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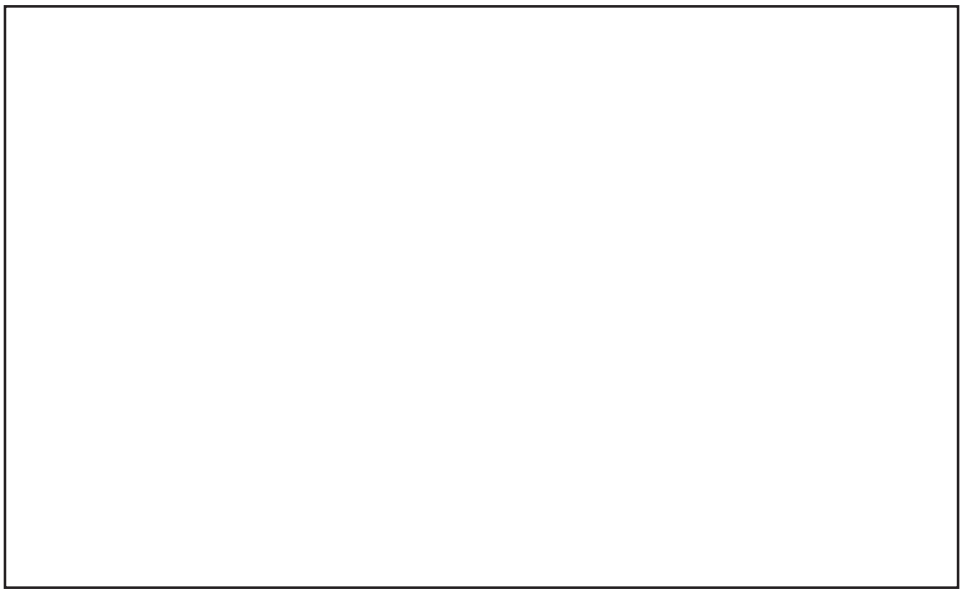
WHEN MEASUREMENTS MATTER

CS615 Water Content Reflectometer



For cost-effective, accurate measurements of soil moisture

Description

The CS615 Water Content Reflectometer measures the volumetric water content of porous media using time-domain measurement methods. A cable tester such as the Tektronix 1502B is not required.

The probe consists of two stainless steel rods connected to a PCB. A shielded 4-conductor cable is connected to the circuit board to supply power, enable the probe and monitor the pulse output. The circuit board is potted in an epoxy block.

Installation

The probe rods can be inserted from the surface, or the complete probe can be buried at any angle to the surface.

The reflectometer connects to the single-ended analogue input of a CR10/10X or CR500 datalogger and is monitored with the Period Measurement instruction. (The pulse count channel of a CR10/10X, 21X or CR7 datalogger can also be used in some applications – see note on electromagnetic interference overleaf.)

Measurements

The CS615 response depends on the dielectric constant of the material surrounding the probe rods. Water is the principal contributor to the dielectric constant value, but solid constituents such as quartz, clay and organic matter also affect the measurement. This means that the same calibration may not apply to all soils. However, the accuracy can be optimised by using calibrations derived for a specific soil.

A nominal first-order calibration provided with the CS615 gives accuracy better than ±4%, depending on the soil type. Soil-specific calibration improves the accuracy significantly.

Key Features

No expensive cable tester required

Rugged probes; not subject to ice damage

Low cost

Direct connection to datalogger

Stable calibration

Long cables available

Easy to use

Typical Applications

Agricultural research

Forestry and ecology

Civil engineering

Studies in avalanche prediction

December 1997

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Operation

High speed electronic components on the circuit board are configured as a bistable multivibrator. The output of the multivibrator is connected to the probe rods, which act as a wave guide.

When the multivibrator switches states, the transition travels the length of the rods and is reflected by the rod ends. This reflection provides feedback to switch the state of the multivibrator and initiate a subsequent wave propagation on the rods. The travel time to the end of the rods and back depends on the dielectric constant of the material surrounding the rods, which in turn depends mainly on the water content.

Digital circuitry scales the multivibrator output to an appropriate frequency for measurement with a datalogger. The datalogger measurement of period or frequency is then converted to volumetric water content using calibration curves.

Calibration

Temperature Dependence

The temperature dependence of the CS615 was evaluated over the range +10°C to +30°C on soil samples at constant water content and a simple temperature correction derived. Application of this correction yields a maximum difference between corrected and uncorrected water content of approximately 1.6%. Considering the accuracy of the measurement and the potential spatial variability of soil temperature along the length of the probe rods, the correction is not necessary in most cases.

Sandy Soils

As with other TDR measurements, using the CS615 in soils with atypical organic matter or quartz fractions requires adjustment of the calibration because these soils commonly have higher intrinsic dielectric constants in the dry state. The offset in the results can be compensated for by a single-point adjustment of the zero-order term of the calibration.

Clay Soils

As with other TDR measurements, soil with high clay contents may require soil-specific calibration for both water content and temperature dependence.

Saline Soils

Measurements on saline soils (soil solution electrical conductivity >1dSm^{-1}) show a shift in the slope of the water content as a function of CS615 period. While a single calibration describes water content well in non-saline mineral soils, specific calibrations are needed to optimise accuracy in saline soils. The probe output becomes unstable at conductivity values greater than 5dSm^{-1}.

Specifications

Accuracy
±2% using soil-specific calibration in unfrozen soil (accuracy obtained using general calibration depends on soil texture and mineral composition; typically <±3% for water content >12%)

Resolution
Using Period Measurement (CR10/10X or CR500): ±0.0001% volumetric water content (v.w.c.) (10^{-6}m^{3}m^{-3})

Using Pulse Count (Instruction 3): ±0.01% v.w.c. (10^{-4}m^{3}m^{-3}) with 1.0s execution interval; ±1% v.w.c. (10^{-2}m^{3}m^{-3}) with 0.1s execution interval

Output
Square wave pulse train with amplitude ±2.5V DC relative to power ground

Power Requirements
70mA @ 12V DC during measurement

Cable Lengths
The maximum cable length available is 100m. The length is limited by susceptibility to lightning damage. Larger distances between the datalogger and the CS615 can be achieved by the use of junction boxes and additional protective earth rods — please contact Campbell Scientific for further advice.

Dimensions
Rods: 300mm long; 3.2mm diameter; 32mm spacing

Head: 110 x 63 x 20mm

Weight
Probe: 280g

Cable: approximately 35gm^{-1}

Electromagnetic Compatibility (EMC)
The CS615 satisfies the general protection requirements of the EU EMC Directive as far as emissions is concerned. When used in accordance with the instruction manual, with a CR10/10X datalogger, the CS615 complies with the following EU regulations:

IEC 801-2: Electrostatic discharge

IEC 801-3: Radiated electromagnetic energy

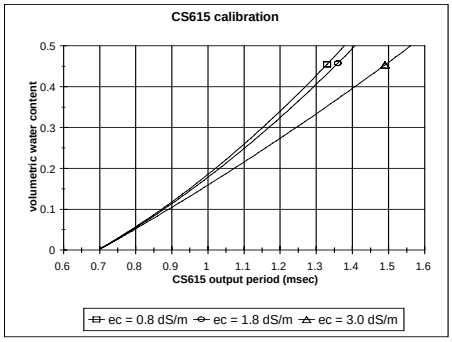
IEC 801-4: Fast transients

Other Products

The CS615 offers several advantages over other methods of soil moisture measurement. Compared to cheaper *soil moisture blocks*, for example, it is more rugged, more accurate and has a more stable calibration.

The Campbell Scientific *TDR Soil Moisture Measurement System* enables you to view a complete TDR trace, which can be useful for detecting problem soils, for example. It also allows you to determine bulk soil conductivity and offers more accurate measurements in saline soils. However, it is significantly more expensive than the CS615 (where a limited number of probes are needed) and has higher power consumption.

Although the TDR system offers greater flexibility in terms of probe length and configuration, the CS615 is easy to use and will provide similar results to the TDR system in many types of soil.



Typical CS615 calibration curves

For assistance with soil moisture measurement call Campbell Scientific or your local representative.

Campbell Scientific products are available from: