a time.

6. Whenever possible, test each section from both ends. Potential faults close to the far end may not have been detected due to signal losses, or may be inaccurately measured because of decreased resolution due to long pulse length. By moving to the far end and repeating the tests, those faults may show up more clearly since shorter range setting may be used. Testing from both ends may compensate for an incorrect VOP setting. A single fault that is detected from both ends of the cable may appear to be at two different locations on the line. In this event, compute the midpoint between the two measurements and inspect that position on the cable for the fault.

7. After locating and repairing a fault, always retest the section. The first fault may have masked a smaller fault farther down the line.

8. When a bump or dip is detected, position the cursor to the leading edge, then use the zoom feature to center the cursor. Increase the display gain to sharpen the leading edge, and reposition the cursor for a more accurate measurement.

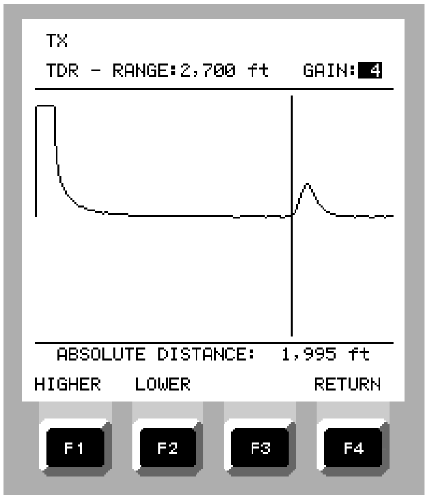
9. Very minor faults at shorter ranges may be more detectable with longer pulse widths. If a 2,500 foot cable appears normal with the tester set to the 2,700 foot range, retest the cable at the higher range settings to generate a stronger reflection.

10. If a fault is suspected within the 40 foot blind zone at the 750 foot range setting, and is not accessible for visual inspection, attach a good section of the same type cable using a good quality connection, and retest the cable. The added section of cable will occupy the blind spot and effectively move the fault onto the usable portion of the trace.

11. Use your technical experience and common sense to recognize discrepancies between test results and your knowledge of the cable being tested. If the displayed distance to a fault is 1000 feet and maintenance has recently been performed at 950 feet, the location of the fault and the location of the maintenance may be the same.

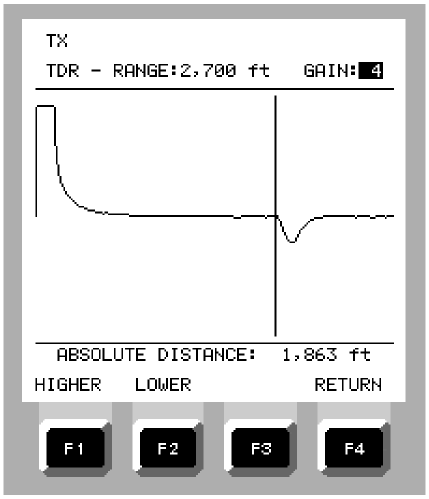
Sample TDR Traces

The TDR screen displays shown in this section are samples of the displays provided by any EZ-TESTER Series test set equipped with Option 40. These displays were selected to demonstrate specific characteristics of a variety of cable faults that may be detected. Multiple faults on a single cable and incorrect data applied during test setup may cause less distinct trace shapes. Experience and care taken by the test set user will enhance the accuracy of the measurement and diagnosis of the fault.



- - NORMAL LINE

The trace for a normal line begins with the initial plateau shape of the blind zone, followed by the drop as the pulse charges the line. The remainder of the trace is flat until the open end of the cable generates the characteristic bump. The sharpness of the bump can be increased by increasing the range setting and gain of the display. It is decreased by longer distances, shorter range setting, lower gain, and by the presence of faults between the test set and cable end.

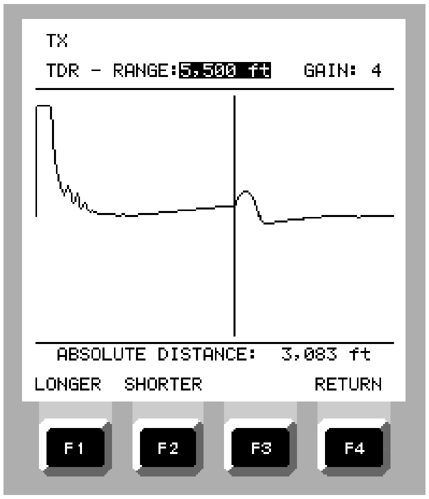


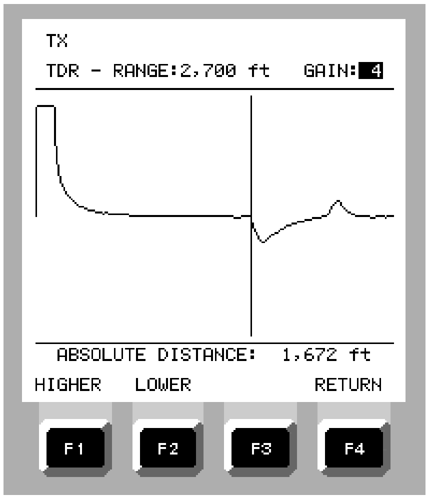
SHORTED LINE - -

A shorted line is displayed as a sharp dip in the trace. In this case, circuit documentation indicates the line is supposed to be 2,000 feet long. Circuit is inoperative and the TDR shows a possible short at 1,863 feet. The short prevents the test set from seeing the open end of the cable. The sharpness of the dip is affected by the same factors that affect the normal line display. Dead shorts are sharpest. Lower resistance shorts may be less distinct.

LOAD COILS - -

Load coils are devices that are used to compensate for higher frequency losses in voice-grade lines over 18,000 feet in length. The first load coil is placed 3000 feet from the central office, and then every 6,000 feet toward the subscriber. The trace resembles that of an open circuit, except that the trace slopes upward toward the peak, the bump is more rounded, and the trailing edge of the bump is lower than the leading edge. A measured distance of about 3,000 feet is also a clue.



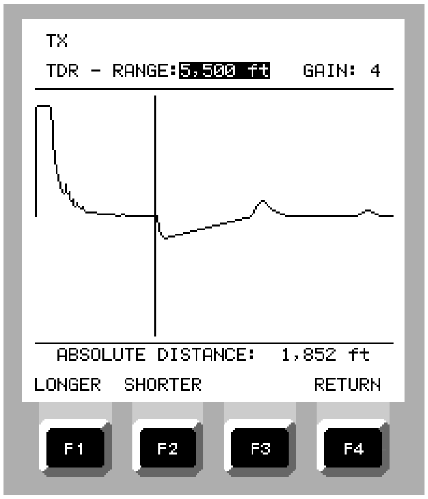


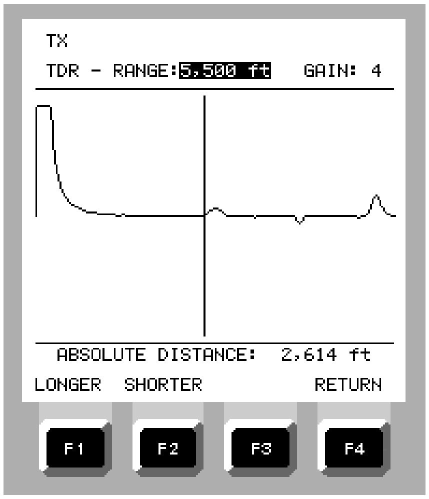
- - WATER INTRUSION INTO CABLE JACKET

A cable suffering water intrusion at a splice can be recognized by a distinctive dip corresponding to the location where the cable enters the water, a curved upward slope toward the normal level of the trace, and a bump where the cable departs the water. Since water absorbs energy very quickly, it's possible that the trace may not show the ending bump or any other changes farther down the line.

BRIDGE TAPS - -

Bridge taps are branches in the line that are usually the result of having a second telephone attached to the original line. The bridged connection changes the line impedance at the connection point and is easily detected by the TDR. A bridge tap closely resembles water intrusion at a splice except that the upward slope is a straight line. Some circuits can tolerate a limited quantity of bridge taps, but it is necessary to know the combined length of the taps. The test set can perfrom a “delta” (difference) measurement to determine the length of each tap by using the cursor to mark the beginning and end of the dip and displaying the distance between both points.





- - SPLITS AND RESPLITS

Splits are wiring errors where a wire from one pair is accidentally connected to a wire of a different pair. Resplits are corrections made farther down the line to correctly match the pairs again. They do not affect POTS lines but will cause problems for digital services. The split and resplit generate a bump / dip pair. The split causes the bump and the resplit causes the dip.

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