LAMPIRAN

Gmail

Laras Triefena <triefenalaras@gmail.com>

[INFOTEL] Editor Decision

1 pesan

Danny Kurnianto <infotel@st3telkom.ac.id> 28 November 2020 07.36

Kepada: Laras Triefena <triefenalaras@gmail.com>

Laras Triefena, Leonardus H. Pratomo, Slamet Riyadi, F. Budi Setiawan:

Letter of Acceptence (LoA)

===

On behalf of the Editor, we are pleased to inform that your submission to JURNAL INFOTEL, "Design and Implementation of Boost Voltage Doubler for Maximum Power Point Tracker Application Using STM32F103CT" **is Accepted**

Here are some important things we would like to you to do in relation do manuscript acceptance:

1. Please kindly complete the payment by below scheme

- Cost paid by Author with Indonesia citizenship is Rp 350.000 (IDR)
- Cost paid by non-Indonesia citizenship is Rp 500.000 (IDR)

The payment should be transferred to the following

Bank Name : Bank BNI 46

Account Holder : Institut Teknologi Telkom Purwokerto

Holder Address : Jl. D.I. Panjaitan No. 128, Purwokerto

Account Number : 1282222128

2. Confirm your payment through our email on: infotel@st3telkom.ac.id by uploading the scan of the receipt of payment and put remarks for any details we need to concern, with Subject: PAYMENT-[INFOTEL_VOLUMEXX_NUMBERXX_YOURNAME]

3. Fill in the Copyright Transfer Form document and send the document along with scan of the receipt of payment. **Download Copyright Transfer Form**

We thank you a lot for your participation and again congratulate for your achievement, we are looking forward to seeing you at the next issue

Danny Kurnianto

Editor-in-Chief

infotel@st3telkom.ac.id

Best Regard,

Editor -in-Chief

JURNAL INFOTEL

Danny Kurnianto

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

Design and Implementation of Boost Voltage Doubler for Maximum Power Point Tracker Application Using STM32F1038CT

Laras Triefena[1*], Leonardus H. Pratomo[2], Slamet Riyadi[3], F. Budi Setiawan[4]
[1,2,3,4]Electrical Engineering Department Soegijapranata Catholic University
Jl. Pawiyatan Luhur IV/1, Semarang 50234, Indonesia
*corresponding email : triefenalaras@gmail.com

Received, Revised, Accepted

Abstract — Photovoltaic is an absolute device in solar power plan system. To obtaine maximum power of photovoltaic, a DC-DC converter with maximum power point tracker (MPPT) algorithm is required. In general, solar power plant application used two-stage converter : the first stage is boost DC-DC converter and the second stage is multilevel inverter. In fact, boost DC-DC converter is usually implemented singly which causes many boost DC-DC converters to be implemented in solar power plant application. Voltage doubler type boost DC-DC converter proposed in this paper is to simplify the circuit so that there is only one converter in solar power plant application. The principle of this converter is a combination of two conventional boost converter which are integrated into one, so that the power circuit and control circuit form become simpler. This proposal is verified through computation simulation and hardware design using the STM32F1038CT microcontroller for the final verification. The efficiency algorithm of the simulation is 99.7% and hardware experimental is 85.65%.

Keywords - MPPT, boost, voltage doubler, STM32F1038CT

I. INTRODUCTION

Nowadays, the usage of photovoltaic has increased in line with the increased long electrical energy. It is caused by increased human population and economic growth. Photovoltaic (PV) is a device of converting energy from sun light to electrical energy and absolutely required in the application of solar power plant. Sun rays intensity affects the photovoltaic power output which the sun rays depends on weather and climate where the photovoltaics are. To achieve maximum work of power output from photovoltaic is uses a system called maximum power point tracker (MPPT) [1], [2]. Some algorithms are often used to achive MPPT such as Ripple Correlation Control (RCC), fractional open voltage and fractional short circuit, perturbation and observation (P&O), incremental conductance (IC), proportional integral controller, fuzzy logic and neural network. From many algorithms, P&O is choosen since it is easier [3], [4].

However, photovoltaic produces the DC voltage output at low range and cannot directly support AC or DC electrical appliances [5]. Therefore, this necessitates two-stage converter [6]: the first stage is to be maximized with a converter based on algorithm MPPT in boost DC-DC converter and second is converted into AC using 5-level inverter. Fig.1 is shown an example of 5-level inverter commonly used in solar power plants application [7].

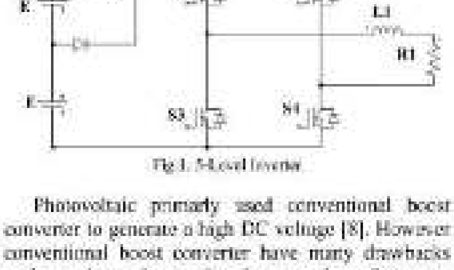


Fig 1. 5-Level Inverter

Photovoltaic primarly used conventional boost converter to generate a high DC voltage [8]. However conventional boost converter have many drawbacks such as have large size because low frequency

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

operation and conduction losses because high voltage stress on switch [9], [10]. That drawbacks make conventional boost converter to be not efficient [11], [12]. In fact, the system uses two conventional boost DC-DC converter which causes many boost DC-DC converters to be implemented in solar power plant application[13], [14], [15]. To realize an efficient step-up converter, voltage doubler technique can be applied. It can reduce the voltage stress of the rectifier diode, thus the conduction losses are greatly reduced and the converter efficiency can be improved [5]. Boost voltage doubler is suitable to operate both of power grid or battery [16] and can achieve the high range voltage output using simple frequency control [17].

Boost Voltage Doubler proposed in this paper is to replace two conventional boost DC-DC converter based on MPPT algorithm with P&O method. Photovoltaic is used power source by implementating solar power plant application. To generate maximum power, converter based on MPPT is used. Hardware implementation uses STM32F1038CT microcontroller. As first section of this research describe the operation mode of boost voltage doubler. The second section describes boost voltage doubler and its integration with MPPT. Algorithm programming will be presented in the third section. Simulation, implementation, and disscussion will presented in the forth section.

II. RESEARCH METHOD

Solar power plant uses two-stage converter which is photovoltaic maximized using a converter based on alogrithm MPPT into DC, then converted into AC as shown in Fig.2. As usual, DC-DC converter used to increase the low voltage from solar panel. In order to increase efficiency.

Research method begins with describing the working principle opf boost voltage doubler, MPPT based on P&O algorithm through flowchart program, and STM32F1038CT as a device to control boost voltage doubler using P&O algorithm method.

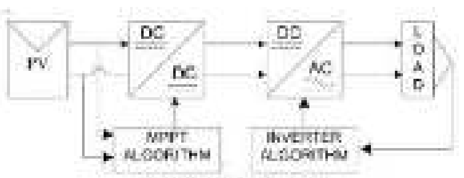


Fig.2. Two Stage Converter

A. Boost Voltage Doubler

Voltage doubler can be used for step-up voltage applications because the output voltage is double of the input voltage [18], [19]. Boost voltage doubler in principle is a combination of two boost DC-DC converter as shown in Fig.3. The equivalent circuit of boost voltage doubler is consist of a resistor (R) as a load, a source voltage (V_{PV}), two switches (S1 and S2), two inductors (L1 and L2), and two capacitors (C1 and C2).

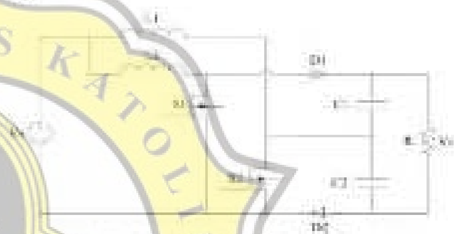


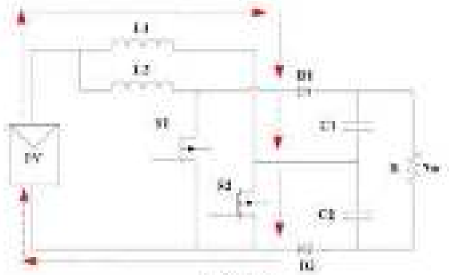
Fig.3. Topology Boost Voltage Doubler

Boost voltage doubler can be divided into four operation modes based on switching cycle.

Operation Mode 1: Power switches S2 as shown in Fig.4(a) and S1 Fig.4(b) are set to ON state. So that, current flows from voltage source V_{PV} and the energy stored in L1 and L2 respectively. The inductor voltage for L1 and L2 can be expressed as

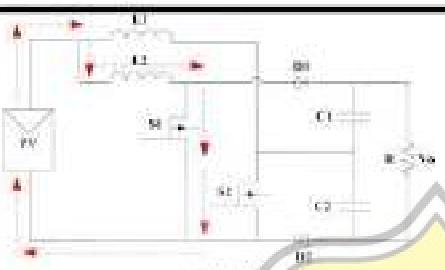
$$V_{L1} = L\frac{di_{L1}}{dt} = V_{PV} \quad (1)$$

$$V_{L2} = L\frac{di_{L2}}{dt} = V_{PV} \quad (2)$$



(a) S2 ON

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997



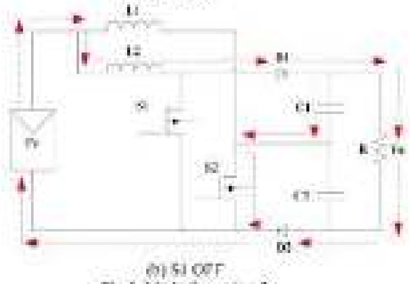
(b) S1 ON
Fig.4. Mode Operation 1

Operation Mode 2: As shown in Fig. 5, power switches S2 Fig.5(a) is set to ON state. So that, current flows from voltage source Vs to L1. Meanwhile, S1 Fig.5(b) is in the OFF state, so current flows voltage source Vs to L2 through D1 and R, then back to source voltage through D2. The inductor voltage for L1 and L2 can be express as

$$V_{L1} = L\frac{di_{L1}}{dt} = V_{PV} \quad (3)$$

$$V_{L2} = L\frac{di_{L2}}{dt} = V_{PV} - V_{C1} \quad (4)$$

(a) S2 ON

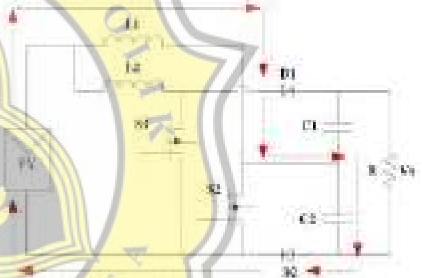


(b) S1 OFF
Fig.5. Mode Operation 2

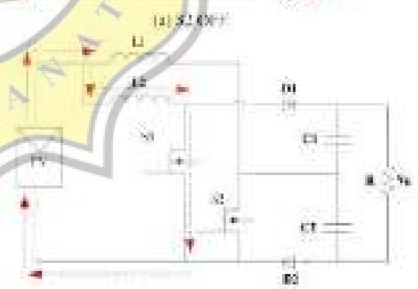
Operation Mode 3: Power switches S2 as shown in Fig.6(a) is set to OFF state. Meanwhile an S Fig.6(b) is set to ON state. The inductor voltage for L1 and L2 can be expressed as

$$V_{L1} = L\frac{di_{L1}}{dt} = V_{PV} - V_{C2} \quad (5)$$

$$V_{L2} = L\frac{di_{L1}}{dt} = V_{PV} \quad (6)$$



(a) S2 OFF



(b) S1 ON
Fig.6. Mode Operation 3

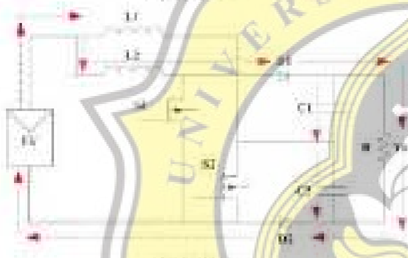
Operation Mode 4: Power switches S2 as shown in Fig.7(a) and S1 Fig.7(b) are set to OFF state. So that, current flows from voltage source (Vs) to load R through L1 and L2, then back to Vs through D1 and D2. The inductor voltage for L1 and L2 can be expressed as

$$V_{L1} = L\frac{di_{L1}}{dt} = V_{PV} - V_{C2} \quad (7)$$

$$V_{L2} = L\frac{di_{L2}}{dt} = V_{PV} - V_{C1} \quad (8)$$

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

(a) S2 OFF



b) S1 OFF

Fig 7. Mode Operation 4

B. Maximum Power Point Tracker

Photovoltaic is used to convert sun rays energy into electrical based on semiconductor principle. Whenever the intensity of sun rays increases, the power output from the cell will increase too. As shown in Fig.8, photovoltaic works by using the maximum performance from the power output cells which stated at maximum point. Besides the sun rays intensity and weather condition, load factor connected on cells also affects the maximum power point.

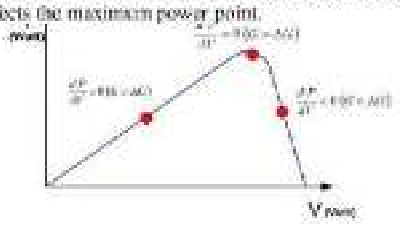


Fig.8. PV Characteristic Curve (P to V)

Perturb and observe (P&O) method as MPPT works based on observation of the array of power output and on the perturbation of the power based on increments of the array current or voltage. [20]. The reference voltage or current will be continuously decrements or increments based on the previous power sample value. P&O method is the simplest for its simplicity to implement with low cost [21].

$\frac{dP}{dt}$ is a change in power per minute, $\frac{dV}{dt}$ is a change voltage per minute. Based on Fig.8, it can be seen that $\frac{dP}{dt}$ is equal $\frac{dV}{dt}$ so the equation as below could be achieved. Therefore maximum power point would be achieve.

$$\frac{dP}{dV}=0 \tag{9}$$

Based on Fig.9, boost voltage doubler as a converter will be integrated with photovoltaic, which uses MPPT algorithm is the proposed of this research.

Fig 9. Topology MPPT Boost Voltage Doubler

C. Algorithm Programming using STM32F1038CT

The boost voltage doubler with P&O MPPT algorithm requires one current sensor and voltage sensor, see Fig.9. Power is generated from multiplication of current (I) and voltage (V). Delay time used to obtained ($\frac{dP}{dt}$)on power and voltage ($\frac{dV}{dt}$). After getting ($\frac{dP}{dt}$) and ($\frac{dV}{dt}$), the equation (9) could be derived. The algorithm of $\frac{dP}{dV}$ value should be compared with the counter to have switching gating signal for S1 and S2. Counter are assumed to be operator. For detail information, the boost voltage doubler with P&O MPPT algorithm flowchart is shown in Fig.10. The algorithm Fig.10 is implemented using a STM32F1038CT microcontroller.

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

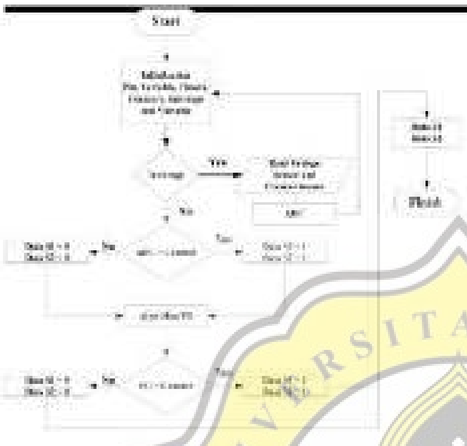


Fig.10. Flowchart Program

III. RESULT

The boost voltage doubler integrated with MPPT was verified by a computation simulation using Power Simulator (PSIM) software and prototype in laboratory test. The parameters are given in Table 1.

Table 1. Simulation Parameter

Parameters	Rating
PV	60 WP
Inductor	3 mH
Capacitor	220 uF
Battery	48 V

The simulation result of power output (Po) of the proposed MPPT boost voltage doubler is always tracking on maximum power (Pi) using photovoltaic 60 WP as shown in Fig.11. It meansPo on MPPT is always follow power output on PV (Pi). Moreover, the simulation result of output voltage formes the DC voltage which is locked at battery voltage as shown in Fig.12. It means the battery was able to be charged at 48 Volt.

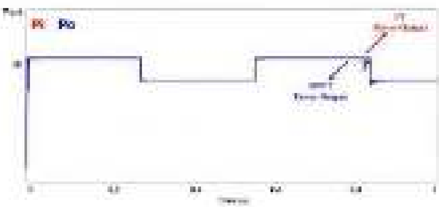


Fig.11. Output Power of PV and MPPT

Fig.12. Output Voltage of PV and MPPT

Based on computation simulation result and waveform as shown in Fig.11, Pi get value 5.4418929e+001 and Po get vaiaue 5.4303644e+001. From the value of Pi and Po, algorithm efficiency is 99.7% and power converter algoritium is on ideal condition 100%. The efficiency is derived by the equation:

$$\eta = \frac{Po}{Pi} \times 100\% \qquad (10)$$

Where:
η = Efficiency
Po = Power Output (Watt)
Pi = Power Input (Watt)

Hardware implementation was done to ensure the system worked properly using STM32F103BCT microcontroller. MPPT boost voltage doubler as shown in Fig.13 is a implementation which uses battery charger.

Fig.13. Implementation of MPPT Boost Voltage Doubler

On testing the boost voltage doubler hardware integrated with MPPT, the EverExceed PV 50 WP is used as a test material in the laboratory. The experimental result is shown in Table 2 it is found that converter and algorithm efficiency value. It start from power input on PV (P_{in}) is obtained by irradiance divided by 1000 W/m² which 1000W/m² is assume maximum irradiance as shown in equation (11). Then

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

power nameplate is maximum power on PV in standar tes condition (STC). Power nameplate is displayed 50WP based data on PV.

$$P_{in,PV} = \frac{Irr}{1000^{W/m2}} \times Power\ Nameplate \quad (11)$$

Where:
$P_{in,PV}$ = Power Input on PV (Watt)
Irr = Irradiance (W/m²)

Table 2. Experimental Result

I_{rr} (W/m²)	$P_{in,PV}$ (W)	V_{pv} (V)	I_{pv} (A)	$P_{o,pv}$ (W)	V_{bat} (V)	I_{bat} (A)	P_{bat} (W)
545	27.25	[illegible]	1.[illegible]1	23.[illegible]9	44.15	0.41	18.2[illegible]
540	27.00	16.[illegible]9	1.[illegible]1	2[illegible].13	44.1	0.41	18.[illegible]
535	26.75	15.[illegible]7	1.6[illegible]	22.77	44.1[illegible]	0.41	18.09
530	26.50	15.[illegible]	1.52	23.[illegible]0	44.0[illegible]	0.42	18.52
565	28.25	15.01	1.5[illegible]	24.03	44.1[illegible]	0.39	17.[illegible]
575	28.75	16.1[illegible]	1.5[illegible]	24.21	44.21	0.38	16.9[illegible]
550	27.50	14.[illegible]	1.5[illegible]	24.[illegible]	44.[illegible]5	0.[illegible]	17.66
555	27.75	14.0[illegible]	1.52	24.19	44.1[illegible]	0.41	18.1[illegible]
570	28.50	15.1[illegible]	1.6[illegible]	24.[illegible]5	44.[illegible]9	0.3[illegible]	16.8[illegible]
560	28.00	14.95	1.[illegible]1	24.07	44.19	0.39	17.25
average	27.63			23.66			17.66
efficiency				85.65			74.64

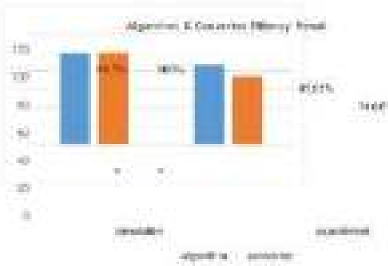


Fig.14. Efficiency Graphic

Based on experimental data as shown in Table 2 it is found that the average power input on PV input ($P_{in,PV}$) is 27.73, power output on PV ($P_{o,PV}$) is 23.66, and power output on battery (P_{bat}) is 17.66. Finally, based on equation (10), the efficiency algorithm is 85.65% and the converter of boost voltage doubler efficiency is 74.64%. Fig.14 shows the comparison efficiency between simulation and hardware implementation in laboratory test.

IV. DISCUSSION

The principle boost voltage doubler converter combines two conventional boost DC-DC converter. To maximize the power of PV, P&O algorithm is integrated with a boost voltage double converter. Based on the simulation result using PSIM software in ideal condition, the algorithm efficiency is 99.7% and converter efficiency is 100%. Therefore, the hardware implementation has an efficiency of algorithm is 85.65% and the converter efficiency is 74.64%. It was caused at simulation, the irradiance was 1000 W/m². Meanwhile at the hardware implementation, the irradiance not at the maximum point due to it is influenced by several other factor such as wire, inductor, sun rays intensity from the photovoltaic, weather and climate conditions, and load shedding [22].

Based on tested result, boost voltage doubler circuit was able to produce two times the voltage of the conventional boost DC-DC converter. Therefore, boost voltage doubler that has been researched can used to replaced the conventional boost DC-DC converter at the solar power plant application. Moreover, it is more efficient in term of circuit, algorithm, and cost. Finally, the future researches would implement boost voltage doubler integrated with MPPT algorithm combine a five level inverter for standalone PV application and/or grid tie inverter for PV application.

V. CONCLUSION

In the experimental laboratory results, it is proven that voltage doubler can work properly. It shown that the output voltage (V_{bat}) is capable of producing double voltage from input voltage. Thus, the voltage doubler can replace the conventional boost DC-DC converter which needed many boost to implemented in solar power plant application. The MPPT boost voltage doubler was generated maximum power which is PV power always tracking on MPPT power with algorithm efficiency 99.7%. Moreover, the hardware implementation using STM32F1038CT microcontroller worked properly with algorithm efficiency 85.65% and converter efficiency 74.64%.

ACKNOWLEDGMENT

Thanks to The Directorate General of Higher Education Ministry of National Education Indonesia

JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

(Dirjen DIKTI) 2020 Number: 010/ LL6/PG/SP2H.1/ AMD/PENELITIAN/2020 for funding.

REFERENCES

[1] L. Guo, A. Brewer, and B. Spaiser, "Design and implementation of a solar battery charger," *ASEE Annu. Conf. Expo. Conf. Proc.*, no. V, pp. 324–327, 2010.

[2] F. Y. Setiono and L. H. Pratomo, "Maximum power point tracker in regulated voltage supply using ripple correlation control," *Proc. 2011 Int. Conf. Electr. Eng. Informatics, ICEEI 2011*, no. July, 2011.

[3] S. Riyadi, "dsPIC33 Based Control for PV-Grid System with a Buck-Boost MPPT," TELKOMNIKA vol.12, no.7, pp.5137-5143, Jul.2014

[4] S. Qin, M. Wang, T. Chen, and X. Yao, "Comparative analysis of incremental conductance and perturb-and-observation methods to implement MPPT in photovoltaic system," *2011 Int. Conf. Electr. Control Eng. ICECE 2011 - Proc.*, pp. 5792–5795, 2011.

[5] C. Lin and F. Huang, "A Novel Voltage Doubler Rectifier for High Output Voltage Applications," pp. 2082–2086, 2010.

[6] I. Sakov, "Two-stage PV Converter Power Production Management During Grid Disturbances," *2019 Int. Conf. Smart Energy Syst. Technol.*, pp. 1–6, 2019.

[7] C. Series, "Design and simulation the carrier strategy in single-phase five-level inverter Design and simulation the control strategy in single-phase five-level inverter," 2020.

[8] S. Kumar, S. S. Member, A. H. Senior, and M. Ieee, "Performance Evaluation of MPPT Using Boost Converters for Solar PhotoVoltaic System," no. 1, 2015.

[9] V. H. Savakhande, "Coupled Inductor and Voltage Doubler Based Boost Converter for High Step-up Application," *2018 Int. Conf. Control. Power. Commun. Comput. Technol.*, pp. 464–468, 2018.

[10] H. Wang, S. Member, S. Dusmez, S. Member, A. Khaligh, and S. Member, "A Novel Approach to Design EV Battery Chargers Using SEPIC PFC Stage and Optimal Operating Point Tracking Technique for LLC Converter," 2014.

[11] J. Fu, B. Zhang, D. Qiu, and W. Xiao, "A Novel Single Switch Cascaded DC-DC Converter of Boost and Buck-Boost Converters Keywords,"

[12] V. A. K. Prabhala, P. Fajri, V. S. P. Gouribhatla, and B. P. Baddipadiga, "A Dc-Dc Converter with High Voltage Gain and Two Input Boost Stages," vol. 8993, no. c, 2015.

[13] B. Zhao, A. Abramovitz, C. Liu, Y. Yang, and Y. Huangfu, "A Family of Single-Stage, Buck-Boost Inverters for Photovoltaic Applications for Photovoltaic Applications," *Energies, MDPI*, vol. 13, pp. 1–21, 2020.

[14] F. Reza Mohammad Rizki, S. Riyadi, and L. Hery Pratomo, "A SPWM Controlled Input in Dual Buck DC-DC Converter - Full Bridge for Single-Phase Five-Level Inverter," *J. Phys. Conf. Ser.*, vol. 1444, no. 1, 2020.

[15] E. Kumari, R. K. Kothari, and S. Banerjee, "Design and implementation of photovoltaic module using multilevel inverter and boost converter," *Int. Res. J. Eng. Technol.*, vol. 4, no. 11, pp. 1064–1068, 2017.

[16] A. S. Martins, C. Flores, and A. T. B. R, "DC-DC AND AC-DC VOLTAGE DOUBLER BOOST CONVERTER FOR UPS APPLICATIONS," pp. 601–606, 2011.

[17] M. I. Shahzad, S. Iqbal, S. Member, and S. Taib, "Interleaved LLC Converter with Cascaded Voltage Doubler Rectifiers for Deeply Depleted PEV Battery Charging," vol. 14300, no. c, 2017.

[18] Y. Zhao, S. M. Ieee, X. Xiang, W. Li, M. Ieee, and X. He, "Advanced Symmetrical Voltage Quadrupler Rectifiers for High Step-Up and High Output-Voltage Converters," no. c, 2011.

[19] B. J. Huang, "Interleaved Voltage-Doubler Boost Converter for Power Factor Correction," *2018 Int. Power Electron. Conf. IPEC-Niigata - ECCE Asia 2018*, pp. 3528–3532, 2018.

[20] H. Bounechba, K. Nabti, A. Bouzid, and H. Benalla, "Modeling and Simulation of Perturb and Observe MPPT Algorithm for PV systems," no. December, 2013.

[21] F. Lei, Y. Li, and J. E. Seem, "Sequential ESC-Based Global MPPT Control for Photovoltaic Array With Variable Shading," vol. 2, no. 3, pp. 348–358, 2011.

[22] F. Y. Setiono and L. H. Pratomo, "Maximum power point tracker in regulated voltage supply using ripple correlation control," *Proc. 2011 Int. Conf. Electr. Eng. Informatics, ICEEI 2011*, no. July, 2011.

PLAGIARISM CHECK.ORG

3.94% PLAGIARISM APPROXIMATELY

Report #11776788

BAB IPENDAHULUAN Latar BelakangPenggunaan photovoltaic pada hari-hari ini bertambah seiring dengan kebutuhan energi yang bertambah. Hal ini disebabkan oleh pertambahan populasi manusia dan pertumbuhan disektor ekonomi [1]. Photovoltaic (PV) adalah alat pengkonversi energi dari energi sinar matahari menjadi energi listrik yang dibutuhkan untuk aplikasi Pembangkit Listrik Tenaga Surya (PLTS) [2]. Intensitas cahaya matahari mempengaruhi daya keluaran pada PV yang mana cahaya matahari tergantung pada musim dan cuaca dimana PV tersebut berada [3]. Untuk mencapai kerja maksimal dari daya keluaran PV digunakan sistem yang disebut maximum power point tracker (MPPT) [4]. Beberapa algoritma yang sering digunakan untuk mencapai titik maksimal antara lain Ripple Correlation Control (RCC), fractional open voltage dan fractional short circuit, pertubation dan obeservation (P&O), incremental conductance (IC), proportional integral controller, fuzzy logic dan neural network [5]. Dari sekian algoritma, P&O dipilih utuk dipergunkan karena memiliki efisiensi yang baik dan mudah diterapkan [6]. Pada aplikasi PLTS, photovoltaic yang digunakan hanya menghasilkan tegangan keluaran DC yang rendah dan tidak dapat secara langsung digunakan untuk mendukung peralatan listrik AC ataupun DC [7]. Lazimnya menggunakan dua buah tahap konversi [8] bagian pertama DC-DC