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Improvement of Solar Home System Performance by Using Charge Controller with Memory

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ABSTRACT

Sustainable electrical sources like solar photovoltaic are becoming progressively significant as environment friendly substitute to fossil fuels. But while they are advantageous for the environment, sustainable sources are not always easy to apply. These sources are categorized by both rigorous peak – power limitations and 'use it or lose it' handiness. Efficacious application of sustainable energy sources therefore depends on strict attention to efficiency in both power conversion and energy storage. A charge controller is an essential part of nearly all power systems that charge batteries, whether the power source is renewables or utility grid. The aim of a charge controller is to keep the batteries properly fed and safe for the long term. A charge controller is a regulator that goes between the solar panels and the batteries. The authors intend to show the importance of charge controller with memory for improving the overall performance of solar home systems.

Key words: *Adaptive Low Voltage Disconnect, Programmable Low Voltage Disconnect, Pulse Width Modulated Charge Controller, Solar Home System Performance, Memory Charge Controller.*

1. INTRODUCTION

Energy is one of the chief interests for the growing future of any state as it is to a great deal the biggest merchandise in earth and a colossal amount of energy is extricated, circulated, converted and spent in our global society every day. The worldwide energy demand is constantly rising. Global energy production in today's world is highly reliant on fossil fuel resources such as oil, gas and coal. In Bangladesh it comes to almost 96.54% [1] dependency on oil, gas, coal or diesel. But these resources are limited and also their usage on a large scale ends up in greenhouse effect due to emanation of greenhouse gases like carbon dioxide. For this concern renewable sources have become popular in today's world. There is a growing demand for energy from renewable resources such as wind, solar, geothermal and ocean to provide a sustainable power production in future and at the same time be concerned about global warming. The sun is the source of the life on our planet. Directly or indirectly, it is the fuel for most of the renewable systems. Photovoltaic and solar thermal systems, as well as solar thermal power stations, convert solar irradiation directly into useable energy. Each square meter of the sun's surface produces a radiant power of 63.1 MW [2], which means that just a fifth of a square kilometer of the sun's surface produces an amount of energy equal to the global primary energy demand of the world. Only a small part of this energy reaches the earth's surface. This resource can be used to meet the worldwide energy demand.

Stand-Alone Solar system is widely used in Bangladesh, especially in the rural areas where grid electricity supply is neither available nor expected in the medium term [3]. It consists of: PV module, a battery bank, a charge controller and load. Of them the most significant one that makes the system costly is the battery bank. So, it is very important to take special care of it. For this, charge controller is used. It acts as a junction between PV module, battery and the loads. Today charge controller is an inevitable item for a Stand – Alone Solar system.

In market, various types of charge controllers are available. Of these, the authors are intended to illustrate the importance of charge controllers with memory. Using a charge controller with memory, the paper has analyzed the performance of two Stand-Alone SHSs.

2. CHARGE CONTROLLER

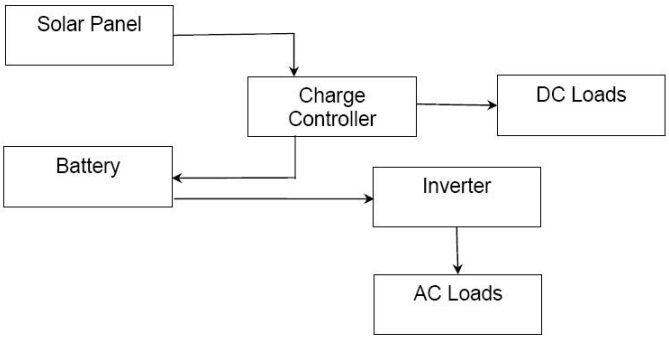

Fig. 1 Block diagram of a standalone solar PV system

A charge controller is a voltage regulator. Normally it saves current in a battery by controlling the current and voltage of the solar panel. Typically a solar panel generates 16 to 21 volts and to keep a 12-volt battery fully charged 14 to 14.8 volt is needed. The work of the controller is to lessen (Buck) this extra voltage. It is basically a chopper or DC to DC converter. In solar panels buck converters are used which converts the high DC voltage to a low DC voltage.

The working procedure of a charge controller is shown in a block diagram (Fig. 1). The battery supplies electricity to the DC loads through the charge controller. Besides, if the loads are operated by AC then the battery converts the DC voltage into AC and then supplies electricity to the loads.

3. OPERATING PRINCIPLE

A controller switch is used for operating the charge controller. It can be a relay or a solid-state switch like power transistor or MOSFET. The controllers, which have relays, have less power loss as they (relays) have some resistance but it can switch on-off for only 100,000 times and hence have less longevity. For making the relays more durable bypass circuits are often used. In case of solid-state switches, though they are more durable but they have some heat losses when high current is passed through them. The controller circuit controls the operation of the controller switch. There are many schemes for the mechanism of switching on-off such as – continuously switched on, on – off, PWM (Pulse Width Modulation) etc. The supply of electricity from solar panels to the battery is controlled by this switching on-off of the controller switch.

Almost all the controllers decrease or increase the supply of electricity by analyzing the voltage of the battery. Microprocessor based charge controllers do this work by evaluating the ampere – hours rather than estimating the state of charge of the battery.

The voltage of the battery at which the controller will reduce or totally terminate the flow of electricity is called the "charge set point" or simply "set point". In many cases, a temperature sensor is incorporated with it to sense the change in temperature. In addition to these, the charge controller also has to prevent the battery from deep discharging, sulphation, overcurrent and short circuit current.

A PWM (Pulse Width Modulated) charge controller is a traditional charge controller. It is widely used as a robust, inexpensive charge controller in PV applications. PWM shunt controllers are used at a small scale, where electrical interference is a concern. The MPPT (Maximum Power Point Tracking) charge controller is the most popular one in today's PV systems. These controllers actually detect the optimum operating voltage and amperage of the solar array and match that with the battery bank. The outcome is additional 15-30% more power out of the array than a PWM controller. Although the MPPT controller is more expensive than its PWM counterpart, it is generally a wise investment for any solar electric system over 200 watt-peaks. So considering these factors the charge controller type can be determined. The authors intend to find a better security for the stand – alone systems in rural areas. Typically in a rural area, the wattage of the loads is much less than that of city – dwellers, around 200 watts. This is why a PWM charge controller is used here to make the investment cost – effective.

4. DESCRIPTION OF A CHARGE CONTROLLER WITH MEMORY

The authors have used Phocos CX10 charge controller which has memory incorporated with it. It is a sophisticated solar charge controller with exceptional features. Beside a perfect PWM regulation with integrated temperature compensation, the controllers provide extraordinary multifunctional LCD display. It has a programmable low voltage disconnect with new ALVD (Adaptive Low Voltage Disconnect) and a sophisticated programmable nightlight function. Moreover, it gives complete electronic protection as it has negative grounding features [4].

The advantages that the authors have come across during using this charge controller in compared to the traditional memory less charge controllers are described below.

This charge controller protects the battery from being overcharged by the solar panel array and also from being over charged by the loads. The charging characteristics include several stages which includes automatic adaption to the ambient temperature whereas the memory less charge controllers do this only by sensing the voltage of the battery bank. The with–memory charge controller adjusts itself automatically to 12V or 24V system voltage but the memory less charge controllers are fixed for a specific voltage. The with–memory charge controller has a push button also that allows switching the loads on and off manually. It can be programmed for lighting applications. Moreover, it has a serial interface which can be used with an optional interface adapter for functions of data logger. These are very useful functions as for these the authors were able to study the overall status of the Stand – Alone system. The memory less charge controllers cannot provide these scopes.

5. CASE STUDY

Two different stand – alone systems have been observed here. One is at the Ahsanullah University of Science & Technology (AUST) premises (Tejgaon, Dhaka, Bangladesh); the second one is at a small hut in Binadangi Bazar (Savar, Bangladesh). The data that has been collected from Binadangi Bazar was of a SHS where no measure had been taken studying the status of battery even though a with-memory charge controller has been installed with it. The authors have collected this data to demonstrate the situation about what happens when a memory-less charge controller is installed with an SHS. As no measure has been taken even though a with-memory charge controller was installed there, the charge controller can be considered as memory-less in this context.

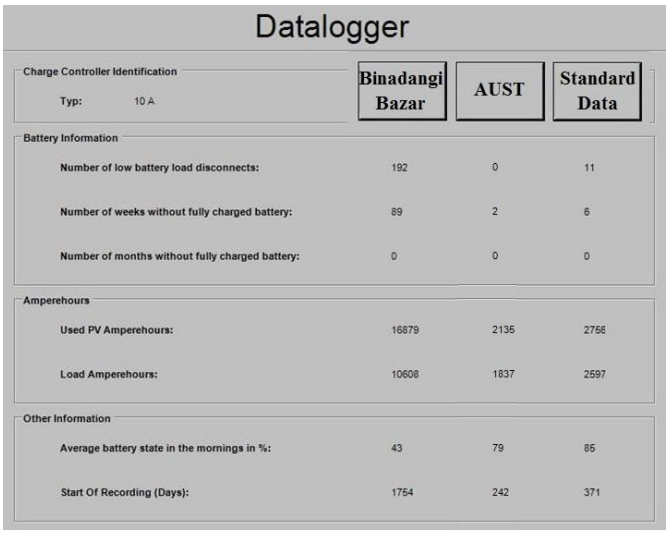

Fig. 2 Comparison of data logger among three systems

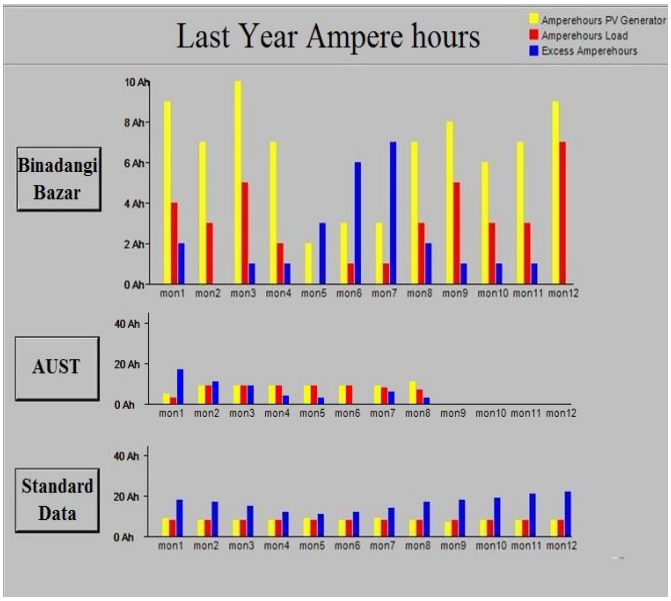

Fig. 3 Comparison of ampere hours diagram among three systems

All the data, which have been used, are collected by this memory charge controller. It can be seen from the graph that more than one year's data has been used for analysis other than the data collected from AUST. It is because though the system in AUST was installed a long ago, the charge controller there had no memory storage earlier. Recently they have installed a charge controller from Phocos having the memory storage feature. That's why only 8 months data of that system have been used. The authors have taken proper care of the battery situated in AUST by following the data of the memory charge controller. A standard data of 371 days has also been added here from phocos website to understand the status of an ideal Standalone SHS.

From the data logger in Fig. 2, it has been learnt that several low voltage disconnections occurred in Binadangi Bazar which is much higher than that of AUST. No of weeks without fully charged battery is also preferable in AUST than Binadangi Bazar. Average battery charge state in the morning is much lower in Binadangi Bazar.

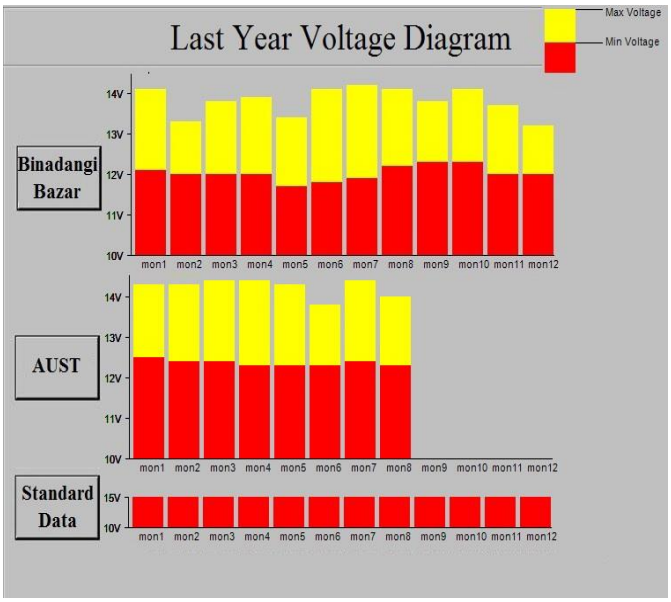

Fig. 4 Comparison of voltage diagram among three systems

From the Fig. 3 and Fig. 4, the comparison among the ampere hour diagrams and the voltage diagrams of the three sets of data can be seen. From the last year ampere hour diagram of Binadangi Bazar, it is observable that the ampere hours supplied to the load is much less than that of the PV generator. This is because the state of battery has worsened to this much that it can barely support the system. From the last year voltage diagram it can be seen that the maximum charge by which the battery is being charged is higher in AUST than Binadangi Bazar. The perfect case is seen in the standard data where the battery is being charged with a constant maximum voltage of around 15V.

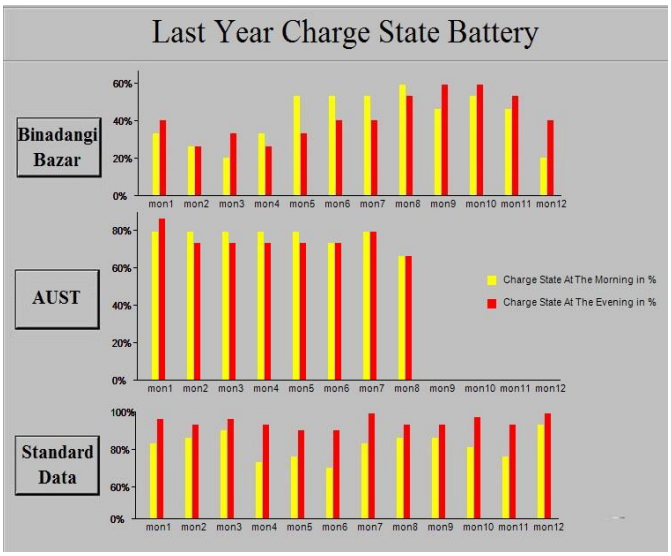

Fig. 5 Comparison of charge state of the battery among three systems

From Fig. 5 it can be seen that the charge state of batteries at morning and evening is of higher percentage in AUST and standard data than Binadangi Bazar. It shows the efficiency of the battery. The higher percentage of charge being stored at the evening, the better is the efficiency of the battery. It shows the remaining battery life also.

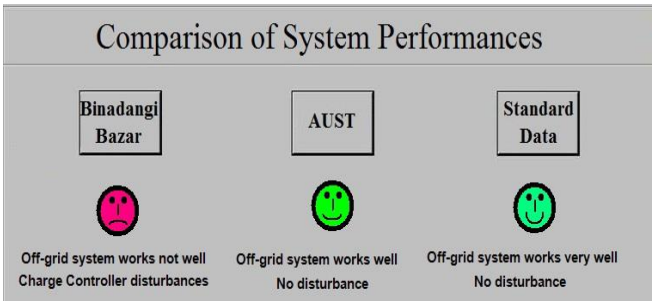

Fig. 6 Comparison of system performances among three systems

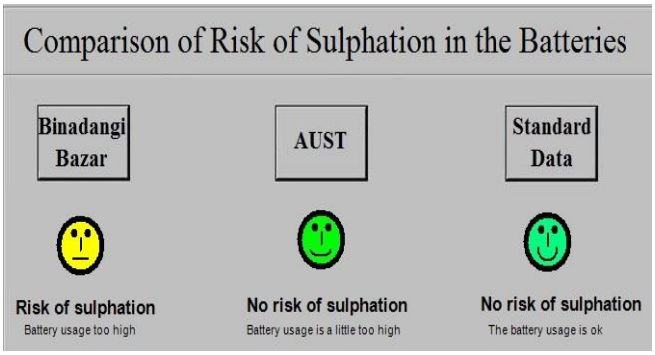

Fig. 7 Comparison of risk of sulphation in the batteries among three systems

From the system performances in Fig. 6, it can clearly be seen that the system situated in Binadangi Bazar is very poorly maintained whereas that of the other two run almost smoothly.

From Fig. 7 it is observable that there is a high risk of sulphation in the battery situated at the Binadangi Bazar as the battery usage is too high, and on the other hand, as the battery situated at AUST premises is regularly maintained by observing the data from the charge controller, so there is no risk of sulphation and the battery usage is almost ok there.

6. JUSTIFICATION FOR USING WITH-MEMORY CHARGE CONTROLLER

From the case study it can be said that, if the battery is maintained by regularly studying the data collected from the charge controller, a severe damage of the battery can be avoided. As the most costly component of a SHS is the battery, so by using a with – memory charge controller, a system owner can be exempted from the huge burden of replacing the battery too often. This saves not only the economic hassle, but also ensures the better continuity of electricity in the household.

7. CONCLUSION

The main problem in an SHS is the durability of the battery. If batteries are routinely allowed to overcharge, their life expectancy will be reduced dramatically within 1-2 years. For this reason many agendas for installing SHS in villages of Bangladesh are now obsolete. Hence, not only proper maintenance of the battery is required but also proper use, charge-discharge, disconnection from load in unsafe situation etc. should be managed with care. And this is done by charge controllers. By the use of an efficient memory charge controller, the authors have demonstrated that the proper use of the solar panel to its utmost efficiency and a higher longevity of the battery can be achieved. This is why it is very important to use a competent charge controller.

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