Design & Implementation of Smart Irrigation System



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Candidate's Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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Certification

This is to certify that this project entitled "**Design & Implementation of Smart Irrigation System**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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ABSTRACT

The Public transport system is a major source of income in densely populated country like Bangladesh especially in cities. But, this public transport system faces several problems. The conductor will face various problems in issuing the tickets or collecting fare. But, this new system will provide the tickets automatically and deduct the fare for the distance travelled from the passenger's account. It is also contain passenger's identification. One can also recharge his fare instantly in the train with the help of ticket checker or a conductor or supervisor. Hence people do not have to carry the money and they don't have the problem in giving the right change to conductor. Conductor also feels free in collecting the fare from the people.

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LIST OF ABBREVIATIONS

DC	Direct Current
AC	Alternating Current.
LCD	Liquid Crystal Display
ADC	Analog-to-Digital Converter
IC	Integrated Circuit
LED	Light Emitting Diode
GSM	Global System of Mobile

CHAPTER I

INTRODUCTION

1.1 Introduction

In the present era one of the greatest problems faced by the world is water scarcity and agriculture being a demanding occupation consumes plenty of water. Therefore a system is required that uses water judiciously. Smart irrigation systems estimate and measure diminution of existing plant moisture in order to operate an irrigation system, restoring water as needed while minimizing excess water use. The soil moisture based irrigation control uses Tensiometric and Volumetric techniques, which are relatively simple but these quantities are related through a soil water characteristic curve that is specific to a soil type. Also the sensors used require routine maintenance for proper performance. Intelligent automatic plant irrigation system concentrates watering plants regularly without human monitoring using a moisture sensor. The circuit is built around a comparator Op-amp and a timer which drives a relay to switch on a motor. The system uses a hardware component, which is subjected to variation with the environmental conditions.

1.2 Background

Bangladesh is the country of agriculture. Agricultural sector is very important as far as Bangladeshi villager's point of view. Productivity of agriculture field's does not depend on excess of water sprinkled to the field, but depends on better matching of water supply with crop demand enduing form environmental conditions that are suitable for farming. To determine the crop watered mind it is essential to estimate the soil humidity. Under irrigation or over-irrigation system leads to excessive or less water supply which may cause worse results i.e. yield reduction. The project is based on activation or deactivation of appliances wirelessly through a software stack called Android which is used for mobile devices that include an operating system, middleware and key applications. The Android provides the tools necessary to begin developing applications on the Android platform. Mobile phones are become an integral part of us serving multiple needs of humans. In this project Commands to the device are given by authenticated person, who will activate or

deactivate the irrigation motor and also provide current status of appliances which in turn gives uniform environmental conditions that are suitable for farming.

1.3 Objectives

The main objective of this system is to introduce a Design & Implementation Smart Irrigation System with microcontroller technology. The supplementary objectives of this project are as follows:

(i) To learn how to configure the Design & Implementation in microcontroller platform.

(ii) To make people understand the advantages of using smart GSM based Irrigation System instead of paying cash.

(iii) To make an Agricultural sector is more developed.

(iv) To develop a smart irrigation system in order to get a significant saving in the consumption of water to irrigate the crops.

(v) To control the water application convenient for giving light and frequent irrigation and higher water application efficiency.

(vi) To use soluble fertilizers and chemicals.

(vii) To provide sufficient flow capacity to meet the irrigation demand.

1.4 Project Organization

In this report, Chapter one covers introduction, background, objectives. Chapter two represents theory, description of the microcontroller Arduino Uno R3, pump, soil moisture sensor, LCD display, DC-to-DC converter and other components. Chapter three describes and working principle of the project. In chapter four we have discussed result and discussion, cost estimation, future modification, conclusion.

CHAPTER II

THEORY OF THE PROJECT

2.1 Introduction

This chapter includes the total over view of the device. In this chapter we have followed-up the theory of Arduino Uno R3, Soil moisture sensor, Crystal LCD display (16x2), GSM module, Transformer, DC- DC voltage regulator, Bread board, and other components. Here we can know that the total system overview of the projects. And we will also know that how the equipment is working with each other.

2.2 Theory

We've developed the system that can handle this critical switching situation perfectly. Our system has several voltage, and current sensors to measure any over, under voltage. Based on those circumstances our system manages that power source switching. For example if any of those power sources get any problems like under voltage, our system immediately switches the power source to other power sources that has no problems. It also can provide stable output voltage depends on the input voltage state.

2.2.1 Arduino Uno

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. 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. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language and the Arduino Software (IDE), based on Processing.

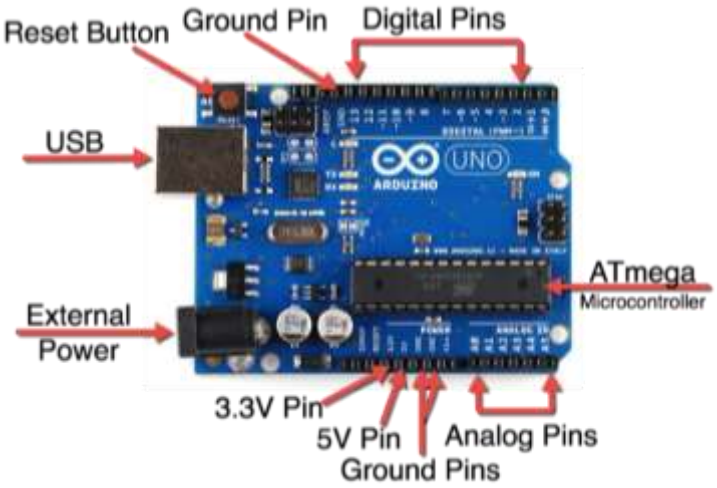


Fig: 2.2.1.1. Arduino UNO Pin Diagram

Technical specifications:

Table 2.1: Technical specifications of Arduino UNO

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

2.2.2 Microcontroller ATMEGA32P

The ATmega328 is a single chip micro-controller created by Atmel and belongs to the mega AVR series. Today the ATmega328 is commonly used in many projects and autonomous systems where a simple, low-powered, low-cost micro-controller is needed. Perhaps the most common implementation of this chip is on the popular Arduino development platform, namely the Arduino Uno and Arduino Nano models. Key features of this device are as below.

- 28-pin AVR Microcontroller
- Flash Program Memory: 32 Kbytes
- EEPROM Data Memory: 1 Kbytes
- SRAM Data Memory: 2 Kbytes
- I/O Pins: 23
- Timers: Two 8-bit / One 16-bit
- A/D Converter: 10-bit Six Channel
- PWM: Six Channels
- RTC: Yes with Separate Oscillator
- MSSP: SPI and I²C Master and Slave Support
- USART: Yes
- External Oscillator: up to 20MHz

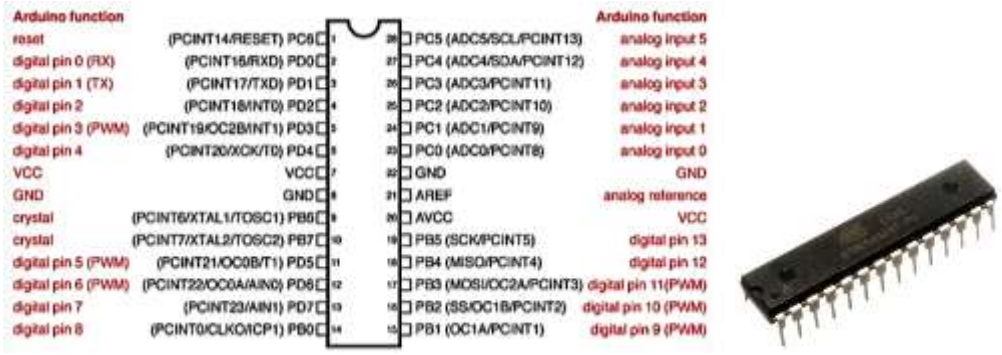


Fig: 2.2.2.1: ATMEGA328P-PU chip to Arduino Pin Mapping

2.2.3. GSM Module

Whether you want to listen to what happens in your house that's miles away from you or activates sprinkler system in your garden just with a silent call; Then SIM800L GSM/GPRS module serves as a solid launching point for you to get you started with IoT!

SIM800L GSM/GPRS module is a miniature GSM modem, which can be integrated into a great number of IoT projects. You can use this module to accomplish almost anything a normal cell phone can; SMS text messages, Make or receive phone calls, connecting to internet through GPRS, TCP/IP, and more! To top it off, the module supports quad-band GSM/GPRS network, meaning it works pretty much anywhere in the world.

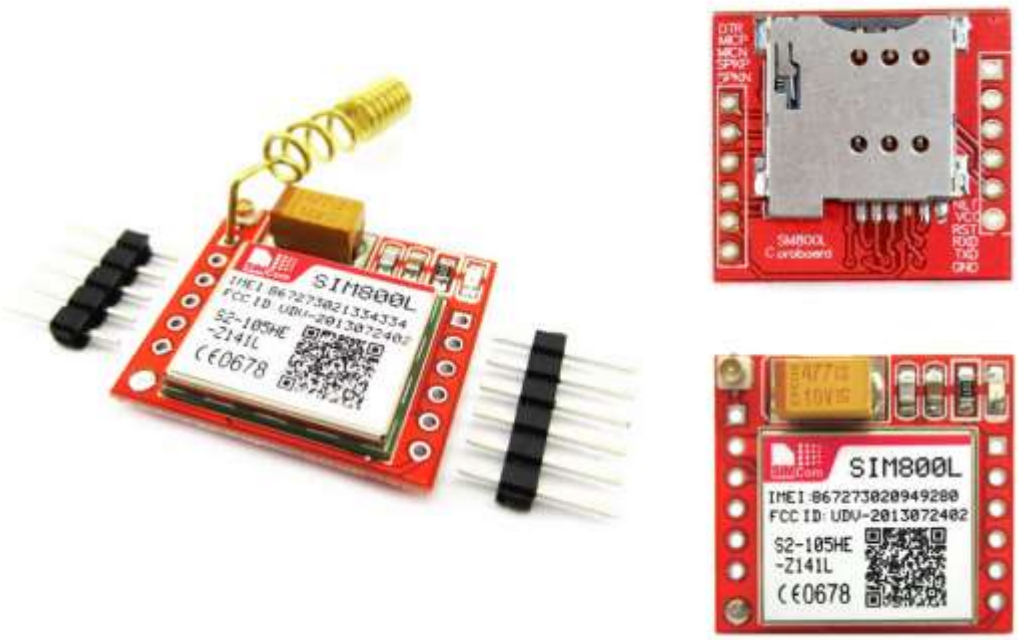


Figure 2.2.3.1: GSM SMS900A Module

It has a few really nice features that you may not have considered use full. -- A real time clock that is set by the network it also knows its Time Zone. -- 15 alarms yes 15 all with repeat function so you can set an alarm for 12 Noon and have it repeat Every day or every weekday etc. The alarm also powers the module on so for say a AMR system you could set the alarm for midnight each day the module would power up send +CALV: <n> to the controller the controller could then tell the module to send the data as a text and power the module down. Which can also be done by a single AT Command? -- A low power mode <1mA. All functionally still works SMS phone etc. but the AT.

How to use it:

1. Connect UART_TXD to RX of the FTDI
2. Connect UART_RXD to TX of the FTDI
3. Connect GND to the GND of the FTDI
4. Connect VCC5.0 To the PWR_KEY pin. This acts like CHIP ENABLE.
5. Connect a Micro Usb for the power(with any smartphone charger)
6. After 4-5 second you can remove the connection between VCC5.0 and PWR Key

You can open any serial monitor software like PuTty, select the port allotted to your FTDI and choose 9600baud. Input "AT", and if you see "OK" it works! The A6 GSM requires a CARRIAGE RETURN after every AT command. This can be done easily with the SET MACROS function of the TERMINAL software. Here you can store AT commands followed by a $ sign & 0D. $ sign is to Append & 0D is the ASCII for Carriage Return. The good new is the AT commands are very close to the Commands for others Gprs/Gsm modules like SIM800L/SIM900A . The CIPMUX command can't be used, maybe it's CMUX

Make a call

ATD+the phone number

For example: ATD0179xxx Push enter and you will receive the call. Note that no semicolon is required as in SIM900A. The no. will be dialed even if you use a semicolon.

Send a message

AT+CMGF=1 to change to TEXT mode.

AT+CMGS="0179xxxxx″ >(write the message here) push Ctrl-Z and Enter, it doesn't work in the Arduino Serial monitor but you can do it in Teraterm ,Putty or SCOM CTRL+Z can be sent using the ASCII code 1A.

You can see all your previous message with:

AT+CMGR=1 for an another message change the number

AT+CMGR=2

AT+CMGR=10

AT+CMGR=24

Etc.

Features:

- Supports Quad-band: GSM850, EGSM900, DCS1800 and PCS1900
- Connect onto any global GSM network with any 2G SIM
- Make and receive voice calls using an external 8Ω speaker & electret microphone
- Send and receive SMS messages
- Send and receive GPRS data (TCP/IP, HTTP, etc.)
- Scan and receive FM radio broadcasts
- Transmit Power:
- Class 4 (2W) for GSM850
- Class 1 (1W) for DCS1800
- Serial-based AT Command Set
- FL connectors for cell antennae
- Accepts Micro SIM Card

POWER UP GSM SIM800L:

3.7v Li-Po Battery (Recommended)

One of the cool things about Li-Po batteries is that their voltage is generally in the range of 3.7V–4.2V, perfect for SIM800L Module. Any 1200mAh or larger sized Lithium ion/polymer battery is best since it can provide the correct voltage range even during 2 Amp spikes.



Figure 2.2.3.1.1: Li-Po batteries

DC-DC Buck Converter

Any 2A-rated DC-DC buck converter like LM2596 would work. These are much more efficient than a liner voltage regulator like LM317 or LM338.



Figure 2.2.3.2: DC-DC buck converter

Features of GPRS:

- **Wide coverage**: GPRS have good coverage, is the world's prevailing 2G communication standards. Basically the phone can call the place by GPRS wireless Internet access;
- **Forever Online**: as long as the activated GPRS applications will remain online, similar to a wireless line network services.
- **By the amount of the charge**: GPRS services, though to be online, but you do not have to worry about the cost issue; because only generated when traffic accounting.
- **High-speed transmission**: GPRS currently supports peak transfer rate of 85.6Kbps, the theoretical peak transfer up to more than 100 Kbps.

2.2.4. Liquid Crystal Display (LCD 16x2):

Nowadays, we always use the devices which are made up of LCDs such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries to replace the utilization of CRTs. **Cathode Ray Tubes** use huge power when compared with LCDs, and CRTs heavier as well as bigger. These devices are thinner as well power consumption is extremely less. The **LCD 16×2 working principle** is, it blocks the light rather than dissipate. This article discusses an overview of LCD 16X2, pin configuration and its working.

Means of LCD 16×2:

The term **LCD stands for liquid crystal display.** It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment **light-emitting diodes** and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

Construction:

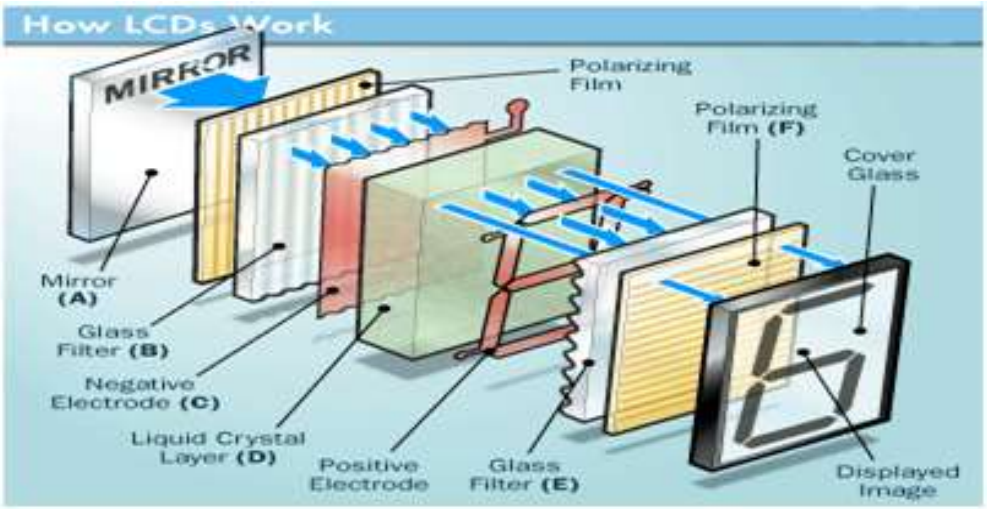


Figure 3: Liquid Crystal Display

Simple facts that should be considered while making an LCD:

1. The basic structure of LCD should be controlled by changing the applied current.
2. We must use a polarized light.
3. Liquid crystal should able be to control both of the operation to transmit or can also able to change the polarized light.

As mentioned above that we need to take two polarized glass pieces filter in the making of the liquid crystal. The glass which does not have a polarized film on the surface of it must be rubbed with a special polymer which will create microscopic grooves on the surface of the

polarized glass filter. The grooves must be in the same direction of the polarized film. Now we have to add a coating of pneumatic liquid phase crystal on one of the polarized filter of the polarized glass. The microscopic channel cause the first layer molecule to align with filter orientation. When the right angle appears at the first layer piece, we should add a second piece of glass with the polarized film. The first filter will be naturally polarized as the light strikes it at the starting stage.

Thus the light travels through each layer and guided on the next with the help of molecule. The molecule tends to change its plane of vibration of the light in order to match their angle. When the light reaches to the far end of the liquid crystal substance, it vibrates at the same angle as that of the final layer of the molecule vibrates. The light is allowed to enter into the device only if the second layer of the polarized glass matches with the final layer of the molecule.

Working of LCDs:

The principle behind the LCD's is that when an electrical current is applied to the liquid crystal molecule, the molecule tends to untwist. This causes the angle of light which is passing through the molecule of the polarized glass and also cause a change in the angle of the top polarizing filter. As a result a little light is allowed to pass the polarized glass through a particular area of the LCD. Thus that particular area will become dark compared to other. The LCD works on the principle of blocking light. While constructing the LCD's, a reflected mirror is arranged at the back. An electrode plane is made of indium-tin oxide which is kept on top and a polarized glass with a polarizing film is also added on the bottom of the device. The complete region of the LCD has to be enclosed by a common electrode and above it should be the liquid crystal matter. Next comes to the second piece of glass with an electrode in the form of the rectangle on the bottom and, on top, another polarizing film. It must be considered that both the pieces are kept at right angles. When there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus the light is blocked from passing through. That particular rectangular area appears blank.

Advantages of an LCD's:

- LCD's consumes less amount of power compared to CRT and LED
- LCD's are consist of some microwatts for display in comparison to some mill watts for LED's
- LCDs are of low cost
- Provides excellent contrast
- LCD's are thinner and lighter when compared to cathode ray tube and LED

Disadvantages of an LCD's:

- Require additional light sources
- Range of temperature is limited for operation
- Low reliability
- Speed is very low
- LCD's need an AC drive

Applications of Liquid Crystal Display

Liquid crystal technology has major applications in the field of science and engineering as well on electronic devices.

- Liquid crystal thermometer
- Optical imaging
- The liquid crystal display technique is also applicable in visualization of the radio frequency waves in the waveguide
- Used in the medical applications

LCD 16×2 Pin Diagram:

- The 16×2 LCD pin out is shown below.

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.

- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

Figure:

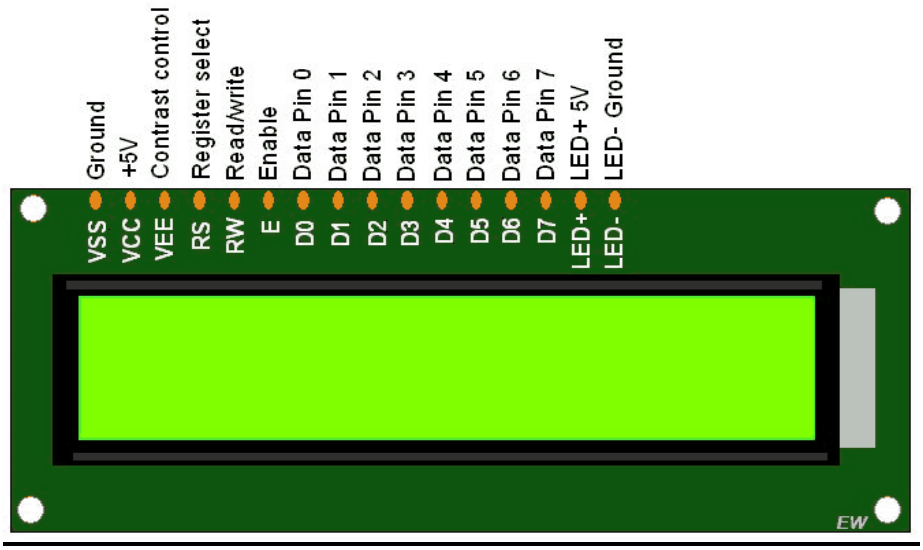


Figure 2.2.4.1: Liquid Crystal Display

2.2.5. Soil Moisture Sensor

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content.

The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.

Technology Technologies commonly used to indirectly measure volumetric water content (soil moisture) include) Frequency Domain Reflectometry (FDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the operating frequency of an oscillating circuit.

Time Domain Transmission (TDT) and Time Domain Reflectometry (TDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the speed of propagation along a buried transmission line.

Neutron moisture gauges: The moderator properties of water for neutrons are utilized to estimate soil moisture content between a source and detector probe.

Soil resistivity: Measuring how strongly the soil resists the flow of electricity between two electrodes can be used to determine the soil moisture content.

Galvanic cell: The amount of water present can be determined based on the voltage the soil produces because water acts as an electrolyte and produces electricity. The technology behind this concept is the galvanic cell.

Application Agriculture

Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

Landscape irrigation

In urban and suburban areas, landscapes and residential lawns are using soil moisture sensors to interface with an irrigation controller. Connecting a soil moisture sensor to a simple irrigation clock will convert it into a "smart" irrigation controller that prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event.

Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground.

Research

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

Simple sensors for gardeners

Relatively cheap and simple devices that do not require a power source are available for checking whether plants have sufficient moisture to thrive. After inserting a probe into the soil for approximately 60 seconds, a meter indicates if the soil is too dry, moist or wet for plants.

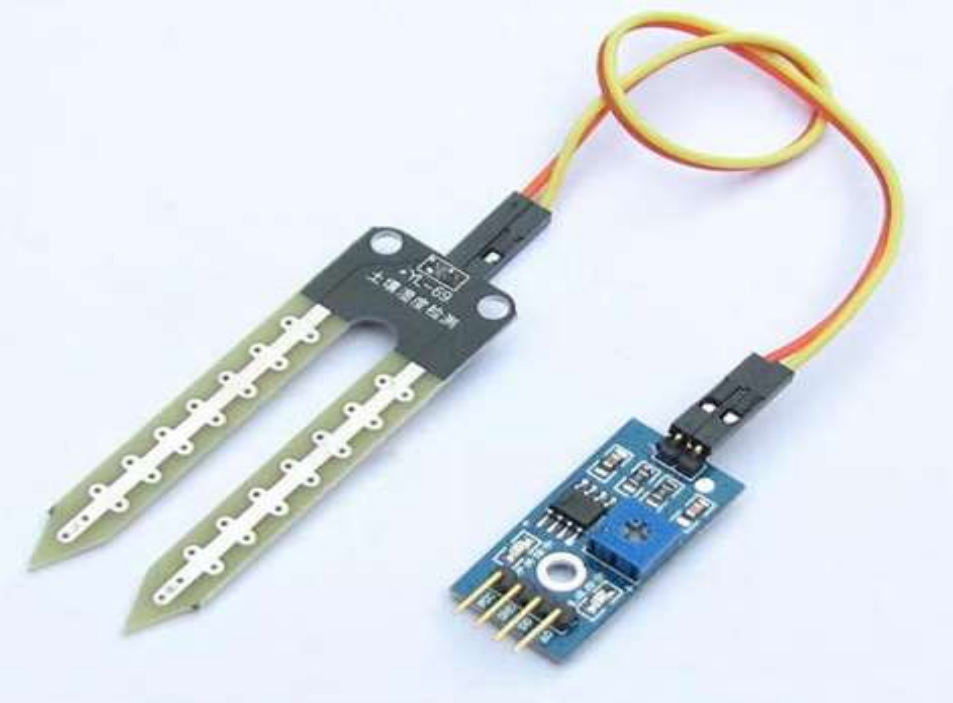


Figure 2.2.5.1: Soil Moisture Sensor

2.2.6. Relay Module

The module is uses SRD relay module to control high-voltage electrical devices. (Maximum 250V).It can be used in interactive projects and can also be used to control the lighting, electrical and other equipments.It can be controlled directly by a wide range of microcontrollers and can be controlled through the digital IO port, such as solenoid valves, lamps, motors and other high current or high voltage devices.



Figure 2.2.6.1: Relay Module

Feature

- Number of I/O Channels: 1
- Type: Digital
- Switching capacity available by 10A in spite of small size design for high density P.C. board mounting technique.
- Control signal: TTL level
- Max. Allowable Voltage: 250VAC/110VDC
- Max. Allowable Power Force: From C(800VAC/240W), From A(1200VA/300W)
- UL, CUL, TUV recognized.
- Indication LED for Relay's Status
- Application Ideas
- Domestic appliance
- office machine
- motors
- equipment
- Automobile, etc.

Application Ideas

- Domestic appliance
- office machine
- motors
- equipment
- automobile, etc.

2.2.7. 9V DC Power supply (Rectifier)

A bridge rectifier circuit is a common part of the electronic power supplies. Many electronic circuits require rectified DC power supply for powering the various electronic basic components from available AC mains supply. We can find this rectifier in a wide variety of electronic AC power devices like home appliances, motor controllers, modulation process, welding applications, etc.

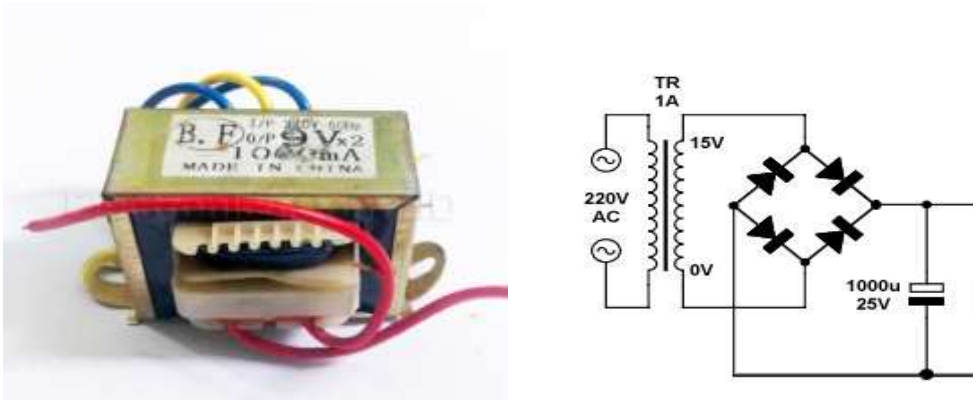


Figure: 2.2.7.1: 220V / 9V rectifier

The bridge rectifier circuit diagram consists of various stages of devices like transformer, Diode Bridge, filtering and regulators. The first stage of the circuit is a transformer which is a step-down type that changes the amplitude of the input voltage. Most of the electronic projects uses 230/12V transformer to step-down the AC mains 230V to 12V AC supply. Next stage is a diode-bridge rectifier which uses four or more diodes depending on the type of bridge rectifier. Choosing a particular diode or any other switching device for a corresponding rectifier needs some considerations of the device like Peak Inverse Voltage (PIV), forward current If, voltage ratings, etc. It is responsible for producing unidirectional or DC current at the load by conducting a set of diodes for every half cycle of the input signal.

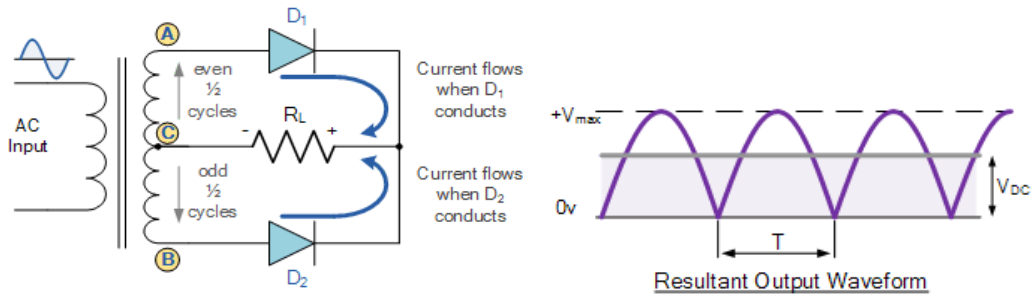


Fig: 2.2.8.1: Output Waveforms of 220V/12V rectifier

Since the output after the diode bridge rectifiers is of pulsating nature, and for producing it as a pure DC, filtering is necessary. Filtering is normally performed with one or more capacitors attached across the load, as you can observe in the below figure wherein smoothing of wave is performed. This capacitor rating also depends on the output voltage.

2.2.8. DC-to-DC converter

The buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a fly back converter using a single inductor instead of a transformer.

Two different topologies are called buck–boost converter. Both of them can produce a range of output voltages, ranging from much larger (in absolute magnitude) than the input voltage, down to almost zero.

The output voltage is of the opposite polarity than the input. This is a switched-mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching transistor. One possible drawback of this converter is that the switch does not have a terminal at ground; this complicates the driving circuitry. However, this drawback is of no consequence if the power supply is isolated from the load circuit (if, for example, the supply is a battery) because the supply and diode polarity can simply be reversed. When they can be reversed, the switch can be on either the ground side or the supply side

A buck (step-down) converter combined with a boost (step-up) converter

The output voltage is typically of the same polarity of the input, and can be lower or higher than the input. Such a non-inverting buck-boost converter may use a single inductor which is used for both the buck inductor mode and the boost inductor mode, using switches instead of diodes, sometimes called a **"four-switch buck-boost converter"**, it may use multiple inductors but only a single switch as in the SEPIC topologies



Figure 2.2.9.1: DC-to-DC converter

2.2.9. Pump

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps.

Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

When a casing contains only one revolving impeller, it is called a single-stage pump. When a casing contains two or more revolving impellers, it is called a double- or multi-stage pump.

In biology, many different types of chemical and biomechanical pumps have evolved; biomimicry is sometimes used in developing new types of mechanical pumps.

Types

Mechanical pumps may be submerged in the fluid they are pumping or be placed external to the fluid.

Pumps can be classified by their method of displacement into positive displacement pumps, impulse pumps, velocity pumps, gravity pumps, steam pumps and valve less pumps. There are two basic types of pumps: positive displacement and centrifugal. Although axial-flow pumps are frequently classified as a separate type, they have essentially the same operating principles as centrifugal pumps.

Positive displacement pumps

Lobe pump internals A positive displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe.

Some positive displacement pumps use an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant through each cycle of operation.

Positive displacement pump behavior and safety

Positive displacement pumps, unlike centrifugal or roto-dynamic pumps, theoretically can produce the same flow at a given speed (RPM) no matter what the discharge pressure. Thus, positive displacement pumps are constant flow machines. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

A positive displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, or both.

A relief or safety valve on the discharge side of the positive displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually used only as

a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank provides increased safety.

A positive displacement pump can be further classified according to the mechanism used to move the fluid:

Rotary-type positive displacement: internal gear, screw, shuttle block, flexible vane or sliding vane, circumferential piston, flexible impeller, helical twisted roots (e.g. the Wendelkolben pump) or liquid-ring pumps

Reciprocating-type positive displacement: piston pumps, plunger pumps or diaphragm pumps

Linear-type positive displacement: rope pumps and chain pumps

Rotary positive displacement pumps

Rotary vane pump

These pumps move fluid using a rotating mechanism that creates a vacuum that captures and draws in the liquid.

Advantages: Rotary pumps are very efficient because they can handle highly viscous fluids with higher flow rates as viscosity increases.

Drawbacks: The nature of the pump requires very close clearances between the rotating pump and the outer edge, making it rotate at a slow, steady speed. If rotary pumps are operated at high speeds, the fluids because erosion, which eventually causes enlarged clearances that liquid can pass through, which reduces efficiency?



Figure 2.2.10.1: Pump

Rotary positive displacement pumps fall into three main types:

Gear pumps – a simple type of rotary pump where the liquid is pushed between two gears

Screw pumps – the shape of the internals of this pump is usually two screws turning against each other to pump the liquid

Rotary vane pumps – similar to scroll compressors, these have a cylindrical rotor encased in a similarly shaped housing. As the rotor orbits, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

Reciprocating positive displacement pumps

Simple hand pump

Antique "pitcher" pump (c. 1924) at the Colored School in Alapaha, Georgia, US

Main article: Reciprocating pump

Reciprocating pumps move the fluid using one or more oscillating pistons, plungers, or membranes (diaphragms), while valves restrict fluid motion to the desired direction. In order for suction to take place, the pump must first pull the plunger in an outward motion to decrease pressure in the chamber. Once the plunger pushes back, it will increase the pressure chamber and the inward pressure of the plunger will then open the discharge valve and release the fluid into the delivery pipe at a high velocity.

Pumps in this category range from simplex, with one cylinder, to in some cases quad (four) cylinders, or more. Many reciprocating-type pumps are duplex (two) or triplex (three) cylinder. They can be either single-acting with suction during one direction of piston motion and discharge on the other, or double-acting with suction and discharge in both directions. The pumps can be powered manually, by air or steam, or by a belt driven by an engine. This type of pump was used extensively in the 19th century—in the early days of steam propulsion—as boiler feed water pumps. Now reciprocating pumps typically pump highly viscous fluids like concrete and heavy oils, and serve in special applications that demand low flow rates against high resistance. Reciprocating hand pumps were widely used to pump water from wells. Common bicycle pumps and foot pumps for inflation use reciprocating action.

These positive displacement pumps have an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation and the pump's volumetric efficiency can be achieved through routine maintenance and inspection of its valves.[6]

Typical reciprocating pumps are:

Plunger pumps – a reciprocating plunger pushes the fluid through one or two open valves, closed by suction on the way back.

Diaphragm pumps – similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.

Piston pumps displacement **pumps – usually simple devices for pumping small amounts of liquid** or gel manually. The common hand soap dispenser is such a pump.

Radial piston pumps - a form of hydraulic pump where pistons extend in a radial direction.

Various positive-displacement pumps

The positive displacement principle applies in these pumps:

- Rotary lobe pump
- Progressive cavity pump
- Rotary gear pump
- Piston pump
- Diaphragm pump
- Screw pump
- Gear pump
- Hydraulic pump
- Rotary vane pump
- Peristaltic pump
- Rope pump
- Flexible impeller pump
- Gear pump

Gear pump

This is the simplest of rotary positive displacement pumps. It consists of two meshed gears that rotate in a closely fitted casing. The tooth spaces trap fluid and force it around the outer periphery. The fluid does not travel back on the meshed part, because the teeth mesh closely in the center. Gear pumps see wide use in car engine oil pumps and in various hydraulic power packs.

Screw pump

A screw pump is a more complicated type of rotary pump that uses two or three screws with opposing thread — e.g., one screw turns clockwise and the other counterclockwise. The screws are mounted on parallel shafts that have gears that mesh so the shafts turn together and everything stays in place. The screws turn on the shafts and drive fluid through the pump. As with other forms of rotary pumps, the clearance between moving parts and the pump's casing is minimal.

Progressing cavity pump

Widely used for pumping difficult materials, such as sewage sludge contaminated with large particles, this pump consists of a helical rotor, about ten times as long as its width. This can be visualized as a central core of diameter x with, typically, a curved spiral wound around of thickness half x, though in reality it is manufactured in single casting. This shaft fits inside a heavy duty rubber sleeve, of wall thickness also typically x. As the shaft rotates, the rotor gradually forces fluid up the rubber sleeve. Such pumps can develop very high pressure at low volumes.

Cavity pump

Roots-type pumps

A Roots lobe pump

Named after the Roots brothers who invented it, this lobe pump displaces the liquid trapped between two long helical rotors, each fitted into the other when perpendicular at 90°, rotating inside a triangular shaped sealing line conFigureuration, both at the point of suction and at the point of discharge. This design produces a continuous flow with equal volume and no vortex. It can work at low pulsation rates, and offers gentle performance that some applications require.

Applications include:

High capacity industrial air compressors

Roots superchargers on internal combustion engines.

A brand of civil defense siren, the Federal Signal Corporation's Thunderbolt.

Peristaltic pump

360° Peristaltic Pump

Main article: Peristaltic pump

A peristaltic pump is a type of positive displacement pump. It contains fluid within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A number of rollers, shoes, or wipers attached to a rotor compresses the flexible tube. As the rotor turns, the part of the tube under compression closes (or occludes), forcing the fluid through the tube. Additionally, when the tube opens to its natural state after the passing of the

cam it draws (restitution) fluid into the pump. This process is called peristalsis and is used in many biological systems such as the gastrointestinal tract.

Plunger pumps

Plunger pumps are reciprocating positive displacement pumps.

These consist of a cylinder with a reciprocating plunger. The suction and discharge valves are mounted in the head of the cylinder. In the suction stroke the plunger retracts and the suction valves open causing suction of fluid into the cylinder. In the forward stroke the plunger pushes the liquid out of the discharge valve. Efficiency and common problems: With only one cylinder in plunger pumps, the fluid flow varies between maximum flow when the plunger moves through the middle positions, and zero flow when the plunger is at the end positions. A lot of energy is wasted when the fluid is accelerated in the piping system. Vibration and water hammer may be a serious problem. In general the problems are compensated for by using two or more cylinders not working in phase with each other.

Triplex-style plunger pumps

Triplex plunger pumps use three plungers, which reduces the pulsation of single reciprocating plunger pumps. Adding a pulsation dampener on the pump outlet can further smooth the pump ripple, or ripple graph of a pump transducer. The dynamic relationship of the high-pressure fluid and plunger generally requires high-quality plunger seals. Plunger pumps with a larger number of plungers have the benefit of increased flow, or smoother flow without a pulsation damper. The increase in moving parts and crankshaft load is one drawback.

Car washes often use these triplex-style plunger pumps (perhaps without pulsation dampers). In 1968, William Bruggeman reduced the size of the triplex pump and increased the lifespan so that car washes could use equipment with smaller footprints. Durable high-pressure seals, low-pressure seals and oil seals, hardened crankshafts, hardened connecting rods, thick ceramic plungers and heavier duty ball and roller bearings improve reliability in triplex pumps. Triplex pumps now are in a myriad of markets across the world.

Triplex pumps with shorter lifetimes are commonplace to the home user. A person who uses a home pressure washer for 10 hours a year may be satisfied with a pump that lasts 100 hours

between rebuilds. Industrial-grade or continuous duty triplex pumps on the other end of the quality spectrum may run for as much as 2,080 hours a year.[7]

The oil and gas drilling industry uses massive semi trailer-transported triplex pumps called mud pumps to pump drilling mud, which cools the drill bit and carries the cuttings back to the surface.[8] Drillers use triplex or even quintuplex pumps to inject water and solvents deep into shale in the extraction process called fracking.[9]

Compressed-air-powered double-diaphragm pumps

One modern application of positive displacement pumps is compressed-air-powered double-diaphragm pumps. Run on compressed air these pumps are intrinsically safe by design, although all manufacturers offer ATEX certified models to comply with industry regulation. These pumps are relatively inexpensive and can perform a wide variety of duties, from pumping water out of bunds to pumping hydrochloric acid from secure storage (dependent on how the pump is manufactured – elastomers / body construction). These double-diaphragm pumps can handle viscous fluids and abrasive materials with a gentle pumping process ideal for transporting shear sensitive media.

Rope pumps

Rope pump schematic

Devised in China as chain pumps over 1000 years ago, these pumps can be made from very simple materials: A rope, a wheel and a PVC pipe are sufficient to make a simple rope pump. Rope pump efficiency has been studied by grass roots organizations and the techniques for making and running them have been continuously improved.

Impulse pumps

Impulse pumps use pressure created by gas (usually air). In some impulse pumps the gas trapped in the liquid (usually water), is released and accumulated somewhere in the pump, creating a pressure that can push part of the liquid upwards.

Conventional impulse pumps include:

Hydraulic ram pumps – kinetic energy of a low-head water supply is stored temporarily in an air-bubble hydraulic accumulator, then used to drive water to a higher head.

Pulser pumps – run with natural resources, by kinetic energy only.

Airlift pumps – run on air inserted into pipe, which pushes the water up when bubbles move upward

Instead of a gas accumulation and releasing cycle, the pressure can be created by burning of hydrocarbons. Such combustion driven pumps directly transmit the impulse from a combustion event through the actuation membrane to the pump fluid. In order to allow this direct transmission, the pump needs to be almost entirely made of an elastomer (e.g. silicone rubber). Hence, the combustion causes the membrane to expand and thereby pumps the fluid out of the adjacent pumping chamber. The first combustion-driven soft pump was developed by ETH Zurich.

Hydraulic ram pumps

A hydraulic ram is a water pump powered by hydropower.

It takes in water at relatively low pressure and high flow-rate and outputs water at a higher hydraulic-head and lower flow-rate. The device uses the water hammer effect to develop pressure that lifts a portion of the input water that powers the pump to a point higher than where the water started.

The hydraulic ram is sometimes used in remote areas, where there is both a source of low-head hydropower, and a need for pumping water to a destination higher in elevation than the source. In this situation, the ram is often useful, since it requires no outside source of power other than the kinetic energy of flowing water.

Velocity pumps

A centrifugal pump uses an impeller with backward-swept arms

Rot dynamic pumps (or dynamic pumps) are a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure is explained by the First law of thermodynamics, or more specifically by Bernoulli's principle.

Dynamic pumps can be further subdivided according to the means in which the velocity gain is achieved.

These types of pumps have a number of characteristics:

Continuous energy

Conversion of added energy to increase in kinetic energy (increase in velocity)

Conversion of increased velocity (kinetic energy) to an increase in pressure head

A practical difference between dynamic and positive displacement pumps is how they operate under closed valve conditions. Positive displacement pumps physically displace fluid, so closing a valve downstream of a positive displacement pump produces a continual pressure build up that can cause mechanical failure of pipeline or pump. Dynamic pumps differ in that they can be safely operated under closed valve conditions (for short periods of time).

Radial-flow pumps

Such a pump is also referred to as a centrifugal pump. The fluid enters along the axis or center, is accelerated by the impeller and exits at right angles to the shaft (radially); an example is the centrifugal fan, which is commonly used to implement a vacuum cleaner. Generally, a radial-flow pump operates at higher pressures and lower flow rates than an axial- or a mixed-flow pump.

Axial-flow pumps

These are also referred to as All fluid pumps. The fluid is pushed outward or inward and move fluid axially. They operate at much lower pressures and higher flow rates than radial-flow (centrifugal) pumps. Axial-flow pumps cannot be run up to speed without special precaution. If at a low flow rate, the total head rise and high torque associated with this pipe would mean that the starting torque would have to become a function of acceleration for the whole mass of liquid in the pipe system. If there is a large amount of fluid in the system, accelerate the pump slowly.[15]

Mixed-flow pumps function as a compromise between radial and axial-flow pumps. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction. As a consequence mixed-flow pumps operate at higher pressures than axial-flow pumps while delivering higher discharges than radial-flow pumps. The exit angle of the flow dictates the pressure head-discharge characteristic in relation to radial and mixed-flow.

Eductor-jet pump

This uses a jet, often of steam, to create a low pressure. This low pressure sucks in fluid and propels it into a higher pressure region.

Gravity pumps

Gravity pumps include the syphon and Heron's fountain. The hydraulic ram is also sometimes called a gravity pump; in a gravity pump the water is lifted by gravitational force and so called gravity pump

Steam pumps

Steam pumps have been for a long time mainly of historical interest. They include any type of pump powered by a steam engine and also pistonless pumps such as Thomas Savery's or the Pulsometer steam pump.

Recently there has been a resurgence of interest in low power solar steam pumps for use in smallholder irrigation in developing countries. Previously small steam engines have not been viable because of escalating inefficiencies as vapour engines decrease in size. However the use of modern engineering materials coupled with alternative engine con Figureurations has meant that these types of system are now a cost effective opportunity.

Valveless pumps

Valveless pumping assists in fluid transport in various biomedical and engineering systems. In a valveless pumping system, no valves (or physical occlusions) are present to regulate the flow direction. The fluid pumping efficiency of a valveless system, however, is not necessarily lower than that having valves. In fact, many fluid-dynamical systems in nature and engineering more or less rely upon valveless pumping to transport the working fluids therein. For instance, blood circulation in the cardiovascular system is maintained to some extent even when the heart’s valves fail. Meanwhile, the embryonic vertebrate heart begins pumping blood long before the development of discernible chambers and valves. In microfluidics, valveless impedance pumps have been fabricated, and are expected to be particularly suitable for handling sensitive biofluids. Ink jet printers operating on the Piezoelectric transducer principle also use valveless pumping. The pump chamber is emptied through the printing jet due to reduced flow impedance in that direction and refilled by capillary action..

Pump repairs

Derelict windmill connected to water pump with water storage tank in the foreground

Examining pump repair records and mean time between failures (MTBF) is of great importance to responsible and conscientious pump users. In view of that fact, the preface to the 2006 Pump User's Handbook alludes to "pump failure" statistics. For the sake of convenience, these failure statistics often are translated into MTBF (in this case, installed life before failure).

In early 2005, Gordon Buck, John Crane Inc.'s chief engineer for Field Operations in Baton Rouge, LA, examined the repair records for a number of refinery and chemical plants to obtain meaningful reliability data for centrifugal pumps. A total of 15 operating plants having nearly 15,000 pumps were included in the survey. The smallest of these plants had about 100 pumps; several plants had over 2000. All facilities were located in the United States. In addition, considered as "new", others as "renewed" and still others as "established". Many of these plants—but not all—had an alliance arrangement with John Crane. In some cases, the alliance contract included having a John Crane Inc. technician or engineer on-site to coordinate various aspects of the program.

Not all plants are refineries, however, and different results occur elsewhere. In chemical plants, pumps have historically been "throw-away" items as chemical attack limits life. Things have improved in recent years, but the somewhat restricted space available in "old" DIN and ASME-standardized stuffing boxes places limits on the type of seal that fits. Unless the pump user upgrades the seal chamber, the pump only accommodates more compact and simple versions. Without this upgrading, lifetimes in chemical installations are generally around 50 to 60 percent of the refinery values.

Unscheduled maintenance is often one of the most significant costs of ownership, and failures of mechanical seals and bearings are among the major causes. Keep in mind the potential value of selecting pumps that cost more initially, but last much longer between repairs. The MTBF of a better pump may be one to four years longer than that of its non-upgraded counterpart. Consider that published average values of avoided pump failures range from US$2600 to US$12,000. This does not include lost opportunity costs. One pump fire occurs per 1000 failures. Having fewer pump failures means having fewer destructive pump fires.

As has been noted, a typical pump failure, based on actual year 2002 reports, costs US$5,000 on average. This includes costs for material, parts, labor and overhead. Extending a pump's

MTBF from 12 to 18 months would save US$1,667 per year — which might be greater than the cost to upgrade the centrifugal pump's reliability.

History of Pumps

In 200 BC Archimedes designed the Archimedean screw pump. It is considered one of the most important inventions of all time. It is still in use for pumping liquids and granulated solids. It can irrigate fields without electrical pumps.[19]

Applications

Metering pump for gasoline and additives.

Pumps are used throughout society for a variety of purposes. Early applications include the use of the windmill or watermill to pump water. Today, the pump is used for irrigation, water supply, gasoline supply, air conditioning systems, refrigeration (usually called a compressor), chemical movement, sewage movement, flood control, marine services, etc.

Because of the wide variety of applications, pumps have a plethora of shapes and sizes: from very large to very small, from handling gas to handling liquid, from high pressure to low pressure, and from high volume to low volume.

Priming a pump

Typically, a liquid pump can't simply draw air. The feed line of the pump and the internal body surrounding the pumping mechanism must first be filled with the liquid that requires pumping: An operator must introduce liquid into the system to initiate the pumping. This is called priming the pump. Loss of prime is usually due to ingestion of air into the pump. The clearances and displacement ratios in pumps for liquids, whether thin or more viscous, usually cannot displace air due to its compressibility. This is the case with most velocity (rotodynamic) pumps — for example, centrifugal pumps. For such pumps the position of the pump should always be lower than the suction point, if not the pump should be manually filled with liquid or a secondary pump should be used until all air is removed from the suction line and the pump casing.

Positive–displacement pumps, however, tend to have sufficiently tight sealing between the moving parts and the casing or housing of the pump that they can be described as self-priming. Such pumps can also serve as priming pumps, so called when they are used to fulfill that need for other pumps in lieu of action taken by a human operator.

Pumps as public water supplies

First European depiction of a piston pump, by Taccola, c.1450.

Irrigation is underway by pump-enabled extraction directly from the Gumti, seen in the background, in Comilla, Bangladesh.

One sort of pump once common worldwide was a hand-powered water pump, or 'pitcher pump'. It was commonly installed over community water wells in the days before piped water supplies.

In parts of the British Isles, it was often called the parish pump. Though such community pumps are no longer common, people still used the expression parish pump to describe a place or forum where matters of local interest are discussed.

Because water from pitcher pumps is drawn directly from the soil, it is more prone to contamination. If such water is not filtered and purified, consumption of it might lead to gastrointestinal or other water-borne diseases. A notorious case is the 1854 Broad Street cholera outbreak. At the time it was not known how cholera was transmitted, but physician John Snow suspected contaminated water and had the handle of the public pump he suspected removed; the outbreak then subsided.

Modern hand-operated community pumps are considered the most sustainable low-cost option for safe water supply in resource-poor settings, often in rural areas in developing countries. A hand pump opens access to deeper groundwater that is often not polluted and also improves the safety of a well by protecting the water source from contaminated buckets. Pumps such as the Afridev pump are designed to be cheap to build and install, and easy to maintain with simple parts. However, scarcity of spare parts for these type of pumps in some regions of Africa has diminished their utility for these areas.

Sealing multiphase pumping applications

Multiphase pumping applications, also referred to as tri-phase, have grown due to increased oil drilling activity. In addition, the economics of multiphase production is attractive to upstream operations as it leads to simpler, smaller in-field installations, reduced equipment costs and improved production rates. In essence, the multiphase pump can accommodate all fluid stream properties with one piece of equipment, which has a smaller footprint. Often,

two smaller multiphase pumps are installed in series rather than having just one massive pump.

For midstream and upstream operations, multiphase pumps can be located onshore or offshore and can be connected to single or multiple wellheads. Basically, multiphase pumps are used to transport the untreated flow stream produced from oil wells to downstream processes or gathering facilities. This means that the pump may handle a flow stream (well stream) from 100 percent gas to 100 percent liquid and every imaginable combination in between. The flow stream can also contain abrasives such as sand and dirt. Multiphase pumps are designed to operate under changing or fluctuating process conditions. Multiphase pumping also helps eliminate emissions of greenhouse gases as operators strive to minimize the flaring of gas and the venting of tanks where possible.

Types and features of multiphase pumps

Helicon-axial pumps (centrifugal)

A rotodynamic pump with one single shaft that requires two mechanical seals, this pump uses an open-type axial impeller. It's often called a Poseidon pump, and can be described as a cross between an axial compressor and a centrifugal pump.

Twin-screw (positive-displacement)

The twin-screw pump is constructed of two inter-meshing screws that move the pumped fluid. Twin screw pumps are often used when pumping conditions contain high gas volume fractions and fluctuating inlet conditions. Four mechanical seals are required to seal the two shafts.

Progressive cavity (positive-displacement)

When the pumping application is not suited to a centrifugal pump, a progressive cavity pump is used instead.[23] Progressive cavity pumps are single-screw types typically used in shallow wells or at the surface. This pump is mainly used on surface applications where the pumped fluid may contain a considerable amount of solids such as sand and dirt. The volumetric efficiency and mechanical efficiency of a progressive cavity pump increases as the viscosity of the liquid does.

Electric submersible (centrifugal)

These pumps are basically multistage centrifugal pumps and are widely used in oil well applications as a method for artificial lift. These pumps are usually specified when the pumped fluid is mainly liquid.

Buffer tank A buffer tank is often installed upstream of the pump suction nozzle in case of a slug flow. The buffer tank breaks the energy of the liquid slug, smooths any fluctuations in the incoming flow and acts as a sand trap.

As the name indicates, multiphase pumps and their mechanical seals can encounter a large variation in service conditions such as changing process fluid composition, temperature variations, high and low operating pressures and exposure to abrasive/erosive media. The challenge is selecting the appropriate mechanical seal arrangement and support system to ensure maximized seal life and its overall effectiveness.

Specifications

Pumps are commonly rated by horsepower, volumetric flow rate, outlet pressure in meters (or feet) of head, inlet suction in suction feet (or meters) of head. The head can be simplified as the number of feet or meters the pump can raise or lower a column of water at atmospheric pressure.

From an initial design point of view, engineers often use a quantity termed the specific speed to identify the most suitable pump type for a particular combination of flow rate and head.

Pumping power

The power imparted into a fluid increases the energy of the fluid per unit volume. Thus the power relationship is between the conversion of the mechanical energy of the pump mechanism and the fluid elements within the pump. In general, this is governed by a series of simultaneous differential equations, known as the Naiver–Stokes equations. However a more simple equation relating only the different energies in the fluid, known as Bernoulli's equation can be used. Hence the power, P, required by the pump:

where Δp is the change in total pressure between the inlet and outlet (in Pa), and Q, the volume flow-rate of the fluid is given in m3/s. The total pressure may have gravitational, static pressure and kinetic energy components; i.e. energy is distributed between change in the fluid's gravitational potential energy (going up or down hill), change in velocity, or change in static pressure. η is the pump efficiency, and may be given by the manufacturer's

information, such as in the form of a pump curve, and is typically derived from either fluid dynamics simulation (i.e. solutions to the Naiver–Stokes for the particular pump geometry), or by testing. The efficiency of the pump depends upon the pump's conFigureuration and operating conditions (such as rotational speed, fluid density and viscosity etc.)

For a typical "pumping" conFigureuration, the work is imparted on the fluid, and is thus positive. For the fluid imparting the work on the pump (i.e. a turbine), the work is negative. Power required to drive the pump is determined by dividing the output power by the pump efficiency. Furthermore, this definition encompasses pumps with no moving parts, such as a siphon.

Efficiency

Pump efficiency is defined as the ratio of the power imparted on the fluid by the pump in relation to the power supplied to drive the pump. Its value is not fixed for a given pump, efficiency is a function of the discharge and therefore also operating head. For centrifugal pumps, the efficiency tends to increase with flow rate up to a point midway through the operating range (peak efficiency or Best Efficiency Point (BEP)) and then declines as flow rates rise further. Pump performance data such as this is usually supplied by the manufacturer before pump selection. Pump efficiencies tend to decline over time due to wear (e.g. increasing clearances as impellers reduce in size).

When a system includes a centrifugal pump, an important design issue is matching the head loss-flow characteristic with the pump so that it operates at or close to the point of its maximum efficiency.

Pump efficiency is an important aspect and pumps should be regularly tested. Thermodynamic pump testing is one method.

2.2.10. Diode:

A **diode** is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. A diode vacuum tube or thermionic diode is a vacuum tube with two electrodes, a heated cathode and a plate, in which electrons can flow in only one direction, from cathode to plate. A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. Semiconductor diodes were the first semiconductor electronic devices. The discovery of asymmetric electrical conduction across the contact between a crystalline mineral and a metal was made by German physicist Ferdinand Braun in 1874. Today, most diodes are made of silicon, but other materials such as gallium arsenide and germanium are also used.



Fig: 2.2.11.1: Diode

2.2.11 Variable Resistor/Potentiometer:



Fig: 2.2.12.1: Variable Resistor/Potentiometer

A potentiometer /variable resistor is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Many inexpensive potentiometers are constructed with a resistive element formed into an arc of a circle usually a little less than a full turn and a wiper sliding on this element when rotated, making electrical contact. The resistive element, with a terminal at each end, is flat or angled. The wiper is connected to a third terminal, usually between the other two types



Fig: 2.2.12.2: Different Types of Potentiometer

Potentiometers are categorized by,

Linear taper potentiometer: A linear taper potentiometer (linear describes the electrical characteristic of the device, not the geometry of the resistive element) has a resistive element of constant cross-section, resulting in a device where the resistance between the contact (wiper) and one end terminal is proportional to the distance between them. Linear taper potentiometers are used when the division ratio of the potentiometer must be proportional to the angle of shaft rotation (or slider position), for example, controls used for adjusting the centering of the display on an analog cathode-ray oscilloscope. Precision potentiometers have an accurate relationship between resistance and slider position.

Logarithmic potentiometer: A logarithmic taper potentiometer has a resistive element that either 'tapers' in from one end to the other, or is made from a material whose resistivity varies from one end to the other. This results in a device where output voltage is a logarithmic function of the slider position.

Most (cheaper) "log" potentiometers are not accurately logarithmic, but use two regions of different resistance (but constant resistivity) to approximate a logarithmic law. The two resistive tracks overlap at approximately 50% of the potentiometer rotation; this gives a stepwise logarithmic taper. A logarithmic potentiometer can also be simulated (not very accurately) with a linear one and an external resistor. True logarithmic potentiometers are significantly more expensive.

2.2.12 Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to temporarily store electrical energy in an electric field. The forms of practical capacitors vary widely, but most contain at least two electrical conductors (plates) separated by a dielectric. The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The no conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge $+Q$

to collect on one plate and negative charge $-Q$ to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.

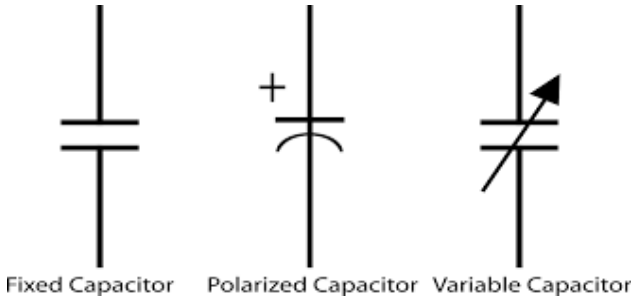




Fig: 2.2.13.1 Capacitor

An ideal capacitor is characterized by a single constant value, its capacitance. Capacitance is defined as the ratio of the electric charge Q on each conductor to the potential difference V between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F).

The larger the surface area of the "plates" (conductors) and the narrower the gap between them, the greater the capacitance is. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow.

2.2.13 Wire

A wire is a single, usually cylindrical, flexible strand. Wires are used to bear carry electricity and telecommunications signals. Standard sizes are determined by various wire gauges. The term wire is also used more loosely to refer to a bundle of such strands, as in 'multi stranded wire', which is more correctly termed a wire rope in mechanics, or a cable in electricity.



Fig: 2.2.14.1: Connecting Wire

Although usually circular in cross-section, wire can be made in square, hexagonal, flattened rectangular or other cross-sections, either for decorative purposes, or for technical purposes such as high-efficiency voice coils in loudspeakers. Edge-wound coil springs, such as the Slinky toy, are made of special flattened wire.

2.2.14. Conclusion

In this chapter we have discussed the components to be used in this system. The main part of this is Arduino Uno R3, pump, soil moisture sensor, LCD display, DC-to-DC converter, Connecting Wire, Capacitor, 9V DC Power supply and others. In the later part of this paper we discussed the block diagram, Circuit diagram and its operation to make the concept clear to anyone.

CHAPTER III
DESING & FEBRICATION

3.1 Introduction

In this chapter fully cover with discuss design and fabrication of this project. Here we will discuss about developed block diagram and briefly describe about the circuit description and also learn about working principle. Total project flow chart is also available in this chapter.

3.2 Block Diagram

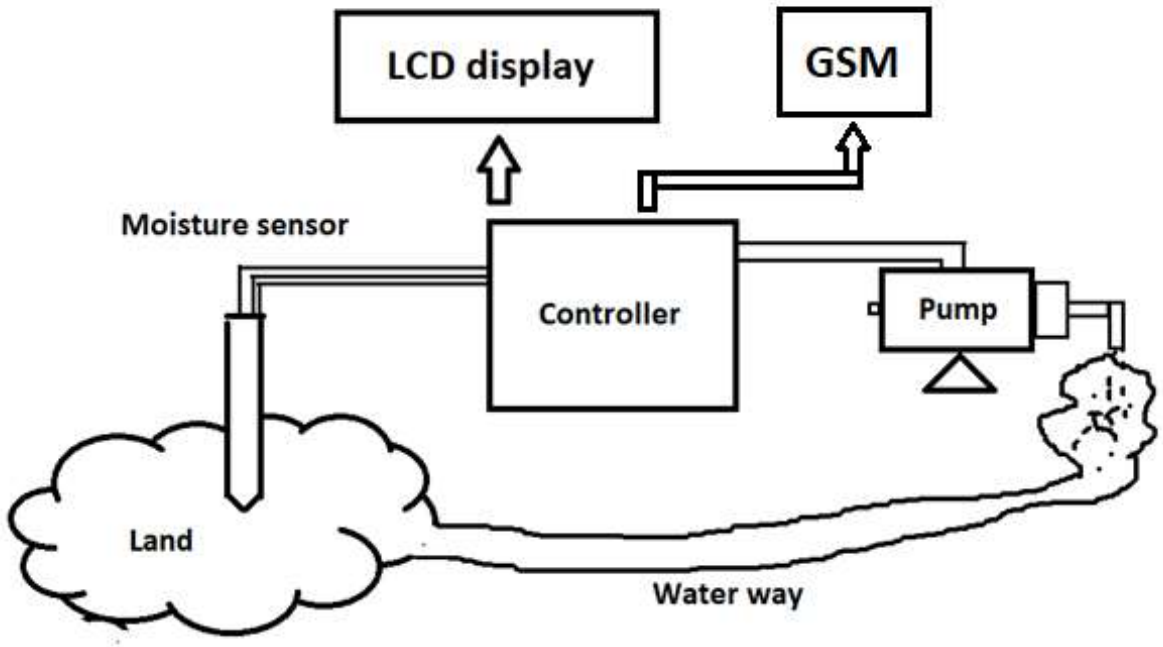


Fig: Block diagram of Advanced Irrigation System

3.3.1 Block Diagram of the project

Smart Irrigation System is nowadays becomes an advanced agricultural system. This system keeps the agricultural system healthy. It takes proper care of your Irrigation system.

In this project, we've used Arduino as our controller that controls the whole Irrigation system by sensing the environment & the soil properties. We've used the moisture sensor to detect the moisture level of soil. According to the moisture level the controller will sent a status

SMS through the GSM module we've used. Meanwhile with an LCD display, it shows the moisture value. And at the same time it can turn on a relay that can turn on your pump whenever it will need.

3.3 Circuit Description

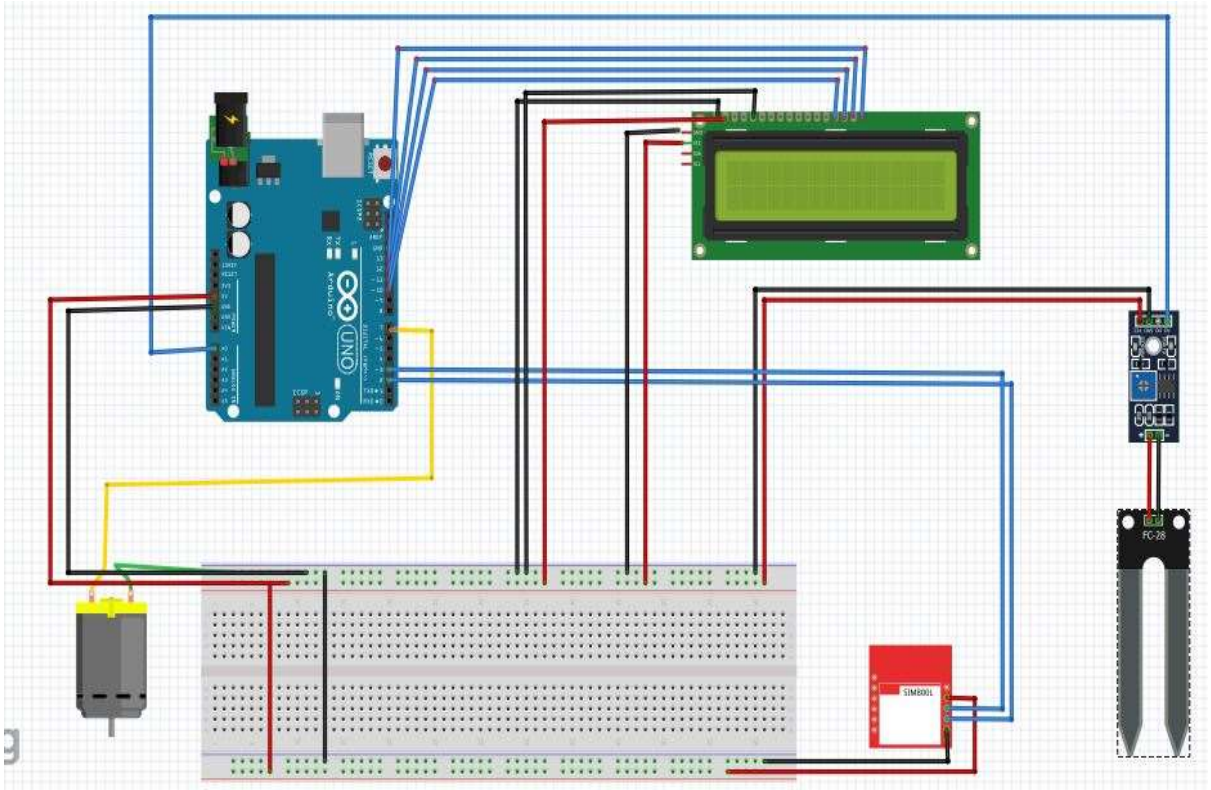


Fig: 3.2.1: Circuit Diagram of the Project

Here in the schematic, we have an Arduino Nano as the main controller, a Soil Moisture sensor to read moisture of the soil, a GSM module to send SMS of moisture level and pump on off status, a Pump to supply water to the soil, a 5V relay to drive the pump and a 12v relay to switch over solar and AC power system. Also we have a voltage regulator to convert 12v to 5v, a NPN transistor to reset the GSM module. An LCD display is also connected to show the Moisture level and Pump on off status.

Here the soil moisture sensor reads the soil moisture data and sends to the Arduino NANOs analog pin 7. Arduino then shows the moisture level to the LCD display and checks whether the moisture level goes up to 100% or below 30%. If the moisture level goes under 30%, then the controller turns on the pump that is connected to the pin 7 and when the moisture level reaches up to 100%, the pumps stops automatically. Each time (pump on and off) the controller sends an SMS to the authorized person through the serial pin 2 & 3.

The 12v relay works as a changeover switch. In normal condition it always turned on by the AC power supply. The power goes through the NO pin of the relay to the system power. When AC supply is not available, the relay turns off and solar power goes through relays NC pin to the system power.

The Soil Moisture Sensor uses capacitance to measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content). Simply insert this rugged sensor into the soil to be tested, and the volumetric water content of the soil is reported in percent.

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.

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3.4 Image of the Project:

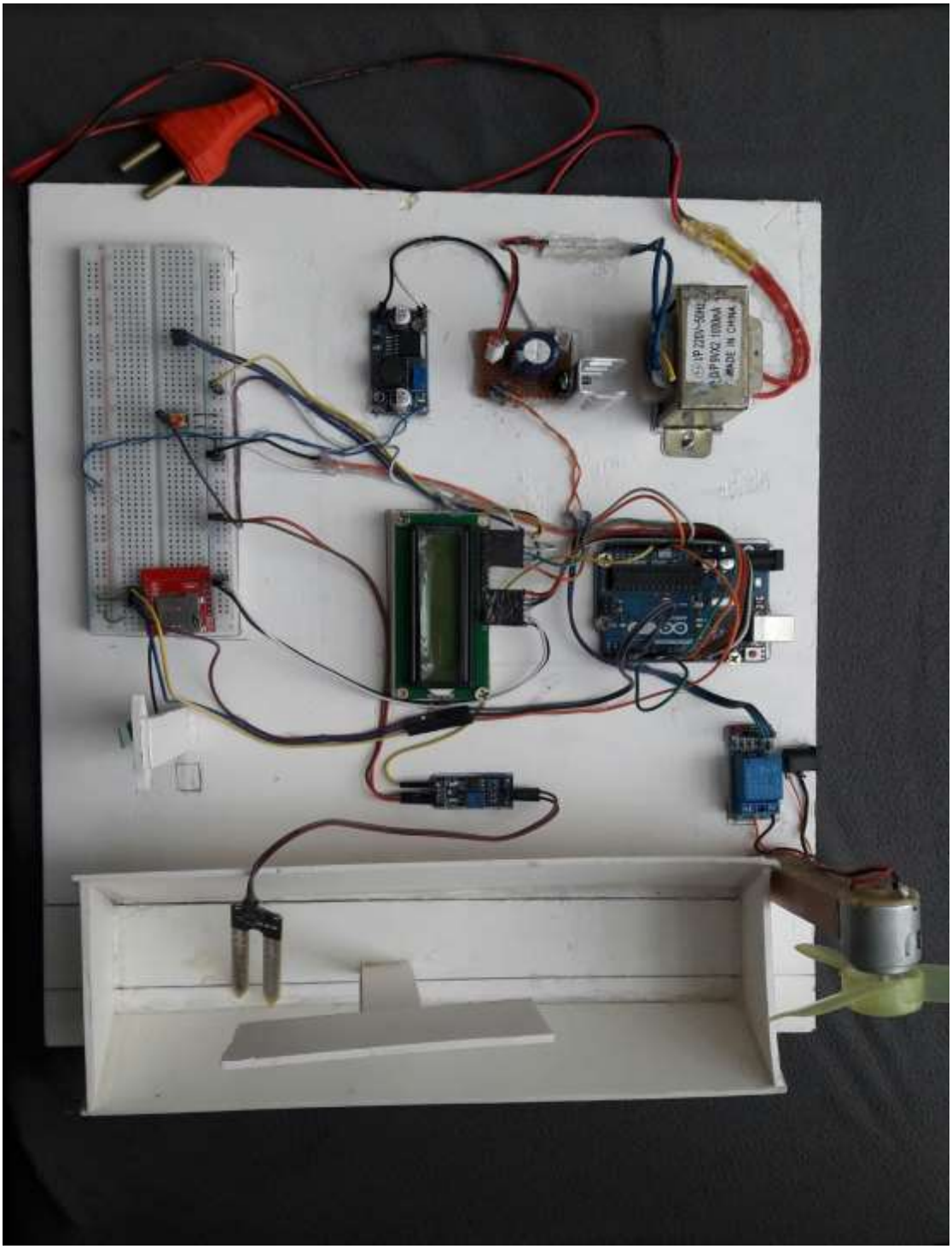


Fig: 3.3.1: Real Image of the project

3.5 Flow Chart

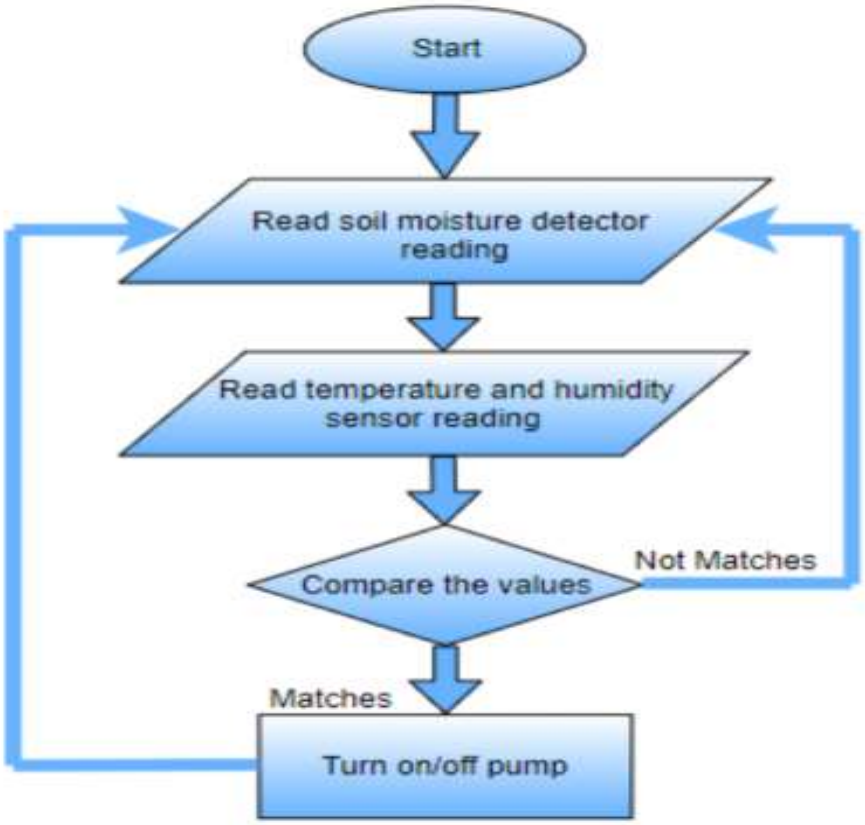


Fig: 3.4.1: Flow chart of the project

3.6 Conclusion

In this paper we discussed our project of Design & Implementation of Smart Irrigation System. This project is very useful for agricultural automation that will help farmers to maintain the soil moisture level. It will also increase the crops health by providing proper water treatment to the crops.

Chapter IV
Result and Discussion

4.1 Introduction

This chapter contains discussion about the project. We have also covered discussions about advantages, disadvantages and limitation of current version of the protection system.

4.2 Result

We see that when the moisture level goes up to 100% or below 30%. If the moisture level goes under 30%, then the controller turns on the pump that is connected to the pin 7 and when the moisture level reaches up to 100%, the pumps stops automatically. Each time (pump on and off) the controller sends an SMS to the authorized person.

4.3 Advantages

- Increase in productivity
- Reduced water consumption
- safe
- No manpower required
- Reduce soil erosion and nutrient leaching
- Require smaller water source

4.4 Disadvantages

- Difficult in case of failure of GSM Modem
- Kit is to be protected from reaching water

4.5 Limitations

- Only the Soil Moisture sensor can be used here. If you use another sensor, it will be difficult to get the value.

4.6 Cost Estimation

Table.2.2Cost Estimation

SI	Particulars	Specification	Qty.	Unit Price	Total Price
1	Arduino Uno		1	400	400
2	Microcontroller	ATMEGA328P	1	200	200
3	Soil Moisture sensor	FC-12	1	220	220
4	DC-DC buck converter	LM2596	1	120	120
5	LCD Display	16x2	1	150	150
6	Transformer	230V/12V, 1Amp	1	100	100
7	wire	As per need	4ft	20	100
8	Capacitor	2200uf, 25V	1	25	25
9	Vero Board		1	99	99
10	Jumper wire		2	45	90
11	Voltage regulator	LM7805	1	10	10
12	Diode	IN4007	6	5	30
13	5v relay module		1	80	80
14	GSM800L	GPRS/GSM	1	950	950
15	Soldering cost				60
16	Others				100
				Total:	**2734**

4.7 Applications

System can be implemented in following sectors:

- Personal garden
- Large crop field
- By specific plant

Chapter V
Conclusion

5.1 Conclusion

This project is very useful for agricultural automation that will help farmers to maintain the soil moisture level. It will also increase the crops health by providing proper water treatment to the crops.

This project is made with pre-planning, that it provides flexibility in operation. This innovation has made more desirable and economical. This project is designed with the hope that it is very much economical and helpful for passengers and as well as conductors during Journey.

5.2 Future Project

Our future project is Smart Blind Stick Project using Arduino and Sensors. The project work has already begun. Hopefully this will happen in a few days

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Appendix

C Programing of this project

```
#include <LiquidCrystal.h>

//initalize the libray with the number of the iterface pins

LiquidCrystal lcd(8,9,10,11,12,13);

//These constants won't change. They're used to give names
//to the pins used:
#include<SoftwareSerial.h>
SoftwareSerial gsm(2,3);// rx dx pin

const int soilPin = A0; // Analog input pin that the  Sensor is attached to
int sensorValue = 0; // value read from the Soil Moisture
int moisture;

int pump = 7;

unsigned long Time;
unsigned long prevTime = 2000;

void setup()
{
  pinMode(pump,OUTPUT);

digitalWrite(pump,HIGH);
//set up the LCD's number of columns and rows:

  lcd.begin(16,2);
  lcd.setCursor(3, 0);
```

```
  lcd.print("D&I SMART ");
  lcd.setCursor(0, 1);
  lcd.print("IRRIGATION SYSTEM ");
  delay(1000);
 lcd.clear();
 lcd.setCursor(3, 0);
  lcd.print("ANALAISING");
  lcd.setCursor(5, 1);
  lcd.print("DATA");
  delay(1000);
  lcd.clear();
}

void loop()
{
  Time = millis();
  sensorValue = analogRead(soilPin); //read the analog in value:

  moisture = map(sensorValue, 1023, 340, 0, 100);
  if (moisture >= 100)
  {
  moisture = 100;
  }
 if((Time - prevTime) == 200)
{
   prevTime = Time;
   lcd.clear();
   lcd.setCursor(2,0);
   lcd.print("Soil Moisture "); // print the result to the LCD Display:
   lcd.setCursor(6,1);
   lcd.print(moisture);
   lcd.print("%"); // print the result to the LCD Display:
}
 if(moisture >= 100)
```

```
 {
   digitalWrite (pump, HIGH);
   send_message()
 }
else if (moisture <= 30)
{
  digitalWrite(pump, LOW);
}
}
void send_message()
{
delay(10000);
  Serial.begin(9600);
  gsm.begin(9600);// bode rate
  gsm.println("AT+CMGF=1");// masses mood on
  delay(1000);
  gsm.println("AT+CMGS=\"YOUR NUMBER\"\r"); //replace x by your number
  delay(1000);
  gsm.println("hello");
  delay(100);
  gsm.println((char)26);// contol+ z
  delay(1000);
}
```