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Original Research Article

Analysis and Design of a Solar Home System

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Abstract

Solar panels-the vital element of this SSHS makes use of exhausted energy. Compared to all other energy solar energy is abundant and free that can be used to charge batteries used for any module or electrical kits which are obvious for daily usage. The Smart Charge Controller will be designed such, so that the solar battery does not get over charged thereby ensuring no reduction of durability of the battery. This kind of system requires sensors to sense whether the battery is fully charged or not. After fully charged, detection safety can be achieved by designing a logic system in the charger, which will automatically disconnect or cut power to the battery when it is fully charged. When the solar batteries come into account, they get charged in a very short time period considering of the solar/sun/light hours per day, which is 5 hours in Bangladesh; whereas Diesel Battery Charging Stations (DBCS) take 1-2 days.

Keywords: Solar Panel, PV, Charge Controller, Battery.

I. INTRODUCTION

Solar Energy, radiation produced by nuclear fusion reactions deep in the Sun's core The Sun provides almost all the heat and light Earth receives and therefore sustains every living being. Bangladesh being a country being concerned about environmental problems, sustainable energy sources is becoming more and more popular here. Solar energy can be converted to electricity directly by SHS systems. Flow of converted electricity from PV is determined by charge controller. An efficient charge controller can be used to do the battery charging and discharging process faster and better. The existing electric grids are not capable of supplying the electric need. Thus the Small Solar Home System (SSHS) is a new project that has emerged to the rural Bangladesh as well as in urban areas to change the scenario. Therefore, our aim is to make solar energy popular as one of the best renewable energy sources among our people by implementing Central Solar Battery Charging Station with a view to provide supplementary electricity. Resultantly, more and more people are now using solar energy as their main source of electricity. Using compound solar cells, solar panels manage to trap huge amounts of energy every single day. When the solar batteries come into account, they get charged in a very short time period considering of the solar/sun/light hours per day, which is 5 hours in Bangladesh; whereas Diesel Battery Charging Stations (DBCS) take 1-2 days [1-2]. The electricity is instantaneously converted and then stored in the charging station which is consumed by the batteries. If the panels produce power which is not required instantly, customers can at rest get hold of that energy in the outlook, whenever they oblige it. People whoever looking for savings and the future of the planet should indeed look into solar energy.

II. BACKGROUND

Crisis of electricity is a major problem in the present era. This problem is even more critical for a densely populated poverty corrupted developing third world country like ours. Many of our people live here without the basic facility of electricity. In some area outside the city side, there is general electricity service called PALLI BIDYUT, which can supply a very limited amount of electricity in that area that is unable cover up the basic demand of people from that area. Day by day crisis of electricity is increasing whereas no other solution is left for us without using the solar power or wind turbine to generate electricity. Again, not only we face electricity crisis but also day by the cost of gas and other natural resources like fuel, diesel, petroleum etc are rising up that is going beyond the availably of general people. We have designed a whole Central Solar Battery Charging Station (CSSHS) along with the successful implementation of hardware and software to represent all activities not only visually but also can be monitored and controlled from remote region. Implementation of SSHS for also includes designing of a smart charge controller with a view to decrease the battery charging time, making it capable of charging more than one battery at a time and getting the desired current from the load.

A. Feature of Solar Panel

1) We can charge the batteries used in solar home system or in IPS in our station and our well developed monitoring software will save the batteries from further destructions caused by the system.
2) Our charging station can be used to charge any battery including Rickshaw battery or batteries used in Solar Home System either in rental or in monthly payment basis.
3) Electric lanterns used in village area can be charged as well.
4) First objective of this thesis is to identify reasons for the failures of existing charge control algorithms that utilize existing technologies.
5) The next goal of the thesis is to create new charge control algorithms that will overcome the issue of false detection while protecting the battery from repetitive overcharges. We present a new voltage based charge control algorithm. 978-1-7281-8301-5/21/$31.00 ©2021 IEEE 2021 6th International Conference on Renewable Energy: Generation and Applications (ICREGA).
6) Ways to increase the charging speed are critical in this application as well as in most of other applications since portable solar panel generally have low power production per square meter. So, this research also develops ways to optimize solar panels‟ output power while charging the batteries.
7) Our software is able to eliminate costs.
8) Followed by some other countries we can also replace kerosene station with Solar Battery Charging Station too with further modification.

B. PV Panel

In a photovoltaic cell, light excites electrons to move from one layer to another through semi-conductive silicon materials. This produces an electric current. Solar cells called photovoltaic's made from thin slices of crystalline silicon, gallium arsenide, or other semiconductor materials convert solar radiation directly into electricity. Cells with conversion efficiencies greater than 30 percent are now available. By connecting large numbers of these cells into modules, the cost of photovoltaic electricity has been reduced to 20 to 30 cents per kilowatt-hour. More complex systems can provide electricity to houses and electric grids. Usually though, solar cells provide low power to remote, unattended devices such as buoys, weather and communication satellites, and equipment aboard spacecraft.

C. Charge Controller

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. Charge controllers are sold to consumers as separate devices, often in conjunction with solar or wind power generators, for uses such as RV, boat, and off-the-grid home battery storage systems. In solar applications, charge controllers may also be called solar regulators. A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full [15].

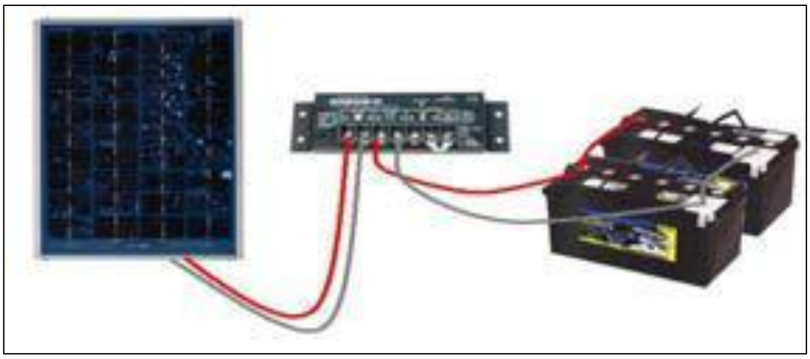

Figure 1: Charge controller and battery wiring *D. Battery*

Battery condition and corresponding state of charge that we gathered from reading of formerly used batteries for solar system is used to measure the PWM states. It's crucial to follow the ratings in our design so that it may work well with batteries from any organization. The following chart represents a clear idea about automotive battery condition that are generally used including charging and discharging both:

Table 1: Battery State of charge

State Of Charge	12 V Battery
20%	11.58
30%	11.75
40%	11.9
50%	12.06
60%	12.20
70%	12.32
80%	12.42
90%	12.5
100%	12.7

III. SYSTEM DESCRIPTION

Solar Home System (SHS) generally have a common design and consists of the following components:

1. A PV Generator composed of one or more PV modules, which are interconnected to form a DC power-producing unit.
2. A mechanical support structure for the PV generator.
3. A 12V lead acid battery.
4. A charge controller to prevent deep discharges and overcharges of the battery
5. Loads (LED lamps)
6. Wire connections (Cable, switches and connection box.) Our whole project consists of two groups.

1. Hardware Implementation

2. Software Implementation

This paper is on the design and implementation of the solar charge controller. For the Solar Battery Charging Station (SBCS), the proposed CARG project has the overall implementation and monitoring system for the Solar Home System (SHS). Each component of the system must fulfill the quality and requirements. Size, voltage thresholds of the charge controller, the quality of installation etc directly effects the lifetime of batteries and lamps.

A. Solar Panel

The use of the Sun as an alternative means to provide electrical energy has always been around us. Solar Power generation has emerged as one of the most rapidly growing renewable sources of electricity. Photovoltaic is a most elegant energy source. Light shines on a crystal and produces electricity. It is as simple as that. There are no moving parts. The fuel source (sunlight) is free, abundant and widely distributed, available to every country and person in the world. At over 165,000 TW the solar resource dwarfs the world's current power usage of 16 TW or even our projected future usage of 60 TW. Doing serious battery charging with solar energy isn't that difficult. Actually, the most critical component aside from the solar panel itself - is a solar charge controller, which is available from many manufacturers. This device protects the battery from being overcharged, which can reduce its life. With a charge controller in hand, setting up a photovoltaic battery charging system is really a simple wiring procedure.

B. Battery

The battery was rechargeable and of lead-acid systems. It should not be overcharged. Otherwise, the battery is completely sealed, maintenance-free and leak proof. It was rated as 12v and 80Ah. It should not be discharged below 80%.

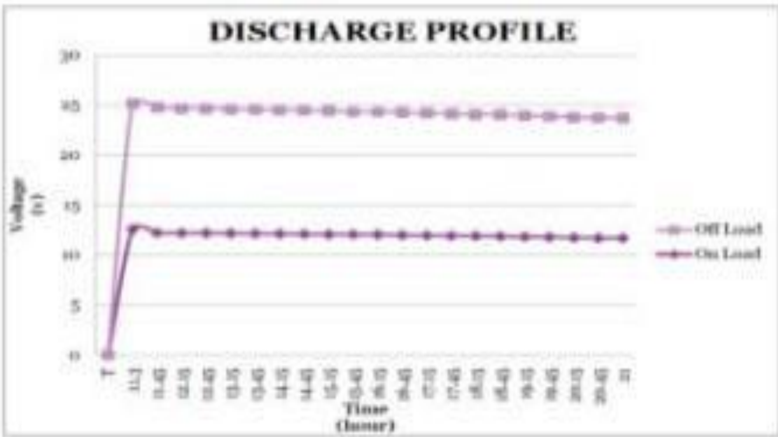

Figure 2: Battery discharge profile

Very simple basic rules for charging the lead-acid batteries (the voltages mentioned are valid for 6 cell, 12V batteries):

- Disconnect the load when the battery voltage decreases below typically 10.5Vwhen loaded,
- It is possible to charge the battery indefinitely (float charging or also calledpreservation charging), if its voltage is kept below certain threshold (variesaccording to battery type between 13.4 and 13.8V),
- When cycled (going through charging and discharging phases consecutively), the battery termination voltages are higher than when charging indefinitely (14.2 to 14.5V),
- It is not good to charge battery beyond the gassing voltage (about 14.4V) forlonger periods of time,
- It is good to change the voltage levels according to battery temperature, asthe voltage values have a significant temperature characteristics,
- It is safe to charge most of lead-acid batteries by currents up to C/10h, where C is the battery capacity in Ah. However, the ideal charging of lead-acid batteries consists of three stages: constant-current charge, topping charge and float charge. Battery voltage and current levels per cell during these stages are illustrated in Figure 3. Most of the energy is transferred to the battery during the first stage. The secondstage overcharges the battery a little while the current decreases. This is importantto recharge battery to 100% of its previous capacity. The losses due to self-dischargeare compensated during the last stage.

C. Charger Unit

1. Charge Controller

The primary function of a charge controller in a Solar Home System (SHS) is to maintain the battery at highest possible state of charge, when PV module charges the battery the charge controller protects the battery from overcharge and disconnects the load to prevent deep discharge. Ideally, charge controller directly controls the state of charge of the battery.

Without charge control, the current from the module will flow into a battery proportional to the irradiance, whether the battery needs to be charging or not. If the battery is fully charged, unregulated charging will cause the battery voltage to reach exceedingly high levels, causing severe gassing, electrolyte loss, internal heating and accelerated grid corrosion. Actually charge controller maintains the health and extends the lifetime of the battery.

2. Pulse Width Modulation (PWM)

Pulse Width Modulation (PWM) [12] controls adjusts the duty ratio of the switches as the input changes to produce a constant output voltage. The DC voltage is converted to a square-wave signal, alternating between fully on and zero. By controlling analog circuits digitally, system costs and power consumption can be drastically reduced. In nowadays implementation, many microcontrollers already include on-chip PWM controllers, making implementation easy. Concisely, PWM is a way of digitally encoding analog signal levels. PWM control can be used in two ways: voltage-mode and current-mode. In voltage mode, control the output voltage increases and decreases as the duty ratio increases and decreases. The output voltage is sensed and used for feedback. If it has two-stage regulation, it will first hold the voltage to a safe maximum for the battery to reach full charge. Then it will drop the voltage lower to sustain a "finish" or "trickle" charge. Two -stage regulating is important for a system that may experience many days or weeks of excess energy (or little use of energy). It maintains a full charge but minimizes water loss and stress. Determine the duty cycle, D to obtain required output voltage.

$$D = Vo/Vd$$

Where, D = Duty cycle, Vo = Voltage output, Vd= Voltage input, D = 12V/17.4V =>D = 0.7 =>%D = 70%

D. Microcontroller

A microcontroller [13] is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. The Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. Microcontrollers [11] are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. In this project is used PIC 16F72 Microcontroller [10] and PIC 16F616 [5-7]. Microcontrollers, as stated, are inexpensive computers. The microcontroller has ability to store and run a unique program makes it extremely versatile. For instance one can program a microcontroller to makes decisions based on predetermined situations and selections. The microcontroller has ability toperform math and logicfunctions allows it to mimic sophisticated logic and electronic circuit.

E. Micro C Coding

1. Programming the PIC

These PIC microcontrollers can be programmed in high-level languages or in their native machine language (Assembly). In this thesis the C language was chosen, using the software MICRO C. The advantages of C language consist of better control and greater efficiency. Another reason for using C language is that the interface with the programmer is quite simple and easy to understand.

2. Charge Controller Algorithm

The charge controller algorithm is shown in flow chart below:

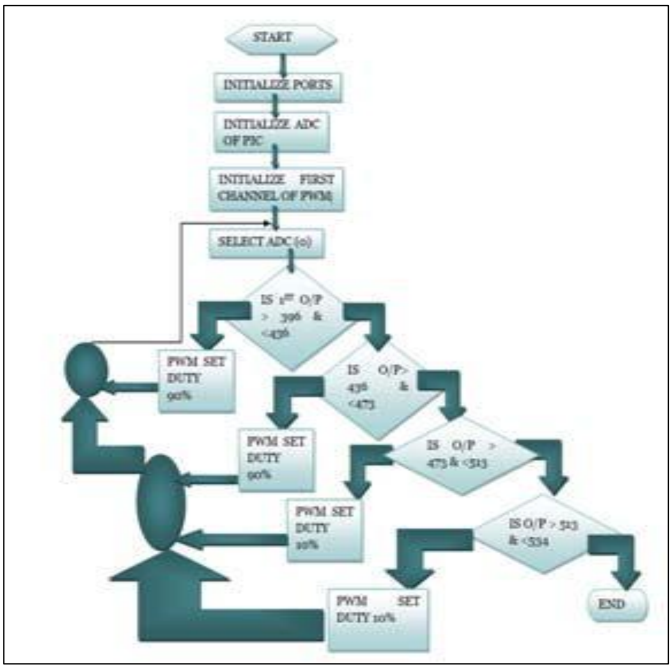

Figure 3: Charge controller algorithm ***F. Circuit Components***

There is no panel or similar instrument available in PROTEUS. Therefore, a DC current source represented the panel. The source had constant current of 5A.The voltage regulator 7805 was omitted from the simulation, as there is no pin 19 or VDD pin in PIC16F876A in PROTEUS. The purpose of the voltage regulator is to feed 5V to the microcontroller. Above this voltage microcontroller will burn. A digital oscilloscope was connected to get the view of PWM. The digital oscilloscope is a virtual instrument that is available in PROTEUS VSM. It has four channels. Channel A is the channel that shows square waves.

G. Schematic Circuit

After the all components of the circuit have been added, the simulation was done. It was done using different values of the battery. With each battery value the value in digital oscilloscope was recorded. It corresponds to the exact value of the PWM.

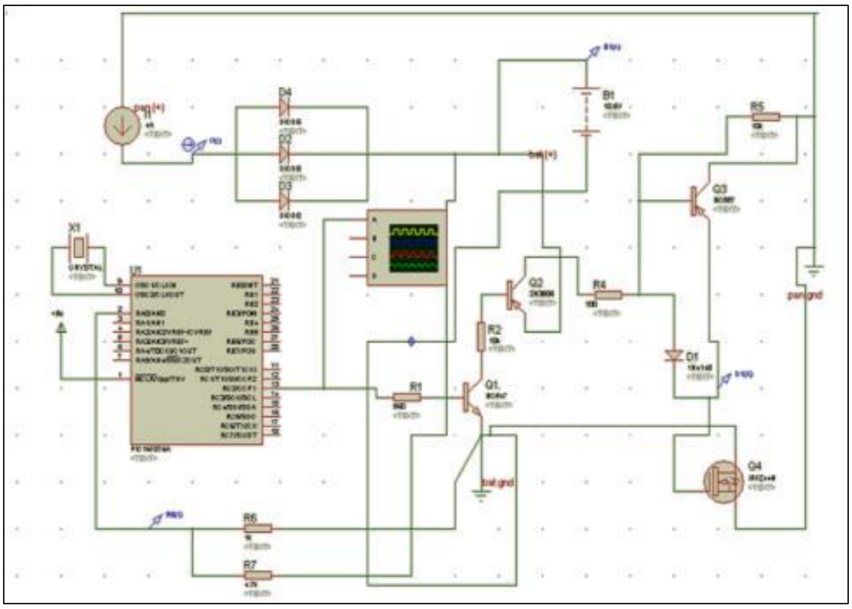

Figure 4: The schematic circuit

IV. SIMULATION RESULT PROTEUS VSM comes with the facility of using Virtual Instrument. Oscilloscope was used to get the PWM output from CCP1 pin. The CCP1 pin generates square waves. Therefore, the 13th pin of the microcontroller was connected to the Channel A of the oscilloscope. The output of three different voltage of the battery cell is given here.

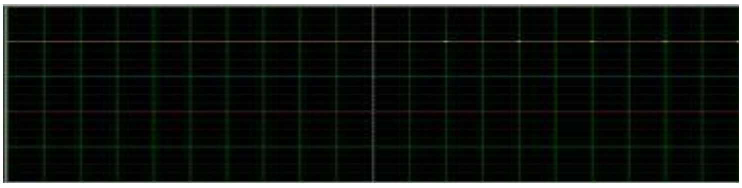

Figure 5: No charge

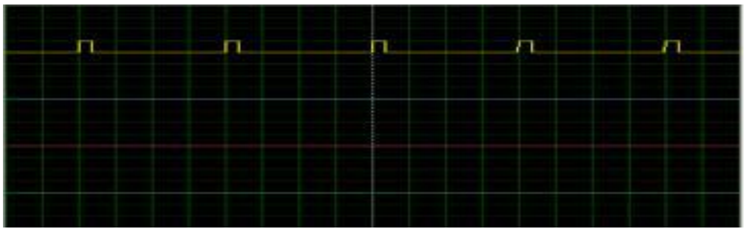

Figure 6: 10% pulse width

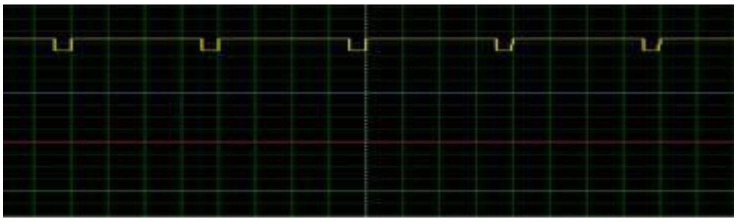

Figure 7: 90% pulse width

V. DESIGN

In order to design a smart charge controller, the following circuit was simulated in ISIS 7 PROFESSIONAL. The PIC16F616 [7] microcontroller can convert input voltage into PWM signal. The PWM signal range was 0 to 100%. There was a IRFZ44N MOSFET [9] for switching between battery and panel. The simulation result was similar to the practical result. The charge controller can be devised in several stages, so that the simple guidelines for charging are met in the prototype stage. After this functionality is implemented and verified, the algorithms to achieve ideal charging (described above) can be implemented to improve the quality of charging process [10-12]. From the basic guidelines it is clear, that the minimum functionality that the hardware of the controller has to implement is voltage measurement and switching off the load and input from solar panel.

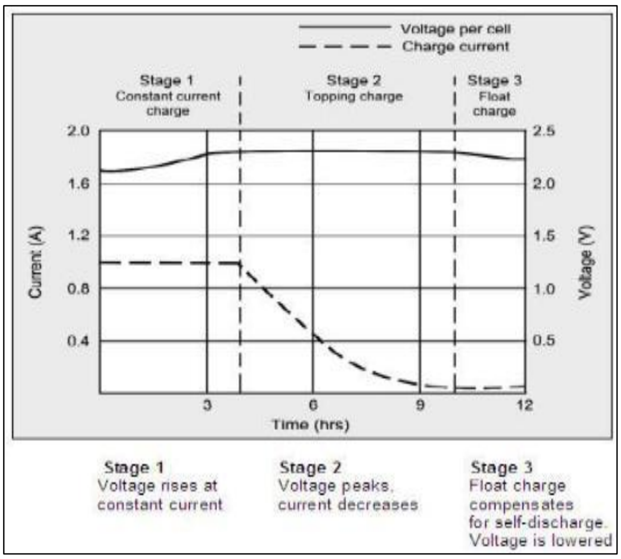

Figure 8: Current Voltage Curve

VI. CHARGE CONTROLLER TYPES

Two basic charge controller types exist:

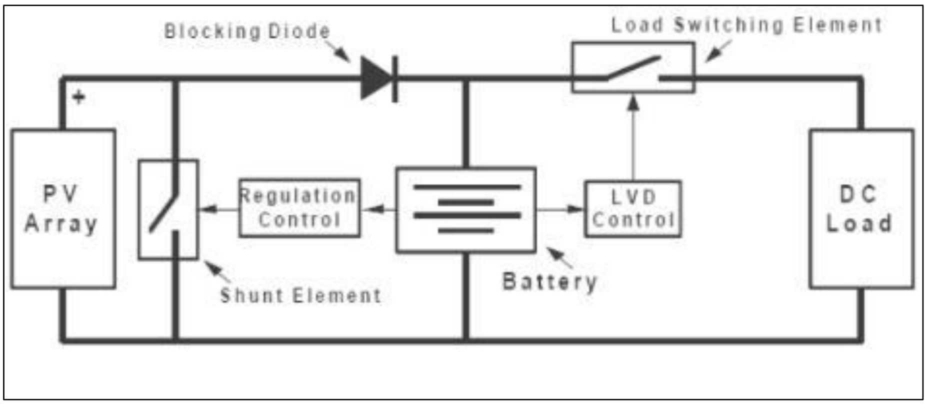

Figure 9: Shunt Controller ***A. Shunt-Interrupting Design***

The shunt-interrupting controller completely disconnects the array current in an interrupting or on-off fashion when the battery reaches the voltage regulation set point. When the battery decreases to the array reconnect voltage, the controller connects the array to resume charging the battery. In general, on-off shunt controllers consume less power than series type controllers that use relays (discussed later), so they are best suited for small systems where even minor parasitic losses become a significant part of the system load. Shunt-interrupting charge controllers can be used on all battery types; however the way in which they apply power to the battery may not be optimal for all battery designs. In general, constant- voltage, PWM or linear controller designs are recommended by manufacturers of gelled and AGM lead-acid batteries. However, shunt-interrupting controllers are simple, low cost and perform well in most small stand-alone PV systems [3, 4].

B. Shunt-Linear Design

Once a battery becomes nearly fully charged, a shunt-linear controller maintains the battery at near a fixed voltage by gradually shunting the array through a semiconductor regulation element. In some designs, a comparator circuit in the controller senses the battery voltage, and makes corresponding adjustments to the impedance of the shunt element, thus regulating the array current. In other designs, simple Zener power diodes are used, which are the limiting factor in the cost and power ratings for these controllers.

C. Series Controller

In a series controller, a relay or solid-state switch either opens the circuit between the module and the battery to discontinuing charging, or limits the current in a series-linear manner to hold the battery voltage at a high value. In the simpler series interrupting design, the controller reconnects the module to the battery once the battery falls to the module reconnect voltage set point [6].

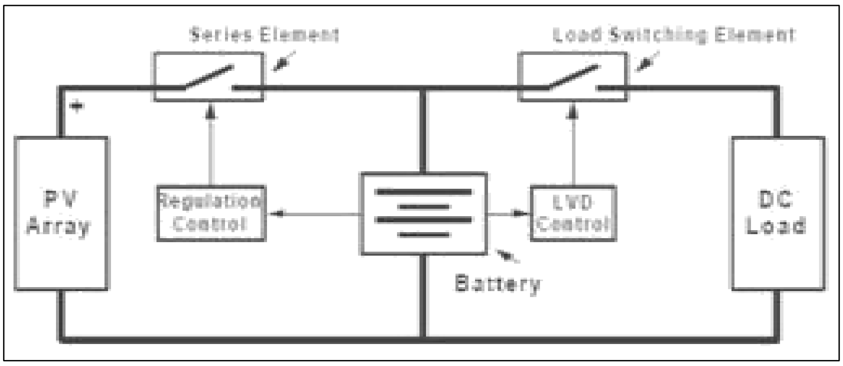

Figure 10: Series Controller ***D. Overcharge Protection***

In a 12 V battery system the voltage vary between 10.5 volts and 14.4 volts, depending on the actual state of charge of the battery, charge current, discharge current, type and age of the battery. When a normal full loaded battery and no charging or discharging current is flowing than the battery voltage is about 12.4 volts to 12.7 volts, when charging current is flowing the voltages jump to a higher level e.g. 13.7 V (depending on the current), when loads are switched on the voltage drops down to a lower lever e.g. 12.0volts or 11.8 volts (also depending on the current). The PV module produces energy and the current is flowing into the battery so voltage level increases up to the range of 14.4 volts. Then over charge protection starts the work. When the battery voltage level is 14.4 volts, the charge controller is switched off the charging current or reduced it (by pulse wide modulation).

E. Deep Discharge Protection

If the voltage of the system falls below 11.5 volts for a period of minimum 20 sec than the charge controller will be switched off for minimum 30 seconds. Than all loads which are connected to the controller is off. If the battery voltage increase above 12.5volts for more than 20 seconds than the charge controller will be switched ON the loads again for a minimum time of 30 seconds. The delay of 30 seconds is integrated to protect the system against a swinging situation.

F. Charge Controller Set Points

Controller set points are the battery voltage levels at which a charge controller performs control or switching functions. Four basic control set points are defined for most charge controllers that have battery overcharge and over discharge protection features. The low voltage load disconnect (LVD) and load reconnect voltage (LRV) refer to the voltage set points at which the load is disconnected from the battery to prevent over discharge [5-7]. Figure 12-1 shows the basic controller set points on a simplified diagram plotting battery voltage versus time for a charge and discharge cycle.

G. Charger Circuit

The charger circuit for the SSHS project is microcontroller based and controls the MOSFET switching [8-10]. It follows the requirements stated above.

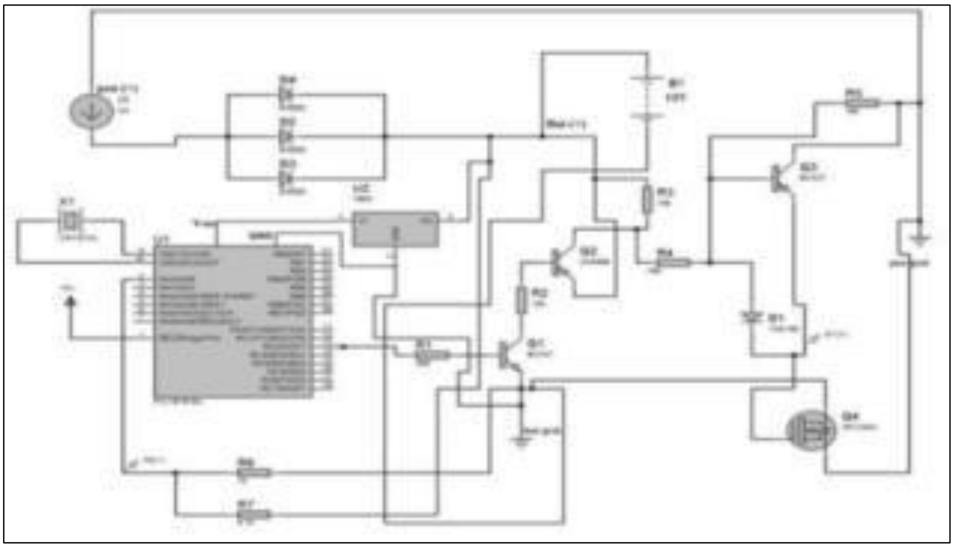

Figure 11: The charger circuit ***H. PCB Implementation***

The PCB (Printed Circuit Board) was implemented to make the charge controller board.

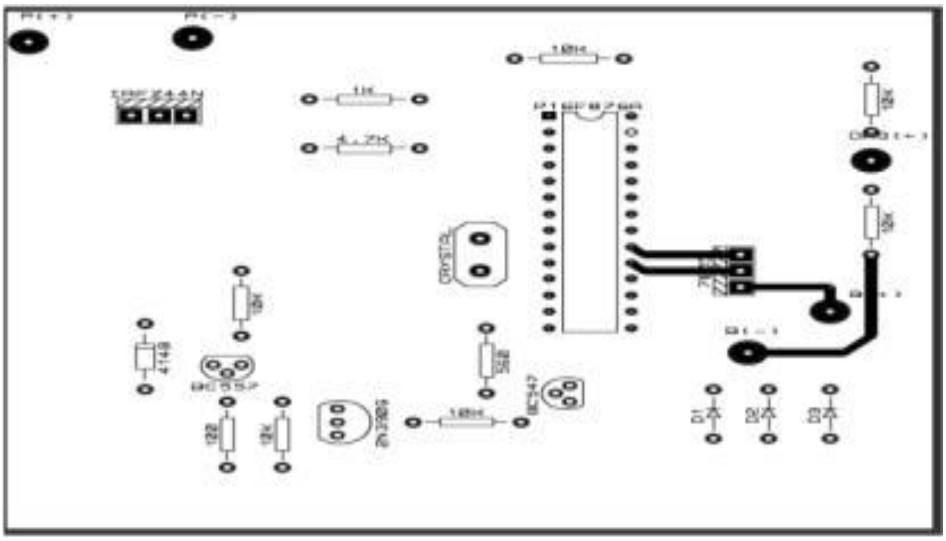

Figure 12: PCB Implementation

VII. EXPERIMENTAL RESULT

A. Balance of System (BOS):

BOS stands for balance of system, which is used for all non-photovoltaic parts of a PV system. They contribute significantly to the overall system and getting these wrong can seriously damage the system. BOS components can be separated into electrical and mechanical components.

The electrical components are:

1) Cables.
2) Fuses.
3) Earthing.
4) Lightning Protection.
5) Battery.
6) Charge Regulation.

Mechanical components are module support structure and tracing system [11-13].

B. Experiments on Different Charge Controller

Two different battery charge controller (a) Rahimafrooz charge controller, (b) Galchip charge controller both product of Bangladesh have been collected and tested. We observed the behavior of the two different charge controllers. The galchip charge controller was tested for primary requirements. It was tested for over current and overcharged protection. It did not have the IDCOL protections. It did not have the reverse leakage current.

Figure 13: Off load test

Table 2: Charge Controller off Load Test

Off Load Test:		
Vrb	**Ib**	**P**
4.98	5.83	29.03
6	7.08	42.48
6.96	8.24	57.35
7.99	8.92	71.271
8.97	9.5	85.22
9.93	10.01	99.399
10.91	11.38	124.156
11.9	7.08	84.25
12.96	7.69	99.66
13.97	8.28	115.672
14.96	9.4	140.62
15.89	9.95	158.106

For this measurement a battery 2.2 Ah @20 hr was connected with Rahimafrooz battery charge controller and the battery were started to charging with a power pack 12V and constant current 200mA. At the beginning the voltage increased. So current was feeding into the battery. And the charge controller did not regulate and all the current was feeding into the battery. Approximately 75 minutes after the battery voltage was reached the regulation voltage set point (14.48 volts) of the battery charge controller, and the controller began to regulate the current. During regulation, the maximum battery voltage was between 14.4 and 14.5 volts. This maximum battery voltage corresponded to the voltage regulation set point for the battery charge controller. The minimum battery voltage was about 13.94 volts. Then a load (CFL lamp 12V/ 0.51 A) was connected in the system to start deep discharging process. The battery voltage decreased steadily from 12.8V to 12.18V after one minute the charge controller disconnected the load. It was observed in the oscilloscope that when battery voltage was 11.9V the charge controller disconnected the load. And there was a sharp rise in the battery voltage as it approached to an open-circuit (no load) voltage of about 12.9 volts. This voltage regulation set point might not be perfect for this type of SHS, because this charge controller was made for solar home system whose discharge battery rated at 100 hours discharge rate. It was fixed the deep discharge disconnect set point in11.5volts and load reconnection voltage set point in 12.5volts [14-16].

C. Laboratory Test Result

The simulation is the same as the actual test. The pulse shows the value that is needed to charge the battery. At different stages, the PWM duty cycle needs to be adjusted to control the battery charging. It is able to disconnect the battery at High Voltage Disconnect (HVD) and Low Voltage Disconnect (LVD).

Not Charging: When voltage is below 10.5V, Duty cycle 0%

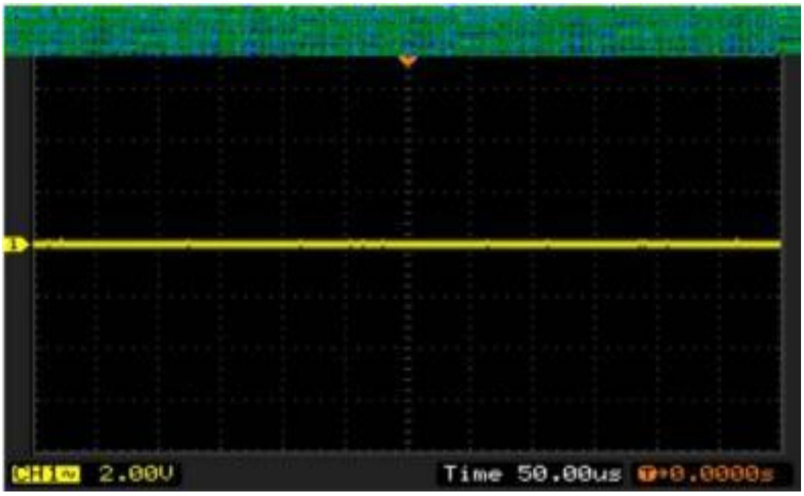

Figure 14: No charge wave shape

Bulk Charge: 40% Ah to be used. It is when voltage is between 10.6 V to 12.6V. Duty cycle used: 90%

Figure 15: Bulk charging wave shape

Float Charge: 5 percent of Ah to be used. It is when voltage is between 12.6 V to 14.3V. Duty cycle used: 10 percent.

Figure 16: Float charging wave shape

Full Charge (HVD): Duty cycle used: 0%, When the battery voltage is 14.4V, circuit is open, the charging current is 0 A.

Figure 17: Full charge wave shape *D. Boundaries of the Current Job*

The present charge controller can charge the battery but it has many restrictions. There are many times when current overflow occurred. It also faced burnout and the PBC is not so efficient.

VIII. CONCLUSION

The emergent need for electricity has led to a countrywide propagation of solar energy based electricity generation systems that integrate battery storage through the use of Solar Home Systems (SHSs) and a large portion of the country's population is dependent on a strenuous means of livelihood that is rickshaw (tricycle) pulling [15]. To tackle the problem, implementation of Solar Battery Charging Station (SBCS) has emerged to the rural Bangladesh as well as in urban areas to change the scenario. Thereby, software implementation of SBCS is vitally important to monitor the system and keep the batteries safe. While maintaining the batteries of the SBCS manually, there might occurs mistakes and batteries can get overcharged. But doing it using software is not only safe but also time and cost effective. Thereby our motto is to make the cost-effective software for monitoring the station from remote region even-though. With the completion of our GUI we will be able to screen multiple batteries concurrently under the same monitor and will allow for the real time visualization of all types of readings, such as the voltage and percentage charge of each battery.

REFERENCES

1. M. N. Uddin, M. Rashid, M. Rahman, B. Hossain, S. Salam, and N. Nithe, "Custom MPPT design of solar power switching network for racing car," in Computer and Information Technology (ICCIT), 2015 18th International Conference on, pp. 11-16. 7.
2. Uddin, M. N., Rashid, M. M., & Mostafa, M. G. (2016). Development of automatic fish feeder. Global Journal of Research In Engineering.
3. Uddin, M. N., Rashid, M., Rubaiyat, M., Hossain, B., Salam, S., & Nithe, N. (2015). Comparison of position sensorless control based back- EMF estimators in PMSM, in Computer and Information Technology (ICCIT), 2015 18th International Conference on, pp. 5-10.
4. Uddin, M. N., Rahman, M. A., & Sir, M. (2016). Reduce generators noise with better performance of a diesel generator set using modified absorption silencer. Global Journal of Research In Engineering.
5. Uddin, M. N., Rashid, M. M., Aziz, M. A., & Nithe, N. A. (2016). Maximum Power Point Charge Controller for DC-DC Power Conversionin Solar PV System. Global Journal of Research In Engineering.
6. Uddin, M. N., Rashid, M. M., & Nithe, N. A. (2016). Comparative study of integrated transceiver for real time monitoring in rescue operation. Einstein International Journal Organization, 1(1), 23-30.
7. Uddin, M. N., Rashid, M. M., Mostafa, M. G., Belayet, H., Salam, S. M., & Nithe, N. A. (2016). New Energy Sources: Technological Status and Economic Potentialities. Global Journal of Science Frontier Research, 16(1), 24-37.
8. Uddin, M. N., Rashid, M. M., Tahir, A. M., Parvez, M., Elias, M. F. M., & Sultan, M. M. (2015, November). Hybrid Fuzzy and PID controller based inverter to control speed of AC induction motor. In 2015 International Conference on Electrical & Electronic Engineering (ICEEE) (pp. 9-12). IEEE.
9. Aziz, M. A., Shams, F., Rashid, M. M., & Uddin, M. (2015). Design and development of a compressed air machine using a compressed air energy storage system. ARPN Journal of Engineering and Applied Sciences, 10(23), 17332- 17336.
10. Uddin, M. N., Rashid, M. M., & Mostafa, M. G. (2016). Development of Controller for TE in Force Adjustable Damper. Global Journal of Research In Engineering.
11. Uddin, M. N., Rashid, M. M., Nithe, N. A., & Rony, J. I. Performance and Cost Analysis of Diesel Engine with Different Mixing Ratio of Raw Vegetable Oil and Diesel Fuel. In Proceedings of the International Conference Biotechnology Engineering, ICBioE (Vol. 16).
12. Uddin, M. N., Rashid, M. M., Mostafa, M. G., & Nayen, M. J. Development of An Absorption Silencer for Generator's Noise Reducing.
13. Uddin, M. N., Rashid, M. M., & Nithe, N. A. (2006). Low Voltage Distribution Level three terminal UPFC based voltage Regulator for Solar PV System. ARPN Journal of Engineering and Applied Sciences, 10(22).
14. Uddin, M. N., Rashid, M., Mostafa, M., Nithe, N., & Rahman, M. (2016). Effects of Energy on Economy, Health and Environment.
15. Uddin, N., Rashid, M. M., Mostafa, M. G., Belayet, H., Salam, S. M., Nithe, N. A., ... & Halder, S. (2016). Development of Voice Recognition for Student Attendance. Global Journal of HumanSocial Science Research: G Linguistics & Education, 16(1), 1-6.

16. Uddin, M. N., Rashid, M., Mostafa, M., & Ahmed, S. Z. (2016). Automated queue management system. Glob. J. Manag. Bus. Res. An Adm. Manag, 16(1), 1-9.
17. Uddin, M. N., Rashid, M. M., & Mostafa, M. G. (2016). Global energy: need, present status, future trend and key issues. Global Journal of Research In Engineering.
18. Uddin, M. N., Rashid, M. M., & Mostafa, M. G. (2016). ECG Arryhthmia Classifier. Global Journal of Research In Engineering.
19. Uddin, M. N., Rashid, M. M., Parvez, M., Sultan, M. M., Ahmed, S. Z., Nithe, N. A., ... & Rahman, M. T. (2016). Two Degree-Of-Freedom Camera Support System. Global Journal of Computer Science and Technology.
20. Uddin, M. N., Rashid, M. M., & Mostafa, M. G. (2016). Design & Development of Electric Cable Inspection. Global Journal of Research In Engineering.
21. Uddin, M. N., Rahman, M. A., Rashid, M. M., Nithe, N. A., & Rony, J. I. (2016). A Mechanism Concept and Design of Reconfigurable Robot for Rescue Operation. Global Journal of Research In Engineering.
22. Rahman, M., Rasul, M. G., Hassan, N. M. S., Azad, A. K., & Uddin, M. (2017). Effect of small proportion of butanol additive on the performance, emission, and combustion of Australian native first- and second-generation biodiesel in a diesel engine. Environmental Science and Pollution Research, 24(28), 22402-22413.
23. Ahmed, R., Haque, M. A., Hossain, K., & Uddin, M. N. (2022). Development of a Controlled Output Wind Turbine. Saudi J Eng Technol, 7(6), 316-326.
24. Rahman, M. T., Ahmed, R., Hossain, K., Haque, A., Ahmed, R., Sultana, N., & Uddin, N. (2022). Assessment of WDM Based RoF Passive Optical Network. Saudi J Eng Technol, 7(6), 290-298.
25. Shahabuddin, M., Uddin, M. N., Chowdhury, J. I., Ahmed, S. F., Uddin, M. N., Mofijur, M., & Uddin, M. A. (2022). A review of the recent development, challenges, and opportunities of electronic waste (e-waste). International Journal of Environmental Science and Technology, 1-8.
26. Uddin, M. N., Rahman, M. A., Taweekun, J., Techato, K., Mofijur, M., & Rasul, M. (2019). Enhancement of biogas generation in up-flow sludge blanket (UASB) bioreactor from palm oil mill effluent (POME). Energy procedia, 160, 670-676.
27. Islam, M. S., Rahman, M. M., Mahabub, Z., Haque, N., Mahmood, M. M., Alauddin, M., ... & Rashid, M. M. (2020). Study on Physicochemical Status, Bacterial Analysis and its Correlation.
28. Ahammed, S., Rana, M. R., Rony, M. A., Hosain, M. M., Mamun, M. A., Alauddin, M., ... & Rashid, M. M. (2020). Review of Coal Fired Power Plants in Bangladesh
29. MN Uddin, K Techato, J Taweekun, M. Mofijur, M. G. Rasul. An overview of recent developments in Biomass pyrolysis technologies. Energies, 2018.