EasyAG®
SOIL WATER CONTENT PROFILE PROBES
INSTRUCTION MANUAL

REVISION: 7/03

Warranty and Assistance

The **EasyAG® SOIL WATER CONTENT PROFILE PROBES** are warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

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RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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EasyAG®
Soil Water Content Profile Probes

1. General

EasyAG® Probes measure soil water content profiles in a wide range of soil types for irrigation scheduling, waste water treatment, and other applications requiring continuous monitoring of water content and water movement in soil. Each probe requires installation with a specialized installation kit.

1.1 Calibration

EasyAG® sensors produce readings which need to be converted to the real volumetric soil water content of a particular soil profile. The relationship between the "raw" sensor reading and the final measuring unit (Vol%) can be described by a mathematical relationship, which constitutes the calibration equation.

1.1.1 Absolute Calibration

Sensors calibrated for a particular site, including the textural layers of a soil profile, will produce absolute and accurate soil water data. Absolute data, however, require that a sensor be calibrated for each soil type and each soil horizon. Absolute calibration is a costly and time consuming process, but must be done if absolute data are required.

1.1.2 Relative Calibration

The other option is to work with relative data. Relative data are produced by an instrument calibrated for a range of soil types, and this calibration is used as a default calibration on all soil types. The readings cannot be considered as absolute data, but instead reflect soil water changes that can be used as key decision criteria in irrigation scheduling.

Relative data have been used since at least 1992 for irrigation management, isolating key factors such as depth of irrigation and rainfall, depth of the effective root zone, onset of crop water stress, and avoidance of water logging. Typically, economic gains recorded with Sentek sensor technologies in commercial agriculture are made using the concept of 'relative' change in soil water dynamics.

2. Specifications

Feature	**EasyAG® SDI-12**	**EasyAG® Voltage**
Maximum cable length to logger or third party device	60 m (200 ft)*	2.0E-09 mV drop/ft cable (differential)** 1.6 mV drop/ft cable (single-ended)**
Maximum sensors per standard probe	4	4
Sensor Measuring Principle	High frequency capacitance	High frequency capacitance
Output Options	SDI-12	Voltage
Protocol options	SDI-12	0 to 5 Volts (can be user specific)
Interface Measuring Principle	16 Bit pulse count	16 Bit pulse count
Output Resolution	16 Bit	12 Bit
Output Method	Serial data	Analog
Current Consumption	250 µA @ Sleep 66 mA @ Standby 100 mA @ Sampling	0 mA @ Sleep <7 mA @ Standby 100 mA @ Sampling
Accuracy when calibrated	$R^2 = 0.8939$ based on field calibration	$R^2 = 0.8939$ based on field calibration
Resolution	0.008%	0.025% minimum or better depending on sensor output
Precision	±0.06% Vol	±0.06% Vol
Reading range	Oven dry to saturation	Oven dry to saturation
Temperature effects	±3% 5°C to 35°C	±3% 5°C to 35°C
Operating temperature range	-20°C to +75°C	0°C to +70°C
Time to read one sensor	1.1 seconds	1.1 seconds
Sphere of influence	99% of the reading is taken within a 10 cm radius from the outside of the access tube	99% of the reading is taken within a 10 cm radius from the outside of the access tube
Sensor diameter	26.5 mm	26.5 mm
Access tube diameter	32 mm	32 mm
Probe length	50 cm (20 inches)	50 cm (20 inches)

* Based on SENSDI12CBL-L cable.

** Based on SENVOLTCBL-L cable with the interface drawing 100 mA of current.

3. Installation

Several configurations are possible when using the EnviroSMART™ / EasyAG® Probes with Campbell Scientific dataloggers. Among those configuration are the following:

Option 1 (Preferred)

Device	Function
Probe	Output scaled frequency
Datalogger	Store scaled frequency, calculate and store water content

Option 2

Device	Function
Probe	Output water content
Datalogger	Store water content

Option 1 allows for use of data in spreadsheet programs as well as Sentek's ES4.1 Software. It also allows for application of new soil calibrations after data are collected. The preferred option is followed in this manual.

Refer to the installation manual published for each probe for information on access tube installation. Appendix A addresses probe assembly. Appendix B addresses probe normalization. Appendix C summarizes access tube installation. Appendix D summarizes site selection.

4. Probe Wiring

A very small flat-point screw driver is used to open the gates of the EasyAG® terminals before insertion of wires. Tighten the gate screws after inserting wires.

4.1 SDI-12 Interface Wiring

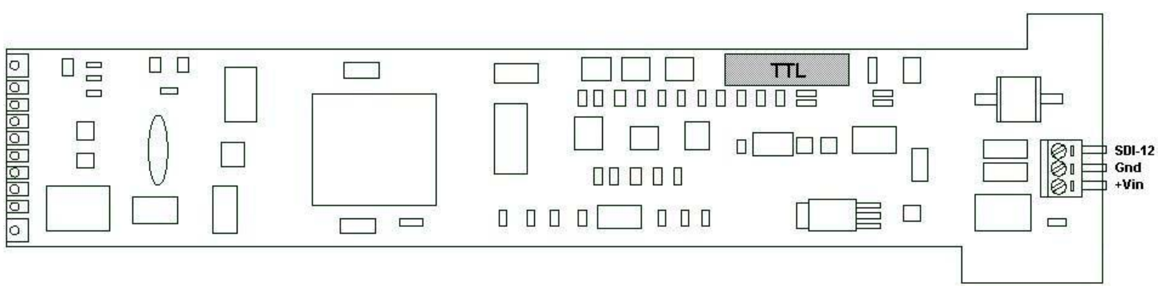


FIGURE 1. EasyAG® SDI-12 Interface

Probe	Pin	CR10X / CR23X	CR200 Series
SDI-12	3	C1	C1 / SDI-12
Gnd	2	G or ⏚	⏚
+Vin	1	12 V	SW Battery

4.2 Voltage Interface Wiring

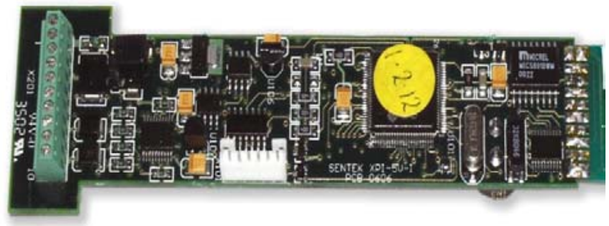


FIGURE 2. EasyAG® Voltage Interface

Probe	Pin	CR10X / CR23X
+V4	10	SE4
Gnd	9	AG
+V3	8	SE3
+V2	7	SE2
Gnd	6	AG
+V1	5	SE1
Gnd	4	AG
+Vpo	3	SW12V
Gnd	2	AG
+Vin	1	12 V
		SW12V CTRL
		C1

4.3 Cable Installation

Securely tighten the gland nut through which the cable passes into the probe cap. Inject a small amount of silicon sealant into the sensor end of the cable to ensure that water or water vapor will not pass into the probe.

5. Datalogger Programming

Example programs correspond to setup examples in Appendix A.

5.1 SDI-12 Interface Programming

Firmware Settings: Probe Configured to Output Scaled Frequency Data

Set Sensor Coefficients:
- Set A = 1
- Set B = 1
- Set C = 0

```
;{CR10X}

*Table 1 Program
  01:  900             Execution Interval (seconds)

;***Water Content Sensor Setup***

;Enter Coefficients to convert scaled frequencies to percent water content
;Defaults = Sentek default calibration
;---Enter A (default = Sentek default calibration Scaled F to %)
Calib_A = .1957
;---Enter B (default = Sentek default calibration SF to %)
Calib_B = .404
;---Enter C (default = Sentek default calibration SF to %)
Calib_C = .02852
;---Enter Mult to Convert % Water Content to inches water / 4 inches of soil
UnitScale = 0.04

1:  SDI-12 Recorder (P105)
  1:    0              SDI-12 Address
  2:    0              Start Measurement (aM0!)
  3:    1              Port
  4:    1              Loc [ SF_Top    ]
  5:    1.0            Mult
  6:    0              Offset

2:  Beginning of Loop (P87) ; ThetaV = (((SF - C) / A) to power of (1 / B))
  1:    0              Delay
  2:    4              Loop Count

3:  Z=X-Y (P35)
  1:    1 --           X Loc [ SF_Top    ]
  2:    13             Y Loc [ Calib_C   ]
  3:    5 --           Z Loc [ WC_Top    ]

4:  Z=X/Y (P38)
  1:    5 --           X Loc [ WC_Top    ]
  2:    10             Y Loc [ Calib_A   ]
  3:    5 --           Z Loc [ WC_Top    ]

5:  Z=1/X (P42)
  1:    11             X Loc [ Calib_B   ]
  2:    12             Z Loc [ RecipWC_B ]

6:  Z=X^Y (P47)
  1:    5 --           X Loc [ WC_Top    ]
  2:    12             Y Loc [ RecipWC_B ]
  3:    5 --           Z Loc [ WC_Top    ]

7:  End (P95)
```

```
8:  If time is (P92)
   1:    0              Minutes (Seconds --) into a
   2:    15             Interval (same units as above)
   3:    10             Set Output Flag High (Flag 0)

9:  Real Time (P77)
   1:    1220           Year, Day, Hour/Minute

10:  Sample (P70)
   1:    4              Reps
   2:    1              Loc [ SF_Top    ]

11:  Sample (P70)
   1:    4              Reps
   2:    5              Loc [ WC_Top    ]

*Table 2 Program
   02:  0.0000          Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 SF_Top
2 SF_2nd
3 SF_3rd
4 SF_4th
5 WC_Top
6 WC_2nd
7 WC_3rd
8 WC_4th
9 _________
10 Calib_A
11 Calib_B
12 RecipWC_B
13 Calib_C
14 UnitScale
15 CSI_R
```

5.2 Voltage Interface Programming

Hardware Setting: JP201 Jumper Removed (Power-Up Mode)

Firmware Settings: Configure to Output Voltage Proportional to Scaled Frequency

Set Sensor Coefficients:

A = 1
B = 1
C = 0

Set Full Scale Voltage
- Set Voltage Lower Level: V*ll* = 0
- Set VWC Lower Level: N*ll* = 0

Set Full Scale Output
- Set Voltage Upper Level V*ul* = 2.5
- Set VWC Upper Level N*ul* = 1.0

Set Error Volts Ve = 3.0 (causes overrange error on CR10X Datalogger)

```
;{CR10X}
;
*Table 1 Program
  01:  900            Execution Interval (seconds)

;***Water Content Sensor Setup***

;Enter Coefficients to convert scaled frequencies to percent water content
;Defaults = Sentek default calibration
;---Enter A (default = Sentek default calibration Scaled F to %)
Calib_A = .1957
;---Enter B (default = Sentek default calibration SF to %)
Calib_B = .404
;---Enter C (default = Sentek default calibration SF to %)
Calib_C = .02852
;---Enter Multiplier to Convert % Water Content to inches water / 4 inches of soil
UnitScale = 0.04

1:  Do (P86)
  1:   41             Set Port 1 High

2:  Excitation with Delay (P22)
  1:   1              Ex Channel
  2:   5000           Delay W/Ex (0.01 sec units)
  3:   0              Delay After Ex (0.01 sec units)
  4:   0              mV Excitation

3:  Volt (SE) (P1)
  1:   4              Reps
  2:   25             2500 mV 60 Hz Rejection Range
  3:   1              SE Channel
  4:   1              Loc [ SF_Top    ]
  5:   .0004          Mult
  6:   0.0            Offset

4:  Do (P86)
  1:   51             Set Port 1 Low

5:  Beginning of Loop (P87) ; ThetaV = (((SF - C) / A) to power of (1 / B))
  1:   0              Delay
  2:   4              Loop Count
```

```
6:  Z=X-Y (P35)
   1:    1 --            X Loc [ SF_Top    ]
   2:    13              Y Loc [ Calib_C   ]
   3:    5 --            Z Loc [ WC_Top    ]

7:  Z=X/Y (P38)
   1:    5 --            X Loc [ WC_Top    ]
   2:    10              Y Loc [ Calib_A   ]
   3:    5 --            Z Loc [ WC_Top    ]

8:  Z=1/X (P42)
   1:    11              X Loc [ Calib_B   ]
   2:    12              Z Loc [ RecipWC_B ]

9:  Z=X^Y (P47)
   1:    5 --            X Loc [ WC_Top    ]
   2:    12              Y Loc [ RecipWC_B ]
   3:    5 --            Z Loc [ WC_Top    ]

10:  End (P95)

11:  If time is (P92)
   1:    0               Minutes (Seconds --) into a
   2:    15              Interval (same units as above)
   3:    10              Set Output Flag High (Flag 0)

12:  Real Time (P77)
   1:    1220            Year, Day, Hour/Minute

13:  Sample (P70)
   1:    4               Reps
   2:    1               Loc [ SF_Top    ]

14:  Sample (P70)
   1:    4               Reps
   2:    5               Loc [ WC_Top    ]

*Table 2 Program
   02:  0.0000           Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 SF_Top
2 SF_2nd
3 SF_3rd
4 SF_4th
5 WC_Top
6 WC_2nd
7 WC_3rd
8 WC_4th
9 _________
```

```
10 Calib_A
11 Calib_B
12 RecipWC_B
13 Calib_C
14 UnitScale
15 CSI_R
```

6. Care and Maintenance

Probe electronics will be damaged if exposed to water or condensation. A proper installation must include active desiccant in the cap of each probe. Be certain the gland nut through which the cable passes is tight. Also, maintain the silicon plug material in the sensor end of the cable to ensure water vapor does not pass into the probe through the cable.

7. Acknowledgements

Campbell Scientific, Inc. gratefully acknowledges the contribution of Sentek Pty Ltd to concepts, text, and images used in this manual.

Appendix A. Normalization and Function Test

Normalization is the setting of the range over which the electronics is effective. This range is bounded by the two extremes of air and water.

A.1 Normalization

Connect +12 Volts DC and ground to the green connector at the top of the probe as shown in Figures A-1 or A-2.

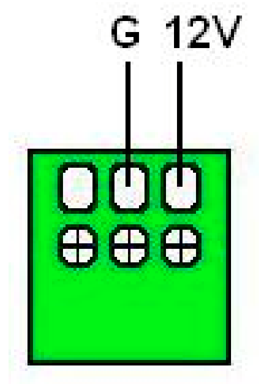


FIGURE A-1. SDI-12 Interface Power Connection

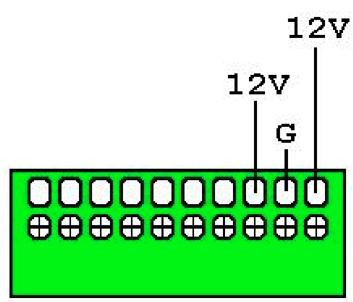


FIGURE A-2. Voltage Interface Power Connection

Connect the Intelligent Probe Utility Cable (P/N SEN06020) to the TTL port near the top of the probe at the location indicated in Figures A-3 or A-4.

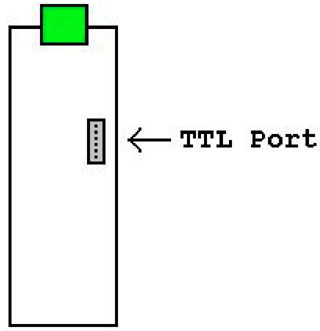


FIGURE A-3. SDI-12 Interface TTL Connection

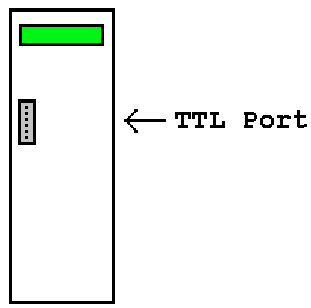


FIGURE A-4. Voltage Interface TTL Connection

Connect the other end of the utility cable to the serial port on a PC. This may require a 9 to 25 pin serial adaptor. CSI serial cable (P/N 7026) is available as an adaptor.

Start the IPConfig Utility (Intelligent Probe Utility Software, P/N SEN06025) on the PC by clicking on the IPConfig Utility icon (shown in Figure A-5).

FIGURE A-5. IPConfig Utility Icon

Click "Connect" in the upper right area of the IPConfig window. The software will connect to the probe and set up a configuration window.

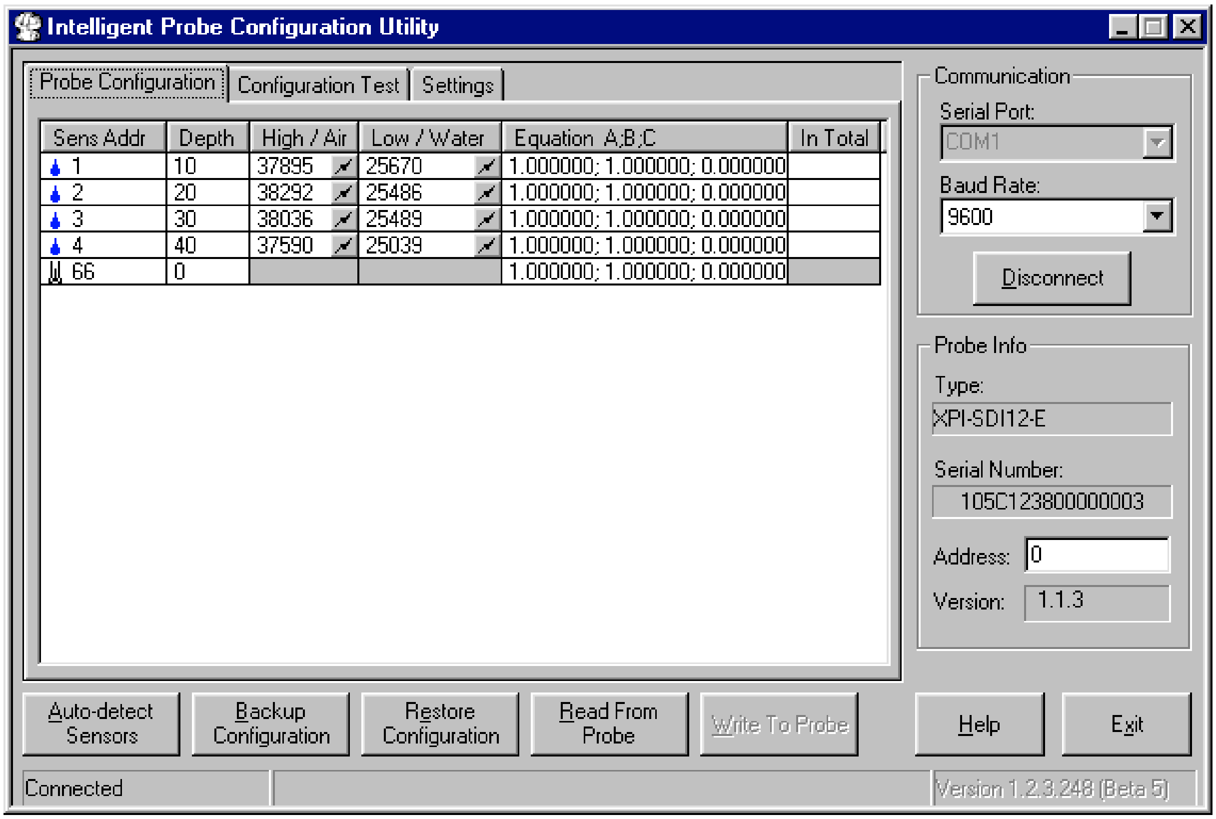


Figure A-6. IPConfig Probe Configuration Window

Figure A-6 shows an IPConfig Utility Probe Configuration window after normalization is complete on a three-sensor probe with sensors placed at 10, 20, and 30 cm. Complete the following operations for a new probe:

1. Click on "Auto-detect Sensors" in the lower left corner. Wait until all sensors are auto-detected. If the number of sensors detected does not correspond with the number of sensors on the probe, check to ensure that each sensor is addressed sequentially, beginning with address 1 on the top sensor.

2. Enter the depth of each sensor in the "Depth" column. Each depth will be a multiple of 10.

3. Enter "1.000000;1.000000;0.000000" on each line in the "Equation A;B;C" column.

4. Hold the probe in the air, away from any other object, with your hands away from the sensors, i.e. set the end of the probe on the floor and hold it upright. For each sensor, press the "High / Air" toggle button . Allow about 10 seconds, then toggle the button off. Values will be within a few thousand of those shown in the example above.

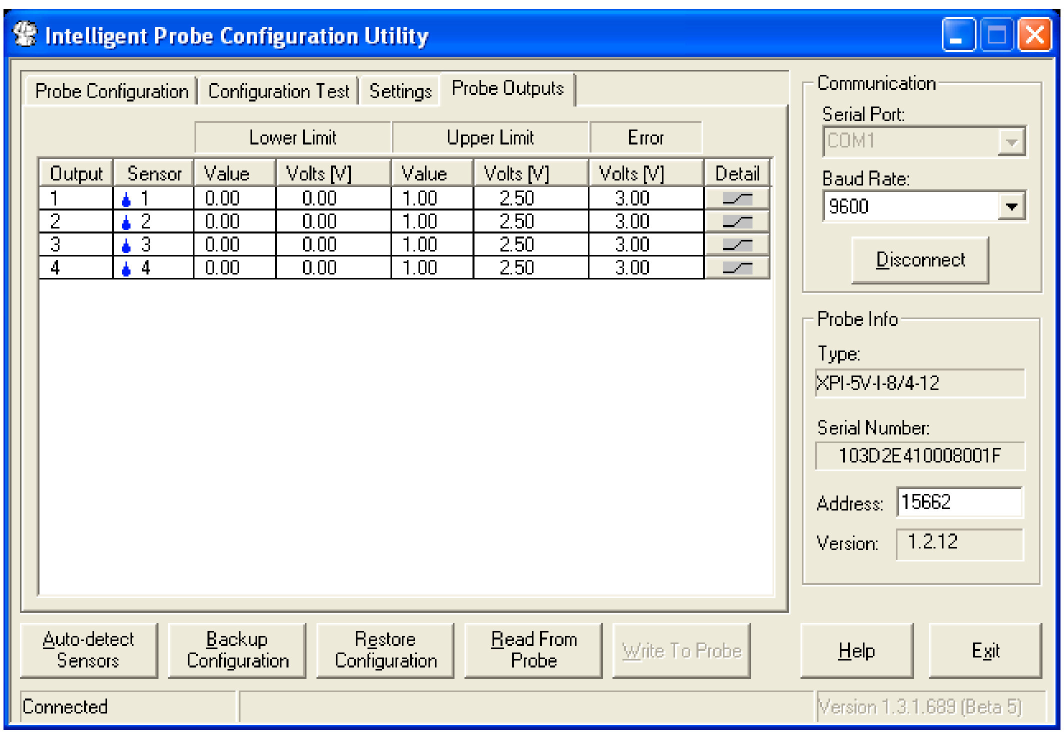
5. Fill the normalization chamber (P/N SEN70056) or a deep bucket with water. If using the normalization chamber, take the probe out of the access tube. For each sensor, slide the probe into the normalization chamber tube such that the sensor is in the center of the tube. If using a bucket, submerge most of the white tube portion of the probe into the center of the bucket. Do not submerge the blue portion of the probe, or allow the electronics to get wet. Press the "Low / Water" toggle button . Allow about 10 seconds, then toggle the button off. Values will be within a few thousand of those shown in the example above.

6. On SDI-12 interfaces, set the probe address in the lower right area of the IPConfig window. The SDI-12 address is used in the datalogger program. If only one probe is to be used on a datalogger, you may leave the address at "0."

7. Press "Write to Probe" in the lower right of center of the window.

8. Press "Backup Configuration" in the lower left of center of the window. Use the default file name.

Normalization of the probe is now complete. Voltage interfaces require that the "Probe Outputs" tab be configured. The settings in this example correspond to the CR10X programming example in Section 5.2.



A.2 Configuration Testing

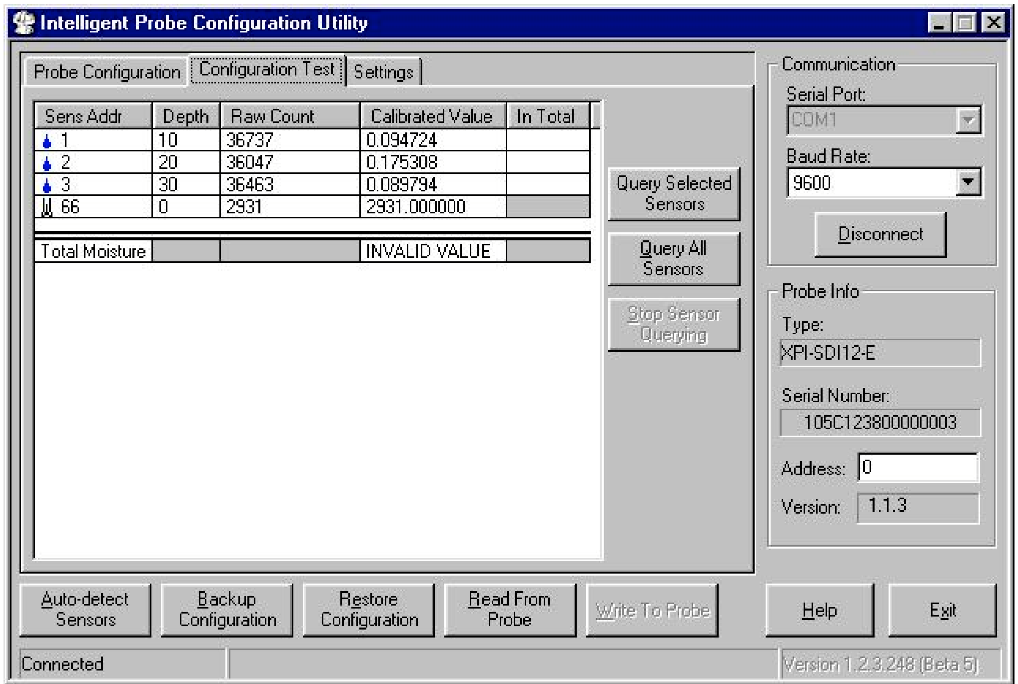


FIGURE A-7. IPConfig Configuration Test Window

Test the configuration by going to the “Configuration Test” tab as shown in Figure A-7. Again, with the probe in the access tube, hold the probe in the air, then press “Query All Sensors.” Press “Stop Sensor Querying” when values appear in the window. Raw counts should be close to the values shown in the example above.

Appendix B. Tube Installation

B.1 Introduction

B.1.1 Soil Suitability

EasyAG™ may be installed into a range of soil types ranging in texture from light sand to heavy clay. It is unsuitable for installation into stony ground where the average stone size is greater than 10 mm. Larger stones may damage the plastic cutting tip of the probe and divert the direction of the insertion.

EasyAG™ is also not suited to insertion into dry ground, as this causes significant back pressure when using the sledgehammer and leads to damage at the top of the access tube. The potential insertion site should be moistened to a depth of 1 meter before installation.

In hard soils, it is possible to cause minor damage to the top of the access tube in the top cap. If this occurs, simply remove the burred edges with a sharp knife or file when fully inserted, so that the electronic circuitry may be installed. Care must be taken in any subsequent re-installations, as the available surface area for contact of the EasyAG™ dolly will be reduced. EasyAG™ is ideal for well tilthed cultivated soils such as commonly found in vegetable production areas.

B.1.2 Sledgehammer Technique

Blows from the sledgehammer should be well directed straight down onto the beating head of the soil auger with as little lateral (sideways) impact as is possible. This minimizes the formation of an air gap between the soil and the access tube. Any air gap here will result in preferential path flow of water down the access tube and into deeper soil layers.

B.1.3 Soil Sampler Extraction

When extracting the soil sampler, care must be taken so that the integrity of the hole is not compromised. The soil sampler must be pulled directly and smoothly upward.

At no stage should the soil sampler be reinserted, as this will damage the hole integrity. It is better to simply start again if the installation is not progressing well.

B.1.4 Air Gap Correction

At every stage, the formation of an air gap between the soil and the access tube must be limited. If this is unavoidable, then there are some corrective measures that may be taken.

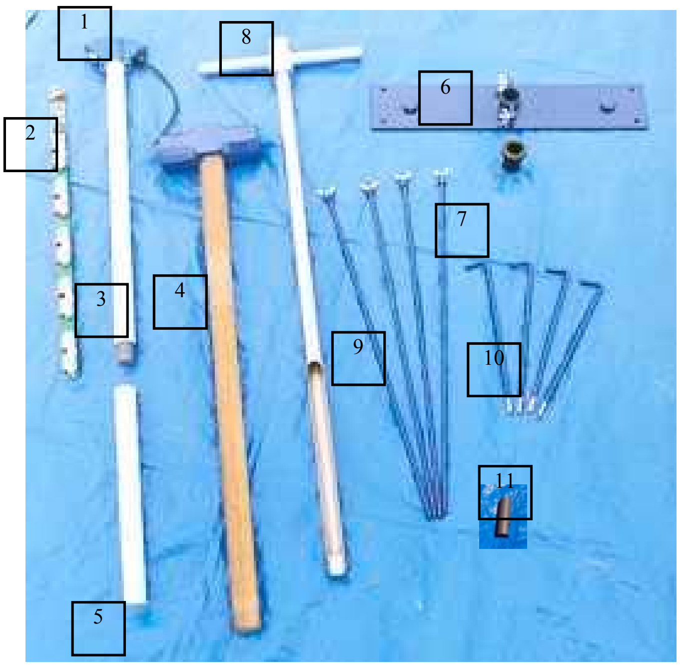
Small air gaps of 1 – 2 mm between the soil and the access tube near the surface may be closed with light finger pressure without causing major errors in the soil moisture detection.

A significant air gap of greater than 2 mm between the soil and the access tube near the surface may be corrected by carefully pushing a spade into the soil adjacent to the probe and gently levering the soil against the tube. The spade should be at least 15 cm away from the access tube when this is done to limit any error in the soil moisture detection. The installation should be re-done at another site if correction of air gaps is not progressing well.

B.2 Installation Tools

The basic components required for the EasyAG™ installation are shown below:

Top Cap
EasyAG™ sensor board
Probe access tube and joiner
Sledgehammer
Cutting tip
Stabilization brace
Soil sampler polyguide
Soil Auger
Stabilization brace pins (long)
Stabilization brace pins (short)
EasyAG™ dolly



The complete list of items required for the installation of the EasyAG™ probe:

Sledgehammer
Soil Auger
Stabilization Brace
Soil Sampler Polyguide
Stabilization Brace Pin (Long)
Stabilization Brace Pin (Short)
EasyAG™ Dolly
Cable
Cable Connector
Fair RiteTM Bead
Bin for Normalization
Screwdriver (flat, small)
Screwdriver (Phillip’s Head, Small)
Screwdriver (Jeweler’s fine, flat – interface dependent)
Wire Cutters
Wire Strippers
Spade
Gloves
Saftey Goggles
Personal Computer
Tarpaulin
Silicone Glue

B.3 Installation Procedure

Step 1 - Assemble and Install the Stabilization Brace

The stabilization brace can be used on both flat ground and raised soil beds. There are two different types of stabilization brace pins. Short pins are for flat ground, and long pins are for raised soil beds.

Option A. Flat Ground

Place the stabilization brace on the ground where the probe is to be situated. Insert the stabilization brace pins through the holes in the stabilization brace.

Drive the stabilization brace pins all the way into the ground using a sledgehammer. The stabilization brace should be in firm contact with the soil without compressing it significantly.

Put the soil sampler polyguide in place. The stabilization brace is now ready for insertion of the AMS soil sampler. Refer below from Step 5: Preparing the hole as for raised soil bed installation.

Option B. Raised Soil Bed

Insert each of the four long stabilization brace pins into the holes in the stabilization brace and tighten the wing nuts with light finger pressure.

Place the assembled stabilization brace on the ground directly above the required position of the probe. Apply gentle pressure directly down onto the stabilization brace to force the pins into the ground.

Using a sledgehammer alternately beat the stabilization brace at the points provided to force it closer to the ground. Do not beat continuously on any one side in advance of the other. The aim is to achieve a situation where the pins are near parallel in the ground.

The stabilization brace should be firm to the ground without causing significant soil compression.

WARNING **Do not compress the soil such that normal water infiltration into the soil is likely to be inhibited. This is particularly important on clay soils.**

Insert the soil sampler polyguide.

Step 2 - Augering the hole

Insert the soil auger and force downward in a single smooth action by hand until the resistance becomes too great.

Using a sledgehammer beat the auger into the ground all the way. Ensure accurate blows are made such that lateral deflection of the soil sampler is minimized. Do not compress the soil with the final blow.

WARNING **Do not compress the soil such that normal water infiltration is inhibited.**

Turn the auger one single complete rotation.

Carefully lift the AMS soil sampler directly out of the ground. If you experience difficulties at this point, remove the soil sampler in stages, or obtain extra assistance to avoid back injury. To remove the soil collected in the soil sampler, simply beat on its side with the hand or foot. The design is such that the soil core taken is slightly compressed, and of a lesser internal diameter than the soil sampler itself. Deposit this soil away from the probe site.

Remove the auger polyguide.

Step 3 - Assembling the EasyAG™ probe

Attach the cutting tip to the base of the probe with firm pressure. No glue is required.

Step 4 - Inserting the access tube

Insert the assembled complete probe into the stabilization brace and push it into the ground in a single gentle movement as far as it will go. Do not cause undue inflection of the access tube, as this will destroy the integrity of the installation.

As the probe enters the prepared hole in the soil, it shaves off a residue that is eventually stored in the cutting tip at the base of the hole.

Remove the lid of the top cap and extract the electronics. Place this safely to one side on a clean, dry surface such as a tarpaulin.

Insert the EasyAG™ dolly into the top cap and position it on top of the internal access tube.

Continue inserting the probe using a sledgehammer until there is a 2.5 cm (1 inch) gap between the base of the top cap and the edge of the stabilization brace tube guide.

NOTE A 2.5 cm clearance height is important.

Remove all of the stabilization brace wing nuts.

Lift both sections of the stabilization brace to clear the threads of the stabilization brace pins.

Separate the two halves of the stabilization brace and remove them.

Continue inserting the probe into the ground with gentle blows of the sledgehammer using the EasyAG™ dolly until the base of the top cap is level with the ground. This will place the top sensor at 10 cm (3.9 inches) below the ground surface.

Remove the EasyAG™ dolly, thread a Fair RiteTM bead onto a loop in the cable but do not tighten it into place yet (refer to final installation photo for this).

Push the cable through the cable gland and attach the wiring according to the diagram in Section 4.

Step 5 - Inserting the Electronics

Reinstall the sensor circuitry and attach the connector or attach wiring as required. Tighten the cable gland and seal around the inside threaded section with silicone glue.

Step 6 – Fitting the Top Cap Lid

Replace the lid of the top cap. Tighten the screws completely to ensure an effective seal.

WARNING **Ensure that the sealing gasket is in good condition and is positioned correctly.**

Remove the stabilization brace pins by turning them and pulling upward.

Tighten the Fair Rite™ bead into place.

B.4 Removing Access Tubes

Removal of access tubes is a relatively easy process in sandy soils. It may be done with the electronics in place. Simply excavate a little soil from near the surface, grab the probe access tube or top cap, give a couple of twists, and pull upward.

In heavy clay soils, removal of the EasyAG™ probe may require a greater depth of soil to be excavated before it is possible to remove it by hand.

To assist in this, a mattock may be used. Apply gentle levering pressure underneath alternate sides of the top cap. Move the access tube a little at a time, adding sufficient height underneath the mattock as required.

WARNING **Caution is required here such that the top cap and access tube are not damaged.**

As no glue is used in the connection of the cutting tip to the probe access tube, the cutting tip section can be removed for easy cleaning using one of the long stabilization brace pins. In heavy soils, the cutting tip may not be recoverable without digging to the full depth. If this is likely to be the case, the cutting tip may be glued into place prior to installation.

WARNING **Under no circumstances should a wrench be used on the access tube, especially while the electronics is still in place, as this may cause damage to the probe.**

Appendix C. Site Selection

Site selection is a critical process for all soil water sensors. A properly selected site will reflect changes in soil moisture and plant water use trends over a larger area. This area may be an entire field, sub-section of a field, a crop variety, a planting, a soil type, etc. Putting a sensor in a 'dry zone' or under the influence of a malfunctioning sprinkler will invalidate data to some degree.

Site selection is carried out by identifying macro-zones and micro-zones.

Macro-zone selection divides the property in zones according to soil type, soil depth, water holding capacity, and water tables and salinity. Irrigation applications can be specifically tailored to these zones to match soil and crop variability as a macro zone consists of areas with similar crop water use.

Micro-zone selection determines the position of access tubes in relation to the crop and irrigation system and considers the areas of the root zone, canopy spread, water distribution uniformity, and moisture pattern of drip irrigation. Measurements are taken from a small part of the root-zone. If the extent and depth of the root-zone is misjudged and/or when sensors are placed in dry or wet spots associated with a bad distribution uniformity of water, the soil water data will not indicate optimal irrigation scheduling.

Important factors to take into consideration for site selection are:

1. Soil spatial variability
2. Topography
3. Aspect of sloping land
4. Crop type
5. Crop age
6. Crop planting density
7. Size and extent of the effective root system of the crop
8. Irrigation system layout and flexibility
9. Water Distribution uniformity
10. Moisture patterns under drip irrigation.