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DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITY OF LAMPUNG

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Bandar Lampung, October 27-28, 2021

Converging Technology for Sustainable Society

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Foreword from Rector of University of Lampung

Assalamu'alaikum warrahmatullahi wabarakatuh

All praise be to Allah SWT who has given us all salvation and blessing in Life. The Lord who created this word.

I'll never forget to sholawat and salam to our beloved Prophet Muhammad SAW who really loved by ALLAH SWT and saved the human life from destruction in the safety, that's the right path of ALLAH SWT.

I would like to say welcome to the First International Conference on Converging Technology in Electrical and Information Engineering (1st ICCTEIE 2021) with the theme: "Converging Technology for a Sustainable Society ".

The University of Lampung is very committed to advancing research and international collaboration as an effort to advance world civilization. ICCTEIE is an international conference co-sponsored by The IEEE Indonesian Section and organized by the Department of Electrical Engineering and Informatics – University of Lampung. The conference is held on October 27-28, 2021, in Bandar Lampung, Indonesia, on a virtual meeting base. This event provides a good platform for researchers, scientists, and the entire engineering community to meet virtually and exchange their ideas on electrical engineering, control engineering, electronics, telecommunications, computer science and engineering, cyber-physical system, informatics, sustainable energy and environment-related fields and their applications.

I do expect this conference will give imperative contributions to the development on the aspects of researches, academics, and industries nationally and globally. I hope that all participants have fruitful and technical discussions and please enjoy the meeting.

See you on next 2nd ICCTEIE 2023.

Thank you for your excellent attention.

Prof. Karomani – Rector of University of Lampung

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Welcome message from General Chair of 1st ICCTEIE 2021

Assalamu'alaikum Warrahmatullahi Wabarakatuh

Peace be upon you and God's mercy and blessings

On behalf of the committee, I am very pleased to welcome you to the 1st ICCTEIE 2021, The International Conference on Converging Technology in Electrical and Information Engineering, 2021.

We are very grateful for all the support from the Rector of the University of Lampung, all vice-rectors, director of the research institute and dean of faculty of engineering. I would also like to extend my sincere gratitude to IEEE Indonesia Section, Advisory Committee, Technical Program Committee, Steering Committee, and Organizing Committee for their support and efforts so that this event can be successfully conducted.

I welcome all the eminent speakers and guests from all over the countries from different walks of life you had come here virtually to share the knowledge and experience among the scientific community.

The conference will highlight recent and significant advances, the state-of-the-art, current status and future challenges on all aspects related to the research and development in the field of Electrical and Information Engineering including:

- Communication, Networking & Broadcasting,
- Components, Circuits, Devices & Systems,
- Computing & Processing (Hardware/Software),
- Engineered Materials, Dielectrics & Plasmas,
- Power, Energy, & Industry Applications,
- Robotics & Control Systems,
- Signal Processing & Analysis,
- Information Technology,
- Internet of Things, and
- Artificial Intelligence

The call for the paper was issued on the 25th of May, 2021 and closed on the 15th of October 2021. There are 46 submissions papers during that time. 31 papers are presented today. After this conference, the reviewing process will continue to ensure each article is ready for submission in the IEEXplore or otherwise it will be excluded.

As The University of Lampung is progressively expanding its research network and contributions to the world of science and technology, it is expected that the conference will significantly provide means to both UNILA's researchers and other researchers to engage in a fruitful discussion during and after the conference.

The 1st ICCTEIE is starting this year as the 1st year and it is projected to continue every 2 years. Hopefully, the Covid-19 pandemic soon subsides so the next conferences would be able to commence in the real meeting. This year our theme is Converging Technology for a Sustainable Society, and we are very happy the experts from the field of electrical and information as well as computer technology are with us today. We cordially welcome our keynote speakers:

1. Dr Laksana Tri Handoko, M.Sc., as the Head of National Research and Innovation Agency Republic of Indonesia,
2. Ir. Bob Saril, M.Eng.Sc., Director of Commerce and Consumer Management Indonesian National Grid Company,
3. Prof. Yasunori Mitani, The President of Kyushu Institute of Technology, Japan,
4. Prof. Prashant Pillai, University of Wolverhampton, England,
5. Prof. Jing-Ming Guo, National Taiwan University of Science and Technology, Taiwan, and
6. Dr Daniel Eghbal, Manager Future Network Strategy at Energy Queensland Australia and Australia Council Chair Institute of Electrical and Electronics Engineers (IEEE)

Also, let me inform you that all of our local committees are now registered as IEEE members as well as 15 of our electrical and informatics students are now also registered. Next month we plan to launch the IEEE Student Branch of Lampung, we hope through this endeavour will be able to broaden their horizons to the international society.

Before coming to a close with these remarks, I would also like to remind you and especially our moderators to strictly stick to our schedule and not to let any session overrun. I sincerely hope you will enjoy today of discussion, debate and networking.

I am sure you will have fruitful and rewarding exchanges on this conference day. I wish you all the best and success.

Thank you.

Dr. Khairudin – General Chair 1st ICCTEIE 2021

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Design of DC to DC Converter for Solar Photovoltaic Power Plant Applications

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***Abstract*—In the application of solar PV power plant, the energy from solar is converted into the electrical energy. For this reason, solar photovoltaic is used as equipment to convert this energy. Due to the voltage generated by the solar PV panel changes every time, a DC voltage regulation system from the solar PV system is needed. As a DC voltage regulator on solar PV, a dc-dc converter is usually used. In this paper, we will discuss the modeling and simulation of a dc-dc converter as a regulator for a solar PV power plant. The modeling and simulation were carried out using MATLAB Simulink Software.**

Keywords—Solar pv, dc-dc converter, power conditioning system, Boost Converter, switched-inductor Boost Converter

I. INTRODUCTION

Solar energy is a renewable energy source that has bright prospects in the future. Solar energy is a clean, abundant, and easy-to-use natural resource. This energy obtained from sunlight is available very much and it is free energy. Solar energy will become increasingly popular as technology advances and the cost of photovoltaic technology decreases. Photovoltaic (PV) has several advantages such as clean energy, not noisy, environmentally friendly, low operating and maintenance costs, and also a long period of use [1]-[3].

The power generated by solar photovoltaics is in the form of DC voltage, before it can be used directly or transmitted to the grid is require DC-DC conversion. The PV power generation system that is commonly used is illustrated in Figure 1. Commonly PV power generation system is composed of Solar PV panels, energy storage batteries, DC-DC converters as voltage regulators, and inverters to generate AC voltage. the output of the solar PV Panel is connected to the DC Bus via a DC-DC converter. Energy storage battery, which is used to store excess power from solar panels connected to DC Bus via DC-DC converter as well. PV systems require a dc-dc converter with a high power rating. This converter serves to increase the voltage from a low solar PV output voltage to a higher voltage required by a high voltage DC bus.

One of the problems in connecting solar PV modules to the grid is that the output voltage of the PV modules is always lower than required. To overcome this problem, several PV modules are generally connected in series to produce a high voltage as needed. However, if so many PV modules are connected in series, this will result in partial shading conditions. If some PV modules are under partial shading condition, this will cause a large reduction in the PV output power [3]-[4].

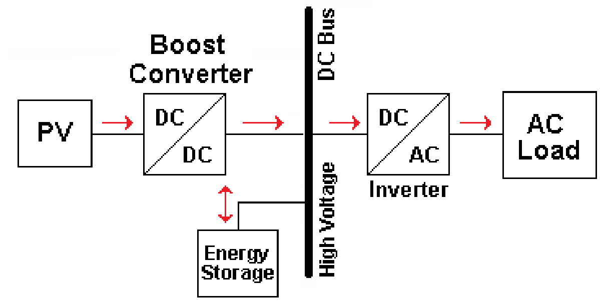

Fig. 1. PV power plant system.

The rapid growth of power electronics technology has made it possible to interface solar PV modules to the grid, or high voltage DC systems. Many topologies have been proposed for this interface. Among them are cascaded systems [1-3] and parallel converter systems [4]. This system can be used for applications on standalone systems as well as systems connected to the grid.

In this system is often use DC-DC boost converter. The DC-DC boost converter is used as a interface between solar PV and DC Bus to convert the low voltage from Solar PV into higher voltage that required by the DC Bus. This particular is done by changing the duty cycle of the switching system of the DC-DC converter.

According to theory, a conventional boost converter has very high gain when the duty ratio is set close to 100% [4]-[7]. But in practice this gain is very limited. This is due to the voltage drop on the power switch and rectifier diode, equivalent series resistance (ESR) of the inductor and capacitor, also the saturation effect of the inductor and capacitor [4]-[7].

Many topologies have been proposed to produce high voltage gain converter. [4]–[8]. One of them is the coupled inductor technique. This technique is able to provide high voltage gain, high efficiency, and low stress voltage on active switches.

In this paper, a dc-dc converter is designed for Solar Power Generation application. The proposed converter is an improvement boost converter based on a switched-inductor dc-dc boost converter. The design and analysis of the proposed dc-dc converter will be discussed in this work. The proposed system will be modeled and simulated using MATLAB SIMULINK.

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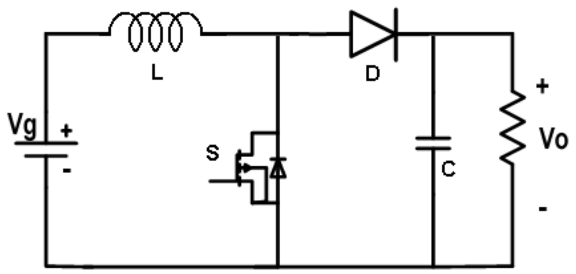

Fig. 2. Conventional dc-dc boost converter (CBC).

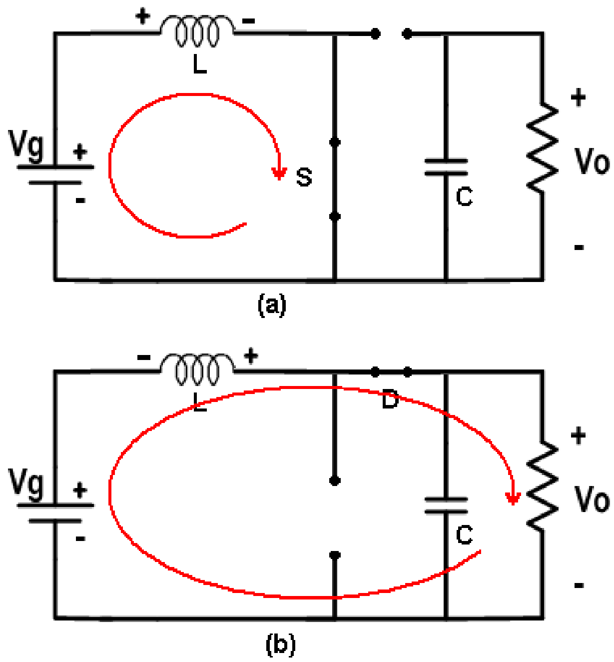

Fig. 3. CBC Switch Operation mode. (a). mode 1, and (b). mode 2.

II. Analysis of Conventional Boost Converter

Boost Converter is a power electronics converter which can produce output voltage higher than its input voltage. Schematic of a conventional dc-dc boost converter is shown in Figure 2. Circuit consists of an inductor, an electronic switch, a diode, an output filter capacitor and a load [8].

The boost converter has two states in its operating mode. It depends on the position of the electronic switch, i.e. open or closed.

The first operation mode starts when the electronic switch is closed at time t = 0 until the switch is opened at time t = ton. In this operation mode the electronic switch works (on), the diode does not work (off), current flows through the inductor L. The inductor stores energy into the magnetic field and the inductor current increase linearly. The equivalent circuit of operating mode 1 is shown in Figure 3a.

The second mode starts when the electronic switch is opened at t = ton until the electronic switch is closed again at t = T. In this operation mode the electronic switch does not work (off), the diode works (on). The equivalent circuit of operating mode 2 is shown in Figure 3b. In the second mode, the circuit is driven by a source of voltage and the stored energy in the inductor during operation mode 1. Current flows from the voltage source, through the inductor, to the capacitor and load. The output voltage appears across the load and also across the capacitor.

The inductor current will be decrease because the impedance of the circuit becomes higher. The stored energy in the magnetic field created in operating mode 1 will maintain current to the load. In this condition the polarity of the inductor voltage is reversed. Inductor polarity will be negative on the left side as shown in Figure 3.b. This causes the source of voltage and the inductor were connected in series connection, so the capacitor will be charge with higher voltage [8].

The conventional dc-dc boost converter output voltage is calculated by equation (1). Here, duty cycle D of the converter is defined as ratio between conduction time of the electronic switches to the switching period.

$$V_O = \frac{1}{1-D} \cdot V_{in} \qquad (1)$$

As a result, the gain of conventional boost converter at steady state condition can be written as:

$$Gain = \frac{V_O}{V_{in}} = \frac{1}{1-D} \qquad (2)$$

III. Analysis Of The Proposed DC-DC Converter

In this research, a topology of DC-DC converter for Solar Power Generation Applications will be discussed. This DC-DC converter is an improvement over the conventional DC-DC Boost Converter.

To increase the voltage gain of conventional dc-dc converter, an improvement has been made by changing the inductor part in the schematic of conventional dc-dc boost converter. The inductor section is substituted by a switched-inductor section that shown in Figure-4.

By changing an existing boost converter inductor with a switched-inductor branch, a circuit called a switched-inductor dc-dc boost converter will be produced. The schematic of the switched-inductor boost dc-dc converter depicted in Fig-5.

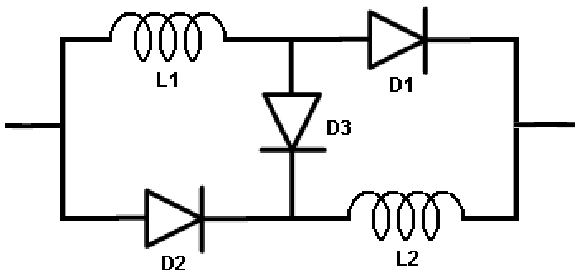

Fig. 4. Switched inductor section

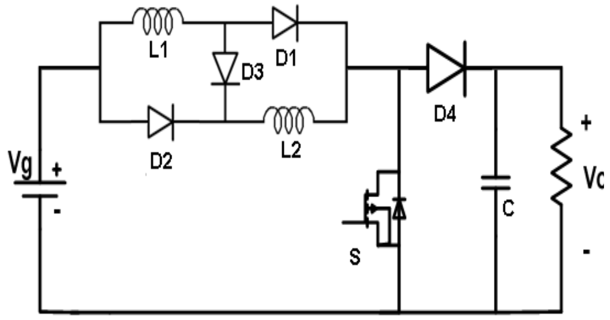

Fig. 5. The proposed DC-DC Converter

Like the conventional dc-dc boost converter, the Switched dc-dc boost converter also has two modes in its operating mode. It also depends on the position of the electronic switch.

The first operation mode starts when the electronic switch is closed at time t = 0 until the switch is opened at time t = ton. In this operation mode the electronic switch works (on), the main diode D4 does not work (off), the branch diode D1 and D2 work (on), and the diode D3 does not work (off). The current flows from the voltage source through inductor L1 and inductor L2 which are connected in parallel. This condition is seen in Figure-6.a. As long as current flows, both inductors are energized by the current. This causes a magnetic field to be formed around it. Some of the energy will be stored. The polarity of the inductor is positive on the left side [5],[8].

The second operation mode starts when the electronic switch is opened at t = ton until the electronic switch is closed again at t = T. In this operation mode the electronic switch does not work (off), the main diode D4 works (on), the branch diode D1 and D2 do not work (off), and the diode D3 works (on). The current flows from the voltage source through inductor L1, diode D3, and inductor L2 which are connected in series. This condition is seen in Figure-6. b.

In the second operation mode, the circuit is driven by a source of voltage and the stored energy in the two inductors L1and L2 during operation mode 1. Current flow from the voltage source via the two inductor, and go to the capacitor and the load. The output voltage appears across the load and capacitor.

The energy stored in the two inductors L1 and L2 will maintain current to the load. In this condition the polarity of the inductor voltage will be reversed. The polarity on the left side of the inductors will change to negative. This causes both inductor L1 and L2 connected in series connection to the voltage source, so the higher voltage will charge the capacitor and the load [5],[8].

The operation mode of the switched-inductor boost converter is shown in Figure-7.

By using steady-state analysis, the switched-inductor boost converter output voltage equation determined as follows:

During the period switch is closed, the voltage across each inductor can be written as:

$$V_{L1} = V_{in} \tag{3}$$

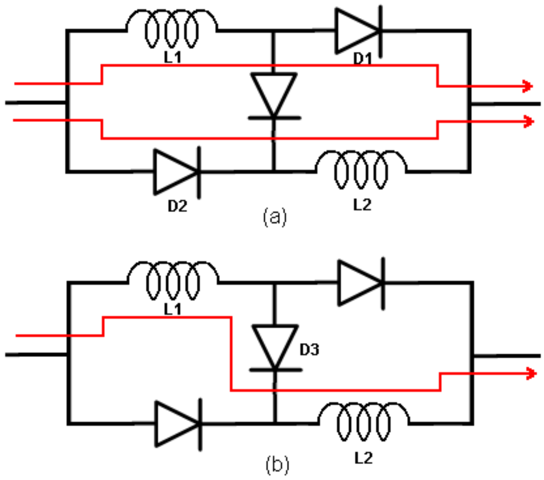

Fig. 6. Switched Inductor branch current flow (a).mode 1 (b).mode 2.

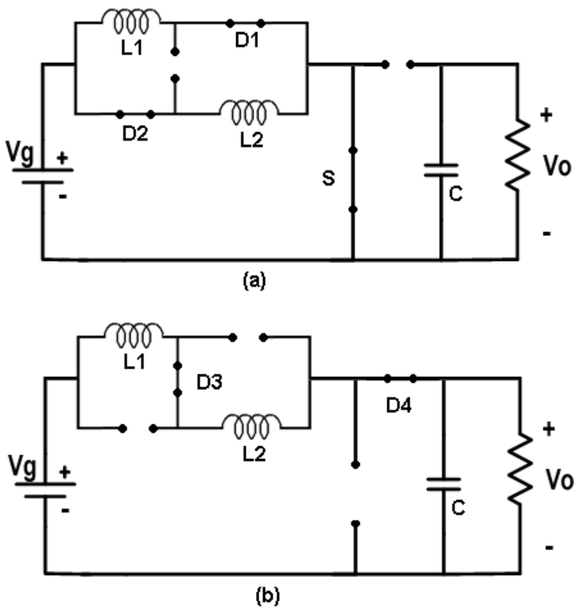

Fig. 7. SIBC Switch operation mode. (a). mode 1 (b). mode 2.

$$V_2 = V_{in} \tag{4}$$

$$V_{L1} + V_{L2} = 2.V_{in} \tag{5}$$

When the switch is opened,

$$V_{L1} + V_{L2} = V_O - V_{in} \tag{6}$$

During one switching period, the average voltage across both of inductors L1 and L2 should be equal to zero. So,

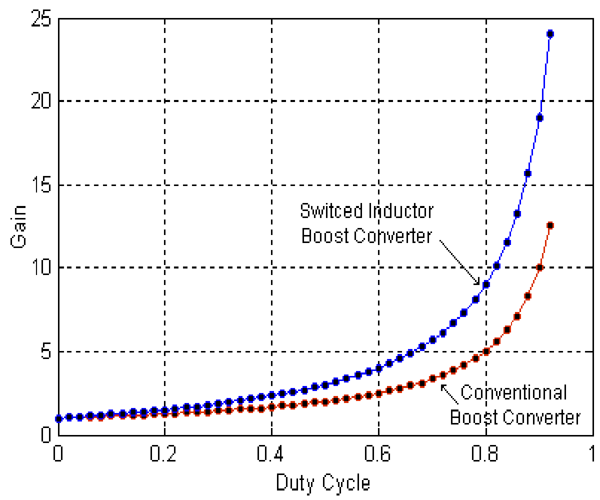

Fig. 8. Gain of converter vs duty cycle.

$$V_{L1} + V_{L2} = D.2V_{in} + (1 - D)(V_o - V_{in}) = 0 \qquad (7)$$

The voltage output of switched-inductor dc-dc boost converter at steady state was expressed as:

$$V_O = \left(\frac{1+D}{1-D}\right)V_{in} \qquad (8)$$

The voltage gain ratio of converter:

$$Gain = \frac{V_O}{V_{in}} = \frac{1+D}{1-D} \qquad (9)$$

From equation (2) and equation (9), it can be concluded that the switched-inductor dc-dc boost converter voltage gain is higher than the voltage gain of conventional dc-dc boost converter. The gain vs duty cycle of the two dc-dc converter are plotted as shown in Figure-8.

IV. Modeling And Simulation

In this section, modeling and simulation of the proposed converter will be carried out. The voltage gain of the switched inductor boost dc-dc converter was compare to the voltage gain of convention boost dc-dc converter.

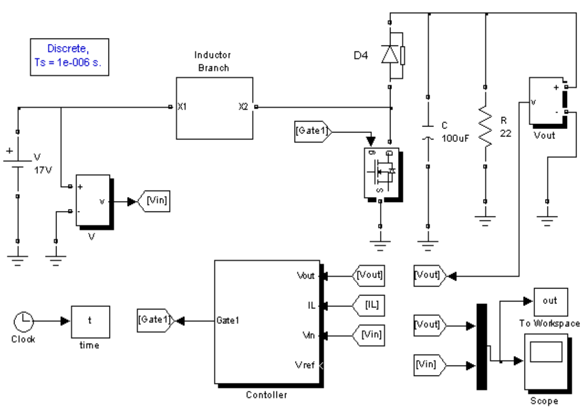

Fig. 9. The Switched Inductor dc to dc boost converter Model.

TABLE-1. CIRCUIT PARAMETERS OF THE CONVERTERS

Parameter	***Value***
Vin	17V
L1	1500uH
L2	1500uH
C	100 µF
F	20 kHz
Load	22 ohm

The converter circuit models are realized by Simulink of MATLAB.

The switched-inductor boost dc to dc converter circuit model shown in Figure-9. In Figure-9 there is a subsystem called inductor branch. Contents of the inductor branch sub-system is depicted in Figure-10. Parameters of the switched-inductor dc to dc boost converter are listed in Table-1.

The performance of the proposed converter is tested by investigating effect of duty cycle variation on the converter output voltage. The output voltage of the switched-inductor dc-dc boost converter will be compared with the conventional dc-dc Boost Converter at the specific value of duty cycle, while input voltage was set at constant value.

V. Result And Analysis

By using the Simulink Model that has been made, an experiment is carried out to compare the performance of the Switched-inductor dc-dc Boost Converters and the Conventional Boost dc-dc Converters.

In this experiment, the input voltage is set equal to 17V. This value is taken correspond to condition of the Solar Panel output voltage when the output power reaches its maximum. Then the duty cycle is set with a value varying from 50% to 85%. The output voltages of the two converters at a certain duty cycle value will be compared.

A. Duty Cycle Variation

Experiments have been carried out for five different duty cycle values. The duty cycle values are selected as 50%, 60%, 70%, 80% and 85%. This study aims to examine effect of change in the value of the duty cycle correspond to the voltage output of both converters being tested. The results for the conventional boost dc to dc converter output voltage shown in

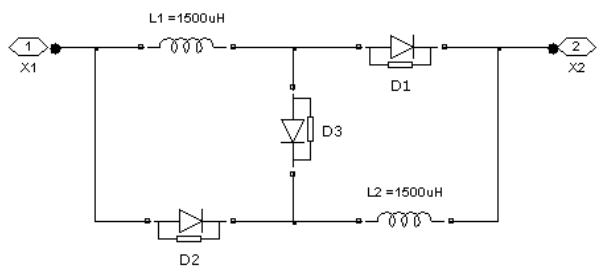

Fig. 10. Inductor branch subsystem.

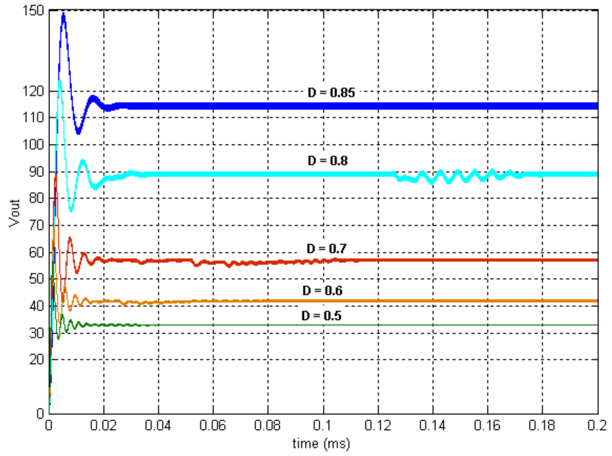

Fig. 11. Conventional dc-dc boost converter output voltage with variation of duty cycle.

Figure-11. While the experimental results for switched-inductor dc-dc boost converter output voltage presented in Figure-12.

B. Steady State Output Voltage Comparison

In this section, an experiment will be conducted to compare the steady state output voltage of the two types of converters. The purpose of this experiment is to find out how big the difference in output voltage produced by the two converters is. From this experiment we can also test the voltage gain that may be obtained using the proposed dc dc converter. The data obtained will be compared with the test data of the conventional boost dc to dc converter.

In this work, the output voltage of booth converters were tested at five different duty cycle values. The duty cycle values taken are 50%, 60%, 70%, 80% and 85%. Then the voltage gain of each converter at any given duty cycle will be recorded. Eventually, the voltage gains at the specific value of the duty cycle of both converters will be compared. Test results of each specific duty cycle were depicted in Figures 13 to 17.

The output voltages of both converters at duty cycle D = 50% are depicted in Figure-13. Here, the input voltage of both converters is set at 17V. From the experiment for D=50%, it is obtained that the output voltage of the switch-inductor boost dc-dc converter is 51V. Meanwhile, for the same input voltage, the output voltage of a conventional dc-dc boost converter is only 33V.

Figure-14 shows the voltage output of the conventional boost dc-dc converter and the output voltage of the switched-inductor boost dc to dc converter at D = 60%. With the input voltage of both converters is set at 17V, the experiment results show the output voltage of the switched-inductor dc-dc boost converter is 68V. Meanwhile, with same input voltage, the conventional dc-dc boost converter produces only 42V output voltage.

The output voltage of both converters at duty cycle D = 70% are depicted in Figure-15. With the input voltage of both converters is set at 17V, the simulation results show the output voltage of the switched-inductor dc-dc boost converter is 99V. Meanwhile, for the same input voltage, the conventional dc-dc boost converter produces only 57V output voltage.

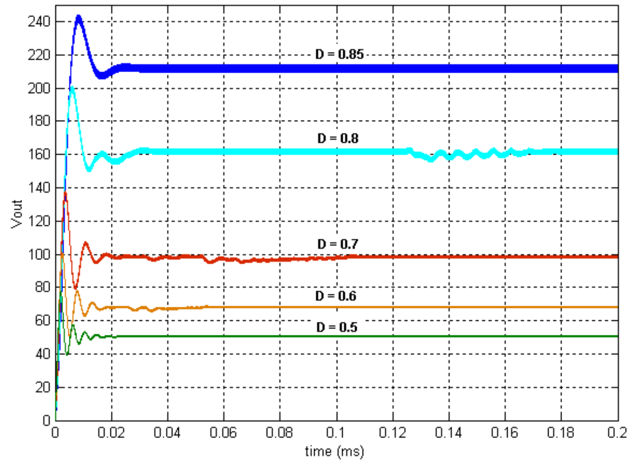

Fig. 12. Switched inductor boost converter Output voltage with variation of duty cycle.

Figure-16 shows the voltage output of the conventional boost dc-dc converter and the output voltage of the switched-inductor boost dc to dc converter at D = 80%. With the input voltage of both converters is set at 17V, the experiment results show the output voltage of the switched-inductor dc-dc boost converter is 161V. Meanwhile, with same input voltage, the conventional dc-dc boost converter produces only 88V output voltage.

The output voltage of both converters at duty cycle D = 85% are depicted in Figure-17. With the input voltage of both converters is set at 17V, the simulation results show the output voltage of the switched-inductor dc-dc boost converter is 212V. Meanwhile, for the same input voltage, the conventional dc-dc boost converter produces only 115V output voltage.

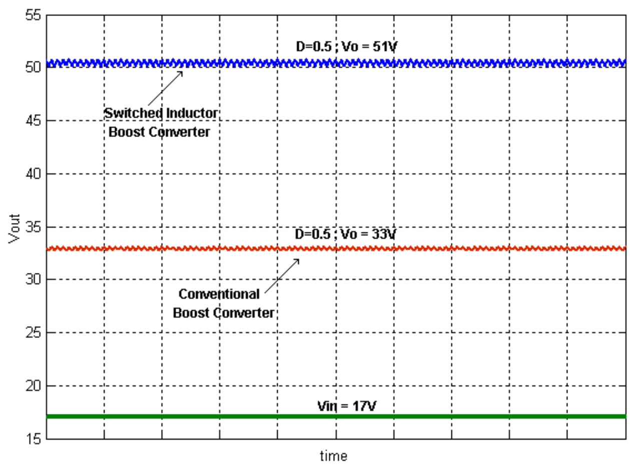

Fig. 13. The converter output voltage at D=50%

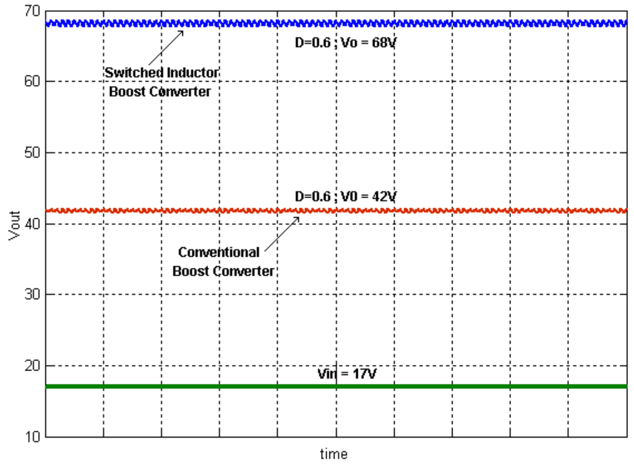

Fig. 14. The converter output voltage at D=60%

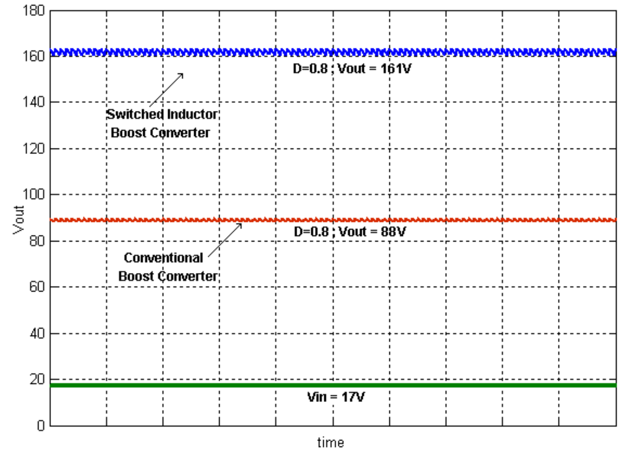

Fig. 16. The converter output voltage at D=80%

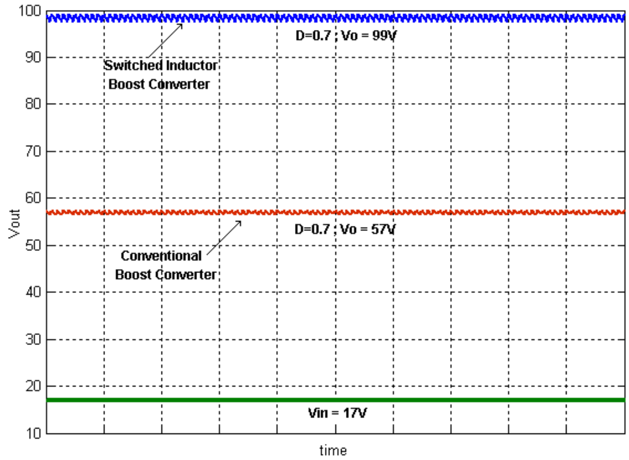

Fig. 15. The converter output voltage at D=70%

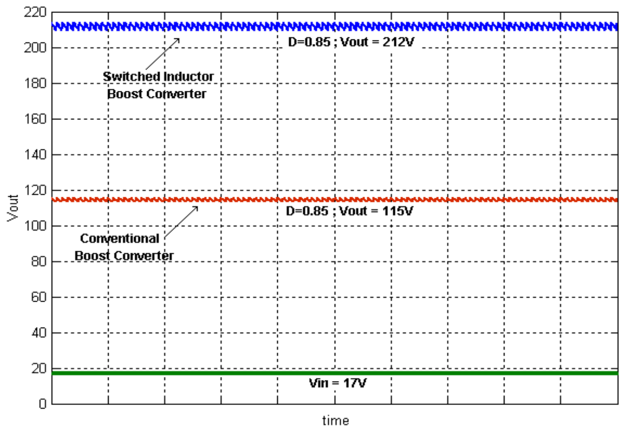

Fig. 17. The converter output voltage at D=85%

VI. Conclusion

A new topology of boost dc to dc converter for solar PV power plant application has been proposed. The main advantage of this converter topology is that the converter has the high voltage gain ratio even though it does not use transformer. A modeling and simulation of the proposed dc to dc converter is presented. The performance of the proposed converter was compared to the conventional dc-dc boost converter. From the experimental results, it is known that the voltage gain ratio of the switched-inductor dc-dc boost converter is higher than the voltage gain ratio of the conventional dc-dc boost converter. The proposed converter has a gain ratio of (1+D)/(1-D).

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