

Radiodetection / BicoTest Time Domain Reflectometer (TDR)

Electrical Industry Fault Locating Techniques

NOTES:

- 1) Time Domain Reflectometers (TDRs) are designed to find open circuit faults where no path exists to ground for successful use of an 'A-Frame' type fault locator. They work on the same principle as RADAR. A pulse is transmitted that travels along the cable. Where there is a large change in the resistance of the cable (short or open), some of that pulse is reflected back. The time it takes to come back is proportionate to the distance.
- 2) We have to know the approximate speed of the pulse in the cable, this is known as the Velocity Of Propagation (VOP or VPF). The more accurate we know this, the more accurate our readings will be. Follow the steps below for ways to determine the VOP of unknown cables.
- 3) In some cases, a TDR can be used to minimize the distance to be walked with an A-Frame. If the fault is detectable by an A-Frame (AVO reading below 1 to 2 M ohms), use a TDR to look for features on the cable under test. If you see a suspected fault, connect the A-Frame system in the normal manner but walk directly to about 80% of the distance to the fault reported via the TDR and begin there.
- 4) There are some faults on primary electric cables that will not show up with a TDR. These are what is normally called 'Flashing' faults, where the cable holds say 1000 volts but not 8k or 14k volts. This is caused by a breakdown in the insulation or dielectric of the cable. The TDR is essentially a low voltage test method and does not generate enough voltage to make the cable fail. A 'Thumper' is usually required to find these.

DETERMINING VOP OF UNKNOWN CABLES

NOTE: When determined, adjust the VOP with the 'DIEL+' and 'DIEL-' keys on the TDR.

- 1) **Setup Menu** ('?' key on T631, then 'Cable Type' then 2 for Power Cables). There are three choices here: PILC (paper insulated lead cable); XLPE (cross-link polyethylene); and MIC (mineral insulated cable). These are also the same choices in the chart in BicoTest T631 Operators manual. Add to this chart as you find vales determined in the steps below.
- 2) **Cable Manufacturers Specifications.** Sometimes the manufacturer can provide this information. Write the VOP number and a good cable description in your manual.
- 3) **Sample Length.** Take a known length of the same cable, either a new roll with the length written on it or uncoil a length 50m or 100m is recommended. TDR the cable, set the cursors to the proper positions (one at end of test lead and one at end of cable) then adjust the VOP controls (DIEL) until the displayed length equals the known length. Write the VOP number and a good cable description in your manual. **NOTE: Don't use very long lengths** (more than 1000m) for this test as distances of 2500m+ can read incorrectly.
- 4) **See Far End of Test Cable.** Sometimes you can see the far end of the cable you are testing. Verify it is the far end by shorting the far end and looking for the TDR trace to change. If you see the far end, locate the cable with a cable locator, measure the distance and verify the VOP.
- 5) **Ratio Method.** TDR the fault from both ends. Add the numbers together to find the total reported distance. Take one of the individual reported numbers, divide it by the total reported distance then multiply that by the actual distance between the two ends as measured with a cable locator and utility measuring wheel.

TESTED VALUES:

XLPE concentric primary cable - average 56% (from 50% to 65%) **COMMON SPC type: 57.7%**

XLPE duplex/triplex street lighting cable - average 52% (from 47% to 55%)

PE insulated duplex/triplex cable - about 70% (from 66% to 73%)

PE/PVC 3 or 4 conductor secondary - **common SPC type: 64.1%**

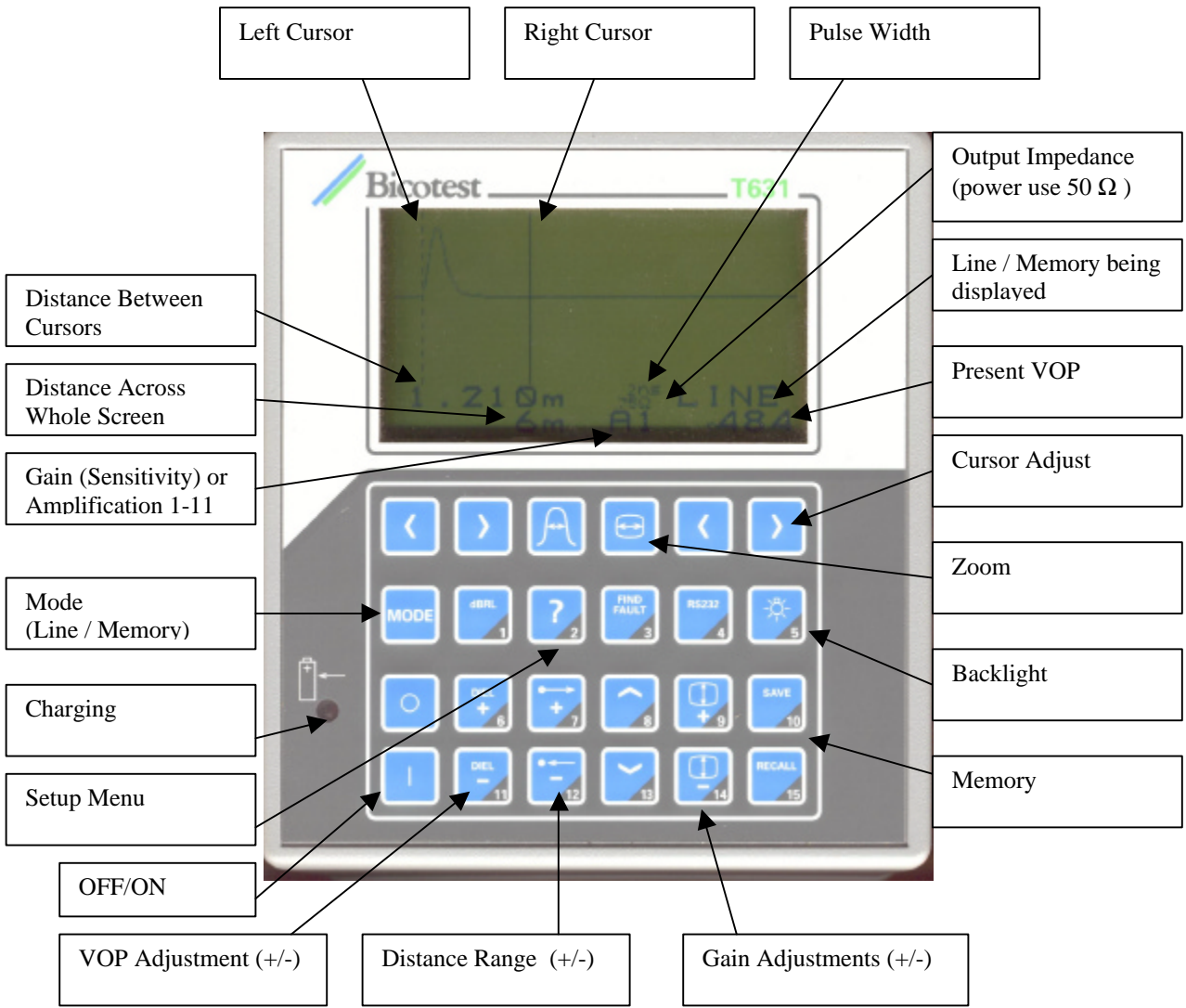
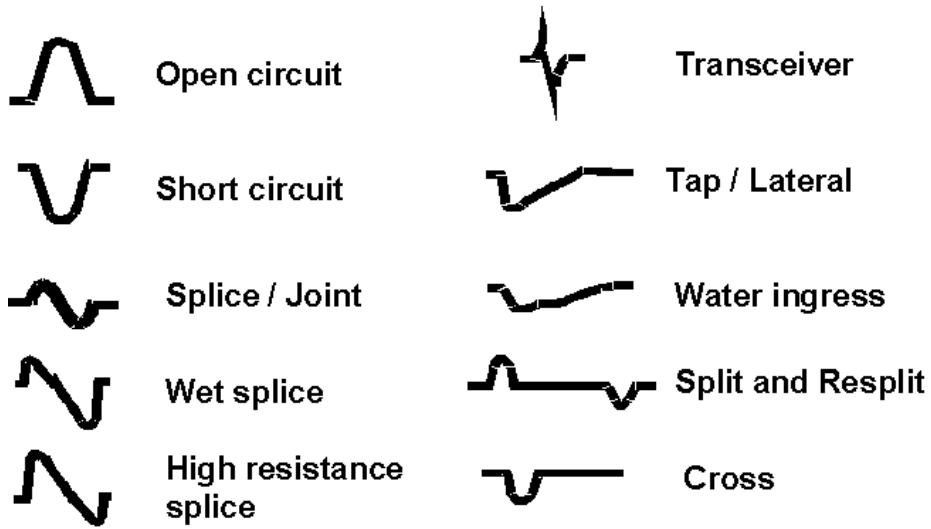
QUICK REFERENCE GUIDE TO USING A TDR

- 1) Disconnect power and open circuit the cable at both ends
- 2) Turn on the TDR with the '| |' key. Set the left cursor at the end of the test leads (upwards reflection with no cable connected) to ignore the length of the test lead. Now the displayed distance is from the cable start to the fault. Connect the TDR to the cable under test.
- 3) Adjust the VOP to the correct value for the cable type you are working on (see other page if unknown).
- 4) Extend the range using the '●—>' key and look for the characteristic shape of a problem (upwards pulse for an open circuit, downwards pulse for a short circuit and a ~ for a splice). **Note:** Expect an upwards pulse at the signal launch and a splice shape at the test lead to cable transition (2-3m out).
- 5) If the reflections are small, increase the sensitivity with the Gain +/- buttons (#9 & #14)
- 6) For more accuracy use the ZOOM key '<=>' to expand the trace. Pushing this button zooms **around the last moved cursor**. The two upper left buttons move the left cursor while the two upper right keys move the other cursor.
- 7) **Don't forget** to include the length in the pole base to the below grade depth (typically 1-1.5m each end).
- 8) If you see multiple reflections have a helper short out the far end (or store in a memory location and do it yourself) and see if an open changes to a short. If you see the far end, measure the distance and verify the VOP. The cable fault will be one of the reflections between the TDR and the far end.
- 9) For more accuracy, also test the cable from the opposite end. Locate that distance and confirm it agrees.
- 10) Use a cable locator and utility distance measuring wheel to improve accuracy.
- 11) TDRs accuracy is entirely dependent on accurate VOPs and correct trace interpretation. This can mean between 0.5% and 5% possible error. 2% inaccuracy over 100m means a 2m hole we may have to dig. An a-frame has 1 foot accuracy, not a percentage so when possible (earth fault) use an a-frame for the final location.
- 12) If there are good and bad phases, connect the TDR to the good phase and store the resulting trace into a memory location with the 'SAVE' key. Then connect the TDR to the bad phase and use the MODE key to work in DUAL mode, showing both the saved trace and the LINE trace at the same time. Look for a large difference between the two.

ADVANCED TOPICS:

Dead Zone: A wide output pulse may 'hide' faults under itself. Use narrow pulses to read in close to the transmitting end. Approximate dead zones are: sub-nS=0m; 2nS=1m; 5nS=2m; 100nS=20m; 500nS=90m

TDR Trace Examples



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