INSTRUCTION MANUAL

TEMPO
COMMUNICATIONS

TV220E and TV220EX CableScout™

Time domain reflectometer (TDR) for

cable TV & other types of metallic cables

Read and **understand** all the instructions for use and safety information before you use this tool. To see the latest updates about this product and its software visit www.TempoCom.com.

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Preface

Description

Tempo Communications Inc. has designed the TV220E and TV22EX CableScout™ Time-Domain Reflectometers (TDR) to aid telecommunications technicians and troubleshooting experts in the outside-plant cable TV and other applications using coaxial and other cables. The uses for this tool include fault identification, fault location, cable installation and cable maintenance. Many customers utilise these TDRs for testing other cable types too, including leak detection wires in insulated pipelines, structural monitoring cables, twisted pair cable (LAN, industrial control and telecoms and signalling) and various antenna cables. The TV220E is easy to use, precise and can characterise cables up to 5.58 km (18.3 kft, at Vp=0.93) in length.

Safety

Safety is essential in the use and maintenance of Tempo tools and equipment. This manual and any markings and indications on the tool including warnings in the software user interface, supply information for avoiding hazards and unsafe practices related to the use of this tool. Observe all the safety information provided. For use by trained personnel only.

Purpose of this Manual

The purpose of this manual is to familiarize you with the safe operation and maintenance procedures for the TV220 CableScout Time-Domain Reflectometer.

Keep this manual available to all personnel. The latest manuals are always available for download from our website. We aim to keep this manual up to date with software changes.

Warranty

Tempo Communications Inc. warrants to the original purchaser of these goods for use that these products will be free from defects in workmanship and material for one year. This warranty is subject to the same terms and conditions contained in Tempo Communications Inc.'s standard one-year limited warranty.

For all Test Instrument repairs, contact Customer Service at +1 800-642-2155 and request a Return Authorization. Or complete the form at: www.tempocom.com/returns.

For items not covered under warranty (such as items abused, dropped, soaked or older than one year), a repair cost quotation is available upon request.

Note: Prior to returning any test instrument, if possible, check that the batteries are charged to no more than 60% and follow any instructions given by Tempo's customer support including those for lithium-ion battery shipping.

All specifications are nominal and may change as design improvements and software updates occur. Tempo Communications Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

Do not discard this product or throw away!
For recycling information, go to www.TempoCom.com.

Important Safety Information

SAFETY ALERT SYMBOL

This symbol is used to call your attention to hazards or unsafe practices which could result in an injury or property damage. The signal word, defined below, shows the severity of the hazard. The message after the signal word provides information for preventing or avoiding the hazard.

DANGER

Immediate hazards which, if not avoided, WILL result in severe injury or death.

WARNING

Hazards which, if not avoided, COULD result in severe injury or death.

CAUTION

Hazards or unsafe practices which, if not avoided, MAY result in injury or property damage.

WARNING

Read and **understand** this manual before you use or service this equipment. Failure to understand how to safely use this tool could result in serious injury or death.

WARNING

Electric shock hazard:

Contact with live circuits could result in severe injury or death.

EX	⚠ **WARNING**
	Fire / Explosion hazard: Do not use this tool in an explosive atmosphere. Failure to heed this warning could result in severe injury or death.

	⚠ **CAUTION**
	Electric shock hazard: • Use only the supplied power/charger adaptors for TV220E. • The power/charger is not weather sealed. Do not expose to moisture. • Do not use the charger if there is any visible damage to the enclosure or cable. • Avoid using TV220E (or open TV220EX) in a very wet environment. Damage may occur. TV220EX is fully dust and weather sealed when tightly closed for transport.
	Servicing: • There are no user serviceable parts within TV220E, do not disassemble. • Contact Tempo's Support Team (details below)
	Wireless: • Wireless options are available for TV220E in select markets. • Where available these are compliant with local regulations; operation of the wireless features in any other location may cause interference to others and may be illegal.

Note: Throughout this manual the term TV220E will normally refer equally to the TV220EX. Where we mention specific TV220EX features, then we will use TV220EX.

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How to Use this Manual

Firmware Version Described

2024-08-20: Application 1.2.7

Note that Tempo aims to keep this manual up to date with the software versions available but there can always be minor differences between the functions described here and those in any later version of firmware available for TV220E/EX.

Tempo Communications use a policy of continuous improvement, and you may notice changes to some operations because of software updates or instrument options. If this copy of the instructions appears out of date, visit the product page at www.tempocom.com to download the latest edition and update your product.

Chapter Summaries:

1. **Test Wizard & Automatic Event Detection**
   Instructions and description of the automatic event detection system. The quickest and easiest way to test a cable.
2. **Controls, User Interface & Connections**
   Location and description of buttons, softkeys, touchscreen functions, and connections
3. **Setting Up**
   Detailed descriptions of how to set up the instrument to test a cable and information on each of the different tests that TV220E can perform.
4. **Testing a Cable**
   Detailed instructions on the three ways that TV220E can be used to check a cable, including TestWizard (quick and easy), Auto TDR (most parameters are controlled automatically) and Manual TDR (for those who want full control of settings).
5. **Cable Library**
   Instructions on adapting the cable library of the TV220E to best suit your work.
6. **Saving and Loading Traces**
   How to save traces to internal memory and how to transfer these to a PC for further analysis.
7. **Maintenance**
   Instructions for the care and feeding of your TV220E.
8. **Specifications**
   Details of the performance of TV220E
9. **Glossary**
   Explanations of technical terms used in this manual.
10. **Tips and Tricks for Effective TDR Test**
    Background information on how to make effective TDR measurements and detail on the theory and physics applied to this function.

Chapter 1. TestWizard

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Chapter 1. TestWizard

TestWizard is the quickest and easiest way to evaluate a cable and to find events. Set some parameters and the TV220E then automatically assesses the cable and displays a trace with the significant events marked.

The automatic event detection system is designed for use on cables with well controlled impedance, such as coaxial cables. But it may work for you on other types; try it.

We place this section of the manual ahead of everything else because as an inquisitive technician we know you will power the unit up and want to try it. Please do continue to read the full manual after trying this, as there are several other functions and helpful features, often unique to Tempo's TDRs, that we promise are not hidden from you but that you may not be aware of without instruction.

Start Here – Initial Settings for Auto Mode

There are some simple things best done before using the unit: Please refer to chapter 2 to find the various controls and ports on the TV220. But after charging the battery (ideally to 100%) and powering on the unit, we recommend that you first enter the settings (see chapter 3) and **set the time and date and local time zone** before clicking on the TDR "app".

The TDR app will normally start up in "auto" mode from the factory, but if your unit has been used by someone else then you may need to switch to "auto" mode: If the status of the unit is "Manual"; press that icon or the button below it (f1), then press the icon "M > A" or (f2).

Choose the correct cable type using the "cables" icon or (f2), see chapter 5.

You access TestWizard from the TDR screen by pressing on the middle function button with the "wand" icon or (f3). You will now see a screen like this:

The event detector must be set to “on” or “auto” to use. When “on” this will highlight events only on the visible window worse than the chosen threshold. When set to “auto” this will highlight the “n” worst events on the entire length of cable, up to the working range chosen.

Now set the working range to a sensible distance for the cable you are testing, doing this ensures the algorithm does not waste time looking for events beyond the practical end of the cable.

It is then most common to choose to show event severity as “Event Return Loss” (ERL) that takes into consideration the approximate loss of the cable between the TDR and the event.

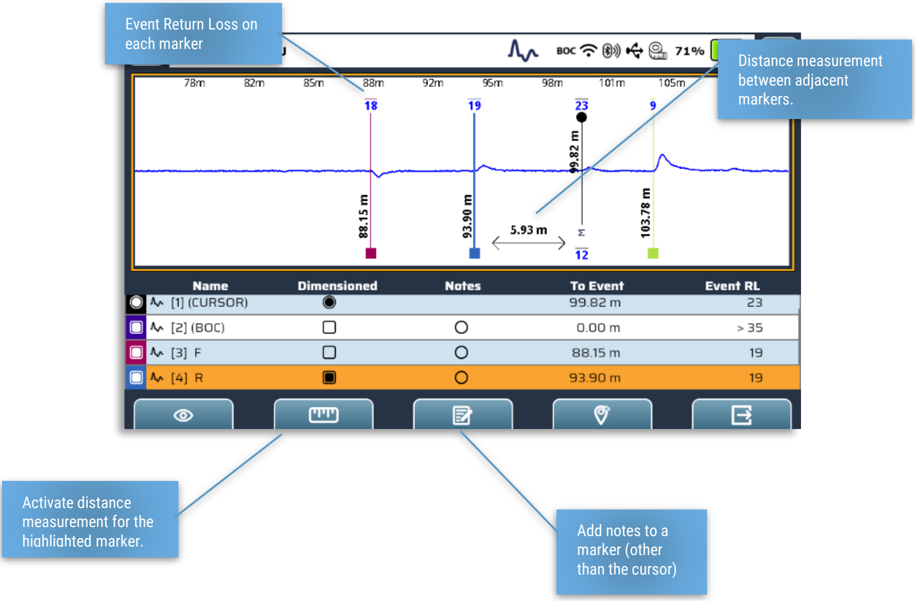
Next choose whether to show the single worst event, up to three or all events that exceed the event threshold.

In “on” mode only, the event-threshold is adjustable in decibels of return loss or event return loss as chosen earlier. These are negative decibels (we omit the minus sign for simplicity) therefore larger numbers are smaller events, see chapter 10 for more details about return loss, reflection coefficients and decibels. An ERL of 0dB, for example, means all (100%) of the energy reaching a point in the cable is being reflected (e.g., a complete open or short will have an ERL of approximately 0 dB).

Press the “exit” icon or (f5) to leave the event detector setup window.

Testing & Checking Event Details

Now that the event detector is active and you have exited the TestWizard setup menu, you may see events highlighted on the detail trace and in the overview window. To see more detail about the highlighted events and to make measurements tap on the “markers” icon (f4). You will see a screen like this:



Chapter 2. Controls & Connections

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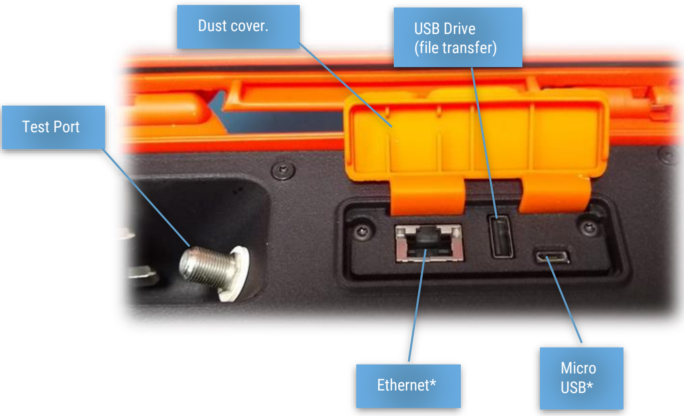
Chapter 2. Controls and Connections

Connections

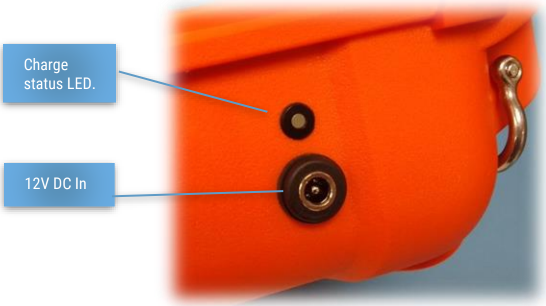
TV220E

TV220EX



* Ethernet and micro-USB connections are currently for factory use only.

You charge TV220EX using the 12V dc port on the right-hand side of the unit. The status LED is alongside. Red for charging, green for full. This simplifies charging with the unit closed.



Controls

We describe the TV220E controls and their typical use in this section of the manual. There may be more detail about the specific functions of any control in a specific mode in the section of the manual that describes that function. All controls are pushbuttons.

Power Button

You use the power button to wake the unit from standby and to return it to standby state by using a short press of about a second. The button will illuminate blue as the unit powers up or down. The TV220E wakes up with the same state as when you placed it into standby.

A long press (>30 seconds) of the power button will force a full power down. Use this ONLY if the unit is “locked up.” Please report this to Tempo customer services so we might be able to update any bugs found.

Menu Button

The “hamburger” menu button (≡) is active when in TDR mode and provides quick access to the following:

- Return to the “home” screen.
- Screenshot saving.
- Backlight brightness.
- Test display type.
- Units
- Vp type

Help Button

You press (?) help to request context relevant information about the current display and functions. You can scroll through the presented information using the cursor keys or by dragging on the screen. Press (?) help a second time to clear the pop-up information window and return to the screen below.

Cursor Keys & Enter Button

When on the opening screen you can use the cursor keys and “enter” button to select the desired “app”. In other screens and sections, the functions vary between highlighting markers or cables and selecting them to selecting and adjusting parameters. Refer to the “help” for each screen for specific details.

Softkeys (function buttons f1 to f5)

The five softkeys across the bottom of the display allow you to select the functions which vary from mode to mode and function to function without touching the screen (perhaps you are wearing heavy gloves, or your fingers are dirty). Descriptions of the softkeys are written in the online help for each screen.

Display

The TV220E uses a full colour LCD with capacitive touchscreen overlay. The resolution of this is 1024x600 pixels. The top line of the display conveys the status of the instrument and has “home” and “menu” touch-buttons in the left and right corners. These navigation functions are also accessible via the keypad, with the “home” function being the default function if the physical menu (≡) button is pressed.

The status line conveys the following information (left to right):

1. Home (⌂) button
2. Cable type selected (or “custom”)
3. Trace type selected (below it shows “saved trace)
4. Filename of any loaded trace (dimmed if that trace is not currently visible)
5. Beginning of Cable (BOC) marker status
6. Wireless status (whether Wi-Fi or Bluetooth are enabled)
7. USB drive status (connected or not)
8. Measurement range limit or not
9. Battery status
10. Menu (≡) button

In TDR mode, the upper trace area shows detail, whilst the lower trace shows an overview of the entire cable alongside four “parameter” buttons. The area highlighted in the “overview” trace is the area shown in the “detail” window above.

The five softkey/function buttons, which are described above, span the lower edge of the display.

Connectors

12V DC Power

Use this port with a 12V dc source to charge the unit (see specifications for exact requirements and limits). The unit can be run whilst charging but be aware that there is no electrical isolation between the test port and the 12V source and noise may be induced on measurements, therefore this is not recommended.

75Ω Test Port

This connector is a 75-ohm, F-type male bulkhead, normally supplied with a “replaceable” F-F (female to female) “barrel” adaptor fitted. This is the port you will connect to the cable under test to. The “barrel” adaptor is present to protect the test instruments own connection from excessive wear and tear. It is normal to connect to this using a short patch cord; a “beginning of cable” marker can be set to the end of your patch cord (see markers).

	⚠ **WARNING**
	Electric shock hazard: Contact with live circuits could result in severe injury or death.

If you have any doubt about the safe isolation of or voltage present on the cable you are about to test, use a suitably rated voltmeter to check before connecting the TDR. TV220E’s test port is protected from electrical damage up to 400V peak, DC, and low frequency AC (see specifications); it is not isolated from ground and not rated for direct connection to hazardous voltages (e.g. mains power) at any time.

USB Type A

This port allows you to connect a USB drive to move files on and off the TV220E.

Micro USB Port

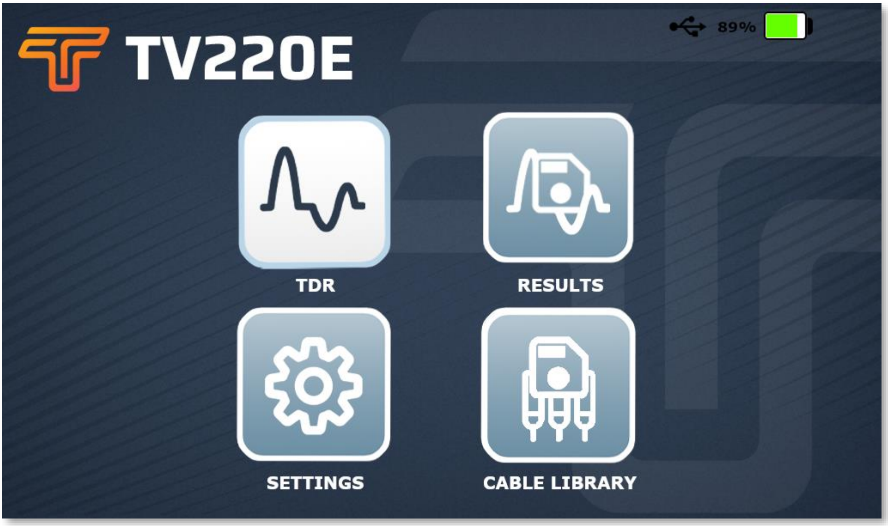
This is currently unused.

Ethernet Port

This is currently only used in production.

Getting Started

After charging the TV220E and then powering it up with a press of the power button, you will see the “home screen” like this:



These four icons on the “Home” ⌂ screen represent the main applications of the TV220E. You can tap them on the touchscreen, or you can use the cursor keys to select one then press the enter key:

1. TDR: the main application of the unit.
2. RESULTS: select this to manage result files on your unit or to copy them to or from a USB drive.
3. CABLE LIBRARY: select this to manage the list of cables you normally use and to copy that to and from a connected USB drive.
4. SETTINGS: configure TV220E the way you want it to behave:
    a. General settings
    b. TDR
    c. Date and time.
    d. Information about the unit and its firmware

Tip: We suggested that you set the date and time as soon as you receive your unit. All saved results will be saved with the date and time therefore this will help you tie results to your work.

If you do not see the above screen when you first power on, tap the “home” icon in the top left of the screen or press the “menu” button (three horizontal lines) and choose the “home” icon and press “enter” (center of the cursor keypad).

Accessories

Straps

Both TV220E and TV220EX kits have a shoulder strap. You can attach this to the two shackles on the back of the TV220EX or to the stainless pins either side of the rear connection plate of the TV220E.

To remove the shoulder strap, squeeze the sprung barb of the hook and manipulate the hook off the pin or shackle.

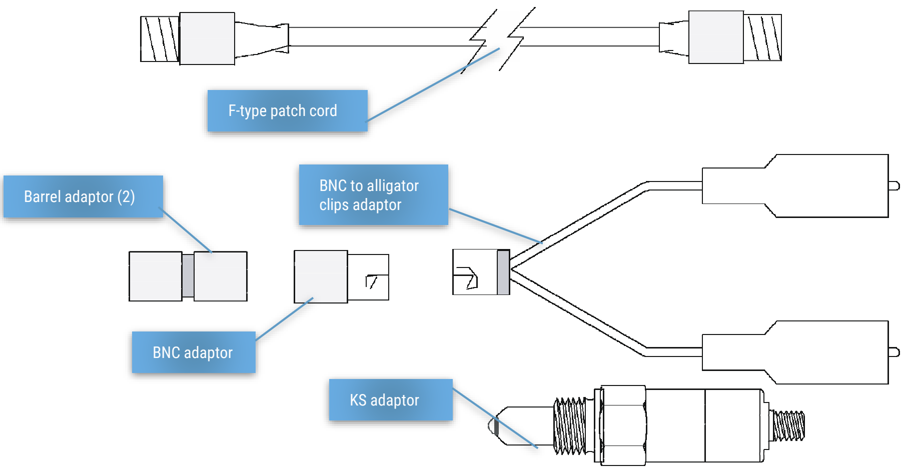
Carry Bag

Tempo supply TV220E with a carry bag. This carry bag has its own shoulder strap that can be attached to the large D rings either side of the top opening.

Test Accessories

TV220E and TV220EX kits have the following accessories:

- One two metre “quick-connect” F-type male to male patch cord.
- One BNC male to F-type female adaptor,
- Two F-type, female to female “barrel” adaptors (one fitted to the unit’s test port, the other spare),
- One BNC female to two alligator clips adaptor.
- One F-type female to “KS” test port adaptor.



Chapter 3. Setting Up the Instrument

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Chapter 3. Setting Up

After selecting “SETTINGS” from the home screen you can configure the TV220E as you would like. Use the f1 to f4 keys or the icons above them to choose which section you would like to configure, f5 exits the settings screens back to the home screen.

General Settings

Here you can set:

- Backlight level.
- Backlight timeout (minutes)
- Sleep timeout (minutes)
- Power down timeout (days)
- Wireless functions*
- Event Marker Text Size
- Language ~

* Where available

~ Note: English & German as of July 2024. Further languages are in development.

Backlight Level

The brightness of the backlight can be set from 1% to 100%. At its brightest the display can be readable in bright sunlight. But beware that the backlight at this brightness becomes the largest user of energy in the unit and the battery will drain more quickly. We recommended that you reduce the brightness of the backlight to maximise use of available battery energy, 10 to 20% brightness is adequate in most indoor locations.

Backlight Timeout

To help save power, after the chosen number of minutes of inactivity, the TV220E automatically reduces the backlight brightness, to save power. As soon as you tap the screen or press a button the backlight will return to the chosen brightness.

Sleep Timeout

After the chosen number of minutes of inactivity, TV220E will enter a “sleep state”. This is the normal “standby” state that you can select by pressing the power button for about half a second. When in the sleep state TV220E will consume approximately 1% of its battery capacity every 24 hours. While in the sleep state, the unit will check its battery level every 24 hours and should the battery level drop below approximately 10% then the unit will enter the “power down” state (off).

Power Down Timeout

To help save the battery from becoming exhausted, should you not use the unit for the chosen number of days or weeks (perhaps a vacation) then the TV220E will enter the full "power down" (off) state. When in the "off" state the use of the battery is minimal and can remain usable for many months.

Tip: To force the TV220E to fully power down, if you are not using it for some time, press and hold the power button, for over twenty seconds, until you see the blue backlight of the power button turn off. The unit is then powered off.

Rebooting from fully powered off will take three to five minutes, while restarting from standby takes approximately eight seconds.

Wireless

Select here to open another window where you can enable Wi-Fi or Bluetooth communications. See "Tempo Report Writer Enhanced."

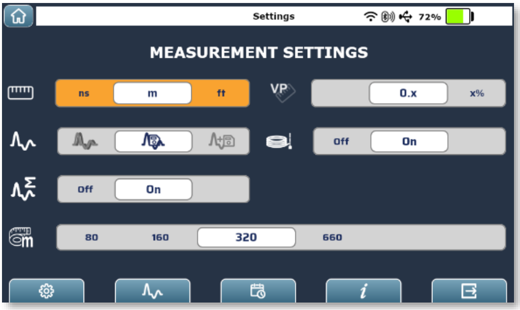
Event Marker Text Size

This choice allows three sizes for the text associated with event markers on the TDR trace: small, medium and large. This only affects the distance and return loss measurements displayed alongside and above the marker. Note that the display may become more congested with larger fonts selected and many markers displayed close to each other. Zoom in to "separate" the markers if this happens or reduce the font size.

Language

Choose your preferred working language here. This will change the names on buttons and the content of the "help" screens.

Measurement Settings



Here you can choose:

- Units of measurement
- Expression of Vp
- TDR Test Type
- End of cable detection
- Sum of Event Return Loss
- Normal working range

Units of Measurement

You can choose for TDR measurements to shown on the trace as nanoseconds (ns), metres (m) or feet (ft). Internally all traces are recorded as samples and calculations conducted in "nanoseconds;" therefore, the units of measurement can be changed without added rounding errors on saved traces.

Vp Setting

You can choose for the Vp (Velocity of Propagation) of the cable under test to be in the following forms:

- Numeric factor of the speed of light "0.x;" acceptable range 0.3 to 1.0 "c"
- Percentage of the speed of light 30% to 100% of "c"
- Metres per microsecond (m/µs)
- Feet per microsecond (ft/µs)

When entering Vp (in the cable library or elsewhere) you always enter this in the form of a numeric factor 0.3 to 1.0 to avoid confusion and conversion errors. Internally, this is the format used for all calculations.

TDR Test Type

Here you can choose between standard TDR and "intermittent" TDR modes. The standard mode shows only the instantaneous trace on the screen whilst the "intermittent" mode can build up a record of the cable over time, this is useful if there are conditions on the cable that change with time, a loose connection maybe, changes are highlighted on the trace.

End of Cable Detector

This allows you to choose whether to allow TV220E to try to automatically find the end of a cable, up to a limit of approximately 2km (6kft) or not (depends on signal loss along the cable). It detects events that are approximately 0dB ERL in scale being a complete short or open. This function, like the automatic event detector only works properly when a cable type is selected that matches the cable under test. Incorrect parameters will result in misidentification of the end-of-cable.

Sum of Event Return Loss

When enabled this function displays the sum of all measured events (whether manually marked or automatically detected) between the "beginning of cable" marker and the cursor at the foot of the cursor.

Normal Working Range

This feature allows you to set the normal working range of TV220E to suit the types of cables you normally work upon. For example, if you regularly work on trunk cables that span over 1km, then you can choose a length greater than this, but if you now work in a predominantly "hybrid-fibre-coax" (HFC) network where drop cables are typically below 300m in length, then choose this as a normal maximum working range.

Time and Date

Here you will set:

- Day of the month
- Month of the year
- Two-digit year
- AM/PM or 24-hour time format
- Hour
- Minute
- Time zone

Please set up the time and date on your TV220E to suit your locality. This will help you correlate saved results and screenshots by date when processing them later.

Product Information

This screen shows you:

- Information about the unit including its model name and serial number, current software versions, the Wi-Fi SSID (name) and password (where enabled) and the most recent calibration date.
- **Update Software:** If you connect a USB drive that holds a valid software update file, then the "Update Software" button will be enabled (blue) as shown here. To update the software, press this button and follow the on-screen instructions.
- **Reset to Factory:** If you need to reset this unit as delivered tap this button. The unit will ask you if you are sure you want to continue. During reset, all user files and customisation will be removed from the unit.

Chapter 4. Testing a Cable

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Chapter 4. Testing a Cable

If you are a beginner or want to refresh your knowledge, or wish to gain more background on the fundamental principles of TDR please refer to chapter 10 **Tips and Tricks for Effective TDR Test**. In this chapter we will explain the user interface and how this relates to making TDR measurements.

Connection

One of the most important things to do when making a TDR measurement is to make a good and reliable connection to the cable to be tested. If the connection to the cable is unreliable, then the results you see may be inconsistent and confusing. It is always good practice to check that the patch lead and any accessories that you are using are behaving as expected before connecting them to a cable to be tested. Check that you have the F-F adaptor correctly screwed into the back of the TDR (ensure it is secure but do not overtighten). Attach the patch cord and check that you see the end of the patch cable as an open; short it too if you can, and check that the trace changes as expected. You can use any suitable patch cord to make connection to the line to be tested.

Beginning of Cable Marker

Whilst checking the patch cord is a suitable time to set a “zero” marker representing the end of the patch cord. You can then reference all measurements from the end of the patch cord and if there is a difference in Vp between the patch cord and the cable under test this difference then becomes irrelevant in distance calculations. Do this in the markers menu; place the cursor on the event shown at the end of the patch cable and tap the “BOC (o)” button (f1) to set your zero position.

To clear the “beginning of cable” marker, just tap “BOC (x)” (f1). While BOC is set (even if the marker is hidden) BOC will be shown on the status line.

Cable Type

From the Home screen’s Cable Library or the Cable Library button within the TDR application you can choose the type of cable that you will be testing. Please see Chapter 5 for details on how to manipulate the cable library.

Testing

There are two main ways to test a cable Auto and Manual modes. When using the Auto mode, the instrument chooses the settings estimated best for the given range on the cable type selected. Manual mode is for the expert user, and all settings are adjustable by the user.

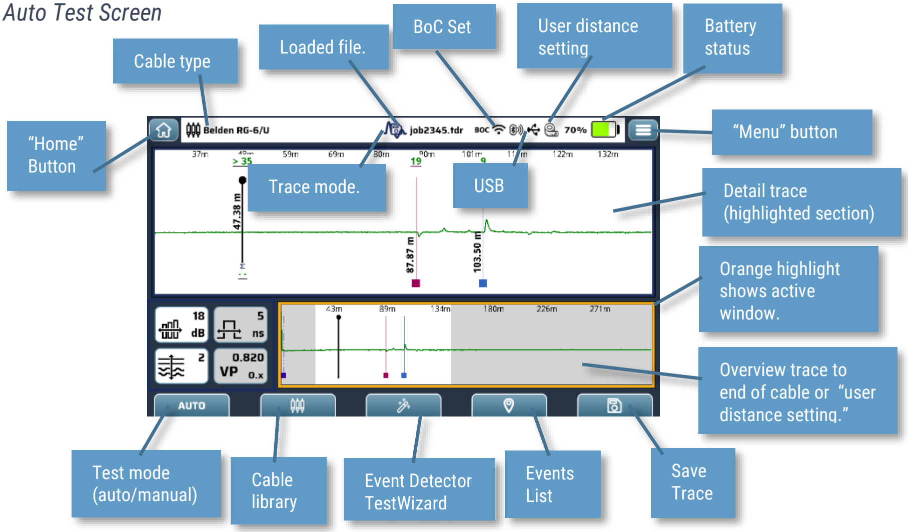
From the “Home” screen choose the TDR application by tapping or selecting this icon:

Auto TDR Mode

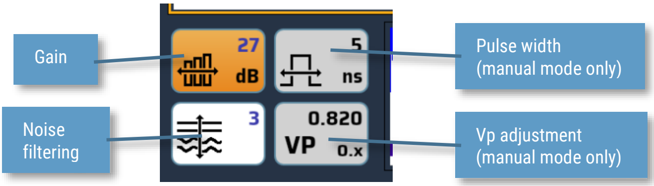
In Auto TDR, the instrument controls most settings. Use Auto TDR when you want an automatic test with limited user control of test settings. In Auto TDR, you can temporarily override the gain setting, noise filtering (averaging), and cable length during the test if you like. But you cannot adjust pulse width or velocity of propagation.

Assuming you have already selected the cable type that you are testing and set the likely working range for the test in terms of distance, next connect the cable to be tested and you should be shown a trace of the whole cable, particularly if the cable is unconnected and there is a clear “open circuit” visible at the far end.

The Auto Test Screen



Detail of Auto Mode Controls



"Button" Navigation Controls

The center button acts as an "enter" or "select" control for highlighted items on the screen but in the "TDR" test window toggles the "highlight" between the "detail" and "overview" traces. The four cursor keys offer distinct functions when either the "detail" or "overview" traces are active.

Detail Trace Cursor Keys

Up and Down keys allow adjustment of the currently selected parameter (gain or number of averages used for noise filtering in Auto mode, additionally you can adjust pulse width and Vp in Manual mode). You can adjust these parameters using the touchscreen by tapping on the parameter and then using the dialogue that appears.

Gain is adjustable from 0dB to 90dB, when set automatically it is adjusted to suit the range and cable type.

Noise filtering setting is adjustable from 1 to 6, this represents the number of traces that are summed to create an average in the form of two to the power of “n-1”. So, the total number of averages ranges from 1 to 32. The number is automatically adjusted depending on range and cable type. The smaller the number, the faster the response to intermittent faults.

Left and right cursor keys move the cursor. If using the touchscreen; just tap the trace and the cursor will move there.

Overview Trace Cursor Keys

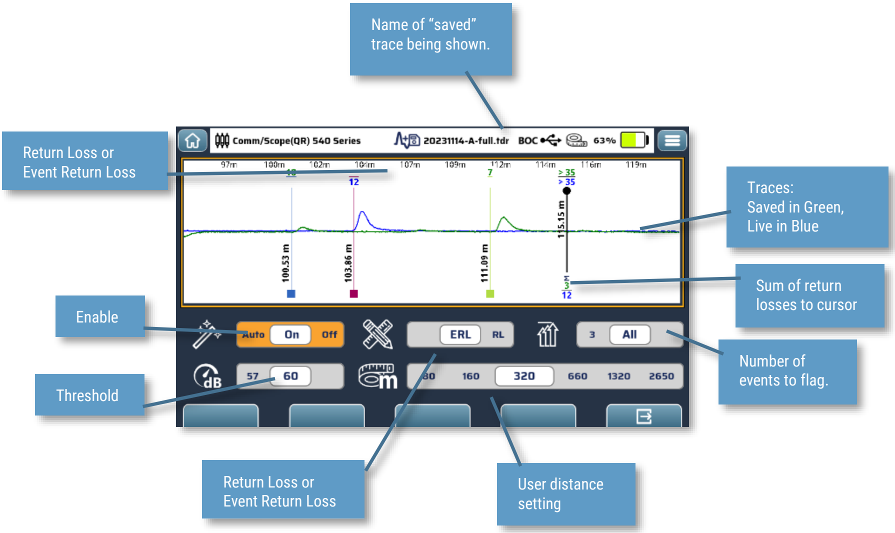
Up and Down keys allow for zooming the active area (you can also do this via the touchscreen using “pinch to zoom”). Left and Right keys move the active are of the window (you can also do this by touching and dragging on the touchscreen).

Automatic Event Detection

While you are using the TV220E in Auto TDR mode you will see the “TestWizard” button available on the softkeys, f3 . If you activate this function, you have options to choose:

1. Most importantly you can set the range (in metres, feet, or nanoseconds) over which to look for events.
2. Next choose the event detector mode; this can be set to Off (no events are flagged), On (events are flagged in the active area), Auto (events are flagged in the trace out as far as the test limit set above or approximately 2km, 6kft if no user limit is set)
3. Choose whether to display event scale in Return Loss (RL) or Event Return Loss (ERL). Event Return Loss takes the round-trip loss of the cable to and from the event into account when calculating the loss.
4. Choose to show, 1, 3, or “all” events. If one or three are selected, then the largest or up to three largest events above the threshold (see below) that are present will be flagged with event markers. See later where we talk more about working with markers and how to add permanent markers at event locations.
5. Finally choose the threshold below which events will not be shown (events with larger numbers are less significant events).

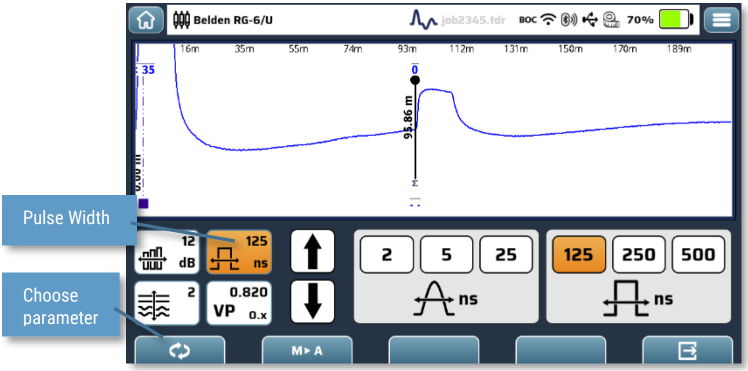
6.



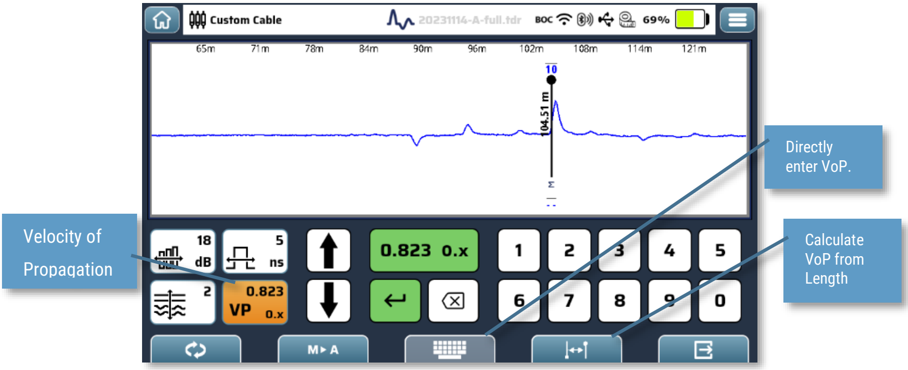
Note that when a return loss is shown with the form ">X" (as shown for the saved trace above ">35") then this shows that X, in this case "35dB" is the maximum ERL that can reliably be shown for the current combination of gain, loss per unit length and the distance of that marker. This is limited by the analogue to digital converter's resolution and the noise floor of the input amplifier chain. To see more detail, zoom in and increase gain and adjust noise filtering (averaging).

Manual TDR Mode

If you want to fully control all aspects of the TDR including setting custom velocity of propagation or using different pulse widths, then choose “Manual TDR.” If you are in Auto mode, press f1 (labelled Auto) and you should see f2 becomes “A > M” standing for “switch from Auto to Manual mode”.



The screen above shows the dialogue available to set the pulse width manually. There are three “digital” (square) pulses available that may help on longer cables. These have a “sub-nanosecond” rise time and can effectively be used for limited “STEP TDR” like functions when at short range too.



The screen above shows the manual “velocity of propagation” Vp setting screen. To directly enter a value of Vp, tap the on-screen keypad (f3) and press the “enter” key. You always enter Vp as a factor, e.g., 0.912 is 91.2% the speed of light. To enter this value, you only need to press digits 912 and tap the highlighted “enter” key.

To adjust using the physical keys, press and hold the up or down keys until the value needed is displayed.

VoP Units

The velocity of propagation can be expressed as a simple factor (0.300 to 1.000) of the speed of light in a vacuum. Or in feet per microsecond or metres per microsecond or as a percentage. However, VoP when entered directly must always be entered as a factor between 0.3 and 1.0 the speed of light. The data entry box and “enter” key will turn green when a valid entry is made.

Converting between measurements:

Here are the numbers you will need to convert from one expression of VoP to another:

$$c = 299{,}792{,}458\, m \cdot s^{-1}$$

$$c = 299.79\, m \cdot \mu s^{-1}$$

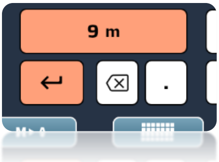
$$c = 983.57 ft \cdot \mu s^{-1}$$

$$1\ ft = 0.3048\, m$$

Note: Don’t forget that the time taken, if using nanoseconds as your preferred unit on the display, is the time taken for the pulse to travel to **and** back from the event, so the actual speed will appear to be half what is expected for a given cable (the TV220E automatically takes this into account for you).

Know the Length, want to calculate the VoP?

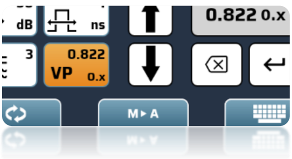
The f4 key with two vertical markers on its icon, allows a known cable length to be entered assuming the cursor is on the end-of-cable and the beginning of cable marker has been adjusted as needed, the required Velocity of Propagation (Vp) is calculated.



The data entry box will turn green when the distance value entered is in the valid range, 0.3 to 1.0 times the speed of light in a vacuum. Here the user is entering “93”, initially the resulting VoP would be too slow, but when the entry is complete the box is valid and “enter” can be pressed to “confirm” the new VoP.

Returning to Auto Mode

To return to auto test mode, tap on the “Manual” key from the test screen and choose “M > A.”



You should then choose a cable from the library if any of the parameters have been changed whilst working manually and the status line shows “Custom Cable” (otherwise the automatic event detector may not work as expected).

Test Types

From the “quick menu” you can choose the test type within the TDR application:

If you do not have any other traces loaded into memory, then you will only see the options for “live trace” and “intermittent” mode as shown to the left.

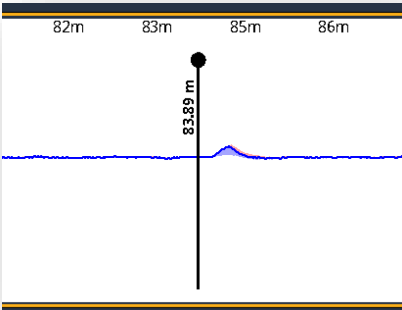
Live Trace

This is the normal TDR mode where what you see on the screen is near real-time analysis of the cable. You can test most cables this way.

Intermittent Mode

This mode cleverly builds up a dual colour trace that can help highlight areas of the trace that change during the test period. Examples could be a cable that has an intermittent connection due to a poorly fitted connector behind a cupboard or an overhead cable is damaged and moving in the wind; intermittent mode will build up a “tell-tale” trace that highlights the areas on the cable where “real-time” changes are occurring.

The pink & blue shaded area of an intermittent trace such as that shown alongside shows the “envelope” of the fault. This is an example of a varying reflection that is leaving a trace at 83.9 metres.



Note that should you change gain or any other parameter the trace will start re-building afresh. Traces saved in “intermittent” mode only save the data from the final trace; to save what may be many minutes or hours of data would be impractical. To save the visual “information” gathered in “intermittent” mode, it is best to set a marker at the point of interest and save a screenshot for reference.

Saved Traces

If you have selected a previously saved trace from the files menu or "results" mini application, then you will see more options for the test type shown on the "quick menu;" these are:

- Saved Trace. Static display of a saved trace.
- Live Trace and Saved Trace. Live and static for direct comparison
- Live Trace and Saved Trace and Difference (these two subtracted from each other to highlight any differences).

When working with a saved trace all parameters are locked by TV220E to the values that were set when the trace was saved. Any markers that were present when the trace was saved will be shown, these can be hidden if needed but not deleted nor added to. Use Tempo Report Writer (see below) if more detail is needed in a report.

These saved trace options are great to help you be sure that you have successfully repaired a fault or to check if cable conditions have changed since the last time the cable was tested. The "difference" mode is especially useful in these terms.

The example alongside shows the saved trace in green of. The blue trace is the "live" trace with the middle "event" cleared. All these methods can be used to spot subtle changes in a cable's performance.

Chapter 5. Cable Library

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Chapter 5. Cable Library

Your TV220E comes with a pre-installed cable library of typical cable TV coaxial cables. But these are not the only cable types that you can test. It is important to remember that you can apply time domain reflectometry to most types of cables. Please see chapter 10 for more information on how to test cables other than coaxial. Users have applied Tempo's TDRs to different cable types over the years such as:

- Cable TV 75-ohm coax cables
- Antenna feeders of both 75 and 50 ohm
- Twisted pair cables for telecom and industrial control
- Special application cables, for example:
    - Leak detection wires embedded in insulated pipe lagging,
    - Vibration detecting piezoelectric cables,
    - Power cables (while safely disconnected)

Cable Data

For each cable type defined in the library you can enter a descriptive name and a velocity of propagation. Ideally, and especially for high performance cables that you would want to test using the automatic and event detection features of TV220E, you must enter the approximate loss per unit length at 500 MHz. TV220E estimates the loss at other frequencies when using wider pulse widths based upon this.

Library Structure

TV220E stores the cable library in a JSON (Java script object notation) file. This is a structured text file which, with care, you can easily edit on a computer. Editing this way can be simpler than using the TV220E user interface, particularly if setting up a large library of cables or one that you are going to copy to multiple TV220E units.

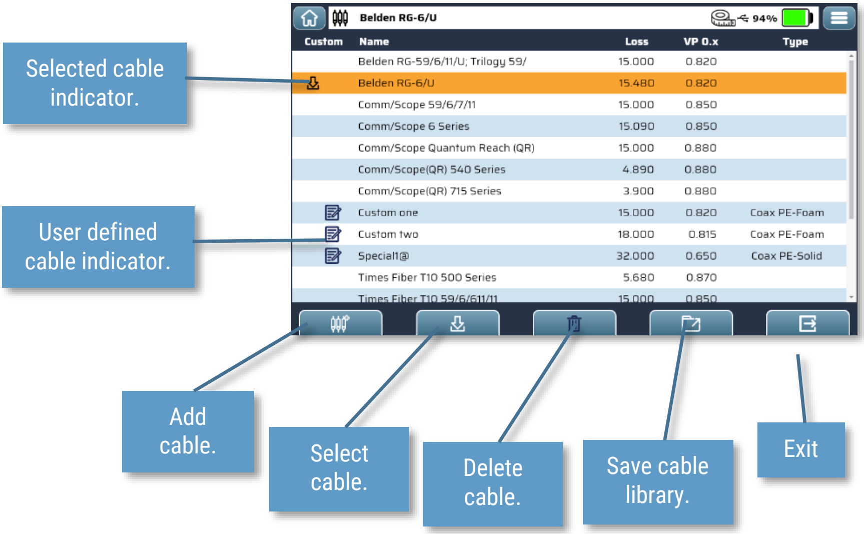
Here is an example of a cable definition:

```
[
        {
                "name": "Belden RG-59/6/11/U; Trilogy 59/",
                "vp": 0.82,
                "loss": 15.12,
                "userdefined": false,
                "FontWeight": "Normal"
        },
```

The parameter "userdefined" can be true or false. You can only delete cables marked as "userdefined": true on the TV220E itself. Therefore, to create a "company" library of cables that all your users can use, tag those important cables as "userdefined": false.

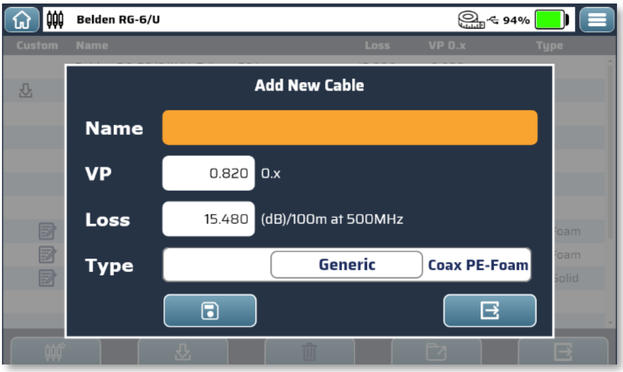
Choosing a Cable

With the list of cables visible on the screen, tap on or use the cursor keys to highlight the cable type you wish to work with. Then press the "download" button (f2) to activate the highlighted cable. The parameters of this cable will now be used for testing until another cable is chosen or parameters are adjusted manually in the "manual" mode.



Adding a Cable

After tapping or clicking "Add a new cable" (f1):

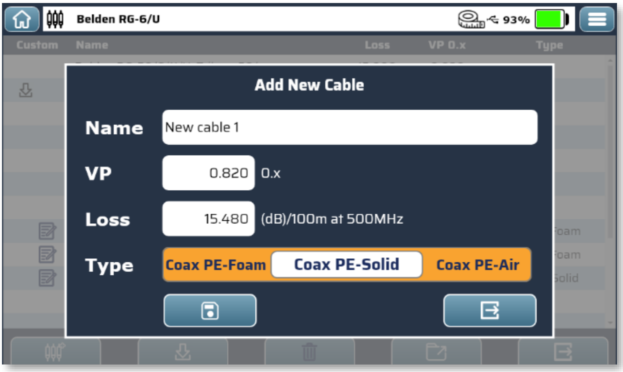


Tap on the "Name" box or highlight it using the cursor keys and enter, then you can enter the name of the cable:

Press or tap on the “Save” icon (f1) to use the name entered.

Enter the “velocity of propagation” Vp of the cable. This must be done in the form of a factor of the speed of light 0.xxx, you only need enter the digits xxx, the zero is implied. Select and enter or tap on “Save.”

Enter the approximate “loss in decibels per 100m at 500MHz” of the cable. You can find this information on the manufacturer’s datasheet. This is needed to accurately calculate the “event return loss” and for the automatic event detector to work well.



Once the above details are entered, you can choose to set the cable “type,” but this is optional and only for your reference & convenience.

Once all details are entered, Select the save icon and enter, or tap on the save icon.

Notes

Editing Cable Parameters

It is not currently possible to edit a cable definition on the TV220E itself. You can export the cable library and then edit the library on a PC and re-import the library or simply remove the cable and quickly re-create it with the necessary changes. Note: It is only possible for you to delete user created cables on the TV220E itself.

Quality of Cable Data

If you review cable manufacturer's data for their cables you will find that there is often no tolerance figure given for any of the technical parameters; VoP, loss, impedance, resistance etc. or if you can find them, the tolerances are somewhat wider than you might expect. In a later chapter we describe how the physical dimensions and materials used to create the cable are critical in setting all these parameters. But for now, just take all specifications as "intentions" and if attempting to make precision measurements then it is always wise to measure from both ends of a cable where possible and if a known length of the cable is accessible, measure it and use this to set a "precise" VoP (for that specific cable). In summary, whilst the TDR can measure time to better than 0.01%, the accuracy of converting that to distance via "VoP" has a much greater uncertainty, that of the VoP figure. Likewise, calculation of "event return loss" is dependent upon both VoP and the actual "loss" of the cable.

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Chapter 6. Saving and Loading Traces

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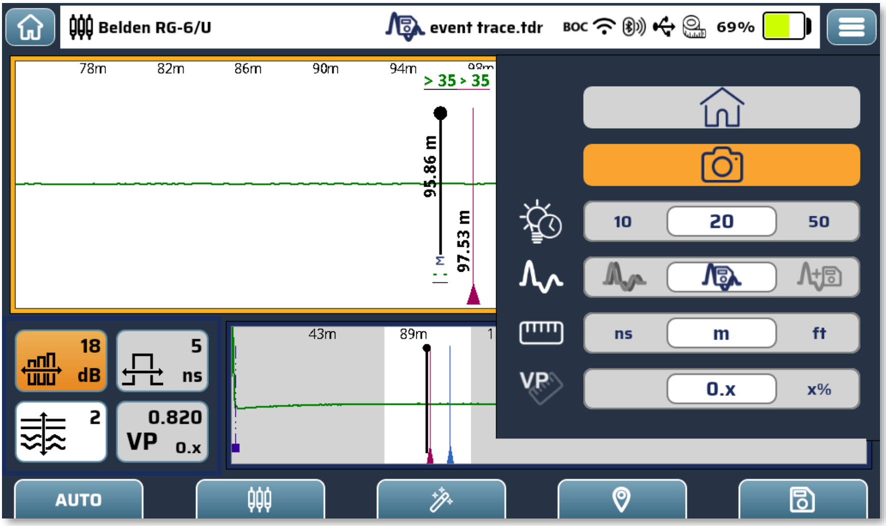
Chapter 6. Saving and Loading Traces

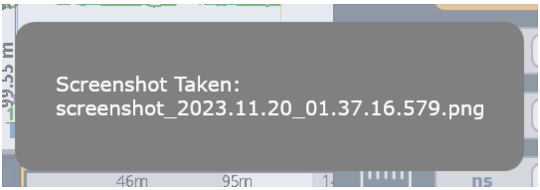
One of the powerful features of the CableScout TV220E is that you can make comparative measurements between old and new traces. This may be because you record “as installed” traces when cables are new or were previously tested and comparing this to the current state of the cable could give a good sign of where a fault may have developed. Equally, you may have been sent a previously captured trace of a faulty cable and asked to “repair” it. You will be able to take an “after” trace to prove that you completed the repair successfully.

Screen Shots

To take a simple screen shot of the content of the TDR screen as a “PNG” (portable network graphics) file; first insert a USB drive, once the USB icon shows it is mounted, simply press the “menu” key (three horizontal bars) or tap the icon in the top right corner of the screen. Then tap the on-screen icon or choose the “camera” icon from the pop-out menu using the cursor keys (down) and “enter” to save a screenshot to the attached USB drive.



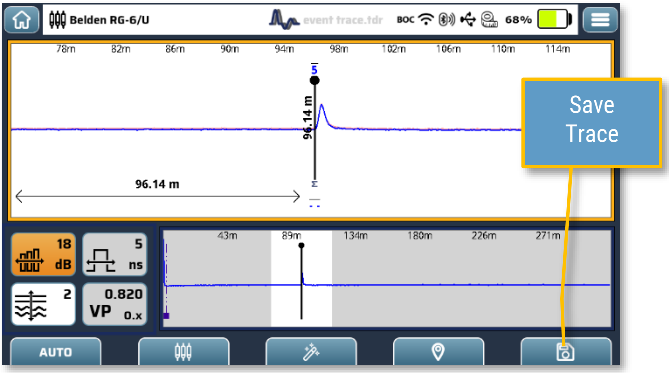
Screen shots are given filenames including the date and time at which the system saves them. Currently, screen shots are only saved to the external USB drive.



Saving or Loading a Trace

When you save a trace, you are saving the "raw" captured data which includes the date and time of the test, the serial number of the unit, details of the cable type selected, any "event markers" that are present on the trace, both manually added markers and those automatically shown by the auto event detector, if used, plus the digitized samples of the trace waveform. You can choose to save each trace as a "minimum" size file, saving only the visible part of the detailed data on the screen (highlighted section of the "overview" trace). Or as a "maximum" size file, where TV220E collects trace data over the entire trace buffer length at various gain and pulse width settings to build up as complete a picture of the cable under test as possible, this includes cable sections that may be before or after the current visible trace on the screen. A "maximum" length saved trace can be further analysed "offline" later.

To save or load a trace, first tap on the "floppy disc" icon (f5)…



You will then see the "files" page:

Here you can see a list of the files currently accessible. These are shown as stored locally on the TV220E or on the attached USB drive.

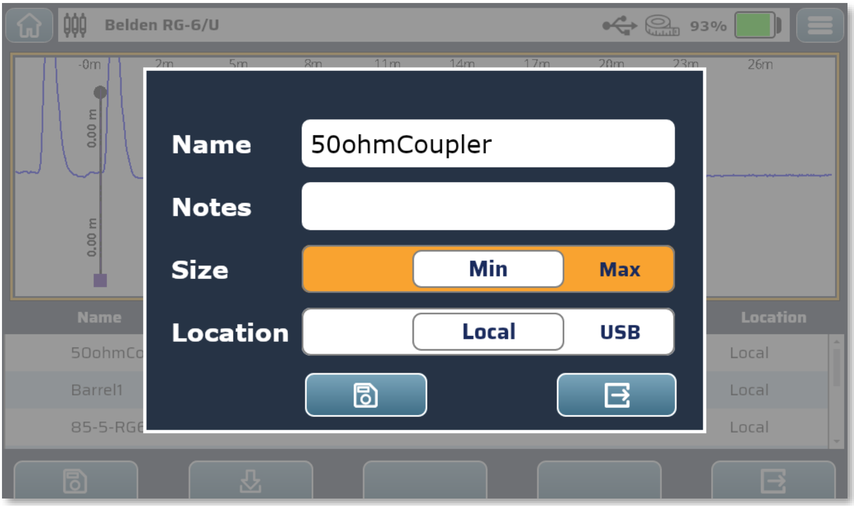
Load a Trace

To load an existing trace into memory of the TV220E, you highlight the chosen trace in the list and press the "load" button (f2). If you then choose to show the saved trace, or live trace & saved trace in the TDR then this trace will be used. When a trace is loaded into the memory buffer, its filename will be displayed on the status line. Whilst this loaded trace is not actually visible its filename will be "greyed out." You can "unload" a trace by pressing on the (f2) "unload" button when needed.

Load:  Unload: 

Save a Trace

To save the current trace you will press the "floppy disc" icon or tap (f1) and be shown a dialogue like this:

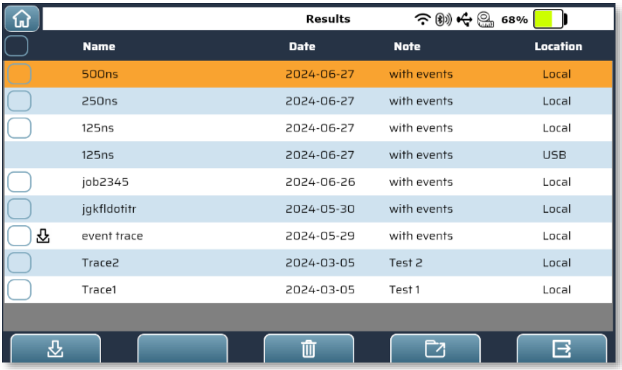


Here you will be asked to give the file a name. You can add notes to the file. Then choose whether to save just the visible trace (min) or the entire maximum trace size (max) and whether to save that locally to the TV220E or to the connected USB drive.

Copying Files from TV220E to USB

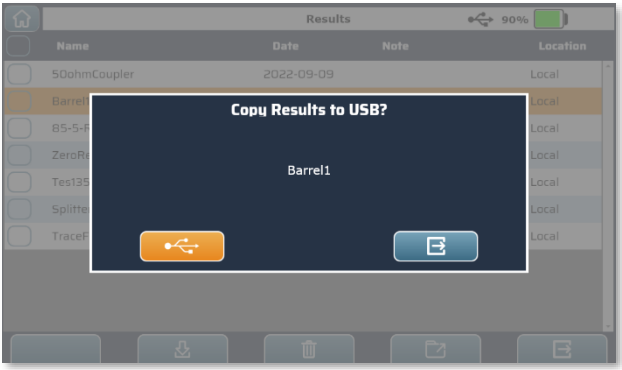
This is done from the "Results" application accessible from the "home" screen as shown below.

When the “results” screen is chosen you will see a screen that lists the files currently visible on the “local” and “USB” drives:



From here you can highlight a file to work with, either using the cursor keys (up and down) or by tapping directly on the screen. You then have options to “load,” “delete” or “copy to USB” each of those files. The fourth button is “exit”.

If you choose to copy a file to an attached USB drive, you will see the following dialogue:



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Chapter 7. Maintenance

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Chapter 7. Maintenance

For information about using your TV220E, questions on applications of TDR techniques, or to send your instrument in for service, refer to the telephone numbers listed under "Warranty" in the Preface section of the manual.

Error Messages

Most error messages are the result of an internal failure, either hardware or software. If any error message is displayed by the TV220E, please try to photograph it, or write down the error message and include it when you call customer service. Please do check the Tempo website for software updates as there have been many improvements since launch.

Inspection and Cleaning

Inspect and clean your TV220E as often as operating conditions require. If used indoors, this may be less often. If used outdoors, this might be after each use, depending on field conditions, but it should be inspected and cleaned whenever it looks grubby.

Inspection

- Inspect the exterior of the TV220E for wear, missing parts, or cracks in the enclosure. Replace any defective parts.
- Inspect connectors for cracked insulation, broken shells, deformed contacts, or dirt in the connectors. Clean or replace broken connectors, as necessary.
- Inspect test cables for bent or broken plugs/clips or frayed/cut insulation. Replace worn cables, as necessary.

Cleaning

- To avoid the possibility of getting water in the instrument, use only enough liquid to dampen the cloth.
- Do not use abrasive cleaners or solvents as damage to the enclosure and seals might result.
- Remove dust from the outside of the instrument by wiping with a dry lint-free cloth or small brush. Use the brush to remove dust from the connectors.
- Clean the remaining dirt with a lint-free cloth, dampened in a solution of mild general-purpose detergent and water.

Calibration

TV220E and TV220EX should not require regular calibration checks. There are no user adjustable parts inside the unit. During production, the pulse shapes and amplitudes are checked along with the receive signal path.

It is recommended that the user check basic performance at a regular interval. This can be done by taking a standard drum of cable which is kept just for the purpose of making device calibration checks. For example, 100m of RG6 is ideal. When you receive your new TV220E/EX unit, make a measurement of this cable using fixed (manual) settings and save the trace. At regular intervals you can then make a measurement of the same cable, using the same settings and check for any significant variation in the resulting trace.

Water Resistance

TV220E, and TV220EX when it is open, are NOT “waterproof” (they can withstand light rain or splashing). If using outdoors in the rain, protect them from prolonged rain or splashing of water. TV220EX is built into a tough and highly water-resistant enclosure and can be carried to your worksite in the rain. Dry its surface to remove the worst of any water before opening. See the specifications.

Chapter 8. Specifications

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Chapter 8. Specifications

Maximum range:	5.58 km (when Vp=0.93)
Trace buffer:	0 to 20,000 ns
Basic Accuracy:	±0.01% ±300ps
Horizontal Resolution (ns):	0.05 to 20 ns (varies with range)
Gain	3 to 90dB in 3dB steps
Pulse Widths:	2, 5, 25, 125, 250, 500 ns ±10%.
Pulse Shapes:	Raised Cosine (2, 5, 25 ns), Fast rise time square (125, 250, 500 ns), rise time (10% to 90% into 75Ω), 700±100ps
Velocity Factor (Vp) Range:	0.300 to 1.000 (numeric factor) May also be expressed as %, metres per microsecond or feet per microsecond
Display resolution:	1024 x 600 full colour (up to 800 nits bright backlight) each pixel representing approximately 4cm/1.5" at maximum zoom for typical cable; span of detail window is approximately 48ns (14m, 50ft with Vp=0.93).
Return Loss:	Automatic measurement, accuracy is dependent upon cable loss accuracy, resolution 1dB
Push-button User Interface:	13 mechanical keys, operable with gloves
Alternate User Interface:	Capacitive Touchscreen with multi-touch
Input Protection:	±400 V peak (AC + peak DC) at up to 440Hz, derate to 10V ac max at 1 MHz for up to 30 seconds.
Output Pulse Amplitude:	4V to 6V
Output Impedance:	75Ω
Event Markers:	>6
Test Connection:	Male F bulkhead connector with replaceable coupler
Test Modes:	Standard Test; Intermittent Fault Detection; Test vs. Saved, Test vs. Saved and Difference
Report Storage:	>100 traces (see "storage" below)
Report Writing Application:	Tempo Report Writer Enhanced for PC, Android and iOS
Size:	TV220E, 27 x 16 x 5 cm, (10.3 x 6.4 x 2.2 in)
	TV220EX 32 x 23 x 11 cm (12.6 x 9 x 4.3 in)
Weight:	TV220E 1200g, (2.6 lbs)
	TV220EX 2109g, (4.6 lbs) excluding accessories.
Battery:	Four cell, Lithium-ion, 60Wh
Battery Run Time:	>8 hours at typical backlight brightness.

Battery Maintenance:	The battery is protected by an internal battery management system (BMS) and designed for many years of service.
Power Input:	12V dc (11 to 15V) at up to 2.5A. 5.5/2.1 Barrel connector, center positive
Environment	
Storage Temperature:	-20 to +60°C (-4 to +140°F)
Operating Temperature	-10 to +50°C (+14 to 122°F)
Battery charging	0 to +50 C (+32 to 122°F, shut off automatically if battery temperature is out of range)
TV220E	IP5x (avoid heavy rain/splashing)
TV220EX	IP67 (closed), IP5x (open, avoid heavy rain/splashing)
Storage	
Internal	>1GB available for user files
USB Drive	Compatible with drives up to 32GB[1]
Wireless	
Wi-Fi	802.11B/G 2.4GHz
Bluetooth	Bluetooth Low Energy (BLE).

[1] Note that some drives may not be compatible with TV220E

Kit Content

Note that kits for some customers may differ. Check with your supervisor if you believe that something is missing. Here we describe the standard kits available from Tempo Communications under the model names TV220E and TV220EX.

Description	TV220E	TV220EX	Spare
Shoulder Bag for TV220E including shoulder strap	1		-
TV220E Main Unit	1		-
TV220EX Main Unit		1	
Shoulder strap for TV220E	1	1	-
Accessory Pouch 601C	1	1	601C*
Universal AC to 12V adaptor	1	1	AGC-PWR
RG6U Quick Connect test cord	1	1	-
F-F "barrel" connectors	2	2	PA9675
F-BNC Adaptor	1	1	PA9751
BNC-Alligator Clips Adaptor	1	1	-
CommScope SV-03 Test Port Adaptor	1	1	See CommScope
12V DC Power Cord for Vehicle	1	1	174173401
Quick Reference Guide	1	1	-

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Chapter 9. Glossary

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Chapter 9. Glossary

AC

Alternating Current: a method of delivering electrical energy by periodically changing the direction of the flow of electric current in the circuit or cable. Even electrical signals designed to deliver direct current (DC) usually fluctuate enough to have a proportion of AC.

Cable Attenuation

See “Line Loss.”

Cable Fault

Any condition that makes the cable less efficient at delivering electrical energy. Broken cables, short circuits, water leaking through the insulation, poorly mated or corroded connectors, and bad splices are typical types of cable faults.

Coaxial Cable

A cable formed from a signal carrying inner core conductor surrounded by an insulating layer and an outer grounded shield. The shield prevents external electric fields from interfering with the signal being carried or noise leaving the cable from the signal being carried.

Conductor

A means of directly conveying an electromotive force (electric field/voltage) from A to B. Generally made of metals as their “free” electrons readily carry the influence of the electric field and can “conduct” an electrical current. Also, ions in the form of a plasma or in a solvent (e.g., salty water) can “conduct” electricity, but not as readily as metals.

Δ

Delta: this symbol indicates a difference or relative measurement. For example, when a marker is placed on the waveform display and enabled for measurement, the instrument then calculates the distance from that marker to any adjacent marker also enabled for measurement.

dB

Decibel: a method of expressing power or voltage ratios. The decibel scale is logarithmic. It is a convenient way to express the efficiency of power distribution systems when the ratio consists of the energy put into the system divided by the energy delivered (or in some cases, lost) by the system. This instrument measures “return loss.” The formula for decibels of return loss (see RL) is: $RL(dB) = 20\log_{10} V_i/V_l$, where V_i is the voltage of the incident pulse, V_l is the voltage reflected back (lost) by the load, and log is the decimal-based logarithm function.

Dielectric

See Insulation

DC

Direct Current: a method of delivering electrical energy by maintaining a constant flow of electrical current in one direction. Even circuits designed to generate only alternating current (AC) may have a DC component.

Event Return Loss (ERL)

Estimates the true severity of an event by subtracting the specified cable loss from the measurement of reflected energy.

Incident Pulse

The pulse of electrical energy sent out by the TDR. The waveform shown by the TDR consists of this pulse and the reflections of it coming back from the cable under test. It is attenuated and distorted by the process of transmission along the cable to the fault.

Insulation

A protective coating on an electrical conductor that will not readily allow electrical energy to flow away from the conductive part of the cable or circuit. Insulation is also called dielectric. The kind of dielectric used in a cable determines how fast electricity can travel through the cable (see "Velocity of Propagation").

LCD

Liquid Crystal Display: a kind of display used in this instrument. Therefore, the terms LCD and display are often used interchangeably in this manual.

Line Loss

The amount of signal that is absorbed in the cable as the signal propagates down it. Cable attenuation is typically low at low frequencies and higher at high frequencies, which should be corrected for in some TDR event measurements (see ERL). Cable attenuation is usually expressed in decibels (dB) loss per unit length at one or more frequencies. See also "dB" above.

Noise

Any unwanted electrical energy that interferes with or partially masks a signal or measurement. Most noise is random with respect to the signals sent by the TDR and can appear as if the waveform moves slightly up and down on the display. Applying noise filtering (averaging) can reduce visible noise on the trace.

Open Circuit

In a cable, a broken conductor does not allow electrical energy to flow through it. Also, may be called broken or high resistance circuits. The circuit is "open" as if a switch which is "off" does not complete a circuit. Appear on the display like a high impedance (upward pulse).

Permittivity

See Relative Permittivity.

PW

Pulse Width: the horizontal size of the transmitted pulse, usually measured in nanoseconds.

Reflection

A reflection occurs wherever there is a change of impedance in the cable. At this point a proportion (see Reflection Co-efficient) of the incident energy is reflected towards the source. Note also that some reflected energy from further along the cable already heading back towards the source may be reflected again causing "false echoes" to appear in the final trace. Always deal with the largest faults first.

Reflection Co-efficient

The reflection co-efficient is the proportion of energy which i reflected at a discontinuity of impedance.

Relative Permittivity ϵ_r

This is the characteristic of a dielectric that directly influences the velocity of propagation in a cable. A measure of the electric polarizability of a dielectric material. Expressed as a factor relative the permittivity of free space $\varepsilon_{0,}$ 8.854×10^{-12} Fm^{-1}

Return Loss (RL)

Return loss is the energy reflected from a change of impedance. Return Loss measures the severity of an event. RL does not account for cable loss in the measurement. See Event Return Loss.

Short Circuit

A low impedance connection between conductors that is not wanted. Often completing the circuit at some point before where it should end, hence "short". As a "short circuit" is a low impedance, these appear as downward pulses on the trace.

TDR

Time-Domain Reflectometer: an instrument that sends out pulses of energy and times the interval to reflections (also called cable radar). If the velocity of the energy through the cable is known, distances to faults in the cable can be computed and displayed. Conversely, the speed that energy travels through a cable of known length can also be computed. The way in which the energy is reflected, and the amount of the energy reflected indicate the condition of the cable.

Twisted Pair Cable

A cable formed by two parallel conductors, each insulated and then twisted together. Even old "open wire" telephone cables carried on wooden poles and porcelain insulators were twisted pairs as the wires swapped sides every five or six poles. These twists help ensure that the balanced signal carried equally and with opposite polarity on each wire of the pair, are subject to equal interference which over the length of the cable cancels to zero.

Velocity of Propagation (Vp)

The speed that the influence of the electric field travels in a cable is often expressed as the relative velocity of propagation. This value is a ratio of the speed in the cable to the speed of light in a vacuum. For TV220E. this is always a number between 0.3 and 1.0. A velocity of propagation value of 0.50 indicates that the electrical energy moves through that cable at half the speed of light.

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Chapter 10. Tips and Tricks for Effective TDR Testing

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Chapter 10. Tips and Tricks for Effective TDR Testing

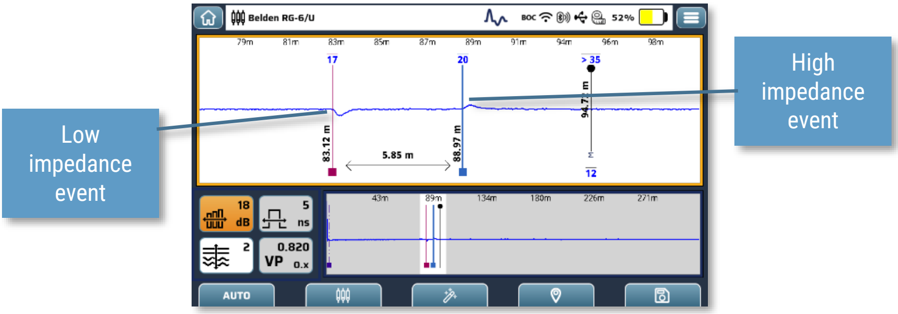
Time Domain Reflectometry

A time domain reflectometer (TDR) is a device that uses a principle like RADAR to measure the time taken for a signal to travel along a cable and back. The TDR sends energy into the cable and records the reflected energy coming back to the source from "events" (changes of impedance) along the length of the cable. By using a TDR, you can precisely measure the time taken for the reflections to return and can convert this into a distance along the cable.

The results are shown as a trace of amplitude vs. time on the screen. The amplitude of the "event" can be used to estimate the scale of the change of impedance and can be expressed as "return loss."

The "events" that can be detected by a TDR are common occurrences such as taps, splitters, couplers and shorts and opens. A TDR can also indicate the location of the start of a flooded section of cable and an estimate of the total length which is wet (it is nearly impossible to be more accurate as the velocity of propagation through a wet section depends on the proportion of water in the cable and its dielectric constant, which is unknown).

Basic Trace Analysis



The TDR displays a graph of the tested cable with time along the horizontal (x) axis, which can be optionally converted to distance by utilising the factor "velocity of propagation".

On-screen cursors can help by displaying nanoseconds, feet, or metres to a point on a cable.

The vertical (y) axis on the graph shows the type and severity of the "event." Events at "lower" impedance compared to the bulk of the cable are shown below the line (e.g. shorts or partial shorts), "higher" impedance events show above the line (e.g. corroded high-resistance joints or cut (open) cables).

Cable Fundamentals

With a TDR you are testing the integrity and uniformity of a cable. It is therefore good to understand a little more of how a cable works. Often the view of a cable having conductors that connect A to B is just too simple. We will try to avoid all complex mathematics here, but what we will present will guide you to hopefully understand exactly what a TDR can and cannot do.

Conductors & Insulators

Cables are made up of parts which are metallic called “conductors” which are then separated from each other and “ground” by “insulators.” When we were in school, we were told that electrons in the conductors carry the electricity from one end to the other. Well, at the “macro” level this is a good generalisation. However, when we are talking about the high frequencies used by TDRs and the signals the cables are designed to carry, we need to get more “quantum.” Do not panic, we will keep this simple, but a little understanding can help you a lot.

Conductors

Conductors, primarily metals, are substances that contain “free” electrons in their crystal lattice; all the atoms are bundled up close to each other and basically “share” electrons among themselves. You can almost imagine a lattice like how large balls might stack into a “ball pit.” Surrounding these balls are tiny objects, let us call them electrons, which fill in the gaps and can move between the nuclei of the atoms in the lattice.

If we apply an electrical potential across a conductor (e.g. battery between the ends of a wire) then the electric field from that battery or other source will “influence” the nearby electrons, either attracting or repelling it (likes repel, opposites attract); yes this will “encourage” the electrons themselves to move, or “drift” as we call it (if a current flows). But the speed of this drift is in millimetres per second. What travels along the “conductor” is the “influence” of the electric field effectively bumping along between electrons at the speed of light. What is being carried or “ducted” by the conductor is the electric field. It is important to understand this.

Electric fields may also be conducted by alternative “conductors” such as:

- Plasma, that state of matter where the electrons and nuclei are separated.
- Superconductors, which are alloys and ceramic compounds that have zero resistance to current flow (when the nuclei are very stable, i.e., cold, the electrons can flow between without hinderance).
- Semiconductors, which are crystalline substances, part way between metals and non-conducting inorganic solids.
- Carbon, particularly in the forms of graphite and graphene
- Ionic solutions, such as salty or contaminated water

We are concentrating upon metallic cables in this instruction.

Insulators

Anything that is not a metal is usually an “insulator.” Some materials are better than others and all have varying characteristics. Their technically correct name is “dielectric.” The reason for this is that they have the capability of “transmitting electric force without conduction, insulating.” They do this because they can become electrically polarized by application of an electric field. It is important to realise that “insulating” dielectrics do not prevent electric fields from leaving a conductor.

Unlike conductors that have virtually unlimited “free” electrons that can influence each other and slowly “drift” along under the influence of an applied electric field forming an “electric current”, dielectrics contain molecules that are tightly bound in place, but which can in many cases physically rotate or shift slightly from their equilibrium position. If a dielectric is composed of weakly bonded molecules, those molecules not only become polarized but can also re-orient so that their symmetry axes align to the field (a good example of a molecule that can do this is water – hence why a microwave oven works). More on water later.

Electric Susceptibility

This is called χ_e and is a measure of how easily the dielectric can be polarized by an electric field. This in turn, determines the electric permittivity ϵ_r of the material and thus influences other phenomena in that medium, from the capacitance to the speed of light.

Cables

Cables are constructed of metallic conductors that carry electric fields from one place to another and are wrapped and insulated by dielectric materials that interact with those electric fields. The dielectric materials change the capacitance per unit length and the speed at which "light" (electromagnetic fields) propagates along the cable ("light" is an electromagnetic phenomenon; what we see with our eyes is just the "visible" part of the spectrum that extends from DC through radio and light to gamma rays).

More on the detail around this later if you want to read it.

Velocity of Propagation

A cable's velocity of propagation (VoP or V_p) specification is simply a measure of how fast a signal travels in the cable. It is typically expressed as a percentage of the speed of light.

For example, a cable with a Vp value of 0.85 indicates that an electric signal can travel along the cable at 85% of the speed of light in a vacuum. Since a TDR is making measurements in the time domain, the distance accuracy of the TDR measurement in terms of distance is dependent upon having the correct Vp value to convert time to distance.

- Electrical pulses travel at different velocities along different cables just as an object will travel at different speeds through different fluids.
- Vp varies between cable types, sizes and manufacturers and is mostly influenced by the types of insulation material (dielectric) and how it is constructed (solid, foam or air spaced).
- Identifying the correct Vp for the cable being tested is imperative to have accurate distance measurements.

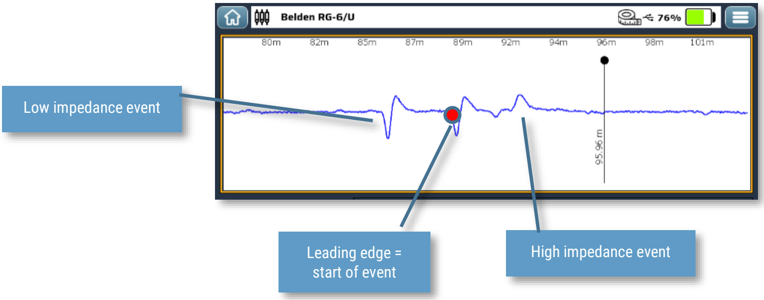
Cable Impedance

The characteristic impedance of the cable is made up of a combination of the resistance, inductance, and capacitance inherent in the cable's construction. TDR as a technique relies upon the fact that energy will be reflected at any point where the impedance changes. TDR can measure reflections caused by series impedances from several hundred ohms down to a few ohms and by shunt impedances (shorts) up to several hundred ohms, sometimes more.

Proper Cable Termination

Cable TV standardizes on 75-ohm termination on all cables, taps and terminations. This impedance was chosen a long time ago as it optimises for lower signal loss within the cable at higher frequencies. When all ports are correctly terminated, the ability to distinguish faults in a cable is enhanced. The 75-ohm termination absorbs all the incident energy resulting in no reflection whilst all incident energy is reflected by an open (cut end) or fully shorted cable.

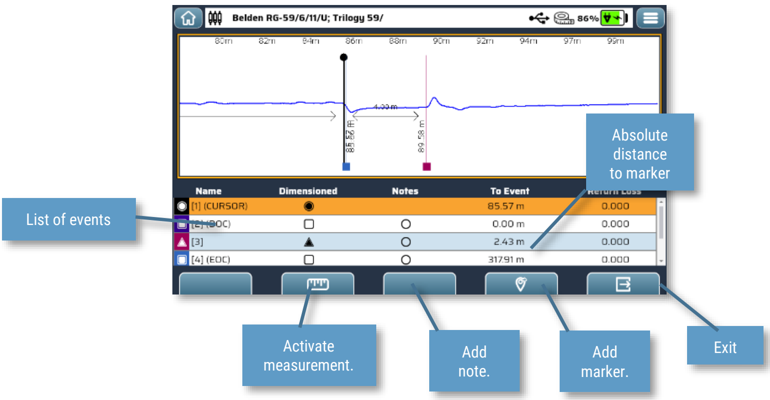
Interpreting the Trace



The leading edge of any event indicates where the event is located. The left edge is the precise point where the waveform breaks the plane above or below the pulse reference line, such as shown by the red dot above.

You can adjust the gain of the TDR which will affect the vertical amplitude (height) of the waveform displayed. However, be careful not to increase the gain so high that waveforms become distorted by clipping at top and bottom.

Using Markers



You can use the automatic event detector to highlight events or you can add markers manually. Each of these events can have their distance measurement activated using the “measure” button. You can also add “notes” to each event. These are saved with the event and therefore readable when the trace is analysed later.

Events

You may also refer to these as “faults” or “markers.” Let us summarise what we have covered above:

Deviations from a straight line on the trace indicate a change of impedance of the cable. Below the line where an event is of “lower impedance” than the surrounding cable. Above the line for events of “higher impedance” than the cable. The amplitude (height) of the wiggle above or below the line is directly proportional to the difference in impedance (see “reflection co-efficient” later).

You can use events, added manually or better still automatically to judge which events are worst on a cable and target these for repair. Your company may have recommendations relating to largest permissible event size, expressed as “percentage” of signal loss or “dB ERL” and maximum total event loss between source and customer.

If your company has specific “rules” that you apply and would like the software of TV220E customized to implement these thresholds, let us know. For now, the simplest way to find “service affecting” faults, is to set the “return loss” threshold in the automatic event detector.

Testing Other Types of Cable

Whilst TV220E is a TDR, primarily aimed at testing 75-ohm CATV and antenna cables, you can use it on other types of cables. Provided you are aware there may be an “event” shown whenever the impedance changes then there is no reason to not use TV220E for example to test 50-ohm antenna cable or leak detection wires embedded in insulated pipelines.

For example, you can test any of the following cable types; TV220 and other Tempo TDRs have been applied to all these applications (and we are sure there are many more that we are not aware of): -

- 75-ohm CATV and antenna cables
- 50-ohm coaxial antenna cables
- Twisted pair cables (e.g., telephone, LAN, or industrial control cables)
- Piezoelectric detector cables
- Underfloor heating cables
- Leak detection wires in insulated pipelines

The fact that the TV220E has a 75-ohm output impedance means that when connected to other cable types there will be a small reflection (insertion loss) of signal. For example, when connecting to a 50-ohm antenna feed the insertion loss will be just 0.2 dB showing as an event with return loss of around 14dB. Keeping things in perspective: Cable matching is important for avoiding noise due to reflections but not critical when testing, provided you are expecting it you can make allowance for it. You can test almost any cable that has a uniform characteristic impedance along its length.

One question we are often asked is “can you determine where one type of cable is spliced to another?” The answer is yes and no. If for example all the cables in a network are 75-ohm and well spliced but differ in velocity of propagation, no, you will not see any significant “events” at each splice. However, if you “splice” from 75-ohm coax to a 50-ohm coax, you will see a reflection event.

Fundamentals

Cables and Velocities of Propagation

Cable Construction

The metals used, “shape” and general makeup of the cable have negligible effect on “speed.” Twisted pairs or coax made with similar materials have the same speed (velocity of propagation), but different frequency responses.

Dielectric Interaction

Cables conduct electric fields from A to B. The insulation between the parts of the cable, which can be called a “dielectric” is the key to understanding the speed of a cable:

- $V_P = \frac{1}{\sqrt{\epsilon}}$ where epsilon is the effective dielectric constant ($\epsilon_0 \epsilon_r$), giving typical “speeds” in cables made with different dielectrics of:

Dielectric Material	**Dielectric Constant ϵ_r**	**Velocity Factor**	**Velocity of Propagation**
Polyethylene (PE)	2.3	0.659	65.9%
Foam Polyethylene	1.3 - 1.6	0.79 - 0.88	79% to 88%
Air Spaced Polyethylene	1.3 – 1.4	0.84 - 0.88	84% to 88%
Solid PTFE	2.07	0.695	69.5%
Air Spaced PTFE	1.2 – 1.4	0.85-0.90	85% to 90%
Polyurethane foam	1.03 – 1.18	0.90-0.95	90% to 95%
Polystyrene foam	1.02 – 1.05	0.97 – 0.99	97% to 99%

Where dielectric materials are not solid and instead “foamed” or formed into a structure containing a proportion of “air,” then the velocity of propagation is increased, and “loss” is reduced. However, the tolerance of the velocity of propagation is dependent upon the density of the foam which can vary a little from batch to batch of cable; most manufacturers do not publish a tolerance.

Return Loss

This is a measure of how much energy is being reflected by an “event” on a cable. We must get mathematical now; do not worry if this appear intimidating, this is here if you want to know the “reasons why.” If you are happy just looking at the numbers, skim over this.

Earlier we said that energy is “reflected” whenever there is a change of impedance of the medium in which a signal is propagating (light from a surface, radio waves from the side of a ship or sound from the wall of a canyon). We are concentrating here on coaxial cables that have a uniform impedance along their length. This impedance is derived from their geometry and the dielectric constant of the dielectric (insulation).

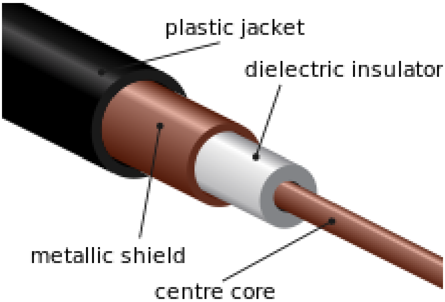
Cable Impedance

You probably already know about "resistance" which can be expressed in ohms; this is the ability or perhaps inability for a conductor to carry current; when some "electrical potential" (field) is applied to a conductor then a current (I) will flow and voltage (V) (assuming a "non-zero" impedance) will be developed across the conductor where:

$$V = R \times I$$

Where R is the "resistance" of the conductor. But what happens as we increase the frequency from DC upwards, through "mains" (50 or 60Hz), past audio (20 kHz) and into the truly "RF" realm?

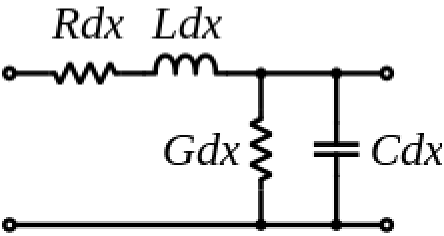
Coaxial Cables



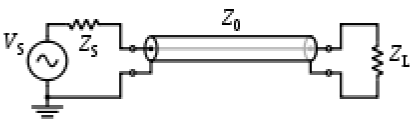
$$C = \frac{2\pi\epsilon_0\epsilon_r}{\ln(D/d)}$$

Where C is expressed as farads per metre, D is the inside diameter of the shield and d is the outer diameter of the core, ϵ_0 is the permittivity of free space, ϵ_r is the relative permittivity of the dielectric (inner insulator).

$$L = \frac{\mu_0\mu_r}{2\pi}\ln\left(D/d\right)$$



Where L is expressed in henrys per metre, D is the inside diameter of the "shield" and d is the outer diameter of the "core," μ_0 is the permeability of free space and μ_r is the "relative" permeability of the dielectric. For most dielectrics this is 1.



Series resistance R in "ohms per metre" is the resistance of the inner core and outer shield at DC and low frequencies. At higher frequencies, skin effect increases this as the conduction is restricted to a thin layer on the surface of each conductor.

Shunt conductance G in "siemens per metre" is normally extremely low because good dielectric insulators are used. However, at high frequencies a dielectric can have significant resistive loss, hence why foam or air cored cables are used to minimise losses. Contaminated water such as from rain or groundwater can have significant conductivity, whilst "distilled water" from condensation of humidity or a leak from district heating systems has a high "dielectric constant" (up to 88 as water is a highly “polar” molecule). So, “water” present in a cable can also be seen with a TDR; but the effects can be hugely variable depending upon temperature and contamination of that water.

At higher frequencies:

$$Z_0 = \sqrt{L/C}$$

With some re-arranging:

$$Z_0 = \frac{1}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\ln\frac{D}{d} \approx \frac{59.9\Omega}{\sqrt{\epsilon_r}}\ln\frac{D}{d}$$

Foam and “Air core” Dielectrics

When working with “foam” dielectrics the proportion of “air” to “dielectric” determines the effective relative permittivity. But foam is less tough than solid insulation and must be treated carefully when manipulated. Some super low loss and super high frequency cables will have construction more like concentric pipes with minimal dielectric material, just spacers keeping the core (tube) in the centre of the “tube” of the shield. These may also be pressurised with dry air or nitrogen to keep water out.

Steel Wires

You will equally note that many CATV coax cables use a steel core with copper plating as it is only that thin “skin” of copper that conducts at the high frequencies of concern. This minimises cost, improves robustness and damages wire cutters (contact Tempo for precision COAX cable cutters that are designed to cut this cable). However, copper cores and multiple layers of screens are essential if “power” is carried otherwise resistance and therefore voltage drop could be too high to supply remote amplifiers and splitters satisfactorily.

Impedance – Final Notes

You can see that the impedance of the coaxial cable is entirely related to the relative permittivity of the dielectric and the dimensions of the core relative to the shield. We can spot damage or other changes to the cables such as increased loss and change of speed due to water ingress etcetera. These all manifest themselves as wiggles in the line of the TDR’s trace.

It should also be clear by now that there are so many variables involved in setting both the cable impedance and its velocity of propagation that relying upon the manufacturer’s data on their cable as “absolute” is not to be recommended. The figures offered in most cable data sheets for VoP, impedance and loss per unit length are rarely offered with any gauge of accuracy such as 75±3 ohm or VoP=0.82 to 0.83 or loss per 100m at 500MHz is 14.5 to 15.3dB. So, all figures used and entered must be treated as a starting point when wanting to make “precision” measurements; particularly of length, as a slight change in foam density or polymer type can change the VoP more than 1%.

Reflection

Reflection co-efficient is a measure of the amplitude of the reflected energy relative to the "incident energy." This can be expressed using the following formula where Z_0 is the source impedance and Z_L is the "load" impedance.

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

When $Z_L = Z_0$ then reflection is zero. When Z_L is less than Z_0 then the co-efficient is negative and with Z_L greater than Z_0 then the co-efficient is positive. This is sometimes expressed as a percentage "loss":

$$\Gamma(\%) = \Gamma \times 100$$

But in the realm of TDRs, we commonly concern ourselves with the relative loss of power that does not reach the destination, because it has been reflected. The equation for "return loss" (RL) gives larger positive values for "low" reflection and tends to zero as the reflected energy approaches 100% of the incident energy (short circuit or open circuit).

$$RL = -20 \log_{10} \Gamma$$

Return Loss is a measure of the severity of a fault at a particular location on a cable. But between the TDR and the "event" there is also normal signal loss in the cable due to resistive and dielectric losses that are unavoidable. Let us account for that…

Event Return Loss

When an event is spotted with a TDR – a wiggle on the trace – then we can apply our knowledge of the loss per unit length of that cable type (this figure must be measured and is often input to the cable library from the cable manufacturer's datasheet) to "correct" for this "loss" in the signal "there and back" to the event.

When we do this, we can express the result as "event return loss" or ERL. This allows us to "normalize" for the losses along the cable and then be able to better compare the true "severity" of different events along a cable whether they are near to the tester or closer to the far end of the cable.

By using ERL, the technician can quickly find the worst service affecting faults and correct these first.

ERL is in effect a convenient way of displaying the normalized impedance of the cable at an event. Here the "normalization" is correction for the approximate signal loss between the event itself and the measured reflected energy.

Percentage Return Loss

Some people like the simplicity of expressing the return loss as a percentage. When simply working with the reflection co-efficient in this way, rather than in decibel form allows for simpler “fault arithmetic” (adding up of reflections). The following table shows the calculated reflection co-efficient based upon the mismatch between source and load impedance. The colour grading used here is arbitrary and provides a guide as to what may be acceptable. Individual companies or applications may apply or require different thresholds. It is common for companies to require RL to exceed 49 dB (0.75%) for individual events in new cable.

Z_L	Reflection co-efficient expressed as a percentage																				
85	13.3	12.6	11.8	11.1	10.4	9.7	9.0	8.3	7.6	6.9	6.3	5.6	4.9	4.3	3.7	3.0	2.4	1.8	1.2	0.6	0.0	
84	12.8	12.0	11.3	10.5	9.8	9.1	8.4	7.7	7.0	6.3	5.7	5.0	4.3	3.7	3.1	2.4	1.8	1.2	0.6	0.0	0.6	
83	12.2	11.4	10.7	9.9	9.2	8.5	7.8	7.1	6.4	5.7	5.1	4.4	3.8	3.1	2.5	1.8	1.2	0.6	0.0	0.6	1.2	
82	11.6	10.8	10.1	9.3	8.6	7.9	7.2	6.5	5.8	5.1	4.5	3.8	3.1	2.5	1.9	1.2	0.6	0.0	0.6	1.2	1.8	
81	11.0	10.2	9.5	8.7	8.0	7.3	6.6	5.9	5.2	4.5	3.8	3.2	2.5	1.9	1.3	0.6	0.0	0.6	1.2	1.8	2.4	
80	10.3	9.6	8.8	8.1	7.4	6.7	6.0	5.3	4.6	3.9	3.2	2.6	1.9	1.3	0.6	0.0	0.6	1.2	1.8	2.4	3.0	
79	9.7	9.0	8.2	7.5	6.8	6.0	5.3	4.6	3.9	3.3	2.6	1.9	1.3	0.6	0.0	0.6	1.3	1.9	2.5	3.1	3.7	
78	9.1	8.3	7.6	6.8	6.1	5.4	4.7	4.0	3.3	2.6	2.0	1.3	0.6	0.0	0.6	1.3	1.9	2.5	3.1	3.7	4.3	
77	8.5	7.7	6.9	6.2	5.5	4.8	4.1	3.4	2.7	2.0	1.3	0.7	0.0	0.6	1.3	1.9	2.5	3.1	3.8	4.3	4.9	
76	7.8	7.0	6.3	5.6	4.8	4.1	3.4	2.7	2.0	1.3	0.7	0.0	0.7	1.3	1.9	2.6	3.2	3.8	4.4	5.0	5.6	
75	7.1	6.4	5.6	4.9	4.2	3.4	2.7	2.0	1.4	0.7	0.0	0.7	1.3	2.0	2.6	3.2	3.8	4.5	5.1	5.7	6.3	
74	6.5	5.7	5.0	4.2	3.5	2.8	2.1	1.4	0.7	0.0	0.7	1.3	2.0	2.6	3.3	3.9	4.5	5.1	5.7	6.3	6.9	
73	5.8	5.0	4.3	3.5	2.8	2.1	1.4	0.7	0.0	0.7	1.4	2.0	2.7	3.3	3.9	4.6	5.2	5.8	6.4	7.0	7.6	
72	5.1	4.3	3.6	2.9	2.1	1.4	0.7	0.0	0.7	1.4	2.0	2.7	3.4	4.0	4.6	5.3	5.9	6.5	7.1	7.7	8.3	
71	4.4	3.6	2.9	2.2	1.4	0.7	0.0	0.7	1.4	2.1	2.7	3.4	4.1	4.7	5.3	6.0	6.6	7.2	7.8	8.4	9.0	
70	3.7	2.9	2.2	1.4	0.7	0.0	0.7	1.4	2.1	2.8	3.4	4.1	4.8	5.4	6.0	6.7	7.3	7.9	8.5	9.1	9.7	
69	3.0	2.2	1.5	0.7	0.0	0.7	1.4	2.1	2.8	3.5	4.2	4.8	5.5	6.1	6.8	7.4	8.0	8.6	9.2	9.8	10.4	
68	2.3	1.5	0.7	0.0	0.7	1.4	2.2	2.9	3.5	4.2	4.9	5.6	6.2	6.8	7.5	8.1	8.7	9.3	9.9	10.5	11.1	
67	1.5	0.8	0.0	0.7	1.5	2.2	2.9	3.6	4.3	5.0	5.6	6.3	6.9	7.6	8.2	8.8	9.5	10.1	10.7	11.3	11.8	
66	0.8	0.0	0.8	1.5	2.2	2.9	3.6	4.3	5.0	5.7	6.4	7.0	7.7	8.3	9.0	9.6	10.2	10.8	11.4	12.0	12.6	
65	0.0	0.8	1.5	2.3	3.0	3.7	4.4	5.1	5.8	6.5	7.1	7.8	8.5	9.1	9.7	10.3	11.0	11.6	12.2	12.8	13.3	
	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	Z_0

Decibel Return Loss

Remember that when working in decibels, the “log” function returns an “indeterminate” result for zero. Therefore, where the impedances match, the “ERL” is a “big number.” Faults need repair when return loss is **less** than about 40 dB or so (you company’s threshold may differ). Adding event losses in decibels is tricky; better to use percentages.

Z_L	Reflection co-efficient expressed as dB (E)RL																					
85	18	18	19	19	20	20	21	22	22	23	24	25	26	27	29	30	32	35	38	45		
84	18	18	19	20	20	21	22	22	23	24	25	26	27	29	30	32	35	38	44		45	
83	18	19	19	20	21	21	22	23	24	25	26	27	29	30	32	35	38	44		44	38	
82	19	19	20	21	21	22	23	24	25	26	27	28	30	32	35	38	44		44	38	35	
81	19	20	20	21	22	23	24	25	26	27	28	30	32	34	38	44		44	38	35	32	
80	20	20	21	22	23	24	24	26	27	28	30	32	34	38	44		44	38	35	32	30	
79	20	21	22	23	23	24	25	27	28	30	32	34	38	44		44	38	35	32	30	29	
78	21	22	22	23	24	25	27	28	30	32	34	38	44		44	38	34	32	30	29	27	
77	21	22	23	24	25	26	28	29	31	34	38	44		44	38	34	32	30	29	27	26	
76	22	23	24	25	26	28	29	31	34	38	44		44	38	34	32	30	28	27	26	25	
75	23	24	25	26	28	29	31	34	37	43		44	38	34	32	30	28	27	26	25	24	
74	24	25	26	27	29	31	34	37	43		43	38	34	32	30	28	27	26	25	24	23	
73	25	26	27	29	31	34	37	43		43	37	34	31	30	28	27	26	25	24	23	22	
72	26	27	29	31	33	37	43		43	37	34	31	29	28	27	26	25	24	23	22	22	
71	27	29	31	33	37	43		43	37	34	31	29	28	27	25	24	24	23	22	22	21	
70	29	31	33	37	43		43	37	34	31	29	28	26	25	24	24	23	22	21	21	20	
69	31	33	37	43		43	37	33	31	29	28	26	25	24	23	23	22	21	21	20	20	
68	33	37	43		43	37	33	31	29	27	26	25	24	23	23	22	21	21	20	20	19	
67	36	42		43	37	33	31	29	27	26	25	24	23	22	22	21	20	20	19	19	19	
66	42		42	37	33	31	29	27	26	25	24	23	22	22	21	20	20	19	19	18	18	
65		42	36	33	31	29	27	26	25	24	23	22	21	21	20	20	19	19	18	18	18	
	65	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	Z_0

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Chapter 11. Tempo Report Writer

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Chapter 11. Tempo Report Writer Enhanced

Tempo has created a set of applications called “Tempo Report Writer Enhanced” (TRWE) that are available for download from the application stores for Android, iOS and Windows. The application is available through these channels as deployment can be better controlled by your own company’s IT team and we can make updates available to everyone more easily.

Android

GET IT ON Google Play

iOS

Download on the App Store

Windows

Get

Alternately search in the stores for “Tempo Report Writer Enhanced” or “TRWE.”

Instructions

The applications include a guided introduction on how to use them with the TV220E’s data files.

Capabilities

1. Files can be browsed on a wirelessly connected TV220E, transferred to the portable device, and added to reports.
2. Alternately, files can be transferred using a USB drive.
3. Markers present in TDR files copied across will be visible.
4. New markers can be added within the application.
5. Notes can be added to markers.
6. Multiple TDR traces can be combined into one report (if the trace parameters such as cable type and velocity of propagation are matching).
7. The report files, TDR files and PDF reports can then be shared using the portable device’s other software, such as email or cloud storage accounts.

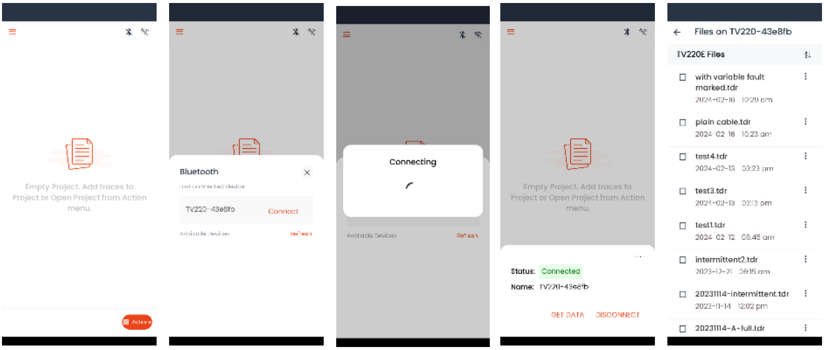
Refer to Chapter 3 for details of settings including activating the Wi-Fi, Bluetooth, or both.

Wi-Fi

To use Wi-Fi, activate the function in “settings.” Then also in “settings” under “information” look at the Wi-Fi SSID and password. Use these credentials to select the correct TV220E/EX to which to connect and enter the password when prompted by your device during the connection process.

Bluetooth

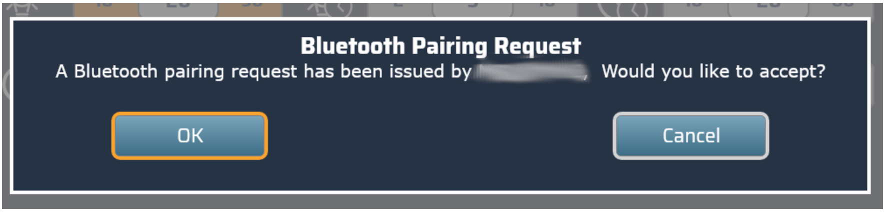
To use Bluetooth, activate the function in “settings.” The connection is made using Bluetooth



Low Energy simple pairing where you identify the TV220E/EX in the application and then respond to dialogue boxes that pop up as needed.

The above screenshots show the connection process in Android. iOS is similar.

During the connection process the TV220E will display a connection confirmation pop-up dialogue box like this:



After you have accepted the pairing request then you can transfer files from TV220E to your device.

When you have downloaded files to the TRWE application you can add them to a current report or create a new report. You will find the files in the TRWE app via the menu and browsing them in “Local Files.”

You will be able to create reports and save them as PDF files which can also then be found in “Local Files” and shared from there using methods available to you on your mobile device.

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TV220E Instruction Manual

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