DESIGN & IMPLEMENTATION OF AUTOMATIC IRRIGATION SYSTEM USING WIRELESS SENSOR NETWORK & ZIGBEE MODULE

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ABSTRACT

The automatic Irrigation System (AIS) is the recent requirement in every part of agriculture in India. It is used to assist in the growing of agricultural crops, maintenance of landscapes and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. The automatic Irrigation System is a machine based system, which automates the irrigation of land by combining microcontroller, sensors, various software, hardware and latest wireless communication technology approaches together for field irrigation. This paper demonstrates implemented embedded system for automatic irrigation which has a wireless sensor network placed in the root zone of the plant for real time in field sensing and control of an irrigation system. Real time data is collected by wireless sensor nodes and transmitted to base station using zigbee. Data is received, identified, saved and displayed at the base station and if it exceeds the desired limit then it will be controlled by android smart phone through GSM network.

KEYWORDS: automatic irrigation, wireless sensor network, zigbee, GSM module, android, sensors, microcontroller.

INTRODUCTION

The irrigated agriculture is one of the primary water consumers in most parts of the world. The irrigation is the artificial application of water to the soil for assisting in growing crops. It is used to assist in the growing of agricultural crops, maintenance of landscapes and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Irrigation system is critical in the development of agriculture of every country. It has been established that efficient irrigation processes has the potential of literally doubling the amount of food a farm processes. Integrating modern technologies in irrigation management systems is one of the ways of enhancing the irrigation processes to optimize the use of water, electric power consumption, and labor costs. The success of irrigation management systems however, depends on the timely application of the water required to meet the water needs of the crops. The timing for watering farmlands is also influenced by factors such as rainfall, soil moisture level, characteristics of the soil composition, and nature of crops. Another important factor that is critical to irrigation management system is the scheduling plan or timetable system, which is mostly developed to maximize crop production with minimal water wastage [3].

Also there is an urgent need for a system that makes the agricultural process easier and burden free from the farmer's side. With the recent advancement of technology it has become necessary to increase the annual crop production output of our country India, an entirely agro-centric economy. The ability to conserve the natural resources as well as giving a splendid boost to the production of the crops is one of the main aims of incorporating such technology into the agricultural domain of the country. To save farmer's effort, water and time has been the most important consideration. Hence systems need to be designed to provide this ability efficiently using wireless sensor networking, automatic irrigation, GSM, SMS technology, zigbee technology and readily available android smart phone devices is a certain help to the farmers to get better yield on a large scale and thereby increasing the agricultural wealth and the economic growth of our country [5].

In this project, a wireless sensor network based intelligent system is implemented and applied for monitoring of soil, temperature and humidity. The network consists of sensing station and a weather station. Each of the sensing station contained data logger, a soil temperature sensor and zigbee communication. The development of WSN based on microcontrollers & communication technologies can improve the current methods of monitoring to support the response in real time. The aim of implementation was to demonstrate that the automatic irrigation system can be used to reduce water use. The soil moisture & temperature sensors deployed in plant root zones. The sensor measurements are transmitted to a microcontroller based receiver. When we are receiving this information from the wireless sensor network we want to monitor the parameters & control these parameters wirelessly form remote station by using android smart phone [1], [2].

IMPLEMENTATION

AUTOMATIC IRRIGATION SYSTEM AND SYSTEM DESCRIPTION

Fig. 2.0 shows Configuration of the Automatic Irrigation system, i.e. the whole system architecture, which consists of two components, wireless sensor units (WSUs) and a wireless information unit (WIU), and linked by radio transceivers that allowed the transfer of soil moisture and temperature data, implementing a WSN that uses ZigBee technology. The WIU has also a GSM module to transmit the data to a smart phone via the public mobile network [1], [2].

THE IMPLEMENTATION OF AIS CONSISTS OF FOLLOWING THREE MODULES

Module1: It consists of implementation of wireless sensor unit. The hardware of this unit includes 8 bit PIC 16F877 microcontroller, simple zigbee module, LM 35 temperature sensor, SY-HS-220 humidity sensor & soil moisture sensors, MAX 232 & 16×2 character LCD module. These components were selected to minimize the power consumption for the implemented application.

Firstly Circuit schematics for wireless sensor unit made by orcad software design tool then the power supply, ADC & serial communication used were simulated by ISIS proteus software. Then PCB layout design prepared by protel software. Coding for PIC 16F877 microcontroller is done by using MPLABX software. Once the PCB completed, Components are soldered & mounted on it. In this way wireless sensor unit was implemented.

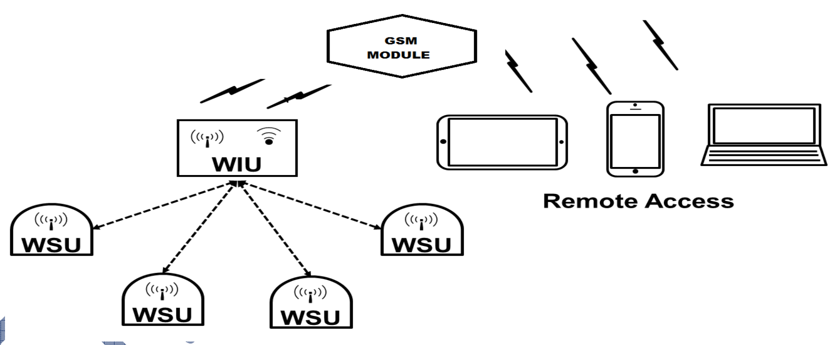

FIG 2.0: Configuration of the Automatic Irrigation system

Module2: It consists of implementation of wireless information unit. The hardware of this unit includes master microcontroller LPC 2138, GSM module SIM 900, simple zigbee module, MAX 232 & 16×2 character LCD module. Similar to WSU, circuit schematics for wireless information unit made by orcad software design tool & PCB layout design prepared by protel software. Coding for LPC 2138 microcontroller done by using Keil µ vision 4 software. After successful implementation of the WIU, the data transmitted by transmitter are received, identified, recorded at the receiver & it will display the parameter.

Module3: At the receiving end measure all parameter continuously, monitor & controlled. It consists of implementation of android app using App inventor. The app inventor is a visual, drag & drop tool for building mobile apps on the android platform. After successful implementation of android app in the android smart phone, if we set the threshold value of parameters in the mobile & start the system. Then it will read the parameters if soil moisture contains less than the threshold, it indicates that there will be requirement of water for the plants. Then DC pump will turn on & if the sensed value is above a certain limit then pump switches off. In this way the total automatic irrigation system using wireless sensor network & GSM module was implemented.

HARDWARE DESIGN OF WSU

A WSU is comprised of a RF transceiver, sensors, a microcontroller, and power sources. Several WSUs can be deployed in-field to configure a distributed sensor network for the automatic irrigation system. Each unit is based on the microcontroller PIC16F877 that controls the radio modem ZigBee and processes information from the soil-moisture sensor and the temperature sensor [2].

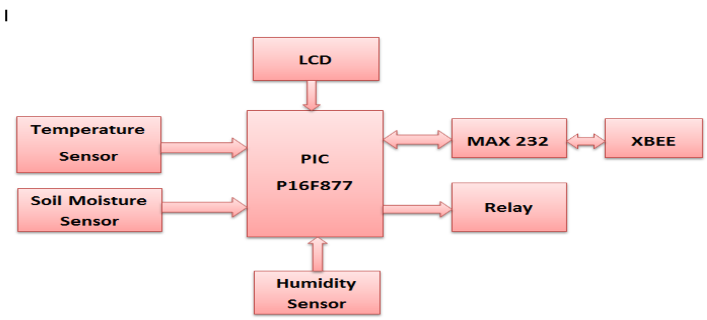

FIG 2.1: Block diagram of the Wireless Sensor Unit

PIC16F877 MICROCONTROLLER:

Microcontroller is the heart of this circuit. The microcontroller used is PIC, PIC16F877, 40 pin, 8 bit CMOS flash microcontroller of Microchip Company. It operates in a range 2.0 to 5.5 V at 20 MHz with internal oscillator. It requires only 35 single word instructions to learn. It has power on reset, power up timer, watchdog timer, programmable code protection & power saving sleep mode. The microcontroller is well suited for this remote application, because of its low-power consumption, high speed CMOS flash technology & wide operating voltage range.

ZIGBEE MODULES:

The zigbee is a RF modem with integrated chip antenna, 20-pins, and 13 general purpose input/output (GPIO) ports available of which four are for ADC. The zigbee RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART or through a level translator to any serial device. It was selected for this sensor network because of its low power consumption & greater useful range in comparison to other wireless technologies [4].

SENSORS USED [2]:

Parameter	Temp. sensor	Humidity sensor	Soil moisture sensor
1) Type	LM 35	SY-HS-220	SMS using rods
2) Functions	Sense the temp.	Convert humidity to voltage	Measure soil moisture content
3) Operating temp.	-55°C to 150°C	-30°C to -85°C	-40°C to 60°C
4) Features	1) Ext. calibration not required	1) Humidity range: 30-90 % RH	1) Range: 0 to 150%
	2) Low cost	2) Accuracy= ±5 %	2) Accuracy= ±4 %
	3) Low impedance output	3) Less Current consumption	3)Power: 3mA@5VDC
	4) Operates from 4V to 30V	4) Rated voltage: DC 5.0V	4) Resolution: 0.05 to 0.4%

Table1 : Sensors used & its features

HARDWARE DESIGN OF WIU:

The WIU consists of a master microcontroller ARM7 LPC2138, a zigbee radio modem, a GSM module SIM900 and MAX-232 interface. The functionality of the WIU is based on the microcontroller, which is programmed to perform diverse tasks. The WIU is ready to transmit the data via zigbee for each WSU once powered. Then, the microcontroller receives the information package transmitted by each WSU that conform the WSN [2].

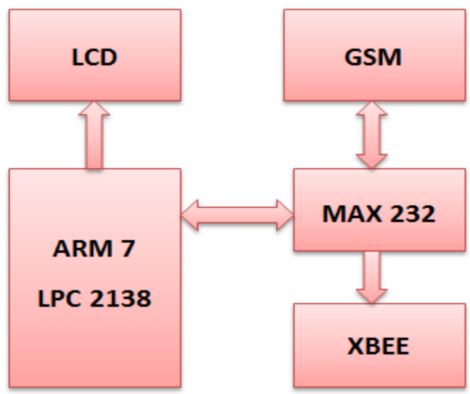

FIG 2.2: Block diagram of the Wireless Information Unit

MASTER MICROCONTROLLER ARM7LPC 2138:
ARM7 LPC 2138 is very well suited for communication gateways and protocol converters, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit 8 channel ADC(s), 10-bit DAC, PWM channels and 47 GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for this control system.

GSM MODULE SIM900:
The SIM900 delivers GSM/GPRS 850/900/1800/1900 MHz performance for voice, SMS, data, and fax in a small form factor and with low power consumption. It has an embedded powerful TCP/IP protocol stack, Weight: 3.4g, control via AT commands, SIM application toolkit, operation temperature:-30 °C to +80 °C, different interfaces like analog audio interface, RTC backup, SPI interface, I2C, GPIO & serial interface.

WORKING
The system works in two parts:
1) Transmitter 2) Receiver

TRANSMITTER:
Initially when power is on, signals are read by different sensors like temperature, humidity, soil moisture and its output is given to microcontroller. Output of microcontroller from sensors is taken through ADC pins and then it is given to zigbee module through Rx & Tx pins. Then it will transmit these data wirelessly to the receiver side [2].

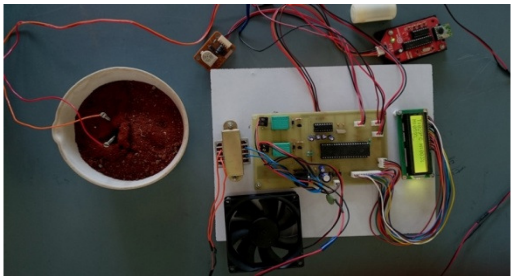

FIG. 3.1: Prototype of Transmitter

RECEIVER:

At receiver side both GSM & zigbee come into picture. The data transmitted by transmitter are received at the receiver & it will display the parameter. It is possible to made no. of slave unit. In this project, I have implemented two slave units. At the receiver both slave units parameter will be displayed. Then these parameters are transmitted to smart phone by using GSM module. This is how total working takes place of automatic irrigation system [2].

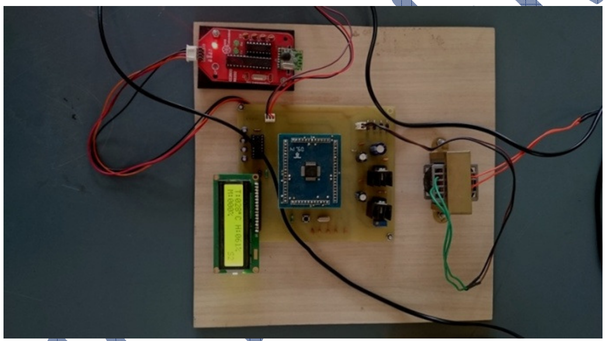

FIG. 3.2: Prototype of Receiver

The total hardware implementation of WSU & WIU with GSM module is shown in Fig.2.3

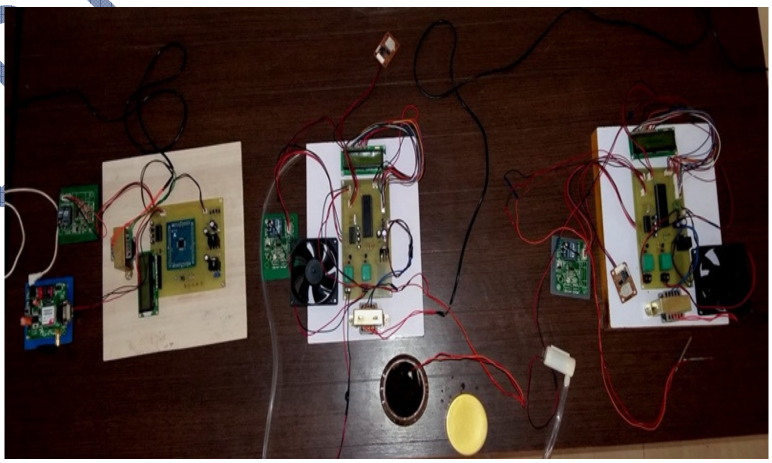

Fig 3.3: Hardware setup

SOFTWARE DETAILS & SIMULATION:

SOFTWARE DETAILS:

MPLAB X IDE software used for coding of PIC microcontroller because it supports editing, debugging & programming of microchip 8 bit, 16 bit & 32 bit PIC microcontrollers. It is used in this project because it supports multiple configuration, multiple debug tools, hyperlinks for fast navigating & live code templates. [2]. The programming in C language that will convert in assembly language program using Keil µVision4 compiler. It is basically used for coding of ARM7 microcontroller. it is easy to learn & use, yet powerful enough for most embedded applications hence it is used in this project [2].Protel 99SE is the latest version of protel's integrated board level design system used in this project to build PCB layout. It gives fast application & design document opening, more responsive performance & more efficient memory usage. Orcad software tool suite used primarily for electronic design automation. In this implemented project version 9.1 of the orcad suite is used to create circuit schematics. It includes a schematic editor, a circuit simulator and a PCB designer. In orcad 9.1 a project manager format is used. Capture is the head unit from which all schematic work is done.

SIMULATION

Proteus is one of the most famous simulators used to simulate almost every circuit on electrical fields. It is easy to use because of the GUI interface. It provides a powerful, integrated and easy to use suite of tools for professional [2]. The schematic view of serial communication used is shown below:

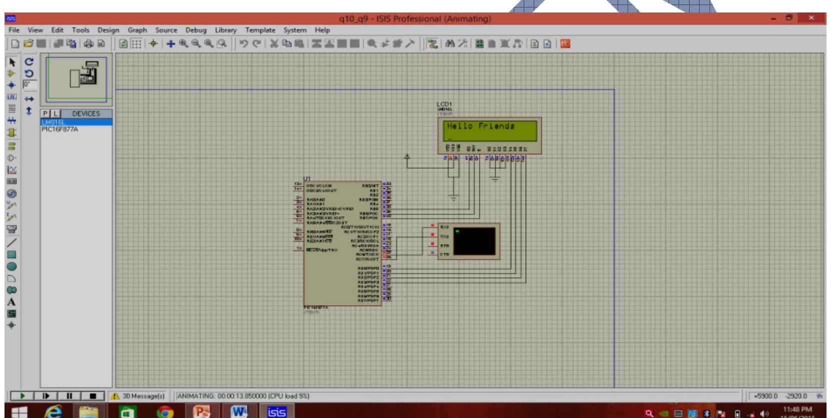

Fig 4.1: ISIS Schematic view of serial communication

RESULT & DISCUSSION

When the system is turned on then the wireless sensor unit sensors like temperature, humidity and soil moisture will sense all their parameter and display on LCD. Then these parameters are transmitted wirelessly to the receiver or wireless information unit through zigbee. The wireless information unit will receive all the parameter, identify it and display both the wireless sensor unit parameter. Then these parameters are transmitted on the android smart phone by using GSM module. The app inventor is a visual, drag & drop tool for building mobile apps on the android platform. App inventor is used to design the user interface of an app using a web-based graphical user interface builder, and then it specifies the app's behavior by piecing together "blocks". The app is a text "answering machine". It is possible to immediately see & interact with the app building on the phone [2].

The system provides the controlling mechanism by using android mobile. If we set the threshold value of parameters in the mobile & start the system. Then it will read the parameters, if soil moisture contains less than the threshold, it indicates that there will be requirement of water for the plants. Then the DC pump will turn ON otherwise pump switches OFF. Similarly if we set the threshold value of temperature & actual temperature is greater than the threshold value then FAN will be turned ON otherwise it will OFF [2]. The Automatic Irrigation System with controlling mechanism & corresponding status of FAN & PUMP is shown in Fig 5.1

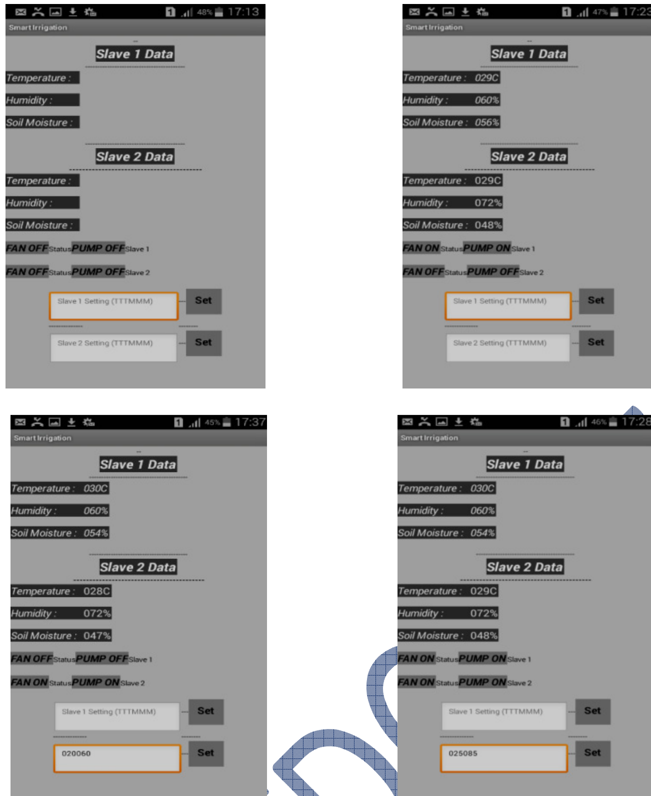

Fig 5.1: Smart phone with controlling mechanism

In Fig 5.1 C, the actual parameter values sensed by slave1 unit are temperature 30°C, humidity 60% & soil moisture 54%. Similarly slave 2 unit values are temperature 28°C, humidity 72% & soil moisture 47% respectively. Then the set threshold values for slave2 data are temperature 20°C & soil moisture 60%. Hence the actual temperature is greater than the set temperature & actual soil moisture is less the set soil moisture value so both the FAN & PUMP will be turned on. This corresponding status is shown in Fig 5.1 D.

CONCLUSION

The implemented automatic irrigation system developed proves that the use of water can be diminished & it has some advantages such as it saves time of farmer, can be adjusted to variety of specific crop needs. It was found to be feasible & cost effective for optimizing water resources for agricultural production. This system has an advantage of using both GSM & zigbee technology which eliminates the cost of network usage to a great extent. By using Zigbee technology it is possible to send as well as receive all the information easily. The microcontroller based this irrigation system using wireless techniques monitor the activities of irrigation system efficiently. The configuration of the irrigation system allows it to be scaled up for larger greenhouses or open fields. It supports water management for agricultural, horticultural lands, parks, gardens irrigation. Thus, this system is reliable & efficient when compared to other type of irrigation system.

ACKNOWLEDGEMENTS

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