Design and Development of Microcontroller Based Solar Charge Controller

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Abstract—Solar Energy- the ultimate and future source of energy is getting its importance day by day and will become the most prime important source of energy for mankind in the near future. Solar powered equipment and applications are gradually getting its way into the various sector of our day to day life. We need a storage or battery to store the solar energy which was harnessed during the day time and to supply power or energy when the sunlight is not available. Smart Solar Charge Controller which is part of solar power system is designed such that the solar battery gets recharged quickly and does not get over discharged thereby ensuring the prolonged lifespan of the solar battery. Once it reaches fully charged condition, a logic system in the charger will keep the battery on trickle charge. The charge controller will have smart battery management system in built. The charge controller will also take care of the deep discharge protection and cut off the load when the battery reaches a certain level when discharged.

Keywords—Charge controller, Battery, Solar panel, Microcontroller, trickle charge.

I. INTRODUCTION

Fossil fuels reserves are diminishing rapidly across the world, due to increased demand, the stress over the existing reserves are intensifies. Nevertheless, fossil fuel contributes 80% of world primary energy which is an enormous impact on environment. Again our environment is affected by production of greenhouse gas emissions which is driven by human activities which has major role leading to climatic changes. Energy is also responsible for producing environmentally harmful substances during its production, distribution and consumption. For the sustainability of modern societies a secure and accessible supply of energy is thus crucial. To meet the present and projected world demand switching of energy system from conventional to renewables is an urgent need. Among the renewable sources of energy solar energy is one of the most promising renewables as it is reliable and less vulnerable to changes in seasonal weather patterns.

Solar Charge Controller act as the central control unit regulating the overall energy flow within Solar Home System and some photovoltaic hybrid system.

A solar charge controller or regulator is a small box consisting of solid state circuits PCB which is placed between a solar panel and a battery. The main function is to regulate the amount of charge coming from the panel that flows into the battery bank in order to avoid the batteries being overcharged.

Solar charge controller has three basic functions:

1. To limit the voltage from the solar panel and regulate the same so as not to overcharge the battery.
2. Do not allow the battery to get into deep discharge mode while dc loads are used.
3. To allow different dc loads to be used and supply appropriate voltage.

II. BLOCK DIAGRAM OF THE PROPOSED SOLAR SYSTEM

![Block Diagram of the proposed system.](image-url)
III. BASIC DESCRIPTION OF SOLAR POWER SYSTEM

A. Solar Panel Basic

A Solar cell or photovoltaic cell is a device that converts light directly into electricity by the photovoltaic effect. Photovoltaic cells combined together to make solar panels, solar modules, or photovoltaic arrays. The solar panel used here is meant to charge a 12V battery and the wattage can range from 200W-500W. Solar cells are usually made from silicon, the same material that is used for making transistors and integrated circuits. In order to generate electric current the silicon is doped or treated so that when light strikes it electrons are released. Types of Solar panels or PV modules: crystalline (monocrystalline and polycrystalline) and amorphous. Crystalline solar cells are wired in series to produce solar panels. To charge a 12V battery 36 cells are required to produce an open circuit voltage of about 20Volts as each cell produces a voltage of between 0.5V-0.6V. Monocrystalline are more efficient than polycrystalline but also the most expensive. Amorphous or Thin film-technology is most often seen in small solar panel, such as in calculators or garden lamps. The efficiency of amorphous solar panel is not as high as crystalline solar cells and it is less expensive.

Photovoltaic Module Specifications
1. Output Power-Pmax (Watts) – 250wp + 3%
2. Nominal Voltage (Vmp) – 36.00V
3. Nominal Current (Imp) – 6.94A
4. Open-Circuit Voltage (Voc) – 43.78V
5. Short-Circuit Current (Isc) – 7.20A
6. Efficiency – 15.26%

B. Charge Controller Basic

A charge controller or regulator is a small box consisting of solid state circuits PCB which is placed between a solar panel and a battery. The main function is to regulate the amount of charge coming from the panel that flows into the battery bank in order to avoid the batteries being overcharged. Solar charge controller has three basic function:
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Types of Charge Controller

Commonly used charge controllers are namely:
1. Series charge regulators
2. Shunt charge regulators
3. DC-DC converter

Various types of charge controllers are available. Analog type charge controllers include operational amplifiers which indicate the battery status by glowing the LED. The status of battery can be known by LED. ON/OFF charge controllers simply make ON and OFF the controlling element like MOSFET so that either full or no current will be passed to the battery.

PWM (pulse-width modulated) charge controllers which charge the battery with constant voltage or constant current are also being used. They have a power device like MOSFET which is made ON and OFF. The efficiency of PWM charge controllers is higher than Analog and simple ON/OFF charge controllers. PWM have ability to recover battery capacity, to increase charge acceptance of the battery. The PWM based charge controllers extends the life of the battery and saves the cost by reducing size.

The MPPT types are newly introduced and are latest trend in market. They are more costly and better suited to large systems, when the investment in an expensive MPPT regulator gives quick returns. The MPPT charge controllers charges the battery at full power by maintaining efficiency of 90% to 93%. Among all discussed charge controllers in this report, the MPPTs provide excellent efficiency however they are costly.

C. Battery

The proposed solar charging application require a deep cycle battery. Deep cycle batteries have larger plates and different chemistry to avoid the corrosive effect of frequently using the full capacity. The solar energy is converted into electrical energy and stored in a lead-acid battery. The ampere-hour is the rated capacity of the battery. There are a few types of lead acid deep cycle batteries:

Flooded: Flooded batteries have the advantage of being significantly less expensive, but they require adequate ventilation, maintenance, and also have the potential liability of tipping or spilling.

Sealed gelled: gel batteries need to be recharged in a specific way that is not optimal for solar.

Sealed AGM: AGM batteries are typically lighter and less expensive per amp-hour compared to gel.
If lead acid batteries are maintained properly, they will function at 80-90% efficiency. To extend the life of the battery and maintain efficiency it is important to maintain a full charge under most condition. Hence the use of a charge controller with solar panels to charge, so they don’t over charge the battery or apply the wrong voltage.

The advent of pulse width modulated controller made possible the efficient three stage charging or trickle charging from a PV array. This system charges batteries with high frequency electrical pulses, and by varying this pulses the amperage being delivered can be continuously changed. When the batteries are discharged the PWM senses this from the battery bank voltage and stays on to deliver full current and this stage is called bulk stage of charging. The next stage of charging is absorption and occurs as the batteries approach a full state of charge (SOC). The controller holds battery bank voltage constant for a period of time and the “off” time of the pulses is increased to gradually reduce current as the bank is topped off. The float charging stage occurs when the batteries are full and is also called the trickle charging.

D. Microcontroller

The PIC16F876A is a powerful yet easy to program CMOS FLASH-based 8-bit microcontroller. PIC16F876A has the following on-chip facilities:

- 28 Pin package,
- 256 bytes of EEPROM data memory
- 2 pwm functions and 5 channel 10-bit adc
- In-circuit debugger, Self programming
- Operating voltage range: 2v to 5.5v.

MOSFET: In this project switch would be a MOSFET. MOSFETS are by far the most popular transistors used for switching in circuits today. It is used for voltage controlled. Therefore, they require less power to drive them, so they are preferred choice.

E. Software Flowchart

F. Requirement of the System Proposed

1. A 200W~500W PV module input.
2. A 12V battery
3. A PIC microcontroller
4. MOSFET
5. DC LOAD
6. LED as function indicators:
   a. charging and charge full indication
   b. Battery voltage level indicator.
   c. Reverse terminal connection indication.
IV. CONCLUSION

In this paper a low cost high performance microcontroller based solar charge controller has been proposed. The proposed system used solar PV module as the input and DC load as the output. The proposed system has an upgrade option to control normal UPS, when connected with the solar charger will convert to SOLAR INVERTER/UPS with solar charge as priority.

REFERENCES


