TDR 350
Soil Moisture Meter

PRODUCT MANUAL

Item # 6435

Spectrum® Technologies, Inc.

CONTENTS

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 using your instrument.

General overview

Thank you for purchasing the Field Scout™ TDR 350 soil moisture, electrical conductivity and soil surface temperature 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. The meter also measures soil surface temperature. The user can quickly transition between taking VWC readings in standard and high-clay mode.

The TDR 350's shaft-mounted probe allows the user to take measurements while standing. The meter's built-in data logger can record data from several sites and eliminates the need to record data manually. The data points can be viewed with the FieldScout Mobile app that maps out soil measurements on logged GPS locations. Measurements can also be saved to a USB drive that is plugged into the built-in USB port.

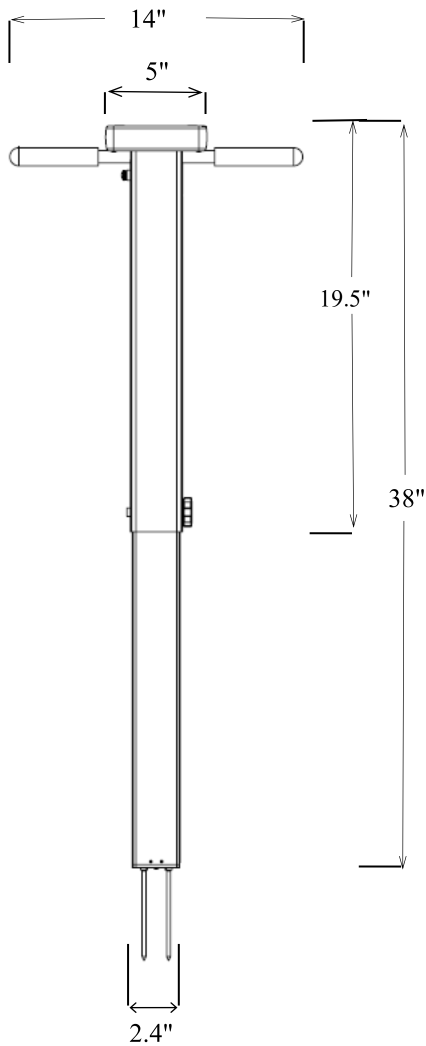
Contents

Your shipment includes the following components:
- TDR 350 meter (in collapsed position)
- Carrying case
- 4 AA batteries

Note: TDR rods are sold separately

Shaft dimensions

The following are the dimensions of a fully extended shaft. It is possible to reduce the length of the meter to 23” (58.5 cm) by adjusting the lower half of the shaft.



Specifications

Measurement Units	Percent volumetric water content (VWC) Period (raw sensor reading)
Resolution	**VWC**: 0.1% VWC units **EC**: 0.01 mS/cm **Temperature**: 0.2 ˚F (0.1 ˚C)
Accuracy	**VWC**: ±3.0% volumetric water content with electrical conductivity < 2 mS/cm **EC**: ± 0.1 mS/cm **Temperature**: ± 1.8 ˚F (± 1 ˚C)
Range	**VWC**: 0% to saturation (*Saturation is typically around 50% volumetric water*) **EC**: 0 to 5 mS/cm **Temperature**: -22 to 140 ˚F (-30 to 60 ˚C)
Power	4 AA batteries Lithium batteries will optimize battery life
Logger Capacity	50,000 measurements
Display	Backlit, high-contrast, graphic LCD
GPS	Accuracy < 2.5m
Weight	4.3 lbs. (1.9 kg)
Probe Head Dimensions	2.4" x 1.4" (6cm x 3.5cm)
Shaft Dimensions	Extended Length: 38" (96.5cm) Collapsed Length: 23" (58.4cm) Width: 1.4" (3.5cm)
Available Rod Dimensions	Turf 1.5" (3.8cm) Short 3" (7.6cm) Medium 4.7" (12cm) Long 7.9" (20cm) Diameter: 0.2" (0.5cm) Spacing: 1.2" (3cm)

Batteries

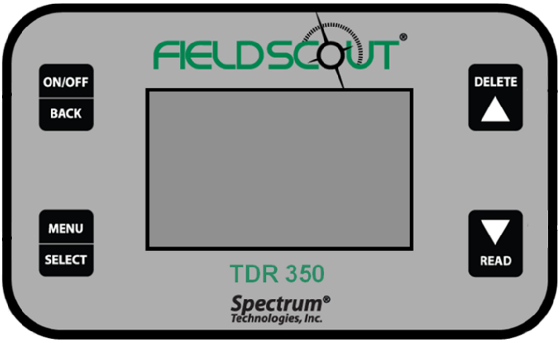
Changing the batteries
The TDR 350 requires 4 AA batteries. The battery holder is on the underside of the display unit. The sensor is attached to the display via a cable that is plugged into a socket between the battery holders. The cable can be pulled out of and pushed back into the shaft through a grommet at the top of the shaft.

STEPS:
1. Turn the TDR 350 upside down and remove the 4 screws. Open the bottom and separate the display module from the base plate. This may require pulling the cable slightly out of the shaft.
2. Unplug the cable connector from the jack to completely detach the display from the base.
3. Install batteries and ensure correct polarity by referencing the (+) positive and (-) negative labels at either end of each slot.
4. Plug the cable connector back into the larger stereo jack.
5. Mount the display box back onto the base plate. As you do this, feed the cable back into the grommet.
6. Reattach the 4 screws.

Battery life
The battery level is checked every time the display unit is turned on. If the battery level is low, or if a battery is inserted incorrectly, this low battery image shows on the full screen for about 10 seconds and then the display will automatically turn off.

In addition to frequency of use, battery life is impacted by use of the backlight and GPS receiver. If not needed, the GPS feature should be disabled. The backlight can be set to AUTO mode (p. 12). This allows enough time to see the reading without unduly taxing the battery.

Button Functions



Basic Button Operations

ON/OFF or **BACK** button

Press this button briefly to turn on the display. The meter will then display the Data screen (p. 11). To turn the meter off, press and hold this button for about 2 seconds.

When in the Settings Menu screen (p. 12), press this button to return to the Data screen. If you are in a settings option that requires its own screen, this button will return you to the Settings Menu screen

MENU or **SELECT** button

When in the Data screen, press this button to go to the settings menu screen (p. 12). When in the Settings Menu screen and on a menu option, press this button to browse through the different choices for that specific menu selection. In some cases, selecting a settings option will take you to another screen for further action.

DELETE or **UP** button

When on the Data screen (p. 11), press this button to delete the last measured data point from the computed Average and decrement the Count.

When on the Settings Menu screen (p. 12), press this button to scroll up to the previous menu item.

READ or **DOWN** button

When on the Data screen, press and release this button to take a sensor reading. Press and hold to clear the average and reset the sample count to 0.

When on the Settings Menu screen, press this button to scroll down to the next menu item.

Display Screens

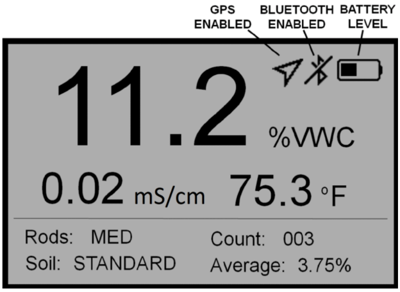
The TDR 350 has 3 main display screens;
- Startup Information screen
- Data screen
- Settings Menu screen

Startup Information screen

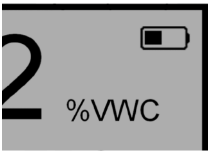
The Startup Information screen is displayed for about 2 seconds after the display is turned on.

If desired, the startup screen can be kept on for a longer duration. While powering up the meter, press and hold the **On/Off/Back** button to continue displaying the Startup Device Information screen. Release the button to proceed to the Data screen.

Data screen



Readings from the sensor are displayed on the Data screen. The battery level indicator appears in the upper right corner. The running average and number of readings included in that average are shown in the lower right corner. Pressing and holding the READ button will clear the average and re-set the counter to 0.

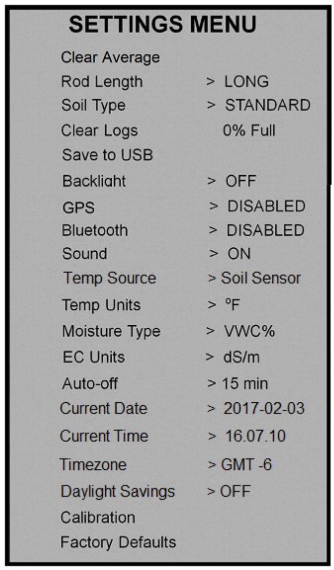


When disabled, the GPS and/or Bluetooth icons will no longer be visible. When visible, the GPS icon will indicate the quality of the GPS fix (p. 27).

When the Bluetooth is enabled but the TDR is not connected to a mobile device, the Bluetooth icon has a bar through I (see image in data screen at top of page). When the TDR is connected to a mobile device, the bar is removed (see image to the right).

Settings Menu screen

The contents of the Settings Menu are shown on the following figure. Use the arrow buttons to scroll to the desired option. The options are described below. For most options, pressing the **Select** button simply toggles you through the different choices for that option. Some options require an additional step or steps.



Clear Average*: Clears the current average and resets the counter to zero.

Rod Length: Select the size rods attached to meter. See p. 5 for options.

Soil Type: Choose Standard or High Clay.

Clear Logs*: Initiates erasing of data from internal memory.

Save to USB*: Initiates transfer of data to USB flash drive.

Backlight: The three options are ON, OFF, and AUTO. In AUTO mode, the backlight will be illuminated for 5 seconds after a measurement is taken and then shut off.

GPS, Bluetooth, Sound: Enable or disable these options. If location is not needed or a mobile devices is not used, disabling these features will improve battery life.

Temp Source: Choose Soil Sensor or IR Sensor (IR sensor accessory will be available soon).

Temp Units: Choose Fahrenheit or Celsius.

Moisture Type: Choose volumetric water content (VWC%), raw sensor reading (Period), or TDR 300 mode. The latter will report a VWC that matches the output of the TDR 300 meter (no EC optimization).

EC Units: Choose simple EC value (mS/cm) or the Salinity Index (see p. 17).

Auto-Off: Choose how long the meter will stay on before automatically powering off.

Current Date, Current Time: These are reported values. They cannot be manually adjusted. This information is acquired from the GPS signal.

Timezone: Choose the offset from Greenwich Mean Time (see p. 32). As you change the offset, the Current Time and Date will be updated.

Daylight Savings: Options are ON or OFF.

Calibration*: Initiates calibration sequence (see p. 14).

Factory Defaults*: Returns all meter settings to the factory default values. See p. 31.

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

Meter Calibration

The meter has internal calibrations for standard and high-clay soil types. It also has the option of outputting a value that matches its predecessor, the TDR 300. These calibrations will work for a large number of soils. However, each meter will have a small difference in how it responds to identical soil conditions. This is due to sensor drift or variability in the electronic components used during manufacturing. The meter allows for adjustments to the calibration to account for these differences. Therefore, if two meters are giving slightly different readings in the same soil, the output of the meters can be standardized such that the meters can be used interchangeably. After calibration, a TDR 350 in "TDR 300" mode (see p. 13) should read the same as a TDR 300 meter.

To perform the calibration, you will need a 6" diameter plastic container of distilled or de-ionized water. The container must be at least as tall as the length of the TDR rods. The procedure is as follows:

1. From the Settings menu (p. 12), scroll to the Calibration option. Press the **Select** button to initiate the calibration process.
2. Hold the meter so the rods are in the air. Press the **Menu/Select** button and wait until the meter indicates it is ready.
3. Immerse the rods completely in the water. 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 one.

Note: This procedure is different than a soil-specific calibration (Appendix 1, p. 28) where a unique calibration curve is generated.

Updating Firmware

The firmware of the TDR 350 can be updated using a USB flash drive. Firmware update files can be found at the Spectrum website.

1. Copy the latest firmware update from your PC onto your flash drive.
2. Power off the meter.
3. Insert the flash drive into the meter's USB port.
4. While holding down the **Delete** button, and press the **On/Off/Back** button. The meter will beep.
5. Release the Delete button after the meter beeps a second time.
6. Remove the flash drive.

The meter will then power up as usual.

Electrical Conductivity

Knowledge of the salinity level of your soil is an important component of irrigation and nutrient management. The source of the salts in the soil ranges from the original parent material to additions from natural sources and management activity. Often, having salt in the soil has a negative connotation. This is because when the soil solution has a high salt concentration, plant roots cannot bring in sufficient soil moisture. However, fertilizer exists as salt ions in that same soil solution. So, if the salt level is too low, the plant cannot get the nutrients it needs.

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. EC is expressed in units of mS/cm. This proxy measurement is possible because, as salts dissolve into the soil, they disassociate into ions which conduct electricity. EC is highly temperature dependent. The temperature correction, in turn, is dependent on the composition of the electrolyte solution. For example, a 0.01m KCl solution would have a temperature correction factor of 0.02 mS/cm per degree C.

The EC measured by an electrode is defined as the bulk EC. The significance of this value depends on how the sample was prepared. The EC reported by a soil lab is typically the saturated media extract. Briefly, distilled water is added the soil until it glistens. The soil solution is given time to equilibrate with ions on the soil exchange sites. This soil water is then suctioned off to be measured. Measuring the EC of diluted soil/water solutions (such as 1 part soil: 2 parts water) is also common. The determination of whether the EC is within an acceptable range is based on the type of sample being measured.

The TDR 350 uses the same metal rods used for soil moisture sensor as the electrodes for the EC circuit. The value measured is an average for the entire depth sampled.

Salinity Index

The TDR 350 measures the bulk EC of soil that may or may not be saturated. There are two competing mechanisms at place. As the soil dries, the remaining solution in the pore space becomes more concentrated which increases its 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. This means that bulk EC will decrease as soil moisture decreases. EC measurements at different sampling times are comparable when the moisture content for each measurement is the same. This is easily accomplished if readings are always taken when the site is at field capacity. Field capacity is defined as the condition that exists when a saturated soil is allowed to drain to the point where the pull of gravity can no longer remove any additional water.

The TDR 350 also gives 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 ($0.25 \div 0.22 = 1.14$). 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.

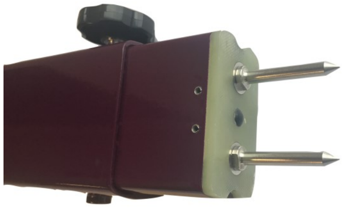


Figure 1. Shaft, fastening bolt, and rods

Setting up the meter
The telescoping shaft (fig. 1) can be used in an extended or retracted position. To adjust the length, remove the fastening bolt and push or pull the shaft into its new position.

Screw the rods into the sockets at the bottom of the probe block.

Configuring the meter
Turn on the meter and ensure that it is properly configured. Configuration is done in the Settings menu (pp. 12 - 13).

The TDR 350 can be set to one of two **Soil Type** modes, Standard or High Clay. The Standard mode will be appropriate for most mineral soils. The High Clay mode will be more accurate for soils with higher clay contents (> 27%). There are 3 **Moisture Type** options. VWC% mode displays the moisture content optimized by the output of the EC sensor. Period mode displays the raw sensor reading. This mode is intended primarily for troubleshooting or for soil-specific calibrations. TDR 300 mode displays a reading that will match the output of a TDR 300 meter.

To geo-reference data, enable the **GPS** capability. If you are using the FieldScout Mobile app (p. 22), **Bluetooth** functionality must be enabled. If **GPS** is disabled, the app will use the phone's GPS instead.

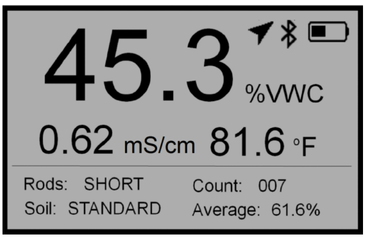


Figure 2.Sample data screen

Display

Figure 2 shows a sample data screen. The GPS, Bluetooth, and battery status are shown in the upper right corner. Soil moisture, EC, and temperature data are displayed in the top half of the display. The average reading and number of readings included in the average are visible in the lower right corner. The current **Rod Length** and **Soil Type** are shown in the lower left corner.

Taking Readings

Push the rods into the soil. When taking a measurement, it is important that the rods be fully inserted into the soil. If not, part of the sampling volume will be composed of air and the reading will be inaccurately low. For the same reason, the probe should be inserted with a steady, downward pressure. If the rods are wiggled into the soil, air pockets can be created adjacent to the rods that will result in low readings. The probe should not be struck with a hammer or other blunt instrument as this can cause damage to the internal electronics. Also, care should be taken to ensure the rods are inserted as parallel to one another as possible. This will not have a large affect on the reading but will decrease the chances the rods will be bent or broken. Likewise, it is best to avoid areas with rocks or other material that can cause the rods to deflect or bend. If the ground is especially hard or compact, you can use a

Pilot Hole maker (item 6430PH) to make 3” holes to aid in starting the insertion of the probe rods.

Press the **READ** button to initiate the measurement sequence. The reading should appear almost instantaneously. If the display does not detect the sensor, it will display dashes. Check that the sensor is securely attached (see p. 21).

Note: The TDR rods are manufactured from type 303 stainless steel and are designed to bend if non-vertical force is applied to them. This serves to protect the TDR block electronics from potential damage that could be caused by excessive force.

Occasional rod bending is normal, and can be expected during the course of sampling. Longer rods will be more susceptible to bending than shorter rods. If bending occurs, rods should simply be bent back to parallel position, perpendicular to the TDR block. Measurements will continue to be accurate provided that rods are reasonably close to parallel.

If care is not taken to reposition rods to a parallel position, subsequent pressure on the rods will accentuate the bending and may cause the rods to break.

Rods should be considered maintenance items that may need to be replaced over time, depending upon the nature and frequency of sampling. The rods will wear most rapidly in sand-based root zones.

Replacing or Re-attaching the Probe Block

Figure 1. Sensor cable connection to board.

Figure 2. Sensor block/ shaft interface

The TDR 350 sensor block is a user-replaceable component (item 6435S). Remove the rods before separating the old sensor.

1. Turn the TDR 350 upside down and remove the 4 screws. Open the bottom and separate the display module from the base plate (fig. 1). This may require pulling the cable slightly out of the shaft.
2. Unplug the cable connector from the jack to completely detach the display from the base.
3. Remove the fastening bolt that joins the probe block to the shaft.
4. Separate the probe block from the shaft (fig. 2).
5. Feed the cable from the replacement probe block through the shaft.
6. Connect the cable to the large socket on the underside of the display module and re-assemble the display.

Field Scout Mobile App/ SpecConnect

In addition to transferring data to a flash drive, the FieldScout Mobile App can be used to send data directly to the SpecConnect web utility. Data can be viewed on a Smartphone in two formats. In grid mode, 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. Average, color-coded data are displayed on the app (Fig. 1). In freeform mode, a color-coded pushpin icon is placed at every sampling point. If the TDR 350 has a good GPS fix (p. 11), the app will use the coordinates from the meter. If not, or if the meter's GPS is disabled, it will use the internal GPS of the smartphone.

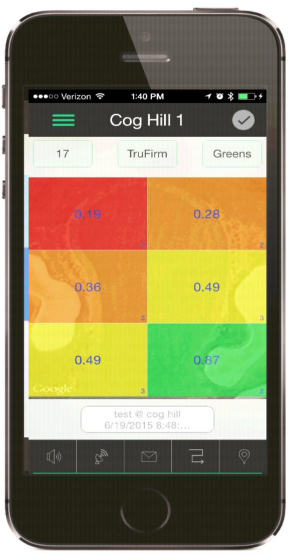


Figure 1. Grid Mode

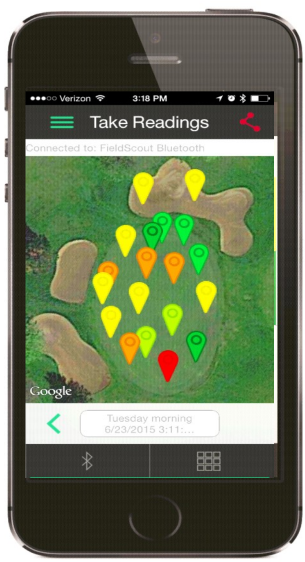


Figure 2. Freeform Mode

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 an Excel spreadsheet, or viewed as a Trend Report (fig. 4).

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

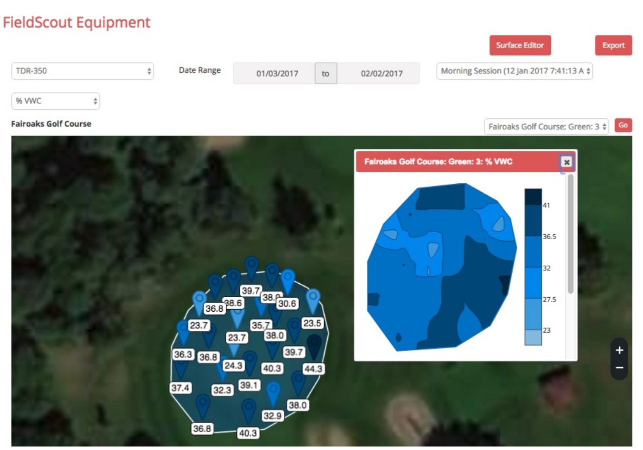


Fig. 3. 2-D Contour Plot in SpecConnect

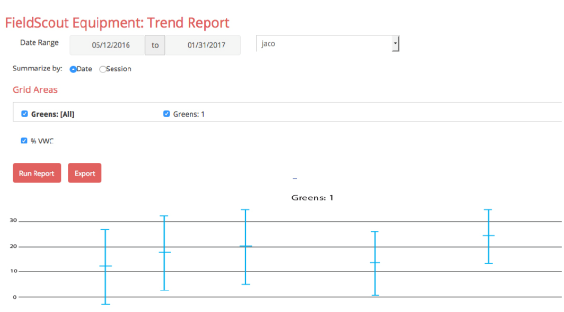


Fig. 4. Trend Report

15000010.csv

	A	B	C	D	E	F	G	H	I	J	K
1	Time	VWC%	Period	EC	Temp(C)	Latitude	Longitude	Satellites	Fix	Rod Length	Soil Type
2	1/23/2017 8:58	25.9	2089	0.21	18.3	4144.3933	08813.6663 W	8	1	S	S
3	1/23/2017 8:59	26.1	2088	0.27	18.1	4144.3947	08813.6668 W	9	1	S	S
4	1/23/2017 8:59	26.1	2088	0.18	17.9	4144.3989	08813.6665 W	11	1	S	S
5	1/23/2017 8:59	26	2088	0.20	17.7	4144.3990	08813.6667 W	11	1	S	S
6	1/23/2017 8:59	26.2	2087	0.19	17.6	4144.3989	08813.6666 W	11	1	S	S
7	1/23/2017 8:59	26.1	2088	0.23	17.5	4144.3995	08813.6670 W	11	1	S	S
8	1/23/2017 8:59	26.1	2088	0.23	17.5	4144.3995	08813.6668 W	11	1	S	S
9											
10											
11											

15000010

Figure 1: Sample TDR 350 data file

Downloading Data

Data stored in the meter's internal memory can be transferred to your PC with a USB flash drive. Connect the flash drive to the USB port on the front of the meter. Press the **Menu/Select** button (p. 8) to open the Settings Menu. Scroll to the **Save to USB** option and, again, press the **Menu/Select** button. The data will be saved to the flash drive as a file with a .csv extension. If you already have a data file on the flash drive for the meter you are downloading, it will be over-written* by this data transfer.

**Caution: If you cleared the data log before taking the current set of measurements, be sure any data on the flash drive has already been saved to your PC.*

Erasing Data

Press the **Menu/Select** button (p. 8) to open the Settings Menu. Scroll to the **Clear Logs** option and, again, press the **Menu/Select** button. Press **Menu/Select** button to complete the process or the **On/Off/Back** button to abort.

Managing Data

The data is stored in comma-delimited text files. The file name will match the serial number of your meter. These files can be opened with text-editing software or spreadsheet software (fig. 1). The data is separated into 11 fields.

Column	Description
1	Date and time[a]
2 - 5	Sensor readings[b] (VWC, Period, EC, Temperature)
6 - 7	GPS coordinates (longitude, latitude)
8	Number of satellites visible during reading
9	Satellite fix status[c]
10	Rod length[d]
11	Soil type[e]

[a] Time is based on the GMT offset selected in the **Timezone** option (p. 13)

[b] If "TDR 300" is selected as the **Moisture Type**, the TDR 300 VWC (without EC optimization) will appear in the VWC% column.

[c] Satellite fix status will be 0 if the meter was unable to determine the a location, 1 if a location was found but without the differential correction, and 2 if the differential correction was available.

[d] Rod length options are **T**urf (1.5"), **S**hort (3"), **M**ed (4.8"), and **L**ong (8").

[e] Soil Type options are **S**tandard and **H**igh Clay.

VWC Measurements

Volumetric Water Content (VWC)
The soil can be thought of as being composed of soil, water and air. The volumetric water content (VWC) is the ratio of the volume of water in a given volume of soil to the total soil volume. This can be expressed as either a decimal or a percent. Three soil moisture levels of 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 is allowed to 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.

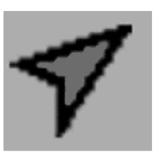
Additionally, we can define Plant Available Water as the amount of water between Permanent Wilting Point and Field Capacity. One rule of thumb is that irrigation should be initiated when half the Plant Available Water has been depleted.

Time Domain Reflectometry (TDR)
The underlying principal of TDR involves measuring the travel time of an electromagnetic wave along a wave-guide. The speed of the wave 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.

Electronics in the TDR 350 generate and sense the return of a high energy signal that travels down and back, through the soil, along the waveguide composed of the two replaceable, stainless steel rods. 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.

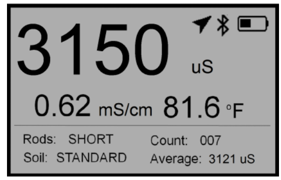
GPS

For best results, wait until the GPS has located as many satellites as possible. When GPS is enabled and the location is fixed, the icon will change from white, to gray, to black. A black icon indicates the meter has detected 10 or more satellites. If differential correction is available, the GPS icon will include a crosshairs icon as well.

GPS coverage will be best when you have a clear view of the sky. The GPS receiver is in the front of the meter (near the USB port). When taking readings, the receiver should be pointed away from any structures or other obstacles such as trees.

Appendix 1
Soil-Specific Calibration



For maximum accuracy, you may choose to perform a soil-specific calibration rather than use either of the internal (Standard or High Clay) soil calibrations coded into the TDR 350's firmware. In these cases, an independent soil moisture content measurement is required. A relation can then be developed that relates the meter's period reading (see **Moisture Type** option, p. 13) to actual volumetric water content (VWC). This is most easily accomplished by doing a regression of one set of data against another.

VWC data can be obtained with a device such as a neutron probe, by measuring the weight of a saturated soil column of known volume as it is gradually dried, or by gradually wetting a known volume soil with the addition of known increments of water. In most cases, however, the calibration will be done with gravimetric sampling. This procedure is briefly described below.

In the field, establish a number of sites to sample. Each site should be wetted to a different soil moisture content by adding varying amounts of water. At each site a Field Scout TDR reading is taken followed by the extraction of a known volume of soil. Ideally, this would be an undisturbed soil core. The wet weight of this soil must be determined. If the soil cannot be weighed immediately, it should be stored in a plastic bag to reduce evaporation. The soil is then oven-dried (105°C for 48 hours is a common requirement) and weighed again. The volumetric water content is calculated as follows:

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

An alternate, but equivalent, calculation can be obtained from the gravimetric water content and soil bulk density.

VWC = GWC $*(\rho_b/\rho_w)$
Where GWC is the gravimetric water content and ρ_b is the bulk density:

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

The final step is to plot the calculated the measured period values with the readings obtained from Field Scout TDR meter. Regression analysis can then be performed on this data to develop an equation to convert from period to VWC.

Appendix 2
Checking VWC Readings

There are two tests that can be performed to check if the meter is operating properly.

Test 1 (No rods): Disconnect the rods from the probe block. Select the Period option for **Moisture Type** (p. 13). With no rods connected, the meter should read 1930 ± 30 µs.

Test 2 (Rods attached): Readings can be taken in three standard environments; air, distilled water, and playground sand saturated with distilled water. It is important that any troubleshooting be done with distilled water. Readings taken in tap water can differ greatly from the expected results observed in distilled water. When readings are taken in water and saturated sand, the container should have a diameter of at least 3 inches (7.5cm) and should be tall enough so the rods can be completely immersed or inserted.

Readings should be taken with the **Soil Type** set to Standard (p. 12) and **Moisture Type** (p. 13) set to TDR 300 mode. Be sure that the correct **Rod Length** (p. 12) is selected. The meter should read VWC=0% in air. In saturated sand, it should read between 35% and 45%. The table below shows the approximate ranges of volumetric water content that are expected for the different rod lengths in distilled water.

Rod Length	Water
8 inches (20 cm)	60 - 65%
4.8 inches (12 cm)	70 - 75%
3 inches (7.5 cm)	75 - 80%
1.5 inches (3.8 cm)	65 - 70%

Note: The meter does not read 100% in water because the soil moisture calibration equations were created to be most accurate in the volumetric water contents typically found in mineral soils.

Appendix 3
FAQ

1. What are the factory default settings?

Rod Length	Turf	**Moisture**	VWC
Soil Type	Standard	**EC units**	mS/cm
Backlight, GPS, Bluetooth	Disabled	**Auto-Off**	15 minutes
		Time Zone	GMT
Sound	On		
Temperature	Fahrenheit		

2. What type of sensor is used to measure surface temperature?
The sensor on the underside of the probe block is a thermistor.

3. What type of differential correction are available for the GPS receiver?
The Wide Area Augmentation System (WAAS) is used in North America. The European Geostationary Navigation Overlay Service (EGNOS) is used in Europe.

4. How do I get access to SpecConnect?
SpecConnect is a subscription-based web utility. Contact Spectrum Technologies or your distributor for details.

Appendix 4
Time zone corrections

Time Zone Correction	City
-11	Wellington
-10	Honolulu
-9	Anchorage
-8	San Francisco, Los Angeles, Vancouver
-7	Phoenix, Denver, Edmonton
-6	Guatemala City, Houston, New Orleans, Chicago, Mexico City, Winnipeg
-5	Atlanta, Indianapolis, New York, Ottawa, Bogota, Montreal, Toronto
-4	Asuncion
-3	Rio de Janeiro, Montevideo
-2	Sao Paulo
-1	Azores
0	Dublin, Lisbon, London
+1	Amsterdam, Barcelona, Berlin, Geneva, Paris, Prague, Rome, Brussels, Madrid, Warsaw, Lagos
+2	Ankara, Athens, Istanbul, Cairo, Johannesburg
+3	Moscow, Nairobi, Kampala, Riyadh
+4	Tehran, Abu Dhabi, Dubai
+5	Kabul, Islamabad
+6	Calcutta, New Delhi

Time Zone Correction	City
+7	Hanoi, Jakarta
+8	Beijing, Hong Kong, Manila, Singapore, Taipei
+9	Seoul, Tokyo
+10	Vladivostok, Brisbane
+11	Adelaide, Melbourne, Sydney
+12	Aukland

Warranty

This product is warranted to be free from defects in material or workmanship for one year 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.

DECLARATION OF CONFORMITY

Spectrum Technologies, Inc.
3600 Thayer Ct.
Aurora, IL 60504 USA

Model Numbers:	6435
Description:	Portable Soil Moisture\Conductivity\Temperature Probe
Type:	Electrical Equipment for Measurement, Control, and Laboratory Use
Directive:	2004/30/EU
Standards:	EN 61326-2:2012 EN 61000-6-1:2007 EN 61000-6-3:2007+A1:2010 ICES-003:2016; ITE Emissions for Canada (ANSI C63.4:2014) FCC Part 15:2016: Emissions for Unintentional Radiators for USA (ANSI C63.4:2014) EN 55032:2015

Paul Martis, Hardware Engineering Manager February 6, 2017

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