Design And Construction Of Microcontroller Based Solar Battery Charger

Zar Ni Tun, Aye Thin Naing, Hla Myo Tun

Abstract: This research paper describes a microcontroller based battery charger by using solar energy. Solar-powered charging systems are already available in rural as well as urban areas. Solar energy is widely used around the worldwide. This system converts solar energy to electrical energy and stores it in a battery. Photovoltaic panel is used to convert solar energy to electrical energy and stored in a 12V battery. Battery is the main component in solar charging system to store the energy generated from sunlight for various application. This system requires sensor to sense whether the battery is fully charged or not. Microcontroller is the heart of the circuit. Lead-acid batteries are the most commonly used power source for many applications. This system consists of voltage sensing, charging, controlling and display unit.

Keywords: Solar panel, switch, microcontroller, battery.

I. INTRODUCTION

Solar energy is renewable energy. Solar energy can be used to generate power in two-ways: solar thermal conversion and solar electric (PV) conversion. PV sources are used in many applications such as battery charging, water pumping, home power supply and swimming-pool heating system. The aim of this paper is to design and construct a microcontroller based battery charger by using solar energy. It includes battery charger, microcontroller, switch, energy source, voltage sensor. Battery charging system is included monitor and control functions. Solar battery charging system is depend on the functionality of the monitor and control functions. Battery life time is reduced if there is low photovoltaic energy available for longer period or improper charging. The microcontroller is used to monitor the output V of solar panel and the battery voltage with the help of an analog-to-digital converter (ADC). The microcontroller needs to know the presence of the solar panel voltage to decide whether the battery should be charging or discharging. The microcontroller prevents the battery from being damage. Voltage sensor circuit is built using a potential divider for sensing solar V and battery V. This system is capable of charging a 12V battery using 35W solar panel.The control function act on the charging and discharging of the battery on the basis of these measure. The microcontroller will be programmed to control and display the battery level of the system. The system status and battery voltage are displayed on an LCD based on microcontroller. LCD is used to display the charging state of this system.

II. BLOCK DIAGRAM

The block diagram of battery charging system is shown in Figure 1. It consists of microcontroller, switching system, input sensors, battery and LCD display. The solar panel is used to convert solar energy to electrical energy.The solar panel is used to charge a 12V battery. The nominal voltage of the solar panel is 14V. Battery is used to store the energy from the output of solar panel. Voltage sensors are used to monitor the solar voltage and battery voltage. MOSFET is used as a switching device. Switching off the MOSFET is controlled by the controller. Switching circuit is used to prevent the battery from being overcharged. Microcontroller is the main part of the system.The microcontroller reads the solar voltage and battery voltage and then determines battery needs to be stopped from charging. LCD is used to display the state of the system. The solar voltage and battery voltage are displayed on the LCD based on microcontroller.

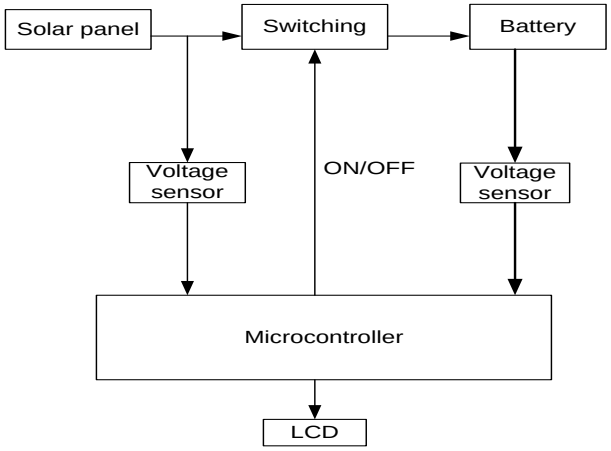

Fig 1. *Block diagram of solar battery charger*

Solar Panel

The solar panel is used to convert solar energy to electrical energy. Solar energy is being used around the world. Solar panel is connected in either series or parallel to achieve the desire output voltage and current. Three types of solar panels are Monocrystalline (single silicon), Polycrystalline (Multi-silicon), Amorphous thin-flim. Crystalline solar cells are wired in series to produce solar panels. Monocrystalline solar panels are more efficient than polycrystalline but also the most expensive. The efficiency of amorphous solar panel is not as high as crystralline solar panel. The solar panel is used to charge a 12V battery. The peak output voltage of solar panel is 20V. A typical 12V panel will contain 36 cells. Photovoltaic cells combine to make solar panel, solar module or PV array. Photovoltaic solar panel is used to absorb current and voltage depends on light intensity.

Battery

Battery capacity (C) is expressed in Amp-hours or mA-hours. Battery charge and discharge currents are expressed in terms of “C-Rate”. The solar energy is converted into electrical energy and stored in a 12V battery. The efficiency of battery charging system is to store the energy from solar panel.The main two types of batteries are rechargeable and disposable.

The most popular types of rechargeable batteries in use today are the Sealed-Lead-Acid (SLA), Nickel-Cadmium (NiCd), Nickel-Metal-Hydride (NiMH), and Lithium-Ion (Li-Ion). Weight, capacity, and cost are the primary consideration in battery equipment. Lead-acid battery is used in this system because it is inexpensive and high capacitied. The 12V of lead-acid battery has 6 cells. It is safe to charge most of lead-acid batteries by current up to 0.1C rate, where C is the battery capacity in Ah. Overcharging battery can cause reduce battery life span.

Microcontroller

The microcontroller is used for development of this project. The microcontroller prevents the battery from being damaged by controlling a switch. The microcontroller in the circuit will read the voltage of solar panel and the voltage of battery. Microcontroller gets 5V power from 7805 voltage regulator which is derived from the battery. The 3-terminal positive V regulator provides a constant V output of 5V. The purpose of voltage regulator is used to feed 5v to the microcontroller.The microcontroller PIC18F4550 is used to control the system. The PIC18F series of microcontrollers have more memory, higher speed and enhanced I/O port architecture. PIC18F4550 controller is selected as a control function.

-It has many features
-High speed of operation
-It has 2 CCP/ PWM codes
-It has 13 channels 10-bit ADC
-Operating voltage is 2 to 5.5 V
-256 bytes of EEPROM data memory
-2048 bytes RAM data memory
-40MHz crystal is used the basic clock frequency

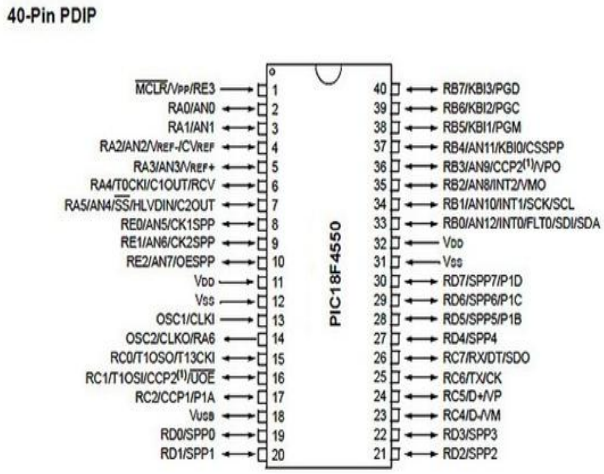

Fig 2. *PIC18f4550 pin configuration*

III. SWITCHING CIRCUIT

MOSFET is used as a switching device because it has fast switching speed and low voltage drop. MOSFET is a voltage-controlled device. It operates in two modes-enhanced mode and depletion mode. IRF9540 MOSFET is used as a switch because it is easy to use and has faster switching speed. In the hardware circuit transistor is used to switch the mosfet from microcontroller. A MOSFET and transistor combination is used for the switching purpose between solar panel and battery.

PIN	Description
1	Gate
2	Source
3	Drain

IV. VOLTAGE DETECTION

The voltage sensor is used to sense the solar voltage and battery voltage. Voltage divider is used as a voltage sensor. The resistors are used for the voltage divider network. Solar voltage and battery voltage is reduced to less than 5V by potential divider because the microcontroller cannot sense the voltage greater than 5V.

V. METHODOLOGY

Microcontroller is used to control the charging system. The functions of microcontroller

- Measure the voltage of solar panel
- Measure the voltage of battery
- Microcontroller control switching device by sensing the voltage of panel and the voltage of battery
- Decide when to stop battery charging

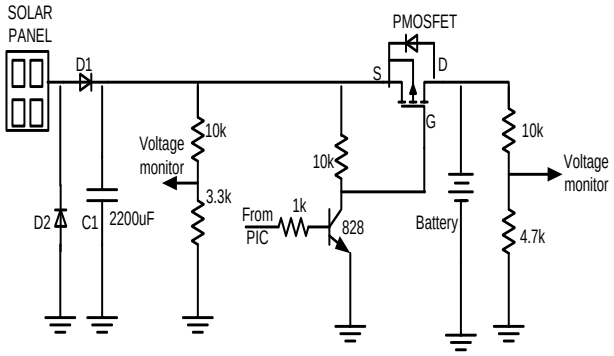

Fig 3. *The circuit diagram of battery charger*

The whole circuit shown above is divided into 4 parts

1. Voltage sensing
2. MOSFET switching and driver
3. Filter and protection
4. Display function

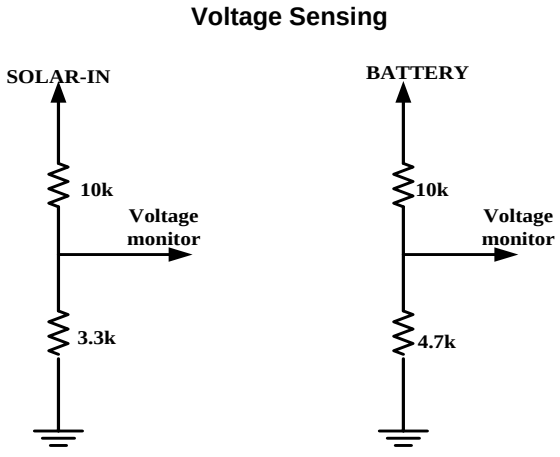

Fig 4. *Circuit diagram of voltage divider*

Voltage divider is used as a voltage sensor. The microcontroller cannot sense the V greater than 5V. So, the solar V and battery V is reduced to less than 5V by a voltage divider and then microcontroller sense this voltage. The resistors used for the voltage from the solar panel are 10k and 3.3k and the voltage from the battery are 10k and 4.7k.

For **" Solar –volt"**
Let R_1=10k and R_2=3.3k
$V_{out} = R_2 / (R_1+R_2)*V$
Maximum solar panel voltage is 20V
Solar-volt = 3.3k / (10k+3.3k)*20
= 4.9V

For **" Bat-volt"**
Let R_3=10k and R_4=4.7k
The battery voltage is 12V
Bat-volt= 4.7k / (10k+4.7k)*12
= 3.8V
Both the voltages from voltage dividers are lower than 5V and suitable for microcontroller.

MOSFET switching and driver
MOSFET is used for controlling the power flow from solar panel to the battery. MOSFET has high switching speed, high input impedance and is ideal for battery charger. This device has low voltage drop than BJT (bipolar junction transistor). P-channel MOSFET (IRF9540) is used for switching between solar panel and battery. MOSFET is controlled by the microcontroller. A MOSFET and transistor combination is used for the switching purpose between solar panel and battery.

Filter and protection
The capacitor (C1) is used after the solar panel at the input side as a filer which removes any unwanted ripple voltage. 2200uF, 35V capacitor is used as a filter. 0.1uF disc capacitor is used in the load side. Ziner diode is used to protect over voltage. A diode is required to prevent reverse current flowing from battery to the power source. Power is coming from the solar panel through diode (D1). A ziner diode (D2) is used at the input terminal to take off the over voltage.

Display function
A 20×4 LCD is used for monitoring the voltage of solar panel and the voltage of battery. The system status and battery voltage are displayed on an LCD based on microcontroller. When solar panel voltage is present, the sensor provides a signal to the microcontroller and then displays solar voltage on the LCD. When the voltage of battery reaches 13.5V, the microcontroller interrupts the charging voltage and display "charging off" on an LCD.

Fig 5. *20×4 LCD display*

VI. REQUIRED COMPONENTS OF THE SYSTEM

1. A 35W solar panel
2. A 12V battery
3. A PIC microcontroller
4. MOSFET
5. LCD

VII. CIRCUIT OPERATION

Solar panel converts solar energy to electrical energy and stores it in a battery. The solar panel output is connected to the battery. The microcontroller reads the solar voltage and battery voltage with the help of the ADC and displays the values on the LCD. MOSFET is used for switching between solar panel and battery. The voltage is applied at the gate, the battery ground is applied at the drain and the panel ground is at the source. Voltage divider is used as a voltage sensor networks. The output from the voltage divider goes to analog pin of microcontroller.The circuit for solar battery charger is microcontroller based and controls the mosfet switching. When MOSFET is on, the power coming from the solar panel to the battery. This circuit is simple to implement for battery charger.

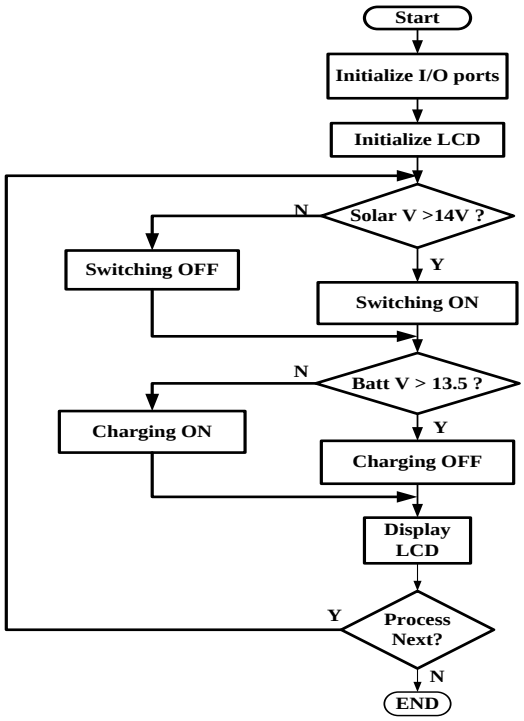

Fig 6. *Flow-chart of battery charging system*

At first, controller will check the solar panel voltage. If solar voltage is greater than battery voltage, the MOSFET is on to charge the battery. Then microcontroller is checked the battery is full-charged or not. When battery voltage reaches 13.5V, the microcontroller interrupts the charging voltage flowing from solar panel to the battery. LCD is used to display the charging state of this system.

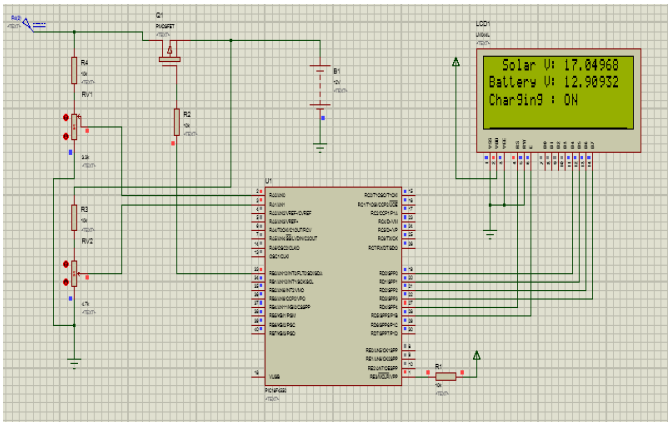

Fig 7.*Simulation test for charging on when the battery is not full*

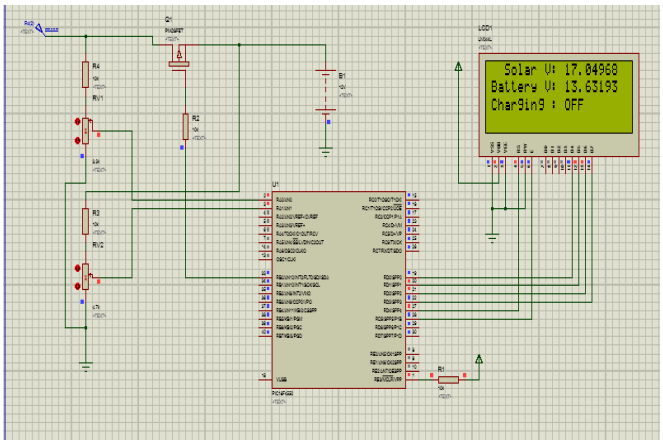

Fig 8. *Simulation test for charging off when the battery is full*

VIII. CONCLUSION

The microcontroller based solar battery charger is presented in this paper. Solar energy is used as a source of power for charging battery. Battery is used to store energy from solar panel. The stored energy is utilized in various applications. The microcontroller is used to measure the voltage and switching off the battery. The microcontroller is the main part of battery charger. This circuit design is suitable for a single battery charger.

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