2

REVIEW OF LITERATURE

CONTENTS

2.1. REVIEW OF LITERATURE

This chapter is an overview and highlights the essential characteristics of the different soil moisture measurement techniques, in relation to estimating the spatial and temporal variation of soil moisture measurement techniques. This chapter allows the development of soil moisture estimation techniques in later on, which will be applicable to the soil moisture measurements available.

The application scenario of sensor based operation for automation is easily available in process, food packaging, aeronautics and other industries etc. Although the history of sensors and their application is very ancient but yet no full-fledged establishment has been observed when it comes to irrigation sector. The advancement is very narrow and dim, however, in tea industry the work involved in processing the green leaves to tea has comparatively high standard of automation than any other agricultural product. But no significant work of automation has been done for nourishing and caring of tea plants. However a recent research development work in drip irrigation has been done by *K. Prathyusha, M. Chaitanya Suman*[10] which features; automated platform with PT1000 as temperature sensor and tensiometer as moisture sensor with 16X1 LCD display for monitoring all the present readings of sensors and current status of control valves. In addition to it a chemical injection unit is used to mix required amount of fertilizers, pesticides, and nutrients with water, whenever required; in addition to flow meter for analysis of total water consumed. Another similar work in the field of tea industry at Tocklai tea estate by C-DAC, Kolkata and Tocklai Experimental Station [11] which features; fully automated, real time, round the clock, online wireless field hourly basis data collection system with help of sensors for ambient & soil temperature, soil moisture and pH, solar radiation, CC camera (infra red imaging even in night) for insect invasion and diseases. Additionally, the system is computer interfaced for enriching database with accurate data; with user friendly online Decision Support System for handling multiple input parameter.

Another milestone using ZigBee Wireless Sensor has been accomplished by *N. Krishna Chaitanya, G. Anand Kumar , P. Aruna Kumari* Department of ECE G.V.P. College of Engineering Visakhapatnam, AP, India. Here ARM7 based 16/32-bit Microcontroller is used for monitoring and measuring the humidity, temperature and soil. The parameters acquired from soil are transmitted using a ZigBee module and the receiver here is also a ZigBee feeding processing part of the system. The received data has been displayed in GUI and saved in the recording system for further analysis.

R. G. Evans and W. M. Iversen et. al. [12] successfully designed a site-specific irrigation system using six sensor station implemented across agricultural field. The system monitors field condition based on soil property map. The next step is to periodical sample inputs from sensor and transmission to the base station via wireless bluetooth medium.

G. V. Satyanarayanads et al. [13] this system shows advanced development in wireless sensor networks for observation of different parameters involved in agriculture. Parameters such as humidity, moisture and temperature, were remotely observed using miniaturized sensor devices a wireless sensor network based on Zigbee helps Central Monitoring Station (CMS) to use General Packet Radio Service (GPRS) or Global System for Mobile (GSM) technologies. The system could also obtain Global Positioning System (GPS) parameters and forward it to a central monitoring station.

Zulhani Rasin et al. [14] a feedback control system in real time which monitors and controls all the activities of drip irrigation system efficiently has been accomplished. It has GSM based Zigbee Controlled Solenoid Valve for drip irrigation system and can minimise manpower, water requirement and power consumption. Electricity consumption has been cut down by between 20% and 30% when compared to other Zigbee technology for monitoring irrigation [14]. The prime objective was to keep water content upto suited level. The result obtained has established the suitability of Zigbee for monitoring big area.

A.N. Jyothipriya el al. [15] suggested a drip irrigation control system using GSM based ZigBee. Results obtained demonstrate the system is capable in water preservation.

Aqeel ur-Rehman et al. [16] provided an evaluation on WSN usage for irrigation, fertilization, pest control, and horticulture. General concepts and brief description were introduced yet it highlighted benfits for using WSN in agriculture.

Zegelin et al. [17] many techniques for measuring soil electrical conductivity have been proposed. It highlightes principal advantages of the electrical conductivity probe for measuring soil moisture content are its ease of use, simplicity, low cost of equipment, for the relatively large volume of soil sampling.

Brocca, L et al. [18] The major advantages of EMI are that it does not need to be inserted in the ground, it is easy and quick to operate, and can provide estimates over large areas and substantial depths (of order 10 m). A disadvantage of this method is that the task of isolating the effects from soil moisture content at a particular depth is difficult.

B. P. Ladgaonkar et al. [19] To monitor humidity for a HighTech Polyhouse Environment‖ wireless sensor was built with AVR ATmega8L microcontroller and RF Zigbee module for protected data transmission. To develop the precision and reliability for monitoring humidity on base station use of smart sensor module has a benefit.

Prof C. H. Chavan et al. [20] The system develop an application for observing various factors such as soil moisture, humidity and give remote monitoring using zigbee which sent data wirelessly.

Aniket H. Hade et al. [21] the system helped to automate irrigation process remotely which is built on embedded system to save farmers time, water and resources brought with money. The important tasks like soil test for water content, salinity, chemical constituents is collected wirelessly and processed further to come up with better drip irrigation plan. This automatic monitoring system model using Wireless Sensor Network (WSN) helped farmer community to improve the yield.

Aji Hanggoro et al. [22] The system developed by Aji Hanggoro and Rizki Reynaldo is based on Greenhouse monitoring and controlling using Android mobile application. It monitors and controls the humidity inside a green house with android mobile phone and Wi-Fi connection via serial communication to a microcontroller and to a humidity sensor.

Swarup S. Mathurkar et al. [23] Smart sensor based monitoring system remotely monitors various agricultural parameter and proposes inductor model for monitoring with wireless protocol implemented using field programmable gate array (FPGA) which was used for the analysis and monitoring of data , a display element and a relay as a control unit.

Guobao Xu et al. [24] it aims to provide real time monitoring of marine environment and provide advantage of easy deployment. The architecture of WSN-based oceanographic monitoring systems is provided with a general architecture of an oceanographic sensor node, sensing parameters and sensors, wireless communication technologies, deployment of wireless sensor networks for marine environment monitoring.

Anjum Awasthi et al. [25] the design is based on low-power Zigbee wireless communication technology for monitoring. The wireless sensor nodes transmit real time soil temperature, soil moisture and humidity to the base station using Zigbee. The data was continuously monitored and displayed at base station and if it exceeded the desired limit, a message was sent to farmer mobile through GSM network requesting control actions. It has advantages of flexible networking, convenient installation and removal of equipment, low cost reliable nodes with high capacity.

S. Thenmozhi et al. [26] Monitoring greenhouse environment parameter is manually controlled with Zigbee network where the status of agricultural environment parameter was transmitted to the control room. The microcontroller based circuits were used to monitor values of parameter, continuously modified and controlled in order to achieve maximum plant growth and yield. The controller communicates with a variety of sensor modules in order to control the light, drainage process efficiently inside a greenhouse by actuating cooler, fogger, dripper and lights according to the needs of the crops.

Ms. Shweta S. Patil et al. [27] it is based on modernizing the irrigation technology using ARM7TDM1 core and GSM. This project helped to detect the exact field condition as well as weather condition in real time. The information was given on user request in the form of SMS. The standard sets of AT (Attention) commands were used to control majority of the functions of GSM modem.

Siuli Roy, Somprakash Bandyopadhyay [28] The real-time and automatic monitoring of site specific environmental and soil conditions using different sensors was presented a test bed influencing crop yield. The system addresses practical issues and technical challenges including the integration of sensors, placement of sensors in outdoor environment, energy management scheme and actual power consumption rates.

N. R. Patel et al. [29] In this review system various agricultural parameters was monitored and controlled by using peripheral devices like valve, watering pump etc. where monitoring was done automatically by using microcontroller to improve the farmer yield.

Xiu-Hong Li et al. [30] this system was presented for monitoring the life conditions of greenhouse vegetables based on Wireless Sensor Network. The whole system architecture included a group of sensor nodes, a base station, and an internet data centre. A GSM- SMS based interface was developed for sending real-time environmental measurements and for alarming when a measurement is beyond some pre-defined threshold.

LIU Yumei et al. [31] a soil monitoring system based on wireless sensor networks using a wireless sensor network as information acquisition and processing platform. The system was a set of low cost, low power consumption, flexible automatic networking temperature humidity monitoring system of soil. Also the system was capable of data acquisition, storage, reporting, solution with man-computer exchange interface.

Joaquín Gutiérrez et al. [32] this system is used for optimizing use of water for irrigation. It has soil moisture and temperature sensors that interact with microcontroller based control unit for water supply

Teemu Ahonen et al. [33] this system could measure four climate variables using three commercial sensors and collected data was used to evaluate the network reliability and its ability to detect the microclimate layers, which typically existed in the greenhouse between lower and upper flora. The network could detect the local differences in the greenhouse climate caused by various disturbances, as direct sunshine near the greenhouse walls. This was the first step in the area of greenhouse monitoring and control, and all depended on the developed sensor network feasibility and reliability.

For WSN one of the most fundamental and difficult problems is localization. Node localization is the problem of determining the location of each node in the system. For example, important points to consider include: the cost of extra localization hardware, communication ranges, location accuracy required, is the system indoors/outdoors, how long should it take to localize, does the system reside in hostile or friendly territory and is the system subject to security attacks.

Depending on the activity level of a node, its lifetime may only be a few days if no power management schemes are used. At the hardware level it is possible to add solar cells or scavenge energy from motion or wind since most systems require much longer lifetime.

The hardware and software platforms allow multiple power saving states (off, idle, on) for each component of the device (each sensor, the radio, the microcontroller) such that only the components required at a particular time is activated. At the software level power management includes (i) minimizing communications to save energy, and (ii) creating sleep/wake-up schedules for nodes.

2.2. INTRODUCTION OF EMBEDDED SYSTEM

An embedded system is a special-purpose system that performs one or a few predefined tasks, usually with very specific requirements, unlike a general-purpose computer. Design engineers can optimize it, reducing cost of the product and the size [35].

An Embedded System has three components

1. Hardware.
2. Application software.
3. Real Time Operating system (RTOS), which holds the instruction set that are given to hardware component to achieve the desire goal of the embedded systems.

2.2.1. CLASSIFICATION OF EMBEDDED SYSTEM

1. **Small Scale Embedded System**
   These require less power and may even be activated by a battery, designed with a single 8 or 16-bit microcontroller. The main programming tools used are editor, assembler, cross assembler and integrated development environment (IDE) [35].

2. **Medium Scale Embedded System**
   These have a 16 or 32 bit microcontroller, RISCs and have both hardware and software complexities for achieving advance solutions.

The main programming tools are C, C++, JAVA, RTOS, debugger, source code engineering tool, simulator and IDE [35].

3. **Sophisticated Embedded System**

   These types of embedded systems are expensive and have enormous hardware and software complexities that may need ASIPs, IPs, PLAs, scalable or configurable processors [35].

2.3 INTRODUCTION OF SENSORS

A sensor is an electronic device which sense real life parameters like temperature, moisture in our environment. The circuitry of a sensor develops a corresponding electronic signal which may be voltage or current [36] [37].

2.3.1 SOIL MOISTURE SENSORS

These sensors could sense water present in surrounding environment called volumetric water content θ. mathematically [38].

$$\theta = \frac{V_W}{V_T}$$

Equation 2.1: Mathematical formula of Volumetric Water Content

Where,

V_W is the net water volume and

V_T is the total volume i.e. soil and water volume

Soil moisture sensors are classified according to how they measure the soil moisture content. Depending on the requirement of real time application selection from a variety of moisture endorsement can be made.

2.3.2 SOIL MOISTURE CALCULATION

The volumetric water content is measured based on the following formula

$$Moisture\ Content(in\ percentage = \frac{\text{Weight of fresh soil} - \text{Weight of dry soil}}{\text{Weight of dry soil}} \text{ X } 100$$

Equation 2.2: Soil Moisture calculation.

[Reference [39] : SS Choudhary, Prabha Choudhary, Sunil K Choudhary, Laboratory Guide in Bio-Science, Kalyani publishers]

2.3.3 TYPES OF SOIL MOISTURE SENSORS

2.3.3.1 Electrical Resistance Block Sensors

These sensors use electrical property to determine the volume of water present in soil. It consists of two electrodes, powered by dc voltage, that gets under soil and circuitry is designed to pass electric current between two electrodes. In absence of water there is very less or low current between electrons but presence of water increases the conduction hence the increase in current is a representation of moisture present in soil [36].

Applying Ohm's law:

R=V/I

Equation 2.3: Ohm's Law

Where, R is resistance

V is biasing voltage I is the current flowing through the electrodes

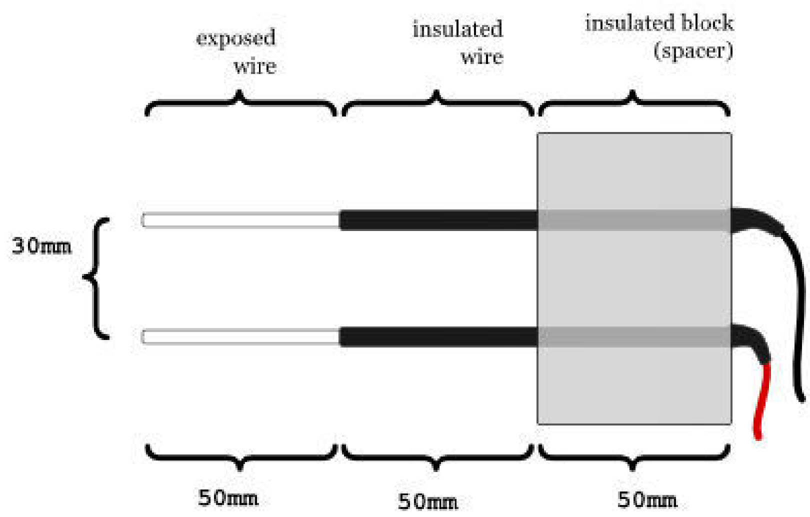


Figure 2.1: Electrical resistance blocks Sensors

2.3.3.2 Dielectric sensors

These sensors measures dielectric permittivity i.e. electrostatic field of the soil. They are available in two types Capacitance sensors and Time Domain Reflectometry (TDR)[40].

2.3.3.3 Capacitance sensors

It has two electrodes, which goes under the soil, and soil becomes between them becomes dielectric medium. The electronic circuitry generate high oscillating frequency, which is applied to electrodes. The frequency change in frequency due to moisture content in soil gives measure of moisture in soil [41]

2.3.3.4 Time Domain Reflectometry (TDR) Sensors

It measures time taken by an electromagnetic pulse to travel along wave guide. The electronic circuitry generates pulse through the electrode inserted in the soil, the return time is high in moist soil .The time taken gives measure of moisture in water [40, 42, 43].

2.3.3.5 Heat dissipation sensors

In most cases heat dissipation sensor are of ceramic kind. The water contained in the medium spaces is directly proportional to the heat dissipated from the medium and soil with high moisture content dissipate more heat than dry soil [45]. The electronic circuitry senses the heat dissipated by soil under test to give measure of moisture content in soil.

2.3.4. SENSOR SELECTION

When deciding on which sensor to use the following factors should be put into consideration [36] [45].

Price: This is the most important parameter when selecting any component. The price of the sensor will ultimately affect the price of the whole system as this is one of the major system modules. Sensor with the most competitive price should be chosen.

Power: In any electrical system power efficiency is critical. Moisture sensor will low power consumption should be selected. Sensors which can be battery powered can be used in areas without electric connection.

Technology: Technology used to design sensor dictate the sensitivity, cost and durability of the sensors. Most low cost sensors have poor sensitivity, rust and corrode over time. Resistive or conductive sensors which are affected by soil (I-28) salinity thus have a short life.

Shape: Long and slender sensors can be used in many applications than bulky ones.

Durability: Soil moisture sensor which are not affected by soil salinity, corrode or rust should be selected. Soil moisture sensor probes that measure conductivity or resistance should be avoided, since they will wear out over time.

Accuracy and Linearity: A quality soil moisture sensor probe should give an output which is proportional to water content over the full output range. In addition, the soil moisture sensor probe should have a good output range to reduce sensitivity to noise.

Voltage Range: Choose a sensor that has a big supply voltage range. Powering a sensor with the wrong voltage will damage the sensor or give inaccurate results.

2.3.5 YL-69 MOISTURE SENSOR WITH LM393 PCB

The sensor has two electrodes inserted in the soil, as moisture content of soil between electrodes increase, drop in resistance is sensed by the sensor circuitry. The net resistance obtained is the measure of soil moisture present [46].

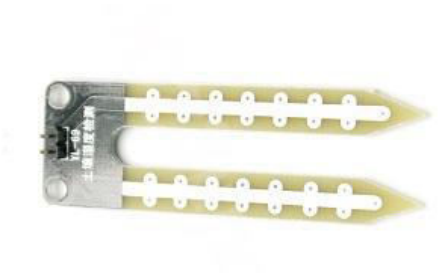


Figure 2.2: YL-69 Sensor

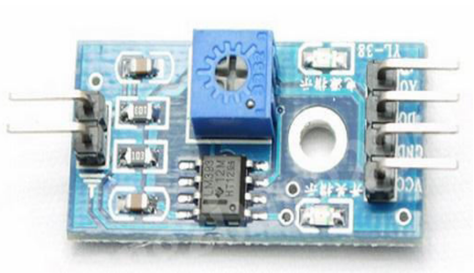


Figure 2.3: LM393 PCB

Table-2.1: Specification of YL-69 Sensor

Vcc power supply	3.3V or 5V
Current	35mA
Signal output voltage	0-4.2V
Digital Outputs	0 or 1
Analog	Resistance (Ω)
Panel Dimension	3.0cm by 1.6cm
Probe Dimension	6.0cm by 3.0cm
GND	Connected to ground

2.3.5.1 LM393 comparator

A compactor is an electronic device which determines the larger quantity between the two quantities being measured by producing a digital signal as output. The two quantities can be two different voltages or currents [46].

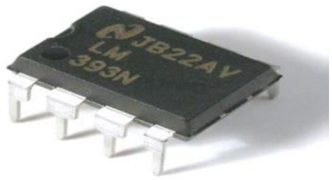


Fig 2.4: LM393 comparator IC

Table-2.2: Characteristics of LM393

Supply Voltage	(2.0 to 36.0) V
Supply	Single or dual (±1.0 to ±18.0) V
Current drain	0.4 mA
Biasing current	25 nA
Offset current	± 5 nA
Offset current	± 5 nA
Saturation Voltage	± 3 mV
Compatibility	TTL, DTL,ECL, MOS and CMOS logic systems
Differential input voltage range	Same as power supply voltage

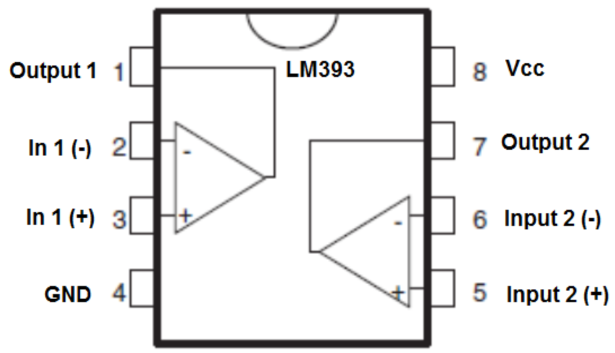


Figure 2.5: LM 393 Pin configuration

2.4 INTRODUCTION OF WSN (Wireless Sensor Network)

The power of wireless sensor networks [47] lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Usage scenarios for these devices range from real-time tracking, to monitoring of environmental conditions. The most straightforward application of wireless sensor network technology [48] is to monitor remote environments for low frequency data trends [49].

2.4.1 SENSOR NODE STRUCTURE

A sensor node normally consists of four basic components

1. A sensing unit
2. A processing unit
3. A communication unit
4. A power unit

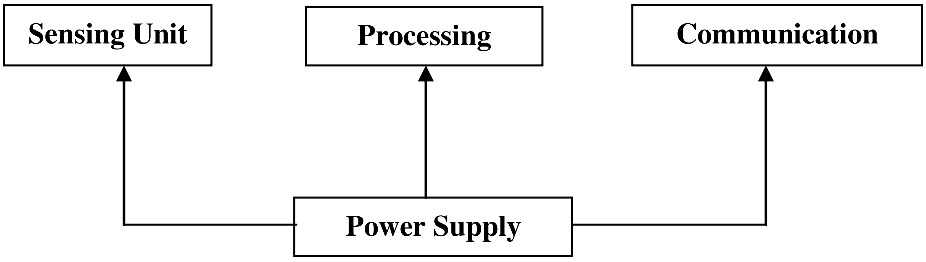


Figure 2.6: Sensor Node structure

2.4.2 CHARACTERISTICS OF SENSOR NODE

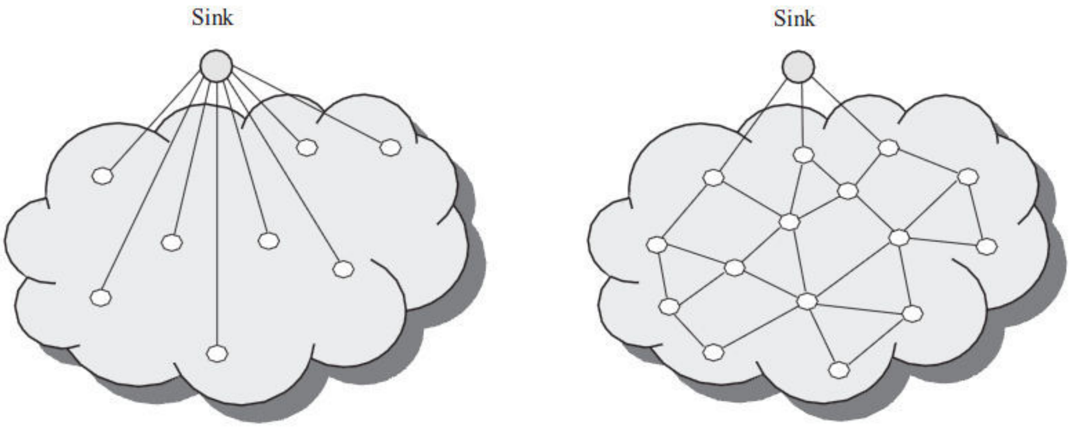
1. **Energy –efficiency-**Energy is scarcest resource that must be utilized properly because it is impossible to recharge each node so it must be energy efficient as possible as. **Low-cost-**WSN is a collection of hundred and thousands sensor nodes, so cost of each node should be node minimum.
2. **Distributed-Sensing-**As large numbers of node are distributed in sensor network so each node for collecting and storing data provides robustness to the system with distributed sensing.
3. **Multi-hop-**As large numbers of sensors are deployed in WSN, so it is not feasible for each node to reach the base station. It may be require intermediate node to reach the base station. Thus, the solution is multi-hop.
4. **Node Types -** In sensor network, there are two types of set or group of node that exist- **homogeneous group of node and heterogeneous group of node**.
5. **Application-oriented- Small Size node-** Sensor nodes are generally small in size where range of each node is restricted about 30m. Due to small size of node; energy is limited which makes processing capability low.
6. **Dynamic Network Topology-** Mostly sensor nodes are deployed in under-developed infrastructure area as a result the network topology always changes due to the addition of new nodes, failure of nodes, and mobility. Thus, the topology is responsible for affecting the sensor network characteristics such as latency, capacity, robustness, complexity and processing of data.

2.4.3. CLASSIFICATION OF WSN

From network architecture point of view WSN classified in two categories [50].

1. Flat Architecture –each node plays the same role in performing sensing task and all sensor nodes are peers.
2. Hierarchical Architecture –sensor nodes are organized clusters, where the cluster members send their data to the sink.

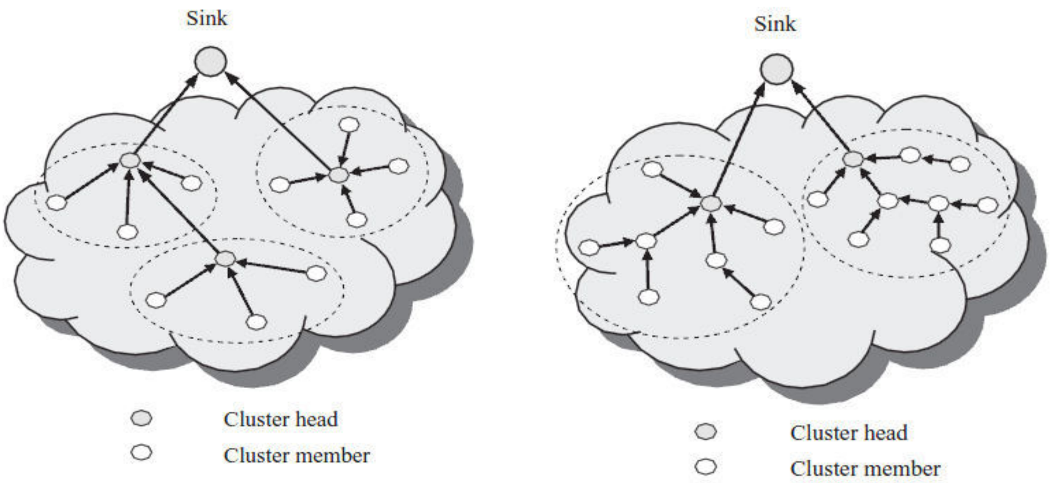
Example of Flat Architecture



Single-hop network Multi-hop network

Fig 2.7: Flat Architecture of WSN

Example of Hierarchical Architecture



Single-hop clustering architecture Multi-hop clustering architecture

Figure 2.8: Hierarchical Architecture of WSN

Figure 2.9: Possible deployment Sensors detect temperature, light levels and soil moisture at hundreds of points across a field and communicate their data over a multi-hop network for analysis.

Source: **System Architecture for Wireless Sensor Networks** By Jason Lester Hill, University of California, Berkeley

2.4.4 APPLICATIONS OF WIRELESS SENSOR NETWORK

Wireless Sensor Network applications are: Soil Moisture Monitoring, Environmental Monitoring, Habitat Monitoring, Air or Water Quality Monitoring, Hazard Monitoring, Disaster Monitoring etc.

Military Applications: Battlefield Monitoring, Object Protection**,** Intelligent Guiding**,** Remote sensing etc.

2.4.5 CHALLENGES OF WIRELESS SENSOR NETWORK

We point out some list of challenges of wireless sensor network. They are as follows [51]:

1. A general architecture that meets the strict efficiency and flexibility requirements of wireless sensor networks.

2. An implementation of the architecture using current microcontroller and low-power radio Technology.
2 An operating system that compliments the hardware capabilities and provides support for sensor network applications.
3 An integrated hardware platform for use in wireless sensor networks.

2.4.6 APPLICATION OF SENSOR NETWORK

We have selected four category of application of sensor network which are environmental data collection, data processing and uploading to web, security monitoring and sensor node tracking.

2.4.6.1 Data Collection

The environmental data collection application is one where collect several sensor readings from a set of points in an environment over some interval of time in order to detect soil moisture level of different location of the garden. We want to collect data from several points spread throughout the garden area and stored it through a database and then analyze the data at runtime and perform the specific operations. We need to collect data over several months or years in order to long-term and seasonal basis. For the data to be meaningful it would have to be collected at regular intervals and the node would remain at known locations. At the network level, the environmental data collection application is characterized by having a large number of nodes continuously sensing and transmitting data back to a set of base stations that store the data using database. These networks generally require very low data rates and extremely long lifetimes. In typical usage scenario, the nodes will be evenly distributed over an outdoor environment. This distance between adjacent nodes will be minimal yet the distance across the entire network will be significant.

After deployment, the nodes must first discover the topology of the network and estimate optimal routing strategies. The routing strategy can then be used to route data to a central collection points. In environmental monitoring applications, it is not essential that the nodes develop the optimal routing strategies on their own. Instead, it may be possible to calculate the optimal routing topology outside of the network and then communicate the necessary information to the nodes as required. This is possible because the physical topology of the network is relatively constant. While the time variant nature of RF communication may cause connectivity between two nodes to be intermittent, the overall topology of the network will be relatively stable.

Environmental data collection applications typically use tree-based routing topologies where each routing tree is rooted at high-capability nodes that sink data. Data is periodically transmitted from child node to parent node up the tree-structure until it reaches the sink. With tree-based data collection each node is responsible for forwarding the data of all its descendants. Nodes with a large number of descendants transmit significantly more data than leaf nodes. These nodes can quickly become energy bottlenecks.

Once the network is configured, each node periodically samples its sensors and transmits its data up the routing tree and back to the base station. For many scenarios, the interval between these transmissions can be on the order of minutes. Typical reporting periods are expected to be between 1 and 15 minutes; while it is possible for networks to have significantly higher reporting rates. The typical environment parameters being monitored, such as temperature, light intensity, and humidity, do not change quickly enough to require higher reporting rates. In addition to large sample intervals, environmental monitoring applications do not have strict latency requirements. Data samples can be delayed inside the network for moderate periods of time without significantly affecting application performance. In general the data is collected for future analysis, not for real-time operation. In order to meet lifetime requirements, each communication event must be precisely scheduled. The senor nodes will remain dormant a majority of the time; they will only wake to transmit or receive data. If the precise schedule is not met, the communication events will fail.

As the network ages, it is expected that nodes will fail over time. Periodically the network will have to reconfigure to handle node/link failure or to redistribute network load. Additionally, as the researchers learn more about the environment they study, they may want to go in and insert additional sensing points. In both cases, the reconfigurations are relatively infrequent and will not represent a significant amount of the overall system energy usage.

The most important characteristics of the environmental monitoring requirements are long lifetime, precise synchronization, low data rates and relatively static topologies. Additionally it is not essential that the data be transmitted in real-time back to the central collection point. The data transmissions can be delayed inside the network as necessary in order to improve network efficiency.

2.4.6.2 Security Monitoring

Our second class of sensor network application is security monitoring. Security monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect an anomaly. A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation. The immediate and reliable communication of alarm messages is the primary system requirement. These are "report by exception" networks. Additionally, it is essential that it is confirmed that each node is still present and functioning. If a node were to be disabled or fail, it would represent a security violation that should be reported. For security monitoring applications, the network must be configured so that nodes are responsible for confirming the status of each other.

One approach is to have each node be assigned to peer that will report if a node is not functioning. The optimal topology of a security monitoring network will look quite different from that of a data collection network. In a collection tree, each node must transmit the data of all of its decedents. Because of this, it is optimal to have a short, wide tree. In contrast, with a security network the optimal configuration would be to have a linear topology that forms a Hamiltonian cycle of the network. The power consumption of each node is only proportional to the number of children it has. In a linear network, each node would have only one child. This would evenly distribute the energy consumption of the network. The accepted norm for security systems today is that each sensor should be checked approximately once per hour. Combined with the ability to evenly distribute the load of checking nodes, the energy cost of performing this check becomes minimal. A majority of the energy consumption in a security network is spent on meeting the strict latency requirements associated with the signaling the alarm when a security violation occurs. Once detected, a security violation must be communicated to the base station immediately. The latency of the data communication across the network to the base station has a critical impact on application performance. Users demand that alarm situations be reported within seconds of detection. This means that network nodes must be able to respond quickly to requests from their neighbors to forward data. In security networks reducing the latency of an alarm transmission is significantly more important than reducing the energy cost of the transmissions. This is because alarm events are expected to be rare. In a fire security system alarms would almost never be signaled. In the event that one does occur a significant amount of energy could be dedicated to the transmission. Reducing the transmission latency leads to higher energy consumption because routing nodes must monitor the radio channel more frequently. In security networks, a vast majority of the energy will be spend on confirming the functionality of neighboring nodes and in being prepared to instantly forward alarm announcements. Actual data transmission will consume a small fraction of the network energy.

2.4.6.3. Node tracking Feature

A third usage scenario commonly discussed for sensor networks is the tracking of a tagged object through a region of space monitored by a sensor network. There are many situations where one would like to track the location of valuable assets or personnel. Current inventory control systems attempt to track objects by recording the last checkpoint that an object passed through. However, with these systems it is not possible to determine the current location of an object. For example, UPS tracks every shipment by scanning it with a barcode whenever it passes through a routing center. The system breaks down when objects do not flow from checkpoint to checkpoint. In typical work environments it is impractical to expect objects to be continually passed through checkpoints. With wireless sensor networks, objects can be tracked by simply tagging them with a small sensor node. The sensor node will be tracked as it moves through a field of sensor nodes that are deployed in the environment at known locations. Instead of sensing environmental data, these nodes will be deployed to sense the RF messages of the nodes attached to various objects. The nodes can be used as active tags that announce the presence of a device. A database can be used to record the location of tracked objects relative to the set of nodes at known locations. With this system, it becomes possible to ask where an object is currently, not simply where it was last scanned. Unlike sensing or security networks, node tracking applications will continually have topology changes as nodes move through the network. While the connectivity between the nodes at fixed locations will remain relatively stable, the connectivity to mobile nodes will be continually changing. Additionally the set of nodes being tracked will continually change as objects enter and leave the system. It is essential that the network be able to efficiently detect the presence of new nodes that enter the network.

2.5 INTRODUCTION OF IRRIGATION

2.5.1. DITCH IRRIGATION

In this system ditches on grounds are made in rows and crops are planted in those ditches

2.5.2. TERRACE IRRIGATION

This method is both time and labour intensive where crops are planted after creating a flat land surface.

2.5.3. DRIP IRRIGATION

In this method water is supplied as close as possible to the roots of plants directly which saves significant amount of water wastage.

2.5.4 ROTARY SYSTEM IRRIGATION

In this method a individual sprinkler is allotted for specific part of land, when sprinkler is activated it sprays water for irrigation in 360 degrees fashion.

2.6 INTRODUCTION OF MICROCONTROLLER

A microcontroller is a single on chip computer which includes number of peripherals like RAM, EEPROM, clock Timers etc., required to perform some predefined task[35][52].

A microcontroller is a digital integrated circuit but used in some specific applications only. A microcontroller has processor core, memory elements and programmable input/output modules present in the single integrated circuit. It also has both combinational circuits and sequential circuits, combinational circuits perform logical operations and are designed with logic gates. The sequential circuits are interconnection of combinational circuits and memory or storage elements like counters, flip-flops, etc.. Microcontrollers are programmable device mostly used in embedded systems, engineering projects

[35]. They are designed for embedded applications and are heavily used in automatically controlled electronic devices such as cell phones, cameras, microwave ovens, washing machines, etc.

2.7 ABOUT ARDUINO

Arduino is an open-source electronics design platform. An Arduino is programmable to interact with physical world via sensors and can be used to generate control actions as a controlling unit [52].

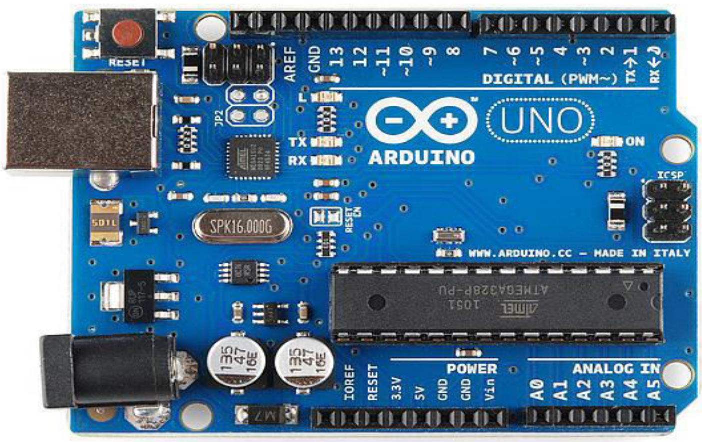


Figure 2.10: Arduino UNO Board

Technical Specification

Microcontroller: ATmega328

Operating Voltage: 5V

Input Voltage (recommended): 7-12V

Input Voltage (limits): 6-20V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

DC Current per I/O Pin: 40 mA

DC Current for 3.3V Pin 50 mA

Flash Memory 32 KB of which 0.5 KB used by boot loader

SRAM: 2 KB

EEPROM: 1 KB

Clock Speed: 16 MHz

2.7.1. Atmega328

It is a very popular microcontroller chip produced by Atmel. It is an 8-bit microcontroller that has 32K of flash memory, 1K of EEPROM, and 2K of internal SRAM [53].

The Atmega328 is one of the microcontroller chips that are used with the popular Arduino Duemilanove boards. The Arduino Duemilanove board comes with either Atmega168 or the Atmega328. The Atmega328 is more advanced has 32K of flash program memory and 2K of Internal SRAM unlike the Atmega168 which has 16K of flash program memory and 512 bytes of internal SRAM, the Atmega328[54].

The Atmega328 has 28 pins. It has 14 digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins. These I/O pins account for 20 of the pins.

The pin out for the Atmega328 is shown below [54]

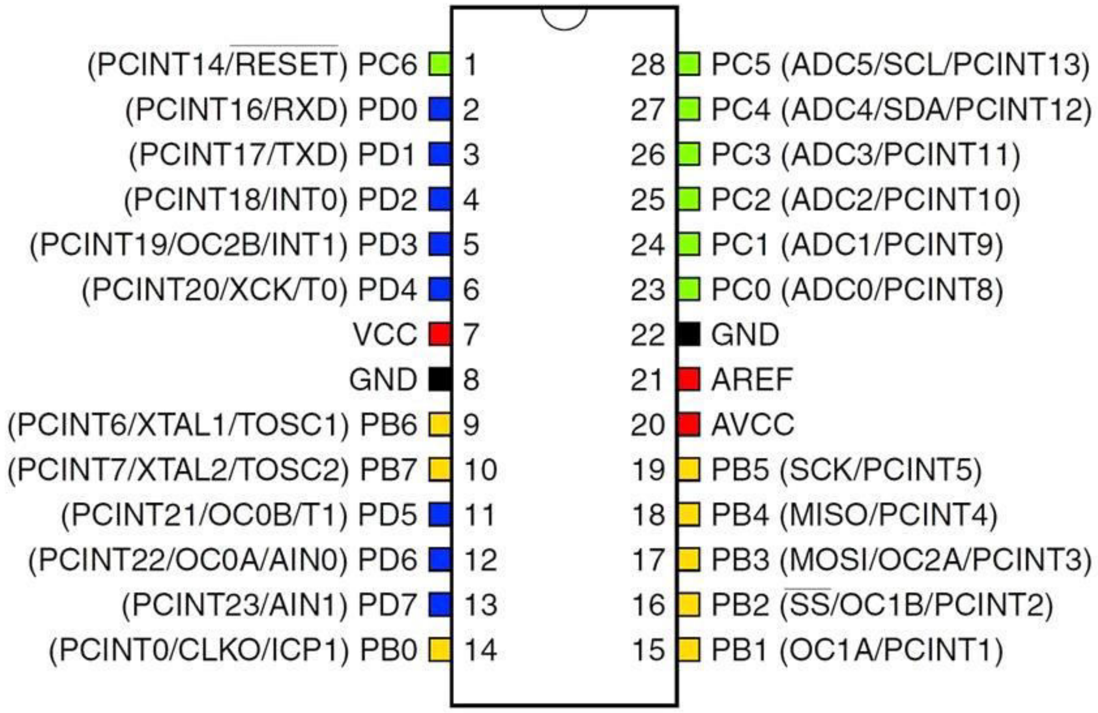


Figure 2.11: Pinout Diagram for Atmega328 Microcontroller

Table 2.3: Pin Description of Atmega328 Microcontroller

Pin Number	Description	Function
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	Vcc	Positive Voltage (Power)
8	GND	Ground

9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

2.8 SOLENOID VALVE

A Solenoid valve is an electromechanical controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core, called the plunger, in its centre. In rest position, the plunger closes off a small orifice. But when electric current is sent through the coil, a magnetic field is generated that exerts a force on the plunger. As a result, the plunger is pulled toward the centre of the coil so that the orifice opens [55].

2.8.1. CIRCUIT FUNCTIONS OF SOLENOID VALVES

Solenoid valves are used to close, dose, distribute or mix the flow of gas or liquid in a pipe. There are types of solenoid valves based on their non energized condition where different type serves different perpose. A 2/2 way valve has two ports (inlet and outlet) and two positions (open or closed). A 2/2 way valve can be 'normally closed' (closed in de-energized state) or 'normally open' (open in de-energized state).

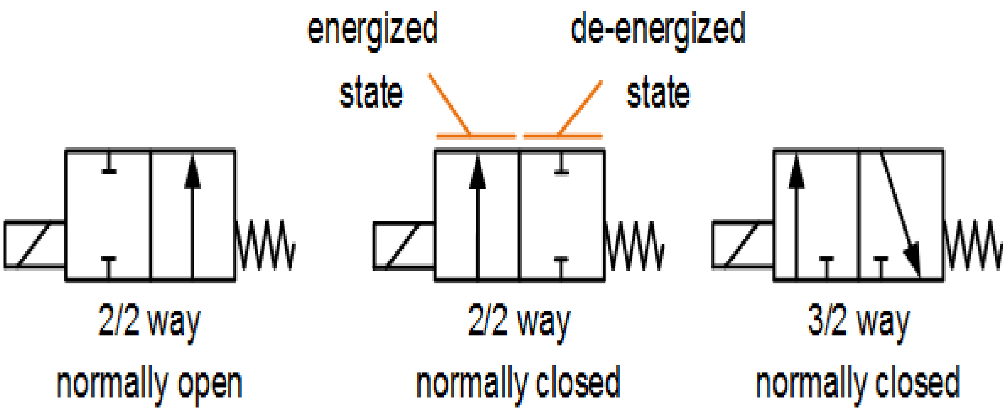


Figure 2.12: Open and Close Solenoid valve

Valve Symbols

For each state of the valve, a single square is drawn. A 2/2 valve has two states (open/close) and is therefore represented by two adjacent squares. In each square is shown how the medium can flow between the ports. This is done with arrows that indicate which ports are connected and what is the flow direction. Closed ports are indicated by a 'T'

To indicate which square is active when the solenoid is electrically energized, a little actuator symbol is used on both sides. On the left square a solenoid symbol is used to show that the left square is the energized state. On the right a spring symbol is used for the rest state.

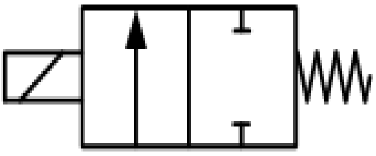
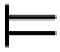
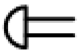
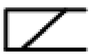


Figure 2.13: 2/2 Solenoid valve

Table 2.4: This table represents the different valve Symbols and its description

Manual		Manual operation
		Push Button
		Lever
		Foot operation
		Detent
Mechanical		Spring
		Pin
		Roller control
Pneumatical		Air operated
Electrical		Coil

2.9 INTRODUCTION TO ZIGBEE

ZigBee is a wireless networking standard applied for remote control and sensor applications which is ideal in harsh radio environments and in isolated locations[56].

The signal transmission from one station to the next extend up to about 70-100 meters, although by relaying data from one node to the next in a network very much greater distances may be reached[57].

The main applications for 802.15.4 ZigBee are focused at control and monitoring applications where one requires relatively low levels of data throughput. A key requirement is low power consumption that's allows for remote, battery-powered sensors application with it. Sensors, lighting controls, security and many more applications are all candidates for the new technology [58].

Data transfer

The applications in which 802.15.4 and ZigBee are likely to be used should not require very high data rates. The data is transferred in packets and have a maximum size of 128 bytes, allowing for a maximum payload of 104 bytes [57, 59].

Network

The ZigBee network must be able to communicate over distances that may be well in excess of the single hop distance achievable by each individual node. A ZigBee network is set up to make sure data messages are sent efficiently across the ZigBee network that may extend over considerable distances.