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Cost Effective Solar Charge Controller UsingMicrocontroller

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Cost Effective Solar Charge Controller Using Microcontroller

Abstract — *In this study, a low-priced Solar Charge Controller (SCC) was developed with the help of a Programmable Intelligent Controller (PIC). Design specifications for building an SCC out of a crystal oscillator, an optocoupler, some ceramic resistors, some LC filters, and a metal-oxide-semiconductor field-effect transistor are provided. The PIC microcontroller's source code is written in C for precise and effective automated disconnection and rejoining. Battery and solar cell may be physically separated during overcharging and rejoined during under draining. According to the over current and under flow current limit, the loads may be cut off. Overcurrent and undercurrent may also trigger a load disconnect. The microcontroller-based suggested charge controller has a liquid crystal display (LCD) for visualizing data such as the charging state of the battery and the amount of current flowing from the solar panel to the load. Our suggested smart solar charge controller is more cost-effective and operates as intended, as seen by its manufacture and use.1*

KEYWORDS; Synchronous synchronous rectifier, microcontroller, optocoupler, crystal oscillator, metal oxide semiconductor field effect transistor.

INTRODUCTION

Existing power plants and generators rely heavily on bio-fuel [1]. However, the bio-fuel stock is very small and will be depleted in the near future [2], making bio-fuel-based power production unsustainable [3]. That is why we are investing heavily in alternative sources of power like wind, tidal, solar, etc. Since we are now interested in renewable energy, we decided to learn about and make some little contributions in the industry by working on a solar charge controller.

Solar power is the most practical alternative energy source currently available. We have an issue with optimizing our country's limited energy resources, and solar power may help.

The current daily demand for power is over 5900MW, whereas our production is just approximately 5200MW [4]. Therefore, we must go elsewhere for our power needs (maybe solar energy or a new power plant). So many people live in Bangladesh.

There are many non-governmental organizations (NGOs) and government organizations (GOs) that provide solar energy and power systems (including solar panels, batteries, and inverters) to rural areas where no electricity connection has been established. However, the solar charge controller is not included in the kit due to its high price and complexity of usage (with the exception of urban areas). However, the poor people in rural regions who have adopted this solar system would feel the effects of this deficit. After a few days, they notice battery issues, likely caused by improper charging and draining. Because of this issue, batteries only last a few days before dying and must be replaced. A new battery costs more than the solar charge controller (SCC) device we suggested, thus increasing the burden on the impoverished rural population. In light of the current state of electricity in Bangladesh, this SCC model was developed and implemented to improve the country's solar power and energy infrastructure.

The transfer of energy from a solar array to a battery or another load is regulated by a microcontroller in a device known as a solar charge controller (SCC) [5]. This ensures that natural energy is used in an efficient manner and that overcharging, rapid charging/discharging, and reverse charging are all prevented. Current measurement is a novel component of our study.

When it comes to managing the solar power used to charge a battery and the system as a whole, many kinds of solar charge controllers have emerged on international markets. In developing nations like Bangladesh, particularly in rural regions, the cost of these SCC is prohibitive. However, solar cells and batteries are relatively costly. Since SCC is costly, it might be difficult for customers in rural locations to justify adding it to their solar energy system. The SCC extends the battery's useful life.

A high-tech solar charge controller was developed to lower the price of SCCs so that they may be made accessible to customers in rural areas. This SCC has a low material cost and is easy to build. Additionally, the operational procedure is straightforward, low-maintenance, and, most importantly, user-friendly. The proposed SCC includes a micro-controller, a crystal oscillator, and a voltage regulator. It regulates solar panel charging of battery based on voltage level at battery terminal, which is adjusted by micro-controller, and therefore extends battery life. It may also prevent the battery from being completely discharged by cutting off power to the load when the battery voltage exceeds a certain threshold. Our goal is to Please provide a low-cost SCC that enhances the performance of the current solar charges controller hardware and the solar system's battery life. The charging and draining of the battery may be precisely regulated, and the SCC can meet practically all conditions necessary for the efficient functioning of the solar energy system.

THEORY AND CONTEXT

In this part, we'll go through all the specifics of how to be ready for your An integral part of any solar power system is the battery. One or more electrochemical cells store chemical energy and release it as electricity in a battery [6]. Since their discovery, batteries have spread around the world to become a reliable source of energy for many uses at home and in industry. Primary batteries (disposable batteries) are intended to be used just once and thrown away once they're dead; secondary batteries (rechargeable batteries) are intended to be charged and used again and again. When compared to primary batteries, secondary batteries provide more efficiency and are thus more widely used. Solar panel power systems rely heavily on auxiliary batteries for charging and discharging functions. Their capacity to produce strong surge currents means the cells retain a reasonably big power-to-weight ratio, despite their poor energy-to-weight and energy-to-volume ratios. These qualities, in addition to their cheap price, make them desirable for use in automobiles to provide the high current needed by automotive starting motors and solar power systems. Because of internal chemical processes, battery capacity varies with discharge circumstances such current (which may fluctuate over time), terminal voltage (within limits), temperature, and more [7]. A battery's usable capacity drops as its discharge rate increases [8]. Discharging a battery quickly can reduce its capacity more than you would think. Lead-acid batteries can have their charging rates sped up with a little fiddling [9]. Capacity ratings for batteries are typically calculated by taking the maximum continuous current that a brand new battery can deliver for 20 hours at 68 F° (20 C°) and multiplying it by 20. This is done until the battery reaches a set terminal voltage per cell. At room temperature, a battery with a 100Ah rating will provide 5A for 20 hours. Discharging it at 50A, however, will reduce its perceived capacity [10]. The battery's internal self-discharge must be accounted for when the current drawn is little. The efficiency of a battery changes when its discharge rate changes because of internal energy losses and the slow diffusion of ions in a realistic battery's electrolyte. However, if the rate is too low, the battery will self-discharge throughout the extended duration of operation, reducing its efficiency once again. [10] Batteries release their energy more effectively when discharged at low rates than at higher rates. When compared to disposable alkaline batteries, particularly LEAD-based ones, rechargeables have a far faster rate of self-discharge.

VII. batteries; a newly charged $PbSO_4$ will discharge at a rate of roughly 10% each month [11] after losing 10% of its charge in the first 24 hours. While charging may replenish a rechargeable battery's energy levels, the batteries do suffer some wear and tear with each use. The number of cycles a lead-acid battery may go through before the internal resistance becomes unusable is specified. As this resistance grows over time, the rated cycle rate drops, reducing the lifetime. Fast charging, as opposed to a leisurely overnight charge, will often reduce battery life [12]. Overcharging is also harmful to the battery, thus it's important that the overnight charger be "smart" enough to determine when the battery is completely charged [13]. As electrolyte moves away from the electrodes or as active material detaches from the electrodes, degradation occurs. The disadvantage of lead-acid batteries is that they need to be completely drained before being recharged. Crystals may form on the electrodes if the battery isn't fully discharged, reducing the active surface area and raising the internal resistance. Because of this, battery life is shortened and the "memory effect" is triggered. Shorts may also be caused when these electrode crystals break through the electrolyte separator. Although they have a chemical composition, lead-acid does not experience the same level of memory impact. At the conclusion of its useful life, a battery's capacity will diminish rather than disappear immediately [14]. A lead-acid battery's internal resistance can cause heat and damage when recharged if it has been depleted to less than 20% of its full capacity [15]. Controlling the cover charge of batteries, which inhibits chemical processes in the cell, is one way to increase battery life. The lifespan of these batteries may be prolonged by roughly 5% with the use of such storage [16]. Batteries need to be stopped to store charge in order to reach their maximum voltage. Therefore, because of these limitations and the process of extending the life of batteries like lead-acid batteries, correct use of SCC may significantly increase battery life expectancy Here, the charging rate of the battery is regulated to be neither too fast nor too sluggish. No less than a 50% discharge is guaranteed. The microcontroller is programmed to know when to begin charging and when to stop receiving power from the solar panel. This suggested SCC may change the load according on the battery's charge and discharge, allowing for more efficient operation.

X. STRUCTURE OF THE SYSTEM *Instrument of Command*

A. *Microcontroller PIC16F876a is shown in Figure 1 regulating the functions of several solar system parts. In this case, the microcontroller sets up bidirectional control. It's linked to the solar and battery systems.   and the load required to regulate the*

B.

C. *procedure. The above image shows the project's overarching theme diagram. Every current solar*

D.

E.

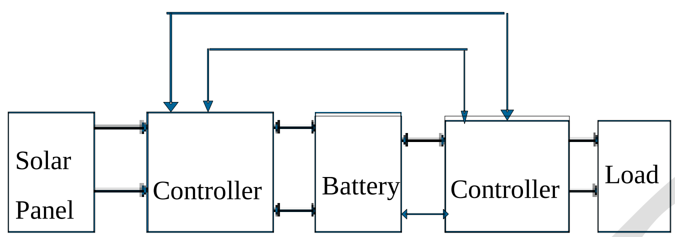


Fig. 1. Manage several parts of the solar system.

The microprocessor keeps tabs on the battery and other components. This microcontroller is the only source of control. The microcontroller only acts in accordance with the pre-installed software. To improve battery performance, this software was built on the basis of theoretical concepts. This is a summary of the important ideas in entire process and controlling:

(i) The controller initiates charging if the battery voltage is below 10V.

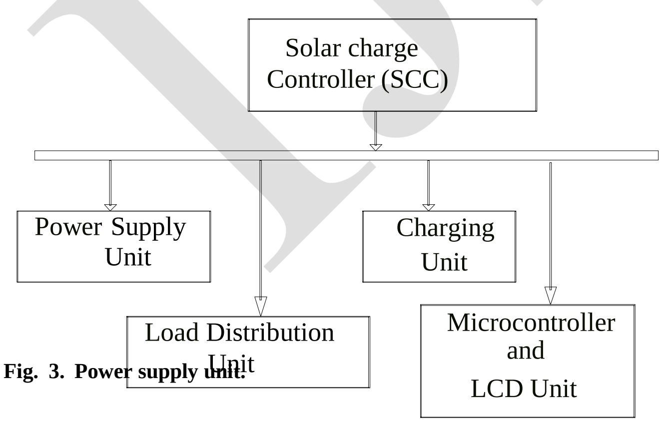
(ii) The load is removed from the battery (for a 12V load) if the battery voltage drops below 12V.

If the battery voltage is over 15V, the controller will stop the charging process.

For a 12V load, the battery may be connected properly if its voltage is more than or equal to 12V.

Our Solar Charge Controller's Functional Building Blocks There are four main building pieces that may be used to explain the whole procedure. The four-block related circuit diagram makes it simple to grasp the whole system's functioning, from the first to the final step, as well as all of the stages inside the system itself. As a result, the following four sections constitute the Solar Charge Controller (SCC): Microcontroller and LCD unit; Charging unit; Load distribution unit; Power supply unit

Fig. 2. Basic block of SCC.



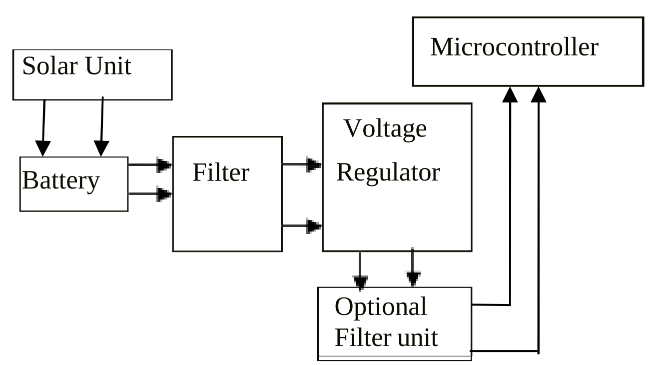


Fig. 3. Power supply unit.

a) Source of electric power

The following block diagram and associated circuit are used to describe the power supply element of the overall process. Diodes, ceramic resistors, an inductive coil, capacitors of varying values, and a voltage regulator are just some of the components needed to build this power supply unit. We utilized energy from the sun to power this circuit. Solar energy is used to power two Diodes. When the battery's potential is lower than the solar panel's, the two diodes prevent energy from flowing backwards from the battery to the solar panel at night. The two ceramic resistors are wired to the output of the diodes. The positive terminal of the battery is linked to these two resistors. The inductive coil was then attached to the battery's positive terminal. The voltage regulator is safeguarded by connecting the other end of the coil to a Diode, which is in turn linked to the regulator's input. The voltage regulator provides the constant 5V required by the circuit. Optional filtering units may be placed after the voltage regulator to further clean up the signal. The microcontroller receives a clean 5V signal from this circuit.

c) Load-sharing module

The following blocks and circuit diagrams depict the regulated load distribution and its accompanying apparatus. All of the loads' positive terminals are linked to the battery's positive terminal, starting with the first. The following figure illustrates the establishment of the (-)ve switching.

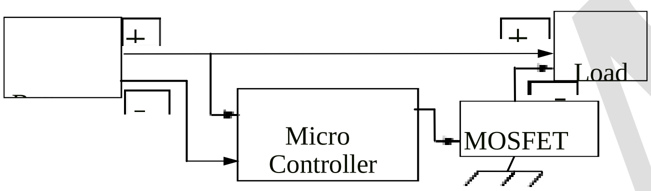


Fig. Fourth, a load-sharing mechanism.

The battery's positive terminal is wired in series with the load's positive terminal. We utilize a microcontroller and a MOSFET to set up and regulate the load functioning. The microcontroller's logic is baked into the device, thus it must be linked to the battery's positive end and its status signal. If everything checks out, the microprocessor will activate the MOSFET. This MOSFET will now establish negative switching with the load, which will help keep the circuit cooler. As a result, the circuit is completed. In this manner, the load procedure is completed successfully.

a) Power supply module

Here, a block diagram and circuit illustration demonstrate how solar energy may be used to charge a battery. Costs are determined by the

microcontroller with a MOSFET switch. The idea of a negative switch is also used here. Fig. 5 shows the charging module.

The positive solar terminal is linked to the positive battery terminal. The microcontroller receives the whole solar and battery status and compares it to the logic programmed into it. If everything checks out, the microcontroller will tell the optocoupler to set up a MOSFET switch between the solar array's (+)ve and (-)ve terminals. The battery then receives electricity or a charge once the circuit is closed. The microcontroller will transmit a signal if the conditional logic fails. optocoupler in such a way that optocoupler passes the signal to ground not to MOSFET. So then circuit is become open and no power or charge flow tobattery. By this way battery is charged or not.

required according the logic of microcontroller are sent to LCD for observing the whole status of the SCC.

As we've described the operation of solar charge controller partly, so whole operation is combination of those four functional blocks, total work is done at a time. When input connector gets input from solar power supply, it generates the operating voltage for the circuit, as well as to store the charge in battery. This operating voltage operates the microcontroller and LCD after regulating this voltage using voltage regulator. So microcontroller takes decision when battery is become overcharged and as we use optocoupler (isolator) which isolate the battery from solar to prevent over charging. This decision is given by microcontroller to optocoupler whether it has to isolate or not. If stored charge is available in the battery for thepermitted loads according the power of battery, the whole setup is ready to operate and makes a smooth operation.

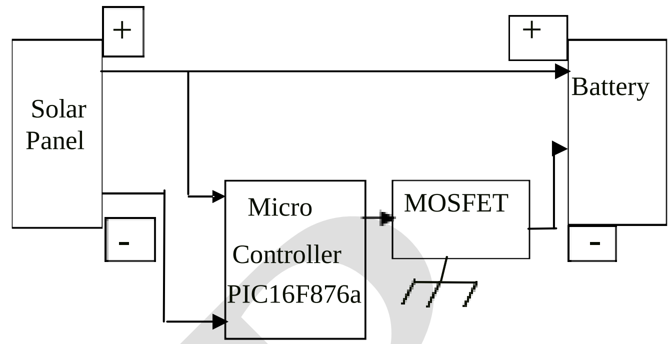


Fig. 5. Charging unit.

Microcontroller and LCD unit

In this part the all input and output operation of microcontroller and LCD are shown by blocks and circuit diagrams. Here some precaution elements are set withregulating the voltage. This voltage control is one of the main important to give the voltage supply to microcontroller and LCD. The status of solar and battery are sent to microcontroller to compare with the logic which is programmed pioneers in the field of microcontrollers. A stream pulse is sent from a crystal oscillator to a microcontroller. The signal is filtered before it reaches the microcontroller from the voltage regulator. The choices that are

Part Two: Findings and Discussion

The project has been evaluated for its intended functions. Both a 15W DC light and a 20W DC fan were used to successfully test the system, which was designed with a maximum power rating of 84W according to battery capacities. To continue using the AC load while staying under the 50% discharge restriction, an inverter may be used. This SCC system has been developed in accordance with the idea, and it can be independently controlled by microcontroller in addition to including other functions. All of the system's constituent parts can function autonomously. This document lays forth the foundational concepts of the solar system and the mechanism used to regulate it for this same reason. The first obstacle was figuring out how to make the primary controller circuit structure for the project as easy and inexpensive as feasible for the client. The primary circuit that meets the criteria has been put up by tracking and evaluating a number of different sources. There were issues right from the start of the rollout. The whole circuit was split into four parts in order to address these issues. Then, those four segments were worked on individually. Some difficulties arose at each stage in particular. In the beginning, a regular resistor was used, however it would be burnt along with the input side of the board if there was a big surge in current coming from the solar panels around midday. Then, a ceramic resistor, which combines a high watt rating and high resistivity, was utilized as a safety measure. According to the idea of potential difference, charge should not be flowing backwards from the battery to the solar panel at night. Therefore, forward biased diodes have been used to counteract this effect. At first, the positive switching technique was used for the load distribution unit, despite the fact that it is inefficient for this kind of power system since it causes the device's internal circuit to overheat. The strategy of negative switching has so far been used. In this case, the positive (+) terminals are hardwired from the get-go, whereas the negative (-) terminals are switched using a MOSFET. Manufacturer guidelines for charge distribution units have been adhered to for optimal battery performance. Care was taken to stay within the battery's safe voltage range (both maximum and minimum). More issues arose with the microcontroller and LCD device. The codes initially failed to activate. After much investigation, we've concluded that our code must be tailored to the specifications of the battery we're utilizing. Therefore, the extensive mathematical computation was essential. The signal then had to travel through the complete circuit before reaching the microcontroller and the display. When the signal was viewed using an oscilloscope, it showed several abnormalities. So here is where the foundation for minimizing noise was laid. With the use of a double LC circuit, the noise and send the pure signal to microcontroller and LCD for their proper operation. Besides for the proper operation of the device a crystal oscillator and an optocoupler are used on the basis of the theory knowledge, which give the perfect satisfaction of this device.

The SCC had to go through plenty of step of test runsbefore the optimum conditions and performance were achieved. The project was completed successfully with all the features and operations of the solar charge control system as desired.

An over charge alarm can be added to the device toprotect batteries from over charging. In commercial system an inverter is always present. Due to the presence of inverter transient are observed during switching.

This affects the working of the device .Hence while using in the commercial schemes the device needs to be modified and correction. If all these modifications can be added for the further betterment a perfect and proper solar power system can be established.

CONCLUSION

Cost effective solar charge controller has been designed andimplemented using PIC microcontroller to have efficient and much longer battery lifetime. From the overall analysis presented, it can be concluded that our proposed SCC can be used to optimize the energy crisis in Bangladesh.

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