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.

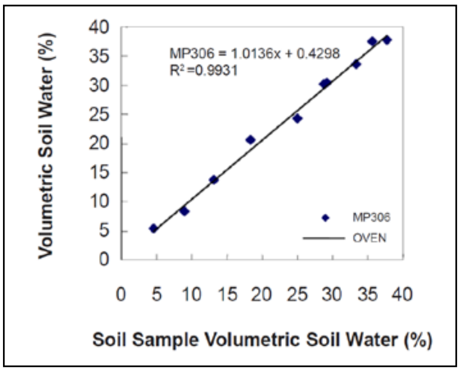


Figure 10. MPKit Measurement of (VSW) % Using Prepared Soil Samples as a Standard.

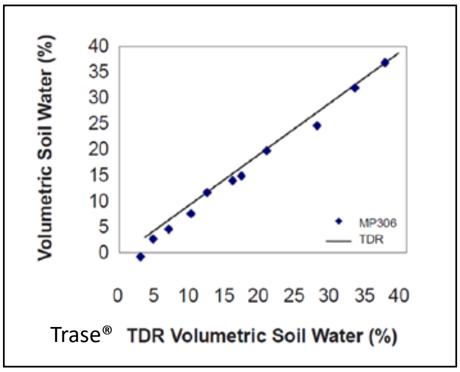


Figure 11. A Comparison of the MPKit and Trase® TDR Measurement of VSW% as a Standard.

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.

Moisture Probe Sensor Calibration

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.

Equations for Programming IoT Nodes that Use MP406

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

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 $0 \le$ Sensor ≤ 1200 mV
{Limits of VSW% $0\% \le$ VSW% $\le 50\%$

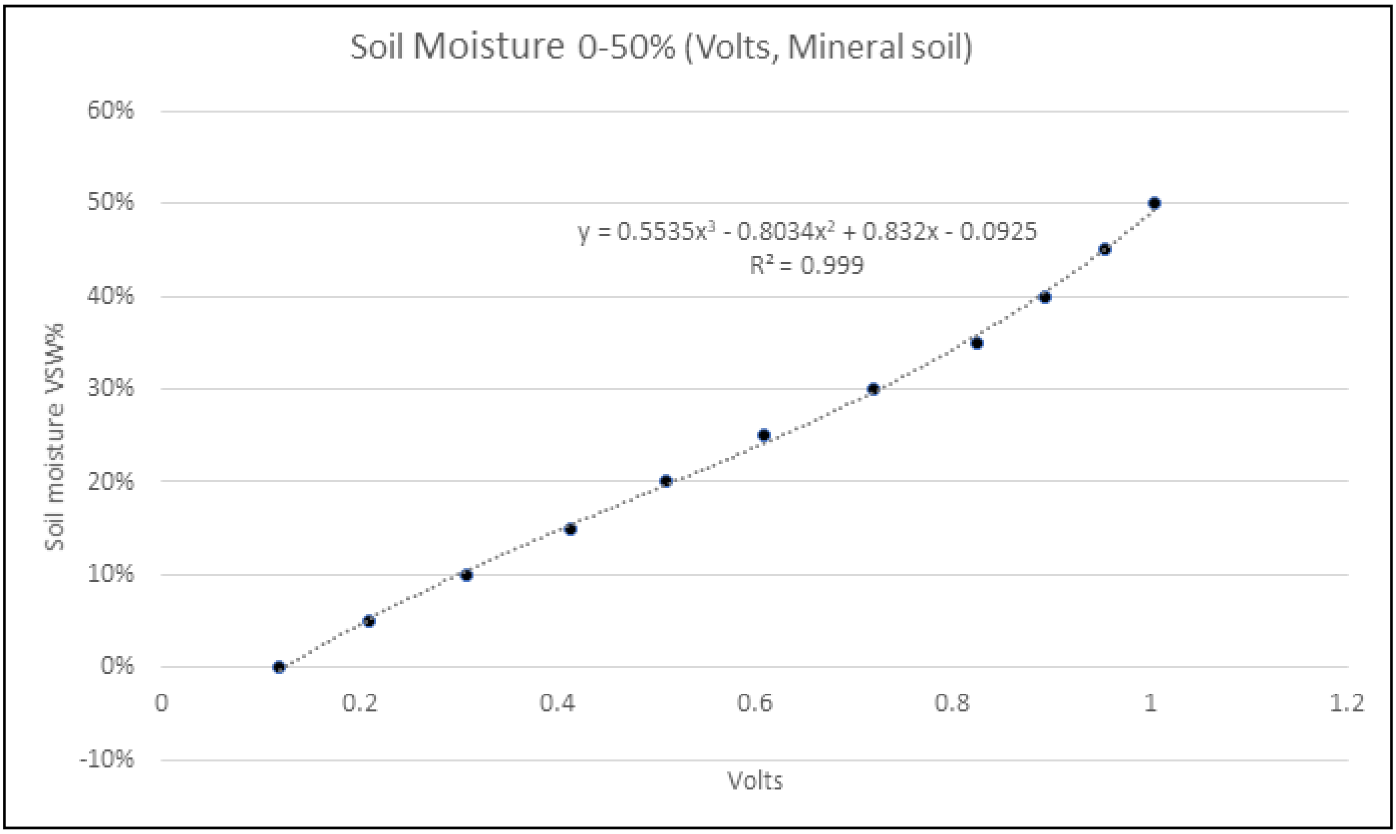
Polynomial Calibration

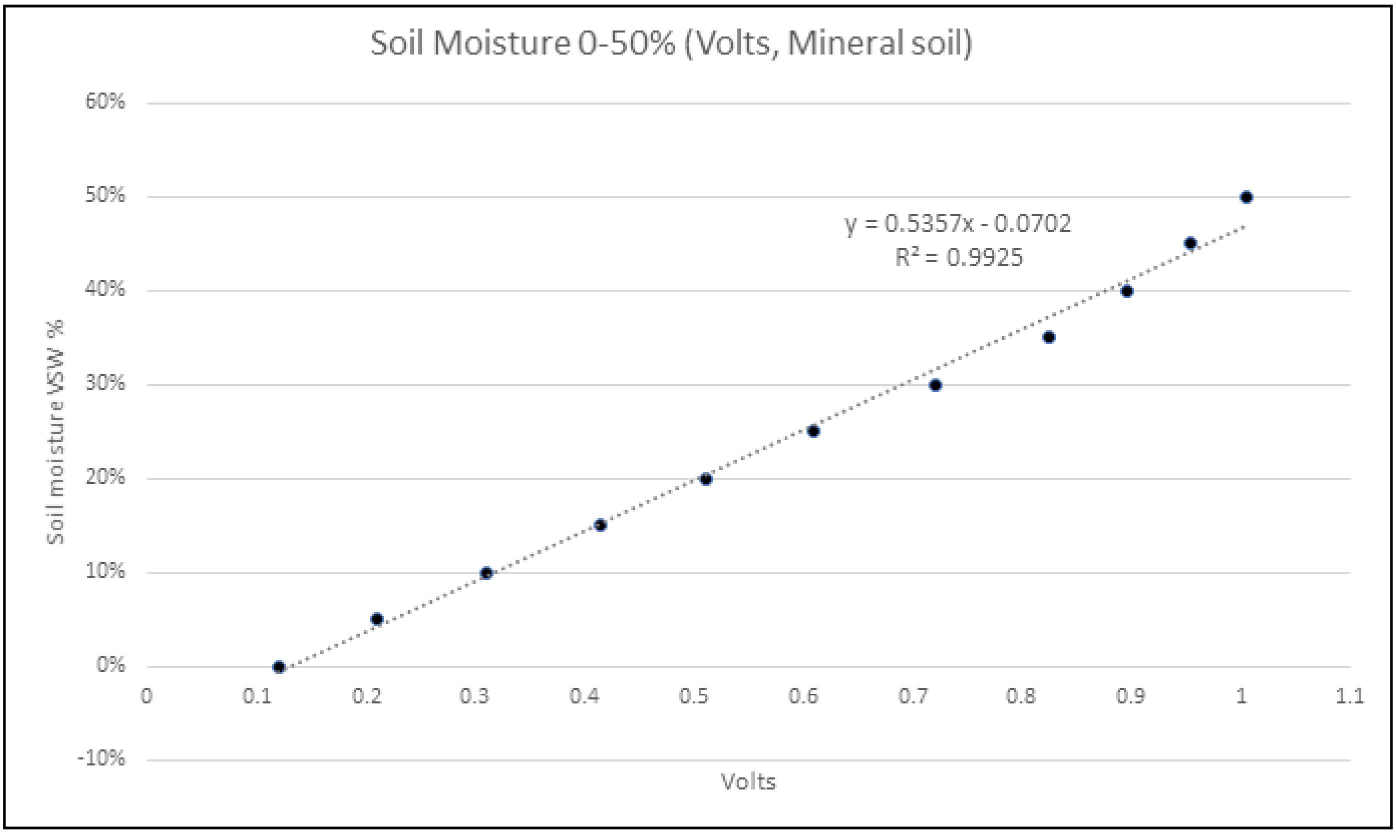
VSW% 0~50	$= a_o + a1\chi + a2\chi^2 + a3\chi^3$
	$= -0.0925 + 0.8319\chi - 0.8034\chi^2 + 0.5535\chi^3$
	R^2 Value =0.9990

Where χ = MP Sensor output in volts

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

Moisture Probe Equations & Polynomial Lookup Table





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

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% = Θv * 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.

Polynomial Lookup Table

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