Design of a Solar Charger Circuit for Recharging Batteries of Communication Devices

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Abstract:
As entire world goes in the direction of the new segment of era our wishes will become greater sophisticated, then again we need velocity, satisfactory, and effectiveness. In current world, we need mobile telephones and different communication gadgets so that it will preserve ourselves communicated. But we want power so as to price them, which is not feasible on every occasion as we’re dealing with energy crisis. From time to time battery turns into flat in the middle of communication especially in the convenient times when get entry to a popular charger isn't feasible. On the earth, solar energy is one of the many sorts of a renewable energy. By using a solar cell or photovoltaic cell we can convert the sunlight directly to the power. On this undertaking, a solar battery charger controller circuit is completely constructed and simulated using NI Multisim 14.2 software.

I. INTRODUCTION

In the modern day situation power has become the large requirement for human lifestyles. Energy is a significant contribution to all the regions of any nation’s economic system. The everyday increasing population and diminishing commonplace hotspots for electricity age, gives a need to think on non-ordinary power belongings. Here we’re anticipating to preserve the sunlight based energy that gone squandered. With the developing rate of innovation progression, advanced cell phone and other specialized gadgets have become the basic part of day by day lifestyles. Solar based power is one of this numerous structures. The earth gets round 1 X 10^12 MW of vitality from the sun each year. Solar based power has verified to be a spotless and secure kind of power for our regular residing and is made accessible normally around the world. As innovation has advanced and made our telephone littler and simpler to make use of we still absurd to expect to charge batteries wherever every time so we need portable charger to charge the portable batteries wherever whenever we want. The sun based fueled battery charger is naturally makes use of sustainable energy source and lessens compound waste since it permits alkaline batteries to be reused for a particular measure of times before being arranged. This form of battery charger likewise has a extra extended lifestyles cycle because it requires insignificant protection and can straightforwardly exchange over energy from the sun to create power.

II. SOLAR CELL

A. Principle of Solar Panel

Solar powered energy has for quite some time been catching eye of the researchers and scientists as obvious interchange association to petroleum by-product power. Anyway the solar oriented power despite the fact that it is available in bounty, the endeavors to utilize this energy and pass it right into a usable shape and drives our regular machines has been futile. This is the reason sun oriented vitality has not become our high wellspring of our power prerequisites. The essential motivation at the back of why we can't utilize the sun oriented vitality is our sun powered boards can't tap over 20% of its vitality. These consequences in extraordinary mission value yet low go back of speculation.

This makes the hobby in sunlight based power unsightly and along those traces is starting to be much less and less well-known. In any case specialists all round the world have had the choice to make use of solar panels a good way to tap this solar based energy all the greater proficiently. Solar panel is classified into 2 types, one is crystalline panel which is made up of crystalline silicon and another is amorphous panel which is made up of amorphous silicon. Several photovoltaic cells are related firmly together forming an array wherein power absorption can be focused. These housings are positioned close to each other over a typically large surface place to be as effective as conceivable while engrossing the light.

An anti-reflective coating is protected to the solar panel to reduce power losses and to get sufficient absorption capacity. Over that layer, a glass plate is applied to make durability and ensure against disintegration. Photovoltaic cells are fabricated from material known as semiconductors which fall directly in the middle of conductors and insulator with regards to the size of electron stream. Typically, the most regularly utilized semiconductor is Silicon. Silicon is the most widely recognized semiconductor utilized in solar panels on the grounds that as its capacity to stay a semiconductor at extremely high temperatures under the sun.
B. Generation of Electricity from Solar Panel

It’s essential operating principle is based upon the semiconductor belongings of silicon. With the intention to see the working principle of solar panel and to see the function of Si at an atomic level. By removing the impurities a Si atom will bond to some other Si atom. Since the Si ion valence number is 8 there will be a 8 electrons in its outermost orbit. Besides in its outer orbit there will be a 4 electrons confined inside the normal state. Henceforth these outer orbit 4 electrons are willing to bond with any other 4 electrons along with the Si particles of 4 numbers around it. The free electrons of 4 numbers which are always ready to pass round at some point of the substance. At some stage in the deficiency of electric potential those free electrons have a tendency to stay near their parent particles so they are at least energy level. Anyway when an electric capability is implemented over the substance those electrons which are free get vitality and move towards the course of applied potential as a consequence creating electric drift. Anyway the current flow in semiconductor may be very much less and these electrons which are free wishes to stay at least energy level conceivable. This makes us to study a case of natural Si semiconductor and which makes us to present a modest phosphorus. Currently this recent ion which has a 5 number of electrons around it. At the factor this recent ion combines with other 4 Si ions, which is unfastened at its fifth electrons level. However, at some stage in the nonappearance of difference in ability, the fifth electron is strengthened along with an atom of phosphorus. With useful resource of ability, the electrons which are free can be passed towards capability difference implemented henceforth electric drift is generated. This atom of phosphorus being charged negatively which also makes the Si/P plate to be charged negatively. Similarly when any other substance, for example, if pure Si plate consists of boron, it seems to be charged positively. This is due to boron has 3 valence electrons and there will be a one free space which is left in the boron ion and this is classified as "hole". Thus this plate desires an electron and consequently turns out to be decided positively charged, and these plates which are charged consolidated to generate a power. At this power generation solar power came into an existence. The radiation which is originated from the sunlight is utilized to start the electric drift movement from the plates which are charged positive to plates which are charged negative. Currently the exact scenario of solar radiation makes the electrons to agitate its photon. The free electrons on the solar plate are always knocked by the photon, which falls on the negatively charged plate of the solar panel. This electron makes contact always with their parent atom, ion is liberated it would be able to pass around the plate. Anyway this electron is pulled by the plates which are positively charged and the electron is bounded once again. Similarly when more number of photons knocks off the electrons, power is produced. The power generated by a solitary solar powered cellular is very low. Numerous solar cells when consolidated together can deliver adequate measure of power.

III. PROPOSED MODEL

Fig.5 suggests the block diagram of proposed systems in which the energy is obtained from the solar panel to the protecting device so that you can suppress the over voltage and lightning on the solar panel terminals. The voltage of the solar panel can be determined with the help of voltage divider circuit placed at the input side and its output voltage is given to the microcontroller. Power diode is used to avoid a reverse polarity and a reverse current flow protection in the circuit, along with it is used to deal with a large amount of current. From the solar panel the obtained power will not move directly towards the battery as an alternative a mosfet driver circuit must be used which acts as a switch. The PWM signal generated by the microcontroller will take care the switching operation of the mosfet. The voltage of the battery can be determined with the help of voltage divider circuit placed at the output side and its output voltage is given to the microcontroller. The buck converter is a DC-to-DC power converter which is used to reduce the voltage from its supply voltage level to its load voltage level. This buck converter is a class of switched-mode power supply (SMPS), and basically it contains at least 2 semiconductors like diode and transistor, and at least 1 energy storage element like capacitor, inductor, or both in combination.
NI Multisim is an electronic schematic capture and simulation program which is a part of the suite for the circuit design program, a suite of EDA (Electronics Design Automation) tools that assists you to carry out the major steps in the circuit design flow. Multisim was originally created by a company named “Electronics Workbench”, and now it is a division of National Instruments which includes microcontroller simulation as well as integrated import and export features to the PCB layout software in the suite. The Multisim is widely used in the academics and industry for circuit’s education, electronic schematic design and SPICE simulation.

A. NI Multisim 14.2 Software

B. Voltage Sensors

Predominantly, a Sensor is an electrical component used to recognize and react to a specific kind of signal like optical or electrical. Execution of sensor techniques in voltage or current has become an extraordinary alternative towards in the estimation of voltage and current methods. The merits of sensors over ordinary methods mainly includes because of less size and weight, high security, high accuracy, non-saturable, eco-friendly, and so on. This sensor is utilized to monitor, estimate and to determine the voltage level. This sensor can estimate the AC or DC voltage level. The estimation of these sensors can rely upon the voltage divider. Here the voltages of solar panel and battery can be determined with the help of voltage sensors. This voltage sensors comprises of 2 resistors R1=20k and R2=100k for monitoring the voltage of the solar panel and comparably R3=20k and R4=100k for monitoring the voltage of the battery as we’re taking solar panel of around 12V and utilizing 12V battery, we’re designing voltage sensor to get around 10V which is lesser than the battery and solar panel voltage.

Design: \[ \text{Vout} = \frac{R2}{R1+R2} \times V \]

- Solar panel voltage \( V = 12V \)
- \( R1 = 20k \) and \( R2 = 100k \)
- \( \text{solar}_\text{volt} = \frac{100}{100+20} \times 12 = 10V \)
- Battery voltage \( V = 12V \)
- \( \text{bat}_\text{volt} = \frac{100}{100+20} \times 12 = 10V \)

C. PWM Circuit

In solar based power system, charge controller is the core of the framework which was intended to secure the storage battery. Pulse Width Modulation is the best way to perform a steady voltage state of the charging battery by modifying the duty cycle ratio of the mosfet. In the solar charge controller, the current obtained from the solar panel tapers as in keeping with the batteries situation and recharging desires. When the battery voltage arrives at the regulation point, the PWM algorithm slowly reduces the charging current to avoid from the heating and gassing of the battery. In the maximum limited time, the energy will be measured by restoring the
continuous charging to the battery. Higher charging performance, longer battery lifestyles, reduces battery overheating, minimizes battery stress, and potential to de-sulfate a battery are the primary preferences for using PWM. We're structuring PWM circuit using comparator which takes AC sinusoidal signal as input, triangular wave as reference signal and producing square output.

**Figure.7. Generation of PWM Signal using Comparator Circuit.**

**D. Buck Converter**
The Buck Converter is also referred to as “step-down converter” which is used in the SMPS circuits to reduce the DC output voltage than the DC input voltage. From the rectified AC or from any DC supply we can derive the DC input voltage. Compared to voltage regulators, buck converter requires low power and produces less noise and withstands fluctuations in the circuits. We are using buck converter to convert the supply voltage obtained from the battery to the load voltage which is used to charge the mobile phones and other communication devices.

**Design:**

\[ V_{in} = 9v \]
\[ V_{out} = 5v \]

\[ iR = V_{out}/R \ (choose \ R=1) \]
\[ I = iR = 5A \]
\[ iL = \text{ripple current in } I = 10\% \ of \ 5A = 0.5 \]
\[ vL = \text{ripple voltage in } V = 1\% \ of \ 5V = 0.05 \]
\[ V_{d} = \text{Diode forward voltage drop} = 0.8V \]
\[ F = 1KHZ \]
\[ Ts = 1 / F = 1ms \]

**Duty cycle:**
\[ D = \frac{V_{d}+V_{out}}{V_{d}+V_{in}} = 0.591 = 59.18\% \]

**Inductance:**
\[ L = \frac{V_{in}-V_{out}}{2*iL}*D*Ts = 2.36 \text{ mH} \]

**Capacitance:**
\[ C = \frac{iL}{8*vL}*Ts = 1.25 \text{ mF} \]

**Figure.8. Circuit diagram of Buck Converter.**

**E. Proposed Solar Charge Controller Circuit**
A solar charge controller is generally a voltage controller or current controller device which is used to charge the batteries and preserve it from the overcharging. From the solar panel, the obtained voltage and current will be regulated with the aid of solar charge controller and it passes the regulated output towards the battery. The proper charging voltage of the batteries can be preserved with the help of solar charge controller. Because from the solar panel the input voltage may rises, and the charge controller will regulates the charge towards the battery by stopping the overcharging. There are 3 exclusive kinds of solar charge controllers, they are: Simple 1 or 2 stage controls, PWM (Pulse Width Modulated) and Maximum power point tracking (MPPT). We’ve got used the PWM charge controller as it’s far consumer friendly for the beginners, has higher charging performance, reduces battery overheating, potential to de-sulphate a battery and treated as the first massive develop in the solar charging battery.

**1) Main Functions of Solar Charger Controller:**

\[ a) \text{ Preventing Battery Overcharge: When the battery becomes fully charged limit the energy provided to the battery with the aid of solar panel.} \]
\[ b) \text{ Preventing Battery Over discharge: When the battery reaches a low state of charge disconnect the battery from electrical loads.} \]
\[ c) \text{ Providing Load Control Functions: At a specific time an electrical load should be automatically connect and disconnect at the circuit.} \]
\[ d) \text{ Protecting from abnormal condition: Protect the circuit from the various abnormal state of affairs like lighting fixtures, overvoltage, over current and short circuit, etc.} \]
2) Three Stages of Charging:

![Diagram of Charging Stages]

- **Bulk:** During this stage the controller will deliver the charge current as much as possible to charge the batteries rapidly. The controller will activate the absorption stage when the voltage of the battery reaches the absorption voltage setting.
- **Absorption:** During this stage the controller will switch to the constant voltage mode, where a suitable battery type is applied to the pre-set absorption voltage. The battery is fully charged when the charge current decreases below the tail current or the pre-set absorption time. Thus the controller will switch to the float stage.
- **Float:** During this stage the fully-charged state can be maintained by applying the float voltage to the battery. A new charge cycle will be triggered when the voltage of the battery drops below the float voltage during at least 1 min.

3) Proposed Circuit

![Circuit Diagram of Charging the Battery]

Fig. 10 represents the circuit diagram for charging the battery. The TVS diode is attached across the solar panel of voltage 12V because the protection device will suppress the lightning and overvoltage at the solar panel terminal. The voltage of the solar panel can be measured with the help of voltage divider circuit (R1 and R2) placed at the input side and its output voltage is given to the microcontroller. Power diode (MBR2045CTG) is used to avoid a reverse polarity and a reverse current flow protection in the circuit. From the solar panel the obtained power will not move directly towards the battery until the mosfet is ON. By generating the PWM signal with the aid of microcontroller we can operate the switching operation of the mosfet. Transistor (Q1) and related resistance (R4) are used for riding the mosfet (Q2). The voltage of the battery can be measured with the help of voltage divider circuit (R5 and R6) placed at the output side and its output voltage is given to the microcontroller. Around 9V to 11V is obtained at the output to charge the battery.

![Circuit Diagram of Proposed Solar Charger Controller]
Fig. 11 shows the entire circuit diagram of the proposed technique, where fig. 10 is just modified with the buck converter as designed in fig. 8. Where buck converter helps in reducing the supply voltage to the required load voltage, within the designed circuit the buck converter is used to reduce the voltage of around 9V-11V to 5V-6V. The charged battery is used for charging any of the communication devices that require the voltage of around 5V to 6V to charge, for example mobile phones, camera, MP3, CD, MD players etc.

IV. SIMULATION RESULTS

In order to show the effectiveness of the proposed technique, simulation is performed using the National Instruments Multisim Software version 14.2.

![Simulation Output at the battery](image)

Figure. 12. Simulation Output at the battery

Fig. 12 shows the simulation output on the battery with respect to the circuit diagram proven in fig. 10. The amplitude of the input sine wave signal given to the Pulse width modulation is set to 3V and is represented by the channel 1 waveform. The PWM signal output is a square wave signal of amplitude 5V, which is obtained using comparator circuit. The mosfet (Q2) operates as a switch based on the PWM signal generated. During the ON condition of the PWM signal, the mosfet will act as a closed circuit and allows a current to flow towards the battery while in the OFF condition of the PWM signal, the mosfet will act as an open circuit and stops the flow of current in the circuit. The channel 3 waveform indicates the simulation output at the battery.
Fig. 13 shows the simulation output at the load with respect to the circuit diagram shown in Fig. 11. The channel 4 represents the waveform at the load. The output voltage obtained at the battery is reduced to the voltage of around 5V using buck converter, in order to charge the communication devices. The output on the load additionally represents the output waveform received at the buck converter output terminal. The mosfet has a huge unavoidable and unwanted capacitance among the terminals, when the mosfet is switched ON or OFF, the capacitance must be charged or discharged. The transistor will not switches immediately from non-conducting state to conducting state, when the transistor is switched ON or OFF, and might also transiently support each high voltage and behaviour a high current. The certain amount of heat will be generated, when the gate terminal current is carried out to a transistor to act as a switch and the heat generated will causes the distortion as received in the fig. 13 channel 3 waveform.

V. CONCLUSION

In this paper, a design of solar charger controller circuit for recharging the batteries of communication devices is proposed to provide the battery charging device which uses the solar power as its energy source. Solar power has the advantage of being much less protection and pollution free. When you consider that solar panels nevertheless have relatively decrease the conversion performance, then the overall system cost may be reduced by using the above proposed solar charger controller circuit which can extract the maximum possible power from the panel. The designed PWM charger controller affords longer battery lifestyles and higher charging efficiency and may be used for charging solar lantern in rural areas, cell phones and other few communication gadgets.

VI. REFERENCES


