DESIGN, FABRICATION AND PERFORMANCE ANALYSIS OF SOLAR ELECTRIC TRICYCLE

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Abstract : Solar energy is being a renewable and non-conventional source of energy which is also a environmental friendly and free of cost. We came to implement an idea to make journey easier to handicapped people by using solar energy to move tri-cycle. This project is about building a tricycle that is motorised and is powered by solar energy, the overall layout of this tri-cycle is economical to fabricate and this type of tricycle may prove mile stone in development of technology for physically challenged people. The main content of the tri-cycle is Solar PV panel, DC motor, Controller, Throttle, battery. In this project it is discussed that how solar tri-cycle will help to reduce the effort of handicapped person.

I INTRODUCTION

The depleting reserves of fossil fuels made the engineers and scientists to look for renewable energy sources. In addition, the environmental decay due to the combustion of fuel is alarming and justifies the design of eco-friendly system. India is spending large amount of foreign exchange to import crude oil even though we have abundant resource of solar energy. If we utilize solar power for local conveyance, a large amount of currency can be saved and we can also ensure pollution free environment and contribute to nation's economy. A Solar E-Tricycle is a E-Tricycle with an integrated electric motor which can be used
for propulsion. There are a great variety of E-Tricycles are available worldwide but they to charge their batteries by ac 230V only and some are engine based which are high in maintenance, to overcome disadvantage our Solar E-Tricycles are here.
Solar E-Tricycle use rechargeable batteries where the solar power is used to charge the battery in ideal condition and they can travel up to 20 to 25 km/h by one-time battery charging and depending up on Ah of battery it will increase. We are mainly concentrated on the students, they can easily travel to their institutes without pedaling to a maximum distance of 25km, and after the discharging of batteries the batteries of cycle will be charged with the help of solar panels. By the evening the cycle will be ready to travel a distance of 25km again. In the absents of solar energy the battery can be charged by using 220v- 240v ac supply.

II BLOCK DIAGRAM

III EQUIPMENT REQUIRED

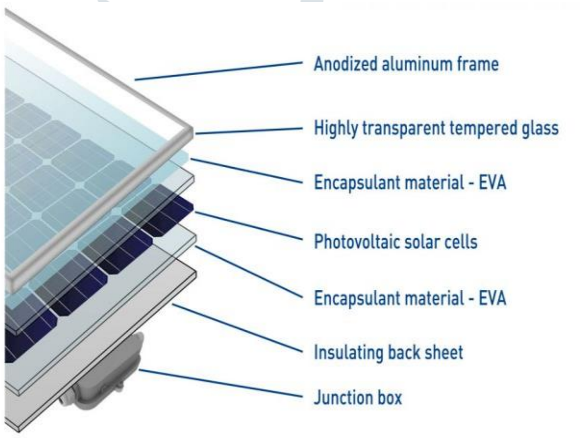
- **Solar photovoltaic panel:**

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. These are solar panels composed generally of silicon that take advantage of the energy of the photons present in the light to make jump an electron of the silicon. By the addition of several of these electrons, an electric current is generated. Photovoltaic panels generate electricity in the form of direct current. 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. The most common application of solar panels is solar water heating systems. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid (there is "grid parity").

- **Poly Crystalline:**

Polycrystalline silicon, also called polysilicon or poly-Si, is a high purity, polycrystalline form of silicon, used as a raw material by the solar photovoltaic and electronics industry. Polysilicon is produced from metallurgical grade silicon by a chemical purification process, called the Siemens process. This process involves distillation of volatile silicon compounds, and their decomposition into silicon at high temperatures. An emerging, alternative process of refinement uses a fluidized bed reactor. The photovoltaic industry also produces upgraded metallurgical-grade silicon (UMG-Si), using metallurgical instead of chemical purification processes. When produced for the electronics industry, polysilicon contains impurity levels of less than one part per billion (ppb), while polycrystalline solar grade silicon (SoG-Si) is generally less pure. A few companies from China, Germany, Japan, Korea and the United States, such as GCL-Poly WackeChemie, OCI, and Hemlock Semiconductor, as well as the Norwegian headquartered REC, accounted for most of the worldwide production of about 230,000 tons in 2013. The polysilicon feedstock – large rods, usually broken into chunks of specific sizes and packaged in clean rooms before shipment – is directly cast into multicrystalline ingots or submitted to a recrystallization process to grow single crystal boules. The products are then sliced into thin silicon wafers and used for the production of solar cells, integrated circuits and other semiconductor devices.

Polysilicon consists of small crystals, also known as crystallites, giving the material its typical metal flake effect. While polysilicon and multisilicon are often used as synonyms, multicrystalline usually refers to crystals larger than 1 mm. Multicrystalline solar cells are the most common type of solar cells in the fast-growing PV market and consume most of the worldwide produced polysilicon. About 5 tons of polysilicon is required to manufacture 1 megawatt (MW) of conventional solar modules. Polysilicon is distinct from monocrystalline silicon and amorphous silicon.



Panel Specifications:

Maximum power-	40 w
O.c. voltage -	21.4 v
S.c.current-	2.58 a
Voltage at max.power -	17.7 v
Current at max.power -	2.26 a
Module efficiency -	12.88%

- **Lead Acid Batteries:**

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, makes 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.

In the discharged state both the positive and negative plates become lead(II) sulfate ($PbSO_4$), and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is driven by the conduction of electrons from the negative plate back into the cell at the positive plate in the external circuit.

In the fully charged state, the negative plate consists of lead, and the positive plate lead dioxide, with the electrolyte of concentrated sulfuric acid. Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which is lost to the cell. The design of some types of lead-acid batteries allow 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.

➢ Solar charge controller (MPPT):

The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is extra 10-30% more power out of your sunoriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric systems over 200 watts.

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day.

The major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point). That is to say: MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery.

Controller specifications:

Voltage Rating - 12V/24V DC
Current Rating - 10A

➢ Brushless DC motors:

Some of the problems of the brushed DC motor are eliminated in the brushless design. In this motor, the mechanical "rotating switch" or commutate or brushgear assembly is replaced by an external electronic switch synchronized to the rotor's position. Brushless motors are typically 85-90% efficient, whereas DC motors with brushgear are typically 75-80% efficient.

Midway between ordinary DC motors and stepper motors lies the realm of the brushless DC motor. Built in a fashion very similar to stepper motors, these often use a permanent magnet external rotor, three phases of driving coils, one or more Hall effect sensors to sense the position of the rotor, and the associated drive electronics. The coils are activated, one phase after the other, by the drive electronics as cued by the signals from the Hall effect sensors. In effect, they act as three-phase synchronous motors containing their own variable-frequency drive electronics.

A specialized class of brushless DC motor controllers utilize EMF feedback through the main phase connections instead of Hall effect sensors to determine position and velocity. These motors are used extensively in electric radio-controlled vehicles. When configured with the magnets on the outside, these are referred to by modelists as outrunner motors.

Brushless DC motors are commonly used where precise speed control is necessary, as in computer disk drives or in video cassette recorders, the spindles within CD, CD-ROM (etc.) drives, and mechanisms within office products such as fans, laser printers and photocopiers.

They have several advantages over conventional motors:

- Compared to AC fans using shaded-pole motors, they are very efficient, running much cooler than the equivalent AC motors. This cool operation leads to much-improved life of the fan's bearings.
- Without a commutator to wear out, the life of a DC brushless motor can be significantly longer compared to a DC motor using brushes and a commutator. Commutation also tends to cause a great deal of electrical and RF noise; without a commutator or brushes, a brushless motor may be used in electrically sensitive devices like audio equipment or computers.
- The same Hall effect sensors that provide the commutation can also provide a convenient tachometer signal for closed-loop control (servo-controlled) applications. In fans, the tachometer signal can be used to derive a "fan OK" signal.
- The motor can be easily synchronized to an internal or external clock, leading to precise speed control.
- Brushless motors have no chance of sparking, unlike brushed motors, making them better suited to environments with volatile chemicals and fuels. Also, sparking generates ozone which can accumulate in poorly ventilated buildings risking harm to occupants' health.

- Brushless motors are usually used in small equipment such as computers and are generally used to get rid of unwanted heat.
- They are also very quiet motors which is an advantage if being used in equipment that is affected by vibrations.

Modern DC brushless motors range in power from a fraction of a watt to many kilowatts. Larger brushless motors up to about 100 kW rating are used in electric vehicles. They also find significant use in high-performance electric model aircraft.

Motor Specifications:

Rated voltage-	24V DC
No-load rpm -	3200RPM
No-load current -	<2.2AMPS
Rated load rpm -	300RPM
Torque -	22 N-M
Rated current -	19AMPS
Efficiency -	78%

➢ Throttle & motor controller(pwm):

The implementation is controlling a BLDC motor in open loop. The motor current is measured and speed is monitored, to be able to respond to stall and overload situations. Three PWM channels are connected to the low side of the driving Half-bridges to control the speed of the motor. A BLDC motor driver stage, consisting of three half-bridges.

Three PWM channels, OC0A, OC0B and OC2B, control the low side of the driver bridge. This gives the possibility to control the current flow using hardware based PWMs with a minimum of timer resources in use.

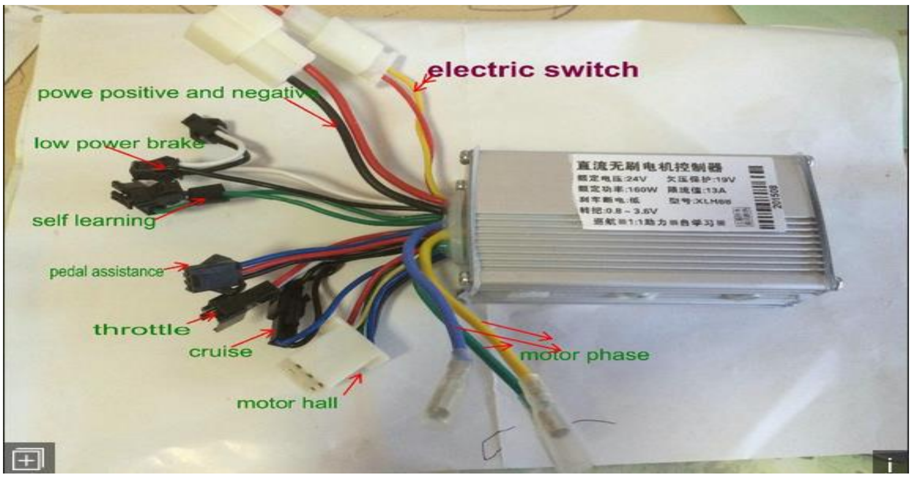
This controls the speed of the motor: by varying the duty cycle of the PWM output the current flow and thereby the speed (and torque) of the motor is controlled. It is also possible to have PWM based control of the high side of the bridge, but that would require all the Atmel ATmega48 timers. Further, it would require either that shoot through protection is integrated in the driver circuit or that dead time is handled in software. If active breaking is used it can be desired to use PWM channels for both high and low side of the drivers to distribute the power dissipation more evenly over the effect transistors. However, in most applications this is not required.

A single ADC channel is used to measure the current flow. The ADC has a resolution of 10 bits and uses an external 2.5V reference; this gives an accuracy of approximately 2.4mV, which is sufficient for over-current detection as the voltage over a 0.22Ω shunt resistor is 220mV when 1A flows through it. If required the ADC can be triggered by the PWM to measure current when not switching or run continuously with a given sampling frequency. A second ADC channel is used to measure an analog voltage (e.g. a potentiometer) used as speed reference for adjusting the motor speed.

The Hall sensor outputs are connected to three pins on PORTB, which all features interrupt on level change (pin change interrupt). In case the Hall sensors outputs change their logic levels, an interrupt is executed and the commutation state corresponding to the new Hall sensor output is determined. Note that the lowest pins on a PORT are used intentionally to speed optimize the decoding of the Hall signals.

Controller Specifications:

Rated voltage -	24V DC
Rated Power -	350W
Max current Rating -	33A
Mini Voltage Rating -	20V



IV RESULTS AND DISCUSSION

S.no	Motor power consumption in watts	Weight or load in kgs
1	13.4	-
2	26.9	30
3	48.3	60
4	69.7	90
5	91.1	120
6	112.56	150

motor power consumption at different loads

S.no	Time	Battery in volts
1	1:45pm	22.5
2	2:15pm	22.8
3	2:45pm	23.1
4	3:15pm	23.4
5	3:45pm	23.6
6	4:15pm	23.8

Charging time through solar

Sno	Speed in rpm	Torque in n-m	Load in kgs
1	300	22.2	-
2	293	22.8	30
3	284	23.5	60
4	277	24.2	90
5	265	25.2	120
6	252	26.6	150

Torque at varying speeds

Complete soalr E-tricycle

V CONCLUSION

Solar assisted E-Tricycle is modification of existing Tricycle and driven by solar energy. It is suitable for both city and country roads, that are made of cement, asphalt, or mud. This E-Tricycle is cheaper, simpler in construction & can be widely used for short distance travelling especially by school children, college students, office goers, villagers, postmen etc. It is very much suitable for young, aged, handicap people and caters the need of economically poor class of society.

It can be operated throughout the year free of cost. The most important feature of this E-Tricycle is that it does not consume valuable fossil fuels thereby saving crores of foreign currencies. It is eco-friendly & pollution free, as it does not have any emissions. Moreover, it is noiseless and can be recharged with the AC adapter in case of emergency and cloudy weather. The operating cost per kilometer is minimal, around Rs.0.70/km. It can be driven by manual pedaling in case of any problem with the solar system. It has fewer components, can be easily mounted or dismounted, thus needs less maintenance.

VI REFERENCE

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