Design of a Soil Moisture Sensing Unit for Smart Irrigation Application

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ABSTRACT

Agricultural sector is backbone of Indian economy. As population growth results in an increasing demand on water supply. Usually, growers determine how much water is needed to irrigate their field based on the amount of time elapsed since last irrigation cycle. An automated irrigation system enables the users to constantly monitor the relative soil moisture at many different locations throughout the field to more precisely schedule irrigation cycles. The sensing system is based on a feedback control mechanism with a centralized control unit which regulates the flow of water on to the field in the real time based on the instantaneous temperature and moisture values. Depending on the varied requirement of different crops, a lookup table has been prepared and referred to for ascertaining the amount of water needed by that crop.

Keywords

Moisture Sensing, Temperature sensing, Microcontroller, WSN.

1. INTRODUCTION

In India, Irrigation is one of the fundamental problems of agriculture in developing countries. Where in traditional Irrigation, farmers irrigate the field based On previous knowledge acquired and present atmospheric condition. Knowledge acquainted at one region and season is varying with the others, hence substantial loss of crop growth. The ability to monitor soil moisture is imperative for growers to conserve considerable amounts of water during fertilization and irrigation cycles, Particularly as water restriction becomes inevitable in the future due to population growth and dry weather. Soil moisture Sensors are typically needed in such situations to indicate to the former when it is needed to irrigate the field and when not needed.

The earliest work in the field of soil moisture has been done by using a cheap soil moisture sensor so the sensor can read the amount of moisture in the soil. The sensor building here is Very simple, cheap and easy to build. It consist of a copper leads and a block of packing foam with a couple of wires shoved into it. Temperature sensors that are currently being used are linear with temperature, 0.05mV/°C scale factor, with 0.5°C accuracy guarantee able (at +25°C) [1, 2, 3].

The current work aims to develop a microcontroller based low cost soil temperature and moisture monitoring system, that can track the soil temperature and moisture at different locations of the field in real time. It allows water to be Drip/sprinkled on to the field if the soil temperature goes above and/or the soil moisture falls below a prescribed limit depending on the nature of crop grown in the soil.

The sensors take the inputs like moisture, temperature and provide these inputs to the microcontroller. The microcontroller requires inputs from sensor and makes comparison between the set points of crops where it stored in program. Based on this comparison decision is taken by the controller to start or stop Irrigation.

2. SCHEME OF THE SYSTEM

The implementation of the system is shown in hardware section.

Hardware section:

- Instrumentation part i.e. sensor and valve.
- Basic mechanical system i.e. piping and pump etc.

2.1 Instrumentation Part

Here two Parameters are sensed-

2.1.1 Temperature Sensor

The current work uses temperature sensors for monitoring the soil temperature. For temperature measurement, LM-35DZ sensor has been used. The soil temperature is one of the important environmental factor with a change of climate, topography, vegetation, soil type, planting form and other factors, the soil temperature is closely related with some processes, such as crop planting time, tillering Growth and wintering safety etc. The change of soil temperature directly impact on soil nutrient absorption and soil moisture keep and sport ,The soil temperature plays a certain role on many of the physical processes of soil. The soil water and heat migration is an important research problem. Therefore, the observation of soil temperature real time and understanding of variation of soil temperature have vital significance to agricultural production and scientific research [4, 5, 6].

The temperature sensor LM-35DZ has an output voltage that is proportional to the temperature being measured. The figure shows a soil temperature sensor LM-35DZ. The scale factor is 0.01V/˚C[11]. The LM-35DZ does not require any external calibration or trimming and maintains an accuracy of 0.4˚C at room temperature and ± 0.8˚C over a range of 0˚C to +100˚C. Another important characteristic of the LM-35DZ is that it draws only 60 µA of current from its supply and possesses a low self-heating capability, the sensor self-heating causes less than 0.1˚C temperature rise in still air.

Figure 1: LM-35DZ Temperature sensor's pin function

2.1.2 Moisture Sensor

Moisture content of the soil is a major factor determining plant growth.The present work Comprises of development of a soil moisture sensor. The soil moisture sensor has been developed using the basic property, that the resistance of the soil between two points decreases with the increase of water content in it. We know that water is a good conductor of electricity in the presence of ions. So, greater the amount of electrolytes in the soil, greater will be the conductivity of the soil [12]. This means that the resistance of the soil decreases. The basic objective of irrigation scheduling is to minimise water stress of the plant, that of over irrigation and under irrigation. Good irrigation water management will increase yields, improve crop quality, conserve water, save energy, decrease fertilizer requirement.

2.1.2.1 Probes

The probes are made using two metal rods tied together using an insulating tape.The two probes are saperated using smaller foam block which keeps the two probes apart[7].

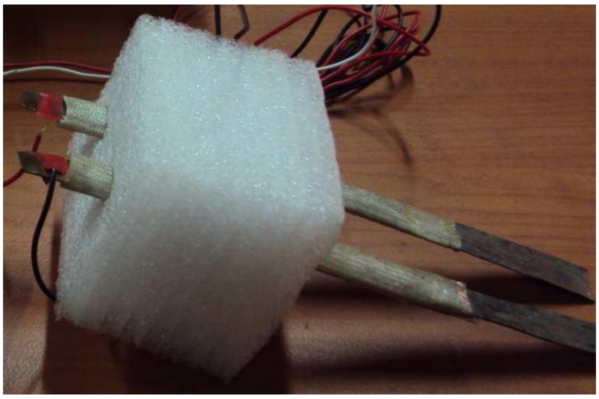

Figure 2: Soil Moisture Sensor

The developed sensor has two probes that are inserted into the soil[8].The distance between these two probes is kept fixed.A resistancr is connected in series with the probe and current passed through it. The photograph of the probe is shown in figure 2.

2.1.2.2 Circuit

The circuit consists of an oscillator that gives a sine wave with frequency of 1 KHz. This sine wave is given to the one end of the probe. At the other end of the probe there is a series resistance and the output between these 2 is given to a half wave rectifier followed by a low pass filter. This setup gives the DC values depending on the resistance due to soil between the probes. The circuit diagram is shown below in figure 3. The output of the sensor is change in resistance as per the moisture contents in the soil. The change of resistance is from 1 K to 15 K depending upon moisture. This change in resistance is required to be converted into corresponding voltage change and for this purpose signal conditioning circuit is used. The signal conditioning card gives a voltage change from 0V to 5V which is compatible with further circuitry. The ***Electrical resistance blocks*** measure soil moisture tension with two electrodes Embedded in a porous material such as foam block. The block allows moisture to move in and out of it as the soil dries or becomes moist. The electrodes measure the resistance to electric current when electrical energy is applied.

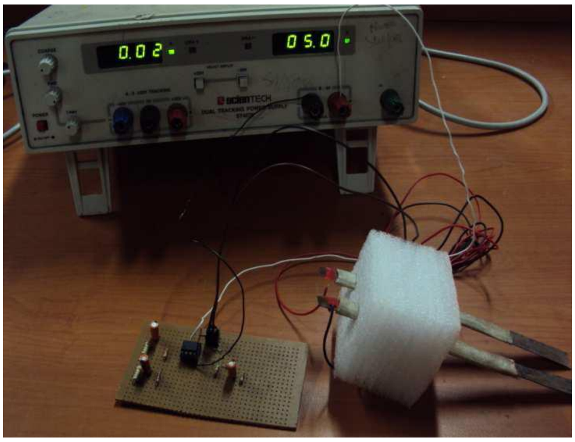

Figure 3: Moisture Sensor Circuit

3. DEVELOPMENT OF THE SMART DATA PROCESSING UNIT

The data processing unit is centred on P89v51 RD2 microcontroller [9]. The PCB for the microcontroller has been developed. The Circuit connection and actual image of microcontroller are shown below in figure 4 and figure 5 respectively:

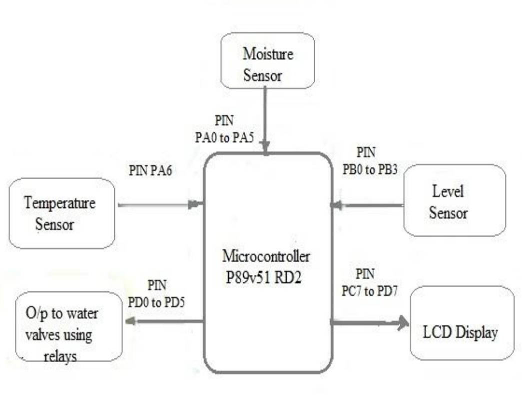

Figure 4: Circuit Connection of the Microcontroller

The pin connections and their data direction that are used for connecting various sensors, LCD and output to water valves is given in figure 4. The whole circuit operates on a 5V power supply. The microcontroller has a program running on it, which acts as a small Operating system. This system results into a reduced size of control board, low power consumption, more reliability and ease of integration within an application design. It has a user interface, and takes inputs from the user and accordingly takes actions. The usage of microcontrollers not only reduces the cost of automation, but also provides more flexibility and can concentrate on applications and development aspects. The device can be programmed to make the system intelligent. This is possible because of the data processing and memory capability of microcontrollers. The temperature sensor output is directly applied to the ADC of the microcontroller and stored in the internal register. The microcontroller takes the analog output of the moisture sensor and converts them into a digital value ranging from 0 to 1023 using its Analog to Digital Convertor. It is used to control the overall action and the program already store in its flash memory.

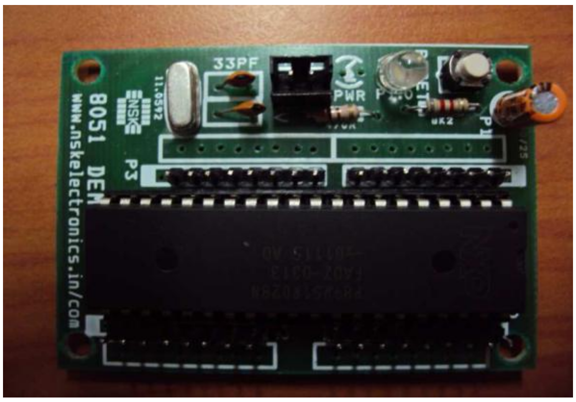

Figure 5: Picture of the signal processing circuit

4. Wireless Sensor Network

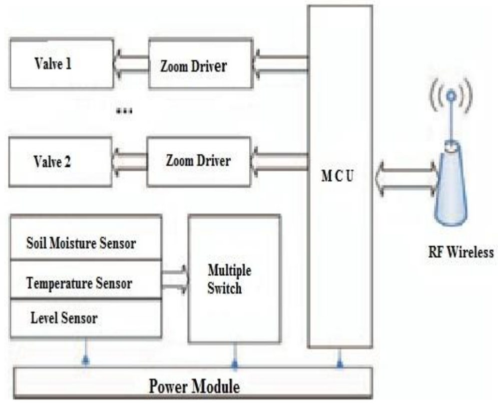

Figure 6: Sensor nodes hardware control Structure

Wireless sensor network technology applied to the water system, its core technology is the application of ZigBee networking technology since. ZigBee is a low heterogeneous, low power, low data rate, low capital, high-solid reliability, a large network capacity two-way wireless communications technology[10,13,14]. By using the layer, network layer, medium access control layer and physical layer. Based on ZigBee wireless sensor networks system can solve the cable transmission bring cost is exorbitant, cabling complex, maintenance trouble, flexibility and expansibility such a series of problems, which saves the human resources, went to the lavatory again information management, has been used steel temperature monitoring, Soil moisture monitoring and level monitoring it is the realization of the system provides a better solution. Main achievement of the system sensor nodes monitoring soil moisture content, temperature value. Monitoring of the state of the solenoid valve, solenoid valve to control the state, various monitoring and control of transmission of communication signals. Through the sensors to collect to of multi-channel data, after A/D conversion, signal processing, in microcontroller, according to different vegetation needs, identifying water amount, then control signal output, combining central management of A computer instruction, control the solenoid Switch, namely can achieve automatic irrigation. Soil moisture sensor used to measure the soil moisture, in order to understand the real irrigation, soil basis, determined irrigation or not and duration, the main block diagram shows Sensor nodes hardware control structure in figure 6.

5. RESULT

The moisture sensor being developed give an analog value ranging from 0 to 5 V for different moisture levels. Figure 7 shows the output performance of the soil moisture sensor.

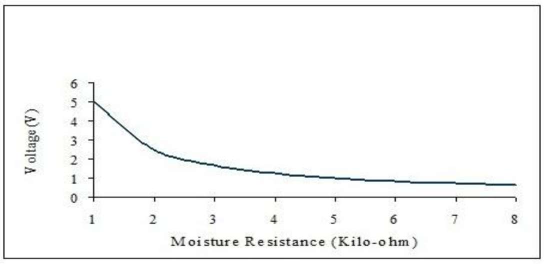

Figure 7:Relation between Soil Moisture Resistance and Voltage

For soil moisture sensor a special sensor is developed which has variable resistance with respect to variation in soil moisture.

The sensing units were placed at distances of 10 meters. They were all networked with the smart signal conditioning unit that sample the sensor outputs. The number of plants that remained alive as a result of irrigation approach monitored. The system is very useful for agriculture applications particularly in semi arid areas that are sparsely populated, so that human involvement and intervention is not needed for irrigation purpose.

7. CONCLUSION

The current work aims to develop a smart irrigation system using soil temperature and moisture sensor. Automation helps in utilization of water for irrigation as per requirement of the crop result in better yield of crop compared to normal practices carried out by farmers. The proposed system enables irrigation of the field only when it is needed and thus serves to conserve water. Also, the proposed system eliminates the intervention of human being for irrigation purposes. The system is particularly useful for agriculture applications in sparsely populated semi arid areas since human involvement and intervention is not needed for irrigation purposes. Further works are going on to increase the efficiency of the moisture sensors so as to minimize the effects of fertilizers on the value of soil moisture.

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