SMARTAQUARIUM

MONITORING SYSTEM

ABSTRACT

Fishkeeping is a popular fad; almost people from all the age groups like to keep fish in their homes, offices, etc., for decoration purposes or as a hobby. Fishkeeping is itself an industry that comes in agriculture. Fishkeeping is not an easy job; we always need an aquarium or a pond for that.It has always been a headache to take care of the fish and aquariums because, During periodic intervals, water needs to be changed, the fish needs to be fed on time, the temperature, pH level and water level of the aquarium needs to be maintained. The project, "SMART AQUARIUM MONITORING SYSTEM" has been designed by keeping in mind, the problem of those who cannot take care of their aquarium every day. The aquarium will perform all the steps automatically like temperature control, light monitor, feeding, water level monitor and control, lightening control, etc., It will reduce the manual effort required in the maintenance of aquariums by automating the aquarium management process. Also, an automatic food feeding system operated by a servo motor mechanism which used to feed fishes on regular time intervals. To continuously check the aquarium's status, the Arduino Mega board is chosen as a central board to collect data from sensors, process the data and declare whether the values are safe or exceeded the limit range indicating danger situation. Our project aims to replace manual maintenance of a fish aquarium with an Automated system by using Arduino.

CHAPTER 1

INTRODUCTION

Pet ownership has been increasing at a steady pace in the last 20 years. After cats and dogs, the most popular pet is now the freshwater fish. The maintenance of fish aquariums is a very difficult task itself. Whenever you have to clean up your aquarium or you have to feed, you have to do a lot of things. You have to turn off your aquarium's power head/air pump and feed manually and turn on the air again after an hour.

The project with which we came up is an Automated Fish Aquarium. The project will be more efficient than the systems available in market, now days. In addition to the efficiency it will be of lower cost as well. The project's audience is the group of people interested to keep fishes at home or offices but don't have time to take care of, or they are worried to keep on asking their neighbors to take care of the fishes in their absence.

The project is an automated system to take care of fishes. It will replace the manual maintenance of fish aquarium with its automated functions. It will monitor the physical changes in the water and will maintain it to the ideal conditions, with required changes.

CHAPTER 2

DESCRIPTION OF COMPONENTS

2.1 ARDUINO MEGA 2560

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontroller and microcontroller kits for building digital devices. Arduino board designs use a variety of microprocessors and controllers.

Fig 2.1 Arduino Mega 2560 board (Top view)

Fig 2.2 Arduino Mega 2560 board (Bottom view)

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

2.1.1 ATmega2560 microcontroller

The Atmega640/1280/1281/2560/2561 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the Atmega640/1280/1281/2560/2561 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

2.1.2 Features of Atmega2560 microcontroller:

64K/128K/256K bytes of In-System Programmable Flash with Read-While-Write capabilities, 4Kbytes EEPROM, 8Kbytes SRAM, 54/86 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), six flexible Timer/Counters with compare modes and PWM, four USARTs, a byte oriented 2-wire Serial Interface, a 16-channel, 10-bit ADC with optional differential input stage with programmable gain, programmable Watchdog Timer with Internal Oscillator, an SPI serial port, IEEE® std.

Fig 2.3 ATmega2560 microcontroller

1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping.

2.1.3 Input and Output

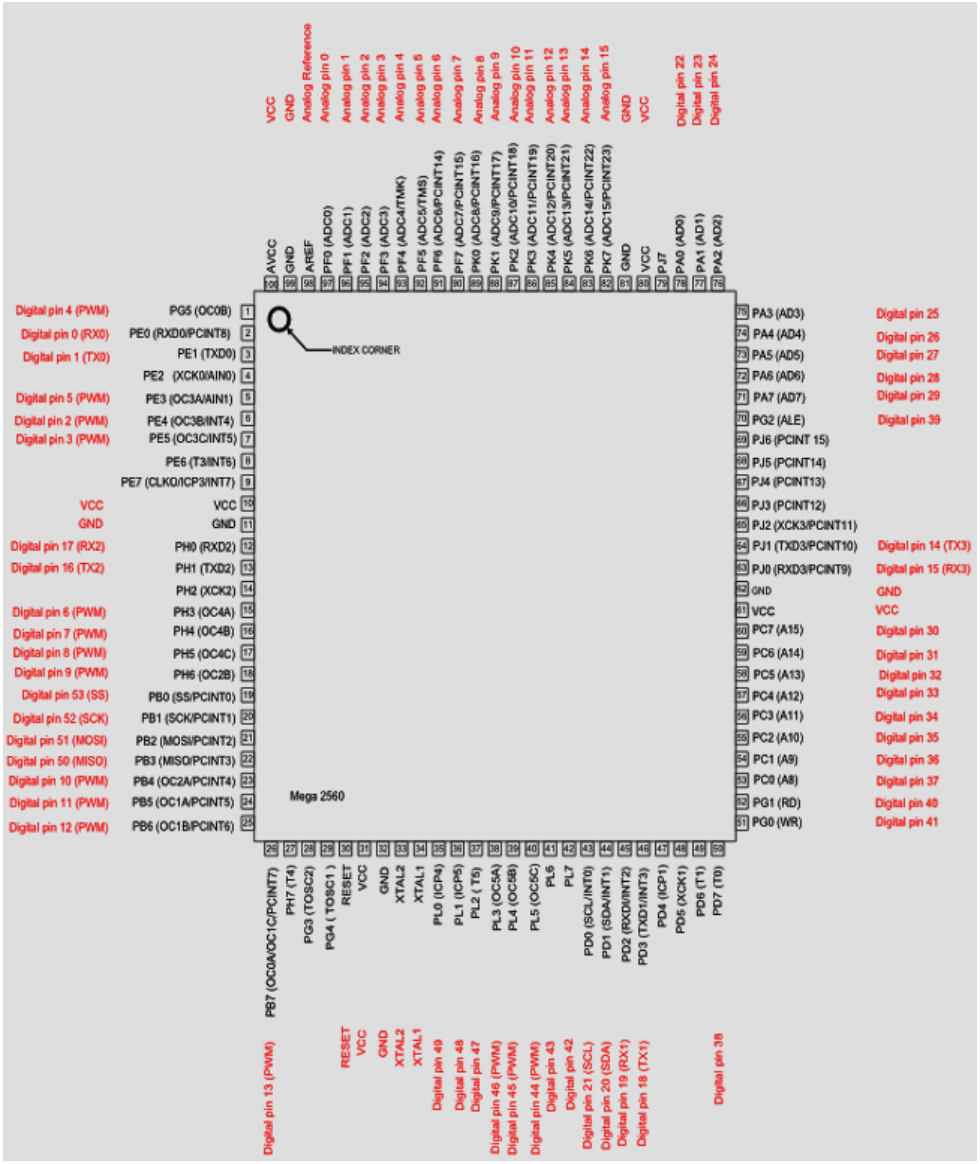

Fig 2.4 Atmega2560 – Arduino Pin Mapping

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50 k ohm. A maximum of 40mA is the value that must not be exceeded to avoid permanent damage to the microcontroller.

In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega16U2 USB-to-TTL Serial chip.
- External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low level, a rising or falling edge, or a change in level. See the attachInterrupt() function for details.
- PWM: 2 to 13 and 44 to 46. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication using theSPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Arduino /Genuino Uno and the old Duemilanove and Diecimila Arduino boards.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Mega 2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function. There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().
- A Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

2.1.4 Technical Specifications

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

Table 2.1 Technical specifications of Arduino board

2.1.5 Power

The Mega 2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

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

5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board.

2.1.5 Advantages of Arduino

- Inexpensive-Arduino boards are relatively inexpensive compared to other microcontroller platforms.
- Cross-platform- The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems.
- Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well.
- Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers.

2.2 pH Sensor

pH is a measure of hydrogen ion concentration, a measure of the acidity or alkalinity of a solution. The pH scale usually ranges from 0 to 14. Aqueous solutions at 25°C with a pH less than 7 are acidic, while those with a pH greater than 7 are basic or alkaline. A pH level of 7.0 at 25°C is defined as "neutral" because the concentration of H_3O^+ equals the concentration of OH^- in pure water. Very strong acids might have a negative pH, while very strong bases might have a pH greater than 14. pH only has meaning in an aqueous solution (in water).

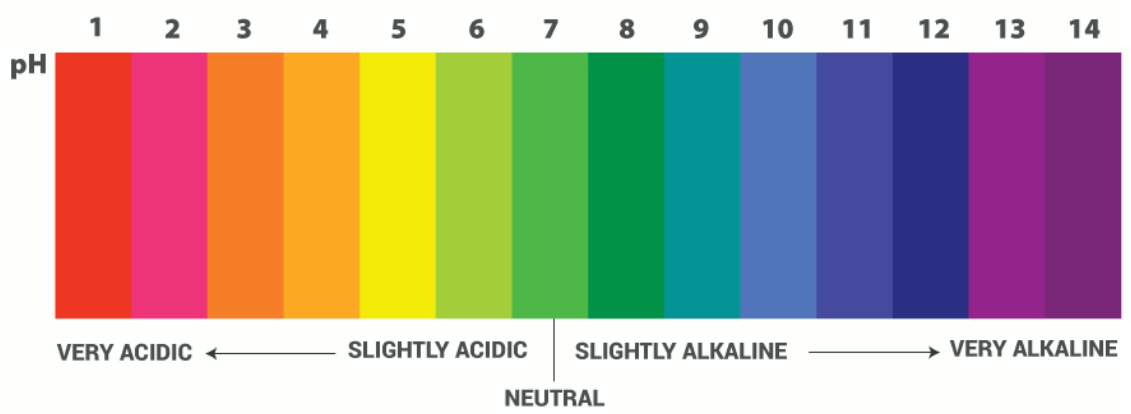

Fig 2.5 pH SCALE

2.2.1 pH Equation

$$pH = -\log[H^+]$$

Where, log is the base-10 logarithm and $[H^+]$ stands for the hydrogen ion concentration in units of moles per liter solution. The term "pH" comes from the German word "potenz," which means "power," combined with H, the element symbol for hydrogen, so pH is an abbreviation for "power of hydrogen."

2.2.2 pH Sensor Components

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter". The difference in electrical potential relates to the acidity or pH of the solution.

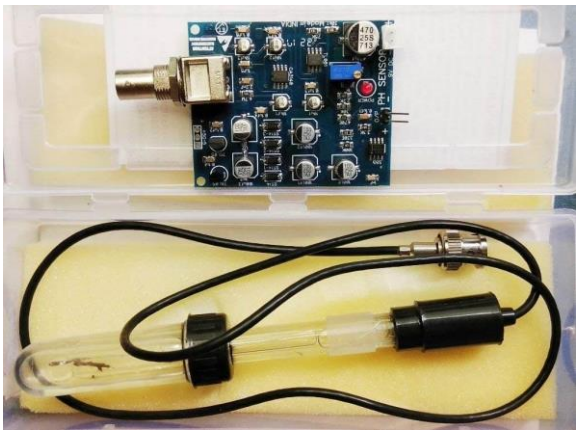

Fig 2.6 pH Sensor with Module

- A measuring electrode: It is a tube made up of glass and consists of a thin glass bulb welded to it, filled up with Potassium Chloride solution of known pH of 7. It also contains a block of silver chloride attached to a silver element. It generates the voltage used to measure pH of the unknown solution

- A Reference Electrode: It is a glass tube consisting of potassium chloride solution in intimate contact with a mercury chloride block at the end of the potassium chloride. It is used to provide a stable zero voltage connection to the complete the whole circuit.

- Preamplifier: It is a signal conditioning device and converts the high impedance pH electrode signal to a low impedance signal. It strengthens and stabilizes the signal, making it less susceptible to electrical noise.

- Transmitter or Analyzer: It is used to display the sensor's electrical signal and consists of a temperature sensor to compensate for the change in temperature.

2.2.3 Working of pH Sensor

The electrode is placed inside the beaker filled with a solution whose pH is to be measure. The glass bulb welded at the end of the measurement electrode consists of lithium ions doped to it which makes it act as an ion selective barrier and allows the hydrogen ions from the unknown solution to migrate through the barrier and interacts with the glass, developing an electrochemical potential related to the hydrogen ion concentration.

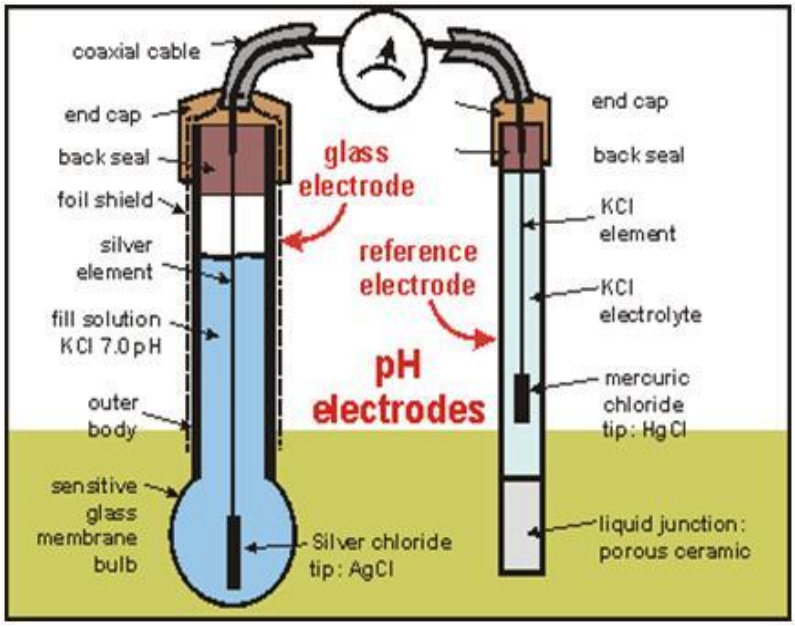

Fig 2.7 Working of pH SENSOR

The measurement electrode potential thus changes with the hydrogen ion concentration. On the other hand, the reference electrode potential doesn't changes with the hydrogen ion concentration and provides a stable potential against which the measuring electrode is compared. It consists of a neutral solution which is allowed to exchange ions with the unknown solution through a porous separator, thus forming low resistance connection to complete the whole circuit. The potential difference between the two electrodes gives a direct measurement of the hydrogen ion concentration or pH of the system and is first preamplified to strengthen it and then given to the voltmeter.

2.2.4 Specifications:

- PH range: 0-14 PH
- Operating Voltage is 9V DC.
- Temperature range: 0-60℃
- Zero-point: 7 ± 0.5PH
- Alkali Error: 0.2PH
- Theoretical Percentage Slope: ≧98.5%
- Internal Resistance: ≦250MΩ
- Response Time: ≦1min

2.2.5 Advantages

- It is used for wide variety of applications such as cheese making, pool maintenance, to grow healthier plants by measuring soil pH, stain removal etc.
- The meters provide numerical value of the pH directly.
- pH meters are very accurate and provide exact pH value with the help of pH sensors.
- It helps in determining how much acidic or basic any substance is.

2.2.6 Applications

- Pharmaceutical and chemical industry
- Quality control
- Controlling of chemical reactions
- Food production
- Quality control at dairies
- Quality control and efficient production in bakeries

2.3 ds18b20 Temperature Sensor

A temperature sensor is a device, usually an RTD (resistance temperature detector) or a thermocouple, that collects the data about temperature from a particular source and converts the data into understandable form for a device or an observer.

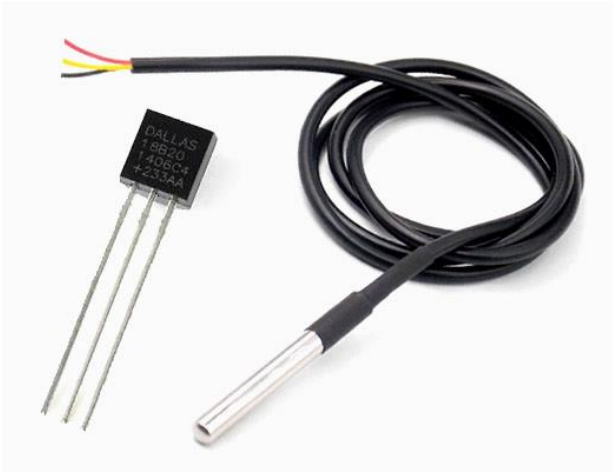

Fig 2.8 ds18b20 Temperature Sensor

ds18b20 is 1-Wire interface Temperature sensor manufactured by Dallas Semiconductor Corp. The unique 1-Wire® Interface requires only one digital pin for two way communication with a microcontroller.

The sensor comes usually in two form factors. One that comes in TO-92 package looks exactly like an ordinary transistor. Other one in a waterproof probe style which can be more useful when you need to measure something far away, underwater or under the ground.

ds18b20temperature sensor is fairly precise and needs no external components to work. It can measure temperatures from -55°C to +125°C with ±0.5°C Accuracy.

The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits. However, the default resolution at power-up is 12-bit (i.e. 0.0625°C precision).

The sensor can be powered with a 3V to 5.5V power supply and consumes only 1mA during active temperature conversions.

2.3.1 Pin Configuration:

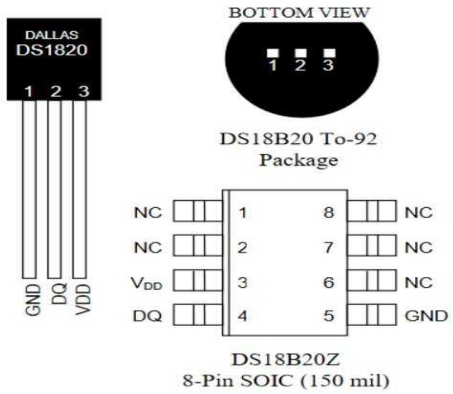

Fig 2.9 ds18b20 Temperature Sensor pin configuration

Sl. No:	Pin Name	Description
1	Ground	Connect to the ground of the circuit
2	VCC	Powers the Sensor, can be 3.3V or 5V
3	Data	This pin gives output the temperature value which can be read using 1-wire method

Table 2.2 pin description of ds18b20

2.3.2 Specifications

- This sensor is a programmable and digital temperature sensor
- The communication of this sensor can be done with the help of a 1-Wire method
- The range of power supply is 3.0V – 5.5V
- Fahrenheit equal s to -67°F to +257°F
- The accuracy of this sensor is ±0.5°C
- The o/p resolution will range from 9-bit to 12-bit
- It changes the 12-bit temperature to digital word within 750 ms time.
- This sensor can be power-driven from the data line

- Alarm options are programmable
- The multiplexing can be enabled by Unique 64-bit address
- The temperature can be calculated from -55°C to +125°C.
- These are obtainable like SOP, To-92, and also as a waterproof sensor.

2.3.3 Working principle

It works on the principle of direct conversion of temperature into a digital value. Its main features are to change its bit numbers according to change in temperature. The core functionality of the ds18b20 is its direct-to-digital temperature sensor. The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12-bit. The ds18b20 powers up in a low power idle state. To initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T [44h] command. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the ds18b20 returns to its idle state. If the ds18b20 is powered by an external supply, the master can issue "read time slots" after the Convert T command and the DS18B20 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done.

2.3.4 Applications

- This sensor is extensively used to calculate temperature within rigid environments which includes mines, chemical solutions, otherwise soil, etc.
- This sensor is used to measure the liquid temperature.
- We can use it in the thermostat controls system.
- It can be used in industries as a temperature measuring device.
- It can be used in devices like which are sensitive to thermal.
- The temperature sensors are used in the military/Defence
- It can be used in the home automation systems like air conditioners, refrigerators, microwave Owens
- It can also use in the industries like warehouses, mushroom cultivation.

2.4 FLOAT SWITCH

A float switch is a type of level sensor, a device used to detect the level of liquid within a tank. The switch may be used to control a pump, as an indicator, an alarm, or to control other devices. One type of float switch uses a mercury switch inside a hinged float.

Fig 2.10 float switch

Float switches utilize a magnetic reed switch, which consists of two contacts sealed in a glass tube. In a float switch, the magnetic reed switch is hermetically sealed in a stem, most often made from plastic or stainless steel. The float encases a sealed magnet, which moves up and down the length of the stem as a fluid level rises and falls.

2.4.2 Working

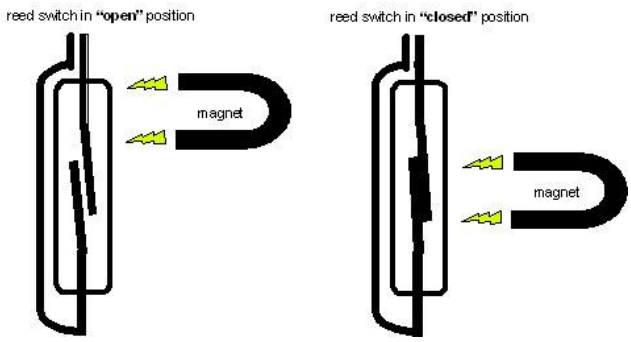

Fig 2.11 floats switch working

The purpose of a float level switch is to open or close a circuit as the level of a liquid rises or falls. All float operated liquid level controls operate on the basic buoyancy principle which states "the buoyancy force action on an object is equal to the mass of liquid displaced by the object." As a result, floats ride on the liquid surface partially submerged and move the

same distance the liquid level moves. Because of this, they are normally used for narrow level differential applications such as high level alarm or low level alarm.

When a magnet comes close to the two contacts, they become attracted to each other and touch, allowing current to pass through. When the magnet moves away, the contacts demagnetize and separate (breaking the circuit).

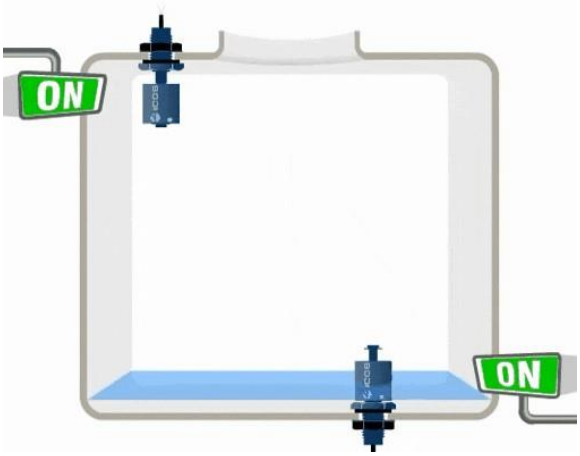

Fig 2.12 float switch working (2)

2.4.3 Advantages

- Cheap
- Can be used for corrosive liquids
- Power saver
- Money saver
- Automatic
- Can deliver millions of on/off cycles

2.4.4 Applications

- High/Low Level Alarms
- Pump/Valve Control
- Heater Protection
- Temperature Sensing
- Interface Level
- High Temp/Slurry
- Bilge Protection

2.5 SERVO MOTOR

A servo motor is a rotary actuator or a motor that allows for a precise control in terms of the angular position, acceleration, and velocity. Basically it has certain capabilities that a regular motor does not have. Consequently it makes use of a regular motor and pairs it with a sensor for position feedback.

Fig 2.13 Servo motor

2.5.1 Types of servo motors:

Servo motors can be of different types on the basis of their applications. The most important amongst them are: AC servo motor, DC servo motor, brushless DC servo motor, positional rotation servo motor, continuous rotation servo motor, and linear servo motor.

DC servomotors:

DC Servomotors are separately excited dc motor or permanent magnet dc motor. They are controlled by armature voltage. The armature is designed to have large resistance so that the torque-speed characteristics are linear and have a large negative slope as shown below. Therefore, a step change in the armature voltage results in a quick change in the position or speed of the motor.

AC servomotor:

It is a two-phase a.c. induction motor. There are two winding, one fixed or reference winding is supplied with a fixed voltage and frequency from a constant voltage source. Second winding is called control winding, with variable supply voltage of same frequency

The stator has two distributed windings displaced 90 electrical degree apart. One winding is the reference phase and is connected to a constant voltage source. The other winding is the control phase and is supplied with a variable voltage of the same frequency as the reference phase but is phase-displaced by 90 electrical degree.

A typical servo motor comprises of three wires namely- power, control, and ground. The shape and size of these motors depends on their applications.

2.5.2 Wire Configuration

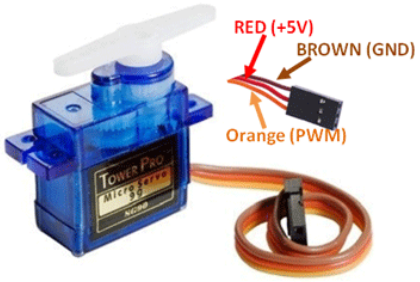

Fig 2.14 Servo wiring

Wire Number	Wire Color	Description
1	Brown	Ground wire connected to the ground of system
2	Red	Powers the motor typically +5V is used
3	Orange	PWM signal is given in through this wire to drive the motor

Table 2.3 Wiring of Servo MG90

2.5.3 Principle of working:

Servo motor works on the PWM (Pulse Width Modulation) principle, which means its angle of rotation is controlled by the duration of pulse applied to its control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears.

2.5.4 Servo Mechanism

1. It consists of three parts:
2. Controlled device
3. Output sensor
4. Feedback system

It is a closed loop system where it uses positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here reference input signal is compared to reference output signal and the third signal is produces by feedback system. And this third signal acts as input signal to control device. This signal is present as long as feedback signal is generated or there is difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

2.5.5 Working of Servo Motors

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly and a controlling circuit. First of all we use gear assembly to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal. This error signal acts as the input for motor and motor starts rotating.

Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

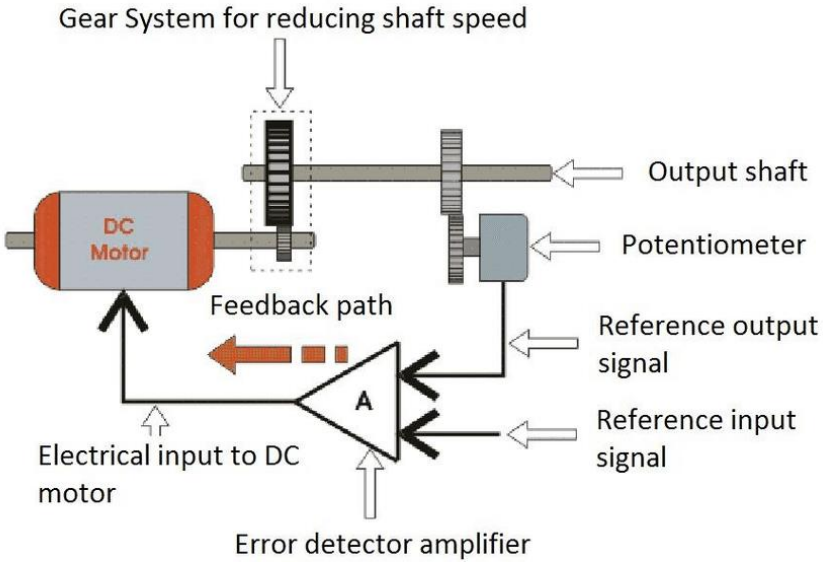

Fig 2.15 Working of Servo motor

2.5.6 Controlling of Servo motors:

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU.

Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°.

Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears. High speed force of DC motor is converted into torque by Gears. We know that WORK= FORCE X DISTANCE, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.

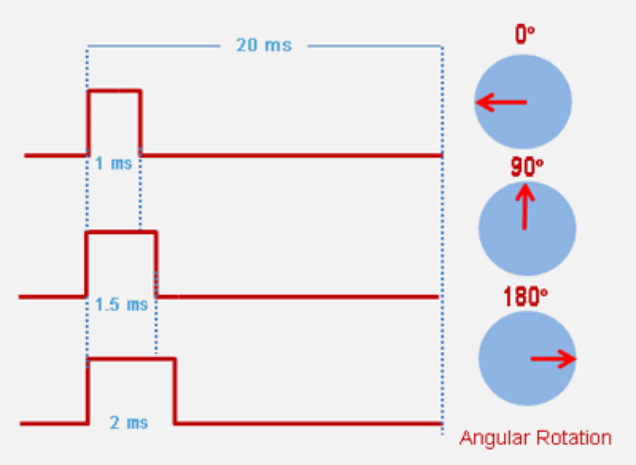

Fig 2.16 Controlling of servo

Servo motor can be rotated from 0 to 180 degree, but it can go up to 210 degree, depending on the manufacturing. This degree of rotation can be controlled by applying the Electrical Pulse of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. Pulse of 1 ms (1 millisecond) width can rotate servo to 0 degree, 1.5ms can rotate to 90 degree (neutral position) and 2 ms pulse can rotate it to 180 degree.

All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper servo shield should be designed.

2.5.7 Specifications:

- Operating Voltage is +5V typically
- Torque: 2.5kg/cm
- Operating speed is 0.1s/60°
- Gear Type: Plastic
- Rotation : 0°-180°
- Weight of motor : 9gm
- Package includes gear horns and screws

2.5.8 Advantages:

- High output power relative to motor size and power
- Encoder determines accuracy and resolution.
- Resonance and vibration free operation
- High efficiency
- There is no out-of-step condition, as heavy load placed on the motor the driver will increase the current to the motor
- High speed operation is possible

2.5.9 Applications

- Used as actuators in many robots like Biped Robot, Hexapod, robotic arm etc.,
- Commonly used for steering system in RC toys.
- Robots where position control is required without feedback.
- Less weight hence used in multi DOF robots like humanoid robots.

2.6 WATER 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.

A submersible pump (or sub pump, electric submersible pump (ESP)) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface as opposed to jet pumps which create a vacuum and rely upon atmospheric pressure.

Fig 2.17 submergible water pump

2.6.1 Water Pump Types

There are two basic types of water pumps: centrifugal and positive displacement. Both types are designed to move water from one place to another continuously.

A centrifugal water pump uses a rotating impeller to move water into the pump and pressurize the discharge flow. Centrifugal water pumps come in several different types, including standard, trash, and submersible models. All liquids can be pumped using centrifugal water pumps, even those with low viscosity. These pumps work well with thin liquids and offer high flow rates.

Positive displacement water pumps deliver a fixed amount of flow through the mechanical contraction and expansion of a flexible diaphragm. Positive displacement pumps are used in many industries that manage high-viscosity liquids and where sensitive solids may be present. They are recommended for applications requiring a combination of low flow and high pressure.

2.6.2 Construction

1. The impeller and shaft are the rotating parts of the pump that converts driver energy into kinetic energy. This inbuilt rotating impeller is the main rotating part used for pumping liquids without any complications. It provides centrifugal acceleration to the fluids. The impeller can be classified according to its mechanical construction. You can find closed, open, semi-open or vortex type. Closed impellers have a drawback and that is they come up with a lot of maintenance issues whereas the open and semi-open types of impellers do not clog, but usually need manual adjustment.

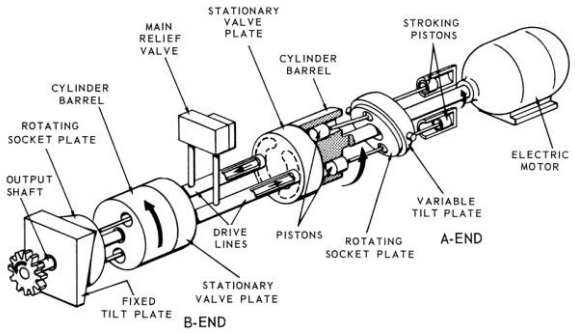

Fig 2.18 construction of Servo

Another important rotating component is the shaft whose basic purpose is to transmit the torque that is encountered during operation. It also has to support the impeller and other rotating parts.

2. The volute or diffuser along with casing, casing cover, and bearings form the stationary parts of the centrifugal pump and are responsible for converting the kinetic energy into pressure energy. These pumps have two types of casings: volute and circular. Volute casings help to balance the hydraulic pressure created on the shaft of the pump while the circular casings are used for high capacity. Even the bearings are very useful components in the centrifugal pumps.

All these various components when put together and when they cooperate well with each other, centrifugal pump achieve a great performance.

Centrifugal pumps are available in various different materials such as metal, plastic and ceramic. Steam turbines, high-speed electric motors and internal combustion engines all use centrifugal pumps. No valves are used in this machine.

2.6.3 Working Principle

Electric submersible pumps are multistage centrifugal pumps operating in a vertical position. Liquids, accelerated by the impeller, lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. This is the main operational mechanism of radial and mixed flow pumps. In the HSP, the motor is a hydraulic motor rather than an electrical motor, and may be closed cycle (keeping the power fluid separate from the produced fluid) or open cycle (mingling the power fluid with produced fluid downhole, with surface separation).

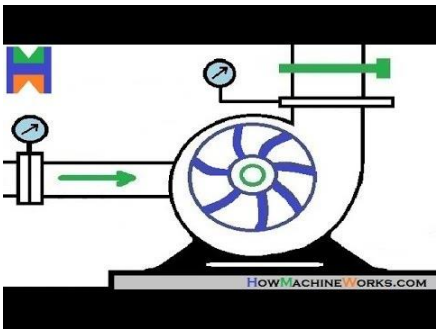

Fig 2.19 construction of Servo

The pump shaft is connected to the gas separator or the protector by a mechanical coupling at the bottom of the pump. Fluids enter the pump through an intake screen and are lifted by the pump stages. Other parts include the radial bearings (bushings) distributed along the length of the shaft providing radial support to the pump shaft. An optional thrust bearing takes up part of the axial forces arising in the pump but most of those forces are absorbed by the protector's thrust bearing.There are also screw-type submersible pumps, there is a steel screw which is used as a working element in them. The screw allows the pump to work in water with a high sand content and other mechanical impurities.

2.6.4 Specifications

- Operating Voltage : 3 ~ 6V
- Operating Current : 130 ~ 220mA
- Flow Rate : 80 ~ 120 L/H
- Maximum Lift : 40 ~ 110 mm
- Continuous Working Life : 500 hours
- Driving Mode : DC, Magnetic Driving
- Material : Engineering Plastic
- Outlet Outside Diameter : 7.5 mm
- Outlet Inside Diameter : 5 mm

2.6.5 Advantages

- Non contamination
- Inexpensive to manufacture
- Low maintenance
- Easy to sterilize
- Cost effective operation

2.6.6 Applications

- They drive water into or out of filtration systems
- Agriculture livestock watering/crop irrigation, home gardens and drip irrigation systems.
- Domestic portable water pump for remote homes, campgrounds.
- Pond water management and water transfer.

2.7 LCD DISPLAY

A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates o a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix.

Fig 2.20 16 x 2 LCD display

2.7.1 Construction

The 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.

2.7.2 Working

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.

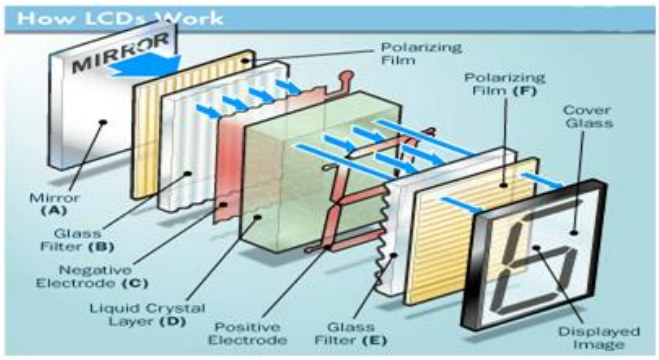

Fig 2.21 working of LCD

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.

2.7.3 Pin description of LCD

Pin No.	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; the best way is to use a variable resistor such as a potentiometer. The output of the potentiometer is connected to this pin. Rotate the potentiometer knob forward and backwards to adjust the LCD contrast.	Vo / VEE
4	Selects command register when low, and data register when high	RS (Register Select)
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given; Extra voltage push is required to execute the instruction and EN(enable) signal is used for this purpose. Usually, we make it en=0 and when we want to execute the instruction we make it high en=1 for some milliseconds. After this we again make it ground that is, en=0.	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight VCC (5V)	Led+
16	Backlight Ground (0V)	Led-

TABLE 2.4 Pin description of LCD

2.7.4 Important command codes for LCD

S.No.	Hex Code	Command to LCD instruction Register
1	01	Clear display screen
2	02	Return home
3	04	Decrement cursor (shift cursor to left)
4	06	Increment cursor (shift cursor to right)
5	05	Shift display right
6	07	Shift display left
7	08	Display off, cursor off
8	0A	Display off, cursor on
9	0C	Display on, cursor off
10	0E	Display on, cursor blinking
11	0F	Display on, cursor blinking
12	10	Shift cursor position to left
13	14	Shift cursor position to right
14	18	Shift the entire display to the left
15	1C	Shift the entire display to the right
16	80	Force cursor to beginning (1st line)
17	C0	Force cursor to beginning (2nd line)
18	38	2 lines and 5×7 matrix

TABLE 2.5 Important command codes for LCD

2.7.5 Features of 16×2 LCD module

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight

2.7.6 Advantages of an 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

2.7.7 Applications

- 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

2.8 LED

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. The process of emitting light in response to the strong electric field or flow of electric current is called electroluminescence.

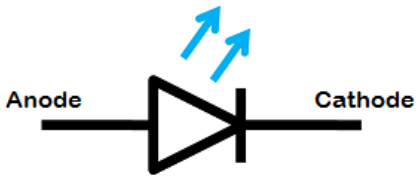

Fig 2.22 symbol of LED

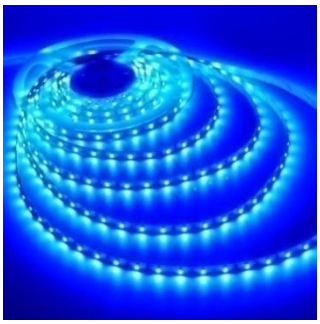

Fig 2.23 LED strip

An LED strip light (also known as an LED tape or ribbon light) is a flexible circuit board populated by surface mounted light-emitting diodes (SMD LEDs) and other components that usually comes with an adhesive backing. Traditionally, strip lights had been used solely in accent lighting, backlighting, task lighting, and decorative lighting applications. Increased luminous efficacy and higher-power SMDs have allowed LED strip lights to be used in applications such as high brightness task lighting, fluorescent and halogen lighting fixture replacements, indirect lighting applications, Ultra Violet inspection during manufacturing processes, set and costume design, and even growing plants.

2.8.1 Construction

Light Emitting Diodes are made from a very thin layer of fairly heavily doped exotic semiconductor compounds such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP), Gallium Arsenide Phosphide (GaAsP), Silicon Carbide (SiC) or Gallium Indium Nitride (GaInN) all mixed together at different ratios to produce a distinct wavelength of colour.

The construction of a Light Emitting Diode is very different from that of a normal signal diode. The PN junction of an LED is surrounded by a transparent, hard plastic epoxy resin hemispherical shaped shell or body which protects the LED from both vibration and shock. Surprisingly, an LED junction does not actually emit that much light so the epoxy resin body is constructed in such a way that the photons of light emitted by the junction are reflected away from the surrounding substrate base to which the diode is attached and are focused upwards through the domed top of the LED, which itself acts like a lens concentrating the amount of light. This is why the emitted light appears to be brightest at the top of the LED.

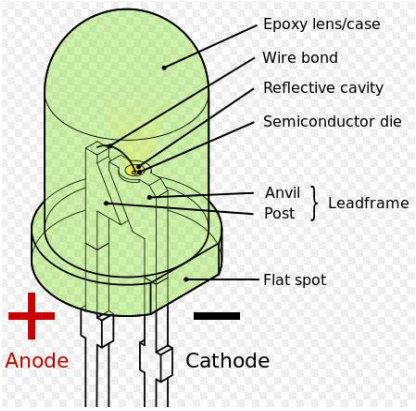

Fig 2.24 Construction of LED

However, not all LEDs are made with a hemispherical shaped dome for their epoxy shell. Some indication LEDs have a rectangular or cylindrical shaped construction that has a flat surface on top or their body is shaped into a bar or arrow. Generally, all LED's are manufactured with two legs protruding from the bottom of the body. Also, nearly all modern light emitting diodes have their cathode, (–) terminal identified by either a notch or flat spot on the body or by the cathode lead being shorter than the other as the anode (+) lead is longer than the cathode (k).

2.8.2 Various semi conducting materials for various colors

The actual color of a light emitting diode is determined by the wavelength of the light emitted, which in turn is determined by the actual semiconductor compound used in forming the PN junction during manufacture.

Semiconductor Material	Wavelength	Colour	V_F @ 20mA
GaAs	850-940nm	Infra-Red	1.2v
GaAsP	630-660nm	Red	1.8v
GaAsP	605-620nm	Amber	2.0v
GaAsP:N	585-595nm	Yellow	2.2v
AlGaP	550-570nm	Green	3.5v
SiC	430-505nm	Blue	3.6v
GaInN	450nm	White	4.0v

Table 2.6 semi conducting materials for various colors

- Gallium Arsenide (GaAs) – infra-red
- Gallium Arsenide Phosphide (GaAsP) – red to infra-red, orange
- Aluminium Gallium Arsenide Phosphide (AlGaAsP) – high-brightness red, orange-red, orange, and yellow
- Gallium Phosphide (GaP) – red, yellow and green
- Aluminium Gallium Phosphide (AlGaP) – green
- Gallium Nitride (GaN) – green, emerald green
- Gallium Indium Nitride (GaInN) – near ultraviolet, bluish-green and blue
- Silicon Carbide (SiC) – blue as a substrate
- Zinc Selenide (ZnSe) – blue
- Aluminium Gallium Nitride (AlGaN) – ultraviolet

2.8.3 Working of LED

Like an ordinary diode, the LED diode works when it is forward biased. In this case, the n-type semiconductor is heavily doped than the p-type forming the p-n junction. When it is forward biased, the potential barrier gets reduced and the electrons and holes combine at the depletion layer (or active layer), light or photons are emitted or radiated in all directions.

A typical figure blow showing light emission due electron-hole pair combining on forward biasing.

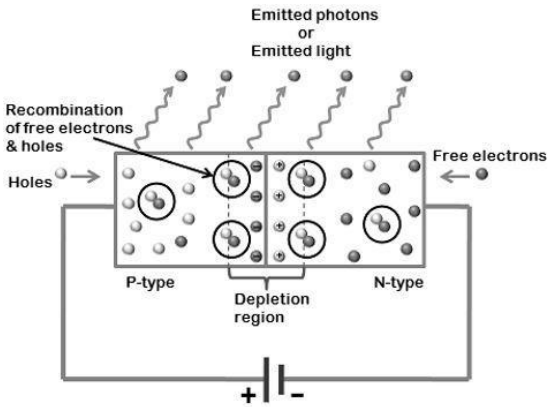

Fig 2.25 working of LED

The explanation behind the emission of photons in an LED diode lies in the energy band theory of solids. According to this theory, whether the electron-hole combining will give out photons or not depends on whether the material has a direct band gap or indirect band gap. Those semiconductor materials which have a direct band gap are the ones that emit photons.

In a direct bandgap material, the bottom of the energy level of conduction band lies directly above the topmost energy level of the valence band on the Energy vs Momentum (wave vector 'k') diagram. When electrons and hole recombine, energy E = hν corresponding to the energy gap Δ (eV) is escaped in the form of light energy or photons where h is the Planck's constant and ν is the frequency of light.

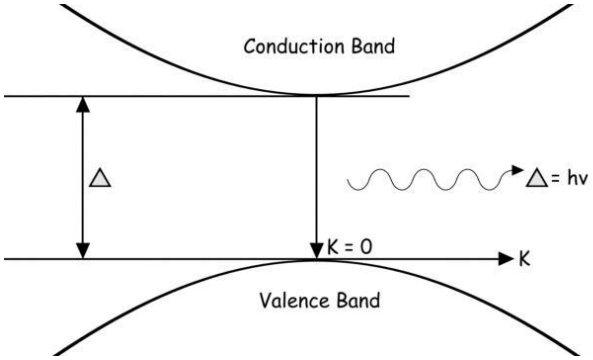

Fig 2.26 direct band gap

While the indirect band gap is non-radioactive in nature as the bottom of the conduction band does not coincide with the top of the valence band and the energy corresponding to the energy gap is mostly given in the form of heat. Examples are Si, Ge etc.,

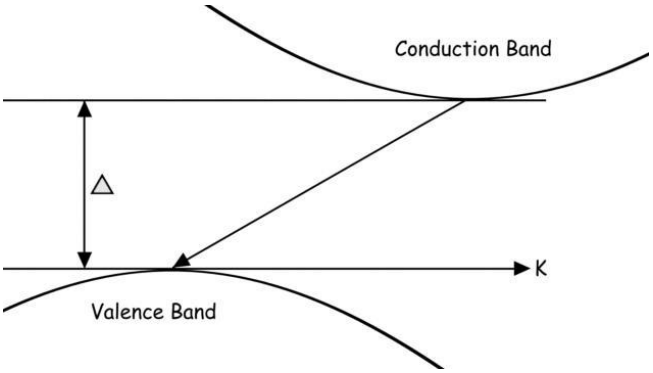

Fig 2.27 indirect band gap

Example of material which has direct band gap is Gallium Arsenide(GaAs), a compound semiconductor which is the material used in LEDs. Dopant atoms are added to GaAs to give out a wide range of colors. Some of the materials used in LEDs are:

- Gallium Arsenic Phosphide(GaAsP) – red, orange, yellow
- Aluminium Gallium Arsenide(AlGaAs) – infrared
- Aluminium Gallium Phosphide(AlGaP) – green.
- Indium gallium nitride (InGaN) – blue, blue-green, near UV.
- Zinc Selenide(ZnSe) – blue.

2.8.4 LED I-V Characteristics

Before emitting light from any light emitting diode, it needs to have current to flow across it, since LED is a current dependant device with its output light intensity being directly proportional to the forward current passing through the LED.

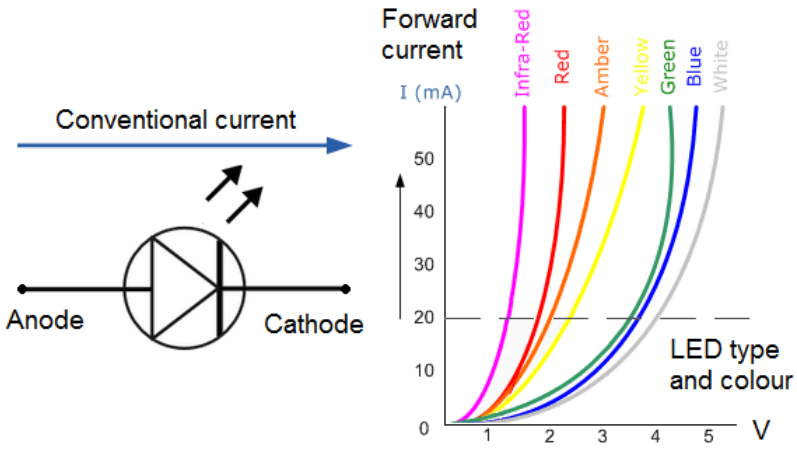

Fig 2.28 I-V Characteristics of LED

Light emitting diode has to be connected in a forward bias combination across the power supply and it should be current limited by using a resistor connected in series to protect it from the excess current flow. LED should not be connected directly to the battery or power supply because excess amounts of current will flow through it and LED may damage.

Each LED has its own individual forward voltage drop along the PN junction and this parameter has been determined by the semiconductor material used in manufacturing of LED for a specified amount of forward conduction current, usually for a forward current of about 20mA.

At low forward voltages, the driving current of the diode is dominated by the non-radiative recombination current due to recombination of charge carriers across the length of the LED chip. At higher forward voltages, the diode driving current is dominated by the radiative diffusion current.

Even at larger voltages than the usual, the diode current is limited by the series resistance. The diode should never reach to reverse breakdown voltage for a short duration of time since permanent damage of the diode may occur. The below figure shows the I-V characteristics of the different color LEDs.

2.8.5 Specifications of LED Strip

- Input voltage(v): DC12V/24V
- Lamp power: 7.2W/m
- Working temperature: -20 to 50
- Working lifetime : 50000 hours
- Emitting color: Blue

2.8.6 Advantages:

- Energy efficient – LED's are now capable of outputting 135 lumens/watt
- Long Lifetime – 50,000 hours or more if properly engineered
- Rugged – LED's are also called "Solid State Lighting (SSL) as they are made of solid material with no filament or tube or bulb to break
- No warm-up period – LED's light instantly – in nanoseconds
- Not affected by cold temperatures – LED's "like" low temperatures and will startup even in subzero weather
- Directional – With LED's you can direct the light where you want it, thus no light is wasted
- Excellent Color Rendering, Environmentally friendly and Controllable(brightness, color)

2.9 LDR

Light dependent resistors, LDRs or photo resistors are often used in circuits where it is necessary to detect the presence or the level of light. They can be described by a variety of names from light dependent resistor, LDR, photo resistor, or even photo cell, photocell or photoconductor.

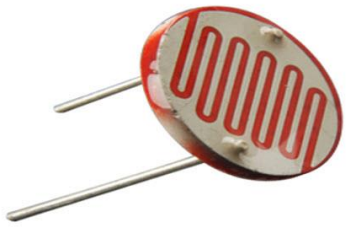

Fig 2.29 LDR

2.9.1 Construction

A light-sensitive material having snake-like structure is placed on an insulating substrate. The light-sensitive material is made of Cadmium Sulphide(CdS) film and the insulating substrate is made of ceramic material.

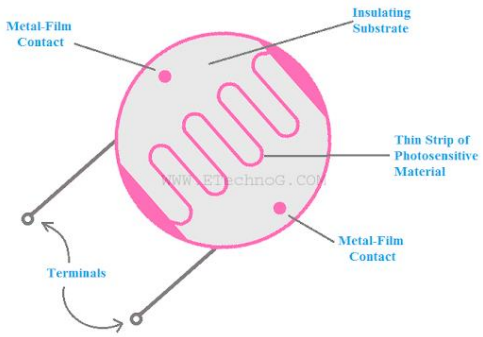

Fig 2.30 construction of LDR

The length of the light-sensitive material is decided depending on the power rating and the resistance rating of the LDR. The whole structure is placed on a plastic or resin case. When the LDR is placed in a dark place, it gives very high resistance (in Mega Ohm). But when light falls upon the LDR its resistance decreases and conductivity increases.

2.9.2 Symbol of LDR

Fig 2.31 symbol of LDR

2.9.3 Working

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material.

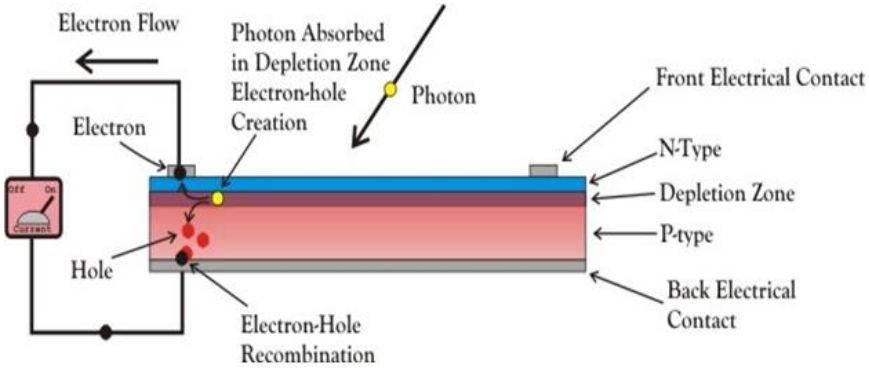

Fig2.32 working of LDR

When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased.

2.9.4 Characteristics of LDR

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 10^{12} Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing.

The changes in resistance are taken along the 'Y' axis and the illumination of the light falls upon the LDR is taken along the 'X' axis.

The above graphical structure also shows how the resistance of LDR is changing with the changing of illumination of the light falls upon the LDR.

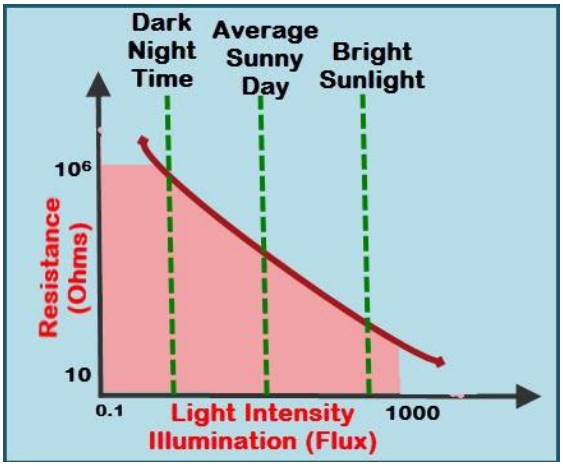

Fig2.33 Characteristics of LDR

Photocells or LDR's are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors.

2.9.5 Specifications

- resistance : 400ohm to 400Kohm
  normal resistance variation: 1Kohm to 10Kohm
- sensitivity: about 3msec
- Voltage ratings: 5V

2.9.6 Advantages

- LDRs are very low-cost devices.
- LDRs are very smaller in sizes.
- LDR is a very simple device.
- The connection of LDR is also very simple.

2.9.7 Applications

- LDRs are used in Light Sensors
- LDR is also used in some cameras to detect the presence of the light.
- LDRs are used Light Intensity measurement meters.
- In the manufacturing industry, LDR is used as a sensor for the counting of the packets moving on a conveyor belt.
- LDRs are also used in Light Activated Control Circuits.
- LDRs are used in Street Lights which are automatically turned ON in the night time.
- LDRs are used in Burglar Alarm Circuits.
- LDRs are used in Photosensitive Relays
- LDR can be used in simple Fire alarm circuits.
- The Light Dependent Resistors are used in modern televisions, computer screens for automatic brightness and contrast control.

2.1HEATER

Electrical heaters are simple electrical devices that convert electric energy into heat. Electric heaters use metals as heating elements.

An aquarium heater is a tool that helps aquarium owners keep the temperature of their aquarium water warm. The water in the aquarium needs to be kept at certain temperatures for it to be a suitable habitat for either saltwater or freshwater animals. The range for these types of aquariums can range from 22 to 30 degrees Celsius or 71 to 86 degrees Fahrenheit. Aquarium heaters can come in various forms. The most popular of these heaters for aquarium are glass immersion heaters, heating mats and under gravel heating.

2.10.1 Types of Aquarium Heaters

Fig2.34 Glass immersion heater

1. Glass Immersion Heaters

A heating element is the core of the heater and it is often enveloped in glass or ceramic material. This is then contained in a glass tube which gives it the ability to be immersed in the aquarium water. This glass tube has an adjustable thermostat that can be used to maintain the aquarium temperature by switching on the heating element. Traditional thermostats use a bimetallic strip composed of two metals that expand at a different rate each as the temperature changes. Modern thermostats use microchip technology instead of bimetallic strips, producing more accurate temperatures because of its digital nature. Most glass immersion heaters are usually fully submersible.

2. Heating Mats

Mats made of metal or plastic can be placed underneath the aquarium as heating devices. Being a flat pad, it provides even heating for the aquarium from the bottom. It uses a thermostat to maintain and control the temperature in the aquarium, thus, preventing overheating and killing the fishes in the tank. This type of heater should always be monitored because they are more prone to malfunction, which can be very destructive, not only for the aquarium inhabitants, but to the aquarium owner's home as well. Heating mats that malfunction may cause death to aquarium animals and even cause a fire to start.

Fig2.35 heating mats

3. Under gravel heating

Fig 2.36 Under gravel Heater

For those having lots of plants inside their aquarium, using an under gravel heating device can be an ideal choice. This form of heating is implemented by burying a heating cable under the aquarium substrate. The aquarium substrate is composed of the materials found at the bottom of the aquarium that include gravel and sand. The heat from the cable is effectively conducted by the aquarium substrate, making it an efficient heating system for the aquarium. The heating cable is controlled by a thermostat. Because it is in a form of a cable, heat may not be dispensed equally throughout the aquarium. This type of heating system benefits plants more than animals, but it is still a very effective device to maintain the overall aquarium temperature.

2.10.2 Construction

Open wire: This type of wire consists of nickel chromium resistance wire. It is mounted on ceramic or mica insulation. It is important to keep the wire covered so that it should not come in the contact of any metal object. One should take care of this safety precaution because it is vital for the protection and to avoid any kind of danger of electric shock.

2.10.3 Working

Electric heating is a process in which electrical energy is converted to heat energy. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating: an electric current passing through a resistor will convert that electrical energy into heat energy. Most modern electric heating devices use nichrome wire as the active element; the heating element, depicted on the right, uses nichrome wire supported by ceramic insulators.

2.10.4 Specifications

- Fully automatic
- Unique wattage, 200 watts, suitable for almost all sized domestic aquariums
- Power rating: 200 watts
- Temperature range from 18 degree centigrade to 32 degree centigrade
- Suitable for almost all types of fish tanks

2.11 DS1307 RTC

The DS1307 Serial Real-Time Clock is a low-power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially via a 2-wire, bi-directional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 has a built-in power sense circuit that detects power failures and automatically switches to the battery supply.

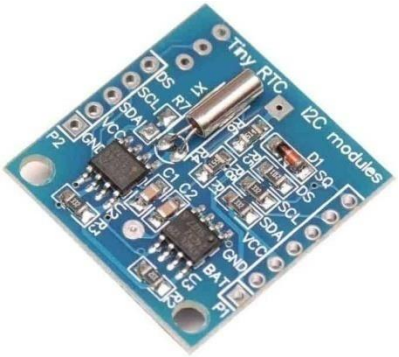

Fig2.37 DS1307 RTC MODULE

2.11.1 Pin assignment:

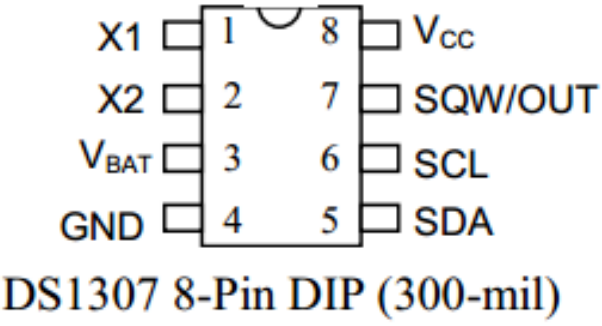

Fig 2.38Pin assignment of DS1307

2.11.2 Pin description

- VCC, GND

DC power is provided to the device on these pins. VCC is the +5V input. When 5V is applied within normal limits, the device is fully accessible and data can be written and read. When a 3V battery is connected to the device and VCC is below 1.25 x VBAT, reads and writes are inhibited. However, the timekeeping function continues unaffected by the lower input voltage. As VCC falls below VBAT the RAM and timekeeper are switched over to the external power supply (nominal 3.0V DC) at VBAT.

- VBAT

Battery input for any standard 3V lithium cell or other energy source. Battery voltage must be held between 2.0V and 3.5V for proper operation. The nominal write protect trip point voltage at which access to the RTC and user RAM is denied is set by the internal circuitry as 1.25 x VBAT nominal. A lithium battery with 48mAhr or greater will back up the DS1307 for more than 10 years in the absence of power at 25ºC. UL recognized to ensure against reverse charging current when used in conjunction with a lithium battery.

- SCL (Serial Clock Input)

SCL is used to synchronize data movement on the serial interface.

- SDA (Serial Data Input/output)

SDA is the input/output pin for the 2-wire serial interface. The SDA pin is open drain which requires an external pull-up resistor.

- SQW/OUT (Square Wave/Output Driver)

When enabled, the SQWE bit set to 1, the SQW/OUT pin outputs one of four square wave frequencies (1Hz, 4 kHz, 8kHz, 32kHz). The SQW/OUT pin is open drain and requires an external pull-up resistor. SQW/OUT will operate with either VCC or Vbat applied.

- X1, X2

Connections for a standard 32.768kHz quartz crystal. The internal oscillator circuitry is designed for operation with a crystal having a specified load capacitance (CL) of 12.5Pf.

2.11.3 Operation

The DS1307 operates as a slave device on the serial bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed. When VCC falls below 1.25 x VBAT the device terminates an access in progress and resets the device address counter. Inputs to the device will not be recognized at this time to prevent erroneous data from being written to the device from an out of tolerance system. When VCC falls below VBAT the device switches into a low-current battery backup mode. Upon power-up, the device switches from battery to VCC when VCC is greater than VBAT + 0.2V and recognizes inputs when VCC is greater than 1.25 x VBAT.

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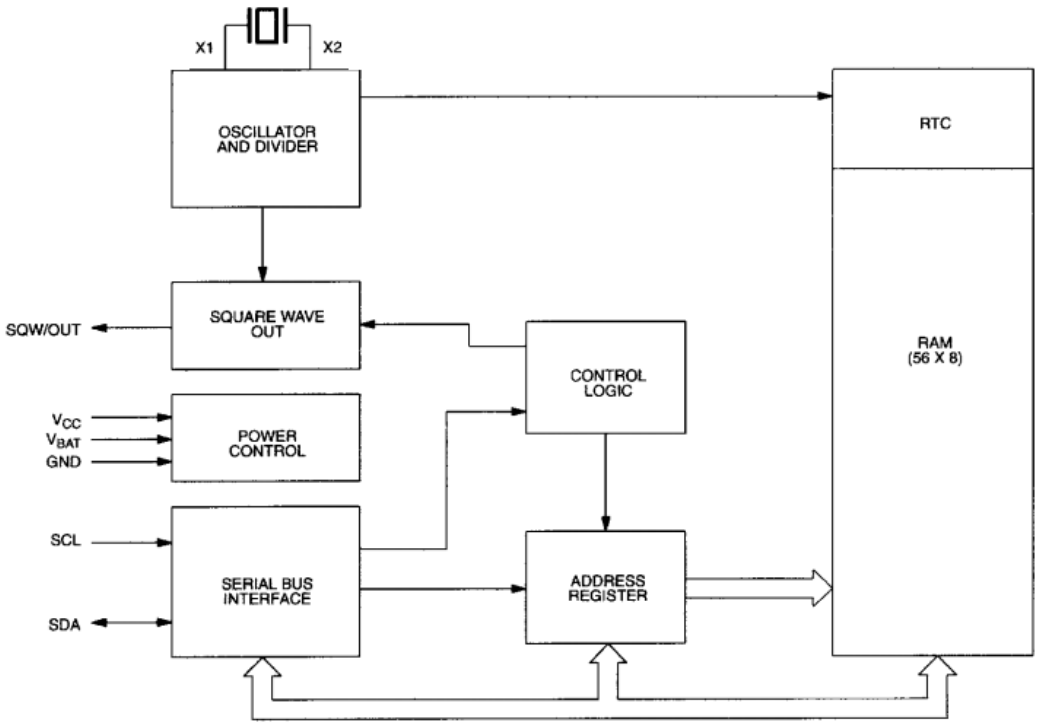

Fig2.39 block diagram of RTC DS1307

2.11.4 Features

- Real-time clock (RTC) counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap-year compensation valid up to 2100
- 56-byte, battery-backed, nonvolatile (NV) RAM for data storage
- Two-wire serial interface
- Programmable square wave output signal
- Automatic power-fail detect and switch circuitry
- Consumes less than 500nA in battery backup mode with oscillator running
- Optional industrial temperature range: -40°C to +85°C
- Available in 8-pin DIP or SOIC
- Underwriters Laboratory (UL) recognized.

2.11.5 Applications

- Smart Energy

  Smart Energy applications can use a real-time clock with a MAC address for wired and wireless communications with other devices.
- Utility Metering

  Digital trimming in the real-time clock can be used to perform software temperature compensation for more accurate time.
- Ethernet

  The EUI-48™ or EUI-64™ MAC Address in the RTCC can provide any Ethernet enabled application with its own unique identification.
- LCD

  The time of day and date from a real-time clock is regularly displayed on the LCD in many systems.

2.12 RELAY

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. In either case, applying electrical current to the contacts will change their state.

Fig2.40 relay

Fig2.41 4 channel relay

Relays are generally used to switch smaller currents in a control circuit and do not usually control power consuming devices except for small motors and Solenoids that draw low amps. Nonetheless, relays can "control" larger voltages and amperes by having an amplifying effect because a small voltage applied to a relays coil can result in a large voltage being switched by the contacts. It uses very low power to control the high amount of Load current. Relays also have the NO and NC contacts. It is usually used for the controlling purpose of various circuits. Relays may be AC (Alternating Current) or DC (Direct Current).

2.12.1 Construction of the Electromagnetic relay

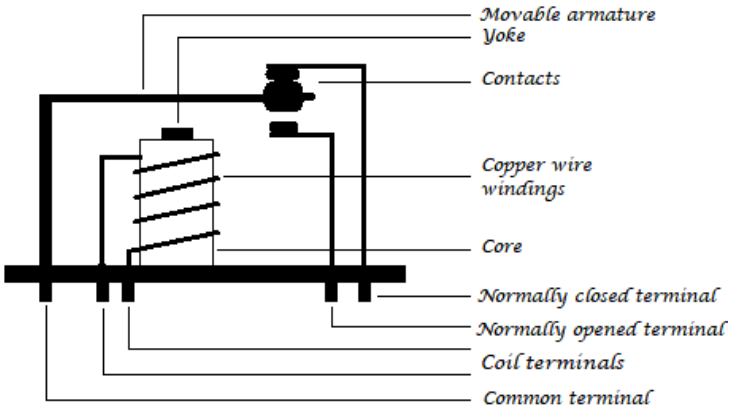

Fig2.42 Construction of Relay and its operation

On a casing, a core with copper windings (forms a coil) winded on it is placed. A movable armature consists of a spring support or stand like structure connected to one end, and a metal contact connected to another side, all these arrangements are placed over the core such that, when the coil is energized, it attracts the armature. The movable armature is generally considered as a common terminal which is to be connected to the external circuitry. The relay also has two pins namely normally closed and normally opened (NC and NO), the normally closed pin is connected to the armature or the common terminal whereas the normally opened pin is left free (when the coil is not energized). When the coil is energized the armature moves and is get connected to the normally opened contact till there exists flow of current through the coil. When it is de-energized it goes to its initial position.

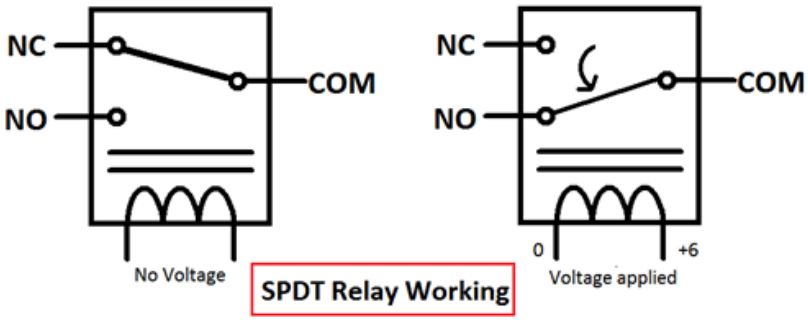

Fig 2.43 SPDT Relay Working

2.12.2 Working of the electromagnetic Relay

Relay in NORMALLY CLOSED condition:

When no voltage is applied to the core, it cannot generate any magnetic field and it doesn't act as a magnet. Therefore, it cannot attract the movable armature. Thus, the initial position itself is the armature connected in normally closed position (NC).

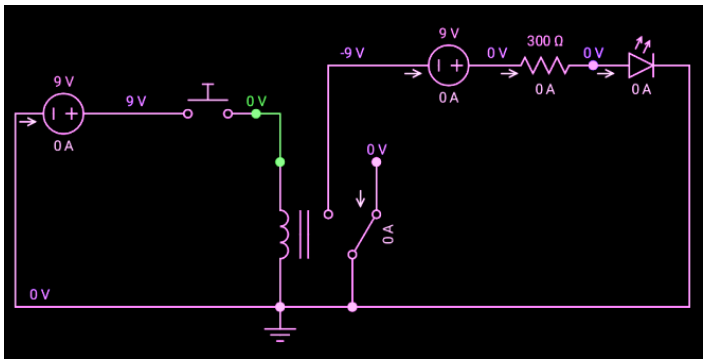

Fig 2.44 Relay in NORMALLY CLOSED condition

Relay in NORMALLY OPENED condition:

When sufficient voltage is applied to the core it starts to create a magnetic field around it and acts as a magnet. Since the movable armature is placed within its range, it gets attracted to that magnetic field created by the core, thus the position of the armature is being altered. It is now connected to the normally opened pin of the relay and external circuit connected to it function in a different manner.

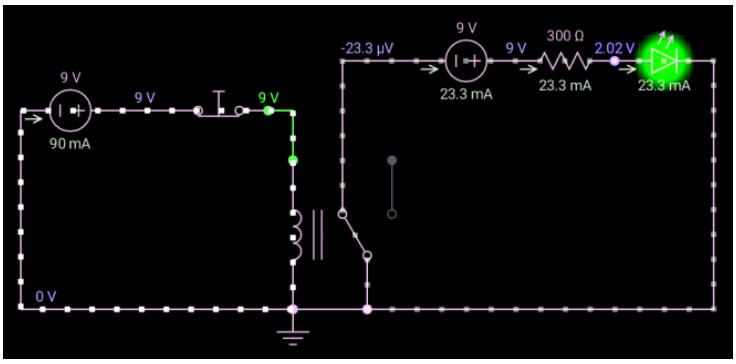

Fig 2.45 Relay in NORMALLY OPENED condition:

So finally, we can say that when a coil is energized the armature is attracted and the switching action can be seen, if the coil is de-energized it loses its magnetic property and the armature goes back to its initial position.

2.12.3 Pole and Throw combinations:

Switches can also be classified based on the number of pole and throw combinations. A *pole* can be considered as an input terminal and a movable part connected to it, whereas a throw can be considered as an output terminal. Its classification is as follows:

- **Single pole, single throw (SPST):**

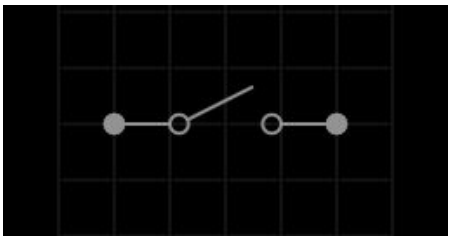

Fig 2.46 SPST

- **Single pole, double throw (SPDT):**

It consists of only one pole and one throw. Generally, the path is either closed or opened (remains untouched to any terminal). A push button is the best example of this type. When we push the button, the contact is in the closed position and when released the contact is in the open position, which can be understood from the below image.

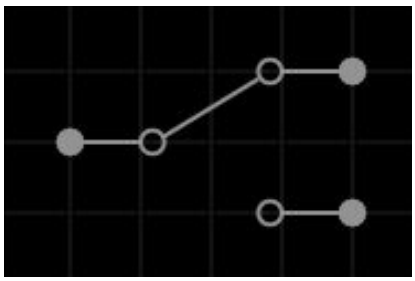

Fig 2.47 SPST

This type of switches consists of only one pole but has two throws. So, the contact is always made to either of the terminals. A slide switch can be considered as its example. The slider is always connected to either of the contacts i.e., a closed path always exists all the time if both the terminals are connected to a circuit.

- **Double pole, single throw (DPST):**

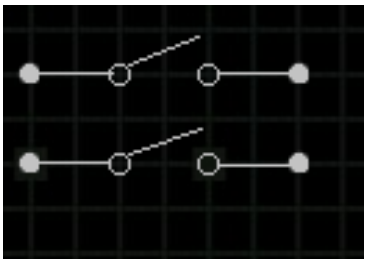

Fig 2.48 DPST

It has two poles and a throw. The contacts of it are either opened or closed which is done simultaneously. Toggle switch works on this property. When the switch is toggled from one position to another, both the contacts are moved simultaneously.

- **Double pole, double throw (DPDT):**

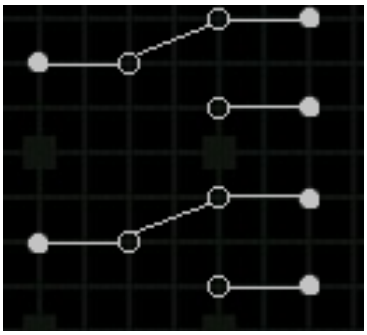

Fig 2.49 DPDT

This type of switches has two poles but the individual pole has two throws. So, it is named as double throw and the switching action is done similarly and simultaneously for both the poles. A switch on a standard trimmer is of DPDT because while we are charging the trimmer and when the switch on the trimmer is in the ON state, it automatically stops charging means the switches are internally opened in the charging circuit.

2.12.4 Specifications:

- 5V 4-Channel Relay interface board
- Requires 15-20mA signal drive Current
- TTL logic compatible
- High-current AC250V/10A, DC30V/10A relay
- Status LED
- Equipped with 3.1mm screw holes for easy installation
- 61g
- 75 x 55 x 19.3mm (2.95 x 2.16 x 0.76")

2.12.5 Advantages of relays:

- Relays can switch AC and DC, transistors can only switch DC.
- Relays can switch high voltages, transistors cannot.
- Relays are a better choice for switching large currents (> 5A).
- Relays can switch many contacts at once.

2.12.6 Applications of Relay:

The applications of the relay are limitless; its main function is to control the high voltage circuit (230V circuit AC) with the low voltage power supply (a DC voltage).

- Relays are not only used in the large electrical circuits but also used in the computer circuits in order to perform the arithmetic and mathematical operations in it.
- Used to control the electric motor switches. To turn ON an electric motor we need 230V AC supply but in few cases/applications, there may be a situation to switch ON the motor with a DC supply voltage. In those cases, a relay can be used.
- Automatic stabilizers are one of its applications where a relay is used. When the supply voltage is other than the rated voltage, set of relays sense the voltage variations and controls the load circuit with the help of circuit breakers.
- Used for the circuit selection if there exists more than one circuit in a system.
- Used in the traffic signal controllers, temperature controllers.

2.13 BUZZER

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical or piezoelectric (piezo for short). In simplest terms, a piezo buzzer is a type of electronic device that's used to produce a tone, alarm or sound. It's lightweight with a simple construction, and it's typically a low-cost product. Yet at the same time, depending on the piezo buzzer specifications, it's also reliable and can be constructed in a wide range of sizes that work across varying frequencies to produce different sound outputs.

Fig 2.50 buzzer

2.13.1 Buzzer Pin Configuration

Pin Number	Pin Name	Description
1	Positive	Identified by (+) symbol or longer terminal lead. Can be powered by 6V DC
2	Negative	Identified by short terminal lead. Typically connected to the ground of the circuit

Table2.7 Buzzer Pin Configuration

2.13.2 Piezoceramic Element Structure

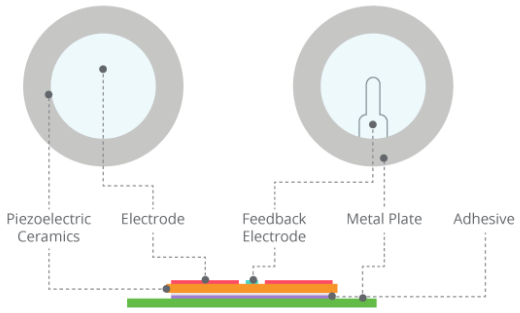

Fig2.51 Piezoceramic Element Structure

At the heart of all piezo-type buzzers is the piezoelectric element. The piezoelectric element is composed of a piezoelectric ceramic and a metal plate held together with adhesive. Both sides of the piezoelectric ceramic plate contain an electrode for electrical conduction. Piezo materials exhibit a specific phenomenon known as the piezoelectric effect and the reverse piezoelectric effect. Exposure to mechanical strain will cause the material to develop an electric field, and vice versa.

2.13.3 Piezo Buzzer Structure

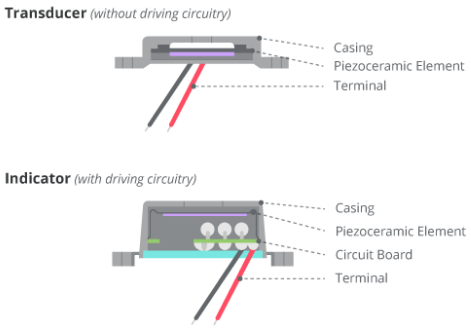

Fig2.52 Piezo Buzzer Structure

There are two types of piezo buzzers - transducers and indicators. Transducers consist of a casing, a piezoceramic element and a terminal. In order to operate a transducer, the user must send a square wave signal to the buzzer. Indicators consist of a casing, a piezoceramic element, a circuit board and a terminal. In order to operate an indicator, the user must send the buzzer a specified dc voltage.

2.13.4 Working Principle of Piezo Buzzers

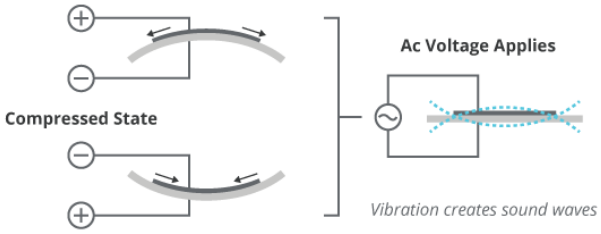

Fig 2.53 working of piezo electric buzzer

When an alternating voltage is applied to the piezoceramic element, the element extends and shrinks diametrically. This characteristic of piezoelectric material is utilized to make the ceramic plate vibrate rapidly to generate sound waves.

2.13.5 Piezo Buzzer Characteristics

- Wide operating voltage: 3~250 V
- Lower current consumption: less than 30 mA higher rated frequency
- Larger footprint
- Higher sound pressure level

2.13.6 Buzzer Features and Specifications

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

2.13.7 Applications of Buzzer

- Alarming Circuits, where the user has to be alarmed about something
- Communication equipments
- Automobile electronics

2.14 GSM

GSM is a mobile communication modem; it is stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

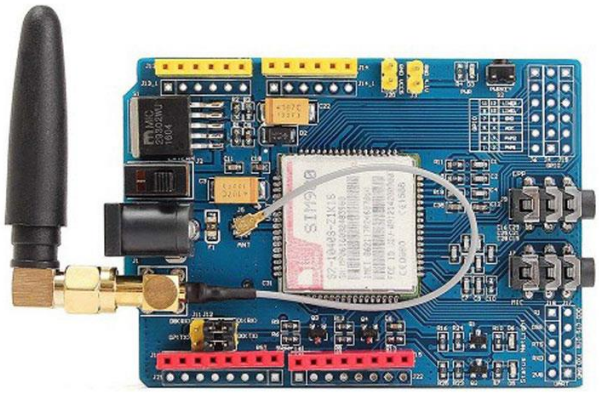

Fig 2.54 GSM sim900 MODULE

There are various cell sizes in a GSM system such as macro, micro, pico and umbrella cells. Each cell varies as per the implementation domain. There are five different cell sizes in a GSM network macro, micro, Pico and umbrella cells. The coverage area of each cell varies according to the implementation environment.

2.14.1 Time Division Multiple Access

TDMA technique relies on assigning different time slots to each user on the same frequency. It can easily adapt to data transmission and voice communication and can carry 64kbps to 120Mbps of data rate.

2.14.2 GSM Architecture

A GSM network consists of the following components:

- **A Mobile Station:** It is the mobile phone which consists of the transceiver, the display and the processor and is controlled by a SIM card operating over the network.
- **Base Station Subsystem:** It acts as an interface between the mobile station and the network subsystem. It consists of the Base Transceiver Station which contains the radio transceivers and handles the protocols for communication with mobiles. It also consists of the Base Station Controller which controls the Base Transceiver station and acts as a interface between the mobile station and mobile switching centre.

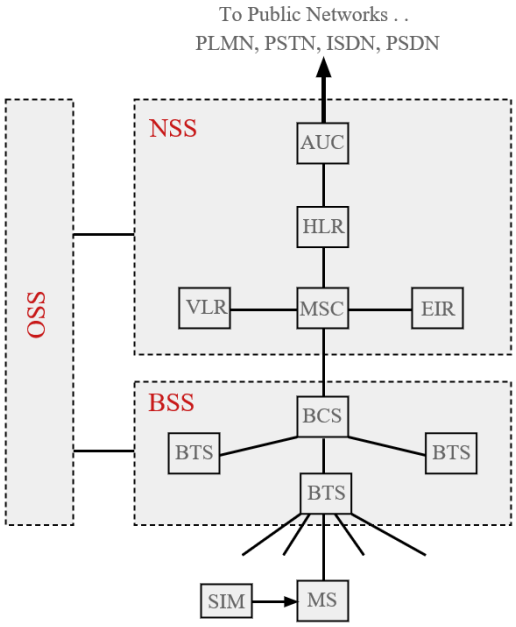

Fig2.55 GSM Architecture

- **Network Subsystem:** It provides the basic network connection to the mobile stations. The basic part of the Network Subsystem is the Mobile Service Switching Centre which provides access to different networks like ISDN, PSTN etc. It also consists of the Home Location Register and the Visitor Location Register which provides the call routing and roaming capabilities of GSM. It also contains the Equipment Identity Register which maintains an account of all the mobile equipments wherein each mobile is identified by its own IMEI number. IMEI stands for International Mobile Equipment Identity.

2.14.3 Features of GSM Module:

- Improved spectrum efficiency
- International roaming
- Compatibility with integrated services digital network (ISDN)
- Support for new services.
- SIM phonebook management
- Fixed dialing number (FDN)
- Real time clock with alarm management
- High-quality speech
- Uses encryption to make phone calls more secure
- Short message service (SMS)

2.14.4 GSM Modem

A GSM modem is a device which can be either a mobile phone or a modem device which can be used to make a computer or any other processor communicate over a network. A GSM modem requires a SIM card to be operated and operates over a network range subscribed by the network operator. It can be connected to a computer through serial, USB or Bluetooth connection.

A GSM modem can also be a standard GSM mobile phone with the appropriate cable and software driver to connect to a serial port or USB port on your computer. GSM modem is usually preferable to a GSM mobile phone. The GSM modem has wide range of applications in transaction terminals, supply chain management, security applications, weather stations and GPRS mode remote data logging.

2.14.5 Working of GSM Module:

A GSM modem duly interfaced to the MC through the level shifter IC Max232. The SIM card mounted GSM modem upon receiving digit command by SMS from any cell phone send that data to the MC through serial communication. While the program is executed, the GSM modem receives command 'STOP' to develop an output at the MC, the contact point of which are used to disable the ignition switch. The command so sent by the user is based on an intimation received by him through the GSM modem 'ALERT' a programmed message only if the input is driven low. The complete operation is displayed over 16×2 LCD display.

2.14.6 Specifications

- Dual-Band 900/ 1800 MHz
- GPRS multi-slot class 10/8GPRS mobile station class B
- Compliant to GSM phase 2/2+
- Dimensions: 24*24*3 mm
- Weight: 3.4g
- Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
- Supply voltage range : 5V
- Low power consumption: 1.5mA (sleep mode)
- Operation temperature: -40°C to +85 °

2.14.7 Applications:

- Remote Data Monitor andControl.
- Water, gas and oil flowmetering.
- AMR (automatic meterreading).
- Power station monitoring andcontrol.
- Remote POS (point of sale)terminals.
- Traffic signals monitor andcontrol.
- Fleetmanagement.
- Power distribution network supervision.
- Central heating systemsupervision.
- Weather station datatransmission.

2.15 SMPS

The SMPS or Switched Mode Power Supply electronic circuit converts power either with the use of switching devices that turn on/off at high-frequencies or with the help of inductors or capacitors to supply power when the switching device is in non- conduction state.

Fig 2.56 SMPS

12.15.1 Why SMPS

SMPS power supply is widely used in electronic equipment namely computers and several other devices which need efficient and stable power supply. Besides overall performance, SMPS have plenty of advantages which range from its size, cost, weight to efficiency.

2.15.2 Working

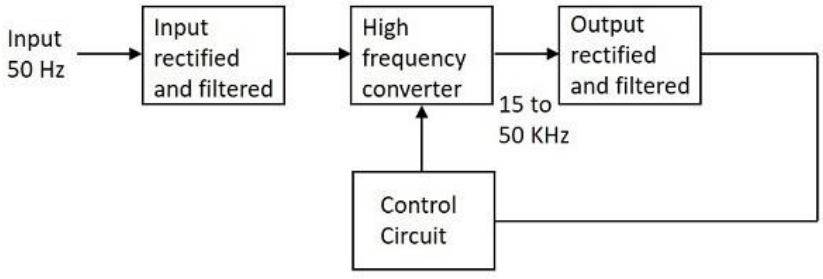

Fig2.57 block diagram of SMPS

The AC input supply signal 50 Hz is given directly to the rectifier and filter circuit combination without using any transformer. This output will have many variations and the capacitance value of the capacitor should be higher to handle the input fluctuations. This unregulated dc is given to the central switching section of SMPS.

Switching Section

A fast switching device such as a Power transistor or a MOSFET is employed in this section, which switches ON and OFF according to the variations and this output is given to the primary of the transformer present in this section. The transformer used here are much smaller and lighter ones unlike the ones used for 60 Hz supply. These are much efficient and hence the power conversion ratio is higher.

Output Stage

The output signal from the switching section is again rectified and filtered, to get the required DC voltage. This is a regulated output voltage which is then given to the control circuit, which is a feedback circuit. The final output is obtained after considering the feedback signal.

Control Unit

This unit is the feedback circuit which has many sections.

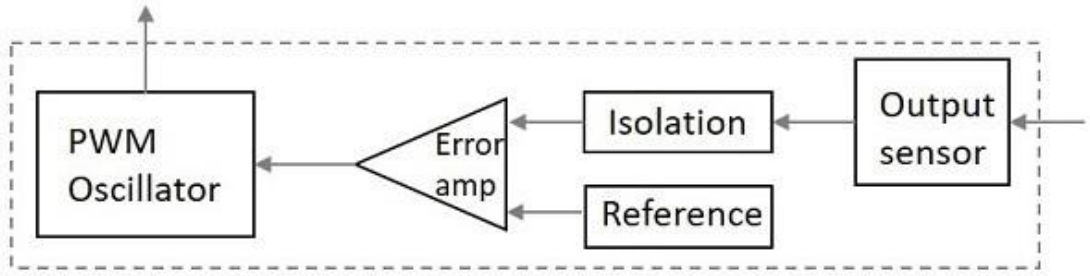

Fig 2.58 feedback circuit

The above figure explains the inner parts of a control unit. The output sensor senses the signal and joins it to the control unit. The signal is isolated from the other section so that any sudden spikes should not affect the circuitry. A reference voltage is given as one input along with the signal to the error amplifier which is a comparator that compares the signal with the required signal level.

By controlling the chopping frequency the final voltage level is maintained. This is controlled by comparing the inputs given to the error amplifier, whose output helps to decide whether to increase or decrease the chopping frequency. The PWM oscillator produces a standard PWM wave fixed frequency.

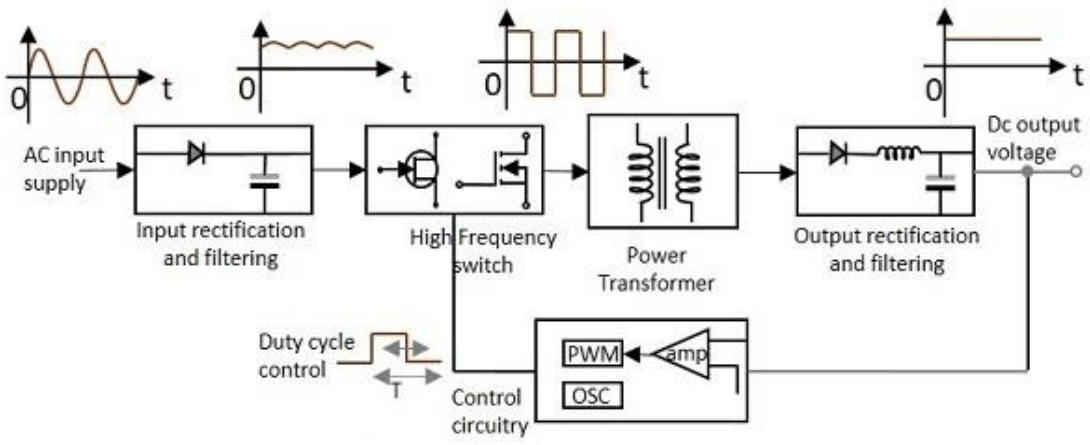

Fig 2.59 Functional Block diagram of SMPS

The SMPS is mostly used where switching of voltages is not at all a problem and where efficiency of the system really matters. There are few points which are to be noted regarding SMPS. They are

- SMPS circuit is operated by switching and hence the voltages vary continuously.
- The switching device is operated in saturation or cut off mode.
- The output voltage is controlled by the switching time of the feedback circuitry.
- Switching time is adjusted by adjusting the duty cycle.
- The efficiency of SMPS is high because, instead of dissipating excess power as heat, it continuously switches its input to control the output.

2.15.3 Types of SMPS

SMPS is the Switched Mode Power Supply circuit which is designed for obtaining the regulated DC output voltage from an unregulated DC or AC voltage. There are four main types of SMPS such as

- DC to DC Converter
- AC to DC Converter
- Fly back Converter
- Forward Converter

The AC to DC conversion part in the input section makes the difference between AC to DC converter and DC to DC converter. The Fly back converter is used for Low power applications. Also there are Buck Converter and Boost converter in the SMPS types which decrease or increase the output voltage depending upon the requirements. The other type of SMPS include Self-oscillating fly-back converter, Buck-boost converter, Cuk, Sepic, etc.

2.15.4 Specifications

- Output: 12V, 5Amp
- Input:180V to 260V AC , 47 to 63Hz
- LED power indication
- DC calibration range: +-10% of the output voltage
- Overload protection: up to 150% with auto recovery
- Over voltage protection: up to 135% of the output voltage
- Short Circuit protection: long term
- Setup time: Less than 1 second
- Hold-up time: greater than 20mS
- Over voltage tolerance for input to output: 1500V AC for 60 seconds
- Over voltage tolerance for input to ground: 1500V AC for 60 seconds
- Over voltage tolerance for output to ground: 500V DC for 60 seconds

- Operating temperature: 0 to 450C
- Operating Humidity: 20% to 80% Non condensing (very important)
- Power conversion efficiency: 80%
- Safety standards: EN60950, GB4943
- Dimension: 129 x 98 x 38mm
- Product weight: 415gms

2.15.5 Advantages

- The efficiency is as high as 80 to 90%
- Less heat generation; less power wastage.
- Reduced harmonic feedback into the supply mains.
- The device is compact and small in size.
- The manufacturing cost is reduced.
- Provision for providing the required number of voltages.

2.15.6 Applications

- The switch mode power supply (SMPS) is used in personal computers.
- It is used in machine tool industries.
- The SMPS is used in security system.
- It is used in railway system.
- It is also used in mobile.
- It is used in battery charger.
- The SMPS is used in vehicles.
- It is also used in lighting.

CHAPTER 3

SOFTWARE DESCRIPTION

3.1 Arduino IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.[6]

3.1.2 Installing the Aurduino IDE

Get the latest version from the download page. One can choose between the Installer (.exe) and the Zip packages. Installing the one that has software and Arduino Software (IDE), including the drivers is recomnded. With the Zip package you need to install the drivers manually. The Zip file is also useful if you want to create a portable installation.

When the download finishes, proceed with the installation and please allow the driver installation process when you get a warning from the operating system.

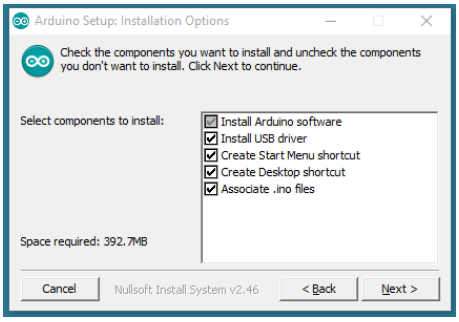

Fig 3.1 Downloading the arduino

- Choose the components to install

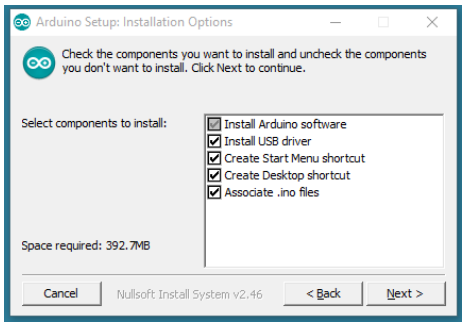

Fig 3.2 Choose the components to install

- Choose the installation directory (we suggest to keep the default one)

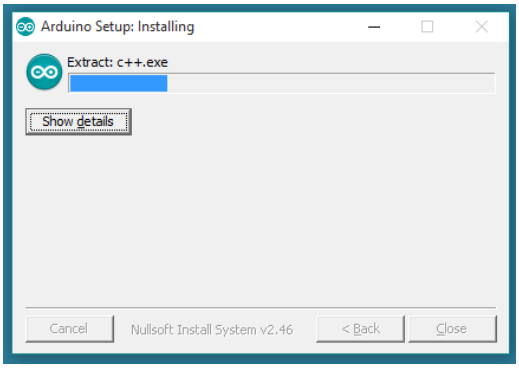

Fig 3.3 installation process

The process will extract and install all the required files to execute properly the Arduino Software (IDE)

3.2 Arduino Software

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

3.3 Structure of Arduino Program

The structure of Arduino program is pretty simple. Arduino programs have a minimum of 2 blocks,

Preparation & Execution

Each block has a set of statements enclosed in curly braces:

```
void setup( )
{
statements-1;
.
.
.
statement-n;
}
void loop ( )
{
statement-1;
.
statement-n;
}
```

3.4 Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

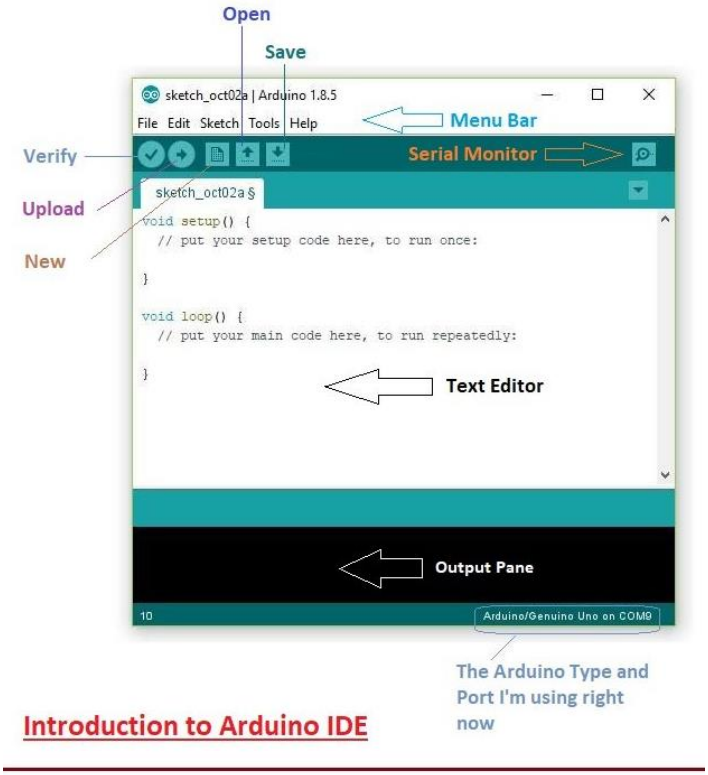

Fig 3.4 Arduino IDE SOFTWARE

3.5 Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial

adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets)

3.6 Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch.

Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

3.7 Advantages of Arduino

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.
- Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
- Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

CHAPTER 4

EXPLANATION

4.1 BLOCK DIAGRAM

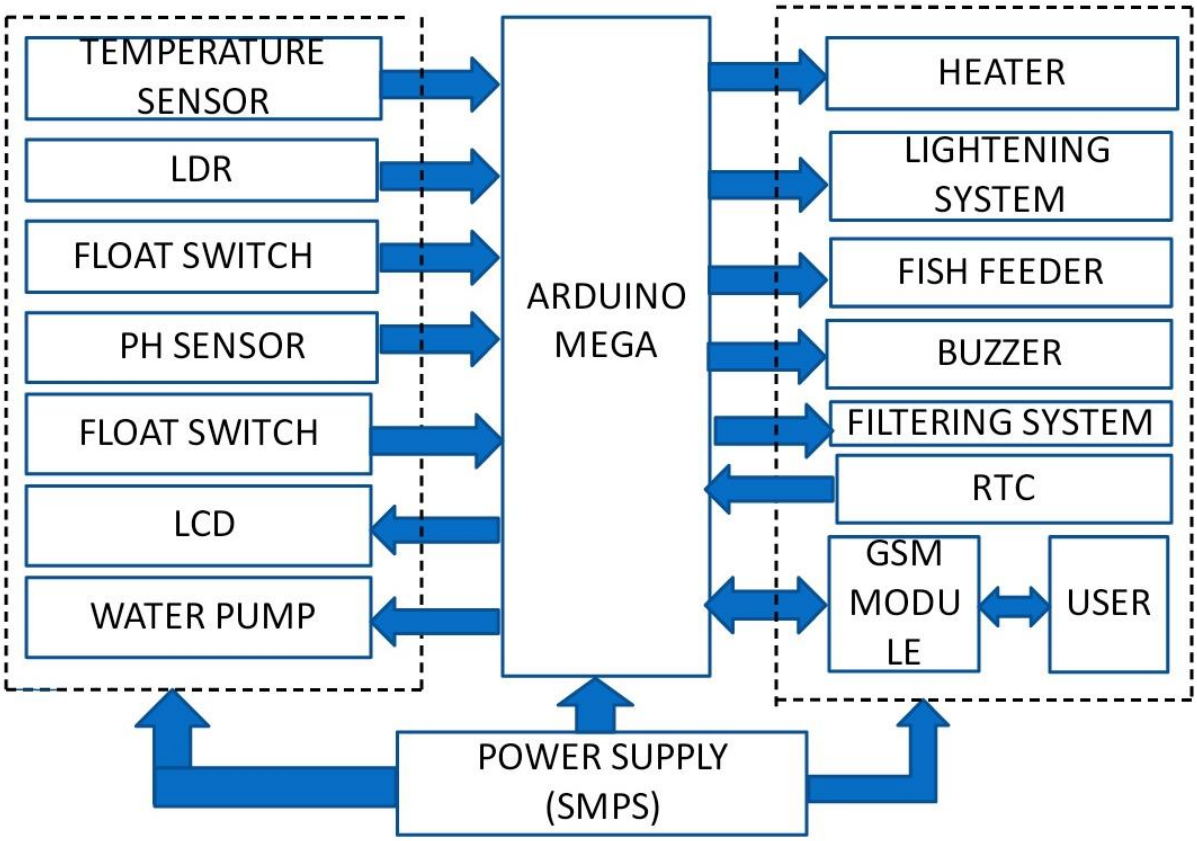

Fig 4.1 BLOCK DIAGRAM

ARDUINO MEGA 2560

- Takes data from various input sensors, process the data and send control signals to various output devices.

TEMPERATURE SENSOR

- Used to measure temperature in the aquarium.

HEATER

- It converts electrical energy into heat energy.
- It ensures that temperature do not get too low.

LDR

- It is a light controlled variable device.
- It exhibits photoconductivity.
- The resistance of LDR decreases with increasing incident light intensity.
- Used to create day and night differences.

LED (LIGHT EMITTING DIODE)

- During the night, they get on and provide a chance to observe fishes even during the night.

WATER LEVEL INDICATOR (FLOAT SWITCH)

- It is used to open or close a circuit as the level of the liquid rises or falls. To detect water level in an aquarium.

WATER PUMP

- Used to pump water to the filtering system .
- Used to transfer fresh water.
- Used to remove unwanted and excess water to balance ph of water.

Ph SENSOR

- The difference in the potentials of known and unknown solution are compared.
- It is used to indicate the how acidic or basic a solution is.

FISH FEEDER

- Fish feeder feeds the fish automatically on time.
- Servo motor is used to drop the food into aquarium at particular time intervals.

RTC

- The purpose of an RTC or a real time clock is to provide precise time and date which can be used to turn on and off of devices at a particular time or sometimes for other applications it can turn on at different times.

BUZZER

- It is an audio signalling device.
- It is used to indicate the danger situations.

LCD DISPLAY

- Liquid crystal display is an electronic display.
- To display the values and stating the condition of each and every component.

GSM MOULE SIM 800

- It acts as an interface between user and aquarium (arduino).
- It receives the data from arduino and send it to user.
- It also transmits some control signals from the user to arduino.
- It is a single chip processor.

POWER SUPPLY

- SMPS stands for switched mode power supply.
- It converts unregulated ac or dc input voltage to a regulated dc output voltage.
- Used to power all the components.

4.2 CIRCUIT DIAGRAM

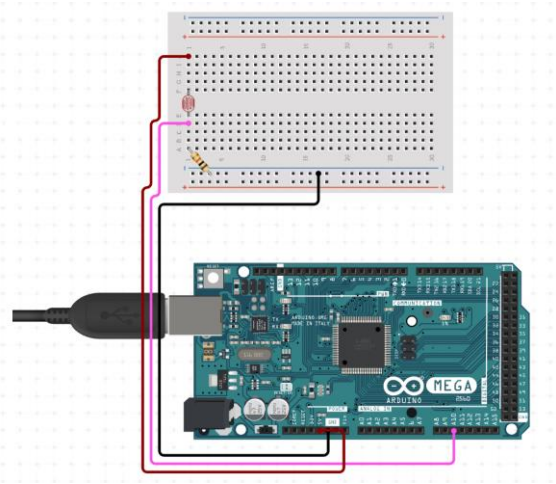

Fig 4.2 LDR with Arduino Mega2560

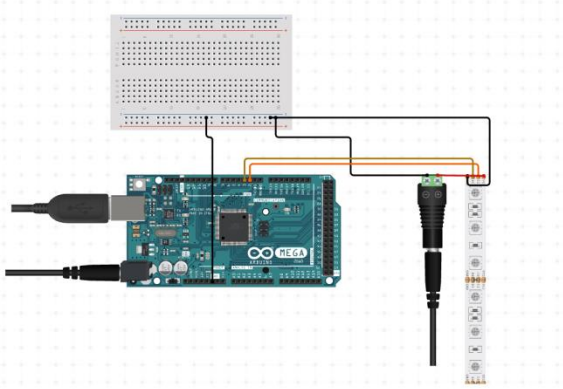

Fig 4.3 LED strip with Arduino Mega 2560

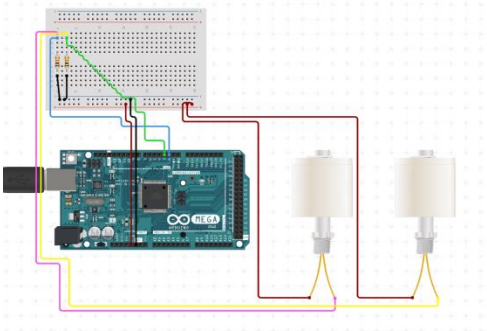

Fig 4.4 Float Switch with Arduino Mega 2560

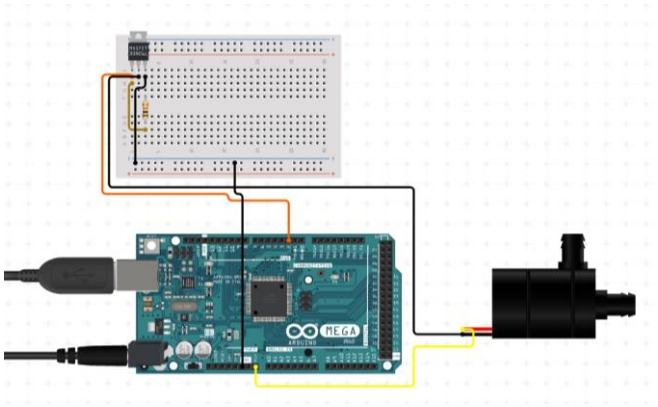

Fig 4.5 Water pump with Arduino Mega 2560

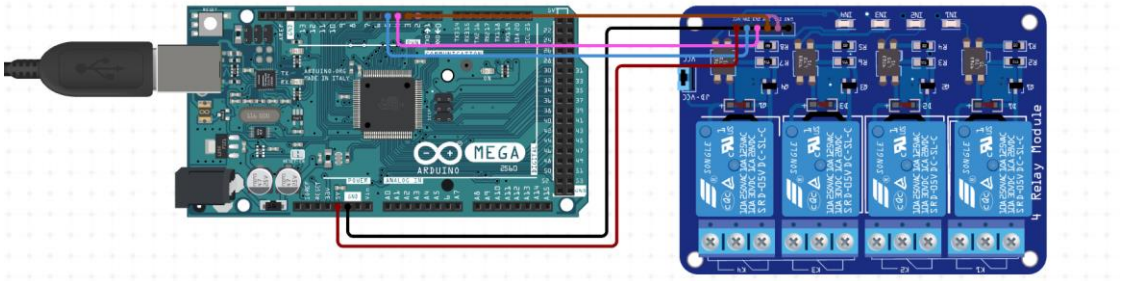

Fig 4.6 Relay with Arduino Mega 2560

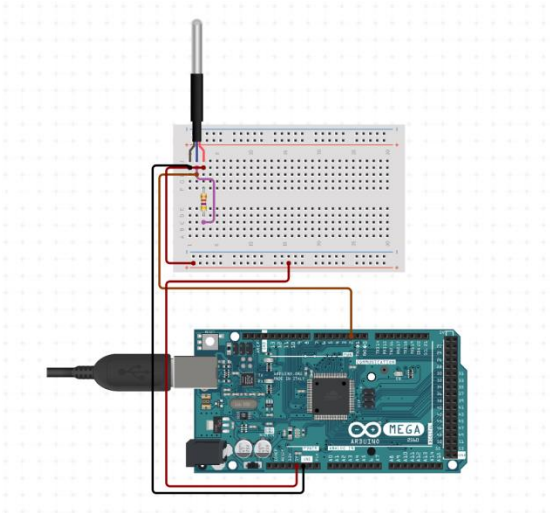

Fig 4.7 ds18b20 Temperature sensor with Arduino Mega 2560

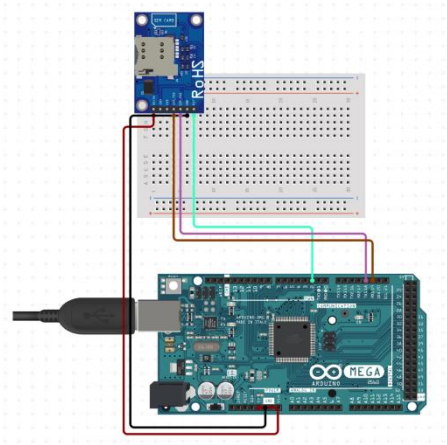

Fig 4.8 GSM SIM 900 with Arduino Mega 2560

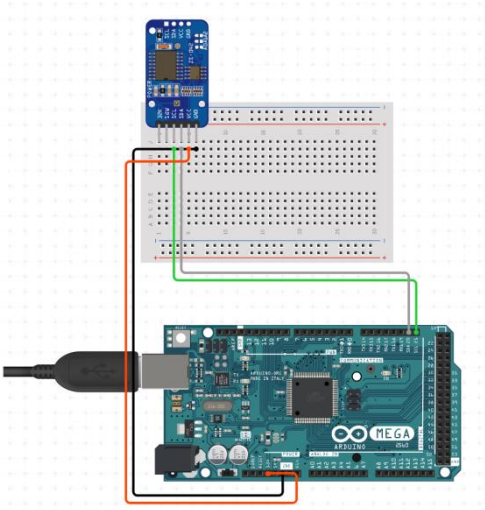

Fig 4.8 GSM SIM 900 with Arduino Mega 2560

4.3 WORKING

All the connections are given as per the circuit diagram. SMPS is chosen as a power supply because it takes 230 v ac input and gives 12V, 5A DC output. Some of the components like water pumps, temperature sensor, servo motor require 5 V DC, and ph sensor requires 9 volts, and lightening system and 12V DC water pump requires 12 V DC INPUT where directly from SMPS it can be provided. Other components will get their respective voltage with the help of regulators, SMPS input given to the respective components. When the power supply is given, all the components get activated, the Arduino starts to collect data from various sensors and process them and says whether the values are in the permissible limits or not, if not in permissible limits buzzer gets activated indicating danger and Arduino sends commands to output devices like water pump gets on for specific amount of time until the water level reaches to the safe point, and if the temperature gets low, heater gets on, and if ph values go low or high, some of the water from the aquarium is taken out and freshwater is filled until the ph gets balanced, continuously aquarium water is pumped to the filtering system to remove any toxins and chemicals or bacteria and to make the environment safe for the fished . the LDR will continuously monitor the light intensity and sends its values to the Arduino, if the light intensity is low that is during the dark Arduino sends the commands to lightening system and the lightening system gets turned on, meanwhile all the data from components will be displayed on the LCD respectively and data values are sent to the user as well with the help of GSM .

CHAPTER 5

RESULT

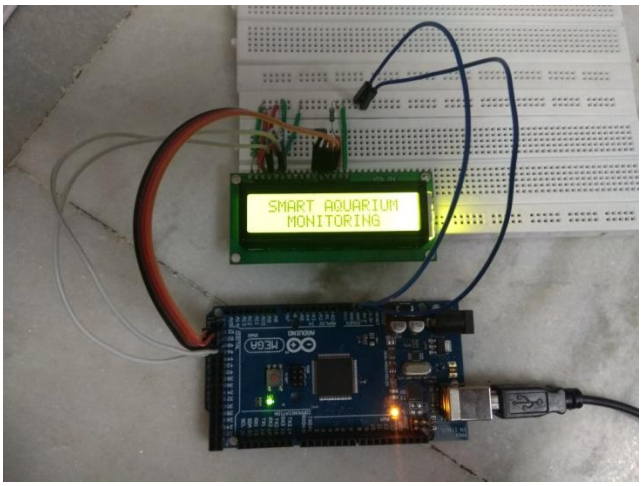

Fig 5.1 LCD DISPLAY

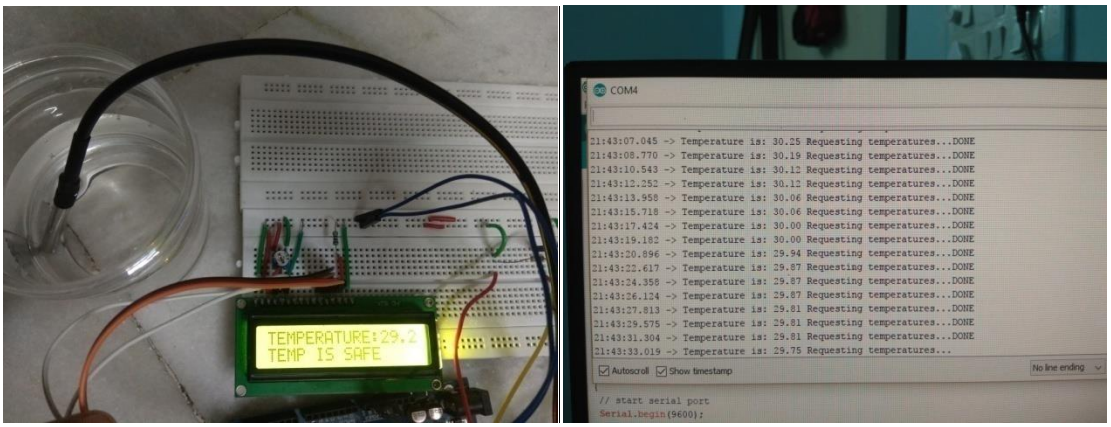

Fig 5.2 temperature sensor

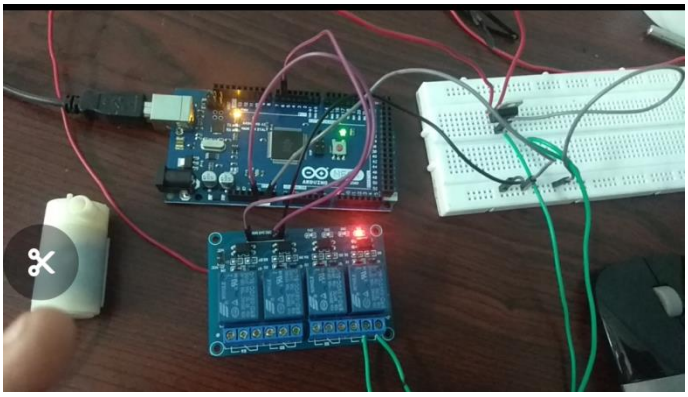

Fig 5.3 RELAY, WATER PUMP

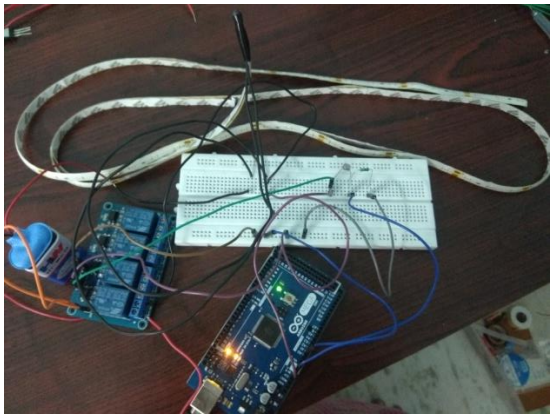

Fig 5.4 lightening system during day time

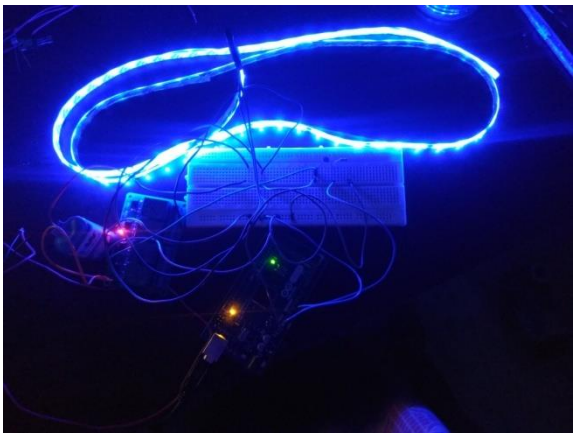

Fig 5.5 lightening system during the Night

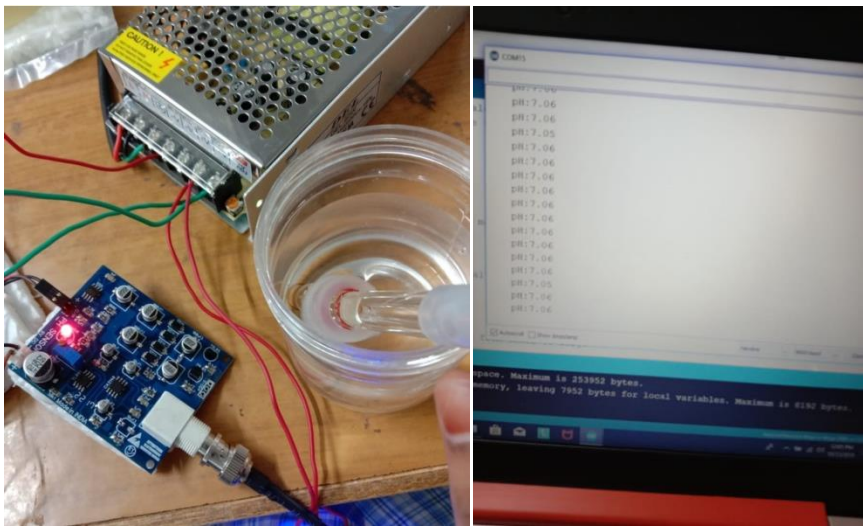

Fig 5.6 PH Sensor , SMPS

Fig 5.7 Filtering System

Fig 5.8 Fish Feeder (Servo motor)

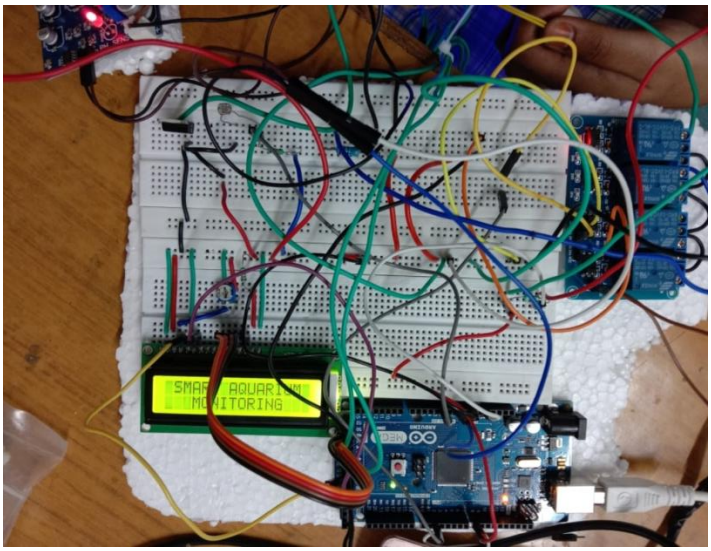

Fig 5.9 Overall Circuit Diagram

CHAPTER 6

CONCLUSION

We started off the project with aim to accomplish the simple looking task of designing an automatic aquarium (SMART Aquarium). But with time and experiences it was learnt that this was not at all an easy task, specially interfacing the sensors and GSM Mobile with the controller.

Though we are able to achieve all the goals of our project but still we think that lots of advancement can be done on this project. We have provided the platform and the platform is ready for everyone to work on it. For advancements, we need more time, money and hard work. Money would remain the critical issue cause in order to upgrade the project many of the stuff would need an up gradation.

Nevertheless this project has been a success as far as learning and practical implementation of Electronics concepts is concerned. The basic idea proposed in this project works well and can be implemented on large scale industries like agriculture etc. Having a SMART AQUARIUM MONITORING SYSTEM, will save our time and we would not have to be worried for our fish and their aquariums for long time.

CHAPTER 7

ADVANTAGES AND APPLICATIONS

6.1 ADVANTAGES

- If the temperature goes high , the metabolism of the fishes increases ,oxygen levels decreases and fishes get suffocated and if the temperature goes lo w their metabolism goes low and they become iactive. So with the help of temperature sensor, we can continuously monitor the aquarium temperature, and do necessary changes.

- If the ph goes high or low , the toxins gets accumulated in the aquarium and fishes gills gets effected , face respiratory problems , get prone to severe diseases and finally die .with the help of Ph monitoring , whenever the ph levels goes high or low , we can change the water and add certain chemicals to maintain the ph.

- With the help of fish feeder, we can replace the manual maintanence with automatic system.

- In this way, with the help of "SMART AQUARIUM MONITORING SYSTEM" can maintain the ideal conditions of the aquarium required for a healthy and happy fish.

6.2 APPLICATIONS

- Home
- Aquarium shops
- Ponds
- Lakes
- Seas
- Oceans

CHAPTER 8

FUTURE SCOPE

8.1.1 Air Cooler:

Sometime the temperature of inside the aquarium or we can say the temperature of water increases in summers that's why fish die because of the sudden increase in the temperature. As there is nothing in the aquarium that could reduce the temperature when it has increased so a small air cooler or a fan can be used to decrease the temperature in case the temperature increases up.

8.1.2 Solar Cell:

As the aquarium needs 24/7 constant power in order to work so lots of power is consumed, GSM mobile also needs a separate constant power. Lots of power is utilized and it can be a burden on your pocket so in order to reduce this, solar cells or panels can be used to get the constant power. So that there will be no issue of over billing and burden on your pocket. If in se of power failure, the aquarium would not stop its work.

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- "Microelectronic Circuits" by Sedra and Smith.
- "Solid State Electronic Devices" by Ben G.Streetman.
- "Integrated Electronics" by Millman and Halkias (Must Read)
- **Current USA**

Title: AquaChef Automatic Fish Feeder | Visiting Date: 02/Feb/2011
©2005-2009 Current Inc. | Updated: March 2, 2009 - 16:10
http://www.current-usa.com/aquachef.html

- **New York Times Company**

Title: Nutrafin ProFeed Automatic Feeder | Visiting Date: 05/Feb/2011
©2011 About.com. All rights reserved. A part of New York Times Company (www.nytco.com)
http://saltaquarium.about.com/od/toppicks/tp/TPautofeeders.htm

- **Alibaba.com**

Title: Automatic Aquarium | Visiting Date: 05/Feb/2011
© 1999-2010 Alibaba.com Hong Kong Limited and licensors. All rights reserved.
http://www.alibaba.com/product-gs/238098574/automatic_aquarium.html

- **Aquarium Guys**

Title: Aquarium size| Visiting Date:25/3/2011
©2011 Aquarium guys. All rights reserved.
http://www.buzzle.com/articles/aquarium-care-choosing-the-right-aquarium-size-for-your-fish.html

- **Keith Seyffarth**

Title: Aquarium and aquarium filters|02/04/2011
©1994-2011, Keith Seyffarth. All rights reserved.
http://www.aqua-fish.net/articles/what-does-my-filter-do.html