



Measures soil values

Using innovative techniques

Overview

The CS650/CS655 Soil Water Content Reflectometers use innovative techniques to monitor soil volumetric water content, bulk electrical conductivity, and temperature. The probe consists of two 30-cm-long (for CS650) and two 12-cm-long (for CS655) stainless steel rods connected to a

printed circuit board. The circuit board is encapsulated in epoxy and a shielded cable is attached to the circuit board for datalogger connection.

Benefits and Features

- › Measures the following soil values:
 - volumetric water content
 - bulk electrical conductivity (EC)
 - soil temperature
 - dielectric permittivity
- › SDI-12 output
- › Serial connection for sensor configuration
- › Robust water content measurement even with high bulk EC
- › Larger sample volume reduces error from spatial variability of measured parameters
- › Measurement corrected for effects of soil texture and electrical conductivity

Measurement Method

The CS650/CS655 measures propagation time, signal attenuation, and temperature. Dielectric permittivity, volumetric water content, and bulk electric 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 bulk EC $\leq 3 \text{ dS m}^{-1}$ (CS650) or $\leq 8 \text{ dS m}^{-1}$ (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.

Common applications of the CS650/CS655 include irrigation scheduling, soil-water transport and flow studies, soil-water model validation, and soil-water balance analyses. It can also be used to compare the effects of varying soil conditions on a plant's health.

Specifications

Sensing Volume¹: CS650: 7800 cm³
 CS655: 3600 cm³ (~7.5 cm radius around each probe rod and 4.5 cm beyond the end of the rods)

Ingress Protection Rating: IP68

Soil Temperature

Measurement Range: -10° to +70°C
Accuracy²: ±0.5°C for probe body buried in soil
Precision³: ±0.02°C

Electrical Conductivity Measurements

	CS650	CS655
Solution EC	0 to 3 dS/m	0 to 8 dS/m
Bulk EC	0 to 3 dS/m	0 to 8 dS/m

Accuracy²: ±(5% of reading + 0.05 dS/m)
Precision³: 0.5% of BEC

Relative Dielectric Permittivity Measurements

Range: 1 to 81
Accuracy²

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

Precision³: <0.02

Volumetric Water Content Measurements

Range: 5% to 50%
Accuracy²: CS650: ±3% typical in mineral soils, where solution EC ≤3 dS/m
 CS655: ±3% typical in mineral soils, where solution EC ≤10 dS/m
Precision³: <0.05%

¹Approximately 7.5 cm radius around each probe rod and 4.5 cm beyond the end of the rods.

²Accuracy 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.

³Precision describes the repeatability of a measurement. It is determined for the CS650/CS655 by taking repeated measurements in the same material.

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: 6V DC to 18V DC; must be able to supply 45 mA @ 12V DC

Current Drain

Active (3 ms): 45 mA typical @ 12V DC (80 mA @ 6V DC, 35 mA @ 18V DC)

Quiescent: 135 µA @ 12V DC

Average: $I = 0.09n + [3.5 + 0.024(n-1)]n/s$

Where, I = average current in milliamps
 n = number of CS650/CS655 probes
 s = number of seconds between measurement

Electromagnetic: CE compliant (EMC compliant performance criteria available upon request). Meets EN61326 requirements for protection against electrostatic discharge and surge. 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.

Interprobe Interference: Probes enabled simultaneously and within ~9 in. of each other can cause erratic measurements. If the probes must be installed within 9 in. of each other, configure the SDI-12 communication such that the probes are not enabled simultaneously.

Physical

Operational Temperature: -10° to +70°C

Maximum Cable Length: 610 m (2000 ft) combined length for up to 10 sensors connected to the same datalogger control port.

Rod Dimensions

Length: CS650 - 300 mm (11.8 in)
 CS655 - 120 mm (4.72 in.)
Diameter: 3.2 mm (0.13 in.)
Spacing: 32 mm (1.3 in.)

Probe Head Dimensions

Height: 85 mm (3.3 in.)
Width: 63 mm (2.5 in.)
Depth: 18 mm (0.7 in.)

Weight

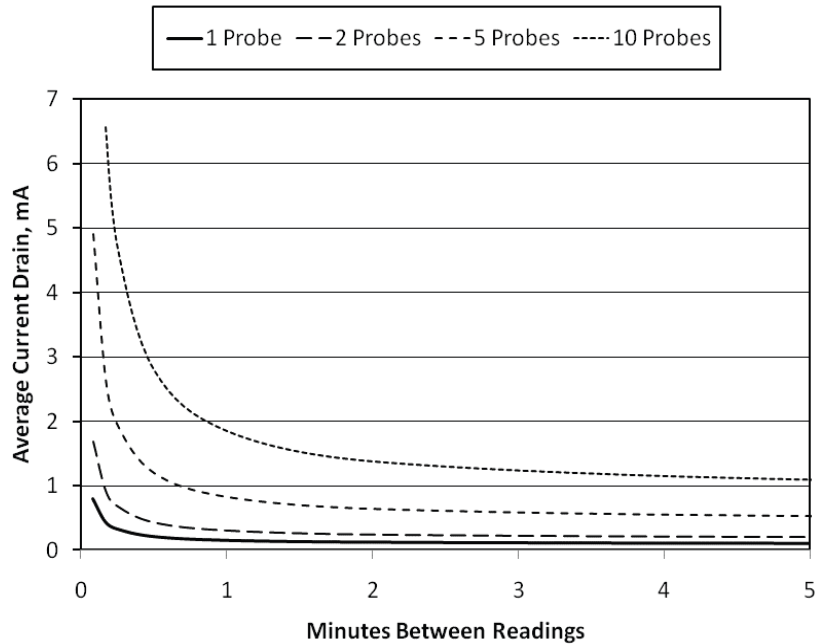
Probe without cable: CS650 - 280 g (9.9 oz)
 CS655 - 240 g (8.46 oz.)

Cable: 35 g per m (0.38 oz. per ft)

CS650G Rod Insertion Guide Tool



The CS650G makes inserting soil-water sensors easier in dense or rocky soils. This tool can be hammered into the soil with force that might damage the sensor if the CS650G were not used. It makes pilot holes into which the rods of the sensors can then be inserted. It replaces both the 14383 and 14384.



The graph shows average current drain for different measurement rates and quantities of CS650/CS655 probes. If the time between measurements is five minutes or longer, average current drain may be approximated at 0.1 milliamps per sensor.

Ordering Information

Water Content Reflectometer

CS650 30-cm Water Content Reflectometer with a standard or user-specified cable length.* Maximum cable length is 300 m (1000 ft).

CS655 12-cm Water Content Reflectometer with a standard or user-specified cable length.* Maximum cable length is 300 m (1000 ft).

*Standard lengths are 3, 5, 10 and 15 metres.

SDI-12 Address Options (choose one)

- DS** SDI-12 Address is set to 0 (standard)
- VS** SDI-12 Address is set to the last digit of the probe's serial number (0 to 9). (Available to special order)

Installation Tools and PC Interface

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)

Commoning blocks

Commoning blocks are available to facilitate wiring of several sensors together, to special order.