SMART SOLAR VEHICLE

A PROJECT REPORT

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ABSTRACT

The idea of this project is to design a solar car that aims to tackle the problems related to pollution and shortage of fuel.

A Smart vehicle is the one that takes all our burdens on maintenance of the vehicle while ensuring safety and comfort for the driver and the passengers. Various parameters have to be taken into account while designing such a vehicle. In our design we have divided the whole system into two major divisions namely,

- Vehicle monitoring system
- Safety system

Vehicle monitoring system includes various sensors that sense the various vital parameters such as Engine temperature, Fuel level and as we have developed it for a vehicle battery chamber temperature is also included. In addition to this accelerometers and speed sensors sense abnormal vibrations in vulnerable parts and over speeding. These data after being sensed is stored in the cloud. This enables monitoring of vehicle's performance and drivers actions remotely.

Safety system includes sensing speed of vehicle approaching to perform safe cuts and lane change over. This also includes sensing objects in the proximity of the vehicle which helps in parking and driving in heavy traffic. An Emergency Shutdown System is designed to stop the vehicle at the flick of a switch when it is out of control.

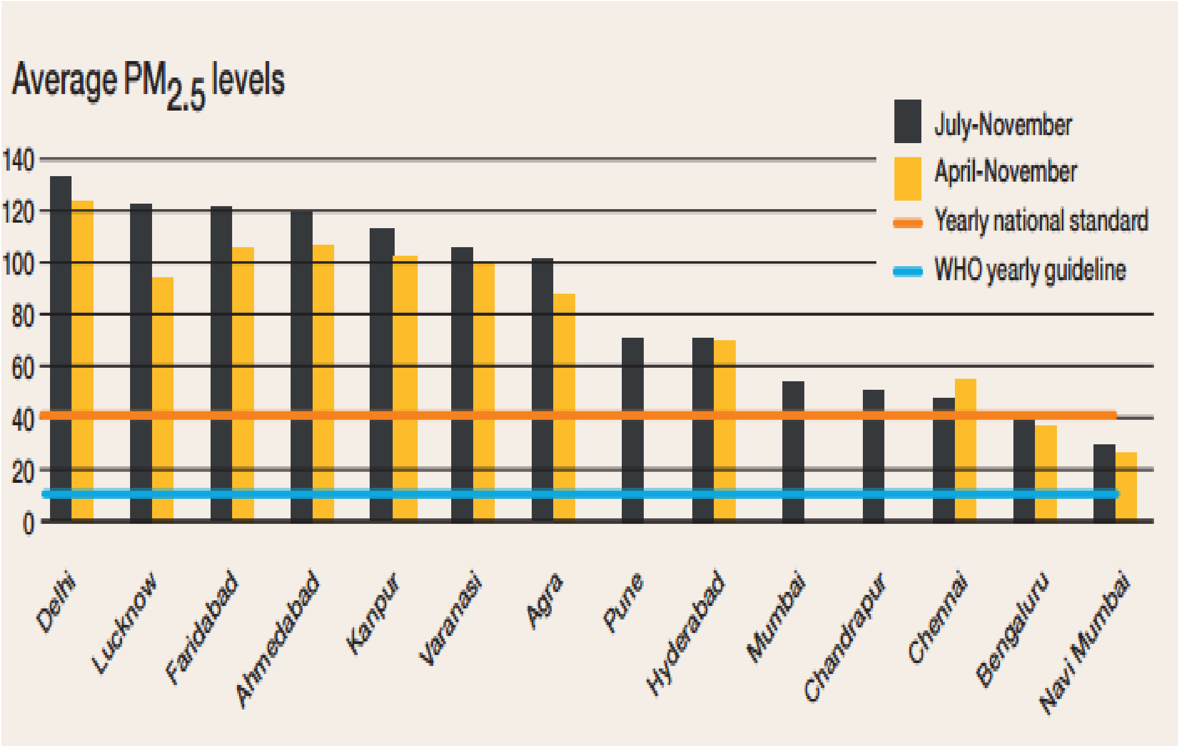
CHAPTER - 1

INTRODUCTION

This chapter will explain the study that is related to the project task. Besides that, this chapter will be important references, journal and the important information about the project. The information got from several sources such as websites, journals, books, magazines, handout and others.

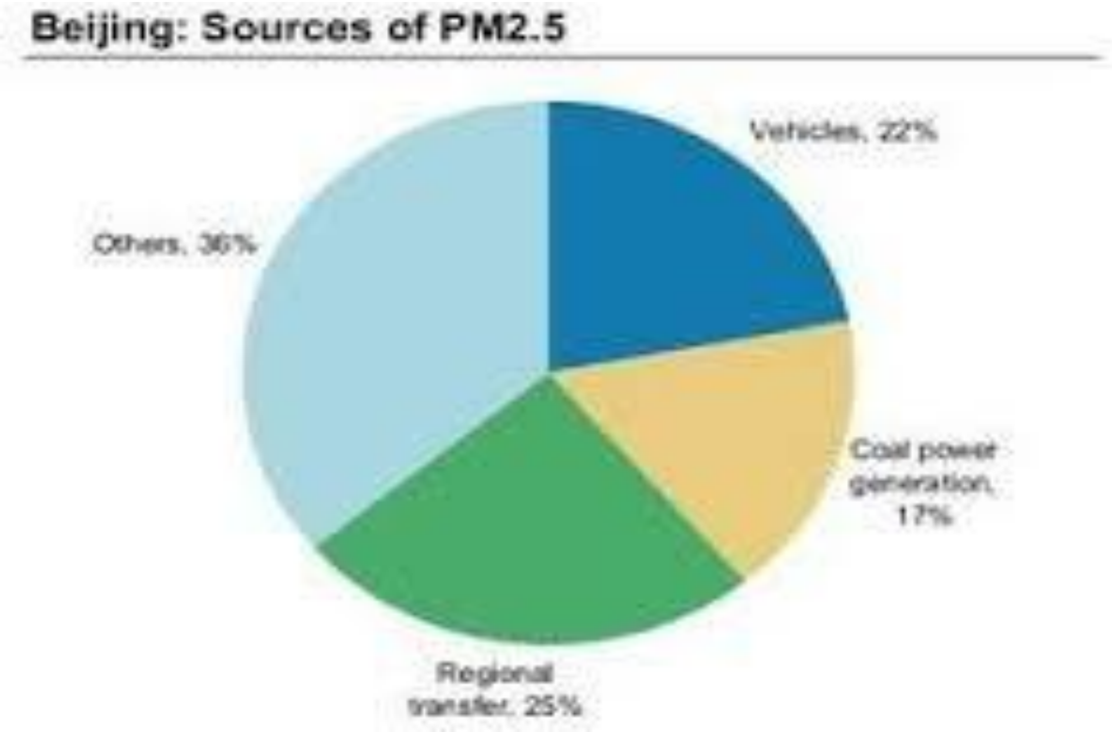
1.1 IMPORTANCE OF RENEWABLE ENERGY

- Delhi, capital city of India is one of the most heavily polluted cities in India as per the Figure 1.1.1. Recent study shows that pollution due to road dust and vehicles account for about 50% of total pollution.
- Number of solution was proposed which mainly includes afforestation and restriction on usage of the vehicles.
- Fine particulate matter ($PM_{2.5}$) is an air pollutant that is a concern for people's health when levels in air are high.



[Figure 1.1.1]

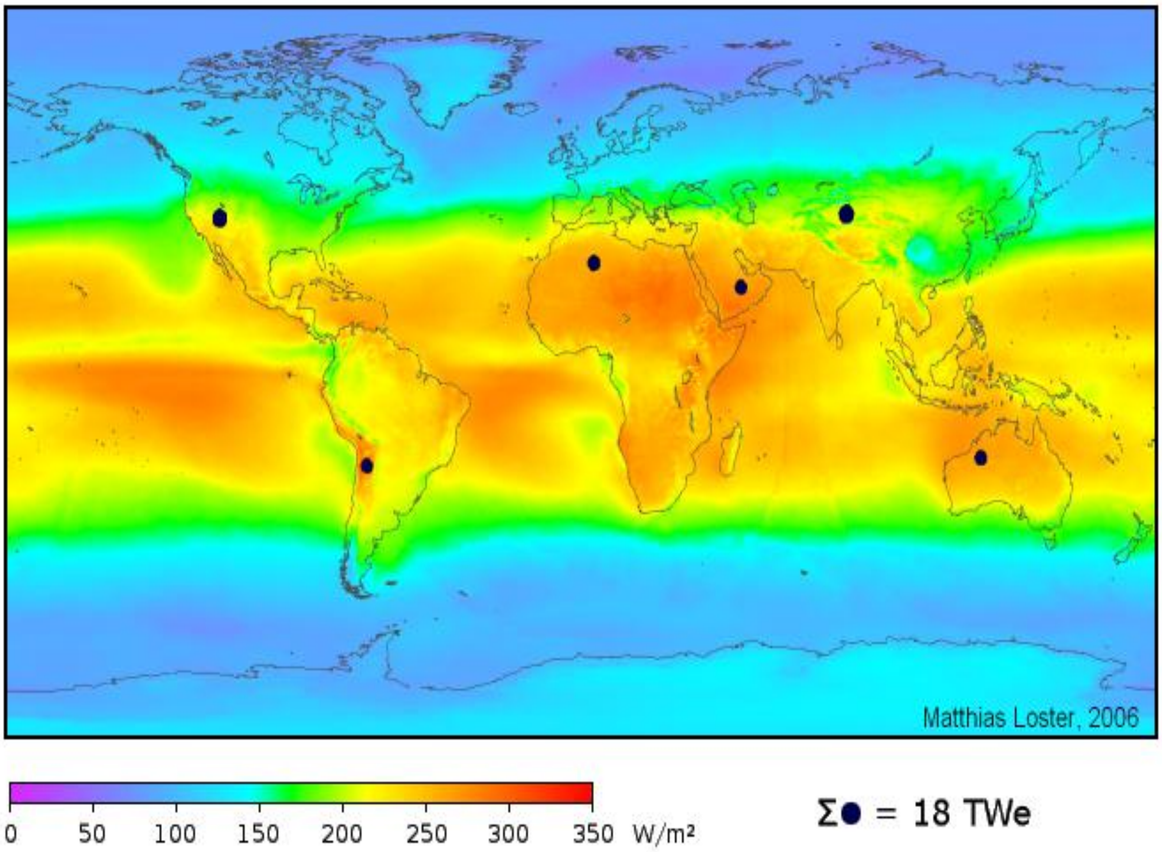
- Air pollution in Japan, China, and Germany forced government to adopt aggressive recycling and thus solar power in Japan has been on the rise since 1990s.
- Now Japan is the leading manufacturer of photovoltaic and it is also has the third largest solar PV installed capacity behind China and Germany.
- Moreover Japan opts for making solar power an important national project since the county's shift in policies towards renewable after Fukushima in 2011.
- As per the pie chart in Figure-1.1.2 about 22% of total pollution in Beijing is due to Vehicles.



[Figure 1.1.2]

1.2 SOLAR POWER

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect.



[Figure - 1.2 Map showing the Solar Energy Distribution across the Globe]

The International Energy Agency projected in 2014 that under its "high renewables" scenario, by 2050, solar photovoltaics and concentrated solar power would contribute about 16 and 11 percent, respectively, of the worldwide electricity consumption, and solar would be the world's largest source of electricity. Most solar installations would be in China and India. The above Figure - 1.2 represents the solar energy distribution across the globe.

Photovoltaics were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The current largest photovoltaic power station in the world is the 850 MW Longyangxia Dam Solar Park, in Qinghai, China.

1.3 SOLAR POWERED CAR

A car powered by solar energy is a vehicle that uses a type of renewable resource that can be obtained when sunlight incident on the solar panel placed on the surface of the vehicle.To keep the car running smoothly, the driver must monitor multiple gauges to spot possible problems. Cars without gauges almost always feature wireless telemetry, which allows the driver's team to monitor the car's energy consumption, solar energy capture and other parameters and thereby freeing the driver to concentrate on driving.

Solar cars combine technology typical aerospace, bicycle, alternative energy and automotive industries. The design of a solar vehicle is severely limited by the amount of energy input into the car. Most solar cars have been built for the purpose of solar car races. Some solar cars are designed also for public use.

Solar cars depend on a solar array that uses photovoltaic cells (PV cells) to convert sunlight into electricity. Unlike solar thermal energy which converts solar energy to heat for either household purposes, industrial purposes or to be converted to electricity, PV cells directly convert sunlight into electricity. When sunlight (photons) strike PV cells, they excite electrons and allow them to flow, creating an electric current. PV cells are made of semiconductor materials such as silicon and alloys of indium, gallium and nitrogen. Crystalline silicon is the most common material used and has an efficiency rate of 15-20%. The first solar family car was built in 2013.

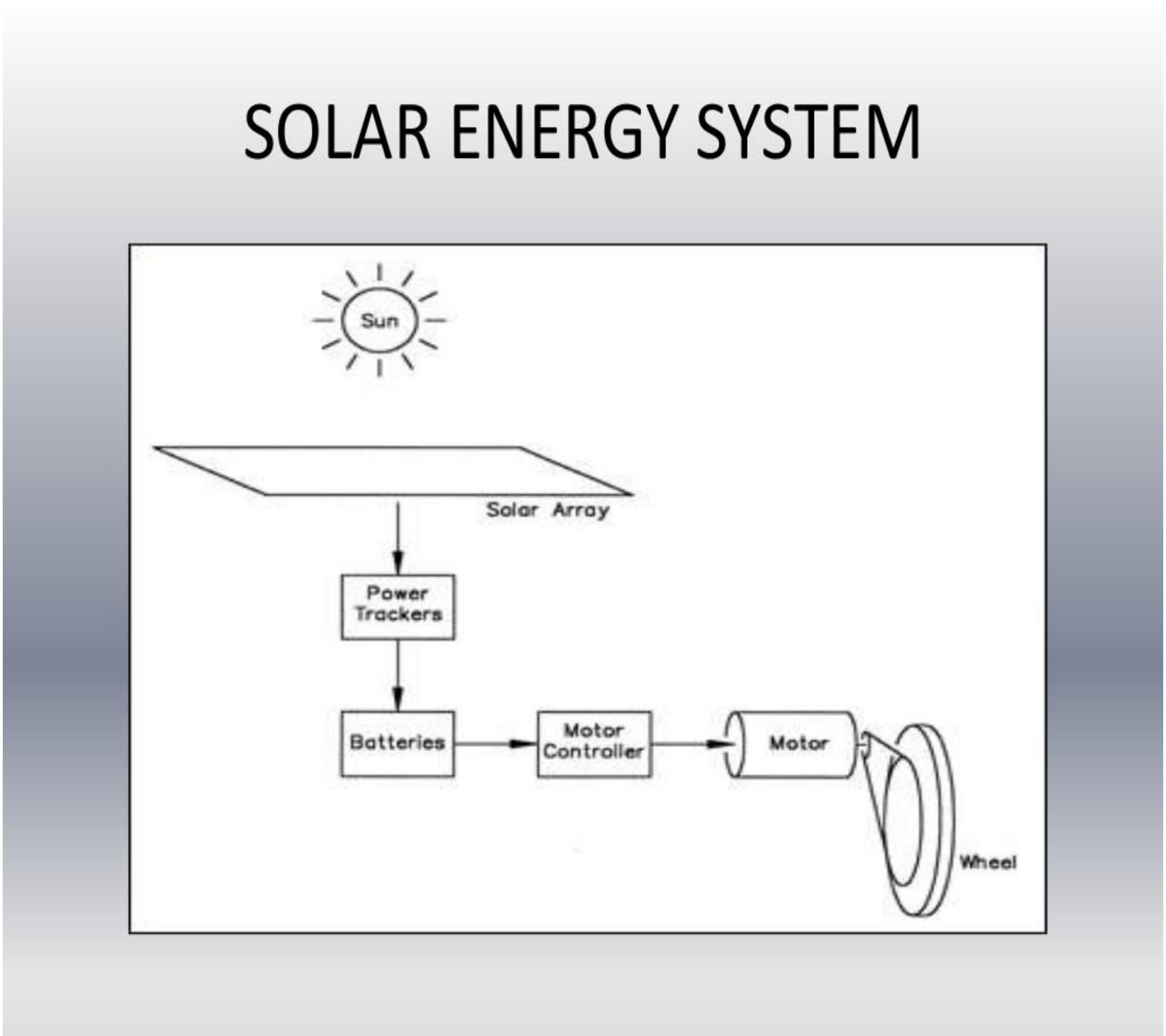
1.4 CONVENTIONAL MODEL

The conventional method consists of drive system powered by a battery which is charged through a solar array as per the diagram in Figure 1.4. The drive system consists of motor, controller and the drive shaft.

While considering the conventional model, less importance is given towards the safety of the driver and monitoring the performance of the vehicle. The conventional solar vehicle is designed merely a simple mode of transport. It ensures limited safety and comfort to the driver.

Drawbacks:

- Poor performance
- Less importance given to safety of the driver
- Absence of sophisticated systems for vehicle monitoring



[Figure - 1.4 - Diagram of conventional system]

1.5 OBJECTIVE

This Project gives a design of more sophisticated safety features and means of monitoring the vehicles performance and drivers vitals. This design also adds remote monitoring facility to monitor the vehicle and the driver via cloud.

1.5.1 REDUCING THE USE OF FOSSIL FUEL

Certain plug-in electric vehicles that pull electricity from gas-fired plants produce up to 60 percent fewer emissions than a conventional car with an internal combustion engine.

Hanergy says that five to six hours of sunlight should allow the cars' thin-film solar cells to generate between 8-10kWh of power a day, allowing the car to travel about 80km on solar power alone. Maximum range is about 350km.

1.5.2 IMPROVING SAFETY OF THE DRIVER

It is done by using impact detectors directly connected to the kill switch. So when there is a collision the kill switch turns off the entire system.

The driver vitals, battery temperature, battery power level and power generated are to be displayed on the dashboard for ease of operation. This information can also be monitored by the manufacturer by storing the information obtained in the cloud for successive improvements.

1.6 PROPOSED MODEL

The proposed model is designed in such a way that it achieves all the mentioned objectives by adding various features to the conventional solar vehicle design. The additional features are mentioned below.

- ✓ Safety features
  - ✓ Impact attenuator
  - ✓ Doppler radar
  - ✓ Emergency shutdown system
  - ✓ Proximity of Obstacles
- ✓ Driver vital monitoring
  - ✓ Sensing pulse of the driver
- ✓ Vehicle tracking and performance monitoring
  - ✓ Battery temperature
  - ✓ Power consumption
  - ✓ Speed of the vehicle

The above mentioned parameters are monitored using sensors and a microcontroller with built in WIFI module and data is uploaded to the cloud.

1.7 TECHNOLOGY USED

BLYNK which is an open source cloud used for the cloud computing application in the design. The controller 'SPARKPHOTON' which has inbuilt WIFI module and facility to be programmed via cloud is registered to this cloud with a e-mail id and password. A unique id is generated for the device which is included in the program for communication purpose. An android app of the same cloud is used to monitor the data via Smart phones.

1.8 LITERATURE SURVEY

Abhinya Chaturvedi, Kirti Kushwaha, Parul Kashyap, Dr. J. P. Navani of Electrical & Electronics Department, Raj Kumar Goel Institute of Technology for Women, Ghaziabad, India presented a paper on april 2015 about solar powered vechicle.This survey aims at reducing fuel cost and to use hybrid technologies including the posibilities of hydrogen fuel.The paper also explains about the history of solar vehicles and development of a telemetry system where solar power cars can serve for better understanding of energy usage in vehicles and the aspects applicable to electric vehicle as a whole.

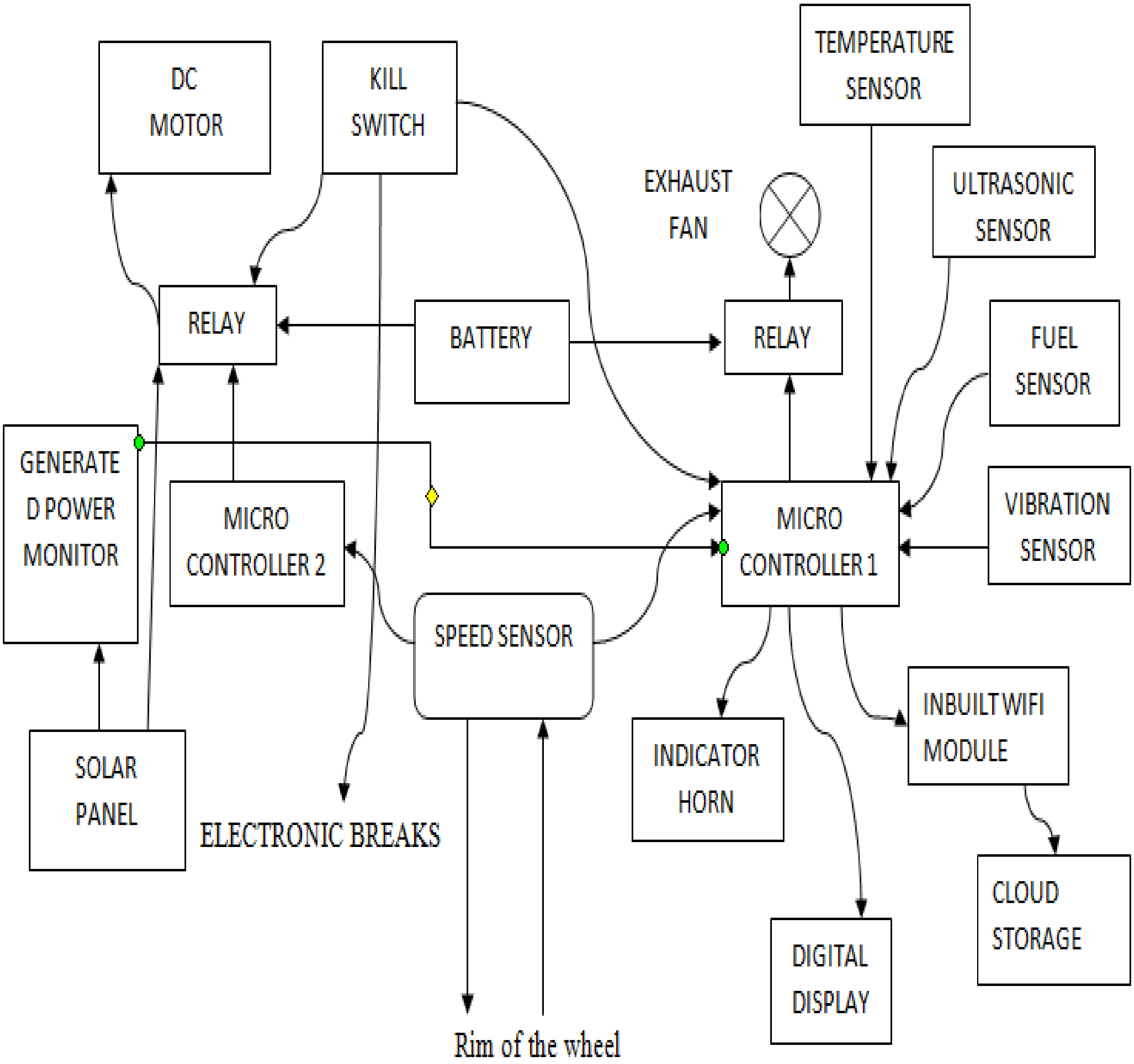
The review work is the study of all previous works related to the electric and solar cars have been done. Solar powered vehicle is a three wheel drive and has been used for shorter distances. The main concentration was made on improving the design and making them cost effective. Energy from Sun is captured by the solar panels and is converted to electrical energy. The electrical energy thus obtained is being fed to the batteries that get charged and is used to run 24 V DC high torques DC series motor. The shaft of the motor is connected to the rear wheel of the vehicle through chain sprocket. The batteries are initially fully charged and thereafter they are charged by panels.

After giving an overview of the cars which are already in use, here is a detailed description of our solar powered vehicle. It is a four wheeler , two seater vehicle. In this vehicle we have used a belt pulley mechanism. The solar energy is harnessed using solar panels which are used for charging the batteries. The batteries run the motor which drives the wheel of the vehicle. The vehicle which we have made as our project uses a belt pulley mechanism in which the shaft of the motor is connected through the belt pulley system. The power supplied to the batteries is from the solar panels which are giving a total output

of 4ooW and they are then used for charging the batteries. The batteries which we are using are lead acid batteries which are of 48V rating each of 12V. The motor's rating is of 48V which gets charged through the four 12V batteries. The belt used in our project is a timing belt which has teeth that fit into a matching toothed pulley. When correctly tensioned, they have no slippage, run at constant speed, and are often used to transfer direct motion for indexing or timing purposes. They are often used in lieu of chains or gears, so there is less noise and a lubrication bath is not necessary. Timing belts need the least tension of all belts, and are among the most efficient. We have laid emphasis on the
economical part so that it can be used to cover short distances without consuming energy from external sources and at the same time keep the environment pollution free.

CHAPTER-2
BLOCK DIAGRAM AND DESCRIPTION

2.1 BLOCK DIAGRAM:



[Figure - 2.1 Diagram of Proposed system]

2.2 OVERVIEW OF THE BLOCK DIAGRAM

The block diagram in Figure 2.1 portrays the proposed model of the solar vehicle that incorporates various sophisticated safety features and vehicle monitoring system comprising the following components

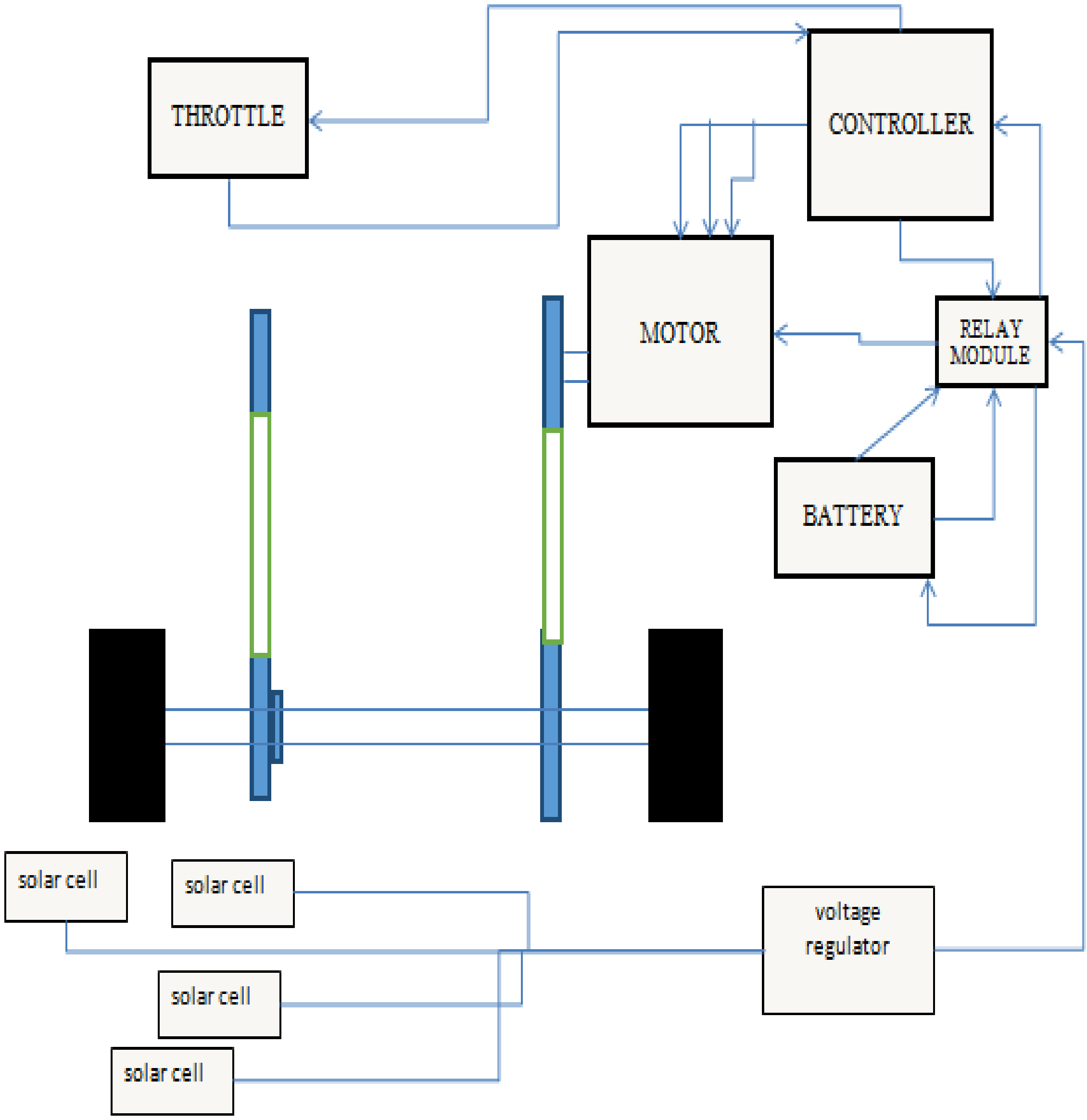
SNO	SENSOR USED	PARAMETER MEASURED
1	SPARK- PHOTON	MICROCONTROLLER WITH INBUILT WIFI MODULE
2	TEMPERATURE SENSOR - LM35	TEMPERATURE OF BATTERY CHAMBER
3	TACHOMETER(USING IR SENSORS)	SPEED
4	ACCELEROMETER	UNUSUAL VIBRATIONS
5	FINGER TIP PULSE SENSOR-MLX90614	DRIVER PULSE RATE
6	DOPPLER RADAR	PROXIMITY OF APPROACHING VEHICLE W

2.3 DRIVE SYSTEM

The drive system consist of a motor, intermediate shaft, differential, a controller for speed control of motor and a throttle. The block diagram of the drive system is given below in Figure 2.3

The power supply to the motor is given from lead acid accumulators through a controller which controls the speed of the motor with reference to the position of the rotor and signal from the throttle. The throttle works under the principle of Hall Effect which gives a varying (0-4V) voltage pulse to the controller for triggering the SCR present in the controller. The rotor position is sensed by inbuilt Hall sensor and it is also used as a reference to the controller. By these reference signals appropriate phases of the motor is energised by triggering respective thyristors and the rotor rotates.

The rotor shaft is coupled with the intermediate shaft by a sprocket and chain arrangement. Chain drive is used instead of belt drives as mentioned in the literature survey as slip in belt drives is maximum and thus efficiency is less.



[Figure - 2.3 Block diagram of drive system]

2.4 SOPHISTICATED SAFTEY FEATURES

2.4.1 IMPACT ATTENUATOR

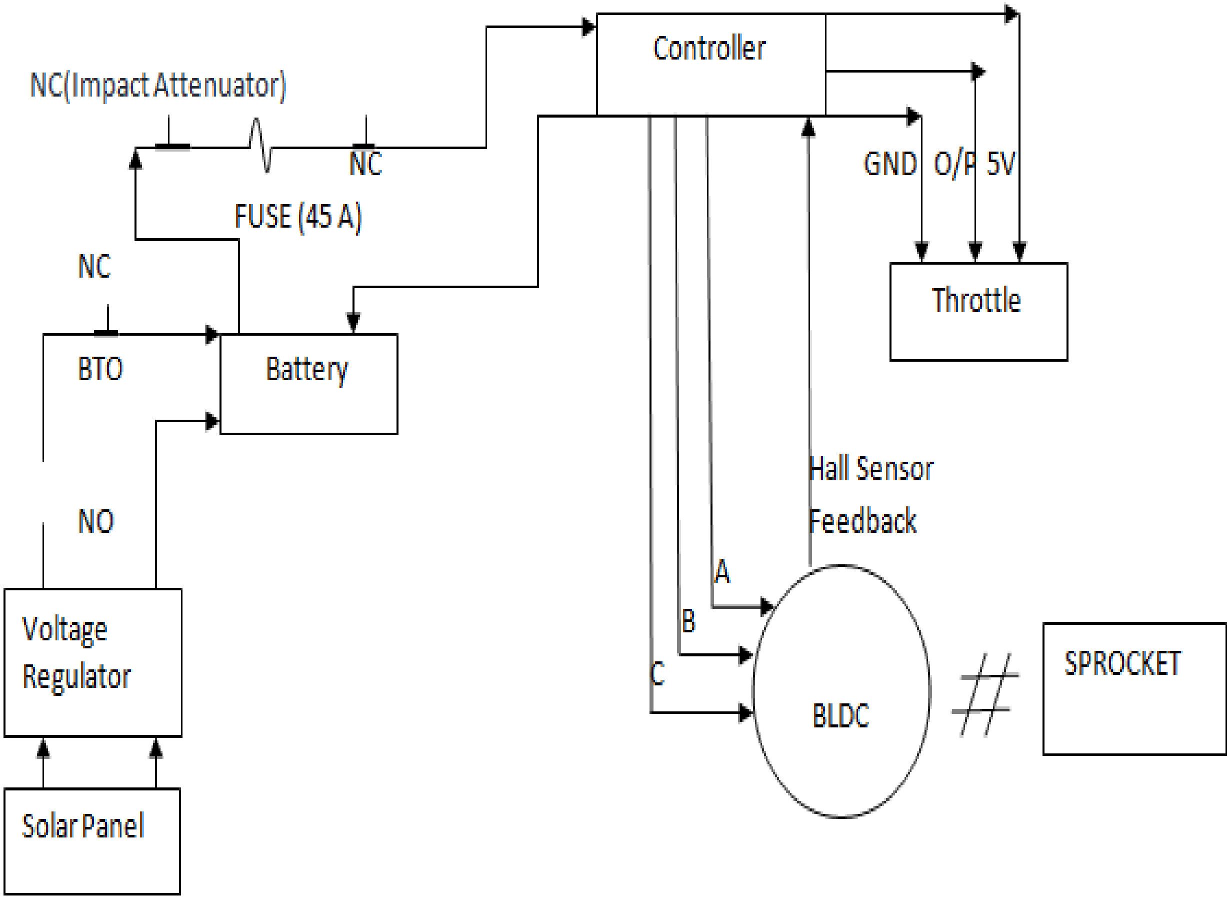
An impact attenuator reduces the force of impact on the chassis of the vehicle during head-on collisions. It is built by reusing waste such as tin cans filled with cotton balls arranged in the form of a cube. It is also provided with a kill switch to shut down all systems during a head-on collision.

[Figure – 2.4.1 Impact attenuator]

2.4.2 EMERGENCY SHUT DOWN SYSTEM

This is for the safety of the driver, at adverse conditions such as Fuel leakage, Break failure, Motor failure, etc. At these conditions the driver loses his control on the vehicle which may lead to major accidents. To avoid this driver is provided with a Kill switch on the dashboard and near the seat. On pressing this switch the whole drive system is disconnected from the supply and thus is shut down and the vehicle is brought to a complete halt.

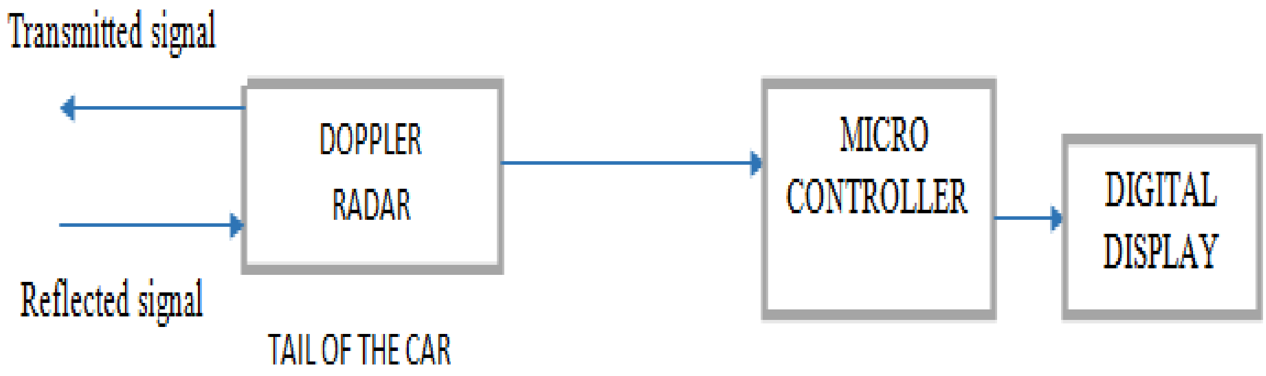
In case of brake failure a special switch called Break Travel over Switch (BTOS) is actuated as a brake pedal is displaced by a large amount than the usual action. During the actuation, the operation resembles as that of the Kill Switch. The Circuit diagram for the Kill Switch and BTOS is represented in Figure - 2.4.2



[Figure - 2.4.2 Main Circuit diagram with Emergency Shutdown system]

2.4.3 CALCULATION OF SPEED OF THE VEHICLE APPROACHING FROM BEHIND:

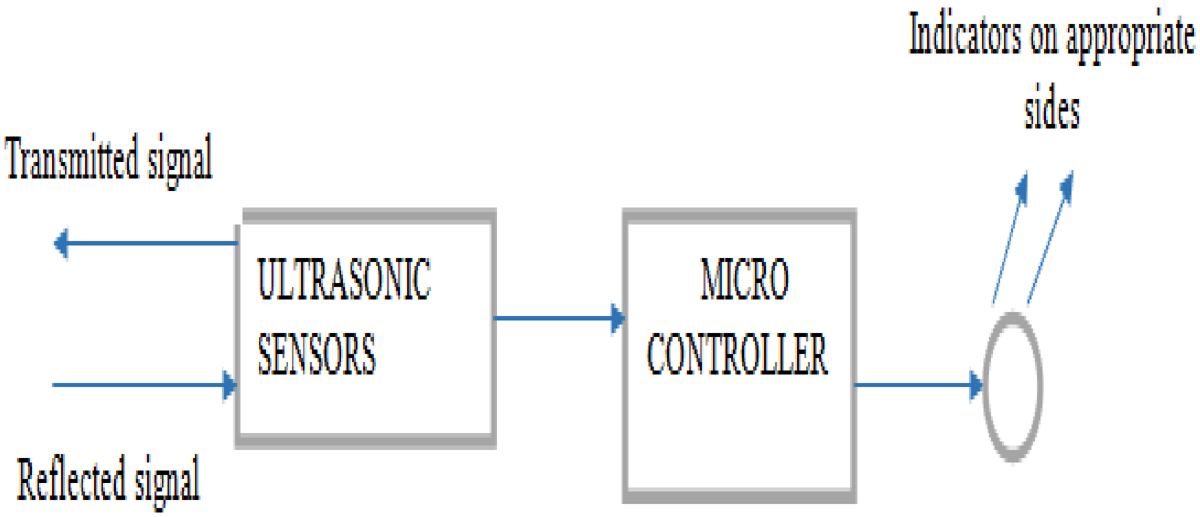
This system is for calculating the speed of the vehicle approaching from behind. This enables the driver to perform safe cuts and overtakes without causing accidents. This is achieved by placing a Doppler radar on the tail of the vehicle. This sensor has a transmitter and receiver on the same board. The time delay between the transmission and reception of the signal gives the speed of the approaching vehicle. The block diagram is represented in the Figure 2.4.3.



[Figure 2.4.3 Doppler radar block diagram]

2.4.4 CALCULATING THE PROXIMITY AROUND THE VEHICLES:

This system includes Ultrasonic sensors placed on both sides of the vehicle (left and right). These sensors detect the presence of vehicle at the turns and ensure the maintenance of safe distance from the vehicle adjacent to our vehicle. The block diagram representing the operation is in Figure - 2.4.4. A safe distance limit is given in the program which is feed to the controller which when exceeded gives a warning signal to both the driver via an indication in the dashboard and to the other vehicle via indicators and horns.

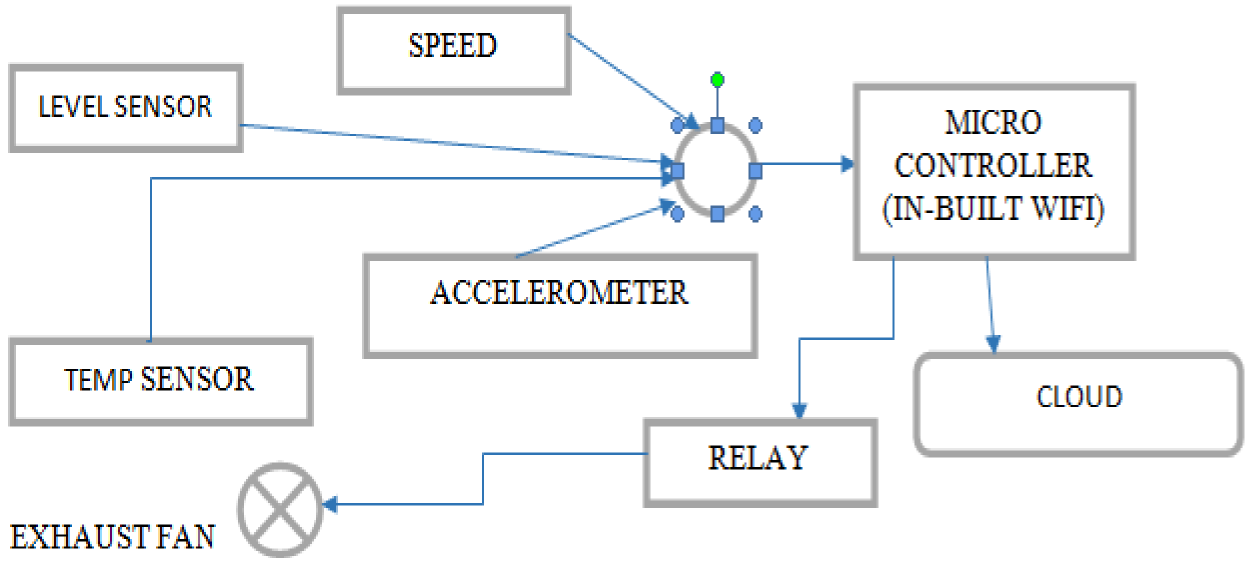


[Figure 2.4.4 Ultrasonic Sensor block diagram]

2.5 VEHICLE AND DRIVER MONITORING SYSTEM

2.5.1 VEHICLE MONITORING AND PERFORMANCE TRACKING

This system is for monitoring various parameters of the vehicle such as Fuel level, Battery chamber temperature, Speed, Unusual vibrations, etc. As per the Block diagram is represented in the Figure - 2.5.1, the operation is achieved by using various sensors for getting the appropriate readings and the values are sent to Spark photon which is a microcontroller with in-built wifi module. The controller then uploads the values to the cloud which can be accessed by an android application called Blynk.



[Figure - 2.5.1 - Block diagram of vehicle monitoring system]

2.5.2 DRIVER VITAL MONITORING

This system constantly monitors driver's vital parameters such as heart rate using a Finger-tip pulse sensor. The sensor sends data to the controller which then uploads it to BLYNK. In case of any emergency distress message is given to the monitor about the state of the driver.

CHAPTER – 3

PROGRAMMING SOFTWARE

3.1 ARDUINO IDE

Arduino is a computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL),permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

The Arduino project started in 2005 as a program for students at the Interaction Design Institute Ivrea in Ivrea, Italy,aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

The name *Arduino* comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014.

Arduino and Arduino-compatible boards use printed circuit expansion boards called *shields*, which plug into the normally supplied Arduino pin headers. Shields can provide motor controls for 3D printing and other applications, Global Positioning System (GPS), Ethernet, liquid crystal display (LCD), or bread boarding (prototyping). Several shields can also be made do it yourself (DIY).

3.1.1 SPEEDOMETER

The speed of the vehicle is measured by an IR module connected to an arduino board. The Proximity for IR sensing can be varied based on the requirement; still care is taken not to increase the range to maximum. The Figure 3.1 displays the speed of the vehicle.

CALCULATION:

- The module is used to sense the number of interrupts per second and then the interrupts multiplied with 60 gives the rpm of the rotating wheel.

  Rpm = Number of interrupts/second x 60

- From the given rpm the speed of the rotating wheel can be calculated.

  Speed (Km/hr) = Rpm x Circumference of the wheel x 0.06

CODING:

```
int irLED = 13;                // The Infrared LED is connected to digital pin 13
volatile byte breakNum;        // "volatile" is used with interrupts
unsigned int rpm;
volatile float s;
#include <LiquidCrystal.h>
LiquidCrystal lcd(8,9,4,5,6,7);
```

```
// Counts the number of interrupts
void break_count()
 {
     breakNum++;
 }
void setup()
 {
pinMode(A1,OUTPUT);
pinMode(A2,OUTPUT);
  pinMode(2,INPUT);
  digitalWrite(A2,HIGH);
  digitalWrite(A1,LOW);

   // Was first using the serial port to print results.
   // Serial.begin(9600);
   lcd.begin(16,2);

   //The Infrared phototransistor is connected to pin 2 which is interrupt 0.
   //Triggers on change from HIGH to LOW
   attachInterrupt(0, break_count, FALLING);

   // Turn on IR LED
   breakNum = 0;
   rpm = 0;
```

```
  s=0;
 }
 void loop()
 {

  // Update RPM every second
  delay(1000);

  // Don't process interrupts during calculations
  detachInterrupt(0);

 // Depending on what you are testing you might need to change the formula for the rpm
 // For instance testing a prop would give 2 breaks per rotation so (60 * rpmcount) / 2
  rpm = (60 * breakNum);
  s = 2*3.14*0.19*rpm*0.06;
  breakNum = 0;

  //Print out result to lcd
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("RPM=");
  lcd.print(rpm);
  lcd.setCursor(0,1);
```

```
lcd.print("SPEED=");
lcd.print(s);
attachInterrupt(0, break_count, FALLING);
}
```

OUTPUT:

[Figure - 3.1.1 Speedometer output]

3.2 PARTICLE IDE

The Dev Desktop IDE provides your team with advanced features that make managing large or complicated firmware projects fast, easy, and efficient. Use your favorite OS, existing versioning tools, Particle firmware libraries, and the speed of over-the-wire debugging to do professional development. It’s easy to download and install for Windows, MacOS, and Linux.

The Web and Desktop IDEs share the same icons and Cloud-connected features, so it’s easy to transition between them. The hundreds of libraries and firmware examples you’re used to online in Build are compatible with the Local IDE, and you can also manage your Particle devices, compile firmware, and flash over the air firmware updates. The Desktop IDE gives you the confidence of storing all your files locally and the convenience of the Particle Cloud. The output of simulation can be seen in Figure - 3.2.

CODING

```
// This #include statement was automatically added by the Particle IDE.
#include <HC_SR04.h>
// This #include statement was automatically added by the Particle IDE.
#include <blynk.h>
// This #include statement was automatically added by the Particle IDE.
#include <Adafruit_MLX90614.h>
// This #include statement was automatically added by the Particle IDE.
#include <SparkIntervalTimer.h>
#define BLYNK_PRINT Serial
#include "application.h"
WidgetTerminal terminal(V2);
void interruptSetup(void);
void serialoutput();
void serialOutputWhenBeatHappens();
void sendDataToSerial(char symbol, int data );
void ledFadeToBeat();
void arduinoSerialMonitorVisual(char symbol, int data );
char auth[] = "04a0b5a48b484ef0a2f6ad8f6ffdbc7d";
int randNumber;
extern int pulsePin;
extern int blinkPin;
extern volatile int BPM;;
extern volatile int Signal;;
```

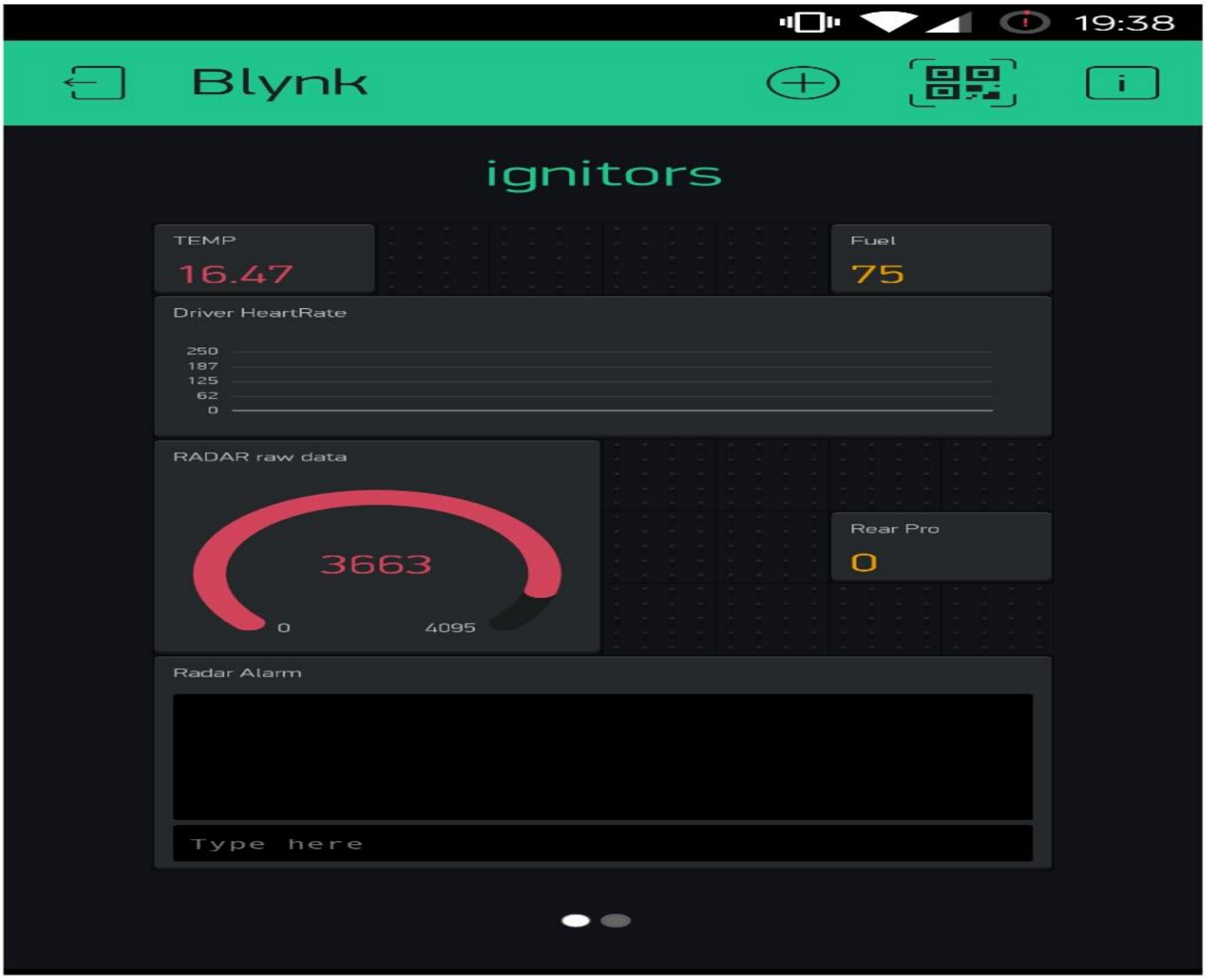
```
extern volatile int IBI;

extern volatile boolean Pulse;

extern volatile boolean QS;

Adafruit_MLX90614 mlx = Adafruit_MLX90614();

static boolean serialVisual = false;

int last,change;

extern int fadePin;

extern int fadeRate;

int sense;

int analogvalue;

void setup()

{

        pinMode(A3,INPUT);          // pin that will blink to your heartbeat!

        interruptSetup();                // sets up to read Pulse Sensor signal every
2mS

   Blynk.begin(auth);

   mlx.begin();

}

void loop()

{

Particle.process();

 analogvalue = analogRead(A3);

 ping(D4, D5, 20, true);

  Blynk.run();

  double temp=mlx.readObjectTempC();
```

```
  Blynk.virtualWrite(V1, temp);
  Blynk.virtualWrite(V0,BPM);
   Blynk.virtualWrite(V5,"75");
}
void ping(pin_t trig_pin, pin_t echo_pin, uint32_t wait, bool info)
{
    uint32_t duration, inches, cm;
    static bool init = false;
    if (!init) {
        pinMode(trig_pin, OUTPUT);
        digitalWriteFast(trig_pin, LOW);
        pinMode(echo_pin, INPUT);
        delay(50);
        init = true;
    }
    /* Trigger the sensor by sending a HIGH pulse of 10 or more microseconds */
    digitalWriteFast(trig_pin, HIGH);
    delayMicroseconds(10);
    digitalWriteFast(trig_pin, LOW);
    duration = pulseIn(echo_pin, HIGH);
    /* Convert the time into a distance */
    // Sound travels at 1130 ft/s (73.746 us/inch)
    // or 340 m/s (29 us/cm), out and back so divide by 2
    // Ref: http://www.parallax.com/dl/docs/prod/acc/28015-PING-v1.3.pdf
```

```
  inches = duration / 74 / 2;
  cm = duration / 29 / 2;
 int range = map(cm, 0, 200, 0, 3);
 switch (range) {
  case 0:    // your hand is on the sensor
  terminal.println("close");
  randNumber = random(3500, 4095);
    break;
  case 1:    // your hand is close to the sensor
  terminal.println("Closing in");
  randNumber = random(3000, 3500);
  break;
  case 2:    // your hand is a few inches from the sensor
  terminal.println("Fallen back");
  randNumber = random(2500, 3000);
  break;
  case 3:    // your hand is nowhere near the sensor
terminal.println("All Clear");
  randNumber = random(1000, 2500);
  break;
}
  Blynk.virtualWrite(V4,randNumber);
//  Serial.println(cm);
//  Spark.publish("distance", String(cm) + " cm");
```

```
Blynk.virtualWrite(V3,cm);
//   delay(100); // slow down the output
}
```

OUTPUT



[Figure - 3.2 Simulation output]

CHAPTER – 4

HARDWARE COMPONENTS

The various hardware components used in the project are described below

4.1 IR SENSOR

An Infrared (IR) sensor is used to detect obstacles in front of the robot or to differentiate between colours depending on the configuration of the sensor. An IR sensor consists of an emitter, detector and associated circuitry. The circuit required to make an IR sensor consists of two parts; the emitter circuit and the receiver circuit as represented in Figure 4.1.

The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, its resistance and correspondingly, its output voltage, change in proportion to the magnitude of the IR light received. This is the underlying principle of working of the IR sensor.

IR sensors are also used to distinguish between black and white surfaces. White surfaces reflect all types of light while black surfaces absorb them. Therefore, depending on the amount of light reflected back to the IR receiver, the IR sensor can also be used to distinguish between black and white surfaces.

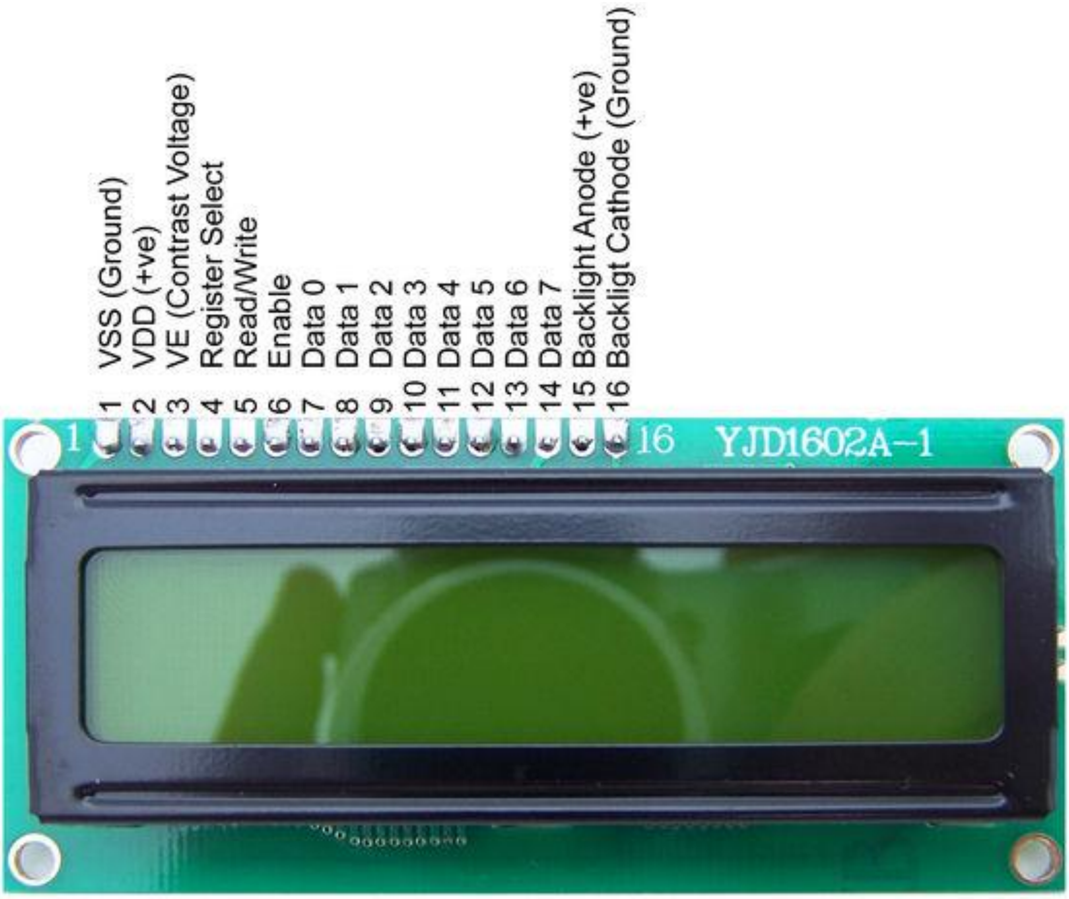
[Figure - 4.1 IR Module]

4.2 LIQUID CRYSTAL DISPLAY

A **liquid-crystal display** (**LCD**) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

The LCD display is represented in Figure 4.2. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and indoor and outdoor signage. Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones. LCD screens are also used on consumer electronics products such as DVD players, video game devices and clocks. LCD screens have replaced heavy, bulky cathode ray tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD screens available in sizes ranging from tiny digital watches to huge, big-screen television sets.

Since LCD screens do not use phosphors, they do not suffer image burn-in when a static image is displayed on a screen for a long time (e.g., the table frame for an aircraft schedule on an indoor sign). LCDs are, however, susceptible to image persistence. The LCD screen is more energy-efficient and can be disposed of more safely than a CRT can. Its low electrical power consumption enables it to be used in battery-powered electronic equipment more efficiently than CRTs can be. By 2008, annual sales of televisions with LCD screens exceeded sales of CRT units worldwide, and the CRT became obsolete for most purposes.



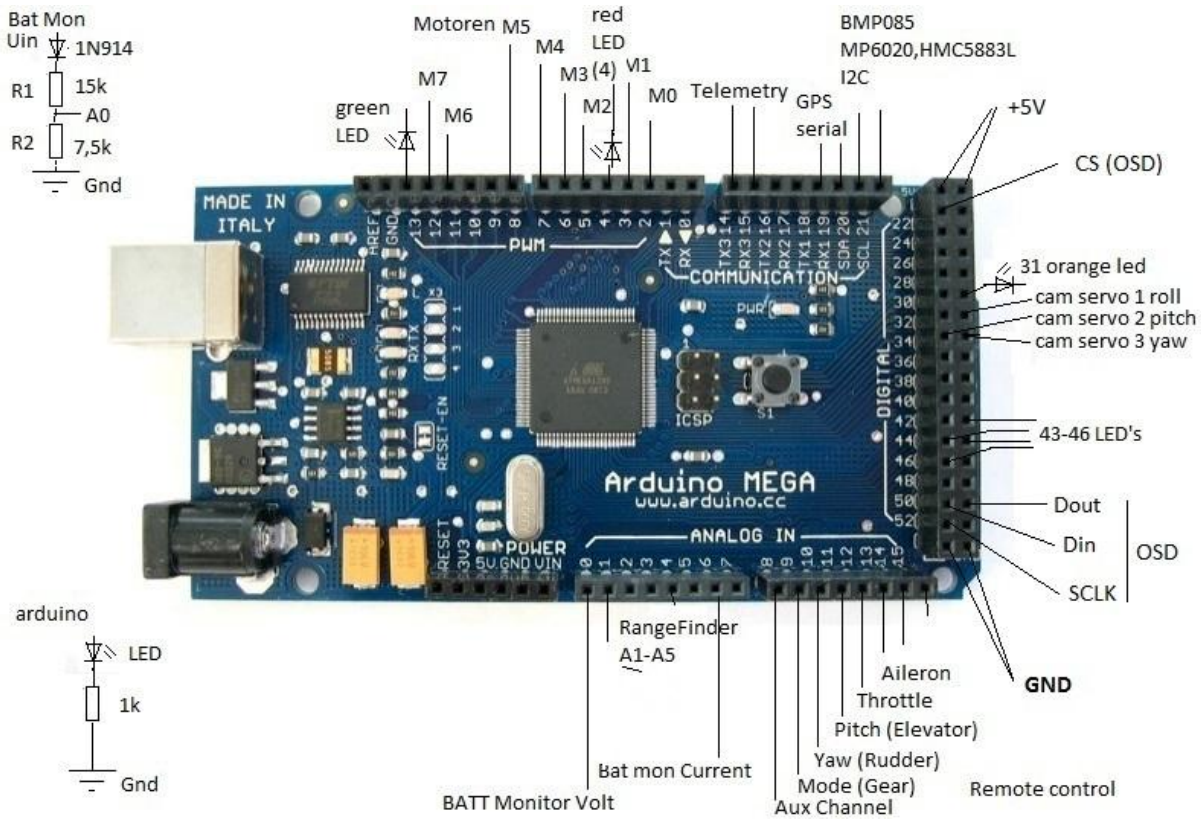
[Figure - 4.2 LCD Module]

4.3 ARDUINO MEGA

The Mega 2560 is a microcontroller board based on the ATmega2560 which is represented in Figure 4.3. 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. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

The Mega 2560 is an update to the Arduino Mega, which it replaces. The Mega 2560 board can be programmed with the Arduino Software (IDE). For details, see the reference and tutorials. The ATmega2560 on the Mega 2560 comes pre-programmed with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar.



[Figure - 4.3 Arduino MEGA Microcontroller]

4.4 LEAD ACID BATTERY

The lead-acid battery was invented in 1859 by French physicist Gaston Planté and is the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make it attractive for use in motor vehicles to provide the high current required by automobile starter motors.

As they are inexpensive compared to newer technologies, lead-acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead-acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems. For these roles, modified versions of the standard cell may be used to improve storage times and reduce maintenance requirements. Gel-cells and absorbed glass-mat batteries are common in these roles, collectively known as VRLA (valve-regulated lead-acid) batteries.

Lead–acid battery, as represented in Figure 4.4 sales account for 40–45% of the value from batteries sold worldwide (1999, not including China and Russia), a manufacturing market value of about $15 billion.

In the fully charged state, the negative plate consists of lead, and the positive plate lead dioxide, with the electrolyte of concentrated sulfuric acid. The design of some types of lead-acid battery allows the electrolyte level to be inspected and topped up with any water that has been lost. Due to the freezing-point depression of the electrolyte, as the battery discharges and the concentration of sulfuric acid decreases, the electrolyte is more likely to freeze during winter weather when discharged.

[Figure - 4.4 Lead-acid battery]

4.5 THROTTLE USING HALL EFFECT SENSOR

A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors as in Figure 4.5 are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced.

Frequently, a Hall sensor is combined with threshold detection so that it acts as and is called a switch. Commonly seen in industrial applications such as the pictured pneumatic cylinder, they are also used in consumer equipment; for example some computer printers use them to detect missing paper and open covers. They can also be used in computer keyboards applications that require ultra-high reliability.

Hall sensors are commonly used to time the speed of wheels and shafts, such as for internal combustion engine ignition timing, tachometers and anti-lock braking systems. They are used in brushless DC electric motors to detect the position of the permanent magnet. Hall effect sensors are linear transducers. As a result, such sensors require a linear circuit for processing of the sensor's output signal. Such a linear circuit:

- provides a constant driving current to the sensors
- amplifies the output signal

In some cases the linear circuit may cancel the offset voltage of Hall Effect sensors.

[Figure - 4.5 Hall effect sensor and Pedal in which hall sensor is incorporated]

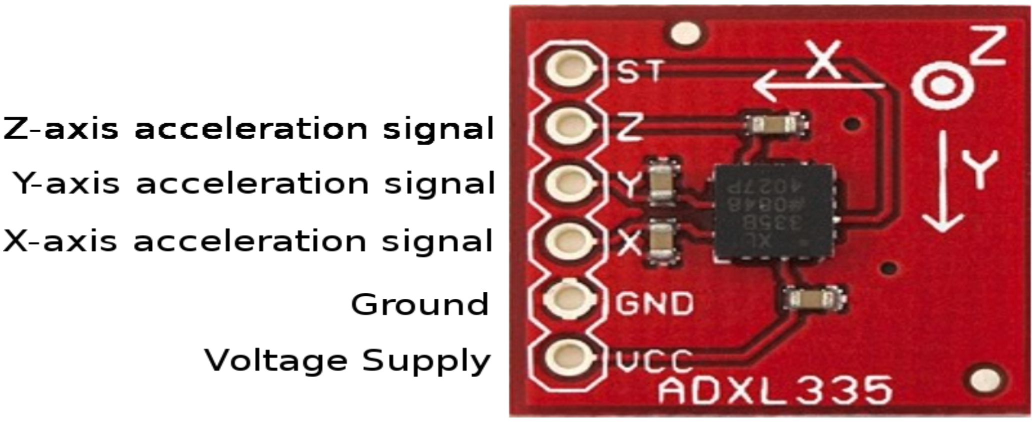
4.6 ACCELEROMETER

An accelerometer is a device that measures proper acceleration; proper acceleration is not the same as coordinate acceleration (rate of change of velocity). For example, an accelerometer at rest on the surface of the Earth will measure acceleration due to Earth's gravity, straight upwards (by definition) of g ≈ 9.81 m/s^2. By contrast, accelerometers in free fall (falling toward the centre of the Earth at a rate of about 9.81 m/s^2) will measure zero.

Accelerometers, as in Figure 4.6 have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles. Accelerometers are used to detect and monitor vibration in rotating machinery. Accelerometers are used in tablet computers and digital cameras so that images on screens are always displayed upright. Accelerometers are used in drones for flight stabilisation. Coordinated accelerometers can be used to measure differences in proper acceleration, particularly gravity, over their separation in space; i.e., gradient of the gravitational field. This gravity gradiometry is useful because absolute gravity is a weak effect and depends on local density of the Earth which is quite variable.

Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration, as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration, vibration, shock, and falling in a resistive medium. Micro machined accelerometers are increasingly present in portable electronic devices and video game controllers, to detect the position of the device or provide for game input.

Accelerometers can be used to measure vehicle acceleration. Accelerometers can be used to measure vibration on cars, machines, buildings, process control systems and safety installations. They can also be used to measure seismic activity, inclination, machine vibration, dynamic distance and speed with or without the influence of gravity. Applications for accelerometers that measure gravity, wherein an accelerometer is specifically configured for use in gravimetry, are called gravimeters.



[Figure - 4.6 Accelerometer]

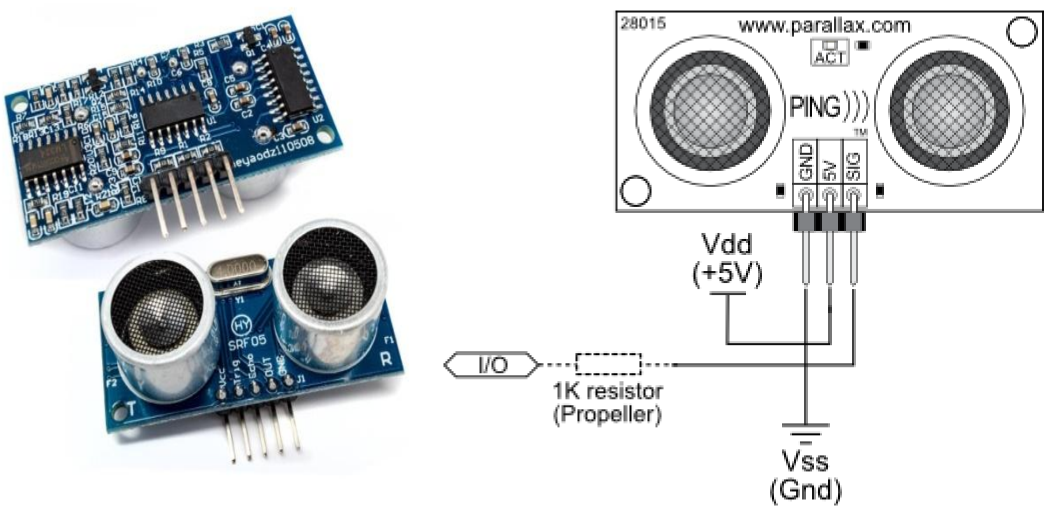
4.7 ULTRASONIC TRANSDUCER

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

Since it is known that sound travels through air at about 344 m/s (1129 ft/s), you can take the time for the sound wave to return and multiply it by 344 meters (or 1129 feet) to find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes the 'trip' from the sonar sensor to the object AND the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half.

The accuracy of Ultrasonic sensor as represented in Figure 4.7 can be affected by the temperature and humidity of the air it is being used in. However, for these tutorials and almost any project you will be using these sensors in, this change in accuracy will be negligible.

It is important to understand that some objects might not be detected by ultrasonic sensors. This is because some objects are shaped or positioned in such a way that the sound wave bounces off the object, but are deflected away from the Ultrasonic sensor. It is also possible for the object to be too small to reflect enough of the sound wave back to the sensor to be detected. Other objects can absorb the sound wave all together (cloth, carpeting, etc), which means that there is no way for the sensor to detect them accurately. These are important factors to consider when designing and programming a robot using an ultrasonic sensor.



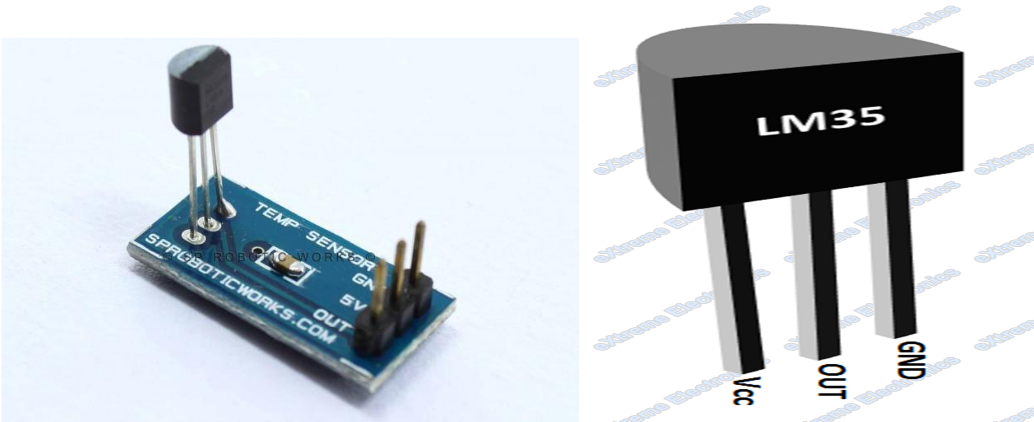
[Figure - 4.7 Ultrasonic sensor and its pin out diagram]

4.8 TEMPERATURE SENSOR

For an objective and reproducible measurement, we need to quantify the temperature values, and to do that, a suitable measurement device is required like a temperature sensor represented in Figure 4.8.

Simply speaking, temperature is the degree of hotness of the body which is a measure of the heat content in the body. The problem to quantify the heat content of the body on a scale did not arise until the invention of the Steam Engine. The curiosity of scientists to understand the behaviour of water at different levels of heat contents gave rise to a formal and better laid out study. Years of rigorous scientific study led to many theories ranging from the simple 'Caloric' concept, which treated heat as a material substance which is exchanged among materials, to Carnot's description of heat as a form of energy (which laid the foundation of the first law of thermodynamics). However, none of them satisfactorily explained the concept of temperature. It was Maxwell's theory which offered good reasoning into it. He defined temperature of a body as is its thermal property which provides information about the energy content of the system. It is the measure of the average kinetic energy (energy by virtue of motion) of the molecules of the substance and signifies a heat potential due to which heat flows from higher temperature to lower temperature.

The word ‘temperature’ itself is said to be derived of the Latin word ‘tempera’ meaning ‘moderate or soften’. Moving along Maxwell’s line of thought, the velocity of molecules should be the basis of selecting the value of temperature, with absolute heatless being a state where the molecules are totally static. But, this measurement is not possible practically, and hence, other manifestations of the effect of heat are utilized to measure temperature, for example, the geometric expansion of materials.



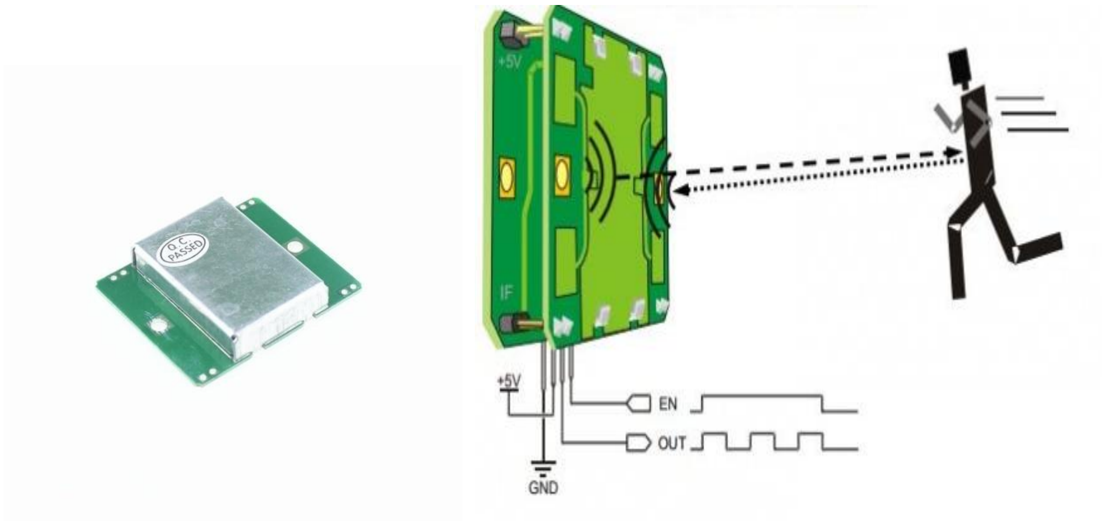
[Figure - 4.8 Temperature sensor]

4.9 DOPPLER RADAR

A Doppler radar as represented in Figure 4.9 is a specialized radar that uses the Doppler Effect to produce velocity data about objects at a distance. It does this by bouncing a microwave signal off a desired target and analyzing how the object's motion has altered the frequency of the returned signal. This variation gives direct and highly accurate measurements of radial component of a target's velocity relative to the radar. Doppler radars are used in aviation, sounding satellites, meteorology, radar guns, radiology and healthcare (fall detection and risk assessment, nursing or clinic purpose), and bistatic radar (surface-to-air missile). Partly because of its common use by television meteorologists in on-air weather reporting, the specific term "*Doppler Radar*" has erroneously become popularly synonymous with the type of radar used in meteorology. Most modern weather radars use the pulse-doppler technique to examine the motion of precipitation, but it is only a part of the processing of their data. So, while these radars use a highly specialized form of *doppler radar*, the term is much broader in its meaning and its applications.

Doppler allows the use of narrow band receiver filters that reduce or eliminate signals from slow moving and stationary objects. This effectively eliminates false signals produced by trees, clouds, insects, birds, wind, and other environmental influences. Cheap hand held Doppler radar may produce erroneous measurements.

CW doppler radar only provides a velocity output as the received signal from the target is compared in frequency with the original signal. Early doppler radars included CW, but these quickly led to the development of frequency modulated continuous wave (FMCW) radar, which sweeps the transmitter frequency to encode and determine range.



[Figure - 4.9 Doppler radar]

4.10 BLDC MOTOR

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors)as represented in Figure 4.10 are synchronous motors powered by DC electricity via an inverter/switching power supply which produces an AC/bi-directional electric current to drive each phase of the motor via a closed loop controller. The controller times commutation (hence rpm) and creates current waveforms (hence torque). In this context alternating current does not imply but does include a sinusoidal waveform, with minimal restriction on waveform; it must be periodic, and its frequency will determine motor rpm, and the waveform does affect how smooth the generated torque is as well as the motors efficiency at transforming electrical to mechanical energy. In a well design PMSM the air gap magnetic flux is spatial sinusoidal and the phase commutation currents are sinusoidal, ninety degrees out of phase.

The motor structural elements of a brushless motor system is typically permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor.

Brushless motors may be implemented as stepper motors as well; however, the term "stepper motor" tends to be used for motors with a radically different design and controlled with an open loop (hence the controller cannot detect when the stepper does not stop due to too high shaft load; there is not shaft position sensor). They are frequently stopped with the rotor in a defined angular position while still producing torque. A well design power supply/controller/PMSM can also be held at zero rpm and finite torque.

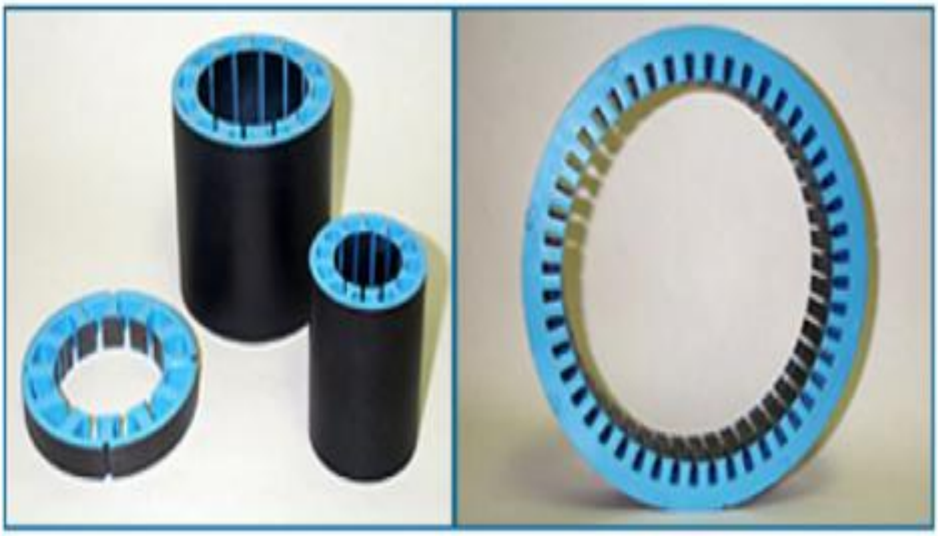
[Figure - 4.10 BLDC Motor]

4.10.1 CONSTRUCTION:

BLDC motors have many similarities to AC induction motors and brushed DC motors in terms of construction and working principles respectively. Like all other motors, BLDC motors also have a rotor and a stator.

4.10.1.1 STATOR

Similar to an Induction AC motor, the BLDC motor stator is made out of laminated steel stacked up to carry the windings. Windings in a stator can be arranged in two patterns; i.e. a star pattern (Y) or delta pattern (Δ). The major difference between the two patterns is that the Y pattern gives high torque at low RPM and the Δ pattern gives low torque at low RPM. This is because in the Δ configuration, half of the voltage is applied across the winding that is not driven, thus increasing losses and, in turn, efficiency and torque.



[Figure 4.10.1.1 - Stator]

Steel laminations in the stator can be slotted or slot less as shown in Figure 4.10.1.1. A slot less core has lower inductance, thus it can run at very high speeds. Because of the absence of teeth in the lamination stack, requirements for the cogging torque also go down, thus making them an ideal fit for low speeds too (when permanent magnets on rotor and tooth on the stator align with each other then, because of the interaction between the two, an undesirable cogging torque develops and causes ripples in speed). The main disadvantage of a slot less core is higher cost because it requires more winding to compensate for the larger air gap.

Proper selection of the laminated steel and windings for the construction of stator are crucial to motor performance. An improper selection may lead to multiple problems during production, resulting in market delays and increased design costs.

4.10.1.2 ROTOR

The rotor as represented in Figure 4.10.1.2 of a typical BLDC motor is made out of permanent magnets. Depending upon the application requirements, the number of poles in the rotor may vary. Increasing the number of poles does give better torque but at the cost of reducing the maximum possible speed.

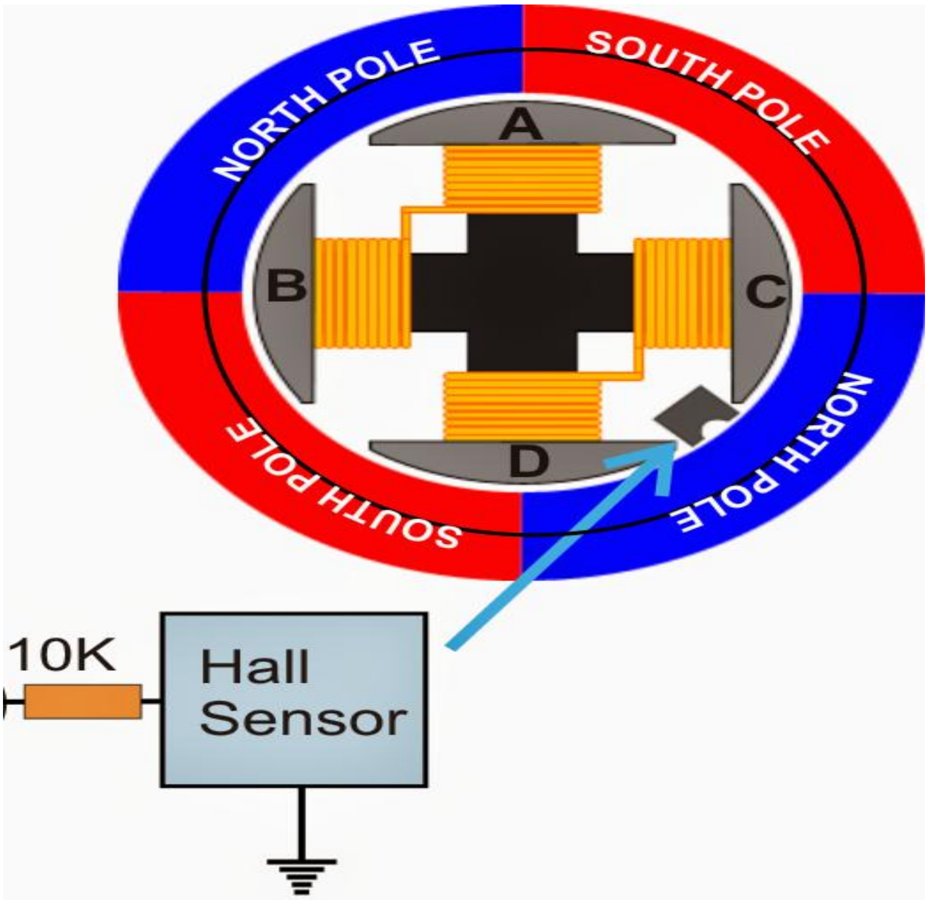
[Figure - 4.10.1.2 4 pole rotor]

Another rotor parameter that impacts the maximum torque is the material used for the construction of permanent magnet; the higher the flux density of the material, the higher the torque.

4.10.2 WORKING PRINCIPLES AND OPERATION

The underlying principles for the working of a BLDC motor are the same as for a brushed DC motor; i.e., internal shaft position feedback. In case of a brushed DC motor, feedback is implemented using a mechanical commutator and brushes. With a in BLDC motor as represented in 4.10.2, it is achieved using multiple feedback sensors. The most commonly used sensors are hall sensors and optical encoders.

In a commutation system – one that is based on the position of the motor identified using feedback sensors – two of the three electrical windings are energized at a time.

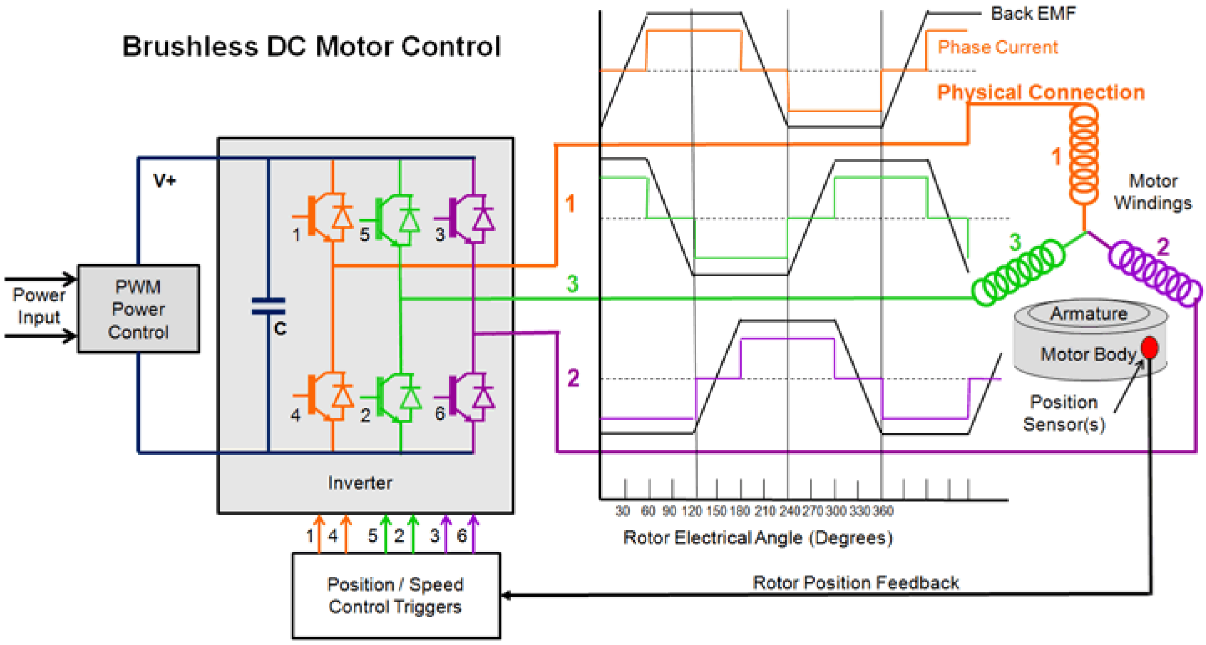


[Figure 4.10.2 Overview of Motor]

4.11 CONTROLLER

While BLDC motors are mechanically relatively simple, they do require sophisticated control electronics and regulated power supplies. The designer is faced with the challenge of dealing with a three-phase high-power system that demands precise control to run efficiently.

Figure 3 shows a typical arrangement for driving a BLDC motor with Hall-effect sensors. (The control of a sensor less BLDC motor using back EMF measurement will be covered in a future article.) This system shows the three coils of the motor arranged in a "Y" formation, a microcontroller, an insulated-gate bipolar transistor (IGBT) driver, and a three-phase inverter comprising six IGBTs (metal oxide semiconductor field effect transistors (MOSFETs) can also be used for the high-power switching). The output from the microcontroller (mirrored by the IGBT driver) comprises pulse width modulated (PWM) signals that determine the average voltage and average current to the coils (and hence motor speed and torque). The motor uses three Hall-effect sensors (A, B, and C) to indicate rotor position. The rotor itself uses two pairs of permanent magnets to generate the magnetic flux.



[Figure - 4.11 Controller Circuit]

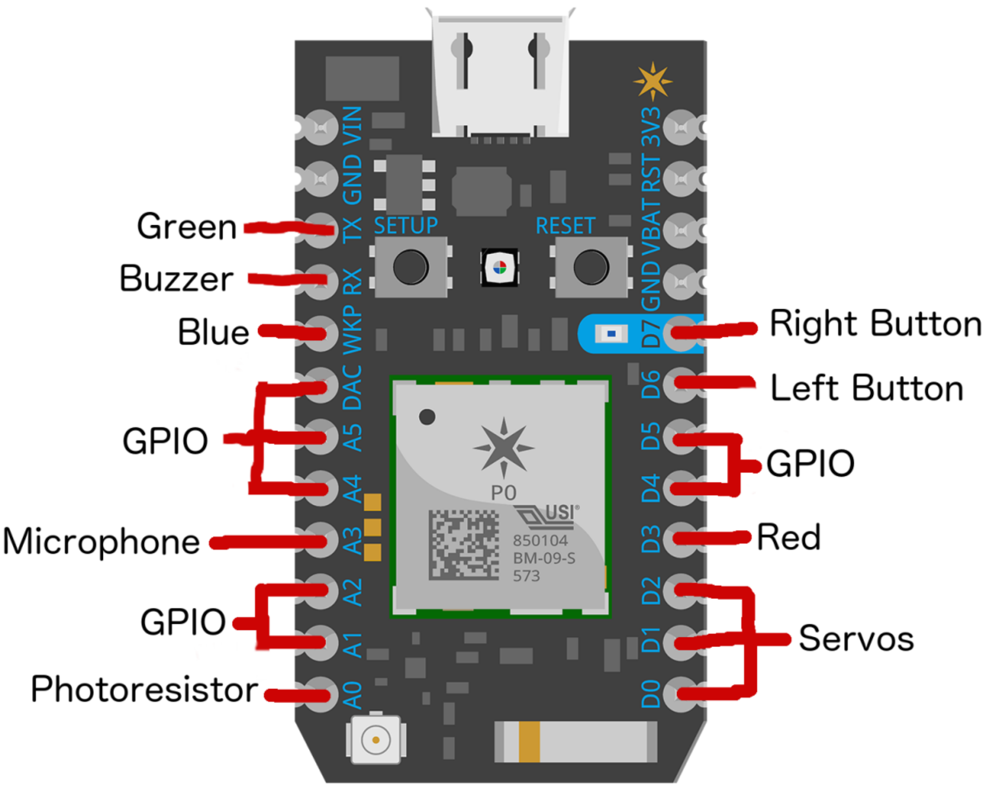
4.12 SPARK PHOTON

Particle's IoT (Internet of Things) hardware development kit, the Photon as represented in Figure 4.12, provides everything you need to build a connected project. Particle has combined a powerful 120 MHz ARM Cortex M3 micro-controller with a Broadcom Wi-Fi chip in a tiny thumbnail-sized module called the PØ (P-Zero). The Photon Kit includes a Photon with headers, a shiny white mini-breadboard, a USB-micro cable, and a couple of extra surprises to help you start building right away.

Prototyping is easy as the Photon plugs directly into standard breadboards and perfboards, and may also be mounted with 0.1" pitch female headers on a PCB. The Photon is not only powerful, but easy to use. The small form factor is ideal for IoT projects with cloud-connectivity. To get you started quickly, Particle has added a rock solid 3.3VDC SMPS power supply, RF and user interface components to the PØ all on a small single-sided PCB.

Your Photon comes with access to the Particle Cloud, a free cloud service. The Particle Cloud has some great features for building connected projects, including over-the-air firmware updates, an easy-to-use REST API, and firmware development supported by web and local IDEs.

This particular edition of the Photon comes in a kit with a few other parts. When combined together, the Photon can implement these parts to create simple experiments and help kindle ideas for different projects by adding parts of your own.



[Figure – 4.12 Spark Photon]

4.13 KILL SWITCH

A kill switch as represented in Figure 4.13, also known as an emergency stop or e-stop, is a safety mechanism used to shut off a device or machinery in an emergency situation in which it cannot be shut down in the usual manner. Unlike a normal shut-down switch/procedure, which shuts down all systems in an orderly fashion and turns the machine off without damaging it, a kill switch is designed and configured to completely and as quickly as possible abort the operation (even if this damages equipment) and be operable in a manner that is quick and simple (so that even a panicking operator with impaired executive function or a bystander can activate it). Kill switches are usually designed so as to be obvious even to an untrained operator or a bystander.

Many kill switches feature a removable barrier or other protection against accidental activation (*e.g.*, a plastic cover that must be lifted or glass that must be broken). Such a removable barrier is commonly called a Mollyguard. Kill switches are featured especially often as part of mechanisms whose normal operation or foreseeable misuse may cause injury or death; designers who include such switches consider damage to or destruction of the mechanism to be an acceptable cost of preventing that injury or death.

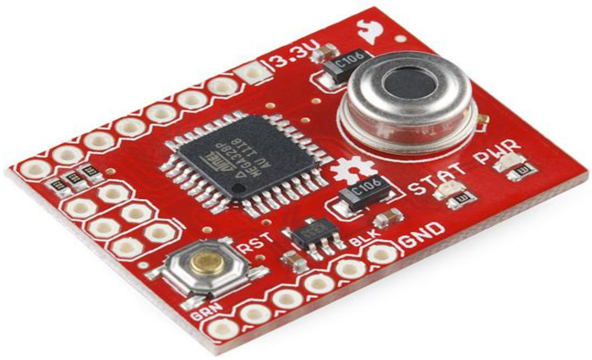
[Figure – 4.13 Kill Switch]

4.14 PULSE SENSOR

Heart rate data can be really useful whether you're designing an exercise routine, studying your activity or anxiety levels or just want your shirt to blink with your heart beat. The problem is that heart rate can be difficult to measure. Luckily, the Pulse Sensor as in Figure 4.14 Amped can solve that problem!

The Pulse Sensor Amped is a plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects.It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications.

Simply clip the Pulse Sensor to your earlobe or finger tip and plug it into your 3 *or* 5 Volt Arduino and you're ready to read heart rate! The 24" cable on the Pulse Sensor is terminated with standard male headers so there's no soldering required. Of course Arduino example code is available as well as a Processing sketch for visualizing heart rate data.



[Figure -4.14 Pulse Sensor]

4.15 SOLAR PANEL

Solar panel as represented in Figure 4.15 refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating.

A photovoltaic (PV) module is a packaged; connect assembly of typically 6×10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few commercially available solar modules that exceed 22% efficiency and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system.

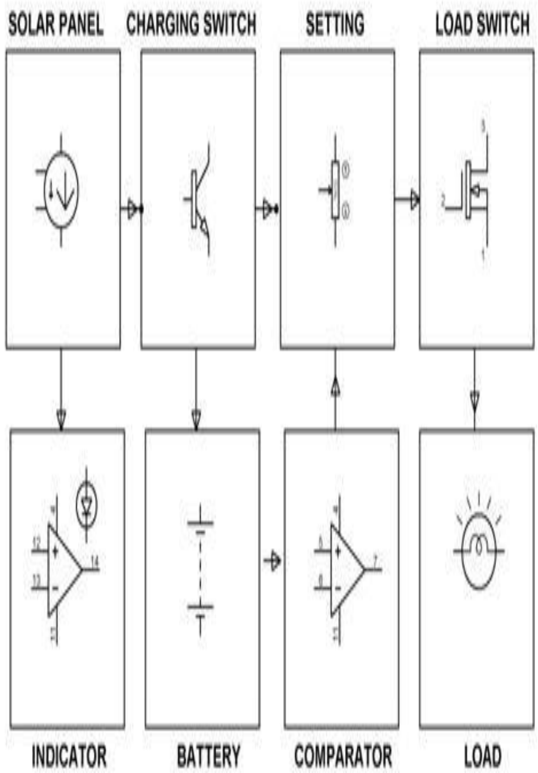
Modules electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive [transition metals]. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.

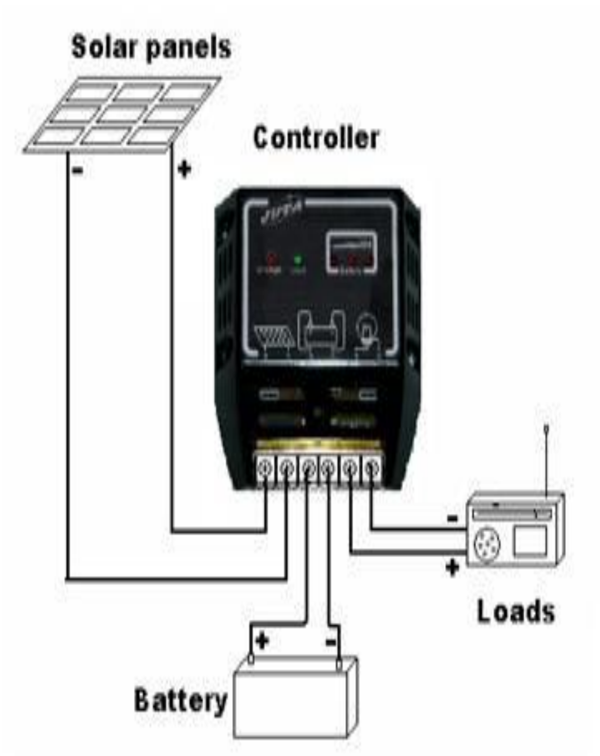
Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

[Figure 4.15 Solar panel]

4.16 CHARGE CONTROLLER

The purpose of a charge controller or solar regulator is to safely charge your batteries while balancing other factors such as efficiency, speed and cost. Without a charge controller it becomes very easy to damage your batteries by exposing them to overcharging and overvoltage conditions.





[Figure 4.16.1 block diagram of charge controller] [Figure 4.16.2 connection diagram]

Charge controllers are sold to consumers as separate devices, often in conjunction with solar or wind power generators, for uses such as RV, boat, and off-the-grid home battery storage systems. In solar applications, charge controllers may also be called solar regulators. Some charge controllers / solar regulators have additional features, such as a low voltage disconnect (LVD), a separate circuit which powers down the load when the batteries become overly discharged (some battery chemistries are such that over-discharge can ruin the battery).

A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full.

Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Pulse width modulation (PWM) and maximum power point tracker (MPPT) technologies are more electronically sophisticated, adjusting charging rates depending on the battery's level, to allow charging closer to its maximum capacity.

A charge controller with MPPT capability frees the system designer from closely matching available PV voltage to battery voltage. Considerable efficiency gains can be achieved, particularly when the PV array is located at some distance from the battery. By way of example, a 150 volt PV array connected to an MPPT charge controller can be used to charge a 24 or 48 volt battery. Higher array voltage means lower array current, so the savings in wiring costs can more than pay for the controller.

Charge controllers may also monitor battery temperature to prevent overheating. Some charge controller systems also display data, transmit data to remote displays, and data logging to track electric flow over time.

4.16.1 INTEGRATED CHARGE CONTROLLER CIRCUITRY

Circuitry that functions as a charge regulator controller may consist of several electrical components, or may be encapsulated in a single microchip, an integrated circuit (IC) usually called a charge controller IC or charge control IC.

Charge controller circuits are used for rechargeable electronic devices such as cell phones, laptop computers, portable audio players, and uninterruptible power supplies, as well as for larger battery systems found in electric vehicles and orbiting space satellites

4.16.2 PWM CHARGE CONTROLLER

This is the traditional type charge controller, for instance anthrax, Blue Sky and so on. PWM stands for Pulse Width Modulation and indicates that the charge controller emits pulses of electricity to the battery in varying lengths. At the end of each pulse the charge controller briefly switches off to measure the battery capacity and adjust its output values to match. A PWM charge controller essentially acts as an intelligent switch between your batteries and the solar panels that controls the voltage and current flowing into the batteries.

Charging a battery with a solar system is a unique and difficult challenge. In the “old days,” simple on-off regulators were used to limit battery out gassing when a solar panel produced excess energy. However, as solar systems matured it became clear how much these simple devices interfered with the charging process.

The history for on-off regulators has been early battery failures, increasing load disconnects, and growing user dissatisfaction. PWM has recently surfaced as the first significant advance in solar battery charging. PWM solar chargers use technology similar to other modern high quality battery chargers.

When a battery voltage reaches the regulation set point, the PWM algorithm slowly reduces the charging current to avoid heating and gassing of the battery, yet the charging continues to return the maximum amount of energy to the battery in the shortest time.

The result is a higher charging efficiency, rapid recharging, and a healthy battery at full capacity. In addition, this new method of solar battery charging promises some very interesting and unique benefits from the PWM pulsing. These include:

1. Ability to recover lost battery capacity and disulphate a battery.

2. Dramatically increase the charge acceptance of the battery.

3. Maintain high average battery capacities (90% to 95%) compared to on-off regulated state-ofcharge levels that are typically 55% to 60%.

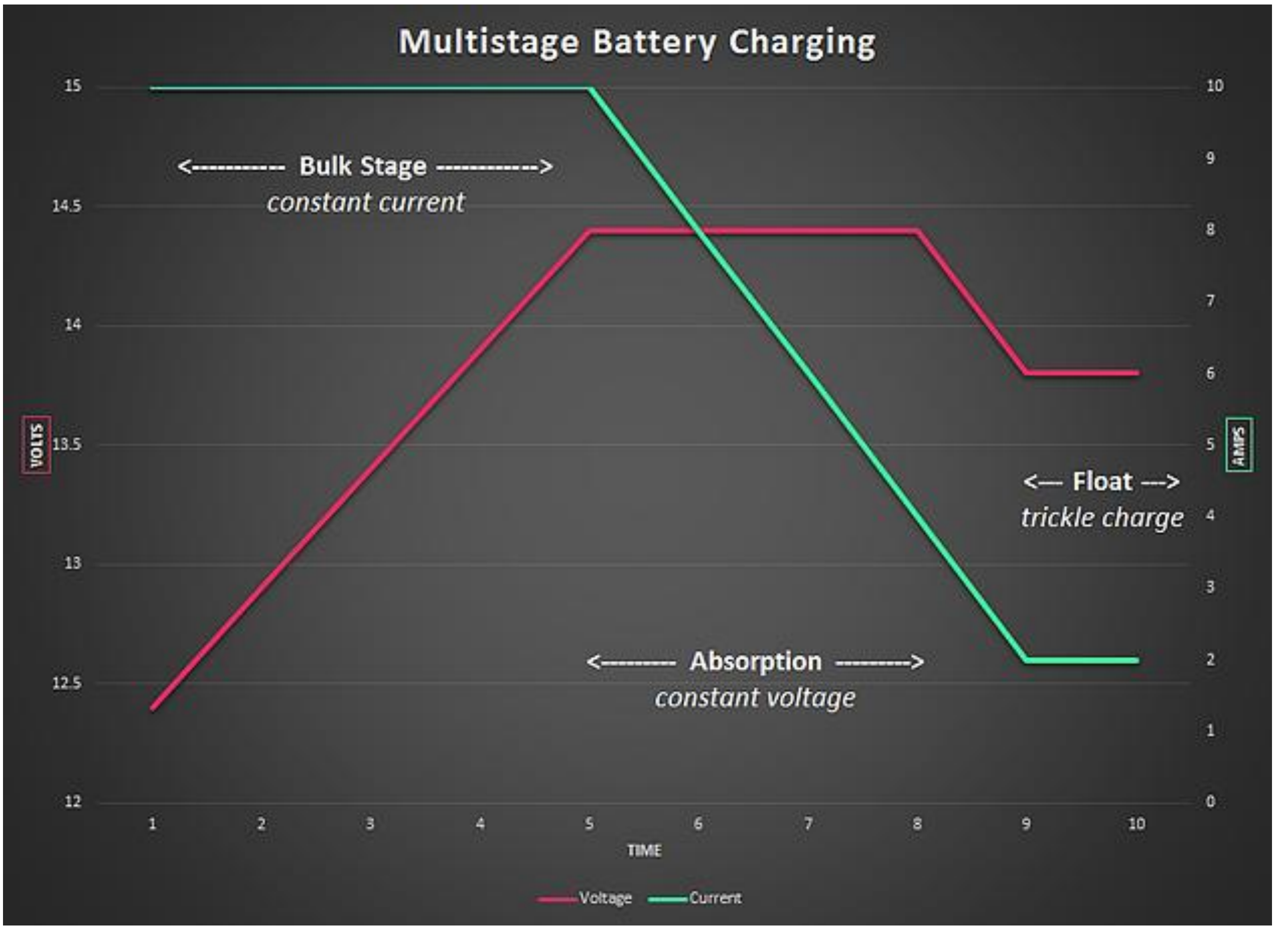
4. Equalize drifting battery cells.

5. Reduce battery heating and gassing.

6. Automatically adjust for battery aging.

7. Self-regulate for voltage drops and temperature effects in solar systems.

Nominal 12V lead acid battery voltages may range from around 11V when ‘empty’ to over 14V when charging. It is the charge controller’s job to take 17-19V from a solar panel and safely feed that to the batteries. PWM charge controllers typically integrate three distinct charging stages to do this: Bulk, Absorption, and Float stages.



[Figure 4.16.3 charging characteristics of PWM Charge controller]

In the Bulk charging stage the charge controller is directly connecting the solar panels to the batteries. The solar panel voltage is drawn down to match the battery voltage and the full current output of the solar panels is dumped into the batteries. This stage will contribute the majority of the charge to the batteries and is sometimes called the constant-current stage. As the battery gets charged its voltage slowly increases until it reaches around 14.4V. At this point the batteries will be around 80% charged, however continued charging at this voltage and max current could be damaging, so the charge controller moves into the next stage.

In the Absorption stage the charge controller slowly tops up the remaining charge. It does this by maintaining a constant voltage of around 14.4V, but slowly limiting the current flow to the battery. This allows the chemical reactions occurring inside the battery to progress at a safe rate and prevents overheating.

Once the battery is nearly full the charge controller switches to the Float stage. This is a ‘trickle-charge’ mode with just a trickle of current and a constant voltage of around 13.8V. The battery can be safely maintained here at 100% capacity for long periods of time while the small power input offsets the natural discharge rate of the battery.

4.16.1.1Good balance of features

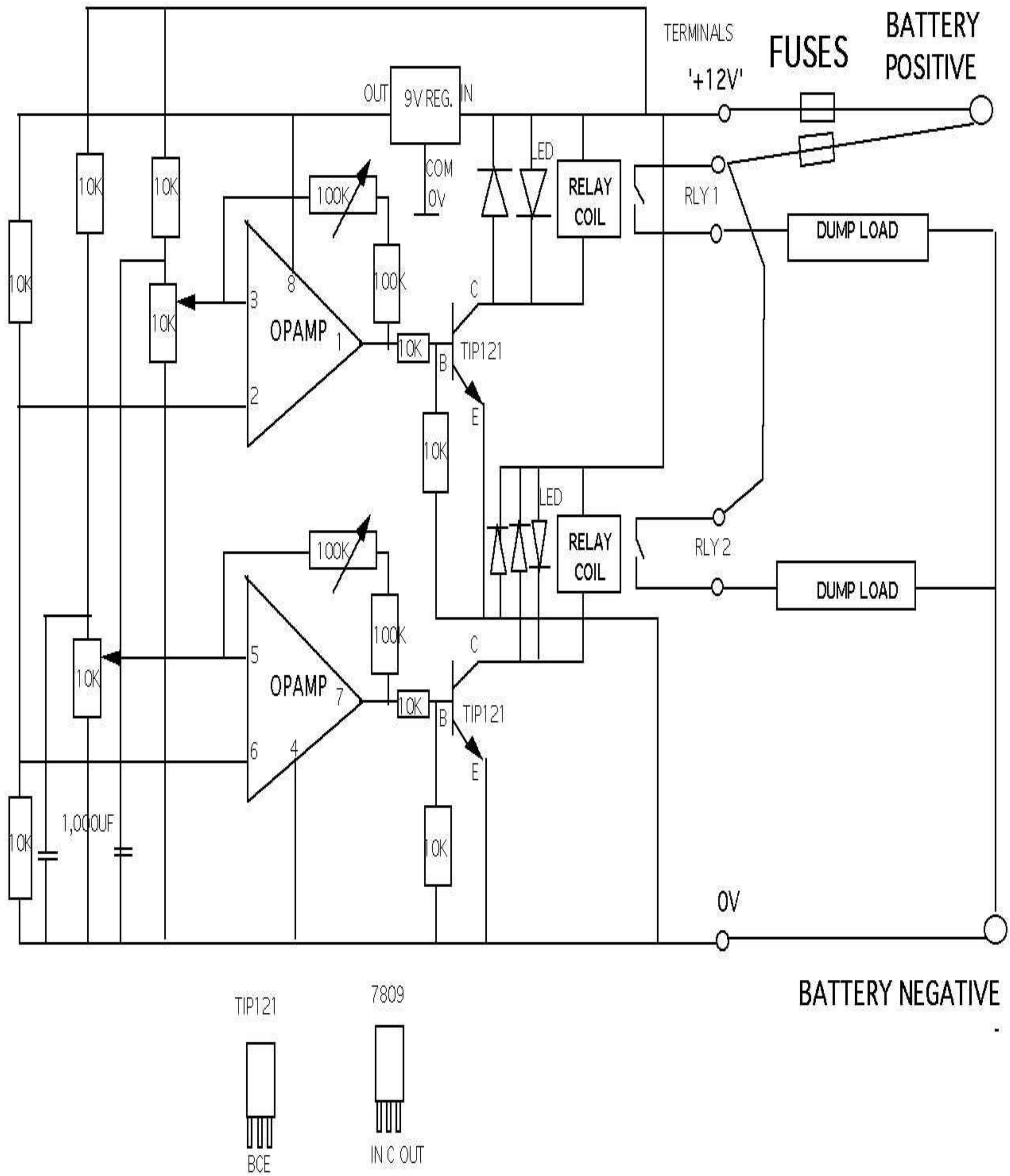
PWM charge controllers are often compared with more expensive MPPT controllers. PWM works best in systems where the solar panel voltages are well matched to battery voltages. For 12V nominal systems this often means a solar panel voltage of 17-19V. MPPT charge controllers are more efficient and offer advantages if solar panel voltages are much higher than battery voltages, however this can be offset by their greater cost.

In a 12V systems with a well matched solar input it can be more cost effective to use a PWM charge controller and put the cost savings from an MPPT charge controller into increasing the solar array. You can spend a similar amount of money for greater overall output.

All voltage levels listed are approximate. Actual real-world battery voltage levels will vary based upon chemistry, construction, temperature, number of cells, and other factors. A good charge controller will allow you to account for these variations.

4.16.1.2 ADVANTAGES OF USING PWM CHARGE CONTROLLER

- ✓ Longer battery life: – reducing the costs of the solar system – reducing battery disposal problems
- ✓ More battery reserve capacity: – increasing the reliability of the solar system – reducing load disconnects – opportunity to reduce battery size to lower the system cost
- ✓ Greater use of the solar array energy: – get 20% to 30% more energy from your solar panels for charging – stop wasting the solar energy when the battery is only 50% charged – opportunity to reduce the size of the solar array to save costs
- ✓ Greater user satisfaction: – get more power when you need it for less money!!


TERMINALS
FUSES
BATTERY POSITIVE
'+12V'
OUT
9V REG.
IN
COM
0V
LED
RELAY COIL
RLY 1
DUMP LOAD
10K
10K
10K
100K
100K
10K
3
8
OPAMP
1
2
10K
C
TIP121
B
E
10K
LED
RELAY COIL
RLY 2
DUMP LOAD
100K
100K
5
OPAMP
7
6
4
10K
10K
C
TIP121
B
E
10K
1,000UF
10K
0V
BATTERY NEGATIVE
TIP121
BCE
7809
IN C OUT

CHAPTER-5

WORKING OF THE WHOLE SETUP

5.1 WORKING OF DRIVE SYSTEM

The drive system consist of BLDC Motor which is powered by a 48V 32ah battery bank through a dedicated motor speed controller. The motor has a built in Rotor position sensor to sense the position of the rotor using Hall effect. The controller has controlled inverter that converts DC voltage from the battery bank into AC voltage that is supplied to the stator of the motor.

The thyristors in the inverter on appropriate phases are switched on and off with reference to the rotor position sensor. The Throttle which works on Hall effect principle modulates the gate pulse width by giving a reference voltage of 0V to 4V and thus controlling the voltage amplitude supplied to the motor and hence the speed of the motor is varied by pressing and releasing the throttle.

The charge level in the battery bank is monitored by the charge controller which is connected to solar panels installed. When the charge in the battery goes below rated voltage. The charge controller transfers the charge generated by the solar panels to the battery until it regains rated voltage.

A fully charged battery can power the vehicle for one hour and can cover a distance of 30 km. As per the solar module rating it takes 4 hours to charge the battery fully from depleted state.

5.2 WORKING OF SOPHISTICATED SAFETY FEATURES

Various sophisticated safety features installed in the car are actuated in appropriate situations in which they are designed to work.

5.2.1 WORKING OF VEHICLE MONITORING SYSTEM AND DRIVER MONITORING SYSTEM

Various parameters of the vehicle such as

- Battery temperature
- Power consumption
- Speed of the vehicle

- Driver vitals
- Proximity of the objects nearby
- Speed of approaching vehicle

are sensed by dedicated sensors and the data is sent to the microcontroller which is connected to the mobile hotspot via inbuilt WIFI module. The controller is connected to an open-source cloud "BLYNK" through the mobile network and updates the data to the cloud. This data can be viewed in GUI real time form in the android app for the same cloud. This data can be accessed by the manufacturers for determining the performance and plan for any upgrades if needed and rectify defects reflected in the performance.

5.2.3 ON THE OCCURANCE OF ACCIDENT

This is where emergency shutdown system comes into action. During an head on collision the impact attenuator reduces the intensity of the impact. On the instance of the first hit, the kill switch is triggered and the whole system is isolated from the source and the system is completely shut down. On the other hand the microcontroller which works on auxiliary power supply sends distress message to the cloud which can be used to alert the person who monitors the driver via cloud.

Even during other types of collisions the kill switch is triggered and the whole system is shut down. This reduces the risk fire or shocks due to sparks resulting from short circuits.