FIELDSCOUT®

TDR 350
Soil Moisture Meter

PRODUCT MANUAL

Item # 6435

Spectrum®
Technologies, Inc.

General overview

Thank you for purchasing the FieldScout™ TDR 350 soil moisture meter. This manual describes the meter's general features and operation.

Soil moisture is a critical, and potentially highly variable, component of the soil environment. Time domain reflectometry is a proven technology for quickly and accurately determining volumetric water content (VWC) in soil. Electrical conductivity (EC) is a function of the moisture and salt in the soil and can be factored out to increase the accuracy of VWC measurements. The meter also measures soil surface temperature. The user can quickly transition between taking VWC readings in standard, high-clay, and sand-based soils.

The TDR 350's shaft-mounted probe allows the user to take measurements while standing. The meter's built-in data logger eliminates the need to record data manually. The data points can be viewed with the FieldScout Mobile app that maps out soil measurements using logged location coordinates. Measurements can also be saved to an external USB flash drive using the built-in USB port.

Contents

Includes the following components:
- TDR 350 meter (in collapsed position)
- Carrying case
- 4 AA batteries already installed

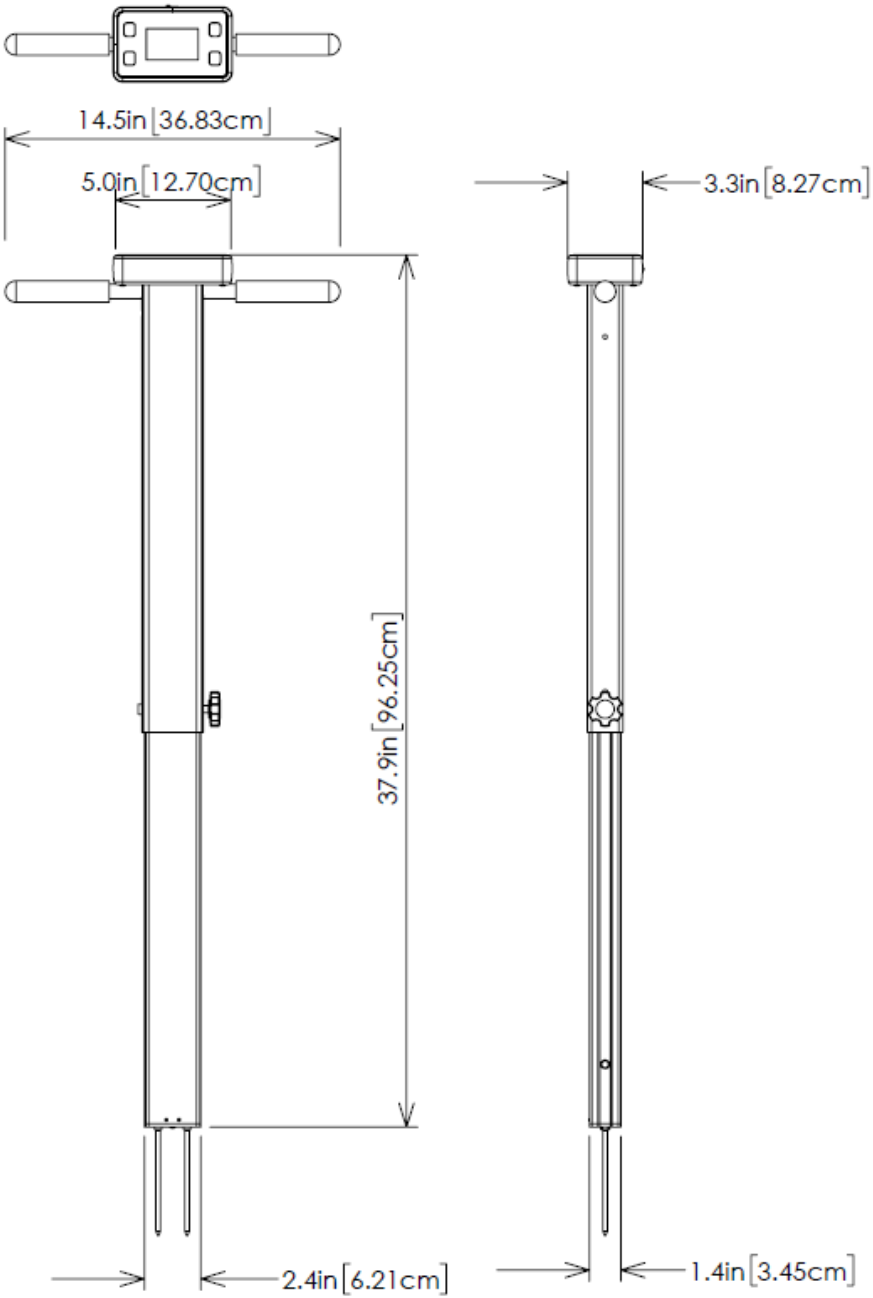
Note: **TDR rods are sold separately**

This manual will familiarize you with the features and operation of your new Field Scout™ TDR 350 Soil Moisture Meter. Please read this manual thoroughly before use

Specifications

Measurement Units	Percent volumetric water content (VWC) Period (raw sensor reading) Electrical Conductivity (EC) in milliSiemens per centimeter
Resolution, Accuracy and Range	**VWC**: 0.1% increment ±3.0% @ < 2 mS/cm 0% to Saturation (*Saturation is typically around 50% volumetric water*) **EC**: 0.01 increment ; ± 0.1 mS/cm; 0 - 5.5 range **Temperature**: 0.2 ˚F (0.1 ˚C) increment ; ± 1.8 ˚F (± 1 ˚C); -22 to 140 ˚F (-30 to 60 ˚C) Thermistor based; Infrared Optional
Connectivity	USB Type A, Bluetooth Low Energy
GNSS	Supported Systems: Galileo, GLONASS, GPS, QZSS (where available) EGNOS, MSAS, SBAS, and WAAS enabled Accuracy: <2.5m Typical, <10m (initial)
Power	4 AA batteries
Log Capacity	50,000 measurements
Display	Backlit, high-contrast, graphic LCD
Weight	4.3 lbs. (1.9 kg)
IP Rating	Display: IP53, Probe: IP67
Available Rod Dimensions	Turf 1.5” (3.8 cm) Short 3.0” (7.6 cm) Medium 4.8” (12.2 cm) Long 8.0” (20.32 cm) Diameter: 0.2” (0.5 cm) Spacing: 1.25” (3.18 cm)

Product dimensions



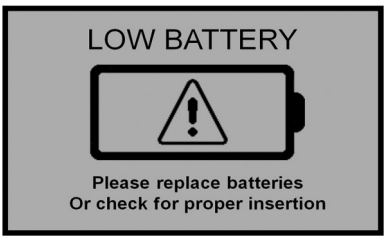
Meter Care

The FieldScout TDR meter will function properly under normal conditions experienced in field use. The sensor block is sealed and will not be damaged by immersion in water. The display is **not** waterproof so it should not be used during heavy rainfall or left exposed during irrigation events. If the display does get wet, it should be dried out immediately.

Follow these tips to prolong the life of the device:
- Store in a cool and dry place when not in use.
- Keep the meter and probe rods clean and dry in between uses.
- Remove the batteries if not used for an extended period (ie: between seasons).

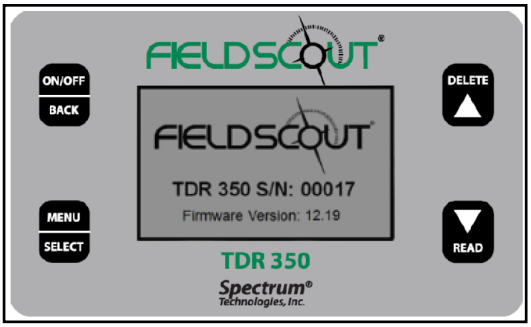
Battery life

A low battery level or improper installation of the batteries will show the low battery message briefly then, the display will power off.



Battery life is affected by the enabled features, connected accessories, and the frequency of use. If not needed, the Bluetooth, GNSS Location, and backlight features can be disabled individually to increase the battery life. The backlight can also be set to AUTO mode (page 10) which illuminates the LCD screen when a button is pressed allowing time to view the screen then, will switch off the backlight to prolong the battery life.

Button Functions



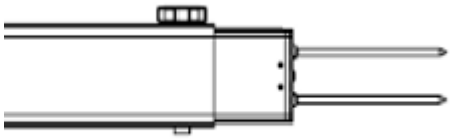
ON/OFF | **BACK** button
- Press briefly to power on.
- Press and hold to power on and stay on the startup screen.
- Press for 2 seconds to power off.
- Press briefly within a menu to return to prior screen.

MENU | **SELECT** button
- Press to enter available menus.
- Press to select or confirm a menu selection.

DELETE | **UP** button
- Press to move up within a menu.
- Delete last measurement from the running average, counter, and its entry from the internal data log (see p. 16).

READ | **DOWN** button
- Press to move down within a menu.
- Press to make a reading from the Reading screen.
- Press and hold to reset the average and count

Meter Operation



Probe base, thumb screw, and probe rods

Setting up the meter

1. Pull the clear battery transport tab out of the display unit.
2. If desired, extend the collapsible shaft by removing the thumb screw (shown above) from the side, grip and extend the lower shaft to its new position, re-insert the thumb screw, and hand tighten.
3. Select a set of probe rods, screw in, and tighten them to the bottom of the probe block.
4. Set the desired user settings in the settings menu. See the Settings Menu (page 10).

Taking Readings

1. Grip the TDR handles to the left and right of the display.
2. Push down on the handles maintaining a steady downward pressure to drive the rods into the soil until the sensor base is in contact with the soil surface. Refrain from any back and forth or side to side movement which can introduce air pockets into the soil medium and alter the reading accuracy.

Caution: Exercise care not to bend or damage the rods.

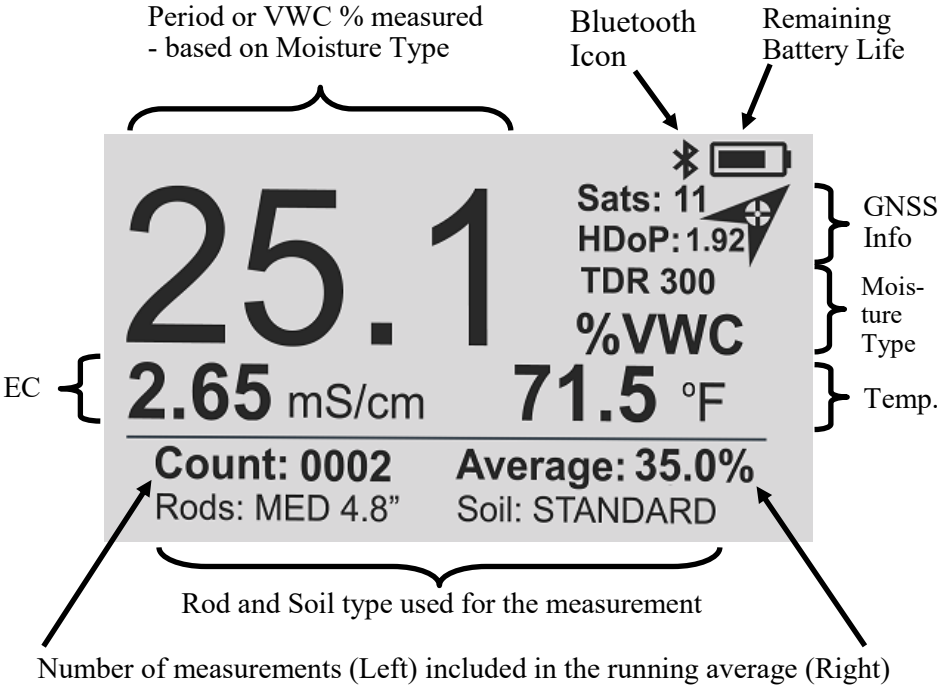
3. Press the **READ** button and observe the change in results on the top display.

Display Screens

The TDR 350 has 3 main display screens:
- Startup (as shown on page 7)
- Reading (shown below)
- Settings Menu (see page 10)

Startup Information screen
Initially displayed after first powered on.
- Displays model, serial number and firmware version.
- Press and hold **ON/OFF|BACK** button to remain on this screen.

Reading screen
Displays the last measurement, EC in milliSiemens per centimeter, temperature, selected rod type, selected soil type, and a reading count with running average. VWC=0% readings will be displayed but will not increment the counter or be included in the average.



Settings Menu screen
Used for changing device features, setting rod length, and working with log files.
Use the arrow buttons to move to the desired option.
Use the **MENU|SELECT** button to toggle option choices.

Clear Average*: Clears the displayed average and count.
Note: Same as a press and hold of the **READ|Down** arrow button.

Rod Length: Select the Rod length. See page 4 for options.

Soil Type: Selects the soil type used in measurements:
- Standard: for most mineral soils.
- Hi-Clay: for soils with higher clay content (> 27%).
- Sand: for sand based fields or turf greens.

Clear Logs*: Erases data logs from internal memory.

Save to USB*: Transfers data logs to a USB flash drive if attached.

Backlight: Sets the LCD backlight: ON, OFF, AUTO. In AUTO mode, the backlight will shut off 5 seconds after a button press

GNSS Location, GNSS Power Save, GNSS Use QZSS: Enable or disable features related to geo-location capability (see p. 13).

Bluetooth: Enable or disable Bluetooth connectivity to the FieldScout™ Mobile app (see p. 18).

Sound: Enable or disable beep for audible feedback.

Temp Source: Changes displayed temperature from the Soil Sensor to the IR Sensor (optional).

Temp Units: Fahrenheit or Celsius scale.

Moisture Type: Selects displayed moisture mode VWC%, Period, or TDR 300.
- VWC%: Volumetric Water Content with EC compensation.
- Period: Raw sensor reading in microseconds (us).
- TDR 300: VWC without EC compensation

EC Units: EC value (mS/cm) or Salinity Index (see p. 25).

Auto-Off: Power off delay: 15, 30, 45, 60 minutes.

Current Date, Current Time: Displays or changes current values. (See p. 12 for details).

Timezone: Offset from Greenwich Mean Time. As the offset changes, the Time and Date will update.

Daylight Savings: ON or OFF.

Calibration*: Overrides factory calibration. See Appendix

Clear User Calibration: Clears the user applied calibration back to factory settings

Factory Defaults*: Resets menu settings and counter to the factory default value.

About: General information (Model and serial number, firmware versions for display and sensor).

Rod Length	Not Set	**Temp Source**	Soil Sensor
Soil Type	Standard	**Moisture**	VWC
Backlight, GNSS, Bluetooth	Disabled	**EC units**	mS/cm
Sound	On	**Auto-Off**	15 minutes
Temperature	Fahrenheit	**Time Zone**	GMT

** Pressing Select button for these options brings up an additional screen.*

Setting Date/Time

By default, the TDR350 gets the date and time from the satellite signal. These values are displayed in the Settings Menu (p. 11). The date and time can also be set manually. When the time and date are set manually, they will over-ride the default value.

Note: When the batteries are removed, the date/time are reset and the meter resumes getting this information from the satellites.

Updating the Date and Time

1. Press the **MENU|SELECT** button to get to the Settings Menu.
2. Press the UP or DOWN arrows to navigate to either the **Current Date** or **Current Time** option.
3. Press the **MENU|SELECT** button to access the Time/Date update screen. There are 3 options:

A. Press the **READ|DOWN** button to download an update from the GNSS satellites. Proceed to an area with a good view of the sky and press the **Menu/Select** button to initiate the process.

B. Press the **DELETE|UP** button to set the date and time manually. The current settings will be displayed. Use the UP and DOWN arrows to adjust the highlighted selection. Press the **MENU|SELECT** button to confirm and proceed to the next parameter. After pressing the **MENU|SELECT** button to set the minutes, the display will return to the Reading screen.

C. Press the **ON/OFF|BACK** button to return to the Settings Menu without making any change.

GNSS (location) Settings

GNSS Location adds the ability to log global position coordinates with measurements to aid in irrigation mapping of crops and turf greens. Location references are stored with the measurement in the data log and can be uploaded to the cloud through the SpecConnect FieldScout Mobile App option (pages 20, 26).

The following menu settings apply to and effect the GNSS location feature:

GNSS Location
Enabled: Measurements will include global position coordinates of the meter position in the data log and\or FieldScout App.
Disabled: No location coordinates appear in the Data Log. SpecConnect FieldScout app measurements will include the global position of the mobile device running the app.

GNSS Power Save
Enabled: After periods of inactivity, the GNSS receiver will be placed in standby to improve battery life. The receiver resumes after the next read button press. A brief pause may be noticed as the receiver resumes operation.
Disabled: GNSS receiver will remain on for faster measurements. It is recommended to keep disabled during the first few days of use to improve accuracy and mapping.

GNSS Use QZSS
Enabled (Default): Improves location accuracy in Australia, Bangalore, Guam, Hawaii, Japan, Singapore and surrounding areas.
Disabled: Can improve location referencing time when outside of the referenced regions.

GNSS Location: Features, Use and Optimization

When enabled, the GNSS Location feature provides active location referencing information to aid in measurement mapping.

HDoP: Actively transitions from a high to low value as the level of precision improves. It may increase in value if conditions degrade. Values typically range between 9.99 to as low as 0.2. The value will appear blank until satellites in range are received and precision is calculated.

Sats: Active number of satellites used for position and location measurements. The value will increase from 00 as more satellites are received and used.

Location Reference Arrow Icon:
Transitions with changes in conditions, available satellites, and higher levels of precision are reached.


Blank icon - GNSS feature is enabled and not ready for location referencing of measurements. Measurements made with this icon will not have a geo-referenced location.


Partially Shaded - HDoP level is high and the satellite count is low. Measurements will have geo-referenced coordinates with a low level of accuracy (< 10m typical).


Dark Shaded - High satellite count without supplemental augmentation. Measurement location accuracy will depend on HDoP and Sats count.


Dark Shaded with Blank Dot - Low Satellite count with supplemental augmentation available to improve accuracy. Measurement location accuracy will depend on HDoP.


Dark Shaded with crosshair - High satellite count with supplemental augmentation available to improve accuracy. Measurement location accuracy is optimal (< 2.5m) and will depend on HDoP.


Clock icon; HDoP: Z.zz - GNSS Power Save has placed the receiver in standby mode. Press **READ|Down** button to resume. Note: First reading will have a slight delay.

Initial Use:

During the first three days of use, the meter's GNSS receiver will build an internal satellite record used for tracking and accuracy. Accuracy during this time may appear low, will depend upon the accuracy of available satellite systems, and can vary to within 10 meters. After the third use, the satellite record will be complete; the speed and accuracy of the location referencing will be at its best as the record is synchronized with the area the meter is being used.

Preparing for measurements:

Expect the first geo-referenced location to take place within a minute or so of operation on a clear day.

A minimum of 4 received satellites are necessary for a location fix. Achieving 10 or more satellites will yield better position data.

For Best Results:

- Keep the meter active for more than 6 minutes per session.
- Avoid powering off the meter between measurement locations within a use session. The meter will acquire the most satellites and better position data when remaining on for longer periods of use.
- Position the meter upright (probes facing down) while moving between locations to allow continued satellite tracking.
- When positioning the meter for a measurement, observe the display for a dark arrow icon, low HDoP value, and high Sats number.
- If possible, keep the meter stationary in position for a moment before pressing the read button.
- For faster results, disable GNSS Power Save to keep the receiver active. When enabled and the meter has been inactive, GNSS receiver may take a few seconds to resume from standby.
- Avoid using close to structures and dense tree canopies which can block satellite signals.
- Adjust standing position to acquire best icon shading and satellite count prior to pressing the read button. Simply standing to the side of the meter may make satellites visible and change the count and precision.

Data Logs

Downloading Data Logs to a USB Flash Drive

1. Remove the protective dust cover from the USB port.
2. Connect the flash drive to the meter's USB port. Note: A USB cable is not required or recommended.
3. Press the **MENU|SELECT** button to open the Settings Menu.
4. Press the **READ|Down** arrow button to reach the **Save to USB** option.
5. Press the **MENU|SELECT** button to select the option.
6. When the download completes, "Logs Saved!" will appear on the LCD screen.
7. Remove the flash drive from the USB port and replace the dust cover.

The data will be saved to the flash drive as a comma-separated text file (.csv) named with the serial number as the filename. These files can be opened with common text-editing or spreadsheet software. If a previous data file exists on the flash drive with the same filename, it will be overwritten. Be sure to save any existing data logs on the flash drive prior to saving a new file.

Erasing the internal Data log

1. Press the **MENU|SELECT** button (p. 10) to open the Settings Menu.
2. Press the **READ|Down** arrow button to reach the **Clear Logs** option
3. Press the **MENU|SELECT** button to select the option.
4. Press **MENU|SELECT** button again to start the process or the **ON/OFF|BACK** button to return back to the menu.

Data Collected

The following information is logged with each reading:

Time, VWC%, Period, EC, Temp_Soil, Temp_Soil(F), Temp_IR, Temp_IR(F), Latitude, Longitude, Satellites, Fix, Rod Length, Soil Type, VWC Mode, HDoP

Time: MM/DD/YYYY HH:MM:SS based on the GMT offset selected in the **Timezone** option (page 12)

VWC%: Volumetric Water Content based on the Moisture Type setting - EC Compensated or "TDR 300" (without EC compensation)

Period: Raw Period result (after any applied user calibration)

EC: Electrical Conductivity in milliSiemens per centimeter

Temp_Soil: Soil temperature sensor reading in degrees Celsius
Temp_Soil(F): Soil temperature sensor reading in degrees Fahrenheit

Temp_IR: InfraRed soil temperature sensor reading in degrees Celsius (if equipped)
Temp_IR(F): InfraRed soil temperature sensor reading in degrees Fahrenheit (if equipped)

Latitude, Longitude: Geo-referenced coordinate acquired in decimal degrees format. Note: A negative sign may appear indicating South or West coordinates.

Satellites: Number of satellites used in geo-referenced location

Fix: GNSS location fix level; 0 - unreferenced, 1 - fixed reference, 2 - fix with additional accuracy correction (SBAS, WAAS, EGNOS)

Rod Length: Depicted as **L:** **L**ong (8"), **M**: **M**ed (4.8"), **S:** **S**hort (3"), **T**: **T**urf (1.5"), **1**: 0.5" Spacer, and **2**: 1.0" Spacer

Soil Type: character depicted as **S:** **S**tandard, **H**: **H**i-Clay, and **D**: sand.

VWC Mode: depicted as V for EC compensated or 3 for non-compensated (TDR-300).

HDoP: Horizonatal Dilution of Precision value achieved with the GNSS coordinates

Field Scout Mobile App/ SpecConnect

The FieldScout Mobile App can be used to view measurement results directly on your mobile device and send data directly to the SpecConnect web interface. Data can be viewed on a Smartphone in two formats:

Basic **Grid mode** - Available with or without SpecConnect subscription. The site is divided into a customizable 2-dimensional grid of 3 to 5 rows and 3 to 5 columns. Measurements are taken in each grid cell. Grid cells are color-coded showing VWC average (fig. 1).

Freeform mode - Available with SpecConnect subscription. Color-coded location icons are placed at every measurement point using the coordinates from the meter (fig. 2). If the meter's GNSS location is disabled or a blank arrow appears on the meter, the app will use the internal location of the app's mobile device.

The data from the Pro version of the app is sent instantaneously to SpecConnect. Data can be viewed in map form (fig. 3), exported to a spreadsheet, or viewed as a Trend Report (fig. 4).

More details are available in the user's guide for the app.

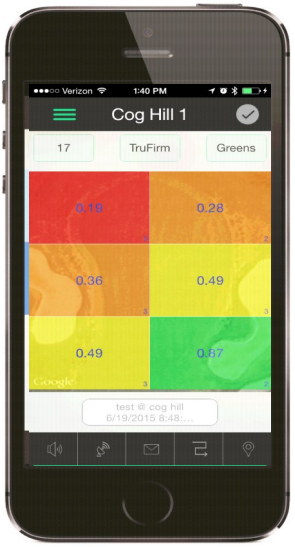


Figure 1. Grid Mode

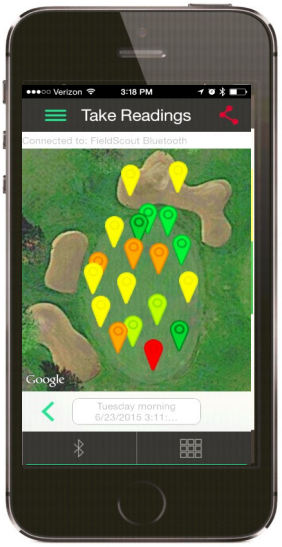


Figure 2. Freeform

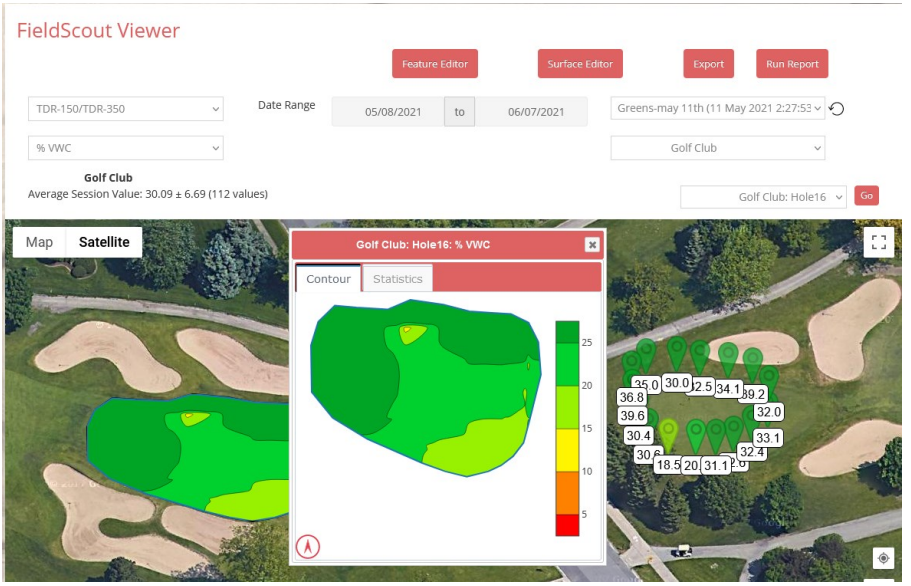


Fig. 3. 2-D Mapped Readings and Contour Plot in SpecConnect

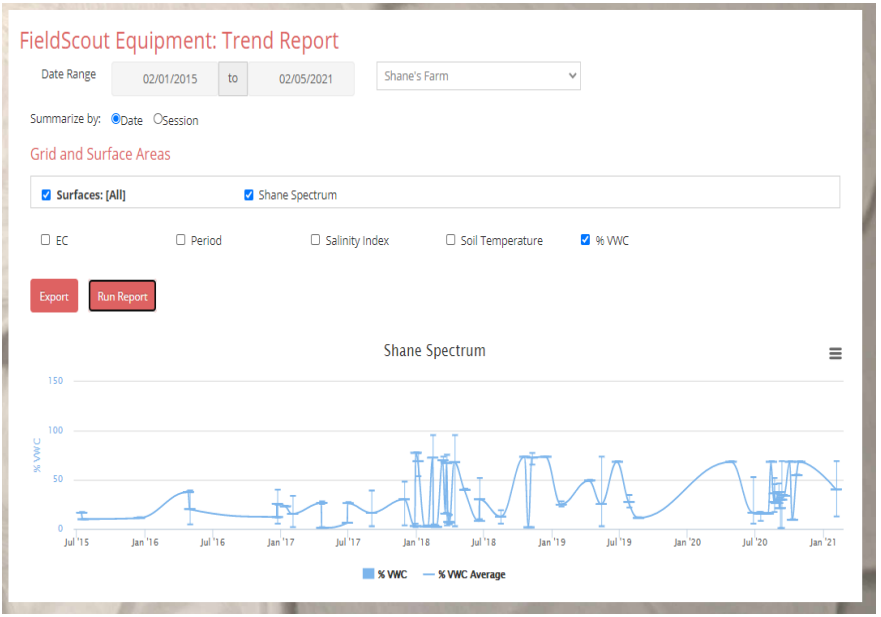


Fig. 4. Trend Report

FieldScout Mobile App: Setup and use

At any time, tap the App's menu icon to view or edit options.

1. Enable the TDR's Bluetooth and GNSS options.
2. Open the FieldScout mobile app.
3. Enter the SpecConnect username and password to send measurements to the cloud account or tap Use FieldScout Basic to start grid mode
4. Upon first use; Tap the Golf or Agriculture icon.
5. Add a course / farm or select an existing session.
6. In Basic mode, the Grid screen appears. Grid Tap on a grid cell where measurements will be added (fig. 1a).

   In SpecConnect Freeform mode, Freeform the app will transition to the session screen (fig. 1b).
7. Tap the **Connect FieldScout Device via Bluetooth** button (figs. 1a and 1b). If Bluetooth is not enabled on the mobile device, a prompt will appear to enable it.
8. Select the TDR from the device list (fig. 2).

Figure 1a. Bluetooth Connect button (grid)

Figure 1b. Bluetooth Connect button (freeform)

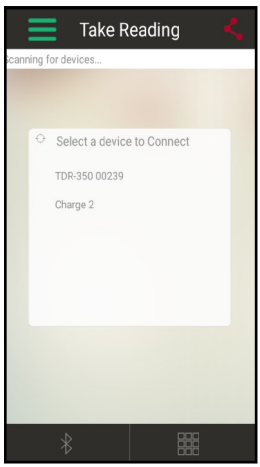


Figure 2. Scanned device list

9. Confirm that the meter you are using appears at the top of the screen. If you are in Grid mode, tap a zone (fig. 3a) to bring up the **Take Reading** screen (fig. 3b). Freeform readings will appear as a pushpin on the map (fig. 4).
10. Press the READ button on the TDR and the measurement data will appear on the mobile device.

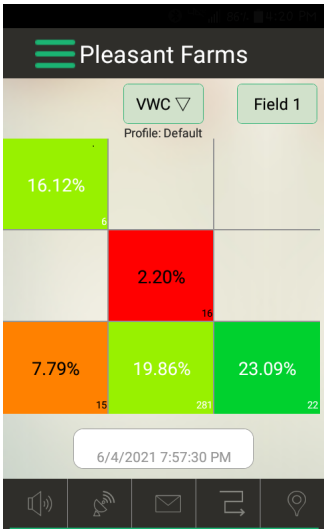


Figure 3a. Grid Mode

Note: Although the device appears in the app, it may not appear on the phone's list of Bluetooth devices.

Left: Grid Mode screens

Right: Freeform Mode screen

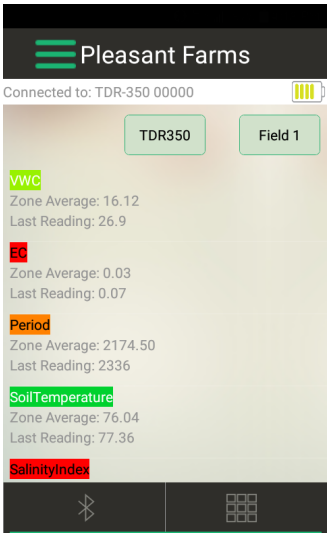


Figure 3b. Grid Mode Readings screen

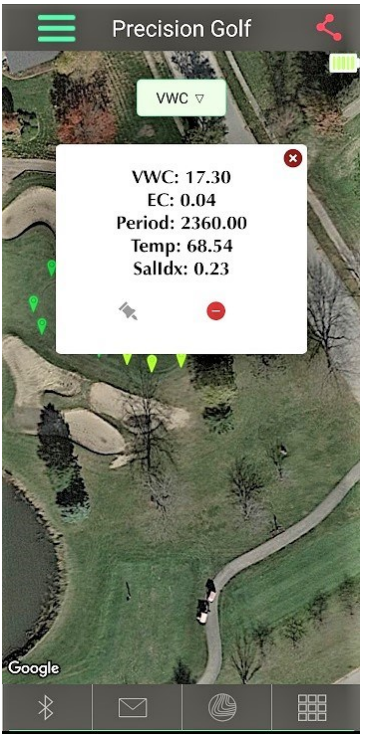


Figure 4. Freeform mode

Maintenance

Separating the Display and Sensor:

1. Remove the probe rods from the sensor base.
2. Flip the display so the backing plate is facing up.
3. Remove the 4 screws on the base using a Philips screwdriver.
4. Gently separate the display from the base plate. Note: The sensor cable connected in the center has limited cable length.

Battery Replacement:

1. Follow the steps in **Separating the Display and Sensor** to access the batteries.
2. Install four new AA batteries observing correct polarity by referencing the (+) positive and (-) negative labels.
3. Follow the procedure on the next page to reinstall the display.

Display Removal:

1. Follow steps for **Separating the Display and Sensor** to access the display and cable connections.
2. Remove the foam spacer and unplug the sensor cable connector from the jack (see below). If an IR temperature sensor is connected, disconnect this plug as well. **Do not discard the foam spacer.**

Display Installation:

1. If previously removed, re-connect the sensor cable to the 3.5mm connector on the back of the display module.
2. Insert the foam spacer back into place behind the sensor cable. The split end fits around the sensor cable molding.
3. If equipped with the IR temperature sensor option, attach it to the smaller diameter connector.
4. Guide the excess cable length back down through the base plate.
5. Align the arrows on the base and display in the same direction. The USB port should face the same side as the serial number label.
6. Tighten the four mounting screws.

Sensor Block Removal / Replacement:

1. Follow steps for **Display Removal** to access the cable connections.
2. Remove the thumb screw lock bolt that joins the lower probe base to the upper shaft.
3. Separate the probe base from the shaft (fig. 1).

Figure 1. Shaft interface

4. Feed the cable from the replacement probe base through the upper shaft. Attaching a string fed down from the top can aide in the process of cable reconnection.
5. Follow the procedure for **Display Installation** to complete the replacement.

VWC Measurements

Volumetric Water Content (VWC)
The ratio of the volume of water in a given volume of soil to the total soil volume expressed as a decimal or a percentage. Three soil moisture levels of most importance can be defined as follows:

Saturation: All soil pores are filled with water. The VWC will equal the percent pore space of the soil.

Field Capacity: The condition that exists after a saturated soil can drain to a point where the pull of gravity is no longer able to remove any additional water.

Permanent Wilting Point: The highest moisture content at which a plant can no longer extract water from the soil.

Additionally, we can define Plant Available Water as the amount of water between Permanent Wilting Point and Field Capacity. One rule of thumb is that irrigation should be initiated when half the Plant Available Water has been depleted.

Time Domain Reflectometry (TDR)
The speed of an electromagnetic wave along a waveguide in soil is dependent on the bulk dielectric permittivity (ε) of the soil matrix. The fact that water ($\varepsilon = 80$) has a much greater dielectric constant than air ($\varepsilon = 1$) or soil solids ($\varepsilon = 3\text{-}7$) is exploited to determine the VWC of the soil. The VWC measured by TDR is an average over the length of the waveguide.

The sampling volume is an elliptical cylinder that extends approximately 3 cm out from the rods. The high frequency signal information is then converted to volumetric water content. High amounts of clay or high electrical conductivity (EC>2 mS/cm) will attenuate the high-frequency signal and affect the reading displayed by the meter. Very high organic matter content will similarly affect the VWC reading.

Electrical Conductivity

Electrical Conductivity

The FieldScout TDR uses EC readings obtained from the same probes used to measure VWC. To improve the VWC measurement accuracy, EC is factored out of the VWC reading. This is a key advantage over its predecessor. The value measured is an average for the entire depth sampled. EC is expressed in units of mS/cm. The EC measured by an electrode is defined as the bulk EC.

The salinity level of soil is an important component of irrigation and nutrient management. The source of soil salts range from the original parent material, additions from natural sources, and management activity. High salt concentration in the soil has a negative effect as plant roots cannot bring in sufficient soil moisture. However, fertilizer exists as salt ions in that same soil solution. Low salt level can result in plants not getting the nutrients needed.

Direct measurement of salt content can only be done by subjecting a field sample to laboratory analysis. Fortunately, the electrical conductivity (EC) is a function of the dissolved salts in the soil. This proxy measurement is possible because, as salts dissolve into the soil, they disassociate into ions which conduct electricity.

Salinity Index

The TDR also has the option to report EC in the form of the Salinity Index. The salinity index is defined as the ratio of the bulk EC to the volumetric water content (expressed as a decimal). For example, if the bulk EC is 0.25 mS/cm and the VWC is 22%, the Salinity Index would be reported as 1.14 (0.25 ÷ 0.22 = 1.14). Therefore, the Salinity Index combines VWC and EC (corrected for temperature) into a parameter that will be less dependent on the sub-saturated water content.

The TDR measures the bulk EC of soil that may or may not be saturated. As the soil dries, the remaining pore space solution becomes more concentrated which increases EC. However, reduced water in the pores leads to a longer and more tortuous path between the sensor electrodes, which decreases EC. The second mechanism dominates. Bulk EC will decrease as soil moisture decreases. EC measurements made at different times are comparable when the moisture content is the same. This is best observed if the readings are always taken when the site is at field capacity - when a saturated soil is allowed to drain to the point where the pull of gravity can no longer remove any additional water.

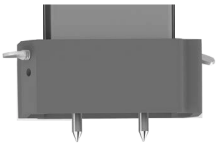
Optional Accessories

There are optional items that can be used to expand the capabilities of the TDR350. Visit www.specmeters.com for more information and installation instructions.

Infrared Temperature Sensor (item 6435TS)
Provides an instantaneous and highly accurate temperature reading as an alternative to the existing surface temperature sensor.

TDR Spacer (item 6435SP)

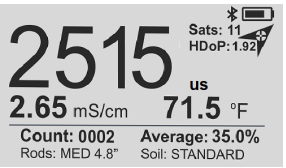
- Placed on the end of the sensor block to aide in identification of how fast and firm the turf greens are. The spacer has two orientations allowing it to work for either desired depth.
- Requires 3.8 cm (1.5”) turf rods.
- Allows for the measurement of 1.3cm (0.5") or 2.5cm (1.0") soil depths.



Pilot Hole Maker (item 6430PH)
If the ground is especially hard or compact, you can use a Pilot Hole maker to make 3” holes to aid in starting the insertion of the probe rods.

1-Year SpecConnect FieldScout Pro Subscription:
Upload measurements to the cloud\web interface for real-time monitoring of field and turf conditions. Access historical data, trends, and generate reports
(Item 3035A) - for up to 3 devices
(Item 3035B) - for up to 7 devices
(Item 3035C) - for up to 8 or more devices

Appendix 1: Soil-Specific Reading Correlation



To improve accuracy, correlate TDR period readings with a soil-specific sample set.
VWC data can be correlated by measuring the weight of a known volume of saturated soil as it is gradually dried, by gradually wetting a known volume soil with measured increments of water, or by using a neutron probe. In most cases, gravimetric sampling is performed. This procedure is briefly described below.

1. Establish the number of field sites to sample.
2. Wet each site with varying amounts of water.
3. Obtain FieldScout TDR period reading at each sample site.
4. Extract a known volume of soil at each sample site. Ideally, an undisturbed soil core. Reduce evaporation - store samples in a sealed plastic container.
5. Weigh the wet soil samples.
6. Dry the samples (105°C for 48 hours) and weigh again.
7. Plot sample measurements against FieldScout TDR readings.

Regression analysis is used to develop a formula to correlate TDR readings to the sample data.

Volumetric water content calculations:

VWC = $100*(M_{wet} - M_{dry})/(\rho_w * V_{tot})$

Gravimetric water content calculations:

VWC = GWC $*(\rho_b/\rho_w)$
GWC = $100*(M_{wet} - M_{dry})/M_{dry}$
ρ_b = M_{dry}/V_{tot}

Where:
M_{wet}, M_{dry} = mass (g) of wet and dry soil respectively
V_{tot} = total soil volume (ml)
ρ_w = density of water (1g/ml)

Appendix 2
Troubleshooting

Verifying operation:
The meter should read a measurement of 0% VWC with clean rods raised in the air. Test measurements should be made using distilled water, not well or municipal tap water, in a container at least 3" (7.6 cm) wide and deep enough to submerge the full length of the sensor rods up to the sensor base. Measurements in water will not read 100% as the equations were set for typical water content of the soil type used.

Below: Typical VWC range in water using VWC% mode and standard settings.

Rod Length	8" (20.3 cm)	4.8" (12.2 cm)	3"(7.6 cm)	1.5" (3.8 cm)
VWC %	60 - 65	70 - 75	75 - 80	65 - 70

Unable to save data to or load firmware from a USB flash drive:
Confirm the drive is not full or write protected. Verify the drive has FAT or FAT32 format. Firmware should be in the root directory, outside of any folders.

"Sensor Not Detected" appears on the display
- Communication lost between the sensor and display. The connection may be dirty, unplugged, or broken. Check the cable condition, clean the connection, and reseat. Power off the meter and then back on to reset.

"No Sensor" appears on the display:
- Sensor unplugged from the display. Be sure to keep the foam insert behind the cable to retain the cable during battery changes. Reconnect the sensor, power off the meter, and then back on to reset.

Clock icon appears on the display:
- Unable to download the date\time. See page 12.
- May also appear with "Zzz" when the GNSS Receiver is in standby.

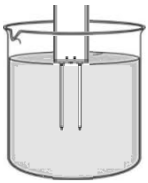
Appendix 3: Updating Device Firmware

Firmware updates may be made available to add or improve the product features. The firmware can be updated using a USB flash drive. Firmware update files can be found on the Spectrum website.

1. Copy the latest firmware update from your PC onto the root directory of the flash drive (FAT or FAT32 format). The file will not be seen by the meter if it is renamed or stored within a folder on the drive.
2. Power off the meter.
3. Remove the protective cap from the meter's USB port.
4. Insert the flash drive into the meter's USB port. Note: A USB cable is not required or recommended.
5. While pressing the **DELETE|Up arrow** button, press and release the **ON/OFF|BACK** button. The meter will beep.
6. Release the buttons. Note: The display screen will remain blank during the update process. The meter will beep a second time once the process has completed and then reboot to the logo screen. The new firmware will now be displayed below the Spectrum logo.
7. The display will alert the user if further updates are to be made and show a message when completed.
8. Remove the flash drive and replace the USB cover.

Appendix 4: Calibration

The FieldScout TDR is fully calibrated at the factory. Further calibration is not required nor recommended. The meter has internal calibrations that will work for many soil types. Each meter will have a small difference in how it responds to identical soil conditions. This can be due to air being introduced while measuring, bent probes, loose probes, sensor drift or component tolerances. The meter allows for adjustments to the calibration to account for these differences. Should the user prefer to perform the calibration; the following are required:



1. A clean glass or plastic container. The container must be at least 10cm (4") wide and 5.08cm (2") longer than the length of the TDR rods.
2. A sufficient volume of unused distilled or de-ionized water to fill the above container. **Note: Well or municipal tap water cannot be substituted**.

Procedure:

1. Pour all the distilled/deionized water into the container. Note: The water and container must be free of minerals and salts to calibrate properly.
2. From the Settings Menu (page 10), set the rod length to the correct length of the rods currently installed.
3. From the Settings Menu, choose the Calibration option.
4. Press the **MENU|SELECT** button to initiate the calibration process. Follow the display messages.
5. While keeping objects and personnel clear from the area; raise the meter so the rods are in the air. Press the **MENU|SELECT** button and wait until the meter indicates it is ready.
6. Immerse the rods completely in the deionized or distilled water until the sensor base is in contact with the liquid. Keep the sensor base and rods centered in the container. Do not submerge the sensor base.
7. Press the **MENU|SELECT** button and wait until the meter indicates it is ready.

The meter will then show that the calibration is complete for that specific rod length. If more than one rod size is being used, a calibration operation must be done for each rod length used.

Glossary

EC: Electrical Conductivity. A measure of soil electrical conduction in milli-Siemens. The EC is influenced by the amount of salt and water in the soil.

EGNOS: (European Geostationary Navigation Overlay Service) Pan-European satellite navigation system. It augments the US GPS satellite navigation system and makes it suitable for safety critical applications.

GNSS: (Global Navigation Satellite System) - Standard generic term for satellite navigation and positioning systems including GPS, GLONASS, Galileo, QZSS, Beidou and other regional systems

HDOP: (Horizontal Dilution of Precision) In global navigation and surveying, provides a descending value to gauge how precise a location measurement is across the Earth's surface.

QZSS: (Quasi-Zenith Satellite System) is a regional system launched by Japan and Australia which serves the local region and immediate surrounding area.

SBAS: (Satellite Based Augmentation System) - used to improve satellite ranging errors

TDR: (Time Domain Reflectometry) A technique for measuring soil moisture content that uses the fact that water has a much higher dielectric permittivity than air, soil minerals, and organic matter.

VWC: (Volumetric Water Content) The percent of the soil volume that is filled with water. At saturation, the VWC will equal the soil porosity.

WAAS: (Wide Area Augmentation System) - a system used by the GNSS receiver which augments received positioning data to aid accuracy.

RE-D EU Declaration of Conformity (DoC) #20210118_1

In accordance with European Parliament and Council Decision No. 768/2008/EC Annex III
we, Spectrum Technologies, Inc., a corporation validly organized and existing under the laws of the United States of America, having its principal place of business at 3600 Thayer Court, Aurora IL 60504 USA
declare under our sole responsibility that the below named

Product: FieldScout TDR Soil Moisture Meter
Model Name (Product Number): TDR-150 (6445), TDR-250 (6250), and TDR-350 (6435)

Object of the Declaration:
FieldScout TDR Soil Moisture Meter providing a means for determining the volumetric water content (VWC) of a growing soil.
Specifications:

- Battery powered device (4 x AA batteries)
- 6.9cm (2.7") Backlit LCD Display
- Durable powder coated aluminium frame (TDR-250 and TDR-350)
- Hand-held Display UI and tethered sensor (TDR-150)
- Removable / Interchangeable sensing rods required for proper operation

to which this declaration relates, conform with the relevant requirements of the Harmonized Legislations mentioned below. Specifically, but not limited, to the following harmonized standards and/or normative documents:

Harmonization Legislation:

2014/53/EU Radio Equipment Directive
2011/65/EU Restriction of Hazardous Substances Directive

Article 3.1(a) Safety of Information Technology Equipment

EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
EN 60950-1:2005(second edition) + Am 1:2009 + Am 2: 2013 (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)

Article 3.1(b) Electromagnetic Compatibility

EN 61000-6-1:2007 Immunity for residential, commercial, and light-industrial environments
EN 61000-6-3:2007 /A1:2011 Emission standard for residential, commercial, and light-industrial environments
EN 55032:2015 /A11:2020 Electromagnetic compatibility of multimedia equipment – Emission requirements
EN 301 489-1 V2.1.1 EMC standard for radio equipment and services; Part 1 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P and GNSS module Antenova Ltd. M20050-1 where used)
EN 301 489-1 V2.2.3; 2019-11 EMC standard for radio equipment and services; Part 1: Common technical requirements
EN 301 489-3 V2.1.1; 2019-03 EMC standard for radio equipment and services; Part 3: Specific

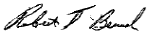
conditions for Short-Range Devices
EN 301 489-17 v3.1.1 EMC standard for radio equipment and services; Part 17 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
EN 301 489-17 V3.2.4; 2020-09 EMC standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems
EN 301 489-19 V2.1.1; 2019-04 EMC standard for radio equipment and services; Part 19: … GNSS receivers operating in the RNSS band providing positioning, navigation, and timing data (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)
EN 303 413 V1.1.1:2017 Global Navigation Satellite System (GNSS) receivers (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)

Article 3.2 Spectrum Efficiency

EN 300 328 V2.1.1; 2016-11 Wideband Data Transmission Systems; 2.4 GHz Band; Emissions, EMC (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
EN 300 440 V2.2.1 2018-07 Short Range Devices 1-40 GHz; Emissions; EMC
EN 303 413 V1.1.1: 2017 Satellite Earth Stations and Systems; Global Navigation Satellite System (GNSS) receivers; (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)

Article 3.3 Other Requirements

EN 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances



Robert T Benesh
Job Title: Electronics Engineer, TDR Product Manager
Email: rbenesh@specmeters.com

UK Declaration of Conformity (DoC) #20210118_2

In accordance with BS EN ISO/IEC 17050-1:2010 we, Spectrum Technologies, Inc., a corporation validly organized and existing under the laws of the United States of America, having its principal place of business at 3600 Thayer Court, Aurora IL 60504 USA
declare under our sole responsibility that the below named

Product: FieldScout TDR Soil Moisture Meter
Model Name (Product Number): TDR-150 (6445), TDR-250 (6250), and TDR-350 (6435)

Object of the Declaration:

FieldScout TDR Soil Moisture Meter providing a means for determining the volumetric water content (VWC) of a growing medium.
Specifications:

- Battery powered device (4 x AA batteries)
- 6.9cm (2.7") Backlit LCD Display
- Durable powder coated aluminium frame (TDR-250 and TDR-350)
- Hand-held Display UI and tethered sensor (TDR-150)
- Removable / Interchangeable sensing rods required for proper operation

to which this declaration relates, conform with the relevant requirements of the Harmonized Legislations mentioned below. Specifically, but not limited, to the following harmonized standards and/or normative documents:

Harmonization Legislation:

2016 No. 1091 The Electromagnetic Compatibility Regulations 2016
2012 No. 3032 The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

Safety of Information Technology Equipment

EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + A2:2013 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
EN 60950-1:2005(second edition) + Am 1:2009 + Am 2: 2013 (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)

Electromagnetic Compatibility

BS EN 61000-6-1:2007 Immunity for residential, commercial, and light-industrial environments
BS EN 61000-6-3:2007 /A1:2011 Emission standard for residential, commercial, and light-industrial environments
BS EN 55032:2015 /A11:2020 Electromagnetic compatibility of multimedia equipment – Emission requirements
EN 301 489-1 V2.1.1 EMC standard for radio equipment and services; Part 1 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P and GNSS module Antenova Ltd. M20050-1 where used)
EN 301 489-1 V2.2.3; 2019-11 EMC standard for radio equipment and services; Part 1: Common technical requirements

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EN 301 489-17 v3.1.1 EMC standard for radio equipment and services; Part 17 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
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EN 303 413 V1.1.1:2017 Global Navigation Satellite System (GNSS) receivers (as applied to internal GNSS module Antenova Ltd. M20050-1 where used)

Spectrum Efficiency

EN 300 328 v2.1.1 (as applied to internal Bluetooth module Silicon Labs BGM113A-V1 or BGM13P where used)
EN 300 440 V2.2.1 2018-07 Short Range Devices 1-40 GHz; Emissions; EMC
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Article 3.3 Other Requirements

BS EN 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Robert T Benesh
Job Title: Electronics Engineer, TDR Product Manager
Email: rbenesh@specmeters.com

Declaration of Conformity
47 CFR § 2.1077 Compliance Information
Unique Identifier: FieldScout Soil Moisture Meter
6435 TDR-350, 6250 TDR-250, 6445 TDR-150

Responsible Party – U.S. Contact Information

Spectrum Technologies, Inc., 3600 Thayer Ct. Aurora IL 60504
Phone: (800) 248-8873 or (815) 436-4440 Fax (815) 436-4460
E-Mail: info@specmeters.com Web: www.specmeters.com

Directive/Standard:
FCC Part 15: 2020: Emissions for Unintentional Radiators for USA (ANSI C63.4:2014)
ICES-003:2019: ITE Emissions for Canada (ANSI C63.4:2014)

FCC Compliance Statement
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an output on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced RF technician for help.

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS (s). Operation is subject to the following two conditions:
(1) This device may not cause interference.
(2) This device must accept any interference, including interference that may cause undesired operation of the device.
This Class (B) digital apparatus complies with Canadian ICES-003.
Cet appareil numériqué de la classe (B) est conformé à la norme NMB-003 du Canada.

Proper Disposal of Waste Electrical and Electronic Equipment

This symbol when found on the product or packaging indicates that this product shall not be treated as common waste and that an effort to recycle materials should be made or may be required. Disposal of used and depleted electrical & electronic equipment may be subject to local laws and regulations for proper collection and recycling initiatives in the local area. This is applicable to areas within the European Union and other participating countries including the USA. The recycling of materials will help to conserve natural resources and prevent negative consequences of inappropriate waste handling at the end of a product's usable life.

For more information about the recycling of waste electrical and electronic equipment, please contact your local civic office, waste disposal service, or the shop where the item was purchased.

Warranty

This product is warranted to be free from defects in material or workmanship for **two** years from the date of purchase. During the warranty period Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty does not cover damage due to improper installation or use, lightning, negligence, accident, or unauthorized modifications, or to incidental or consequential damages beyond the Spectrum product. Before returning a failed unit, you must obtain a Returned Materials Authorization (RMA) from Spectrum. Spectrum is not responsible for any package that is returned without a valid RMA number or for the loss of the package by any shipping company.

Changes, modification, or use of this product beyond the scope of this instruction manual may void the warranty and/or void the user's authority to operate the device.

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