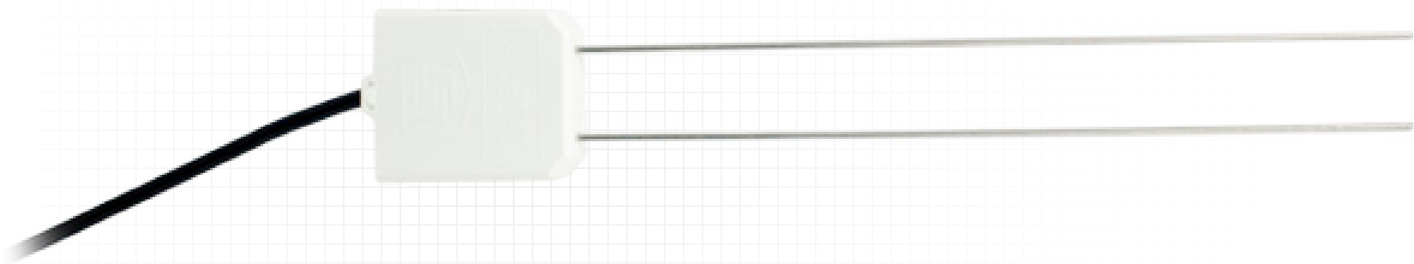
CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

CS616

Water Content Reflectometer

Measures volumetric water content



Overview

The CS616 Water Content Reflectometer measures the volumetric water content of porous media using time-domain measurement methods. A cable tester such as the TDR100 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 encapsulated 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 directly to one of the datalogger's single-ended analogue inputs. A datalogger control port is typically used to enable the CS616 for the amount of time required to make the measurement. Datalogger instructions convert the probe square-wave output to period which is converted to volumetric water content using a calibration.

Measurements

Each CS616 requires a single-ended input channel. A control port is used to enable one or more probes.

Campbell Scientific's AM16/32B multiplexers can be used to increase the number of CS616s the datalogger can measure. A dedicated measurement instruction is used with the CR800 series, CR1000, CR3000 and CR5000 dataloggers to measure the probe's output period. A control port parameter within the Instruction allows you to enable a single CS616 or automatically increment control ports to monitor multiple CS616s connected to sequential analogue inputs. Measurement time using the Instruction is about 0.5 milliseconds.

NOTE: The CS616 is not compatible with our CR300-series, CR200(X)-series or CR9000(X) dataloggers.

Benefits and 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
- Use with multiplexers to increase the number of CS616s that the datalogger can measure

Typical Applications:

- Agricultural research
- Forestry and ecology
- Civil engineering
- Studies in avalanche prediction

Operation

The differentially-driven probe rods form a transmission line with a wave propagation velocity that is dependent on the dielectric permittivity of the medium surrounding the rods. Nanosecond rise-times produce wave-form reflections characteristic of an open-ended transmission line.

The return of the reflection from the ends of the rods triggers a logic state change which initiates propagation of a new wavefront. Since water has a dielectric permittivity significantly larger than other soil constituents the resulting oscillation frequency is dependent upon the average water content of the medium surrounding the rods. The megahertz oscillation frequency is scaled down and easily read by most Campbell Scientific dataloggers.

Response Characteristics / Calibration

The signal propagating along the parallel rods of the CS616 is attenuated by free ions in the soil solution and conductive constituents of the soil mineral fraction. In most applications, the attenuation is not enough to affect the CS616 response to changing water content, and the response is well described by the standard calibration.

However, in soil with relatively high soil electrical conductivity levels, compacted soils, or soils with high clay content, the calibration should be adjusted for the specific medium. Guidance for making these adjustments is provided in the operating manual. Figure 1 shows calibration data collected during laboratory measurements in a loam soil with a bulk density of $1.4gcm^{-3}$ (porosity = 0.47). The bulk electrical conductivity at saturation was $0.4dSm^{-1}$ (solution electrical conductivity @ $2dSm^{-1}$). The linear calibration works well in the typical water content range of 10% to 40%. Outside this range, a quadratic calibration may be needed.

In soil with relatively high soil conductivity levels, compacted soil or soil with high clay content, the calibration must be adjusted for the specific application to maintain measurement accuracy. Figure 2 shows calibration data collected during laboratory measurements for a sandy clay loam soil with a bulk density of $1.65gcm^{-3}$ (porosity = 0.38) and bulk electrical conductivity at saturation of $0.4dSm^{-1}$ and also $0.75dSm^{-1}$ (high EC).

The low EC density soil response curve is shown for reference. The compacted soil response curve shows the effect of compaction. Since fine textured soils seldom have a water content of less than 10%, the adjustment is simply an offset. The compacted soil, high EC response curve shows the expected bulk electrical conductivity increase with increasing water content. Again, the response above 10% volumetric water content is nearly linear, which simplifies the calibration adjustment.

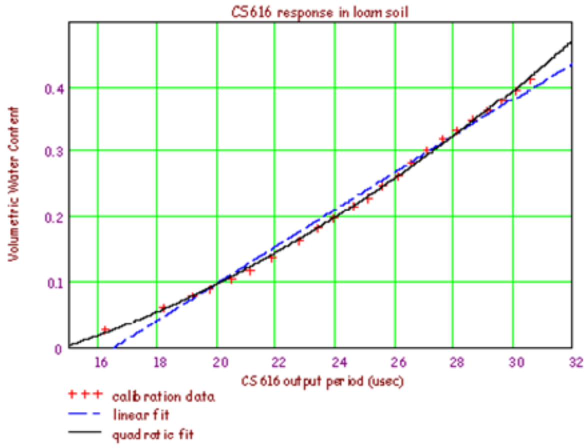


Fig. 1 CS616 linear and quadratic calibration derived from loam

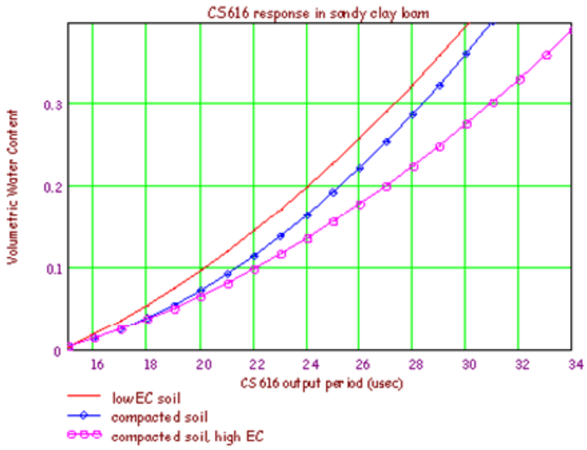


Fig. 2 CS616 response in compacted, sandy clay loam soil and low EC loam for comparison

Specifications

Accuracy
±2.5% VWC using standard calibration iwith bulk electrical conductivity ≤ 0.5 deciSiemen metre^{-1} (dSm^{-1}) and bulk density ≤1.55g cm^{-3} in measurement range 0% VWC to 50% VWC

Precision (reproducability) 0.05% VWC

Resolution 0.1% VWC

Probe-to-probe variability ±0.5% VWC in typical saturated soil

Output
±0.7 volt square wave with frequency dependent on water content

Typical Power Requirements
65mA @ 12V DC during measurement

45μA quiescent

Measurement Time
With the CS616 Instruction: 0.50ms

Power Supply Voltage
5V DC minimum, 18V DC maximum

Enable Voltage
4V DC minimum, 18V DC maximum

Maximum Cable Length
The maximum cable length available is 300 m.

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

Head: 110 x 63 x 20 mm

Weight
Probe (without cable): 280g

Cable: approximately 35gm^{-1}

Electromagnetic Compatibility (EMC)
The RF emissions are below FCC and EU limits as specified in EN61326 if the CS616 is enabled less than 0.6 milliseconds, and measurements are made no more frequently than once a second. The CS616 instruction limits the enable time to less than 0.6 milliseconds. As a consequence of the principle of operation, external RF sources can also affect the CS616 operation. Consequently, the CS616 should be located away from significant sources of RF such as AC power lines, radio transmitters and motors. The CS616 meets EN61326 requirements for protection against electrostatic discharge.

Ordering Information

Water Content Reflectometer

CS616 Water Content Reflectometer with user-specified cable length. Recommended cable length is 3, 5, 10, 15 or 20 m, maximum length is 300 m (1000 ft).

Installation Tool

CS650G Rod Insertion Guide Tool with Pilot Rod that helps maintain the proper spacing and parallel oreitnation of the rods during probe insertion. It also helps the insertion of the probe in high density or rocky soils.

Other Products

The CS616 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 CS616 (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 CS616 is easy to use and will provide similar results to the TDR system in many types of soil.