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Automatic Battery Charger Using Solar Energy

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Abstract
In recent years, the utilization of renewable energy sources has become an attractive alternative to fossil fuels because of the latter's negative impact on the environment. Among different sustainable power sources, sunlight based vitality is required to be a standout amongst the most encouraging means as future vitality arrangements. It is exchanged to the earth as electromagnetic radiation and conveniently changed over to electric vitality shapes through different sunlight based power innovations, for example, photovoltaic (PV). The electricity produced by solar power systems can be delivered to the consumer via electrical transmission grid, and stored in batteries but the problem of that generation system is that the energy source (sun) is intermittent throughout the day so the generated power is intermittent too. Therefore, it is necessary to find a solution for storage energy produced by PV to charge batteries; one of the suggested solutions is designing an automatic charger controller to regulate the voltage across the battery in spite of the variation of the voltage source and the load connected to the storage devices. The state space model of the converter is first linearized to facilitate the controller design. The proposed control technique is sliding mode control (SMC) which is suitable technique for controlling nonlinear systems by forcing system states to specified sliding manifolds on which the system has desired properties such as stability, and tracking the required output voltage to supply the load system.

Keywords: *Renewable energy; solar cell; charger*

1. Introduction

Getting an access to electrical energy is one of the basic needs for a civilized and industrialized world. It's a fact that around the world, 1.2 billion people need electricity but the consistent supply of electricity lacks and plays the major hindrance in power generation. Considering the fact, that many of these people live in remote or rural areas, where it is often too difficult for an electrical supply. Installation using standard electrical extensions by a power grid will be an expensive option. These reasons resulted to a lack of access to electricity and will surely hamper the remote place's economic progress considering that electricity plays a major element or contribution for industrialization as well as to ensure an economic progress [1].

For the present, the world faces a criticalness of need to build up a spotless and sustainable power sources, taking care of the vitality demand of creating nations [2]. Alternatives and decisions for these sustainable power source assets come in assortment yet the sun based vitality comes as the least expensive and cleanest among them. Sun oriented vitality has risen as a standout amongst the most quickly developing sustainable wellsprings of power because of the tenacious cost decrease (for the general system) and cleaner as far as power age [3].

The photovoltaic (PV), or the solar, power systems are a sustainable way to convert the energy of the sun into useable electricity [4]. Also, the electricity produced by solar power systems can be delivered safely to the consumers using an electrical transmission grid as well as storing in storage devices for future uses (considering the variations and types of stand-alone PV systems) in which batteries are used for storing energy. In the process of storing energy in batteries, a battery is often used in PV array during the day as well as supplying electrical loads (as needed) [5]. In most cases, a battery charge controller is used for these procedures protecting the battery from overcharging or over discharging [6]. Variety of types of charger regulators can be used with solar energy charging procedures namely; the linear and non-linear regulator. Also, he denotes the slight differences between linear regulators from a non-linear regulator. The linear

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regulator types are simple, but mostly waste large amount of power during the process of regulating voltages [7].

The procedure significantly works by taking the distinction between the info and yield voltages by simply consuming the voltages as waste warmth. Bigger contrasts between the info and yield voltage, more warmth will be delivered [8]. By these ages of more warmth that will result for a bigger warmth squander prompts harm the battery life.

Despite what might be expected, switch-mode controllers have a higher productivity; they deliver lesser measure of vitality, which implies lesser lost during the time spent vitality exchange, and as far as size examination, they are littler contrasted with the direct controllers. For instance, the exchanged mode DC-DC converters are probably the most generally utilized power gadgets circuits for its high transformation effectiveness and adaptable yield voltage [9]. Such converters utilized for electronic gadgets are intended to direct the yield voltage versus the progressions of the information voltage and load current. By utilizing converter such Buck-Boost converters, exchanged mode DC/DC converters make probability to productively change over a DC voltage in a lower or higher voltage. These Buck-support converters are proficient being used for PV greatest power following purposes, which impartially draw the conceivable most extreme power from the sun based boards whenever and paying little heed to its heap [10].

As of late, control systems for different power electronic machines had expanded colossally. Vitally, these requests must be dealt with and settled. Numerous electronic scientists or architects have been restless in finding the most sensible and temperate and additionally the most dependable controller will can meet expanding requests. Having a control system in DC-DC converter is to guarantee the coveted voltage yield, which must be delivered effectively when contrasted with open circle system. Likewise, the Sliding Mode Control gives a few focal points as far as other control techniques: Robustness, soundness for even vast line and load varieties, great unique reaction however least complex in usage. The sliding mode control technique is the one being perceived as one the most productive devices in outlining strong controllers particularly managing high-arrange nonlinear unique plant activities with vulnerability of conditions [11-13].

The yield voltage of the solar system isn't consistent as a result of the difference in the daylight power. The irregularity of the sun powered photovoltaic innovation is one of the key difficulties as a result of the vacillations of the created power for the duration of the day. To acquire a steady voltage from an information supply that is higher and lower than the yield, a high productivity and least swell converter required in the system for private power creation. Subsequently, it is required to interface the yield of the nearby solar system to the capacity gadgets as batteries utilizing charging circuit keeping in mind the end goal to store the vitality created by PV. In this work, DC-DC buck support converter is utilized to direct the voltage over the capacity gadget regardless of the variety of the voltage yield from the PV and the heap associated with the capacity gadgets. The point of this work is to plan a programmed sun powered charger controller for 12v battery to be utilized as lighting system and give 500 W to a solitary home in remote territory since the power transmission line isn't accessible for them. Sliding mode control technique will be utilized to manage the yield voltage from DC/DC Buck Boost Converter.

2. Prototype Description

2.1 System Architecture and Functionality

PV system is capable of providing enough DC electricity to power a single home. DC/DC Converter will be use to input voltage from solar panel to supply load system. The automatic solar battery charging system in this project is illustrated in Figure. 1

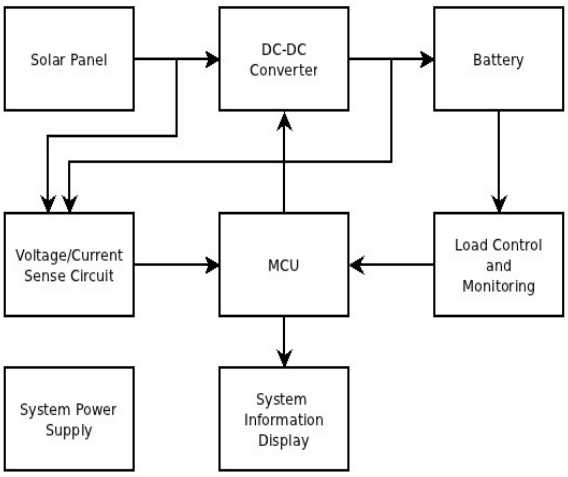

Figure 1: Block Diagram of Automatic Solar Battery Charger System

Solar PV system includes different components that should be selected according Factors influencing the selection include, the site location and application. The component of lighting solar system is divided into the following parts which are solar panel, charge controller and battery.

2.2 Project Specification and Features

The microcontroller sends the control signals to the electronic switches in the buck boost converter according to the reading of the voltage and current sensors at the PV and the battery terminals. The charging process will be ended when the battery is fully charged (using voltage sensor) or when the current exceeds the maximum limit (using current sensor). Visually Impaired people need a safe and efficient tool that helps them to navigate. In this work, Arduino Uno, is an open-source hardware platform designed around an 8-bit microcontroller, or a 32-bit

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Atmel ARM with a clock speed of 16 MHz was used. Next, lead acid battery (80h) was used as the battery source. Thirty-six-cell modules produce the best voltage for charging a 12V battery and were used for this work. We have calculated the required solar panel that is suitable to charge the 12V lead acid battery that has capacity of 80 Ah. These solar panels are durable and efficient in providing power. Other component that was used in this work is LED light, Voltage sensor (DC0-35 V) and current sensors (±30A).

3. Design and Analysis

3.1 Assumptions and Parameters Used in the Design and Modeling

Some specific suppositions to ponder the elements of the buck support converter as expressed underneath was considered:

i) Capacitor is thought to act naturally contained and separated, with no net electric charge and no impact from any outside electric field.

ii) Diode and change are thought to be perfect

iii) Resistor is thought to be the heap of the circuit. Outwardly Impaired individuals require a sheltered and effective device that encourages them to explore, recognize.

3.2 Analysis of the Buck Boost Converter

There are two distinct methods of task in DC-DC converters: Continuous Conduction Mode (CCM), and Discontinuous Conduction mode (DCM). CCM is characterized by current streaming constantly in the inductor amid the whole exchanging cycle in enduring state task. DCM is characterized by the inductor current being zero for a time of the exchanging cycle. It begins at zero, achieves a pinnacle esteem, and comes back to zero amid each exchanging cycle. To accomplish high productivity and proficient use to Semiconductor Switches and uninvolved segments, the CCM is best.

3.3 Proposed Control Method

In the previous decades, with the improvement of nonlinear control hypothesis practically speaking, there has been impressive enthusiasm for use of cutting edge control procedure, for example, the fluffy rationale controller, PI controller, PID controller, to oversee the Buck-Boost converter outline issues. In the interim, there are still some down to earth issues for the previously mentioned control strategies to defeat for the long haul task of intensity systems progressively applications. In such manner, an uncommon sort of controller strategy, i.e. sliding mode controller (SMC), is brought into the control plan of Buck-Boost converter for PV system as pursue. As a notable nonlinear control technique, SMC controller is a ground-breaking and vigorous way to deal with controlling direct, nonlinear. The fundamental favorable position of SMC controller is its high strength to the parameter vulnerabilities and unsettling influences. Once the system is on the sliding mode surface, the conduct of the system is dictated by the surface of sliding mode and failing to be influenced by the variety in the system. This one of a kind favorable position permits more opportunity in planning controllers since it can adjust the system display by acquainting virtual unsettling influences contribution with fulfill certain power conditions and uncommon necessities, and gives a somewhat exact following outcome, in this way SMC controller has progressively turned into a focused hopeful controller that against aggravations and system vulnerabilities in the control systems picked

4. Result and Discussion

4.1 Software Result

The model appeared in Figure 2 speaks to a PV cell exhibit associated with a variable resistor. Inside the cluster subsystem are 36 cell modules create the best voltage for charging a 12V battery, shaped by 6 Solar Cells of SimElectronics library. The structure model can be worked in any setups by masterminding different strings of sunlight based cells in parallel or in arrangement. The upside of utilizing of this abnormal state of execution is to make an identical circuit, which contains more mind boggling parameters, for example, the impact of temperature in the gadget which is vital for conduct of this sort of system. The PV demonstrates is approved by mimicking at an estimation of irradiance of 1000W/m2 and a temperature of 25°C.

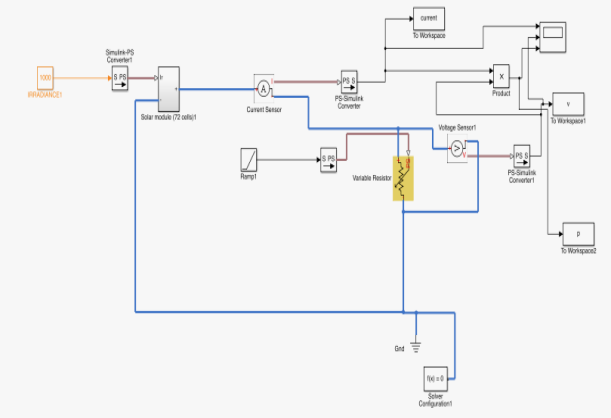

Figure 2: PV module connected to a variable resistor

The I-V and P-V attributes of the PV is given in Figure 3 and Figure 4. The I-V bend speak to the standard conduct of the PV cell and PV cluster separately. In the center purpose of this bend is the most extreme power point. The most extreme power point is exceptionally basic for this sort of system for greatest power extraction from the PV cluster. In this way the primary target is to influence the photovoltaic cells to work around of this most extreme point with a specific end goal to get the greatest productivity.

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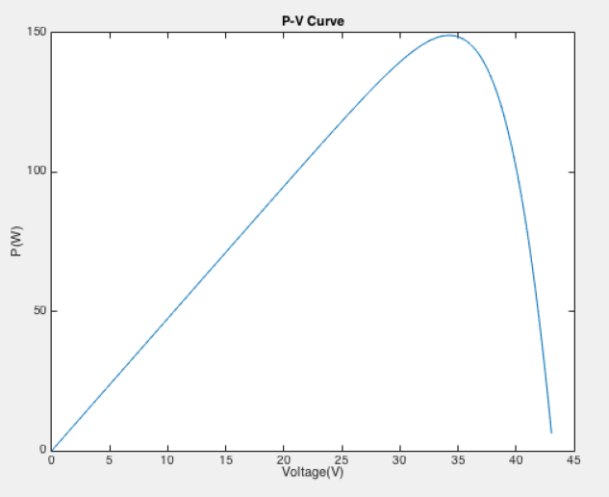

Figure 3: P-V characteristics

The simulation was made to test the output of open loop buck-boost modes using MATLAB software; the system is simulated in 2 cases, the first case when the voltage of the solar panel is equal to 18V and the second case when the voltage from the solar panel dropped to 9V. This simulation in Figure 5 shows the output of the buck boost when the input =18V. We got a constant 12V output with oscillations in the in the transit period. These oscillations occur due to the effect of the filter L and C.

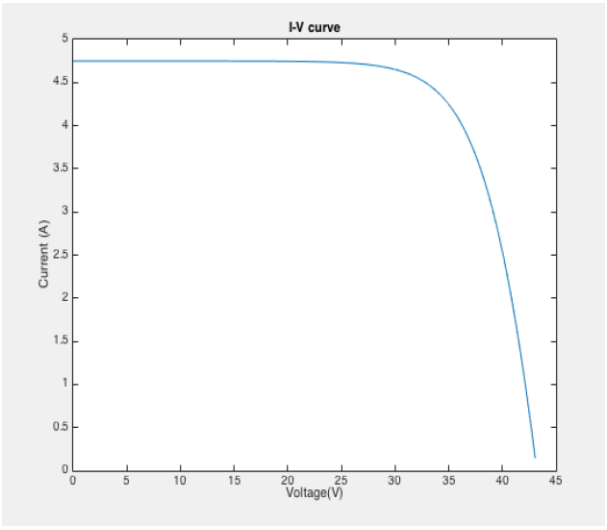

Figure 4: I-V characteristics

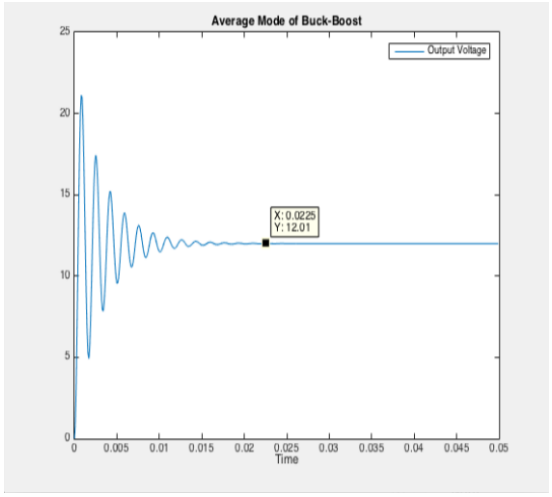

Figure 5: Average Model of Buck-Boost -Input Voltage = 18V

According to the simulation in Figure 6 the simulation of open loop buck boost convertor, when the voltage varies from the solar panel the output voltage from the buck boost regulator is not constant. Therefore, it is required to design a feedback control system for the DC/DC buck boost convertor to produce a constant output voltage.

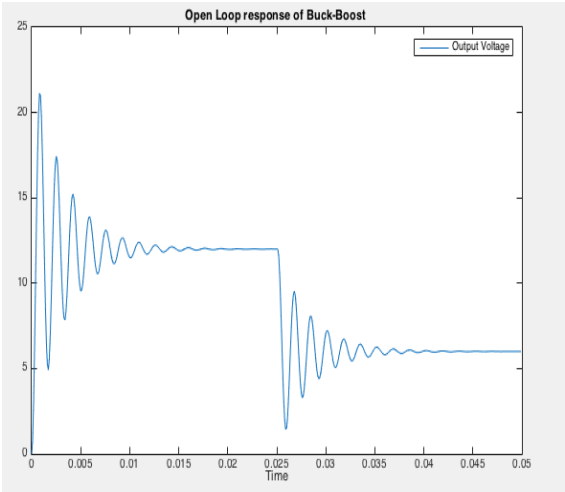

Figure 6: Average Model of Buck-Boost -Input Voltage dropped to 9V

4.2 Hardware Result

After the simulation was done and refine the flaw based on component choosing, the hardware then implemented. The principle goal of this task is to outline a criticism control system for the DC-DC buck help convertor to deliver a consistent yield voltage. The picked control strategy is sliding mode controller (SMC) once the system is on the sliding mode surface, the conduct of the system is dictated by the surface of sliding mode and failing to be influenced by the variety in the system. Such remarkable favorable position allows more effectiveness

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in planning controllers since it can adjust the system show by acquainting virtual aggravations contribution with fulfill certain vigor conditions and extraordinary necessities. Along these lines SMC controller has turned into an aggressive competitor controller that against aggravations and system vulnerabilities in the control methodologies picked.

The project test setup is shown in Figure 7, Figure 8 and Figure 9 respectively.. The desired output is set to be 14.5v in the Arduino code. When the input from the power supply equal 20V, the buck boost converter produced a DC output voltage of around 14.5v. Based on Figure 9, finally, we can conclude that by increasing or decreasing the input, the output voltage remains constant. Compared to a desired output voltage of 14.5V, a percent error of0.9% was recorded. Since the output error of the system is 0.9%, it can be concluded that the results from the system were fairly acceptable.

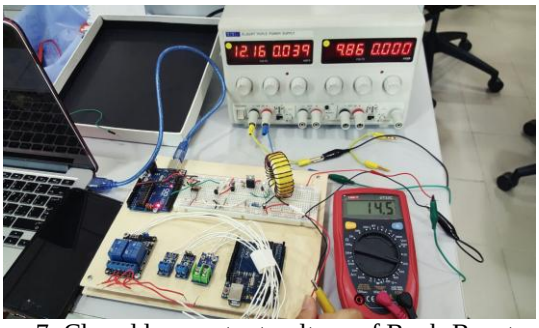

Figure 7: Closed loop output voltage of Buck-Boost when input voltage=12v

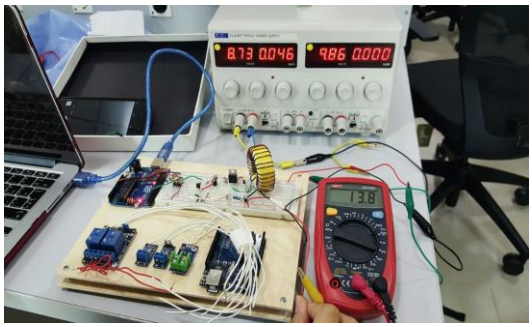

Figure 8: Closed loop output voltage of Buck-Boost when input voltage=8v

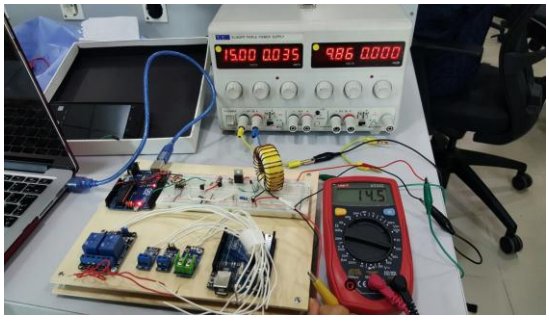

Figure 9: Closed loop output voltage of Buck-Boost when input voltage=15v

Authors have connected the solar panel to the charger controller and charger controller to battery to check the charging process. Thus confirm that the charging process was successfully completed as it shown in Figure 10.

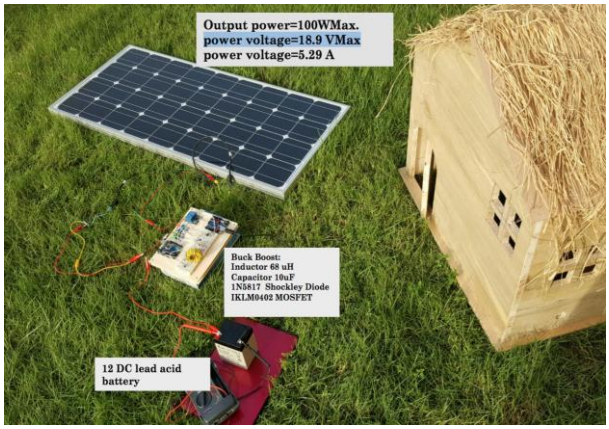

Figure 10: Overall connection of the system

5. Conclusion

In conclusion the scope of the project was achieved by designing an automatic charger controller for the battery to be charged and provides enough power for lighting system to helps and improves the livelihoods of thousands of people living in remote area to go about their activities even during nighttime. The systems were first trained then tested. The implementation and testing are all done using Matlab software. Finally, it is concluded that by increasing or decreasing the input voltage, the output voltage remains constant. Compared to a desired output voltage of 14.5V, a percent error of 0.9% was recorded. Since the output error of the system is 0.9%, it can be concluded that the results from the system were fairly acceptable. In the future, our plan is to develop the control for this power generation system using a PLC: programmable logical controller, and make it user friendly with interfacing through a HMI: Human Machine Interface software that can help to detect battery percentage.

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