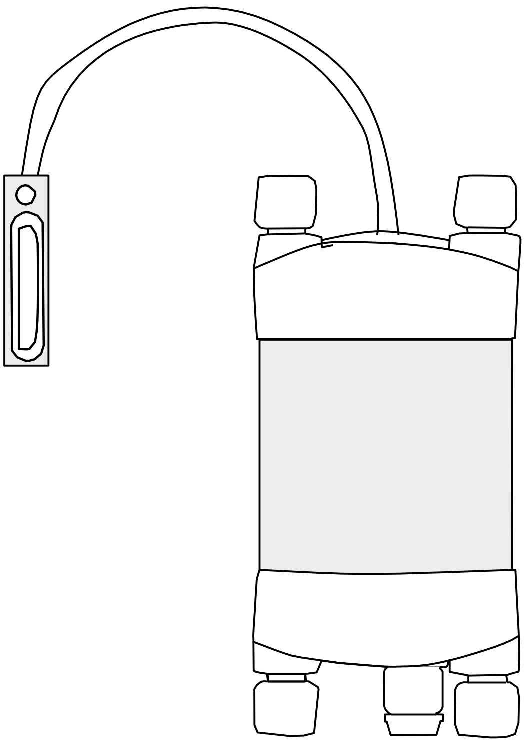
SMM
Soil Moisture Meter



April 2014

Contents

1. Introduction

The SMM Soil Moisture Meter is a complete system for collecting and storing data from up to ten Sensors in the field or laboratory. The SMM is equipped with an internal battery which provides power to the instrument as well as the sensors. A fully charged battery should have the capacity to provide several hours of data collection in the field before recharging is required. Depending on logging interval, the internal battery can also last several days.

There are three parts to the SMM system:

1. The instrument (also known as the data logger).
2. Break-out box for connection between the sensors and the instrument.
3. Sensor

The system is plug-and-play in that it is ready to go from the box. You will need to plug a sensor into a vacant channel, assign a logging interval, and connect external power supply to the instrument.

The output from the sensors is either millivolt (mV) ***u***mol/m^2/s (for photosynthetically active radiation PAR, sensors) or W/m^2 (for solar radiation, pyranometer, sensors). The mV data are the raw data from the sensors. The calculated data are derived from either a lookup table or user script supplied with the SMM from ICT International.

This manual outlines how to start your SMM and connect power supply. It also shows how to download data and configure your instrument.

2. System Requirements

2.1 CPU Processor

The ICT Instrument software does not require large processing power. For example it is compatible with NetBooks.
Minimum Recommended Processor Capacity:
Intel Atom Processors with a CPU N270 @ 1.66 GHz and 1GB RAM or higher.

2.2 Software

The ICT Instrument software is compatible with the following Windows Operating Systems:

a. Windows XP
b. Windows Vista
c. Windows7
d. Windows Virtual OS run from a Mac computer

2.3 Screen Resolution

The ICT Instrument software is written to a fixed screen resolution of 857 x 660 dpi (it does not Auto Resize) and works best on current model laptops that have a screen size of 11.6" or larger and a default screen resolution of 1366 x 768 (the vertical height of 768 being most important otherwise you can't see the bottom of the software).

3. Charging the SMM Internal Battery

The SMM is a self contained instrument that incorporates a lithium polymer battery. Before using the instrument, this battery MUST be charged. To choose from a range of charging options see Connecting a Power Supply to the Instrument (pages 6 to 11).

You can see a demonstration video on how to turn on and connect power supply to your instrument via this link:
http://www.youtube.com/watch?v=S5OsGL7Wj-8

The SMM has an internal battery which can supply power for several hours to days depending on frequency of use. It is recommended to charge the internal battery with a solar panel, solar panel battery pack (SPBP) supplied by ICT International, or in the lab or glasshouse with a CH7, 12V, power supply.

An external power supply can be connected to the SMM in the field. See Connecting a Power Supply to the Instrument (Field Operation) (pages 10 & 11) for more details.

The unique power-bus plug design was developed by ICT International to simplify the electrical wiring process. It minimises the need for custom tools in the field requiring only that the outer cable sheath be stripped back to expose the copper wire.

As shown in Connecting a Power Supply to the Instrument (page 6) no other tools are required with all necessary components and fixings fully incorporated into the instrument design. Retaining straps ensure the power-bus plugs do not separate from the instrument when removed from the power-bus during wiring preparation and connection of external power.

3.1 Connecting a Power Supply to the Instrument

3.1.1 Individual Power Supply Connections

Important: Do not connect external power until the final step

1

Remove both ICT Bus plugs from either end of the sensor.

2

Unscrew the end of the plug 1 to 2 turns.

3

Remove the Bus plug sealing cap.

4

Insert either polarity of the external power source cable.

5

Strip a maximum of 15mm from the end of the cable.

6

Pull the cable back so only that the stripped wires protrude from the ICT bus plug.

7

Bend the stripped wires back over the end of the ICT bus plug.

8

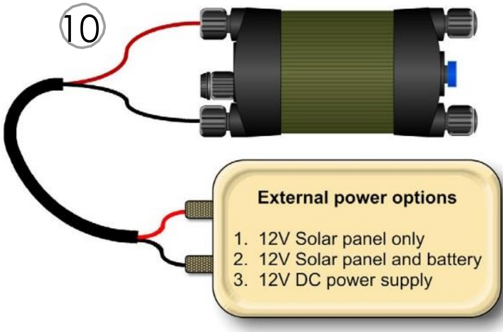
Important : Seal the cable against water ingress by tightening the end of the plug.

9

Repeat for second bus plug

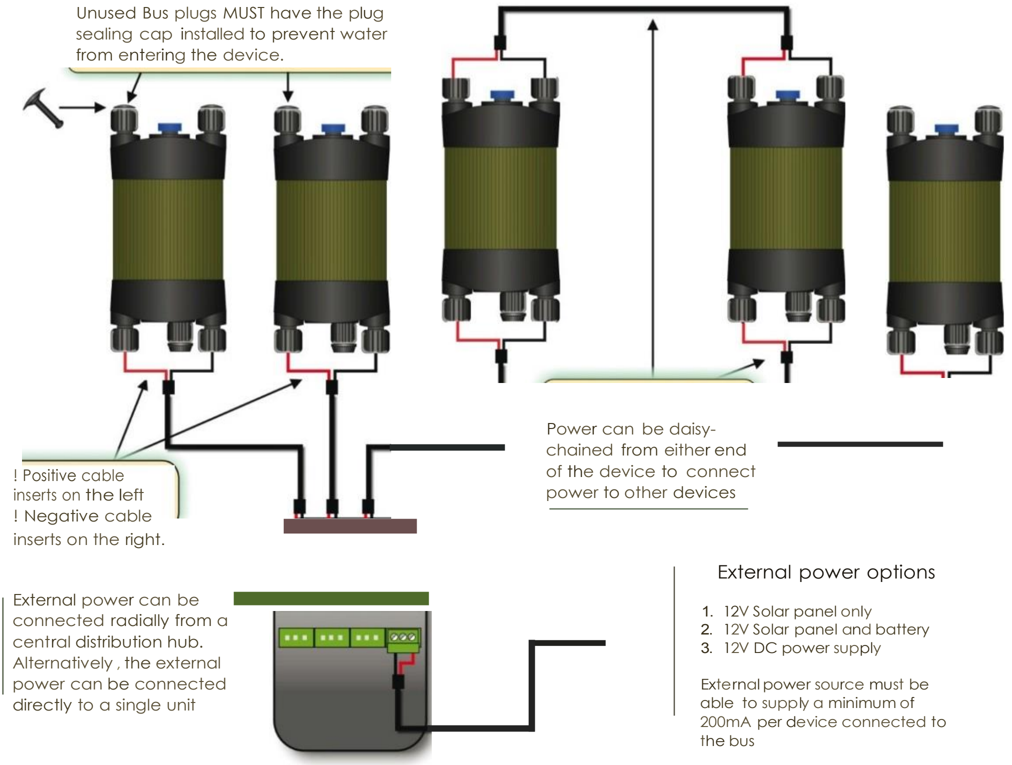
Insert the ICT bus plugs into the endcap of the sensor. The plugs can be inserted in either polarity and will click when seated into position.

10

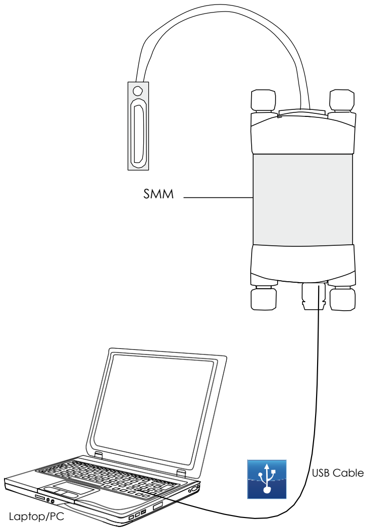


Connect the power cable to the external power source.

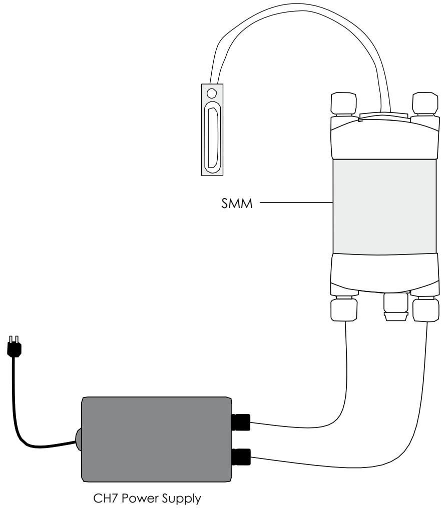
3.1.2 Shared Power Supply for Multiple Instruments



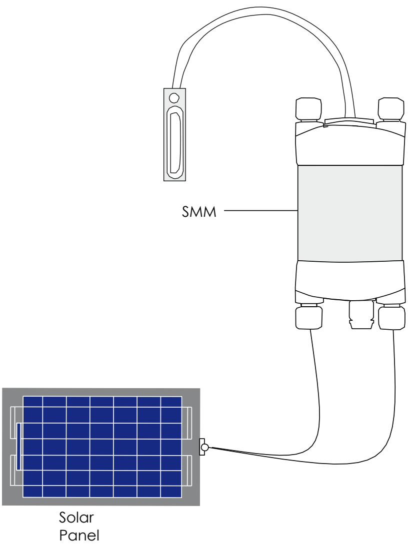
3.1.3 Connecting Power via USB cable to a laptop/PC



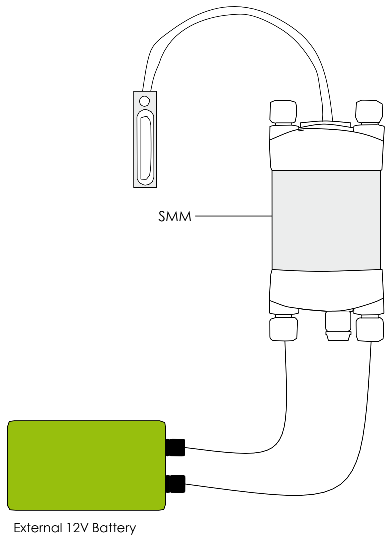
3.1.4 Connecting Power Directly via CH7 Power Supply



3.1.5 Connecting Power Directly via Solar Panel (Field Operation)



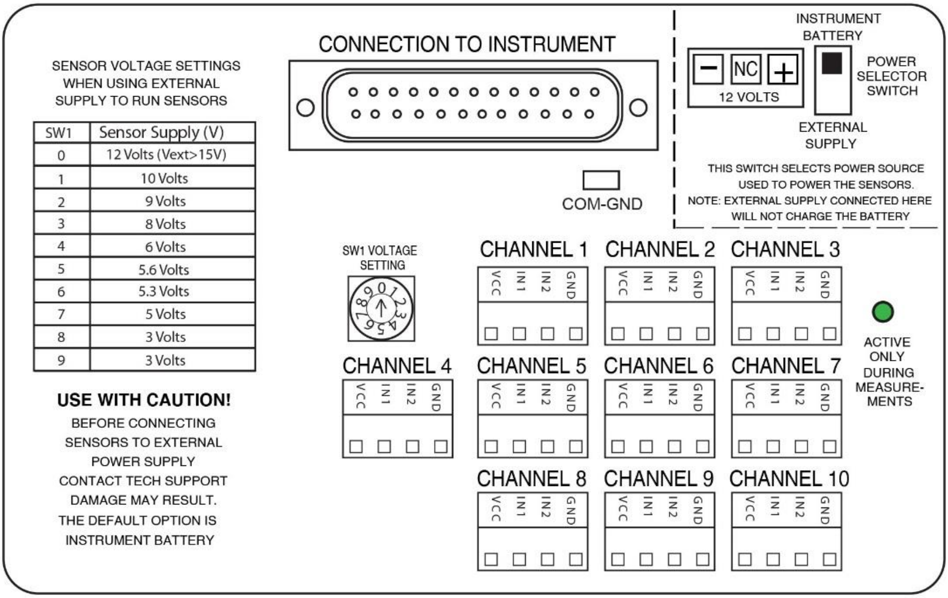
3.1.6 Connecting Power via External 12V Battery (Field Operation)



Note: The SMM Soil Moisture Meter is non-polarized

4. Connecting sensors to the SMM

The sensor is connected to the logger by inserting the green connector into the appropriate channel in the break–out box supplied with the system.



4.1 Additional Information on the Break-Out Box

When your ICT Instrument and Break-Out box arrives from ICT International you do not have to change any of the settings. The ICT Instrument and Break-Out box have already been configured for your instrument and sensors.

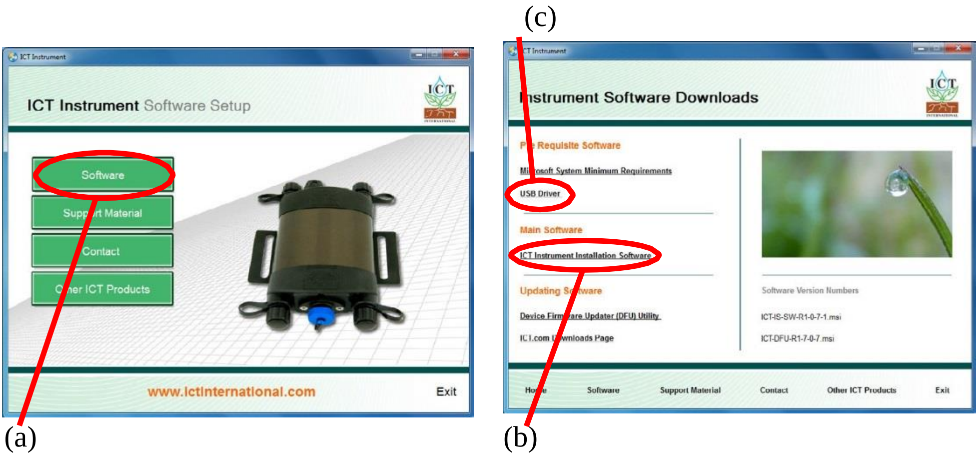
The Break-Out box should have the Power Selector Switch ALWAYS set to Internal Battery. This means that the power supply is coming from the ICT Instrument. If the Power Selector Switch is set to External Power then voltage is being delivered directly to the Break-Out box. If the wrong amount of voltage is supplied to the Break-Out box then you could potentially damage your sensors. External power supply is only ever used by advanced users on very rare occasions.

If on the very rare occasion you need to supply External Power, ICT recommends you consult with an ICT engineer or technician first.

If External Power is supplied to the Break-Out box, then the SW1 Voltage Setting dial becomes important. The numbers around the dial correspond to column 1 in the SW1 table printed on the Break-Out box diagram. The SW1 Voltage Setting Dial controls the supply voltage from the external power. If the dial is set to 0, then the input voltage from the external supply will be 12 Volts. If the dial is set to 1, then the input voltage from the external supply will be 10 Volts and so on. The level to which you set the input voltage will depend on your sensor specifications. ICT recommends consulting your sensor's manual, manufacturer's information, or directly contact engineers at ICT.

5. Install the SMM Software & USB Driver

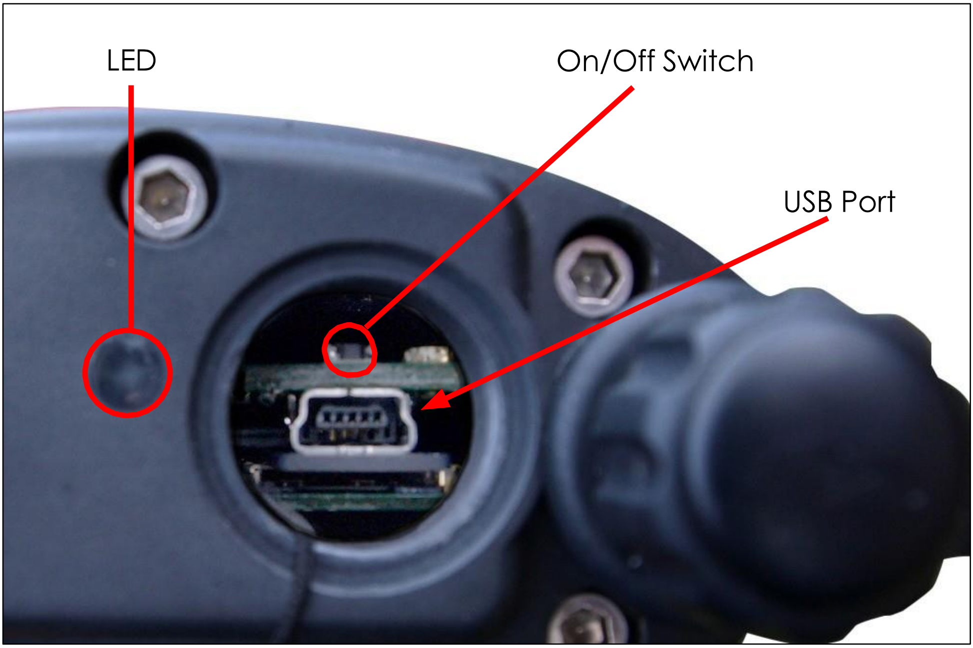
Insert the supplied CD into the computer. The CD will auto-run to present a menu. Choose software (a) then choose ICT Instrument Installation Software (b).
The software installation will begin follow the screen prompts until the finished installation screen appears. To install the USB driver choose USB Driver (c) and wait for the installation to complete.



The SMM software can also be downloaded from the ICT International Software Downloads Page.

6. Turn the Instrument On

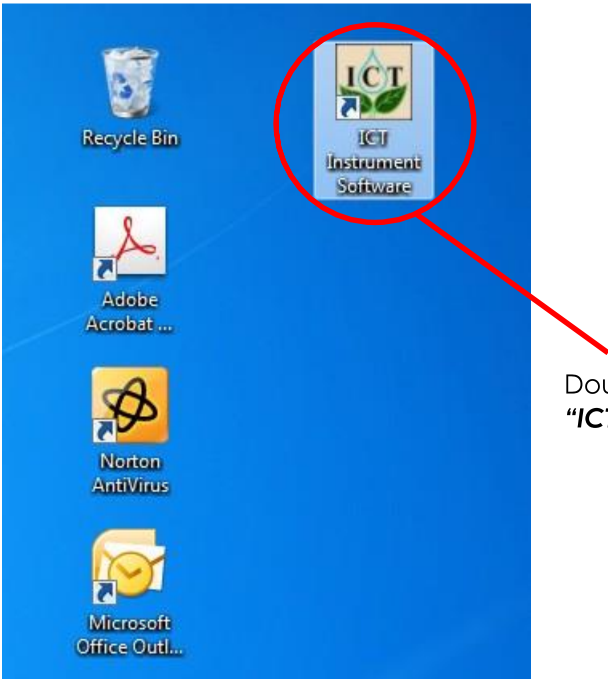
To charge and turn on your SMM Light Sensor Meter connect the Instrument to a computer via a USB cable. Alternatively the SMM can either be turned on manually by pressing the power button or automatically by connecting an external power supply.



7. Connect to the Instrument

7.1 Connect Via USB

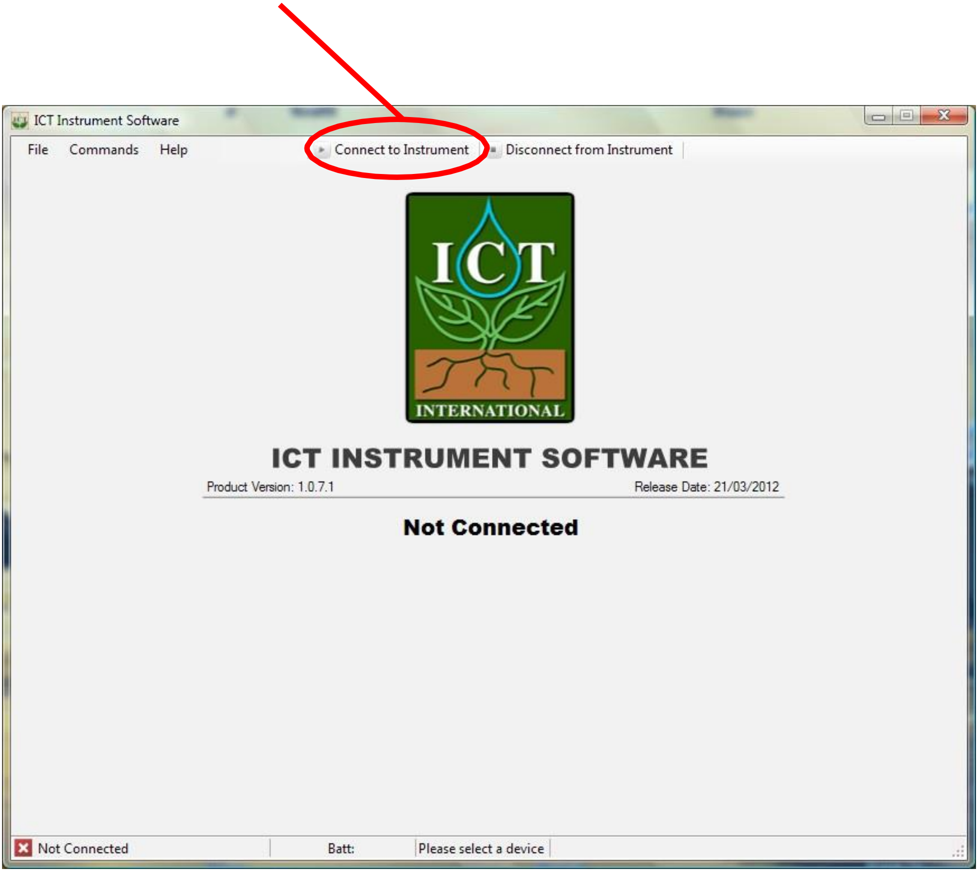
Connect the USB cable to the instrument. The LSM will automatically be detected by the computer as with any USB device. Double click the ICT Instrument icon on the Desktop to open the software and click the icon ***"Connect to Instrument"***, then click ***"Find Devices"*** to search for the instrument and select the named instrument from the Available Devices within the Device Selection Window.



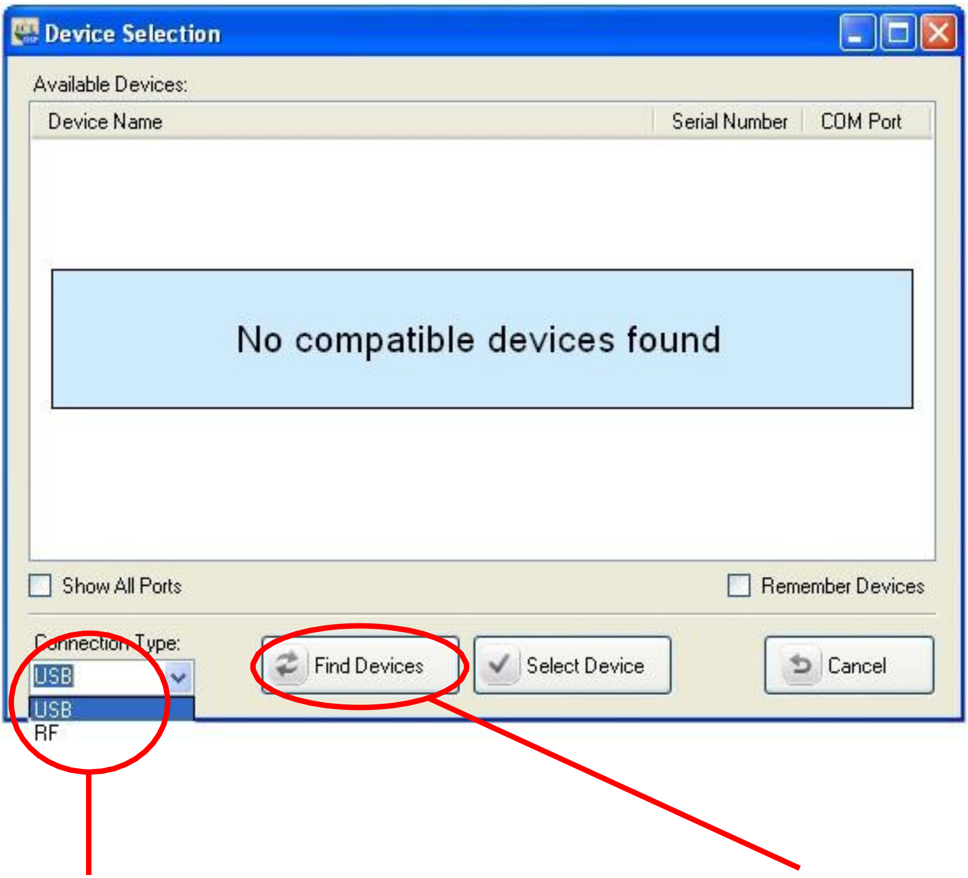
Double click the icon
"ICT Instrument Software"

7.1.1 Software Procedure Step 1:

Click the icon ***"Connect to Instrument"***



7.1.2 Software Procedure Step 2:

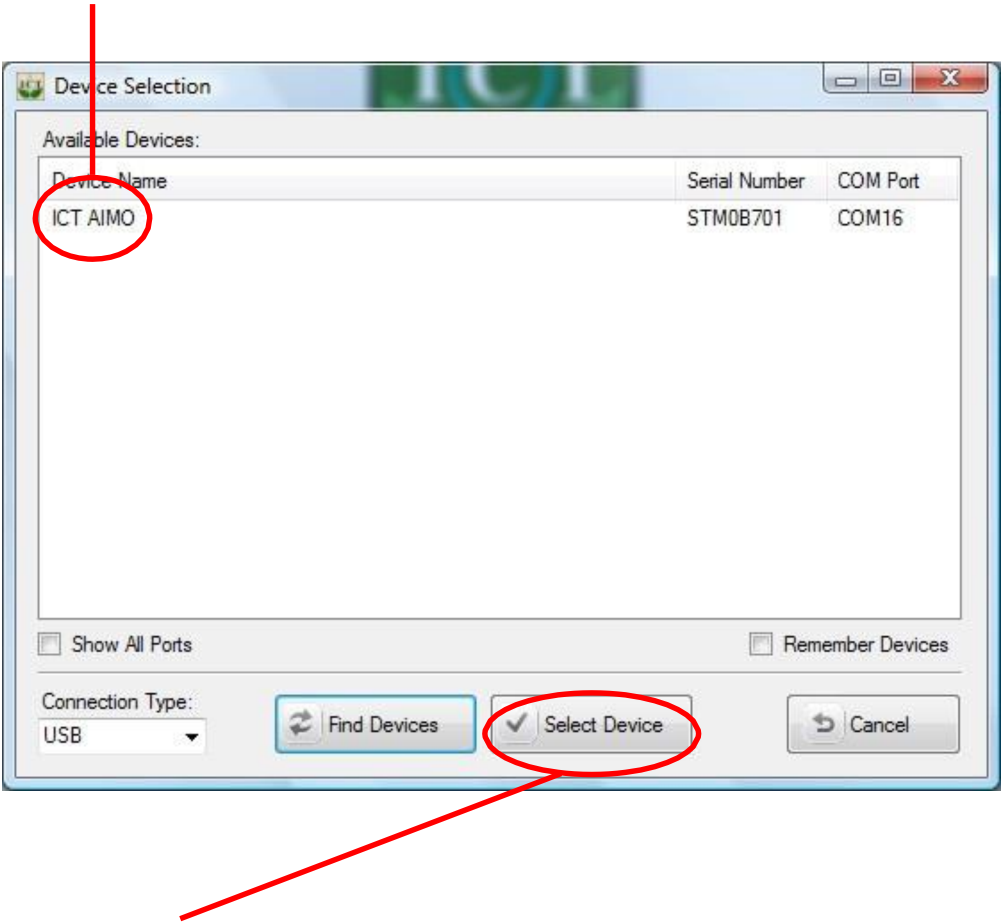


You must first choose the connection type ***"USB"*** then Click ***"Find Devices"*** to search for the instrument.

7.1.3 Software Procedure Step 3:

Note: The software will display a message to ***"Please Wait"*** after which the following screen will be displayed.

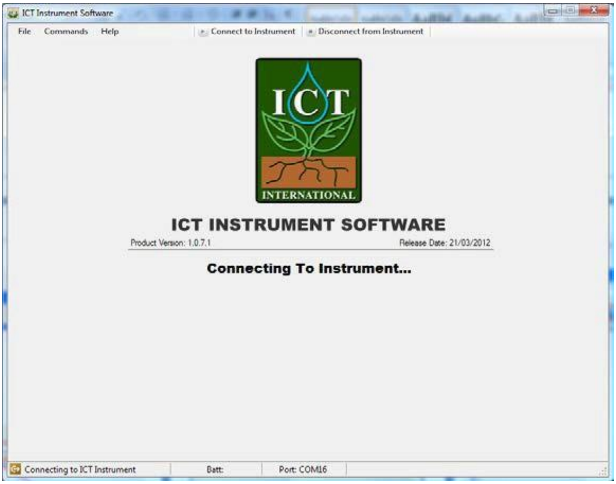
You must click on device and highlight.



After you highlight the device then click ***"Select Device"***.

7.1.4 Software Procedure Step 4:

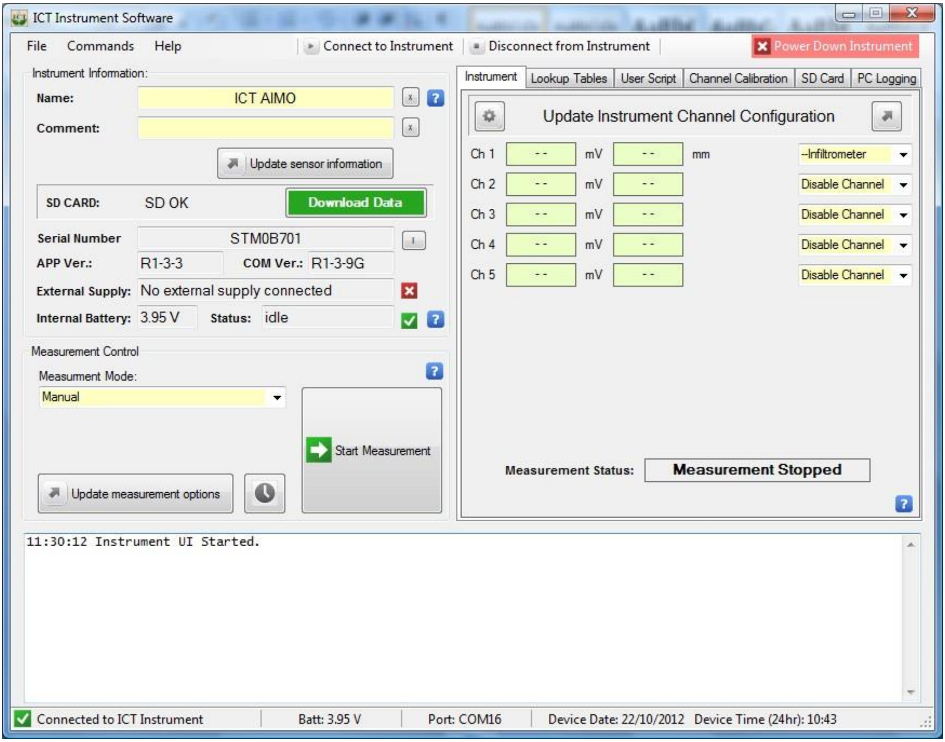
Note: The following screens will be displayed.



7.1.5 Software Procedure Step 5:

When the software has finished loading the instrument parameters the following screen will be displayed.

From here the measurement parameters can be set and the measurement sequence started.



8. Set the Measurement Parameters

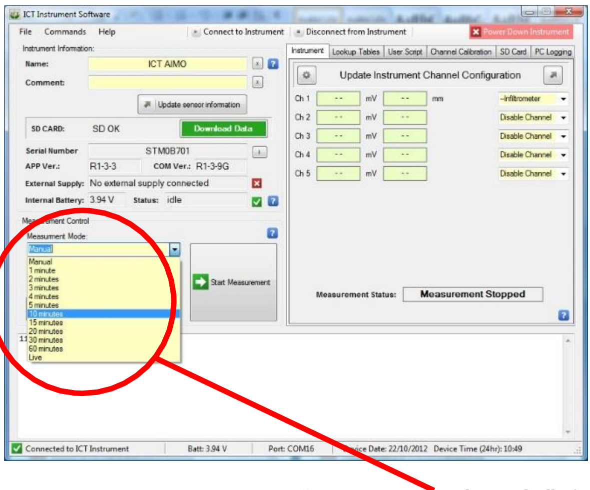
8.1 Software Procedure Step 1:

Position the cursor on the measurement mode drop down box and left click. A list of timing intervals will be displayed. Move the cursor over the timing interval you want between measurements and left click.

In Manual mode the SMM will only take a single reading each time the ***"Start Measurement"*** box is clicked. This is the default setting when the logger is to be powered down or set to standby mode.

8.1.2 Selecting Logging Periods from 1 Minute to 60 Minutes

If any parameter from 1 minute to 60 minutes is selected the SMM will record a reading at the respective time interval selected. In ***"Live Mode"*** the logger will continually take and record readings while ever Live Mode is selected. For measurement intervals of less than 60 seconds, see Selecting Logging Periods of 60 Seconds or Less (page 23) for more details.

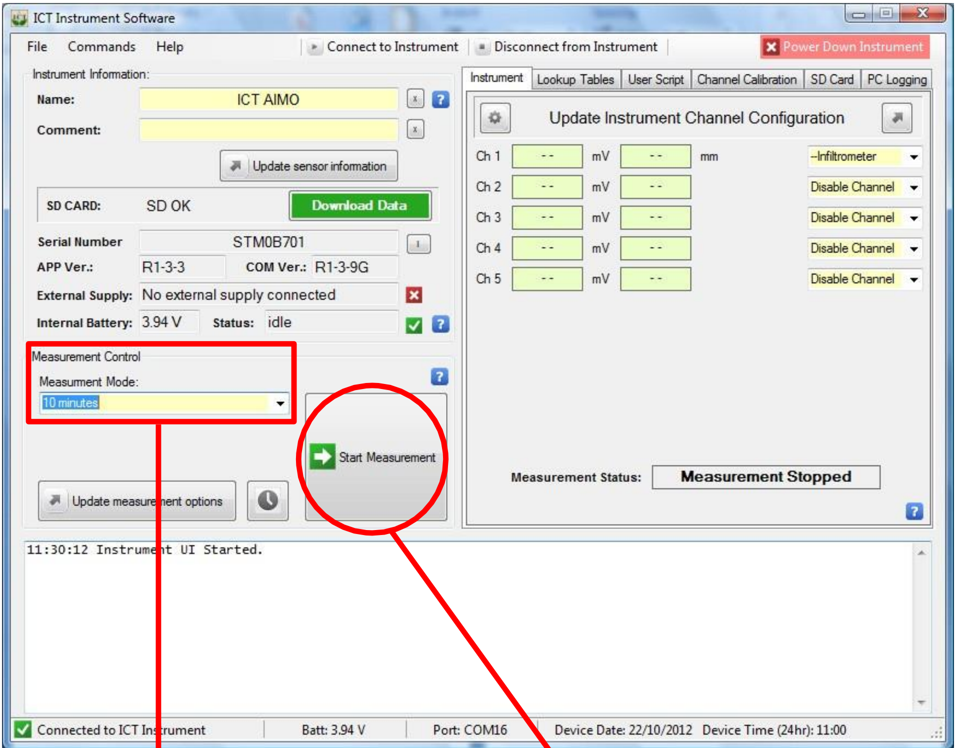


"Measurement Mode" drop down box

8.1.3 Software Procedure Step 2:

Left click on the ***"Update Measurement Options"*** box. Then click on the ***"Start Measurement"*** box to begin logging . Data will be recorded on the internal SD card.

To stop logging set the Measurement Mode to ***"Manual"***.

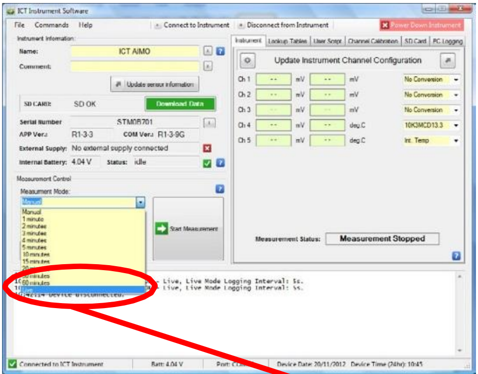


Click ***"Start Measurement"*** box to begin logging

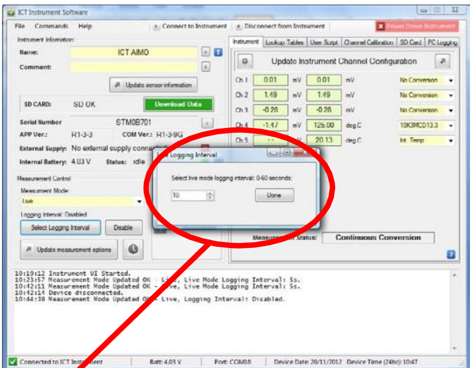
To stop logging set the Measurement Mode to ***"Manual"***

8.1.4 Selecting Logging Periods of 60 Seconds or Less

The Measurement Mode drop box will allow you to select logging intervals of between 1 minute and 60 minutes or continuous conversion in Live Mode. Logging intervals of less than one minute can be set using the following procedure.



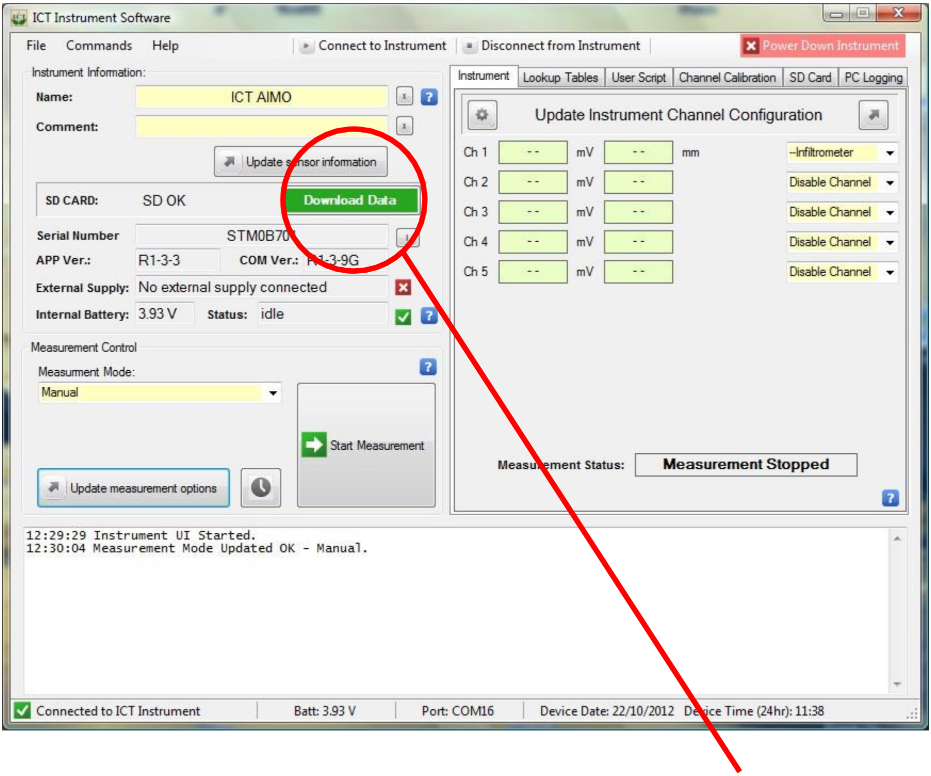
From the Measurement Mode drop down box select ***"Live Mode"*** then update measurement options.



A new menu button will appear ***"Select Logging Interval"***. Click on this button and the ***"Live Logging Interval"*** window will appear. Use the up/down arrows in the window to select the required logging interval anywhere from 0 to 60 seconds and click done. The logger will now start collecting data at the set interval.

9. Download Data

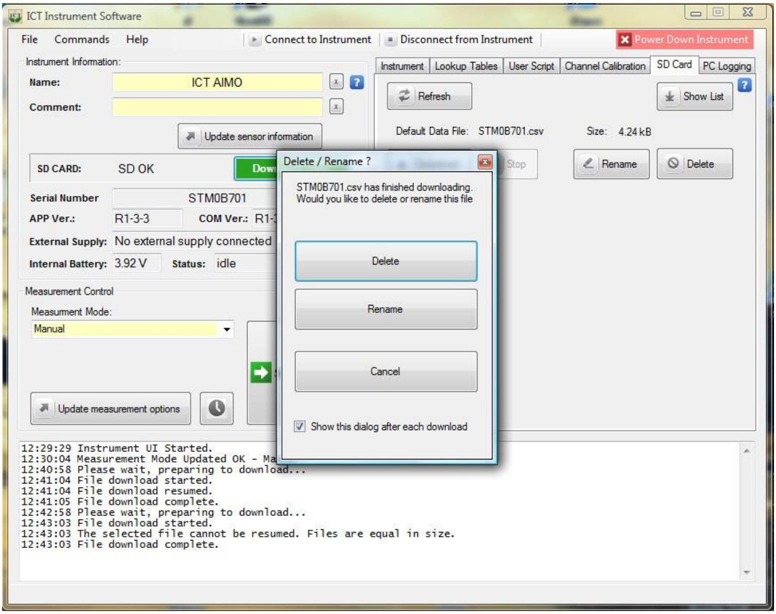
Data can be downloaded in a number of ways. The simplest is to click the green ***"Download Data"*** icon on the main window under the Instrument Information section. (circle)



"Download Data" button

Windows will prompt you for a file name and location to store the data. The file will be stored as a .csv file and the data can be viewed in an excel spreadsheet.

When the download is complete you will be prompted to delete, rename or cancel.



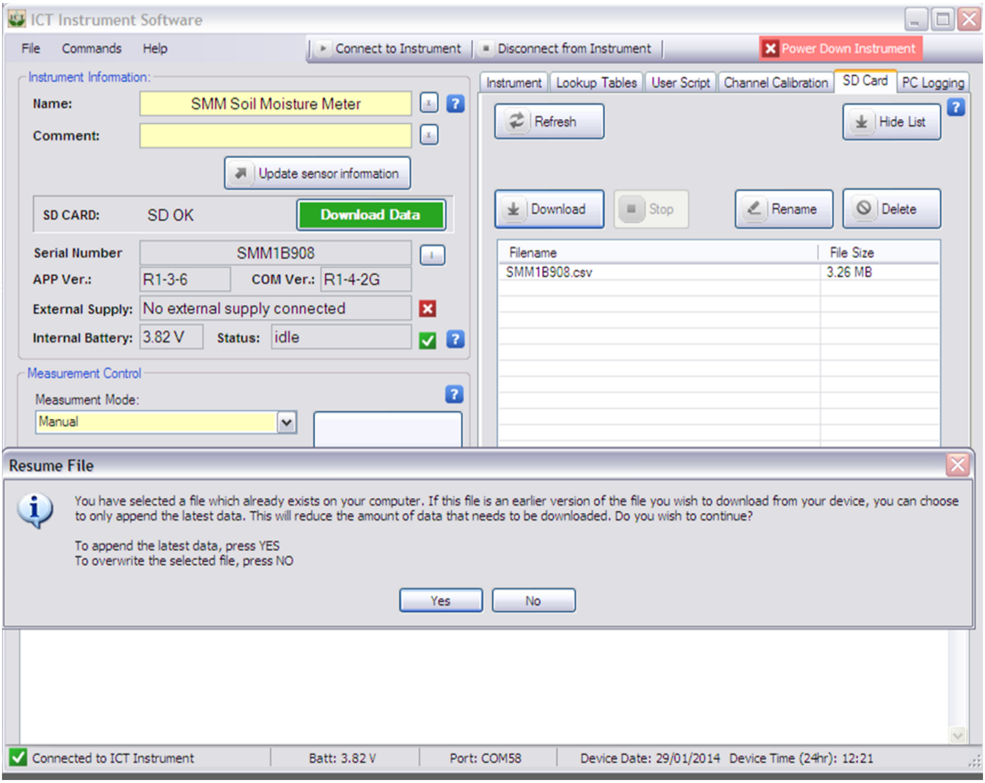
Delete will delete the csv file from the micro SD card. Note that once deleted the file cannot be retrieved. ICT only recommends this options at the end of your experiment or monitoring period when all data has been backed-up and is no longer needed on the instrument.

Rename will change the file name of the file which you have just downloaded. The renamed file will be stored on the micro SD card for later use. All new data will be downloaded to a new csv file with the default name corresponding to the serial number of your instrument.

Cancel will return you to the download screen. Your data has been downloaded and any new measured data will be appended to the end of your download file. ICT highly recommends user choose this option whenever possible. All data will be stored on a single csv file in your instrument under the serial number file name. When you download the data in the future, save the file as the same csv file name and all new data will append to the existing file.

9.1 Append File / Resume File

When attempting to download a file with the same name as an existing file, a dialogue box will appear with 2 options:



Click "YES" to append data to the existing file. This will append all new data to the existing file. This is an excellent option to choose for efficient data and file management. All your data will be stored in a single csv file which will lead to easier management later during data analysis or viewing with Sap Flow Tool Visual module.

Click "NO" and the file you will download will overwrite the existing file on your computer.

10. Lookup Tables

Lookup Tables convert raw millivolt (mV) sensor output into meaningful measurements such as volumetric soil moisture content (%VWC), temperature, solar radiation, or oxygen concentration.

Lookup Tables need at least 2 values to be valid and then assumes there is a linear relationship between the 2 values. Typically, the sensors minimum and maximum range is entered. These values can be found on a sensor's specification sheet under a subheading such as Range.

Your ICT Instrument has already been pre-programmed with a Lookup Table or User Script. Rarely would you need to change the Lookup Table or User Script. Lookup Tables commonly used for the ICT Instrument described in this manual are found in Appendix. If you cannot find the table corresponding to your sensor please contact engineers at ICT International.

11. User Script

User Scripts allow the conversion of millivolt (mV) sensor output into meaningful measurements such as volumetric soil moisture content (%VWC), temperature, solar radiation, or oxygen concentration. User scripts are particularly useful if the relationship between the mV and the converted value is non-linear, but it can also be used for linear relationships.

Your ICT Instrument has already been pre-programmed with a Lookup Table or User Script. Rarely would you need to change the Lookup Table or User Script. User Scripts commonly used for the ICT Instrument described in this manual are found in Appendix. If you cannot find the table corresponding to your sensor please contact engineers at ICT International.

12. Channel Calibration

Introduction

The ICT Instrument has a unique feature where individual sensors can be calibrated to a known standard. This feature is advantageous where a sensor is known to vary from the standard specifications provided by the manufacturer. Most sensors will vary from the standard specifications, the critical factor is where such variation is outside of the desired parameters for accurate test results. The ICT logger is supplied with a standard Lookup Table or User Script to suit the sensor provided with it. It is good practice to use a known standard test medium to check the calibration of the sensor before commencing a detailed field survey, to avoid errors in test results.

ICT Instrument Software

Calibration of the sensors is carried out using the ICT Instrumentation Software provided free with the ICT Data Logger. If your computer is connected to the internet the software will automatically check for any updates when you run the program. Connect your computer to the ICT Instrument using methods described in Chapter 7, "Connecting to the Instrument", and start the ICT Instrument Software.

Calibration of individual sensors is carried by calibrating the channel that the sensor is connected to. Care must be taken to ensure that the same sensor is connected to the channel where the original calibration is performed. Select the Channel Calibration tab on the logger software screen. Note that the logger must be in Manual measurement mode to enable calibration.

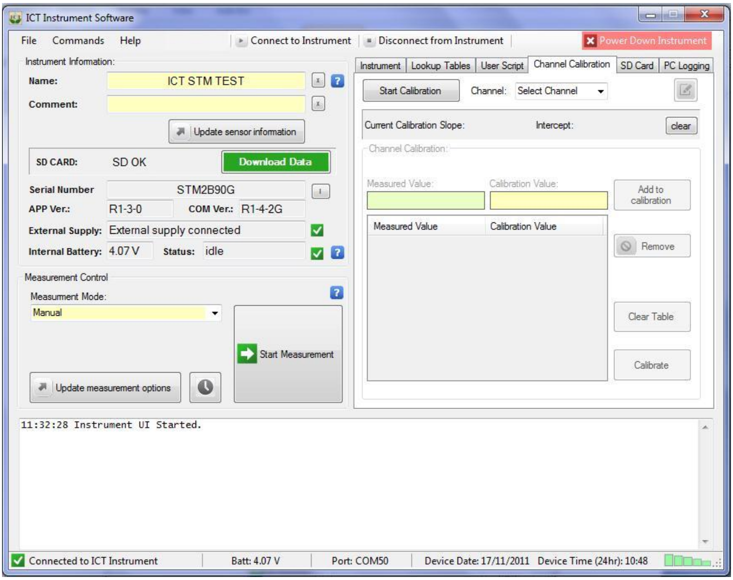


Figure 2 - Calibration Screen

Use the '**Select Channel**' drop down box to choose the required channel. The current calibration settings for that channel are displayed immediately below the selection. If no previous calibration has been performed on this channel the values will be as shown in Figure 2, with Slope set to 1.000, and Intercept set to 0.000. Alternatively, you can remove any previous calibrations by clicking the 'Clear' button to the right of the calibration values.

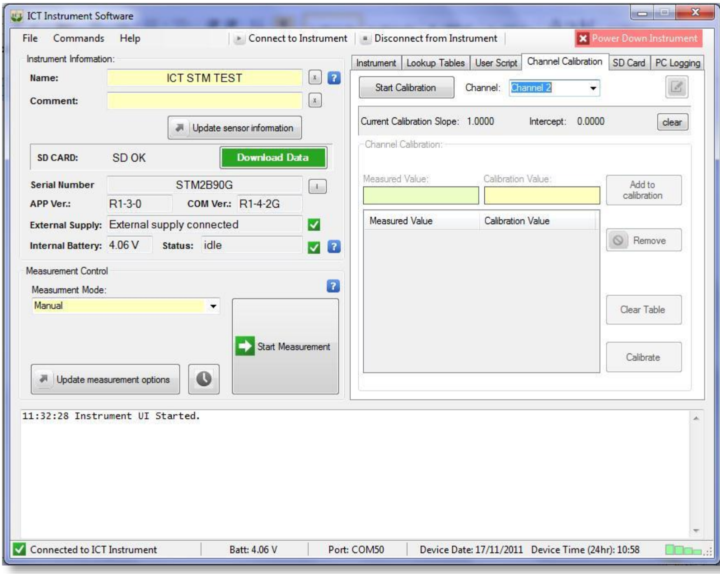


Figure 3 - Channel Selection

The next step is to click on the 'Start Calibration' button. The calibration screen will change to appear as shown in figure 3. Calibration can be done using a lookup table consisting of 3 sets of values, one of which can be a zero value entry to determine the start point of the sensor readings. The zero value is entered manually using the steps described later. The zero value entry will depend on the output values of the particular sensor to be calibrated. If you require more information on this setting contact ICT technical support. If the sensor does not use a zero value in the output ignore this step.

As stated above, the calibration process requires at least three value entries in order to develop a functioning graph of the sensor performance. In this example it is assumed that the sensor is reading 10% below correct values. The first value is straight forward, and is obtained by taking a reading from the sensor in its current state. Click on the 'Start Measurement' button to take a reading from the sensor. The value will appear in the Measured Value box as shown in figure 4. The true or corrected value is entered manually into Corrected Value box, and the '**Add to Calibration**' button is clicked to enter the values into the calibration lookup table, as shown in figure 5.

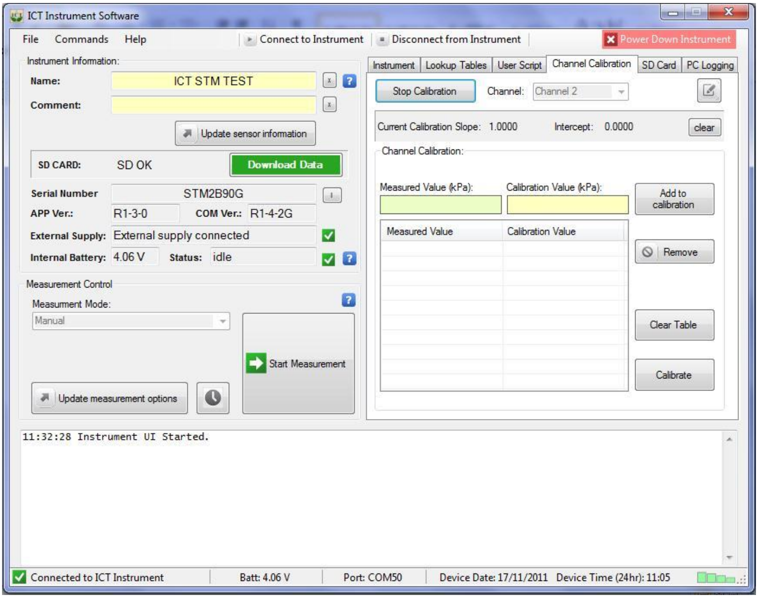


Figure 4 - Calibration Started

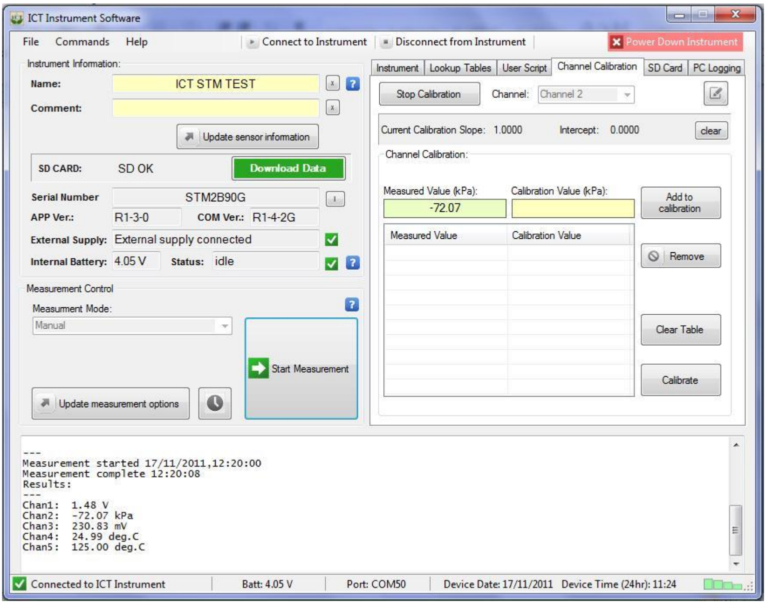


Figure 5 – Measured Value Entry

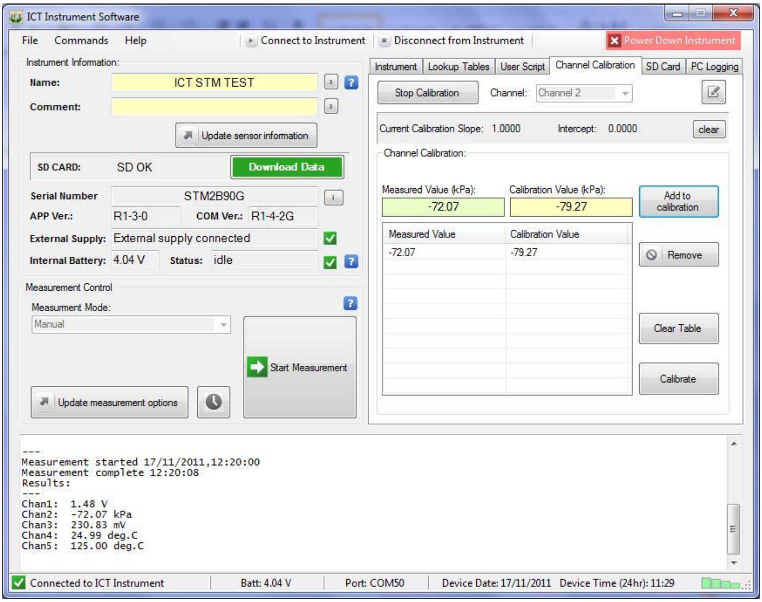


Figure 7 - Enter Corrected Value

The second and third calibration values are generated by calculation. The values for 'Measured Value' and 'Calibrated Value' are entered manually by using values within the range provided by the sensor. For example, if the expected readings for this sensor are in the range of -20kPa to -80kPa, then these values can be used to create the lookup table.

It is necessary to click on the Manual Entry pen button to enter new values. This button is located to the right of the Channel selection box, and looks like a pencil. Note that it may be necessary to click the button twice to enter the manual mode. The dialog box should appear as shown in figure 6.

You can now place the cursor in the Measured Value and Calibration Value boxes and enter a number in each box. In this example we will enter -20 in the Measured Value box, and -22 in the Calibrated Value box. This becomes the second calibration entry. After typing in the values click on the 'Add to Calibration' button to insert the values into the table. The same process is used to enter values in the range for -80 as the Measured Value, and -88 for the Calculated Value. Once again the 'Add to Calibration' button is used to add the new entries into the Calibration Table.

If you wish to you can add further entries to the calibration table. The software will create a new slope and intersection reference curve using the values you have provided. Additional values will create a more complex, and more accurate curve. However if the sensor variation is linear over the range then the 3 values will be sufficient. Note that the lowest and highest values you enter should cover the full range of readings you expect to generate from the sensor, otherwise you will obtain zero values if the measured value is outside the range of the Calibration lookup table. Should you enter incorrect values into the table, click on the particular entry and use 'Remove' button to delete that entry.

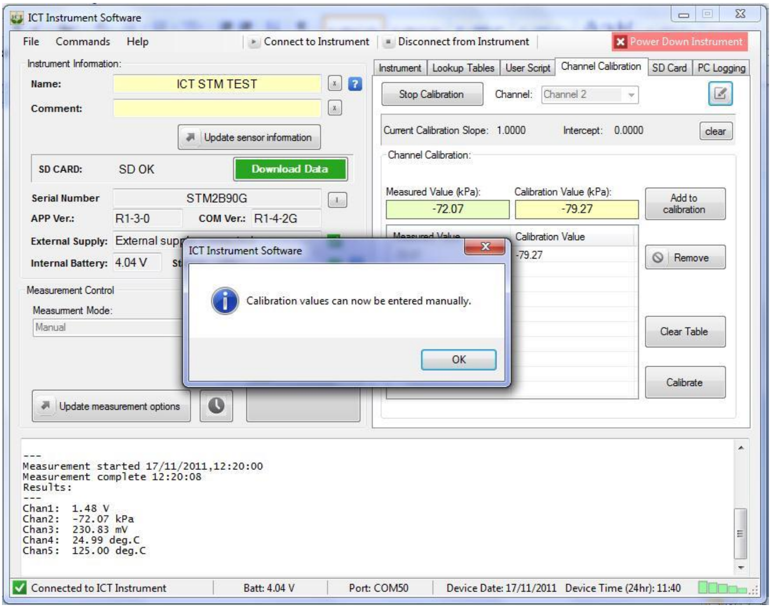


Figure 8 - Manual Entry Mode

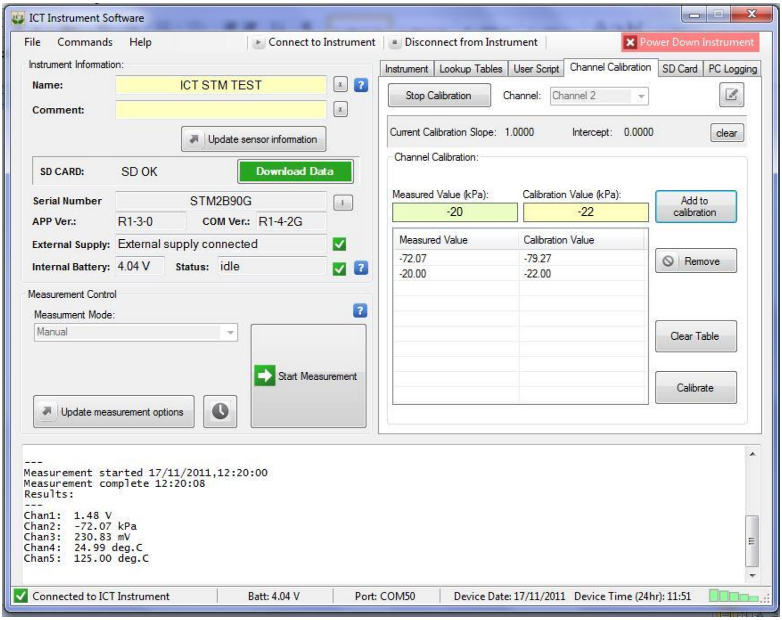


Figure 10 - New Calibration Values Entered

The calibration table is now ready to be used for the selected channel.

Click on the 'Calibrate' button to update the calibration settings. The calibration curve as shown in Figure 8 will be displayed on screen. Note the slope and intercept values, in this case representing a simple 10% change in values. If the curve is correct, click on the 'Use' button to finalise the Calibration. If the curve does not represent the desired change in values, then return to the calibration process and enter new values. A dialog box will appear asking you to confirm the calibration. To finish the process click on the 'Stop Calibration ' button, and run a Test Measurement to confirm a correct reading.

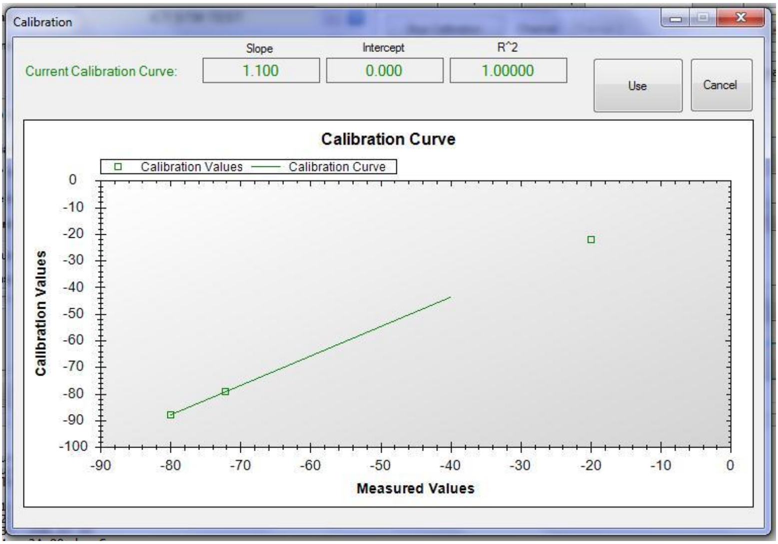


Figure 12 - Calibration Reference Curve

The selected channel is now calibrated to the sensor connected to it. If a new sensor is connected to this channel then the calibration will have to done again. Calibration of the other channels is a repeat of the same process. Note that the calibration settings are stored in the data logger, not in the software on your computer.

Once a particular channel has been calibrated the values box displaying the reading changes colour, as shown in Figure 9. The calibrated channels are shown is a darker green shading in the values box. In the figure below channel 2 is calibrated. Removing the calibration will cause the colour of the values box to revert to the lighter green shading.

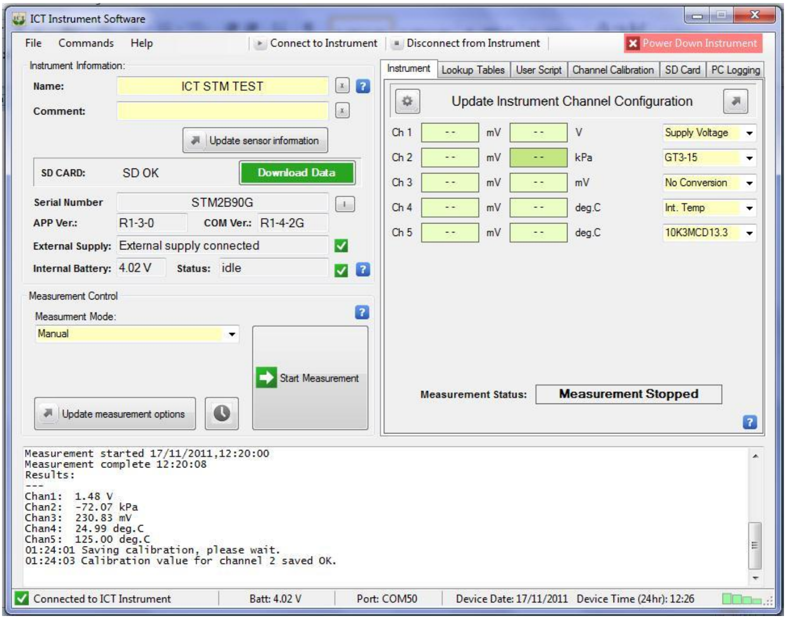


Figure 14 - Calibrated Channel

Note that the Channel Calibration can only support linear relationships between uncorrected and calibrated values. If your calibration curve is curvilinear, such as an exponential or logistic curve, then the Channel Calibration feature cannot be used. In this instance you will need to input a User Script. See Chapter 11 for more details on User Scripts.

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14. Appendicies Contents

14.1 User Scripts

14.1.1 MP306 & MP406

```
R1 = CURCHAN * CURCHAN
R2 = R1 * CURCHAN
R3 = 0.0011965 * CURCHAN
R4 = -2.5356E-06 * R1
R5 = 1.9961E-09 * R2
R6 = -0.05334 + R3
R7 = R6 + R4
R8 = R7 + R5
RES = R8 * 100
```

14.1.2 EC-5

```
VSWC%
r1 = 0.00119
r2 = r1 * curchan
r3 = r2 - 0.401
res = r3 * 100
```

14.1.3 THERM EP & THERM SS

Thermistor 3V & **Thermistor 10V**

Thermistor 3V	Thermistor 10V
deg C	deg C
r1 = 3220 - curchan	r1 = 10040 - curchan
r2 = 1000000 * curchan	r2 = 1000000 * curchan
r3 = r2 / r1	r3 = r2 / r1
res = lookup r3 11	res = lookup r3 11

Note: the value r1 can be checked on your ICT Instrument by testing the voltage bridge across VCC and GND on the Break-Out Board with a volt meter. The values 3220 and 10040 correspond to a volt meter measurement of 3.22V and 10.04V respectively.

14.2 **Lookup Tables**

14.2.1 MP306 & MP406

Raw Count	Calibrated VWC (%)
0	0
120	2
210	5
310	10
415	15
510	20
610	25
720	30
825	35
895	40
955	45
1005	50
1015	55
1025	60
1035	65
1045	70
1055	75
1065	80
1075	85
1085	90
1105	95
1160	100

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1. Introduction

The MP406 Moisture Probe can be used to measure the moisture content in many materials such as soil, food and materials used in roadway and building construction.

The MP406 can be used to measure the soil moisture for scientific research or irrigation management. In either situation the MP406 can:
- rapidly measure the soil moisture by pushing the needles of the sensor into the soil surface or soil profile;
- make measurements over time by permanently burying the MP406 and connecting it to a data logger;
- control irrigation by permanently burying the MP406 and connecting it into an irrigation controller.

2. Operation

2.1 Hand Held Moisture Probe Meter

The MP406 has a connector which plugs directly into the MPM-160 hand held meter for direct readout.

The meter provides the power to the MP406 for the reading, display and storage of measurements. The returned mV signal is displayed directly as mV and is also converted and displayed as Volumetric Water Content (VSW%). Refer to section 2.4.4 for the conversion table.

When being used with a hand held meter the MP406 is usually connected to a set of chrome extension rods which have a T handle on the end.

The extension rods enable the operator to insert the needles of the MP406 into the soil surface without bending over and then for him to more conveniently read the MPM-160 meter.

2.2 Data Logging or Irrigation Control

2.2.1 General

The MP406 exterior is made from extremely durable ABS plastic formed into a custom designed tube. The electronics is totally sealed within this tube. The needles are made from high quality stainless steel. Then the MP406 can be buried permanently at a location as part of either an input to a data logging system or for an input to an irrigation controller or environmental monitoring system.

2.2.2 Installation

The MP406 can be installed by drilling a close fitting hole into the soil profile, either at an angle or vertically or it can be installed horizontally from a larger augered hole or soil pit. In all situations care must be taken to ensure the needles are in contact with soil profile after installation. It is usual practice to install the MP406 with the 3 needles in a horizontal plane in order to maximise the measurement of soil spatial variability. The MPM-160 meter should be used during the installation process to ensure good contact of the needles and the soil is maintained during back filling of the hole.

The MP406 has a connection allowing a chain to be connected for retrieval after burial when an experiment is finished. It is important not to pull on the cable when retrieving the MP406 from a buried location as this may damage the cable.

2.2.3 Cable Length

The standard cable length is 4.5 m. This may be extended by using suitable cable.

Multi Core Polypropylene Insulated Irrigation Control Cable, specifications 9 core (9 x 7/0.30) has been tested successfully over 500 m. Two wires were connected for power supply positive from the data logger to the MP406.

2.2.4 Power

The MP406 is normally powered by a voltage in the range 7.0 to 18.0 volts using 18 mA of power.
It can function satisfactorily within the voltage limits of 7.0 to 18.0 volts provided 18 mA is maintained.

1 x MP406 = 32 mA (maximum power use)

5 seconds of warmup/hour = 5/3600 x 32 = 0.04 mAh

Total of 16 x MP406 = 16 x 0.04 mAh = 0.64 mAh

Logging for 24 hours on an hourly frequency = 0.64 x 24 = 15.36 mAh/day

Gel Cell Battery 7 Ah capacity. Then = 7/0.01536 = 455 days

In other words a Gel Cell battery is capable of supplying enough power for about 455 days.

The battery would need to be recharged within about 30 days as it will self discharge in this time.

2.3 Theory of Operation

2.3.1 Theory

The MP406 has a high frequency moisture detector which uses the standing wave principle to indicate the ratio of two or more substances forming a body of material, each substance having a different electric constant (Ka).

The moisture measurement of the material is based upon the fact that in a water: soil: air matrix, the dielectric constant is dominated by the amount of water present. The dielectric constant of water is approximately equal to 80 whereas the dielectric constant of soil is approximately equal to 3 or 4 and air is equal to 1. Therefore any changes in the volume matrix ratio of water will result in a substantial change in the dielectric constant of the matrix. Then the soil water content can be measured exactly because changes in water content of the soil result in changes in the dielectric constant of the soil.

The material that can be measured by the MP406 is often soil but can be any composition of non-metallic powdered, liquid or solid phase substance into which the needles are inserted.

2.3.2 Results

The results from measurement of absolute volumetric soil water percent (VSW%) from prepared soil samples using the MP406 are given in Figure 1. This result is typical of the results obtained from comparative testing of the MP406 in prepared soil samples, for a wide range of agricultural soils.

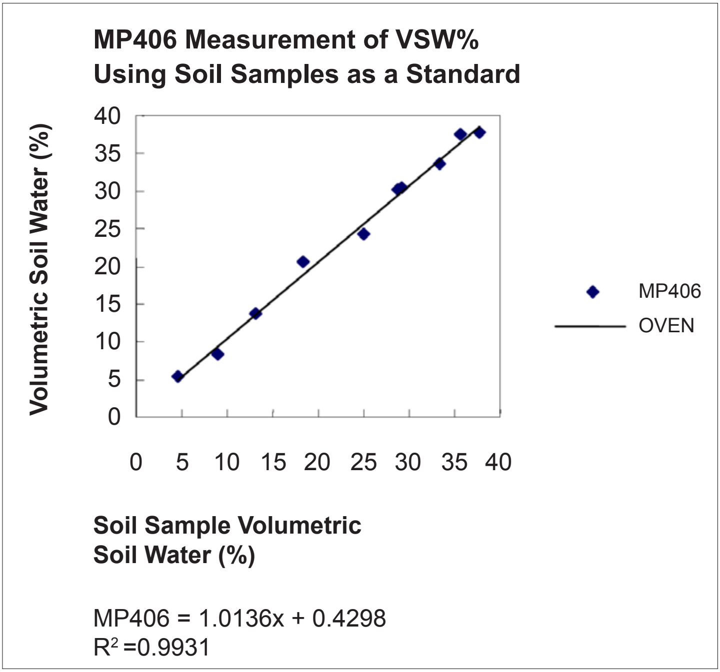

Figure 1. MP406 Measurement of Absolute Volumetric Soil Water Percent from Prepared Soil Samples as a Standard.

The results from measurement of the absolute volumetric soil water percent (VSW%) using the MP406 when compared with TDR technology are given in Figure 2. This result is typical of the results obtained from comparative testing of the MP406 compared to TDR technology for a wide range of agricultural soils.

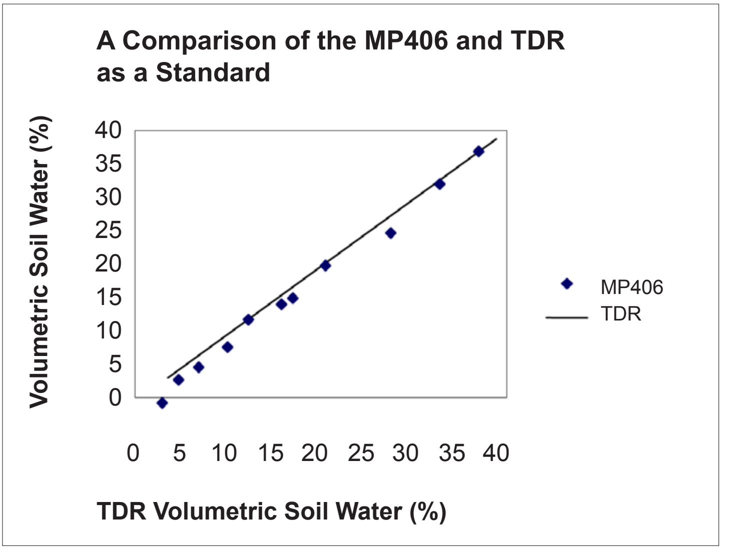

Figure 2. The MP406 in comparison to TDR Measurement of Absolute Volumetric Soil Water Percent as a Standard.

2.3.3 Definitions

Gravimetric Soil Water Content is defined as

$\theta_G = \frac{Mw}{Ms}$ Where Mw is the mass of water in the soil sample and Ms is the total mass of the dry soil sample.

Volumetric Soil Moisture Content is defined as

$\theta_V = \theta_G * Ps$ Where Ps is the bulk density of the soil sample $\left(= \frac{Ms}{Vs} \right)$

Where Ms is the total mass of the dry sample and Vs is the total volume of the dry soil sample.

Volumetric Soil Water Percent (VSW%)

$VSW\% = \theta v * 100$

The VSW% typically varies in the field from 2–5% for sandy soils at permanent wilting point to 45–55% for clay soils at saturation.

2.4 Calibration

2.4.1 General

The results obtained from measurement of the absolute volumetric soil water content (VSW%) using the MP406 are expected to be within ± 2–5% of the actual soil moisture as determined in the laboratory by gravimetric and volumetric methods of determination. Recalibration is not expected to be necessary for most applications in most commonly occurring agricultural soils. This is especially so when it is considered that for practical end uses such as irrigation scheduling and irrigation control the change in VSW% is the most important variable to be determined for management decision making. The change measured will be correct in absolute VSW% units or mm of water applied as the relationship of voltage output to water content, hence calibration slope remains constant, across all soil types.

Scientists or regulatory authorities may wish to calibrate the MP406 to verify the data measured. In these cases it is simply necessary to compare the MP406 output in mV (0–1 mV) to the VSW% from the soil samples, either prepared in the laboratory or obtained in the field. The resultant regression of these variables will provide the new calibration of the MP406. As all MP406 respond to changes in water content of the soil and the resultant changes in the dielectric constant in the same way the calibration would apply to all MP406.

Data Loggers variously are able to store linear, polynomial or polynomial lookup tables depending on their specifications. Then various forms of the MP406 soil calibration are supplied for these data loggers.

2.4.2 Linear Calibration

$$\begin{aligned} VSW\% &= a + b\chi \\ &= INTERCEPT + SLOPE\ (\chi) \\ &= -0.1552 + 0.80829\ (\chi) \end{aligned}$$

Where χ = MP406 output in volts

{Output Range of MP406 $0 \le MP406 \le 1.20$ V
{Limits of VSW $0 \le VSW < 1.00$

2.4.3 Polynomial Calibration

$$\begin{aligned} VSW\% &= a_o + a_1\chi + a_2\chi^2 + a_3\chi^3 \\ &= -0.05334 + 1.19650\chi - 2.5356\chi^2 + 1.9961\chi^3 \end{aligned}$$

Where χ = MP406 output in volts

{Output Range of MP406 $0 \le MP406 \le 1.20$ V
{Limits of VSW $0 \le VSW < 1.00$

2.4.4 Polynomial Lookup Table

Linearisation tables can be added to Data Loggers using the following data:

VSW%	mV MP406	VSW%	mV MP406
0.00	0	55.00	1015
2.00	120	60.00	1025
5.00	210	65.00	1035
10.00	310	70.00	1045
15.00	415	75.00	1055
20.00	510	80.00	1065
25.00	610	85.00	1075
30.00	720	90.00	1085
35.00	825	95.00	1105
40.00	895	100.00	1160
45.00	955		
50.00	1005		

2.5 Wiring

The MP406 is supplied with 4.5 m of four wire screened cable.

Wiring

Red = 9-15V dc

Blue and shield = Ground (0v)

Yellow = signal +

Black = signal -

2.6 Technical Specifications 2.6.1 Mechanical Diagram

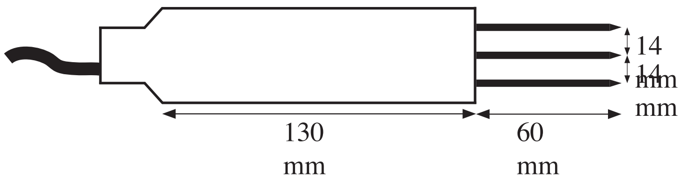

Figure 3. Mechanical Dimensions

2.6.2 Electrical and Mechanical Specifications

Measurement Range	0–100 VSW%
Accuracy	2 VSW% after calibration to a specific soil type, or 5 VSW% using the supplied soil calibration
Interface	Input requirements: 7–18 V DC unregulated Power consumption: 32 mA typical Output signal: 0–1 V for 0–50 VSW%
Response Time	Less than 0.5 seconds
Stabilization Time	5 seconds approximately from power-up
Mechanical	Total length 215 mm. Diameter 40 mm Needle length 60 mm, needle separation 14 mm Exterior ABS Plastic Needles Stainless Steel, Cable 4.5 m Standard
Environment	Designed for permanent burial

NOTES