ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika

ISSN(p): 2338-8323 | ISSN(e): 2459-9638 | Vol. 13 | No. 3 | Halaman 286 – 299
DOI : http://dx.doi.org/10.26760/elkomika.v13i3.286 Juli 2025

Design and Implementation of Cuk H-Bridge Inverter Voltage Control using STM32F407VET6

Article History:
Received
03 March 2025
Revised
03 June 2025
Accepted
19 June 2025

GIOVANI CHRISANTUS ANGGORO, LEONARDUS HERU PRATOMO

Electrical Engineering, Soegijapranata Catholic University, Indonesia
Email : giovanianggoro25@gmail.com

ABSTRAK

Perkembangan energi terbarukan dengan memanfaatkan perangkat konversi daya listrik berkembang pesat. Konversi daya listrik berupa inverter bekerja dengan mengubah DC menjadi AC. Lazimnya inverter bekerja sebagai penurun tegangan, namun pada kondisi tertentu bekerja sebagai penaik tegangan dengan jangkauan operasi terbatas. Mengatasi permasalahan yang terjadi diimplementasikan inverter dengan converter penaik dan penurun tegangan pada satu rangkaian yang sama. Pada penelitian ini telah diinvestigasi penggabungan inverter dengan Cuk Converter sehingga menjadi Cuk H-Bridge Inverter dengan pengendalian penaik dan penurun tegangan. Cuk H-Bridge Inverter mengimplementasikan delapan buah saklar daya dengan menggabungkan H-Bridge Inverter dan Cuk Converter. Sensor tegangan LV25-P mendeteksi tegangan keluaran yang konstan dengan kendali propotional intergral menggunakan mikrokontroller STM32F407VET6. Uji laboratorium menggunakan peralatan sesuai standar. Total Harmonic Distortion (THD) yang dihasilkan pada pengujian memenuhi standar IEEE 519 sebesar 4,1%.

***Kata kunci**: H-Bridge Inverter, Cuk Converter, Tegangan Terkendali, THD*

ABSTRACT

The development of renewable energy utilizing electrical power conversion devices is growing rapidly. Electrical power conversion in an inverter works by converting DC into AC. Typically, the inverter works as a voltage reducer, but under certain conditions, it works as a voltage booster with a limited operating range. To overcome the problems, an inverter with a voltage-increasing and decreasing converter is implemented in the same circuit. This research has investigated the combination of an inverter with a Cuk Converter so that it becomes a Cuk H-Bridge Inverter with voltage boosting and reducing control. The Cuk H-Bridege Inverter implements eight power switches by combining the H-Bridge Inverter and Cuk Converter. LV25-P voltage sensor detects constant output voltage with integral proportional control using STM32F407VET6 microcontroller. The laboratory uses equipment according to the standard. A Total Harmonic Distortion (THD) generated in the test meets the IEEE 519 standard of 4.1%.

***Keywords**: H-Bridge Inverter, Cuk Converter, Voltage Control, THD*

1. INTRODUCTION

The development of modern times and the increasing need for energy, along with the increase in population, and the existence of problems in the commercial, industrial, and office sectors **(Güney, 2019)** make electrical energy an important thing in life. Conventional energy sources such as coal and oil become sources of electrical energy. As time goes by, these conventional fuels will run out **(Mostafaeipour et al., 2022)**. Environmentally friendly renewable energy sources can be found in energy sources such as wind, water, and solar **(Elum & Momodu, 2017)**. Renewable energy is a solution to meet sustainable development **(Østergaard et al., 2022),** dealing with environmental issues and solving non-renewable energy problems **(Pratomo & Christiawan, 2023)**. Solar energy is an energy source often used to produce electrical energy using Photovoltaic (PV). Solar energy utilization is more widely used because its availability will not run out **(Purwoto et al., 2018)**. PV modules have a Maximum Power Point (MPP) to adjust solar radiation, temperature, cell area on the PV module, and its load **(Bendib et al., 2015)**. PV requires additional devices to maximize its operation, such as a converter **(Gong & Zhao, 2023)**. The output voltage of PV is in the form of Direct Current (DC), so a converter is needed to convert it to Alternating Current (AC) according to general needs.

The Cuk Converter is one of the voltage-boosting and reducing converters that provides higher efficiency than a Conventional non-isolated DC-DC Converter. **(Mahdizadeh et al., 2022)**. The Cuk converter is a conventional DC-DC converter without isolating the input voltage on the load side as a sustainable solution to solve the PV system problem **(Maroti et al., 2017)**. Cuk converters typically use two active power switches, two inductor (L) and two capacitor (C) filters. The utilization of LCL filters reduces noise at high frequencies and minimizes current ripple better than traditional LC filters **(Şehirli, 2022)**. Cuk converters are used because they have advantages, such as having an energy transfer capacitor, good steady-state performance, continuous input and output current, and low output voltage ripple **(Almalaq & Matin, 2018)**. Cuk converters also have low switching losses and high efficiency **(Wibisono et al., 2022)**. Cuk converters typically use the Continuous Condition Mode (CCM) switching method to produce Pulse Width Modulation (PWM) signals with the same duty cycle and the current in the converter does not reach zero **(Anand & Singh, 2019; Trilaksono et al., 2015)**. Utilization of the Cuk converter is used to maximize the output and efficiency of Maximum Power Point Tracking (MPPT) **(Pratomo et al., 2024)**. H-Bridge Inverter becomes a conventional power conversion device by converting DC to AC voltage. H-Brigde Inverter is controlled with one leg, which was successfully researched by **(Hasan et al., 2016)**, with the Voltage Source Inverter (VSI) method and produces reasonable output. H-Bridge inverter into DC-AC converter with Sinusoidal Pulse Width Modulation (SPWM) switching method **(Rizki et al., 2020)**. H-Bridge with voltage control type produces better power quality with Total Harmonic Distortion **(Siahaan et al., 2020)** by IEEE Std 512-2014 standards. AC-AC Converter is a voltage amplitude converter topology that has been developed and researched. General Cuk Converter topology has advantages however, the Cuk converter topology will be developed further in this research. Modifying four power switches will produce better power output. This study aims to develop the inverter topology and Cuk Converter to produce a new type of inverter. The combination of the H-Bridge Inverter and the Cuk Converter produces a topology that is the Cuk H-Bridge Inverter. This type of inverter can operate in the broader range. This topology uses eight switches consisting of four on the H-Bridge Inverter and four on the AC-AC Cuk.

A new inverter topology based on an H-Bridge inverter with a Cuk AC-AC converter is derived based on the operation mode to obtain a new control structure. H-Bridge Inverter and Cuk

AC-AC Converter result in a new topology with voltage-controlled voltage source operation. The new inverter topology, operation mode, and control strategy will be further discussed in section 2, and simulation results, computation, laboratory hardware testing, and analysis will be further described in section 3. The results of the work based on simulation results and hardware implementation will be discussed in the conclusion section.

2. METHODS

This research method describes a power circuit of the H-Bridge Inverter and Cuk AC-AC Converter, a proportional integral-based control concept, a voltage sensor, and an overall system block diagram to support the verification that will be done by computational simulation and prototype implementation.

2.1 Schematic of the circuit

Figure 1 shows the H-Bridge Inverter power circuit using four power switches (S1-S4). the source voltage V_{DC}, on the output side in the form V_{AC} is connected through V_{AB} to the Cuk AC-AC Converter circuit shown in Figure 2.

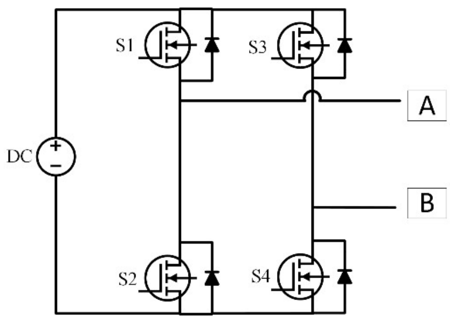


Figure 1. H-Bridge Inverter

The working principle of the H-Bridge Inverter is described in three operating modes: positive cycle, freewheeling, and negative cycle. In the positive cycle, operation modes S1 and S3 will be active so that the current flows from the V_{DC} source to inductor L1 and load, and then through the power switch S3, the output voltage is positive, as indicated.

$$V_{DC} = V_L + V_{out}$$

$$V_{DC} = L\frac{di_L}{dt} + V_{out}$$

$$L\frac{di_L}{dt} = V_{DC} - V_{out}$$

$$L\Delta i_L = (V_{DC} - V_{out})\Delta t = (V_{DC} - V_{out})t_{on} \quad (1)$$

Negative cycle operation mode, where the power switches (S2-S4) are active, so that the current from the V_{DC} source will go to the load through S2 and back through S4 to the source is shown below.

$$-V_{DC} = V_L + V_{out}$$

$$-V_{DC} = L\frac{di_L}{dt} + V_{out}$$

$$L\frac{di_L}{dt} = V_{out} - V_{DC}$$

$$L\Delta i_L = (V_{out} - V_{DC})\Delta t = (V_{out} - V_{DC})t_{on} \quad (2)$$

Freewheeling transpires when filter L in the circuit sustains electric current as a magnetic field. During the positive cycle, S3 activates and conducts current from filter L to the load, then returning via diode S4 to filter L. The process mirrors that of the negative cycle, whereby current traverses the diode via power switch S1 and returns to filter L via power switch S2, culminating in the consequent equation.

$$V_L = V_{Out}$$

$$L\frac{di_L}{dt} = V_{out} \quad (3)$$

Equations (1) and (2) provide the general equation for the inverter output voltage, as shown below.

$$V_{out} = m.V_{DC} \quad (4)$$

m is the modulation index, its magnitude is $0 \leq m \leq 1$.

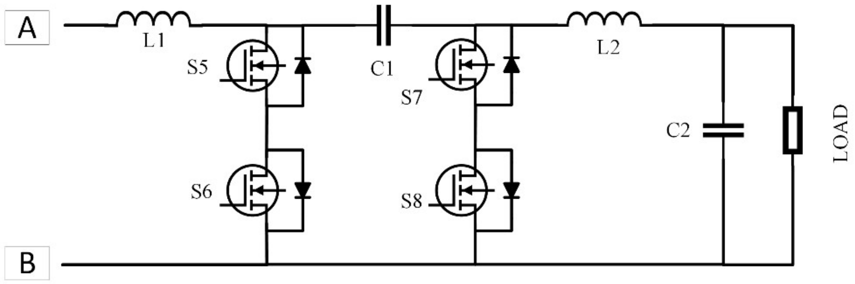


Figure 2. Cuk AC-AC Converter

Figure 2 is a power circuit Cuk AC-AC Converter using four power switches (S5-S8) connected through points A and B as V_{AC}. Two inductors (L1-L2) are used as storage and filter and capacitors (C1-C2) are used as storage and filter. The switch-on time of S5 and S6 is DT_s, in one switching cycle T_s is the switching time D is *Duty Cycle*, while the switch-on time of S7 and S8 is $(1 - D)T_s$. Cuk AC-AC Converter with operation modes (S5-S8) is expressed by equation (5).

$$\Delta I_{L1} = \frac{1}{L1}\int_0^{DT_s} V_{L1}\,dt = \frac{V_i}{L_1}DT_s \quad (5)$$

The input voltage V_i as V_{AC} will charge the voltage on inductor L1 so that $V_{L1} = V_i$ and the current in ΔI_{L1} on L1 is shown in equation (5) above. At the same time, the capacitor at C1 releases voltage towards the load and is directed to the inductor L2, so the voltage L2 as $V_{L2} = V_{C1} + V_{out}$. Thus, the increase in current ΔI_{L2} is shown in the equation (6).

$$\Delta I_{L2} = \frac{1}{L2}\int_0^{DT_s} V_{L2}\,dt = \frac{V_{C1}+V_{out}}{L_2}DT_s \quad (6)$$

In the next operating mode where (S6-S7) is active, V_i and inductor L1 charge C1, so the voltage on L1 is $V'_{L1} = V_i - V_{c1}$ and the current increase $\Delta I'_{L1}$ is shown below.

$$\Delta I'_{L1} = \frac{1}{L1}\int_{DT_s}^{T_S} V'_{L1}\,dt = \frac{V_i - V_{C1}}{L_1}(1-D)T_s \quad (7)$$

At the same time, C1 applies voltage to the load and L2 charges C1, so the voltage drop at L2 is $V'_{L2} = V_{out}$ and the current increase $\Delta I'_{L2}$ is shown below.

$$\Delta I'_{L2} = \frac{1}{L2}\int_{DT_s}^{T_S} V'_{L2}\,dt = \frac{V_{out}}{L_2}(1-D)T_s \quad (8)$$

Based on the khircoff voltage law, the current increases at L1 and L2 when the commutation cycle = 0.

$$\Delta I_{L1} + \Delta I'_{L1} = 0 \quad (9)$$

$$\Delta I_{L2} + \Delta I'_{L2} = 0 \quad (10)$$

Based on the results of equations (5) to (10), it is obtained as follows.

$$V_i = (1-D)V_{C1} \quad (11)$$

$$V_{out} = -DV_{C1} \quad (12)$$

The correlation between the input voltage and the output voltage is shown as.

$$V_{out} = -\frac{D}{1-D}V_i \quad (13)$$

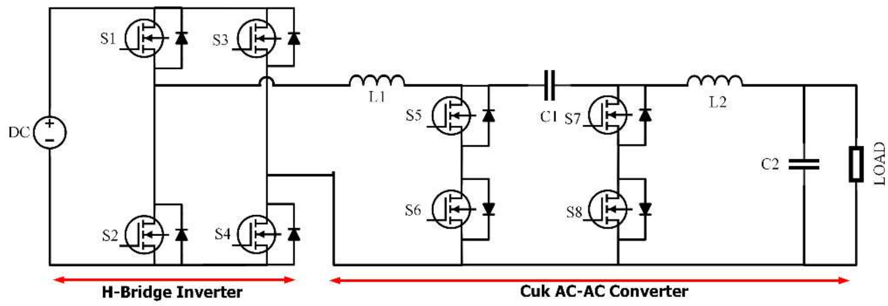


Figure 3. Cuk H-Bridge Inverter

Figure 3 illustrates the Cuk H-Bridge Inverter circuit suggested in this research. The output voltage polarity of the H-Bridge Inverter is incorporated into the Cuk AC-AC Converter via points A and B. The proposed topology is more efficient due to its broader operating range. The output voltage produced by the H-Bridge Inverter will be linked to the Cuk AC-AC Converter, which operates as a voltage step-up and step-down converter. The Cuk H-Bridge Inverter operates in two modes step-down mode and step-up mode. The amalgamation of these two topologies will provide an equation whereby, in step-down mode $V_{out} < V_{DC}$ and in step-up mode $V_{out} > V_{DC}$ as shown.

$$V_{out} = \left(\frac{\mathrm{D}}{1-\mathrm{D}}.m.V_{DC}\right) \quad (14)$$

D is the *duty cycle* of the Cuk AC-AC Converter, confined to the range $0 \le D \le 1$.

2.2 Proportional Integral Control

The research conducted uses Closed-Loop control with Proportional Integral (PI) control type. Figure 4 is a PI control block diagram in general.

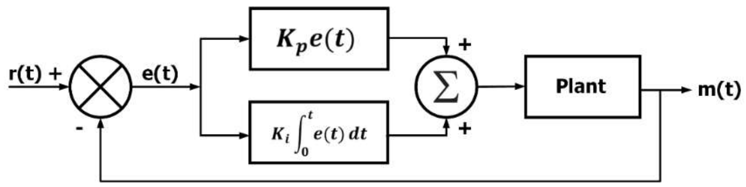


Figure 4. PI Control Block Diagram

PI control is generally a combination of Proportional and Integral control. PI control has a fast response time and low noise so that it can be a solution to the voltage control of the Cuk H-Bridge Inverter. The equation form of PI control is shown below.

$$m(t) = K_p e(t) + K_i \int_0^t e(t)\, dt \tag{15}$$

K_p is the value of the proportional gain, K_i is the value of the integral gain and $m(t)$ is the output value of the hardware, namely V_{act}. The determination K_p and K_i values are determined by trial-and-error testing until the appropriate value is found. $e(t)$ s the value of the system error, the difference in value between the reference value $r(t)$ and the value of $m(t)$.

$$e(t) = r(t) - m(t) \tag{16}$$

2.3 LV-25P Voltage Sensor

This section will discuss the voltage control strategy of the proposed new topology. The Cuk H-Bridge Inverter topology generates an output voltage controlled using a Proportional Intergral (PI). The purpose of controlling the output voltage is to ensure that it remains stable despite load changes. This section utilises a voltage sensor in the form of LV-25P to read V_{act} which will be scaled to the ADC value (V_{ADC}) and processed by the STM32F407VET6 microcontroller. The LV-25P voltage sensor is more commonly used because it is highly efficient and accurate in closed-loop control.

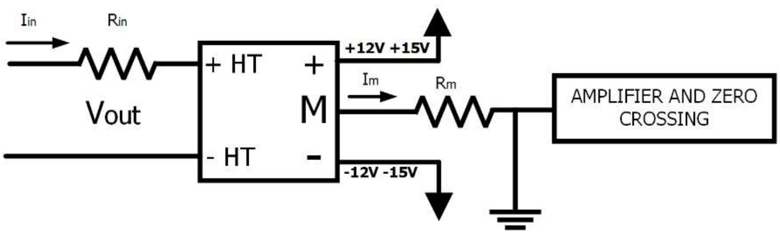


Figure 5. Schematic of LV-25P Voltage Sensor

Figure 5 is a schematic of the LV-25P voltage sensor based on the datasheet. On the primary side, there are '+ HT' and '- HT' connected from V_{out}. On the secondary side, there is a $12 - 15\,V$ power supply and Measure (M), which produces V_{act}. V_{act} can be set up $20\,V_{AC}$ On the datasheet, the inlet current I_{in} is $10\,mA$.

$$R_{in} \geq \frac{V_{out}}{I_{in}} = \frac{20}{10mA} = 2k\Omega \tag{17}$$

Then R_{in} is used as $2k\Omega\ 3W$. In the M section, there is R_m, whose value adjusts the input V_{ADC}, which is $3.3\ V$. The LV-25P voltage sensor also has a conversion ratio of 2500: 1000 based on the datasheet, which is the ratio of the secondary RMS current I_m to I_{in}. if, $I_{in}\ 10\ mA$ then the value I_m is $25\ mA$ with a V_{ADC} value of $3.3V$, so the value of R_m is determined by equation (18).

$$R_m \geq \frac{V_{ADC}}{I_m} = \frac{3.3V}{25mA} = 132\Omega \quad (18)$$

2.4 Voltage Control Strategy

Figure 6 shows a schematic of voltage control on the Cuk H-Bridge Inverter. The control process starts from V_{out} and is then entered into the sensor in the form of V_{act} and compared to V_{ref} to produce an error value $e(t)$. The PI algorithm control process produces a switching signal in SPWM and PWM. Zero Crossing SPWM signal as a switch control (S1-S4) on the H-Bridge Inverter. To produce an SPWM signal requires a triangular wave with a frequency of 10 kHz so that the phase shift is 180 ° for the positive and negative cycles.

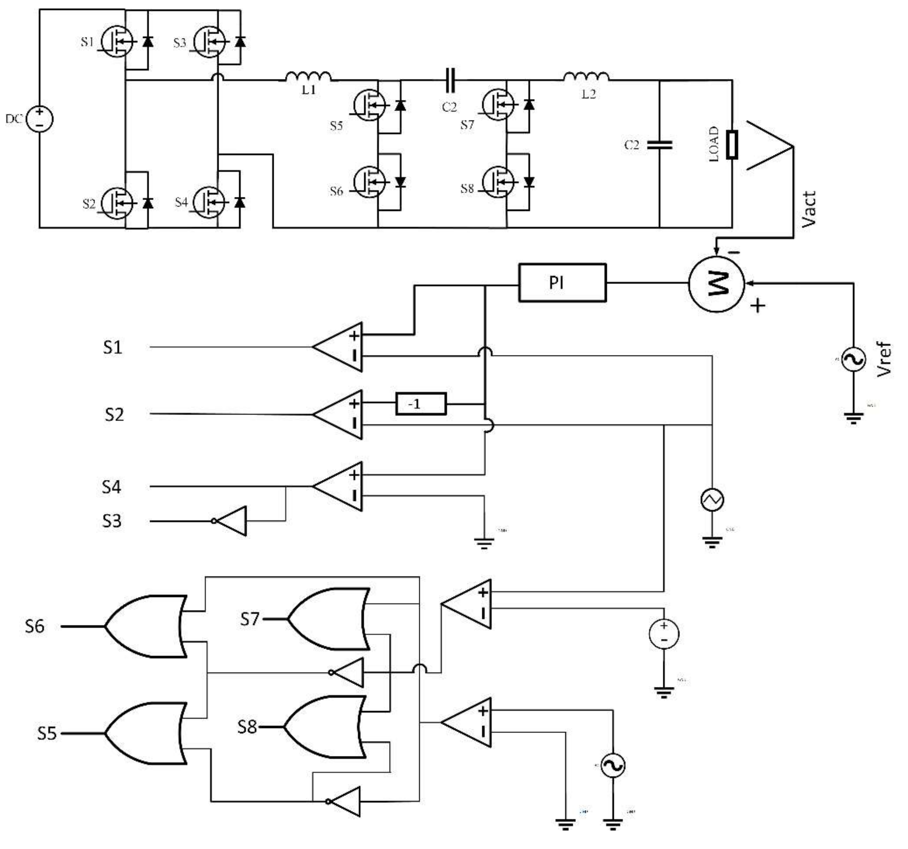


Figure 6. H-Bridge Inverter Cuk Voltage Control Strategy

The switching (S5-S8) on the AC-AC Cuk uses the high-frequency PWM method of reverse switching so that switching on the positive and negative cycles does not occur simultaneously.

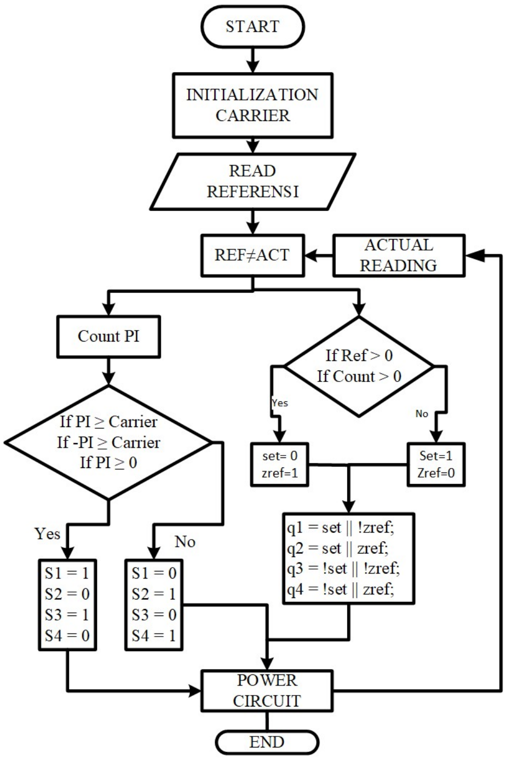


Figure 7. Flowchart of Programming Algorithm

A programming algorithm is proposed to simplify the control process, as shown in Figure 7. Figure 7 shows a programming algorithm, while the Cuk H-Bridge Inverter serves as a control in Figure 6.

3. RESULTS AND DISCUSSION

The new topology, in the form of a Cuk H-Bridge Inverter, has been tested in the laboratory to verify the simulation results and analyses in the Power Simulator software (PSIM). Table 1 displays the component value parameters implemented in the hardware. The component's value is intended for testing the Cuk H-Bridge Inverter in the laboratory.

Table 1. Hardware Implementation Parameters

Parameters	Value
DC Input	10 Volt DC
Capacitor non-polar (1)	10 uF
Capacitor non-polar (2)	100 uF
Inductor 1	2 mH
Inductor 2	0.2 mH
Load	50-100 Ω
Gain Proportional	14
Gain Integral	0.0005
Frequencies	10KHz

In the simulation tests, several changes in component values were made to recognize the characteristics of the proposed new topology.

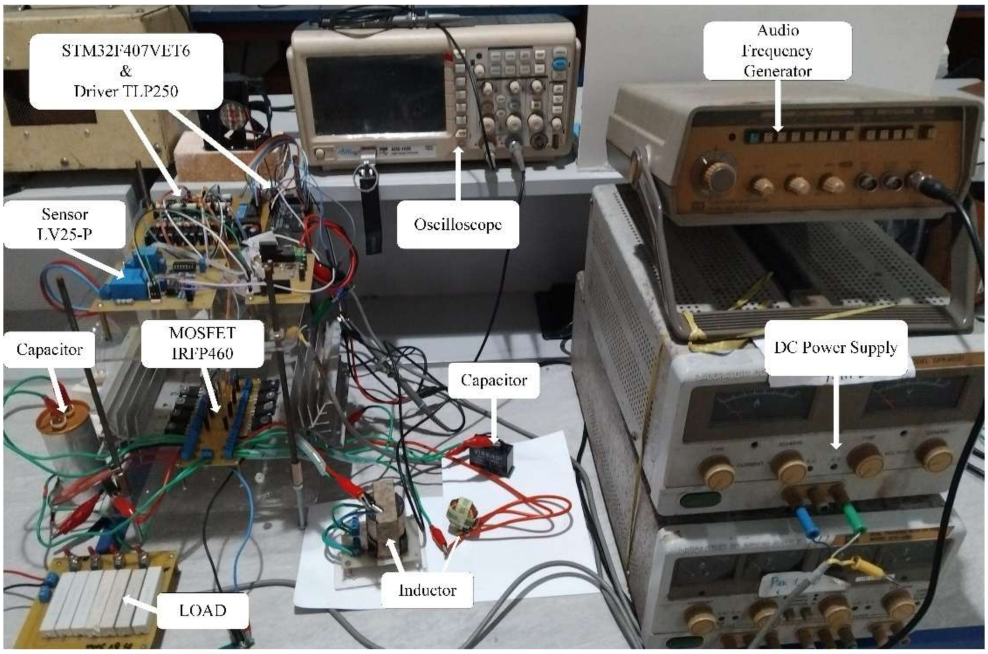
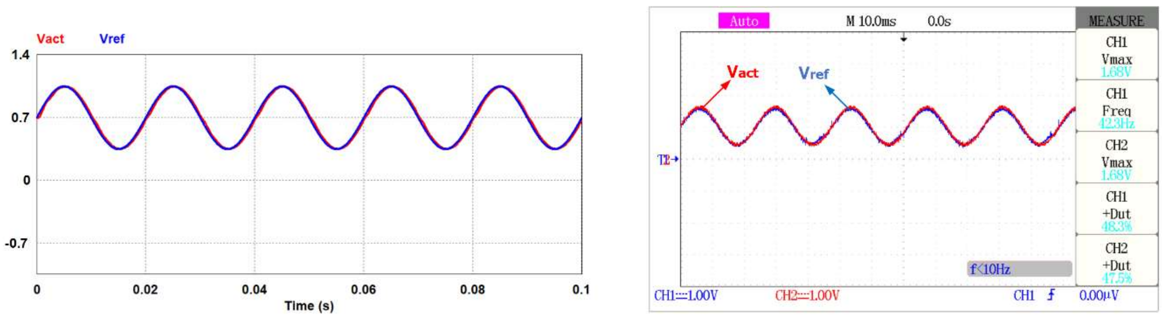


Figure 8. Implementation of Cuk H-Bridge Inverter Topology

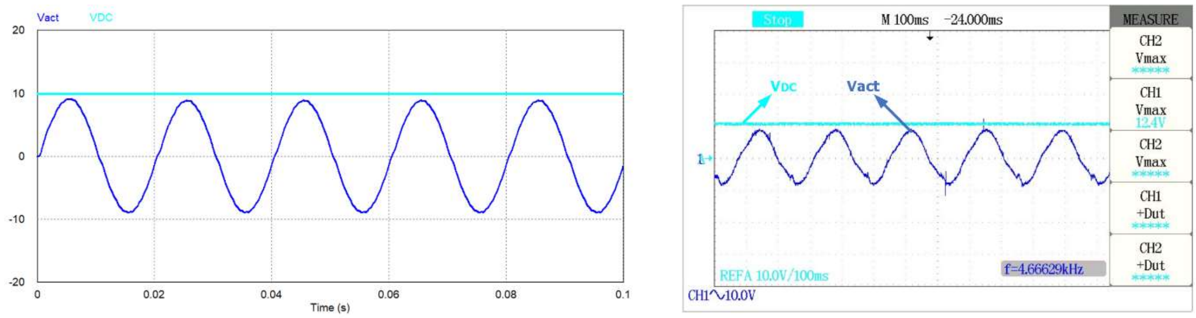
Figure 8 shows the hardware implementation of the proposed topology with laboratory tests. The tests were conducted according to the parameter values in Table 1, supported by additional devices such as an oscilloscope, variable and regulated DC power supply, audio frequency generator as variable V_{ref}, voltage sensor as feedback for STM32F407VET6 microcontroller, driver for MOSFET, and resistive load.



(a) **(b)**

Figure 9. Comparison of V_{act} and V_{ref} Sinusoidal Waves: (a) Simulation; (b) Oscilloscope

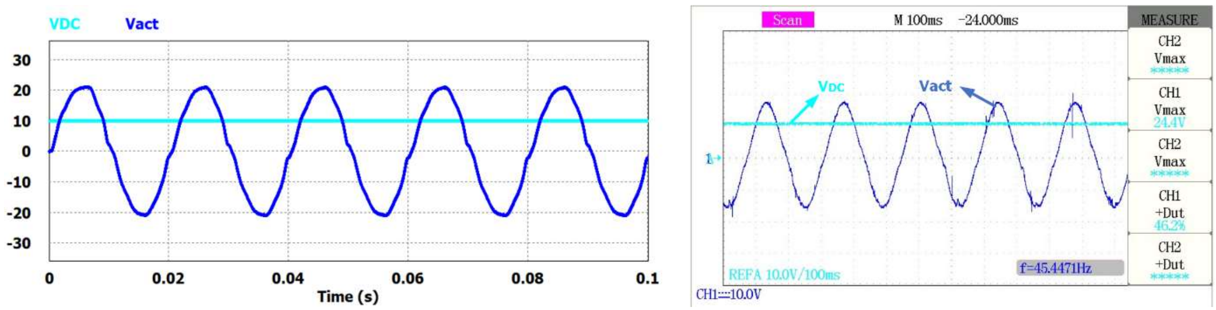
Figure 9 shows the output results with a sinusoidal test signal, ensuring that V_{act} (red) always follows V_{ref} (blue) by adjusting the gain and offset on the LV-25P. Figure 9 (a) tests using PSIM computational simulation, while Figure 9 (b) shows measurement results with an oscilloscope on the hardware.



(a) **(b)**

Figure 10. V_{DC} and V_{act} Measurements of Voltage Step-down Mode (a) Simulation; (b) Oscilloscope

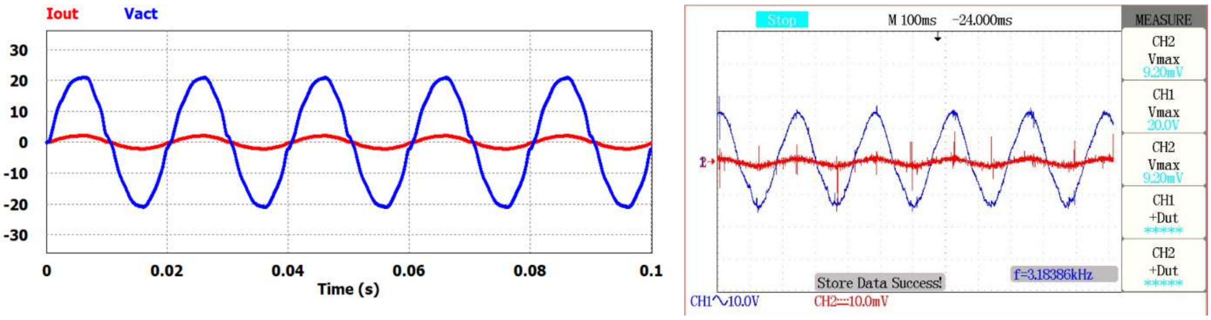
Figure 10 shows the test results of the H-Bridge Cuk Inverter as a voltage step-down. The results of this test display the measurements of V_{DC} (light blue) and V_{act} (dark blue). Figure 10 (a) is the result of testing with PSIM computational simulation, and Figure 10 (b) is the result of oscilloscope measurements on hardware. The value of V_{DC} has been determined to be $10\ V_{DC}$ while the voltage value of V_{act} is lower than V_{DC} thus proving that the voltage step-down mode on the Cuk H-Bridge Inverter using the LV-25P voltage sensor can work properly.



(a) **(b)**

Figure 11. V_{DC} and V_{act} Measurement of Voltage Step-up Mode (a) Simulation; (b) Oscilloscope

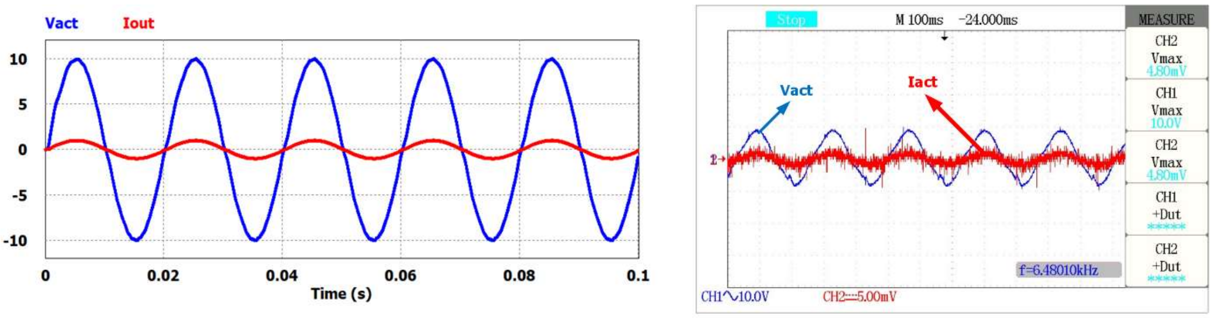
Figure 11 shows the test results of the Cuk H-Bridge Inverter in a voltage step-up mode. The test results display V_{DC} dan V_{act} measurements. Figure 11 (a) shows measurement results with PSIM computational simulation, and Figure 11 (b) shows results from oscilloscope measurements on hardware. The input value is $10\ V_{DC}$ and the output value is $20\ V_{act}$.



(a) **(b)**

Figure 12. Output Results of I_{act} and V_{act} Voltage Step-up Mode: (a) Simulation; (b) Oscilloscope

Figure 12 compares I_{act} dan V_{act} output waves with voltage step-up mode. Figure 12 (a) is the result of testing using the PSIM computational simulation. Figure 12 (b) is the result of Cuk H-Bridge Inverter hardware testing displayed on the oscilloscope V_{act} (blue) and I_{act} (red). The comparison results have the same shape, where V_{act} and I_{act} are in phase.



(a) **(b)**

Figure 13. Output Results of I_{act} and V_{act} of Voltage Step-down Mode: (a) Simulation; (b) Oscilloscope

The next test using voltage step-down mode, Figure 13 displays the results of comparing I_{act} and V_{act} on the Cuk H-Bridge Inverter. Figure 13 (a) is a test with PSIM computational simulation and figure 13 (b) displays hardware testing using a digital oscilloscope V_{act} (blue) and I_{act} (red). The results of this test display the outputs V_{act} and I_{act} s in phase on voltage step-down mode.

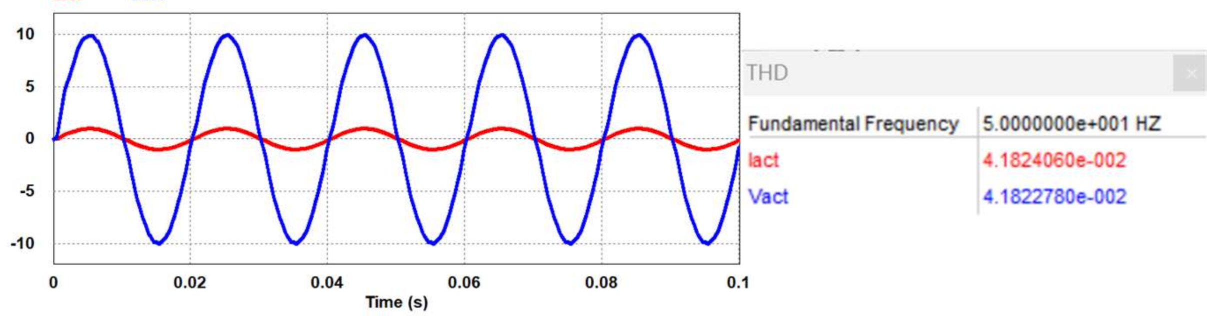


Figure 14. THD Value of Output I_{act} and V_{act}

The next test is based on the Total Harmonic Distortion (THD) value measured on I_{act} dan V_{act} with a THD meter. According to the IEEE 519 standard, the maximum THD value is 5%. Figure 14 displays a THD test of 4.1%. Thus, it can be ascertained that the Cuk H-Bridge Inverter in the study complies with IEEE standards.

4. CONCLUSION

Research and testing, using PSIM computer modeling programs and direct laboratory experimentation, indicate that the H-Bridge Inverter architecture integrated with a Cuk Converter works well. The hardware test findings were compared with PSIM models, yielding identical outcomes and an output power that is double the input power. The implemented PI control effectively sustains output voltage stability and consistently adjusts the reference value. The test yielded a THD result of 4.1%, compliant with the IEEE 519 standard, which stipulates a threshold of 5%. The Cuk H-Bridge Inverter is the newest inverter architecture, applicable as an industrial-scale AC voltage source employing renewable energy.

ACKNOWLEDGMENT

The authors extend their appreciation to the Electrical Engineering Laboratory for facilitating the study. This research was financed by a grant from the Faculty of Engineering at Soegijapranata University Semarang.

REFERENCE

Almalaq, Y., & Matin, M. (2018). Three Topologies of a Non-Isolated High Gain Switched-Inductor Switched-Capacitor Step-Up Cuk Converter for Renewable Energy Applications. *Electronics*, *7*(6), 94. https://doi.org/10.3390/electronics7060094

Anand, A., & Singh, B. (2019). Modified Dual Output Cuk Converter-Fed Switched Reluctance Motor Drive With Power Factor Correction. *IEEE Transactions on Power Electronics*, *34*(1), 624–635. IEEE Transactions on Power Electronics. https://doi.org/10.1109/TPEL.2018.2827048

Bendib, B., Belmili, H., & Krim, F. (2015). A Survey of the Most used MPPT Methods: Conventional and Advanced Algorithms Applied for Photovoltaic Systems. *Renewable and Sustainable Energy Reviews*, *45*, 637–648. https://doi.org/10.1016/j.rser.2015.02.009

Elum, Z. A., & Momodu, A. S. (2017). Climate change mitigation and Renewable energy for sustainable development in Nigeria: A discourse approach. *Renewable and Sustainable Energy Reviews*, *76*, 72–80. https://doi.org/10.1016/j.rser.2017.03.040

Güney, T. (2019). Renewable energy, non-renewable energy and sustainable development. *International Journal of Sustainable Development & World Ecology*, *26*(5), 389–397. https://doi.org/10.1080/13504509.2019.1595214

Hasan, M. M., Abu-Siada, A., & Islam, Md. R. (2016). Design and implementation of a novel three-phase cascaded half-bridge inverter. *IET Power Electronics*, *9*(8), 1741–1752. https://doi.org/10.1049/iet-pel.2015.0951

Mahdizadeh, S., Gholizadeh, H., & Gorji, S. A. (2022). A Power Converter Based on the Combination of Cuk and Positive Output Super Lift Lou Converters: Circuit Analysis, Simulation and Experimental Validation. *IEEE Access*, *10*, 52899–52911. IEEE Access. https://doi.org/10.1109/ACCESS.2022.3175892

Maroti, P. K., Padmanaban, S., Wheeler, P., Blaabjerg, F., & Rivera, M. (2017). Modified high voltage conversion inverting cuk DC-DC converter for renewable energy application. *2017 IEEE Southern Power Electronics Conference (SPEC)*, 1–5. https://doi.org/10.1109/SPEC.2017.8333675

Mostafaeipour, A., Bidokhti, A., Fakhrzad, M.-B., Sadegheih, A., & Zare Mehrjerdi, Y. (2022). A new model for the use of renewable electricity to reduce carbon dioxide emissions. *Energy*, *238*, 121602. https://doi.org/10.1016/j.energy.2021.121602

Østergaard, P. A., Duic, N., Noorollahi, Y., & Kalogirou, S. (2022). Renewable energy for sustainable development. *Renewable Energy*, *199*, 1145–1152. https://doi.org/10.1016/j.renene.2022.09.065

Pratomo, L. H., & Christiawan, H. D. E. (2023). Pengendalian Arus pada Inverter Lima Tingkat Penaik dan Penurun Tegangan. *ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika*, *11*(3), 783. https://doi.org/10.26760/elkomika.v11i3.783

Pratomo, L. H., Paudel, S., & Cahyadi, B. K. (2024). A simple method for controlling buck-boost SEPIC H-bridge inverter. *International Journal of Applied Power Engineering (IJAPE)*, *13*(3), Article 3. https://doi.org/10.11591/ijape.v13.i3.pp670-678

Purwoto, B. H., Jatmiko, J., Fadilah, M. A., & Huda, I. F. (2018). Efisiensi Penggunaan Panel Surya sebagai Sumber Energi Alternatif. *Emitor: Jurnal Teknik Elektro*, *18*(1), Article 1. https://doi.org/10.23917/emitor.v18i01.6251

Renxi Gong & Cheng Zhao. (2023). An Optimized Carrier Phase-Shifted Modulation Strategy for Cuk PV Inverter. *IEEE Access*, *11*, 34119–34127. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3256887

Rizki, F. R. M., Riyadi, S., & Pratomo, L. H. (2020). A SPWM Controlled Input in Dual Buck DC-DC Converter – Full Bridge for Single-Phase Five-Level Inverter. *Journal of Physics: Conference Series*, *1444*(1), 012031. https://doi.org/10.1088/1742-6596/1444/1/012031

Şehirli, E. (2022). Analysis of LCL Filter Topologies for DC-DC Isolated Cuk Converter at CCM Operation. *IEEE Access*, *10*, 113741–113755. IEEE Access. https://doi.org/10.1109/ACCESS.2022.3218162

Siahaan, F. J., Silalahi, E. M., Widodo, B., & Purba, R. (2020). PENGUKURAN TOTAL HARMONIC DISTORTION (THD) TERHADAP LAMPU HEMAT ENERGI (LHE) DAN LIGHT-EMITTING DIODE (LED). *Lektrokom : Jurnal Ilmiah Teknik Elektro*, *3*(1), 8. https://doi.org/10.33541/lektrokom.v3i1.3372

Trilaksono, A., Facta, M., & Nugroho, A. (2015). OPERASI DC-DC KONVERTER TIPE CUK DENGAN MODE DCM & CCM DENGAN TRANSISTOR SC2555 SEBAGAI SAKLAR. *Transient: Jurnal Ilmiah Teknik Elektro*, *4*(2), Article 2. https://doi.org/10.14710/transient.v4i2.261-267

Wibisono, A., Riyadi, S., & Martanio, A. (2022). Desain dan Implementasi Kendali Digital Proportional-Integral pada Cuk Converter. *Majalah Ilmiah Teknologi Elektro*, *21*(1), 149. https://doi.org/10.24843/MITE.2022.v21i01.P20