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AN INVESTIGATION INTO A BOOST CONVERTER INTEGRATED WITH A SOLAR PHOTOVOLTAIC SYSTEM TO ACHIEVE MAXIMUM ENERGY EFFICIENCY

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Abstract

A solar panel's performance relies on factors such as temperature, array layout, solar insolation, and shading. Using SPV modules to convert solar energy, the variation in insolation conditions significantly impacts the modules' efficiency and power output. Enhancing the efficiency of solar energy conversion can be achieved by monitoring the maximum power point of a PV module. A variety of MPPT charge controllers can be found on the market. A DC-DC converter plays a crucial role in a solar panel system, serving as the link between the load and the SPV module. These dc-dc converters boost algorithm performance, resulting in greater overall efficiency for the Solar Panel. This paper outlines the circuit of a solar photovoltaic module paired with a boost converter, resulting in improved efficiency.

Keywords: *Photovoltaic; Volt; Power.*

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1. Introduction

Also known as non-conventional energy, renewable sources are those continuously replenished by natural processes. For example, solar energy, bioenergy from sustainably grown biofuels, wind power, and hydropower, among others. These are some examples of renewable energy sources. A renewable energy system transforms energy from sources like sunlight, falling water, wind, ocean waves, geothermal heat, or organic matter into usable formssuch as heat or electricity. Most renewable energy derives either directly or indirectly from the sun and wind, and since these sources are inexhaustible, they are termed renewable [12]. However, most of the world's energy still comes from conventional fossil fuels like coal, natural gas, and oil. These fuels are commonly referred to as non-renewable energy sources. Although the available supply of these fuels is extremely large, their levels are declining daily due to the depletion of fossil fuels and oil, and they will eventually run out in a few years. Therefore, demand for renewable energy sources rises because they are environmentally friendly and produce no pollution, thereby helping to reduce the greenhouse effect [12].

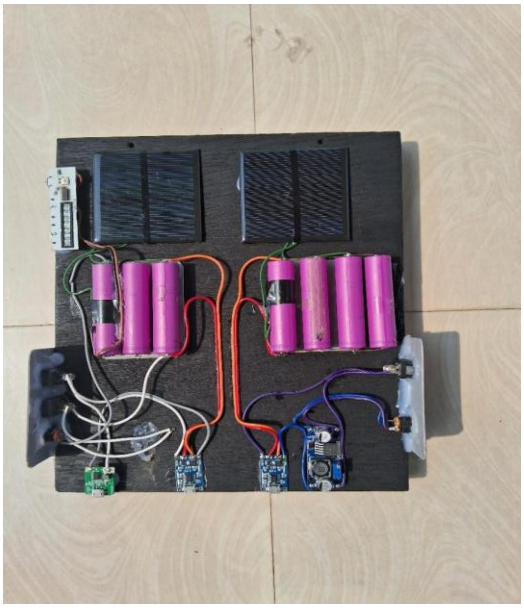
Solar energy falls under the category of unconventional energy sources. Humans have utilized solar energy since ancient times, employing a range of technologies to capture it. Solar radiation, alongside other solar-derived energy sources like wind, waves, hydropower, and biomass, makes up the majority of Earth's non-conventional energy supply. Just a small portion of the available solar energy is utilized [13]. Solar-powered electricity generation depends on photovoltaic systems and heat engines. The applications of solar energy are constrained only by the limits of human imagination. The most common method for capturing solar energy involves using photovoltaic panels, which absorb photons from the sun and transform them into electrical energy. Solar technologies are generally divided into two categoriespassive solar and active solarbased on how they capture, transform, and deliver solar energy. The solar constant refers to the intensity of solar radiation at Earth's surface, measured at 1369 watts per square meter. It's crucial to understand that the measurement is not based on intensity per square meter of Earth's surface, but rather per square meter on a sphere whose radius is 149,596,000 kilometers and whose center is the Sun.

The total solar radiation captured by Earth equals the Solar Constant times the planet's cross-sectional area. Dividing the calculated value by Earth's surface area reveals the average amount of solar radiation received per square meter [10]. A solar cell panelalso known as a solar electric panel, photo-voltaic PV) module, PV panel, or simply solar panelis a grouping of photovoltaic cells set within a typically rectangular frame. When arranged in an orderly fashion, such panels collectively form a photovoltaic system or solar array. Solar panels collect sunlight, a form of radiant energy, and transform it into direct current (DC) electricity. Photovoltaic arrays can produce solar electricity to power equipment directly or send it back to an AC grid through an inverter.

2. Methodology

As we move toward renewable energy sources, solar power stands out as one of the most important. However, its use presents challenges such as cell shading and inconsistent voltage distribution. Solar panels consist of solar cells, which are primarily made from silicon. Panel efficiency drops when some of the 100 cellsespecially those not contributing to power generationare affected, possibly due to light blockage or other issues. demonstrate how the efficiency of solar panels declines. or when a device requires voltage but only a very small current, and if a high potential difference is needed, some devices that use chargers activate the device at a lower voltage as well.

SOLAR BOOSTER MODULE



WORKING

The setup includes two partially identical sets, each featuring one solar panel that captures sunlight and stores the energy in a battery. The battery is then linked to a DC-to -DC step-up converter, which boosts the voltage from 2 volts to 24 volts, aided by a capacitor. The output passes through an LM05/ LM12 regulator, delivering both 5 volts and 12 volts. The 5-volt output can power smartphones or small electronics, while the 12-volt output may optionally be converted to 110 volts AC, suitable for devices requiring AC input.

PRINCIPLE

The principle is straightforward: we're storing a small amount of energy from the solar panel into batteries, then stepping up the 5-volt current to a higher voltage to achieve the desired output.

$$P=W/t$$

$$P=VI$$

W= work done

P= power,

V= potential difference,

I= current(A),

T= time

3. MATERIALS USED

1 PHOTOVOLTAIC CELL

Photovoltaic cells are constructed from semiconductor materials, including silicon. In solar cells, a thin semiconductor wafer is specially processed to create an electric field, with a positive charge on one side and a negative charge on the other. When light energy hits the solar cell, it dislodges electrons from the atoms in the semiconductor. When electrical conductors connect the positive and negative terminals, creating a circuit, electrons flow as an electric currentessentially, electricity. This electricity can subsequently be used to power a load [16]. A PV cell can be built in either a circular or square shape.

2.DC COVERTERS

A DC-DC converter is an electronic circuit that transforms direct current (DC) from one voltage level to another. DC-DC converters are commonly employed in regulated switch-mode DC power supplies and in DC motor drive systems. Switch-mode DC-DC converters transform an unregulated DC input into a regulated DC output at the required voltage level. At the core of MPPT hardware lies a switch-mode DC-DC converter. MPPT employs the converter to serve a distinct function: maintaining the input voltage at the PV module's maximum power point and enabling optimal load matching to achieve maximum power transfer. A switching converter includes capacitors, inductors, and switching elements. Ideally, these devices draw no power, leading to highly efficient switching converters. When the device is turned on, the voltage drop across it approaches zero, resulting in minimal power dissipation.

4.0 BOOST CONVERTER

The boost converter, also referred to as the step-up converter, is illustrated in Figure 10. The name suggests its common use in stepping up a low input voltage to a higher output voltage, essentially operating like a buck converter running in reverse.

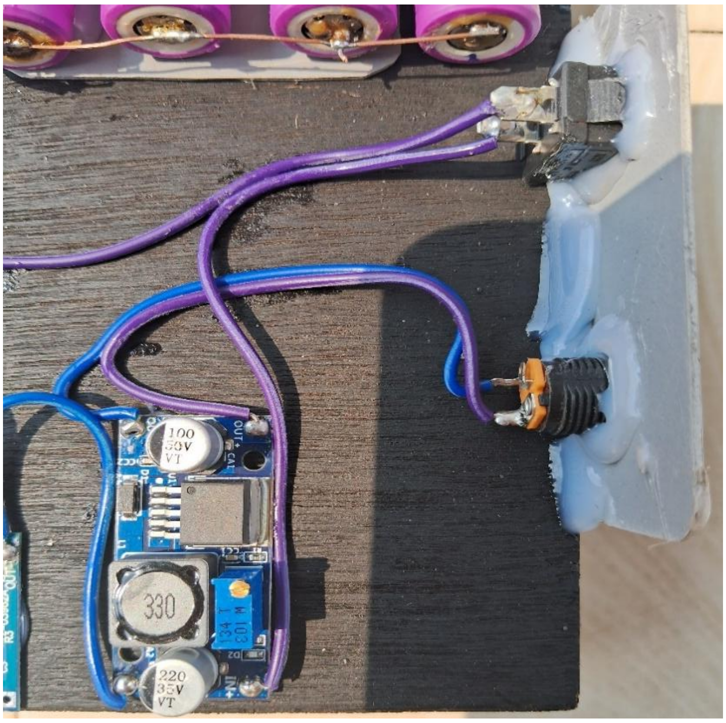


Figure 8

4. Result and Discussions

Larger solar panels experience greater power loss. In the meantime, we can utilize 48V, 24V, and similar voltages. but the panel's efficiency remains lower. To boost efficiency, we've opted for a smaller solar panel in our project. According to the First Law of Thermodynamics: energy can not be created or destroyed; it can only be transformed from one form to another.

According to the Second Law of Thermodynamics:

In an isolated system, the total entropy of the universe will continually increase over time. The second law also asserts that the change in entropy of the universe can never be negative.

Principle The concept is straightforward: we're capturing a small amount of solar energy, storing it in batteries, and then stepping up the 5-volt current to a higher voltage to achieve the desired output..

P=W/t

P=VI

W= work done

P= power

V= potential difference

I= current(A)

T= time

Using smaller solar panels can boost efficiency by raising voltage and reducing current durationwhile keeping power output steady For example Suppose you have a 12V, 14Ah battery. In this case, the current (I) is delivered at a peak of 14A for one hour if drawn directly from the battery. It signifies that:

P=VI

P= 12x14x60x60 J

We're cutting the duration from 1 hour to x hours (where x is less than 1), and by doing so, we maintain the same current while achieving a higher voltage in less time.

Therefore, we can draw more voltage from a battery with a lower voltage rating. This device is called a DC-DC boost converter.

This entire system can serve as a backup device for home use, powered by a small 5 V solar panel. This system can provide multiple voltages, including 5V, 4.2V, and 12 to 24V.

Adding more batteries to the panel will extend the system's operating time.

We can connect small fans, lights, and charge mobile devices, headphones, and higher-voltage batteries.

For Panel 1

Solar Input 5.5V, 100mA

Battery

4.2V 1200mah which are 3 in parallel

If in Parallel potential difference remain same but the current increases to 3600mah

Backup

Powerbank-1 5V 1A - 5watt Output 1.5-2hrs

Powerbank-2 5V 1A-2A - 1hr

5V output 1-2A -40min to 1.5hrs

<u>For panel 2-</u>

Solar Input

5.5V 100ma

12V Variable Power supply 12v to 24v (1a)

Backup- 15-20 min

5vto 6v -- 1hr to 1.5 hr.

In the future, with further research, higher-voltage appliances can be connected to the solar booster module by enhancing its efficiency. Therefore, by harnessing renewable energy sources, we can attain net zero carbon emissions in the future. Expanding the supply of renewable energy would enable us to substitute carbon-heavy energy sources and substantially cut U.S. greenhouse gas emissions.

5. Conclusion

A single solar panel with standard insolation and temperature values has been demonstrated. The simulated solar panel displays varying I-V and P-V characteristics in response to changes in insolation and temperature, as illustrated. This model allows for the simulation of various DC-DC converters, and performance and efficiency can be enhanced through the use of the booster.

As we move toward renewable energy sources, solar power stands out as one of the most important. However, its use presents challenges such as cell shading and inconsistent voltage distribution. Solar panels consist of solar cells, which are primarily made from silicon. Panel efficiency drops when some of the 100 cellsespecially those not contributing to power generationare affected, often due to issues like blocked sunlight. demonstrate how the efficiency of solar panels declines. or when a device requires a high voltage but only a small current, some charging-powered devices activate at low voltage as well.

This entire system can serve as a backup device for home use, powered simply by a small 5 V solar panel. This system can provide multiple voltage outputs, including 5 V, 4.2 V, and 12 to 24 V.
Adding more batteries to the panel will extend the system's operating time. We can connect small fans and lights, and use it to charge mobile devices, headphones, and higher-voltage batteries.

In the future, with further research, higher-voltage appliances can be connected to the solar booster module by enhancing the module's efficiency. Therefore, by adopting renewable energy sources, we can attain net zero carbon emissions in the future. Expanding the supply of renewable energy would enable us to substitute fossil-fuel -based energy sources and substantially cut U.S. greenhouse gas emissions.

For instance, a 2009 UCS study concluded that implementing a 25 percent national renewable electricity standard by 2025 would reduce power plant CO2 emissions by 277 million metric tons each year by that timeroughly equivalent to the annual output of 70 standard (600 MW) new coal plants.

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