MPKit Manual
MPKit-306B & MPKit-406B

Contents

1. Introduction

The MPKit enables rapid sampling of Volumetric Soil Water Percentage (VSW%). The MP406/MP306 sensor needles are fully inserted into the soil and the moisture content is displayed on an Android mobile App. The readings are also stored for later recall or to download to a computer.

The MP406 or MP306 Moisture Sensor uses a high frequency technology to measure the dielectric constant (Ka) of soil and other fine powdered materials or liquids. In these instances, the dielectric constant will be shown in millivolts (mV). The specific measurement of the dielectric constant of the soil and the conversion of the resultant millivolt output from the sensor probes is processed by the App, which enables direct measurement of the Volumetric Soil Water Percentage (VSW%).

The results displayed as Volumetric Soil Water Percentage (VSW%) come from a calibration relating Ka and mV output to the VSW%. The calibration curve used in the Android mobile App interface is the result of systematic calibration of many mineral soils. For common agricultural soils the results displayed can meet the needs of most applications. If a higher resolution is required, the customer may wish to take the mV output and recalibrate it directly to the VSW% of the soil being measured.

Sensors MP306 and MP406 are identical in terms of mV output to soil moisture content. The MP406 is generally used in field applications, both portable and fixed. The MP306 is designed for use in soil column applications typically in soil mechanics.

1.1 MPKit Checklist

The MPKit consists of:

- ☐ 1x MP406 or MP306 Moisture Probe
- ☐ 1x Bluetooth Interface
- ☐ 1x Android Phone with *ICT MPKit* App pre-loaded
- ☐ 1x 35cm Moisture Probe Extension Rod and 1x 35cm Extension rod with a T-Handle
- ☐ 1x Carry Case

Figure 1. MPkit - Inside The Carry Case

2. Operation

2.1 Bluetooth Interface

The MP406 or MP306 sensor has a male connector which plugs directly into the Bluetooth Interface.

This Bluetooth Interface provides power to the sensor for reading the soil moisture content and transmits this data to an Android phone. The sensor signal is displayed directly as mV and is also converted and displayed as Volumetric Soil Water Percentage (VSW%). Refer to section 4.4 for the conversion table.

Figure 2. Male connector

2.2 Recommended System Specifications

The MPKit Bluetooth interface works with any Android mobile phone with the following system specifications:

Operating System	Android 6.0 or above
RAM	1 GB or above
Available Storage	At least 200 MB
Communication	Requires Bluetooth Low Energy (BLE) compatibility

2.3 Mobile App Installation*

*The MPKit comes standard with an android mobile phone handset, pre-loaded with the phone app ICT MPKit. The *ICT MPKit* app can also be downloaded from Google Play if necessary, and will receive any updates through Google Play.

2.4 Storage Capacity

Each project will require a unique number of measurements per site and a unique number of sites over a period of time. The following example should indicate the incredible storage capability and efficiency of the *ICT MPKit*: If one csv file happens to contain 1,000 measurements it will take up approx. 100KB. Therefore 1GB of available data on the phone handset has the capacity to contain 10,000 CSV files that are sized 100KB. It is recommended that all csv files are exported by email and/or backed up to a computer.

2.5 Connecting To The Sensor Device

Power up the Bluetooth Interface by pressing the blue button. The button has an LED that will flash periodically while the device is powered on (see Figure 3 below).

Open the MPKit application in the mobile phone by tapping the icon. The App will automatically search for Bluetooth devices (see Figure 4 below).

Select BM71_BLE from the list of devices to connect the phone to the MPKit. The MAC address number will be unique to each MPKit Bluetooth Interface (See the back of the white box for the unique serial/model number). Then the App will ask the user to set the site name where the current measurement set is taking place. This will set the name of the csv file, making it easier to find in future (See Figure 5-7 below).

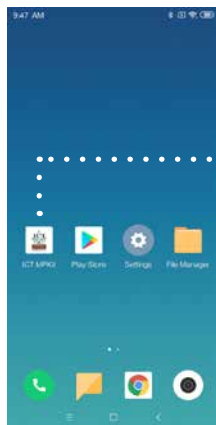**Figure 3.** Push Button on the MPKit's white hardware box.

Figure 4. Touch/Tap on the ICT MPKit Phone Application Icon to open it.
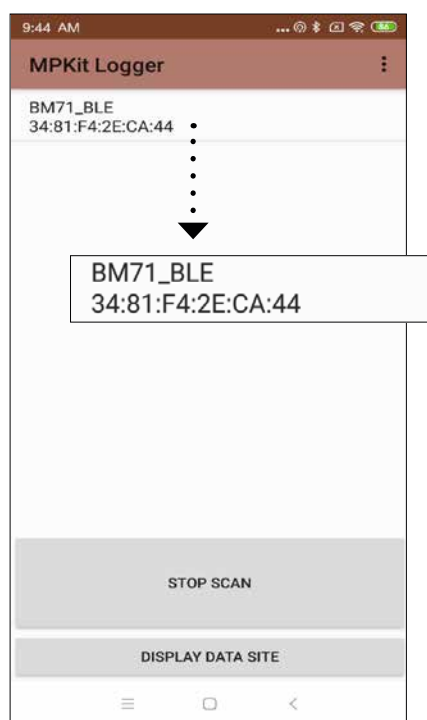

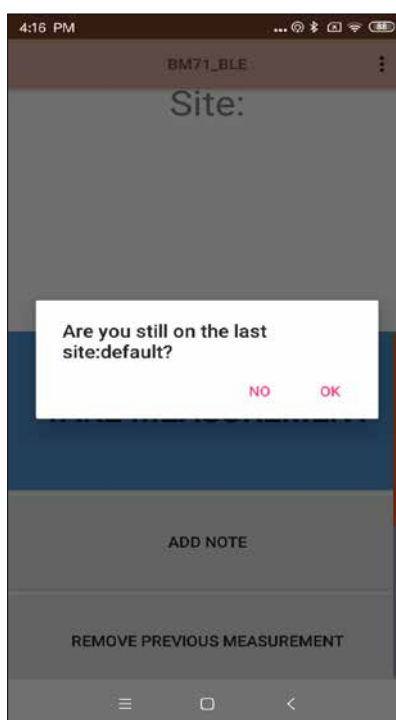**Figure 5.** Touch/Tap the file-name showing the unique MAC address number of the MPKit's white hardware box.

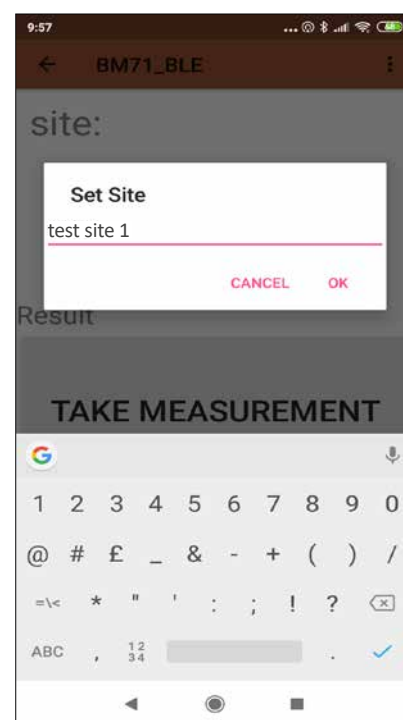
Figure 6. Set the site which will also name the csv file.

Figure 7. Set the site which will also name the csv file.

2.6 Main Screen Interface

The Main Screen Interface contains the following controls (via touch):

Control	Description
Mineral [Default Selected Table]	Select Lookup Table – Mineral soil (default), Organic or a customised Lookup Table.
Take Measurement	Take and save a measurement (Time/Date, VSW%, raw mV and related data).
Add Note	Adds a note to the last measurement taken.
Remove Previous Measurement	Delete the last measurement from the data file.
Display Data	Display the collected measurements of the Site.
Set Site	Set the name of the site/ location.
Create Lookup Table	Create a custom Lookup Table (file will be stored on the phone).
Disconnect	Disconnect from the MPKit Bluetooth Interface.
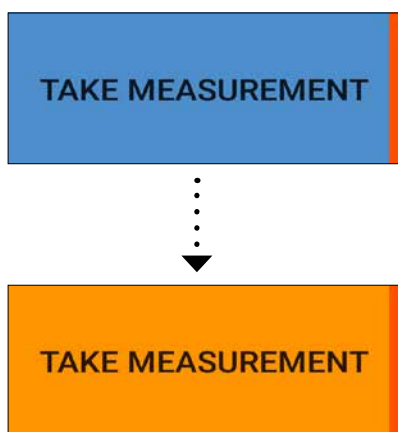
Figure 8. Take Measurement Button turns orange temporarily when selected by touching.
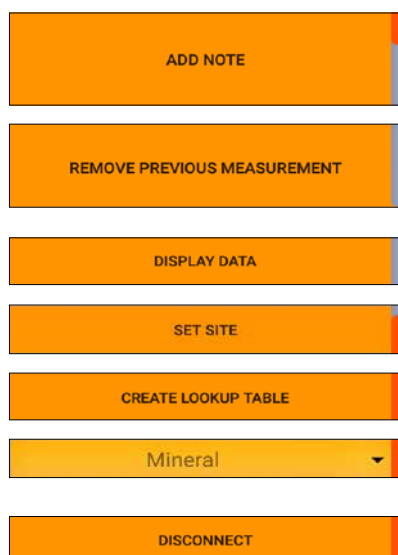
Figure 9. All labelled buttons turn orange temporarily when selected.

2.6.1 Main Screen Screenshots
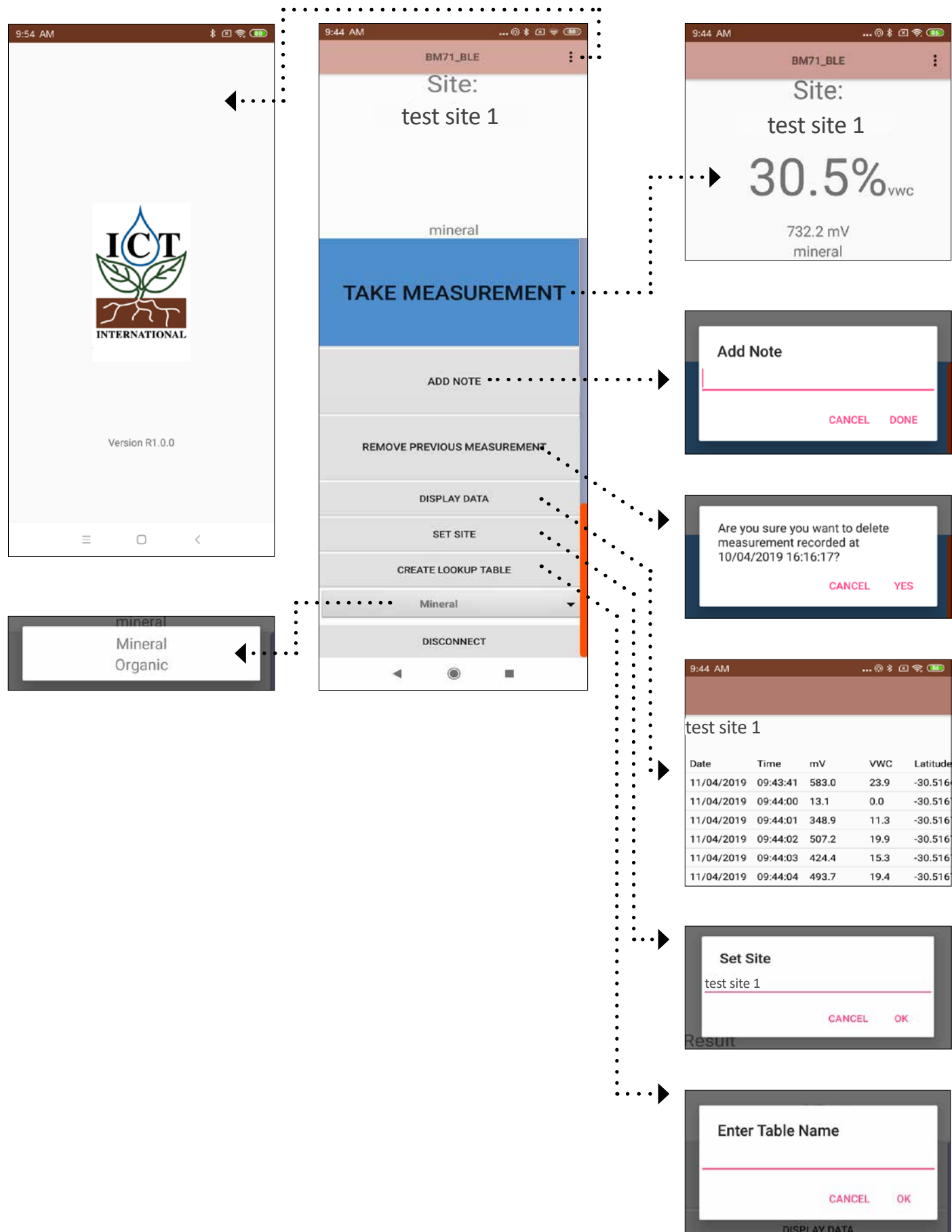
2.6.2 Deleting Lookup Tables and CSV files

Touch/tap and hold down to select relevant item.

Touch/tap and hold down to select relevant item.

Once relevant item is selected options to delete as well as to send/share become available.

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2.6.3 Troubleshooting

To turn on the device, press the blue button. If the blue button is not flashing, the device is off.

Once the device is switched on, the device's blue button will pulse steadily between a single Flash-ON state and a single Flash-OFF state.

Once a first measurement has been taken, the blue button will pulse between three quick Flash-ON-and-OFF states, and a longer Flash-OFF state.

Issue 1. The Scan doesn't register the device

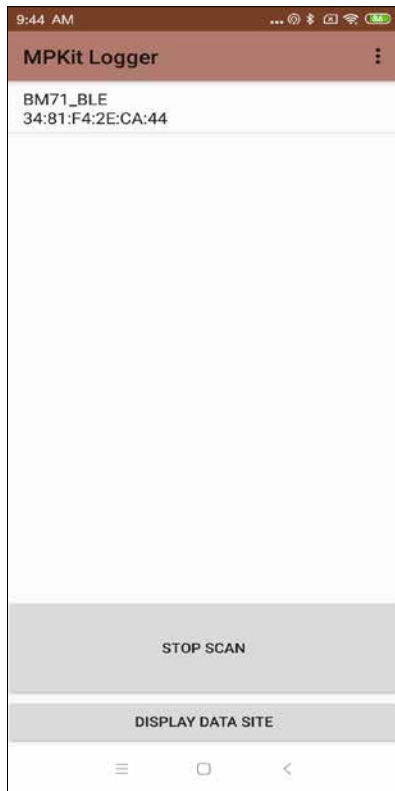Make sure the Bluetooth Interface is switched on. If it is switched on the box's blue button will be pulsing between on and off flash states. Push the blue button if there is no flash.

Make sure the pulsing rate of the button is steady between a single flash 'on' state and a single flash 'off' state. If the button is pulsing between flashing 'on' and 'off' quickly three times and then the regular 'off' state, the Bluetooth Interface may be connected to another device. If so, push blue button to disconnect from any other device (it will turn off), wait around 30 seconds and then switch the blue button on again.

If, after pushing the blue button on the Bluetooth Interface, it is still not flashing on and off, the Bluetooth Interface may require new batteries.

Also try disconnecting/quitting the phone app, waiting around 30 seconds and tap/touching it to restart it.

Issue 2. The 'Take Measurement' button is not responsive

Make sure the Bluetooth Interface is switched on. The Interface will time out after 10 minutes to save power. See previous troubleshooting issue.

2.7 Using the Sensor

2.7.1 General

The MP406 and MP306 sensor exterior is made from extremely durable ABS plastic formed into a custom designed tube. The electronics are totally sealed within this tube. The needles are made from high-quality stainless steel (Spec No. SS316) suitable for use in the most hostile environments. Contact ICT International if you are unsure of the suitability of the MP306/MP406 for your application.

2.7.2 Installation

The MP406 and MP306 sensor can be pushed into the ground using the included T-Handle for surface measurements, or a hole can be augured to the desired depth. Care should be taken to ensure the needles are in solid contact with the soil. The sensor should be pushed directly and firmly into the soil. The sensor should not be wobbled when inserting. This will create an air gap and the reading from the sensor will be less than the actual soil moisture (VSW%).

While the MP406 and MP306 sensor needles are quite robust, they may be bent or damaged if you attempt to force the sensor into rocky soils. If they bend, since they are welded to the body then just push the needles to straighten the bend.

2.7.3 Cable Length

The standard cable length is 70cm. This may be extended upon request; please contact ICT International for more information.

2.8 Power

The MPKit-406B/MPKit-306B Bluetooth Interface is powered by 3x standard AAA batteries. An internal step-up transformer converts battery voltage to 12V for sensor excitation.

Figure 10. Power supplied as AAA batteries (included)

2.9 Replacing the Batteries

To replace the batteries from the Bluetooth Interface:

1. Remove the 4 pcs. screws located at the back of the enclosure by using a Phillips screwdriver.

2. Replace the 3 pcs. AAA batteries with a new one. Check for the correct orientation of the polarity.

3. Install back the 4 pcs. screws into the enclosure.

3. Theory of Operation

3.1 MP406 & MP306 Soil Moisture Sensor

The MP406 and MP306 sensor has a high frequency moisture detector which uses the standing wave principle to indicate the ratio of two or more substances forming the body of a material, each substance having dielectric constant (Ka).

Water (Ka)	= 80
Clay (Ka)	= 3
Sand (Ka)	= 2
Air (Ka)	= 1

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. Soil water content can be measured exactly as changes in the water content of the soil result in changes in the dielectric constant of the soil.

Materials that can be measured by the MP406/MP306 sensor are most often soil, but can also be any composition of non-metallic powdered, liquid or solid phase substance into which the needles are inserted.

Figure 10. MPKit Measurement of (VSW) % Using Prepared Soil Samples as a Standard.
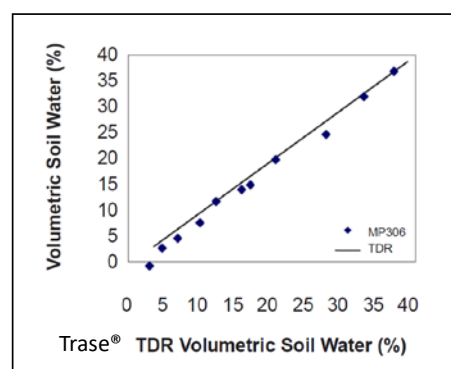
Figure 11.   A Comparison of the MPKit and Trase® TDR Measurement of VSW% as a Standard.

3.2 Results

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

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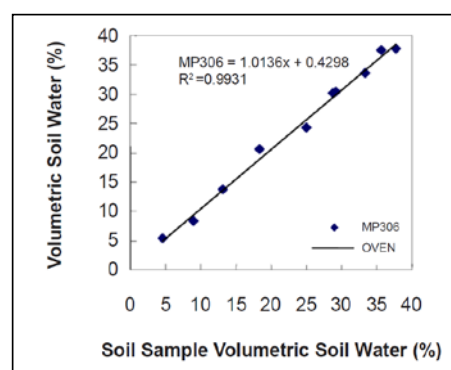
3.3 Definitions

Gravimetric Soil Water Content

$\Theta_G = \dfrac{Mw}{Ms}$ 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

$\Theta_G = \Theta_G * \rho b$ Where ρb is the bulk density of the soil sample

$\left(= \dfrac{Ms}{Vs} \right)$ Where Ms is the total mass of 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.

3.4 Bluetooth Compliance

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules.

These limits are designed to provide reasonable protection against harmful interference in residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- ☐ Reorient or relocate the receiving antenna.
- ☐ Increase the separation between equipment and receiver.
- ☐ Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- ☐ Consult the dealer or an experienced radio/TV technician for help.

4. Calibration

4.1 General

The results obtained from measurement of the absolute volumetric soil water percent (VSW%) using the MPKit 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 MPKit to verify the data measured. In this case, it is simply necessary to compare the MPKit output in 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 MPKit. All MP306/MP406 are manufactured to be identical. All MPKit respond to changes in water content of the soil and the resultant changes in the dielectric constant in the same way and hence the same calibration will apply to all MPKits.

4.2 Linear Calibration

VSW% 0~50	$= a + b\chi$
	$=$ INTERCEPT + SLOPE
	$= -0.5357 + 0.0702$
	$R^2 = 0.9925$

Where χ = MP Sensor output in volts

{Output Range of Sensor $0 \leq$ Sensor ≤ 1200 mV
{Limits of VSW% $0\% \leq$ VSW% $\leq 50\%$

4.3 Polynomial Calibration

VSW% 0~50	$= a_o + a1\chi + a2\chi^2 + a3\chi^3$
	$= -0.0925 + 0.8319\chi - 0.8034\chi^2 + 0.5535\chi^3$
	R^2 Value $= 0.9990$

Where χ = MP Sensor output in volts

{Output Range of Sensor $0 \leq$ Sensor ≤ 1.20 V
{Limits of VSW% $0\% \leq$ VSW% $\leq 50\%$

Soil Moisture 0-50% (Volts, Mineral soil)

$y = 0.5535x^3 - 0.8034x^2 + 0.832x - 0.0925$
$R^2 = 0.999$

Soil Moisture 0-50% (Volts, Mineral soil)

$y = 0.5357x - 0.0702$
$R^2 = 0.9925$
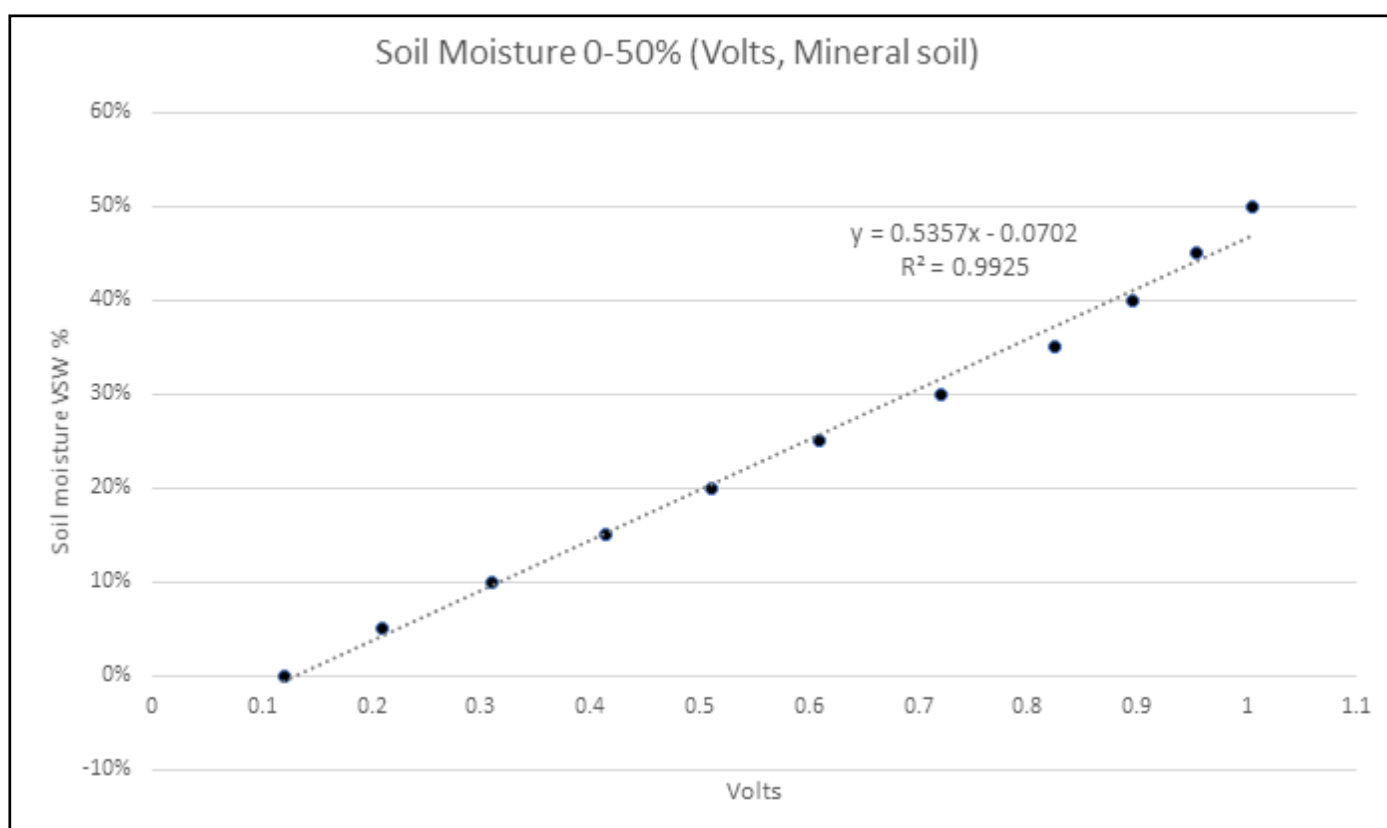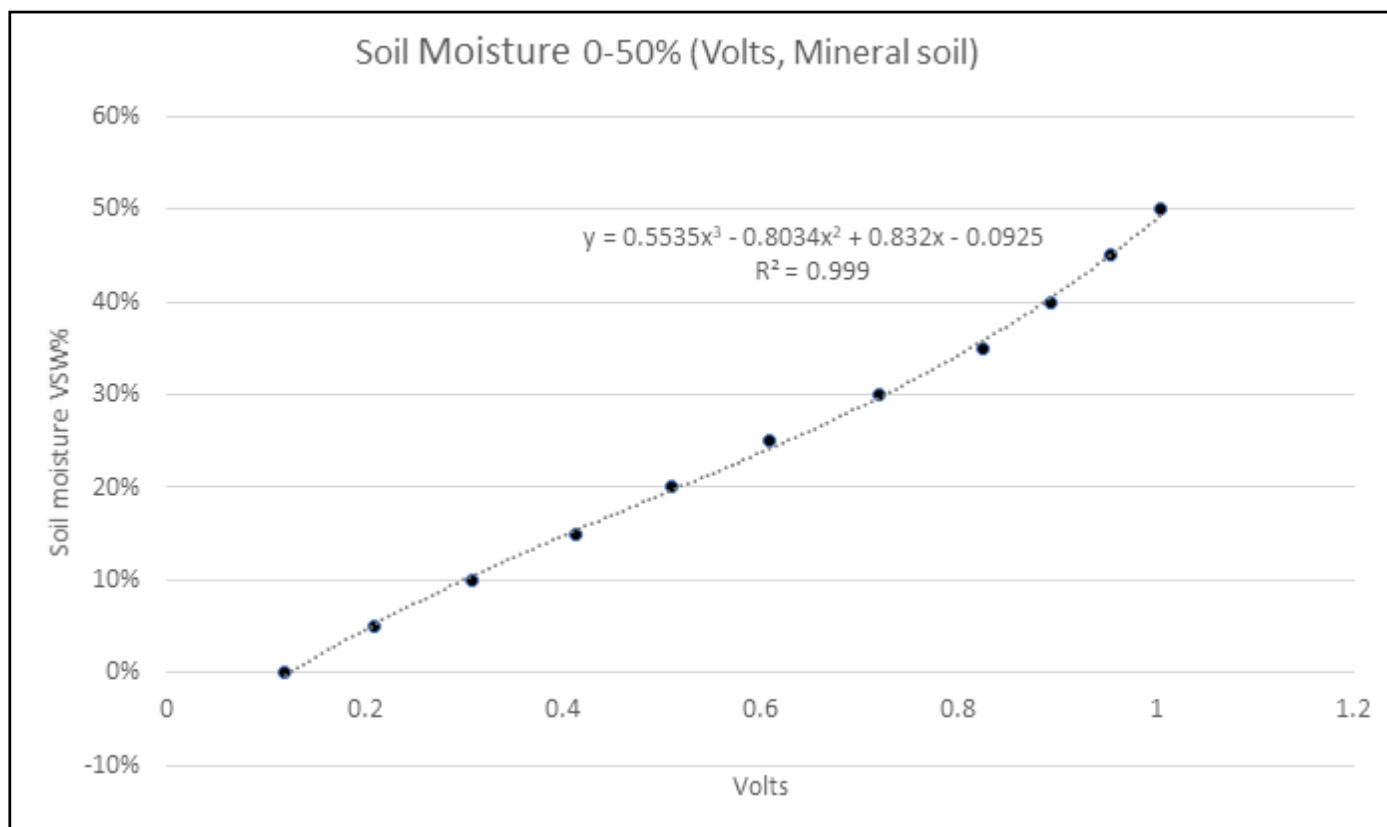
The formulas to derive these equations are available as both Microsoft Excel files and as an R Script on request.

4.4 Polynomial Lookup Table

Linearisation tables can be added to the *ICT MPKit* Phone Application using the following default conversion data for MPKit-306B/MPKit-406B for mineral soils:

Soil Moisture (%)	mV, mineral soil	Volts
0	120	0.120
5	*210*	*0.210*
10	310	0.310
15	*415*	*0.410*
20	510	0.510
25	*610*	*0.610*
30	720	0.720
35	*825*	*0.825*
40	895	0.895
45	*955*	*0.955*
50	1005	1.005
55	*1015*	*1.015*
60	1025	1.025
65	*1035*	*1.035*
70	1045	1.045
75	*1055*	*1.055*
80	1065	1.065
85	*1070*	*1.070*
90	1080	1.080
95	*1095*	*1.095*
100	1106	1.106

4.5 Wiring

The MPKit-306B/406B is supplied with 70cm of four core shielded wire and connector. Wiring:

Red = 9-18V dc
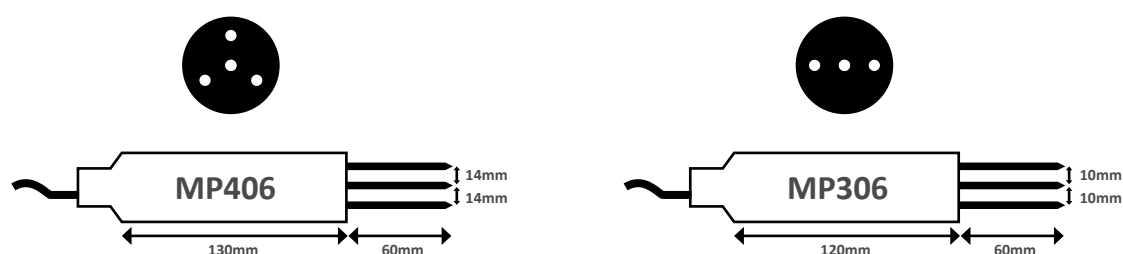Bare wire/shield = Cable Drain Wire (N/C to Signal or Power ground)
Yellow = signal +
Black = DC Ground
Blue/Green = Analogue Ground

4.6 Technical Specifications

4.6.1 Mechanical Diagrams:

4.6.2 Electrical and Mechanical Specifications

Measurement Range	0-100 VSW%
Accuracy	+/-1 VSW%
Interface	**Input requirements:** 3 x AAA Batteries **Power consumption:** MPKit-306B : 14 mA typical, 16 mA max MPKit-406B : 24 mA typical, 30 mA max **Output signal:** 0-1000 mV for 0-50 VSW% 1106 mV maximum
Response Time	Less than 0.5 seconds
Stabilisation Time	3 seconds
Mechanical	Total length 215 mm. Diameter 40 mm Needle length 60 mm

Warranty & Service Terms

What is Covered

All products manufactured by ICT International are warranted to be free from defects in materials and craftsmanship for a period of one (1) years from the date of shipment from our factory. To be considered for warranty coverage an item must be evaluated either at our factory or by an authorized distributor.

What is Not Covered

The customer is responsible for all costs associated with the removal, re-installation, and shipping of suspected warranty items to our factory. The warranty does not cover equipment that has been damaged due to the following conditions:

1. Improper use or abuse.
2. Operation of the instrument outside of its specified operating range.
3. Natural occurrences such as lightning, fire etc.
4. Unauthorized modification.
5. Improper or unauthorized repair.

Who is Covered

This warranty covers the original purchaser of the product or other party who may own it during the warranty period.

What We Will Do

At no charge we will:

1. Either repair or replace (at our discretion) the item under warranty.
2. Ship the item back to the customer by the carrier of our choice. Different or expedited shipping methods will be at the customer's expense.

How To Return An Item

1. Please do not send any products back to ICT International until you have filled out an online RMA (Return Merchandise Authorization) and have been advised to return the item by our service team. The form can be found at http://www.ictinternational.com/support/rma-form/. We will use your RMA number for tracking of the service item.

2. Send all RMA sensors and meters back in the following condition: Clean the instruments exterior. Do not modify the sensors or wires, including splicing, cutting wire leads etc.

3. Please write the RMA number on the outside of the shipping container.

4. Return the item with freight pre-paid and fully insured to our factory address shown below. We are not responsible for any costs associated with the transportation of products across international borders.

5. Upon receipt, ICT International will determine the cause of failure. If the product is found to be defective in terms of operation to the published specifications due to a failure of product materials or craftsmanship, ICT International will repair or replace the items free of charge.

Repairs / Replacement

If it is determined that your product is not covered under warranty, you will be informed and given an estimated repair/replacement cost. The available remedy of defects under this warranty is for the repair or replacement of the original product, and ICT International is not responsible for any direct, indirect, incidental, or consequential damages, including but not limited to loss of income, loss of revenue, loss of profit, loss of wages, loss of time, loss of sales, accruement of debts or expenses, injury to personal property, or injury to any person or any other type of damage or loss.

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Previous Models

This manual should be used with reference to [MPKit-406B](#) or [MPKit-306B](#) purchased after the 01/04/2019 containing the Bluetooth transmitter and using the android application. For earlier models purchased before the 01/04/2019 using the MPM-160 hand meter please refer to the legacy manual on the MPKit product page of our website: www.ictinternational.com.

*Enabling better global research outcomes in soil,
plant & environmental monitoring.*