AUTOMATED IRRIGATION SYSTEM USING WSN AND GPRS/GSM

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ABSTRACT

Fresh water is the basic need of living organisms on earth. The fresh water is consumed by living beings to be alive including plants and animals. The amount of fresh water available is limited. Also; population has increased as compared to available water and food resources. Agriculture consumes about 85% of the total fresh water quantity available and hence, there is an urgent need to create strategies based on science and technology for sustainable use of water, including technical, agronomic, managerial & institutional improvements. There are many systems using various techniques to achieve water savings in various agricultural practices. The system using remote access and wireless communication is discussed in this paper. The system explained here is a network of wireless sensors and a wireless base station to process the sensor data to automate the irrigation system. The sensors are soil moisture sensor, air and soil temperature sensor. The Base station microcontroller is programmed such that if the either soil moisture or temperature parameters cross a predefined threshold level, the irrigation system is automated, i.e. the motor relay that is connected to water pump, switches to ON otherwise OFF. The system will have a distributed wireless network of soil-moisture and soil temperature sensors, placed in the root zone of the plants. An atmospheric temperature sensor is used to measure atmospheric temperature in field. In addition, a gateway unit will handle sensor information, trigger actuators, and transmit data to a control station. An algorithm with threshold values of soil temperature and soil moisture will be programmed into a microcontroller-based gateway to control water motor switching to supply water based on the information collected. The system will be powered by solar panels (Optional for prototype). This system can achieve water savings up to as much as 70% compared with traditional irrigation practices used. Because of its energy autonomy and low cost, the system has the potential to be useful in water limited geographically isolated areas.

Keywords: *Wireless sensors, soil moisture sensor, Soil temperature sensor, Wireless Base station, sensor data.*

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1. INTRODUCTION

The sources of fresh water present on earth are limited. The sources include underground and ground surface sources. These are rivers, lakes, wells etc. The 97% of water on earth is in form of oceans and is saline water. The total fresh water is about only 2.6% & 0.6% available for use for living beings. The 2% of fresh water is inaccessible in form of polar ice. Thus, the water present for use to survive on earth is limited. If water is not properly utilized, the coming next generations will have to struggle to survive. Hence it's high time to conserve water implementing different strategies and with help of science and technology the task is easy and fast. There are number of systems and a lot of research work being done since last decade on the water conservation techniques. Also electronics field has boosted in recent years. Hence we can think for electronic system to be used in all strategies for water management to save used water. Agriculture is largest user of fresh water so water management is essential in agriculture. The wireless sensor network can be used to save water used for agriculture.

1.1 Literature survey

There are many systems to achieve water savings in various agricultural practices. For example, one system plant water status was monitored and irrigation scheduled based on canopy temperature distribution of the plant, which was acquired with thermal imaging [2]. Some systems have been developed to schedule irrigation of crops and optimize water use by means of a crop water stress index (CWSI) [3]. The empirical CWSI was first defined over 30 years ago [4]. CWSI was later calculated using measurements of infrared canopy temperatures, ambient air temperatures, and atmospheric vapour pressure deficit values to determine when to irrigate broccoli using drip irrigation [5].

A system was used for malting Barley cultivations in large land with decision software integrated with an infield wireless sensor network (WSN) which controlled a machine that controlled sprinkler nozzles. This system had five sensing stations each contained a data logger with two soil water reflectometers soil temperature sensor, GPS and Bluetooth communication [6]. Other system monitored crop conditions by means of soil moisture and soil, air and canopy temperature measurement in cropped fields. Handheld computer connected via a serial port was used for data downloading, analysis and storage [7].

Another system that showed effective water management by monitoring drainage water using lysimeters, WSN and a weather station for internet monitoring [8]. There are systems that have hybrid structures with wireless modules inside greenhouse with great flexibility and wired modules outside area as actuator controllers [9]. WSN using microcontrollers and communication technologies can improve present methods of monitoring to improve response in real time [10],considering the need of deployed area, such as terrestrial, underground, underwater, multimedia and mobile [11]. WSN used in agricultural applications are used to collect data for appropriate management, such as

weather, soil moisture content, soil temperature, soil fertility, mineral content, and weed disease detection, monitoring leaf temperature, moisture content, and monitoring growth of the crop, automated irrigation facility and storage of agricultural products [12]-[14].

Presently, WSNs available are ranging from limited and low-resolution devices with sensors and embedded processors to complete and expensive acquisition systems that support diverse sensors and include several communication features [15].

Recent advances in microelectronics and wireless technologies created low-cost and low-power components, which are important issues especially for such systems such as WSN [16]. Power harvesting depends on ambient energy sources, including environmental vibration, human power, thermal, solar, and wind that can be converted into useable electrical energy [17]-[19]. In a wireless node radio modem is major power consuming component recently wireless standards have developed with Medium access

Protocols to provide multitask support, data delivery, along with energy efficiency performance [20], such as the standard IEEE 802.15.4 [ZigBee] [21]. An automated irrigation system was developed to optimize water use for agricultural crops using WSN and GPRS module [22].

1.2 Block diagram

The project discussed here is prototype model. The system is composed of hardware and software. The software is decision making and is used to program the microcontrollers at the sensor station and control station. There are two wireless sensor stations and one wireless control station and are separately programmed according to their functions to be performed. The hardware also is different for wireless sensor station and wireless control station. The project can be divided into Hardware and software. The following sections discussed give the hardware and software details. The system includes two wireless sensor units WSU1 & WSU2 and one wireless control unit WCU.

1.2.1 Wireless sensor unit

Wireless sensor station comprises main components having PIC18F4550 microcontroller, input sensors including soil moisture sensor, soil temperature sensor and air temperature sensor, Relays, LCD display and power supply. Figure2 shows block diagram of WSU. The figure 2 shows block diagram of Wireless sensor unit. The figure2 shows following blocks, viz. soil temperature sensor, air temperature sensor and soil moisture sensor, microcontroller unit, ZigBee RF transreciever, power unit, LCD, RS232. A WSU consists of RF transreciever, sensors, and microcontroller and power sources. Several WSU's can be deployed in – field to configure a distribute sensor network each unit has a PIC18F4550 microcontroller, that controls the radio ZigBee S2 Series modem. It processes information from soil moisture sensor and soil temperature sensor deployed at the root zone of the crops and LM 35 DZ temperature sensor to measure air temperature. All the components are powered by power supply source. The figure2 shows following blocks, viz. soil temperature sensor, air temperature sensor and soil moisture sensor, microcontroller unit, ZigBee RF transreciever, power unit, LCD, RS232. A WSU consists of RF transreciever, sensors, and microcontroller and power sources. Several WSU's can be deployed in – field to configure a distribute sensor network each unit has a PIC18F4550 microcontroller, that controls the radio ZigBee S2 Series modem. It processes information from soil moisture sensor and soil temperature sensor deployed at the root zone of the crops and LM 35 DZ temperature sensor to measure air temperature. All the components are powered by power supply source.

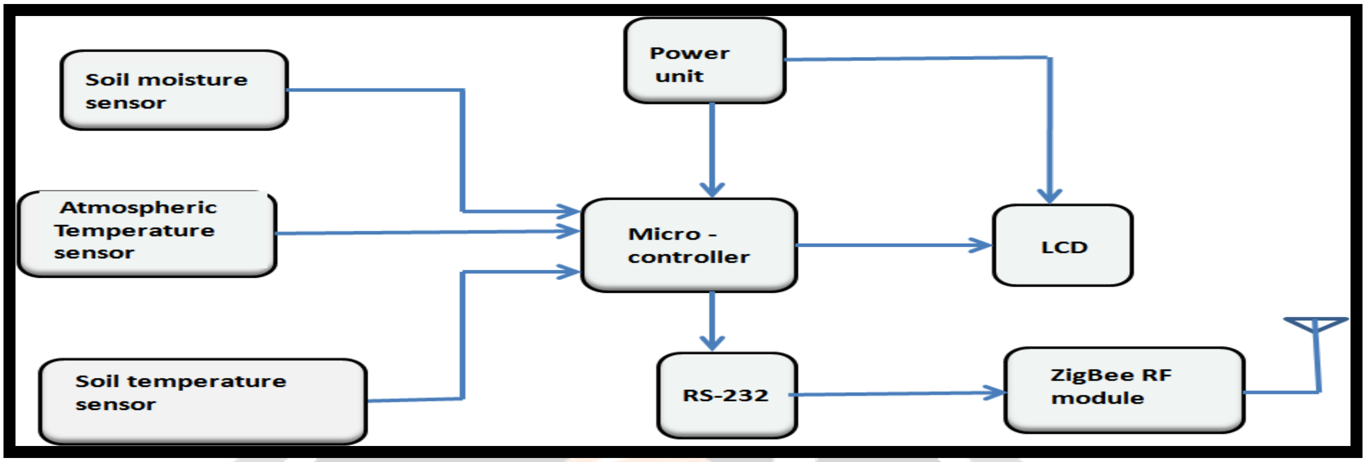


Figure 1. Wireless sensor unit.

1.2.2 Wireless control unit

The soil moisture and temperature data from each WSU are received, identified, recorded, and analysed in the Wireless control unit. The WCU shown in figure8 consists of a master microcontroller PIC 18F4550, GSM module, LCD display, Relays, Max 232, ZigBee module power supply. The microcontroller, ZigBee module, LCD display, Max 232, power supply used in wireless sensor unit are the same as that used in wireless control unit. The transmitted field parameters from open field via transmitting ZigBee module are received by base station by using ZigBee receiving section. Microcontroller links forward data towards the LCD display unit and again it is carry forward to the webpage or users mobile phone via GSM network that has been implemented by GSM module. User can initiates the controlled commands for field parameters against the detected thresholds. The microcontroller compares data received data from all sensors with the framed look up table. The comparison between the input values with pre-set values stored in its memory & comes out with the resulting action to be switching. If the threshold values of either soil temperature or soil moisture are crossed, then relay connected to pump motor switches ON/OFF. And air temperature is displayed on LCD. The thresholds are set for soil moisture and temperature and air temperature. The lower threshold for soil moisture is 25%,the upper threshold is 40%,the soil temperature threshold is 40^0C.The air temperature threshold is 40^0C.

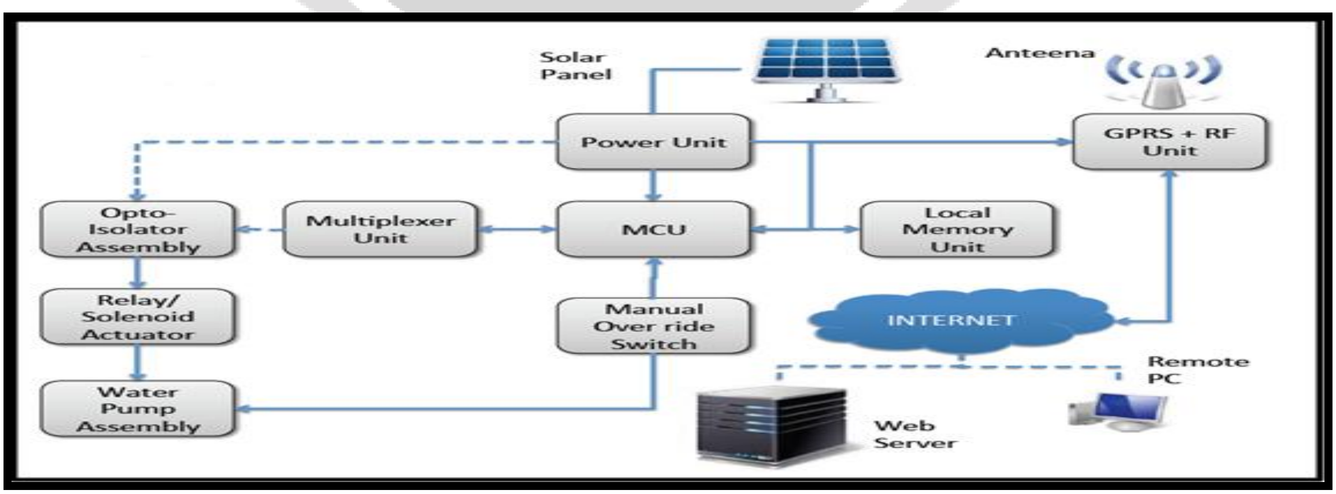


Figure 2. Wireless control unit.

2. SOFTWARE DETAILS

The software deals with framing the look up table and comparing the input values with pre-set values & coming out with the resulting action to be switching. The Microcontrollers are programmed using Basic language using MPLAB IDE and simulation using Proton IDE. The PCB design, testing and simulations are done by using Proteus professional software. The web page is designed using html. Following sections show the detailed flow charts used to program the microcontrollers.

2.1 Algorithms

The algorithm is different for wireless sensor unit and wireless control unit. They are shown by flowcharts. They are explained as following sections

Software required

MPLAB IDE, Proteus professional 8.0, Proton IDE v8.3.

Language: Basic

Algorithm for wireless control /Interface unit

Algorithm for microcontroller of Wireless control unit :

1. Power ON the WCU and WSU.
2. Initialize all the peripherals, GSM.
3. Send command to WSU1 and then after WSU1 send to WSU2 for sending data from all sensors.
4. Firstly, pull sensor data from WSU1.
5. Display data on LCD then forward to web page and also simultaneously check for valid data for switching motor relay and valve 1 relay
6. If valid sensor data (Soil moisture is below 25% or soil temperature is above 40 °C along with soil moisture below 40%) is received than process the information. If valid data is received from WSU1 switch ON the relay motor and valve1.
7. If the data received from WSU1 is above 40% for soil moisture than switch OFF the valve1 relay (valve1 relay is switched OFF even if soil temperature is above 40 °C).
8. After data from WSU1 is processed and forwarded to web page, pull data from WSU2 and display it on LCD then forward it to web page and simultaneously check for valid data for switching motor relay and valve 2 relay.
9. If valid sensor data (Soil moisture is below 25% or soil temperature is above 40 °C along with soil moisture below 40%) is received than process the information. If valid data is received from WSU2 switch ON the relay motor and valve2.
10. If the data received from WSU2 is above 40% for soil moisture than switch OFF valve 2 Relay (valve 2 relay is switched OFF even if soil temperature is above 40 °C). Motor is switched OFF if both valves are OFF.
11. After this step go to step 3 for new command from WCU for new data from both WSU1 and then WSU2.

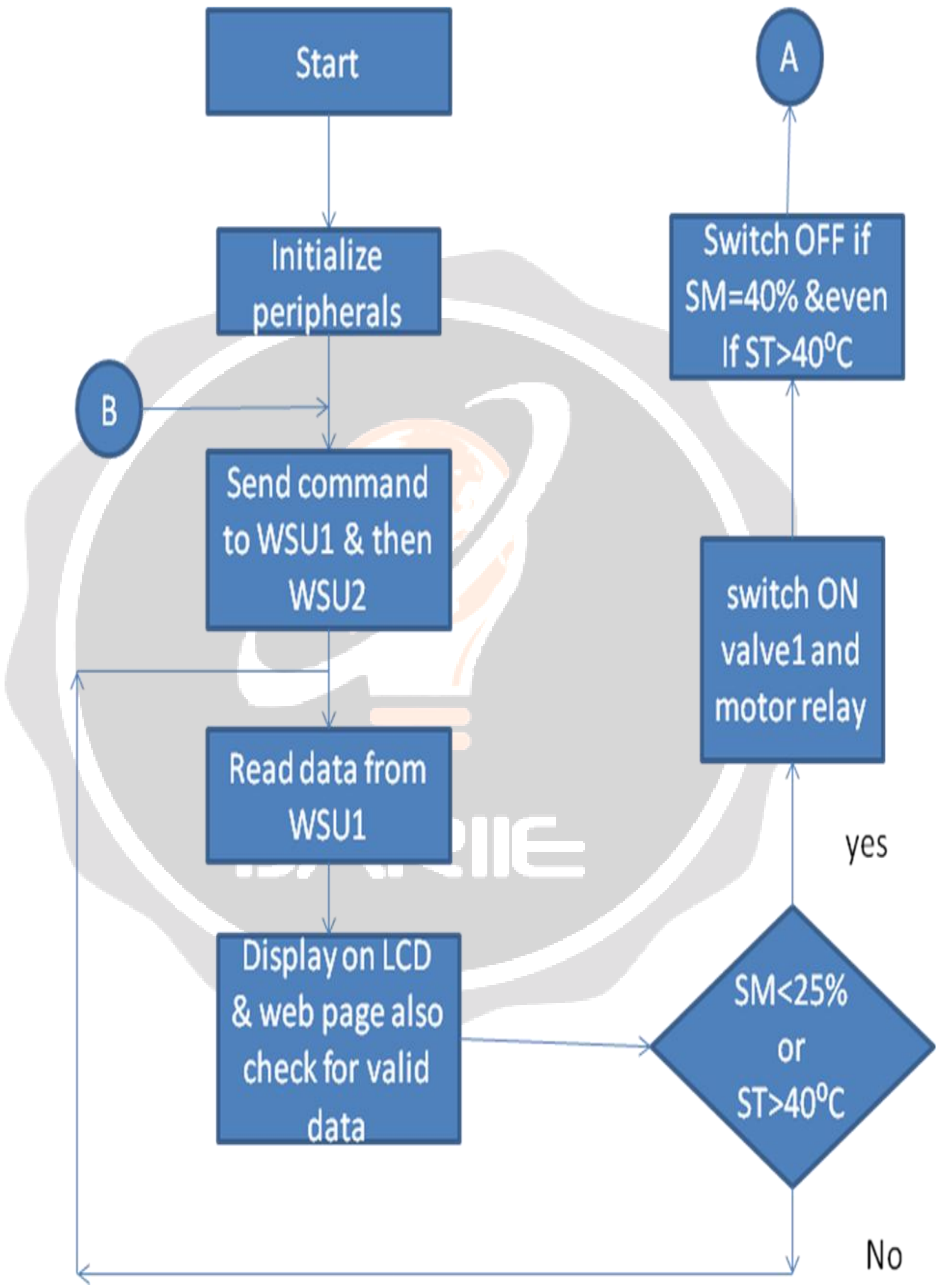
Algorithm for microcontroller for both wireless sensor unit:

1. Initialize all the peripherals.
2. Start the timer.
3. Poll the timer flags.
4. Read soil temperature then air temperature and lastly soil moisture values.
5. Wait for command from WCU for 5 seconds for one set of above sensor values.
6. If any command for sensor data from WCU is received by WSU within 5 sec., then send all sensor data to WCU. If not go to step 4.

2.2 Flowcharts

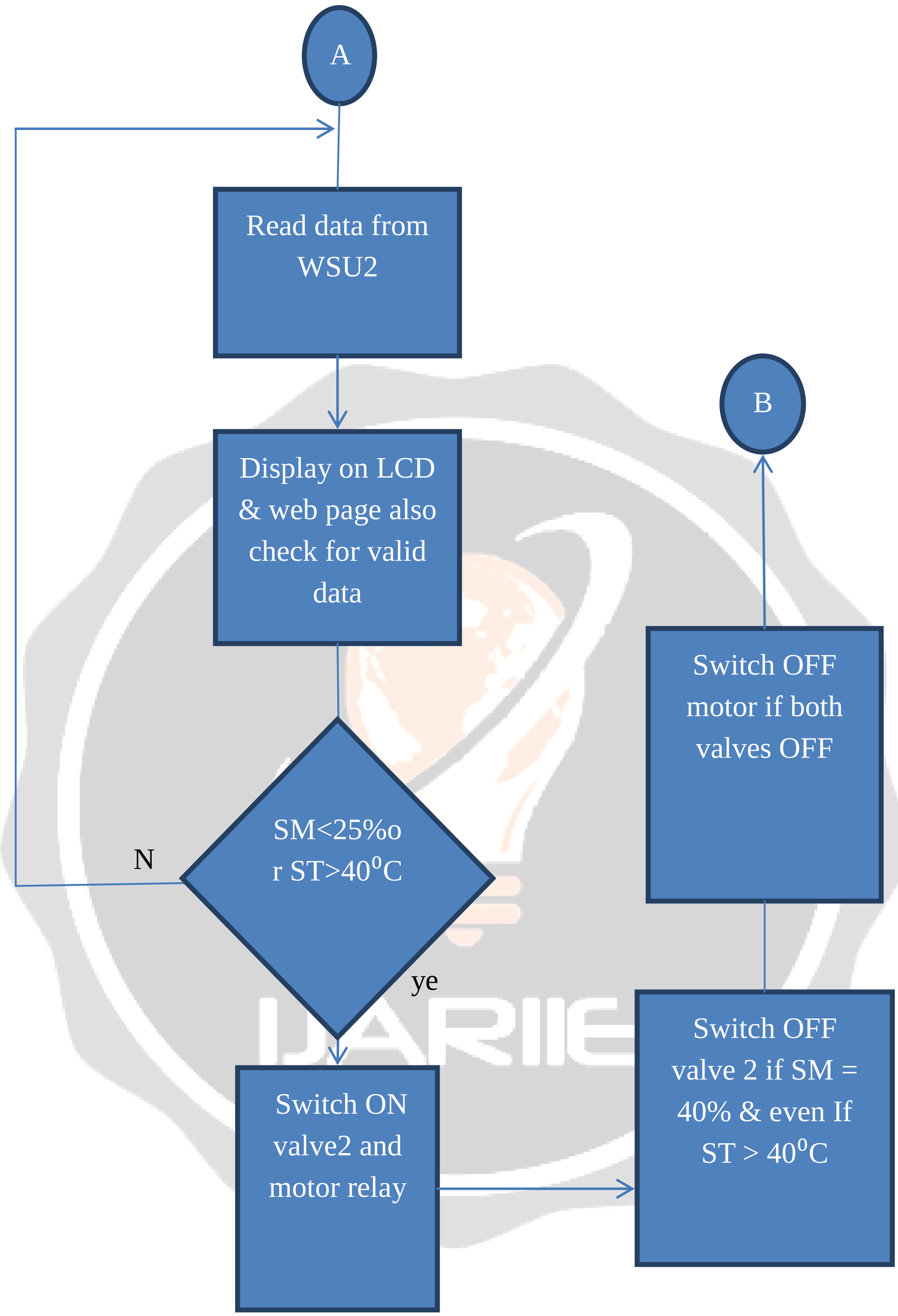
The flowcharts for WCU & WSU are as follows

Flow Chart for WCU



SM – soil moisture; ST – soil temperature

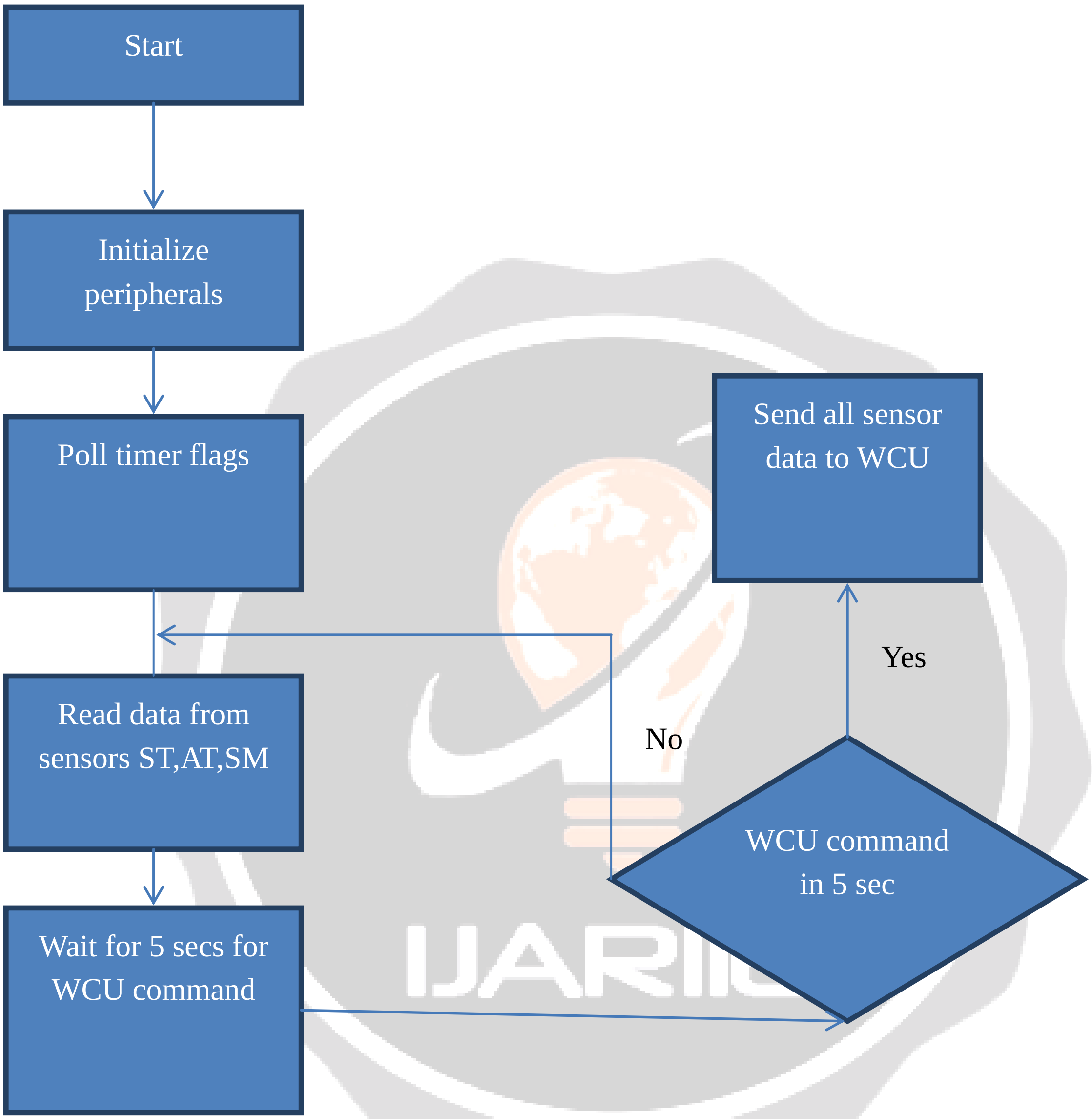
Figure 3. Flowchart for WCU.



SM – soil moisture; ST – soil temperature

Figure 4. Flow chart for Wireless control /Interface unit

Flow chart for wireless sensor unit

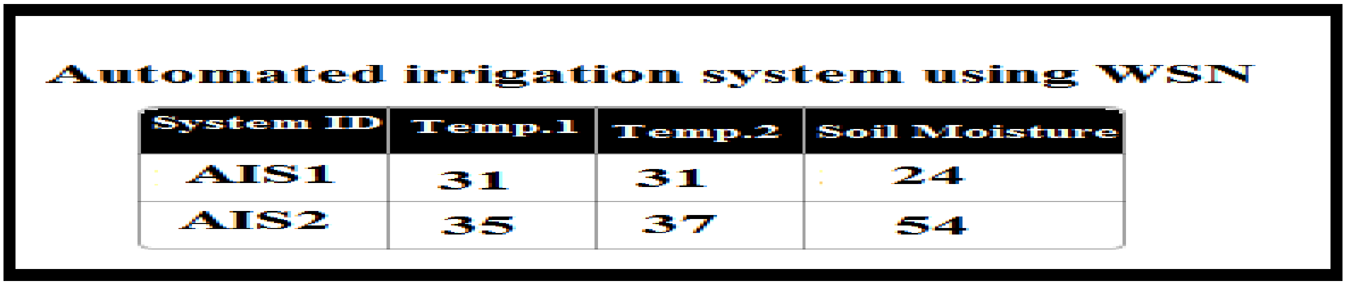


SM – soil moisture; ST – soil temperature; AT – air temperature

Figure 5. Flow chart for Wireless Sensor unit.

3. WEB APPLICATION

Graphical user interface software was developed for real time monitoring of irrigation based on soil moisture and temperature data. The software application permits the user to visualize the data from each WSU online. The web application was coded in HTML language. Figure 1 below shows Information displayed on web page. The sensed data results can be accessed in real time by following web address http://soil.jvt.co.in/.



Automated irrigation system using WSN

System ID	Temp.1	Temp.2	Soil Moisture
AIS1	31	31	24
AIS2	35	37	54

Figure6. Web page

The web page shows sensor ID as AIS 1 and AIS 2 for WSU1 and WSU2, respectively.

4. OBSERVATIONS

The PIC microcontrollers are programmed according to their functions. The PIC processor at WSU is programmed for sensing data from time to time, transmitting/receiving data over RF module to WCU. The PIC Processor at WCU is programmed for processing valid data received from WSU and then forwarding that data to web server. If the data obtained from WSU shows that soil moisture at minimum level of 25% then output of soil moisture sensor is 1.9V. If moisture falls below 25% i.e. 1.9 v the motor relay switches to ON. If the data received from soil moisture sensor is 1.9 V to 3.4 V, it is optimum moisture. The motor is ON till 3.4 V output. When excess water is given to soil then output voltage of moisture sensor is above 3.4 V up to 4.2 V. When moisture sensor voltage crosses 3.4 V (i.e. above soil moisture 40%), the motor is OFF. If the received valid data from WSU contains soil temperature is above 40 °C and if soil moisture is below 25% soil moisture, then the motor relay switches to ON. When the motor relay is ON the LED connected at the output of respective relay glows. If the soil is moist up to 40% the relay of motor is not switched to ON, even if soil temperature is above 40 °C The air temperature is displayed at each sensor unit board.

Table 1. Observations

WSU1 ST (°C)	WSU1AT (°C)	WSU1SM (%)	WSU2ST (°C)	WSU2AT (°C)	WSU2SM (%)	WCU Valve1	WCU Valve2	WCU Motor
40	41	24	40	41	20	ON	ON	ON
31	31	24	35	37	24	ON	ON	ON
33	34	30	35	37	30	OFF	OFF	OFF
31	33	45	33	35	41	OFF	OFF	OFF
41	33	27	40	33	28	ON	OFF	ON

5. RESULTS AND CONCLUSION

The water is saved using this system. This is because the drip system is automated. The water is supplied to crops when soil has minimum moisture or maximum bearable air temperature. Thus, the crops can save from drying. The system also saves time, energy and money to supply water to plants. This system discourages weed growth since water is provided only to root zone of plants. This also avoids soil erosion in farms and avoids nutrient runoff in soil due to over irrigation. Since water is available at root zone and stays for longer time, using this system crops grow properly as compared to other irrigation systems. Also system helps in controlling fungal diseases, as fungal diseases grow in wet foliage. The automated irrigation system implemented will be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system will allow cultivation in places with water scarcity thereby improving sustainability. The automated irrigation system developed will prove that the use of water can be diminished for a given amount of fresh biomass production. Other benefits of the system are that it operates with less manpower. The system is more advantageous to the farmers residing away from farm or is out of station. This system saves money as it avoids drying/dying of plants. The system is adaptable to programming to requirements of crop growth and season.

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