Metallic Time Domain Reflectometry (MTDR) System Installation and User Manual

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REVISION HISTORY

Rev.	Revision History	Date	Prepared By	Approved By
A	Initial Release	11 June 2024	SM	CA, SP, JP
B	Edits to Section 6.5: Setting up TDR Sensor and TDR200 Data Logger	13 May 13, 2025	SM	SP

1 Intended Audience

This guide is for the personnel responsible for installing or using the Metallic Time Domain Reflectometry (MTDR) System. This manual provides steps for installing the system, and how to take and interpret readings.

2 Icons and Conventions Used In This Guide

This guide uses the following icons to call attention to important information.

WARNING: This icon appears when an operating procedure or practice, if not correctly followed, could result in personal injury or loss of life.

CAUTION: This icon appears when an operating procedure or practice, if not strictly observed, could result in damage to or destruction of equipment.

NOTE: This icon appears to highlight specific non-safety related information.

3 Abbreviations and Acronyms

This section lists abbreviations and acronyms used in the document.

Abbreviation or acronym	Definition
TDR	Time Domain Reflectometry
MTDR	Metallic Time Domain Reflectometry
SDM	Synchronous Device for Measurement
Mux	Multiplexer

4 Safety and Precautions

WARNING: Always follow safety precautions and use proper personal protective equipment (PPE) including safety glasses and high-visibility clothing when working in the field with this equipment.

- Avoid touching the inner part of the panel BNC connector or center rod of TDR probes connected to the TDR200 to prevent electrostatic discharge damage.
- The total length of all SDM cables should not exceed 500 ft (152 m), since longer lengths cause unreliable communication between SDM devices.

5 INTRODUCTION

Metallic Time Domain Reflectometry (MTDR) offers a simple and cost-effective approach that uses coaxial cables grouted in boreholes for continuous ground monitoring. It can detect ground movement and identify if acceleration is occurring or not. It can also detect and interpret the response of rock and soil masses to underground and surface mining activities.

MTDR effectively locates soil and rock mass movements.

NOTE: Coaxial cable is a shielded cable consisting of an inner conductor, insulating layer, conductive shielding, and outer jacket. The cable's shielded design ensures fast data transmission without interference or damage from environmental factors.

The MTDR system involves installing a coaxial cable in a borehole filled with grout that mimics existing soil or rock conditions. A TDR unit is used to generate a voltage pulse along the cable and receive reflections back. Reflections are generated by cable deformations, abrasions, and severing. Crimps at known locations along the cable provide depth datum.

As movement occurs, the cable deforms and the reflections along the cable change. By connecting the TDR200 to a PC using a Type A to Micro B USB cable, the associated PC-TDR software can interpret reflections. This helps determine the location, type, and rate of earth movement. MTDR systems can also be combined with data loggers and multiplexers to enable remote readings of multiple cables.

5.1 SYSTEM OVERVIEW

The complete TDR200-based system can include the TDR200, SDM8X50 coaxial multiplexers, data logger, power supply, enclosures, TDR probes/cables and PC-TDR software.

Figure 1: Portable MTDR (TDR200)

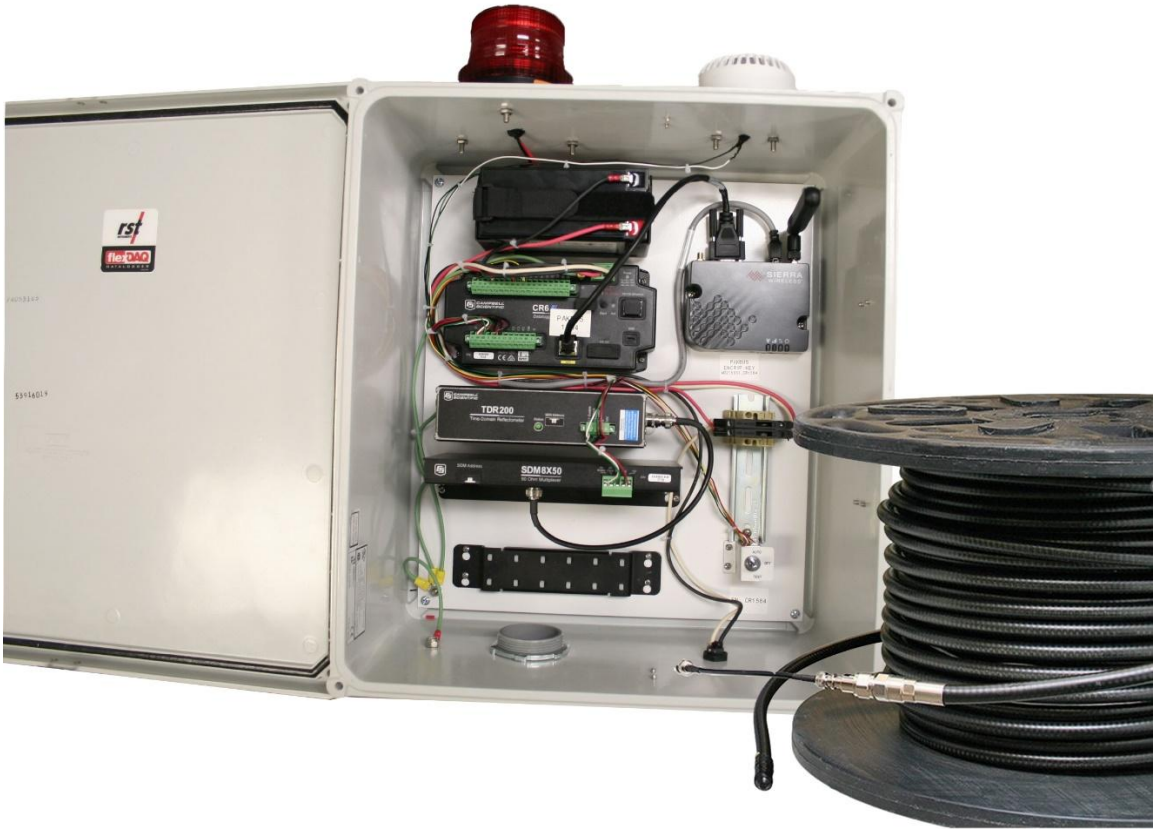


Figure 2: FlexDAQ Data logger with TDR interface including optional TDR Mux (Multiplexer)

NOTE: Optional TDR Mux (multiplexer) enables monitoring of up to 8x TDR cables.

RST provides built-in auditory and visual alarms upon request.

5.2 POWER REQUIREMENTS

The power supply needs are determined by factors such as the number of sensors being measured, data retrieval frequency, retrieval method, and site location.

Systems that measure a larger number of sensors or record data more frequently may need a deep-cycle rechargeable battery (available from RST Instruments) or connection to an AC power source.

5.3 FEATURES

- Cost-effective installation
- Low costs of data acquisition
- Enables deformation monitoring along the entire length of the borehole
- Compatible with:
  - Data logger: RST's FlexDAQ data loggers
  - Visualization software: GeoViewer and GeoExplorer

5.4 APPLICATIONS

- Rock and soil mass movement monitoring
- Monitoring subsidence above abandoned underground mines
- High wall slope monitoring in open-pit mines
- Determination of cable fault location (i.e. distance to fault)

6 INSTALLATION

6.1 INSTALLATION PREREQUISITES

6.1.1 Initial Inspection

The carry case includes the instrument and standard accessories.

In case of missing components, mechanical damage or failed operational checks, contact RST Instruments for support.

The instrument has been inspected mechanically and electrically before shipment, to meet electrical specifications and ensure intactness.

Prior to installation and usage, conduct operational performance checks as outlined in the section below.

6.1.2 Operational Performance Checks

- Ensure all cables are properly connected and free of debris and moisture.
- Check battery voltage and ensure it reads 12 Volt or greater. If lower, charge the battery before taking measurements.
- Inspect the coaxial cable port on the TDR200 for any damage, debris, or moisture before connecting a TDR cable.
- Inspect each TDR instrument cable individually for any damage, debris, or moisture before connecting it to the unit.

6.2 TOOLS AND COMPONENTS

Before installing the MTDR System, ensure the following components and tools are present:

- Anchoring-grade grout or neat cement

NOTE: Neat cement is composed of 1 part water to 2 parts Portland cement.

- 20 mm tremie pipe
- Sweep type conduit or conductor

6.3 INSTALLATION OF TDR CABLE

NOTE: For details of RST's coaxial cable specifications, refer to Section 8.

Referring to Figure 3, complete the following steps:

1. Drill the borehole to accommodate the tremie pipe and TDR cable.
2. Prepare the grout, ensuring the consistency is brittle so that it breaks and transfers movement of the ground to the TDR cable.
3. Strap/tape the TDR cable to the 20 mm tremie pipe and insert into the borehole. Ensure protection of the cable jacket from damage.

NOTE: The tremie pipe can be abandoned downhole upon grouting; retrieval is not mandatory.

CAUTION: Ensure there are no kinks or bends in the TDR cable as they will show up in the readings as false spikes.

4. Ensure the TDR cable is grouted slowly (at a rate of about 10-15L/min) from the bottom to the surface.
5. Stage grouting is typically not required. Top off the grout or fill with sand routing.

CAUTION: Avoid sharp bends in the readout cable.

6. Measure the length of the TDR that is downhole and the length that is over ground.

   This is the 'Window Length' vs 'Cable Length' that is going to be needed later.

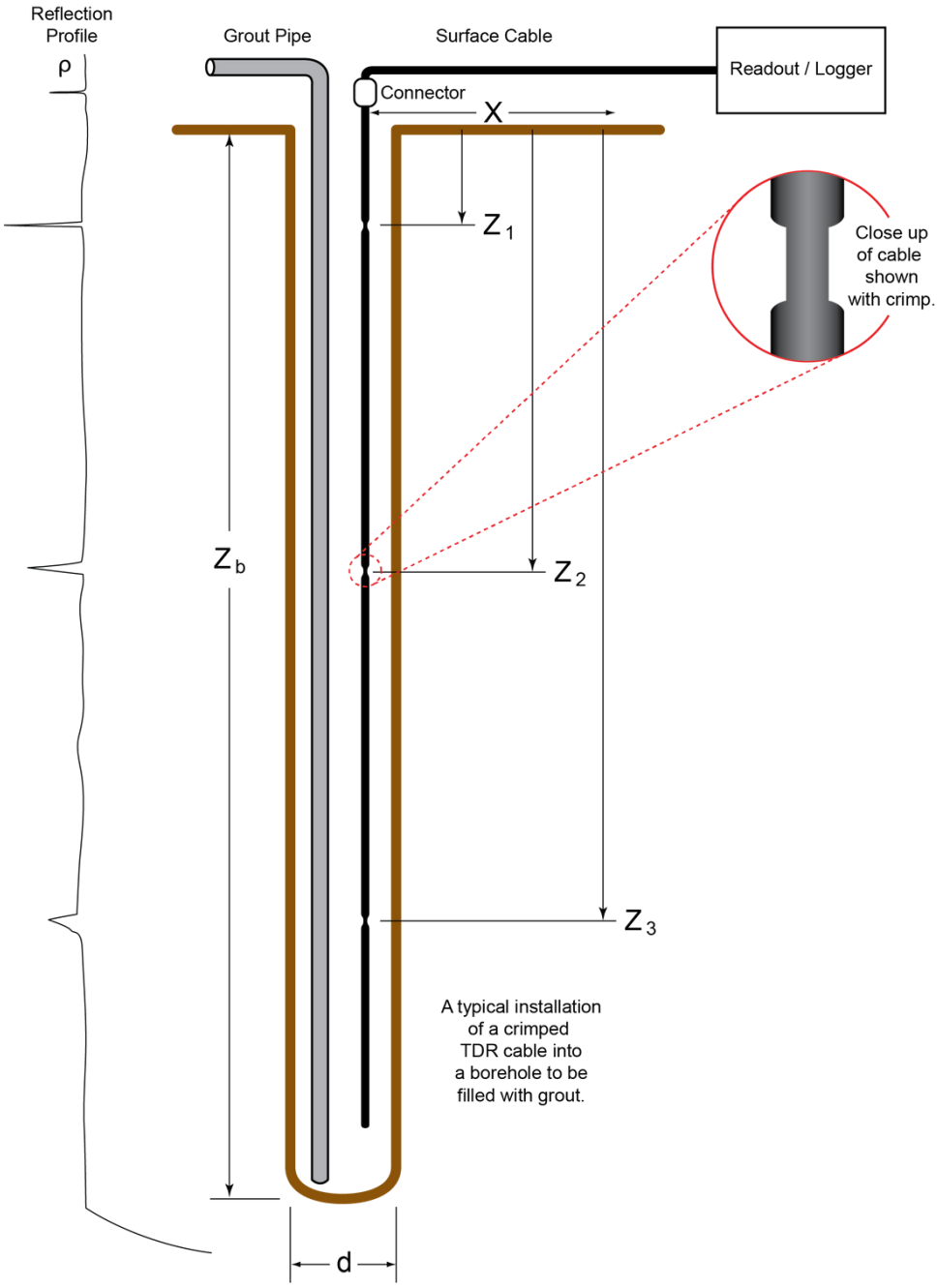
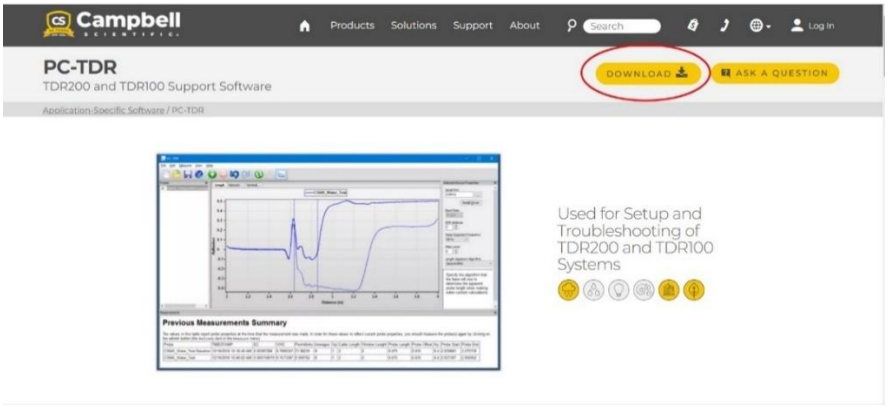


Figure 3: TDR Cable Installation Overview

6.4 INSTALLING THE PC-TDR SOFTWARE

1. Visit https://www.campbellsci.com/pc-tdr and click on the DOWNLOAD button on the top right section of the page.



2. Follow the prompts to download the PC-TDR software.

NOTE: The PC-TDR software is free of charge but requires user registration on Campbell Scientific's website.

6.5 SETTING UP TDR SENSOR AND TDR200 DATA LOGGER

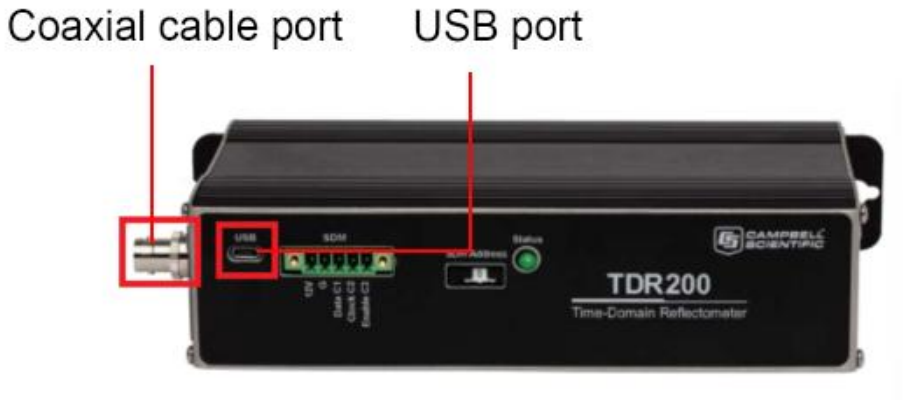
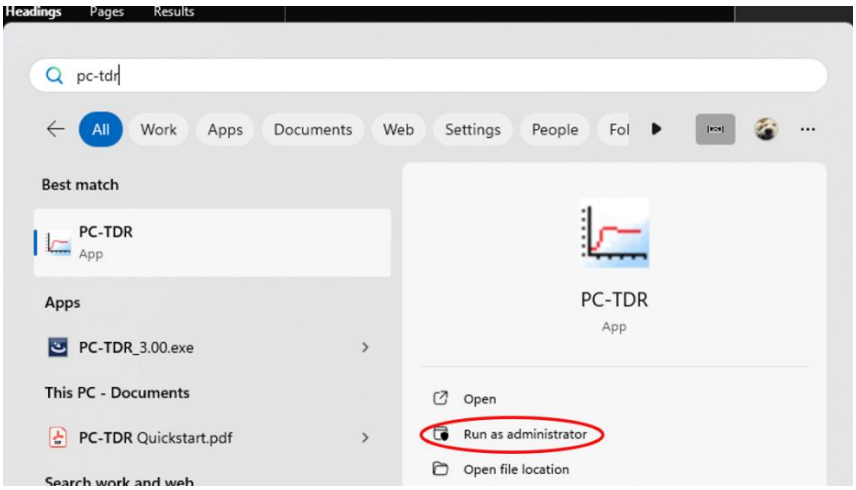


Figure 4: TDR200 Connections Overview

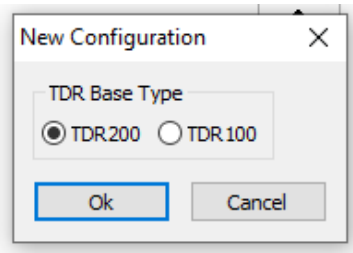
1. Connect the coaxial cable to the coaxial port on the TDR200.
2. Connect the Type A to Micro B USB cable to the TDR200 and the computer device.

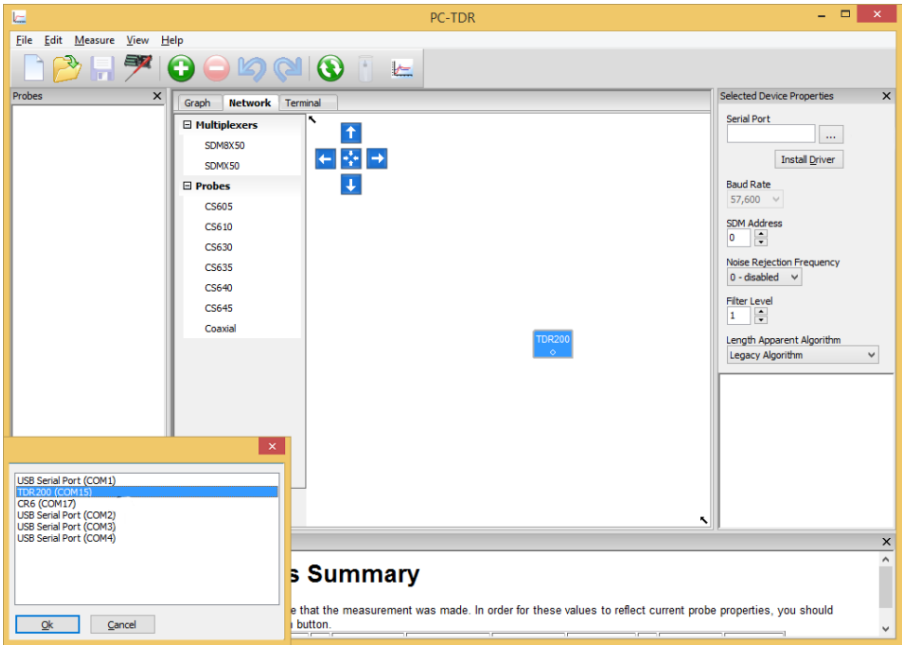
NOTE: When the TDR200 is connected to the computer with the micro-USB communication cable, the device will be powered.

3. Launch the PC-TDR software. If this is the first time using the software, enter “PC-TDR” in the computer’s search bar and select Run as administrator under the application’s options.

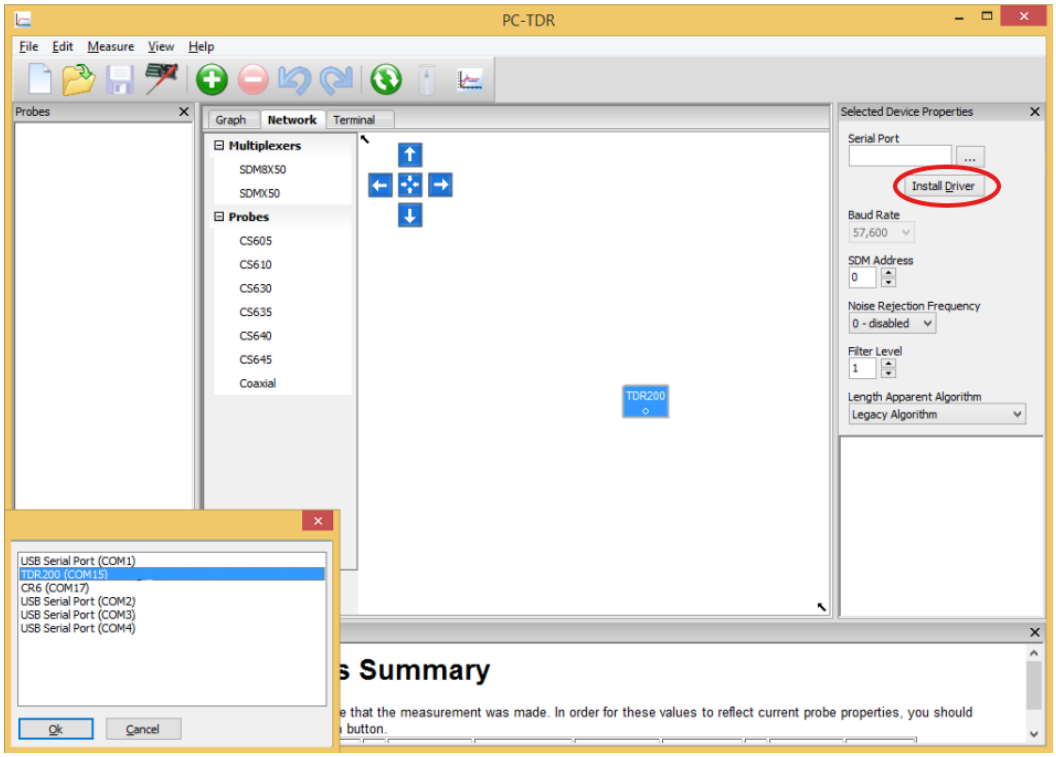


4. Once the software is launched, the New Configuration dialog box appears. Select TDR200 as the TDR Base Type.

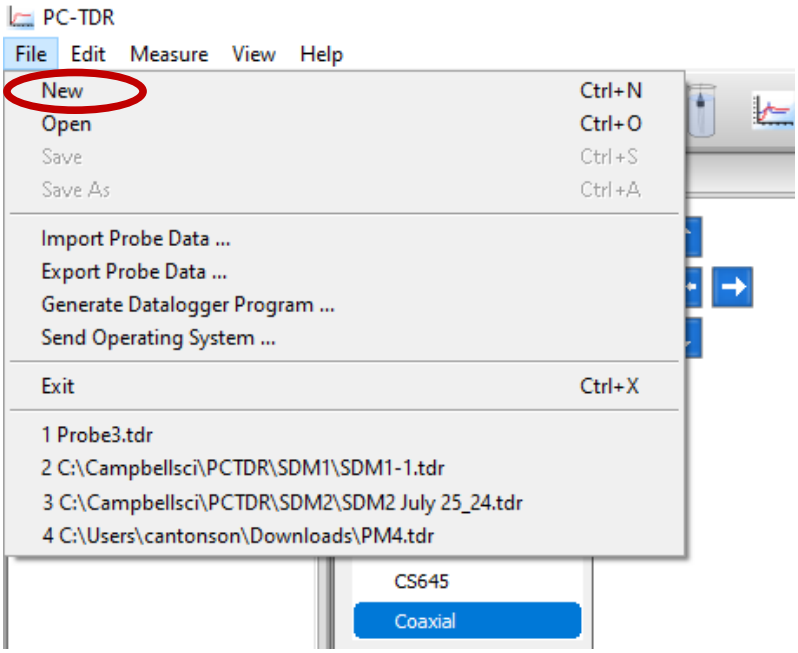




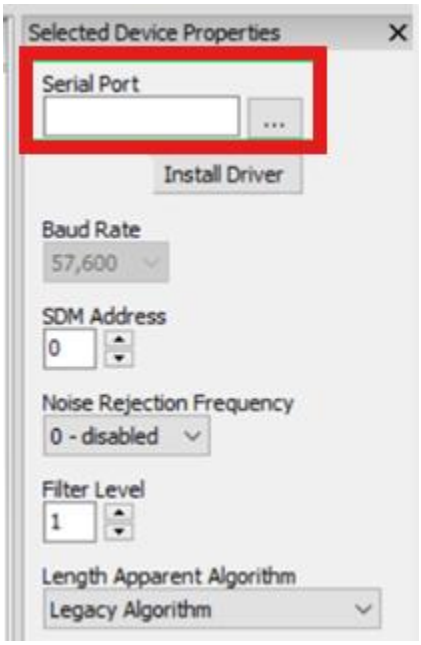
5. The USB driver is usually installed with the PC-TDR software. If the driver is not installed, select the Install Driver button from the main PC-TDR window, and follow the appearing prompts.



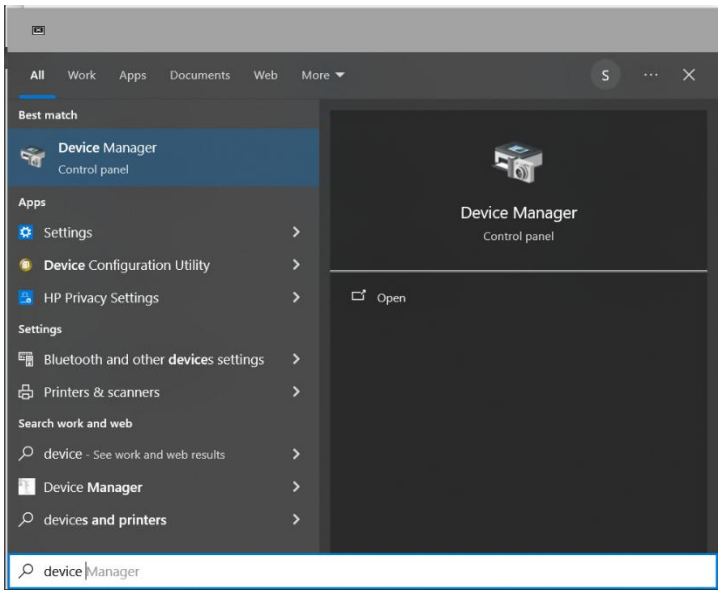
6. To add a new configuration and TDR, go to File → New.



7. In the Selected Device Properties window (on the right side of the main software screen), click on the More Options Icon (...) to specify the computer's USB port being used to connect to the TDR200.

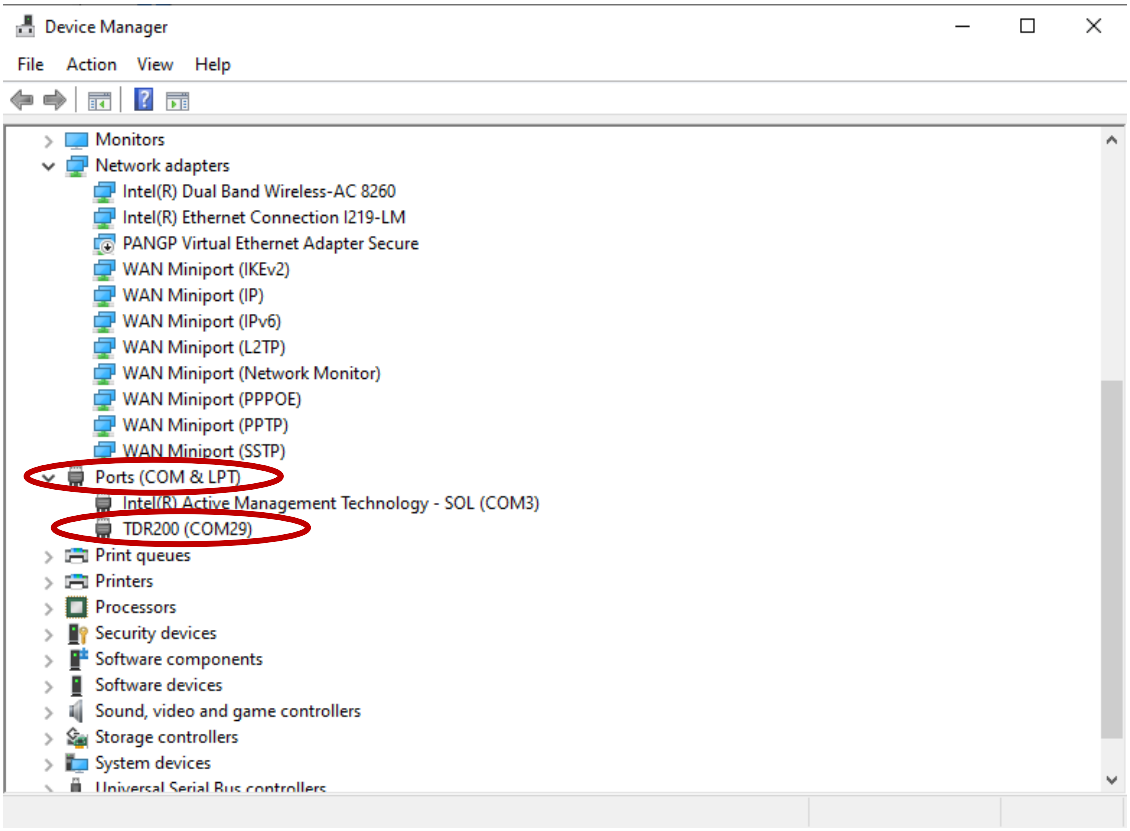


8. Launch the PC's Device Manager window using the computer's search bar.



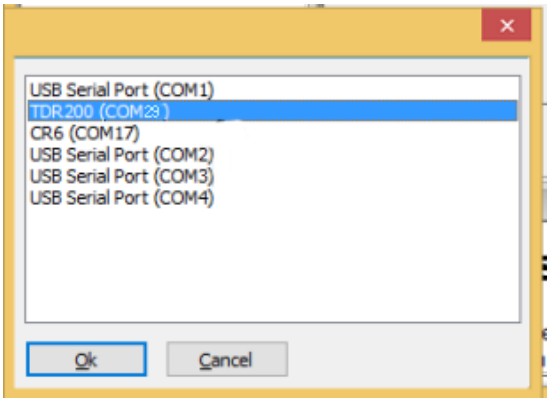
9. In the appearing Device Manager window, under the Ports (COM & LPT) menu, identify the port on the computer that the TDR is connected to.

In this example, the TDR200 is connected to port 29 (COM29).



NOTE: The port number appearing for the user may differ. Port 29 (COM29) is used here as an example.

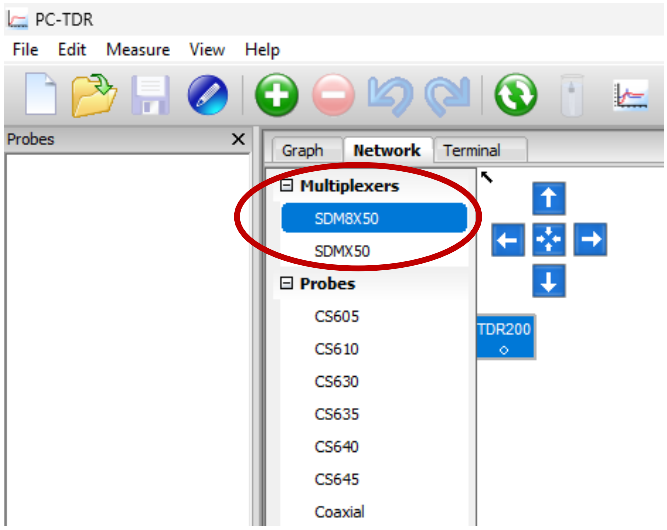
10. Close the Device Manager window and return to the PC-TDR software window. Confirm proper connection by verifying that the TDR200 is listed in the com port options window.



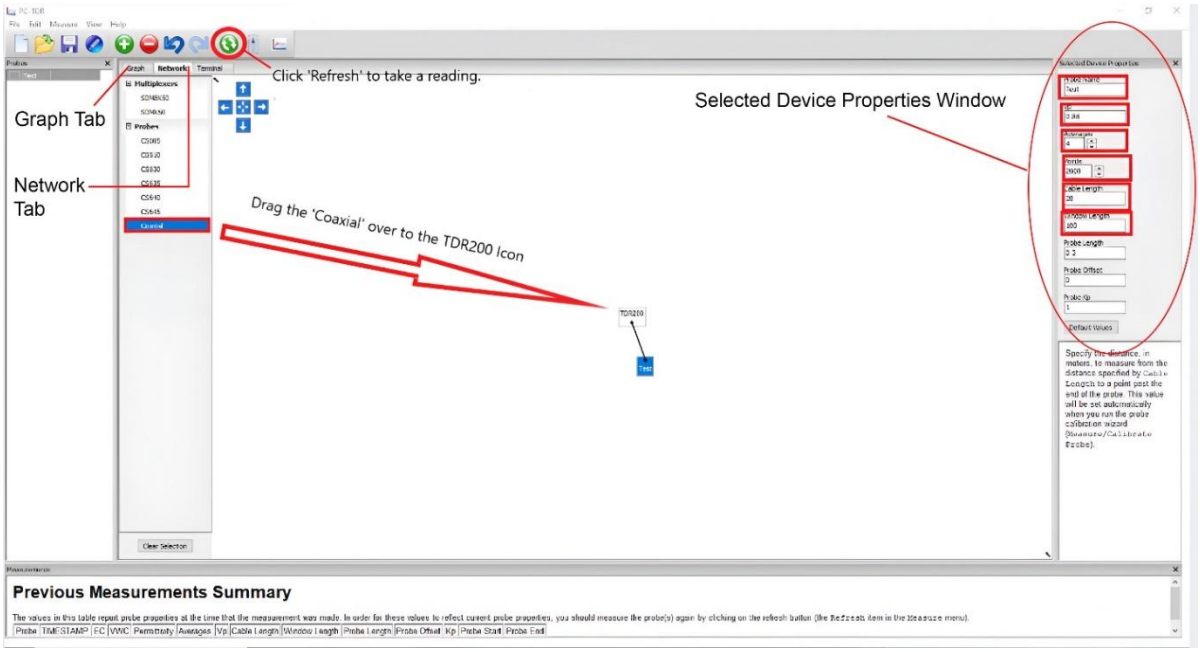
NOTE: The TDR200 should show up as a TDR200 in Device Manager, but it may not identify the same in the com port options window in the PC-TDR software.

If any issues are encountered, please contact RST Support.

11. If using a multiplexer, select the appropriate multiplexer under the Multiplexers menu.



12. Under the Probes menu in the Network tab, click and drag “Coaxial” over to the TDR200 icon in the middle of the software window.



When adding devices, the green + button and can also be used to choose a ‘Coaxial’ instrument.

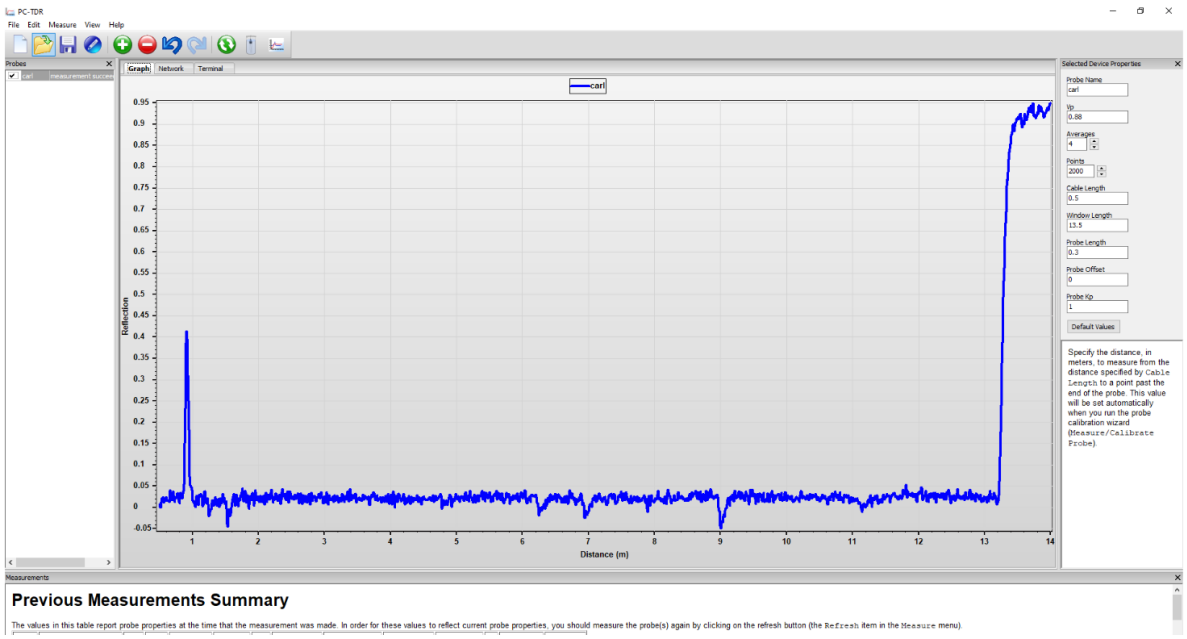
13. In the Selected Device Properties window, enter the following parameters:

- In Probe Name, assign a name to each TDR cable/probe.
- Set the V_P (Velocity of Propagation) value to 0.88.
- Set Averages to 4.
- Set Points to 2000 (this creates 2000 measurement points along the entire length of the TDR cable).
- Cable Length: length of the cable protruding above the ground surface.
- Window Length: length of the cable installed inside the borehole.

14. Select the Graph tab to view the graph for the 2000 measurement points over the length of the cable that is buried in the borehole.

The Y axis values for Reflection range from -1 to +1, with the end of the cable tending towards +1.

The X axis measures Distance (m).

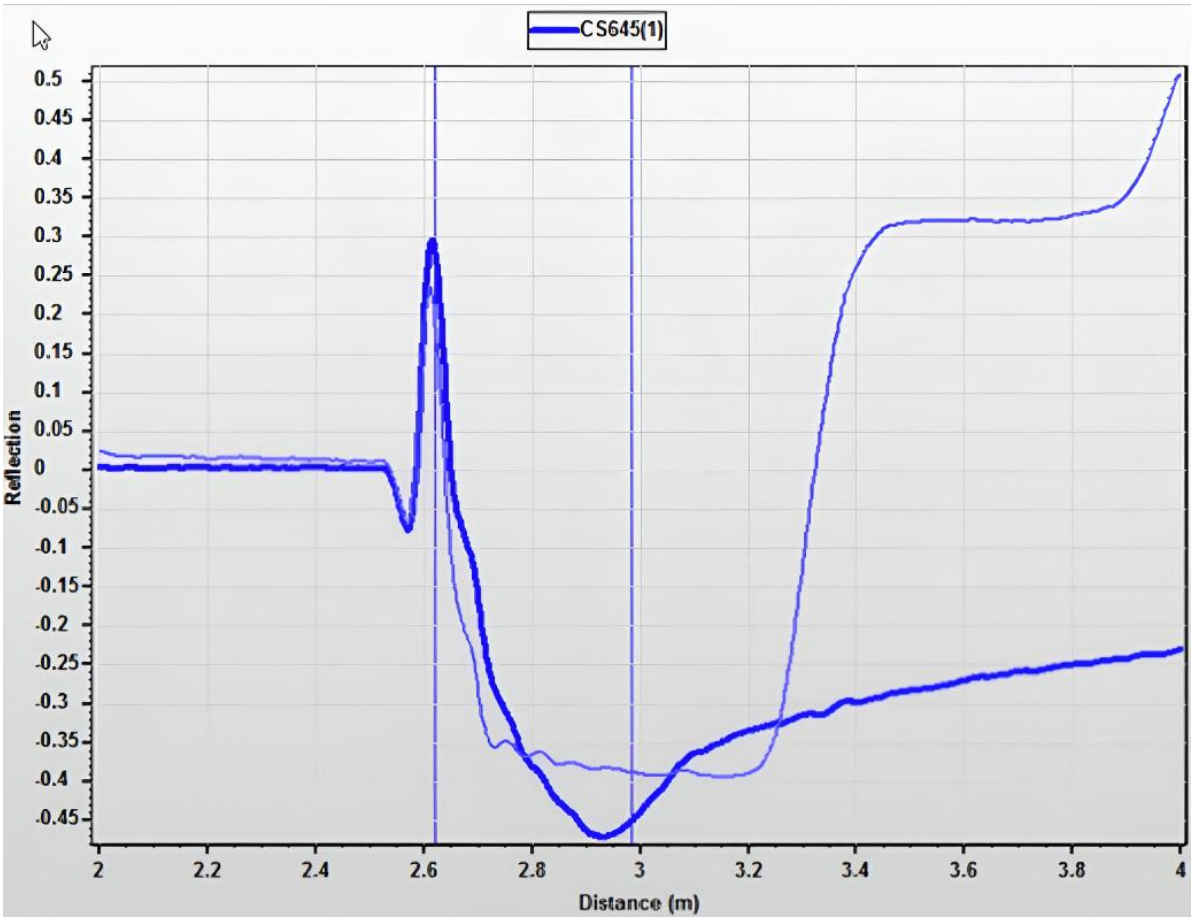


15. To record a measurement of the coaxial cable, press the refresh button on the toolbar. The measurements will be displayed in the Graph tab.

After taking a measurement, select Measure | Set Probe Baseline to use the current measurement/waveform as a baseline.

The baseline waveform will remain on the graph as subsequent measurements are taken and displayed.

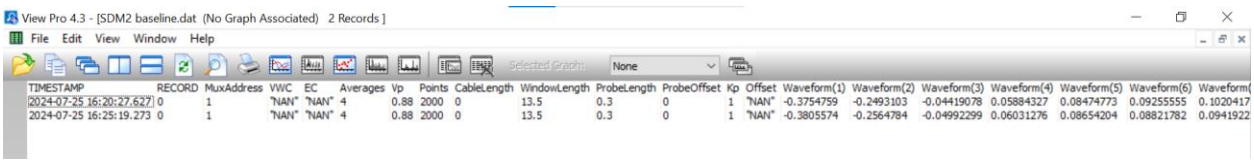
NOTE: To make the baseline measurement visible, ensure View | Show Baseline is selected.



NOTE: In the above screenshot, the thinner blue line represents the baseline waveform, and the bolder blue line represents the current waveform.

16. Exporting Data: Under File, select Export Probe Data and follow the displayed instructions. The screenshot of the graph can be saved in the file as well.

Export Readings with check box to ‘append selected’.



Saving Data: Choose the directory to save the data.

NOTE: For more information on operating the software, choose PC-TDR Help under Help on the top menu.

7 MAINTENANCE

Please follow the guidelines outlined below for ensuring optimal performance and durability of the MTDR system.

- Ensure connectors are protected in between measurements.

NOTE: Wrapping tape or using a protective cap over the connectors will help keep dust and debris out.

- Keep connectors off the ground to prevent damage due to submersion.
- Ensure any exposed surface cables are visible and protected to prevent damage from vehicles/personnel.
- Ensure the connectors are dry and free of debris when taking measurements.

8 PRODUCT SPECIFICATIONS

Item	Specification
Tensile Strength	113 kg
Maximum Tensile Force	1100 N (247 lb)
Maximum (Recommended) Clamp Spacing	0.6 / 1 m (2 / 3.25 ft)
Minimum Bending Radius, Single Bending	70 mm (3 in.)
Minimum Bending Radius, Repeated Bending	125 mm (5 in.)
Bending Moment	6.5 Nm (4.79 lb-ft)
Installation Temperature	- 40 to +60 °C (-40 to 140 °F)
Operation Temperature	- 50 to +85 °C (-58 to 185 °F)
Storage Temperature	- 70 to +85 °C (-94 to 185 °F)
Inner Conductor	Copper-Clad Aluminium Wire, 4.8 mm (0.19 in.)
Dielectric	Foam Polyethylene, 11.9 mm (0.47 in.)
Outer Conductor	Corrugated Copper, 13.8 mm (0.54 in.)
Jacket Material	Polyethylene, PE 15.8 mm (0.62 mm)
Weight	0.2 kg/m (0.14 lb/ft)
Characteristic Impedance	50 ± 1 Ω
Relative Propagation Velocity	88%
Capacitance	76 pF/m (23.2 pF/ft)
Inductance	0.19 µH/m (0.058 µH/ft)
Maximum Operating Frequency	8.8 GHz
Jacket Spark Test RMS	8000 V
Peak Power Rating	38 kQ
RF Peak Voltage Rating	1950 V
DC Resistance, Inner Conductor	1.57 Ω/km (0.45 Ω/1000ft)
DC Resistance, Outer Conductor	2.7 Ω/km (0.82 Ω/1000ft)

9 ORDERING INFORMATION

Item	Part Number
TDR Coaxial Cable with Connector Kit	EL810918
FlexDAQ Data Logger (with TDR200)	Contact RST for details
Portable Time Domain Reflectometer	ELGL3000

10 SERVICE, REPAIR AND CONTACT INFORMATION

This product does not contain any user-serviceable parts. Contact RST for product services or repairs.

- For sales information: sales@rstinstruments.com
- For technical support: https://support.rstinstruments.com/support/tickets/new
- Website: www.rstinstruments.com
- Toll free: 1-800-665-5599

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