CABLE FAULT LOCATOR
MEGGER® CFL510F (TDR1000/2)

User Guide

MEGGER®

SAFETY WARNINGS

Although this tester does not generate any hazardous voltages, circuits to which it can be connected could be dangerous due to electric shock hazard or due to arcing (initiated by short circuit). While every effort has been made by the manufacturer to reduce the hazard, the **user must assume responsibility for ensuring his, or her own safety.**

For use on energised systems rated up to 300V Installation Category III* the fused clip set AVO Part Number 6111-218, must be used.
* Relates to the transient over voltages likely to be met in fixed wiring installations.

4mm plug to BNC Adaptor:
This 4mm plug to BNC adapter is intended for use with telecomm network cables only, it is not designed or intended for direct connection to an energised mains supply. However, in normal use it may be subject to telecom network voltages (TNV) as defined by IEC 60950 3rd edition (1999-04).

The BNC plug and socket are, by necessity, accessible. The outer sheath for this connector is normally at SELV levels, however under single fault conditions it may carry hazardous voltages. The operator must therefore verify that the accessible plug or socket is at SELV levels prior to touching, or alternatively wear appropriate insulated gloves.

- The instrument should not be used if any part of it is damaged.
- Test leads, probes and crocodile clips must be in good order, clean and with no broken or cracked insulation.
- Check that all lead connections are correct before making a test.
- A Fused Lead Set must be used to connect to energised live systems. Refer to the accessories section for options.
- Disconnect the test leads before accessing the battery compartment.
- Refer to operating instructions for further explanation and precautions.
- Safety Warnings and Precautions must be read and understood before the instrument is used. They must be observed during use.

NOTE

THE INSTRUMENTS MUST ONLY BE USED BY SUITABLY TRAINED AND COMPETENT PERSONS.

Contents

Symbols used on the instrument are:

Caution:Referto accompanying notes.

Equipment protected throughout by double or reinforced nsulation.

Instrument flash tested to 3.7kV rms.

Equipment complies with current EU directives.

Introduction

Thank you for purchasing the CFL510F cable fault locator. Before attempting use of your new instrument please take the time to read this user guide, ultimately this will save you time, advise you of any precautions you need to take and could prevent damage to yourself and the instrument.

The CFL510F is an advanced instrument capable of identifying a wide range of cable faults. The instrument uses a technique called Pulse Echo (also known as Time Domain Reflectometry or TDR). A pulse is launched into a cable from one end. This can be on either a pair of conductors, or a conductor and the screen. The pulse travels down the cable at a velocity determined by the insulation between the conductors and this resistance to the flow of the pulse is characterised as impedance for the cable. Any changes in cable impedance will cause a proportion of the pulse to be reflected.

The pulse velocity is normally described as a fraction of the speed of light and is called the Velocity Factor. By measuring the time between the transmitted pulse and the reception of the reflected pulse, and multiplying this by the speed of light and the velocity factor, the actual distance to the reflection point can be established.

Reflections are caused by changes in the cables characteristic impedance, such as poor joints or discontinuities. Faults showing an impedance higher than that of the cables normal impedance will cause a reflection of the same polarity, i.e.positive, whilst faults with an impedance lower than that of the cable will cause an inverse negative going reflection. Matched cable terminations absorb all the pulse hence no “end of cable” reflection will occur, the cable appearing endless. Open or short circuits will reflect all the pulse and a large reflection will be displayed. At an open or short circuit all the transmitted energy is reflected and the TDR will not ‘see’ the cable beyond that fault.

As a pulse travels down a cable, the size and shape of that pulse is gradually attenuated by the cable. The pulse reduces in amplitude and becomes more elongated or stretched. The level of attenuation (or losses) is determined by the cable type, the condition of the cable and any connections along its length. The limit of how far you can see is determined by the point beyond which you will not be able to see or distinguish a reflection. To help identify small reflections, especially at greater distance the CFL510F has an adjustable gain setting. By increasing the gain small reflections become more obvious.

The CFL510F can be used on any cable consisting of

at least two insulated metallic elements, one of which may be the armouring or screen of the cable. The CFL510F has internal matching networks to allow testing of 25, 50, 75 and 100 cables. (These typically correspond to power, coaxial data and data/telecoms cable). By selecting the TDR impedance closest to that of the cable under test, maximum power can be transmitted into the cable allowing long cables to be tested.

The velocity factor of the TDR must be adjusted to match that of the cable under test, allowing an accurate distance measurement to be read directly from the instrument. Where the VF of a cable is not known, but the length is, the cursor can be set to the end of the cable and the VF on the TDR adjusted until the correct cable length is displayed.

Other configuration settings include changing the distance units between metres and feet, changing the propagation velocity units between a ratio and a distance per microsecond. Display contrast is fully adjustable to compensate for all viewing conditions. A backlight aids viewing in low ambient light conditions.

The instrument can be powered by manganese-alkali, nickel-cadmium or nickel-metal-hydride batteries. All cells must be of the same type.

Battery fitting and replacement

When the low battery symbol  appears in the display window the cells are nearly exhausted and should be replaced as soon as possible. Use alkaline cells IEC LR6 (AA) 1.5V or 1.2V rechargeable cells only.

To install or replace the cells, switch the instrument off. Disconnect the test leads, loosen the battery cover retaining screws and remove the cover. Lift out and disconnect the battery holder.
Replace the cells, ensuring that correct polarity is observed (shown on the battery holder).

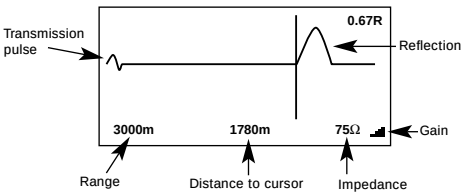
Incorrect battery cell polarity can cause electrolyte leakage resulting in damage to the instrument

Refitting the battery holder is the reverse of removing it.

User controls and display

The controls of the TDR have been arranged such that the instrument is easy to learn and use. The instrument controls consist of the following

Instrument Display: The display shows the user the current settings of the instrument and the reflected energy trace from the cable connected.



T**x Null:** This rotary control allows the user to match the internal balance circuit of the TDR to that of the cable under test. When correctly adjusted the majority of the displayed transmitted pulse can be nulled out, allowing cable features close to the start of the cable to be identified. Refer to section TX Null for further details.

Cursor Left: Moves the ‘distance’ cursor to the left. Auto repeats if held down.

Cursor Right: Moves the ‘distance’ cursor to the right. Auto repeats if held down

User controls and display

Find key: Automatically moves the cursor to the first potential fault (change of impedance).

Power: Pressing this button will turn the instrument on or off depending on its current state.

Range: A bi-directional button allowing range adjustment from 10m (30ft) to 3km (10 000ft) in 6 steps. The bi-directional feature allows ranges to be selected forward and backward, without having to scroll through all the ranges in one direction

Gain: This control is used to increase or decrease the gain of the instrument. This helps the user identify faults over the entire cable length.

Velocity Factor: Adjusts the Velocity Factor (VF) of the instrument to match that of the cable under test.

IMPORTANT: The VF value must match the VF of the cable under test to give an accurate distance measurement.

Menu: Allows the user to change the units of measurement for Distance, Velocity Factor, Impedance and Test Rate. Refer to menu section later in this text.

Backlight: Pressing this button will toggle the backlight on and off. The backlight will automatically switch off after 1 minute

Contrast: Allows the user to manually correct the display contrast to suit local ambient lighting conditions.

Output Sockets: 4mm shrouded sockets designed to accept the leads supplied with the instrument.

Battery cover: Located on the back of the instrument and provides the user with access to the battery compartment. The cover must not be removed while the instrument is switched on or connected to a cable. The instrument must not be operated with the cover open.

General Testing procedure

Ensure the correct test leads are firmly fitted into the sockets of the instrument.

Switch on the instrument. The CFL510F will display the start screen for a couple of seconds, followed by a trace. The instrument will be set to the range and velocity factor last used. If these settings are different for the cable under test (C.U.T) then use the **RANGE** and **VF** keys to set the correct values. Refer also to 'Velocity factor' later in this text.

Connection to Cable Under Test

Connect the test lead to the cable under test. Connection may be made to a live system with a voltage to earth (ground) less than 300V with an installation (over voltage) category of III or lower. This means that the instrument may be connected to any fixed wiring of a building installation, but not to primary supply circuits such as overhead cables.

A Fused Lead Set must be used to connect to energised live systems. Refer to the accessories section for options.

When selecting 25 cable impedance, an internal 50Hz/60Hz filter is automatically switched in.

Measuring distance to fault

Ensure that the whole length of the cable can be seen on the display, and that the range selected is correct.

Find key

The Find key  searches for the furthest major change of impedance. This may be a fault or the end of the cable if this is a short or open circuit.

When found the event is displayed and the cursor placed on the leading edge. The gain, zoom and cursor position may need to be adjusted for accurate measurement. Note that Find does not adjust the TxNull or Velocity Factor.

To enable 'difficult to see' faults to be identified, the gain of the instrument can be adjusted. With the gain at minimum small changes of cable impedance may be overlooked. By increasing the gain the fault becomes more obvious.

If no faults are obvious, adjust the gain until any major reflections appear. Open and short circuits should easily be identified. Partial faults can be less obvious.

If no significant reflections can be seen use the "TX Null" to minimise the effect of the output pulse on any potential "near end" faults (refer to section on TX Null).

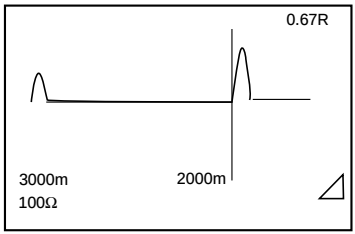
In the event of no reflections being visible, increase gain until any reflection can be easily identified.

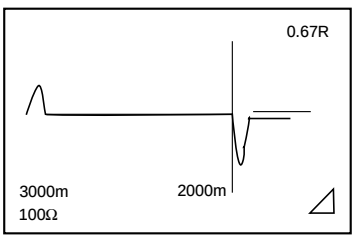
(If no reflections can be seen, try shorting or earthing the far end of the cable to ensure that you are “seeing” the whole length of the cable).

The cursor can also be moved using the LEFT and RIGHT cursor keys. Move the cursor to the beginning of the reflection. The distance to the fault can then be directly read from the display.

NOTE: The distance calculation is performed using the velocity factor set in the TDR. If this velocity factor is not correct for the circuit under test, the displayed distance will be incorrect.

Opposite are shown two typical trace displays. The top shows an open circuit at 2000m away; the second a short circuit at 2000m away.





Instrument Features

Menu

The **Menu** key allows the user to change the units of measurement for Distance, Velocity factor, Impedance and Test Rate.

By pressing the **Menu** key the CFL510F will display:

Distance Unit	m
VF Format	RATIO
Impedance	75Ω
Test rate	1s

To select a function use the GAIN key to scroll up or down the menu.

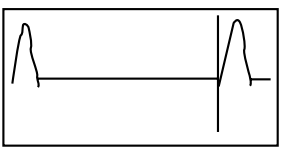
To change the units us the LEFT or RIGHT cursor keys.

Available options	Description	Options
Distance Unit	The Units in which the distance to fault is displayed.	m (metres) or ft(feet).
VF Format	TDR velocity factor (which should be adjusted to match the cable under test)	RATIO, m/us or ft/us
Impedance	Output impedance of the TDR	25/50 75/100
Test Rate	Refresh rate	1/second or 3/second

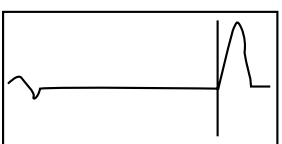
TX Null

Without the “TX Null” control, the transmitted pulse would be visible at the beginning of the trace, swamping any reflections within the pulse length (the dead zone). The ‘TX Null’ circuit matches the characteristic impedance of the cable under test to produce an equivalent pulse. Subtracting this equivalent pulse from the transmitted pulse effectively removes the dead zone from the display and allows “near end” reflections to be seen.

NOTE: In some cases, it may not be possible to completely null the transmitted pulse.



Unbalanced



Balance adjusted

Velocity Factor

The velocity factor is used by the instrument to convert the measured time for a pulse to be reflected, into a distance. It can be displayed as a ratio of the speed of light (eg 0.660 = 66% of the speed of light), or as a distance per microsecond in ft/us or m/us.

If the exact length of cable is known and the reflection from the cable end is visible then an accurate velocity factor can be determined:

- Locate the reflection caused by the end of the known length of cable with the instrument set on the shortest possible range to see the end of the cable.
- Locate the start of this reflection as described in the Operation section of this manual.
- Adjust the velocity factor until the correct cable length is shown.
- Note the VF value for future reference.

The measurement of the distance to the fault can now be made with more confidence. The ability of the instrument to accurately measure the distance to a cable feature relies on the velocity factor being correct. Any errors in the velocity factor are directly related to distance measurement errors.

Pulse Widths

As the RANGE and IMPEDANCE matching of the TDR are adjusted so the duration of the transmitted pulse changes. The pulse widths range from 7ns to 3µs to overcome signal attenuation and enable the instrument to see further down a length of cable. The greater the range selected on the TDR, the wider the transmitted pulse.

The accuracy of the “Distance to fault” is not affected by the length of the pulse. However, if two or more features exist close together (excluding open or short circuits), then the second or subsequent feature may be partially masked by the reflection from the first fault. Hence, for potential multiple features, the instrument should be used with the shortest suitable range, and so the smallest pulse width, that can see both features.

For output pulse characteristics, refer to output pulse data in the TDR Specification at the end of this guide.

Techniques

To improve on the accuracy of the measurement, numerous techniques can be used, depending on the situation encountered. Not every situation can be described, but the following points are effective and the most common and easily implemented methods.

Test the cable from both ends

When fault finding a cable it is good practice to take measurements from both ends. Particularly in the case of open circuit faults, when the true end of the cable is not visible. If the measurement is made from both ends, then the combined answer should equal the expected length of the cable. Even when the true end of the cable is visible on the display, the reflections after the fault may be too obscure to analyse clearly. In this case, measurement from both ends yields a clearer picture as well as improved accuracy.

It is also good practice to follow the cable route with a cable tracer, as not all cable runs will be straight. It can save a great deal of time if the exact route of the cable is known as faults are often found at these points and can be accredited to third party intervention.

Care and Maintenance

Other than replacing the batteries, the instrument has no user serviceable parts. In case of failure it should be returned to your supplier or an approved **AVO INTERNATIONAL** repair agent.

Cleaning the instrument should only be done by wiping with a clean cloth dampened with soapy water or Isopropyl Alcohol (IPA).

Except where otherwise stated, this specification applies at an ambient temperature of 20C.

General

Ranges: 10m, 30m, 100m, 300m, 1000m, 3000m (30ft, 100ft, 300ft, 1000ft, 3000ft, 10000ft)

Accuracy: 1% of range pixel at 0.67VF

[Note- The measurement accuracy is for the indicated cursor position only and is conditional on the velocity factor being correct.]

Resolution: 1% of range.

Input Protection: This instrument complies with IEC61010-1 for connection to live systems up to 300V CAT III. Fused leads must be used if the voltage between the terminals exceeds 300V.

Output pulse: 5 volts peak to peak into open circuit. Pulse widths determined by range and cable impedance:

	25Ω	**50Ω**	**75Ω**	**100Ω**
10m	7ns	7ns	7ns	7ns
30m	20ns	20ns	20ns	20ns
100m	100ns	60ns	100ns	100ns
300m	300ns	120ns	170ns	300ns
1000m	1000ns	520ns	680ns	1000ns
3000m	3000ns	2020ns	2340ns	3000ns

Gain: Set for each range with four user selectable steps.

Velocity Factor: Variable from 0.01 to 0.99 in steps of 0.01

Impedance matching: 25, 50, 75, 100

Tx Null: 0 to 120

Refresh Rate: Selectable from the menu.Once per second or three times a second.

Power Down: Automatic after 5 minutes with no key press.

Specifications

Backlight: Stays on for 1 minute when activated.

Batteries: Six LR6 (AA) type batteries, Manganese-alkali or nickel-cadmium or nickel-metal-hydride cells

Nominal voltage:

9V for Alkali or 7.2V for NiCad.

Battery consumption:

100mA nominal, 140mA with backlight. (20/30 hours continuous use depending on backlight use)

Safety: This instrument complies with IEC61010-1 for connection to live systems up to 300V CAT III. Fused leads must be used if the voltage between the terminals exceeds 300V.

EMC: Complies with Electromagnetic Compatibility Specifications (Light industrial) BS EN 61326-1, with a minimum performance of 'B' for all immunity tests.

Mechanical

The instrument is designed for use indoors or outdoors and is rated to IP54.

Case Dimensions: 230 mm long (9 inches)
115 mm wide (4.5 inches)
48 mm deep (2 inches)

Instrument weight: 0.6kg (1.32lbs)

Case material: ABS

Connectors: Two 4mm-safety terminals.

Test Lead: 2 metres long consisting of 2 x 4mm shrouded connector to miniature crocodile clips

Display: 128 64 pixel Graphics LCD.

Environmental: Operational Temperature:
-15C to +50C (5F to 122F)
Storage Temperature:
-20C to 70C (-4F to158F)

Ordering information

TDR 1000/2			
Included Accessories		**Optional Accessories**	
Test & Carry case with strap	6420-125	Fused prod and clip set	6111-218
Miniature Clip Test Lead Set	6231-652		
User Guide	6172-659		

For use on energised systems rated up to 300V CATIII use the fused prod and clip set AVO Part Number 6111-218, must be used.

AVO INTERNATIONAL

Archcliffe Road
Dover
Kent, CT17 9EN.
England.
Tel: +44 (0) 1304 502100
Fax: +44 (0) 1304 207342

PO Box 9007
Valley Forge
PA 19484-9007
U.S.A.
Tel: +1 (610) 676-8500
Fax: +1 (610) 676-8610

4271 Bronze Way
Dallas
TX 75237-1017
U.S.A.
Tel: +1 (800) 723-2861 (U.S.A. only)
Tel: +1 (214) 330-3203 (International)
Fax: +1 (214) 337-3038

MEGGER SARL
29 Allée de Villemomble
93340 Le Raincy
Paris, France
Tel: +33 (1) 43.02.37.54
Fax: +33 (1) 43.02.16.24

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