الجمهورية الجزائرية الديمقراطية الشعبية

Peoples Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

جامعة غرداية

University of Ghardaïa

Registration number
/…../…../…../…../…..

كلية العلوم والتكنولوجيا

Faculty of Science and Technology

قسم الآلية و الكهروميكانيك

Department of Automation and Electromechanics

Dissertation at the end of the study, with a view to obtaining the diploma

Master

Field: Science and Technology.

Sector: Automatic.

Specialty: Automatic and systems.

Theme

Realization of a 1000W Single-Phase Inverter dedicated to Renewable Energy Systems

Presented by:

Cherif Aness
Moulay Abdallah Mohammed

Before the jury composed of:

ZAGAOUI Abdallah	**Prof**	**University Of Ghardaia**	**Supervisor**
BOURAGHDA Skander	**MAA**	**University Of Ghardaia**	**Examiner**
MEDOUKALI Hemza	**MCB**	**University Of Ghardaia**	**Examiner**

Academic year:2021/2022

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Dedication 1

To my dear mother

To my dear father

No honor can match the love that never stoppedto fill me up. God for them, brings good health and long life.

To my brothers and sisters who they have always supported me

To all my colleagues and friends who love me

I dedicate this humble work.

<<Mohammed>>

Dedication 2

I dedicate this modest work to:

To my dear relatives

Those who have sacrificed themselves andhave done everything to achieve what I do

To my brothers and my sisters,my grandparents those who haveshared with me every moments of emotion during the realization of this work

To my family, my loved ones and thosethat give me love and liveliness

<<*Aness*>>

ACKNOWLEDGEMENT

Above all, we would like to thank almighty God for giving us the strength and courage to do this humble research work, and below we would like to thank Professor Mr. ZEGAOUI Abdallah, our supervisor, who made great efforts with his scientific informations, his advices and encouragement.

We express our sincere thanks and deep gratitude to the members of the jury who agreed to review and judge this work.

We also take this opportunity to express our sincere thanks to all the teachers who have contributed to our training during our university career.

TABLE OF CONTENTS

Chapter I Renewable Energy Single-phase Inverters

Chapter II Single-phase Inverter Control Strategies

Chapter III Simulation, realization and results

LIST OF FIGURES

CHAPTER I

CHAPTER II

CHAPTER III

Abstract:

The objective of this project is to design and implement a single-phase inverter dedicated to renewable energy systems. Solar and wind power generation are preferred nowadays as the world is increasingly focusing on environmental concerns. Power inverters, which convert DC current from solar cells into AC for home use, are one of the key technologies for providing efficient AC power. The low-voltage DC source is reversed to a high-voltage AC source in a two-step process. First, the DC voltage is boosted to a much higher voltage. This high voltage DC is then waved to AC voltage using several technic controls to the inverter.

To deliver such performance, the inverters are powered by a simple 16F877A PIC microcontrollers (MCUs) that can achieve a high level of inverter control. The microcontroller is programmed using codes written under CCS compiler software to generate several control techniques: full wave command, sine pulse-width-modulated (SPWM) pulses and MPPT algorithm that are used to drive the H-bridge power switches. By means of the two-footed switches of the 400V DC alternating H-bridge, the voltage is converted into a 220-volt AC voltage.

The design mainly focuses on high-power electronic devices such as personal computers, chargers, and televisions. To build the design, it is first modeled mathematically and then simulated under ISIS/Proteus software, microcontroller is programmed within CCS compiler and finally the results are practically implemented.

- **Keywords:** inverter, microcontroller,fullwave, PWM technique, MPPT.

Résumé :

L'objectif de ce projet de mémoire de master est de concevoir et de mettre en œuvre un onduleur monophasé capable de convertir une tension continue en tension alternative avec un rendement acceptable. Pour atteindre cette efficacité, l’onduleur est piloté par un microcontrôleur PIC 16F877A qui peut assurer un haut niveau de contrôle de l'onduleur. Le microcontrôleur est programmé à l'aide d'un compilateur CCS Compiler intégré et dans un interpréteur CCS spécifique pour générer différents techniques de commandes : la commande pleine onde, la commande MLI et la commande MMPT réservée aux systèmes à énergie renouvelable. Pour cela, L’onduleur H-Bridge coté DC est alimenté par un bus photovoltaïque 400 volts pour donner une tension sinusoidale monophasée 220V et 50 Hertz coté AC. Cette conversion est assurée par les signaux de commande assurés par un microcontrôleur PIC de Microship. En premier lieu, une modélisation mathématique et un dimensionnement des composants de l’onduleur et une compréhension des différentes techniques de commande ont été faites suivi en second lieu par une simulation de l’entité du système sous l’environnement ISIS/Proteus.

Mots clés : onduleur, microcontrôleur,Pleine Onde, PWM Technique, MPPT.

الملخص:

الهدف من مشروع مذكرة الماستر هذا هو تصميم وتنفيذ عاكس أحادي الطور قادر على تحويل الجهد المباشر إلى جهد متناوب بكفاءة مقبولة. لتحقيق هذه الكفاءة ، يتم تشغيل العاكس بواسطة متحكم PIC 16F877A الذي يمكن أن يوفر مستوى عالٍ من التحكم في العاكس. تمت برمجة المتحكم الدقيق باستخدام مترجم CCS متكامل وفي مترجم CCS محدد لتوليد تقنيات تحكم مختلفة: التحكم الكامل في الموجة والتحكم في PWM والتحكم MMPT المخصص لأنظمة الطاقة المتجددة. لهذا الغرض ، يتم تشغيل العاكس H-Bridge على جانب التيار المستمر بواسطة ناقل ضوئي بقوة 400 فولت لإعطاء جهد جيبي أحادي الطور 220 فولت و 50 هرتز على جانب التيار المتردد. يتم توفير هذا التحويل من خلال إشارات التحكم التي يوفرها متحكم Microship PIC. أولاً ، تم إجراء نمذجة رياضية وتحجيم مكونات العاكس وفهم تقنيات التحكم المختلفة ، يليها ثانيًا محاكاة لكيان النظام في بيئة ISIS / Proteus.

الكلمات المفتاحية: العاكس ، الميكروكونترولر ، الموجة الكاملة ، تقنية PWM ، MPPT.

General Introduction

General Introduction:

Renewable energy systems are actually a good tool to provide electrical charges. Electronic devices run on AC power, however, batteries and some forms of power generation produce DC voltage, so it is necessary to convert the voltage to a source that the devices can use. Hence a power rating inverter is needed for the smooth running of electrical and electronic appliances. Most marketed available inverters are actually square or semi-square wave inverters. Electronic devices powered by this inverter will be damaged due to harmonic contents [1]. Available sine wave inverters are expensive and their output is not good. To get a pure sine wave, we have to apply sine pulse width modulation (SPWM) technique. This technology has been the primary choice in power electronics due to its simplicity and is the most widely used method for inverter application [2]. To generate this signal, the triangular wave is used where the carrier signal is compared with the sine wave at the desired frequency.

Advances in microcontroller technology have made it possible to perform functions previously performed by analog electronic components. With the ability to multitask, today's microcontrollers can perform functions such as comparator, analog-to-digital conversion (ADC), input/output (I/O) setting, and counters/timers, among others, replacing analog components assigned to each specific task, enabling significantly reduces the number of components in the circuit. Flexibility was also introduced into the design using a microcontroller with the possibility of flash programming/reprogramming of tasks [3]. The proposed approach is to replace the traditional method with a microcontroller. In this project a PIC16F877A microcontroller was used. It reduces the circuit complexity of the single-phase full bridge inverter [4].

This master thesis focuses on the design and testing of a prototype DC-to-AC converter that efficiently converts a DC voltage source into a high voltage AC source similar to power supplied by an electrical outlet (220 V, 50 Hz) with a power rating of 1000 Watts. The method by which DC power is reversed to low voltage is completed by converting a 400 volts DC photovoltaic bus voltage into an 220 volts 50 Hertzs AC waveform using three control techniques: Full wave, pulse width modulation and MPPT techniques. Another way to complete the desired result is to convert low-voltage DC power to alternating current, and then use a transformer to increase the voltage to 220 V [5].

This master thesis focused on the first described method, specifically converting a high voltage DC source into an AC output. In this way, how inverter controls are implemented using a numerical approach using a microprocessor to the control system and the effectiveness and efficiency of the selected control technique are detailed. The H-bridge inverter will be also implemented and simulated under ISIS/Proteus software and controlled via algorithms stored into PIC microcontroller [1].

Chapter I

Renewable Energy Single-phase Inverters

I- Introduction:

The photovoltaic (PV) inverter is a power electronic converter witch transforms DC PV energy from PV generator to AC energy even connected to the power network or destined for off-grid uses. The main objective of this study is to size, simulate, design and realize a one kilowatts single-phase PV inverter which convert an input DC voltage of 400 V to an output AV voltage of 220 V at a frequency of 50 Hz. Several control types of PV inverter power switches are involved and so experimented in order to have an acceptable output voltage signal.

The PV inverter designed in this study, works with several commands. Full wave, offset command, Pulse Width Modulation control and Maximum Power Point Tracking (MPPT) control are considered to generate an alternative voltage with a power of 1 kW. These several control technics are used as a switching pulse to turn on and off the MOSFET or IGBT in order to generate an alternating current waveform at the output of the PV inverter. This is performed by the use of inverter-based PIC16F877 microcontroller programmed via the PIC CCS COMPILER software which is used to induce the microprocessor to form a sine wave to the corresponding load. Using this microcontroller, digital component, improves operations, reduces system components, reduces system cost, and increases efficiency.

First, the H-bridge inverter has been simulated under PROTEUS/ISIS software in order to pass easily to experimental model. The above cited of several control technics are implemented on the microcontroller which generates the command signals to several power switches in the PV inverter.

I.1- Semiconductor switches:

The principle of converters consists in switching currents between adjacent meshes, which requires the use of components making it possible to perform the switch function. Ideally, the closed switch will have practically zero voltage across its terminals, while the current will be fixed by the rest of the device. On the other hand, the open switch will have a voltage imposed from outside on its terminals, but it will not be crossed by any current.

Power semiconductor elements can be classified according to their controllability. For the most used elements, three classes of power semiconductors can be defined:

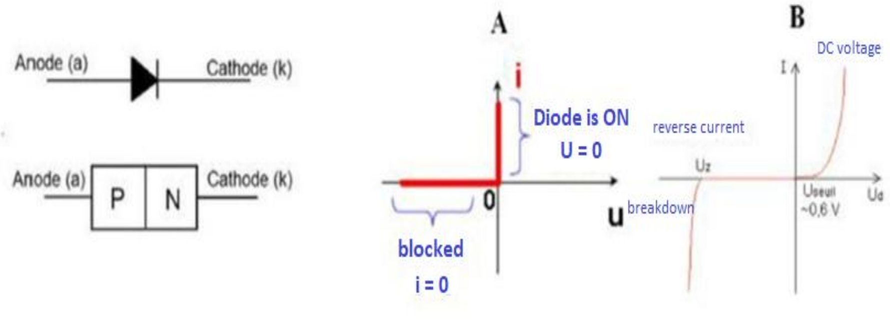
- ✓ Non-controllable elements (diodes)
- ✓ Controllable elements on closing (thyristors, triacs)

- ✓ Controllable elements on closing and opening (bipolar transistors, MOS transistors, IGBT, GTO).

Currently, the most widely used power electronic switches are diodes, thyristors, GTO-thyristors, bipolar transistors, MOSFETs, and IGBTs.

I.1.1-Diode:

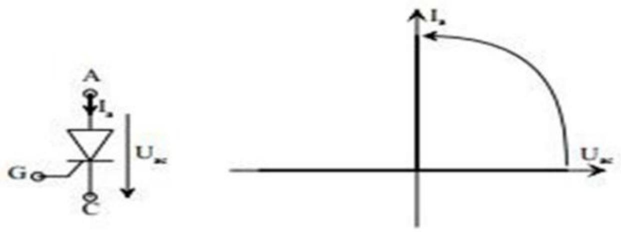
The diode is an uncontrolled rectifier element consisting of a PN junction; it allows the current to pass only in one direction and only if the voltage applied to it is positive terminal.(Figure I:.1illustrates the electrical symbol of the diode and its current-voltage characteristics in both direct and reverse biasing modes).



FigureI.1 : Symbol and diode switching

I.1.2-Thyristor:

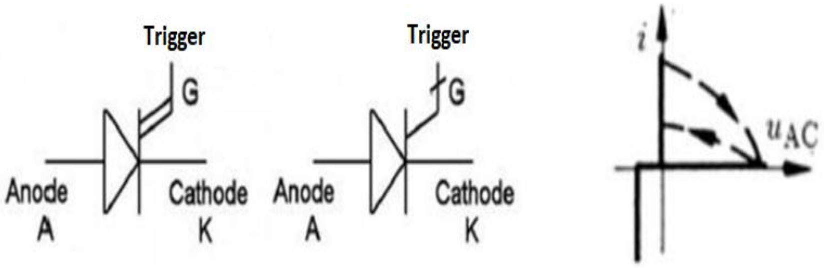
Thyristor is a controlled diode and more specifically a controlled rectifier, hence its name (SCR), which means ‘Silicon Controlled Rectifier’. This component is triggered when the voltage across its terminals is positive, and a trigger pulse is applied to its gate. The blocking of the thyristor is spontaneous, when the current which crosses it becomes zero. At this time, and to avoid any untimely re-ignition, the voltage applied to the thyristor must be negative.(Figure I-2 presents the thyristor symbol and its ideal I-V characteristic).



FigureI.2 : Thyristor symbol and switching .

I.1.3-GTO Thyristor

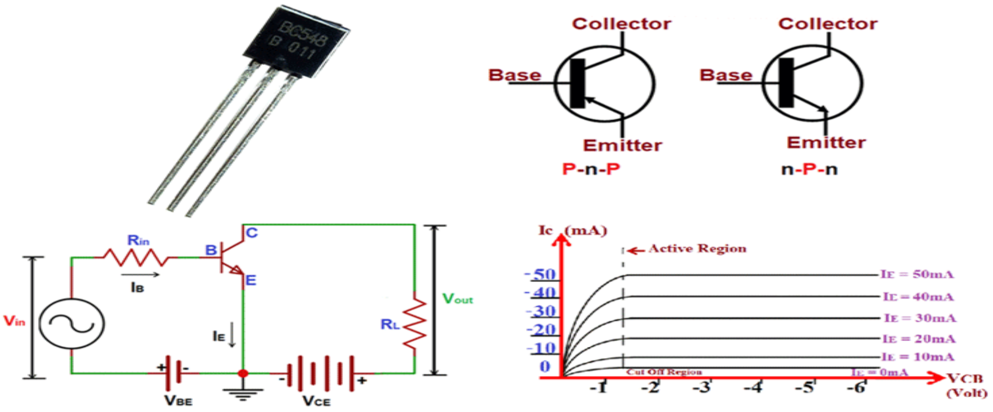
The GTO thyristor (Gate Turn Off thyristor) is an evolution of the classic thyristor. It is controllable on opening and closing unlike classic thyristors. It is used for switching high powers: voltages of 2500 V, 4500 V , and 6000 V and currents of 600 A to 6000 A approximately. It is widely used to control the traction motors of a train because it is able to withstand very high powers. [6].(Figure I-3shows the GTO thyristor symbol and its ideal characteristic). I-V characteristic is shown in figure I.3.



FigureI.3: Symbol and characteristic of GTO thyristor.

I.1.4-Bipolar Transistor

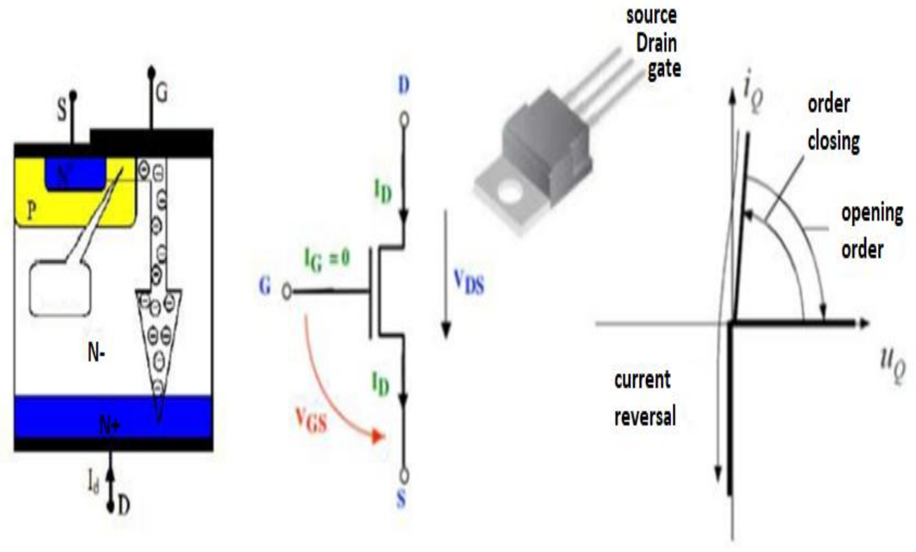
Bipolar transistor is a current controlled switch. It requires a current to be injected into its base to make it conductive. It is almost no longer used in power electronics because the gain being low. In figure I-4, one can see the symbols of both NPN and PNP bipolar transistors, the base current characteristic according to the base voltage and the characteristics representing the collector current as function of the voltage across emitter-collector of the bipolar transistor.



FigureI.4: Symbol and characteristic of bipolar.

I.1.5-MOS transistor:

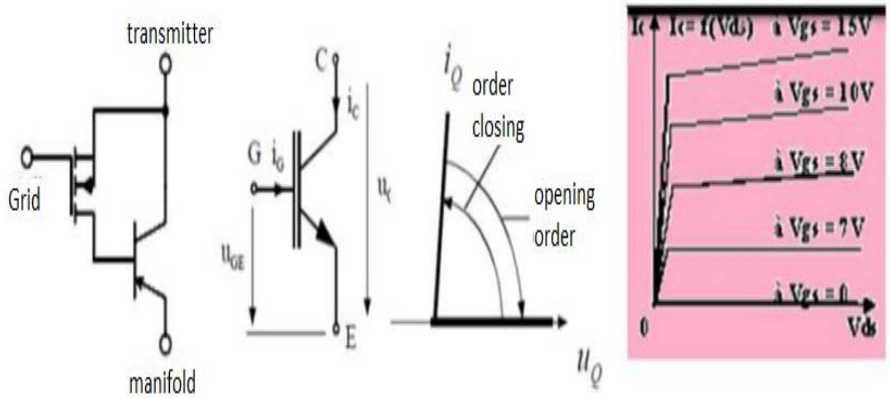
The MOS (Metal Oxide Semiconductor)transistor is a field effect transistor (Field Effect Transistor) sometimes called MOSFET, has the advantage of a relatively simple control which requires little power but can operate at high frequency. Indeed, when a voltage V_{GS} is applied between the gate and the source greater than a threshold voltage V_{th}, a channel is created and connects the two zones N+ and N-. This allows electrons to flow from the N+ doped source to the drain, see figure I.5, the MOSFET therefore enters into conduction. To block it, it is only necessary to remove the channel by bringing the voltage $V_{GS}$to a value lower than the threshold voltage V_{th}[7]. In figure I-5, we observe both the symbol and the characteristic of the MOSFET power switch.



FigureI.5: principle, symbol and characteristic of the MOS transistor.[7]

I.1.6-IGBT (Insulated Gate Bipolar Transistor)

The IGBT is a hybrid transistor, combining a MOSFET type field effect transistor at the input and a bipolar transistor at the output. This structure allowed it to combine the advantages of the bipolar transistor (low voltage drop in the on state, direct voltage) with those of MOSFET. Symbol and characteristic of the IGBT are presented in figure I-6.



FigureI.6 : Symbol and characteristic of the IGBT.

I.1.7-Main Differences between IGBT and MOSFET:

IGBT and MOSFET are both voltage-controlled but, one main noticeable difference is that IGBT is a 3-terminal device and MOSFET is a 4-terminal device. Although they are very similar, both of them have a few differences between the two transistors:

1. IGBT conducts charges through electrons and holes whereas MOSFET carries charges through electrons.
2. IGBTs are better in power handling than MOSFETs.
3. IGBTs operate at a higher voltage rating than MOSFETs.
4. Since MOSFETs have a thin metal oxide layer to separate the gate terminal, they are susceptible to electrostatic discharges. IGBTs, on the other hand, are more tolerant towards high voltages.
5. IGBTs are preferred for narrow load variations, whereas MOSFETs are preferred for wide load variations.
6. IGBT is preferred for low frequency, high temperature, and low duty cycle applications whereas MOSFET is preferred for high frequency, low temperature, and large duty cycle applications [7].

Table 1 summarizes the comparison between these two types of power switches.

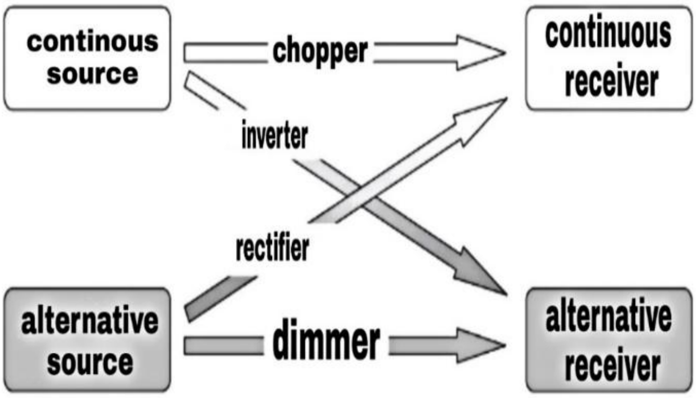
Table 01: Comparison between IGBT and MOSFET.

Parameters of Compa	**IGBT**	**MOSFET**
Terminals	Its terminals are collector, emitter, and gate.	Its terminals are the source, drain, gate, and body.
Charge carriers	Electrons and holes both are carriers of charge.	Electrons are the major conductors.
Junctions	It has PN junctions.	It does not have PN junctions.
Switching frequencies	It has a lower switching frequency than MOSFET.	It has a higher switching frequency.
Electrostatic discharge	It is highly tolerant to electrostatic discharge.	Electrostatic discharge may be harmful to the metal oxide layer.

IGBTs and MOSFETs are fast replacing the older types of transistors and other mechanical devices used in electrical circuits. Their high efficiency and high switching frequency are strongly making them an indispensable part of the circuit since both are voltage controlled a choice between them is often difficult. Even though an IGBT is a cross between a MOSFET and a BJT, it is not the best answer in all situations. MOSFETs have also been widely improved over the years and have shown to be a more dynamic device. However, as IGBTs run efficiently at high voltages and MOSFETs run amazingly well at low voltages, the choice often depends on what output requires from the device [7].

I.2 - Power converters:

A static power converter is a system for adapting the source of electrical energy to a given receiver. The inverter transforms the direct voltage (DC) of the batteries, or any DC source, into alternating voltage to supply AC charges. Depending on both the type of application to be supplied and the nature of the power source, there are several families of static converters as shown in figure I-7:



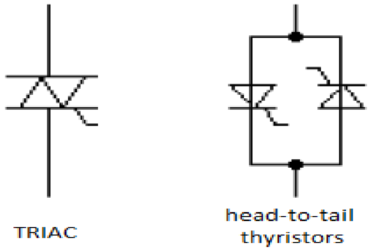
FigureI.7 : Families of static converters.**[8]**

I.2.1.1- Cycloconverter (AC/AC)

The dimmer is an assembly which makes it possible to vary the value of the effective voltage at the terminals of a load such as a motor without changing the frequency of the alternating wave of the source. This assembly is very common in the domestic field, in particular at the level of light dimmers for halogen lamps [8].

FigureI.8: dimmer's symbol and voltage input-output signal.[8]

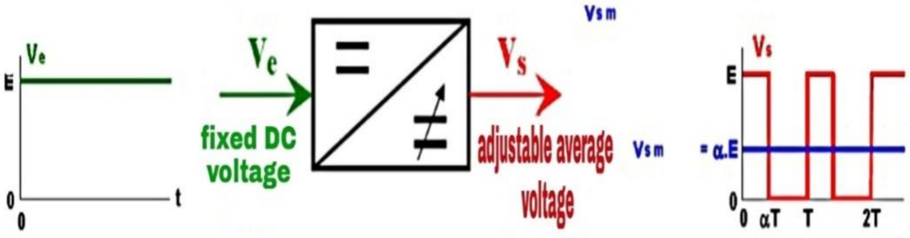
The basic structure relies on an electronic switch capable of driving in both directions in the on state and to support a voltage also in both directions in the off state. This switch can then be made: Either with 1 single component: the triac, either by assembling two head-to-tail thyristors as indicated in figure I.9.



FigureI.9: Triac and head-to-tail thyristors.[8]

I.2.1.2- DC to DC Converters (Choppers)

The chopper supplies a DC load under an adjustable DC voltage from a fixed DC source.This source may, for example, be an accumulator battery or come from another prior conversion such as AC to DC converter (rectifier) or PV generator. A mean value voltage of variable is obtained by establishing and periodically interrupting the power supply to the load by the source thanks to electronic switches as presented in figure I.10.



FigureI.10 : Chopper’s symbol and voltage input-output signal.[8]

I.2.1.3-AC to DC converters (RECTIFIER)

Rectification is the conversion of an alternating voltage into a direct voltage. It is used to supply a receiver continuously from the AC power distribution network.

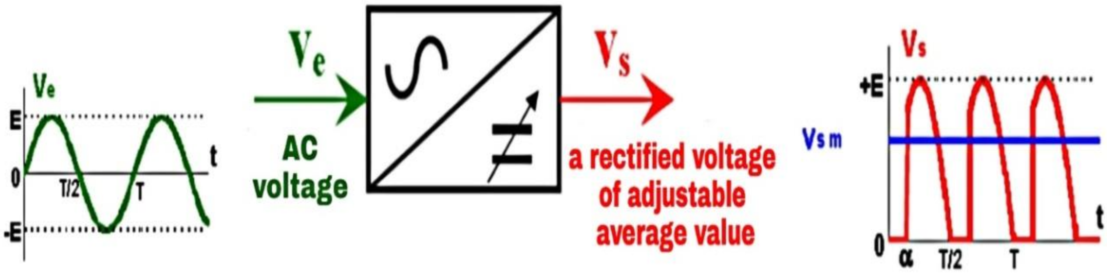
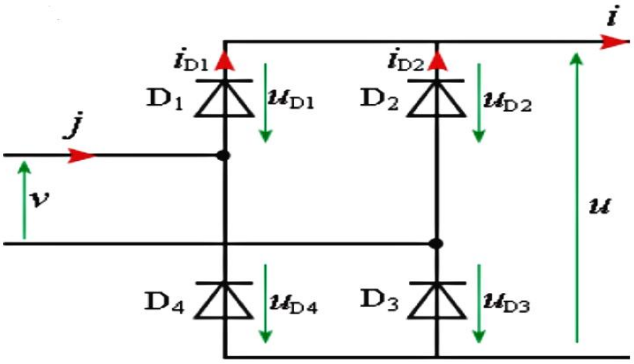


Figure I.10A: rectifier’s symbol and voltage input-output signal.[8]

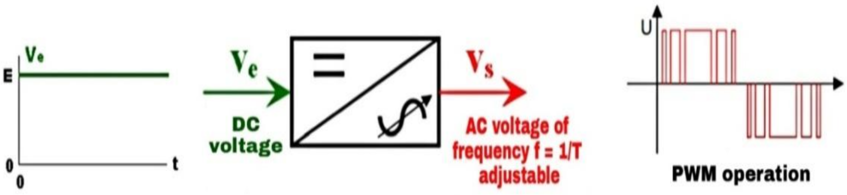
The controlled rectifier is made up of bridge-mounted thyristors. Figure I.11 presents the uncontrolled rectifier made up of bridge diodes. Here in single-phase bridge (called GRAETZ bridge).



FigureI.11: Single-phase diodes bridge rectifier.[8]

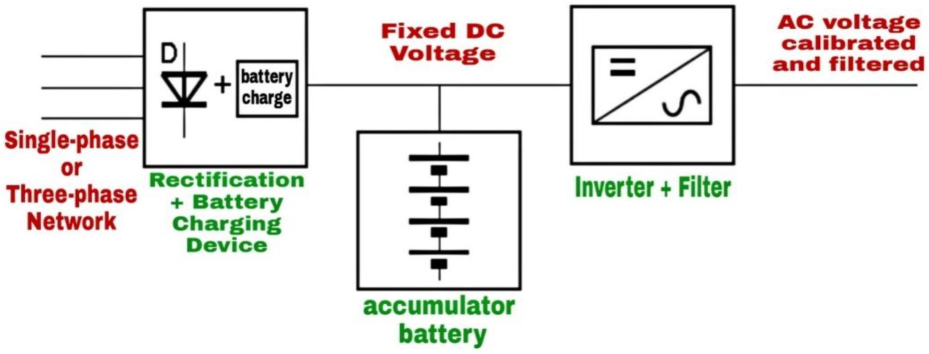
I.2.1.4- INVERTER (DC/AC)

A DC-AC converter, see figure I.12, allows us to obtain an AC voltage (possibly adjustable in frequency and amplitude) from a DC voltage source.



FigureI.12: Inverter’s symbol and voltage input-output signal.[8]

The back-up inverter for computer equipment ensures continuity of supply in the event of power outages. It is also used to filter any network voltage faults (interference or voltage surges when used as active filters) [8].The structure includes an accumulator with charging device and aninverter with filtered output (diagram below in figure I.13):



FigureI.13: A battery with charging device and an inverter with filtered output.[8]

I.2.2- Classification of Inverters:

There are several inverter designs, each corresponding to a specific type of application or providing the desired performance.Inverters are generally classified according to the switching modes of their switches.

I.2.2.1- Autonomous inverters:

This is a system that requires components controlled both on closing and on opening of variable frequency. It does not always need an electrical network to operate, for example a travel converter that is plugged into the cigarette lighter socket of a car uses the vehicle's 12 V DC to generate 120 or 230 V, alternating in 50 or 60 Hz [9].

I.2.2.2- Non-autonomous inverters:

A non-autonomous inverter is an all-thyristor rectifier assembly (Graetz Bridge) which, in natural switching assisted by the network, to which it is connected, allows operation as an inverter.The main application of this type of inverter is in drives for very high power synchronous motors where thyristors are often the only usable components[8].

- **Role of Inverter:**

The inverter ensures the protection of many devices in the event of a power cut. This is the case, for example, of industrial devices, computer peripherals and computers. This type of electronic device can be considered an excellent way to protect devices against lightning, micro-cuts, voltage variations, electrical noise and power outages.

I.3- Single-phase inverter:

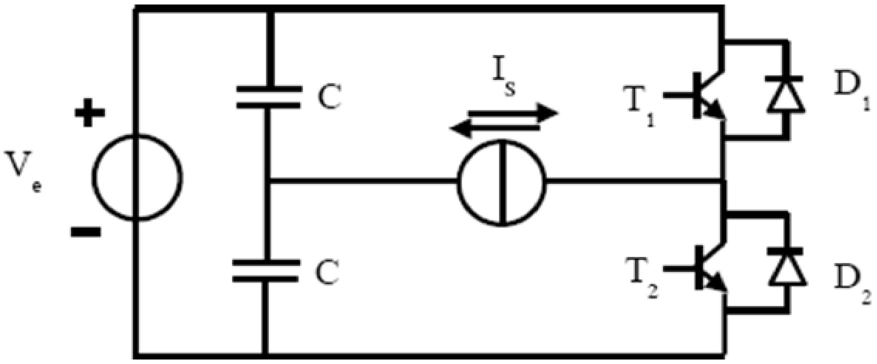
Inverters can be classified according to their three-phase or single-phase regimes. The study carried out must focus on the study, the sizing and the realization of a single-phase inverter dedicated to renewable energy systems. Such inverter is composed by power switchesthat convert power from a DC voltage source which should be renewable in our case study. One can use either bridge or half-bridge mounting for inverter conception.

I.3.1- Single-Phase Half Bridge Inverter:

It consists of a single switching cell. In this type, two bidirectional current switches and one directional voltage switch are needed [10].

As indicated in figure I.15, Veis a DC voltage source, reversible in current and T1, T2 are two electronic switches, controlled periodically, t indicates the time and T is the period of switching of the power switches (T1 and T2):

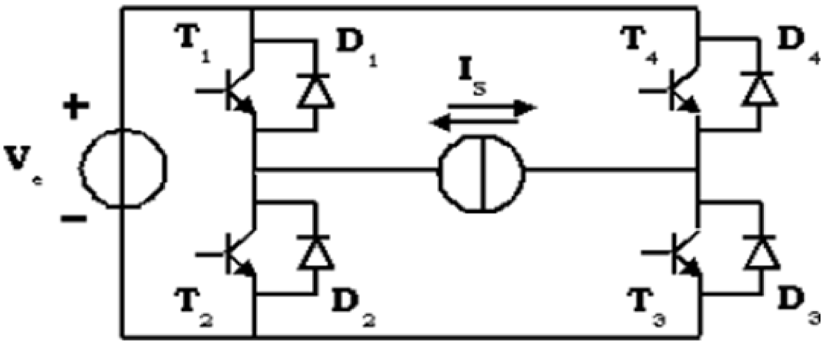
- ➢ 0 < t < T/2 : K1 is Closed and K2 is Open : Us = +Ve (>0V).
- ➢ T/2 < t <T : K1 is Open and K2 is Closed : Us = -Ve (<0V).
- ✓ The voltage *Us* is alternating
- ✓ The current *Is*is alternating.



FigureI.15: Half-bridge single-phase inverter.[10]

I.3.2- Single-phase full-bridge inverter:

To this type, inverter has two switching cells. So we have four switches with anti-parallel diodes on each switch.The output voltage can take the value $+V_e$,$-V_e$, or 0V on the period switching. This implies a bridge structure as indicated in figure I.16[10].



FigureI.16: Single-phase full-bridge inverter.[10]

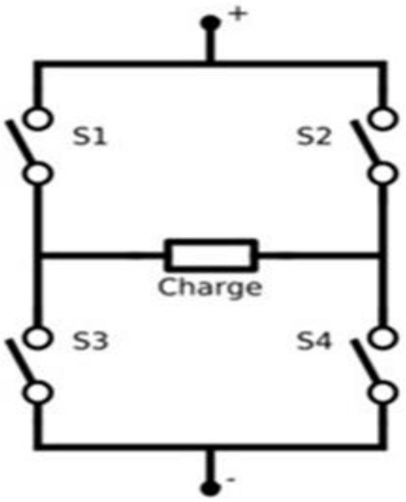
- ➢ 0 < t < T/2 : K1 and K3 are closed : Us = +Ve (>0V).

- ➢ T/2 < t <T : K2 and K4 are closed : Us = -Ve (<0V).

I.4- Operating Principle:

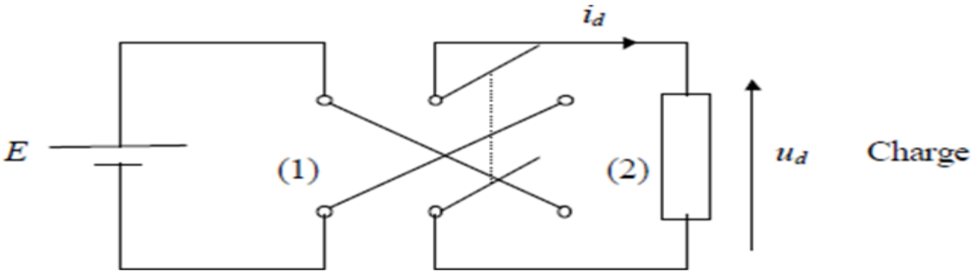
Inverters are based on an H-bridge structure, usually consistof electronic switches such as power transistors or thyristors. By a set of appropriately controlled switching (generally pulse width modulation), the source is modulated in order to obtain an alternating signal of desired frequency.

The **H-Bridge** is an electronic structure used to control the polarity across a dipole. It is made up of four switching elements generally arranged schematically in an H-shape hence the name as presented in figure 1.17. The switches can be electric relays, transistors, or other switching elements depending on the intended application [10].



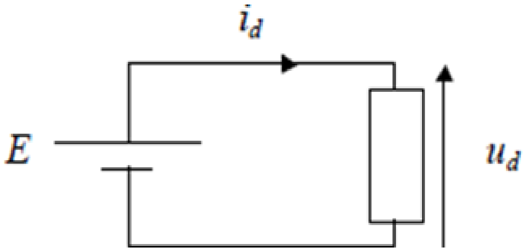
FigureI.17: Circuit of an H-bridge inverter, $S_{i\ (i=1,2,3,4)}$ is power switch.[10]

To make an **autonomous inverter**, all you need is an inverter switch K and a DC voltage source E.



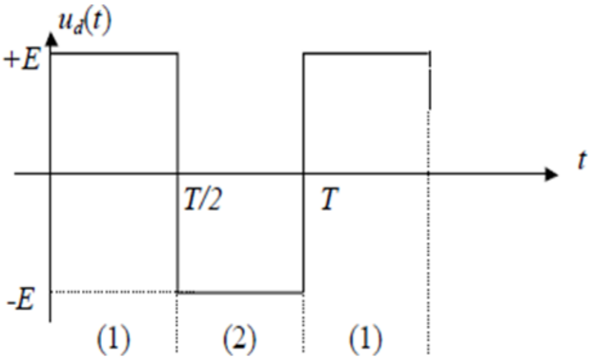
FigureI.18 : Principle of the autonomous inverter

- **When K** is in position (1), we obtain the assembly of figure I.18.



FigureI.19 : K in position (1).

- ✓ Let : Ud (t) = E .
- ➢ When K is in position (2) , we get: Ud (t) = -E .
- ➢ Figure I.19 gives the shape of Ud(t) over a full period of operation.



FigureI.20: Voltage $U_d(t)$ at inverter output.

I.5-Invertercontrol techniques:

I.5.1- Symmetrical control:

This type of control is called "simultaneous control" because the switches K1 and K3 are controlled simultaneously (the same for the switches K2 and K4) in the H-Bridge. It is also called "symmetrical control" because the voltage V of the supplied charge is equal to +E or –Ewhere E is the voltage of the DC source [10].

I.5.2- Offset command:

The shifted control makes it possible to partially eliminate the harmonics and therefore improves the converter. Moreover the pace of the current is felt. At the level of the command, it suffices to shift the closure of the various switches in a precise order.

I.5.3- PWM control (Pulse Width Modulation):

PWM control is most frequently control technique used with inverters (scalar and vector PWM). Its purpose is to reduce current harmonics when the load is inductive (electric motors for example). This is a natural filtering (without using additive filters) only performed by the control strategy [10].

I.6- CONCLUSION:

This study allowed us to understand the principle of a control techniques among several existing alternatives to ensure the inverter switch control. We have studied the four static converters which play a very important role in converting electrical energy, the classification of inverters and we have said that inverters are generally classified according to the switching modes of their switches. We also studied the single-phase inverter and gave a general view of the three inverter controls.

Chapter II

Single-phase Inverter Control Strategies

II- Introduction

Inverters are used in large applications, including situations where low-voltage DC sources such as batteries, solar panels, or fuel cells must be converted so that devices can run from AC power. An example in this case is converting electrical energy from a car battery to power a computer, mobile TV or mobile phone.

The method by which DC power is reversed for low voltage is completed in two steps. The first is to convert low-voltage DC power into a high-voltage DC source, and the second step is to convert the high-voltage DC source into an AC waveform using pulse width modulation. Another way to complete the desired result is to convert low-voltage DC power to alternating current, and then use a transformer to increase the voltage to 220 volts. The third one is to convert the desired high voltage ensured by PV generators. This project focused on the third described method and specifically the conversion of a high voltage renewable DC source into an AC output.

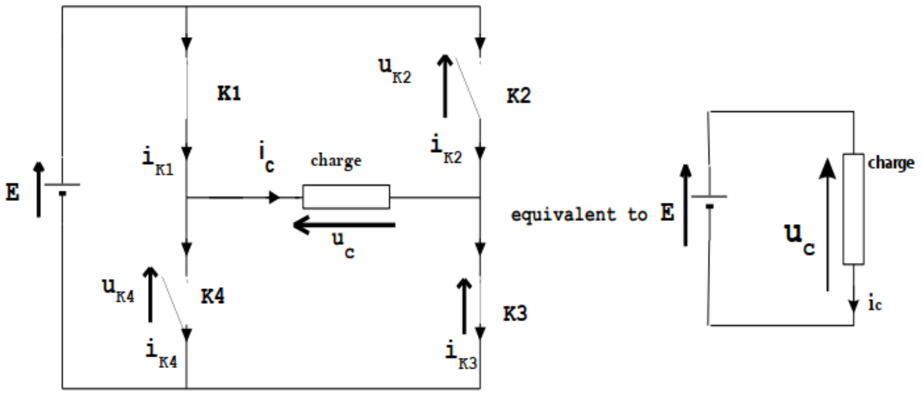
II.1- Different types of command Techniques

II.1.1- Full wave Control technique (Commande pleine d’onde in french)

This command boils down to command the switches K1 and K3 to closing for a half-period then commanding K2 and K4 during the second half-period switching (We assume that switches not controlled on closing mode but they are in fact controlled on opening mode).

The analysis is divided into two phases:

- ***1^st^ phase:*** K1 and K3 are controlled on closing from time 0 to T/2, where T is the sampling time switching. During this time K2 and K4 are open. We therefore obtain the following very simple equivale diagram [12] [13]:

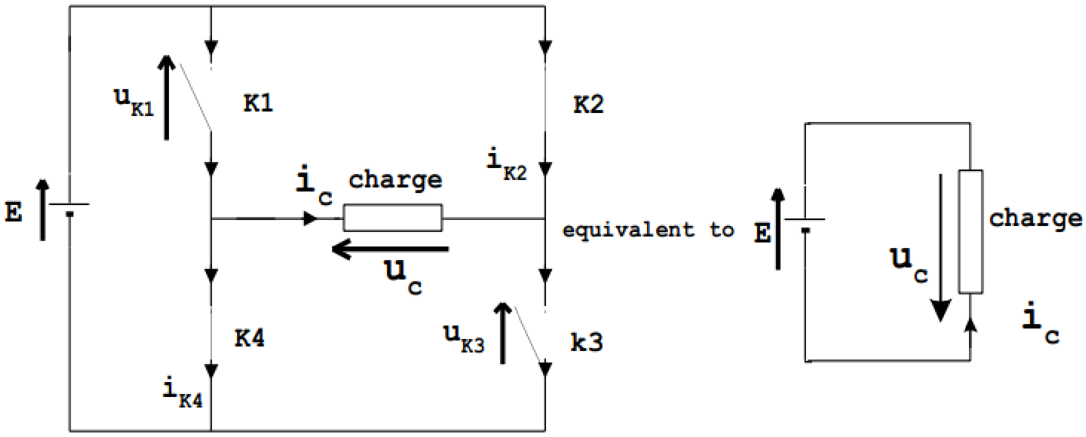


FigureII.1: H-Bridge of the symmetrical control in 1st phase of operating of inverter .[12]

The voltage across the terminals of the load will therefore have the value of $U_c = +E$.

- ***2***

- ***2^{nd}phase :***K2 and K4 are in turn on mode at the closing of time T/2 at T. The equivalent diagram will be as follows:

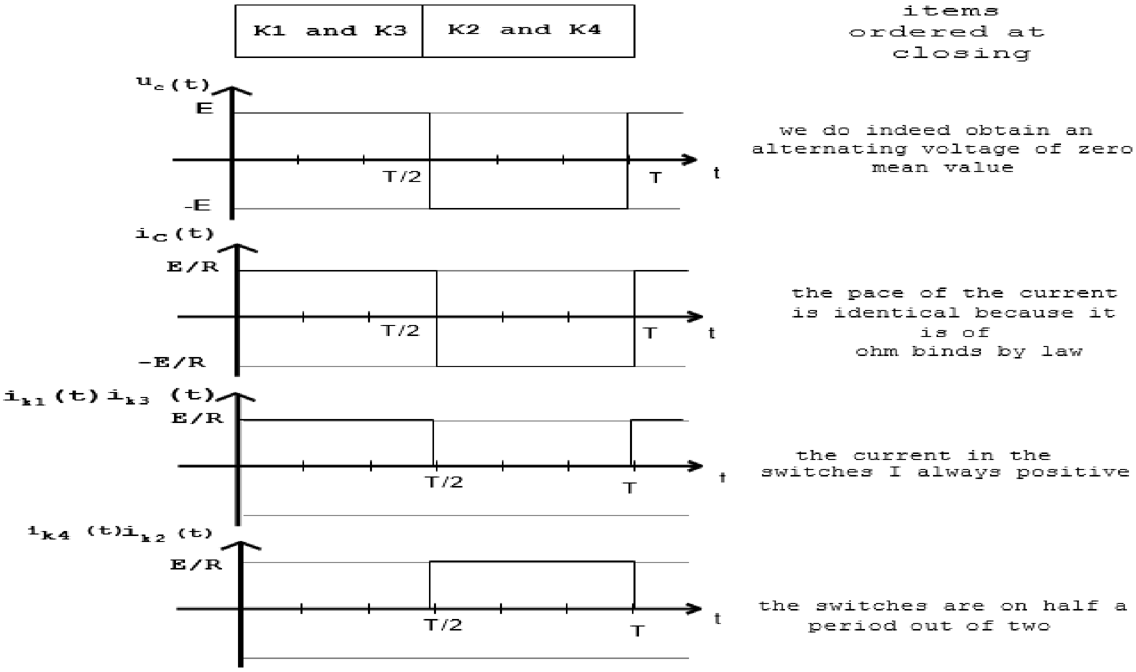


FigureII.2 : Bridge H of the symmetrical control[13]

During this operating phase, we have ***U_c = -E***

It is therefore sufficient to draw oscillograms according to the chosen load:

a) For a resistive load R:



we do indeed obtain an alternating voltage of zero mean value

the pace of the current is identical because it is of ohm binds by law

the current in the switches I always positive

the switches are on half a period out of two

FigureII.3:full wave voltage

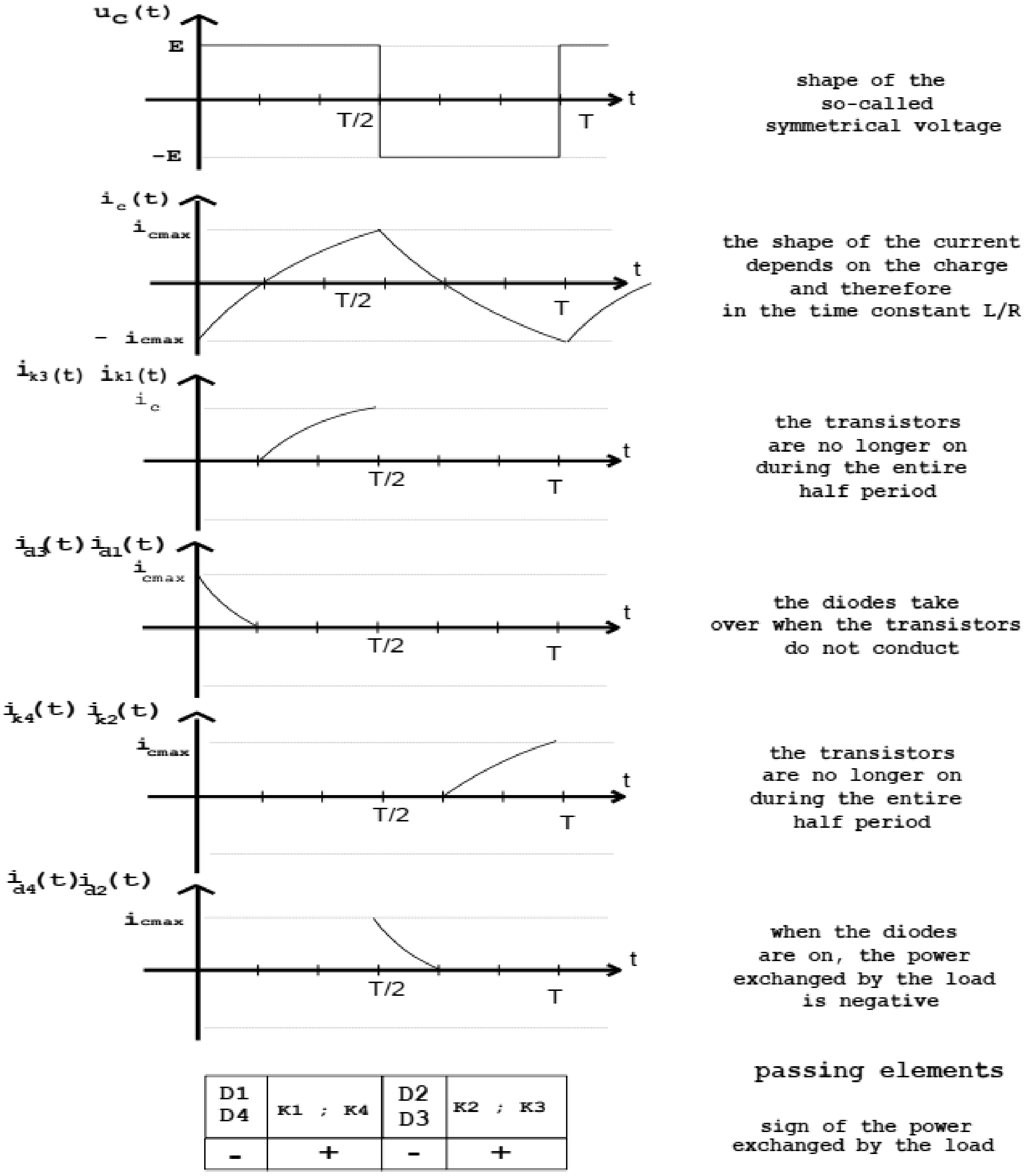
The effective value of the voltage at the terminals of the resistive charge is fixed by the supply voltage.So, we get the following values:

U_c=+E, U_c = - E within a mean value <U_c> = 0 V as indicated in figure II.3.

b) Inductive load (charge RL):

The inductive charge simulates an AC motor, transformers and so on. We realize that for this load, only the shape of the different currents changes.We see that diodes are unnecessary and they find their function in the case of an inductive load. They avoid a discontinuity in the conduction of the current and therefore take over from the transistors, when these, although controlled on closing, cannot conduct because they are unidirectional.In addition, it should be noted that the load supplied from the power to the power supply when the diodes are on. These are **recovery phases**.These recovery phases require the use of current-reversible voltage supplies[12].

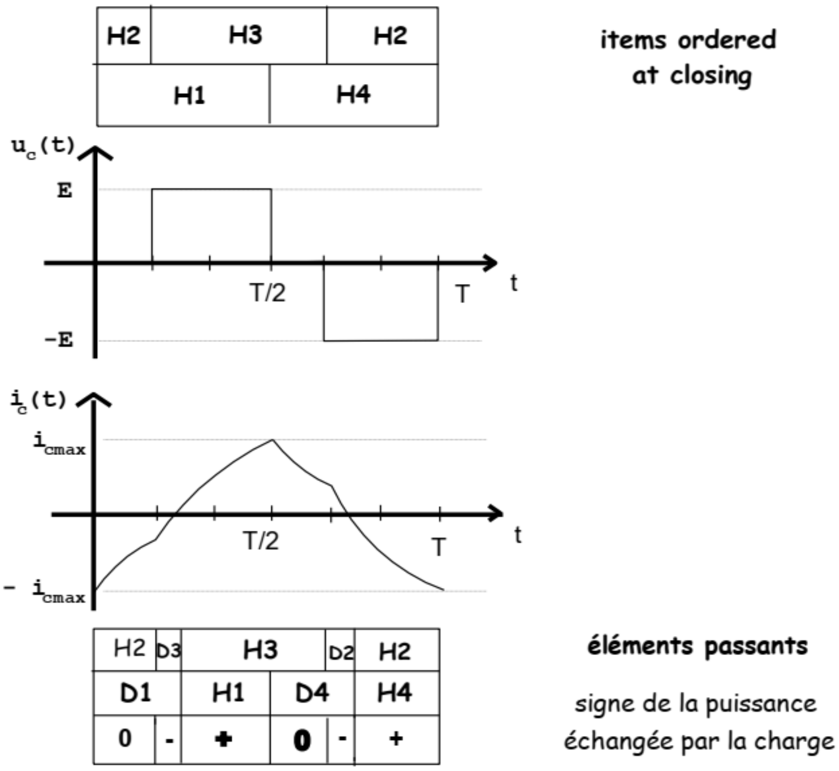
Figure II.4 shows the wave forms of different electrical parameters of the inverter components.



FigureII.4: Wave form infull wave control.[12]

II.1.2-The offset control technique (commande décalée in french)

This control, more sophisticated in its design, is a first step towards obtaining a sinusoidal current. Spectral analysis shows that we would see in the previous command that the voltage, as well as the current, are rich in harmonics which poses problems for use with motors (Joule losses, pulsating torques, etc.).The shifted control makes it possible to partially eliminate these harmonic effects and therefore improves the converter. Besides, the pace of the current is affected.At the control level, all we have to do is stagger the closing of the various switches in a specific order (order given below). We plot the oscillograms againin figure II.5 [11-12].



FigureII.5: Wave forms under the offset command current.[11]

The power exchanged by the charge has one more phase with the shifted command. Here, the load voltage has three levels voltage in the switching period: ***+E**, **0*** and ***–E*** volts. During two time intervals, it is zero: this is the freewheel operating phase. During these intervals, the energy stored by the coil of inductance is transferred to the resistance because the voltage at the terminals of the charge is zero. In addition, we find the recovery phases.

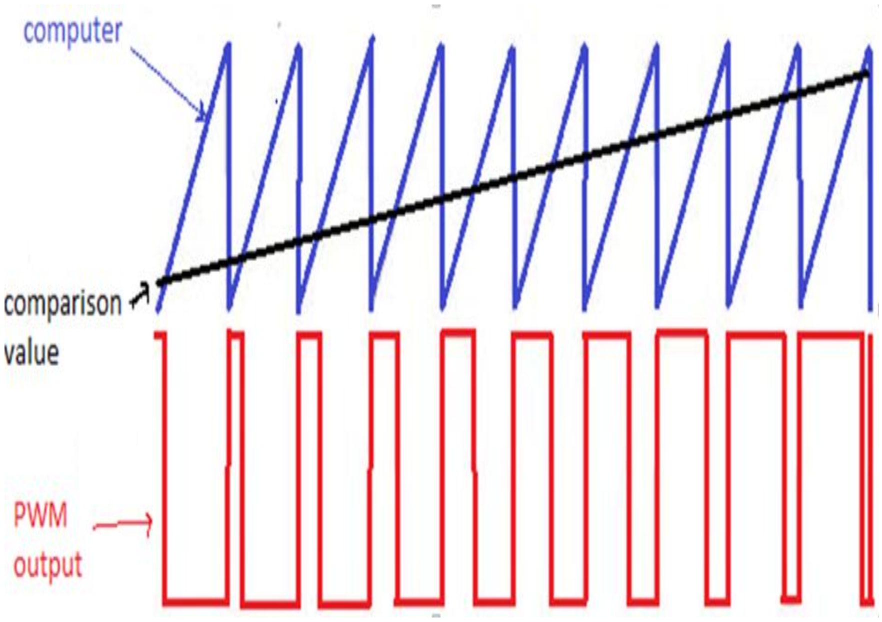
II.1.3- Pulse Width Modulation (PWM):

PWM (Pulse width Modulation) orMLI in french (*Modulation de la Largeurd'Impulsions*), is used to keep the output voltage of the inverter at the rated voltage (110V AC / 220V AC) (depending on the country) irrespective of the output load. In a conventional inverter the output voltage changes according to the changes in the charge. To nullify effect caused by the changing charge, the PWM inverter correct the output voltage according to the value of the charge connected at the output. This is accomplished by changing the width of the switching frequency generated by the oscillator section. The AC voltage at the output depend on the width of the switching pulse. The process is achieved by feed backing a part of the inverter output to the PWM controller section (PWM controller IC). Based on this feedback voltage, the PWM controller will make necessary corrections in the pulse width of the switching pulse generated at oscillator section. This change in the pulse width of the switching pulse will cancel the changes in the output voltage and the inverter output will stay constant irrespective of the load charge variations [14].

II.1.3.1. PWM signal generation module:

A PWM signal is a signal whose duty cycle varies. Analog to digital conversion (ADC) is a simple and efficient way to generate an analog voltage with a microcontroller. Few of them are indeed equipped with an ADC.

The principle is to generate a logic signal (worth 0 or 1), at a fixed frequency but whose duty cycle is controlled digitally. The average of the output signal is equal to the duty cycle: it is therefore sufficient to put a filter in order to obtain the desired analog value, [14], as indicated in figure II-6.

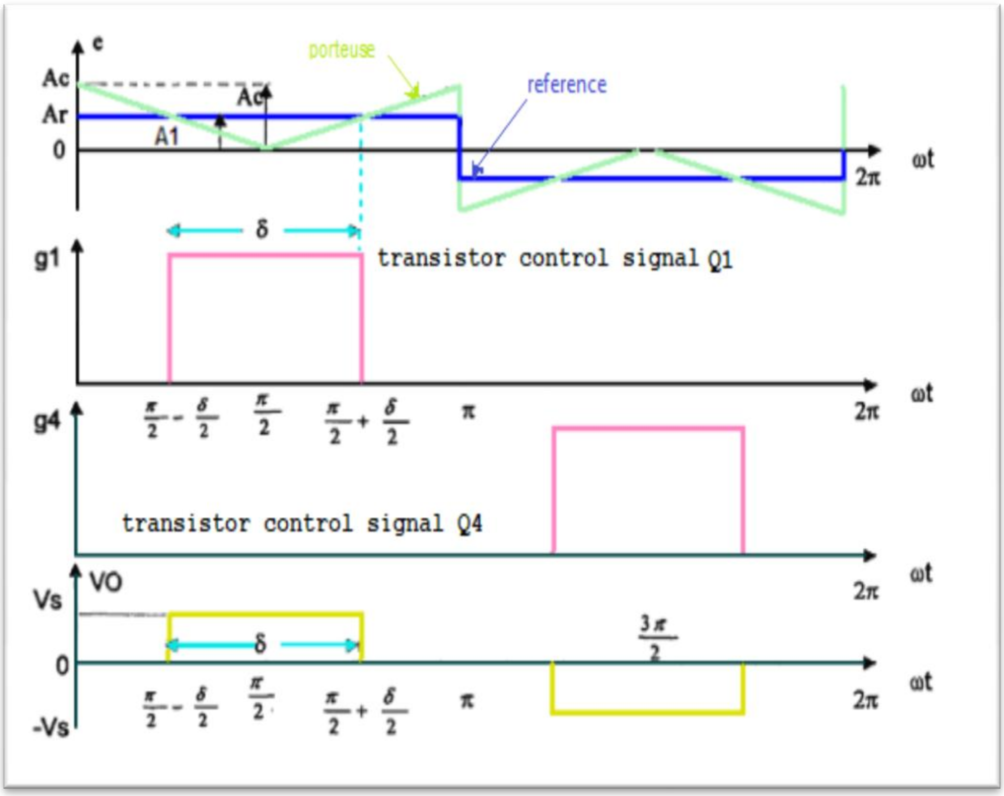


FigureII.6:PWM control signal generation[14]

II.1.4-Different types of PWM commands:

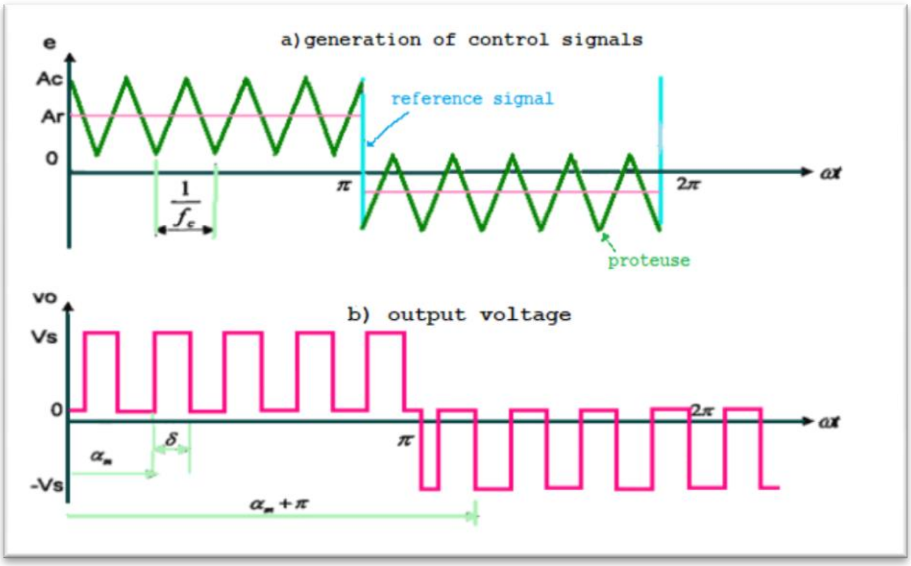
II.1.4- a) Single PWM:

This PWM uses a single pulse per half cycle and the width of this pulse varies the amplitude of the voltage at the output of the inverter.



FigureII.7: PWM of a single pulse

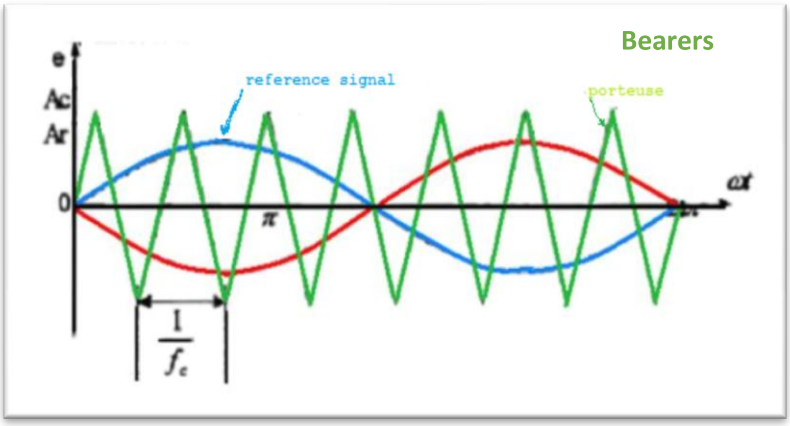
II.1.4- b) Multiple PWM:



FigureII.8 : Multiple PWM

II.1.4- c) Sinusoidal PWM control strategy (SPWM):

In the SPWM control strategy, the width of each pulse varies with the amplitude of a sine wave evaluated at the center of the same pulse [14] as seen in figure II-9.

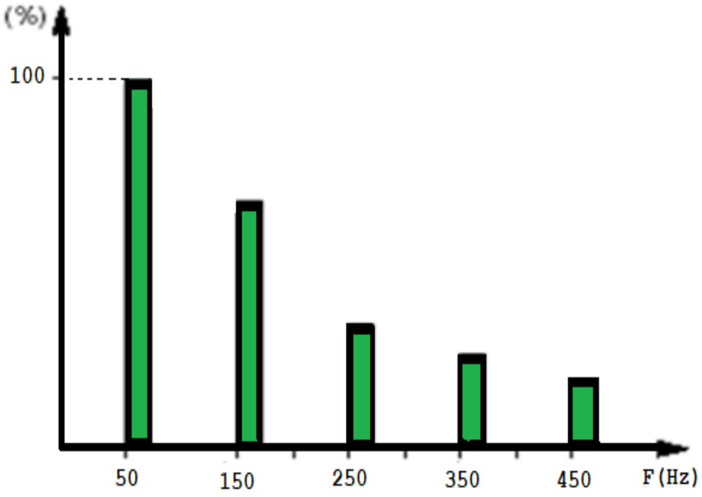


FigureII.9: SPWM, generation of control signals by a sinusoidal triangular carrier.

We can remark the following:

- None of these techniques significantly reduces the harmonics problem.
- The PWM makes it possible to get closer to the desired signal.
- It generates torque oscillations in rotating machines,Acoustic noise and electro-magnetic resonance.
- They inject noise on the control and introduce non linearities that can destabilize the system. It is therefore imperative to minimize the harmonics.

In figure II-7, the spectrum is a histogram providing the amplitude of eachharmonicaccording to it'srankand importance.



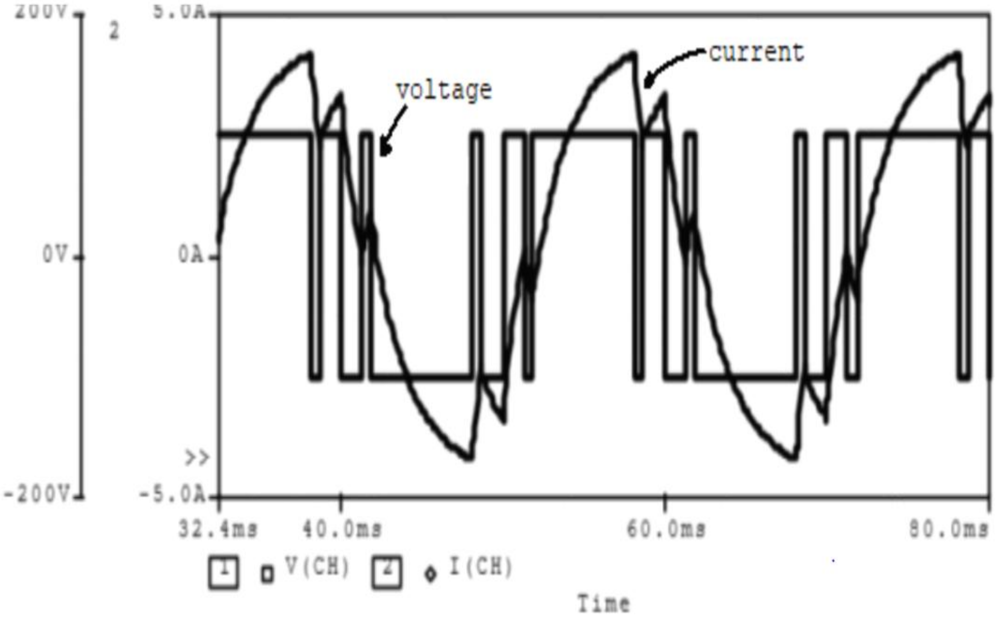
FigureII.10: Harmonic spectrum

- ✓ The most frequently encountered harmonics in the case of three-phase networks are odd order harmonics.
- ✓ Beyond the 50th order, the harmonic currents are negligible andtheir measurement is no longer significant.
- ✓ The 3rd, 5th, 7th, 9th, 11th and 13thorder harmonics are the most monitored.
- ✓ Compensation of harmonics up to rank 13 is imperative, good compensation will also take into account harmonics up to rank 25.

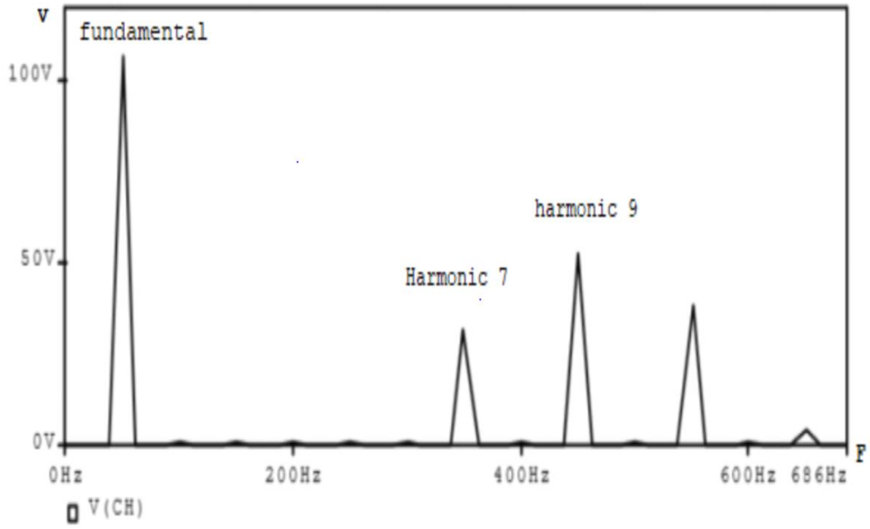
We check the suppression of the 3rd and 5th harmonics. We will notice that the amplitude of the fundamental has decreased and that of the remaining harmonics has increased. We conclude that this strategy makes it possible to increase the frequency of the first harmonics and therefore facilitates filtering.

II.2- PWM inverters

The output voltage is composed of voltage pulses of variable width PWM switching are calculated in such a way as to eliminate a certain number of harmonics. Here is an example where harmonics 3 and 5 are removed[12, 14].



FigureII.11: Output voltage spectrum



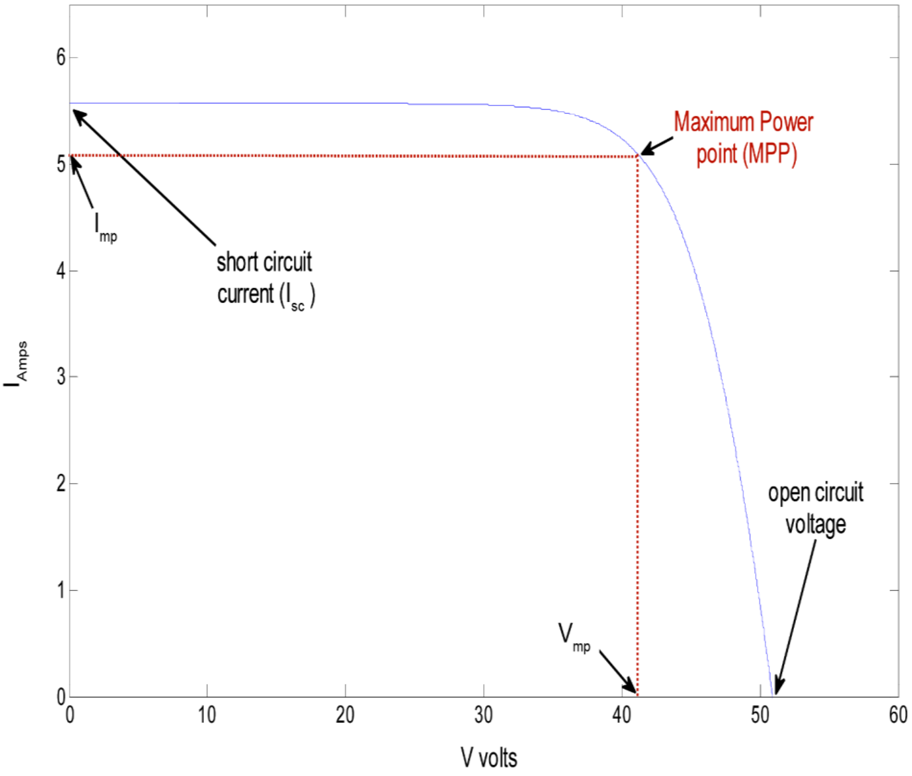
FigureII.12: Harmonics 3 and 5 eliminated.

II.2.1- Pure Sine Wave Inverters:

The best power source for most applications is a pure 50Hz sine wave, identical to the 220Vrms source available from any electrical power company. All low power household plug-in devices are designed towork with this source (high power devices such as cooking ovens use a 240V source) and, as such, will be most likely to work properly and most efficiently on such a source. A true sine wave source is produced most easily for high power applications through rotating electrical machinery such as naval gas-turbine generators, house-hold diesel or gasoline backup generators, or the various generators employed by power companies that employ a shaft torque to create an AC current. These sources provide a relatively clean, pure sine wave (lacking significant harmonics and high frequency noise) thanks to their analog rotational make-up. Such rotating machinery can be inappropriate for low-power backup supply usage due to their high cost, large size and required maintenance. As such, a smaller, digital pure sine wave inverter can be extremely useful.

II.2.2- Maximum power point tracking (MPPT) control technique:

Throughout the world, photovoltaic power generation is becoming increasingly popular due to a combination of factors: low maintenance, minimal wear and tear of components due to the absence of moving parts, lack of audible noise, absence of fuel cost, and pollution-free operation after install. Small-scale PV installations are very popular as lighting and water pumping solutions in developing countries, remote villages, and small rural and urban communities. These systems are also commonly used in developed countries that have a considerable amount of solar irradiation. As PV systems are required to be low-cost, compact in size, and operate as efficiently as possible, they use maximum power point tracking control algorithms for standalone PV systems, with the aim of delivering optimum performance over the widest range of operating possible conditions. Since PV systems exhibit nonlinear behavior, the maximum power point (MPP) varies with solar insolation levels, and there is a unique PV panel operating point at which the power output is at a maximum, as shown in Figure II-13. Therefore, for maximum efficiency, it is necessary to use a maximum power point tracking (MPPT) algorithm to deliver optimal available PV output power at different operating points to the charge[15].



FigureII.13: Characteristics of a typical PV panel with MPPT control

II.2.2.1- MPPT Algorithms control:

There are many MPPT algorithm which can be used for implementation: Perturb and Observe method, Incremental conductance method, constant voltage method, Fuzzy logic based method etc. Different MPPT algorithms, are briefed about their features and limitations as follows [16-17]:

1) Incremental conductance (INC) method, of tracking the MPP does not depend upon PV array, tracking efficiency is good, and implementation is medium. Sensing parameters are voltage and current, convergence speed is medium and of analog type[17].

2) Fuzzy logic control based MPPT, is PV array dependent, Tracking efficiency is good, implementation is very complex, convergence speed is fast and of digital type[17].

3) Neural network based MPPT is also PV array dependent, tracking efficiency is good, implementation is very complex, convergence speed is fast and of digital type[17].

4) Linear current control based MPPT[18], is PV array dependent, tracking efficiency is not so good, implementation complexity is medium, convergence speed is fast, sensing parameter is irradiance and of digital type.

5) Temperature based MPPT depends upon PV array[17],tracking efficiency is excellent, implementation is simple and MPP is comparatively accurate and sensing parameters are voltage and PV cell temperature.

6) Array reconfiguration based MPPT is PV array dependent, tracking efficiency is poor, convergence speed is slow, implementation complexity is high, sensing parameters are voltage and current and of digital type[16].

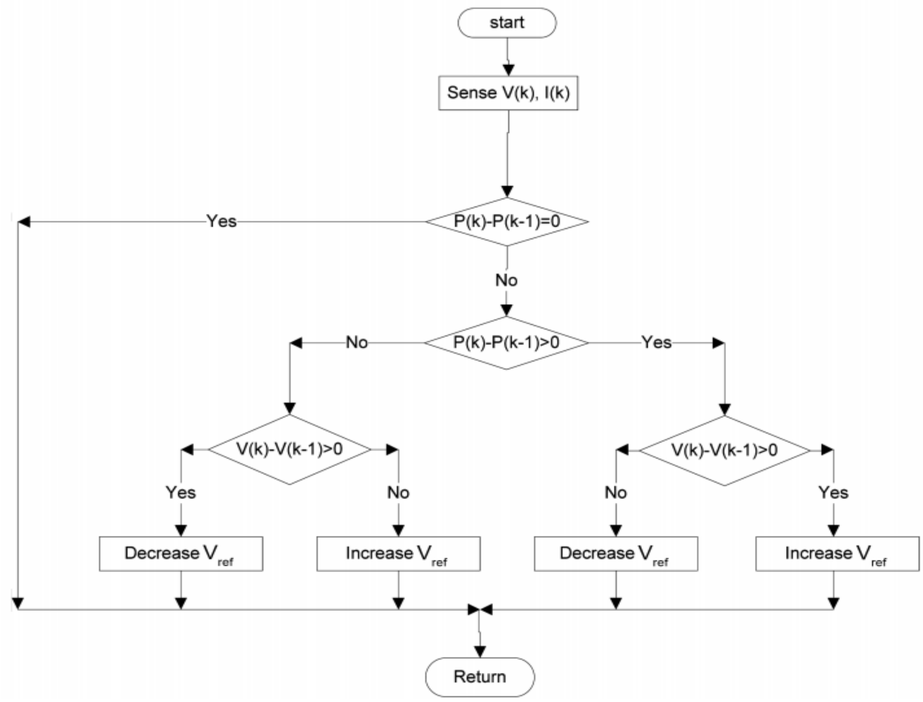
7) Perturb and observe based MPPT[16],is not PV array dependent, tracking efficiency is good but with unstable operating points, implementation is simple, sensing parameters are voltage and current.

8) Advanced Perturb and Observe based MPPT is not PV array dependent[16], tracking efficiency is very good with stable MPPs, implementation is medium, sensing parameters are voltage and current.

II.2.2.2- Perturb and Observe (P&O) Method:

The P&O MPPT algorithm, as shown below in Figure II-14, operates by increasing or decreasing the array terminal voltage, or current, at regular intervals and then comparing the PV output power with that of the previous sample point. If the PV array operating voltage changes and power increases ($dP/dV_{PV} > 0$), the control systemadjusts the PV array operating point in that direction; otherwise, the operating point is moved in the opposite direction. At each perturbation point, the algorithm continues to operate in the same manner.

The main advantage of this approach is the simplicity of the technique. Furthermore, previous knowledge of the PV panel characteristics is not required. In its simplest form, this method generally exhibits good performance provided the solar irradiation does not vary too quickly.



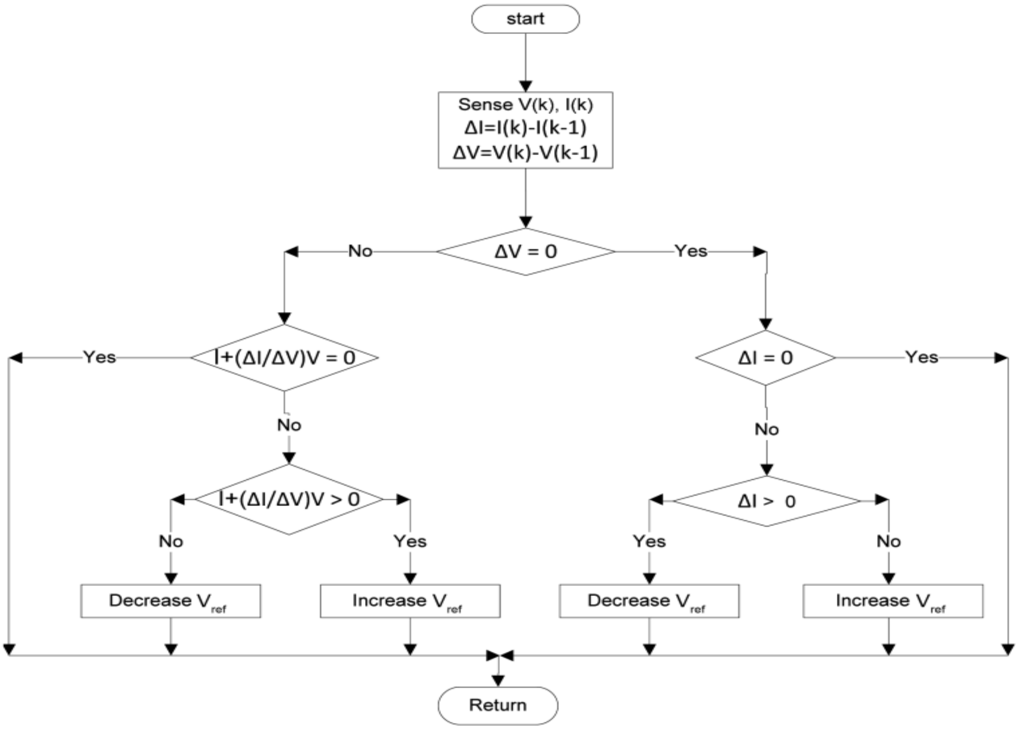
FigureII.14: Flowchart of the P&O MPPT method.

At steady state, the operating point oscillates around the MPP voltage and usually fluctuates lightly. For this reason, the perturbation frequency should be low enough so that the system can reach steady state before the next perturbation. Also, the perturbation step size must be sufficient so that the controller is not significantly affected by measurement noise, and generates a measurable change in the photovoltaic array output[16].The classic perturb and observe (P&O) method has the disadvantage of poor efficiency at low irradiation.For this reason, alternative solutions have been proposed[15-16].

II.2.2.3-Incremental Conductance (InC) Method:

The incremental conductance (InC) MPPT algorithm which its flowchart is shown in Figure II-19, seeks to overcome the limitations of the perturband observe MPPT algorithm by using the incremental conductance of the photovoltaic module or generator. This algorithm works by searching for the voltage operating point at which the conductance of PV generator is equal to their incremental conductance. At this point, the MPP is well reaching, the system stops perturbing the operating point. The advantage of this algorithm is that it has the ability to ascertain the relative “distance” to the maximum power point (MPP), therefore it can determine when the MPP has been reached.

Also, it is capable of tracking the MPP more precisely in highly variable weather conditions, and exhibits less oscillatory behavior around the MPP compared to the P&O MPPT method, even when this last method is optimized. Nevertheless, the InC algorithm has the disadvantage that instability can result due to the use of a derivative operation in the algorithm. Also, under low levels of insolation, the differentiation process difficult and prone to measurement noise; and results can be unsatisfactory[15].



FigureII.16: Flowchart of the InC MPPT method.

II.3- Conclusion :

In general, the InC MPP tracking approaches use a fixed iteration step size, which is determined by the accuracy and tracking speed requirement. The step size may be increased to improve tracking speed; however, accuracy is decreased. Likewise, reducing the step size improves the accuracy, but sacrifices the speed of convergence of the algorithm. To solve this problem, some researches proposed an InC technique with a variable step size. This approach automatically adjusts the step size to the solar array operating point. When the operating point is judged to be far from the MPP, the algorithm increases the step size to enable the algorithm to operating point of approach quickly towards the MPP. However, when the operating point is close to the MPP, the step size is decreased. Through the variation of the step size, both improved accuracy and speed are accomplished [15].

Chapter III

Simulation, realization and results

III- Introduction:

After studying the principle and mode of operation of inverters and after explaining the principle of several control techniques, we will describe in this chapter the steps we followed to make our prototype.

III.1- PIC programming

To program the microcontroller, we used the C language of the CCS "Custom Computer Services" compiler for Micro Chip family processors. Built-in functionality makes code development easy. The integrated C development environment offers the user a fast way to produce efficient code using the advanced C language. The software adapted to the hardware circuit (programmer) is "UsbPicProg".

Before continuing our investigation, we validated the operation of the global assembly with an electronic assembly simulator integrated into the ISIS/PROTEUS software of the Electronics Center. Using this program is simple thanks to the graphical interface. The library is rich and contains almost all known electronic component models as they exist actually.

III.1- Sizing Of Inverter :

The choice criteria of IGBT is based on two factors, first the current crossing the transistor which take the maximum value (load current) that is, according to the specifications will not exceed5A, the chosen transistor (IGBT) can withstand up to 30A, a value large enough for the normal operating range, second the voltage that the transistor must withstand should be greater than the DC bus voltage (500V maximum), this voltage is lower than the voltage given by the transistor (see datasheet 1200V), this makes our choice of IHW30N120R2 IGBT reasonable.

IGBTs of the H-bridge that are chosen (G20N60B3) can withstand a current up to 40A, and a voltage up to 600v this is because the H-bridge circuit will be after the buck converter stage which renders the electrical quantities to be lower.

III.2- Simulation and results

In this section we will use two types of commercial software in order to simulate our process:

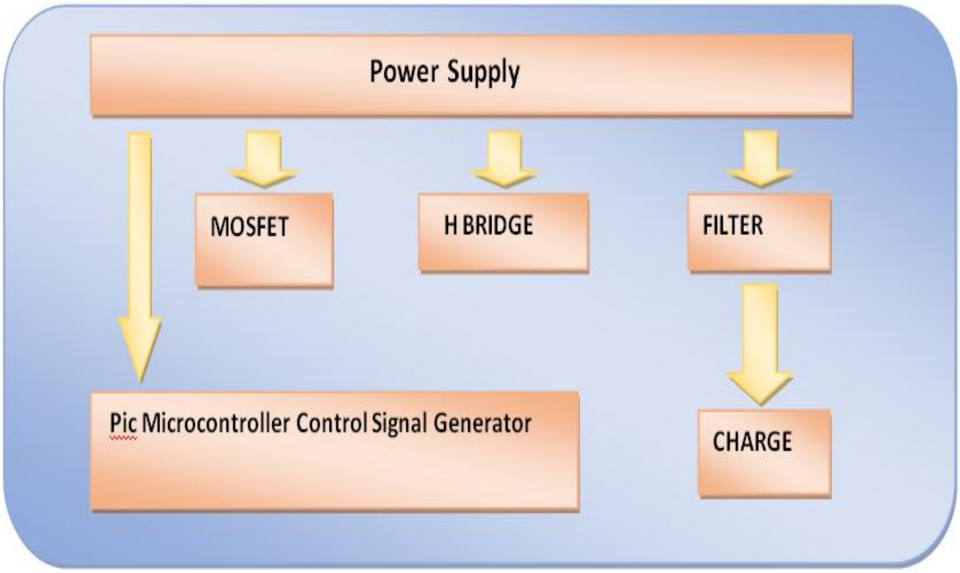
1- Proteus: to extract more realistic result values.

2-Psim: to extract ideal result values.

III.3- Synoptic diagram:

Our prototype is presented according to the general diagram below, and it consists of two main panels:

- ✓ **Control card.**
- ✓ **Energy card.**



FigureIII.0: Synoptic diagram.

We aim to simulate the types of command strategies for the inverter (full-wave, off-set, PWM). To simulate and realize the considered single phase inverter, we need:

- ✓ 4 units of type: (BUZ 10) for hot-swap.
- ✓ Gate Driver for MOSFETs of type: (IR2112).
- ✓ Battery (50 V).
- ✓ 2 Resistances (100 Ohm).
- ✓ Inductance (0.175 H).
- ✓ 2 Capacitors (2 uF).
- ✓ 2 Diodes (1N4007).
- ✓ 2 Diodes (1N4148).
- ✓ Capacitors.
- ✓ PV generator ensuring 400 VDC.
- ✓ MicrocontrollerPIC 16F877A.

III.4- Full Wave control:

III.4.1- Diagram Circuit:

Figures III.1 and III.2 represent the electrical circuit of our 1 kilowatt single phase H-Bridge inverter implemented under ISIS/Proteus and PSIM softwares respectively. Under ISIS/Proteus, the full wave control is generated by a code uploaded in a PIC 16F77A microntroller of Microship. Whereas, under PSIM, this command is generated simply via Vpulse component. Simulations were performed for a period of 20 ms (a frequency of 50 Hz).

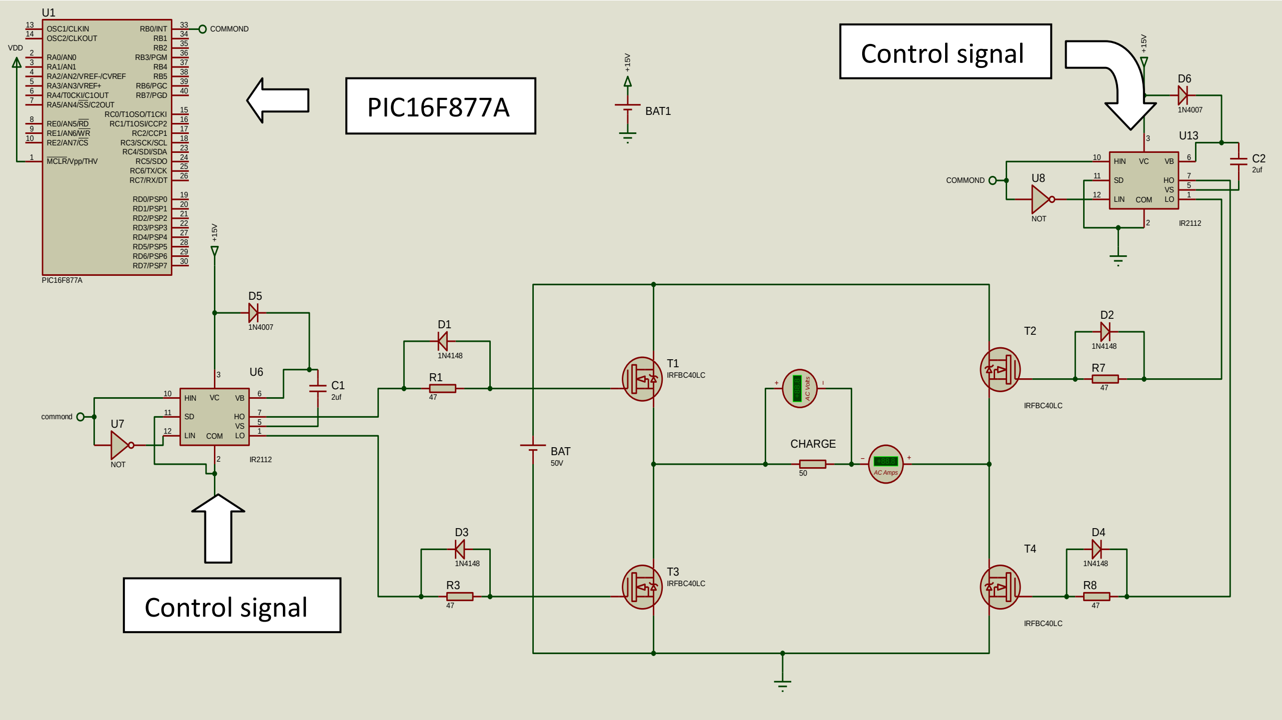


Figure III.1: Electrical circuit of single-phase inverter controlled with Full Wavetechnique under ISIS/Proteus software.

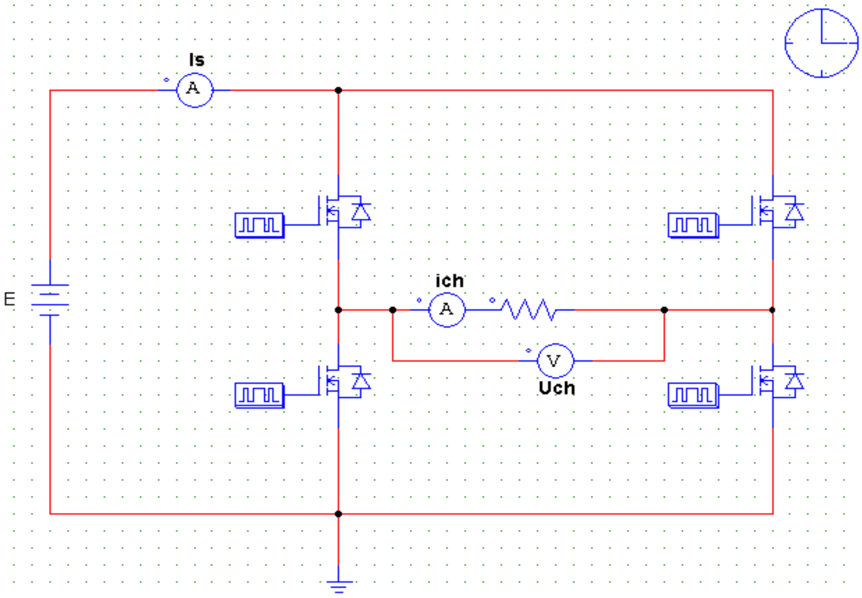


Figure III.2: Electrical circuit of single-phase inverter controlled with Full Wave technique under PSIM software.

Below are the simulation results of the firing angles for controlling the four power switches of according to a signal full wave 50 Hz of the inverter as consigned in figure III.3. it is clear that the commands of each two power switches are the same.

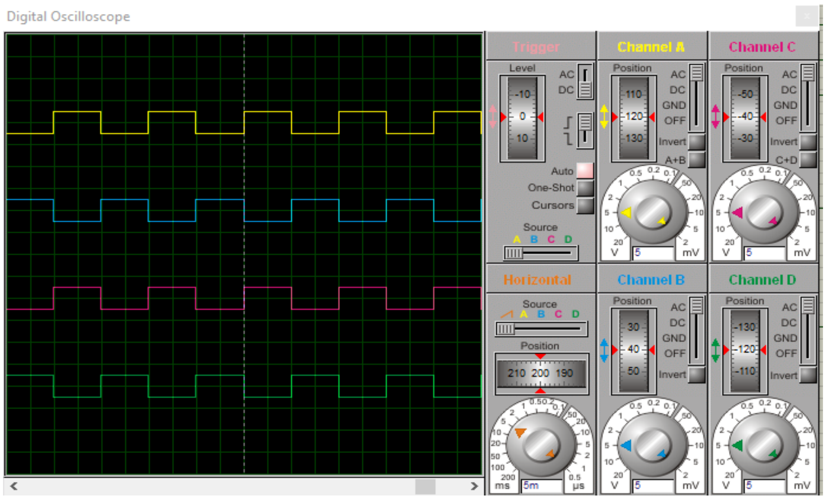


Figure III.3: Firing angle signals for each power switch of inverter with Full Wavecontrol technique under ISIS/Proteus.

Due to the limitation voltage of the used MOSFETs to a DC voltage of 50VDC as indicated previously, Figure III.4shows us the output voltage inverter as a square signal of magnitude of what about 50VAC under 50Hz.

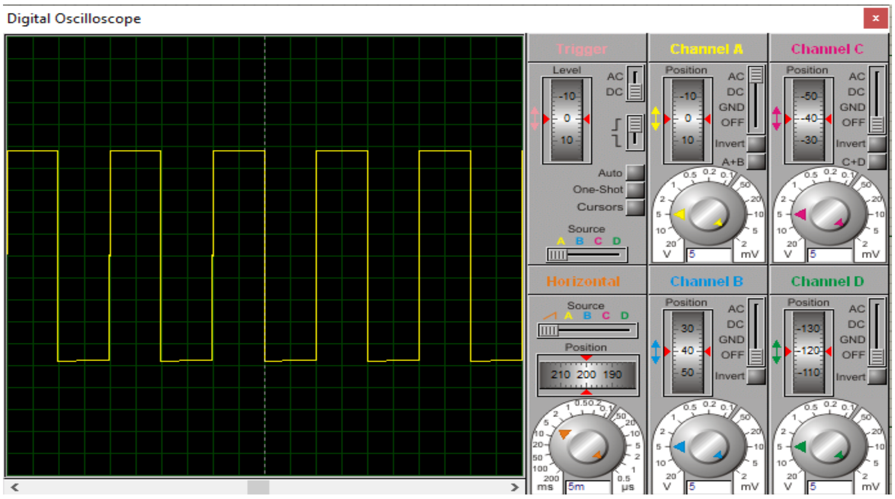


Figure III.4:output **v**oltage of single-phase inverter with full-wave under ISIS/Proteus simulator.

But in Figure III.5, one can see a voltage of the ideal condition of the inverter with a voltage of 400 V.

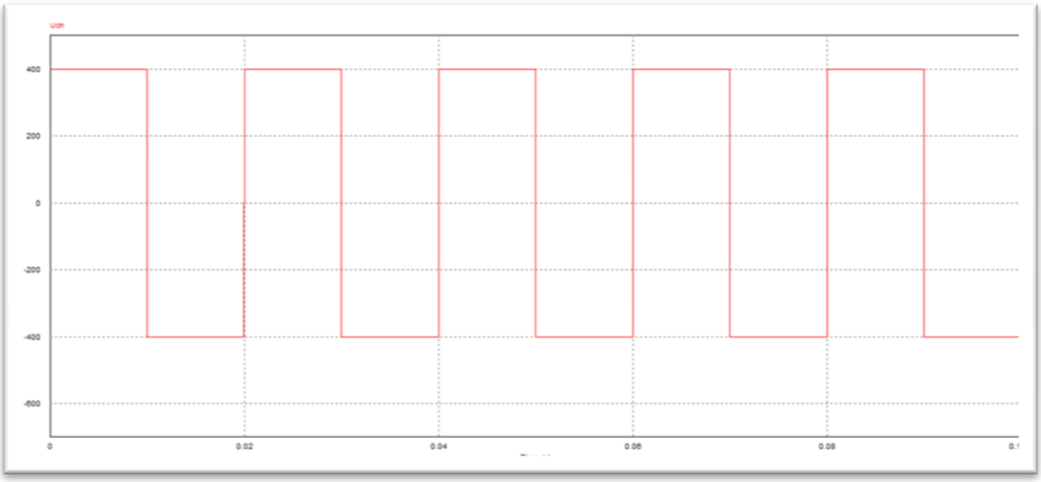


Figure III.5:output voltage of single-phase inverter with full-wave under PSIM simulator.

For the current wave forms, simulations were performed for both resistive and resistive inductive loads. For the resistive load, Figure**s** III.6 and III.7, under Proteusand PSIM respectively, show us the graph of current by resistance load, as we notice that they are similar to the graph of voltage:

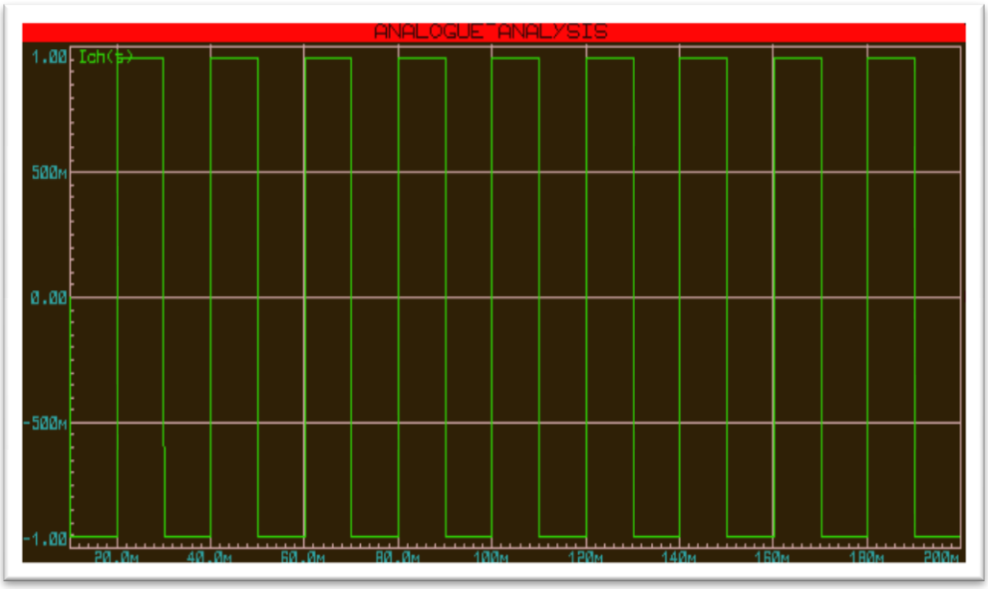


Figure III.6: Current with R load under Proteus.

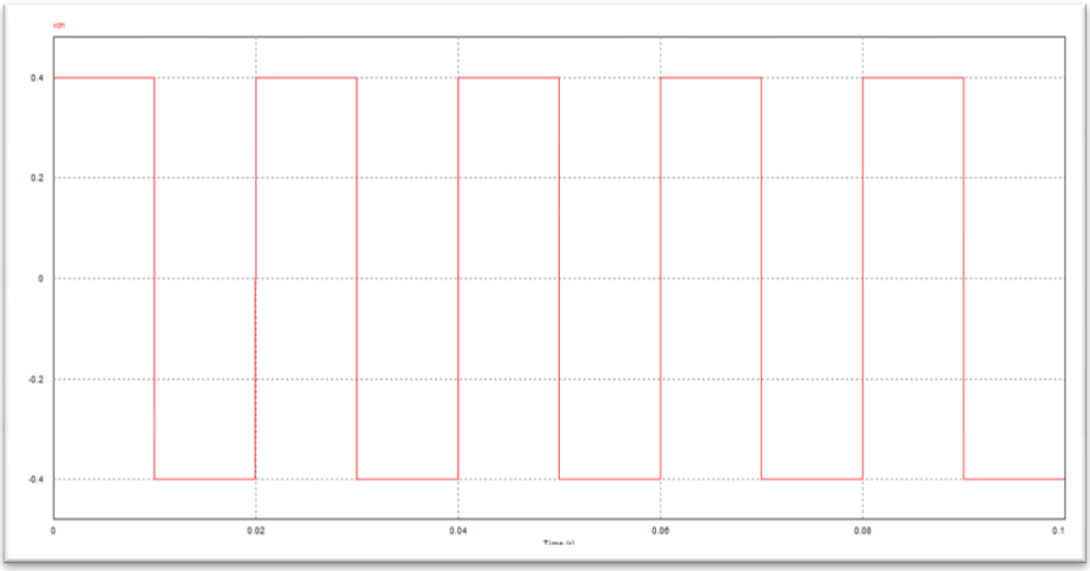


Figure III.7: Current with R load under PSIM.

In case of resistive-inductive load, Figures III.8 and III.9 show us the graph of the current. As we can see from the two figures that by adding the inductor, the current takes a form a little closer to the sinus wave. So the inductive effect on the current is very visible.

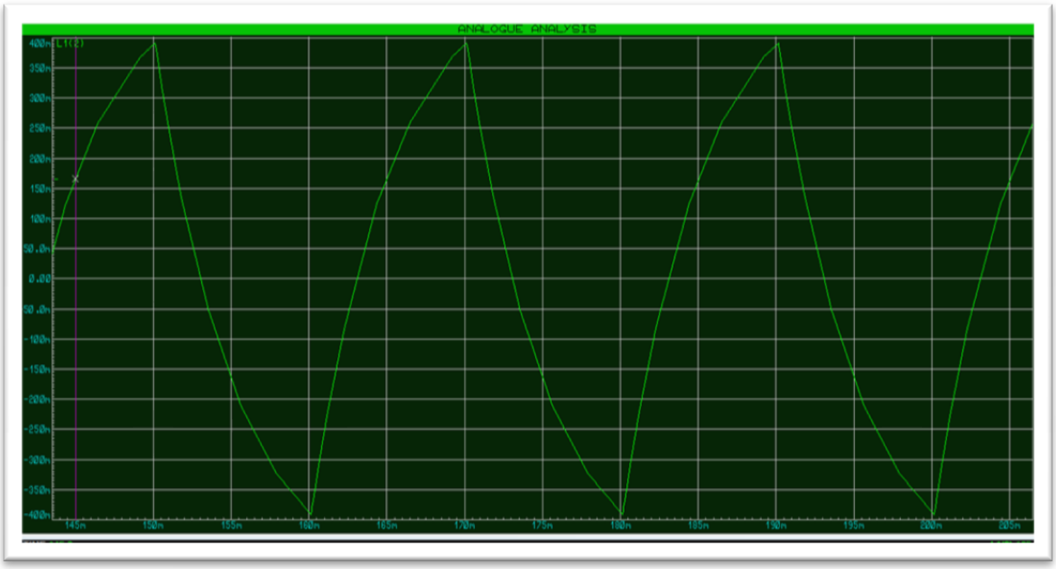


Figure III.8: Current with RL load under Proteus.

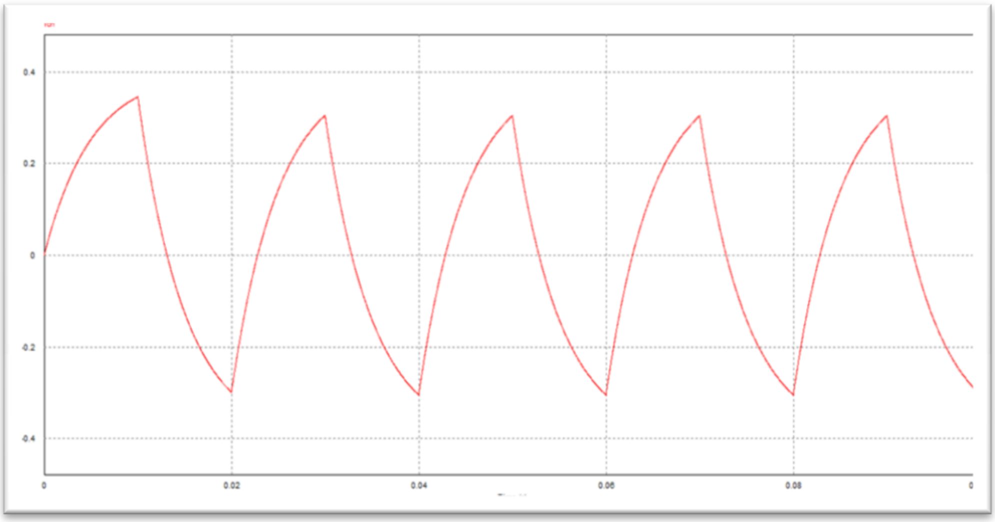


Figure III.9 : Current with RL load under PSIM.

III.5 –OFF-SET command:

We present in figure III.10 the electrical circuit of our inverter controlled by OFFSET command implemented under ISIS/Proteus. The OFFSET command has been implemented and generated via the microcontroller. It is to be noted that the scheme of off-set command under PSIM is the same as that performed for the full wave command, so there is no need to put it again.

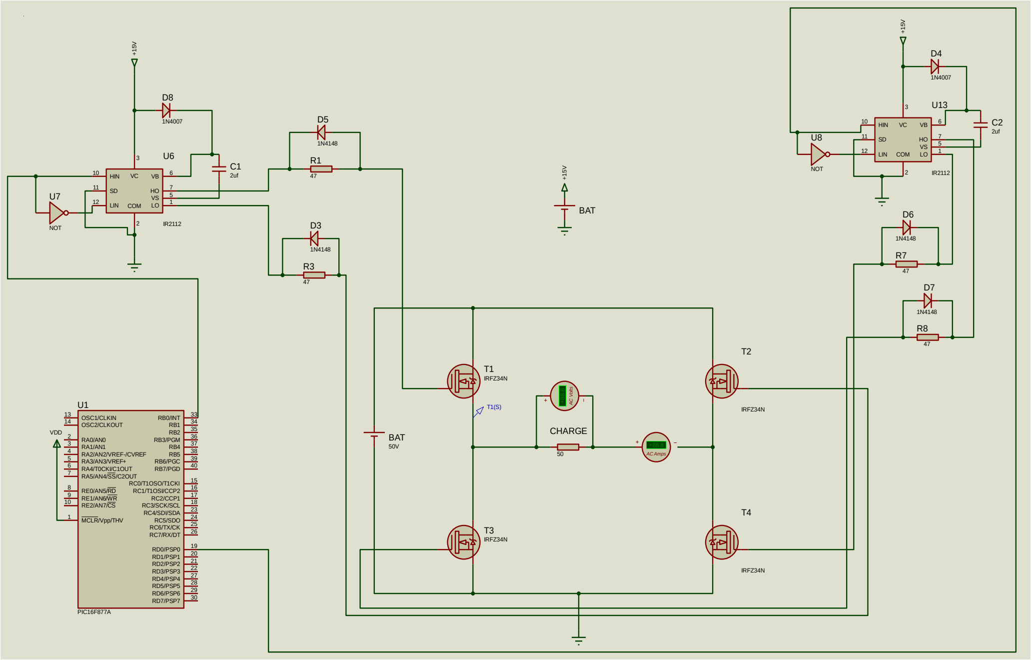


Figure III.10: electrical circuit of single-phase inverter controlled by digital OFF-SET under Proteus.

For a period of T=20 ms and as we can see in **Figure III.11,** there is a lag between the four signal which explain the use of the offset command type. The lag is expressed by a delay of 2,5ms.

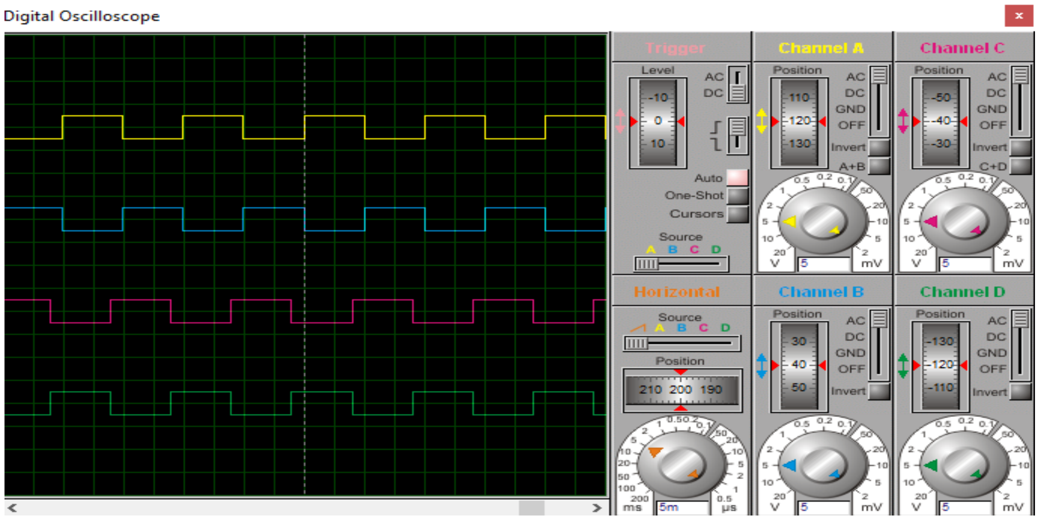


Figure III.11: Command of single-phase inverter with OFF-SET.

Figures III-12 and III-13 express the inverter output voltage, the voltage across the load, performed via Proteus and PSIM respectively. We can see in both simulation results that exists the same lag in the voltage waveform and this is due to the lag imposed by the control signals. Here, the voltage waveform seems very close the sine wave and this is what reduce the harmonic effects with the absence of passive filters.

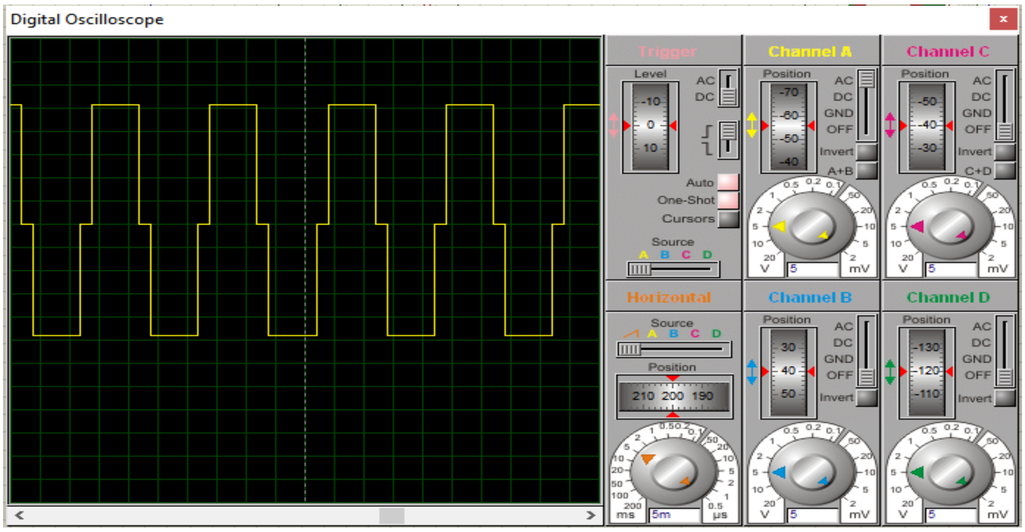


Figure III.12: Voltage of single-phase inverter with OFF-SET.

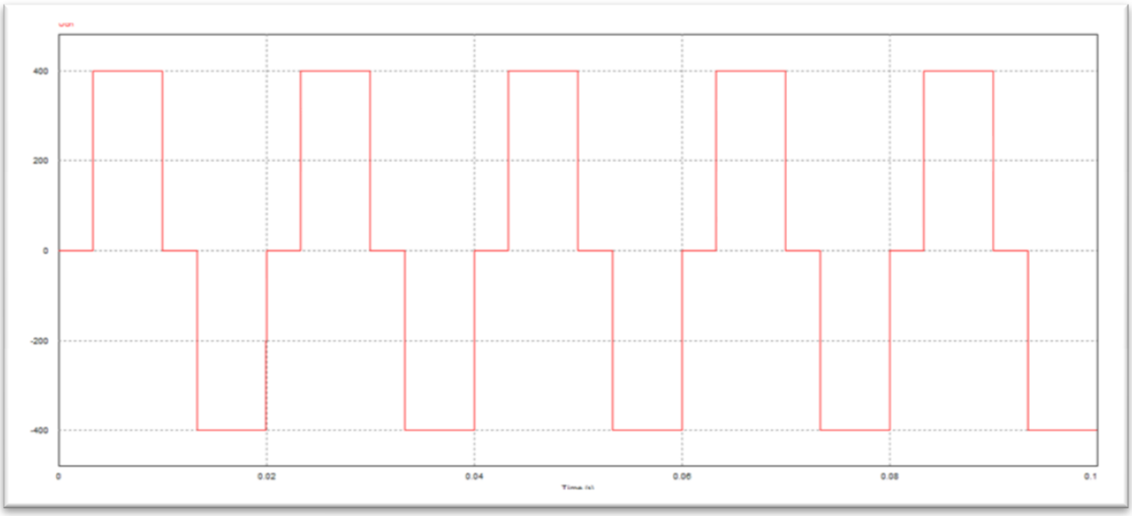


Figure III.13: Voltage graph of OFF-SET command (PSIM).

In figures III.14 and III.15, we draw the current wave forms for a resistive charge under Proteus and PSIM respectively. We observe that the current takes the identical shapes of the output voltage since the resistive load maintains a zero phase shift between current and voltage across its terminals.

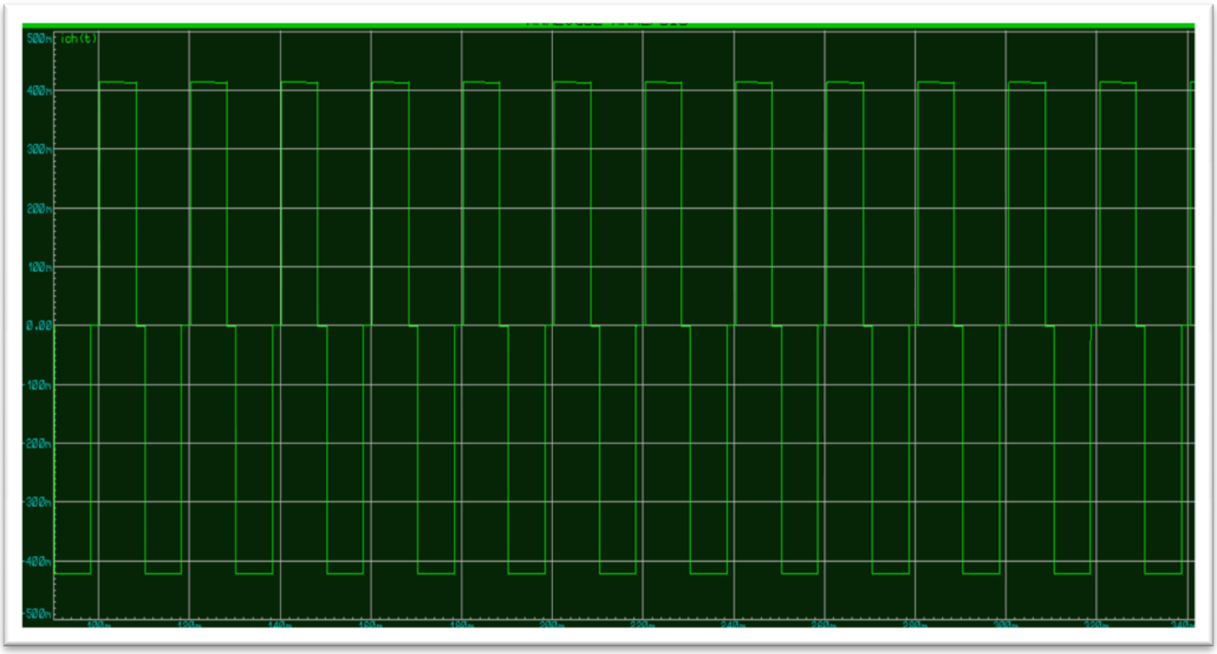


Figure III.14: Current waveform with resistor load under Proteus, case of OFFSET control.

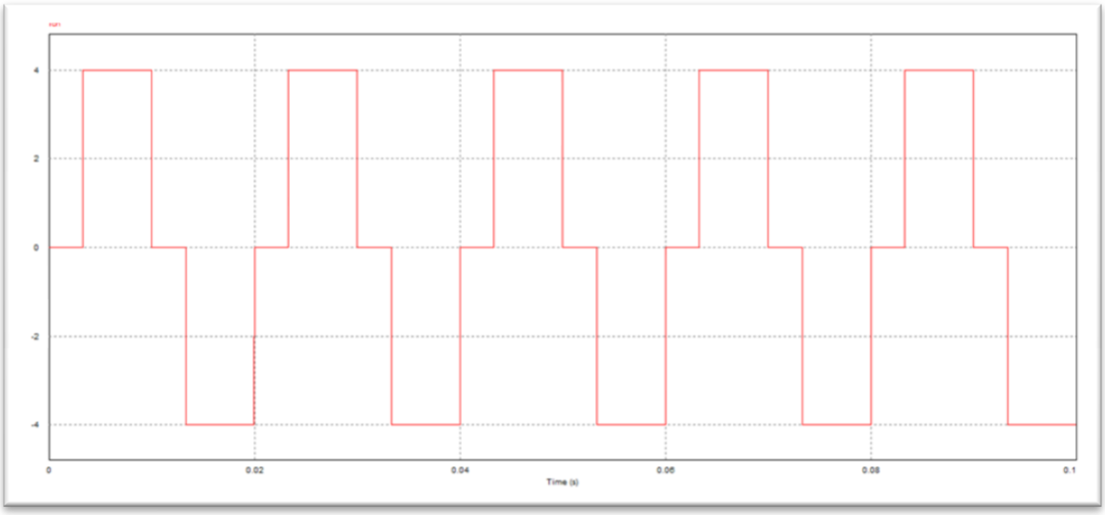


Figure III.15: Current waveform with resistor load under PSIM, case of OFFSET control.

Figures III.16 and III.17 shows the load current waveforms under Proteus and PSIM respectively. It is very clear the presence of the inductance effect compared to the resistor effect when acts alone. It is clearly shown the two phases of energy flow: the storage phase energy by the inductance and so the restitution of its energy from inductance to the resistor.

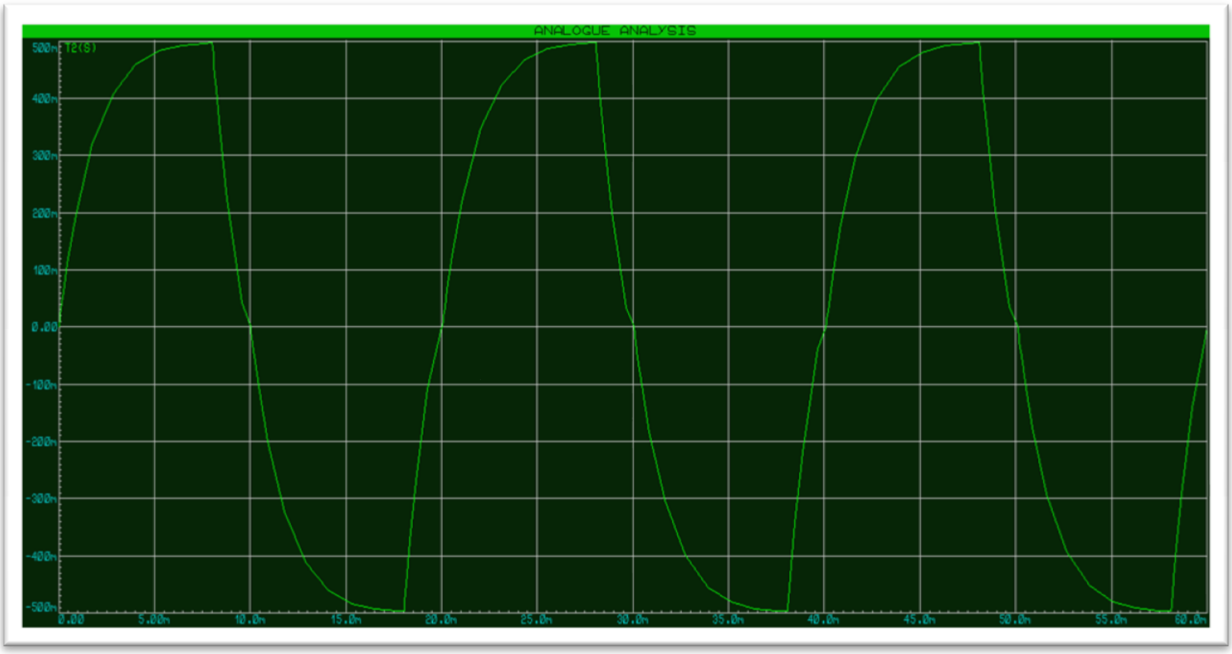


Figure III.16: Current waveform with inductance load under Proteus, case of OFFSET control.

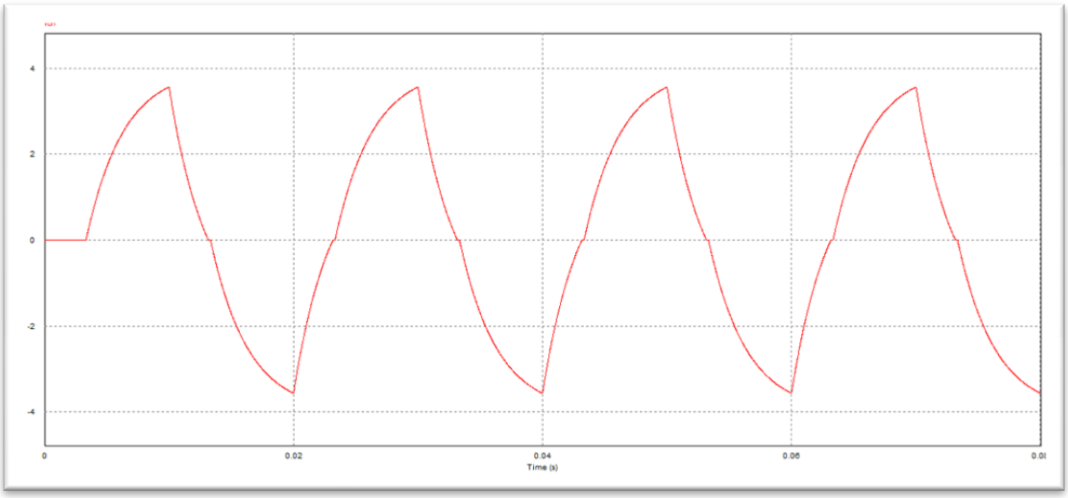


Figure III.17: Current waveform with inductance load under PSIM, case of OFFSET control.

III.6– Simulation results of PWM control strategy:

Figures III-18 and III-19 draw the electrical circuit of the inverter controlled by the PWM strategy implemented under both Proteus and PSIM respectively. As indicated above, PWM control was digital under Proteus and analog under PSIM. One can remark also, under Proteus, the presence of MOSFET drivers for adapting the signal delivered by microcontroller to the MOSFET grill signal which will be greater than the threshold voltage.

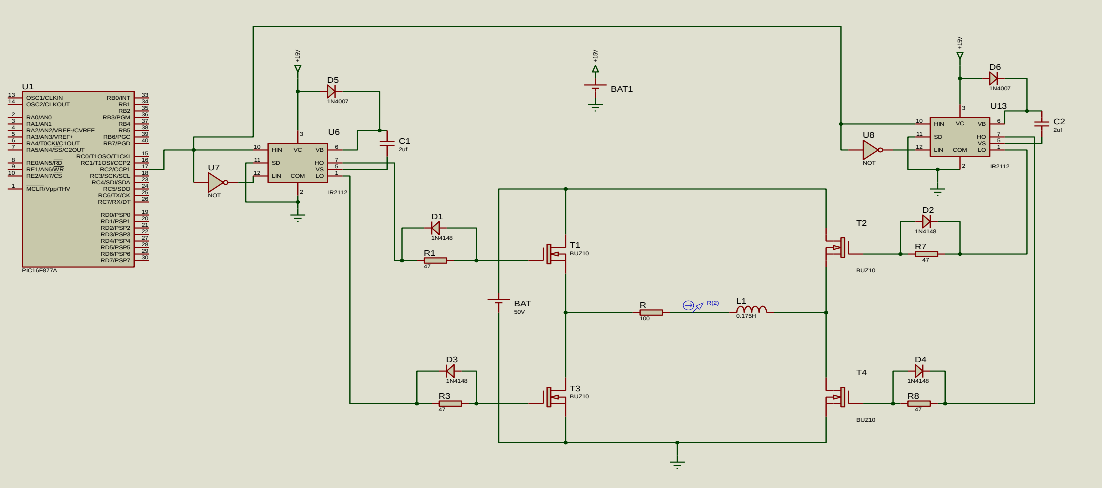


Figure III.18:electrical circuit of inverter controlled by digital PWM technique implemented under Proteus.

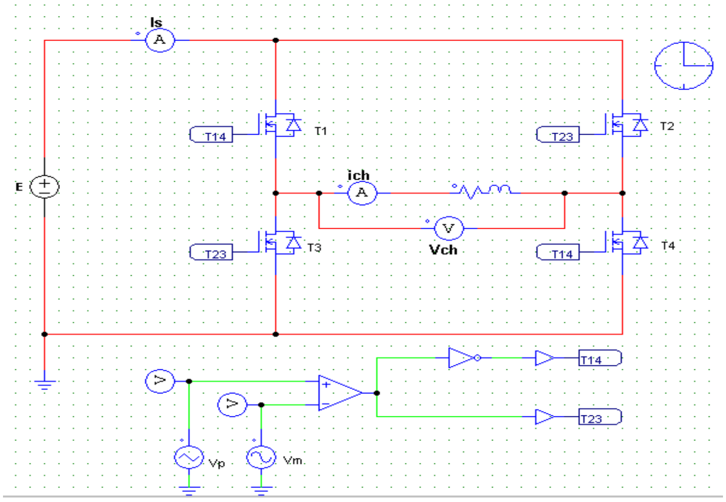


Figure III.19: electrical circuit of inverter controlled by analog PWM technique implemented under PSIM.

Figures III.20 and III-21 show the plots of digital PWM and the logical PWM implemented under Proteus and PSIM respectively. Under PSIM, the logical PWM was implemented as two signals: the modulating signal which is a sinusoidal signal of 220 volts and 50 Hz and a triangular carrier wave signal with a high switching frequency compared to that of the message signal.

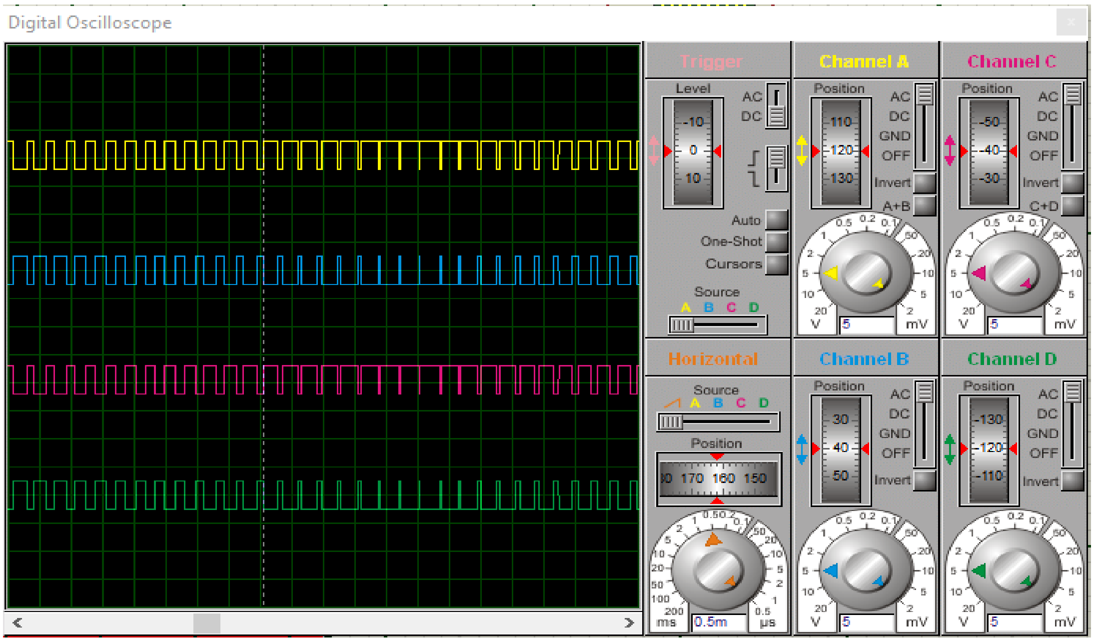


Figure III.20: Duty cycles for each power switch of the inverter in case of PWM control.

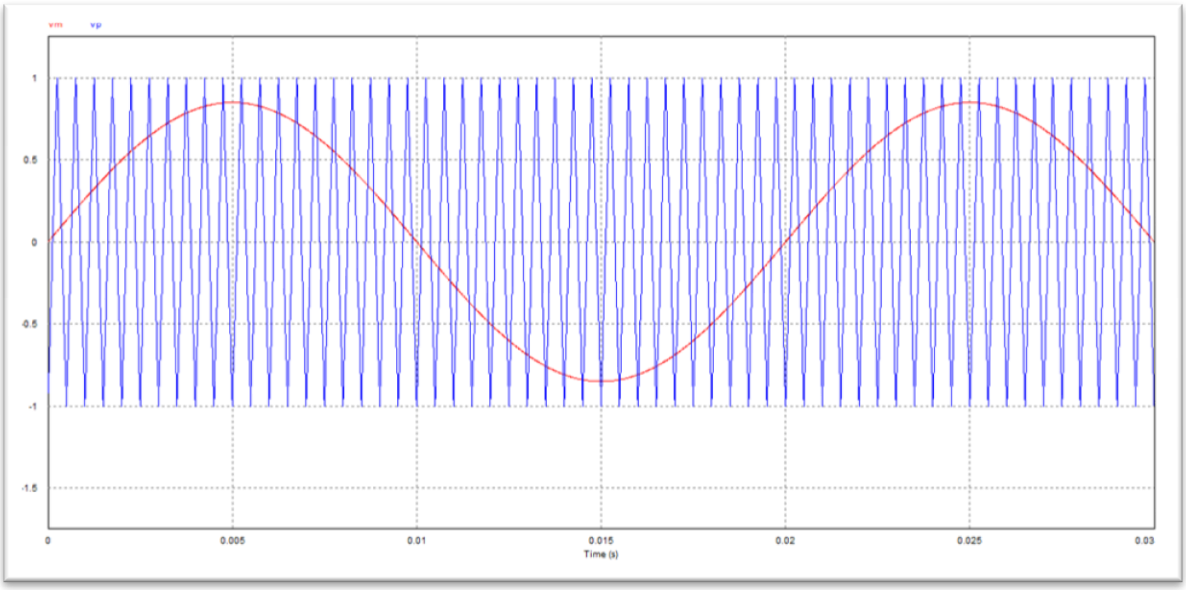


Figure III.21: PWM control technique in case of 2 kHz of triangular signal and the modulating sinusoidal signal of 50 Hz.

Figures III-22 and III-23 present the voltage simulation results of the inverter splaying a resistive load. In the voltage graph, we note that it is different from off-set and full wave command, this is in order to create the sinusoidal current.

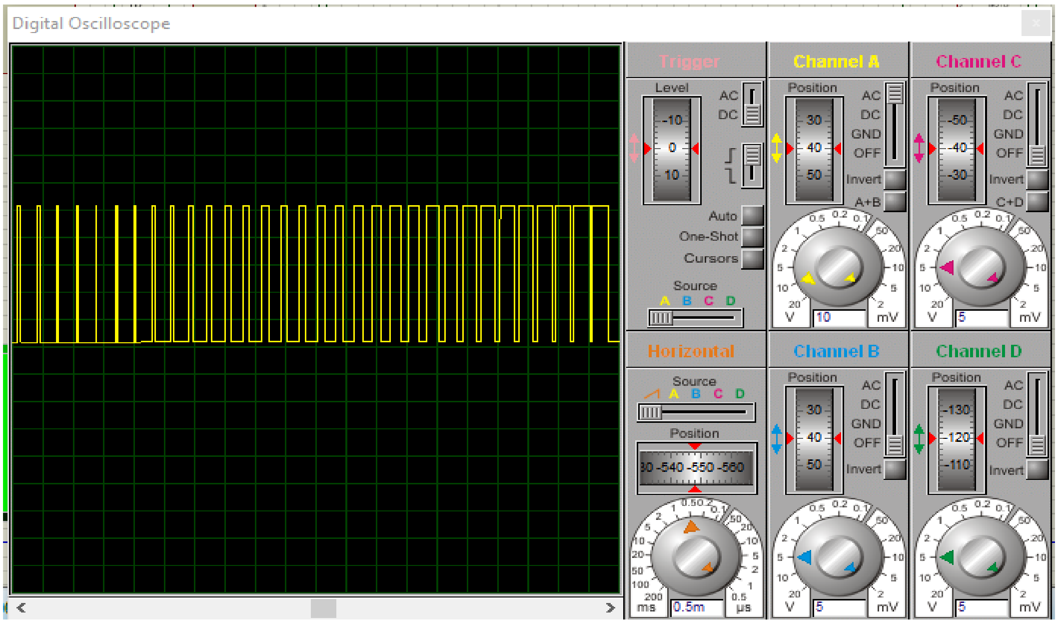


Figure III.22: Inverter output voltage with PWM control technique under Proteus.

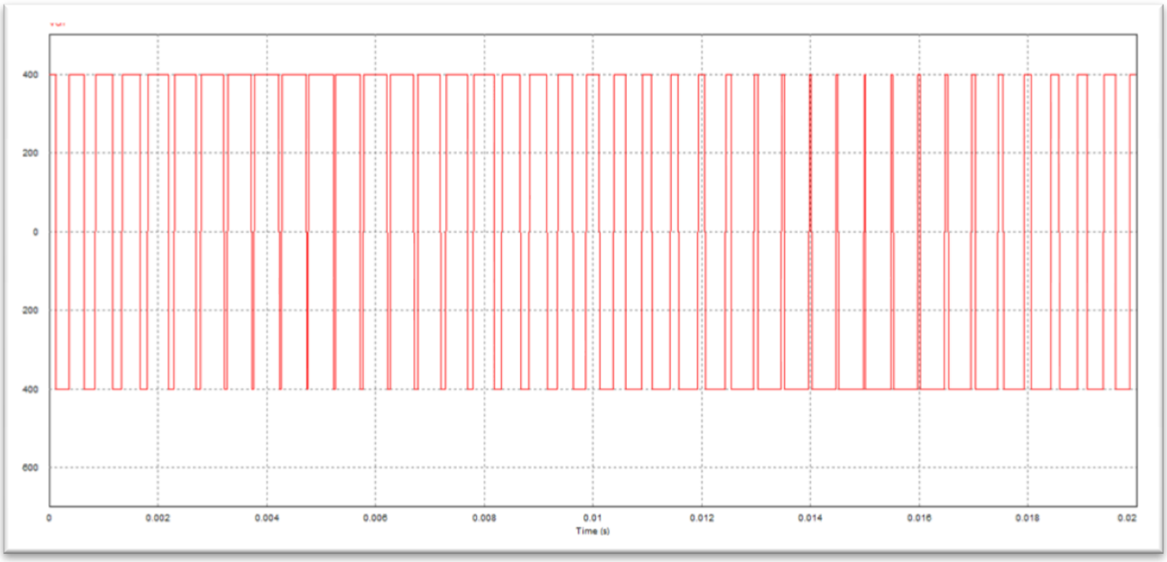


Figure III.23: Inverter output voltage with PWM control technique under PSIM.

Figures III-24 and III-25 present the current simulation results of the inverter splaying a resistive load. Like what we saw earlier, the current waveforms with resistance load are the same shapes compared to the voltage waveforms.

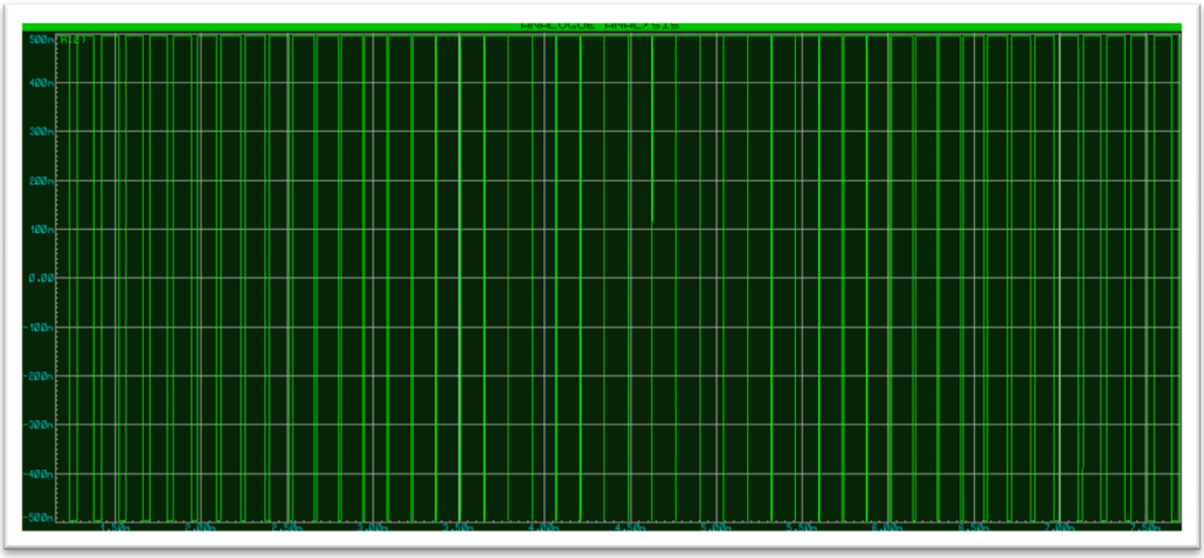


Figure III.24: Load current waveform in case of resistive load and with PWM control technique under Proteus.

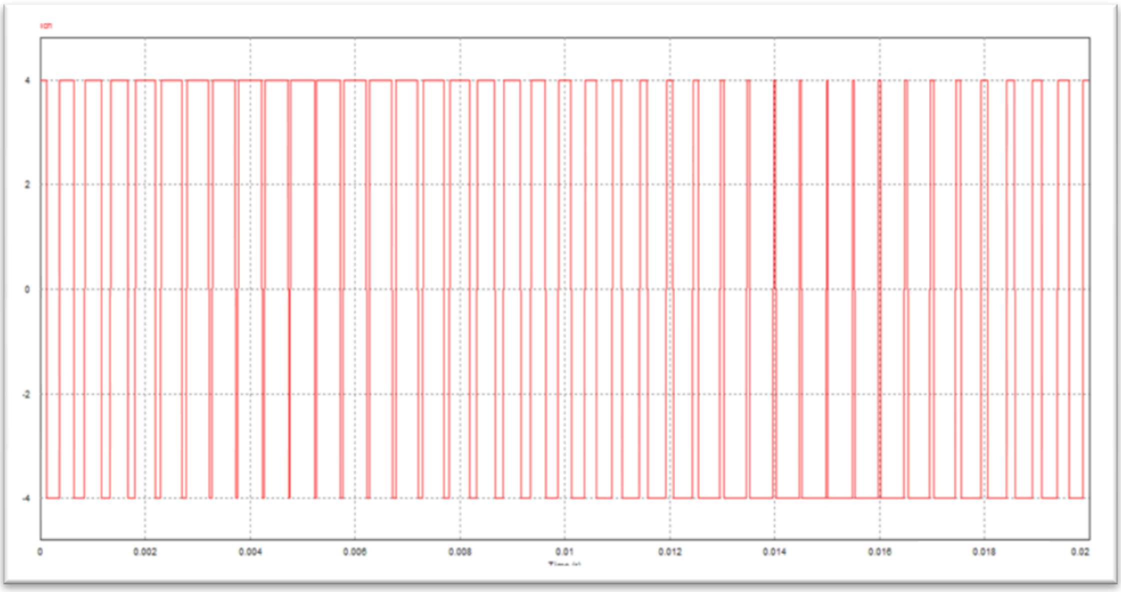


Figure III.25: Load current waveform in case of resistive load and with PWM control technique under PSIM.

figures III-26 and III-27 present the current simulation results of the inverter splaying a inductive load. Here, we notice that the graphs were become almost sinusoidal.

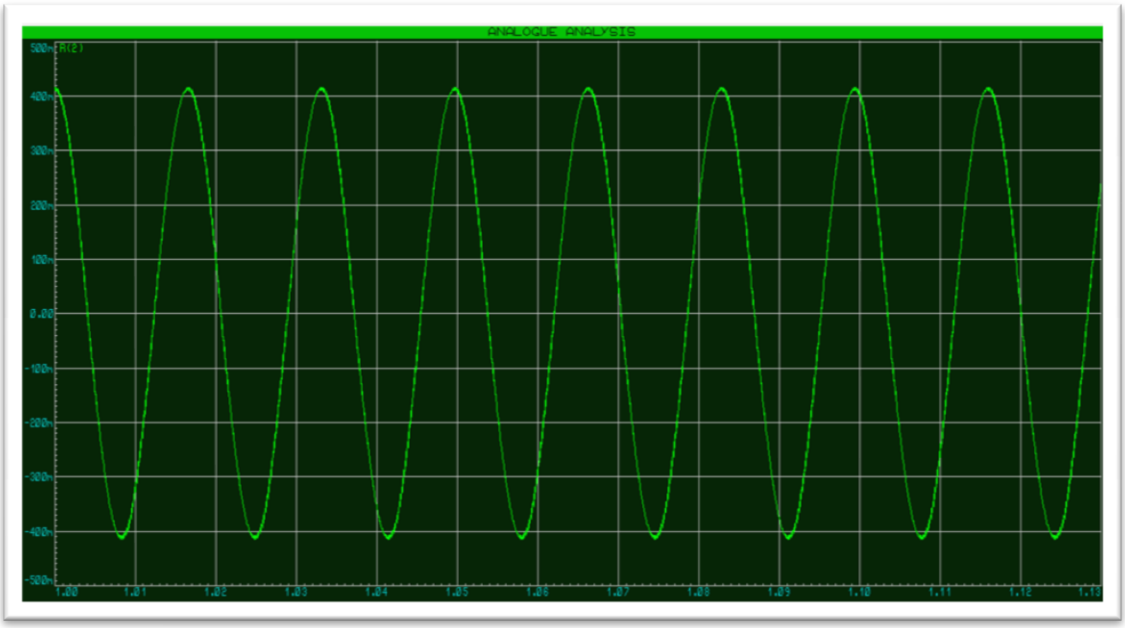


Figure III.26: Load current waveform in case of inductive load and with PWM control technique under Proteus.

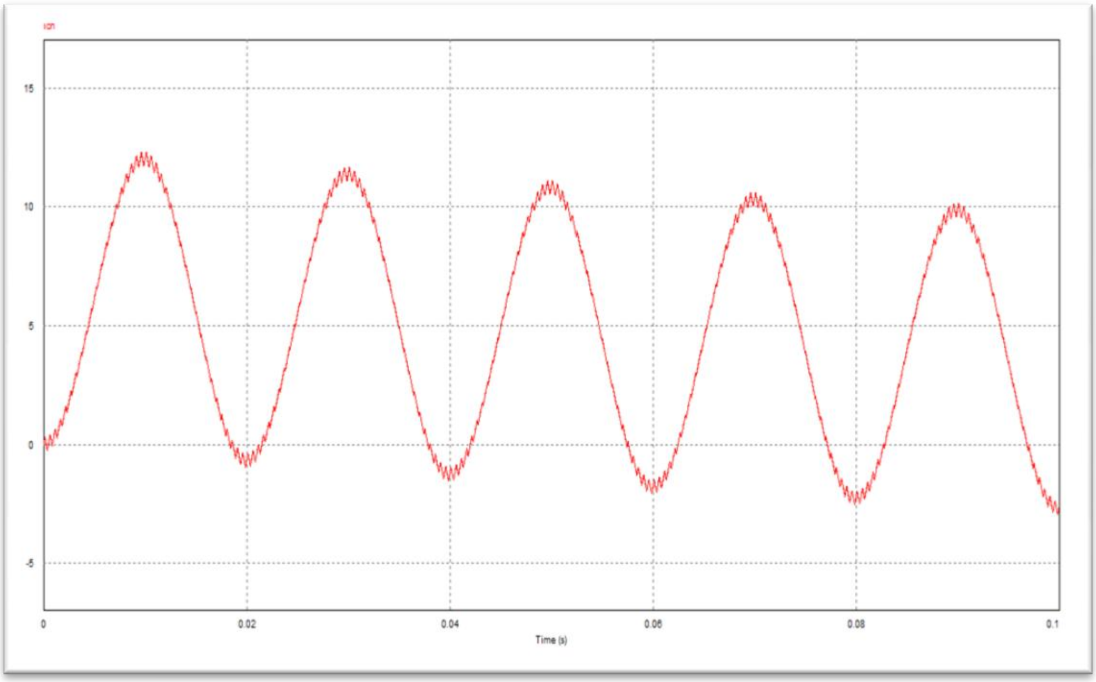


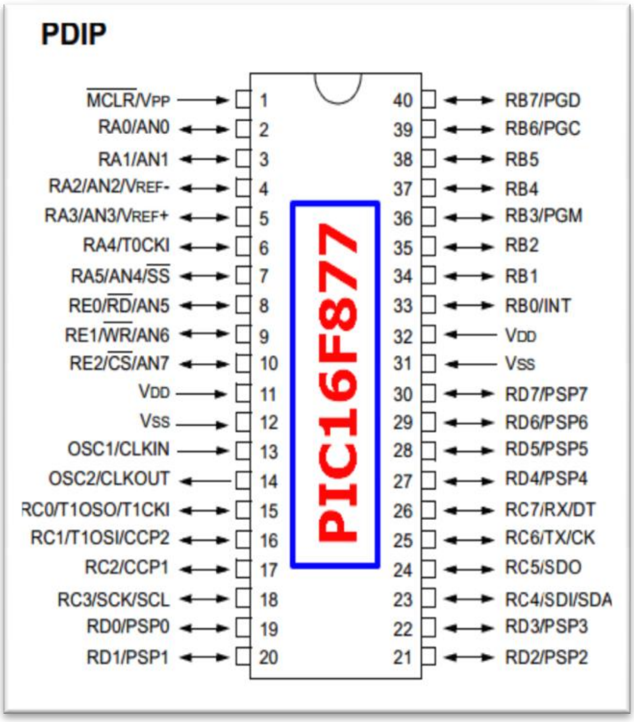
Figure III.27: Load current waveform in case of inductive load and with PWM control technique under PSIM.

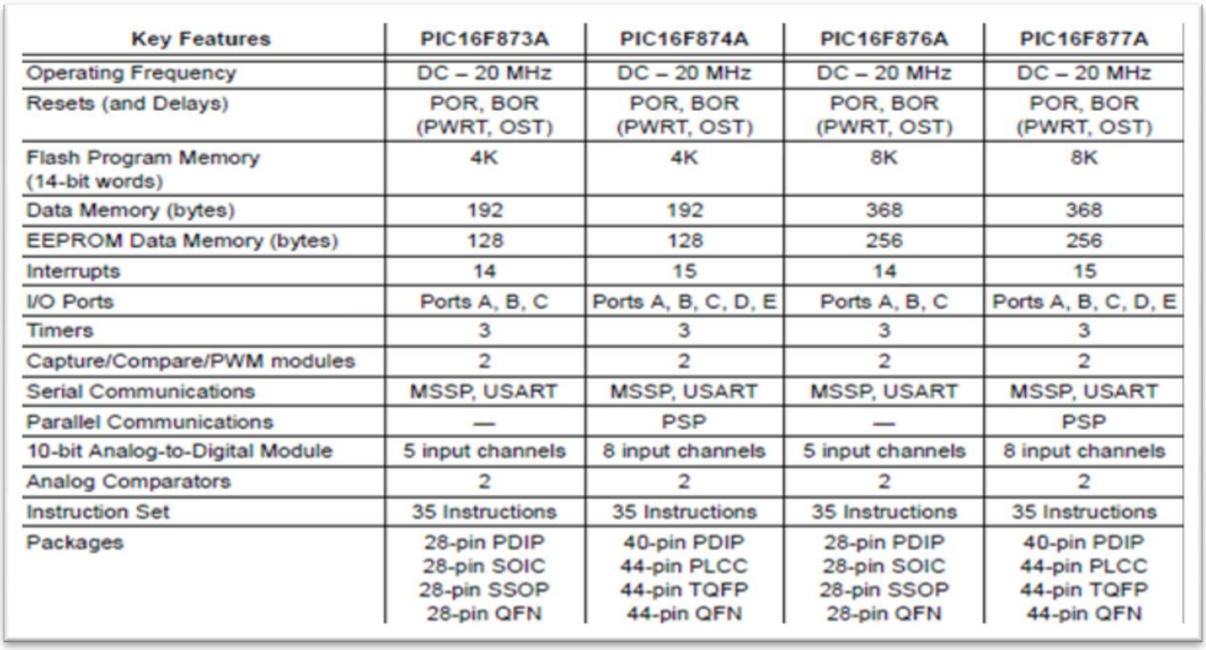
III.7 - REALIZATION OF THE INVERTER

III.8- Material used:

- ✓ **Pic16F877:[19]**

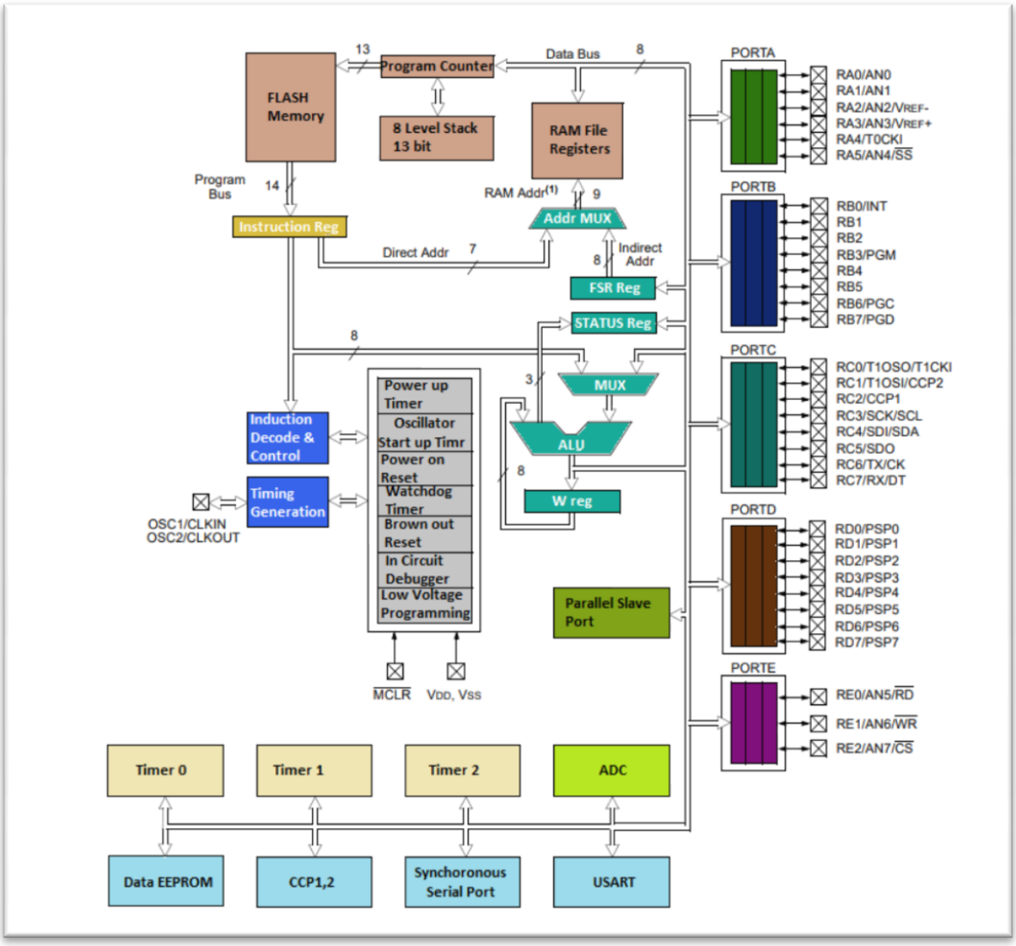

PIC16F877
MICROCHIP
PIC16F877


PDIP
PIC16F877
MCLR/VPP 1
RA0/AN0 2
RA1/AN1 3
RA2/AN2/VREF- 4
RA3/AN3/VREF+ 5
RA4/T0CKI 6
RA5/AN4/SS 7
RE0/RD/AN5 8
RE1/WR/AN6 9
RE2/CS/AN7 10
VDD 11
VSS 12
OSC1/CLKIN 13
OSC2/CLKOUT 14
RC0/T1OSO/T1CKI 15
RC1/T1OSI/CCP2 16
RC2/CCP1 17
RC3/SCK/SCL 18
RD0/PSP0 19
RD1/PSP1 20
40 RB7/PGD
39 RB6/PGC
38 RB5
37 RB4
36 RB3/PGM
35 RB2
34 RB1
33 RB0/INT
32 VDD
31 VSS
30 RD7/PSP7
29 RD6/PSP6
28 RD5/PSP5
27 RD4/PSP4
26 RC7/RX/DT
25 RC6/TX/CK
24 RC5/SDO
23 RC4/SDI/SDA
22 RD3/PSP3
21 RD2/PSP2



Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

Figure III.28:pic16f877 datasheet.



FigureIII.29: pic16877 block diagram.

✓ **TC4420:**[20]

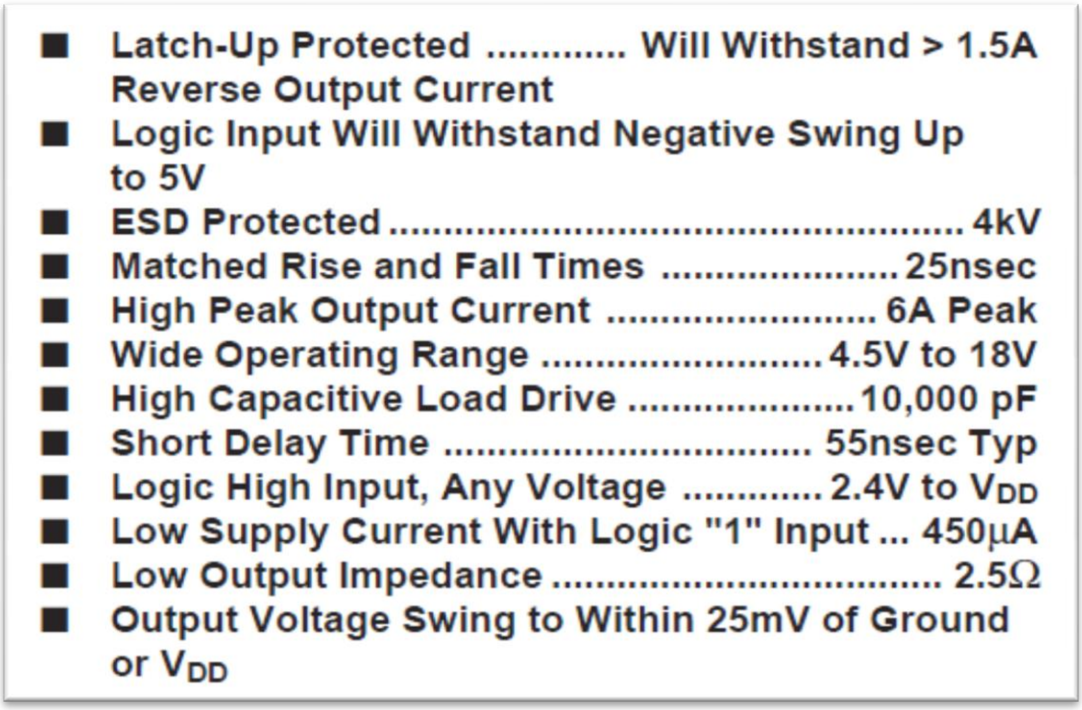
GENERAL DESCRIPTION:

The TC4420/4429 are 6A (peak), single output MOSFET drivers. The TC4429 is an inverting driver (pin-compatible with the TC429), while the TC4420 is a non-inverting driver.

These drivers are fabricated in CMOS for lower power, more efficient operation versus bipolar drivers.

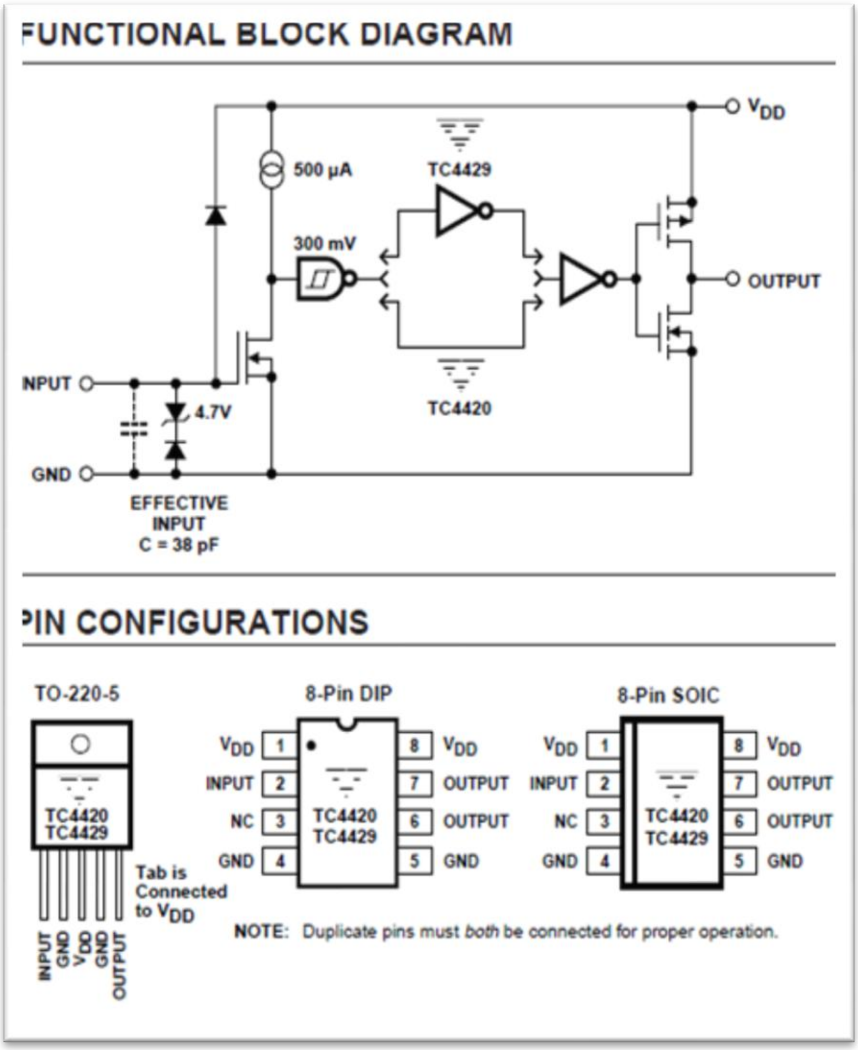
Both devices have TTL-compatible inputs, which can be driven as high as VDD + 0.3V or as low as – 5V without upset or damage to the device. This eliminates the need for external level shifting circuitry and its associated cost and size. The output swing is rail-to-rail ensuring better drive voltage margin, especially during power up/power down sequencing. Propagational delay time is only 55nsec (typ.) and the output rise and fall times are only 25nsec (typ.) into 2500pF across the usable power supply range. Unlike other drivers, the TC4420/4429 are virtually latch-up proof. They replace three or more discrete components saving PCB area, parts and improving overall system reliability.

FEATURES



- Latch-Up Protected .... Will Withstand > 1.5A Reverse Output Current
- Logic Input Will Withstand Negative Swing Up to 5V
- ESD Protected 4kV
- Matched Rise and Fall Times 25nsec
- High Peak Output Current .... 6A Peak
- Wide Operating Range .... 4.5V to 18V
- High Capacitive Load Drive .... 10,000 pF
- Short Delay Time .... 55nsec Typ
- Logic High Input, Any Voltage .... 2.4V to V_{DD}
- Low Supply Current With Logic "1" Input ... 450μA
- Low Output Impedance 2.5Ω
- Output Voltage Swing to Within 25mV of Ground or V_{DD}

FigureIII.30: features of TC4420.



NOTE: Duplicate pins must *both* be connected for proper operation.

FigureIII.31: function block diagram & pin configurations of tc4420.

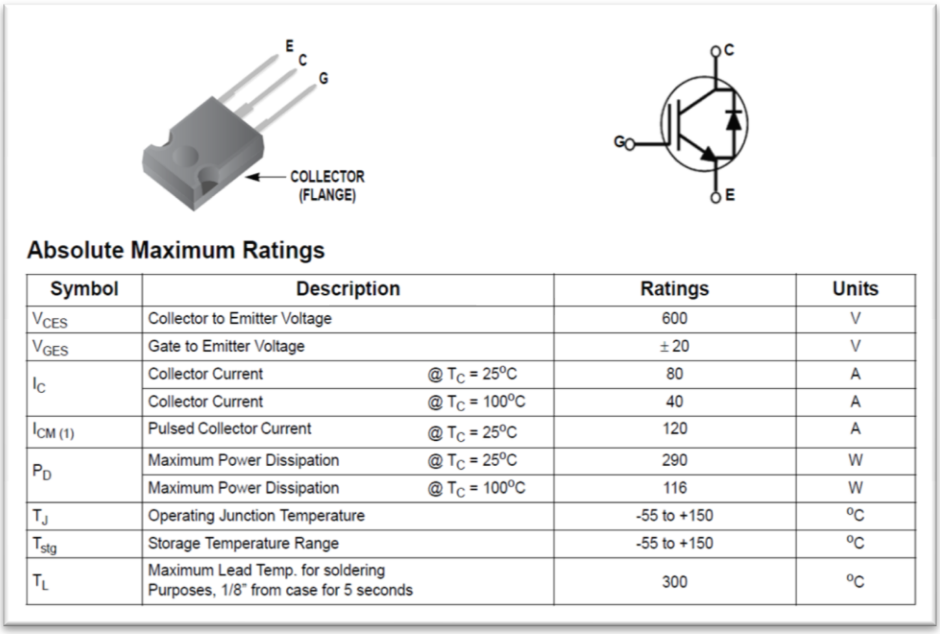
✓ IGBT 4060UFD:[21]

General Description:

Using Novel Field Stop IGBT Technology, Fairchild's new series of Field Stop IGBTs offer the optimum performance for Induction Heating, UPS, SMPS and PFC applications where low conduction and switching losses are essential.

Features:

- High current capability
- Low saturation voltage: VCE (sat) =1.8V @ IC = 40A
- High input impedance
- Fast switching
- RoHS compliant



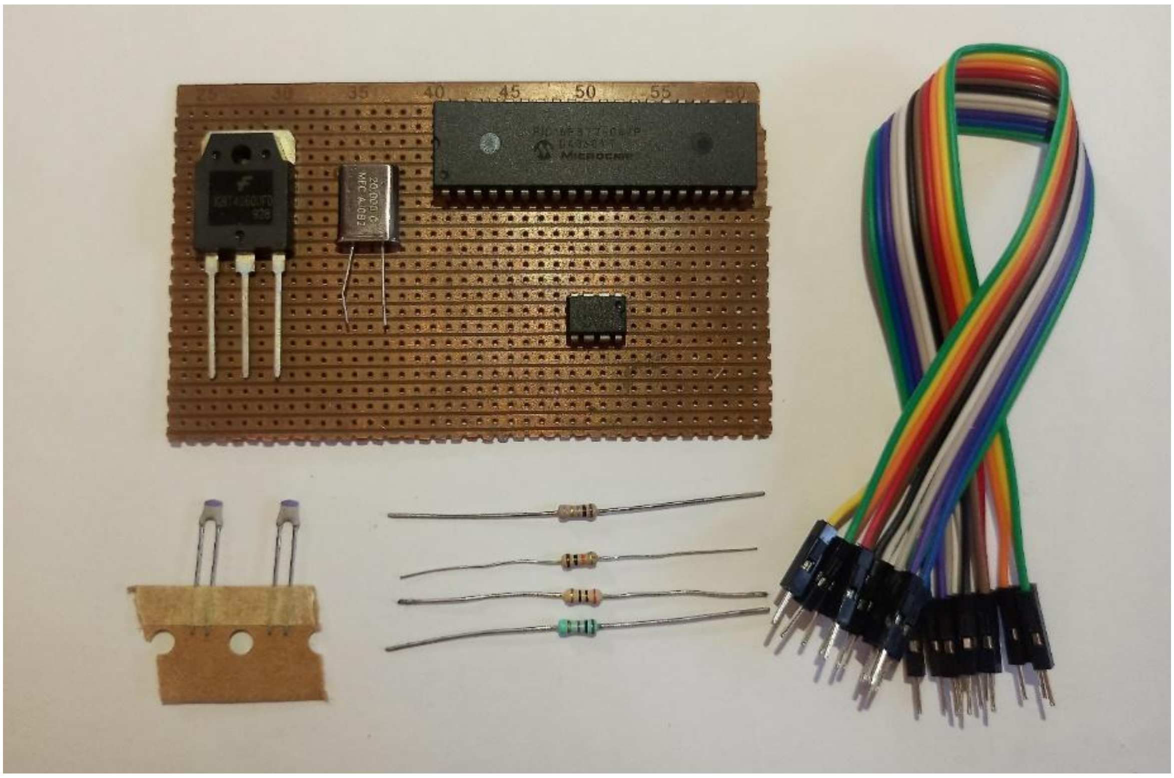
Absolute Maximum Ratings

Symbol	Description	Ratings	Units
V_{CES}	Collector to Emitter Voltage	600	V
V_{GES}	Gate to Emitter Voltage	± 20	V
I_C	Collector Current @ T_C = 25°C	80	A
	Collector Current @ T_C = 100°C	40	A
$I_{CM\ (1)}$	Pulsed Collector Current @ T_C = 25°C	120	A
P_D	Maximum Power Dissipation @ T_C = 25°C	290	W
	Maximum Power Dissipation @ T_C = 100°C	116	W
T_J	Operating Junction Temperature	-55 to +150	°C
T_{stg}	Storage Temperature Range	-55 to +150	°C
T_L	Maximum Lead Temp. for soldering Purposes, 1/8" from case for 5 seconds	300	°C

FigureIII.32: IGBT 4060UFD datasheet.

III.8.1- Rest Of The Components:

- ✓ **2 Resistance:** (1ohm to protect IGBT; 100ohm is the load).
- ✓ **2 Capacitors:** (22pf).
- ✓ **Wires.**
- ✓ **Perf board.**



FigureIII.33: Rest of the Components.

III.9- Conclusion :

The study of a 1000W single-phase inverter for renewable energy systems has been successfully simulated under various control techniques and the circuit has been tested by simulations of both resistive and inductive loads under two programs: ISIS/Proteus and PSIM. Three types of control techniques are implemented and tested with satisfactory results. And due to the unavailability and lack of tools, it was practically not implemented.

General Conclusion

GENERAL CONCLUSION :

The study of a 01 kilowatts single phase inverter dedicated to renewable energy systems has been successfully simulated within several control techniques. This inverter power output can be used for splaying loads of 1000 watts and the circuit was tested by simulations for both resistive and inductive loads under two softwares: ISIS/Proteus and PSIM. Threekinds of control techniques are implemented and tested within satisfactory results. It is to be noted that under ISIS/Proteus software, these several control commands are implemented on a microcontroller PIC 16F877A. All codes are written on C-Code and uploaded into the microcontroller with CCS compiler.For the realization part, we introduced all components that the realization of the inverter needs but we notice the absence of MOSFETs or IGBTs drivers in the Algerian markets.

In addition of the previous conclusions, we can also advance: The resulting waveform frequency was found to be satisfactory at 50 Hz equivalent to the standard power system; The sinusoidal pulse with modulation circuit is greatly simplified by using the PIC16F877A microcontroller; In addition to the high programming flexibility, the design of the switching pulses can be changed without further hardware changes. We hope strongly that the faculty provides the pedagogies laboratory with components that allow the realization of this practical projects to be easy.

There are some perspective for future work such as: realizing the inverter circuit, testing the circuit with a PV generator using MPPT algorithm technique for the circuit control. We can also work on the inverter efficiency by a comparative study between several control techniques.

References

[1] A.AliQazalbash, Awais Amin, Abdul Manan and Mahveen Khalid, “Design and Implementation of Microcontroller based PWM technique for Sine wave Inverter*”, International Conference on Power engineering, Energy and Electrical Drives*, POWERENG '09. 2009 pp.163-167, IEEE.

[2] S. M. Mohaiminul Islam, Gazi Mohammad Sharif, “Microcontroller Based Sinusoidal PWM Inverter for Photovoltaic Application*”, First International Conference Developments in Renewable Energy Technology (ICDRET)*, December, 2009 pp. 1-4, IEEE.

[3]] Julio Sanchez and Maria P. Canton, Microcontroller Programming the microchip pic, 1st edition, CRS press 2009.

[4] PIC16F87XA Datasheet – 40 Pin Enhanced Flash Microcontroller by Microchip

[5] M. H. Rashid, “Power Electronics Circuits, Devices and Applications,” 3rd Edition, Prentice-Hall of India, Private limited, New-Delhi, 2004.

[6] BOUKAROURA Abdelkader « Modélisation et Diagnostic d’un Onduleur Triphasé
par l’Approche BondGraph » 2009 Magister en électrotechnique.

[7] AHMANEANISSA«Etude et Réalisation d’une Carte de Commande
d’un Onduleur Monophasé PWM»Master Génie Électrique«2016».

[8]Makerhattab«2014»«réalisationd’unonduleurmonophasécommanderparpic16F877»universitéHassan1er–settat.

[9]cours électronique de puissance « conversion continu alternative » . université Joseph
fourrier .

[10] Hasnaouiothman « cours d’électronique de puissance » , université de Tunis.

[11] Zarour .Z « Réalisation d’une carte de commande d’un convertisseur DC/AC à base»

[12] EL IDRISSI Ramzi ; SEMLALI Amine ;AGHMADI Ahmed« Réalisation d’un onduleur monophasé autonome commandé par PIC 16F877 »Le 03/06/2014.

[13] https://seeprm.wordpress.com/2017/04/19/commande-pleine-onde/

[14]https://www.sciencedirect.com/topics/engineering/pulse-width-modulation

[15]SalehElkelaniBabaa, Matthew Armstrong, Volker Pickert«Overview of Maximum Power Point Tracking Control Methods for PV Systems»1 July 2014; revised 10 August 2014; accepted 27 August 2014

[16]Dinesh Kumar Sharma ;GhanshyamPurohit«Advanced perturbation and observation (P&O) based maximum power point tracking (MPPT) of a solar photo-voltaic system».December 2012.

[17] TrishanEsram and Patrick L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Transactions on Energy Conversion, vol. 22, no.2,June,2007.

[18] Marcelo GradellaVillalva, Jonas Rafael Gazoli, Ernesto RuppertFilho, "Analysis and simulation of the P&O MPPT algorithm using a linearized PV array model", Industrial Electronics, 2009. IECON '09. 35th Annual Conference of IEEE.

[19]PIC16F877 Datasheet.

[20] TC4420 Datasheet.

[21] IGBT 4060UFD Datasheet.