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High Efficient Solar Grid System

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ABSTRACT

Generally solar panels are used to generate electricity by receiving light energy from the sun. In a conventional solar power system, parallel connections are made between two panels. In a parallel connection, current gets summed up and the voltage remains the same. During day time, the light intensity will be very less which is not sufficient to charge the battery because of the low voltage. At this time if series connections are made between the solar panels, the voltage gets summed up which is sufficient to charge the battery. Whenever the sun light falls on the solar panel, the electrical energy is produced. When the light intensity is less, there will be less voltage at the output of the panel which is not sufficient to charge the battery. If the output voltage is below the threshold value, the control unit sends a signal to the connection switching module to change the connection from parallel to series. Our project is to design a module which automatically switches the series and parallel connections of the solar panels based on the light intensity.

Keywords: Relay, MPPT, Microcontroller, Battery

I. INTRODUCTION

Solar photovoltaic (pv) modules generate electricity from sunlight, which can be fed into the mains electricity supply of a building or sold to the public electricity grid. Reducing the need for fossil fuel generation, the growing grid-connected solar PV sector across the globe is helping create jobs, enabling families and businesses to save money and cut greenhouse emissions.

PV modules use semiconductor materials to generate dc electricity from sunlight. A large area is needed to collect as much sunlight as possible, so the semiconductor is either made into thin, flat, crystalline cells, or deposited as a very thin continuous layer onto a support material. The cells are wired together and sealed into a weatherproof module with electrical connectors added.

II. METHODS AND MATERIAL

A. Existing Method

Solar power is the use of solar energy battery components directly into electrical energy. Solar Module (Solar cells) is the use of electronic characteristic of semiconductor materials to achieve solid PV conversion device.

Solar power generation system include: solar module (array), controller, batteries, inverters, lighting load that is composed of the user. Among them, the solar battery components and batteries for the power system, controller and inverter for the control and protection system, the load for the system terminals.

Single cell is a silicon diode, according to the electronic characteristic of semiconductor materials, when the sun light shines from the P-type and N-type conductivity of two different types of homogenous composition of semiconductor materials.

B. Proposed Method

To increase the efficiency and to reduce the power loss of the normal solar grid system, we propose a system by changing the series to parallel connections and vice versa of the solar plates automatically. Whenever the sun light falls on the solar panel, the electrical energy is produced. When the light intensity is less, there will be less voltage at the output of the panel which is not sufficient to charge the battery. If the output voltage is below the threshold value, the control unit sends a signal to the connection switching module to change the connection from parallel to series.

C. System Specifications

Hardware Requirements:
Solar Panel
Msp430(Controller)
Relay
Mppt
Voltage Divider

Software Requirements : Energia

Software Description:

Energia is an open-source electronics prototyping platform started by Robert Wessels in January of 2012 with the goal to bring the Wiring and Arduino framework to the Texas Instruments connector launch pad and MSP430 based Launch Pad. The Energia IDE is cross platform and supported on Mac OS, Windows and Linux. Energia includes an Integrated Development Environment (IDE) that is based on Processing.

The foundation of Energia and Arduino is the Wiring framework that is developed by Hernando Barragan. The framework is thoughtfully created with designers and artists in mind to encourage a community where both beginners and experts from around the world share ideas, knowledge and their collective experience. The Energia team adopts the philosophy of learning by doing and strives to make it easy to work directly with the hardware. Professional engineers, entrepreneurs, makers and students can all benefit from the ease of use Energia brings to the microcontrolle

Energia started out to bring the Wiring and Arduino framework to the Texas Instruments LaunchPad. Texas Instruments offers a connector launch pad TM4C1294X, MSP430,TM4C, C2000and CC3200 Launch Pad. The Launch Pad is a low-cost microcontroller board that is made by Texas Instruments.

D. Block Diagram

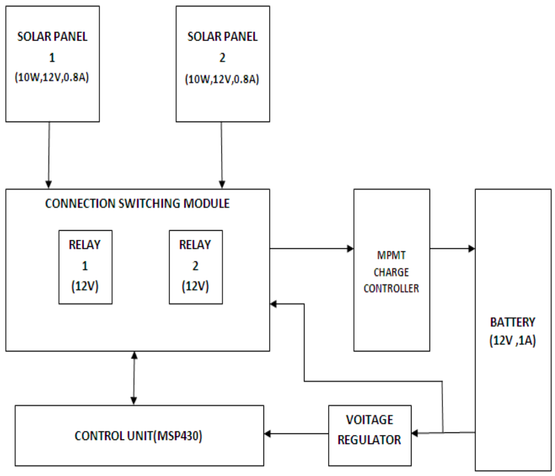

Figure 1. Block Diagram Description

Figure 2. Solar Panel

E. Theory and Construction

Solar 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 based on cadmium telluride or silicon. 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 solar modules are rigid, but semi-flexible ones are available, based on thin-film cells. These early solar modules were first used in space in 1958.

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]. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic modules use MC3 (older) or MC4 connectors to facilitate easy weatherproof connections to the rest of the system. The current and power output are approximately proportional to the sun's intensity. At a given intensity, a solar panel's output current and operating voltage are determined by the characteristics of the load. If that load is a battery, the battery's internal resistance will dictate the module's operating voltage.

A solar panel, which is rated at 17 volts will put out less than its rated power when used in a battery system. That's because the working voltage will be between 12 and 15 volts. Because wattage (or power) is the product of volts multiplied by the amps, the module output will be reduced. For example, a 50-watt solar panel working at 13.0 volts will products 39.0 watts (13.0 volts x 3.0 amps = 39.0 watts). This is important to remember when sizing a PV system.

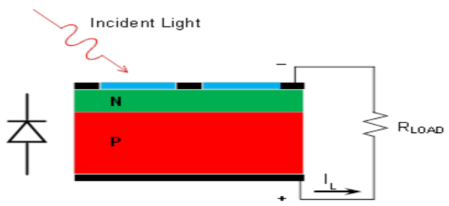

Figure 3. Construction of Solar Panel

EFFICIENCY

Solar cell efficiency may be broken down into reflectance efficiency, thermodynamic efficiency, charge carrier separation efficiency and conductive efficiency. The overall efficiency is the product of these individual metrics.

A solar cell has a voltage dependent efficiency curve, temperature coefficients, and allowable shadow angles.

Due to the difficulty in measuring these parameters directly, other parameters are substituted: thermodynamic efficiency, quantum efficiency, integrated quantum efficiency, V_{OC} ratio, and fill factor. Reflectance losses are a portion of quantum efficiency under "external quantum efficiency". Recombination losses make up another portion of quantum efficiency, V_{OC} ratio, and fill factor. Resistive losses are predominantly categorized under fill factor, but also make up minor portions of quantum efficiency, V_{OC} ratio.

I-V CHARACTERISTICS OF A SOLAR PANEL

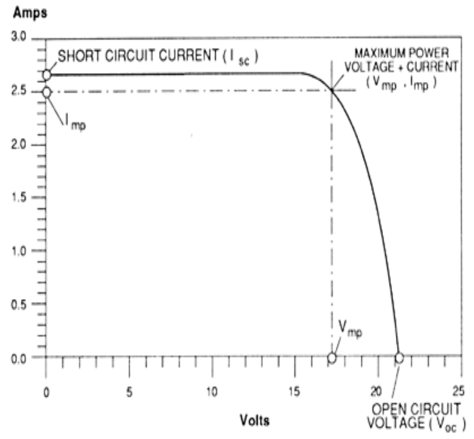

Figure 4. I-V Characteristics of A Solar Panel

F. MSP430 MICROCONTROLLER

DESCRIPTION

The Texas Instruments MSP430 family of ultra-low-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications.

The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 1 µs.

The MSP430G2x13 and MSP430G2x53 series are ultra-low-power mixed signal microcontrollers with built-in 16-bit timers, up to 24 I/O capacitive-touch enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. In addition the MSP430G2x53 family members have a 10-bit analog-to-digital (A/D) converter.

Typical applications include low-cost sensor systems that capture analog signals, convert them to digital values, and then process the data for display or for transmission to a host system.

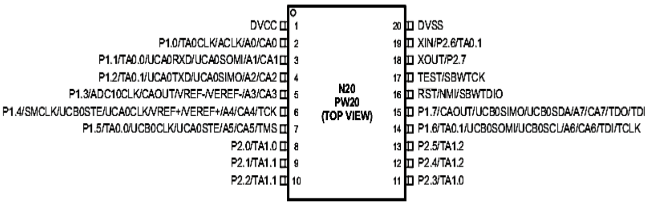

Figure 5. Pin Diagram of MSP 430

OPERATING MODES

The MSP430 has one active mode and five software selectable low-power modes of operation. An interrupt event can wake up the device from any of the low-power modes, service the request, and restore back to the low-power mode on return from the interrupt program.

The following six operating modes can be configured by software:

1. Active mode (AM)
– All clocks are active
2. Low-power mode 0 (LPM0)
– CPU is disabled
– ACLK and SMCLK remain active, MCLK is disabled
3. Low-power mode 1 (LPM1)
– CPU is disabled
– ACLK and SMCLK remain active, MCLK is disabled
– DCO's dc generator is disabled if DCO not used in active mode
4. Low-power mode 2 (LPM2)
– CPU is disabled
– MCLK and SMCLK are disabled
– DCO's dc generator remains enabled
– ACLK remains active
5. Low-power mode 3 (LPM3)
– CPU is disabled
– MCLK and SMCLK are disabled
– DCO's dc generator is disabled
– ACLK remains active
6. Low-power mode 4 (LPM4)
– CPU is disabled
– ACLK is disabled
– MCLK and SMCLK are disabled
– DCO's dc generator is disabled
– Crystal oscillator is stopped

FEATURES

1. Low Supply-Voltage Range: 1.8 V to 3.6 V
2. Ultra-Low Power Consumption
– Active Mode: 230 µA at 1 MHz, 2.2 V
– Standby Mode: 0.5 µA
– Off Mode (RAM Retention): 0.1 µA
3. Five Power-Saving Modes
4. Ultra-Fast Wake-Up from Standby Mode in Less Than 1 µs
5. 16-Bit RISC Architecture, 62.5-ns Instruction Cycle Time
6. Basic Clock Module Configurations
– Internal Frequencies up to 16 MHz With Four Calibrated Frequency
– Internal Very-Low-Power Low-Frequency (LF) Oscillator
– 32-kHz Crystal
– External Digital Clock Source
7. Two 16- Bit Timer A with Three Capture/Compare Registers
8. Up to 24 Capacitive- Touch Enabled I/O Pins

G. RELAY

DESCRIPTION

A **relay** is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contractor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic Latching Relays Magnetic Latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic Latching relays are useful in applications where interrupted power should not be able to transition the contact

Figure 6. RELAY

H. BASIC DESIGN AND OPERATION

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Such diodes were not widely used before the application of transistors as relay drivers, but soon became ubiquitous as early germanium transistors were easily destroyed by this surge. Some automotive relays include a diode inside the relay case.

If the relay is driving a large, or especially a reactive load, there may be a similar problem of surge currents around the relay output contacts. In this case a snubber circuit (a capacitor and resistor in series) across the contacts may absorb the surge. Suitably rated capacitors and the associated resistor are sold as a single packaged component for this commonplace use.

If the coil is designed to be energized with alternating current (AC), some method is used to split the flux into two out-of-phase components which add together, increasing the minimum pull on the armature during the AC cycle. Typically this is done with a small copper "shading ring" crimped around a portion of the core that creates the delayed, out-of-phase component, which holds the contacts during the zero crossings of the control voltage.

FEATURES

- Wide range of relay types and coil voltages.
- High reliability.
- High insulation.
- Choice of three types of contact material.
- Wide choice of contact configurations.
- Low power consumption.
- Low contact resistance.

- Compact design which can be panel, PC, or DIN rail mounted.
- Wide operating and storage temperatures.

I. MPPT

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that “physically moves” the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different.

Figure 7. MPPT

WORKING

The Power point tracker is a high frequency DC to DC converter. They take the DC input from the solar panels, change it to high frequency AC, and convert it back down to a different DC voltage and current to exactly match the panels to the batteries. MPPT's operate at very high audio frequencies, usually in the 20-80 kHz range. The advantage of high frequency circuits is that they can be designed with very high efficiency transformers and small components. The design of high frequency circuits can be very tricky because the problems with portions of the circuit "broadcasting" just like a radio transmitter and causing radio and TV interference. Noise isolation and suppression becomes very important.

There are a few non-digital (that is, linear) MPPT's charge controls around. These are much easier and cheaper to build and design than the digital ones. They do improve efficiency somewhat, but overall the efficiency can vary a lot - and we have seen a few lose their "tracking point" and actually get worse. That can happen occasionally if a cloud passed over the panel - the linear circuit searches for the next best point, but then gets too far out on the deep end to find it again when the sun comes out. Thankfully, not many of these around anymore.

The power point tracker (and all DC to DC converters) operates by taking the DC input current, changing it to AC, running through a transformer (usually a toroid, a doughnut looking transformer), and then rectifying it back to DC, followed by the output regulator. In most DC to DC converters, this is strictly an electronic process - no real smarts are involved except for some regulation of the output voltage. Charge controllers for solar panels need a lot more smarts as light and temperature conditions vary continuously all day long, and battery voltage changes.

J. VOLTAGE DIVIDER

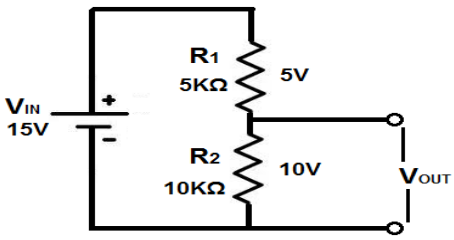

Figure 8. Voltage Divider Circuit

In electronics, a **voltage divider** (also known as a **potential divider**) is a passive linear circuit that produces an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). **Voltage division** is the result of distributing the input voltage among the components of the divider. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them.

Resistor voltage dividers are commonly used to create reference voltages, or to reduce the magnitude of a voltage so it can be measured, and may also be used as signal attenuators at low frequencies. For direct current and relatively low frequencies, a voltage divider may be sufficiently accurate if made only of resistors; where frequency response over a wide range is required (such as in an oscilloscope probe), a voltage divider may have capacitive elements added to compensate load capacitance. In electric power transmission, a capacitive voltage divider is used for measurement of high voltage.

General Equation

A voltage divider referenced to ground is created by connecting two electrical impedances in series. The input voltage is applied across the series impedances Z_1 and Z_2 and the output is the voltage across Z_2. Z_1 and Z_2 may be composed of any combination of elements such as resistors, inductors and capacitors.

If the current in the output wire is zero then the relationship between the input voltage, V_{in}, and the output voltage, V_{out} , is:

$$V_{\text{out}} = \frac{Z_2}{Z_1 + Z_2} \cdot V_{\text{in}}$$

Proof (using Ohm's Law):

$$V_{\text{in}} = I \cdot (Z_1 + Z_2)$$
$$V_{\text{out}} = I \cdot Z_2$$
$$I = \frac{V_{\text{in}}}{Z_1 + Z_2}$$
$$V_{\text{out}} = V_{\text{in}} \cdot \frac{Z_2}{Z_1 + Z_2}$$

The transfer function (also known as the divider's **voltage ratio**) of this circuit is:

$$H = \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{Z_2}{Z_1 + Z_2}$$

In general this transfer function is a complex, rational function of frequency

LOADING EFFECT

The output voltage of a voltage divider will vary according to the electric current it is supplying to its external electrical load. To obtain a sufficiently stable output voltage, the output current must either be stable or limited to an appropriately small percentage of the divider's input current. Load sensitivity can be decreased by reducing the impedance of the divider, though this increases the divider's quiescent input current and results in higher power consumption (and wasted heat) in the divider. Voltage regulators are often used in lieu of passive voltage dividers when it is necessary to accommodate high or fluctuating load currents.

K. BATTERY

An electric **battery** is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell has a positive terminal, or cathode, and a negative terminal, or anode. The terminal marked positive is at a higher electrical potential energy than is the terminal marked negative. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Although the term *battery* technically means a device with multiple cells, single cells are also popularly called batteries.

Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics.

III. RESULTS AND DISCUSSION

DESIGN

Batteries are typically made of six galvanic cells in a series circuit. Each cell provides 2.1 volts for a total of 12.6 volts at full charge .Each cell of a lead storage battery consists of alternate plates of lead (cathode) and lead coated with lead dioxide (anode) immersed in an electrolyte of sulfuric acid solution. A 12 V lead-storage battery consists of six cells, each producing approximately 2 V. The actual standard cell potential is obtained from the standard reduction potentials. This causes a chemical reaction that releases electrons, allowing them to flow through conductors to produce electricity. As the battery discharges, the acid of the electrolyte reacts with the materials of the plates, changing their surface to lead sulfate. When the battery is recharged, the chemical reaction is reversed: the lead sulfate reforms into lead dioxide. With the plates restored to their original condition, the process may be repeated.

Some vehicles use other starter batteries. The 2010 Porsche 911 GT3 RS has a lithium-ion battery as an option to save weight. Heavy vehicles may have two batteries in series for a 24V system or may have series-parallel groups of batteries supplying 24V.

Heat is the primary cause of battery failure as it accelerates corrosion inside the battery. A vehicle with a flat battery can be jump started by the battery of another vehicle or by a portable battery booster, after which a running engine will continue to charge the battery but it is preferable to use a battery charger. Corrosion at the battery terminals can cause electrical resistance, which can be prevented by the proper application of dielectric grease. Salvation occurs when a battery is not fully charged and remains discharged.

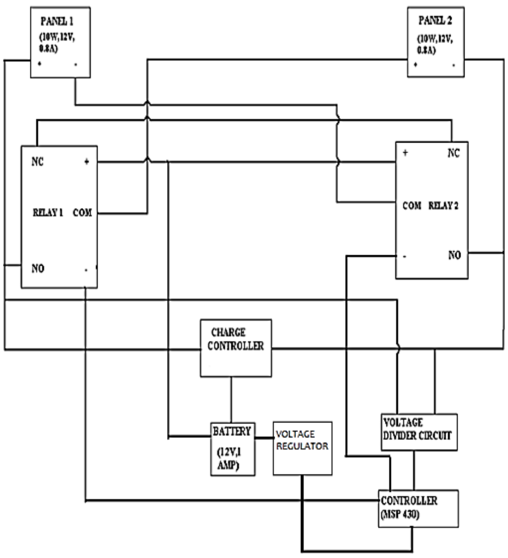

Figure 9. Circuit Diagram

HARDWARE IMAGES

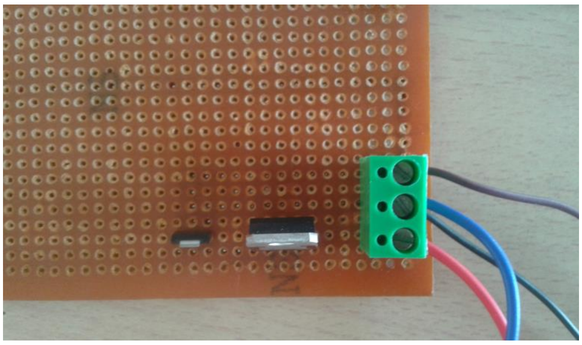

Figure 10. 3.3 v and 5v power supply unit.

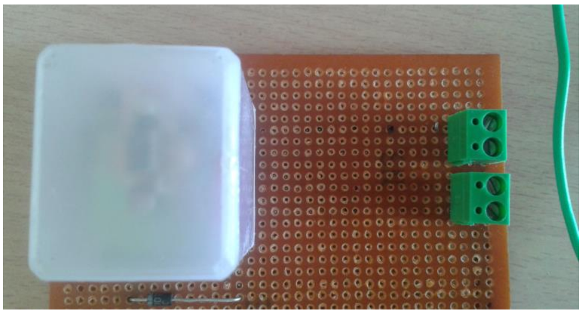

Figure 11. Relay switching unit (to switch the connection from parallel to series and vice versa).

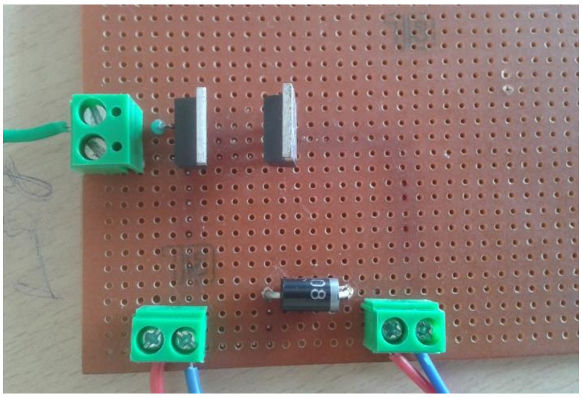

Figure 12. MPPT charge controller unit(to maintain voltage level to battery).

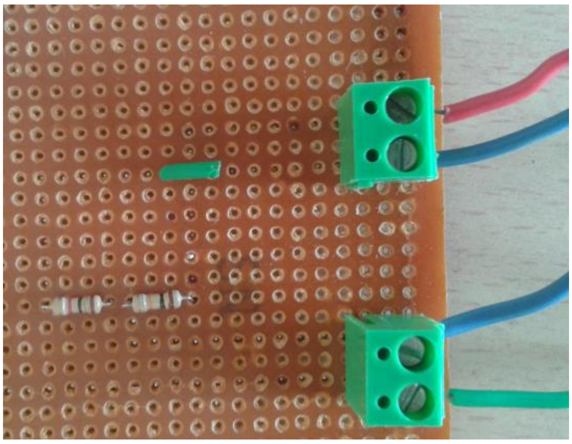

Figure 13. Voltage Divider Unit

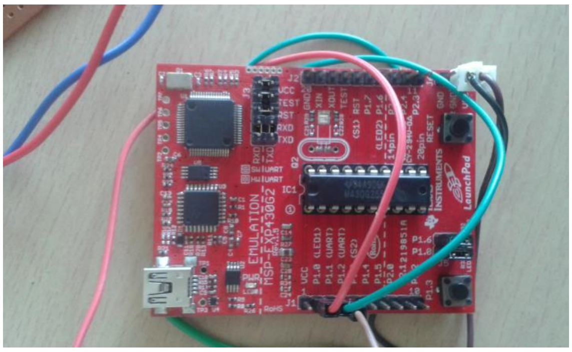

Figure 14. Microcontroller unit(Msp430)

IV. CONCLUSION

To increase the efficiency and to reduce the power loss of the normal solar grid system, we propose a system by changing the series to parallel connections and vice versa of the solar plates automatically. Whenever the sun light falls on the solar panel, the electrical energy is produced. When the light intensity is less, there will be less voltage at the output of the panel which is not sufficient to charge the battery. If the output voltage is below the threshold value, the control unit sends a signal to the connection switching module to change the connection from parallel to series

V. ACKNOWLEDGEMENT

We thank Dr S. Muthukrishnan Ph.D.,our project guide for helping and guiding us throughout the entire project and also providing us information about the statistical reports.

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