Bio Instruments S.R.L.

SENSORS AND SYSTEMS
FOR MONITORING GROWING PLANTS

SMTE-3z

Soil Moisture, EC and Temperature Sensor

www.phyto-sensor.com

Introduction

Volumetric Water Content

The SMTE-3z sensor uses an electromagnetic field to measure the dielectric permittivity of the surrounding medium. The sensor supplies a 70 MHz oscillating wave to the sensor prongs that charges according to the dielectric of the material. The stored charge is proportional to substrate dielectric and substrate volumetric water content. The GS3 microprocessor measures the charge and outputs a value of dielectric permittivity from the sensor. The dielectric value is then converted to substrate water content by a calibration equation specific to the media you are working in.

Temperature

The SMTE-3z uses a small thermistor to take temperature readings. It is located underneath the sensor over mold, next to one of the prongs so it remains in thermal equilibrium with the medium, and will read the temperature of the prong surface. The SMTE-3z will output temperature in °C.

It is important to note that even though the sensor head is white, if it is in direct sunshine, the temperature measurement may read high. Exposure of the sensor head to direct UV radiation may also degrade the vinyl surface and causing it to discolor. Use caution when installing the sensor with the over mold in the sun.

Electrical Conductivity

Electrical conductivity (EC) is the ability of a substance to conduct electricity and can be used to infer the amount of polar molecules that are in solution. EC is measured by applying an alternating electrical current to two electrodes, and measuring the resistance between them. Conductivity(referred to as "bulk electrical conductivity") is derived by multiplying the inverse of the resistance (conductance) by the cell constant (the ratio of the distance between the electrodes to their area). The bulk EC measurement is calibrated at the factory to be accurate within ±10% from 0 to 10 dS/m. This range is adequate for most greenhouse and nursery applications. However, some special applications in highly saline substrates may require measurements with bulk EC greater than the specified range. The SMTE-3z will measure up to 23 dS/m bulk EC, but user calibration is required above 10 dS/m. Additionally, EC measurements above 10 dS/m are very sensitive to contamination of the electrodes by skin oils, etc. Be sure to read the sensor cleaning section at the end of the manual if you plan to measure the EC of salty soils.

Communication

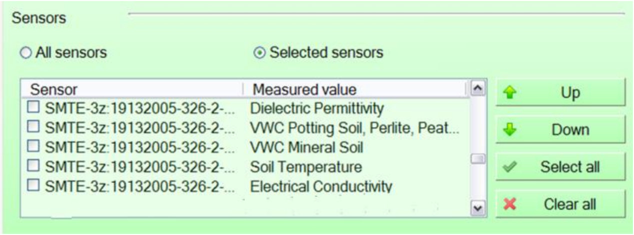
The SMTE-3z communicates over the radio 2.4 GHz channel with a datalogger. Activation of the sensor and measurement settings are described in the 'PM-11z Phytomonitor Quick Start Guide'

Power

The SMTE-3z is powered by 3 AA Alkaline batteries.

Readings

SMTE-3z represents five values:



Dielectric Permittivity, Soil Temperature, and Electrical Conductivity are primary measurement values. The VWC values are calculated by using factory calibrations.

The calibration for several potting soils, perlite, and peat moss at salinities ranging from 0 to > 4 dS/m is given:

$$VWC(m^3/m^3) = 0.118\sqrt{\varepsilon} - 0.117,$$

Where ε is dielectric permittivity.

The calibration for mineral soils ranging from 0 to > 5 dS/m is given:

$VWC\ (m^3/m^3) = 5.89\times10^{-6}\varepsilon^3 - 7.62\times10^{-4}\varepsilon^2 + 3.67\times10^{-2}\varepsilon -$

7.53×10^{-2}

The SMTE-3z has been calibrated in media types including potting soil, perlite and peat. The goal of these calibrations is to create a generic calibration equation that will work in all types of each substrate, with an accuracy of better than ±5% volumetric water content (VWC). If you need more accuracy, you can perform a media-specific calibration to get the accuracy down to ±1 to 2%. It is interesting to note that the main difference between the calibrations is caused by the high air volume in the organic soils that lowers the starting (dry media) dielectric of the sensor.

Installation

The GS3 sensor can be inserted into soil less substrates in a variety of ways; however, the orientation of the sensor will possibly affect the sensor accuracy. In addition, high spatial variability in soil less substrates will drastically affect the difference between sensor readings from one location to another.

Orientation

The goal of installing a sensor into a substrate is to measure those parameters important to plant growth while not changing them. The GS3 can be installed in many different orientations, depending on your needs. However, common sense should be used. For example, installing the sensor in the top of a pot that is being irrigated by micro-sprinkler may cause water to drip around the sensor head, leaving a dry patch of soil immediately below. A better option would be to insert the sensor into the side of the root mass with the needles horizontal, aligned in a vertical row. This will allow water to flow freely through the pot and measurements to be made directly around the roots. Still, when irrigation water is not applied from the surface, it may be entirely appropriate to install the sensor on top of the substrate. However, please keep in mind that the sensor only measures the VWC in its sphere of influence.

Sensors can either be inserted into the top of the plant pot or into the side of the root ball. Insertion into the side of of the root ball may be the best option, as it will give the best indication of the water available to the plant.

Removing the sensors

The GS3 is easily removed from substrates. The stainless steel needles slip easily in and out of all types of growing media. Still, we recommend the sensors never be pulled out by their cables, as this can put immense strain on the wires inside. If the sensor is buried, carefully dig down to the sensor, taking care not to damaging the cable with your digging implement. After removing the media around the head, simply grab onto the sensor and remove it.

Cleaning the Probes

1. Clean each pin using a mild detergent such as liquid dish soap and a non-abrasive sponge or cloth. NOTE: Avoid detergents that contain lotions or moisturizers.

2. Rinse the sensor and prongs thoroughly with tap or DI water.

Note: Be sure not to touch the prongs with an un-gloved hand or contactthem with any source of oil or other non-conducting residue.

Specifications

Volumetric Water Content

Accuracy: ε±1 (unit less) from 1-40 (soil range), ±15%from 40-80:

• Using a generic calibration: ±0.03 m3/m3 (±3% VWC)typical in mineral soils that have solution electrical conductivity< 5 dS/m

• Using medium specific calibration, ±0.01 - 0.02 m3/m3(± 1-2% VWC) in any porous medium

Resolution: 0.1ε (unitless) from 1-20

<0.75 ε(unitless) from 20-80

0.002 m^3/m^3 (0.2% VWC) from 0 to 40% VWC

0.001 m^3/m^3 (0.1% VWC) >40% VWC

Range: Apparent dielectric permittivity (ε): 1 (air) to 80 (water)

Bulk Electrical Conductivity

Accuracy: ±10% from 0 to 10 dS/m, user calibration required above 10 dS/m

Resolution: 0.001 dS/m from 0 to 23 dS/m

Range: 0 to 23 dS/m (bulk)

Temperature

Accuracy: ±1 °C

Resolution: 0.1 °C

Range: -40…50 °C

General Specifications

Probe Dimensions: 9.3 x 2.4 x 6.5 cm

Prong Length: 5.5 cm

Dielectric Measurement Frequency: 70 MHz

Measurement Time: 150 ms (milliseconds)

Power requirements: 3 AA Alkaline batteries

Output: 2.4 GHz RF module

Operating Temperature: -40 to 50 °C

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