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# Implementation of Voltage Stabilizers on Solar Cell System Using Buck-Boost Converter

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**ABSTRACT** Electricity is one of the basic needs of modern human life and is already so integrated into everyday life. This is understandable given the coal's ample resources. Another factor that influences the growth of coal use is that coal plants are designed asa basic burden because the price of coal is relatively cheaper. However, coal's existence as fuel for power plants is on the decline and is not renewables. One of the applications of renewable energy potential is solar power generation technology. On this system using solar panels using 30 wp power. Solar dependence on the environment affects the change in output values in hybrid plant systems, resulting in easy damage to both domestic and industrial appliances or in battery storage systems, so a mechanism is needed to stabilize the output voltage supplied to the battery or load. So, out of this renewable energy potential, it creates innovation Implementation of Voltage Stabilizers on Solar Cell System Using Buck-Boost Converter. Aided by current and voltage sensors controlled by arduino uno so that they can insulate input and output from buck-boost converter. Results from the testing of this device indicate that the buck-boost converter is able to stabilize output output from solar panels with a 14.4 volt set of points. The average efficiency obtained at buck-converter converter testing at buck mode is 85.4 %. On boost mode is 80%. On buck-boost mode is 79.2%.

**INDEX TERMS** Renewable Energy, Solar Energy, Buck-Boost Converter.

## I. INTRODUCTION

Electricity is one of the basic needs of everyday life. Electricity is so integrated with everyday life. Indonesian people, especially those who have lived in cities, carry out daily life by relying on electrical energy [1]. Electricity is an important factor in the development of the quality of people's life energy and, at the same time, contributes to national development in the various economic sectors. To address growing power needs to be increased in a large supply of electricity and will need to be increased in the long run. Therefore, it will require planning for long term national electricity development. In such planning, forecasting needs and power supplies need serious attention [2].

During the 2012-2035 period, the capacity of installed national power plants (PLN and non PLN) for basic scenarios would increase from 44.8 to me or grow an average of 7.1% per year. For the high scenario of 2035, its recousion capacity would run 26% higher than the basic scenario or 270 gw, and grow an average of 8.1% per year. In both scenarios, coal plants continued to dominate until 2035 with Numbers reaching 65% (139) for the odor scenario and 72% (194 gw) for the high scenarios. This is understandable given the coal's ample resources. Another factor that influences the growth of coal use is that coal plants are designed as a basic burden because coal costs are relatively cheaper than other fossil fuels [3]. Given that coal is not renewable and has been generated from geological processes over tens and even hundreds of millions of years, it is unfortunate that its use has no added value [4]. Furthermore, burning coal for power plants also produces dangerous and toxic dendroves [5]. Thus, by enhancing renewable energy use, long-term energy supply costs will be lower and affordable [6]. Unlike fossil-energy generation that tend to rise year after year because of fuel prices, the impact of exchange rate and inflation and rising awareness. Capital capex (capex) PLTS plant, large-scale wind PLT also tends to descend. Thus, expanding renewable energy portions in the long-term power supply can lower the cost of power plant [7].

Solar energy use as a source of electrical energy can be applied by means of solar panels that use sunlight to be converted into electrical energy [8]. Solar panels are an environmentally clean and promising source of energy because they cause no pollution and abundance, especially in tropical countries like Indonesia [9]. However, solar energy cannot be directly used because energy generated by a fluctuation depends on the intensity of the sun's light, causing damage to both domestic and industrial appliances or in battery storage systems, so a mechanism is needed to stabilize the output voltage supplied to the battery or load [10].

Based on previous research, there's a potential solar energy treatment solution on a buck-boost converter recharge battery. According to Suwarno, Sutikno T., [11]. Entitled Implementation of Buck-Boost Converter as Low Voltage Stabilizer at 15 V. In his research implementation of the buck-boost converter design which is a power electronics application that can stabilize voltage, even though the input voltage changes. Regulator to stabilize the voltage using PWM pulse that triger pin 2 on XL6009. In this design of buck-boost converter is implemented using the XL6009, LM7815 and TIP2955. LM7815 as output voltage regulator at 15V with 1A output current, while TIP2955 is able to overcome output current up to 5A. When the LM7815 and TIP2955 are connected in parallel, the converter can increase the output current to 6A. Testing is done using varied voltage sources that can be set. The results obtained from this design can be applied to PV (Photovoltaic) and WP (Wind Power), with changes in input voltage between 3-21V dc can produce output voltage 15V.

So from the research, researchers wanted to develop a buck-boost converter voltage stabilizer on a solar power plant [12]. An advantage of this system is the voltage output of the buck-boost converter that its value makes would remain on a set of points even if input from the renewable energy is fluctuating [13]. The controller's charge in the market is not equipped with an interface of input and output value points from the system so that the user must monitor manually to know that the input and output of both systems and systems can be easily corrected when the damage is done and can be developed into a more complex system [14]. The results of this research are expected to support optimizing the use of renewable energy from solar energy as one of the alternatives to electrifying energy providers and may increase the effectiveness of battery chargers in charge batteries and may extend lifetime batteries using buck-boost converter [15].

## II. MATERIALS AND METHODE

### A. MATERIALS AND EQUIPMENT

#### 1) SOLAR PANEL

Solar panels are devices made up of solar cells that convert sunlight into electricity [16]. The sun is the most powerful source of light that can be harnessed. Solar panels are often called photovoltaic cells. Solar cells or PV depend on photovoltaic effects to absorb solar energy and cause a current to flow between opposing charged layers. Solar panels are a vital tool in solar power, which serves to convert solar (solar) energy into electrical energy. Within a solar panel is a solar cell that plays an important role in the solar panel to maximize sunlight [17].

In this study the solar panels used are 30 wp. Here's at table 1 the specification of the solar panel of researchers.

TABEL 1
SOLAR PANEL SPESIFICATION

| No. | Parameters Solar Panel 30 Wp | Value |
|---|---|---|
| 1 | Maximum Power (Pmax) | 30 Watt |
| 2 | Maximum Power Current (Imp) | 1,69 A |
| 3 | Maximum Power Voltage (Vmp) | 17,8 V |
| 4 | Open Circuit Voltage (Voc) | 21,8 V |
| 5 | Short Circuit Current (Isc) | 1,85 A |
| 6 | Operating Temperature | 25 °C |

#### 2) BUCK-BOOST CONVERTER

Buck- boost converter is a dc converter (direct current) which his voltage output can be greater or lower than input voltage, as well as output voltage is always negative. As with buck and converter, buck-weaving converters have a circuit of indutors, capacitors, diode frewheel, and switching components such as thyristor, mosfet, igbt, and gto. The switching process on the converter is also ignited by the PWM as the setup of duty cycle is very influential in the enormous output of the buck-boost converter [18].

The non-inverting buck-boost (NIBB) chain uses two mode switches that are the buck switch mode and boost switch mode. The series nibb has three mode of operation, which is buck, boost, and buck-boost. When the input voltage is lower than the desired voltage, the set becomes the boost mode. Instead, when the input voltage is higher than the desired voltage, it becomes a buck mode. When the voltage from the input is steady near the desired voltage, it will be operating in buck-boost mode. Output of non-inverting buck-converter's value positive [19].

#### 3) ARDUINO UNO

Arduino uno is an atmega328p micro-controller board. Arduino uno has 14 input/output digital (6 of which can be used as output PWM), 6 analog inputs, ceramic resonators 16 MHZ, usb connections, electrical plugs, icsp headers, and reset button. It contained everything that was needed to support the microcontroller; Just plug it into the computer by usb cable or turn it on to the ac-dc adapter or the battery to start activating it [20].

#### 4) VOLTAGE SENSORS

The sensor is a transducer environment parameters in its analogies. Basically, each sensor will be converted into a voltage that can be processed for the next process. so will arduino. If the voltage range is read between 0-5v then you can use an analog pin directly, whereas if the voltage range is read > 5v you need to use the additional set of voltage because the arduino pin works on Max 5v [21].

5) CURRENT SENSORS INA129

In a 219 is a sensor module that can check the electrical values of a dc electrical circuit. Ina 219 is supported by interfaces I2C or SMBUS-COMPATIBLE where these devices are able to monitor shunt voltage and bus voltage supplies, by conversion programs of The Times and filtering. Ina 219 has a maximum input amplifier which is a post ± 320 mV which means it can measure up to the next ± 3.2 A. With the internal 12 bit adc, the resolution on the approximate ± 3.2 A range is 0.8 mA. With the internal gain established at div8 minimum, Max currently is at ± 400 mA and resolution 0.1 mA. Ina 219 identified shunt voltage on bus 0-26 V [22].

6) STORAGE

A battery is a direct stream power generator. There are some types of batteries on the market - those of wet/conventional, hybrid and mf (maintenance free). Wet/conventional batteries still use sulfuric acid ($H_2SO_4$) in liquid form. The mf battery is often called a dry battery because its sulfuric acid is in gel/ jam. When it comes to weighing the position of removal, the dry battery has no problem; it is no problem. The battery storage used in the research is the VRLA 12 v. 7.2 Ah battery [23].

7) LCD (LIQUID QRYSTAL DISPLAY)

A type of medium display that USES liquid crystals to produce visible images. Liquid crystal displays (LCD) or liquid crystal displays (LCD) are widely used in such products as a laptop screen, a cellphone screen, a calculator screen, a digital clock screen, a multimeter screen, a computer screen, a television, a portable game screen, a digital thermometer and other electronic products. [24]

A liquid liquid display consists basically of a double backlight and a liquid crystal. As mentioned earlier, the LCD does not emit any light, it merely reflects and transmits the light through it. Therefore, the LCD needs a backlight or background light for the source of the light. The backlight is generally white. Liquid crystals are, in turn, an organic fluid between two sheets of glass that have a transparent, conductive surface.

8) CUT OFF RELAY

The cut off relay is an automated relay when a voltage reaches a certain level of voltage. This circuit includes relay, transistor, diode zener, switch, capacitor and resistor [25].

9) MECHANICAL DESIGN

The design of these solar panels is a buffer on solar panels. The design plans to use a lightweight steel c channel material of 75 x 0.6 mm (0.6 mm) for details to be seen in the following picture. The solar panel used is a 30 Wp solar panel that has a dimensions of 650 mm long, 350 mm wide and 25 mm thick. The design of this power plant was created using the Autocad 2017 application. FIGURE 1 shows the design to be used in this research.

**FIGURE 1. Solar Panel Design**

10) ELECTRICAL DESIGN

This research uses an electric energy source from a 30-wp solar panel. The voltage output from the solar panel will be stabilized through buck-converter with a voltage output of 14.4 dc volt to match the 12-volt battery charge. In FIGURE 2 showing an electric design to be used in the research.

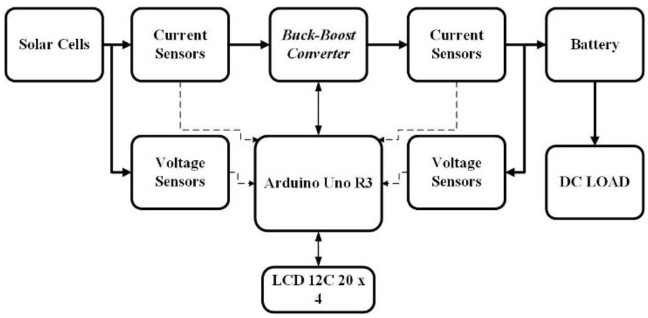


**FIGURE 2. Electrical System Design**

The design below shows a block diagram representing a system to be implemented. The block diagram can see that there is one input of the source of electrical energy from solar energy. There are voltage sensors and current sensors that are each attached to a solar panel output. The sensor reading will be received by arduino uno R3 for the next showing of voltage and current readings on I2C 20x4. The output of the voltage in the solar panel will be accepted by buck-converter and controlled by arduino to generate the voltage desired by the battery. Then there are voltage sensors and current sensors attached to the buck-converter output to measure current output and voltage. The sensor reading will be received by arduino uno R3 and displayed on LCD I2C 20x4. Then the output on the buck-boost convrter will be connected to the cut off relay, the function of the cut off relay is as protection when the charge capacity is full it will cut off the battery charge.

The buck-boost converter design on this research uses a non-inverting buck-boost converter chain which on this circuit uses the two mosfet that serve as switching. The mosfet used on this research is the type IRF9540N P-chanel as a buck switch and the IRFZ44N type of N-chanel as a boost switch. In FIGURE 3 showing a buck-boost converter schematic that was made on proteus's software.

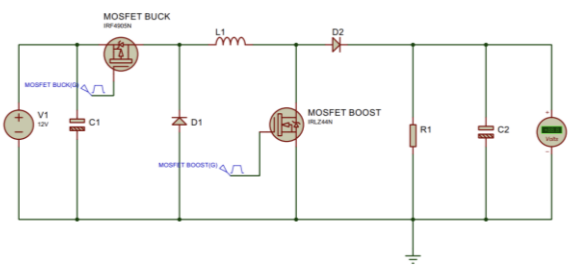


FIGURE 3. **Buck-Boost Converter Schematic**

After the design of PCB buck-converter, the next phase is PCB printing. PCB printing starts with printing the component circuit and layout through HVS paper, then the bottom circuit line and the layout of the component on the paper is transferred to the bare PCB board using an iron. Once the circuit path has been attached to the PCB board, next cool the PCB board with water and dry it. Next, the etching of the PCB board is done using ferric chloride solution (feCL3). Next phase is drilling component holes in pathways already made on PCB boards.

When PCB are completed, the narrate of the components to the PCB has been made. In FIGURE 4 is the product of PCB making and assembly of components on the PCB board.

FIGURE 4. **Buck-Boost Converter Design**

## III. RESULTS

The research discussed the testing of devices that have been created and the analysis of data that have been done. Testing consists of testing solar panels, testing of buck-bosst converter systems, and testing of integrated systems.

### A. SOLAR PANEL TESTING

Testing solar panels. The test aims to know the characteristics of the solar panel. The data to be retrieved in light intensity data, the voltage output in the generated solar panels. The testing of this solar panel is 30 wp solar. Testing on this solar panel involves measuring the luxmeter, thermo gun and multimeter. The solar panel test results can be seen at TABLE 1.

TABLE I
SOLAR PANEL TESTING

| Time (Hours) | Voltage (V) | Current (A) | Power (Watt) |
|---|---|---|---|
| 07.00 | 19.17 | 0.4 | 7.67 |
| 08.00 | 19.33 | 0.31 | 6 |
| 09.00 | 19.75 | 0.3 | 5.92 |
| 10.00 | 19.88 | 0.2 | 3.97 |
| 11.00 | 19.97 | 0.3 | 6 |
| 12.00 | 19.6 | 0.4 | 7.84 |
| 13.00 | 18.74 | 0.3 | 5.62 |
| 14.00 | 18.38 | 0.3 | 5.51 |
| 15.00 | 18.09 | 0.2 | 3.61 |
| 16.00 | 17.64 | 0.13 | 2.23 |

From the results of the tests that have been carried out, a graph can be made,as shown in FIGURE 5.

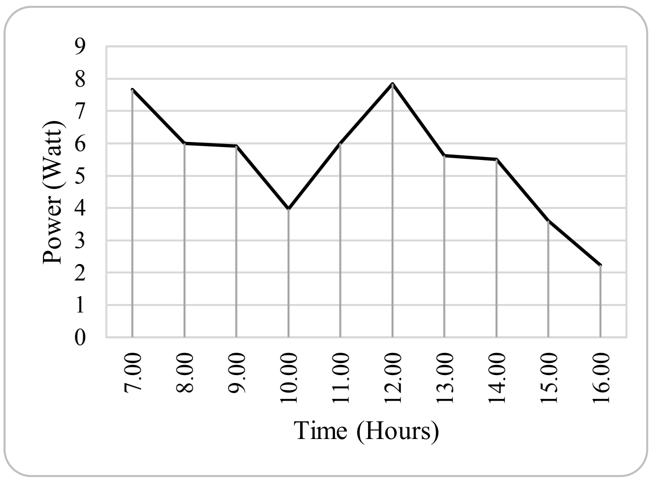


FIGURE 5. **Solar Panel Power Test Chart**

The test results on the solar panels produce power reaching 54.37 watts a day.

### B. BUCK-BOOST CONVERTER TESTING

1) BUCK MODE TESTING

At the testing of buck mode, it is expected that the completed buck-boost converter will be able to raise the voltage at a set of 14.4 volts. Testing was done by charging with resistance 220 ohms and presenting variations of voltage with 15-20 volts. Test results can be seen on TABLE 2.

TABLE 2
Buck Mode Testing

| Vin (V) | Iin (A) | Vout (V) | Iout (A) | Vout theory (V) | Duty Cycle (%) | Error (%) |
|---|---|---|---|---|---|---|
| 15 | 0.82 | 14.2 | 0.79 | 14.76 | 98 | 3.79 |
| 16.1 | 0.85 | 14.34 | 0.88 | 14.04 | 87 | 2.12 |
| 17 | 0.85 | 14.41 | 0.90 | 14.45 | 85 | 0.28 |
| 17.3 | 1.59 | 14.23 | 1.65 | 14.57 | 84 | 2.36 |
| 17.8 | 1.55 | 14.51 | 1.64 | 14.67 | 82 | 1.09 |
| 17.5 | 1.58 | 14.44 | 1.65 | 14.40 | 82 | 0.28 |
| 18.8 | 2.19 | 14.46 | 2.38 | 14.34 | 76 | 0.83 |
| 18.9 | 2.24 | 14.37 | 2.39 | 14.18 | 75 | 1.38 |
| 19.3 | 2.20 | 14.42 | 2.42 | 14.33 | 74 | 0.65 |
| 20.2 | 2.15 | 14.35 | 2.41 | 14.36 | 71 | 0.04 |

From the obtained buck mode testing could be created an average value efficiency. Efficiency calculations are done by comparing power on the output side and power on the input side. Power is a multiplication between voltage and current. Efficiency results on buck mode can be seen at TABLE 3.

TABLE 3
Efficiency Buck Mode

| No. | PowerIn (Watt) | PowerOut (Watt) | Efficiency (%) |
|---|---|---|---|
| 1 | 12.4 | 11.2 | 90.3 |
| 2 | 13.7 | 12.6 | 92.0 |
| 3 | 14.5 | 12.9 | 89.0 |
| 4 | 27.64 | 23.5 | 85.0 |
| 5 | 27.7 | 23.78 | 85.8 |
| 6 | 27.8 | 23.8 | 85.6 |
| 7 | 41.32 | 34.48 | 83.4 |
| 8 | 42.4 | 34.4 | 81.1 |
| 9 | 42.6 | 34.89 | 81.9 |
| 10 | 43.5 | 34.65 | 79.7 |

From the average efficiency result acquired at buck mode tests, it was obtained that an average efficiency of 85.4 %.

TABLE 4
Boost Mode Testing

| Vin (V) | Iin (A) | Vout (V) | Iout (A) | Vout theory (V) | Duty Cycle (%) | Error (%) |
|---|---|---|---|---|---|---|
| 8.45 | 2.07 | 14.5 | 0.89 | 14.57 | 42 | 0.47 |
| 8.89 | 1.95 | 14.45 | 0.89 | 14.34 | 38 | 0.78 |
| 9.56 | 1.73 | 14.38 | 0.88 | 14.06 | 32 | 2.28 |
| 9.78 | 1.70 | 14.41 | 0.91 | 14.17 | 31 | 1.67 |
| 10.1 | 1.61 | 14.39 | 0.89 | 14.43 | 30 | 0.27 |
| 10.63 | 1.52 | 14.46 | 0.90 | 14.36 | 26 | 0.66 |
| 11.98 | 1.31 | 14.43 | 0.90 | 15.36 | 22 | 6.05 |
| 12.45 | 1.23 | 14.38 | 0.89 | 14.48 | 14 | 0.67 |
| 12.86 | 1.19 | 14.41 | 0.90 | 14.45 | 11 | 0.27 |
| 13 | 1.13 | 14.4 | 0.88 | 14.29 | 9 | 0.80 |

2) BOOST MODE TESTING

At the testing of boost mode, it is expected that the completed buck-boost converter will be able to raise the voltage at a set of 14.4 volts. Testing was done by charging with resistance 220 ohms and presenting variations of voltage with 8-13 volts. Test results can be seen on TABLE 4. From the obtained boost mode testing could be created an average value efficiency. Efficiency calculations are done by comparing power on the output side and power on the input side. Power is a multiplication between voltage and current. Efficiency results on buck mode can be seen at TABLE 5.

TABLE 5
Efficiency Boost Mode

| No. | PowerIn (Watt) | PowerOut (Watt) | Efficiency (%) |
|---|---|---|---|
| 1 | 17.46 | 12.89 | 73.8 |
| 2 | 17.33 | 12.92 | 74.6 |
| 3 | 16.54 | 12.68 | 76.7 |
| 4 | 16.67 | 13.08 | 78.5 |
| 5 | 16.23 | 12.87 | 79.3 |
| 6 | 16.13 | 13.04 | 80.8 |
| 7 | 15.67 | 12.98 | 82.8 |
| 8 | 15.35 | 12.83 | 83.6 |
| 9 | 15.25 | 12.96 | 85.0 |
| 10 | 14.67 | 12.73 | 86.8 |

From the average efficiency result acquired at buck mode tests, it was obtained that an average efficiency of 80.2 %.

3) BUCK-BOOST MODE TESTING

At the testing of buck-boost mode on the completed buck-boost converter is expected to be able to raise and lower the voltage at a setpoint of 14.4 volts. Testing was done by charging with resistance 220 ohms and varying the voltage of another 8-20 volt. Test results can be seen on TABLE 6.

TABLE 6
Buck-Boost Mode Testing

| No. | Vinput (V) | Iin (A) | Vout (V) | Iout (A) | Mode |
|---|---|---|---|---|---|
| 1 | 8.00 | 2.08 | 14.38 | 0.85 | Boost |
| 2 | 9.00 | 1.86 | 14.34 | 0.88 | Boost |
| 3 | 10.00 | 1.63 | 14.39 | 0.86 | Boost |
| 4 | 11.00 | 1.46 | 14.44 | 0.86 | Boost |
| 5 | 12.00 | 1.29 | 14.41 | 0.85 | Boost |
| 6 | 13.00 | 1.17 | 14.23 | 0.88 | Boost |
| 7 | 14.00 | 1.03 | 14.19 | 0.88 | Boost |
| 8 | 17.00 | 0.89 | 14.23 | 0.84 | Buck |
| 9 | 18.00 | 0.86 | 14.48 | 0.84 | Buck |
| 10 | 19.00 | 0.81 | 14.34 | 0.86 | Buck |
| 11 | 20.00 | 0.77 | 14.37 | 0.88 | Buck |

From the obtained buck-boost mode testing could be created an average value efficiency. Efficiency calculation from the average efficiency result acquired at buck mode tests, it was obtained that an average efficiency of 79.2 %.

### C. INTEGRATED TESTING

This test is done by applying a buck-boost converter to a solar panel. In this test the input value and buck-boost converter output have been integrated with the system. The overall testing is aimed at knowing the system's performance as charging a battery of vrla 12 v 7.2 ah. The value of the chimes will be displayed on I2C LCD. For more details, you can see TABLE 8.

TABLE 8
Buck-Boost Mode Testing

| Time (Hours) | Vin (V) | Iin (A) | Vout (V) | Iout (A) | Battery |
|---|---|---|---|---|---|
| 09.00 | 19.57 | 0.58 | 14.24 | 1.2 | Charge |
| 10.00 | 19.48 | 0.56 | 14.35 | 1.3 | Charge |
| 11.00 | 20.2 | 0.59 | 14.46 | 1.21 | Charge |
| 12.00 | 19.63 | 0.53 | 14.41 | 1.15 | Charge |
| 13.00 | 19.75 | 0.54 | 14.31 | 1.3 | Charge |
| 14.00 | 19.7 | 0.55 | 14.49 | 1.4 | Charge |
| 15.00 | 19.33 | 0.52 | 14.39 | 1.21 | Charge |
| 16.00 | 17.24 | 0.44 | 14.47 | 1.32 | Charge |

## IV. DISCUSSION

Based on the results of the solar panel testing, buck-boost converter and systems integration test. The test resultson the solar panels produce power reaching 54.37 watts a day. At the buck-boost converter testing with buck mode, was obtained an average of 14.37 V of ouput voltage, an eror average of 0.23 % and an average efficiency of 85.4 %. At the buck-boost converter with boost mode, it's averaged 14.42 V of output voltage, an eror average of 0.15 % and an average efficiency of 80.2 %. At the test the buck-boost converter with buck-boost mode, was given a 14.34 V average output voltage and an average efficiency of 79.2 %. At the testing of the buck-boost converter integration with the solar system obtained data that the testing was done at 09.00-16.00. Solar panels are capable of producing a maximum voltage of 20.2 volts and a minimum of 17.24 volts. Then the buck-boost converter solar panel vout is maximizing the voltage with a 14.24-14.49 volt range. Even though the voltage of output on the resulting solar panels is fluctuating, the converter output produced is fairly stable. Based on previous research According to Suwarno, Sutikno T., [11]. Entitled Implementation of Buck-Boost Converter as Low Voltage Stabilizer at 15 V. In his research doesn't reflect the results of the buck-converter efficiency made that writers can hardly compare the results. In the study the output generated from converters is only 1 A. The research also made buck-converters are not applied to solar or other energy panels and are not applied to battery chargers so the buck-converter's performance is unknown.

## V. CONCLUSION

The output voltage of the buck-boost converter that is made can reach the desired set point of 14.4 Volts, it can be seen in the buck-boost converter test during buck mode where the average output voltage is 14.37 Volts and an average efficiency of 85.4 %. then in the buck-boost converter test boost mode where the average output voltage is 14.42 Volts and an average efficiency of 80.2 %. in the buck-boost converter test the buck-boost mode is where the average output voltage is 14.42 Volts and and an average efficiency of 79.2 %. Remains at the set point even though the input value varies. From this, it can be concluded that the buck-boost converter can function properly and can be used for charging the 12 Volt 7.2 Ah battery used by researchers in implementing the buck-boost converter as a solar panel output voltage stabilizer.

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