



GROUP B DOCUMENT

TEAM ZON

TEAM ID-ESVC16060



**NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008**

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1.ELECTRICAL SYSTEM SPECIFICATIONS

1. MOTOR:-

The BLDC motor is widely used in applications including appliances, automotive, aerospace, consumer, medical, automated industrial equipment and instrumentation. The BLDC motor is electrically commutated by power switches instead of brushes. Compared with a brushed DC motor or an induction motor, the BLDC motor has many advantages:

- Higher efficiency and reliability
- Lower acoustic noise
- Smaller and lighter
- Greater dynamic response
- Better speed versus torque characteristics
- Higher speed range
- Longer life

A BLDC motor accomplishes commutation electronically using rotor position feedback to determine when to switch the current. The structure is shown in Figure . Feedback usually entails an attached Hall sensor or a rotary encoder. The stator windings work in conjunction with permanent magnets on the rotor to generate a nearly uniform flux density in the air gap. This permits the stator coils to be driven by a constant DC voltage (hence the name brushless DC), which simply switches from one stator coil to the next to generate an AC voltage waveform with a trapezoidal shape.

CONTROLLER IMPLEMENTATION

Because the controller must direct the rotor rotation, the controller requires some means of determining the rotor's orientation/position (relative to the stator coils.) Some designs use Hall effect sensors or a rotary encoder to directly measure the rotor's position. Others measure the back EMF in the undriven coils to infer the rotor position, eliminating the need for separate Hall effect sensors, and therefore are often called *sensor-less* controllers.

In a Brushless DC motor, two coils are energized at a time with equal and opposite polarities, one pushes the rotor away from it while the other attracting the rotor towards it. This increases the overall torque capacity of the motor and Hall effect sensors or a rotary encoder determines which two coils have to be energized to achieve this strategy.

A typical controller contains 3 bi-directional outputs (i.e. frequency controlled three phase output), which are controlled by a logic circuit. Simple controllers

employ comparators to determine when the output phase should be advanced, while more advanced controllers employ a microcontroller to manage acceleration, control speed and fine-tune efficiency. Controllers that sense rotor position based on back-EMF have extra challenges in initiating motion because no back-EMF is produced when the rotor is stationary. This is usually accomplished by beginning rotation from an arbitrary phase, and then skipping to the correct phase if it is found to be wrong. This can cause the motor to run briefly backwards, adding even more complexity to the start-up sequence. Other sensor-less controllers are capable of measuring winding saturation caused by the position of the magnets to infer the rotor position.

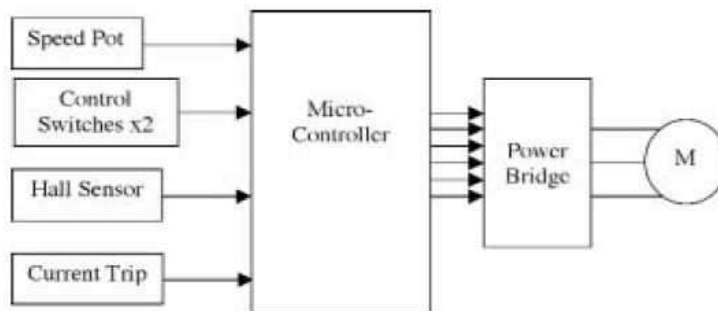


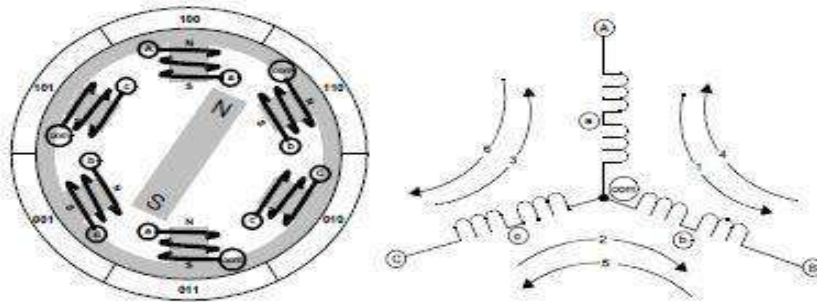
Figure 1 – BLDC Motor Control Block diagram

Motor specifications:

Model NO.	ET-58-IKH-48
Watt	1000 W/ 1.5 HP
Speed	3000
Torque	35 N-m
VDC	48 VOLTS
Dimensions	DIA -168 mm, L-94 mm
Amp.	21 AMP
Shaft	DIA – 22.2 mm, L- 50 mm
Weight	4.5 kg

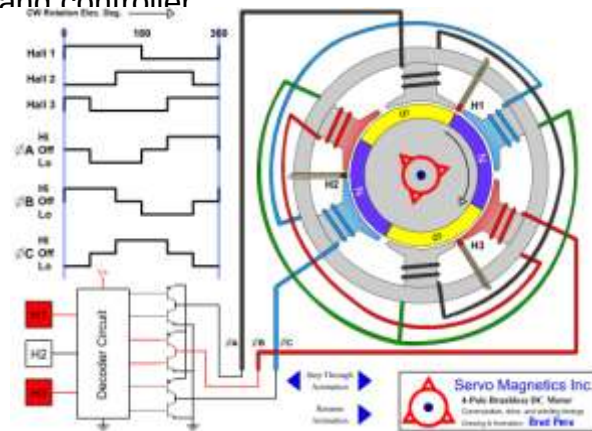
Constructional features:

As the name implies, BLDC motors do not use brushes for commutation; instead, they are electronically commutated.



BLDC motors are a type of synchronous motor. This means the magnetic field generated by the stator and the magnetic field generated by the rotor rotates at the same frequency. BLDC motors do not experience the “slip” that is normally seen in induction motors. BLDC motors come in single-phase, 2-phase and 3-phase configurations. Corresponding to its type, the stator has the same number of windings. Out of these, 3-phase motors are the most popular and widely used.

This application note focuses on 3-phase motors. Our motor has Hall Effect sensors and controller



A, B, C are three phases given to the coil of motor. The rotor part is generally a permanent magnet. In the stator there are coils wound on the core. When electric current passes through these coils in an alternating manner, a magnetic field is produced and it interacts with the magnet of stator. The magnetic field in the stator is so produced that it repels the magnetic field of rotor, as a result the rotor rotates and output is taken from the shaft connected to the rotor. The hall-effect sensors are fitted just in between the two coils of stator. When rotor magnetic pole crosses the sensor it creates a high/low level signal which is sent to the controller. The controller interprets this signal and changes the phase of stator coils accordingly so that repulsion should go on.

2. BATTERY INDICATOR USING CURRENT SENSOR AND LCD:-

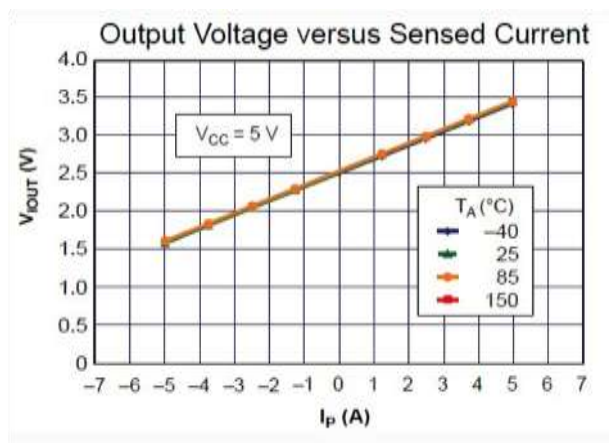
CURRENT SENSOR:- ACS712

SPECIFICATIONS:-

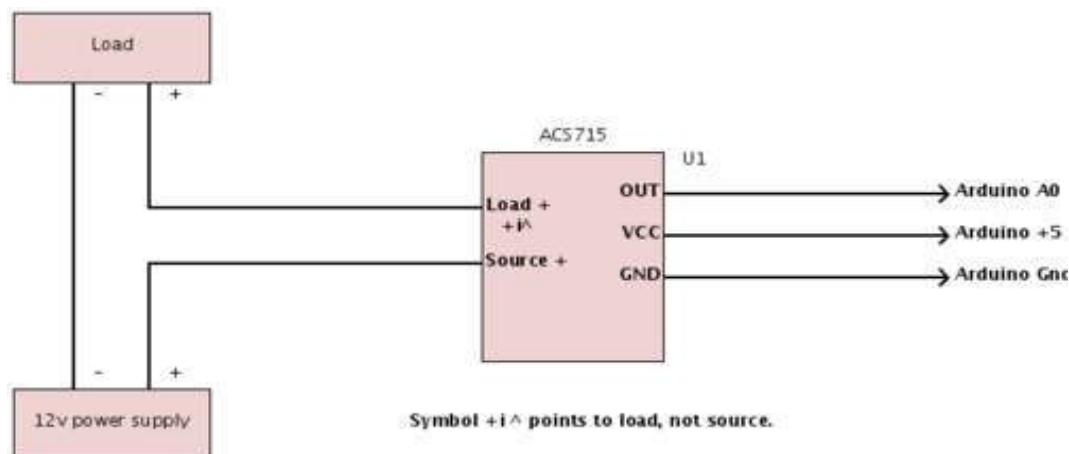
1. INPUT VOLTAGE:- 5V
2. MAXIMUM CURRENT SENSING:-30A

INTRODUCTION:-

A current sensor is a device that detects and converts current to an easily measured output voltage, which is proportional to the current through the measured path.



INTERFACING WITH ARDUINO:-



The T1 and T2 pin of the sensor is connected to the power rail in series. The output pin is connected to an analog pin of Arduino.

The sensor outputs an analog voltage correspondence to the current flow. Therefore to get the current reading from the Arduino. So we need to perform analog to digital conversion inside the Arduino and multiply with calibrating constant to get the actual value

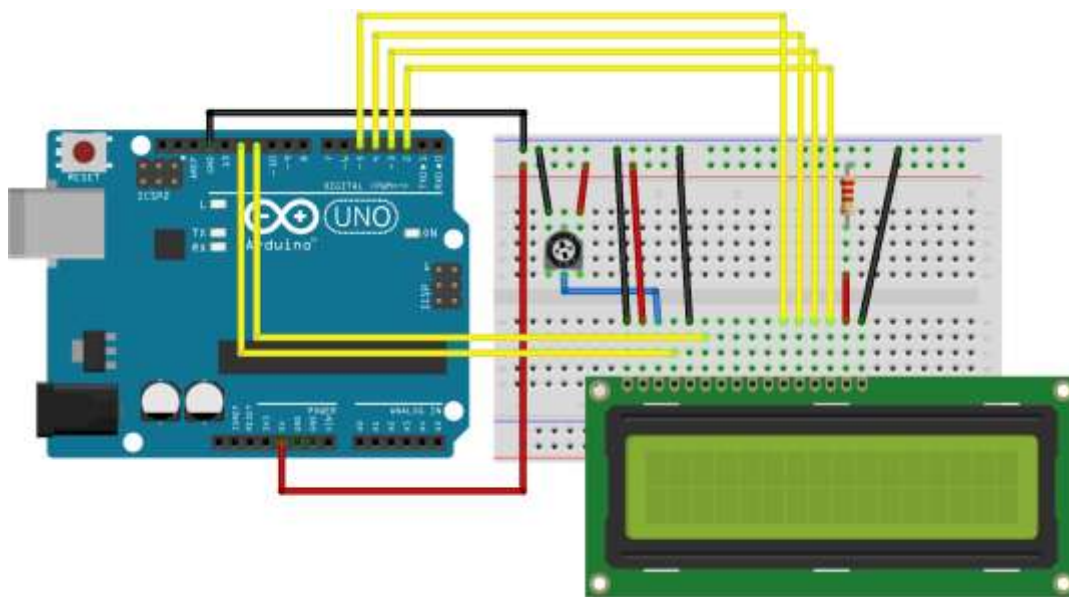
LCD:-

SPECIFICATIONS:-

1. LCD MODULE:- 16*2
2. INPUT VOLTAGE:- 5V

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.

INTERFACING WITH ARDUINO:-



3. HALL EFFECT SENSOR:-

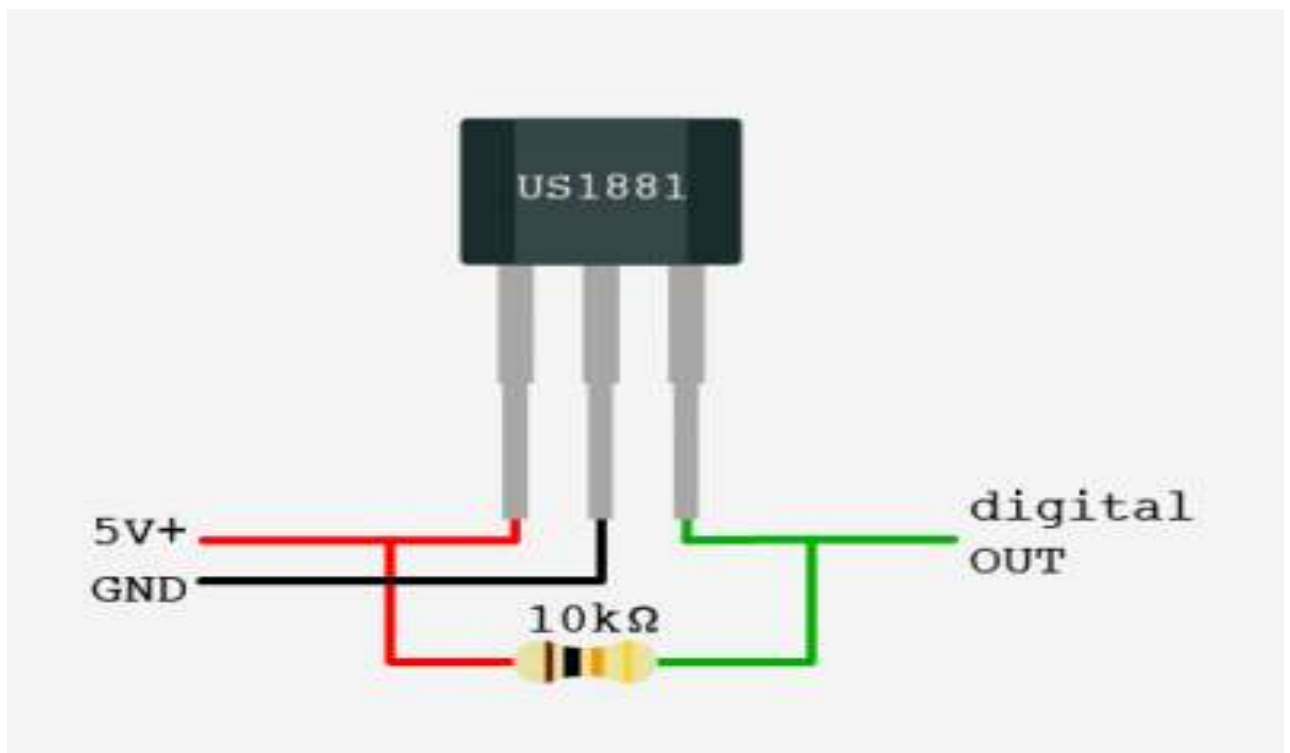
SPECIFICATIONS:-

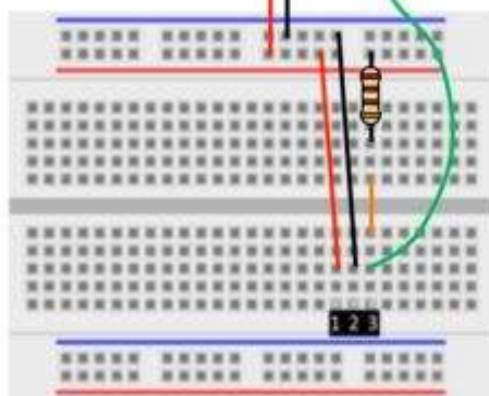
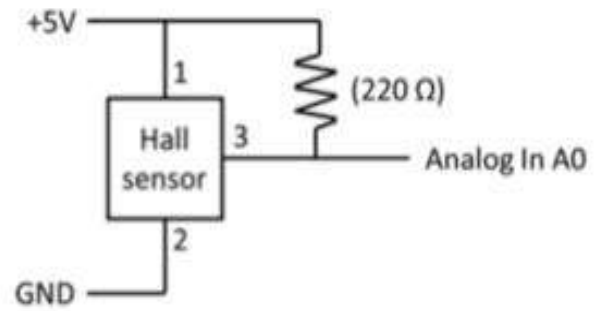
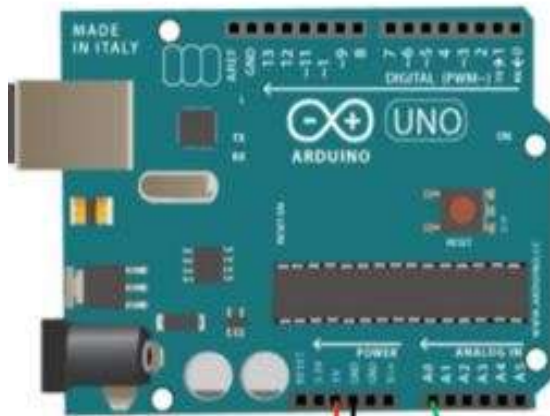
1. VOLTAGE:- 5V
2. MAXIMUM CURRENT:- 50mA

INTRODUCTION:-

The Hall Effect sensor is a device that senses the magnetic field around, for example from a magnet or a wire with electric current. This sensor works as an on-off switch. If you get a magnet and put a magnetic north close to the sensor, it will be on, if you put south, the sensor will be off.

INTERFACING WITH ARDUINO AND MOTOR:-





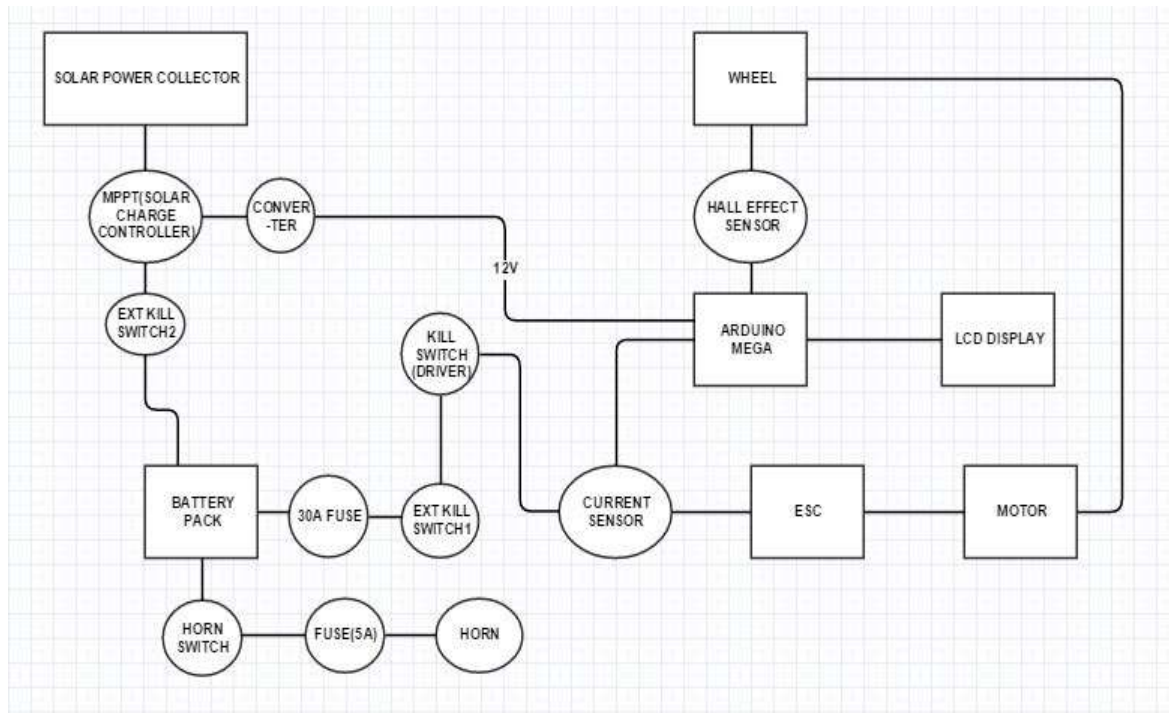
220 Ohm resistor

Hall Effect Sensor



Neodymium magnet
connected to the motor shaft

BLOCK DIAGRAM

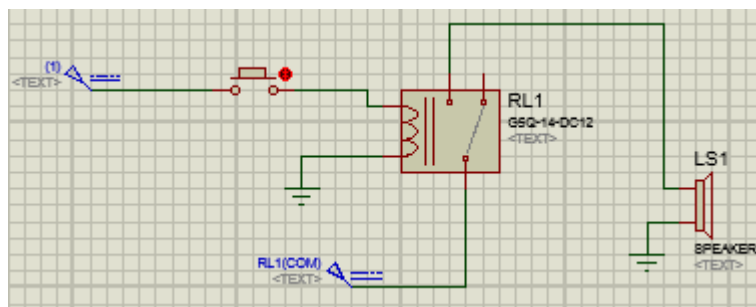


4. HORN SPECIFICATIONS: - 12V(Nominal voltage)

48 watts power consumption

5A fuse(placed between relay input and power source)

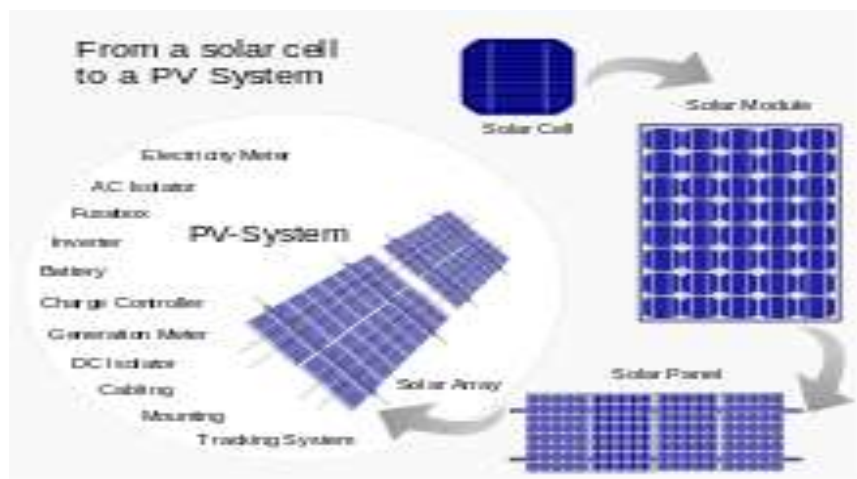
HORN WIRING DIAGRAM



2.SOLAR COLLECTOR SPECIFICATIONS

1. SOLAR PANELS: Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. A photovoltaic (in short PV) module is a packaged, connected assembly of typically 6×10 solar cells. Solar Photovoltaic panels constitute the solar 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.

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 solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, a solar inverter, and sometimes a battery and/or solar tracker and interconnection wiring.



Solar panel specifications:

Maximum power	200 watt
Maximum power voltage	27.42 volts
Maximum power current	6.62 A
Open circuit voltage	34.61 volts
Short circuit current	7.13 A
Module efficiency	15.29%
No. and type of solar cells	60, monocrystalline
Performance Tolerance	3%

Operating Temperature	-40° C to 85° C
Storage temperature	-40° C to 85° C
Dimensions	1440*990*40 mm³
Weight	19 kg
Maximum Series fuse	15A

2. SOLAR CHARGE CONTROLLER:

A charge controller, or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels going to the battery. Most "12 volt" panels put out about 16 to 20 volts, so if there is no regulation the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged

Need of charge controller:

Not always, but usually. Generally, there is no need for a charge controller with the small maintenance, or trickle charge panels, such as the 1 to 5 watt panels. A rough rule is that if the panel puts out about 2 watts or less for each 50 battery amp-hours, then you don't need one.

For example, a standard flooded golf car battery is around 210 amp-hours. So to keep up a series pair of them (12 volts) just for maintenance or storage, you would want a panel that is around 4.2 watts. The popular 5 watt panels are close enough, and will not need a controller. If you are maintaining AGM deep cycle batteries, such as the Concorde Sun Xtender then you can use a smaller 2 to 2 watt panel.

The obvious question then comes up - "why aren't panels just made to put out 12 volts". The reason is that if you do that, the panels will provide power only when cool, under perfect conditions, and full sun. This is not something you can count on in most places. The panels need to provide some extra voltage so that when the sun is low in the sky, or you have heavy haze, cloud cover, or high temperatures*, you still get some output from the panel. A fully charged "12 volt" battery is around 12.7 volts at rest (around 13.6 to 14.4 under charge), so the panel has to put out at least that much under worst case conditions.

The charge controller regulates this 16 to 20 volts output of the panel down to what the battery needs at the time. This voltage will vary from about 10.5 to 14.6, depending on the state of charge of the battery, the type of battery, in what mode the controller is in, and temperature. (See complete info on battery voltages in our battery section).

Using High Voltage (grid tie) Panels With Batteries

Nearly all PV panels rated over 140 watts are NOT standard 12 volt panels, and cannot (or at least should not) be used with standard charge controllers. A voltage on grid tie panels varies quite a bit, usually from 21 to 60 volts or so. Some are standard 24 volt panels, but most are not.

Standard (that is, all but the MPPT types), will often work with high voltage panels if the maximum input voltage of the charge controller is not exceeded. However, *you will lose a lot of power* - from 20 to 60% of what your panel is rated at. Charge controls take the output of the panels and feed current to the battery until the battery is fully charged, usually around 13.6 to 14.4 volts. A panel can only put out so many amps, so while the voltage is reduced from say, 33 volts to 13.6 volts, the amps from the panel cannot go higher than the rated amps - so with a 175 watt panel rated at 23 volts/7.6 amps, you will only get 7.6 amps @ 12 volts or so into the battery. Ohms Law tells us that watts is volts x amps, so your 175 watt panel will only put about 90 watts into the battery.

Using an MPPT controller with high voltage panels

The only way to get full power out of high voltage grid tie solar panels is to use an MPPT controller. See the link above for detailed info on MPPT charge controls. Since most MPPT controls can take up to 150 volts DC (some can go higher, up to 600 VDC) on the solar panel input side, you can often series two or more of the high voltage panels to reduce wire losses, or to use smaller wire. For example, with the 175 watt panel mentioned above, 2 of them in series would give you 66 volts at 7.6 amps into the MPPT controller, but the controller would convert that down to about 29 amps at 12 volts.

Charger Controller Types

Charge controls come in all shapes, sizes, features, and price ranges. They range from the small 4.5 amp (Sunguard) control, up to the 60 to 80 amp MPPT programmable controllers with computer interface. Often, if currents over 60 amps are required, two or more 40 to 80 amp units are wired in parallel. The most common controls used for all battery based systems are in the 4 to 60 amp range, but some of the new MPPT controls such as the Outback Power FlexMax go up to 80 amps.

Charge controls come in 3 general types (with some overlap):

Simple 1 or 2 stage controls which rely on relays or shunt transistors to control the voltage in one or two steps. These essentially just short or disconnect the solar panel when a certain voltage is reached. For all practical purposes these are dinosaurs, but you still see a few on old systems - and some of the super cheap ones for sale on the internet. Their only real claim to fame is their reliability - they have so few components, there is not much to break.

3-stage and/or PWM such Morningstar, Xantrex, Blue Sky, Steca, and many others. These are pretty much the industry standard now, but you will occasionally

still see some of the older shunt/relay types around, such as in the very cheap systems offered by discounters.

Maximum power point tracking (MPPT), such as those made by Midnite Solar, Xantrex, Outback Power, Morningstar and others. These are the ultimate in controllers, with prices to match - but with efficiencies in the 94% to 98% range, they can save considerable money on larger systems since they provide 10 to 30% more power to the battery. For more information, see our article on MPPT. Most controllers come with some kind of indicator, either a simple LED, a series of LED's, or digital meters. Many newer ones, such as the Outback Power, Midnite Classic, Morningstar MPPT, and others now have built in computer interfaces for monitoring and control. The simplest usually have only a couple of small LED lamps, which show that you have power and that you are getting some kind of charge. Most of those with meters will show both voltage and the current coming from the panels and the battery voltage. Some also show how much current is being pulled from the LOAD terminals.

All of the charge controllers that we stock are 3 stage PWM types, and the MPPT units. (in reality, "4-stage" is somewhat advertising hype - it used to be called equalize, but someone decided that 4 stage was better than 3). And now we even see one that is advertised as "5-stage"....

What is Equalization?

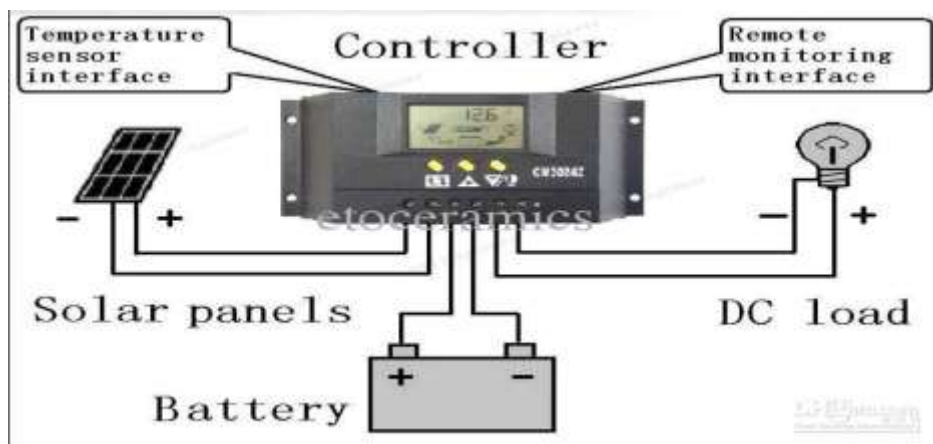
Equalization does somewhat what the name implies - it attempts to equalize - or make all cells in the battery or battery bank of exactly equal charge. Essentially it is a period of overcharge, usually in the 15 to 15.5 volt range. If you have some cells in the string lower than others, it will bring them all up to full capacity. In flooded batteries, it also serves the important function of stirring up the liquid in the batteries by causing gas bubbles. Of course, in an RV or boat, this does not usually do much for you unless you have been parked for months, as normal movement will accomplish the same thing. Also, in systems with small panels or oversized battery systems you may not get enough current to really do much bubbling. In many off-grid systems, batteries can also be equalized with a generator charger.

What is PWM?

Quite a few charge controls have a "PWM" mode. PWM stands for Pulse Width Modulation. PWM is often used as one method of float charging. Instead of a steady output from the controller, it sends out a series of short charging pulses to the battery - a very rapid "on-off" switch. The controller constantly checks the state of the battery to determine how fast to send pulses, and how long (wide) the pulses will be. In a fully charged battery with no load, it may just "tick" every few seconds and send a short pulse to the battery. In a discharged battery, the pulses would be very long and almost continuous, or the controller may go into "full on" mode. The controller checks the state of charge on the battery between pulses and adjusts itself each time.

What is a Load, or "Low Voltage Disconnect" output?

Some controllers also have a "LOAD", or LVD output, which can be used for smaller loads, such as small appliances and lights. The advantage is that the load terminals have a low voltage disconnect, so it will turn off whatever is connected to the load terminals and keep from running the battery down too far. The LOAD output is often used for small non-critical loads, such as lights. A few, such as the Xantrex C12, can also be used as a lighting controller, to turn lights on at dark, but the Morningstar SLC lighting controller is usually a better choice for that. Most systems do not need the LVD function - it can drive only smaller loads. Depending on the rating of the controller, this may be from 6 to 60 amps. You cannot run any but the smallest inverter from the LOAD output. On some controllers, such as the Morningstar SS series, the load output can be used to drive a heavy duty relay for load control, gen start etc. The LOAD or LVD output is most often used in RV & remote systems, such as camera, monitor, and cell phone sites where the load is small and the site is unattended.



3.ENERGY STORAGE SYSTEM DESIGN AND SPECIFICATION

1. **BATTERIES:** Battery is required for power storage. Batteries for eg – lithium ion batteries, lead acid batteries, Ni-MH batteries and any other rechargeable chemical batteries, can be used. Batteries should have maximum 48v and 50AH all the time of the event. All the batteries which store the energy must be enclosed by a fire proof cover.

For our vehicle we have used Lead Acid Batteries. Lead acid batteries have the following advantages.

- Easily available
- Inexpensive as compared to other batteries
- ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio.

It has some disadvantages too. They are:

- very low energy-to-weight ratio
- low energy-to-volume ratio

For our vehicle we are using **deep cycle type lead acid battery** as specially designed deep-cycle cells are much less susceptible to degradation due to cycling.

These batteries have thicker plates that can deliver less peak current, but can withstand frequent discharging.

Battery Specifications:

Lead-acid battery	
Specific energy	42 Wh/kg
Energy density	110 Wh/l
Specific power	180 W/kg
Charge/discharge efficiency	50–95%

Energy/consumer-price 7(sld)to 18(fld)Wh/US\$

Self-discharge rate 3–20%/month

Cycle durability 500–800 cycles

Nominal cell voltage 2.0 V

Charge temperature interval min. –35 °C, max. 45 °C

CALCULATION OF ELECTRIC VEHICLE MOTOR SPECIFICATIONS

From the analysis of the design report we have:

- Mass of the vehicle = 180 Kg
- Wheel diameter = 19 inch/ 0.4826 m

Let us consider the following data:

- Maximum speed = 50 kmph
- Average speed = 40 kmph
- Battery weight = 36 kg
- Coefficient of friction = 0.08 (on tar roads)
- Motor rating = 1000 watt
- Rated torque = 3.2 N-m

1. Calculation of torque at starting and maximum speed:

Let us assume constant power = 1000 watts

Targeted speed = 50 kmph = $50 \times (5/18)$ m/sec
= 13.88 m/sec

Wheel radius = $0.4826/2$ m = 0.2413 m

Now using the relation $N = (30 \times V) / \pi R$ rpm
= 549.7 rpm

Initial Torque required at wheels = $\mu W g R$ N-m
= $0.08 \times 180 \times 9.81 \times 0.2413$
= 34.08 N-m

Taking 1.5 times the initial torque required at wheels = $34.08 \times 1.5 = 51.12$ N-m
For a reduction ratio of 5.45: 1,

we have, motor starting torque required = $51.12/5.45$
= 9.37 N-m.

Now , torque at maximum speed = $60000 / (2\pi N)$ N-m
= 17.38 N-m

2. Calculation of torque at continuous(average) speed:

Calculation for Air Resistance-

Using the formula,

$$\begin{aligned}\text{Air resistance} &= (5 / 100000) \times \text{mass of vehicle} \times (\text{Average Speed})^3 \\ &= (5 / 100000) \times 180 \times 40^3 \\ &= 576 \text{ watt}\end{aligned}$$

Calculation for Rolling Resistance-

Using the formula,

$$\begin{aligned}\text{Rolling resistance} &= 0.092 \times \text{mass of the vehicle} \times \text{average speed} \\ &= 0.092 \times 180 \times 40 \\ &= 662.4 \text{ watt}\end{aligned}$$

$$\begin{aligned}\text{So continuous or average / continuous power required} &= \text{air resistance} + \text{rolling resistance} \\ &= 576 + 662.4 \\ &= 1238.4 \text{ watt}\end{aligned}$$

$$\begin{aligned}\text{Now continuous speed} &= \text{Average Speed} \times 60 / (2 \times \pi \times \text{Radius of Wheel}) \\ &= 40 \times 5/18 \times 60 / (2 \times \pi \times 0.2413) \\ &= 440 \text{ rpm}\end{aligned}$$

$$\begin{aligned}\text{So continuous torque at average speed} &= \text{average power required} \times 60 / (2\pi \times 440) \\ &= 1238.4 \times 60 / (2 \times \pi \times 440) \\ &= 26.87 \text{ watt}\end{aligned}$$

3. SOLAR CALCULATIONS

Specification of motor

Power	1000W
Operating Voltage	48V

Battery Specification

Voltage	12V
Capacity	42AH
Quantity	4

Solar Panel Specification

Power	200W
Open Circuit Voltage	34.61V
Short Circuit Current	7.13A
Voltage at maximum power	27.42
Current at maximum power	6.62A
Quantity	4

Dimension 1440*990*40
mm³

Energy consumed by motor for a period of time (say 3hrs)
= 1000 watt x 3hrs
= 3000 Wh

Energy generated by solar panel over that period of time
= 4 x 200 x 3 Wh
= 2400 Wh

Energy that can be stored in battery = capacity x voltage
= 42 x 48
= 2016 Wh

Discharging time of battery (*considering battery to be fully charged*)

Discharging time (without power loss) = (capacity x voltage)/ power of load
= (42 x 48) /1000
= 2.016 hrs

Discharging time (with power loss of about 25%) = 2.016 x (75/100)
= 1.512 hrs
= 1hour and 30 minutes

Charging time of battery

Charging time (*from 0 to 100% without considering power loss*) = Energy Stored in Battery/Power of panel
= 1.52 hrs

Charging time (*from 0 to 100% considering power loss factor as 1.5*) = 1.5 x 1.52 hrs
= 2.28 hrs

4.ELECTRICAL SYSTEM SAFETY MEASURES

- The battery box is made up of non conductive material(preferably wood).
- Flooded lead acid battery creates hydrogen gas upon charging. In order to release the generated hydrogen gas a 2 inch hole is made at the side of the box to which a PVC pipe is connected in order to aid the release of the hydrogen gas.
- The battery box is grounded in order to protect a person from getting shock (due to stray voltage from lightning or any other source) upon touching the battery box.
- An external kill switch is installed to cut the power supply from the solar charge controller (MPPT converter).This kill switch is externally accessible and thus can be pressed externally in the event of a failure in the battery pack. Pressing this switch will cut the supply of the power from the charge controller to the battery.
- A kill switch is installed at the dashboard (accessible to the driver).The purpose of this kill switch to cut the connection of the battery pack to the motor resulting in an complete halt of the vehicle.
- A starter switch is installed at the driver's dashboard to start the vehicle. This switch is installed in series with drivers kill switch.
- A 30A fuse is installed at the output of the battery pack in order to protect the current sensor and the rest of the circuit.
- A 5A fuse is installed at the input to the horn inorder the protect the horn from damage.
- Brake indicator light and side indicator lights are installed as a safety measure.
- **AUTOMATIC INDICATOR LIGHT:-** The automatic car indicator turns on when the indicator switch is pressed as well as the wheel is in turning position. If any of these conditions is not met then the indicator does not glow which also implies that the vehicle is not taking any turn. After the turn is taken the indicator light automatically turns off implying that the vehicle has taken the desired turn. The indicator switch is a solenoid controlled one which comes to it's original state after the turn has taken place.

Specifications :- Indicator Light

5 port 12V relay

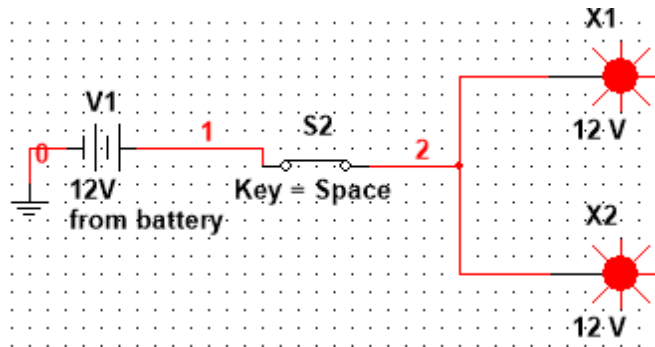
5A fuse

- **BRAKE LIGHT SPECIFICATION** :- 12V(Nominal voltage)

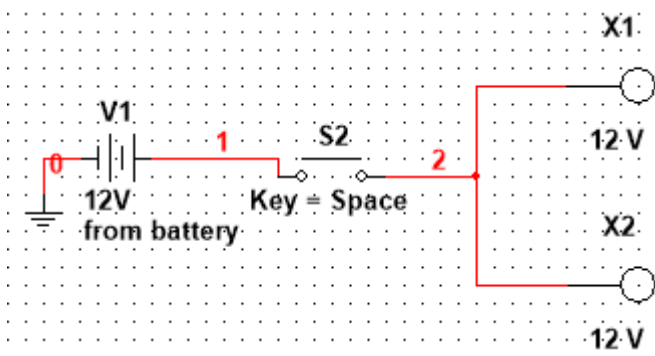
24watts power consumption

5A fuse

Brake lights on



Brake lights off



- **KILL SWITCH:** - Two kill switches are used. One kill switch is installed for the driver to cut-off power in emergencies. Another kill switch installed outside of vehicle body for an external agent to cut-off power supply in emergencies.

*THANK
YOU!!*