

A Smart Irrigation System for Agriculture Based on Wireless Sensors

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ABSTRACT: A smart irrigation system was developed to ensure proper use of water for agricultural crops. The system has two sensing units each having a soil moisture and temperature sensor.

These sensors were placed near the roots of the crop. The threshold values of temperature and soil moisture were programmed to control supply of water. The system was powered using regulated power supply. Irrigation scheduling could be monitored using an Android Application.

KEYWORDS: Agriculture, Android, irrigation, moisture, wireless sensors.

I. INTRODUCTION

Irrigation is the process of application of water to a land or soil. It is used for enhancing the growth of agricultural crops, maintaining landscapes, and revegetation of degraded soils in dry areas and periods of inadequate rainfall. Irrigation in India includes a wide network of major and minor canals from rivers, groundwater well based systems, and other rainwater harvesting projects for agricultural activities. Of these the groundwater system occupies the major part. In 2010, the total agricultural land in India that was properly irrigated accounted for only 35%. In India, about 2/3rd of the cultivated land depends on rains. Irrigation helps to improve security of food, reduce reliance on monsoons, increase crop productivity and enhance rural job opportunities. Dams used for irrigation projects help in the generation of electricity and transport facilities, also they provide drinking water supplies to a growing population, control floods and prevent droughts.

There are a number of methods to obtain water savings for different types of crops. Various parameters are considered to determine the irrigation needs of a crop. For example, in one system the distribution of canopy temperature was considered for scheduling the irrigation for the crop [1]. Moreover, there are other systems that have been developed to optimize water consumption by taking into account crop and water stress index (CWSI) [2]. Instead of a predetermined schedule of irrigation, the systems can acquire information on volumetric water content of soil and be automated [3]. As compared to manual irrigation system based on direct soil water measurement, the automated irrigation proves to be valuable for cotton fields [4].

Another parameter that can be taken into consideration for determining the irrigation needs of a particular crop is the plant evapotranspiration (ET). ET is affected by several factors. Systems based on ET have allowed up to 42% water savings [5].

In one of the systems, an electromagnetic sensor was used to measure soil moisture. Water saving of about 53% were achieved as compared with the ones using sprinklers [6]. Reduction in water use have been achieved, using sensor based scheduling of irrigation. A soil sensor and an evaporimeter were incorporated in this system [7].

The use of automated irrigation system to reduce water consumption was done in a system that composed of a distributed wireless network of soil moisture and temperature sensors placed near roots of plants [8].

In this paper, the design and development of a smart irrigation system using sensors and microcontrollers is presented. The aim of the implementation was to optimize water consumption by crops in an agricultural field and improve

sustainability. The system consists of soil moisture and temperature sensors embedded in the root zone of the plant. Each wireless sensor node is comprised of a soil moisture probe, a temperature sensor probe, a microcontroller for acquisition of data, and a radio transceiver. The receiver unit comprises a master microcontroller, radio transceiver, Global System for Mobile Communication (GSM) module and a pump. The communication link between the transmitter and receiver units is via the ZigBee protocol [9]. The soil and temperature levels are graphically displayed through an Android application interface. This enables the scheduling of irrigation according to requirements of crop. The system can be used to get rid of weeds as water will be supplied only to the crops and not the entire field.

II. SMART IRRIGATION SYSTEM

The smart irrigation system hereby reported, comprised of two major units (Fig.1), wireless transmitter units (WTUs) and wireless receiver unit (WRU), linked by radio transceivers. The transceivers allow the exchange of data between the two units using ZigBee technology. The WRU has a GSM module using which the sensor values and motor condition is monitored using an Android Application.

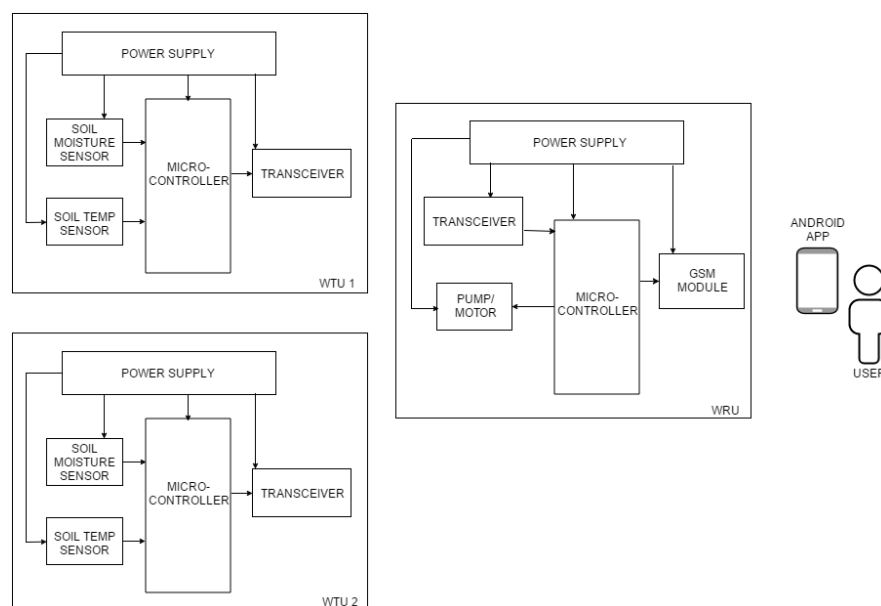


Fig. (1) Block diagram of smart irrigation system

A. Wireless Transmitter Unit

A WTU is comprised of a soil moisture sensor, a temperature sensor, a microcontroller, a RF transceiver and power source. Several WTUs can be incorporated in field to form a distributed network of sensors. Each unit consists of the microcontroller PIC16F877A (Microchip Technologies, Chandler, AZ) that controls the radio modem XBee S2 (Digi International, Eden Prairie, MN) and processes information received from the soil-moisture sensor YL-69 (JMoon Technologies), and temperature sensor DS18B20 (Maxim Integrated, San Jose, CA). These components are powered using regulated power supply. The power consumption is minimum as possible.

1) PIC16F877A: An 8-bit microcontroller with 40-pins that operates in a range 2.0 to 5.5 V. It has 8 input channels of 10-bit analog-to-digital converters (ADC), 2 serial peripheral interface modules (SPI), 8 KB of FLASH memory, and 3 timers. The microcontroller is well suited for this application, because of its low-power operating current, which is less than 0.6 mA at 3 V at 4 MHz, 20 μ A at 3 V at 32 kHz and less than 1 μ A for standby current.

International Journal of Innovative Research in Science, Engineering and Technology

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2) ZigBee Modules: ZigBee (over IEEE 802.15.4) technology is based on short range networks and it was selected for this application because of its low cost, low power consumption, and greater useful range in comparison with other wireless technologies. The ZigBee devices operate at 2.4-GHz radio band.

3) Sensors: There are two soil sensors namely moisture and temperature that are inserted in the root zone of plants. The YL-69 probe was selected to determine the soil moisture because of its low cost and availability. The probe measures the resistance of the water content in the soil which is inversely proportional to the moisture present in the soil. The probe was powered at 5 V using ADC port of the microcontroller.

The soil temperature measurements were done using digital thermometer DS18B20. The sensor converts temperature to 9-12-bit digital word. The temperature is acquired using a read command and transmitted using 1-Wire bus protocol implemented in the microcontroller using one digital port. The sensor has $\pm 0.5^\circ\text{C}$ accuracy over -10°C to $+85^\circ\text{C}$ temperature range and a unique 64-bit serial number.

B. Wireless Receiver Unit

The soil moisture and temperature data from each of the sensing units are received, identified, recorded, and analysed in the receiver unit. The WRU consists of a master microcontroller PIC16F877A, an RTC DS1307, a XBee radio modem, a GSM module, an RS-232 interface MAX3232, two 12V electronic relays, motor/pump, and power source.

1) Master Microcontroller: The master microcontroller acquires the information from both the sensor units. The soil moisture and temperature data are compared with programmed values of minimum soil moisture and maximum soil temperature to activate the watering module for a desired time period.

2) GSM Module: The GSM sim900 module includes an embedded transmission control protocol/Internet protocol stack to bring Internet connectivity, a UFL antenna connector, and subscriber identity module (SIM) socket.

3) Watering Module: The irrigation is performed by controlling a pump through relays connected to the microcontroller.

C. Android Application

A graphical user interface software was developed for real time monitoring of irrigation based on sensor data. The software enables the user to keep a check on the data from sensor units.

III. FLOWCHART

Figures show the mechanism of system. The fig. (2) represents the flow of operation of the wireless transmitter unit. The function of WTU is to acquire the values of moisture and temperature of the soil and to transmit them to the WRU via ZigBee module.

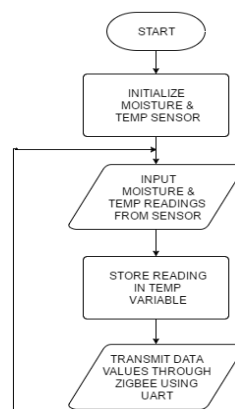


Fig. (2) Flowchart for WTU

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

The following figures show the operational flow of WRU. The WRU receives the soil moisture and temperature values sent by WTU via ZigBee module. These values are compared with the threshold values depending upon which the motor or pump is turned on.

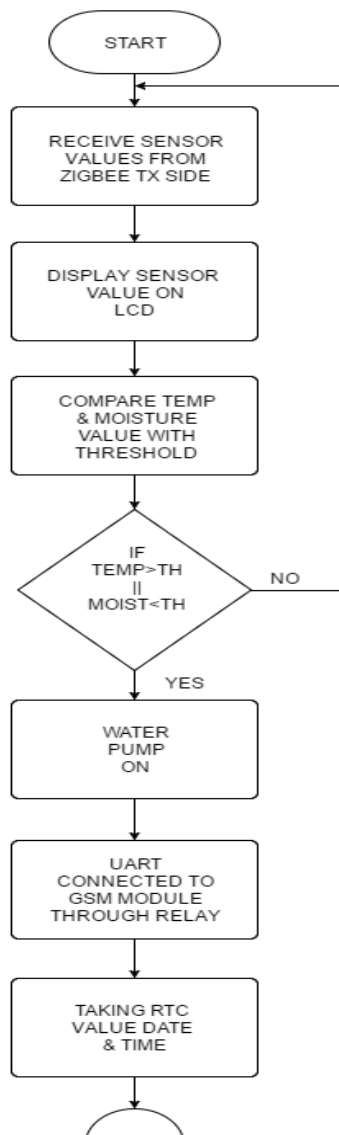


Fig. (3.1) Flowchart for WRU part 1

In the first part, the values of moisture and temperature are received from ZigBee transmitter side and displayed on LCD. These values are compared with threshold values depending on which the motor is to be turned on or off.

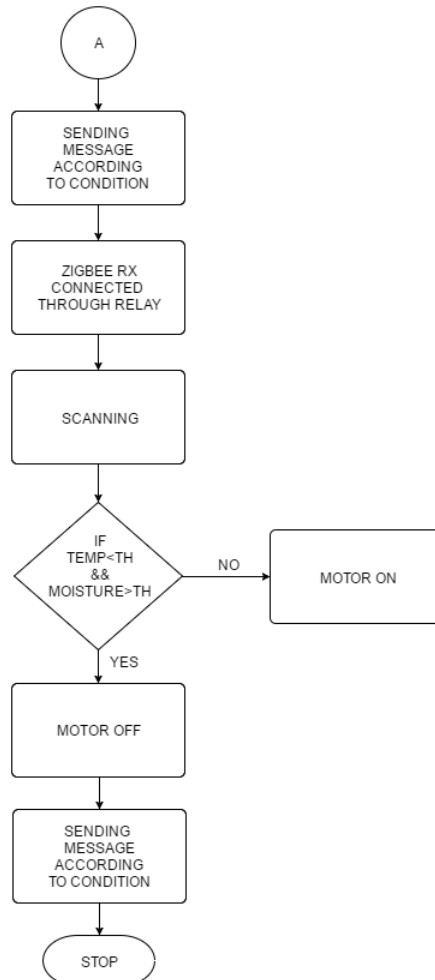


Fig. (3.2) Flowchart for WRU part 2

If the soil moisture value is below the threshold or the temperature exceeds the threshold value, then the motor is turned on till the levels of moisture and temperature are optimized. Otherwise the motor is off. The sensor values and motor status is displayed on an Android App. The screenshots of App are shown in the next section.

IV. RESULTS

The results of experiment are analysed using Android Application designed for the system. Fig. (4) and (5) are the screenshots of Android Application working. It displays the sensor values and status of motor. These values are viewed on the Android Application. It also displays the date and time at which the motor was turned on or off.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 5, May 2016



Fig. (4) Screenshot of Android App when Motor is turned ON

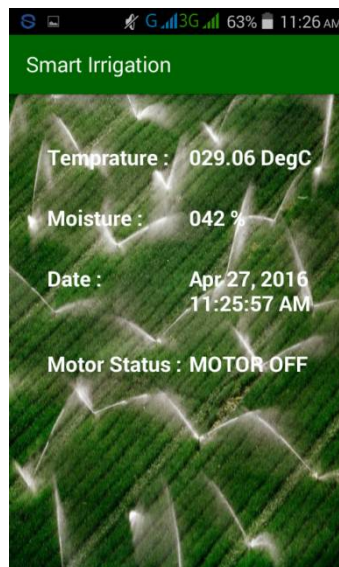


Fig. (5) Screenshot of Android App when Motor is turned OFF

V.CONCLUSION

The irrigation system implemented was found to be effective in minimizing water consumption in fields. As the water is supplied only near the roots of the crops and not the entire field, the problem of weeds is eradicated. The Android application enables the user to monitor the values of sensors. The preservation of natural resource can thus be done.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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