18TH INTERNATIONAL CONFERENCE OF YOUNG SCIENTISTS ON ENERGY AND NATURAL SCIENCES ISSUES

CYSENI 2022

24-27TH MAY, 2022
KAUNAS, LITHUANIA

WWW.CYSENI.COM

ORGANIZED BY

LITHUANIAN ENERGY INSTITUTE

LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

CENTER FOR PHYSICAL SCIENCES AND TECHNOLOGY

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Dear Colleagues,

The International Conference of Young Scientists on Energy and Natural Sciences Issues (CYSENI 2022) has been organized already for the 18th time since 2004, which became an annual tradition. We are very proud to bring together talented young scientists to participate in the 18th CYSENI conference. We expect that this will contribute to exchange of ideas, improved knowledge of young researchers, development of their acquired abilities and contribute to increasing level of exercised research activities. The initiative for such an event came from young and enthusiastic researchers of Lithuanian Energy Institute (LEI). They realised that there are a lot of young, smart and science-oriented young people and they do need a place to share their views, generated ideas and present the latest research results.

This year, Lithuanian Energy Institute with partners from the Lithuanian Research Centre for Agriculture and Forestry, the Center for Physical Sciences and Technology as well as RTO Lithuania continued a partnership in co-organizing the CYSENI 2022 conference. This partnership allowed us to expand the topics of the conference and maintain a high number of participants – more than 150 from around 20 countries.

The conference once again has brought together young researchers and scientists to discuss recent trends in energy and natural sciences sectors worldwide. We are pleased that young scientists further found the conference valuable to present their up to date research results and share scientific experience.

We thank all the contributors who made this conference possible. This includes all people from scientific and organising committees. We would like to thank all participants for their contributions to the Conference and submission of their research papers. Moreover, special thanks to Keynote speakers – Olga Sumińska-Ebersoldt, Marcos António Nogueira, Shulan Zhang, Viktorija Vaštakaitė-Kairienė, Gintaras Valušis, Wojciech Królas and Darius Milčius.

Sincerely,

Conference Organizers



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  Project Manager at Karlsruhe Institute of Technology (KIT), Germany:
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- **SPEAKER | Marcos António Nogueira**
  H2020-AURORAL Project Coordinator, Belgium:
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- **SPEAKER | Shulan Zhang**
  Professor at Northwest A & F University, China:
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  Senior Researcher at Lithuanian Research Centre for Agriculture and Forestry, Lithuania:
  LIGHTING STRATEGIES FOR IMPROVED QUALITY OF LEAFY GREENS INDOORS

- **SPEAKER | Gintaras Valušis**
  Director at the Center for Physical Sciences and Technology (FTMC), Lithuania:
  SEMICONDUCTORS CHIPS AND THEIR EMPLOYMENT FOR “COLOUR” PHOTOS IN INVISIBLE LIGHT

- **SPEAKER | Wojciech Królas**
  Professor at the Institute of Nuclear Physics of the Polish Academy of Sciences in Kraków, Poland:
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- **SPEAKER | Darius Milčius**
  Head of Center for Hydrogen Energy Technologies, Lithuanian Energy Institute, Lithuania:
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MODELLING AND DESIGN DC-DC BOOST CONVERTER FOR SOLAR ENERGY

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ABSTRACT

The decline and inadequacy of fossil fuels have accelerated the exploration and use of renewable energy sources to meet increasing energy demands. In addition, the use of fossil fuels hurts the environment. For this reason, one of the most important renewable energy sources that are coming to the forefront of research is the sun.

Theoretical and general information about solar energy, which is a renewable energy source, such as power generation, storage, main components, power quality of solar energy, and problems with sources, are studied and explained in detail.

A photovoltaic system has been designed, which is widely used in solar energy. The system is formed by increasing the output voltage to the circuit fed by a panel in a certain ratio. In this process, the voltage is raised to the desired voltage level in the case of direct current with the help of the DC-DC Boost Converter.

Keywords: Renewable Energy, Solar Energy, Power Quality, Solar Photovoltaic Panel, DC-DC Boost Converter

INTRODUCTION

In the 21st century, with the development of technology and the rise in living standards, energy consumption has increased traditional practice to meet this requirement. Fossil fuels, which are energy production methods, have a noticeable negative impact on environmental effects [1].

Considering the statistics in the last five years of the last century, almost 90% of the energy production consisted of fossil fuels. During this period, it was observed that fossil fuels, gas, dust, and the like emitted around us during energy production adversely affected the universe we live in. In addition, it has been seen that gases affect the health of living things and cause global warming. Generating energy from fossil fuels' negative effects and exhaustible resources is why the search for alternative energy paved the way for its onset [2-3].

This is clean energy. The biggest advantage of these resources is that they are renewable, that is, inexhaustible, and also, as a result of their use, there are no harmful elements to the environment. This is the most important type of clean energy, photovoltaic energy [5]. On average, the total solar energy reaching our world is productive for a few hours. If it can be used as an energy source, the annual energy need of the world can be satisfied [6].

Photovoltaic energy, being an endless and very powerful source, being reliable, can be directly converted to electrical energy, does not contain moving parts and maintenance future due to its advantages such as almost non-existent costs. It is one of the promising energy sources [7]. Photovoltaic energy technology‘s aim is comparable to or even more costly than other energy sources. Advantageously, electrical energy can be obtained from the sun.

SOLAR ENERGY

What Is Solar Energy?

Solar can be defined as the energy emitted from the sun. Solar energy photons are the radiation energy released as a result of the conversion of hydrogen atoms in the sun into helium atoms.

The sun is so big that 1 million earth can fit inside it, and the amount of energy it emits is so great that 564 million tons of hydrogen turn into 560 million tons of helium per second. The 4 million tons of energy lost during this transformation is also dispersed into space. This energy emanating from the sun is known as solar energy and ensures the continuation of life on our planet [8].

Solar energy, with its distinctive feature of inexhaustibility, is a great renewable and has potential for sustainable development at present as an environmentally friendly energy source that proposes solutions [9].

METHODS (WHAT IS A PHOTOVOLTAIC SYSTEM?)

Photovoltaic literally means the production of electricity from the photon. This product is provided by Photovoltaic Panels (PV). Photovoltaic systems are the most common method used to generate electricity from the sun. These systems consist of many components.

Although almost everyone thinks of photovoltaic systems as consisting of solar panels, basic components such as batteries, inverters, and charge controllers are also very important for this system [10].

ELECTRICITY GENERATION IN PHOTOVOLTAIC PANEL

The structure of the solar panels used in our time is made of semiconductor materials such as a thyristor, diode, and transistor. Gallium arsenide, cadmium telluride, and the most preferred silicon are used as semiconductor materials in solar panel construction. If we examine in general, it is possible to realize photovoltaic conversion in semiconductors. For this, it is necessary to drop a photon (sunlight) on the joint area.

When a photon is dropped on the region of the semiconductor, an electron-hole pair is formed. The electron-hole pairs are separated from each other by the effect of the magnetic field formed in the environment. In this way, light is converted into electrical energy in semiconductors [11]. In solar cells, the region where this event occurs is divided into three. These are conductive tape, forbidden energy band, and valence band.

The conductive and valence bands are the energy bands. The energy of the incoming photon is the forbidden energy. If it is greater than or equal to the valence band, the photon can lose its energy by removing an electron from the valence band [12]. Thus, it is ensured that the detached electron reaches the conduction band, and the electron-hole pair is formed. This pair is connected by the effect of the electric field in the p-n junction region.

They are separated from each other, like a pump that pushes electrons to the n region and the holes to the p region. Thus, power flow occurs between the ends of the solar cells. This event is the photovoltaic called event.

WHAT ARE THE PHOTOVOLTAIC (PV) SYSTEM TYPES?

Off-Grid Photovoltaic Systems (Storage Systems)

Off-grid photovoltaic systems are systems that are installed separately from the electricity grid, store the electricity produced by solar panels via batteries and convert it into electrical energy that we use at home with inverters. Off-Grid systems consist of four main parts. These are solar panels, battery packs, charge controllers, and inverters.

The system working principle is the electrical energy produced from the solar panel is regulated by the charge controller and stored in the batteries. This stored energy is converted into electrical energy that we use at home with inverters. In a way, this is similar to the principle of charging the car battery of the alternator in vehicles. Battery quality is very important for off-grid photovoltaic systems. Batteries with high charge-discharge efficiency, resistance to high temperatures, and long life should be preferred.

On-Grid Photovoltaic Systems (Grid-Connected Systems)

Photovoltaic On-Grid system consists of four basic elements solar panels, inverter, bidirectional, and data logger.

The system working principle is the electrical energy produced from the solar panels is arranged by coming to the grid-connected inverters and converted into a form that can be transferred to the power line. The electricity produced from the solar panel is used directly

for the load, and the excess is transferred to the grid. When the air is closed, or the production is low, the electricity need is met by transferring electricity from the grid to the load. If there is a problem caused by the mains, the inverter turns itself off. In other words, if there is a power outage in the network, your home will also be cut off [13].

WHAT ARE THE MAIN ELEMENTS OF SOLAR TRIBUNES (PHOTOVOLTAIC (PV) SYSTEM BASIC ELEMENTS)?

The components of solar tribunes are shown in Fig 1. Some of the most important components are described below.

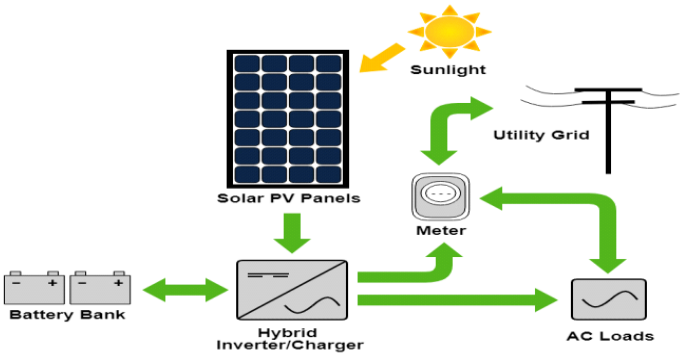


Fig. 1. Photovoltaic Systems

Solar Panel

Solar panels, which are the most basic part of photovoltaic systems, are the part where electricity is produced from the sun. The solar panel converts solar energy into electrical energy using solar cells made of semiconductor silicon material. Solar panels of different capacities are available. These vary according to the area and arrangement of solar cells. Solar panels are widely used in the market. They are solar panels with a capacity of 5W (Watt), 10W, 60W, 100W, 150W, 260W, and 275W.

Charge Controller

The charge controller regulates and stabilizes the dc energy coming from the solar panel and creates stable dc electrical energy for the charging of the batteries. To charge the batteries from a dc source, the charging current and voltage must be regulated and constant. The voltage and current produced by the solar panel are not constant, so a charge controller is needed for efficient charging of the batteries. Charge controllers also prevent reverse current from flowing from the battery to the panels. It protects the battery from overcharging. The charge controller cuts off the electricity from the solar panel when the battery is full. There are two types. These are PWM (Pulse Width Modülation) and MPPT (Maximum Power Point Tracking) charge controllers.

Batteries

Battery quality is very important for off-grid photovoltaic systems with solar storage. The battery should have high charge-discharge efficiency and long life. It should be resistant to temperature and adverse environmental conditions. Batteries commonly used in solar systems are gel batteries and some deep cycle leads acid batteries.

Inverters

Inverters are electronic devices that convert DC electrical energy into AC electrical energy. There are three types of Off-Grid photovoltaic systems square wave, modified sine, and full sine. Modified sine and full sine models are frequently used in solar systems [14].

HOW IS PRODUCED ENERGY STORED?

Excess solar energy can be stored with a Solar Cell. The solar battery is useful in many ways because it helps you take advantage of the electricity your solar system produces when you need it. We use energy to heat and cool our homes during the day, but lights and other electronic devices are mostly used after work and at home in the evening. Unfortunately, this is also when solar panels stop producing energy.

The solar battery helps alleviate this problem by storing the excess electricity produced by your solar panels for your evening consumption. That way, you can continue to use clean energy when you get home from work instead of drawing energy from the power grid, which likely uses coal or some other form of fossil fuel energy.

POWER QUALITY PROBLEMS OF SOLAR PANEL

Power quality problems in solar power plants are as follows can be sorted:

- Transient voltage
- Continuous voltage variations: The general output power voltage level in renewable energy sources may increase or decrease.
- Voltage imbalance: Another important factor affecting power quality is voltage imbalance.
- Wave distortion-Harmonics: The total high-frequency waveform makes up the distorted fundamental waveform.
- Voltage fluctuations and flickers: In a healthy network, the voltage is 50 Hz, and a pure sine wave should be in the form. However, this is not always the case. Network voltage can sometimes oscillate at lower frequencies.
- Power frequency variations: Frequency is one of the most important factors in power quality at the power source, and demand imbalances cause frequency oscillations. For this reason, in grid-connected systems, grid frequency and system frequency are synchronized should be done [15].

DESIGN AND SIMULATION WORKING

DC-DC Converter

The converter is an electronic circuit or electromechanical device that converts a source from one voltage level to another. It is a type of electric power converter. Generally, there are 4 converters. These are AC-AC, AC-DC, DC-AC, and DC-DC.

NOTE: In this project, only DC-DC converters were mentioned. Because "DC-DC Boost Converter Modelling and Design for Solar Energy" will be studied. A DC-DC converter is an electronic circuit or electromechanical device that converts a DC direct current source from one voltage level to another. It is a kind of Electric Power Converter.

Specific to these converters is that the energy flows in both directions of the converter. These converters are commonly used in various applications, and they are connected between two levels of DC voltage, where energy is transferred from one level to another [16]. These converters are; the Boost DC-DC converter, Buck DC-DC converter, Boost-buck non-inverting DC-DC converter, and Boost-buck inverting DC-DC converter.

Which Is The Best Dc-Dc Converter To Use With Solar Pv Panels?

DC-DC Boost Converter is more suitable for PV (photovoltaic) systems connected in series. Since the voltage level of PV is usually low, a boost converter is preferred in most cases. PV cells break down when the pulsed current is consumed. The most typical solution is a boost converter with a constant frequency resonant converter (when you have full resonance and almost no switching losses).

The microprocessor to be used represents the control of the converter. As known, the boost converter is the variable DC voltage of the input, the operating ratio of the switch D (Duty Cycle=D). It is used by changing the PWM (pulse width modulation). It amplifies by switching and passes it to the output. PWM manages the modulation cycle.

Buck, flyback, forward converter, etc., can be used, but to design a good solution, you need to add a current filter that should be taken into account. However, this negatively affects my overall efficiency and power density. The use of the converter depends on the voltage level required for the application. Since the voltage level of the PV is usually low, in most cases, a step-up converter is preferably used. In this project, it will be more useful to use “Boost Converter” as the booster is dc-dc.

Dc-Dc Boost Converter (Topology of Dc-Dc Boost Converter)

The DC voltage applied to increase the converter input gives higher DC to the output. They are circuits that transfer by converting to voltage. Boost converter circuit includes inductance, capacitor, diode, and switching element. When the switch is switched on, the diode is in reverse polarity, it is in the cut. The circuit, coil, and key are completed. This word stores some energy on the coil. The load capacity at the outlet is fed. Here the capacitor current is high is worth. When the switch is switched off, the source voltage and the coil voltage a total tension is seen. The current drawn from the source is continuous. Key in key control, handed over by a control. The state of switching on and off by changing the operating ratio D (Duty Cycle). This toggle can show the status according to the input voltage and, accordingly, the output voltage [17]. Fig.2 shows the design of the DC-DC Boost Converter Topology Circuit.

The microprocessor to be used will show the control of the amplifier converter. As it is known, the amplifying converter, the incoming variable DC voltage of the input, and the switch operating ratio (Duty Cycle=D) by changing D, i.e. PWM (Pulse Width Modulation-Pulse Width Modulation). It raises and transfers it to the output through its switching. Here is microprocessor comes into the circuit, and this PWM (Pulse Width Modulation-Pulse Width). It manages the modulation switching.

CONVERTER CALCULATIONS
Converter coil value;

$$L = \frac{V_{in} \times (V_{out} - V_{in})}{\Delta IL \times fs \times V_{out}}$$

Converter minimum capacity value;

$$C_{\min} = \frac{I_{out\max} \times (V_{out} - V_{in})}{\Delta V_{out} \times fs}$$

Duty Cycle;

$$D = 1 - \frac{V_{in}}{V_{out}}$$

D value varies between 0 <D <1, and the output voltage is higher than the input voltage. Thus, this circuit booster type converter. It is called "Boost Converter". The lowest value of the output voltage D = 0, and the output voltage becomes equal to the input voltage. When the fill ratio is D=1, the output voltage becomes infinite. Therefore, in applications, the D value is selected in the range of 0.1 <D <0.9.

So parameters such as: L (Inductor) =1000uH, C (Capacitor) = 2200uF, R (Resistance) =10Ω and fs (Switching Frequency) = 5MHz.

DC-DC BOOST CONVERTER EXPERIMENTAL WORKING OF SIMULATION DESIGN

Solar energy, wind energy, biomass energy, geothermal energy, hydraulic energy, hydrogen energy, and wave energy are used as renewable energy. The most widely used type of renewable energy is solar energy. Because solar energy is an environmentally friendly energy source with its unique inexhaustible feature and great renewable potential. [5].

Due to certain weather and climatic conditions, the desired output voltage and power of PV panels cannot be obtained. Therefore, efficiency can be increased by using DC-DC boost converters.

Of course, when designing this circuit, attention should be paid to the calculation of circuit elements suitable for the topology, such as PWM, duty cycle, and microprocessor.

If Vin = 20, Vout = 29.85 V, fs = 5 MHz in Equation (3);

$$D = 1 - \frac{V_{in}}{V_{out}} = 1 - \frac{20}{29.85} = 0.33 \Rightarrow \%33$$

If Vin = 20, Vout = 57.4 V, fs = 5 MHz in Equation (3);

$$D = 1 - \frac{V_{in}}{V_{out}} = 1 - \frac{20}{57.4} = 0.65 \Rightarrow \%65$$

Comparing the calculation results, I found that at a high switching frequency (fs = 5 MHz), the output voltage changes (Vout = 29.85 and Vout = 57.4 V), even if I apply a constant input voltage (Vin=20V) and change the duty cycle. This study can benefit from the low cost and high speed of the control circuit. For this reason, it can be recommended to use boost converters for solar energy.

When designing this experiment, the minimum output voltage and current were found at the lowest (D=33%) value of the duty cycle in the 1st experiment. In the second experiment, the maximum output voltage and current were obtained at the highest value of the duty cycle (D=65%).

In section 3.1.2. DC-DC Boost Converter (Topology of DC-DC Boost Converter), dc boost topology is explained. In this direction, the DC-DC Boost converter is obtained in Fig.2. Dc-Dc Boost Converter Circuit in MATLAB, using the Matlab program.

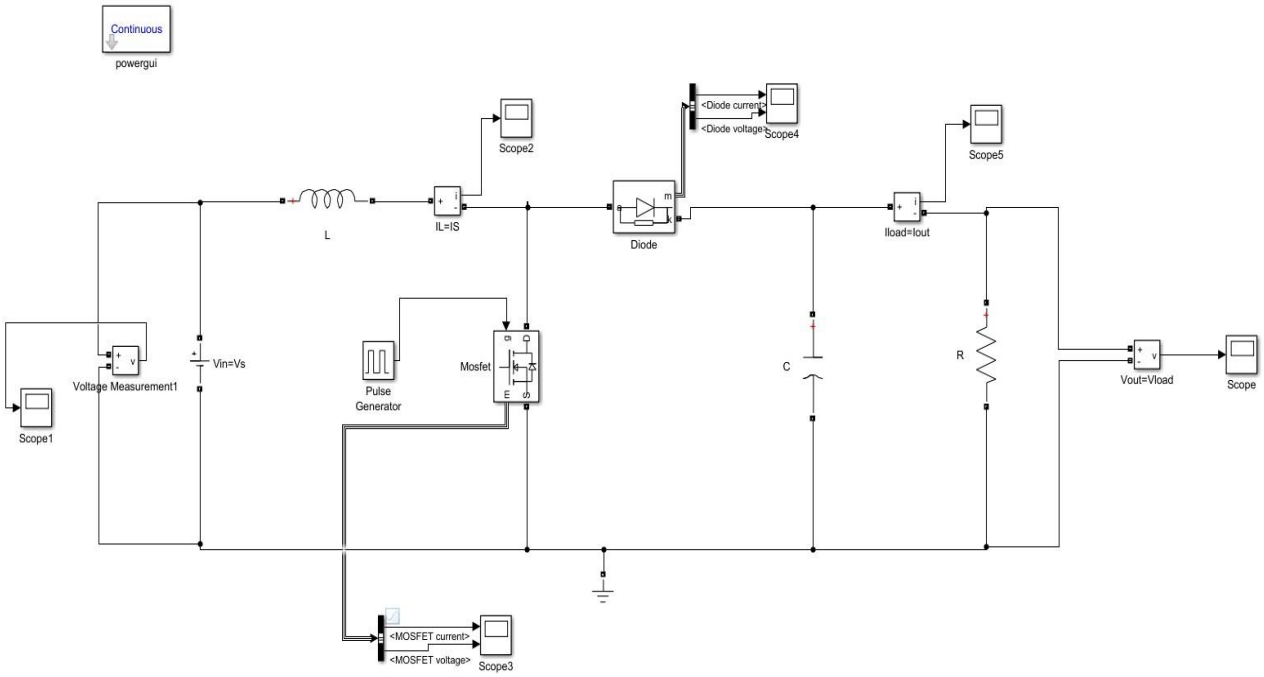


Fig. 2. Dc-Dc Boost Converter Circuit in MATLAB

EXPERIMENT 1: DUTY CYCLE FOR %33

In Fig.3, while the Duty Cycle is 33%, the Minimum Output Voltage value is 29.62 V.

In Fig.4, while the Duty Cycle is 33%, the Output or Load current value is 2.93 A.

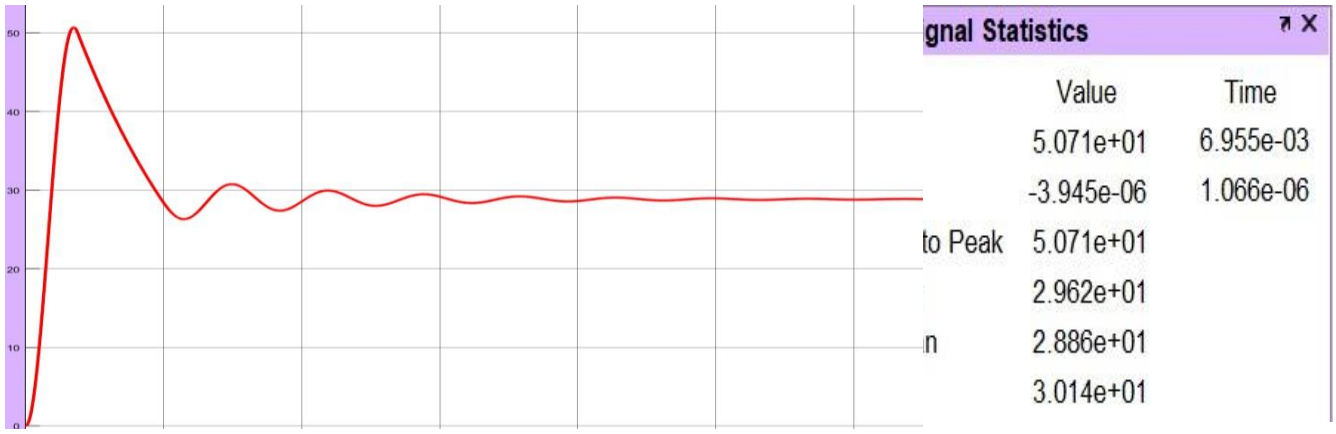


Fig. 3. Vout=Vload=29.62V

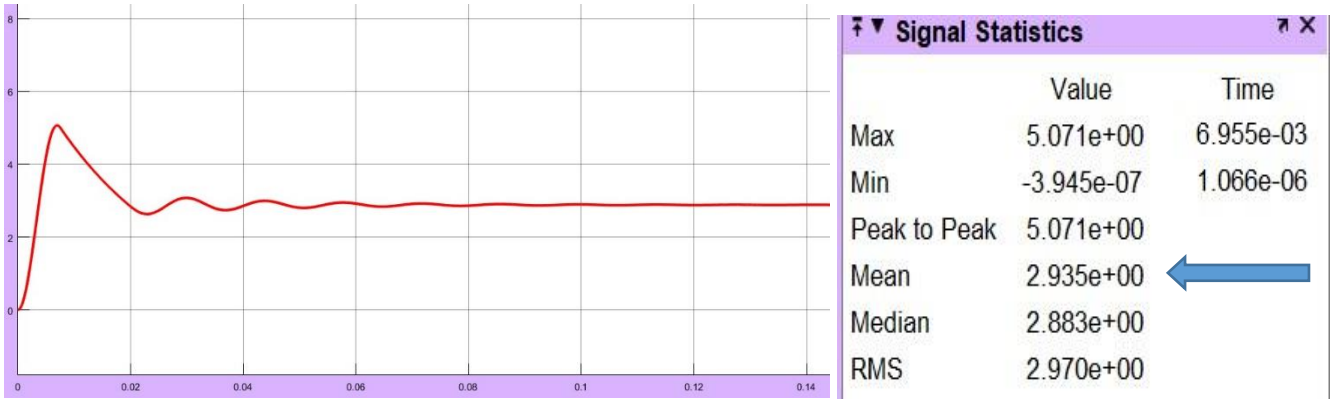


Fig. 4. Iload=Iout=2.93A

EXPERIMENT 2: DUTY CYCLE FOR %65

In Fig.5, while the Duty Cycle is 65%, the Maximum Output Voltage value is 53.18V

In Fig.6, while the Duty Cycle is 65%, the Output or Load current value is 5.291 A

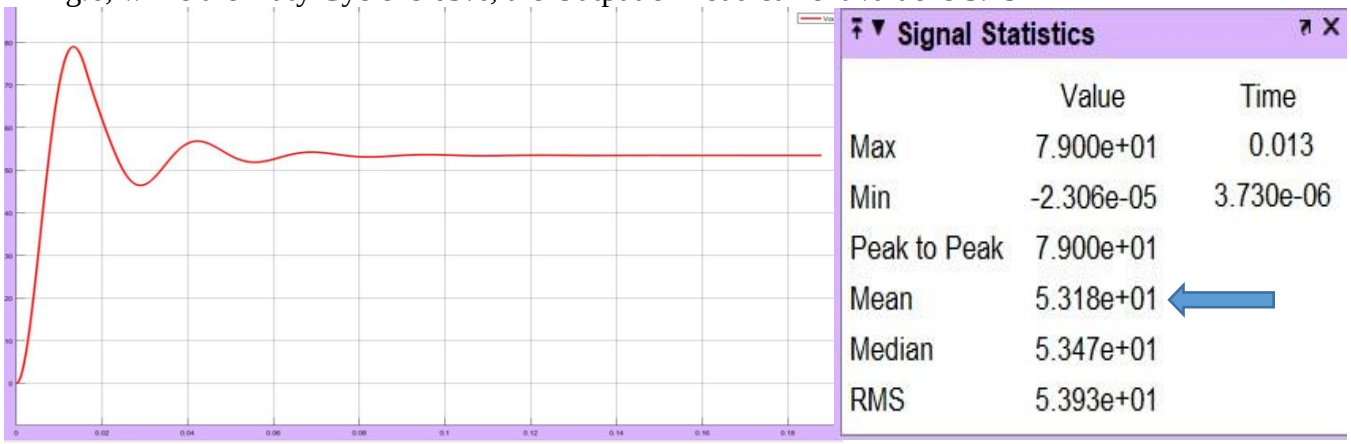


Fig. 5. Vout=Vload=53.18V

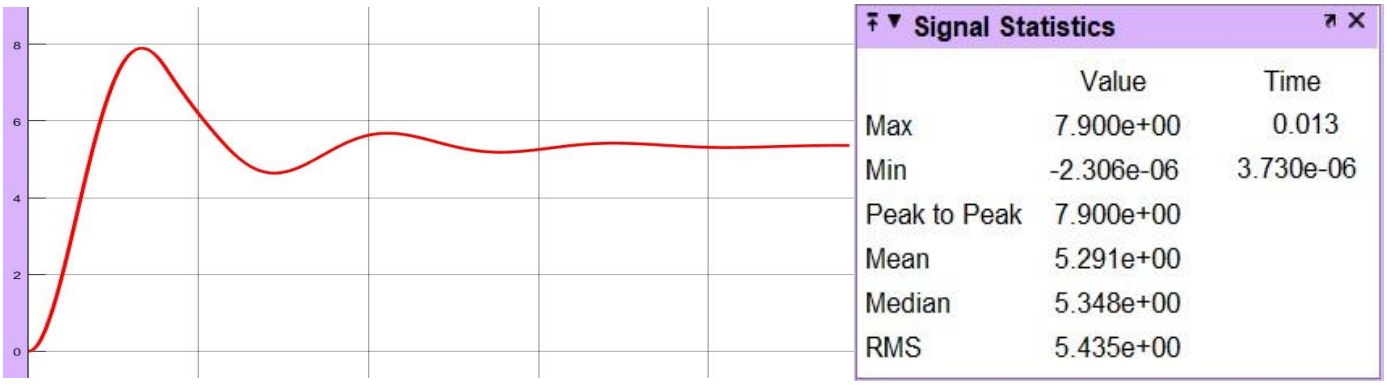


Fig. 6. Iload=Iout=5.291A

RESULTS AND DISCUSSION

The most popular renewable energy source application using solar energy is the generation of energy. Photovoltaic panel applications are energy generation with the solar source of the methods. Solar energies have been examined separately, and the types, how it produces electricity, how they store electricity, and the factors that disrupt their power quality have been examined.

In this Project, the output voltage of the solar photovoltaic panel is generally low and should be increased for proper use. So using DC-DC Boost Converter to provide this voltage boost. In this study, a microcontroller-controlled Boost Converter was offered.

As a result of this work, as seen in Fig. 3 and Fig. 4. Show minimum voltage value is Vout=Vload=29.62 V, and the minimum current is Iload=Iout=2.93A. Fig. 5 and Fig. 6 show maximum voltage is Vout=Vload=53.18V, and the maximum current is 5.291 A. So it has been proven that minimum and maximum voltage values can be obtained in different duty cycles.

Necessary studies have been done for the system, and the result may be a circuit. Necessary circuit applications were made according to these simulations and their results. The system can be developed further by carrying out the necessary research and development studies. The system can be made more useful by making studies that will reduce the losses and increase the efficiency even more.

Realized power and control circuit, different duty cycle situations, and it has been operated for different occupancy rates. With this work, the control circuit implemented software and hardware low from the advantages of costly and high speeds. Therefore, it is recommended to be used in Boost Converters. So, the experimental results obtained approximately coincide with the theoretical analysis. It shows the success of the work.

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