I2C Soil Moisture Sensor Calibration (Catnip Electronics)

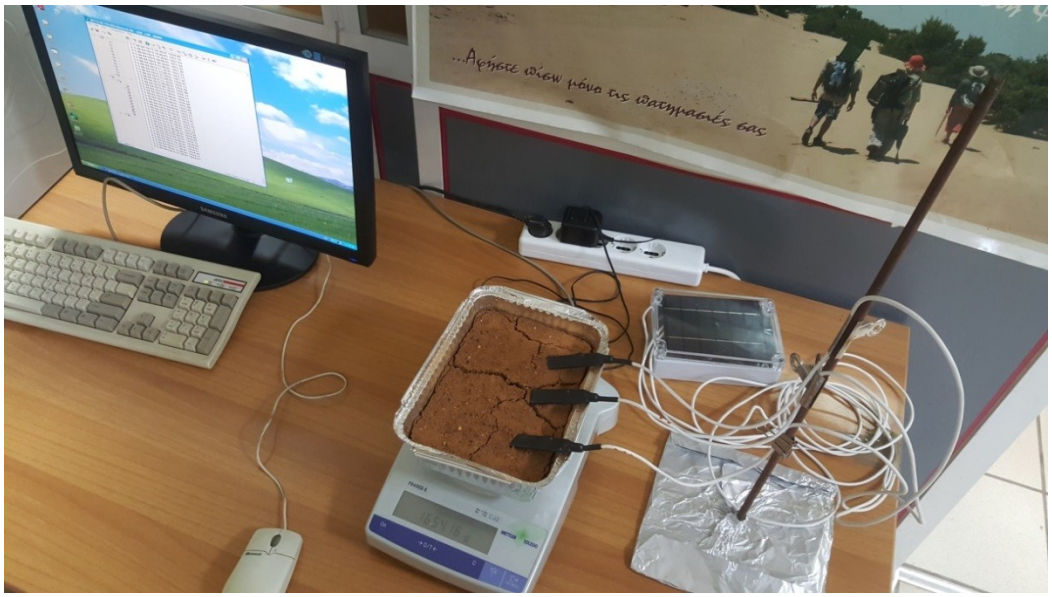
Converting the raw capacitance values of the soil moisture sensors to dry basis moisture content (%) of the soil

Materials and Methods

- Soil moisture sensor was powered at 3V3,
- Soil sample was collected from the field (Niato),
- Soil sample was sieved (2 mm) and cleaned from stones and roots,
- Soil sample was placed in the oven at 105^{o}C for 24 hours,
- After 24 hours, when the soil was completely oven dried, the soil sample was removed from the oven and placed in an aluminum disk (23x17x6 cm),
- The weight of the empty disk and the dry soil were measured on an analytical balance,
- Three soil moisture sensors were buried in the soil,
- The aluminum disk containing the dry soil and the three soil moisture sensors was placed on an analytical balance,
- The sample weight (aluminum disk containing the dry soil and the three soil moisture sensors) was recorded,
- The raw capacitance values from the three soil moisture sensors were also recorded (completely dry soil),
- Distilled water was added to the dry soil until full saturation. Water was added evenly throughout the aluminum disk. This is critically important to ensure that moisture is thoroughly and evenly spread through the entire sample and not clumped at the surface or some other location (Picture 1),
- Balance readings of the sample weight (aluminum disk containing the wet soil and the three soil moisture sensors) and the raw capacitance values from the three soil moisture sensors were recorded **simultaneously** at an interval of 30 minutes for 26 days at room temperature (Picture 2),

Picture 1: Full saturated sample on the balance

Picture 2: Balance readings of the sample weight and the raw capacitance values from the three soil moisture sensors recorded **<u>simultaneously</u>** at an interval of 30 minutes for 26 days



Picture 3: Dry sample after 26 days - balance readings of the sample weight and the raw capacitance values from the three soil moisture sensors recorded **simultaneously** at an interval of 30 minutes

- The real dry basis moisture content (MC_d) of the soil sample at 30 minutes interval was calculated as:

  MC_d = (Wet soil weight – Dry soil weight) / Dry soil weight

- Having the real dry basis moisture content of the soil sample and the readings of its corresponding raw capacitance values from the three soil moisture sensors (30 minutes interval), the following **2nd order polynomial equation** was developed using regression analysis in Excel:

$$MC_d = (0.000001007*X^2)+(0.000024885*X)-0.062508722$$

Where MC_d is the calculated dry basis moisture content of the soil sample and X is the average readings of the soil moisture sensors.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,997707255
R Square	0,995419766
Adjusted R Square	0,995410093
Standard Error	0,007208576
Observations	950

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	10,69467422	5,347337	102905,5	0
Residual	947	0,049209503	5,2E-05		
Total	949	10,74388372			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,062508722	0,005054067	-12,368	1,12E-32	-0,072427189	-0,052590256	-0,072427189	-0,052590256
X	0,000024885	2,43462E-05	1,022122	0,306984	-2,2894E-05	7,26635E-05	-2,2894E-05	7,26635E-05
X^2	0,000001007	2,7467E-08	36,67815	5,5E-184	9,53536E-07	1,06134E-06	9,53536E-07	1,06134E-06

Figure 1: Excel summary output of the regression

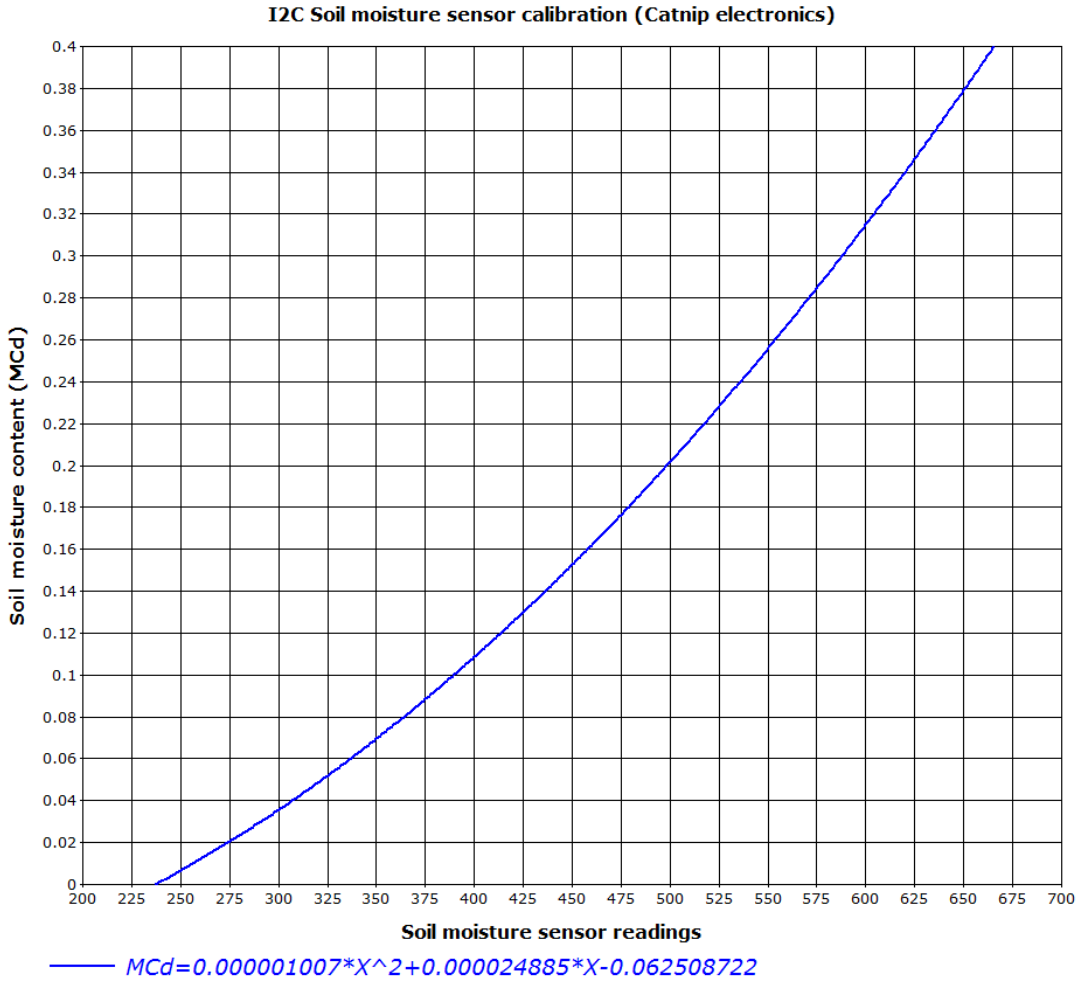


Figure 2: Graph of the polynomial equation

The developed equation can be used in Excel using the following formula:

=(0,000001007*A2^2)+(0,000024885*A2)-0,062508722

Where A2 is the cell containing the soil moisture sensor raw capacitance reading

Example:

The calculated dry basis moisture content ($\mathbf{MC_d}$) of the soil when a soil moisture sensor reads a capacitance value of **550** corresponds to:

$\mathbf{MC_d}$ = (0.000001007*$\mathbf{550}^2$)+(0.000024885*$\mathbf{550}$)-0.062508722

$\mathbf{MC_d}$ = 0.2558 or 25.58 %