Soil Moisture Probe Manual

MP306 & MP406

Contents

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.

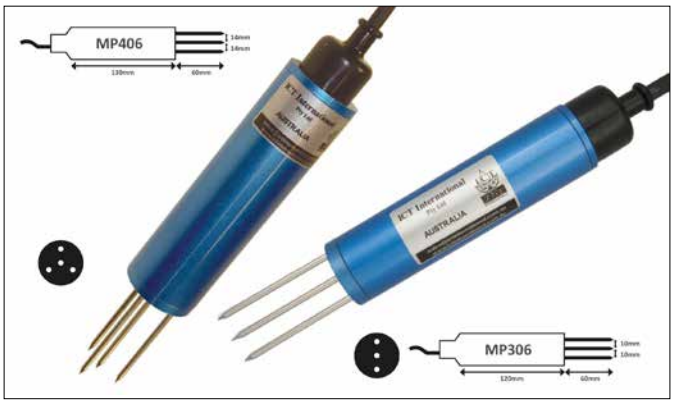

Figure 1. MPkit - Inside The Carry Case

2. Operation

2.1 Hand Held Moisture Probe Meter

The MP406 or MP306 sensor 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 ... 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.

Figure 2. Male connector

2.1 Data Logging or Irrigation Control

The MP406 or MP306 moisture probe 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 moisture probe 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.The extension rods enable the operator to insert the needles of the moisture probe into the soil surface without bending over and handling the soil material, and more convenient to read the MPM-160 meter.

2. Installation

2.1 General

The soil moisture probe 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.

2.1 Versatility in Long Term Installation

The MP-306 and MP-406 are versatile soil moisture instruments, ideal for long term installation. In some scenarios it is sufficient to install them using a hand auger and then burying the instrument; however, ensuring the pins have good contact in the soil can be difficult.

Due to the design of the sensor unit, it is possible to add an extension piece to the unit and use this to guide the cable up to the surface, as well as use the extension to install and remove the unit. The thread on top of the MP306/MP406 is a standard 20mm/¾" plumbing/irrigation fitting that enables the use of readily available connections and pipe.

In the case of the recent installation that ICT International have undertaken as part of their work with Australian research organisations, the following installation configuration was used to bury MP406 sensors at varying depths.

2. Installation

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2. Augered Installation Instructions

2.1 Assemble all the Pieces at the Various Lengths Required

Ensure you have calculated the various poly riser lengths to suit the required depths, factoring how deep they will reach as a complete, buried unit.

These units (left) are using a 900mm riser (top) and 750mm (bottom) that enable the MP306/406 to be buried at depths of up to 1070mm and 920mm respectively.

2.2 Connect the ¾" Coupling to the Poly Riser and the MP-406/MP306

1. Coupling to the Poly Riser

Screw the 3/4" coupling to the poly riser (Cut to the desired length; see instruction 2.1 as a guide).

2. Remove the Rubber Gland

Remove the rubber gland that is supplied on the MP306/406 and set aside.

2.2.3 Coupling to the Sensor

Pull the MP406/MP306 cable through the coupling end of the poly riser out the other side. Then screw the coupling directly onto the threads on the top of the MP306/MP406.

2.2 Screw the ¾" 90° M-F Elbow to the Poly Riser and Seal With The Rubber Gland

Pull the cable through the elbow, and screw the 3/4" 90° M-F elbow to the poly riser.

Then take the rubber gland that is supplied with the MP406 and seal it onto the elbow end and the cable outlet. This will reduce water ingress.

Complete and ready all units for burying.

2.4 Augering the Hole & Burying the MP403/MP306

2.4.1 Augering the Holes

If the ground is particularly dry, or in certain soil types, it is a good idea to wet the soil as you auger the hole to ensure that the hole is to the required depth (also mark the auger with the hold depth you are aiming for) without loose soil collecting at the bottom. Soil that has a higher moisture content is easier to remove than dry, loose soil.

2.4.2 Burying the Sensors

Once the hole is to the required depth, add some more water to the base of the hole (this is to allow the pins to make good contact into the soil) and then gently push the MP406 into the ground. In the case of this installation, the location was alongside an irrigation line – this gave a path for the cable to follow from the installed MP406 and riser to the IoT Node that was sending the data back to the dashboard.

Complete all holes at the required depths for each unit and bury to finish the install.

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).

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.

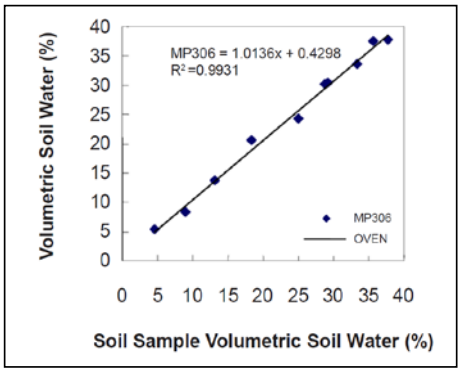


Figure 10. MPKit Measurement of (VSW) % Using Prepared Soil Samples as a Standard.

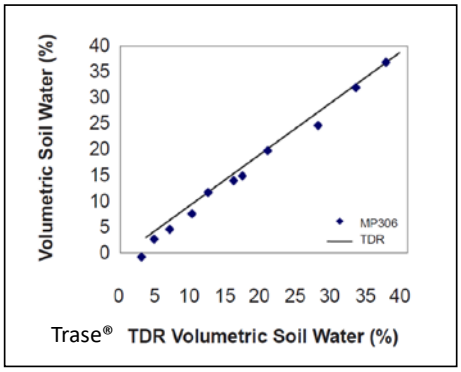


Figure 11. A Comparison of the MPKit and Trase® TDR Measurement of VSW% as a Standard.

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

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

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

$(= \frac{Ms}{Vs})$ 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 χ
	= INTERCEPT + SLOPE
	= -0.5357 + 0.0702
	R^2 =0.9925

Where χ = MP Sensor output in volts

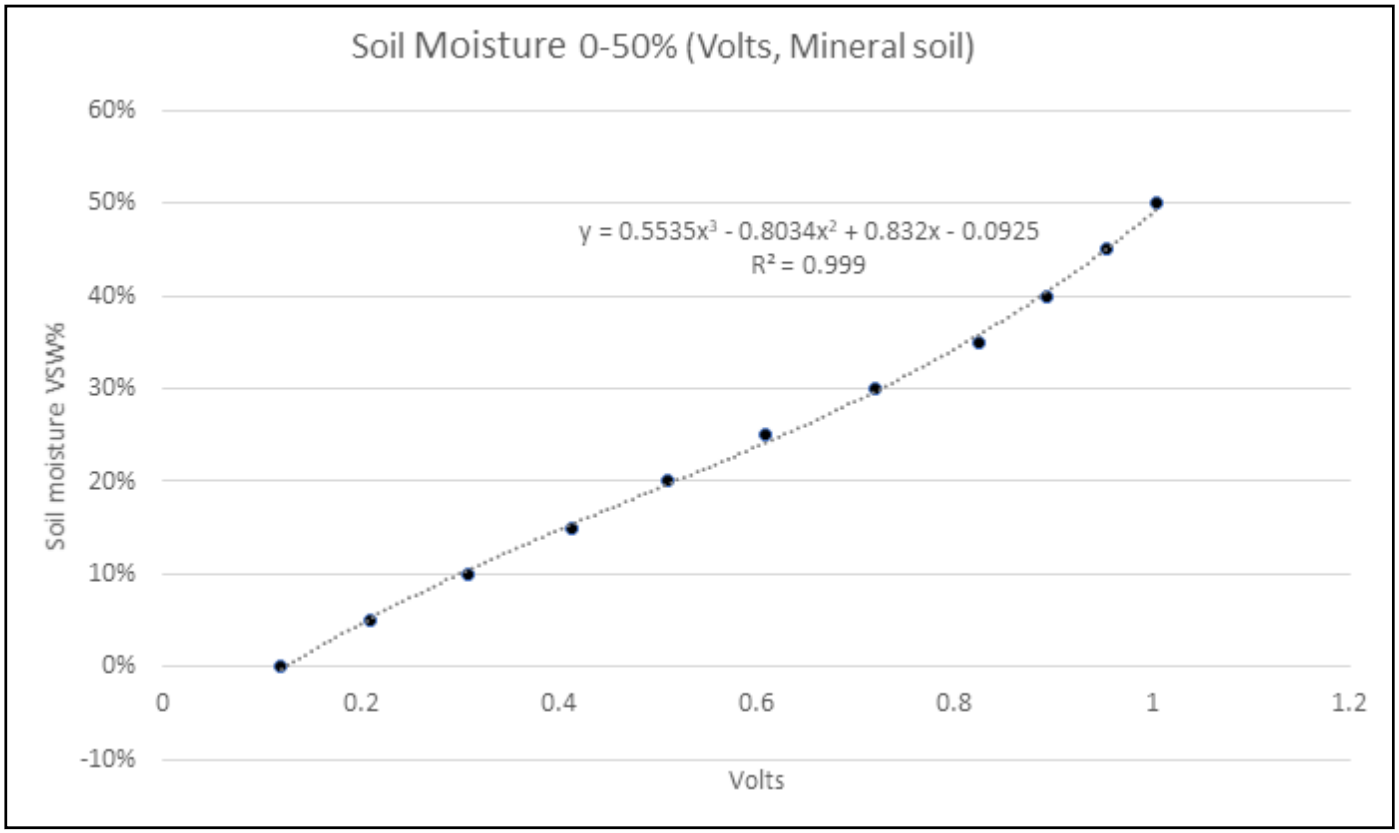
{Output Range of Sensor 0 ≤ Sensor ≤ 1200 mV
{Limits of VSW% 0% ≤ VSW% ≤ 50%

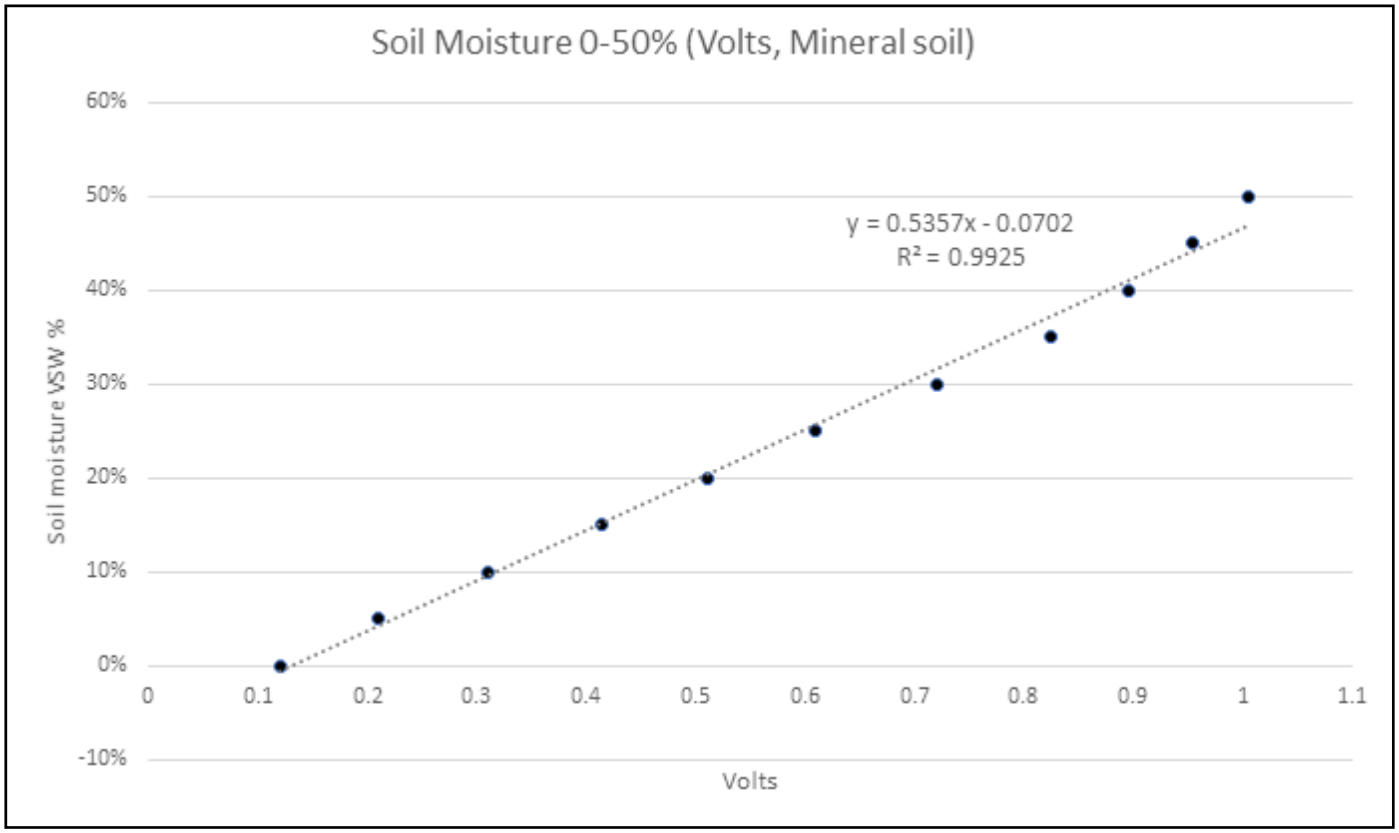
4.3 Polynomial Calibration

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 ≤ Sensor ≤ 1.20 V
{Limits of VSW% 0% ≤ VSW% ≤ 50%





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

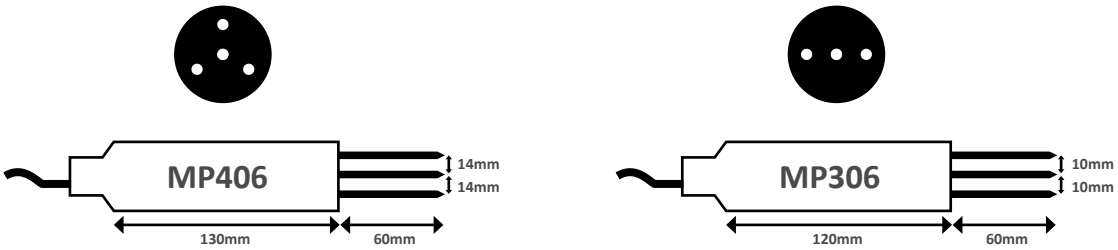
4.5 Wiring

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	2 VSW% after calibration to a specific soil type, or 5 VSW% using the supplied soil calibration
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.

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