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High Sensitive Soil-Moisture Sensors Development and Automatic Watering for Irrigation Systems

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ABSTARCT: Soil-Moisture sensing and automated system is an automatically water releasing system in agriculture and green house area. Here in this paper, it proposes the new structures of sensors for high sensitivity and three types of moisture level indication systems which can be easily used in fields to save the power and crop. The performance comparison made for homemade sensors and readily available sensors, sensitivity improved to the homemade sensors. The high sensitivity and consistency achieved by tin coating to the sensor electrodes. The system monitors the land moisture every time and maintains the fixed water levels by turning on and off the water motor. According to the security aspects and repeatability it is good. Its implementation is easy and low cost for affording the system

KEYWORDS: Sensors,Signal conditioning system,Sensitivity, power management.

I. INTRODUCTION

A sensor is a device that detects changes in physical parameter and provides its output into an electrical signal which can be notified by instrument. In available sensors, Soil moisture sensors are the sensors which measures water content present in soil. Majorly we have five methods to measure the soil moisture content as explained with the following [1]. (i) The classical method of measuring the amount of water in a soil sample used to call as Gravimetric Technique. This method involves taking a volume of soil, accurately weighing it, completely drying it out in an oven, re-weighing the dry sample and calculating soil moisture percentage from the weight loss [2]. (ii) Second method is called Neutron Probe technique. In this method, a typical neutron probe contains a pellet of americium-241 and beryllium. The alpha particles emitted by the decay of the americium collide with the light beryllium nuclei, which produces fast neutrons. When these fast neutrons collide with hydrogen nuclei present in the soil being studied, they lose much of their energy. The detection of slow neutrons returning to the probe allows an estimate of the amount of hydrogen present. Since water contains two atoms of hydrogen per molecule, this therefore gives a measure of soil moisture. Because of the radioactive transmissions, these instruments are very expensive and measurements need to be taken by qualified personnel. Usually the services of a Neutron Probe company are employed to take soil moisture percentage readings on a weekly basis [3]. (iii) There are several instruments which indicate the percentage of water in the soil by measuring its capacitance. These instruments give instantaneous volumetric moisture contents quickly and easily by measuring the dielectric properties of the soil [4, 5 and 6]. Probes are inserted into the soil to the required measurement depth and the measurement can either be displayed on a meter or can be recorded using a data logger. However, the dielectric property of the soil not only depends on the amount of water present, but also on the type of soil, its porosity and its organic content. So for accurate volumetric soil water content readings, each measurement site should be individually calibrated. One example of a technique measuring the capacitance of soils is Time Domain Reflectometry (TDR) [7, 8]. (iv) Generally, soil conductivity decreases with decreasing soil moisture. Resistance or gypsum block sensors measure soil conductivity and are quite inexpensive. However, conductivity of the soil water is different in different soil types (alkaline or acid soils) and can change according to the sprays or fertilizers applied [9, 10]. (v)The soil suction technique measures water availability to plants, rather than actual percentage of water in the soil. This water availability

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measurement is more valuable in agriculture and irrigation of crops than is water percentage values. This measurement is also independent of soil type and gives a measurement of the plant or crop's actual water requirements [11].
Above methods are time consuming, expensive and are not good sensitive. To overcome these drawbacks we have made different types of structures on copper FR4 sheet with tin coating. These will increases the sensitivity and also cost effective solution for a former.

II. SENSOR FABRICATION AND ESTIMATIONS

The soil moisture sensor is consisting of two copper electrodes; two electrodes structure on rigid FR4 sheet has got some holes, helix, spiral, comb shape or plane. These patterns are developed on double side copper sheet using the chemical process and tin is coated to avoid the dielectric formation on copper. Before coating the tin on the sensors the surface is cleaned thoroughly and a 1micron etching of copper was done by dipping them into ammonium persulphate 150g/L and sulphuric acid 10% of ammonium persulphate solution for a minute. These tin coated different structures will increases the sensitivity of the sensors. The two electrodes acts as sensing elements which were dipped into soil about3cm depth for test, these electrodes will senses for moisture content present in the soil, this sensor will gives some levels and these levels are inversely proportionality to the moisture level present in the soil.

Fig.1 Lab made sensors with different patterns.

The output of the sensor is in orders of millivolts, this value is not readable by microcontroller, for this reason, the signal is amplified using signal conditioning circuit. Then signal conditioning output fed to microcontroller analog input (A_0). The relay circuit consists of dual op-amp IC, for our circuit one op-amp used as comparator for controlling the relay (i.e. motor ON/OFF) and buzzer by keeping the pre-defined threshold at one input of comparator. The threshold value is depending on sensitivity of a particular soil. Following equation shows, how to convert sensing voltage to the required level of representation to micro controller. Based on the large value we can say soil is dry and opposite is moisture content is very high.

$$V = S_v * (5.0/1023) \qquad (1)$$

Where V is voltage from the sensor, S_v is sensor value

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III. SOIL-MOISTURE SENSING SYSTEM AND AUTOMATION FUNCTION

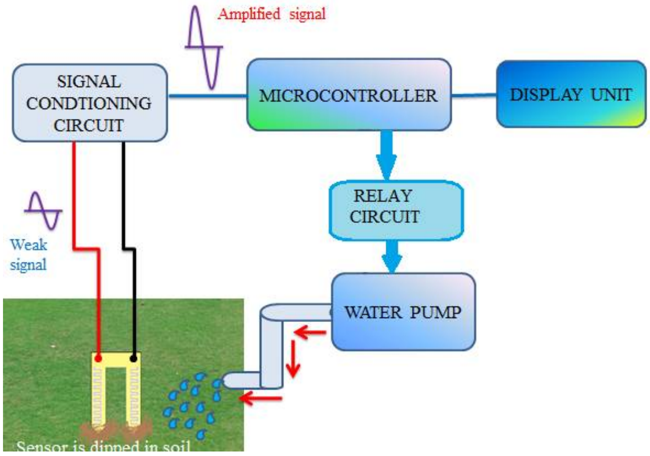

Fig.2.Block diagram irrigation system

Block diagram of soil moisture sensor based automatic watering for irrigation is shown in figure 2. The block diagram contains sensor head, sensor amplifier, arduino board, relay circuit, water pump and display unit.Arduino board is similar to microcontroller board but different packages. The soil moisture sensor will read the moisture levels and is given to the microcontroller. The water pump and display unit is controlled by microcontroller depending on condition of the soil. The relay circuit will protect the microcontroller and other components from high voltages.

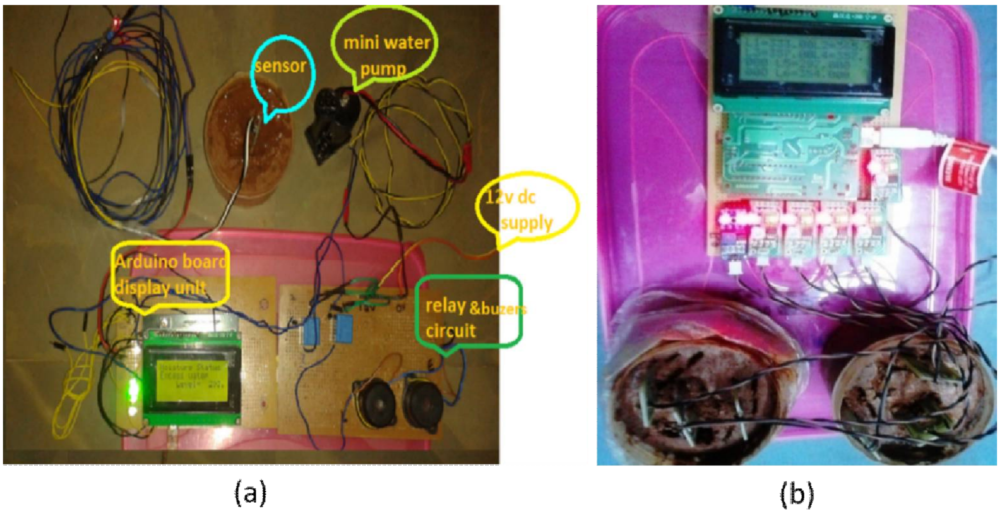

Fig.3 (a) Physical components diagram of automatic watering system. (b): Six sensors at a time are checking to make the sensitivity level

The figure.3 (a) shows physical interfacing diagram of soil moisture sensor based automatic watering for irrigation system. The system consist of soil moisture sensor, microcontroller, display unit, relays and mini water pump. For test we have taken 280gms of soil in a small pot, in that we have dipped sensor head as shown figure 3 (a).The sensor head has two copper electrodes, which acts as sensing element. These electrodes will read the moisture levels and these levels are inversely proportional to the conductivity of the soil. The output of sensor is weak signals; microcontroller cannot read these signals, to avoid this we are giving these signals to signal conditioning circuit and output of the signal conditioning circuit fed to analog input of microcontroller. The soil moisture sensor has got three lines such as supply (Vcc), ground (GND) and analog port (A0). The microcontroller will control the mini water pump, buzzer and display unit. Buzzer will make sound if soil condition is dry. Depending on moisture conditions motor will on/off and at the

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mean time moisture levels are displayed on display unit as shown in the figure.3 (a). Six sensors were dipped in a section of the soil; all six sensors will read the moisture level of the soil and it gives the average of all six sensors to the microcontroller is shown in figure 3 (b).

Fig.4: Ina cropping field the moisture level is tested in dry area and the excess water area. Display shows the excess water level with one of the sensor.

The figure.4shows the tested diagram of soil moisture sensor with display unit in the grass land of instrumentation and applied physics department (IISc-Bangalore). Depending on soil condition moisture status and moisture level is displayed on the display unit as shown in figure 4.

IV. RESULTS AND DISCUSSIONS

Two different structures of the sensors are used to steady under same conditions. Sensor with some pattern compare to the plain sensor has a good response. Sensor electrodes are kept in different conditions like open electrode, dipping in dry soil, wet soil, water, water + salt, and water + salt + soil. Different saline concentrations are also studied with both sensing electrodes and the same is shown in below figure 5.

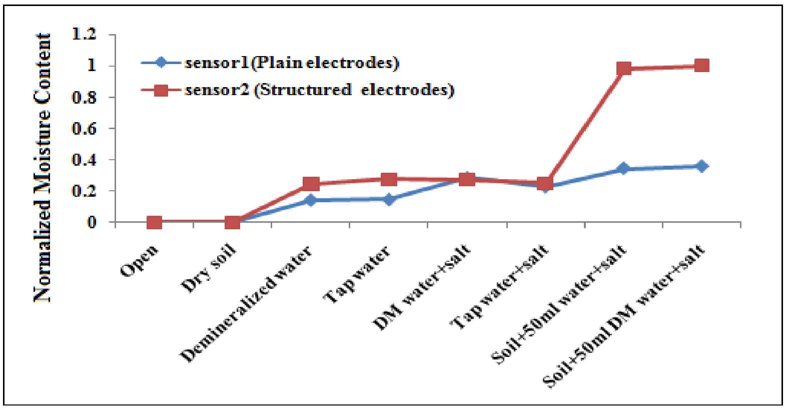

Fig.5: Sensitivity of existed sensors

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There is no moisture content in the open air and dry soil, which is shown in figure 5. There is an increase of moisture level for DeMineralized (DM) water and tap water, after adding salt to DM and tap water moisture content extremely increases.

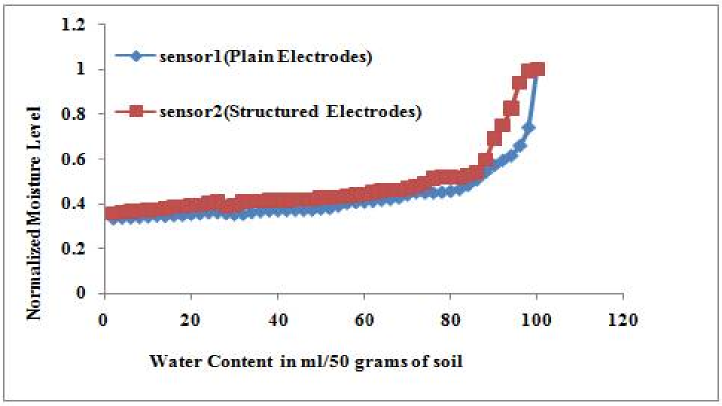
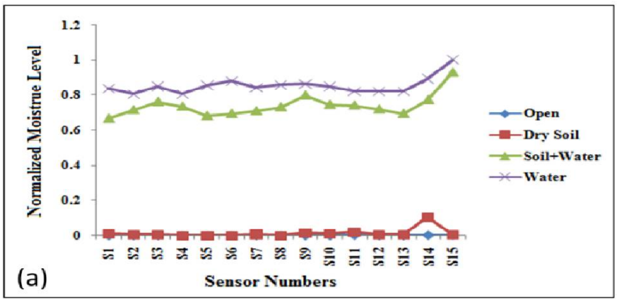


Fig.6: Normalized sensed value corresponding to water content in ml/50grams of soil in a container.

For an experiment, we took 280gm of soil. Figure 6shows the variation of moisture levels of two sensors. Adding water to soil, moisture contentvariation is shown and average of the sensors data also given. Two sensors will give two different values, because one has got structure electrode on it and another has plane electrode. The change of moisture level is for adding every 2ml of water. From the figure 6data we predicts that sensor 2 has more sensible to moisture compared to sensor 1.
We had taken the dry soil sample and wet soil samples, Sensors are kept for long time to steady the reduction in dry sample and steady value in the dry sample. As we expected the sensors shows the variation between the two samples. Dry sample remain same as the first hour value to the 100. For every one or two hours the sensor reads the data and is plotted in figure 7 (a).



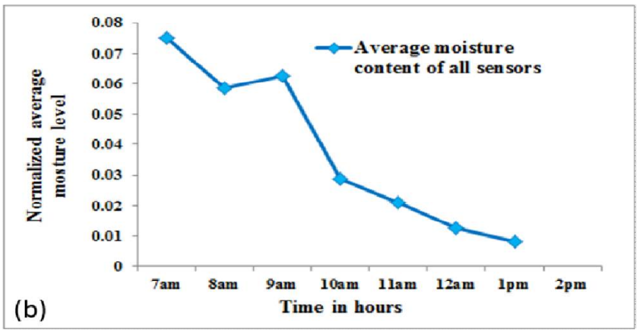


Fig.7 (a) Normalized data of moisture levels vs 15 number of homemade sensors. (b) Average moisture content of all homemade sensors.

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In the figure 7 (a), it has the sensing data of 15 sensors in four varieties of conditions. Which are open, dry soil, wet soil and water. These results show the more sensitivity compared to existing sensors. The data is normalized to get the ranges 0-1 values to all conditions and for all sensors.Open air and dry condition no moisture content and in water and salt water moisture content is very high, which is shown in figure 7 (a).All homemade sensors were dipped in a section of soil. Initially we had put water to soil to make it high moisture and then every one hour we have taken the readings. The average moisture content all the sensors is high, by increasing number of hours average moisture content is decreased and finally it came to less moisture condition is shown in figure 7 (b).

V. CONCLUSION

Developed homemade sensors and the system architecture readily fulfill the requirements for the vast irrigated fields, and helps in real time monitoring of the moisture content present the soil and around the roots of the individual planted corp. The experiments are carried out using these sensors shows the water absorption property of the soil and also show water retention property of the soil. And also it helps to provide the information related to water requirements for a particular soil, particular crop and at particular weather conditions in real time.

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BIOGRPAHY

Navin Kumar H A has received under graduation (B.E) degree in ECE from REVA ITM - VTU, Bengaluru in 2014. And he is pursuing post-graduation (M.Tech) degree in specialization of Signal processing form Bangalore Institute of Technology – VTU, Bangalore in 2014. Areas of interested includes machine learning and embedded systems development.

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