



MPKit Quick Start Guide

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1. Introduction

The MPKit-406B / MPkit-306B is a portable soil moisture kit that enables rapid sampling of Volumetric Soil Water Content (VSW%). The Moisture Probe (MP406 / MP306) is inserted to the required depth of measurement and the moisture content read out is displayed in an Android mobile App using Bluetooth (BLE – Bluetooth Low Energy). The readings are also stored for later recall or to download to a computer.

The Moisture Probe 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.

1.1 MPKit Checklist

The MPKit consists of:

- ❑ 1x Either 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



MPkit - Inside The Carry Case

2. Operation

2.1 Bluetooth Interface

The MPKit 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 returned mV 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 1. Male connector

2.2 Recommended System Requirements

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* phone application can also be downloaded directly onto an android mobile phone from the ICT International website, and installed from the download folder. Alternately, the app can be copied to the phone from a computer. Download the app from the ICT International website - MPKit1.0.3.apk (later versions will have a file-name with an updated number). The app will also be published on the Google app store *Google Play*; please search for *ICT MPKit*. Updates will be available through *Google Play*.

Using a USB Micro B cable (included), connect the Android phone to the computer and copy the app (MPKit1.0.3.apk or later) to the download folder on the mobile phone. Once completed, open the download folder on the phone through settings and tap the application to install. Upon first running the app, it will ask for the following permissions: Bluetooth, write to storage, and GPS. These must be enabled in order to use the App.

2.4 Storage Capacity

Each project will require a unique number of measurements per site, as well as 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 mobile phone handset has the capacity to contain 10,000 CSV files that are sized 100KB. It is recommended that the csv files is exported by email and/or saved to a computer for further use, and for backup.



2.5 Bluetooth Connection

Power up the Bluetooth Interface by pressing the button. The button has an LED that will flash periodically while the device is powered on (see Figure 2 below).

Open the MPKit application in the mobile phone by tapping the icon. The App will automatically search for Bluetooth devices (see Figure 3 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 Bluetooth Interface (See the back of the white box).

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 4-5 on page 9).



Figure 2. Push Button on the Bluetooth Interface box.



Figure 3. Touch/Tap on the *ICT MPKit* Phone Application Icon to open it.

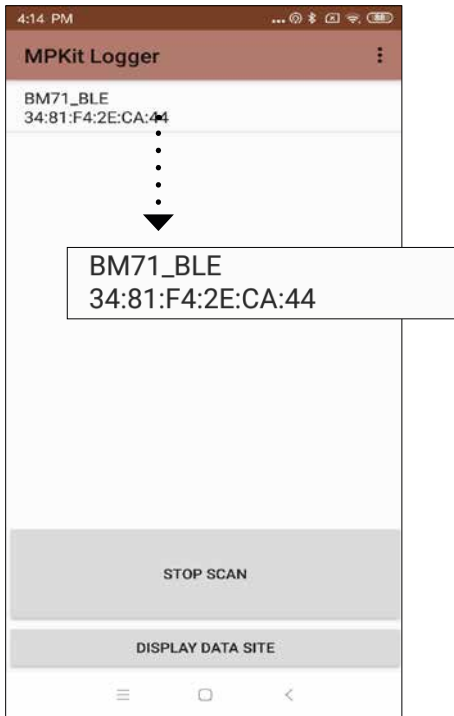


Figure 4. Select (Touch/Tap) the file-name showing the unique MAC address number of the Bluetooth Interface (See the back of the white box).

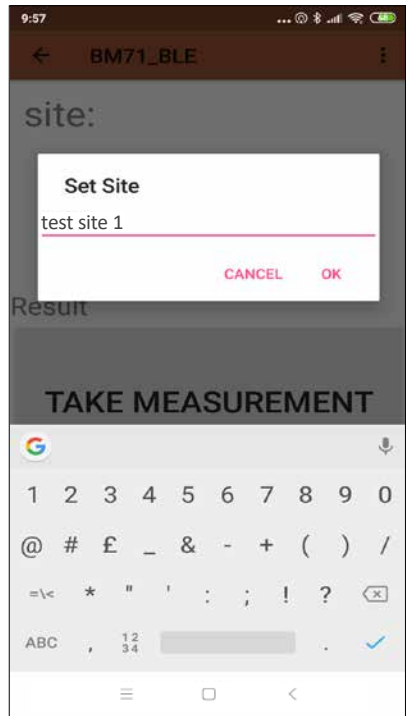
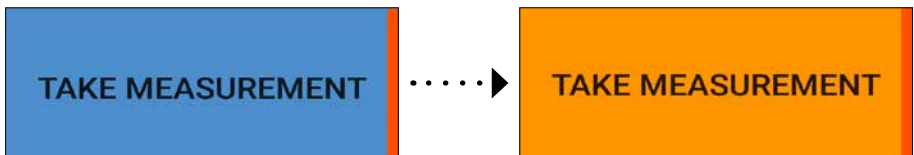


Figure 5. Set the site which will also name the csv file.

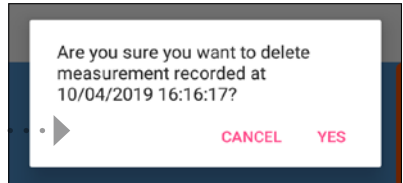
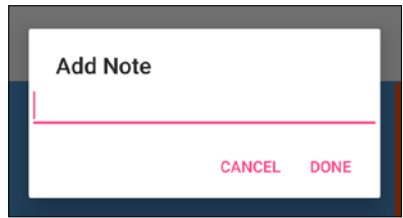


All labelled buttons turn orange temporarily when touched/selected.

2.6 Main Screen Interface

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

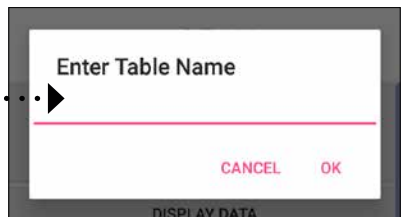
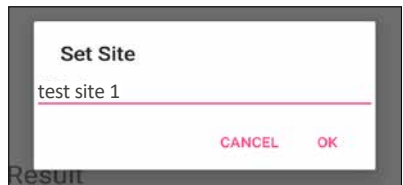
Control	Description
Mineral [Default Selected Table]	Select lookup table – Mineral soil (default), Organic (soil mainly comprised of plant matter) or a customised Lookup Table.
Take Measurement	Take and save a measurement (Time/ Date, VSW%, raw mV and related data).
Add Note	Adds a note to the last measurement 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 adapter.



4:20 PM

site 1

Date	Time	mV	VWC	Latitude
10/04/2019	16:20:30	3.8	0.00	-30.516
10/04/2019	16:20:33	3.6	0.00	-30.516
10/04/2019	16:20:35	413.8	14.96	-30.516
10/04/2019	16:20:40	9.0	0.00	-30.516
10/04/2019	16:20:44	514.2	20.17	-30.516



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 (included). An internal step-up transformer converts battery voltage to 12V for sensor excitation.



2.9 Replacing the Batteries

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

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

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).

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.

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.



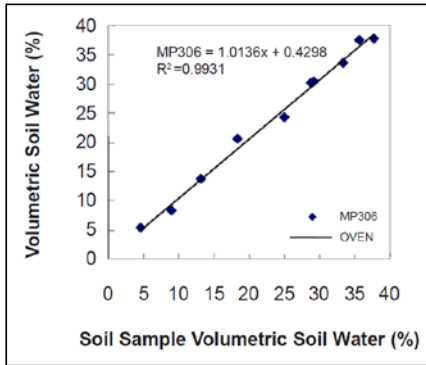


Figure 1. MPKit Measurement of (VSW) % Using Prepared Soil Samples as a Standard.

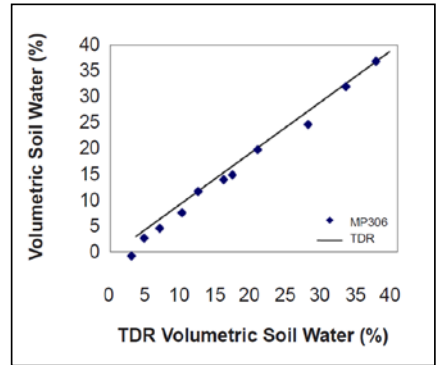


Figure 2. A Comparison of the MPKit and TDR Measurement of VSW% as a Standard.

3.3 Definitions

Gravimetric Soil Water Content

$$\Theta_G = \frac{M_w}{M_s} \quad \text{Where } M_w \text{ is the mass of water in the soil sample and } M_s \text{ is the total mass of the dry soil sample.}$$

Volumetric Soil Moisture Content

$$\Theta_G = \Theta_G * \rho_b \quad \text{Where } \rho_b \text{ is the bulk density of the soil sample}$$

$$\left(= \frac{M_s}{V_s} \right) \quad \text{Where } M_s \text{ is the total mass of dry sample}$$

$$\left(= \frac{M_s}{V_s} \right) \quad \text{and } V_s \text{ is the total volume of the dry soil sample}$$

$$\text{Volumetric Soil Water Percent (VSW\%):} \quad \text{VSW\%} = \Theta_v * 100$$

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.

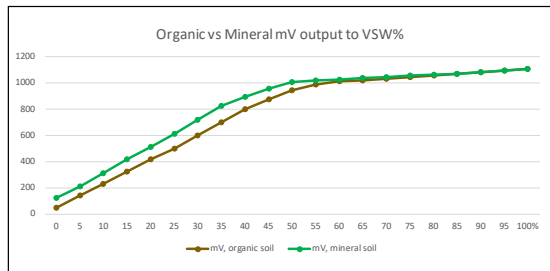
4. Calibration

4.1 General

The results obtained from measurement of the absolute volumetric soil water percent (VSW%) using the MPKit are expected to be within $\pm 2\text{-}5\%$ 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 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	0.415
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

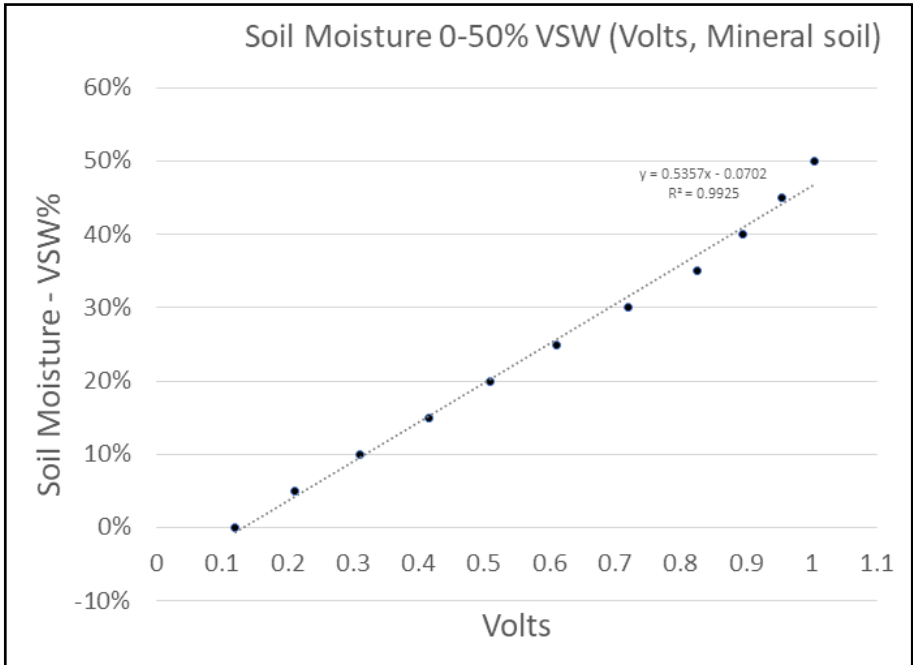
4.3 Linear Calibration

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 $0 \leq \text{Sensor} \leq 1.005 \text{ V}$

{Limits of VSW% $0\% \leq \text{VSW}\% \leq 50\%$



The formulas to derive these equations are available as both Microsoft Excel files and as an R Script on request.



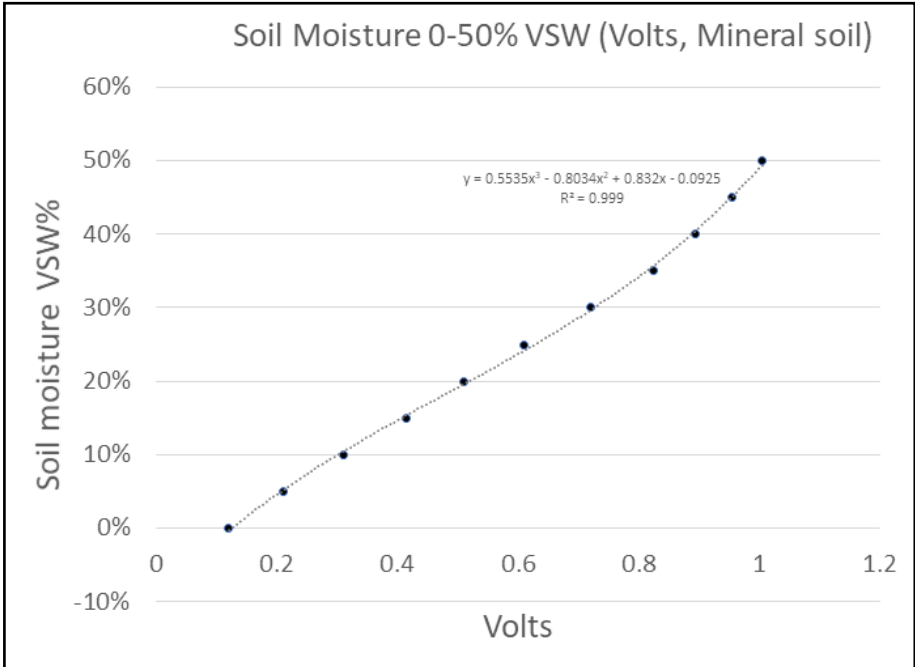
4.4 Polynomial Calibration

VSW % 0~50	$= a_0 + a_1\chi + a_2\chi^2 + a_3\chi^3$
	$= -0.0925 + 0.8319\chi - 0.8034\chi^2 + 0.5535\chi^3$
	$R^2 \text{ Value} = 0.9990$

Where χ = MP Sensor output in volts

{Output Range of Sensor $0 \leq \text{Sensor} \leq 1.005 \text{ V}$

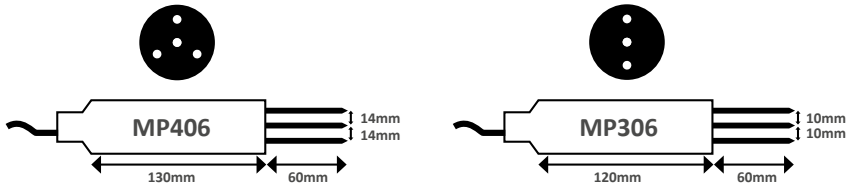
{Limits of VSW% $0\% \leq \text{VSW}\% \leq 50\%$



The formulas to derive these equations are available as both Microsoft Excel files and as an R Script on request.

4.6 Technical Specifications

4.6.1 Mechanical Diagrams:



4.6.2 Wiring Details

The MPKit-306B/MPKit-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

4.6.3 Electrical and Mechanical Specifications

Measurement Range	0-100 VSW%
Accuracy	+/-1 VSW%
Interface	<p>Input requirements: 3 x AAA Batteries</p> <p>Power consumption: MPKit-306B : 14 mA typical, 16 mA max MPKit-406B : 24 mA typical, 30 mA max</p> <p>Output signal: 0-1000 mV for 0-50 VSW% 1106 mV maximum</p>
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 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, accrument 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.*