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UNIVERSITE MOHAMED BOUDIAF - M’SILA

Department of Electrical Engineering

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Design and Implementation of a Pure Sine Wave Inverter with an Isolated DC-DC Converter Stage

Presented by:

ZAITER RAIANE
KASRI OSEMA
DJILAT DIYA EDDINE

Defended before the jury composed of:

CHOUDER Aissa	Professor	Université M’sila	Rapporteur
BENGUSMIA Hani	Professor	Université M’sila	Chairpersons
LALLOUANI Hellali		Université M’sila	Examiner

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Contents

List of Figures

List of Tables

Abbreviations

- MPPT: Charger regulator

- THD: Total Harmonic Distortion

- PWM: Pulse Width Modulation

- DC: Direct Current

- AC: Alternating Current

- N_p: Number of turns of primary
- N_s: Number of turns of secondary
- m: Transformer ratio
- V_{in}: Input voltage
- V_1: Primary voltage
- V_2: Secondary voltage
- V_o: Output voltage
- I_{in}: Input current
- I_o: Output current
- P_{in}: Input power
- $P_{out:}$ Output power
- V_{sin}: Voltage Sin
- V_{tri}: Voltage Triangular

Introduction

With the increasing demand for cleaner and greener energy sources worldwide, solar energy has been one of the most viable renewable alternatives for electricity generation, especially for remote locations or areas with sparse connection to the electrical grid. One of the key technical issues in this area is the conversion of the low-voltage direct current (DC) output of solar panels into alternating current (AC) at appropriate voltage and electrical requirements to feed residential or industrial loads.

This project involves the design and construction of a 1000-watt (1 kW) solar pure sine wave inverter system, consisting of two stages:

The first stage is to step up the low-voltage DC (12V DC) from batteries to a high-voltage DC level (400V DC) via a boost converter, a PWM controller generates pulse-width modulation (PWM) signals to supply MOSFETs, which are input to a high-frequency step-up transformer. Galvanic isolation for electrical safety and isolation of the control circuit from the power stage is provided using opto-isolators.

The second stage is the conversion of the high voltage DC to a sinusoidal AC output voltage of 230V at 50Hz through sinusoidal pulse-width modulation (SPWM) techniques. Inversion is achieved through an H-Bridge inverter topology.

This 1000W inverter system is a cost-effective and efficient means of solar energy conversion to useful electrical energy, based on electrical safety standards, efficiency, and output waveform quality.

The following figure is a system illustrates of a solar-powered pure sine wave inverter. Energy is first harvested from a solar panel and regulated by an MPPT controller to ensure optimal charging of a 12V battery. The stored DC voltage is then boosted to 400V using a DC-DC converter. This high-voltage DC is fed into a pure sine wave inverter, controlled by SPWM controller module. Then the inverter converts the DC into a clean 230VAC output suitable for powering sensitive loads such as household appliances.

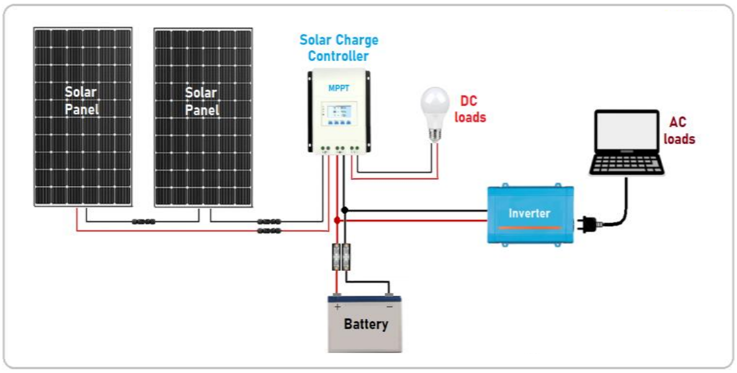

Figure I.1: represent the full system structure

I. DC-DC Converter

DC-DC converters or DC choppers are power electronic circuits that are used to control the levels of DC voltage by high-speed switching devices such as BJTs, IGBTs, and MOSFETs. They are broadly classified based on switching methods as hard-switching PWM converters and soft-switching or resonant converters with reduced switching loss. They are operationally categorized as buck (step-down), boost (step-up), or buck-boost (step-up/down) based on the ratio of the output to the input voltage. Soft-switching topologies enhance efficiency along with reducing electromagnetic interference. Isolated topologies, as represented by the Push-Pull converter, are developed from buck-boost topologies. The Push-Pull topology employs several PWM-controlled switches in conjunction with a transformer for voltage conversion and electrical isolation. These topologies find extensive applications in renewable power systems, electric vehicles, and embedded power supply [1]

I.1 Principal Operation of Push-Pull Converter

A Push-Pull converter is a type of DC-DC converter that uses a center-tapped transformer and two switching devices (e.g., MOSFET, IGBT) to convert a DC input voltage into another level DC output voltage. The following figure shown the structure of push-pull converter [1]

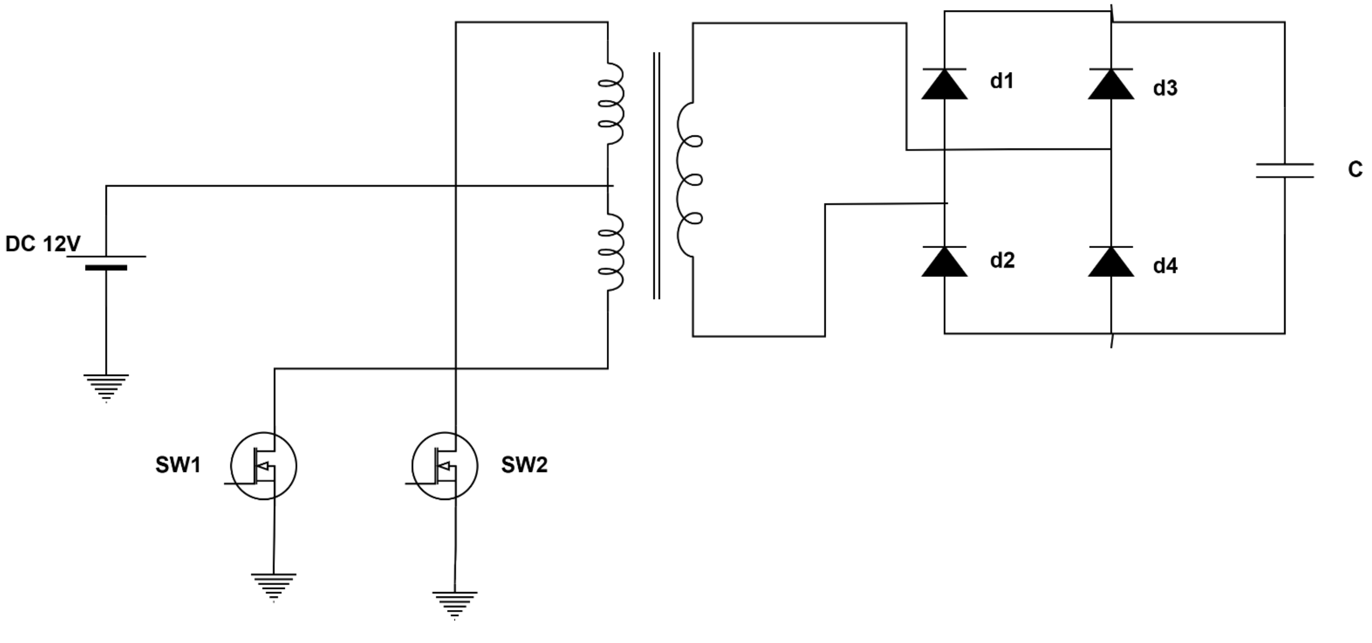

Figure I.2: Push-Pull Topology

I.1.1 Expression of Output Voltage and Output Current

The push-pull converter operates in two switching cases:

- **Case 1 (k_1=on; k_2= off) For $0 < t < T/2$:**

When the first switch k1 is on the current flows from the center tap through the first half of the primary wending, this make a magnific flux in the transformer core in one direction, The secondary winding sees a voltage induced due to the changing magnetic field and create a positive voltage in it, this voltage is rectified and filtered for producing the output voltage. Figure **I.3** shown the first case of switching [2]

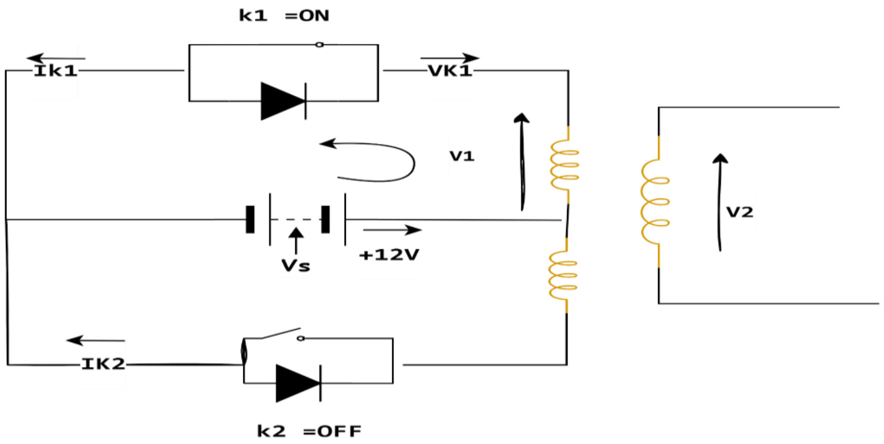

Figure I.3: The First States of Push-Pull

The Primary Wending Voltage

$$V_1 = V_{in} \qquad \text{I.1}$$

The Secondary Wending Voltage

$$V_2 = \frac{N_2}{N_1} V_1 = m \qquad \text{I.2}$$

The Voltage of Switch K_1:

$$V_{K1} = 0 \qquad \text{I.3}$$

The Current of Switch K_2

$$i_{K2} = 0 \qquad \text{I.4}$$

- **Case 2 (k_1=off; k_2=on)** For **T/2< t < T:**

When the first switch k_2 is on the current flows from the center tap through the second half of the primary wending, this make a magnific flux in the transformer core in secondar direction, The secondary winding sees a voltage induced due to the changing magnetic field and create a negative voltage in it, this voltage is rectified and filtered for producing the output voltage. Figure **I.4** shown the second case of switching [2]

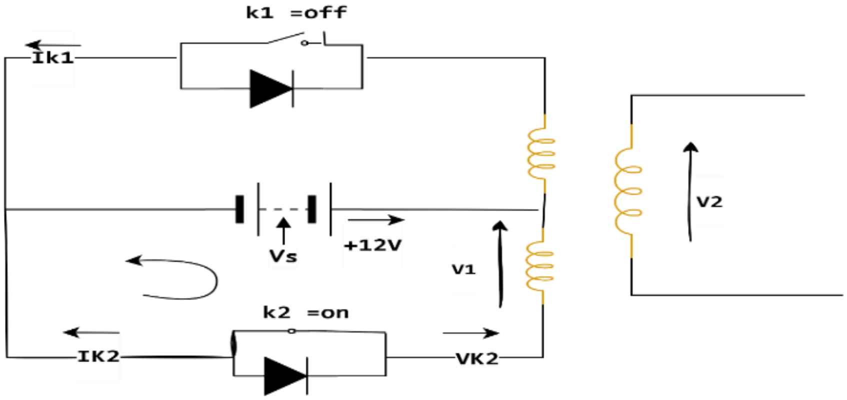

Figure I.4: The Second Case of Push-Pull

The transformer's magnetic flux reverses, inducing an opposite polarity voltage in the secondar

The Secondary Wending Voltage

$$V_2 = mv_1 \tag{I.5}$$

The Switch Wending Voltage:

$$V_{K2} = 0 \tag{I.6}$$

The current

$$i_{K1} = 0 \tag{I.7}$$

The rectified voltage: (for each half-cycle of duration)

$$V_{rec} = m \cdot V_{in} \tag{I.8}$$

The output voltage**:**

$$V_o = 2V_{in} \cdot D \cdot m \tag{I.9}$$

- **Current Output**

$$P_{in} = P_{out} \qquad \textbf{I.10}$$

$$P_{in} = V_{in} \cdot I_{in} = V_o \cdot I_o \qquad \textbf{I.11}$$

$$I_o = \frac{V_{in} \cdot I_{in}}{V_o} \qquad \textbf{I.12}$$

$$I_o = \frac{I_{in}}{2D \cdot n} \qquad \textbf{I.13}$$

- **Push-Pull Waveforms**

The following figure shown the Waveforms of a push-pull converter:

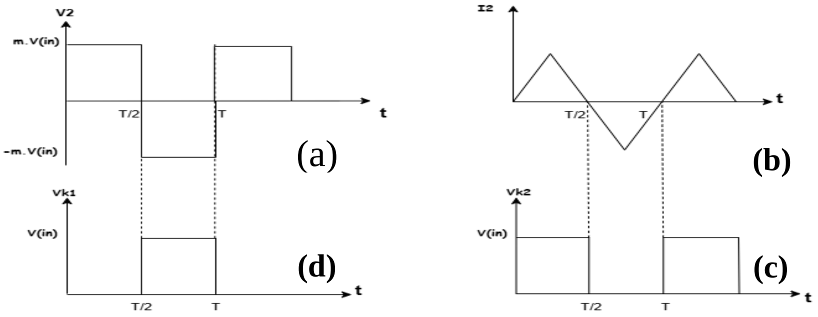

Figure I.5: Waveforms of a Push-Pull converter :(*a*) Secondary Output Voltage, (*b*) Current I₂, (c) Second Switch Voltage, (d) First Switch Voltage

I.2 Simulation of Push-Pull

This figure illustrates the simulation of a Push-Pull type DC-DC converter, used to step up a continuous voltage using a transformer and modulation control.

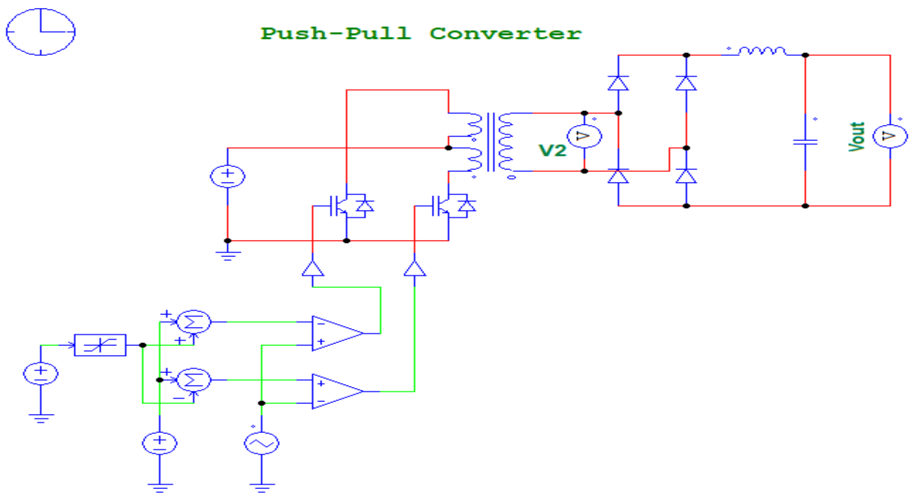

Figure I.6: Simulation Push-Pull Converter

This figure represents the secondary wending voltage waveform of the Push-Pull converter circuit

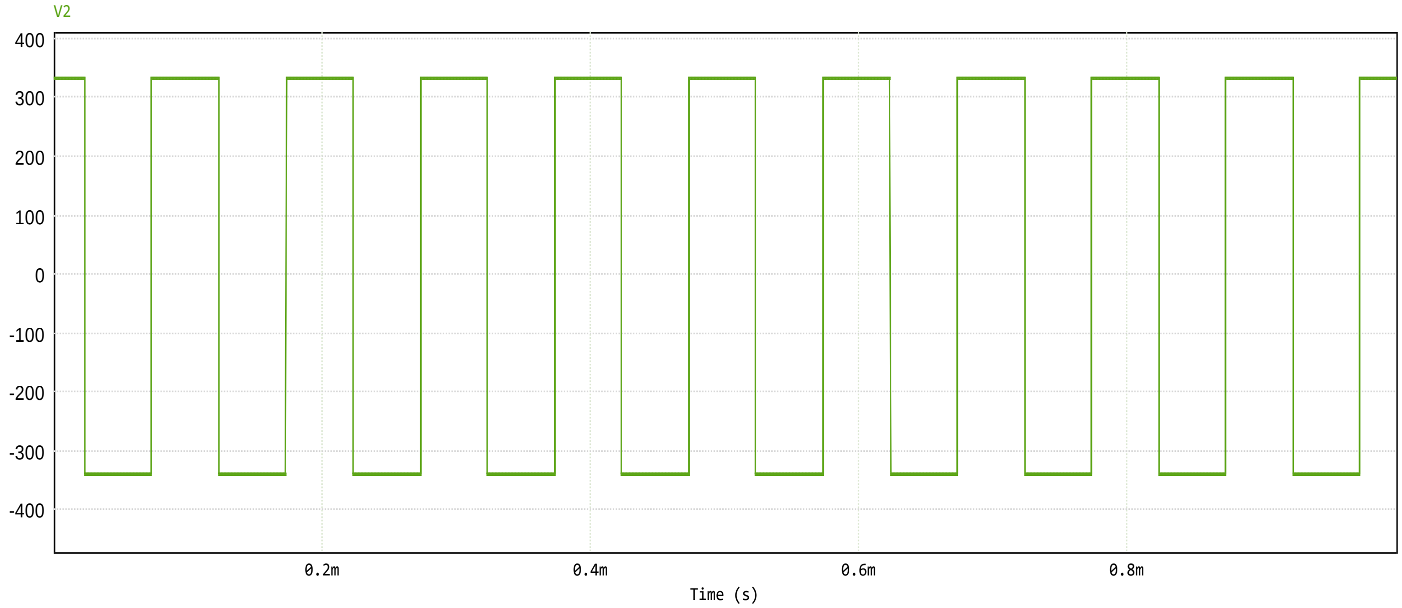

Figure I.7: Secondary Wending Voltage of the Push-Pull Converter.

The following figure shown the output voltage of Push-Pull converter

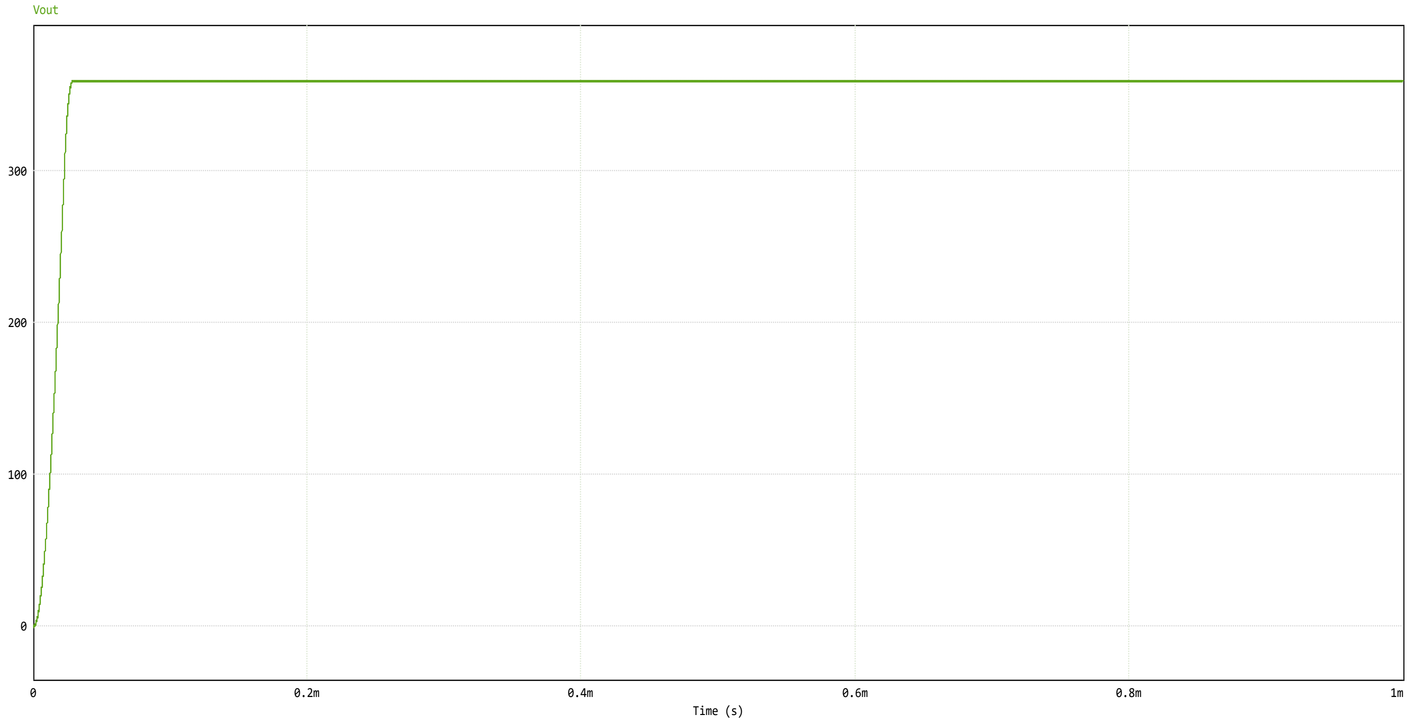

Figure I.8: Output Voltage of the Push-Pull Converter

This figure Figure **I.9** illustrates the output current waveform of the Push-Pull converter, showing a nearly triangular periodic behavior, characteristic of the converter’s switching dynamics under continuous conduction mode.

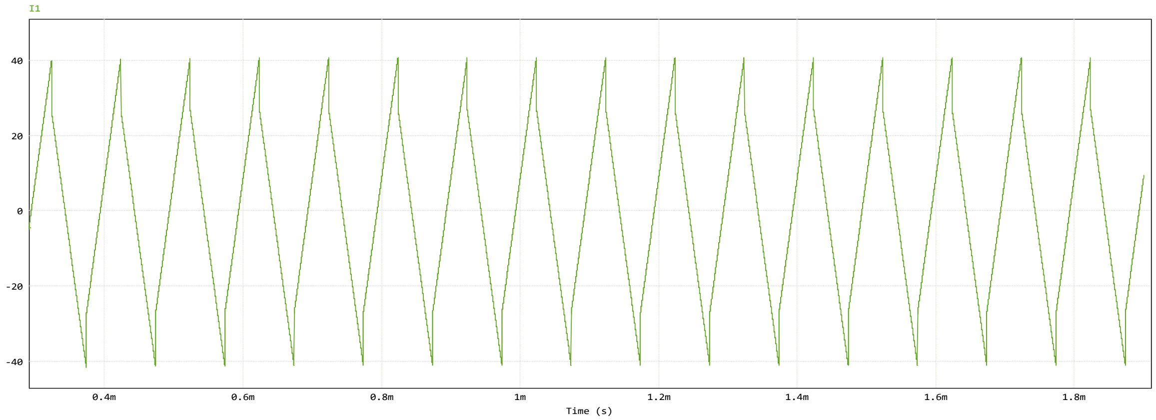

Figure I.9: The Output Current of the Push-Pull Converter

This figure.10 shows the two Pulse-Width Modulation (PWM) signals, V5 and V6, used in the Push-Pull converter; they operate in a complementary manner to ensure the alternate switching of the transistors, enabling efficient power conversion.

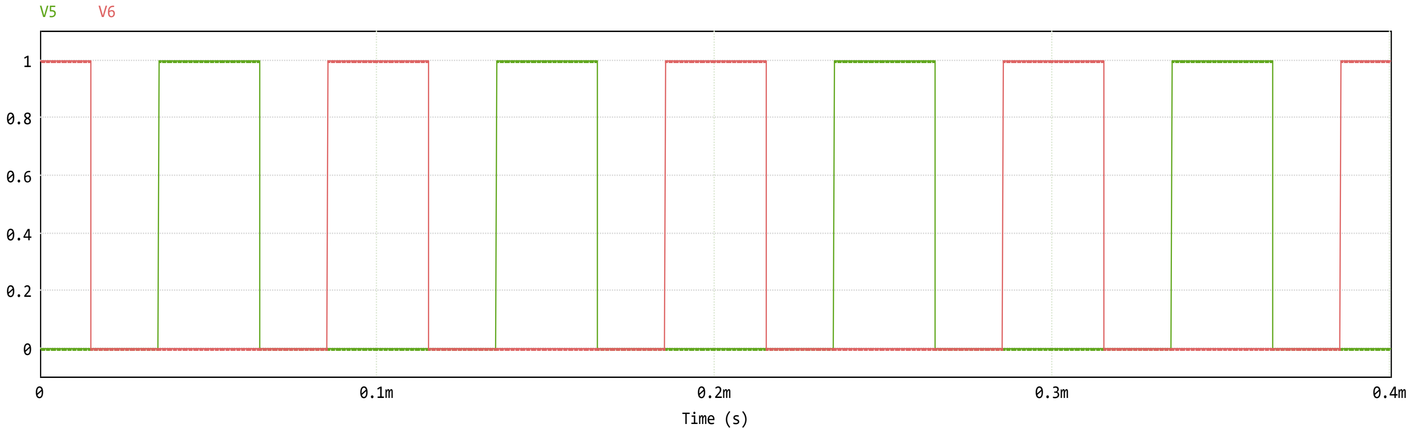

Figure (I.10): PWM Singles

II. Signale Phase Inventer

An inverter is a static converter ensuring the conversion of electrical energy from the direct current (DC) to the alternating current (AC). In fact, this energy conversion is satisfied through a control device (semiconductors). It allows obtaining at the receiver terminals an alternating voltage adjustable in frequency and effective value, by using an appropriate control sequence [4]

The operating principle of an inverter is based on switching electronics, which generates an alternating voltage waveform from a direct voltage, as shown in the following figure:

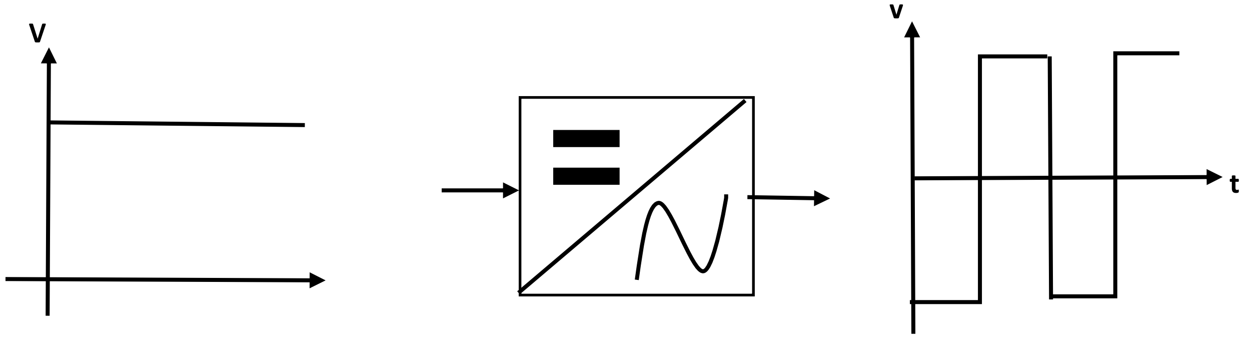

Figure II.1: The Operating Principle of an Inverter

II.1 **Principal Operation of The Full-Bridge Inverter**

The direct use of a pair of basic switches involves adjusting the frequency and duration of connections between the source and the output. This results in a time-based approach, leading to the use of pulse width modulation techniques. Amplitude control can be achieved either continuously by creating an adjustable source (which implies the existence of another conversion stage), or discretely by having a sufficient number of sources. When switches **S_1 – S_2** are closed (On) and switches **S_3 – S_4** are open (Off) for **$0 < t < T/2$**, a positive half- cycle $\boldsymbol{u(t) = V_{dc}}$ is obtained, as shown in the figure [4]

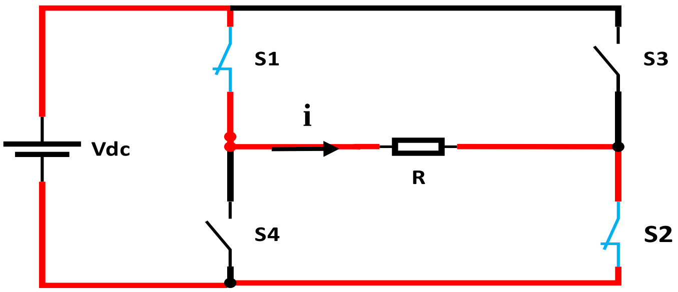

Figure II.2: The First Case of Full-Bridge Inverter

When S_1 – S_2 are open (Off) and S_3-S_4 are closed (On) for **$T/2 < t < T$**, we obtain a negative half-cycle

$\boldsymbol{u(t) = -V_{DC}}$ as shown in Figure (II.3).

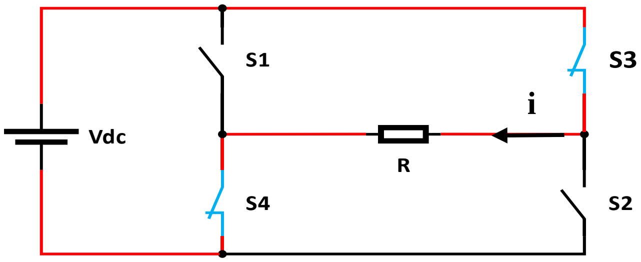

Figure (II.3): The Second Case of Full-Bridge Inverter

The resulting signal over the full period is shown in **Figure II.4**

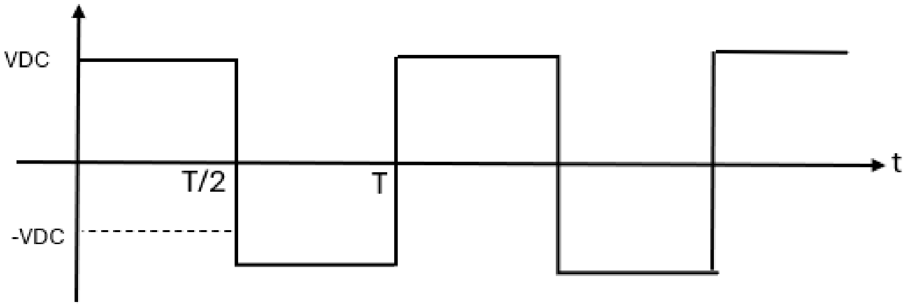

Figure (II.4): The Output Voltage of Full-Bridge Inverter

II.2 Pulse-width Modulation

Pulse-width modulation (PWM) is an effective method for reducing the total harmonic distortion (THD) of the load current. A PWM inverter, when combined with appropriate filtering, can generally satisfy THD requirements more easily than an inverter using square wave switching. Although the unfiltered PWM output may have relatively high THD, the harmonics are shifted to much higher frequencies compared to square waves, which simplifies the filtering process.

Additionally, the amplitude of the output voltage in PWM can be controlled using the modulating waveforms. These two factors—reduced filtering requirements due to high-frequency harmonics, and the ability to regulate output voltage amplitude—are key advantages of PWM.

Disadvantages include more complex control circuits for the switches and increased losses due to more frequent switching [3]

Bipolar Switching

Figure II.5 illustrates the principle of sinusoidal bipolar pulse-width modulation. Figure II.5a show a sinusoidal reference signal and a triangular carrier signal. When the instantaneous value of the sine reference is larger than the triangular carrier, the output is at $+V_{DC}$, and when the reference is less than the carrier, the output is at $-V_{DC}$:

$V_o=+V_{DC}$ for $V_{SINE}>V_{Tri}$

$V_o=-V_{DC}$ for $V_{SINE}<V_{Tri}$

This version of PWM is *bipolar* because the output alternates between plus and minus the dc supply voltage.

The switching scheme that will implement bipolar switching using the Full-Bridge inverter of Figure **II.5b** is determined by comparing the instantaneous reference and carrier signals [3]

S_1 and S_2 are on when $V_{SINE} > V_{Tri}$ $(V_o = +V_{DC})$

S_3 and S_4 are on when $V_{SINE} < V_{Tri}$ $(V_o = -V_{DC})$

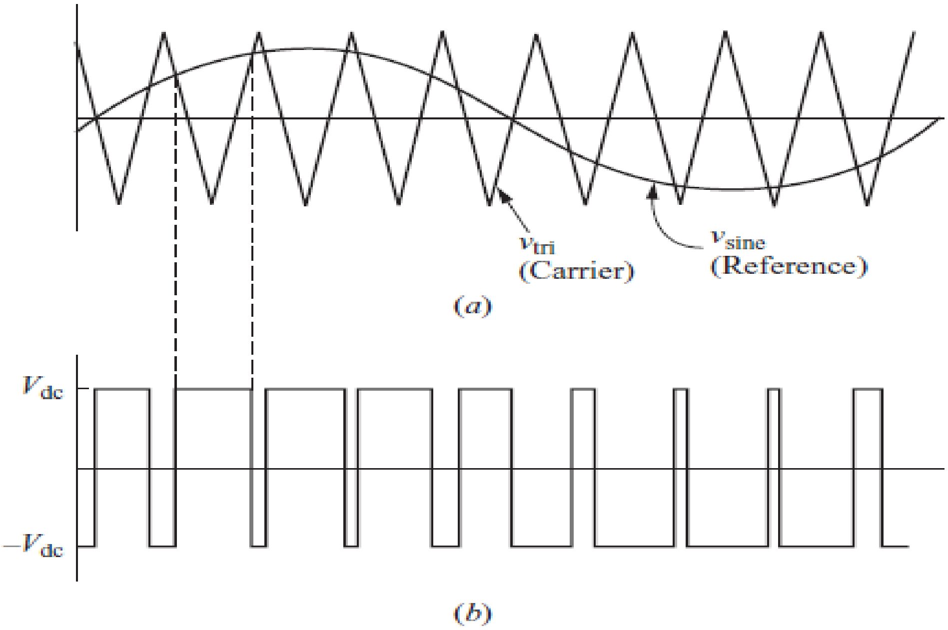

Figure II.5: Bipolar Pulse-Width Modulation.

(a) Sinusoidal Reference and Triangular Carrier; (b) Output Voltage.

Unipolar Switching

In unipolar Pulse-Width Modulation (PWM) switching, the output switches either from a high level to zero or from a low level to zero, instead of switching between high and low levels directly as in bipolar switching. One of these unipolar switching methods is illustrated by the arrangement of the switch control given in Figure **II.6** [3]

. if $V_{sine} > V_{tri}$ S_1: ON

. if $V_{sine} < V_{tri}$ S_4: ON

. if $-V_{sine} < V_{tri}$ S_2: ON

. if $-V_{sine} > V_{tri}$ S_3: ON

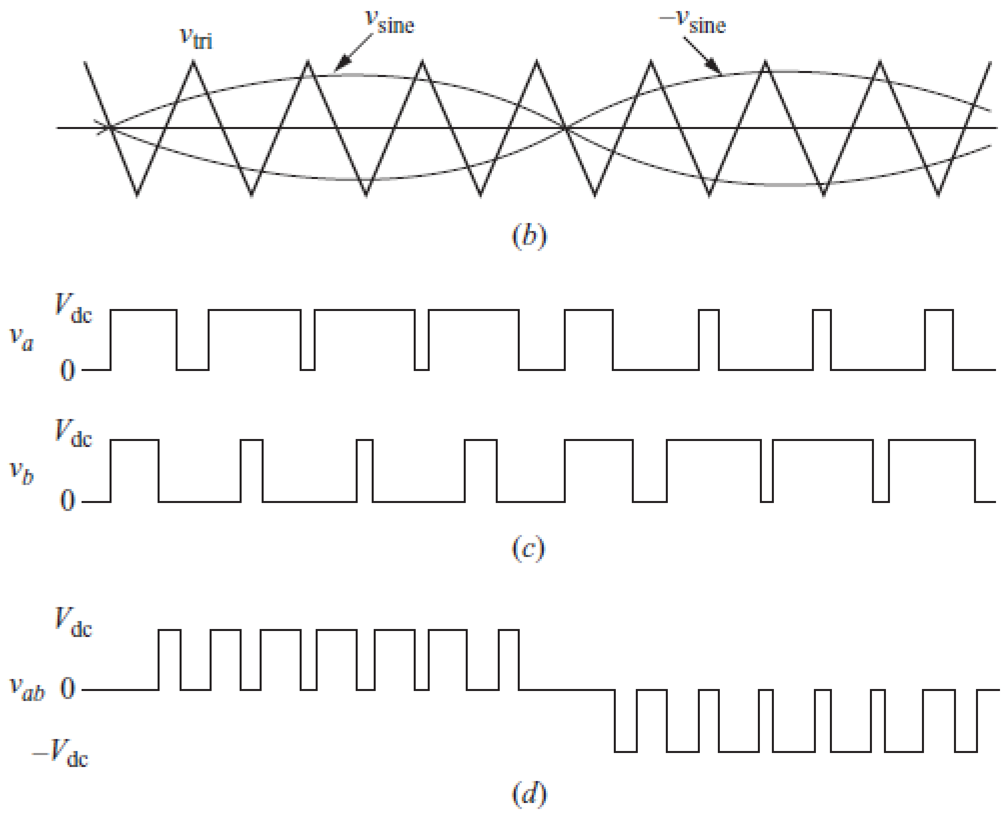

Figure II.6 (*a*) Full-bridge converter for Unipolar PWM; (*b*) Reference and Carrier Signals; (*c*) Bridge Voltages *va* and *vb*; (*d*) Output Voltage.

II.3 Simulation Single-Phase Inverters

This is a simulation of the Inverter using PSIM

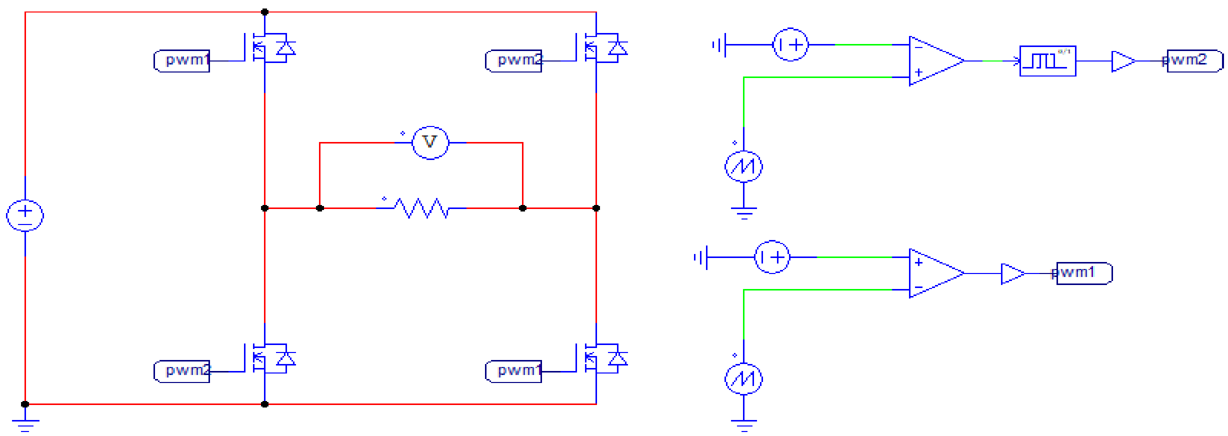

Figure II.7: full-bridge inverter

The result

Figure **II.8** shows the output signal of a Full-Bridge Inverter, which displays a square waveform with voltage levels of approximately ±380volts. This waveform is a direct result of switching the full-bridge inverter's power devices in a way that produces a bipolar alternating voltage across the load.

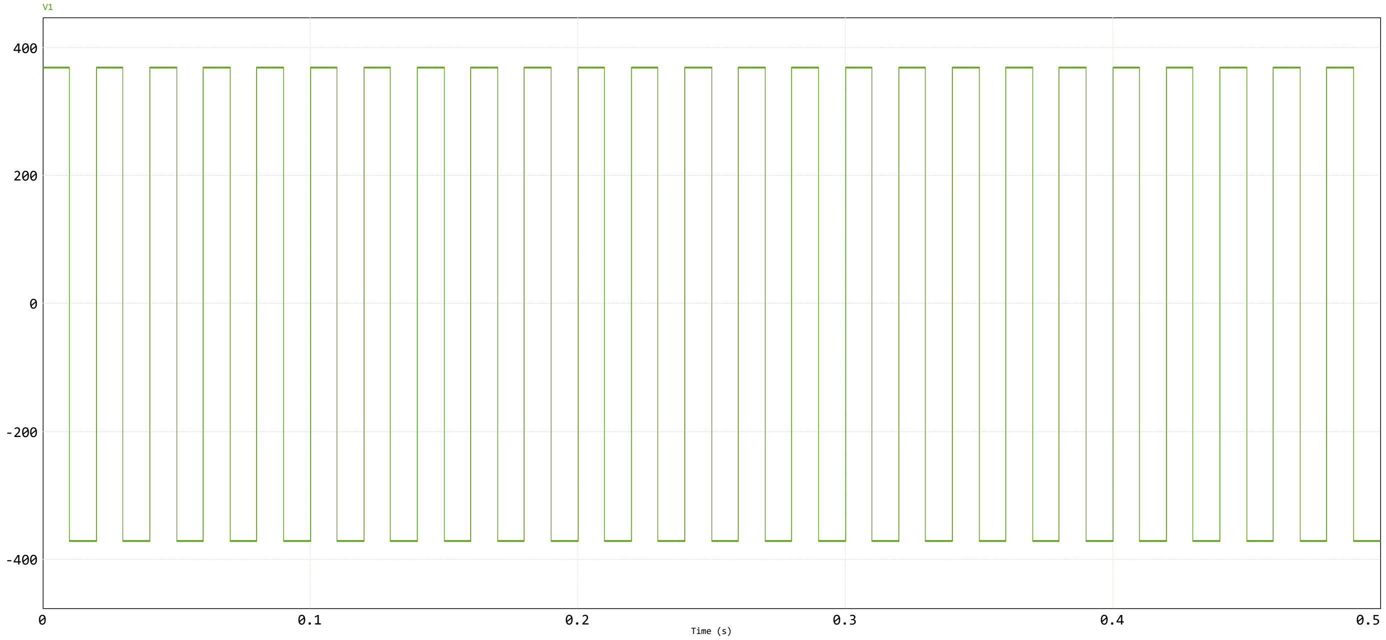

Figure II.8: The Output Voltage of Inverter

This Figure illustrates the frequency-domain analysis of the inverter output waveform using the Fast Fourier Transform (FFT) technique. This method decomposes the time-domain signal (in this case, a square wave output from a full-bridge inverter) into its frequency components to evaluate its harmonic content and spectral distribution

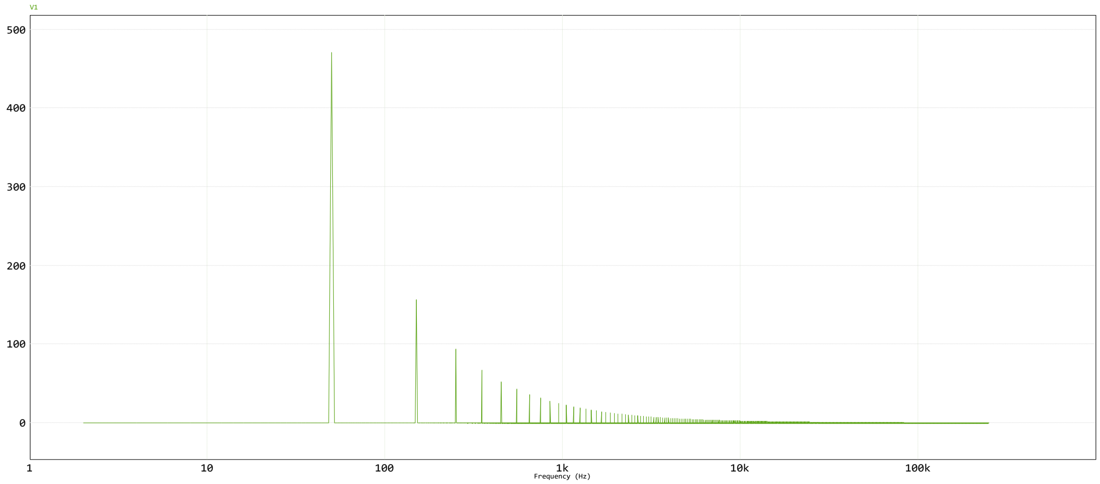

Figure II.9: Fast Fourier Transformer (FFT)

II.4 Harmonic Distortion (THD)

Harmonic distortion refers to the appearance of additional frequency components (harmonics) in the output voltage or current signal of the inverter, instead of having a pure sinusoidal waveform. Technical standards express the level of harmonic distortion using the Total Harmonic Distortion (THD), which is the ratio of the total harmonic power to the power of the fundamental component.

Harmonic distortions in inverter systems occur for several main reasons, including:

Switching operations of power devices: The rapid turning on and off of semiconductors (such as IGBTs and MOSFETs) produces high-frequency pulse signals, which generate wide-spectrum harmonics. [3]

Nonlinear loads: Such as electronic units and transformers that draw current disproportionate to the voltage, creating pulsed currents that result in additional harmonic distortion. [1]

Other factors: These include voltage source asymmetry, switching precision, and variations in turn-off time all of which cause deviation of the signal from the ideal phase.

Occurrence of harmonic distortion in single-phase PWM inverter: When generating AC power through PWM in a single-phase inverter, the switches are turned on/off rapidly according to a sinusoidal reference signal. This produces an output in the form of a series of pulses, which, when analyzed in the frequency domain, show a fundamental component (e.g., 50 or 60 Hz) along with harmonics at its multiples. In the absence of proper filtering, the THD remains high because the output signal is not a pure sine wave.

II.5 Sinusoidal-Pulse Width Modulation (SPWM)

This type of inverter provides output voltage waveform which is very similar to the voltage waveform that is received from the Grid. The sine wave has very little harmonic distortion resulting in a very „clean‟ supply and makes it ideal for running electronic systems such as computers, digital fx racks and other sensitive equipment without causing problems or noise. Things like mains battery chargers also run better on pure sine wave converters [5]

Benefits of using True Sine Wave Inverter:

- Most of the electrical and electronic equipment are designed for the sine wave.
- Some appliances such as variable motor, refrigerator, microwave will not be able to provide rated output without sine wave.
- Electronic clocks are designed for the sine wave.

- Harmonic content is less.

II.5.1 Sine Wave Generation

The most common and popular technique for generating True sine Wave is Pulse Width Modulation (PWM). Sinusoidal Pulse Width Modulation is the best technique for this. This PWM technique involves generation of a digital waveform, for which the duty cycle can be modulated in such a way so that the average voltage waveform corresponds to a pure sine wave. The simplest way of producing the SPWM signal is through comparing a low power sine wave reference with a high frequency triangular wave. This SPWM signal can be used to control switches. Through an LC filter, the output of Full Wave Bridge Inverter with SPWM signal will generate a wave approximately equal to a sine wave. This technique produces a much more similar AC waveform than that of others. The primary harmonic is still present and there is relatively high amount of higher-level harmonics in the signal [5] The following figure represent how to generate the SPWM signal from comparison of a sinusoidal signal and a triangle signal.

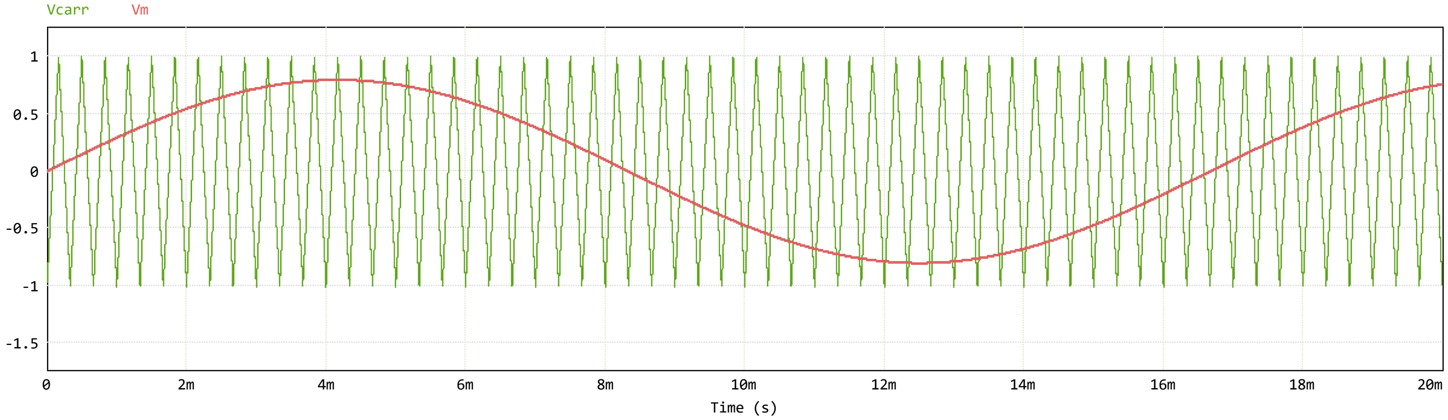

Figure II.10: SPWM Comparison Signals

This figure II.11 shows the SPWM (Sinusoidal Pulse Width Modulation) signal generated for inverter control

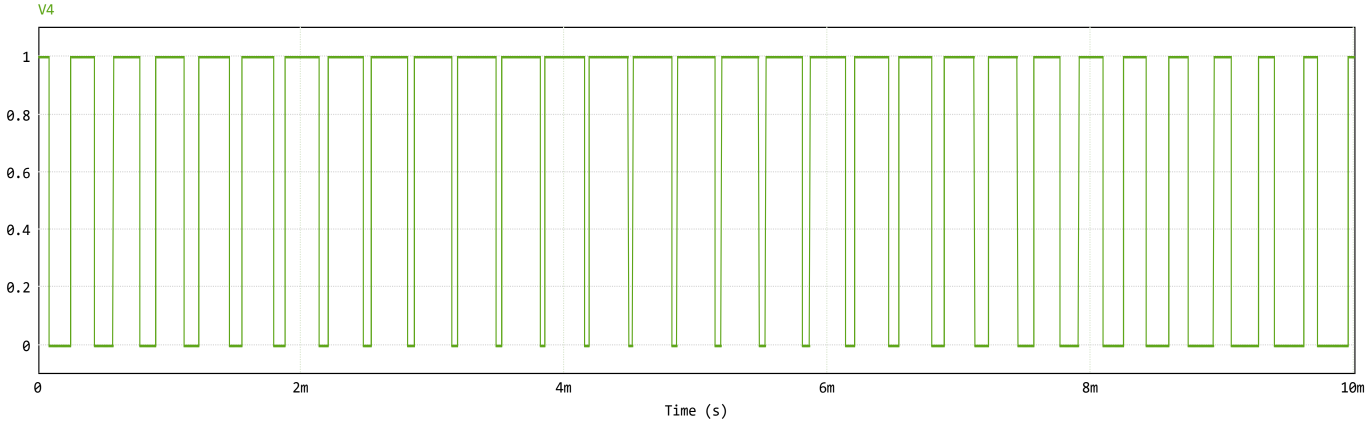

Figure II.11: SPWM Signal

This Figure **II.12** represents the unfiltered SPWM signal, which is typically generated by comparing a sinusoidal reference wave with a high-frequency triangular carrier wave.

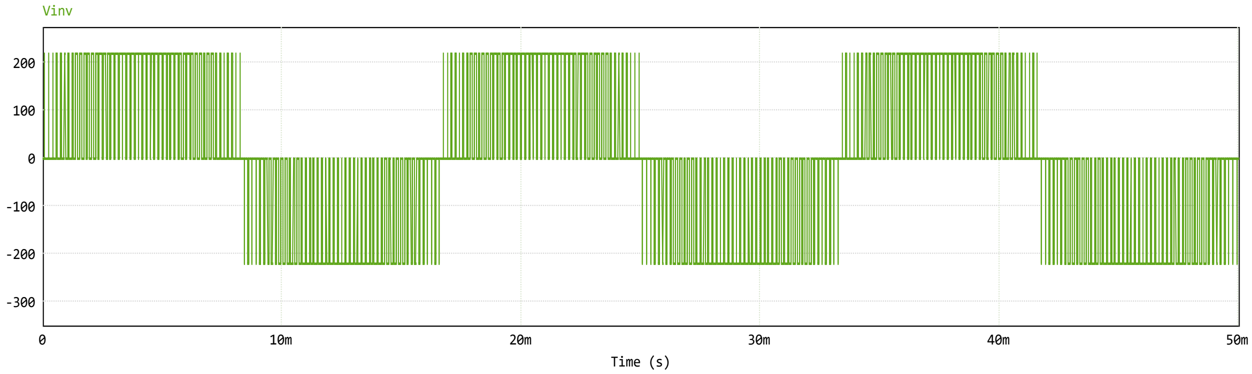

Figure II.12: Unfiltered SPWM Output Voltage

This Figure **II.13** represents the filtered SPWM signal:

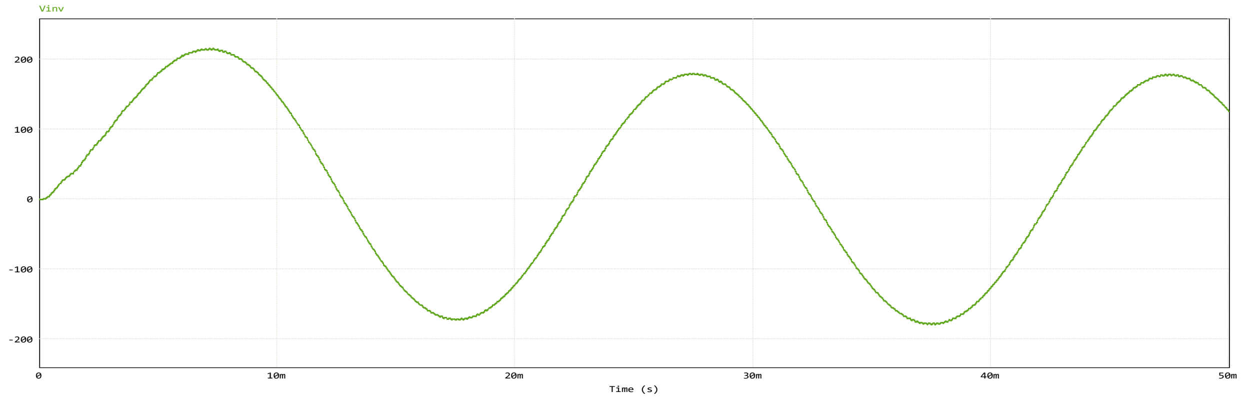

Figure II.13: Filtered SPWM Output Voltage

This figure **II.14** illustrates the frequency-domain analysis of the output signal using the Fast Fourier Transform (FFT) technique. Hz, corresponding to the fundamental frequency, with a significant attenuation of higher-order harmonics. This indicates that the circuit effectively filters out high-frequency noise, ensuring a cleaner and more stable output waveform**.**

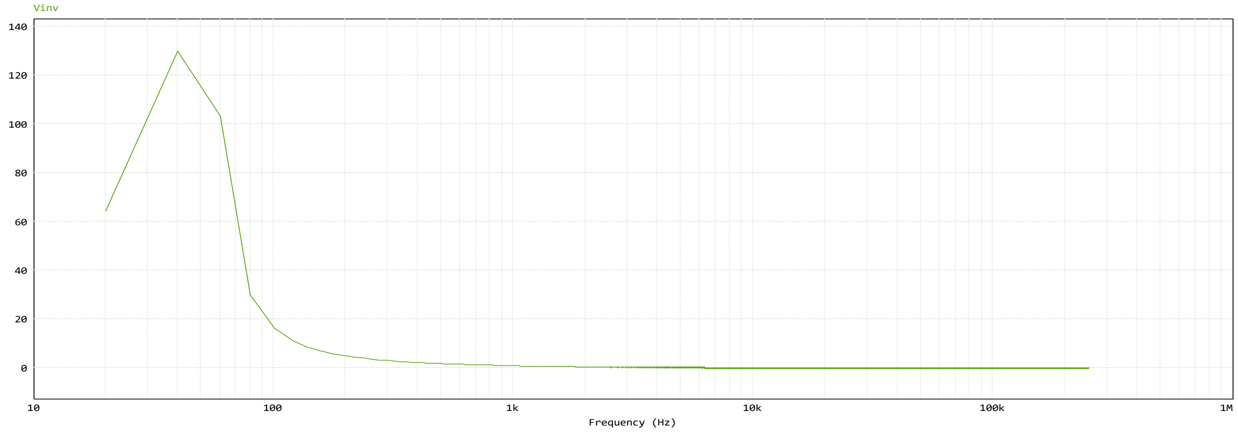

Figure II.14: Fast Fourier Transformer (FFT)

III. Implementation of the sinewave Inverter

After studying the theoretical principles related to inverters, energy conversion, and power electronics, this section is dedicated to the practical implementation of our system. The device under study aims to convert a direct voltage supplied by a photovoltaic source into a stable sinusoidal alternating voltage that complies with grid standards. The implementation includes two fundamental stages:

DC-DC Stage: This first stage involves boosting or regulating the DC voltage coming from the solar panels to match the requirements of the inverter. It typically relies on a switching converter (boost or push-pull) and may include regulation using an analog or digital controller (such as the SG3525).

DC-AC Stage: Once the voltage is adapted, it is converted into a sinusoidal wave using an inverter bridge controlled by a modulation technique (usually SPWM – Sinusoidal Pulse Width Modulation), which enables the generation of a clean and stable AC voltage. This diagram represents the full structure of the inverter

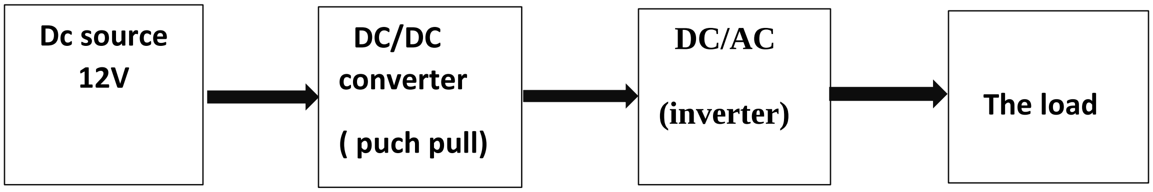

Figure III.1: **Block Diagram of The Inverter**

III.1 DC/DC Converter Diagram

The DC-DC boost stage in this system is based on a push-pull converter topology, an efficient and compact solution for stepping up low voltage (12V) to high voltage (around 400V DC).

The main of this stage is the SG3525 Pulse Width Modulation (PWM) controller IC, which provides two complementary PWM outputs to drive the gates of the two switching MOSFETs. These MOSFETs alternately switch the 12V supply across the center-tapped primary winding of a high-frequency ferrite transformer, effectively generating an alternating magnetic field and stepping up the voltage through transformer action.

The secondary winding of the transformer is connected to high-speed rectifier diodes and a high-voltage filter capacitor to provide a stable 400V DC output.

We have low voltage protection which detect the voltage input when this latter is going low this protection send a signal to SG3525 shutdown pin to turn off the circuit

Also, we have an overload protection witch measure the output current and when its reach the maximum value (2.7A) it sends a turn off signal to SG3525.

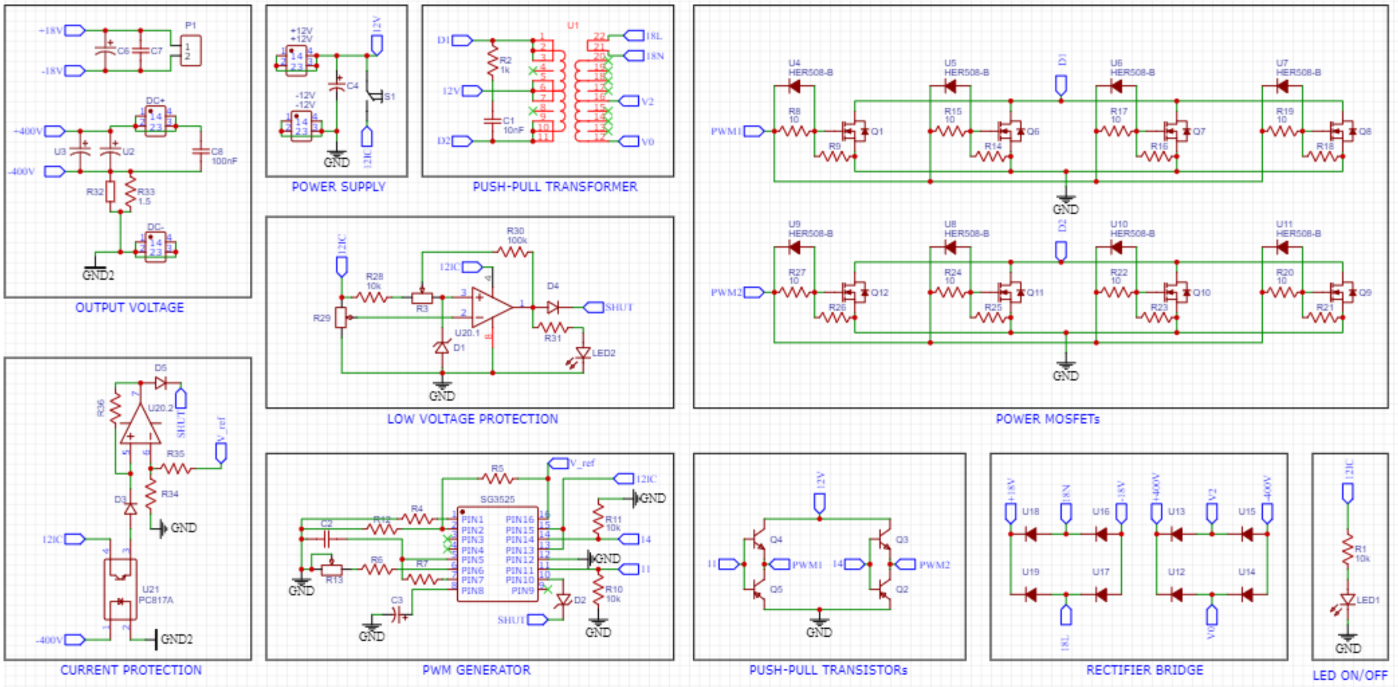

Figure III.2: DC-DC Converter

III.1.1 Description of The SG3525 MLI Controller

The SG3525A is a Pulse Width Modulation (PWM) controller integrated circuit, offering enhanced performance compared to its predecessors. It also requires fewer external components when used in control circuits for all types of switching power supplies [6]

Key features:

- Operating voltage range is from 8V to 35V, connected through Pin 13 and Pin 15.
- Provides an internally regulated reference voltage of 5.1V on Pin 16.

(Note: The original had corrupted characters; the intended value is clearly 5.1V.)

- The internal oscillator has a variable frequency, controlled by an external resistor RT (Pin 6) and capacitor CT (Pin 5), allowing frequency adjustment from 100 Hz to 400 kHz.
- Dead time is adjustable using an external resistor RD, connected between Pin 7 and Pin 5.
- Output stage is suitable for push-pull configuration, and can deliver a maximum current of ±400 mA.

III.1.2 Description the pins of SG3525

The article explains the function of the different pins of the SG3525, which is a regulator for the signal of pulse-width modulation (PWM). Let’s understand the details:

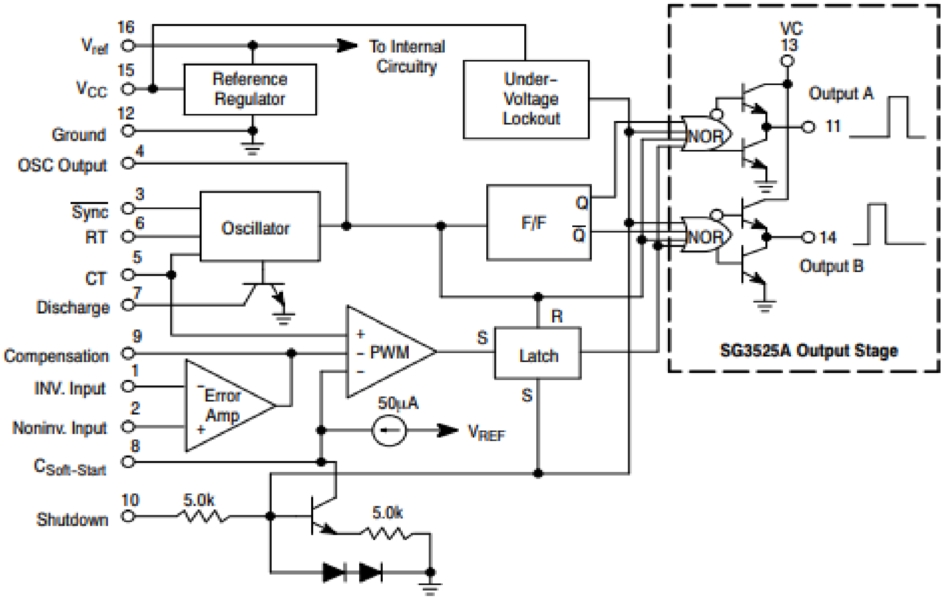

Figure III.3: **Internal Block Diagram SG3525 [6]**

- **Pin 1 (INV. Input) and Pin 2 (Non-Inv. Input):** These are the inputs of the operational amplifier — the error amplifier integrated in the IC. The error signal is used to modify the duty cycle of the output voltages at Pin 11 and Pin 14.

- **Pin 3 (Sync):** This pin can be used to synchronize the IC with the frequency of an external oscillator. This is generally done when multiple ICs are used and need to be synchronized to a common oscillator frequency.

- **Pin 4 (OSC Out):** This is the oscillator output signal of the IC.

- **Pin 5 (CT) and Pin 6 (RT):** These pins are connected to external resistors and capacitors to set the frequency of the internal oscillator.

- **Pin 7** (DT - Dead Time): This pin is used to set the dead time between the switching of the two outputs (A and B). A resistor connected between Pin 7 and ground determines the dead time.

- **Pin 8 (Soft-Start):** Used to gradually start the operation of the IC to avoid electrical shocks during startup. A capacitor connected between this pin and ground performs this function.
- **Pin 10 (Shutdown):** Used to block the output signals of the IC in the event of a circuit malfunction or fault.
- **Pin 11 (Output A) and Pin 14 (Output B):** These two outputs operate in a push-pull configuration.

- **Pin 12 (Ground):** This pin is directly connected to the circuit ground.
- **Pin 13 (Vc):** This pin is connected to the power supply of the output stage that drives the push-pull power converter. Vc ranges between 4.5V and 35V.
- **Pin 15 (Vcc):** This pin supplies power to the internal logic part of the IC. Vcc ranges from 8V to 35V.
- **Pin 16 (Vref):** This pin provides a stable internal reference voltage of 5.1V. This voltage can be used for duty cycle regulation via the internal error operational amplifier of the IC [6]

- **Component values**

SG3525 component values

R_{10}=10 **K**Ω	R_4= 10 kΩ	**R_{13}**=2 kΩ	**R**= **R_7**=100 Ω	**R_6**=10 KΩ
R_{11}=10 KΩ	**R_5**=10 kΩ	**C_2**=100 nF	**C_{10}**=1 uF	**R_{12}**=10 kΩ

Table III.1: SG3525 Component Values

the frequency can be calculated by using the following formula

$$F = \frac{1}{C_T}(0.7 \times R_T + 3 \times R_d) \qquad \text{III.1}$$

The timing capacitor C_T is set to 100 nF

$$R_T = \frac{(F - 3R_d)}{0.7} C_T \qquad \text{III.2}$$

$$R_T = 3K\Omega \qquad \text{III.3}$$

III.1.3 Implementation of the Experimental Device

This Figure shows the practical part of the DC-DC converter we developed:

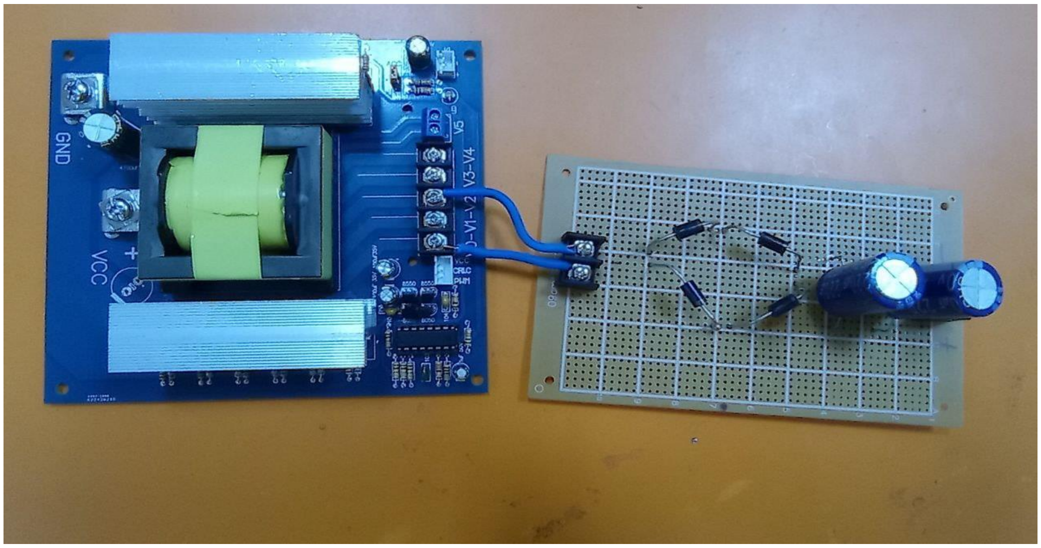

Figure III.4: the DC-DC Converter

III.1.4 Practical Results of SG3525

The two output signals out **A** and out **B** are represented in figure **III.4** are of same maximum amplitude. Where we notice that the signals are out of phase, and therefore this means that they can never be in the high state at the same time. The frequency corresponding to the signals of outputs out **A** and out **B** is **20 KHZ**

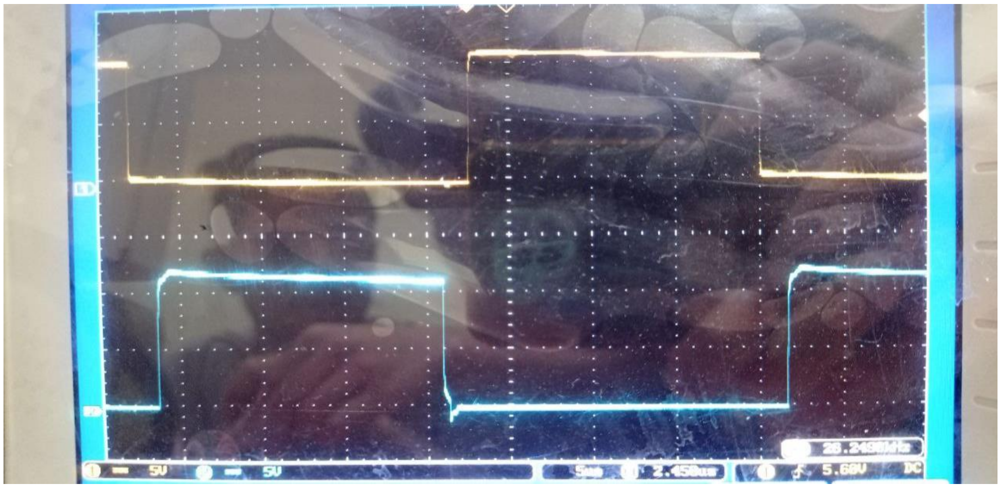

Figure III.5 The Output Signals Waveforms of the SG3525 IC

III.1.5 Practical Results of DC/DC Converter

We successfully designed a DC/DC conversion circuit capable of boosting the voltage from 12V to 380V DC

Figure III.6: The Waveform of DC/DC Converter

III.2. Implementation of Inverter

The operating principle of the pure sine wave inverter based on the EGS002 module relies on generating Sinusoidal Pulse Width Modulation (SPWM) signals to control a full-bridge inverter stage. The system begins with a DC power source, which may be stepped up and isolated using a high-frequency transformer if galvanic isolation is required. The EGS002 module, built around the EG8010 controller and two IR2110 gate drivers, produces complementary SPWM signals that precisely switch four MOSFETs arranged in an H-bridge configuration. These rapid switching signals, modulated in accordance with a sinusoidal reference waveform, cause the output voltage across the load to alternate in a sinusoidal pattern. The resulting high-frequency modulated waveform is passed through an LC low-pass filter, which attenuates high-frequency harmonics and smooths the output into a clean 50 Hz or 60 Hz sine wave. Integrated feedback loops for voltage, current, and temperature enable the EGS002 to dynamically adjust or shut down the inverter in case of abnormal conditions, ensuring a stable and protected AC output suitable for sensitive electronic equipment

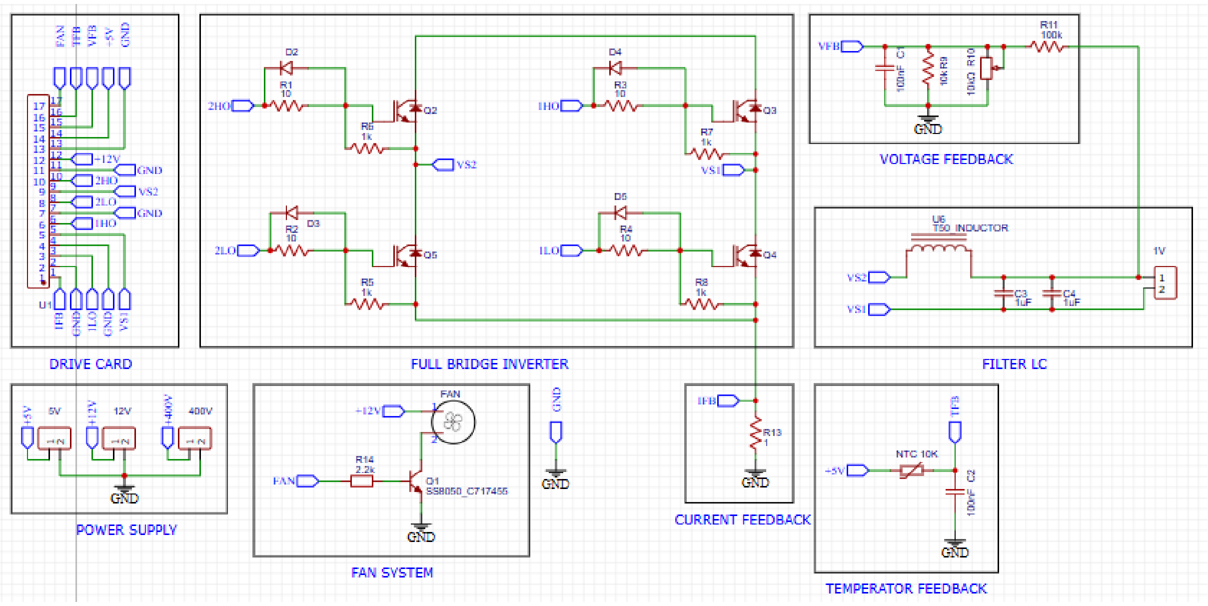

Figure III.7: Full Structure of Inverter

III.2.1 The EGS002 Module

At the core of this inverter design is the EGS002 driver module, an integrated control board designed specifically for generating high-quality Sinusoidal Pulse Width Modulation (SPWM) signals. It simplifies the implementation of pure sine wave inverters by providing a reliable and compact control solution.

The central component of the EGS002 module is the EG8010, a specialized microcontroller developed by Elegant Inverter Technology. It is designed specifically to generate digital SPWM signals for driving full-bridge or half-bridge inverters

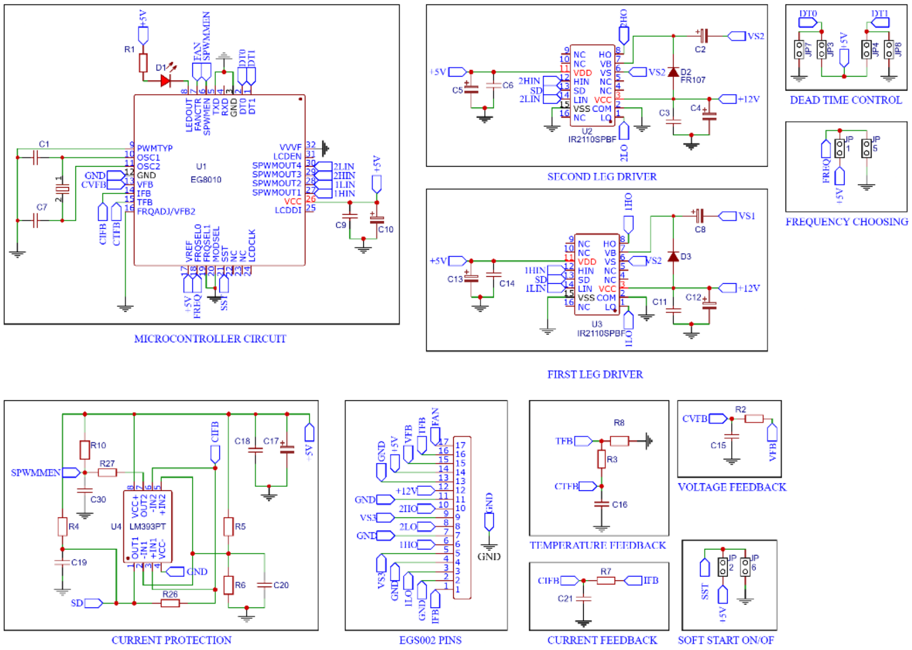

Figure III.8: Internal Block Diagram EGS002 [7]

- ## Pin Description

This table highlights the function of each pin of the EGS002 module [7]

Designator	Name	I/O	Descriptions
1	IFB	I	AC current feedback, overcurrent protection turns on when pin's input voltage is over 0.5
2	GND	GND	Ground
3	1LO	O	Right bridge low sidgate drive output
4	GND	GND	Ground
5	VS1	O	Right bridge high side floating sipply return
6	1HO	O	Right bridge high side gate drive output
7	GND	GND	Ground
8	2LO	O	Left bridge low side gate drive output
9	VS2	O	Left bridge high floating supply return
10	2HO	O	Left bridge side gate drive return

11	**GND**	**GND**	Ground
12	**+12V**	**+12V**	+12V voltage input. (Range : 10V-15V)
13	**GND**	**GND**	Ground
14	**+5V**	**5V**	+5V power supply
15	**VFB**	**I**	AC Output voltage feedback. Referring to EG8010 datasheet for specific function and circuit
16	**TFB**	**I**	Temperature feedback. Overtemperature protection turns on when pin’s input voltage is over 4.3V
17	**FANCTR**	**O**	Connect to the fan control. When detects a temperature over 45°C, FANCTR outputs high level “1” to turn on the fan. When the temperature is lower than 40°C, FANCTR outputs low level “0” to turn off the fan.

Table III.2: EGS002 Pin Functions

III.2.2 Implementation of the Experimental Device

This Figure shows the practical part of the INVERTER:

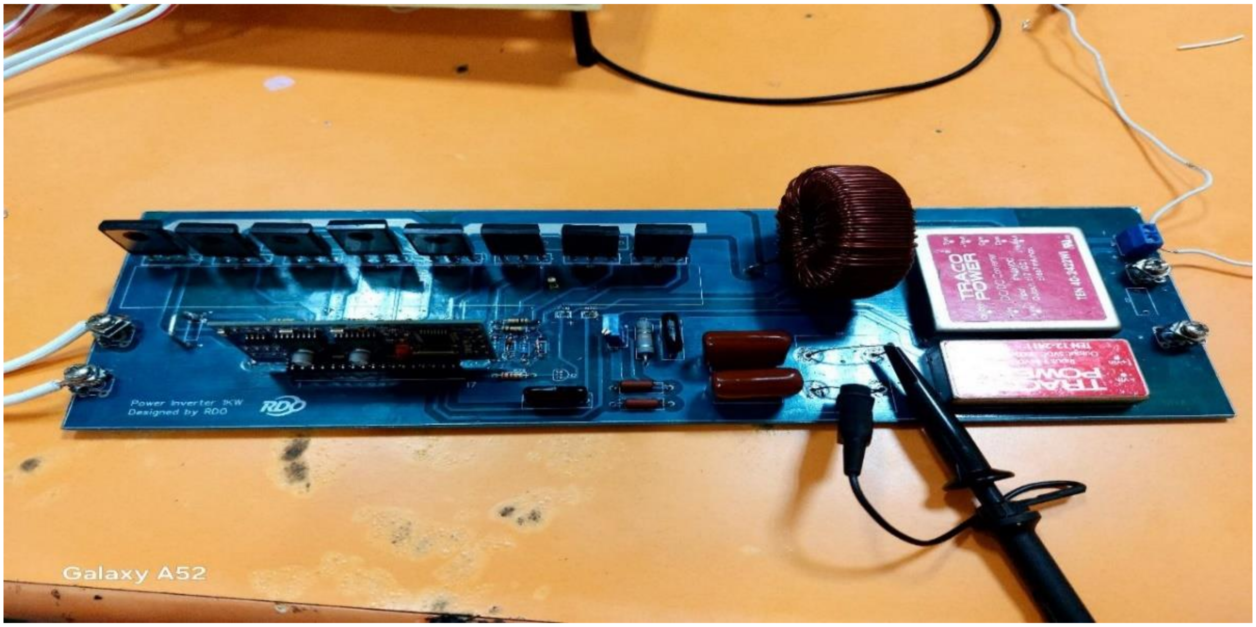

Figure III.9: The DC-AC Inverter Circuit

III.2.3 Practical Results of The Inverter

This oscilloscope capture confirms that the inverter under test is generating a stable and regular sine wave at 50 Hz, with appropriate amplitude and frequency. The clean sinusoidal shape indicates that the SPWM control and LC filtering are working effectively. This result validates the inverter’s performance for supplying AC loads reliably.

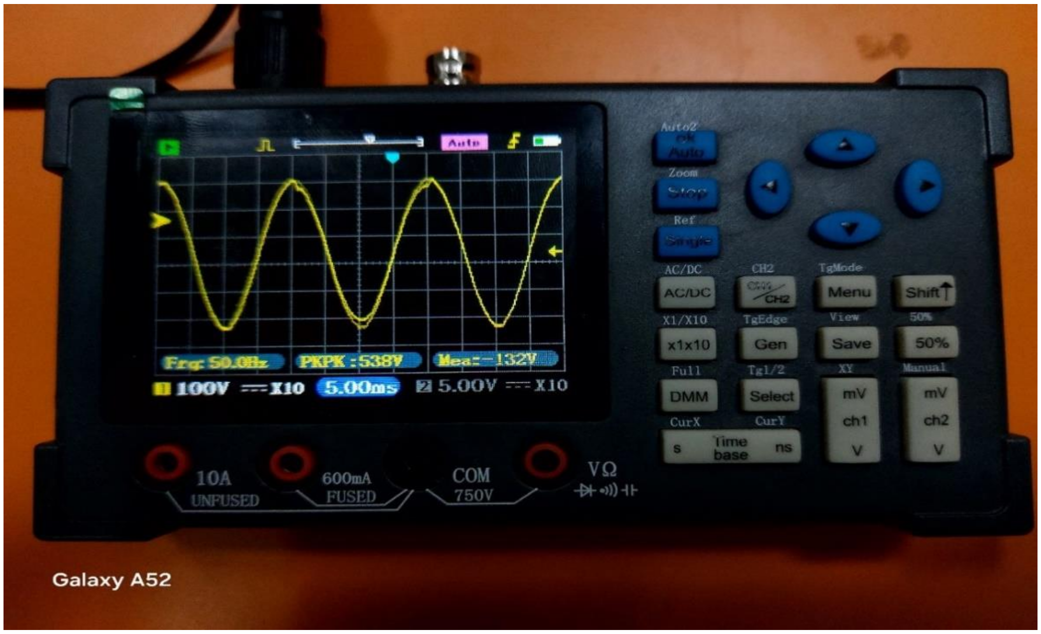

Figure III.10: The Waveform of Inverter Output Voltage

Conclusion

In this project, a 1 Kw solar inverter was designed with a 12VDC input and a 230VAC output at a frequency of 50Hz. The design is based on two main stages: a Boost Converter stage that steps up the voltage from 12V to approximately 380VDC, followed by an H-Bridge stage to generate the required AC voltage. Unipolar Pulse Width Modulation (Unipolar PWM) technique was employed to improve the quality of the output waveform and reduce harmonic noise, instead of the traditional bipolar PWM method.

This choice helps reduce unwanted harmonic components and enhances the purity of the output sine wave. The significance of the adopted solution lies in its ability to produce clean and regulated AC power from a low-voltage DC source (12V), making it suitable for household and industrial load requirements. Results showed that the output sine wave had relatively low total harmonic distortion (THD), thanks to the effectiveness of unipolar PWM in suppressing switching-frequency harmonics.

This also contributed to reducing electromagnetic interference and improving conversion efficiency, confirming the feasibility of the integrated design in providing high-quality power. From a technical standpoint, the main challenges included designing a high-efficiency Boost stage, managing thermal safety parameters, and accurately generating the 50Hz sine wave by controlling the switching timing of the H-Bridge and synchronizing with the reference waveform. Despite these challenges, the adopted solution demonstrated stable performance and acceptable signal quality. In the future, the system can be further developed to enhance power extraction efficiency and improve the system's response to load variations.

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