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Battery Charging System using PV Array & Buck-Boost Converter

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1. ABSTRACT

DC-DC converters are the most widely used circuits in power electronics. They can be found in almost every electronic device nowadays, since all semiconductor components are powered by DC sources. They are basically used in all situations where there is a need to stabilize a given dc voltage to a desired value. This is typically accomplished by chopping and filtering the input voltage using an appropriate switching action, which is typically implemented using pulse width modulation (PWM). In this project, we concentrate our research on buck-boost DC converters.

The buck-boost is a popular non-isolated, inverting power stage topology, sometimes called a step-up or step-down power stage. Power supply designers choose the buck-boost power stage because the output voltage is inverted from the input voltage, and the output voltage can be either higher or lower than the input voltage. The topology gets its name from producing an output voltage that can be higher (like a boost power stage) or lower (like a buck power stage) in magnitude than the input voltage. Nowadays, DC-to-DC converters are widely used in electronic circuits, and all electronic components, like semiconductors, are powered by a DC source. They are useful in any application where it is necessary to stabilize the applied voltage over a particular range.

Key Word – Buck - Boost , Converter , Arduino , DC

2. Introduction

Direct Current (DC) is produced in daily life thanks to the advancement of power electronics. DC input voltage is converted to DC output voltage in order to produce lower or higher output voltage. The term "DC-DC Converter" is frequently used to describe this DC voltage conversion. Utilising resources with relatively low voltage values, like batteries and batteries, where the output voltage source can be adjusted based on usage requirements, is now possible thanks to the use of DC-DC converters in electronic devices.

As a DC voltage regulator, the DC-DC converter, also referred to as the DC chopper, is frequently used to both increase and decrease voltage. Generally speaking, DC voltage produced by renewable energy sources is unstable since it is influenced by external elements like light intensity. Solar panels and other renewable energy sources are currently frequently used with DC-DC converters.

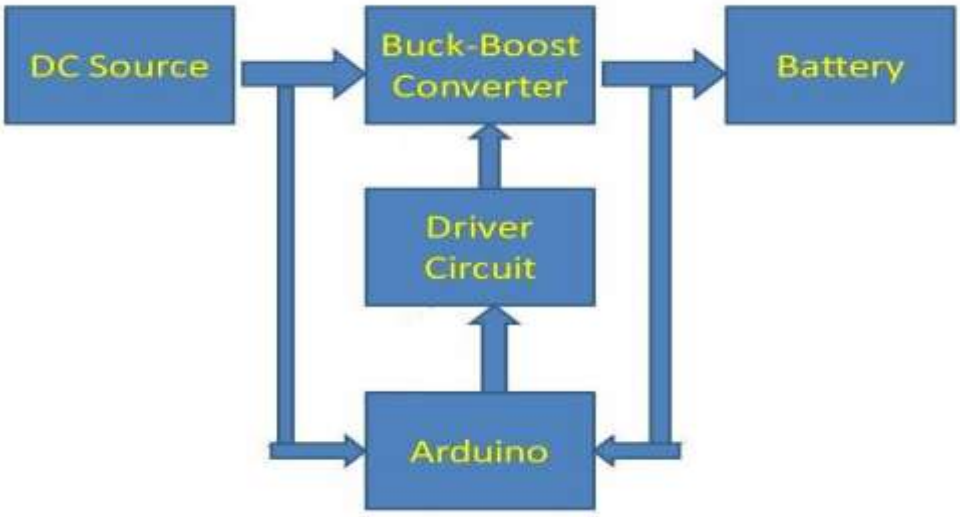
There are various configurations of DC Chopper, but the Buck, Boost, Buck-Boost, Cuk, and SEPIC versions are the most widely utilised. The boost converter can increase the voltage by modifying the duty cycle from Pulse Width Modulation (PWM) in the buck converter system, which is a non-isolated switching type DC converter.

In numerous studies, Arduino microcontrollers are growing in popularity. This open-source platform was created as a prototype and is based on user-friendly hardware and software, giving researchers access to important features that could have an impact on both the economy and daily life.

It is preferable to use a microcontroller with several digital or analogue pins, such as an Arduino microcontroller, when applying a buck-boost converter with an integrated energy source because these devices can also be used to generate PWM for switching components. Therefore, in this study, we used the buck-boost converter's design and implementation using an Arduino Uno as a substitute for maintaining a constant output voltage with varying input voltage and as a solution that can be applied to renewable energy sources.

3. Methodology

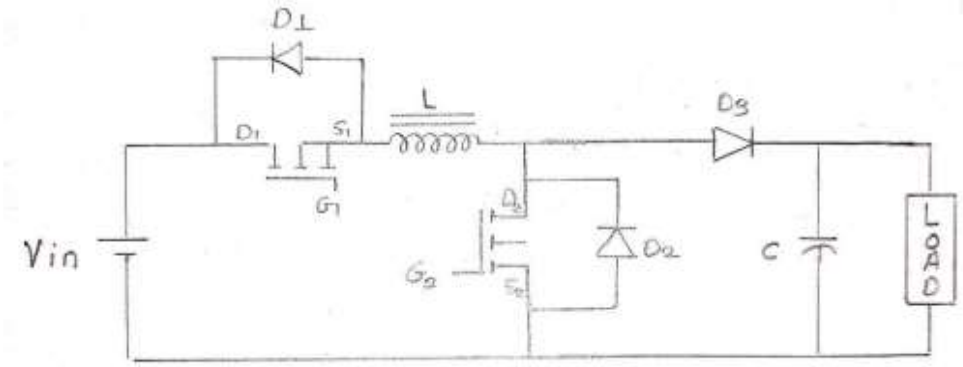
Block Diagram –



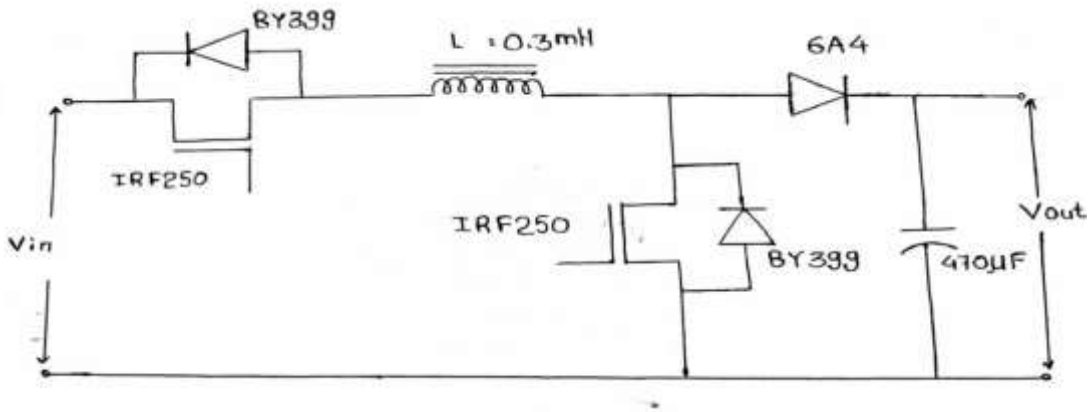
Solar PV panels are used to generate the electricity this generated DC voltage is given to the Buck-boost converter circuit. Buck-boost converters are a form of switching-mode power supply that can supply a regulated DC output from a source voltage either above or below the desired output voltage. The Arduino is the controller circuit, It is control the whole circuit.

Circuit Diagram –

At Normal Mode Buck Boost Converter



OR

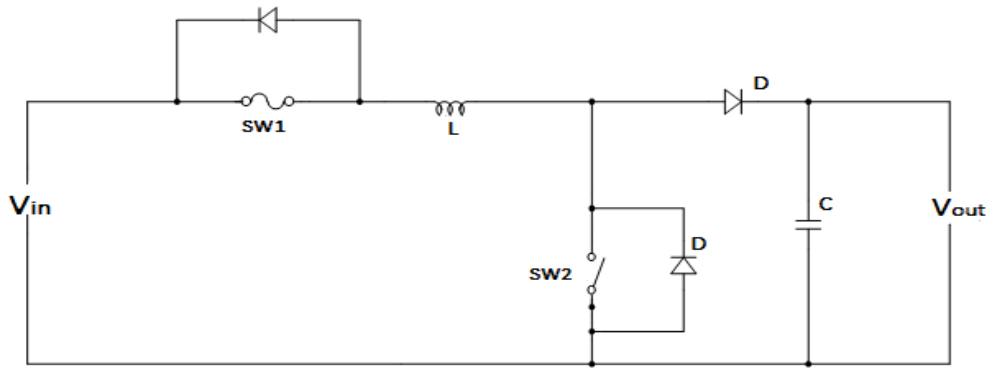


Solar PV panels are used to generate the electricity this generated DC voltage is given to the Buck-boost converter circuit. Buck-boost converters are a form of switching-mode power supply that can supply a regulated DC output from a source voltage either above or below the desired output voltage. This can be particularly helpful in battery-powered applications in which the battery voltage starts out above the desired output but falls below as the battery drains. Itâ€™s useful for every engineer to understand the fundamentals of buck-boost converters because theyâ€™ve become such an important element in electronic systems. As their name implies, buck-boost converters combine elements of both the buck converter and the boost converter, both of which can operate with either an AC or a DC input voltage source. The buck converter produces a DC output between 0 V and just below the input voltage.

The aptly named boost converter can produce an output voltage higher than the input voltage. This is done by switching the circuit between a mode that stores energy in an inductor while a capacitor supplies the output and one that releases that stored energy in order to recharge the capacitor. When current through the inductor is shut off, the energy stored in its magnetic field gets released in a high-voltage pulse as the field collapses, and the resulting current is sent to the capacitor to boost the output voltage. Through the battery charging unit the output voltage is stored in battery also if we require to direct use so it the it is easy to use.

At Buck Mode-

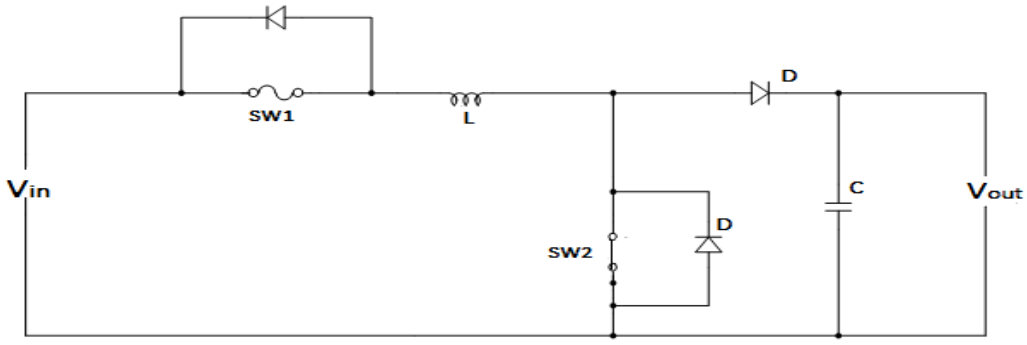
S2= OFF, S1=Active



At buck mode SW1 is closed and SW2 is open. The buck mode is on when the input voltage is greater or higher than 14v.In this mode the voltages is steped Down. At buck mode when we supply input to 18v then the converter is convert or steped the voltage and give output 14v for battery Charging.

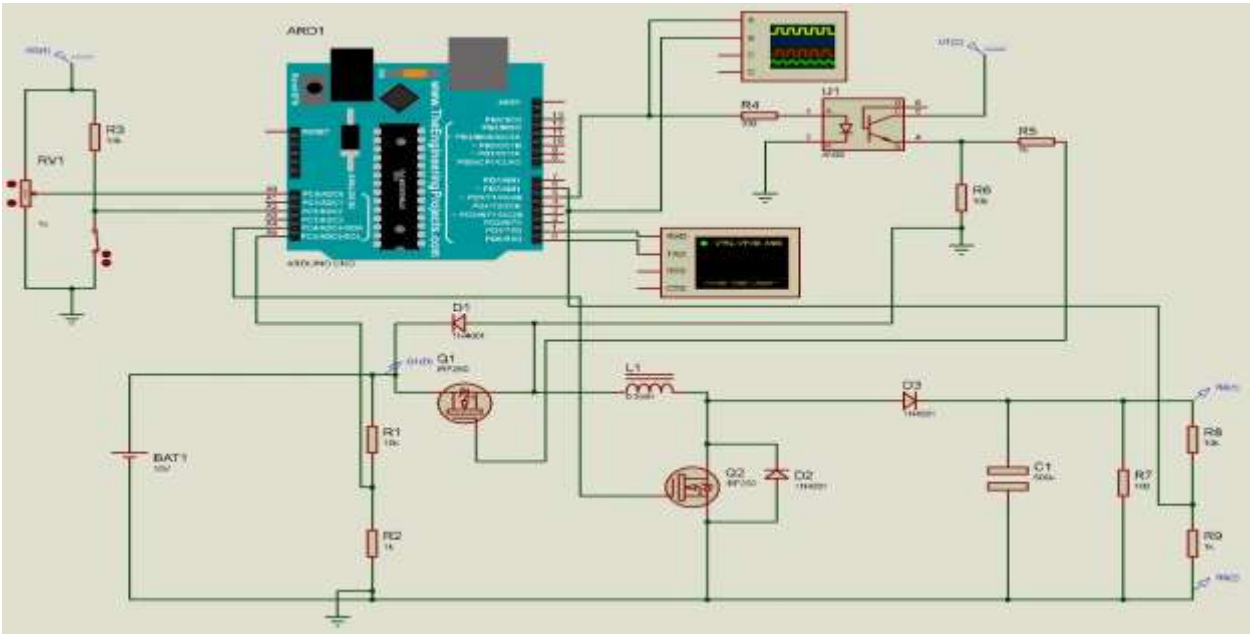
At Boost Mode-

S2=Active, S1=OFF

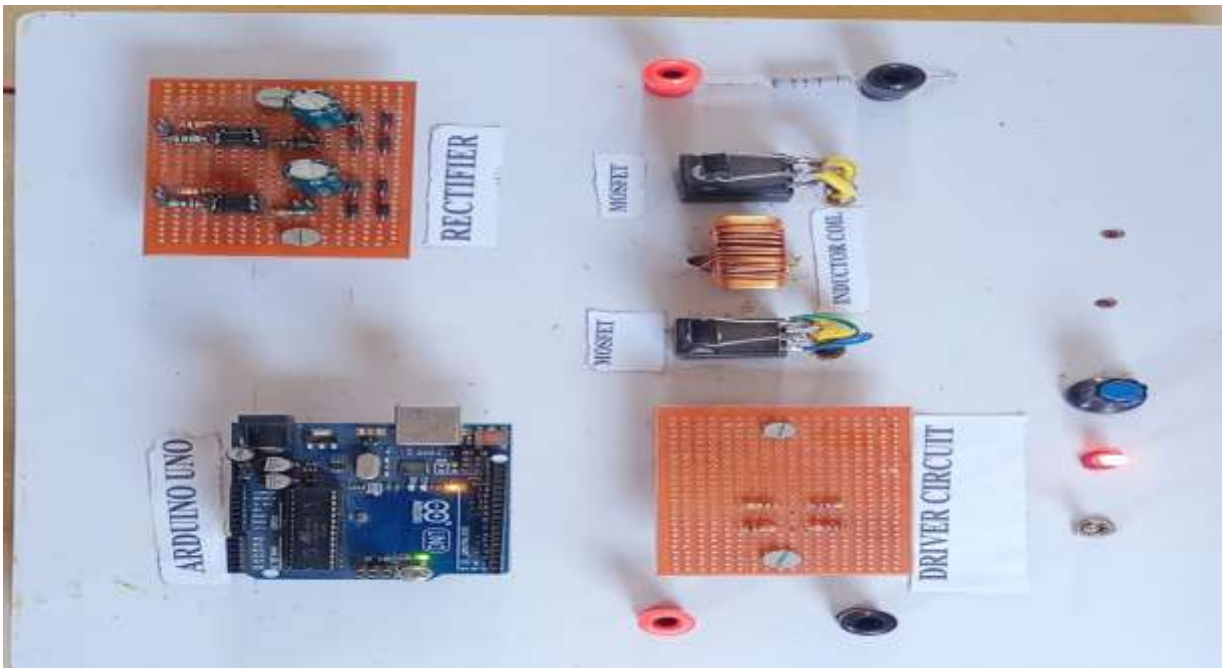


At boost mode SW2 is closed and SW1 is always Close. Because the buck mode is always on in the circuit. The Boost mode is on when the input voltage is lesser or lower than 14v.In this mode the voltages is steped up. At boost mode when we supply input to 9v then the converter is convert or steped up the voltage and give output 14v for battery Charging.

4. Simulatio



5. Modeling and Analysis



6. Results

SR. No.	Input Voltage	Output Voltage	Operating Mode
1	9.2v	14v	Boost
2	11.7v	14v	Boost
3	12v	14v	Boost
4	18v	14v	Buck
5	21v	14v	Buck

7. Main Components

1. MOSFET-

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronicdevices. The MOSFET is a core of integrated circuit and it can be designed and fabricated in a single chip because of these very small sizes. The MOSFET is a four terminal device with source(S), gate (G), drain (D) and body (B) terminals. The body of the MOSFET is frequently connected to the source terminal so making it a three terminal device like field effect transistor. The MOSFET is very far the most common transistor and can be used in both analog and digital circuits. The MOSFET works by electronically varying the width of a channel along which charge carriers flow (electrons or holes). The charge carriers enter the channel at source and exit via the drain. The width of the channel is controlled by the voltage on an electrode is called gate which is located between source and drain.

Working Principle of MOSFET-

The aim of the MOSFET is to be able to control the voltage and current flow between the source and drain. It works almost as a switch. The working of MOSFET depends upon the MOS capacitor. The MOS capacitor is the main part of MOSFET. The semiconductor surface at the below oxide layer which is located between source and drain terminal. It can be inverted from p-type to n-type by applying positive or negative gate voltages respectively. When we apply the positive gate voltage the holes present under the oxide layer with a repulsive force and holes are pushed downward with the substrate. The deflection region populated by the bound negative charges which are associated with the acceptor atoms. The electrons reach channel is formed. The positive voltage also attracts electrons from the n+ source and drain regions into the channel.

2. CAPACITANCES-

Capacitances that are used are 470Î¼F 100V and 470Î¼F 35V

The 470Î¼F 100V capacitors are used in main converter circuit.

The 470Î¼F 35V capacitors are used in the driver/control circuit.

3. Opto-coupler-

An opto-coupler is a semiconductor device that allows an electrical signal to be transmitted between two isolated circuits. Two parts are used in an opto-coupler, an LED that emits infrared light and a photosensitive device that detects light from the LED. Both parts are contained within a black box with pins for connectivity. The input circuit takes the incoming signal, whether the signal is AC or DC, and uses the signal to turn on the LED. The photo sensor is the output circuit that detects the light and depending on the type of output circuit, the output will be AC or DC. Current is first applied to the opto-coupler, making the LED emit an infrared light proportional to the current going through the device. When the light hits the photo sensor a current is conducted, and it is switched on. When the current flowing through the LED is interrupted, the IR beam is cut-off, causing the photo sensor to stop conducting.

4. Diode-

A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction.

Diodes are also known as rectifiers because they change alternating current (ac) into pulsating direct current (dc). Diodes are rated according to their type, voltage, and current capacity.

Diodes have polarity, determined by an anode (positive lead) and cathode (negative lead). Most diodes allow current to flow only when positive voltage is applied to the anode.

5**. Inductor-**

An Inductor, also called a choke, is another passive type electrical component consisting of a coil of wire designed to take advantage of this relationship by inducing a magnetic field in itself or within its core as a result of the current flowing through the wire coil. Forming a wire coil into an inductor results in a much stronger magnetic field than one that would be produced by a simple coil of wire.

Inductors are formed with wire tightly wrapped around a solid central core which can be either a straight cylindrical rod or a continuous loop or ring to concentrate their magnetic flux.

6. Arduino-

The Arduino controller is used to generate the PWM pulses for converter and converter circuit. The Arduino controller pulses are given to the driver circuit as input. Driver board is mainly used to isolate and amplify the input signals from the controller. The amplified driver output is connected to the main power circuit devices. The ac supply is converts into dc by using bridge rectifier. And the dc voltage is boosted by boost converter. That dc voltage is applied to resistive load and duty cycle of the converter is varying the output voltage also varied.

7. Solar Panel-

For the system with the help of solar panel electricity is generated and this generated electricity is further given to the converter circuit.

8. Application –

- E - vehicle self Charging system.
- To step up/step down the DC Voltage.

9. Advantages-

1. Buck converter offers most efficient solution with smallest external components.

2. It performs step-up or step-down of voltage using minimum components.

3. It offers lower operating duty cycle.

4. It offers high efficiency across wide input and output voltage ranges.

5. It is less expensive compare to most of the converters.

10. Disadvantages-

1. Input current and charging current of output capacitor is discontinuous as it results in large filter size and more EMI issues.

2. Output is inverted which results in complex sensing and feedback circuit. As sensed voltage is negative, inverting op-amp is needed for feedback and closed loop control.

3. High gain cannot be achieved with this converter type as efficiency is poor for high gain (i.e. very small duty cycle or large duty cycle).

4. There is no isolation from input side to output side which is very critical for many applications.

5. Transfer function of the converter contains right half plane as zero which introduces control complexity. Hence it is very difficult to control such converter type.

11. Conclusion-

DC-DC converters are electronic devices used to change DC electrical power efficiently from one voltage level to another. The advantages over AC because DC can simply be stepped up or down. They provide smooth acceleration control, high efficiency, and fast dynamic response. DC converter can be used in regenerative braking of DC motor to return energy back into the supply, and this feature results in energy saving for transportation system with frequent stop; and also are used, in DC voltage regulation. In many ways, a DC-DC converter is the DC equivalent of a transformer. There are FOUR

main types of converter usually called the buck, boost, buck-boost and Boost converters. The buck converter is used for voltage stepdown/reduction, while the boost converter is used for voltage step-up.

12. Future Scopes-

In this project we have successfully completed the design of a buck-boost converter which can easily be used to get the output as required for the load to run properly. For the upcoming future the converter can be further improved and its output voltage can be varied to see that which of the loads are easily used. Now as of now the converter is used for conversion of high voltages. To make this project viable and for further use we can use it to change the range of conversion and use it for more practical purposes and real world expertise.

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