

CS650 and CS655

Soil Water Content Reflectometers



The CS650 and CS655 soil water content reflectometers use innovative techniques to monitor soil volumetric water content, bulk electrical conductivity, and temperature. They consist 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 data-logger connection.

Features/Benefits

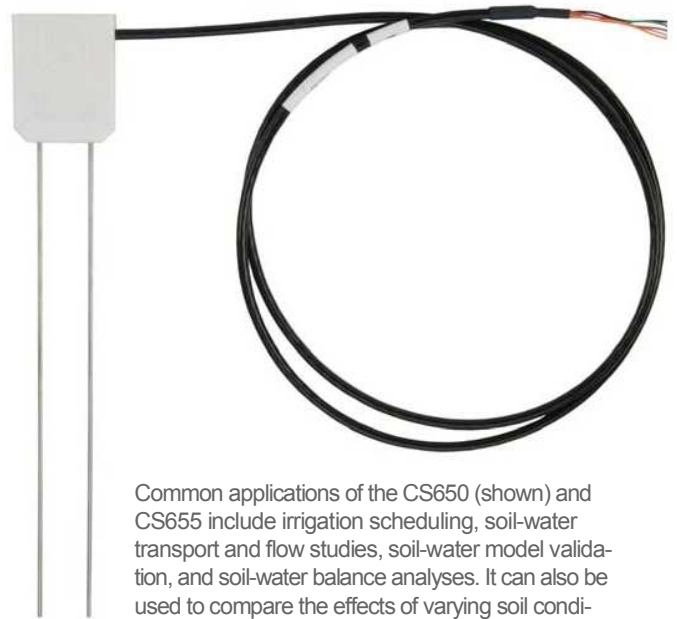
- Measures the following soil values:
 - Volumetric water content
 - Bulk electrical conductivity (EC)
 - Soil temperature
 - Dielectric permittivity
- SDI-12 output
- Serial connection for operating system (OS) upgrade; requires A200 interface
- Robust water content measurement with bulk EC of $\leq 3 \text{ dS m}^{-1}$ (CS650) or $\leq 8 \text{ dS m}^{-1}$ (CS655)
- 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 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.

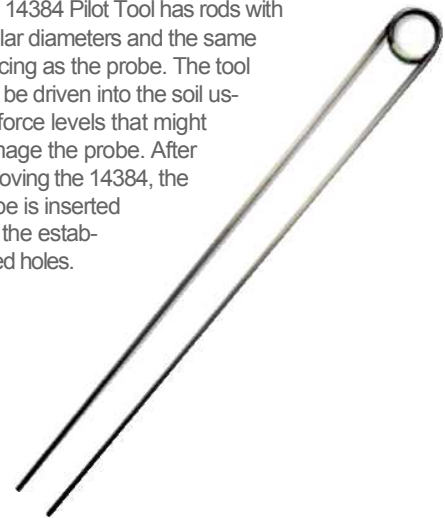
Measured signal attenuation is used to correct for the loss effect on reflection detection and thus propagation time measurement. This loss-effect correction allows accurate water content measurements in soils with bulk EC $\leq 3 \text{ dS m}^{-1}$ (CS650) or $\leq 8 \text{ dS m}^{-1}$ (CS655) without 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 (shown) and 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.

The 14384 Pilot Tool has rods with similar diameters and the same spacing as the probe. The tool can be driven into the soil using force levels that might damage the probe. After removing the 14384, the probe is inserted into the established holes.



The 14383 Installation Tool can be used to help maintain the proper spacing and parallel orientation of rods during insertion. Use of the 14383 may reduce measurement errors by minimizing soil disturbance.

Ordering Information

Water Content Reflectometers

For either reflectometer, must choose a cable termination option and SDI-12 Address option (see below).

CS650-L 30-cm Water Content Reflectometer with user-specified cable length. Enter cable length, in feet, after -L. Refer to specifications for maximum cable length.

CS655-L 12-cm Water Content Reflectometer with user-specified cable length. Enter cable length, in feet, after -L. Refer to specifications for maximum cable length.

Cable Termination Options (choose one)

- PT** Cable terminates in pigtails for direct connection to datalogger's terminals.
- PW** Cable terminates in a connector for attachment to a prewired enclosure.

SDI-12 Address Options (choose one)

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

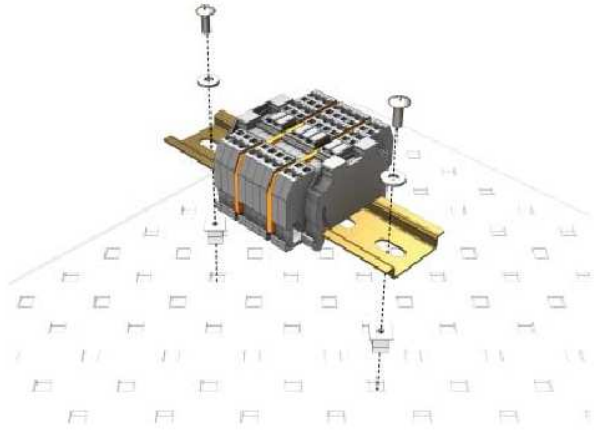
Installation Tools and PC Interface

- 14383** Installation Tool that helps maintain the proper spacing and parallel orientation of the rods during probe insertion. Often used with the 14384 Pilot Tool (see below).
- 14384** Pilot Tool that helps the insertion of the probe in high density or rocky soils. Best results are obtained when the 14384 is used with the 14383 Installation Tool (see above).
- A200** Sensor to PC Interface (for configuring sensor)

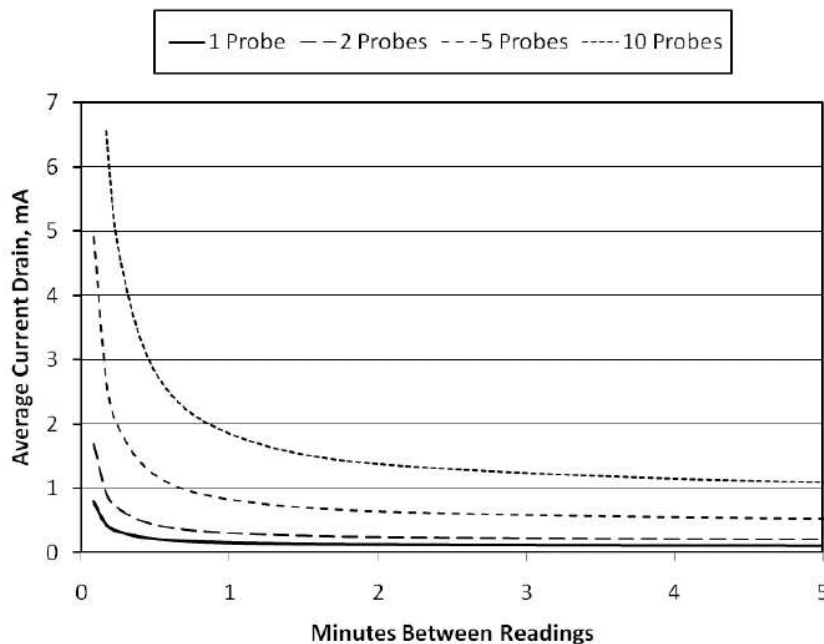
DIN-Rail Accessories

The following accessories can facilitate wiring when several reflectometers need to be connected to one terminal.

- 25458** 5-in. Din Rail Mounting Kit. A complete configuration requires terminal strips, end plates, and jumpers (see below).
- 15920** 3-Pin 4-mm Spring Loaded Din Rail Connectors that provide connection points for individual wires. Up to 20 of these terminal strips may be fastened to the 25458.
- 15909** Horizontal Jumper for Din Rail Connector that electrically connects terminals on the 15920 connectors.
- 15907** The 15907 End Plates separate the terminal strips.



The above configuration has one 25458 bracket, nine 15920 connectors, seven 15909 jumpers, and two 15907 end plates.



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

Specifications

Sensing Volume¹

CS650:	7800 cm ³
CS655:	3600 cm ³

Physical

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

Rod Dimensions

CS650 Rod Length:	300 mm (11.8 in.)
CS655 Rod Length:	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

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)
14384:	2 oz. (57 g)
14383:	9.2 oz. (260 g)

Soil Temperature

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

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%

Electrical Conductivity Measurements

Range

	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

Accuracy: ±(5% of reading + 0.05 dS/m)

Precision³: 0.5% of BEC

Electrical

Sensor Output: SDI-12; serial RS-232

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

Current Drain (see graph on previous page)

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

Quiescent Average: 135 μA typical @ 12 Vdc
 $I = 0.09n + [3.5 + 0.024(n-1)]n/s$

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

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:

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.

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

² 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.

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

