An Effective Method for Soil Moisture Sensing using Arduino Uno and Interfacing with GSM Sim900

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Abstract— India being a land of agriculture, it is of prime importance to focus and improve the methods used for farming. This is called Precision farming wherein agricultural processes like irrigation or testing the nutrition content of the soil in terms of fertility is taken care of. Also, better yield requires advanced irrigation which can maintain adequate moisture in soil providing optimal water to the crops. Soil moisture sensors have been widely used to monitor the moisture. This paper proposes a novel method to improve the conductivity of a soil moisture sensor. A YL-69 soil moisture sensor is coated with Polyaniline nanofiber (PANI) to improve its conductivity. A GSM module is also used to send the sensor readings directly to an output device – in this case a computer. This low cost manufacturing process is a significant enhancement in the field of Precision Farming.

Key words: Soil Moisture Sensor, Arduino Uno, Polyaniline Nanofiber, Nanotechnology, Precision Farming

I. Introduction

Soil sensors are used to measure the volume fraction of water in soil. They are used for smart agricultural purposes wherein the irrigation process is controlled based on data obtained from soil moisture sensors. This serves a twofold purpose: optimal use of water and prevent damage of crops. A soil moisture sensor detects the water level and provides information to accordingly control the supply of water. Also, different crops require varying amounts of water for cultivation. A farmer can bury different sensors at different depths along the root of a plant. Doing so he can determine if water reaches the lowest level of root or not, if water seeps much below the root level resulting in wastage, if stagnation occurs at a certain level in soil. Similarly these sensors are used in urban planning, in researches to improve soil and crop quality, local gardening, in house plantations, horticulture, climatic studies, etc. Geologists can study the moisture content at different depths at a particular location. By analysing the data from these sensors, they can determine the amount of rain/wind which will result in erosion, the danger levels of moisture on hilly slopes which could cause landslides or flash floods. The number of probes in these sensors and their lengths vary with the application that they are designed for. Several methods have been used in over the years to detect the moisture level – namely Frequency Domain Reflectometry (FDR), Time Domain Reflectometry (TDR), Time Domain Transmittometry (TDT), neuron based, soil resistance and galvanic cell based methods.

II. Literature review

In the year 2009, Sangkil Kim et al. for the first time demonstrated novel ink-jet printer passive RFID-enabled soil moisture sensor on paper for agricultural purposes. A prototype made of passive RFID tag integrated with a capacitance sensor consisted of printed interdigitated capacitor (IDC) was printed on low-cost paper substrate. The sensor demonstrated shift of minimum power level due to soil moisture variation. Slobodan Birgermajer et al. (2011) developed a novel miniature soil moisture sensor based on band-stop structures. Two sensors were designed that integrated conventional RFID systems for practical large scale agricultural applications with microstrip technology used for measurement and mapping of soil moisture in available land. The proposed two novel sensors which operate at 2.54 GHz and 2.75GHz offered two times wider ranges of phase delay. Sensor solutions significantly improved phase shift ranges and sensitivities compared to conventional microstrip sensors.

Kun Xu et al proposed a twostep β method is suitable for calibration of soil moisture sensor. A capacitive measurement circuit was designed based on resonant principle. A relationship between soil moisture model (β model) sensor output was obtained. Bianca Will et al. (2014) developed a miniature soil moisture sensor that was based on. TDT. The sensor has sensitive part in the form of one wire line and the feeding structure works on basis of concentric coaxial lines. It provides access to large cross sectional area and large soil volume.

G.J. Gaskin et al. in the year 1995 designed a probe to measure soil water level using an impedance measuring system. The probe costs less, is easily constructed and can withhold field conditions. Jose Antonio et al. (2008) presented design and construction of soil moisture sensor (ITM-01) which used network called back propagation neural network. The output of the proposed sensor, after the learning phase, matched with TDR based measurements. J.M.Blonquist Jr et al (2005) proposed a need for new time domain transmission (TDT) sensor that has low cost and all the properties of common TDRs and reduced attenuation time.

Harlow et al. (2003) used two TDT techniques to derive water content of saturated sands with wide range of pore water electrical conductivities. This was done by connecting two rods parallel transmission line to the network analyser. TDT method was compared with frequency based methods by converting measurements into frequency domain using Fourier transforms. Hook et al. (2004) also conducted a similar study comparing TDT with TDR. Guneet Mandar etal.(2014) proposed design for capacitive sensor that can monitor soil moisture content and analyze analog voltage with varying moisture. Two aluminium knitting needles were used as probes. It was observed that both analog voltage and capacitance follow linear pattern in addition of water.

III. FABRICATION OF SOIL SENSOR

Fig. 1: YL-69 sensor used for this work

The sensor used in the work is a model YL-69 (Fig. 1) which uses two copper strips embedded in a PCB chip and painted with epoch paint on both sides for better conductivity. Also, one of the probes of the sensor is made up of aluminium and the other one coated with Polyaniline nanoparticles (PANI) for better conductivity. Polyaniline nanofibers were synthesized by oxidative polymerization of aniline in acidic medium of Dodecylbenzenesulphonic acid (DBSA). DBSA acts as an oxidant as well dopant allowing the aqueous use of the compound. The sensor was used for both dry and wet sensing. Basically it sensed the level of water in the soil sensor, thus exhibiting its resistive properties. This compound was made into its micellar solution. This resulted in the formation of nanoparticles having very high thermal stability. As the concentration of DBSA was increased, the rate of polymerization was seen to increase. SEM results exhibited the average size of the PANI particles to be 100-500nm as shown in Fig. 2 below.

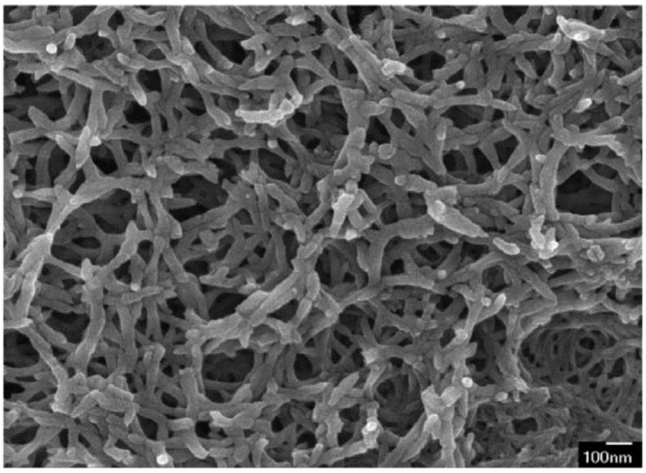

Fig. 2: SEM images of Polyaniline Nanofiber (PANI) 100nm

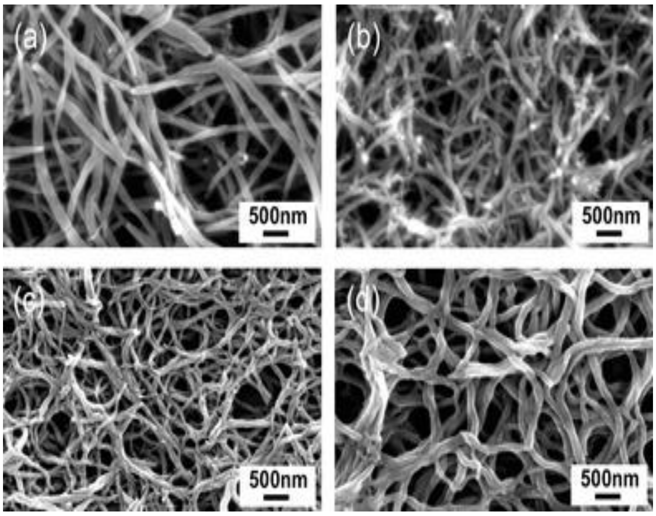

Fig. 3: SEM images of Polyaniline Nanofiber (PANI) 500nm

IV. HARDWARE

An Arduino Uno circuit shown in Fig. 4 was used to interface with the YL-69 sensor. It has an onboard ATmega328 microcontroller and an operating voltage of 5V. The components of ARDUINO UNO include 14 I/O pins which give digital output, 6 inputs which are analog in nature and 6 MHz crystal oscillator. A USB connection and an ICSP header are also used along with a power jack. The circuit also has a reset button

Fig. 4: Arduino Uno circuit used with the soil moisture sensor

It is recommended that the circuit should be used in the voltage range of 7-12 V, but in required cases can be increased to 20V. Of the 14I/O pins, each pin carries a DC current of 40mA while the DC current for 3.3V pin is 50mA. The circuit has a flash memory of 32KB and 0.5 KB of it is used by bootloader. The clock speed of the circuit is 16MHz while SRAM accounts to 2KB and EEPROM accounts 1KB.

The sensor was further connected to the circuit consisting of LM393 (Fig. 5) as comparator including a potentiometer, which is used to get the output values up to a maximum and making it stable.

Fig. 5: LM393 used between the sensor and Arduino circuit to provide stable outputs to the microcontroller

The comparator is mounted on a breadboard and connected to the microcontroller and sensor. The whole setup is shown in Fig. 6.

Fig. 6: Experimental setup used for the soil moisture sensing in this work

A GSM Module was also connected to Arduino with TTL output. SIM900 means the GSM supports all the signals used in communication in range 900MHz (used in India). The GSM module was powered using a 12V and 1Ampere DC power supply. This enables to send and receive readings as SMS interface with microcontroller on board the Arduino Uno circuit.

V. Results

Soil samples were taken from four different places namely black alluvial soil from a field in Satara, red alluvial soil from a field in Wai (Maharashtra), Loamy soil from Mumbai and Clayey soil from the coastal region at Uran. The microcontroller was programmed to interface with the soil sensor YL-69. The Baud rate was set at 9600 and a delay in the sensing readings was kept at 1000 milliseconds.

Basically a threshold value is introduced in the program for a particular type of soil and its moisture requirements. At the initial stage no threshold value was introduced. So for the dry and wet sensing the following readings were obtained:

Range of values 1019 to 1023 for the sensor kept in air

Range of values 179 to 181 for sensor kept in only water

Range of values 491 to 650 for sensor help with finger tips to the sensor held tight in palm for a longer time with increasing pressure on the probes

VI. Conclusion

The research works gives a comparative study of the capacitance and resistance of soils at various temperatures n atmospheric conditions.This would prove to be helpful in fabricating sensors according to regions, according to temperatures, according to level of water in the ground at that place. Thus precision farming can be taken to a new horizon with such sensors being fabricated using the techniques of NEMS in Nanotechnology.

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