DEVELOPMENT OF WIRELESS SENSOR NETWORK FOR IRRIGATION CONTROL

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PROJECT REPORT

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DECLARATION

We hereby declare that this thesis entitled "Development Of Wireless Sensor Network For Irrigation Control" is a bonafide record of project work done by us during the course of project and that the thesis has not previously formed the basis for the award to us of any degree, diploma, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report entitled **"Development of Wireless Sensor Network For Irrigation Control "** is a record of project work done jointly by Ms.Swaliha N and Uttam Kumar Singh under my guidance and supervision and that it has not previously formed the basis for any degree, diploma, fellowship or associateship or other similar title of another University or Society.

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Swaliha N.

Uttam Kumar Singh.

DEDICATED TO THE GLOBAL FARMING COMMUNITY

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SYMBOLS AND ABBREVIATIONS

%	-	Percentage
Δt	-	Differnce between wet bulb and dry bulb temperature
°C	-	Degree Celsius
A	-	Ampere
A	-	Measuring humidity coefficient
AC	-	Alternating Current
ATMEGA	-	Atmel megaAVR series
Avg	-	Average
cm	-	centimetre
DC	-	Direct Current
DHT11	-	Digital Humidity and Temperature sensors
e.g	-.	Example
et al	-.	and others
etc.	-	etcetra
GIS	-	Geographical Information System
GSM	-	Granular Metric Sensors
i.e	-	that is
IDE	-	Integrated Development Environment
In	-	inch(es)
IWUE	-	Irrigation Water User Efficiency
KB	-	Kilobyte(s)
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
km	-	kilometre(s)
kPa	-	kilo Pascal
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
m/s	-	metre per second

mA	-	milli Amperes
MAD	-	Management Allowable Depletion
Max	-	Maximum
MHz	-	Mega Hertz
Min	-	Minimum
Min	-	minute(s)
Ml	-	millilitres
Mm	-	millimetre
No.	-	number
NPN	-	Negative-Positive-Negative
PAW	-	Plant Available Water
PCB	-	Printed Circuit Board

CHAPTER I

INTRODUCTION

Agriculture has been the most important practice from very beginning of the human civilization. It has seen many iterations of development in technology with time. A good agricultural practice is still an art. Environmental parameters such as soil moisture, temperature, humidity, pH, solar radiation etc. plays very important role in overall development of the plant. Temperature affects many of plant activities such as pollination, germination etc. It is observed that, at higher temperature, respiration rate increases that result in reduction of sugar contents of fruits and vegetables. At lower temperatures photosynthesis activity is slowed down. Humidity is responsible for moisture loss and temperature management of the plant. For high humid environment, evapo-transpiration will be less and more water will saturated in the leaf area. This results in enlargement and formation of fungus in the porous area of the leaf. Moisture is critical for seed germination and uptake of nutrients by the plant. Excess water may stop gaseous exchange between soil and the atmosphere which reduces root respiration and root growth. Optimum level of moisture ensures healthy growth of the root and overall development of the plant.

A sustainable approach is required to maintain balance between these parameters and environment. Hence there is a need of efficient monitoring and control system. In today’s era, the traditional methods that are used for irrigation, such as overhead sprinkler and flood type, is not that much efficient. They results in a lot of wastage of water and can also promote disease such as fungus formation due to over moisture in the soil. Automated irrigation system is essential for conservation of the water and indirectly viability of the farm since it is an important commodity. About 85% of total available water resources across the world are solely used for the irrigation purpose . In upcoming years this demand is likely to increase because of increasing population. To meet this demand we must adopt new techniques which will conserve need of water for irrigation process. In automation system water availability to crop is monitored through sensors and as per need watering is done through the controlled irrigation.

The advancement in the technologies has enabled the use of state-of-art technology at a reasonably low cost. Wireless sensor network (WSN) can be used in such system to enhance its monitoring capability by distributing sensors all over the field and monitoring environmental parameters remotely. WSN consist of small nodes which work on its own and has sensors embedded. They collect the data and transmit it over wireless medium to a central system where data from all the nodes is collected and processed.

“Arduino” is considered as the brain of wireless sensor network ,which can be simply called a tiny computer, consisting of a microcontroller board and its software. Arduino is a tool for making computers that can sense and control more of the physical world than a desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running on the computer (e.g. Flash, Processing, and MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE (Integrated Development Environment) can be downloaded for free.

The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

The present systems of automated irrigation work on the basis of calculating the required amount of irrigation based on the field conditions and crop requirements which have been observed over a few years in the past. Their major disadvantage is that they fail to work according to the varying conditions in the field, say, in the event of an unexpected drought or flood in a particular season. This is where the significance of real time sensing comes in irrigation automation. When there are sensors to detect the real time field conditions, automation can be programmed to be based on the varying parameters existing at the moment which affect irrigation.

Thus in simple words, development of wireless sensor network can be achieved by using suitable sensors for real time sensing of parameters, providing this as input data for Arduino, writing a program to express moisture content, temperature, humidity, etc based on sensor data and to display on LCD , assembling the sensors, Arduino board and its software putting these to work.

ZigBee is IEEE 802.15.4 standard technology, used for short range WSN with small, low-power digital radios. It was selected for battery operated sensor network because it is simpler, less expensive, low power consumption and greater useful range as compared to other wireless networks (WPANs) such as Bluetooth or Wi-Fi. ZigBee devices can transmit the data over long distance through mesh networking where intermediate devices are used to reach more distant ones. The ZigBee communication protocol is basically useful for low data rate applications such as control and monitoring systems that require long battery life, short range and secure networking. Low battery consumption, low cost, low data rate, and ease to implement are the main features.

Specific objectives are:

- To develop a low cost,low power wireless sensor network to monitor agricultural parameters such as moisture content ,humidity, temperature etc.
- To decide strategies for agricultural activities based upon the sensor data.

CHAPTER II
REVIEW OF LITERATURE

Automatic irrigation is the use of a device to operate irrigation structures so the change of water from one bay or set of bays to another can occur in the absence of irrigator. It can be used to start and stop irrigation through supply channel outlets ,to start and stop pumps ,to cut –off the flow of water from one irrigation area – either a bay or a section of channel directing the water to another area .These changes occur automatically without any direct manual effort ,but the irrigator may need to spend time preparing the system at the start of the irrigation and maintaining the components so it works properly

Vellidis, *et. al* (2007), presented the use of wireless sensors in the agriculture, this project shed light on the collection of information from rain gauges, soil moisture sensors and other devices, control equipment (start pumps, close gates, etc.) and how these motes will communicate with each other by using a wireless technology.

Kim, *et. al*. (2008), proposed an efficient water management based on distributed wireless sensor network for cropping systems. This system was electronically controlled by a programming logic controller that updates geo-referenced location of sprinkler from differential global positioning system and wirelessly communicates with a computer at the base station.

Ye and Wang(2009) have a WSN system which is based on IRIS mote hardware platform which consists of ATmega 128 microprocessor, a RF230 radio chip and external flash memory for over the air programming. The sensors are programmed to collect and deliver sensor data periodically.Sensor data is sent on an "event" basis, which means that whenever there is a sudden change in the environment, the sensor data is sent. However, the sensors are always"listening", i.e. they wait for changes in environment and report only once a drastic change is detected. These sensors are user-defined and act based on requirement. The sensors used are barometric pressure, ambient temperature,humidity, wind direction, wind speed, and rainfall sensors.Once data from all the nodes are collected, this information is transmitted to a local base station (ATmega 128) through multi-hop transmission . This data is stored in an embedded database SQLite3 and displayed on a web-page using TCP/IP.

Luis Ruiz-Garcia, *et.al.*(2009),presented a review of wireless sensor technologies and applications in agriculture and food industry. The project focus on WSN and RFID (Radio Frequency Identification), presenting the different systems available, including ZigBee based WSN.

Ruchi Mittal and Bhatia(2010) proposed a system in which they detect irregular patterns of sensory data with respect to time and space. They designed a system which continuously queries and monitors sensor data to detect any deviations from the norm. This is essential in detecting a faulty sensor node and ensuring it can be quickly replaced. This system is especially helpful when detecting environmental activity like forest fire. In order to achieve desired results, Data preprocessing and sensor data clustering is used. In data preprocessing,the sensor data is cleaned by putting in missing values and removing any unwanted data. Mittal and Bhatia analyze this data cluster by plotting data, comparing them against expected/predicted patterns and detect anomalies.

Xiu-hong Li, Xiao Cheng , Ke Yan and Peng Gong (2010) proposed that a wireless sensor network-based automatic monitoring system is designed for monitoring the life conditions of greenhouse vegetables. The complete system architecture includes a group of sensor nodes, a base station, and an internet data centre. For the design of wireless sensor node, the JN5139 micro-processor is adopted as the core component and the Zig-bee protocol is used for wireless communication between nodes. With an ARM7 microprocessor and embedded ZKOS operating system, a proprietary gateway node is developed to achieve data influx, screen display, system configuration and GPRS based remote data forwarding. Through a Client/Server mode the management software for remote data centre achieves real-time data distribution and time-series analysis. Besides, a

GSMshort-message-based interface is developed for sending real-time environmental measurements, and for alarming when a measurement is beyond some pre-defined threshold .

Li,*et.al.*(2010) designed a monitoring system for vegetable greenhouses based on a wireless sensor network. The complete system architecture includes a group of sensor nodes, the base station, and an internet data center. A GSM (global system for mobile communications)-short-message-based interface is developed for sending real-time beyond some pre-defined threshold.

LIU Yumei, ZHANG Changli, ZHU Ping(2011) proposed that the big coverage is, effectively resolves the disadvantages of wired communications. Adopting the technology of wireless sensor network based on Zigbee,GPRS and Web Services technology .They design a set of low cost, low power consumption, flexible automatic networking temperature humidity monitoring system of soil.And the system is a complete set of wireless sensor network induction, acquisition, storage, application, reporting, solution, has a good man-computer exchange interface. Through commissioning in the demonstration base of soybean in Northeast Agricultural University, it shows that the system can meet the requirements of the temperature and humidity of soil environmental monitoring and unified management .

Ragheid Atta, *et. al.* (2011), proposed a smart irrigation system for wheat in Saudi Arabia using wireless sensors network technology. The system consists of real-time sensor data acquisition, a decision module for calculating the optimal quantity and spread pattern for a fertilizer and an output module to regulate the fertilizer application rate. The system was proven to be cheap, reliable and simple to use.

Ramya, *et. al.* (2012), proposed an embedded System for automatic irrigation of the cardamom field using Xbee-PRO technology this wireless system supports the cardamom field which has both plain and slope areas. This system has software for real-time in-field sensing and control of an irrigation system and provides uniform and required level of water for both plain and slope areas and therefore it avoids the water overflow at the slope areas which saves the plant and also water.

Purnima *et.al* (2012) Proposed an economical and generic automatic irrigation control system using GSM and Bluetooth. This paper gives a detailed survey of various remote monitoring and control systems based on different technologies. In the proposed system, both GSM and Bluetooth modules are interfaced with the 8-bit microcontroller.GSM is used for remote monitoring and controlling the devices via messages and Bluetooth was also used for the same purpose but within a range of few meters which eliminates the cost of network usage to a great extent. If the moisture or temperature exceeds the predefined threshold values then the system informs the user via SMS from the GSM Module to the user's smartphone and actions will be taken by the user accordingly. But this system was not efficient for strong real-time monitoring.

Divya, *et. al.*(2013),proposed smart irrigation technique using vocal commands. In this system, the farmer just needs to call a fixed number and utter the control commands through his phone. The control system at the field involves a PIC microcontroller interfaced with GSM modem to receive a command from the farmer and a voice recognition unit which decodes it. The motor is turned on/off according to the decoded commands by the controller.

Hanggoro and Reynaldo(2013) proposed that the existing system has the ability to yet lack the ability to control indoor humidity. Green House Monitoring and Controlling is a complete system designed to monitor and control the humidity inside a green house. This software uses an Android mobile phone, connected using Wi-Fi to a central server which connects via serial communication to a microcontroller and humidity sensor. The result shows that the condition specified in sensor’s datasheet and system in reality is appropriate .

Joaquí Gutiérrez, Juan Francisco Villa-Medina(2013), proposed that an automated irrigation system was developed to optimize water use for agricultural crops. The system has a distributed wireless network of soil-moisture and temperature sensors placed in the root zone of the plants. In addition, a gateway unit handles sensor information,triggers actuators, and transmits data to a web application. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller-based gateway to control water quantity. The system was powered by photovoltaic panels and had a duplex communication link based on a cellular-Internet interface that allowed for data inspection and irrigation scheduling to be programmed through a web page.

Kay Smarsly(2013) proposed that automatically scheduling irrigation events based on soil moisture measurements has been proven an effective means to reduce freshwater consumption and irrigation costs, while maximizing the crop yield. Focusing on decentralized autonomous soil moisture monitoring, this paper presents the design, the implementation, and the validation of a low-cost remote monitoring system for agricultural ecosystems. The prototype monitoring system consists of a number of intelligent wireless sensor nodes that are distributed in the observed environment. The sensor nodes are connected to an Internet-enabled computer system, which is installed on site for disseminating relevant soil information and providing remote access to the monitoring system. Autonomous software programs, labelled "mobile software agents", are embedded into the wireless sensor nodes to continuously analyse the soil parameters and to autonomously trigger irrigation events based on the actual soil conditions and on weather data integrated from external sources .

Joaquin G., *et. al*. (2014) suggested an automated irrigation system to optimize water use for agricultural crops. The system has a distributed wireless network of soil moisture and temperature sensors placed in the root zone of the plants. It is also has a gateway unit handles sensor information, triggers actuators, and transmits data to a web applications. The system was tested in a sage crop field for 136 days and water savings up to 90% compared with traditional irrigation systems.

Gutierrez, *et al*.(2014) proposed an automated irrigation system using GPRS Module for the effective utilization of water in agriculture. It consists of distributed wireless sensor unit with soil moisture and temperature sensors deployed in plant root zones. The data from the wireless sensor unit is transferred to the main controller where the data is identified, recorded and analysed. This main controller permits the automated activation of irrigation when the threshold value of soil moisture and temperature are reached. The communication between the sensor node and the main controller is via ZigBee protocol under the IEEE 802.15.14WPAN.The receiver unit also has a duplex communication link based on a cellular-Internet interface, using general packet radio service (GPRS) protocol, which is a packet-oriented mobile data service used in 2G and 3G cellular global system for mobile communications (GSM).The data is allowed to transfer to the web server in real time through the internet, where the soil moisture and temperature levels are graphically displayed and stored in a database server.

Patel, *et.al* .(2015) proposed a system that aims in designing an automatically operated system which is capable of controlling the electrical devices based on sensor unit. The system uses solar panel for power supply and charging battery for WSN. The entire system is divided into two parts one is WSU (wireless sensor unit) and another is WUI (wireless information unit). WSU contain all sensors and ZigBee transmitter which is located in the field section of the soil. WIU contain ZigBee receiver, Wi-Fi module and electrical devices coolant fan and motor pump and buzzer which is located in the monitoring section of control room. Whenever the sensors unit gets the input from respected sensors like temperature LM35 sensor, water level indicator sensor LM324 and Gas leakage detector these inputs are fed to the ARM 7 microcontroller and the controller takes the responsibility to transmit the monitored data to the monitoring section using ZigBee module. The Another ZigBee module which is located at monitoring section receives the data and fed as input to another ARM-7 Microcontroller performs an appropriate task related to the data received like motor ON/OFF control, fan as coolant control system. The data is also transmitted directly to the predefined web page using router connected to Wi-Fi wireless network. The monitored data displays the status directly to the webpage.

Chikankar *.et.a.l*(2015) Proposed, an automatic irrigation system using ZigBee and WSN to make effective utilization of water resources for agriculture. It consists of distributed wireless sensor system consisting soil moisture and temperature sensors fixed near roots of the plants and all the components are powered by a solar panel for charging the battery so that need not to worry about the battery replacement every time. All the data received from the wireless sensor unit is identified,recorded, analysed and the information is transferred to the web server via GPRS Module. The farmer can set croptypes such as Wheat, Bajra, Rice, and Jowar in the master node. Moisture, temperature and humidity value required for a particular crop are set in the microcontroller as a threshold value. The actual values are compared with the threshold values. If the actual value crosses the threshold values then corresponding pump, buzzer, fan is switched on. In future mobile can be used to receive messages directly instead of PC.

Galande *et. al.*(2015) Proposed, the ARM control based Drip irrigation system for sensing various parameters of the soil. The proposed system utilizes micro sensors for N, P, K measurement, temperature, humidity, soil moisture, soil PH for the agriculture environment and interfaced with ARM LPC2148 Microcontroller. The content measurement of N, P, K elements helps to decide fertilizers requirement and also useful to manage the content of these elements in chemical mixing during the formation of fertilizers. This system uses a wired communication network to control the valves of the drip irrigation system.

CHAPTER III

MATERIALS AND METHODS

3.1 ARDUINO

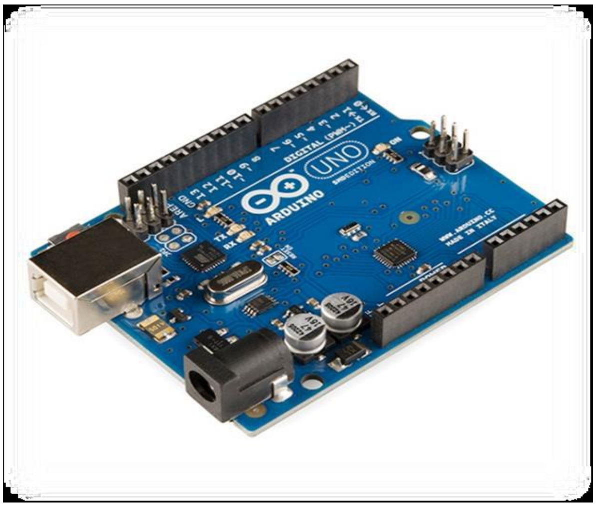


Fig.3.1Arduino Uno hardware

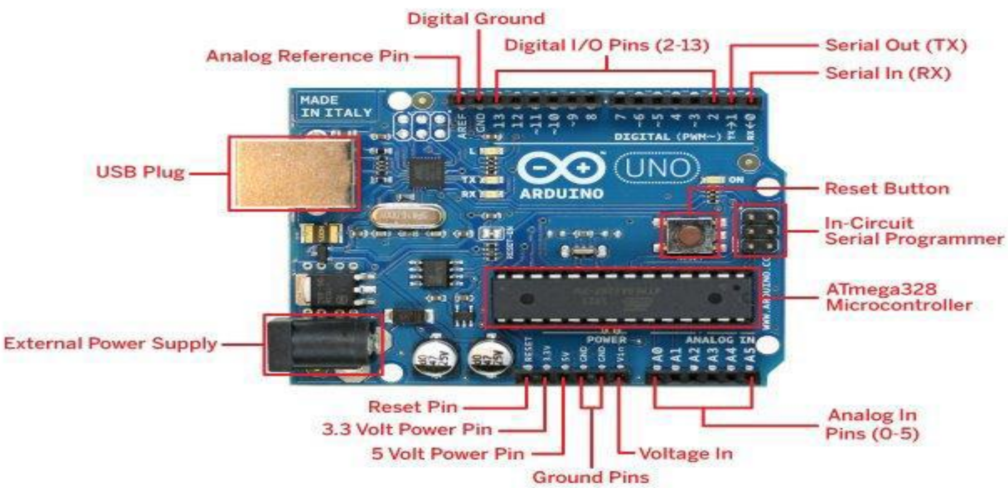


Fig. 3.2 Arduino Uno pin configuration

Arduino is an open-source electronics platform based on easy-to-use hardware and software intended for anyone making interactive products. The prototyping Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. One can tell the board what to do by sending a set of instructions to the microcontroller on the board. To do so the Arduino programming language based on „Wiring‟, (another development platform) is used, along with the Arduino Software (IDE), based on „Processing‟ (a similar programming language).

The specifications of the Arduino Uno board used for the study are as follows.

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analogue Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P)of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm

Width 53.4 mm

Weight 25 g

For the purpose of the study, the board was powered from the computer itself using which the coding was done. For field installations, the Uno board can be powered via the USB connection or with an external power supply.External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm centre-positive plug into the board's power jack. Leads from a battery can be inserted in the “GND” and “Vin” pin headers of the POWER connector.

The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7 V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

3.2 JUMPER WIRES

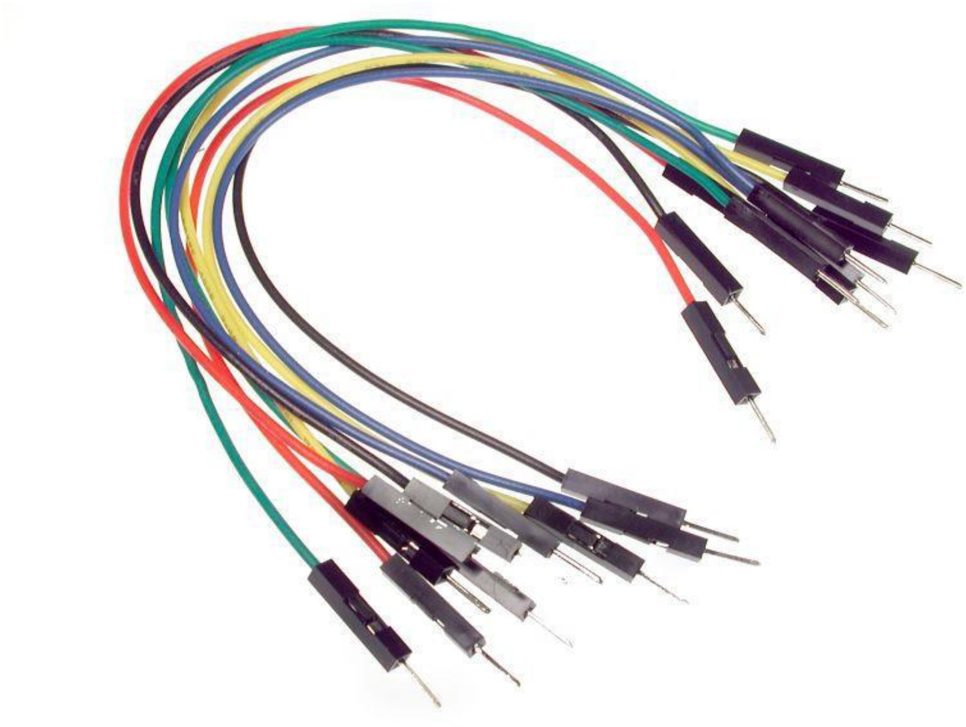


Fig. 3.3 Jumper wires (male - to - male)

A jumper wire (or simply jump wire) is a short electrical wire with a solid tip at each end (or sometimes without them, simply tinned), which is normally used to interconnect the components in a breadboard. They are used to transfer electrical signals from anywhere on the breadboard to the input/output pins of a microcontroller.Jump wires are fitted by inserting their end connectors into the slots provided in the breadboard that beneath its surface has a few sets of parallel plates that connect the slots in groups of rows or columns depending on the area. The end connectors are inserted into the breadboard, without soldering, in the particular slots that need to be connected in the specific prototype.For the purpose of the study, jumper wires with insulated terminals were used. When using those with insulated solid tips the arrangement of the elements and ease of insertion of the insulated jump wire connectors on the breadboards allows increasing the mounting density of both -components and jump wires- without fear of short-circuits. The jumper wires vary in size and colour to distinguish the different working signals. Variation of jump wires with insulated terminals as per male-female combinations:

a) Male to Male (solid tips at both ends)

b) Male to Female (solid tip at one end and slot at the other end)

c) Female to Female (slots at both ends)

3.3 SOIL MOISTURE SENSOR

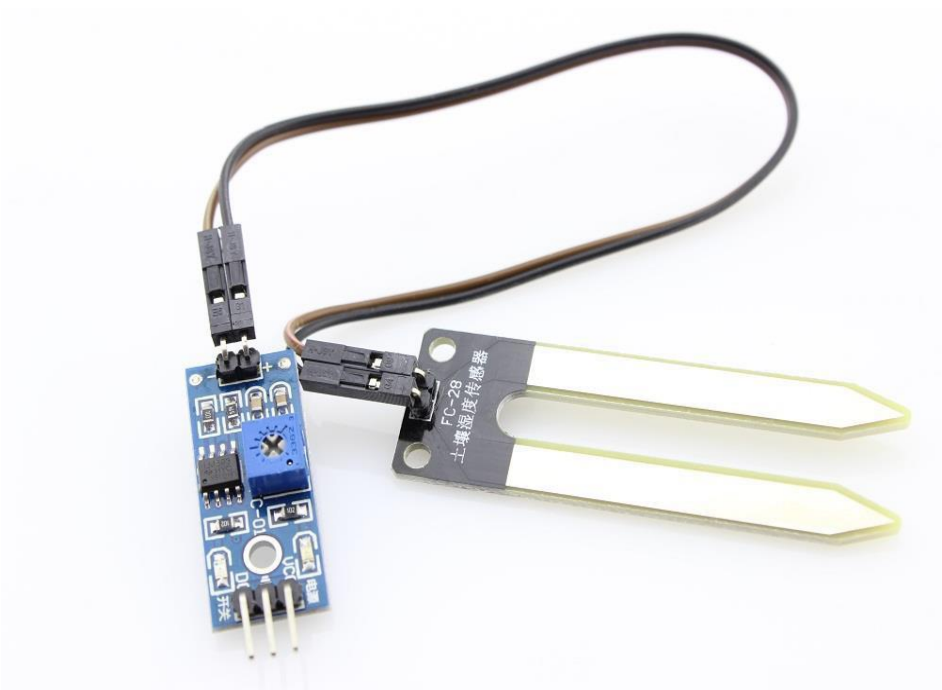
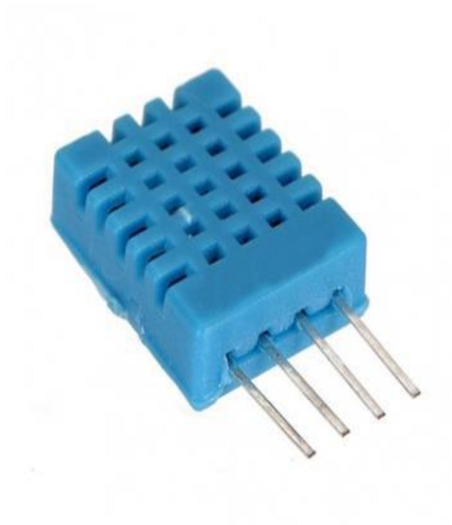


Fig. 3.4 Soil moistures Sensor

The soil moisture sensor was used to measure the water content(moisture) of soil. It shows the deficit of soil moisture, i.e., in open air, the sensor shows a reading of 99% to 100% whereas when dipped in soil, the value lowers according to the amount of water in the soil being sensed. The soil moisture sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. There is a 2 cm zone of influence with respect to the flat surface of the sensor, but it has little or no sensitivity at the extreme edges. The sensor is commonly used to measure the loss of moisture over time due to evaporation and plant uptake, evaluate optimum soil moisture contents for various species of plants, monitor soil moisture content to control irrigation in greenhouses and enhance bottle biology experiments. One commonly known issue with soil moisture sensors is their short lifespan when exposed to a moist environment. To combat this, sensors with the probe coated in gold finishing (ENIG or Electroless Nickel Immersion Gold) were used. The soil moisture sensor uses an LM393 chipset with a working voltage of 3.3V-5V and having a fixed screw hole for easy installation. The sensor weighs 21 g and has dimensions 43 mm x 14 mm x 0.8 mm.

3.4 TEMPERATURE AND HUMIDITY SENSOR



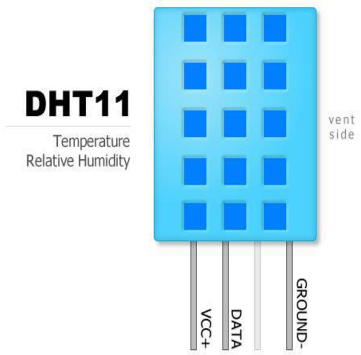


Fig. 3.5 Humidity and-temperature sensor

Fig.3.6 Humidity and temperature sensor pin-configuration

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process.The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package.

The specifications of the Humidity and Temperature Sensor are as follows:

Table 3.1 Specifications of humidity and temperature sensor

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1	4 Pin Single Row

Item	Condition	Min	Typical	Max	Unit
Power supply	DC	3	5	5.5	V
Current supply	Measuring	0.5		2.5	mA
	Stand-by	100	Null	150	uA
	Average	0.2	Null	1	mA

3.5 LCD

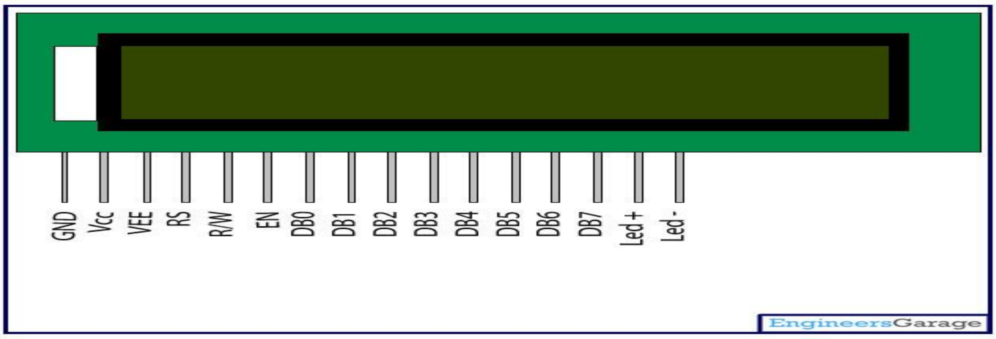


Fig 3.7 LCD pin configuration

LCD(Liquid Crystal Display)is an electronic display module and find a wide range of applications.A 16×2 LCD display is very basic module and is commonly used in various devices and circuits .These modules are preferred over seven segments and other multy segment LEDs.The reasons being LCDs are economical,easily programmable ,have no limitation of displaying special and even custom characters (unlike in seven segments) animations and so on.

A 16×2 LCD means it can display 16 characters per line and there are 2 such lines .In this LCD each character is displayed in 5×7 pixel matrix .This LCD has two registers ,namely command and data .The command register stores the command instructions given to the LCD .A command is an instruction given to do a predefined task like initializing it ,clearing its screen , setting the cursor position , controlling display etc. The data register stores the data to be displayed on the LCD . The data is the ASCII value of the character to be displayed on the LCD.

3.6 XBEE SHIELD

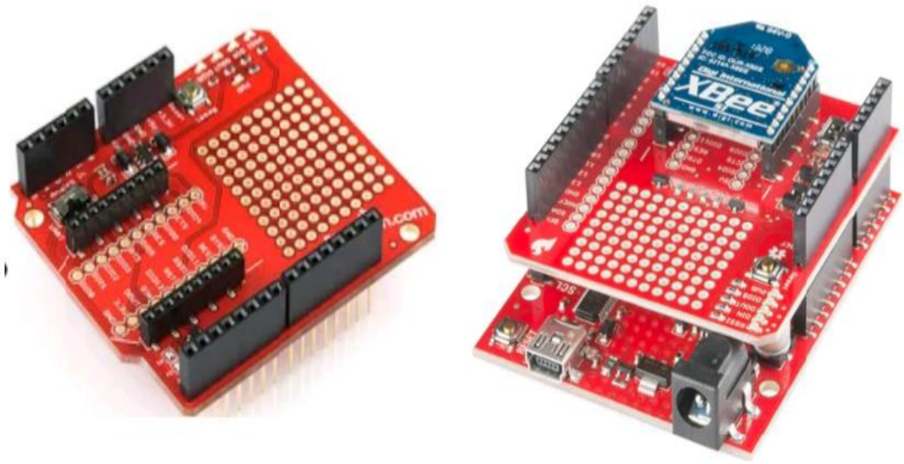


Fig 3.8 XBee Shield

The XBee shield mates directly with an arduino board .XBee transmittermodule is mounted on it and equips the arduino board with wireless communication capabilities .This XBee module transmits sensor reading to the XBee module mounted on XBee explorer.

3.7 XBEE EXPLORER

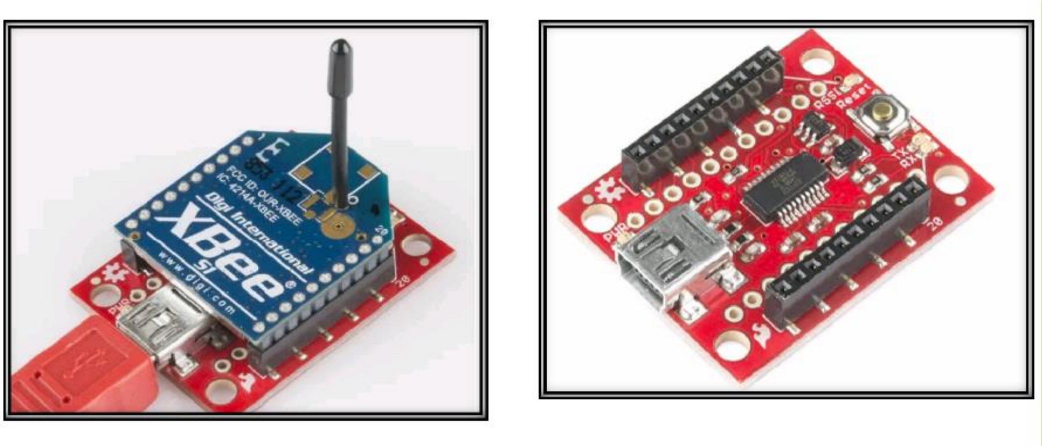


Fig 3.9 XBee Explorer

It is used for configuring both the XBee modules with same network address and compatible destination and MY address .One of the XBee remains mounted on it which serves as receiver to receive sensor reading and then sending to the computer using usb cable .

3.8 XBEE MODULE

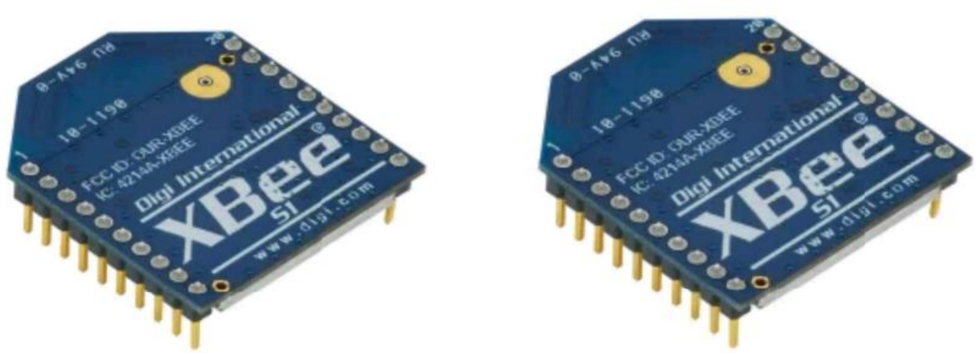


Fig 3.10 XBee Module

The X-Bee XB24-Z7WIT-004, improves on the power output and data protocol and they allow to create complex mesh networks based on the X-Bee ZB Zig-Bee mesh firmware. These modules allow a very reliable and simple communication between microcontrollers, computers, systems, really anything with a serial port, Point to point and multi-point networks are supported .

One XBee module acts as a transmitter and is mounted on the XBee shield .The other acts as a receiver and mounted on the XBee explorer,which is connected to the computer.The transmitter XBee module transmits soil moisture sensor reading from arduino board to the receiver XBee module .For both XBee modules to communicate ,they are configured using X-CTU software installed on the computer with same network address ,compatible MY and destination address .For configuring ,receiver and transmitter modules are mounted on XBee explorer one by one .

CHAPTER IV

RESULTS AND DISCUSSION

The work entitled "Development Of Wireless Sensor Network For Irrigation Control "was undertaken to receive soil moisture value wirelessly. The result of this work is explained in this chapter.

4.1 ASSEMBLING THE ARDUINO SYSTEM AND CODING

The Arduino Uno board and the components were assembled according to the circuit diagram. Arduino home screen looks like:

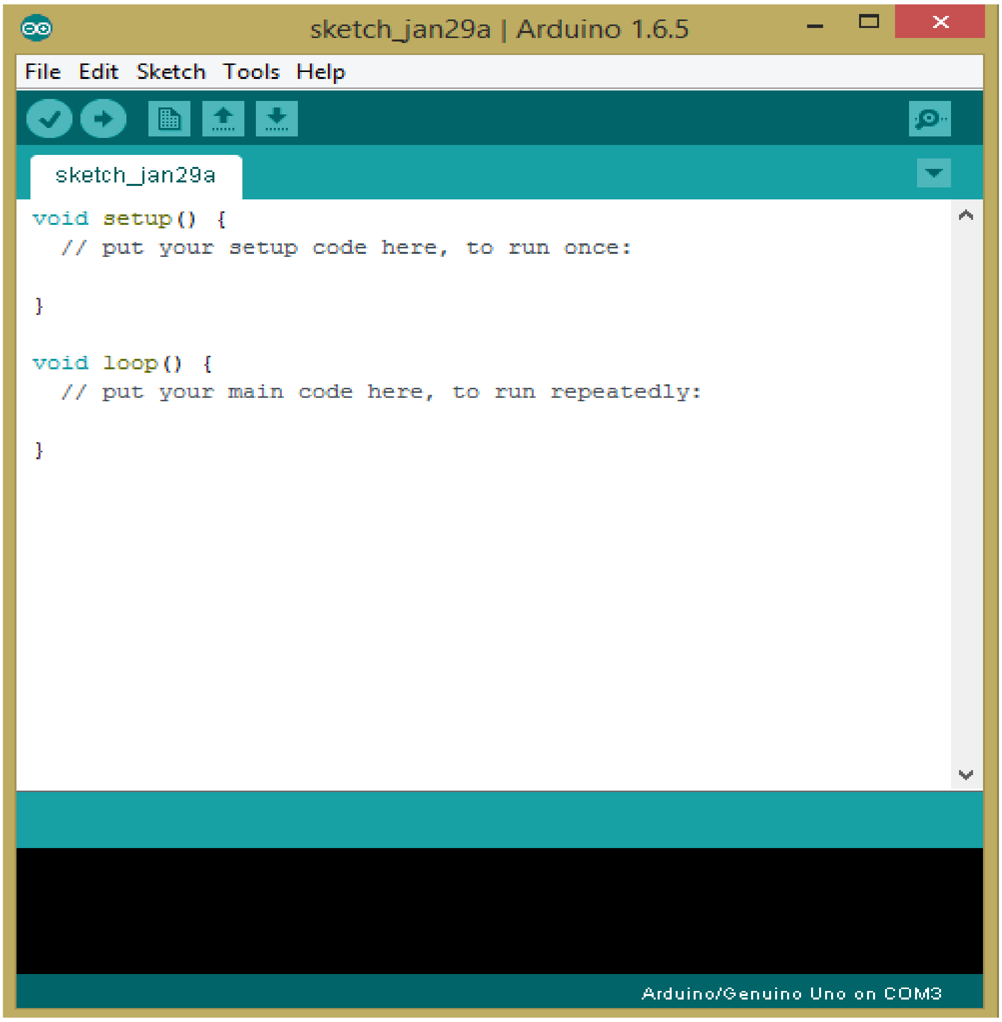


Fig. 4.1 Arduino home screen

To verify and compile the written code, i.e., to check for errors in the code the "Verify / Compile" command was used.

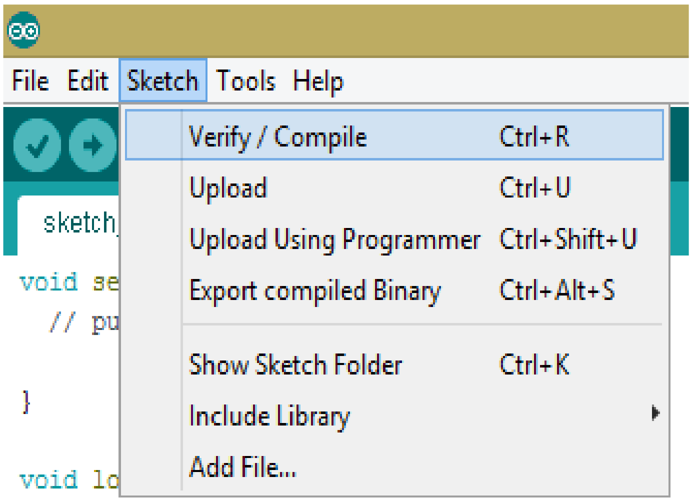


Fig 4.2 Compiling a code in Arduino

Then the program was uploaded to the Arduino board using the "Upload" command.

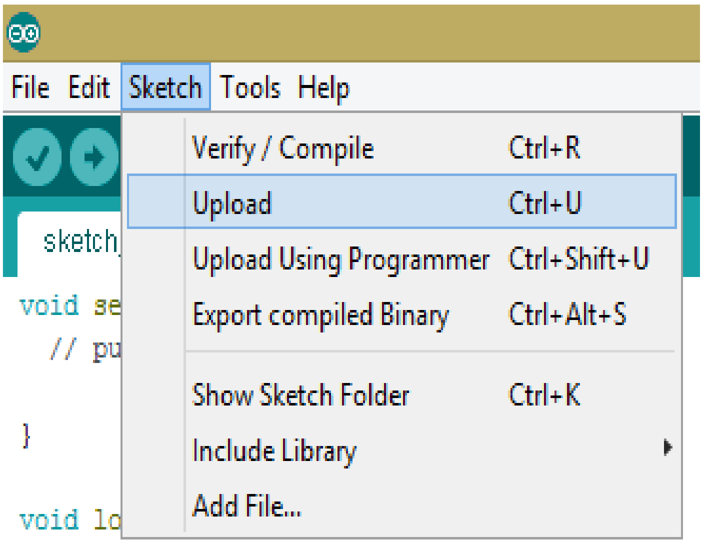


Fig. 4.3 Uploading the code to the Arduino board

To see the running status of the system, the "Serial Monitor Command" was used.

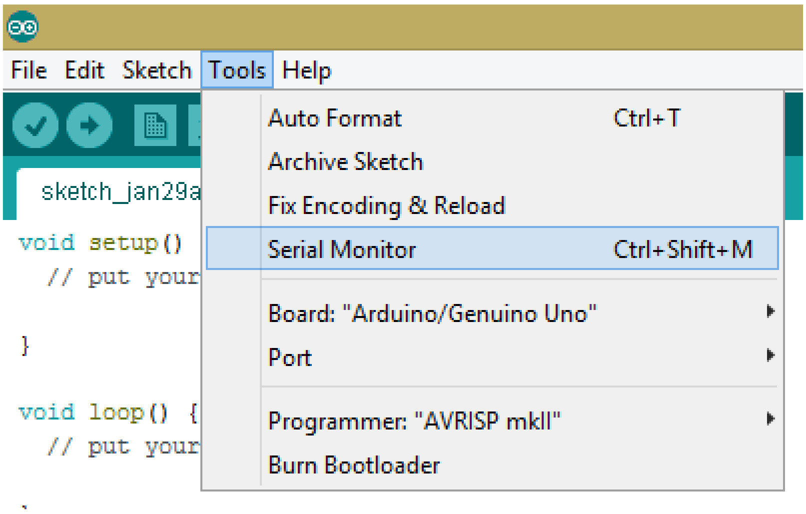


Fig. 4.4 Serial Monitor command

The serial monitor shows the readings from soil moisture sensors and the humidity and temperature sensor. A sample of what the serial monitor showed during the testing of the sensors is shown next.

```
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.22%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.12%
Current humidity = 53.00%  temperature = 30.00C
Soil Moisture : 99.02%
```

Fig 4.5 Serial Monitor window during sensor testing

The soil moisture sensor data was transmitted wirelessly from the arduino board via XBee module connected to the board with XBee shield as interface between the XBee shield and the arduino board .

The soil moisture sensor data transmitted by the arduino board is received by the XBee module mounted on the XBee explorer,which in turn is connected to the computer .

4.2.INTERPRETATION OF SOIL MOISTURE SENSOR DATA

The sensor data gives the resistivity of the soil .The following program was used :

```
sketch_dec15a

void setup()
{
  Serial.begin(9600);
  pinMode(A0,INPUT);
}

void loop()
{
  int sensorValue = analogRead(A0);
  Serial.print("soil moisture-");
   Serial.println(analogRead(A0));
   if(sensorValue>=1000)
   {Serial.print("probe is out of soil\t");}
   else if(sensorValue<1000&&sensorValue>=600)
   { Serial.print("soil is dry\t");}
   else if(sensorValue<600&&sensorValue>=370)
   Serial.print("soil is humid\t");
   else if(sensorValue<370)
   Serial.print("soil is saturated\t");
  delay(1000);
}
```

a)When sensor reading ≥1000 ohm-m ,sensor is out of the soil .

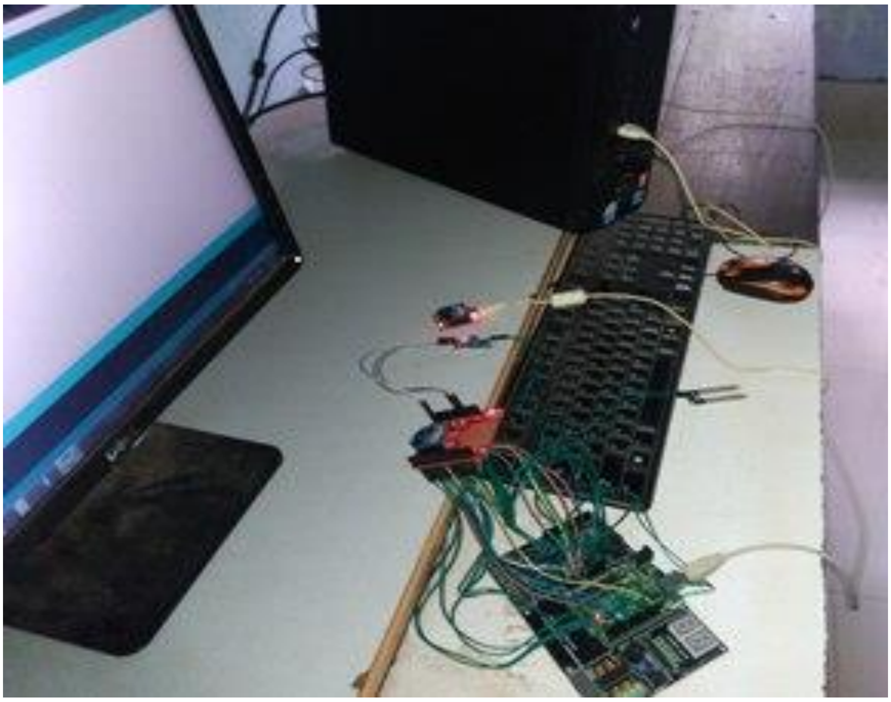
b)When sensor value <1000 ohm-m,and >600 ohm-m soil is dry.

c)If sensor value is <600 ohm-m and >370 ohm-m then soil is humid .

d)If sensor value is <370 ohm-m, then soil is saturated .

Depending on the type of crops and soil, we can determine the sensor reading that corresponds the permanent wilting point and field capacity .When the sensor data corresponds to permanent wilting point we start irrigation pump and when sensor reading corresponds to field capacity we stop irrigation pump.

The entire system is shown below :



4.1 Circuit Powered Using a Computer USB

CHAPTER V
SUMMARY AND CONCLUSION

5.1 SUMMARY

The present setup for the wireless transfer of sensor data can be used for precision irrigation to avoid unnecessary flooding of field .It can be used in conjunction with a programmed solenoid to operate pump to atomize the irrigation system to eliminate manual operation of the irrigation pump .Thus it saves energy ,lowers cost and increases the crop yield .

Soil moisture sensor reading readings were interpreted carefully .When the sensor reading corresponds to permanent wilting point ,then irrigation pump is started .When the sensor reading corresponds to field capacity ,pump is switch off .The study focused only on the wireless transfer of sensor data .The present setup can be used for automization irrigation control .

5.2.CONCLUSION

The implemented irrigation system is found to be feasible and cost effective for minimizing the usage of water resources. We have designed ZigBee wireless sensor network for monitoring the crop field area by deploying moisture sensors in the land to detect the places where the water level is low. From those results we can irrigate to that particular place only. So we can conserve water and minimize the problem of water logging in the land. We used humidity sensor to sense the weather. By using pH sensors we get the information about the soil and analyse the acid level of the soil. By which we can apply fertilizer to the place where it needs, also we can avoid over fertilization of the crops. Temperature is a randomly varying quantity in crop environment. Temperature reading gives information to the farmer. The overall cultivation can be increased effectively. Due to automation, man power is reduced and effective measures are taken to increase the yield.The automated irrigation system will prove to be useful and reducing use of water and this will be useful for cultivators to check the level of chemical fertilizers etc. For one of the quality of minimum maintenance, the irrigation system can be adjusted to a variety of specific crop needs. The configuration of the automated irrigation system allows it to be scaled up for larger greenhouses or open fields. The transmission system i.e. ZigBee is found to be cheaper and faster than others.

Besides the monetary savings in water use, the importance of the preservation of this natural resource justify the use of this kind of irrigation systems.

Hence the study titled "DEVELOPMENT OF WIRELESS SENSOR NETWORK FOR IRRIGATION CONTROL" has proved to be feasible and successful.

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DEVELOPMENT OF WIRELESS SENSOR NETWORK FOR IRRIGATION CONTROL

By

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ABSTRACT

Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology
in
Agricultural Engineering

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2017

ABSTRACT

At present there is less than 1% of fresh water available on earth. One of the important usage of fresh water is for agricultural production and the use of fresh water will continue to increase since growth in population and food demand increases. This lead to the necessity of automated controlling approach for irrigation system. This system is designed to have a control approach on water that is used in agriculture. The defined system here has a WSN(wireless sensor network) includes WSU(wireless sensor unit) and WIU(wireless information unit) which are used to maintain quantity of water by monitoring following parameters such as temperature, soil moisture and humidity. This system can save maximum water and produce good yield compared to traditional methods of irrigation. The design is also resource efficient by itself by consuming low power.