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DESIGN AND DEVELOPMENT OF SOIL MOISTURE SENSOR AND RESPONSE MONITORING SYSTEM

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Abstract---The efficient irrigation management practices based on the monitoring of the moisture in the soil provide a great benefit for the appropriate amount of water applied in the fields. This paper presents design and development of a soil moisture sensor and a response monitoring system. The probes used in this sensor are made of nickel which is an anti-corrosive and robust material for use in agricultural related applications. The response monitoring system measure the moisture of the soil, compare it with the desired values given by the user and generate alert if soil moisture goes below desired value. It helps in problems related to growing of crops in which irrigation is required at irregular interval. It is also helpful in monitoring of soil moisture in golf fields.

Keywords- Volumetric Water Content, Water Tension, Probes, Response Monitoring.

I. INTRODUCTION

India is a developing nation with a very large population. Due to increasing population, the basic need such as food and water is increasing day by day. Thus there is a need of saving these resources and utilize them in an efficient manner. Since water is one of the most important elements in our daily life, thus we must use efficient ways to utilize water and save it for future generations. One of method is efficient irrigation management practices for fields. Irrigation water management practices could greatly benefit by the knowledge of moisture in the soil. To determine the soil moisture we have designed and developed a nickel probes based soil moisture sensor and a response monitoring system. By knowing the moisture value, we can estimate when to water and how much to water the fields so that there is no over-watering or wilting of crops. These practices will increase crop yield, improve quality of crops, conserve water resources, save energy, and decrease fertilizer supplies [5]-[7].

II. SOIL MOISURE SENSOR

A soil moisture sensor as the name indicates is used to determine the moisture present in the soil. The moisture of the soil depends upon various factors such as type of soil whether its sandy, clay, loam, sandy loam and salts present in soil such as iron, manganese, calcium, phosphorus, nitrogen, sulphur etc. it also depends upon temperature. Based on the reading of moisture sensor, irrigation is done. Soil moisture sensors can be classified into following types based on the methods to determine the soil moisture:-

A. Soil Volumetric Water Content-based soil moisture sensors: These sensors are used to determine the amount of water present in the soil. VWC can be calculated by mass (g/g) or volume (cm^3 / cm^3). It gives output in percent content.

B. Soil Water Tension-based soil moisture sensors: These sensors measure energy of water in the soil. Water tension is measured in energy/mass of the soil. Units are Joules/kg (J/kg) or kilopascal (kPa). It tells how much difficult or easy it will be for the plant to extract water from the soil.

III. Design of Soil Moisture Sensor Probe

Moisture sensor is a two-probe sensor made up of pure nickel. Nickel is used since it has fair conductive properties and also strength to get buried in the soil for long time. It will not get corroded in the soil. The length (L) of nickel probes is 9.5cm and width (W) of each probe is 0.7cm. The distance (d) between the two probes is 0.5cm the tips of sensor probes are designed in the shape of the triangle so that can be easily buried in the soil [1]-[4], [8]. The soil moisture sensor probes are shown in figure 1.

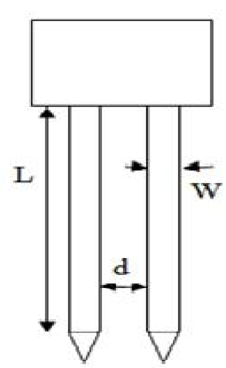


Fig. 1 Soil Moisture Sensor probes

For the Sensor, capacitor of co-planar plate structure has been used i.e. instead of standard shape of the capacitor which is parallel plate. This is done so that the soil does not occupy the area in the middle of the probes. This increases the area of influence of the sensor up to which it can give correct readings. Figures 2 and 3 shows the standard parallel plate capacitor and the designed co-planar structure.

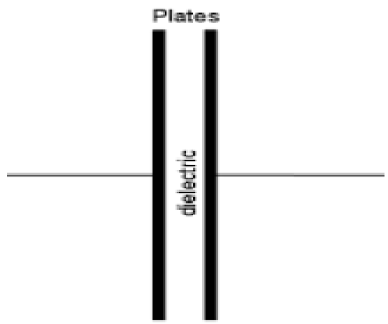


Fig. 2- Standard parallel plate construction of capacitor

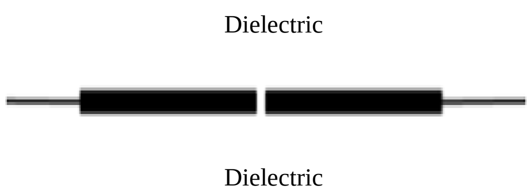


Fig. 3 Co-planar structure

The electric field lines will extend outwards from the plates of the capacitor into the dielectric i.e. soil on both sides as shown in following figure 4.

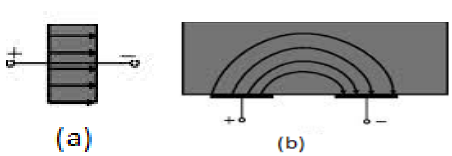


Fig. 4 Electric field lines in a (a) parallel plate structure (b) coplanar structure

The conical tip of the sensor which will be buried at the root zone of the crop is shown in figure 5 below:

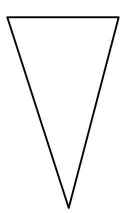


Fig. 5 Conical tip of sensor

IV. Soil Moisture Sensor Based Response Monitoring System

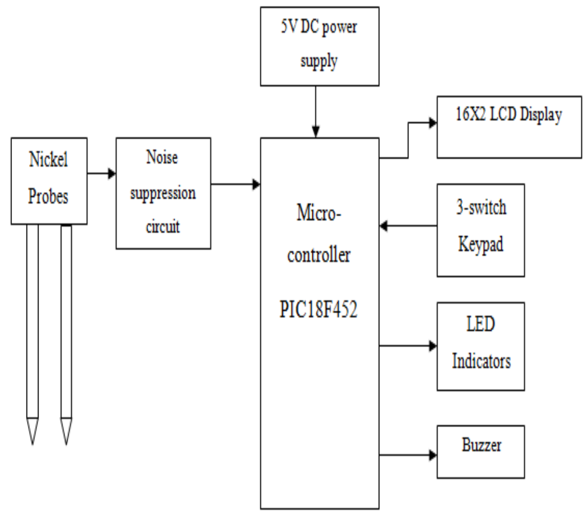


Fig. 6 Block diagram of soil moisture sensor based response monitoring system

The block diagram of soil moisture sensor based response monitoring system is shown in figure 6. The complete system is incorporation of a controller, power supply unit, LCD display, keypad, buzzer, LED indicators and moisture sensor. The central part of system consists of PIC18F452 microcontroller which is powered up by 5V power supply. Power supply circuit is made up of a crystal oscillator of 4MHz clock frequency, a reset switch, a LED indicator and two capacitors of 22pF each to filter the noise. PIC microcontroller is favored over other controllers because this is high performance, enhanced flash microcontroller with inbuilt 10-bit ADC.

Moisture sensor is connected to the controller. The 3-switch keypad is used to enter the desired value of moisture in the field. It is made up of an increment switch, a decrement switch and the third switch is to enter or save the required value. After the desired value is set by the user, moisture sensor calculates moisture from the field. This value is compared with the desired value entered. If the moisture is less than the desired value, it means there is need of irrigation. A buzzer is also interfaced with the controller which will get ON and OFF according to the moisture values. The moisture value is displayed in terms of volumetric water content. The schematic flow diagram is shown in figure 7.

It shows how a sensor obtains moisture from the field. Then these values are compared with the desired value entered by the user. There are different indications used to alarm the user that the moisture is low and there is a need of irrigation. There are LED indicators and a buzzer connected to the controller. Moreover there is a LCD to display the %VWC continuously.

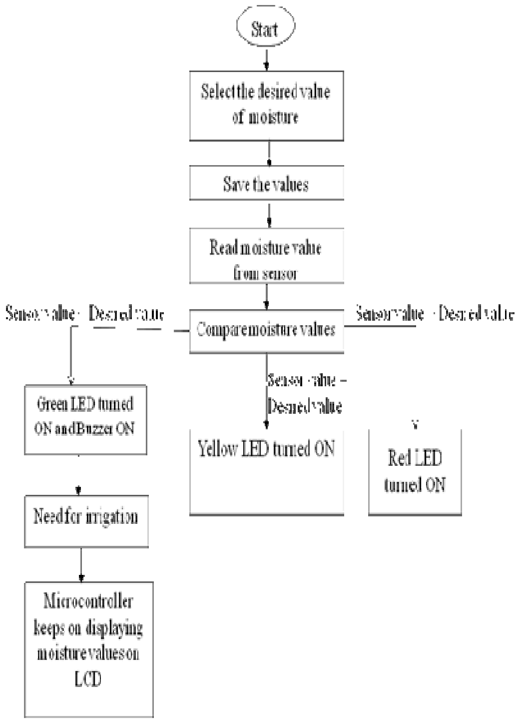


Fig. 7- Schematic flow diagram soil moisture response monitoring system

V. RESULT

The results of the moisture values are displayed on the LCD as shown in fig. 8.

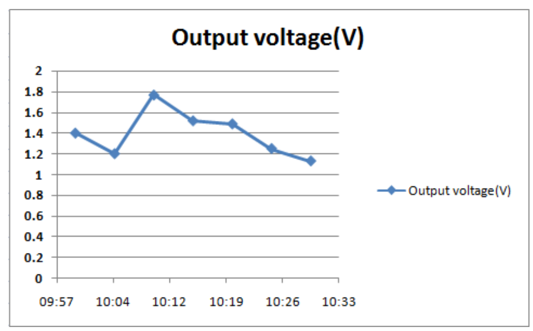
Fig. 8- Results on LCD

The table I lists the different parameters of the designed sensor and the response monitoring system.

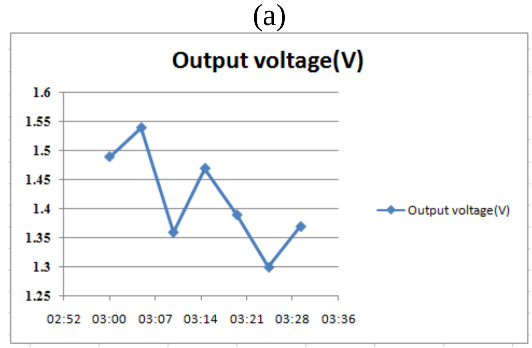
TABLE 1 Design parameters

Parameters	Values
Dimensions	9.5cm x 0.7cm x 0.5 cm
Power supply	5V
Output	0-100%VWC
Voltage signal	0-4.2V
Area of influence	25 cm
Conversion time of ADC	72µs
Resolution	4.8mV

The graphs showing measurements in the morning and evening are shown below in figure 9.



(a)



(b)

Fig. 9- Output measurements in the (a) morning (b) evening

Comparison of the output voltage of the designed sensor and the PCB based nickel plated sensor is shown in figure 10.

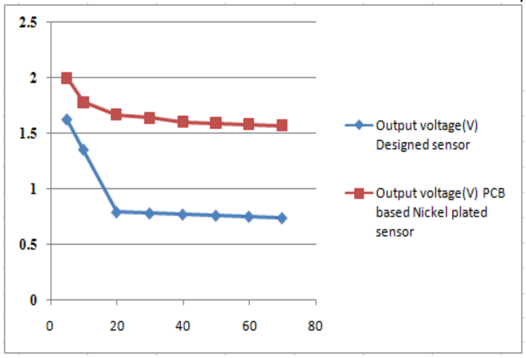


Fig. 10- Comparison of the output voltage of the designed sensor and the PCB based nickel plated sensor

IV. CONCLUSION

The soil moisture response monitoring system designed is very simple to understand and handle. It can be operated by all age-groups of farmer. It can be reprogrammable to add more features. The moisture is measured up to the root zone of the crop. Thus it can be used to check the moisture value for any crop. Sensor can be placed vertically in the soil to check the depth of irrigated water and also it can be placed horizontally at different heights in the soil according to the crop. It is user friendly and can also be used by uneducated farmers. The moisture is checked in the morning and the evening and it is found that moisture is linear up to 20%VWC (volumetric water content) and afterwards output voltage becomes almost constant.

VII. FUTURE SCOPE

Soil moisture sensor can be designed according to the various types of soil. A database can be formed. It can be used to determine the types of acids, alkalis or salts present in the soil. Salinity of soil can also be calculated by correlating it with the output voltage. Wireless transmission of the output data directly to the user can be done using Zigbee or Bluetooth. We can get the values from stored data base in PC so that the moisture holding capacity of the soil can be determined.

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