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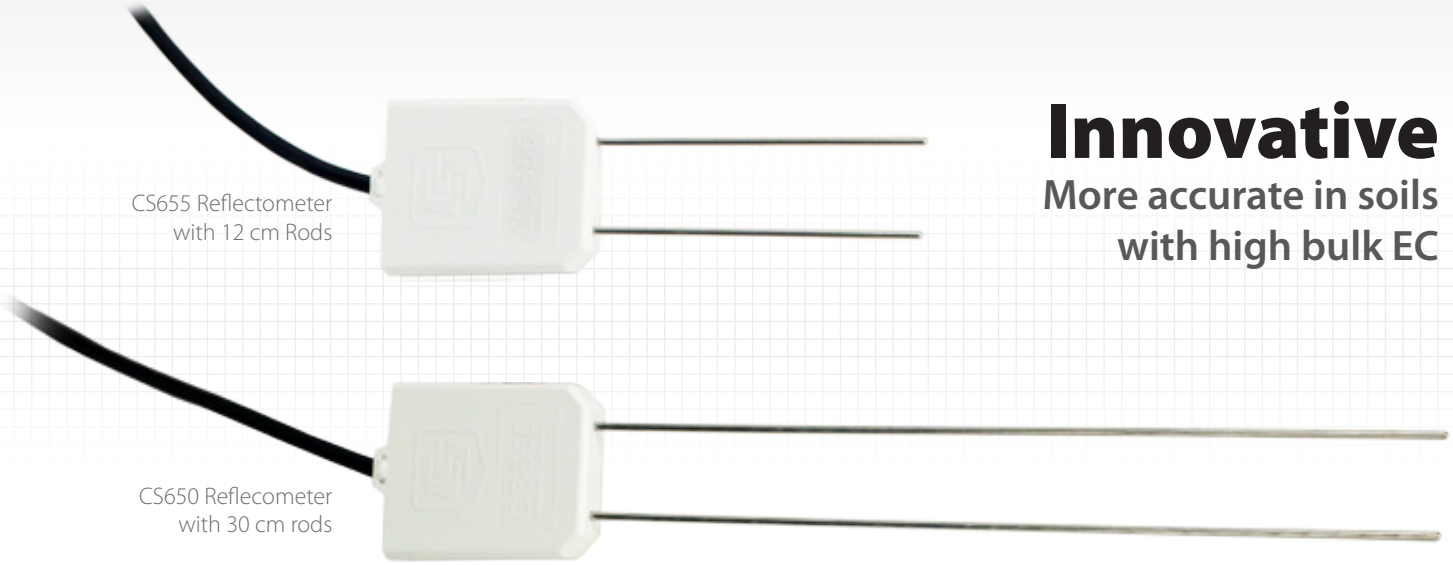
WHEN MEASUREMENTS MATTER

CS650 and CS655

Soil Water Content Reflectometers



CS655 Reflectometer with 12 cm Rods

CS650 Reflecometer with 30 cm rods

Innovative

More accurate in soils with high bulk EC

Overview

The CS650 and CS655 soil water content reflectometers use innovative techniques to monitor soil volumetric water content, bulk electrical conductivity, and temperature. They consists of two stainless-steel rods connected to a printed circuit board. The CS650 has 30 cm rods, and the CS655 has 12 cm rods. The probe's circuit board is encapsulated in epoxy and a shielded cable is attached to the circuit board for datalogger connection.

Benefits and Features

- More accurate water content measurements in soils with solution EC ≤3 dS m^{-1} (CS650) or ≤8 dS m^{-1} (CS655) without performing a soil-specific calibration
- Larger sample volume reduces error
- Measurement corrected for effects of soil texture and electrical conductivity
- Estimates soil-water content for a wide range of mineral soils
- Versatile sensor—measures dielectric permittivity, bulk electrical conductivity (EC), and soil temperature

Options and Accessories[a]

Options

- Cable lengths (ft): 10, 17, 33, 50 or user-defined
- Cable termination options: tinned leads that attach directly to the datalogger or a connector that attaches to a prewired enclosure
- SDI-12 address options: SDI-12 address set to 0 or SDI-12 address set to the last digit of the probe's serial number

CS650G Rod Insertion Guide

Accessories

- CS650G Rod Insertion Guide Tool with Pilot Rod that helps maintain the proper spacing and parallel orientation of the rods during probe insertion. It also helps the insertion of the probe in high density or rocky soils.
- A200 Sensor-to-PC Interface (for configuring sensor)
- Din Rail Accessories that can facilitate wiring when several reflectometers need to be connected to one terminal. A complete configuration consists of the Din Rail Mounting Kit (pn 25458), terminal strips (pn 15920), end plates (pn 15907), and jumpers (pn 15909)

[a]*For more information about the options and accessories, refer to: www.campbellsci.com/order/cs650 or www.campbellsci.com/order/cs655.*

Measurement Method

The CS650 and CS655 measure propagation time, signal attenuation, and temperature. Dielectric permittivity, volumetric water content, and bulk electrical conductivity are then derived from these raw values.

Measured signal attenuation is used to correct for the loss effect on reflection detection and thus propagation time measurement. This loss-effect correction allows accurate water content measurements in soils with solution EC ≤3 dS m^{-1} (CS650) or ≤8 dS m^{-1} (CS655) without performing a soil specific calibration. Soil bulk electrical conductivity is also calculated from the attenuation measurement.

A thermistor in thermal contact with a probe rod near the epoxy surface measures temperature. Horizontal installation of the sensor provides accurate soil temperature measurement at the same depth as the water content. Temperature measurement in other orientations will be that of the region near the rod entrance into the epoxy body.

Specifications

- Sensing Volume[b]: 7800 cm^3 (CS650), 3600 cm^3 (CS655)
- Ingress Protection Rating: IP68
- Maximum Cable Length: 610 m (2000 ft) combined length for up to 25 sensors connected to the same datalogger control port.
- Probe Head Dimensions: 85 x 63 x 18 mm (3.3 x 2.5 x 0.7 in)
- Rod Diameter: 3.2 mm (0.13 in)
- Rod Spacing: 32 mm (1.3 in)

Rod Length

- CS650: 300 mm (11.8 in)
- CS655: 120 mm (4.72 in)

Weight

- CS650 without cable: 280 g (9.9 oz)
- CS655 without cable: 240 g (8.5 oz)
- Cable: 35 g per m (0.38 oz per ft)

Soil Temperature

- Measurement Range: -50° to + 70°C
- Accuracy[c]: ±0.1°C (for typical soil temperatures [0° to 40°C] when probe body is buried in soil), ±0.5°C for full temperature range
- Precision[d]: ±0.02°C

Volumetric Water Content Measurements

- Range: 0% to 100% (with **M4!** SDI-12 command)
- Precision[d]: <0.05%

Accuracy[c]

- CS650: ±1% (with soil specific calibration), ±3% (typical with factory VWC model) where solution EC < 3 dS m^{-1}
- CS655: ±1% (with soil specific calibration), ±3% (typical with factory VWC model) where solution EC < 10 dS m^{-1}

Electrical Conductivity Measurements

- Range

	CS650	CS655
Solution EC	0 to 3 dS m^{-1}	0 to 8 dS m^{-1}
Bulk EC	0 to 3 dS m^{-1}	0 to 8 dS m^{-1}

- Accuracy[c]: ±(5% of reading + 0.05
- Precision[d]: 0.5% of BEC

Relative Dielectric Permittivity Measurements

- Range: 1 to 81
- Accuracy[c]

Range	CS650	CS655
1 to 40	±(2% of reading + 0.6) for solution EC ≤3 dS m^{-1}	±(3% of reading + 0.8) for solution EC ≤8 dS m^{-1}
40 to 81	±1.4 for solution EC ≤1 dS m^{-1}	±2 for solution EC ≤2.8 dS m^{-1}

- Precision[d]: <0.02

Electrical

- Sensor Output: SDI-12; serial RS-232.
- Warmup Time: 3 s
- Measurement Time: 3 ms to measure; 600 ms to complete SDI-12 command
- Power Supply Requirements: 6 Vdc to 18 Vdc; must be able to supply 45 mA @ 12 Vdc
- Electromagnetic: External RF sources can affect the probe's operation. Therefore, the probe should be located away from significant sources of RF such as ac power lines and motors.
- EU Declaration of Conformity document available at: www.campbellsci.com/cs650
- Interprobe Interference: Multiple reflectometers can be installed within 4 inches of each other when using the standard datalogger SDI-12 **M!** command. The SDI-12 **M!** command allows only one reflectometer to be enabled at a time.

Current Drain (see graph in manual)

- Active (3 ms): 45 mA typical @ 12 Vdc (80 mA @ 6 Vdc, 35 mA @ 18 Vdc)
- Quiescent: 135 µA typical @ 12 Vdc
- Average: I = 0.09n + [3.5 + 0.024(n-1)]n/s
  Where,
  I = average current in milliamps
  n = number of probes
  s = number of seconds between measurement

[b] *Approximately 7.5 cm radius around each probe rod and 4.5 cm beyond the end of the rods.*
[c] *Accuracy specifications are based on laboratory measurements in a series of solutions with dielectric permittivities ranging from 1 to 81 and solution electrical conductivities ranging from 0 to 3 dS m^{-1}.*
[d] *Precision describes the repeatability of a measurement. It is determined for the reflectometer by taking repeated measurements in the same material.*