TDR Cable Fault Locator
Model 535 Catalog No 655535

OPERATING INSTRUCTIONS AND APPLICATIONS GUIDE

Refer to inside cover before operating

BIDDLE INSTRUMENTS
510 Township Line Road Blue Bell Pennsylvania 19422
Telex: 83 4423 BIDDLE PMTG Tel: (215) 646 9200

PRINTED IN ENGLAND

SAFETY PRECAUTIONS

BEFORE OPERATING THIS INSTRUMENT, CAREFULLY READ THE SAFETY PRECAUTIONS ON PAGE (2) AND IMPORTANT NOTE ON PAGE (3).

TIME DOMAIN REFLECTOMETER (TDR)

MODEL 535

OPERATING INSTRUCTIONS
AND
APPLICATION GUIDE

SAFETY PRECAUTIONS
PLEASE CAREFULLY READ BEFORE OPERATING.
SAFETY IS THE RESPONSIBILITY OF THE USER

There are minimal safety problems when operating the Model 535 in accordance with the Operating Manual, however, special attention should be given to the following:

ALTHOUGH THE INSTRUMENT IS PROTECTED AGAINST VOLTAGES UP TO 400 V PEAK, IN THE INTEREST OF OPERATOR SAFETY:

- MAKE A SEPARATE VOLTAGE TEST ON THE CONDUCTORS TO BE TESTED BEFORE CONNECTING THEM TO THE INSTRUMENT (NOTE THAT THE INSTRUMENT IS NOT TO BE GROUNDED).
- DO NOT CONNECT THE OUTPUT OF THE INSTRUMENT TO ENERGISED AC CONDUCTORS ABOVE 105 VOLTS. (TESTS ON TELECOMMUNICATIONS AND CABLE TV LINES ARE NOT CONSIDERED A HAZARD.)
- TAKE PRECAUTIONS TO AVOID ANY IMPACT ON THE CATHODE RAY TUBE - AS IMPACT COULD CAUSE IMPLOSION OF THE TUBE.

Interior work on the instrument must be performed by those acquainted with the possible shock hazard of cathode ray oscilloscope circuits therefore routine precautions must be taken to avoid an accident.

Within the instrument there are voltages as high as 2 kV during operation, and such voltages can exist even after the instrument has been switched off.

Do not operate the instrument with the case removed except when following the procedures of the Service Manual.

IMPORTANT NOTE

This instrument is supplied with the internal battery discharged. Before using charge the battery as described in 4.4.

Complete discharge of the internal battery is prevented by a sensing circuit which automatically disconnects the battery when its voltage falls below a pre-determined level, thus rendering the equipment inoperative. In order to restore operation either:

1. charge the internal battery
or 2. operate from the ac supply
or 3. operate from an external 11.5 to 28 volt dc supply

This document does not contain servicing information. A servicing manual is available as an accessory.

LIST OF CONTENTS

LIST OF CONTENTS (Continued)

MODEL 535 TIME DOMAIN REFLECTOMETER OPERATING MANUAL

1. USE OF MANUAL

This Manual is to be used as an aid in the operation of the Model 535 TDR. It should be stored in the instrument lid or in the padded carrying case.

Specifications, Calibration and Maintenance Procedures can be found in the Model 535 Maintenance and Repair Manual.

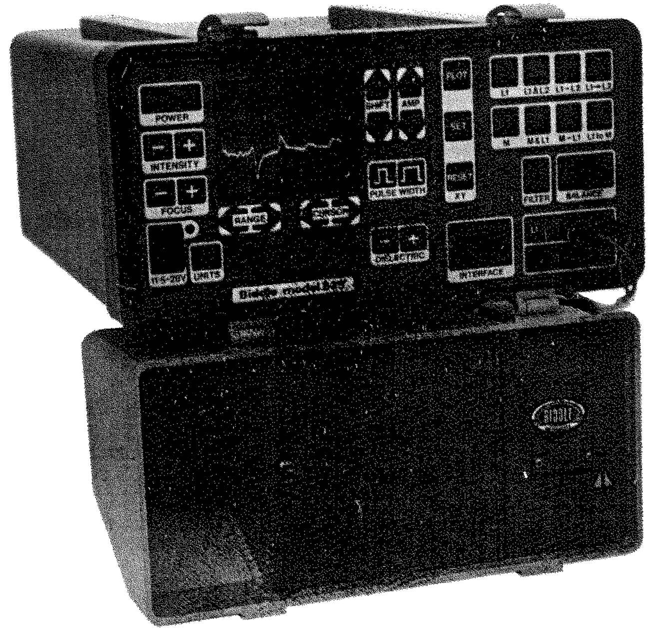


Figure 1. TIME DOMAIN REFLECTOMETER (TDR) MODEL 535

2. DESCRIPTION OF INSTRUMENT

The BIDDLE Model 535, CAT No. 655535 is a long range Time Domain Reflectometer (TDR) also known as Pulse Echo or Radar. It uses the TDR principles to test cables and provides a visual electronic display of the cable under test. It operates by generating a high frequency pulse which is transmitted through the L1 and L2 output jacks into the cable under test.

Reflections of cable discontinuities are displayed on the Cathode Ray Tube (CRT). The distance to any discontinuity can be measured and displayed in Feet, Meters or Microseconds.

The speed of the generated pulse, travelling down the cable, is known as the Velocity or Propagation (Vp) which varies with different cable insulations. The Vp or Dielectric number can be preset on the instrument by depressing the dielectric control.

Note: A chart of common Vp or dielectric numbers is listed on Page No. 21 and for quick reference is duplicated on the lid.

The instrument provides for:

(a) Examination of a single line.
(b) Comparison between a good pair and a faulty pair.
(c) Difference between a good pair and a faulty pair, so that scope reflections cancel from common features such as splices and change of wire gauge or insulation, thus permitting obscure faults to be more readily indentified.
(d) Location of crosstalk points, ie splits and resplits, by transmitting on one pair and receiving on the other.
(e) 'Before and after' comparison using the memory facility.
(f) Several methods of recording the scope reflections including the built-in memory.

This manual provides sufficient information for successful operation of the instrument.

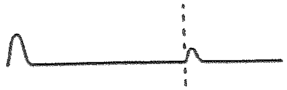
The instrument has been designed primarily for testing telephone pairs, control cables, computer cables, coaxial cables, flat cables and power cables. Ranges are from 30 meters, 100 ft, 0.3 microseconds to 15 km, 50,000 ft and 150 microseconds. Full scale and measurement accuracy is ± 1% of any one of the 10 ranges.

Examples of Displayed Waveforms

HIGH IMPEDANCE FAULT

Transmitted

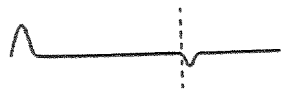
Reflected Pulse
(Fault or cable end)



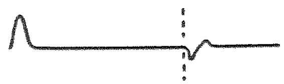
1. Open Circuit or Series Fault

3. Inductive Mismatch

LOW IMPEDANCE FAULT



2. Short Circuit or Shunt Fault



4. Capacitive Mismatch

Pratical examples are given in Section 5

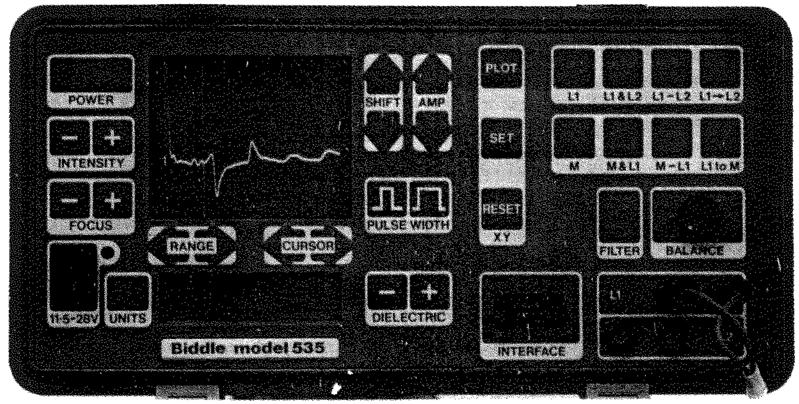


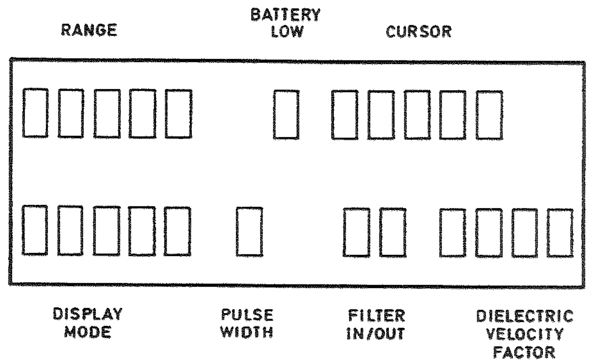
Figure 2 : View of Front Panel

The controls consist of pressure operated membrane switches which are either single operation (SINGLE) only, or single operation with auto repeat if held (AUTO).

POWER	-	SINGLE,	Equipment power ON - OFF.
INTENSITY	-	AUTO,	Varies the brightness of the CRT display.
FOCUS	-	AUTO,	Varies the definition of the CRT display.
UNITS	-	SINGLE,	Selects units of measurement METERS, FEET or MICROSECONDS.
RANGE	-	AUTO,	Selects the displayed range.
CURSOR	-	AUTO,	Adjusts the position of the vertical line cursor.
SHIFT	-	AUTO,	Adjusts the vertical position of the CRT display.
AMP	-	AUTO,	Adjusts the vertical amplitude of the CRT display.
PULSE WIDTH	-	SINGLE,	Selects the narrow or wide pulse available on each range.
DIELECTRIC	-	AUTO,	Selects the appropriate propagation velocity factor (Vp) for the line under test
XY PLOT	-	SINGLE,	Initiates the analog output to an external X-Y plotter or Y-T recorder.
XY SET	-	SINGLE,	Provides the full scale output to the plotter
XY RESET	-	SINGLE,	Terminates the plot resetting output to 0 Volts.

L1	- SINGLE,	Trace from line connected to L1 sockets displayed.
L1 and L2	- SINGLE,	Traces from lines connected to both the L1 and L2 sockets displayed.
L1 - L2	- SINGLE,	Difference between the traces of the lines connected to the L1 and L2 sockets displayed.
L1→ L2	- SINGLE,	Crosstalk between the lines connected to L1 and L2 displayed.
L1 to M	- SINGLE,	Trace obtained on L1 transferred to memory.
M and L1	- SINGLE,	Trace from the line connected to L1 and the trace stored in memory displayed simultaneously.
M - L1	- SINGLE,	Difference between the trace from the line connected to L1 and the trace stored in memory displayed.
M	- SINGLE,	Trace stored in memory displayed.
FILTER	- SINGLE,	Switches in a high pass filter to reject low frequency components from the received signal.
BALANCE	-	Continuously variable control used to minimize the amplitude of the transmitted pulse appearing at the start of the CRT trace.
INTERFACE	-	15 Way D type socket for interfacing with external accessories.
11.5 - 28 V	-	2 Pin socket for dc supply. Associated lamp indicates presence of supply.

LCD - The LCD provides the following information.



The background is illuminated to facilitate use in low ambient light.

4 PREPARATION FOR USE

4.1 Introduction

The front panel lid houses the ac power unit and provides storage for the power supply leads, two 10 foot (3 m) connecting leads, the instruction manual and a 2 pin dc input lead.

The cover also acts as a tilt stand, by releasing the two retaining clips and folding under the unit.

The unit will operate from the internal battery in the absence of any other power supply.

4.2 Operation from an ac supply

Check that the voltage selector on the power supply unit is set to suit the local ac supply.

The dc supply lead to the unit is contained in the middle compartment of the front cover. Release the catch and feed the dc lead through the slot provided and plug into the 11.5-28 V socket.

Connect the ac power lead to the local supply. The 11.5-28 V indicator lamp will light to indicate the presence of the dc supply to the unit.

4.3 Operation from an external 11.5-28V dc supply

A 2 pin dc input lead is available as an accessory. When making connections observe the polarity.

Positive BROWN
Negative BLUE

Neither side is connected to ground.

Connect to a dc supply in the range 11.5 to 28 Volts, insert the plug into the unit and observe that the 11.5-28 V indicator lamp is lit.

4.4 Operation from the internal battery

The Test Set will operate from the internal battery in the absence of any other supply.

Complete discharge of the battery is prevented by a sensing circuit which disconnects the battery when its voltage falls below a predetermined value. If this should happen in use, operation can be restored for a short time by switching off for 5 minutes, allowing the battery to recover, and then switching back on.

The battery can be recharged either from ac or external dc ie vehicle supply.

<u>Recharging from ac</u>

Connect the unit as for ac operation, with the unit switched OFF and allow to change for 14 hours.

<u>Recharging from dc</u>

Connect the unit to operate from external dc, with the unit switched OFF. The battery will charge providing the supply exceeds 12.5 volts ie with the vehicle engine running. Full recharge will take 14 hours, battery can be partially charged from the vehicle supply.

LIST OF PROPAGATION VELOCITY FACTORS

DIELECTRIC SETTING FOR TYPICAL CABLES	
AIR	0.980
AIR SPACED COAXIAL	0.940
- RG 58U	0.780
- RG 59U	0.660
- RG - HIGH TEMP.	0.695
FOAM POLY	0.820
PTFE (TEFLON)	0.710
POLYETHENE (PIC)	0.667
JELLY FILLED POLY	0.640
PAPER (PULP .083 μF/MILE)	0.720
PAPER (PULP .072 μF/MILE)	0.880
PAPER, OIL FILLED (PILC)	0.500-0.560
CROSS LINKED POLY (XLPE)	0.520-0.580
HMW	0.560-0.620

DIELECTRIC SETTING FOR TYPICAL CABLES

5 OPERATING PROCEDURE

5.1 Preliminary Adjustments

Connect the test set to the required power source.

Switch the test set ON by depressing the POWER switch once. Check that the LCD indicates.

The following parameters are automatically set each time the test set is switched on.

Display Mode	L1
Amplitude	Minimum
Pulse Width	Narrow

The settings of the INTENSITY, FOCUS, CURSOR, SHIFT, RANGE, UNITS, FILTER, DIELECTRIC and the contents of the memory will be retained from the equipment's previous operation.

Allow 10 seconds for the CRT trace to appear.

Adjust INTENSITY and FOCUS if required to obtain a well defined trace.

Adjust the SHIFT control to position the trace in the middle of the CRT screen.

5.2 Single Line Testing

Note: The fault distance displayed includes the length of the connecting lead used which should be subtracted from the reading obtained.

The FILTER is used to filter out low frequency components, ie: 50-60 Hz. This has the effect of sharpening up the reflection from long cables. For short cables the filter should be switched out.

1) Plug the test lead into the L1 sockets.
2) Set the DIELECTRIC velocity factor to suit the cable type under test. A list is provided on Page 21.
3) If the cable type or the velocity factor is not known refer to Para 6.2. and then continue with this procedure as appropriate. Select the RANGE to cover the full cable length.

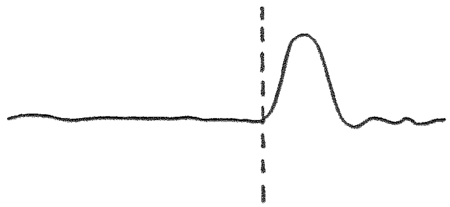
Note: The range can be incremented in single steps by separate operations of the RANGE control, or progressively, by applying continuous pressure to the control. Each time the RANGE control is released, the CRT display is blanked out for a few seconds, while the range selected is automatically calibrated.

Increase the AMPLITUDE until the fault reflection is observed.

Select the wide pulse if preferred.

Adjust the BALANCE control to minimize the transmitted pulse at the start of the trace.

Move the CURSOR either in single steps or progressively until it coincides with the point, at which the start of the reflected pulse just leaves the horizontal as shown.



The distance to the fault (cursor position) is displayed in the top right hand corner of the LCD.

5.3 Comparison of Two Lines

Using both connecting leads, connect one line to L1 and the other to L2.

Select L1 and L2. Both L1 and L2 traces are displayed overlapping on the CRT.

Adjust the controls as for Single Line Testing in Para 5.2.

Select L1 if required to assist in discriminating between L1 and L2.

5.4 Difference between Two Lines

Using both connecting leads, connect one line to L1 and the other line to L2.

Select L1 - L2 control, the trace displayed on the CRT is the difference between L1 and L2.

Select L1 and L2 control or L1 to assist in identifying on which line the deviation occurs.

5.5 Location of Crosstalk (Splits and Resplits)

Connect one line to L1 and the other to L2

Select L1 -> L2 Control

Obtain a display as described in Para 5.2 except that the BALANCE control is inoperative.

Typical Response

Should crosstalk result from any form of resistive or capacitive coupling, the location of the fault point is determined in the same way.

5.6 Use of the Memory

The memory is principally provided to facilitate 'before and after' comparison testing of the same line.

Note: Only the trace of the line connected to L1 can be stored.

To store a trace, connect the line in question to the L1 sockets.

Obtain the L1 trace as described in Para 5.2.

Depress the L1 to M control, the trace displayed is now transferred to memory.

To observe the trace stored in memory, depress the M control. The LCD will indicate M and will also display the stored trace.

The line can now disconnected from the Model 535 and analyzed in a more desired or safe location.

Reconnect the line to the L1 sockets. Depress the L1 and M control if a comparison is desired, both the line and stored traces will now be displayed. The SHIFT control can be used to separate the traces.

If the fault is not obvious, depress the L1 - M control and the difference between the line and stored traces is displayed.

Should the RANGE, PULSE WIDTH, FILTER OR DIELECTRIC be inadvertently changed during the exercise, thus rendering the comparison between the direct and stored trace invalid, the LCD will flash and indicate the parameter in error. Note the indicated error, switch back to L1 and correct the error.

Comparison betweeen the line and stored trace can now proceed as previously described.

5.7 X-Y, Y-T Recording

The output to the external plotter is via the 15 way D type interface plug. The output voltage is 0 to 1 V dc.

EXTERNAL VIEW

OUTPUTS		
X	Pin	15
Y	Pin	14
Common	Pin	7

Note: Only the trace stored in memory can be plotted.

Connect the plotter observing the connections detailed above. Switch the plotter to accommodate 1 volt full scale.

To check the full scale deflection depress the SET control to obtain a 1 volt signal.

Depress RESET to reset to zero.

With the desired trace from L1 displayed on the CRT, depress L1 to M to transfer the trace into memory.

Depress M to check that the trace has been transferred into memory.

To initiate plotting depress the PLOT control.

The LCD will now indicate 'PLOTTING'

The complete recording takes 60 seconds

To terminate plotting at any time depress the RESET control.

Other optional methods of recording are available ie:

Scope Trace Overlays (CAT. No. 653445 Overlays and 653446 Marker

Oscilloscope Polaroid Camera (CAT. No. 655120 Camera and 655321 Hood)

Digital Data Logger (CAT. No. 655437 A)

5.8 RS232/V24 Compatible Interface

5.8.1 Interface Connections

The output is via the 15 way D type interface Plug.

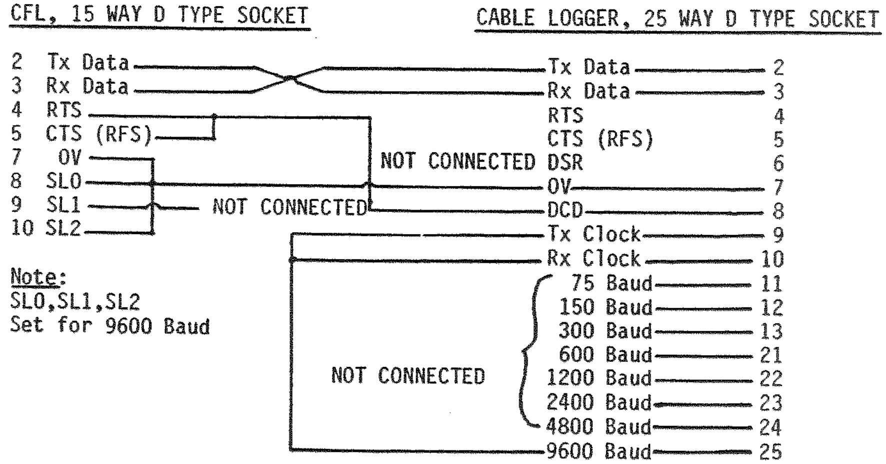
CONNECTIONS

Pin 2 Tx Data
Pin 3 Rx Data
Pin 4 RTS
Pin 5 CTS (RFS)
Pin 7 0V
Pin 8 SL0)
Pin 9 SL1) Link on mating socket to set data
Pin 10 SL2) rates defined in table below.

EXTERNAL VIEW OF PLUG PINS

Data Rate	Link
9600 Baud	8 and 10 to 7
4800 Baud	10 to 7
2400 Baud	8 and 9 to 7
1200 Baud	9 to 7
600 Baud	8 to 7
300 Baud	No Links

Lead between a CFL and a Cable Logger Model 437A



Note:
SL0,SL1,SL2
Set for 9600 Baud

5.8.2 Operation with a Cable Logger (Model CL437A)

INTRODUCTION

The 437A Cable Logger is a portable, lightweight, Battery/ac powered Digital Cassette Recorder which, when used with the TDR allows traces to be stored for future reference

The Digital Cable Logger allows 40 records on each side of a mini-cassette tape (1 record being 1 screen trace and associated information) to be stored on, and recovered from, a mini cassette. This is particularly useful for maintenance assessment, as any degradation or water ingress can be shown by comparing the installation signature recalled from the cassette, with the current cable profile. The comparison facilities on the instrument allow areas of degradation to be quickly and easily identified. Duplicate copies of tapes can be made by using two Cable Loggers 'back to back' or on a one by one basis through the TDR.

Preliminary

Connect the lead as detailed in 5.8.1 between the Cable Logger (MODEM INTERFACE) and the instrument (INTERFACE). Switch both units on.

CAUTION... It is recommended that the Cable Logger is not switched ON or OFF with a cassette in position as this might corrupt any stored data. To record on a cassette ensure that the write enable plug is fitted in the hole in the cassette, corresponding to the side being used. Information on the Cable Logger is given in the Cable Logger User's Handbook.

Recording from the Instrument

Set the instrument to L1, and obtain the desired trace. Press L1 to M on the instrument to transfer the L1 trace to the memory.

Set the instrument to display the Memory by pressing M.

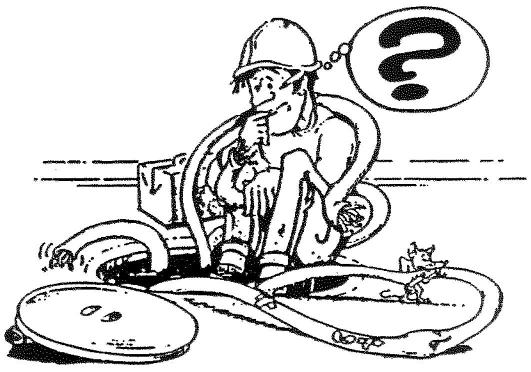
Select a number (1 to 20) on the Cable Logger, to define the record position on the cassette at which the trace is to be stored. Press RECORD control while holding down INTERLOCK.

The memory contents of the instrument will now be recorded on the cassette in the record position selected. When the recording operation is complete, the Cable Logger will indicate STOP. Any incorrect connection, incorrect operation or cassette fault will be indicated by the error light on the Cable Logger. Refer to the Cable Logger manual for instructions.

Replaying to the Instrument

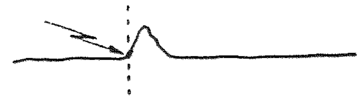
Set the instrument to MEMORY by pressing control M. Enter the desired record number on the Cable Logger. Press PLAY. The record on the cassette will now be found then written into the instrument Memory, and displayed on the CRT. Any incorrect connection, incorrect operation or cassette fault will again be indicated by the error light on the Cable Logger.

6. APPLICATION GUIDE



6.1 General hints on fault locating

The position on the trace to which the cursor is set is the point at which the reflected pulse just leaves the horizontal trace line.



The amplitude of the reflected pulse decreases with increased distance because of signal loss in the cable, and the AMP control should be adjusted accordingly to compensate for the loss.

Multiple faults may or may not be observed. If the first fault encountered is severe, most or all of the pulse energy will be reflected, disguising other possible faults. After clearing the indicated fault, check again to ensure that no other faults are present.

Telephone cables by the nature of their construction produce displays not as 'clean' as for a coaxial cable or power cable. This is why the instrument has the facility for comparing two lines or displaying the difference between two lines so that common reflections cancel.

Whenever possible obtain a second location of the fault from another access point.

Experience has shown that most faults occur at splices, beneath pedestals where water accumulates or where the cable has been damaged due to new construction.

(a) Check in the area of the indicated fault position for any disturbance of the ground.

(b) If the instrument shows the fault position to be close to a splice, the chances are that the fault is at the splice.

Insulation faults with resistance above a few kilohms are more likely to be located by using a high-resistance bridge; unless water is present, when the instrument will locate the change in capacitance caused by the water ingress. Many of these faults are found by placing one output lead on the cable sheath and the other on the entire cable pair or several pairs if necessary.

The instrument will not 'see' through load coils, which appear as high-impedance series faults but tests can be made on either side of the load coil without removing them from the circuit.

The transmitted pulse is subject to high attenuation (loss of signal) in telephone pairs because of the small-diameter conductors used. The smaller the conductor the higher the attenuation and the less the effective range. It may be necessary to go to the next higher range and wide pulse width to be more effective.

6.2 <u>To determine the DIELECTRIC (Velocity Factor)</u>

If the propagation velocity factor (Vp) is not known, it can be calculated from (a), (b), and (c) below, or alternative methods of measurement can be used as in (d) and (e) below. These calculations and measurement methods are described in sub-paras 6.2.1 to 6.2.5 below. Refer to Para 5.2 for the general operating procedure.

(a) Velocity of propagation for the cable known)
) DIELECTRIC
(b) Dielectric constant for the cable insulation known) setting
) can be
(c) Short length of the same type of cable available) calculated

(d) Route length known of a good pair in the same cable

(e) Route length known with both ends accessible.

(f) Both ends accessible, length unknown (3-Stake Method).

6.2.1 Velocity of Propagation Known

Calculate propagation velocity factor (pvf): $pvf = \frac{v}{c}$

where v = velocity of propagation for the cable in m/µs or ft/µs.

c = velocity in free space 300 m/µs or 984 ft/µs.

6.2.2 Dielectric constant known

Propagation velocity factor $= \frac{1}{\sqrt{e}}$

where e = dielectric constant for the cable

Example : For Polyethylene e = 2.25: $pvf = \frac{1}{\sqrt{2.25}} = \frac{1}{1.5} = 0.667$
(PIC Cable)

Set DIELECTRIC control to 667

6.2.3 Short length of same type of cable

(1) Measure the physical length of the sample cable

(2) Set the DIELECTRIC control to any value in the range 0.400 to 0.999

(3) Obtain a reading for the apparent distance to the end of the cable.

(4) Keep the cursor at the point of reflection, and re-adjust the DIELECTRIC setting until the distance on the readout is the same as the physical length, less the distance of the output leads. Note the reading of the DIELECTRIC setting should be recorded for later reference. This setting can be applied to ANY instrument, not just the one on which the measurement was made.

6.2.4 Route length known of a good pair in the same cable

METHOD 1

(1) Connect the instrument to a good pair.

(2) Determine the propagation velocity factor as previously described for a sample length and set the DIELECTRIC control.

(3) Connect to the faulty pair and measure the distance to the fault.

METHOD 2

(1) Connect the instrument to the good pair with any DIELECTRIC setting in the range 0.400 to 0.999 and measure the apparent distance (d_1) to the end of the cable.

(2) Connect the instrument to the faulty pair with the same DIELECTRIC setting and measure the apparent distance (d_2) to the fault position.

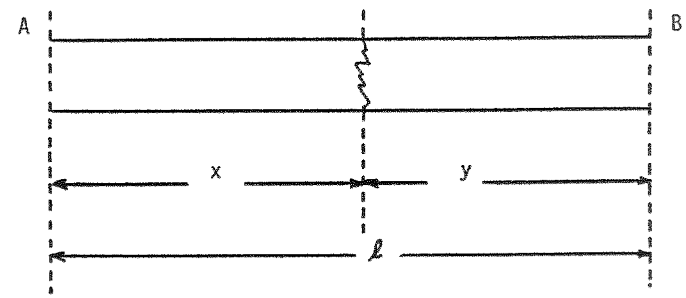
$$\text{True distance to the fault} = \frac{d_2}{d_1} \times \ell$$

where ℓ = true length of the cable

6.2.5 Route length known and both ends accessible

(1) Set the DIELECTRIC to any setting between 0.400 and 0.999.

(2) Measure the apparent distance (x) to the fault from end A and the apparent distance (y) to the fault from end B.



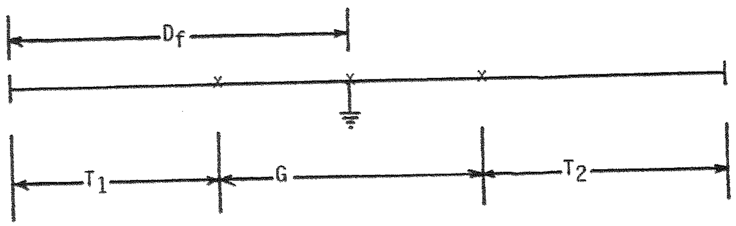
Then distance to the fault from end A

$$= \frac{x}{x + y} \cdot \ell$$ where ℓ = route length of the cable

6.2.6 <u>Three Stake Method</u>

If cable dielectric is unknown and cable distance is unknown, the 3 stake method can be used.

Set Dielectric Control to PIC or any insulation setting and continue using the same setting.



x = Stake or marker.

D_f = Unknown distance to fault.

T_1 = Distance in feet to the first reading. Place first stake at this location.

T_2 = Distance in feet from the far end of the cable. Place second stake at this location.

G = Measured distance between stakes 1 and 2. And complete the following:

$$\frac{T_1}{T_1 + T_2} \times G = C_1 \text{ (Correction Factor for } T_1\text{)}$$

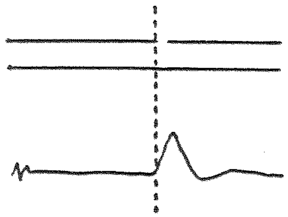
$$\frac{T_2}{T_2 + T_1} \times G = C_2 \text{ (Correction Factor for } T_2\text{)}$$

NOTE: If stakes T_1 and T_2 fall short add the correction factor, however if they over-lap subtract the correction factor

6.3 Practical examples

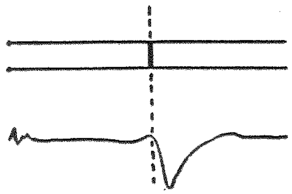
(1) Open conductors

The reflection from an open conductor is a positive or upward pulse. If only one conductor is open the amplitude of the reflection will be smaller.



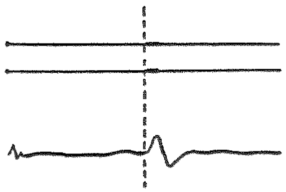
(2) Shorted conductors

The reflection from a shorted pair is a negative or downward pulse.



(3) Splices

A splice produces an 'S' shaped or sine wave reflection.

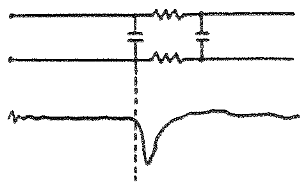


High resistance splice

A high-resistance splice produces a sine wave reflection with a higher positive pulse than the negative pulse reflection.

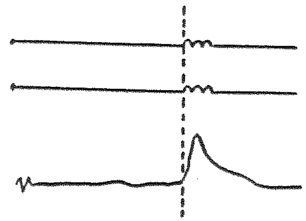
(4) Capacitor networks

A capacitor network presents a low shunt impedance to the transmitted pulse and produces a negative or downward reflection followed by a small positive overshoot.



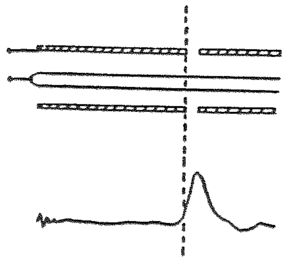
(5) Loading coils

A loading coil presents a high series impedance to the transmitted pulse and positive or upward reflection. It is not possible to 'see' beyond the first loading coil.



(6) Open sheath

An open sheath may be located where the sheath is completely open, for example, where there is a missing strap. The sheath must be isolated in the measuring direction and the test connection made between the sheath and a shorted, twisted pair.



(7) Grounded sheath

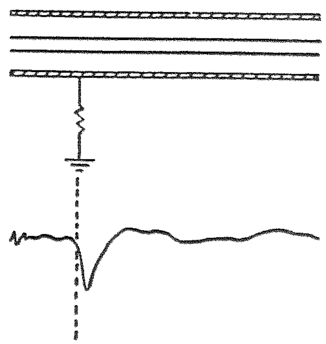
Grounded sheaths are difficult to locate with T.D.R. instruments and may be more readily located by using a high-resistance bridge.

However, in some circumstances where the earth is moist, it may be possible to locate the fault.

Either: (a) connect between the sheath and a pair

or (b) connect between the sheath and ground

In (a) the velocity of propagation is that of the cable. In (b) the velocity of propagation is unknown and the fault can be located by knowing the route length of the cable.



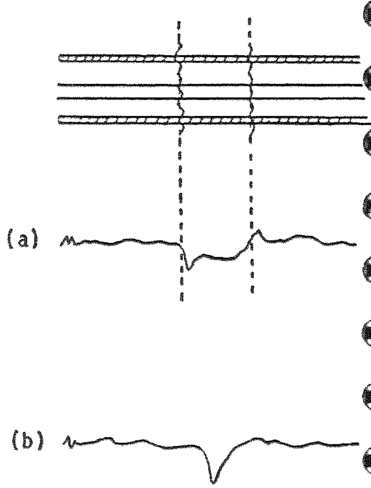
(8) Water Ingress

Water present in a cable increases the mutual capacitance of the cable which restricts the pulse speed.

The water boundary produces a 'noisy' negative reflection, of amplitude dependent upon the degree of saturation, with a positive pulse at the end. See Waveform (a).

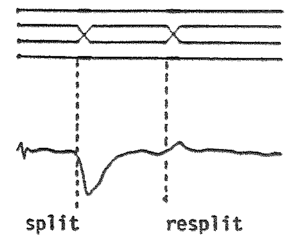
Because the Velocity of Propagation (Vp) is slower in the wet section, for accurate location of the far end of the wet section repeat the test from the other end of the cable. Faults such as open-circuits can often up in the display of the wet section.

Waveform (b) shows a wet splice case.



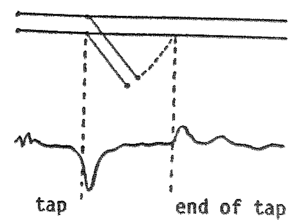
(9) Superimposed or split pairs

The splice at which the split occurs is indicated by a positive reflection. The resplit is indicated by a pulse of opposite polarity, but of smaller amplitude.



(10) Taps

The tap appears as a negative pulse followed by a positive pulse if the tap length is shorter than the main cable. If both the tap length and main cable length are the same length they will cancel out and no tap will be observed. An additional length of cable can be added to either end to overcome this phenomenon.



(11) Change of Cable Insulation

The point at which a change of cable insulation occurs results in a negative or reversed sine wave.

Polyethlene (Vp 0.67) to Paper (Vp 0.54)

Since the velocity of propagation is different for each cable type, care should be taken to ensure that the correct dielectric number (Vp) value is used. In the case illustrated, first select Vp 0.67 for Polyethylene (PIC) cable for an accurate location in the 'Poly' section. Record this distance to the splice and then change the dielectric number to 0.54 without moving the cursor. Record the second number and record the difference.

Move the cursor to the fault measurement 'D' and add the difference measurement. This will provide the correct distance to the fault (D_2) less the test lead measurement.

If the second section of cable run has a dielectric number (Vp) of higher value, the difference number will be subtracted.

6.4 Ghost reflections

It is sometimes convenient to select a range shorter than that necessary to cover full cable length. Under these circumstances it is possible for a reflection resulting from a point beyond the range selected to appear on the display, giving a false indication of a fault. This is referred to as a 'ghost reflection'. It is caused by a reflection resulting from one transmitted pulse occurring during the trace period of the second or a subsequent transmitted pulse.

To identify possible ghost reflections:

NOTE: ALL SIGNIFICANT REFLECTIONS ON A RANGE THAT COVERS THE FULL CABLE LENGTH. WHEN SWITCHING TO A SHORTER RANGE, ANY APPARENT REFLECTION, OTHER THAN THOSE PREVIOUSLY IDENTIFIED, IS A GHOST REFLECTION. SHORT THE END OF THE CABLE IF POSSIBLE AND THE REFLECTION SHOULD DISAPPEAR.

7 SPECIFICATION

Displayed Ranges	10 ranges, nominal full scale based on a velocity factor of 0.667. 0 - 15 Km 0 - 50,000 ft 0 - 150 µS
Resolution	0.4% of selected range
Accuracy	Better than 1% of range selected
Dieletric Velocity Factor	0.400 to 0.999
Fault Location	Set by means of a vertical line cursor.

Transmitted Pulse Characteristics

Waveform	sine squared approx
Amplitude	20 V peak into 100 ohms
Output Impedance	100 ohms

Half Height Width ± 20%

Range	Wide *	Narrow **
1	30 ns	30 ns
2	30 ns	30 ns
3	80 ns	30 ns
4	80 ns	30 ns
5	210 ns	80 ns
6	210 ns	80 ns
7	560 ns	210 ns
8	560 ns	210 ns
9	1.8 µs	560 ns
10	1.8 µs	560 ns

* Pulse width automatically selected with Range selection switch
** Manually selected with 'Narrow' control

Sensitivity

A reflected signal of 3 mV produces a vertical deflection of at least 1 cm.

Balance	Up to 2K ohms.
Line Connections	4 mm banana sockets 19 mm (3/4 inch) spacing
Filter	High Pass cut off frequency 150 kHz

Display Modes

Direct

L1	-	Single Line
L1 and L2	-	Two Lines
L1 - L2	-	Difference between two lines
L1→ L2	-	Transmit on L1 Receive on L2

Memory

L1 to M	-	Transfer L1 to Memory
M	-	Memory trace displayed
M and L1	-	Memory and L1 direct displayed
M - L1	-	Difference between memory and L1 direct traces displayed

Displays

CRT 7 x 5 cm display area

LCD Alpha numeric, two rows of 16 characters.

XY

X and Y axis outputs 0-1 V nominal into at least 5K ohms
Plotting time 60 seconds.

V24/RS232

Via 15 way D type connector
Data transfer rates 300, 600, 1200
2400, 4800, 9600 Baud.

Power Requirements

ac single phase : 93 - 130 V
45 - 440 Hz 186 - 260 V

dc Operating: 11.5 V to 28 V
Charging: 12.5 V to 28 V
Neither side is connected to ground.
Internal Battery: 4.5 hours continuous operation
Recharge in 14 hours.

Dimensions

5.5" D x 11.4" W x 10.2" H (16" H with lid)
(140 x 290 x 260 mm)

Weight

16.5 lbs (7.5 Kg) including battery

Safety

IEC 348 Class 2

Environmental

IEC 68 for field portable test equipment

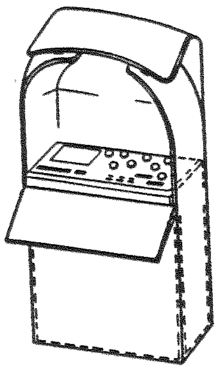
Ambient Temperature

Operating	-25°C to +55°C -13°F to +131°F
Non Operating	-40°C to +70°C -40°F to +158°F

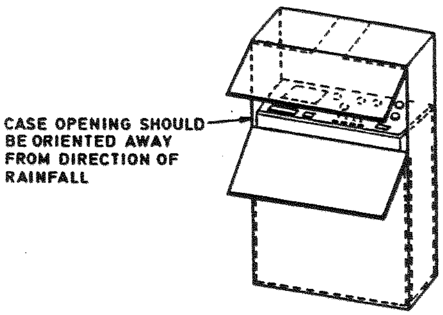
8. **PADDED CARRYING CASE**

CATALOG NO. 655430

The Apparatus bag can be fixed in either of the illustrated positions to improve readability in sunshine or for protection from rain and snow.



FLAP POSITION 1
(SUN SHIELD)



FLAP POSITION 2
(RAIN SHIELD)

9. SERVICING

No attempt should be made to service this equipment other than by personnel acquainted with the hazards of Cathods Ray Oscilloscope circuits. It is strongly recommended that any servicing be performed by BIDDLE INSTRUMENTS.

BIDDLE INSTRUMENTS
510 TOWNSHIP LINE ROAD
BLUE BELL PA. 19422

Telephone 215-646-9200
Telex 83-4423- BIDDLE PMTG
Fax 215-646-9200 Ext. 296