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Testing Existing Prototypes of Conductivity Sensors for Monitoring the Concentration of Organic Fertilizers in Fertigation Systems

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Javier Rocher received his M.Sc. in Environmental Science in 2014 at the Polytechnic University of Valencia and he finished a postgraduate Master in Environmental Engineering in 2016. He has presented some papers about the development of sensors, on the Internet of things, and the application of sensors for water and soil monitoring. His academic interests and research are in the development of sensors, and the application of sensors.

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Introduction

- The use of an incorrect technique of fertilizing cause:
  - Nitrification of groundwater,
  - Pollution of surface water,
  - Transport of pollutants in soils, and accumulation of fertilizer in soils
- The limiting nutrient is the nutrient that its bioavailable in lower concentration.
- It is essential that fertilization does not produce huge imbalances between the limiting nutrient and the other nutrients.

Introduction

- The uses of sensors in crops has grown in the last years (Precision farming).
- For monitoring the state of the fruit, saving water, detecting disease, etc.

- Our proposal:
  - We propose an inductive sensor to monitor the use of organic fertilizer in irrigation. The proposed sensor is based on two copper. One coil is powered by alternative current and induces the other coil. Our sensor is located in the pipes that distribute the water in drip irrigation.

Related Work

- Feng et al. proposed a controlled/slow-release fertilizer. Usually,slow-release fertilizers have increased the discharge of nutrients with temperature and pH.
- Vijayakumar and Nelson Rosario used different sensors for monitoring the water and fertilizer need. The soil moisture sensor has been used for monitoring the water needs of the crop. With the pH value, it selects the amount of fertilizer.
- Zhang et al. used the information of sensors system (weather, soil, and crop growth sensors) in the crops and big data for determining the needs of water and fertilizer

Related Work

- Wood et al. developed a system to measure the salinity. The system is based on two sensors a temperature sensor, i.e., conductivity sensor, and a microcontroller.
- Parra et al. developed a system based on two coils for monitoring the conductivity in aquifers.

- These papers did not study the use of organic fertilizer.

Test Bench

- PVC pipe, 3mm of thickness, and a diameter of 25mm.
- Copper used is enameled copper of 0.4 mm.
- 40 spires in the powered coil and 80 spires in the Induced Coil
- The copper is located on PVC pipe distributed in 2, 4, or 8 layers.

- Powered with 3.3 Vpp and a resistance of 47 Ohm in serie.
- Induced coil has a capacitor of 10 nF in parallel

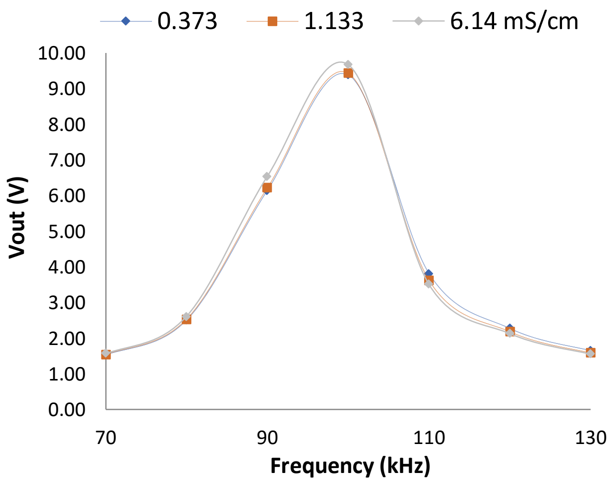
Test Bench

- We tested it with concentrations of 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20 g/l of organic fertilizer.
- We prepare 500 ml of the concentrations.
- 6 samples are for calibrated, 3 samples are for validation

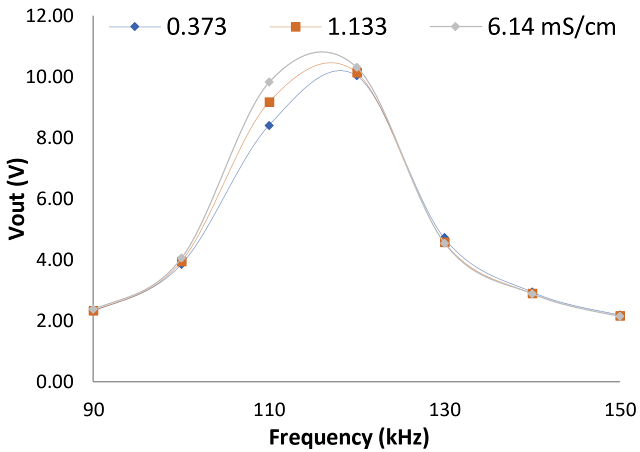
Prototype 1 (P1)	Prototype 2 (P2)	Prototype 3 (P3)
		
Spire: 40 PC 80 IC Layers: 2	Spire: 40 PC 80 IC Layers: 4	Spire: 40 PC 80 IC Layers: 8

Results

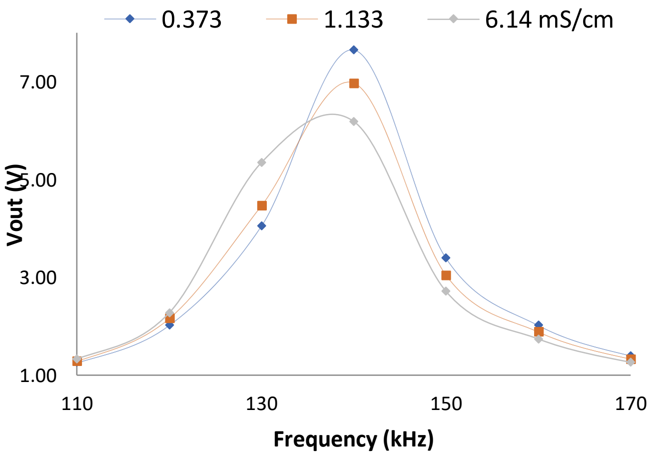
- Working frequency



P1



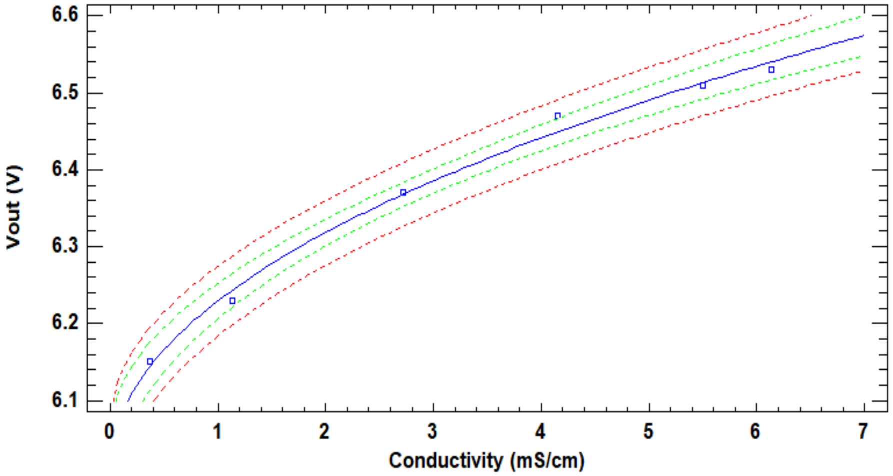
P2



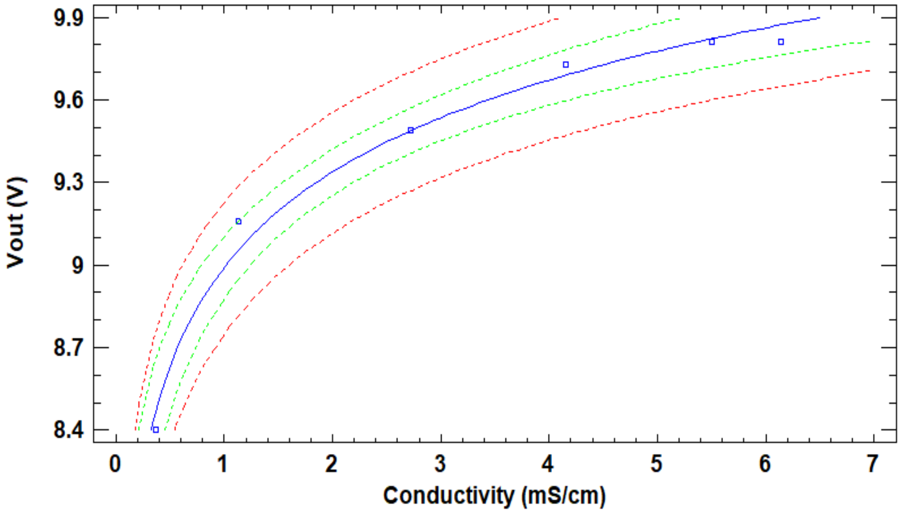
P3

Prototype	Frequency(kHz)	IV difference (V)
P1	90	0.39
P2	110	1.41
P3	140	1.47

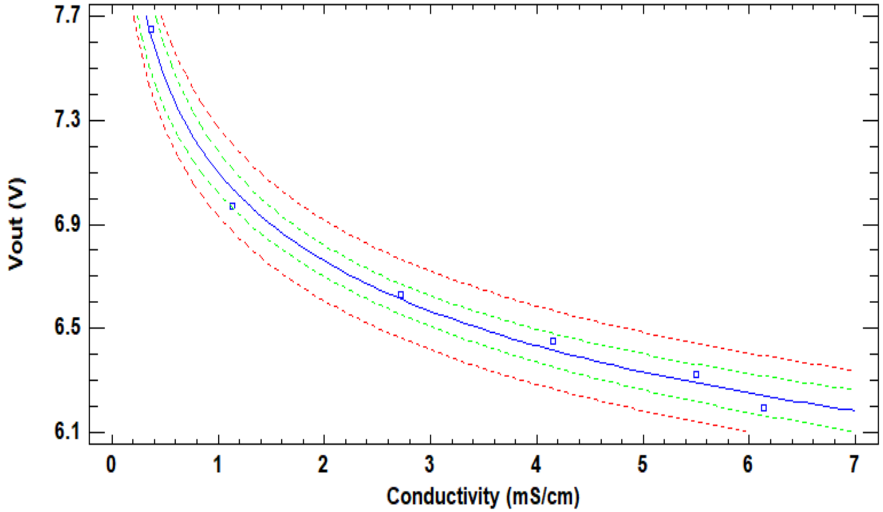
Results



P1



P2



P3

We discard the use of P1

$$Vout\ (V) = \sqrt{36.1247 + 2.68502 * \sqrt{Conductivity\ \left(\frac{mS}{cm}\right)}}$$

$$Vout\ (V) = \sqrt{80.8549 + 9.15809 * \ln\left(Conductivity\ \left(\frac{mS}{cm}\right)\right)}$$

$$Vout\ (V) = e^{1.96023 - 0.0713772 * \ln\left(conductivity\ \left(\frac{mS}{cm}\right)\right)}$$

Results

- Acuracy

		P2		P3		P2		P3	
OF. (g/L)	Conductivity (mS/cm)	Real (V)	Model (V)	Real (V)	Model (V)	Absolute error (V)	Relative error (%)	Absolute error (V)	Relative error (%)
5.0	1.98	9.39	9.33	6.77	6.76	0.05	0.57	0.01	0.15
10.0	3.54	9.73	9.87	6.33	6.35	0.03	0.27	0.02	0.23
15.0	4.81	9.39	9.33	6.77	6.76	0.05	0.57	0.01	0.15
					AVERAGE	0.03	0.32	0.01	0.22

- We choose the P3 as the best prototype to measure organic fertilizer.

- In future works, we are going to study the effect of the extreme temperatures in the values of the measures. Furthermore, test with different kinds of organic fertilizers is to be done.

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Thanks you for your attention!!

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