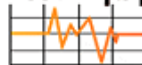


## CFL535F and CFL535P Cable Fault Locator

**User Guide**

**Test Equipment  
Depot**



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Melrose, MA 02176  
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## SAFETY WARNINGS

- This instrument meets the safety requirements of IEC 61010 part 1 to 300V CAT III.
- 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\* use the fused clip set Part Number 2000-151, must be used.

\* Relates to the transient over voltages likely to be met in fixed wiring installations.

CAUTION (Risk of electric shock)

4mm plug to BNC Adaptor:

- This 4mm plug to BNC adaptor 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 3<sup>rd</sup> 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 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 INSTRUMENT MUST ONLY BE USED BY SUITABLY TRAINED AND COMPETENT PERSONS.

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Symbols used on the instrument are:

-  Caution: Refer to accompanying notes.
-  Equipment protected throughout by double or reinforced insulation.
-  Instrument flash tested to 3.7kV rms.
-  Equipment complies with current EU directives.

# Introduction

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Thank you for purchasing the CFL535 cable fault locator. Before attempting to use your new instrument please take the time to read this user guide, this will save you time, advise you of any safety precautions you need to take and prevent damage to yourself and the instrument.

The CFL535 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 transmitted into a cable from one end. Any changes in cable impedance will cause a proportion of the pulse to be reflected. These reflections are displayed as a trace on the instrument.

The CFL535 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.

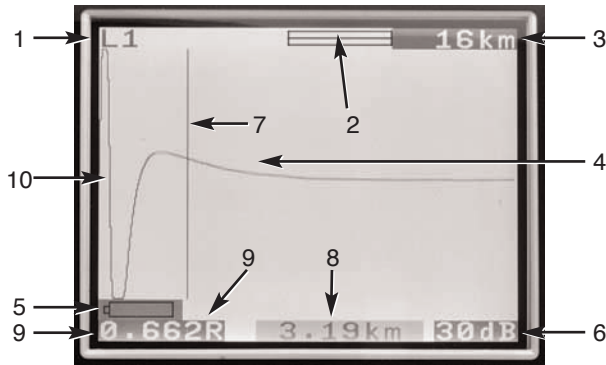
Dual inputs and large graphic display allow a wide range of comparative tests to be performed between cable pairs and/or stored results.

The instrument has 15 memories, enabling test results to be displayed and compared with “live or real time” results.

The download feature allows transfer of waveform data to and from a computer, using the TraceMaster software, for analysis and storage for future reference.

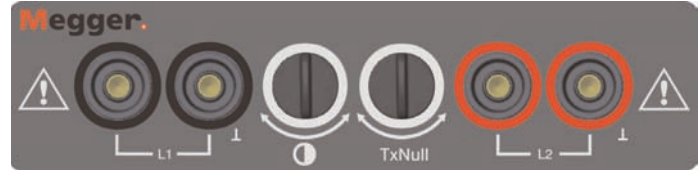
# User Controls and Display

The display and controls of the CFL535 have been ergonomically arranged so that the instrument is easy to use. The displayed information consists of the following:



- (1) Selected channels
- (2) Magnification or Zoom bar
- (3) Range
- (4) Reflected pulse
- (5) Low battery indication
- (6) Gain setting
- (7) Cursor (Distance) bar
- (8) Distance to cursor
- (9) Velocity Factor
- (10) Transmitted pulse

The Instrument controls consist of the following.

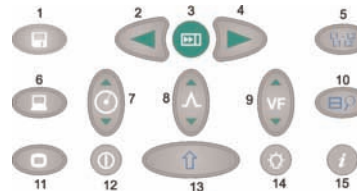


- L1 Input channel 1
- L2 Input channel 2.

\* Only test leads supplied with the instrument should be used.

Contrast: Display contrast adjustment allows the user to adjust the contrast of the LCD Display for optimum viewing comfort.

Tx Null: Allows the user to reduce the amplitude of the transmitted pulse on the displayed trace, allowing reflections close to the start of the cable (normally referred to as the "Dead Zone" to be identified. Refer to the section on Tx Null for further details.



1 Cursor left: Moves cursor left, on the display. Auto repeats if held down.

SHIFT/Cursor left – Dual cursor mode: Press with the SHIFT

---

key to select alternative cursor in dual cursor mode. Press the SHIFT and Cursor key again to swap active cursors.

2 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 hazardous voltage is present.

3 Cursor Right: Move cursor right, on the display. Auto repeats if held down.

SHIFT/Cursor right – Dual cursor mode: Press with the SHIFT key to select alternative cursor in dual cursor mode. Press the SHIFT and Cursor key again to swap active cursors.

4 Velocity factor: A bi-directional key for setting of the cable velocity factor in the range 0.300 to 0.999 of the speed of light. Auto repeats if held down. Refer to the section on 'Velocity factor' for further information.

5 L1-L2 Mode: Selects the test mode by cycling between L1, L2, L1 & L2, and XTALK. The selected mode is shown in the top left of the display screen.

SHIFT/Mode – Difference measurement: (L1-L2 or L1-M1, 2...15)  
To display the difference between two channels the TDR must be in either L1&L2 or L1&M# modes. Press the MODE key with the SHIFT key depressed. The instrument will display L1-L2, or L1-M1.

6 Zoom: The ZOOM key toggles the display between the whole display range and a zoomed in view. This allows more accurate positioning of the cursor bar and hence the distance measured.

The modes are shown as 'normal' and 'zoom' at the top of the display window.

SHIFT/Zoom – Intermittent mode: By pressing the ZOOM key with the SHIFT button held down, the instrument switches to 'Intermittent mode'. While in this mode the CFL will accumulate any transient reflections as a permanently displayed trace. To exit the Intermittent mode press the ZOOM key with the SHIFT button down, or by change the range, gain or mode settings.

7 Help Key: These screens provide help on the use of the CFL535F. Press the help key followed by the function key on which you require help.

8 Backlight key: Toggles back light on or off. Backlight automatically switches off after 1, 2 or 5 minutes (as set in the configuration menu).

9 Gain: A bi-directional key allowing adjustment of the instrument gain from 0dB to 90dB in steps of 6dB. Auto repeats if held down.  
Refer to the Operation section for further details.

10 Shift: Used in combination with other keys to access alternative modes.

11 Range: A bi-directional key which adjusts the instruments measurement range from 16km (48kft) down to 50m (150ft). Auto repeats if held down. A full range of details can be found in the product specification.

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12 On/Off: Switches instrument on and off. The instrument automatically switches off after a default time of 5, 10 or 15 minutes, as set in the configuration menu, or if the battery voltage is too low to continue testing.

13 Menu: Pressing the Menu key displays the instrument menu. For full details, refer to the menu guide opposite.

14 Download/Upload: Initiates the download or upload of stored results between the CFL and the PC. Refer to the section on downloading later in this user guide.

15 Save: Toggles the display between an active display and one of 15 stored memory locations.

SHIFT/Save: Initiates a save routine to store the currently displayed trace. By saving to a memory location, traces can be recalled later.

## MENU

The MENU includes all those settings that would not be accessed in daily use. To enter this mode press the MENU key. (13)

MENU	
TEST RATE	[1/s] [3/s]
PULSE WIDTH	Dependant on range, refer to specification
PULSE HEIGHT	[3V] [5V] [14V]
AVERAGING	[x1] [x2] [x3] [x4] [x5]
ZERO (ns)	[0ns to 50ns in steps of 1ns]
POWERDOWN	[5min] [10min] [15min]
DISPLAY (min)	[1min] [2min] [5min]
LANGUAGE	[ENGLISH, ...]
VF UNITS	[RATIO] [m/us] [ft/us]
DISTANCE UNIT	[m] [ft] [ns]
50/60 Hz FILTER	[ON] [OFF]

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## MENU definitions:

**Test Rate:** This sets the screen update rate to once per second or three times per second.

**Pulse Width:** This option allows the user to override the default pulse width set by the instrument for a particular measurement range and select an alternative pulse width.

(See the Instrument Specification at the end of this user guide for full details on the pulse options for each measurement range).

**Pulse Height:** Three pulse heights options exist. 3V, 5V and 14V. 14V is not available when the instrument test range is less than 400m.

**Averaging:** When trying to locate cable features when a high gain is required, any noise on the Cable Under Test (C.U.T) will be amplified as well as the reflected pulse. This noise may make accurate location of the cable feature more difficult. To overcome this, the instrument has the ability to average two or more results. Any noise will be reduced. Options of 1x, 2x, 3x or 4x over-sampling can be set in the MENU.

**Zero (ns):** This setting enables the zero point of the instrument to be set at the end of the test leads, so the test lead length is automatically deducted from any distance calculation. The nominal zero point setting for the standard test leads is 20ns, however to zero non standard test leads proceed as below:

- 1 Set the instrument measurement range to 50metres.
- 2 Enter the MENU (key 13)
- 3 Set the Distance Units to ns.
- 4 Set the ZERO (ns) to 0.
- 5 Press the MENU key again to exit the configuration menu.

- 6 Select display mode L1
- 7 Measure the time (in ns) to the ends of the test leads.  
To identify this point on the trace open circuit and close circuit the end of the test leads and note the distance.
- 8 Enter the MENU again (key 13).
- 9 Set the ZERO (ns) to the measured time.

All measured distances will now be shown relative to the end of the test leads.

**Power down:** Allows the user to set the automatic power-down to 5, 10 or 15 minutes after the last key press.

**Display:** Switches off the backlight after a pre-defined period, 1, 2 or 5 minutes.

**Language:** This allows the user to select the language required, from English (default) to French, German, Spanish, Italian. Other languages can be downloaded from the Tracemaster CD supplied with the instrument.

**VF Unit:** The velocity factor (VF) can be displayed as a ratio of pulse speed to the speed of light, or as a distance per microsecond in either feet or metres. Refer to the Velocity Factor section for more details.

**Distance Unit:** The distance to cursor measurement can be displayed in metres [m], feet [ft] or in time, eg [ns].


**50/60Hz Filter:** If ON, a power supply frequency filter is switched on.

# Operation

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## Battery Fitting and Replacement

### For **CFL535**


When the battery low 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.

### For **CFL535FR / CFL535 FM**

When the battery low symbol  appears, switch off the unit. Connect the Battery charger to the TDR charger socket. Switch on the Charger. Allow 14 hours to fully charge the CFL535.

## Initial Power Up and Configuration

The first time the CFL535 is switched on the operator will be asked to choose a language. There are five languages (English, French, German, Spanish and Italian) stored in the instrument. The selected language will become the default language for the instrument.

A sixth language is 'user definable' and can be uploaded from the Tracemaster CD.

### Uploading languages

In Tracemaster:

Select **UPLOAD LANGUAGE FILE** from the **OPTIONS** menu  
Select a language and press **OPEN**.

On the instrument:

Connect the communication lead from the serial connector of the CFL to the serial port of the PC.  
Switch on the CFL535  
Press **UPLOAD/DOWNLOAD** key

The selected language should now transfer to the CFL535.

# Using the TDR2000


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Switch on the instrument. The CFL535 will display the AVO logo for a few seconds, followed by a trace. Set an appropriate RANGE and Velocity Factor (keys 11 and 4) for the cable to be tested. Refer to 'Velocity factor' later.

## 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.

## Measuring distance to fault

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 Tx Null or Velocity Factor.

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

To enable 'difficult to see' faults (small reflection) to be identified, the gain of the instrument can be adjusted, key (9). With the gain at minimum small changes of cable impedance may be overlooked. by increasing the gain the fault becomes more obvious. Adjust the gain until all major reflections can be easily identified.

Using the CURSOR LEFT and CURSOR RIGHT keys (1 and 3) move the cursor to the start of the first reflection. To position the cursor more accurately, press the ZOOM key (6) to zoom into the current cursor position. The cursor is now fixed and using the cursor keys, the trace will move relative to that point. The current zoom location with respect to the whole trace range is shown at the top of the display. The distance is then directly read from the display.

## NOTES

Cursor: All distance measurements are made to the vertical cursor. By moving the cursor left or right the distance displayed will increase or decrease.

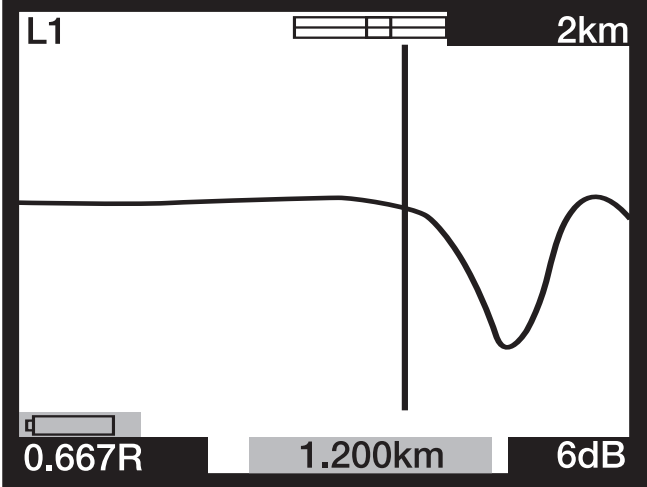
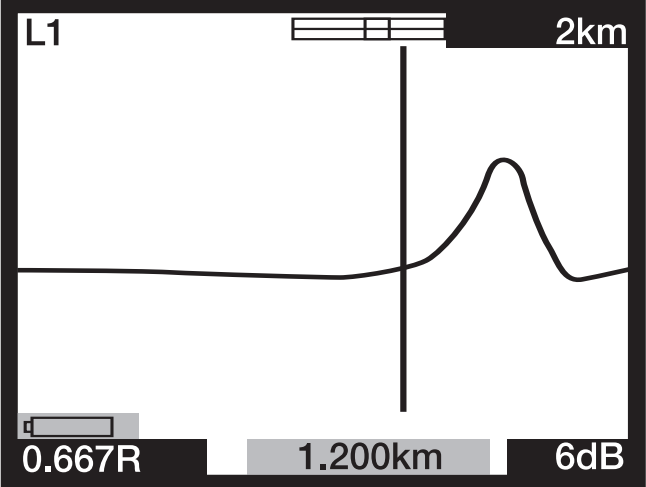
Dual cursor: Enabled by pressing the SHIFT and CURSOR LEFT key or SHIFT and CURSOR RIGHT keys. In dual cursor mode, the distance to the active cursor is displayed together with the difference between the two cursors.

If no significant reflections can be seen use the "Tx Null" adjustment to minimise the effect of the output pulse on any potential "near end" faults. (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 distance to the fault can then be directly read from the display.

NOTE: The distance calculation is performed using the velocity factor (VF) set in the CFL. If this velocity factor is not correct for the cable under test, the displayed distance will be incorrect.

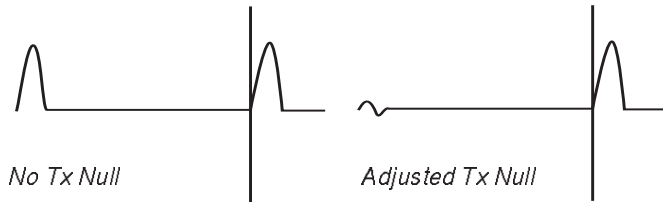
Below are shown two typical trace displays. The left trace shows an open circuit at 1.200km away; the second, a short circuit at 1.200km away.



# Instrument Features

## 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 will be impossible to completely null the transmitted pulse.

Alternatively, using the L1-L2 mode, where L2 is connected to a known good length of the cable under test, L2 is used instead of the balancing circuit to automatically null the transmitted pulse. In this case only the difference between the good line and the bad line will be displayed.

## 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 velocity factor of the cable under test (C.U.T) is not known, it may be accurately established by:

- Testing a known length of cable, locate the reflection for the end of the cable on the display. Use the shortest possible range setting.
- Use the ZOOM button to accurately position the distance cursor.
- Adjust the velocity factor of the CFL using the VF key (4) until the CFL displays the correct length of cable.
- Make a note the VF value for future reference.

The table of velocity factors in the HELP pages of the instrument is a rough guide and in practice, the settings are subject to many variable factors. By using the previous procedure on a known length of cable, a more accurate VF can be established.

The measurement of the distance to the fault can now be made with more confidence that the measurement will be correct. 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 proportional to distance measurement errors. Hence, the instrument uses the velocity factor to three decimal places to reduce any errors.

## Pulse Widths

As the RANGE of the CFL is adjusted (Key 11) so the duration of the transmitted pulse changes. Each of the instrument ranges has a default pulse width. The pulse widths vary from 7 ns to 16  $\mu$ s. The greater the range set on the CFL, the wider the transmitted pulse.

At short range, a short pulse width will have good resolution. As

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the test range increases, cable attenuation prevents distant faults from being seen.

The default pulse width can be changed. To change the pulse default width, refer to the menu section of this user guide.

#### Pulse Height

Three pulse height options are available: 3V, 5V and 14V pk-pk, although 14V pulses are not available when the instrument test

range is less than 400m. By increasing the pulse height the displayed reflections are larger hence easier to identify. However, large pulse heights may 'skip' faults, especially those close to the instrument.

#### Trace Storage (M1 to M15)

The CFL535 has 15 memory locations, which can be used to save traces. These may be stored for future analysis or downloaded to the TRACEMASTER software for analysis on a PC. Each memory location stores the graphical trace along with the test parameters, gain, range and mode settings.

#### Saving a trace

With the desired trace visible on the display, hold down the SHIFT key together with the SAVE key.

The display should display a memory location in the top left corner of the screen and 'SAVE MODE'.

With the extensive dual trace and difference modes available to the CFL535, memory locations can be used as comparisons for live traces. This is useful if the known good cores that would normally be used in the L1-L2 mode are too far away from the C.U.T. Instead, a memory trace of a known good cable can be compared against the C.U.T.

#### Recalling a trace

From any of the display modes L1, L2, L1&L2, etc, press the SAVE key. The instrument will display the trace in memory location M1 or other previously selected location. The range and gain settings are also recalled.

To scroll through all memory locations, press the UP or DOWN arrow on the GAIN key (9).

A recalled trace can be compared with L1 by pressing the MODE key. Press SHIFT and MODE together to switch between displaying L1&M and L1-M. The range, gain and pulse width are recalled and automatically set to the stored values, and it will not be possible to change these when showing a stored trace. However, the cursor can be re-positioned, ZOOM mode selected and the velocity factor changed so that full analysis of the stored trace may be made.

To exit trace recall mode press the SAVE key.

#### Downloading to a PC

To download the stored trace to a PC, connect the CFL535 to the PC using the null modem download lead, supplied with the instrument.

To set the instrument to data transfer mode, hold down the SHIFT key (10) and press the PC key (14). The CFL535 is ready to send or receive data.

Run TRACEMASTER on the computer and set to receive data (refer to your Tracemaster help file for full details). All stored traces will be copied to the computer. The stored trace can be annotated and kept on file for future reference.

## Techniques to improve accuracy

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### Uploading from a PC

To upload a trace to the instrument using the TRACEMASTER software the procedure is the same as downloading.

To set the CFL535 to data transfer mode, hold down the shift key (10) and press the UPLOAD/DOWNLOAD key (14). The CFL535 is ready to send or receive data.

To set Tracemaster to transfer data, refer to the TRACEMASTER help file.

To improve the accuracy of a 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.

For accurate location and before undertaking any tests the route of the cable under test should be known. It should be remembered that cables are not straight as they twist/uncoil during installation and they are often coiled at either end..

If the route is unknown, tracing it may also give you an indication of any third party damage – however this in itself can be misleading!

### 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.

## Care and maintenance

Other than replacing the batteries, the instrument has no user serviceable parts. In the event of failure the instrument should be returned to your supplier or an approved Megger repair agent.

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

## Specification

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

### General

Ranges: 50m, 100m, 200m, 400m, 1km, 2km, 4km, 8km, 16km, (150ft, 300ft, 600ft, 1200ft, 3000ft, 6000ft, 12000ft, 24000ft, 48000ft)

Resolution: 0.1m (4inches) up to 200m/600ft  
0.2m up to 400m/1200ft  
0.1% of range above 400m/1200ft

### Measurement Accuracy:

0.1% of Range

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

Input Impedance: 120Ω

Input Protection: 300V CATIII working.

Output Pulse Amplitude: Nominal 3V, 5V and 14Vpk to pk into an open circuit

### Pulse width user selectable:

50m range:	<u>7ns</u>	20ns	40ns	60ns	80ns
100m range:	<u>7ns</u>	40ns	60ns	80ns	100ns
200m ranges:	<u>7ns</u>	40ns	80ns	140ns	200ns
400m range:	<u>40ns</u>	80ns	160ns	200ns	400ns
1km range:	<u>80ns</u>	160ns	260ns	500ns	1s
2km range:	<u>160ns</u>	260ns	500ns	<u>1μs</u>	<u>2μs</u>
4km range:	<u>240ns</u>	500ns	<u>1μs</u>	<u>2μs</u>	<u>4μs</u>
8km range:	<u>500ns</u>	<u>1μs</u>	<u>2μs</u>	<u>4μs</u>	<u>8μs</u>
16km range:	<u>1μs</u>	<u>2μs</u>	<u>4μs</u>	<u>8μs</u>	16s

(Default pulse width for each range underlined)

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Gain: 0 to 90dB in steps of 6dB  
Velocity Factor: Variable from 0.300 to 0.999 in steps of 0.001  
Tx Null: 0Ω to 120Ω  
Test Modes: L1, L2, L1-L2, L1&L2, M, L1-M, L1&M  
Screen Update Rate:  
Once per second or three times per second, (user selectable).  
Power Down:  
Automatic after 5, 10 or 15 minutes with no keys pressed, (user selectable).  
Communications Port:  
RS-232C compatible  
1 start bit, 8 data bits, 1 stop bit and no parity, 19200 baud standard  
Internal Memory:  
Storage capacity of 15 waveforms and data  
Batteries:  
CFL535F Eight LR6 (AA) type batteries, manganese-alkali or nickel-cadmium or nickel-metal-hydride cells.  
CFL535FR Nominal voltage: 12V for Alkali or 9.6V for NiCad and NiMH.

## BATTERY CHARGER

Supply voltage:

European Version	230Va.c.	10%	50Hz
North American Version	115Va.c.	10%	60Hz

Safety:

This instrument complies with IEC61010-1 for connection to live systems up to 300V CAT III with fused leads

## EMC

The instrument will comply with EN 61326-1, classified as 'class B'. If connected to a live domestic power supply, the operation of this instrument could cause interference with other equipment connected to the same supply. To reduce this interference, select the lowest voltage and narrowest width pulse as consistent with accurate measurement.

## MECHANICAL

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

Case Dimensions:	250 mm long 200 mm wide 110 mm deep
Instrument weight:	1.5kg (3.3lbs)
Case material:	ABS
Connectors:	Two pairs of 4mm safety terminals. 9 way D-type connector for serial communication.

# Accessories

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Display: 320 x 240 pixel eight colour backlight LCD.

## ENVIRONMENTAL

### **CFL535F/CFL535P**

Operational Temperature: -15°C to +50°C (5°F to 122°F)

Storage Temperature -20°C to +70°C (-4°F to 158°F)

Humidity <95% at +40°C non-condensing

## Included Accessories

Test and carry Pouch	6420-114
Serial data lead	25955-025
Carry Strap for Pouch	6220-611
Tracemaster software	6111-458
User Guide	6172-663
“Bed of Nails” Test lead set (see note 2)	6231-655
Battery Charger	See Supplier

## Optional Accessories CFL535F

Fused lead set (see note 1)	6111-218
Optional Accessories CFL535P	
Fused lead set (see note 1)	2000-151

(1) Two lead sets required for 2 channel measurements.

(2) Only supplied with the North American version.