



IJITCE

ISSN 2347- 3657

International Journal of Information Technology & Computer Engineering

www.ijitce.com



Email : ijitce.editor@gmail.com or editor@ijitce.com

USING A MICROCONTROLLER TO CREATE AN AFFORDABLE SOLAR CHARGE CONTROLLE

Suma G C, Dr. Sindhu R, S Prakasha

Asst. Prof, Asst. Prof, Asst. Prof & HOD

sumasavita@gmail.com, rethisindhoo@gmail.com, prakashshanbog@gmail.com

Department of EEE, Proudhadevaraya Institute of Technology, Abheraj Baldota Rd, Indiranagar, Hosapete, Karnataka-583225

Abstract — Using a Programmable Intelligent Controller (PIC) to regulate and coordinate the operations correctly, this article provides a Solar Charge Controller (SCC) that is both cost-effective and efficient. The paper lays out the intricate blueprints for building SCC with the use of a crystal oscillator, an optocoupler, ceramic resistors, LC filters, and a MOSFET. The PIC microcontroller's source code is developed in C to provide precise and efficient automated connection and disconnecting. Thus, when the battery is about to be overcharged, it may be detached from the solar cell; when it is about to be discharged, it can be reattach. When the current flows too high or too low, the loads may be separated. Overcurrent and undercurrent may also cause loads to be disconnected. To show the current flowing from the solar cells to the load via the microcontroller and the present state of the battery, the suggested charge controller has a Liquid Crystal Display (LCD). We propose this smart solar charge controller, and its construction and operation show that it works well and is more cost-effective.1

Key Words — SCC, microcontroller, optocoupler, crystal oscillator, MOSFET.

I. INTRODUCTION

Most of the existing power plant or power generating units is dependent on bio-fuel [1]. But the reserve of the bio-fuel is very limited and about to use up in near future [2], so power generation, based on bio-fuel is not sustainable [3]. Therefore we are focusing on renewable energy like wind, tidal, solar etc. So to be with our current focus of renewable energy we selected solar charge controller and tried to gain some knowledge and contribute a little bit in this field.

Solar energy is the most viable renewable energy that we have. In our country we have limited resources of energy, in that case solar energy can play a vital role to optimize such problem.

Now a day's daily need of electricity is about 5900MW, where we produce nearly 5200MW [4], so we have limitations. So we need another source to get electricity (like solar energy and power system). In Bangladesh there are so

many NGOs and also some government organizations that provide the solar energy and power system (with the set of solar panel, battery, and inverter) to the rural areas where till no electricity connection has been established yet and in many areas where the problem of electricity is more than other areas. But they don't provide the solar charge controller with their supplied set because of its high cost and hard to understand to use (exception in the city). But the affect of this lacking is faced by the poor people of rural areas who have taken this solar system. They get the battery problem after some days due to the charging and discharging problem. For this problem the battery lifespan goes down in a few days and need a new battery to replace the old one. So again expense is increased to buy a new battery for the poor rural people which is more than a solar charge controller (SCC) device (which we proposed here). So basis on the low cost, better protection, availability and reliability this SCC model is designed and implemented for the further betterment of our solar power and energy system in the present condition of electricity in Bangladesh.

A Solar charge controller (SCC) is a device that controls the flow of charge from a battery to load or from solar panel to battery through a micro-controller [5]. So, we can prevent over charging and fastest charging and discharging, also the blocking of the reverse charge also, maintaining the proper use of natural energy. There is a new feature included in our project which is measurement of current.

There are various types of solar charge controller in the foreign markets which are developed according to the requirements of controlling the solar charging of battery and its whole system. Comparatively, these SCC are very costly in under-developed countries like Bangladesh, especially at the rural areas. At the same time, solar cell and battery are very expensive. So, it is difficult for the consumers of rural areas to afford the additional costs for the expensive SCC in their solar energy system. The SCC enhance the lifetime of the battery.

To make the SCCs available to the rural consumers with the affordable cost, a sophisticated solar charge controller has been designed and constructed. This SCC is very simple in construction, and cost effective. The operation process is also very simple, easy to maintain and above all user friendly. The proposed SCC consists of a voltage regulator, a micro-controller and a crystal oscillator. Depending upon voltage level at battery terminal, which is set by the micro-controller, it controls the charging of battery from solar panel and hence improves the operational life of a battery. It can also prevent the battery from complete discharging by disconnecting the load from the battery when the voltage level reaches to a critical value set by the micro-controller. It is our purpose to

propose a cost effective SCC which improves the existing solar charges controller devices and the battery life of the solar system. This SCC can fulfill nearly all requirements which are needed for proper operation of solar energy system and the charging or discharging of battery can be controlled accurately.

II. THEORETICAL BACKGROUND

This section covers the details regarding preparation of your Battery is an important element to set up a solar panel power system. An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy [6]. Since the invention batteries have become a common power source for many household and industrial applications. There are two types of batteries: primary batteries (disposable batteries), which are designed to be used once and discarded when they are exhausted, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. Among all types of batteries secondary batteries are more efficient and popular for its multipurpose uses. For the charging and discharging facilities the secondary batteries are exceedingly used for the solar panel power system. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors as well as solar power system.

Because of the chemical reactions within the cells, the capacity of a battery depends on the discharge conditions such as the magnitude of the current (which may vary with time), the allowable terminal voltage of the battery, temperature and other factors [7]. The available capacity of a battery depends upon the rate at which it is discharged [8]. If a battery is discharged at a relatively high rate, the available capacity will be lower than expected. The speed of recharging for lead-acid batteries may be increased by manipulation [9]. The battery capacity that battery manufacturers print on a battery is usually the product of 20 hours multiplied by the maximum constant current that a new battery can supply for 20 hours at 68 F° (20 C°), down to a predetermined terminal voltage per cell. A battery rated at 100A·h will deliver 5A over a 20 hour period at room temperature. However if it is instead discharged at 50A, it will have a lower apparent capacity [10].

For low values of current drawn from battery internal self-discharge must be included. In practical batteries, internal energy losses, and limited rate of diffusion of ions through the electrolyte, cause the efficiency of a battery to vary at different discharge rates. When discharging at low rate, the battery's energy is delivered more efficiently than at higher discharge rates [10], but if the rate is too low, it will self-discharge during the long time of operation, again lowering its efficiency. Rechargeable batteries self-discharge more rapidly than disposable alkaline batteries, especially LEAD-based

batteries; a freshly charged PbSO₄ loses 10% of its charge in the first 24 hours, and thereafter discharges at a rate of about 10% a month [11]. Although rechargeable batteries have their energy content restored by charging, some deterioration occurs on each charge/discharge cycle. Lead-acid batteries tend to be rated cycles before their internal resistance permanently increases beyond usable values. Day by day this resistance increases so the rated cycle rate also decreases and by that the lifespan becomes decrease. Normally a fast charge, rather than a slow overnight charge, will shorten battery lifespan [12]. However, if the overnight charger is not "smart" and cannot detect when the battery is fully charged, then overcharging is likely, which also damages the battery [13]. Degradation usually occurs because electrolyte migrates away from the electrodes or because active material falls off the electrodes. Lead-acid batteries suffer the drawback that they should be fully discharged before recharge. Without full discharge, crystals may build up on the electrodes, thus decreasing the active surface area and increasing internal resistance. This decreases battery capacity and causes the "memory effect". These electrode crystals can also penetrate the electrolyte separator, thereby causing shorts. Lead-acid although similar in chemistry, does not suffer from memory effect to quite this extent. When a battery reaches the end of its lifetime, it will not suddenly lose all of its capacity; rather, its capacity will gradually decrease [14]. Lead-acid batteries should never be discharged to below 20% of their full capacity [15], because internal resistance will cause heat and damage when they are recharged.

Battery life can be extended by storing charge of the batteries, as in controlling the cover charge of batteries which slows the chemical reactions in the battery. Such storage can extend the life of these types of batteries by about 5% [16]. To reach their maximum voltage, batteries must be stopped to store of charge. As a result, due to these drawbacks and lifespan improvement process of these types of batteries like lead-acid batteries if we use SCC properly then lifespan of batteries can be extended.

Basically here it's controlled that battery charging rate is kept normal, not fast or slow. The discharge limit will not go under the 50%. The microcontroller can sense according the program that when it's needed to give charge and when at nearly full charged it's needed to cut off from the solar panel. For further operation this proposed SCC can control the movement of the load according the charge and discharge of the battery.

III. SYSTEM STRUCTURE

A. Controlling Unit

Figure 1 shows the controlling the Functions of different sections of solar system are controlled by microcontroller PIC16F876a. Here the bi-directional controlling is established by the microcontroller. It's connected with the solar, battery

and load to control the whole process. The above diagram is the theme diagram of the whole project. All the status of solar

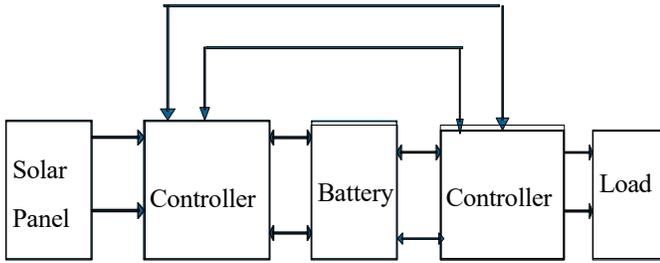


Fig. 1. Controlling of different sections of solar system.

and battery are observed by the microcontroller. The whole decision is being come from this microcontroller. This microcontroller follows the program which is burned into it. This program is written on the basis of theoretical concept to increase the battery efficiency. The main theme of whole process and controlling can be summarized as follows:

- (i) If battery voltage is less than 10V, then controller turns on the battery charging.
- (ii) If battery voltage is less than 12V, load is disconnected from battery (for 12V load).
- (iii) If battery voltage is greater than 15V, controller turns off the battery charging.
- (iv) If battery voltage is greater than and equal 12V, load can be connected with battery normally (for 12V load).

B. Functional Blocks of Our Solar Charge Controller

The whole process can be described using four functional blocks. By this way it's easy to understand the individual operation of step by step process of whole system diagram from the first to last including its internal all steps using the all related circuit diagram of four blocks. So here Solar Charge Controller (SCC) is divided into four blocks: Power supply unit; Load distribution unit; Charging unit; Microcontroller and LCD unit

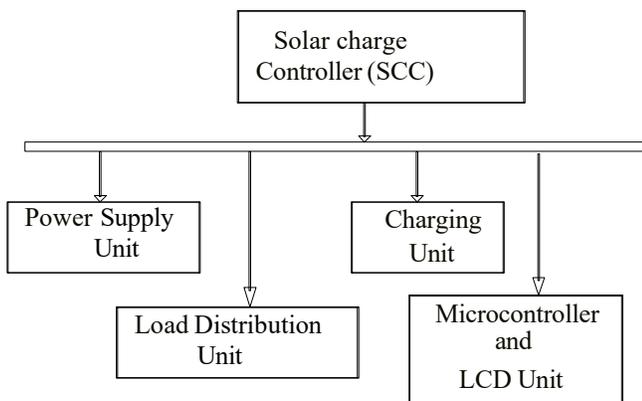


Fig. 2. Basic block of SCC.

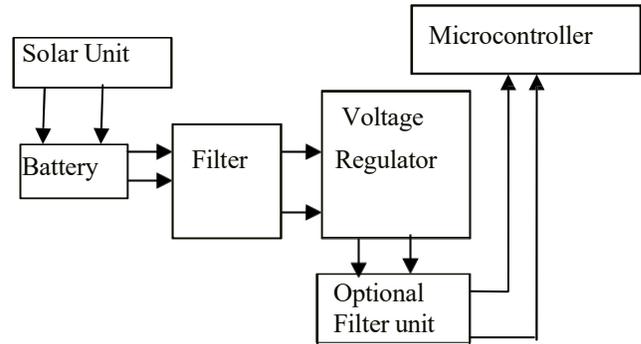


Fig. 3. Power supply unit.

a) Power supply unit

To describe the whole step firstly the power supply portion is described maintaining the following block diagram and its corresponding circuit. To establish this power supply unit there are some necessary equipments are used, such as diodes, ceramic resistors, inductive coil, capacitors (various values), and voltage regulator. In this circuit, we used solar as input. From solar, power is delivered to two Diodes. This two Diodes act as forward bias, that don't allow the flow of charge from battery to the solar panel reversely at night due to the potential difference between battery and solar. This two Diodes output is connected to the two ceramic resistor. These two resistors are connected to the battery's positive voltage end. After that, this positive end of battery connected to the inductive coil. Then the coil end is connected to the Diode which is connected to the input of the voltage regulator and it's used for protection of the voltage regulator. For this circuit we need fixed 5V, which is generated from voltage regulator. After the voltage regulator there are some optional filters units which is prevent noise and make the signal more pure. This pure signal (5V) is sent to the microcontroller.

b) Load distribution unit

Here the controlled load distribution and its all featuring equipments are shown by the following blocks and circuit diagrams. From the first all (+)ve ends of loads are connected with the (+)ve end of battery. Then the (-)ve switching is established which is clearly understand by following diagram.

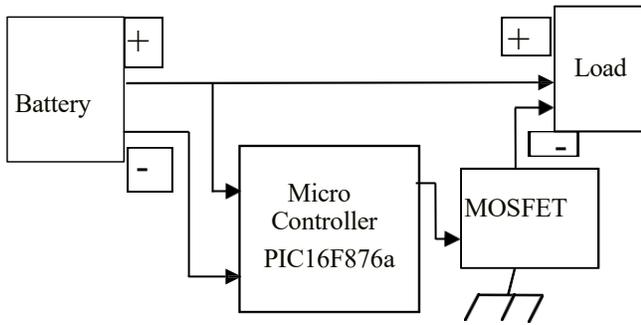


Fig. 4. Load distribution unit.

The positive end of battery is directly connected with the positive end of load. To establish and control the load operation we use microcontroller and MOSFET. The battery positive end and its status signal are connected to microcontroller to verify with the logic which is burned into microcontroller. If the requirement is fulfilled then microcontroller sends the signal to MOSFET. Now this MOSFET establish the negative switching (to reduce heat in the circuit) with the load. So the circuit becomes close. By this process the load operation is fulfilled.

c) Charging unit

Here the battery charging process from solar is shown by blocks and circuit diagram. The charging is controlled by the microcontroller and switched by the MOSFET. Here also the (-)ve switching concept is used. The charging unit is shown in Fig. 5.

From the first the (+)ve end of solar is connected with the (+)ve end of battery. The whole status of solar and battery go to microcontroller to compare with the logic which is set inside the microcontroller. If all the requirement is fulfilled then microcontroller send signal to optocoupler to establish a switching between the (+)ve end (-)ve end of solar using MOSFET. After that the close circuitry is established and power or charge flow to battery. If the logic is not fulfilled then microcontroller send signal to 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 to battery. By this way battery is charged or not.

d) 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 with regulating 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 from the first in microcontroller. The crystal oscillator is used to generate stream pulse to microcontroller. The purified signal comes from voltage regulator to

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 over charged 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 the permitted loads according the power of battery, the whole setup is ready to operate and makes a smooth operation.

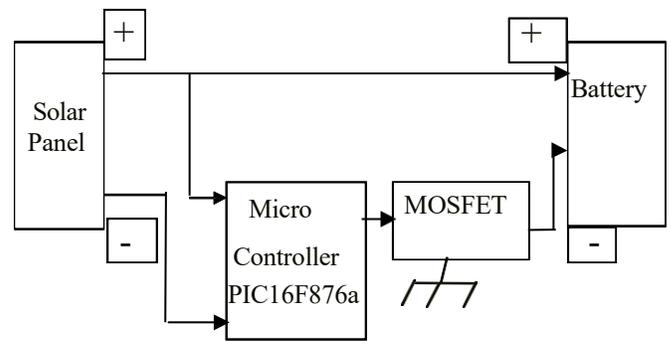
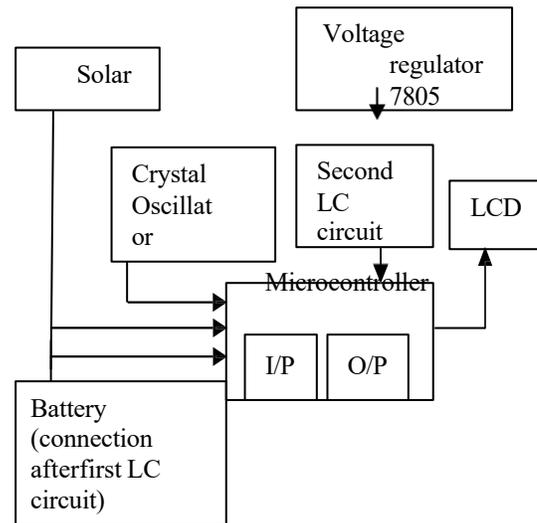


Fig. 5. Charging unit.



microcontroller through filter. The decisions which are

Fig. 6. Microcontroller and LCD unit.

IV. RESULTS AND ANALYSIS

The project has been tested according its operational purposes. Maximum power rating of the experimented solar charge controller is 84W according battery capacities, so the system has been tested by both 15W DC light and 20W DC fan, which is operated successfully. For the further use an inverter can be utilized to operate the AC load maintaining 50% discharge limit.

According the concept this SCC system has been designed which can not only be controlled independently by microcontroller but also incorporated other function. The internal components with the whole system are independent as possible. For this purpose the basics and principles of solar system and its controlling method has been set here.

The first challenge that was faced to develop the main controller circuit structure for the project was which will be as simple as possible and cost effective for the customer. By following and analyzing various sources the main circuit has been set up, which satisfies the requirements.

From the first implementation some problems were occurred. To solve these problems the whole circuit was divided into four sections. Then the work was done on those four sections step by step. In every step particularly some problems were occurred.

For power supply unit a problem in the input side was created, because firstly normal resistor was used, which was burned itself with the input side of the board at sudden high current flow from the solar panel at the mid day. Then for the precaution a special resistor was used called ceramic resistor, which has high watt rating along with high resistivity. At night it was observed that according the theory of potential difference charge is flowing from battery to source solar panel, which is not the proper action. So to prevent that, the forward biased diodes have been used here.

For load distribution unit at first the positive switching method was maintained, which is not an effective method for this kind of power system, because here more heat is produced in the internal circuit of the device. So now the negative switching method has been followed. Here from the first all (+)ve ends are connected with each other, just the (-)ve ends are controlled by switching using MOSFET.

For charge distribution unit the instruction of manufacturers about the battery normal operation has been followed. The suitable voltage ratings (upper limit and lower limit) for the battery were carefully maintained.

For microcontroller and LCD unit, the more problems were occurred. At first the codes were not working. After the long research it is decided that the code must be written according the rating of the battery, which we are using. So the long mathematical calculation was needed. Then the problem was about the signal, which is passing through entire the circuit and lastly go to microcontroller and LCD. Some distortions of signal are raised when it was observed into the oscilloscope. So the basic theory of noise reduction was set here. Using the two times of LC circuit, it is fully reduced 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 runs before 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 to protect 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.

V. CONCLUSION

A solar charge controller with an efficient design and a much longer battery life has been developed and implemented using a PIC microcontroller. Our suggested SCC may be used to optimise Bangladesh's energy situation, according to the overall study given.

REFERENCES

- [1] www.smartpowergeneration.com.
- [2] renewable.50webs.com.
- [3] www.hawaiisenergyfuture.com/articles/Biofuels.html
- [4] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=126&Itemid=17
- [5] kitsnspares.com/admin/pdf/Solar%20Charger.pdf.
- [6] "battery" (def. 4b), Merriam-Webster Online Dictionary (2009). Retrieved 25 May 2009.
- [7] Battery Knowledge - AA Portable Power Corp.. Retrieved 16 April 2007.
- [8] Battery Capacity - Techlib. Retrieved 10 April 2007.
- [9] Increasing recharge speed of lithium-ion batteries.
- [10] Buchmann, Isidor. Discharge methods. Battery University. Retrieved 14 August 2008.
- [11] Buchmann, Isidor. Non-Correctable Battery Problems. Battery University. Retrieved 3 February 2009.
- [12] Rechargeable battery Tips - NIMH Technology Information. Retrieved 10 August 2007. Archived August 8, 2007 at the Wayback Machine.
- [13] battery myths vs battery facts - free information to help you learn the difference. Retrieved 10 August 2007.
- [14] <http://www.mpoweruk.com/life.html>/ Battery Life and How To Improve It.
- [15] Car and Deep Cycle Battery FAQ. Rainbow Power Company. Retrieved 3 February 2009.
- [16] Ask Yahoo: Does putting batteries in the freezer make them last longer?. Retrieved 7 March 2007.