

TDR-315L Acclima Reflectometer Sensor

The TDR-315L is a true Time Domain Reflectometer system wrapped up in a small, rugged, permanently installable package. This model is ultra low power yet it sacrifices none of the accuracy of its big brother, the TDR-315. TDR technology is a major, patented breakthrough in soil water and EC measurement technology.

Performance:

- Sensor accurately reports soil VWC, temperature, permittivity, and EC in all soils.
- Permittivity is derived from first principles using a digitized TDR waveform - exactly like comparable systems costing 20x more. The permittivity reading is $\pm 1\%$ accurate in soils out to 4 dS/m Bulk EC.
- Volumetric Water Content is calculated from permittivity using a proprietary dielectric mixing model that closely tracks the Topp Equation to around 50% VWC but provides additional range to 100% VWC.
- Bulk EC is measured using well proven TDR techniques based on long term waveform amplitude readings, and Pore Water EC is also reported.
- Temperature is reported to better than $\pm 0.5^\circ\text{C}$.
- Operates on any SDI-12 version 1.3 compliant data logger including Acclima's DataSnap.

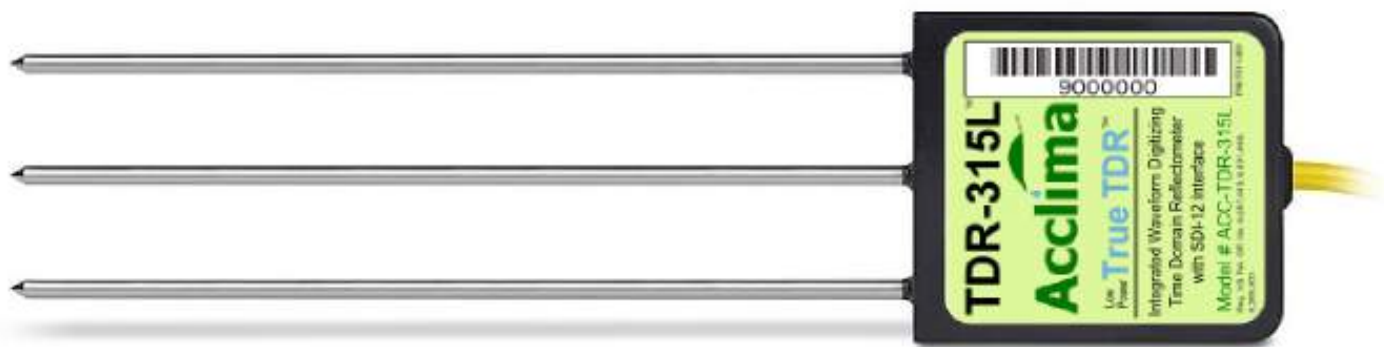


Advantages Over Conventional TDR:

- The sensor is a completely self-contained TDR system which includes a microcomputer in the sensor head with waveform interpreting software preloaded.
- Much lower cost - affordable and rugged enough to be permanently deployed in-situ.
- No bandwidth constraining coaxial cable between electronics and the waveguide.
- Fast 300ps rise time delivered to the soil.
- 5ps resolution in digitizer and signal processing algorithms.
- 8 GHz input bandwidth to the receiver digitizer.
- Deliberate small electronics housing to facilitate easy installation and soil re-compaction.
- Very low power, battery operable.



TDR-315L Acclima Reflectometer Sensor



Description:

The TDR-315L is a true waveform digitizing Time Domain Reflectometer that derives soil permittivity and water content from the propagation time of an electromagnetic impulse conveyed along its waveguide. Like many of its expensive predecessors (conventional TDR mainframes) it contains an ultra-fast rise time step function generator, a waveform digitizer (200 GSPS) and a picosecond-resolution time base (5ps). Unlike these predecessors it eliminates the bandwidth-constraining coax cable, the bulky console, and 90-97% of the cost. Because it is a true time domain device its readings are not derived from current and voltage magnitudes and relationships and hence are not impacted by soil electrical conductivity and compaction. Its high immunity to EC allows credible application in non-saturated soils wetted with sea water. It uses the standard SDI-12 interface and is compatible with all data recorders that are version 1.3 compliant.

Functions:

Volumetric Water Content (0 to 100% with 0.1% resolution)

Permittivity (1 to 80 with 0.1 unit resolution)

Soil Electrical Conductivity a.k.a. Bulk EC (0 to 5000 $\mu\text{S}/\text{cm}$ - resolution depends on reading range)

Soil Temperature (-40 to +60°C with 0.1 degree resolution)

Pore Water Electrical Conductivity (0 to 55000 $\mu\text{S}/\text{cm}$)

Features:

10 meter, flexible, waterproof cable

15 cm X 3.5mm stainless steel 3-element waveguide

Rugged, waterproof epoxy housing

Typical 350ps incident wave rise time applied directly to the soil (no bandwidth limiting coax cable).

Input bandwidth to the waveform digitizer is also unrestrained because of the absence of a coax cable.

Operating Parameters:

Read time:	0.7 seconds
Voltage Requirements: Idle	6 to 15 volts DC
Current Consumption: Read	<30 μA @ 6 to 15 VDC
Current Consumption:	170 mA @ 6 to 15 VDC
Idle Energy Consumption:	15 J per day at 6 VDC
Read Energy Consumption:	0.7 J per reading at 6 VDC, 1.4 J per reading @ 12 VDC



TDR-315L Acclima Reflectometer Sensor

VWC and Permittivity Performance Specifications: Permittivity to VWC conversion method = Proprietary Dielectric Mixing Model with 0 to 100% range.

- Closely follows Topp Equation to 46% VWC.

Permittivity Reporting Accuracy: $\pm 1\%$ of full scale 1 to 80 relative permittivity units

- From 0 to 4000 $\mu\text{S}/\text{cm}$ Bulk (in-soil) Electrical Conductivity
- From -20°C to $+50^\circ\text{C}$, however permittivity of water changes drastically in solid vs liquid states. Therefore the VWC reading will only report liquid water.

Volumetric Water Content Reporting Accuracy: Dependent upon soil type – but typically $\pm 2\%$

- Less than 1 percentage point change with Bulk EC changes from 0 to 4000 $\mu\text{S}/\text{cm}$
- Change in VWC with compaction follows only the change in soil volume.

Temperature Performance Specifications: Temperature is measured using a precision thermistor. The thermistor is located within 2 mm of the outer waveguide rod where it enters the epoxy housing.

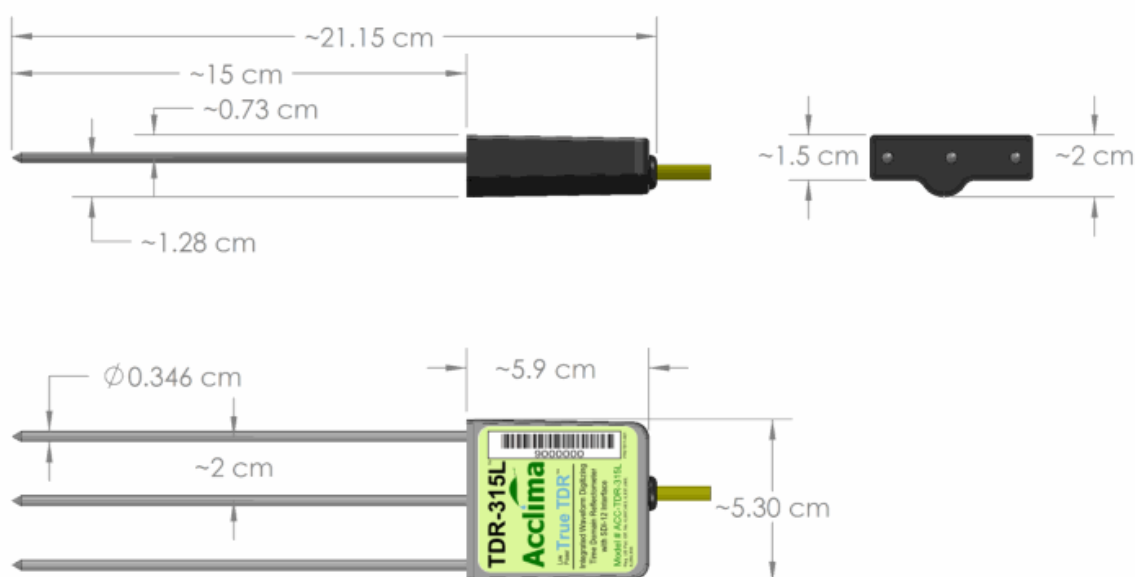
Temperature Reporting Performance: Typical: $\pm 0.2^\circ\text{C}$, Worst Case: $\pm 0.5^\circ\text{C}$ over -12 to $+50^\circ\text{C}$

Electrical Conductivity Performance Specifications: EC is calculated from the long term (200 ns) amplitude of the reflected wave using a geometric parameter called the 'waveguide constant'. This constant is derived in the factory during factory calibration.

EC Reporting Accuracy: $\pm 1\%$, $\pm 35 \mu\text{S}/\text{cm}$ maximum error from 0 to 5000 $\mu\text{S}/\text{cm}$ Bulk EC.

- Note that the 1% error applies to higher values of EC while the 35 $\mu\text{S}/\text{cm}$ error applies to very low values of EC.
- Pore water EC is calculated from the Hilhorst model using an average pore size to represent all soils. Hence its accuracy is not specified. The reading does provide a 'ballpark' indication of the salinity of the water in the soil as opposed to the soil/water mixture or 'Bulk EC' property.

Dimensions:



Logging solutions with the TDR-315L

ICT International Telemetry Hub

The ICT International Telemetry Hub is a powerful and flexible electronic platform that operates remotely in any climate, forming the foundation for specialised scientific and industrial equipment systems. Typically used as a telemetry gateway to transmit data from ICT International instruments to the 'Cloud', it is supported by an extensive software suite that can be customised to suit a wide range of IoT applications.

The Telemetry Hub can be optioned to communicate via Satellite (using the Iridium Short Burst Data service), Penta-band GSM, Wi-Fi, 2.4GHz proprietary wireless networking, Bluetooth, RS485, RS232, Ethernet, USB and SDI-12. It can also be optioned to provide analogue and digital outputs and inputs.

It discovers, connects, concentrates and logs data collected from Smart Sensors and ICT International Instruments in CSV format on its SD memory card, and sends it to the Cloud.

The ICT International Telemetry Hub manages power supplied to externally connected devices. The ICT International Telemetry Hub is powered by a Lithium-Ion battery, with an inbuilt solar charging controller. It can also be connected to an external 24V DC power supply.

The SDI-12 Logger

A rugged, self-contained, standalone logger designed to collect data from SDI-12 sensors. The SDI-12 Logger is able to receive up to 250 parameters from a maximum of 10 individual sensors via Combined Instrument Software (CIS).

Designed to allow easy access to the collected data, the SDI-12 Logger stores data on an internal micro SD card for retrieval either using the USB port, 2.4GHz wireless network, or when combined with the ICT International Telemetry hub via the mobile phone or satellite networks.

Within Combined Instrument Software common SDI-12 sensors are pre-programmed in a look up database, requiring minimal prior knowledge of the sensor outputs. Additional sensors that are not in the database can be added for future applications, Combined Instrument Software is compatible with both Windows and Mac. Powered by a Lithium Polymer battery charged either via a solar panel for field applications, or the CH24 24Volt power supply from ICT International for laboratory applications, the SDI-12 Logger is a versatile logger for a variety of applications.

The AML Advanced Multifunction Logger

The ICT AML (Advanced Multifunction Logger) is capable of performing a broad range of analogue and pulse / counter type measurements. It has 10 analogue inputs (10 single ended, or 5 differential), 2 pulse inputs, as well as RS485, SDI12, i2c, USB and 2.4GHz wireless interfaces. It can record up to 64 separate channels with 24bit precision. It also monitors and records its own power supply voltages and currents, temperature, air pressure and wireless signal strength.

The Voltage Sensor Logger (VSL)

A stand-alone logging instrument for the measurement of any sensor with a voltage input/output. The VSL can support up to 5 differential or up to 10 single ended sensors with the same voltage input requirements.

The VSL is a fully self-contained unit requiring power input from a 11 or 22W solar panel (field applications) or 24V power supply (laboratory applications). Communication is via a USB port or wireless connectivity. The VSL is IP-65 rated and has a Windows driven GUI interface for complete logging solutions including look-up tables, scripts and sensor calibration capabilities. The VSL is ideally used in combination with the ICT International range of soil, plant and environmental sensors.

