Sudan University of Science and Technology
College of Engineering
School of Electrical and Nuclear Engineering

Study of DC Inverter welder

دراسة ماكينة اللحام الالكترونية

A Project Submitted In Partial Fulfillment for the Requirements of the Degree of B.Sc. (Honor) In Electrical Engineering

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الآية

(وَلَا تَقُولَنَّ لِشَيْءٍ إِنِّي فَاعِلٌ ذَلِكَ غَدًا(23) إِلَّا أَنْ يَشَاءَ اللَّهُ وَاذْكُرْ رَبَّكَ إِذَا نَسِيتَ وَقُلْ عَسَى أَنْ يَهْدِيَنِ رَبِّي لِأَقْرَبَ مِنْ هَذَا رَشَدًا (24))

سورة الكهف :الايات(23-24)

الإهداء

إلى من بلغ الرسالة وأدى الأمانة .. ونصح الأمة .. إلى نبي الرحمة ونور العالمين

سيدنا محمد صلى الله عليه وسلم

إلى من بها أكبر وعليه أعتمد ، إلى شمعة متقدة تنير ظلمة حياتي

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الشكر والتقدير

. الحمد لله الذي أنار لنا درب العلم والعمل وأعاننا على أداء هذا الواجب ووفقنا إلى انجاز هذا العمل ...

نتوجه بجزيل الشكر والامتنان إلى كل من ساعدنا من قريب أو من بعيد على انجاز هذا العمل وفي تذليل ما واجهناه من صعوبات , ونخص بالذكر..

الدكتور المشرف / **نجم الدين عبده مصطفى** , الذي لم يبخل علينا بتوجيهاته ونصائحه القيمه التي كانت عونا لنا في اتمام هذا البحث .

ولا يفوتنا ان نشكر الباشمهندس / **دراج محمد جمعه...**

نسال الله ان يوفق خطاه ويرفعه اعلى درجات العلم والأدب ونساله ان يعطيه خير الدنيا والآخرة

Abstract:

This research study DC inverter welder for application in a welding power source that is cost - competitive with the more traditional and reduces the weight and size of the transformer uses for welding . To have an arc welding machine that is more efficient which produce neat welding.

مستخلص :

هذا البحث دراسه لماكينة اللحام الالكترونيه لتطبيقات مصادر تيار اللحام ,حيث تعتبر ذات تكلفه تنافسيه مقارنة بالماكينات التقليديه وتقلل من حجم و وزن المحولات المستخدمه حتى يكون لدينا ماكينة لحام ذات كفاءة عاليه وتنتج لحام دقيق.

Contents

List of Figures

List of Tables

List of Abbreviations

IGBT	Insulated Gate Bipolar Transistor
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
IGFET	insulated gate f ield-effect transistor
PWM	pulse-width modulation
PSPWM	Phase shift pulse-width modulation
ZVT	Zero voltage transition
ZVS	Zero voltage switching
PSFB	Phase shifted full bridge
PIC16F877	Type of micro-controller
IRF150	International rectifier
SMPS	Switched- mode power supply
DSP	Digital signal processor
DAC	Digital to analog converter
LP	Low pass filter
PCB	Printed circuit board
DC	Direct current
AC	Alternator current

CHAPTER ONE

INTRODUCTION

1.1 The Background:-

Welding is a way of heating pieces of metal using electricity or a flame so that they melt and stick together. It can simply be defined as the process of joining two or more pieces of metal to make the act as a single piece. This is often done by melting the work pieces and adding a filler material to form a pool of molten material that cools to become a strong joint. Because of its strength, welding is used to join beams when constructing buildings, bridges and other structures. Welding can also be used to join pipes in pipelines, power plants at the construction sites and in home appliance. Furthermore, welding is used in shipbuilding, automobile manufacturing and repair, aerospace applications. There are many kinds of welding which include arc welding, resistance welding, gas welding among others. Emphasis will be laid on arc welding because it is the most common type of welding as well as the main aim of this project [1].

Arc welding is the process of welding that utilizes an electrical discharge (arc) to join similar materials together. Equipment that performs the welding operation under the observation and control of a welding operator is known as welding machine. To solve the problem of weight and size of conventional arc welding machine, it is necessary to design an inverter. The inverter provides much higher frequency than 50Hz or 60Hz supply for transformer used in welding [1]. So transformer of much smaller mass is used to permit the handling of much greater output power. The welding noise produce by conventional arc welding machine is reduced by selecting the operating frequency over the hearing of human ability. The choice of 20Khz for the inverter type arc welding machine was determined to meet the above expectation. The output welding current is controlled by controlling the power supply for transformer at high frequency. This power supply is provided by a frequency inverter. Power switch (IGBT) or (MOSFET) is used for the inverter design due to its high switching. The control circuit use to control the output welding current is design to drive the power switch at high frequency. Insulated Gate Bipolar Transistor power switch is more efficient and less prone to failure than (MOSFETs) power switch.

An arc welding machine provides the required current and voltages at deferent stages of the arc process.

High voltage is produced at no load, which is also called open-circuit voltage. When the electrode is touched to the piece a short circuit occurs and the current increases suddenly. After the output current reaches the reference current level, the arc welding machine regulates the output voltage to maintain a constant current, which is required for metal transfer. The voltage produced in the steady state is proportional to the current.

This depends on the arc length and electrode diameter. During the transient state of the arc process, the load varies between open circuit and short circuit.

In welding machines, a transformer is used for voltage transformation and isolation, and inductance at the output stage to filter output current. Currently, high-frequency inverter welding machines are preferred to conventional welding machines due to their high efficiency and high performance. The converter should operate at high frequency in order to realize high-performance control and decrease the size of magnetic elements. By means of high frequency operation, the converter volume and output current ripple decrease.[2]. Welding quality is improved due to the fast response of the system to sudden changes in load during the welding process. The inverter can be operated at high frequency by means of soft switching techniques.

1.2 Problem Statement:-

The problem with designing an old machine for the retail market is its cost compared to the inverter welder machine and also the size and weight and the efficiency of the machine.

Also the inverter welder machine is more economic and effective compare to the old machines.

1.3 Objectives of the project:-

The main objective of this project is to design and build and arc welding machine that operates on 220v ac at variable frequency which of benefit to urban area (50Hz). This reduces the weight and size of the transformer use for welding. To have an arc welding machine that is more efficient which produce neat welding.

1.4 Significant of the Study:-

The significant of this project is that it seeks to develop an arc welding machine that is cost effective, strong and portable. Not only that the arc welding machine is strong and portable, it is also mobile.

CHAPTER TWO
LITERATURE REVIEW
2.1 Introduction:-

The history of joining metals goes back several millennia that are Bronze Age or Iron Age in Europe and the Middle East. At that age, the process of joining similar or dissimilar materials is by forge welding. Arc welding did not come into practice until much later. In 1802, vastly Petro discovered continues electric arc and subsequently proposed its possible practical application including welding. The French electrical inventor Auguste De Metitens produced the first carbon arc torch, patended in 1881, which was successfully used for welding lead in the manufacture of lead-acid batteries. In 1881-1882, a Russian inventor Nikolai Bernados created the electric arc welding method for steel known as carbon arc welding. This type of arc welding uses carbon electrodes [2].

The advantages in arc welding continued with the invention of metal electrodes in the late 19th century by a Russian Nikolai Slavyanor (1888), and an American, L.C Coffin. Around 1900, A.P Strohmenger released in Britain a coated metal electrode which gave a more stable arc. In 1905 Russian scientist Vladimir Mitkerich proposed the usage of three phase electric arc for welding. In 1919, alternating current welding was invented by C.J hoslag but did not become popular for another decade [3]. Competing welding processes such as resistance welding and oxy fuel welding were developed during this time as well, but both, especially the later, faced stiff competition from arc welding especially after metal coverings (known as flux) for the electrode, to stabilize the arc and shield the base material from purities, continued to be developed [3].

During World War I, welding started to be used in ship building in Britain in place of riveted steel plates. The Americans also became more accepting of the new technology when the process allowed them to repair their ships quickly after a German attack in the New York Harbor at the beginning of the war. Arc welding was first applied to aircraft during the war as well, and some German airplane fuselages were constructed using this process []. In 1919, the British shipbuilder Cammell Laird started construction of merchant ship, the fullagar, with an entirely welded hull.

During the 1920s, Major advances were made in welding technology. Shielding gas became a subject receiving much attention as scientist attempted to protect welds from the effects of oxygen and nitrogen in the atmosphere. Porosity and brittleness were the primary problems and the solutions that developed included the use of hydrogen, argon, and helium as welding atmospheres. During the following decade, further advances allowed for the welding of reactive metals such as an aluminum and magnesium. This in conjunction with developments in automatic welding, alternating current, and fluxes fed a major expansion of arc welding during the 1930s and then during World War II [1].

Many new welding methods were invented in the middle of the century. Submerged arc welding was invented in 1930 and continues to be popular today. In 1932 a Russian, Konstantin khrenor successfully complemented the first underwater electric arc welding. Gas tungsten arc welding was perfected in 1914 and gas metal arc welding followed in 1948, allowing for fast welding of non-ferrous materials but requiring expensive shielding gases. Using a consumable electrode and a carbon dioxide atmosphere as a shielding gas, it quickly became the most popular metal arc process. In 1957, the flux-cored arc welding process debated in which the self shielded wire electrode could be used with automatic equipment, resulting in greatly increased welding speeds. In that same year, plasma arc welding was invented. Electro slag welding was released in 1958 followed by Electro gas welding in 1961.

Arc welding is a type of welding power supply to create an electric arc between and electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, and/or slag .

2.2 Arc welding power supplies:-

To supply the electrical energy necessary for arc welding processes, a number of different power supplies can be used. The most common classification is constant voltage power supplies.

In arc welding, the voltage is directly related to the length of the arc, and the current is related to the amount of heat input. Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding and shielded metal arc welding, because they maintain a relatively constant current even as the voltage varies. Constant current is used in manual welding because it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate. Constant voltage power supplies hold the voltage constant and vary the current. Constant voltage power supplies are most often used for automated welding processes such as gas metal arc welding.

The direction of current used in arc welding also plays an important role in welding. Consumable electrode processes such as shielded metal arc welding and gas metal arc welding generally use direct current, but the electrode can be charged either positively or negatively. In welding, the positively charged anode will have a greater heat concentration and as a result, changing the polarity of the electrodes has an impact on weld properties. If the electrode is positively charged, it will melt quickly, increasing weld penetration and welding speed.

Alternatively, a negatively charged electrode results in more shallow welds [2]. Non-consumable electrode processes such as gas tungsten arc welding, can use either type of direct current as well as alternating current (AC). With direct current however, because the electrode only creates the arc and does not provide filler material, a positively charged electrode causes shallow welds, while a negatively charged electrodes makes deeper welds [1].

Alternating current rapidly moves between these two, resulting in medium-penetration welds. One disadvantage of (AC) is that arc must be re-ignited after every zero crossing. This disadvantage has been addressed with the invention of special power units that produce a square wave pattern instead of the normal sine wave, eliminating low-voltage time after the zero crossings and minimizing the effect of the problem [3]. Shielded metal arc welding and gas tungsten arc welding will use a constant current source. Constant voltage source is preferred in gas metal arc welding and flux-cored arc welding.

The welding power supplies most commonly seen can be categorized within the following types.

2.2.1 Transformer:-

A transformer style welding power supply converts the high voltage and low current electricity from the utility mains into a high current and low voltage (typically between 17 to 45 volts and 55 to 590 Amps). A rectifier is used to convert (AC) into (DC) to obtain dc output [4].

By moving a magnetic shunt in and out of the transformer core helps to vary the output current. A series reactor to the secondary controls the output voltage from a set of taps on the transformer’s secondary winding. This type of power supply is least expensive but bulky. It is a low frequency transformer which must have as high magnetizing conductance to avoid wasteful shunt currents. The transformer may also have significant leakage conductance for short circuit protection in the event of a welding rod becoming stuck to be workforce. The leakage inductance may be variable so the operator can set the output current [4].

2.2.2 Generator and Alternator:-

Welding power supplies may also use generators or alternators to convert mechanical energy into electrical energy. Modern designs as usually driven by an internal combustion engine but older mechanics may use an electric motor to drive an alternator or generator. In this configuration the utility power is converted first into mechanical energy to achieve the step-down effect similar to a transformer. Because the output of the generator can be direct current or even a higher frequency (AC) current, older mechanics can produce DC from AC without any need for rectifiers.

2.2.3 Inverter:-

Since the advent of high-power semi conductors such as insulated gate field-effect transistor (IGFET) also known as (MOSFET) it is also now possible to build a switched-mode power supply capable of copying with the high loads of arc welding. These designs are known as inverter welding machine. In the isolated pulse-width modulation (PWM) DC-DC converters, transformer leakage inductance leads to switching losses when the converter operates with hard switching and decreases efficiency of the circuit due to the requirement of passive snubber elements. The (PSPWM) method is proposed to solve these problems. In this method, a quasiresonance is formed between the

Parasitic capacitance of power switches and transformer leakage inductance so that the leakages are utilized beneficially and soft switching is obtained . In this topology the energy stored in inductance is used for the discharging of the parasitic capacitors of the (MOSFET). The (MOSFET) is turned on with zero-voltage transition (ZVT) and turned on with zero-voltage switching (ZVS). In the conventional (PSPWM) method, the soft-switching range is limited due to the insufficient energy of the leakage inductance at low currents. The parasitic capacitor of the (MOSFET) is not discharged at low load currents. In addition, the output diodes are exposed to excessive voltage stress in the phase-shifted full bridge (PSFB) PWM converter. In order to solve these problems, many approaches have been proposed in the literature.

The utility (AC) power is first rectify to (DC) power; then the (DC) power switch (invert) into a step-down transformer at high frequency to produce the desire welding voltage or current. The switching frequency is typically about 20khz to 100khz [5]. The high switching frequency drastically reduces the bulk of the step-down transformer. The mass of magnetic components (transformer & conductors) goes down rapidly as the operating (switching) frequency increases. The converter circulatory can also provide features such as power control and overload protection. This type of welding machines (inverter based) are more efficient and provide better control of variable functional parameters than conventional welding machines. The (IGBTs) or (IGFETs) in an inverter based machine are controlled by a micro controller so the electrical characteristics of the welding power can be changed by software. There are other types of arc welding machines which some were mentioned. We are to emphasis on Inverter type arc welding machine, since it is the topic of the project.

CHAPTER THREE

SYSTEM ANALYSIS

3.1 Introduction:-

The approach of this project is realized through the design and implementation of its input subsystem, control unit and output subsystem. The welding of a metal occurs when the control unit and the output subsystem links together through the conductive objective to be welded. Welding is the process of joining two or more similar or dissimilar material with/without the application of heat and/or pressure with or without using the filler material.

3.2 Design Methodology:-

The design started with the overall system. The handy tool used at this stage is the block diagram shown below in fig3.1 the block diagram depicts the hierarchy of how the inverter sub-circuits will interact and interface with each other. A computer aided design software known as protease (matlab) was used for the design simulation of the paper design before the first hardware prototype was actualized or realized on an experimental breadboard. This was achieved through the implementation of the inverter input subsystem to the output subsystem. These were carefully done according to the project block diagram and the final schematic circuit diagram.

The system block diagram of the inverter arc welding machine project is shown in Figure (3.1).

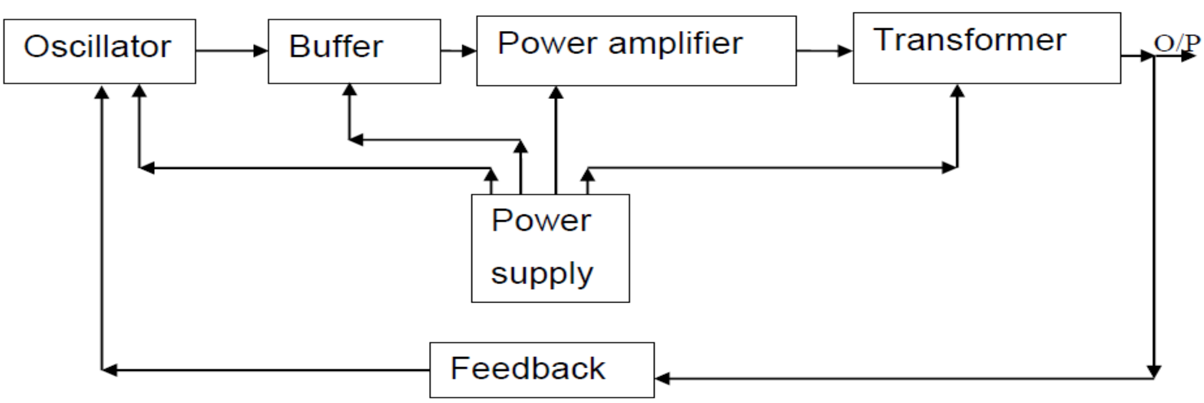


Fig3.1 Block diagram of an inverter type welding machine

The system is a flexible power supply designed as current source [6], corresponding to the block diagram shown above in fig1which consists of the following stage.

3.3 Design Analysis:-

3.3.1 Power stage: In this stage rectifier supplies the oscillator, buffer, power amplifier, and transformer stage with the necessary voltage

. A 230v Ac is use in our design to power the circuit.

3.3.2 Oscillator Stage:

A (PIC16F877) is use to generate the necessary pulse needed to drive the (MOSFET) to alternate the (DC) supply. The output from the oscillator stage is amplified using transistor (9013). This amplified signal triggers the metal-oxide field-effect transistor with Vgs greater the threshold voltage. The frequency at which circuit operate is determined with the oscillator stage

3.3.3 Power amplifier stage:

This stage determines the primary power of the transformer. MOSFET (IRF150) is use in the design for power amplification.

3.3.4 Transformer:

This is the final stage which transforms the 36v (modified square wave) to about 25v depending on the frequency of the pulse generated at the oscillator stage

3.4 System Components:-

The system (arc welding machine) consists of several components are:

1- Two Rectifiers full bridge.
2- The inverter consists of :
   - Four (MOSFET).
   - (PIC16f877) controller to produce PWM.
   -Two filters the first with capacitor and the second with inductance.
   -High frequency transformer.

3.5 Design specification:-

Output Voltage =36v

Output Current= 160A

Input Voltage = 220v

Duty cycle = 20%

3.6 Component/Device Identification and description:-

The components/devices used for the construction of the inverter arc welding machine are explained below with their uses in the project.

3.6.1 Diode:-

Figure (3.2) physical view of a high power diode.

Diode is defined as a two terminal p-n junction semiconductor. Silicon and Germanium is semiconductor materials for making diodes. Diode made of silicon has a voltage drop of 0.7v whereas germanium has 0.3v.

Diodes can be used as rectifiers, signal limiters, voltage regulator and switch. Diode conducts in one direction only. The fig 3.3 below shows the symbol of diode. A diode is said to be forward bias when the cathode is negatively charged relative to the anode and reverse bias when the cathode is positively charged with respect to the anode. Diode is use as rectifier as well as regulator in the project design [4].

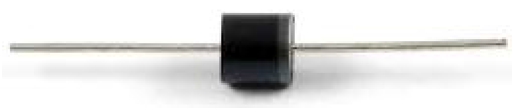


Figure (3.2) Diode

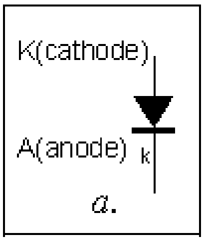


FIGURE (3.3) Diode symbols: a- standard diode

3.6.2 Metal-Oxide Semiconductor Field-Effect Transistor (MOSFET):-

(MOSFET) can also be called Insulated Gate Field-Effect Transistor (IGFET) because the metal gate is insulated from the channel [4]. (MOSFETs) are much faster switch power device than relays and mechanical switches. They are best suited for digital circuit. We have two types of (MOSFETs) which is known as Mode of operation. They are Enhancement (MOSFET) and Depletion (MOSFET). N-channel enhancement Metal-Oxide Semiconductor Field-Effect Transistor is use as a switch. The above mode of operation is subdivided into N-channel and P-channel. N-channels are more popular than P-channel because of their higher speed switching.

(MOSFETs) are un polar devices which can be used as high power switch. They are voltage controlled devices. Figure (3.4) depicts (MOSFET) used as a switch.

If vi = 0, the transistor is cut-off because the voltage between the gate and is vi>0, the $vo \approx$ 0v which below the threshold voltage. Therefore vo = vDD.If tells the ON state. Equations for (MOSFET) calculations are as follows.

$$ID = (VGS - VGS(th))\ 2 \text{------------------------ } (3.5)$$

$$VDG = VDS - VGS \text{ ----------------------------- } (3.6)$$

$$VD(sat) = VGS - VT \text{ -------------------------- } (3.7)$$

Where,

ID = drain current

K = constant which depends on the particular MOSFET

VDG = Drain-Gate voltage

$VG(th)$ = VT = threshold voltage

$VG(th)$ = VT = threshold voltage

VDS = Drain- Source voltage

VGS = Gate-Source voltage

From equation (3.5):

$$K = \frac{\mathbf{ID(ON)}}{\mathbf{(VGS(on) - VT)2}} \quad (A/V2) \text{ ----------- } (3.8)$$

Obtain from MOSFET data sheet $I(on)$,VGS, $and\ VGS(th)$to calculate for K

Note: $I(on) = ID$, $VGS = VGS(on)$

3.6.3 PIC (16f877): -

It's one of the most development controllers and available in (microchip) it is used on a large scale in experimental and modern applications because:

- Low price.
- The extent of the widespread use.
- Operate at high frequencies.
- High quality.
- Easily available.

They are ideal for applications such as control of machinery and equipment and measurement applications.

Controller (Pic16f877) contains 40-party, as shown in the FIGURE (3.4) following:

- Program memory type Flash EEPROM. 14 * worth of 8102
- Type of data RAM memory. Worth 368
- 33 outlets (input \ output).
- 8 adapter's channels of analog-to-digital.
- Records comparison.

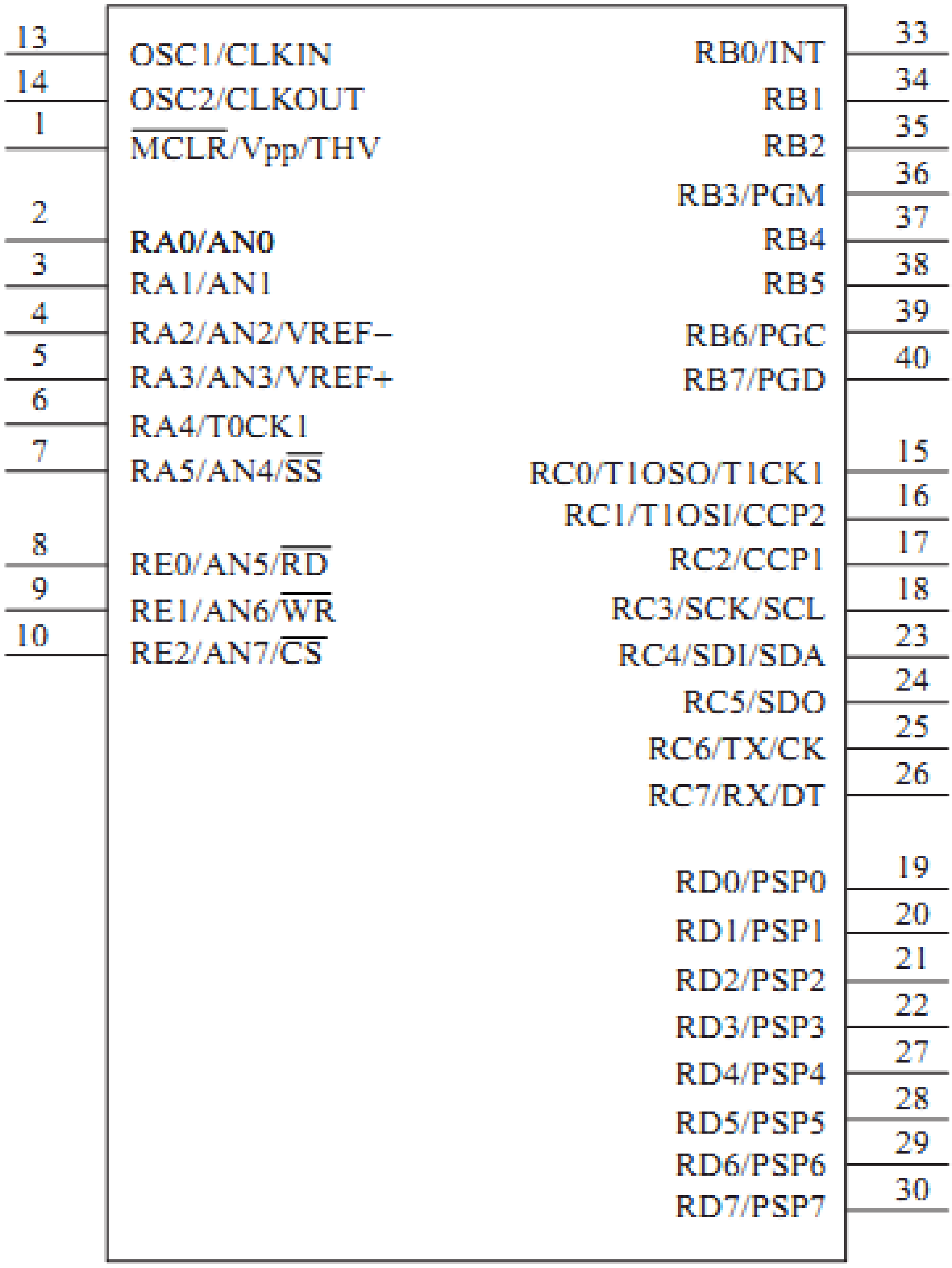


Figure (3.4) (PIC16F877)

3.6.4 Gate drive IR2112:-

Its importance lies in that it helps to control the gate of the MOSFET or the IGBT like turn off the circuit when the output is not stable as it provides a high voltage running (greater than the voltage of micro-controller) which helps the playback speed of the MOSFET or the IGBT. As they contain a mechanism to accelerate the closing process also provides protection for the circuit.

Basic conductivity shown in Figure (3.5)

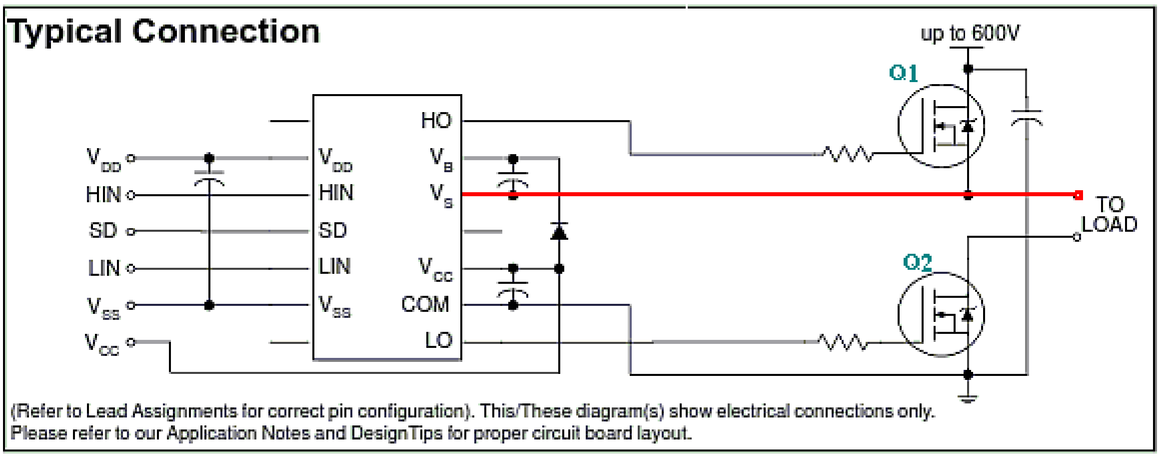


Figure (3.5) gate driver

3.6.5 Resistor:

In electronics, resistor is one of the basic components. Resistor is an electronic component which opposes the flow of current.

Resistance which is the property of a resistor is measured in Ohms and it is represented by 'R'. The value of a resistor is determined by the color coding. The color coding is found on the surface of a resistor. Fixed and variable resistors are the two types of resistor which there symbol. Fixed resistor is the type of resistor which the resistance does not vary while in variable the reverse is the case. Equation 3.10 is use to determine the voltage across a resistor of a resistance with a current I

$$V = IR \text{ ---------------------------------- } (3.10)$$

Where,

V = voltage across the resistor (volts)

I = current through the resistor (Amp)

R = resistance of the resistor (ohms)

3.6.6 Capacitor:-

A capacitor is a passive two terminal electrical component used to store energy. It is originally refer to as condenser. Capacitors are widely used in electronic circuit for blocking direct current while allowing alternating current to pass. It can be use to smooth (i.e. removing the ripple) the output of power supplies. In electric power transmission systems capacitor stabilize voltage and power. In our design capacitor is use as voltage reservoir. Mathematically, the capacitance of a capacitor is C = Q/V

Q = charge.

V = potential difference.

C = Capacitor.

3.6.7 Transformer:-

Transformer is defined as a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux. We have two types of transformer according to construction classification as core-type and shell-type. In the design of the inverter arc welding machine we used shell type transformer. Fig3.6.7 shows the schematic diagram of the mentioned two types. For an inverter type arc welding machine, the transformer is design to be small in size and less weight compare to conventional type. In an arc welding machine electric discharge is use for welding. This electric discharge is known as an arc[5]. The voltage requires in maintaining an arc is calculated using the equation 3.11

$$V = C + DL \text{ ----------------- } (3.11)$$

Where;

C = 15 to 20 volts

D = 2 to 3 volts

L = length of arc in mm and its value is about 2 to 4 mm

An arc is maintained at a voltage of about 24 to 30 volts.

3.6.8 High Frequency Transformers:-

A high frequency transformers transfer electric power. Its mechanical size depends on the power to be transfer and on the operating frequency. The higher frequency is the reason of smaller mechanical size. Usually frequencies are from 20 to 100 kHz. The material of the core is ferrite.

Data books for appropriate cores provide information about the possible transfer power for various cores.

The first step to calculate a high frequency transformer is to choose an appropriate core with the help of the data book, the size of the core is dependent on the transfer power and the frequency. The second step is to calculate the number of primary turns. This number determines the magnetic flux density within the core. The number of secondary turns is the ratio of primary to secondary voltage. Following this the diameters of the primary and secondary conductors can be calculated depending on the RMS-values of the currents[5] .

3.7 Implementation of inverter arc welding machine with the proposed converter:-

The circuit diagram of the developed 5 kW and 10 kHz single-phase soft-switched arc welding machine is shown in Figure (3.6). The circuit diagram mainly consists of the switching power supply (SMPS), (DSP) circuit, (PIC16F877) circuit, auxiliary control circuit, and drive circuits. The nominal output current of the proposed welding machine is 160 A. The input voltage of the DC inverter is V_d = 300 V, and operation frequency (f_s) is 10 kHz.

In the simulation, the control of V_{rec} voltage is realized with (PWM) output directly. In practice, in order to control the V_{rec} voltage, the(PWM) output is converted to an analog value and then applied to PIC16f877. Because (DAC) output is not available in (DSP), the high-frequency (PWM2) module of the (DSP) and the analog filters are used to obtain analog voltage representing *y* output. The selected (PWM) frequency is 10 kHz. PWM output is filtered by the RC filter and converted to an analog value with a second-order low pass (LP) filter.

This analog output voltage (V_{ref}) is applied to (16f877) IC, and phase shift is adjusted by V_{ref} . (16f877)IC provides 0%{100% phase shift for a [4] 1 V input voltage range.

The nominal values of the components used in the welding machine are listed in Table (3-1). The saturated inductances are connected in a series with the output diodes to prevent parasitic oscillations, which occur at the turn-of_ process of the output diodes. The voltage across the(DC) blocking capacitor C_S is low because the capacitor value is high. Appropriate heat-sinks are used for power semiconductor devices, and the cooling is supported with a fan. Over-current, short-circuit, and temperature protection are implemented in the converter.

Primary current is measured with a current transformer, and current information is given to the control IC for over-current protection. The current limit selected is 200 A.

The turn-off_ losses of the(MOSFET) at a high current level are greatly reduced with the selection of the high- value capacitor. In the case of the high-value capacitor at no-load, switching devices can cause damage due to the discharge of the capacitors through the switches. The experimental tests realized for the turn-o_ process of the (IGBT) show that a parallel snubber capacitor value of around 20 nF minimizes turn off losses of the selected (MOSFET). Selecting a high-value L_S inductance maintains soft switching at low output currents. However, high-value inductance increases the reset time of the primary current; thus, the duty cycle losses increase and efficiency of the circuit decreases. In the application, L_S and C_S are high enough to avoid insufficient dead time.

The waveforms taken from the operating welding machine for different reference currents are shown in Figure (3.6). Welding current is kept constant by controlling the duty cycle. The regulation is provided against both arc voltage and (DC) bus voltage ripple.

Additional functions for initial and short-circuit cases are implemented with the welding algorithm.

Output current and voltage are measured for the welding algorithm. The welding voltage (V_o) is the sum of arc voltage, the voltage on the wire resistance, and electrode resistance. The arc voltage is the largest component of the welding voltage.

In Figure , at the beginning of the welding process, the waveforms of I_o , V_o , and V_d are given for I_{ref} = 90 A. At no-load, V_d is 300 V and the output voltage is 60 V, because duty is maximum. The welding process starts with the touch of the electrode to the piece. The welding current rises rapidly to the maximum value, and after the 2.5 ms hot-start duration it decreases to the reference value. Welding voltage decreases from 60 V to 20 V. If the welding process continues without a short circuit for a long time, a constant current flows through the electrode.

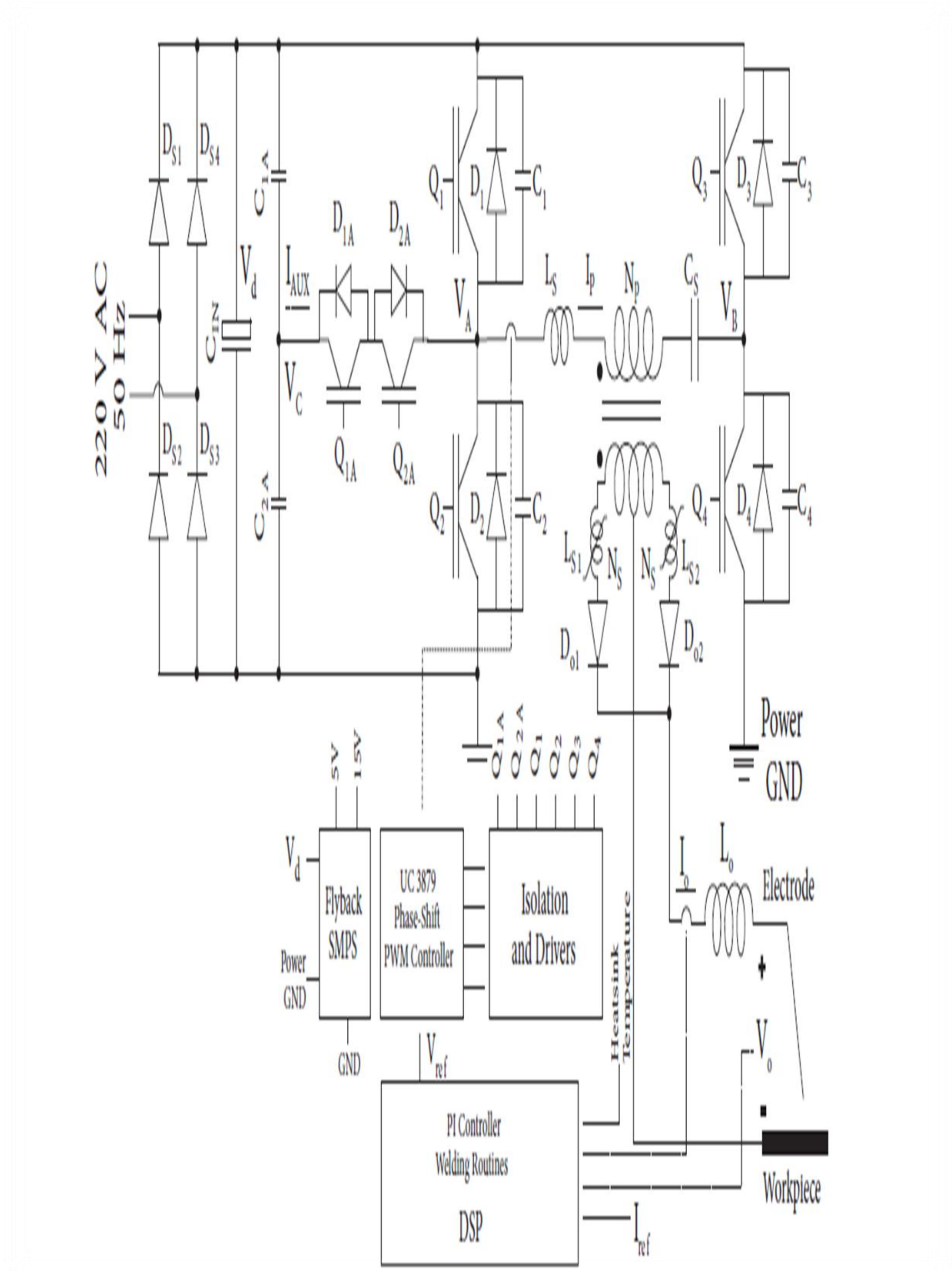

220 V AC
50 Hz
Vd
Flyback
SMPS
Power
GND
GND
UC 3879
Phase-Shift
PWM Controller
Isolation
and Drivers
PI Controller
Welding Routines
DSP
Electrode
Workpiece
Power
GND
Heatsink
Temperature

Figure (3.7)

Item	Symbol	Value
Rectifier	D_{S1}–D_{S4}	GBPC5008
Input filter capacitor	C_{IN}	3 × 470 μF - 450 V
Main and auxiliary switches	S_1, S_2, S_3, S_4, S_{1A} S_{2A}	IXGH60N60C2D1
Auxiliary circuit snubber capacitors	C_{1A}, C_{2A}	10 nF - 630 V
Lagging lag snubber capacitors	C_1, C_2	2.2 nF - 630 V
Leading lag snubber capacitors	C_3, C_4	10 nF - 630 V
Resonant inductor	L_S	5 μH
Transformer turns ratio	$N = N_P/N_S$	5:1
Output diodes	D_{o1}, D_{o2}	DSEI 2 × 121
Output inductor	L_o	30 μH
Saturable inductor	L_{S1}, L_{S2}	10 μH

Table (3.1)

CHAPTER FOUR

SUSTEM SIMULATION AND RESULT

4.1 Introduction:-

The simulation is a process that mimesis real system or physical process .Simulation trying by this tradition to determined characteristics of the default behavior of the system , and can be achieved by another system similar to the first , simulation includes many methods and applications which are usually done on a computer by using Appropriate software .

4.2 Simulation Stages:-

The simulation of any physical system pass by different stages as;
-Depth understanding of the system and related activities mechanism work.
- Modeling what you need the system as a preliminary step, by putting hypotheses that allows to simplify the study as much as possible , and to put mathematical equation descriptor for its behavior.
-Translation model chosen using simulation software, or by writing mathematical equation ruling and computer programming language.
- Ensure computer model with the real system, his experience in simple cases, already knows the behavior of the system.
- Designed experiments to be carried out on the computer model and the expected results of these experiments.
-Analysis of the results and drop it in the real system.
- Determine the validity of the model and the use of the results in line with the hypotheses developed during the construction of sample.

4.2.1 Advantages of simulation:-

Simulation is used in many scientific studies and industrial applications in order to examine some of the action plans in the real or the security of some of the information or determine the extent of the scientific and economic feasibility of testing the world. It is often the researchers, engineers and others interested in the wonders result that will get them if subjected one of the elements of the system to change. Experience may be the obvious way, is that in many cases, experience may be unattainable, or expensive, and then resort to simulation by applying the change to the system similar to the studied system their behaviors

Simulation in engineering applications is very important, where many systems work depends on a large number of transactions vary in the extent of their impact in the work of the system, and improve the performance of the system is to develop a work mechanism to control these transactions.

As well as electronic circuits require long experiments, and can be simulated by these studies and shortened time to study a fairly acceptable. In addition many of the experiments and studies that can't be implemented in reality forever and resort to simulation to see the results.

Simulation costs are generally much lower than the trial and allow avoiding risk, especially when the rights part of the system under study, as it can get results more quickly.

4.3 Simulation programs:-

In this project was worked of simulations by using two programs:

-Proteus and MIKROC.

-PSIM (power simulation).

4.3.1 Proteus program:-

We used PROTEUS program in circuit simulation, which is a program used to simulate electronic circuits and find the value of effort and currents for each branch in the circuit before the workout circuit in practice.

Among the advantages of this program that simulates real-time circuit with a best simulation program exists so far for the efficiency, speed and ease.

This program puts in the hands of the student and professional engineer and an integrated environment that contains all the necessary tools for practical and realistic simulation, it combines elements of circuit simulation and electronic systems (illustrated in clips sham Animations for easy handling and accuracy) and models of processors to facilitate the later stage of simulation systems for electronic-based controllers, was the first developed test methods and performance simulation of these systems pre-application stage Practical to design the circuit

This program combines the ease of use and powerful tools in the edit circuit , it can support the entered charts, whether to carry out the simulation or designed as a printed circuit.

It is worth mentioning that the tools available in the program provides a wonderful possibilities in the drawing and shape operations and , is shown in terms of latitude and writing lines , packing types ...... etc, which are the advantages of employing.

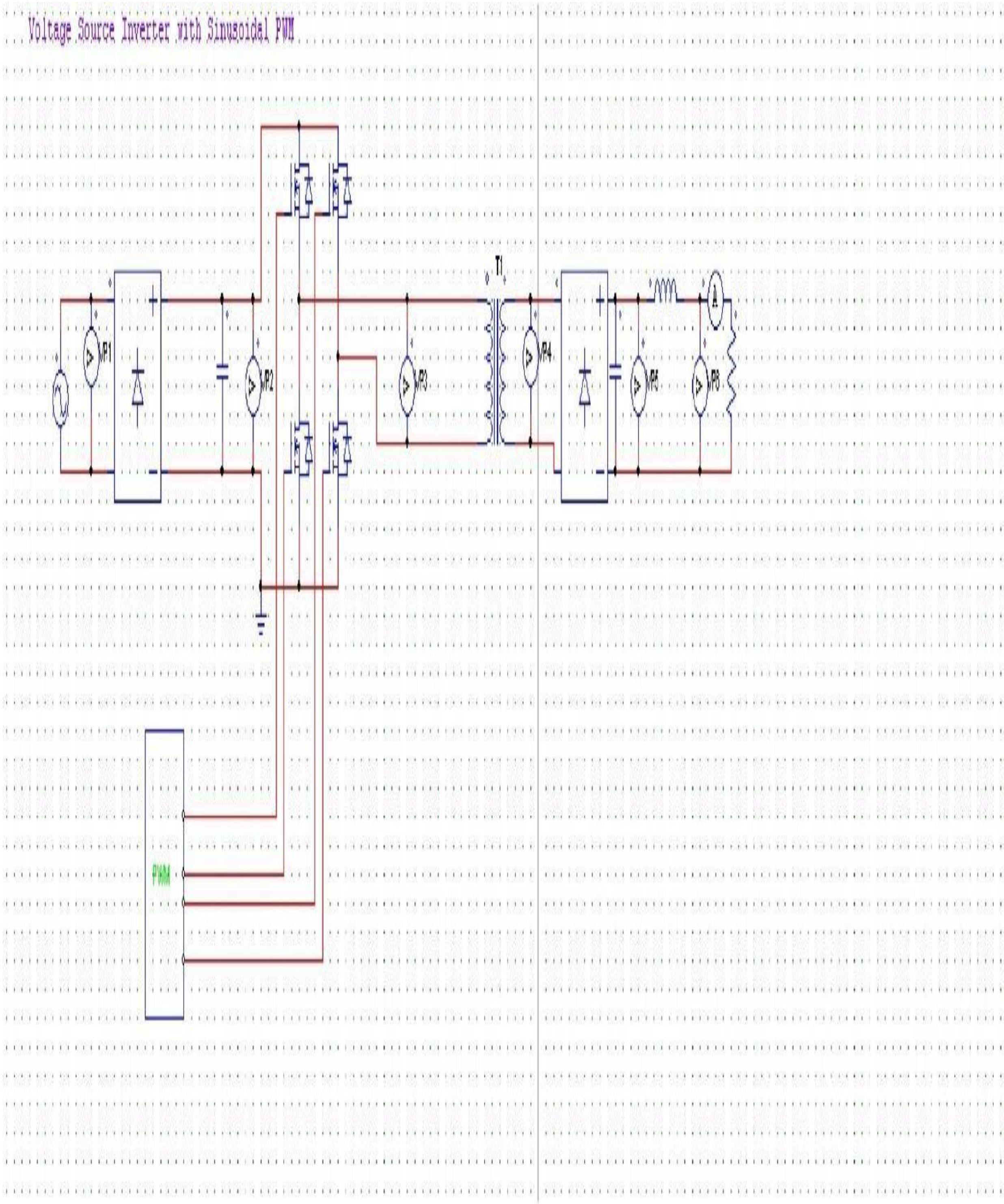
For a complete achievement to necessary fees described the stages of work on the program.

4.3.2 PSIM Program:-

It is a simulation of electronic circuits program is specifically designed for industrial electronic circuits and frequency converters but it can simulate any electronic circuit. The program has been developed by Power- sim , and PSIM uses integration method according to the trapezoidal rule as a basis in the simulation algorithm. The program provides an interface schematic of the circuit and an observer of the waveforms. The program has several models and that its functions extend to specific areas of design and circuit simulation such as: control theory, electric motor and photovoltaic panels Portal and it also use in industry for research and development of electric products, in addition use to educational institutions for research and teaching have.

4.4 System design by using PSIM program:-

Figure (4.1) shown the installation of the system complete with voltmeter After each components of the system.



Figure(4.1) integrated system by PSIM program

4.4.1 First rectifier output:-

It's a full-wave rectifier (Full bridge rectifier),it's income from the AC voltage source and output shown in the Figure (4.2) output is the first rectifier after filtering through parallel capacitor .

At X-axis the time and at Y- axis the voltage.

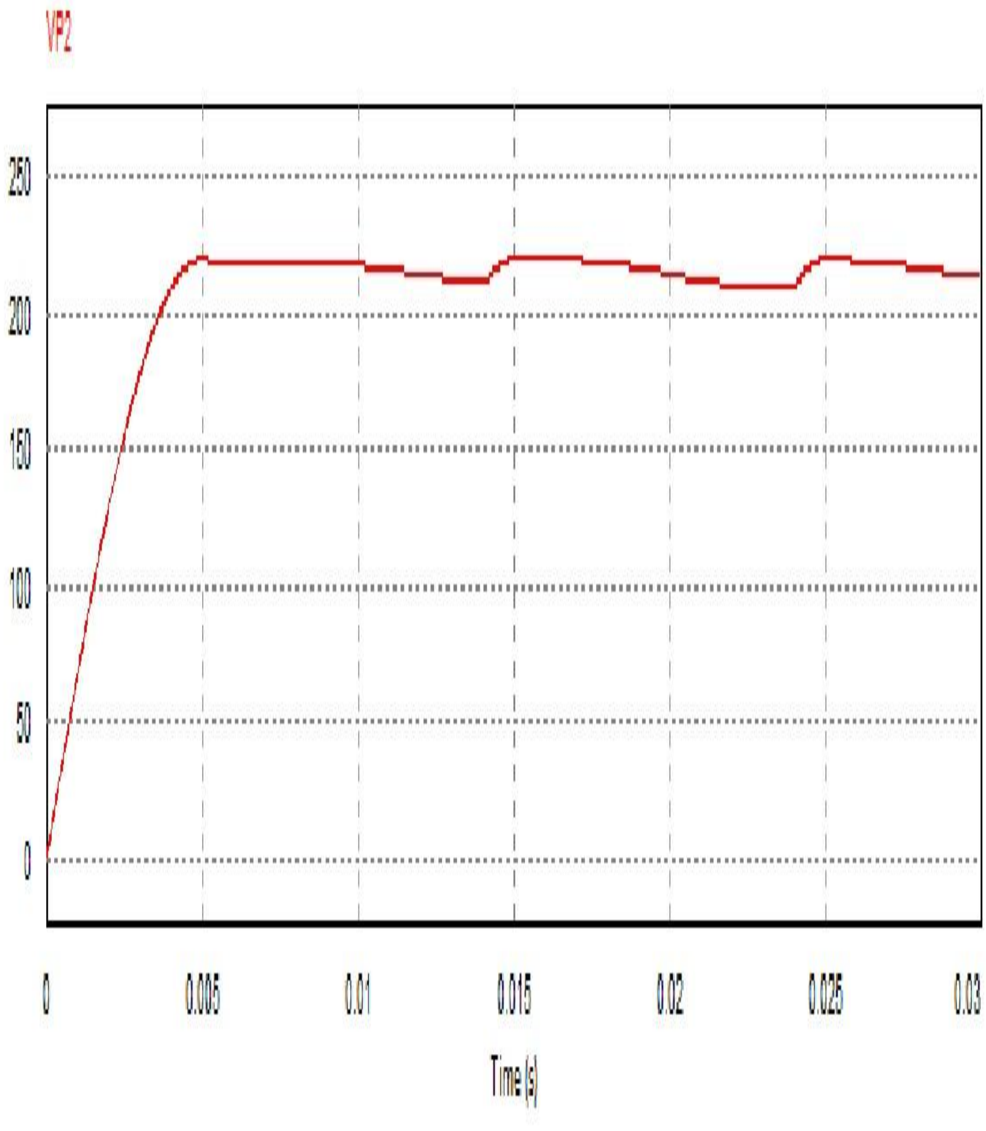


Figure (4.2) First rectifier output after filtering

4.4.2 Inverter output:-

This inverter is a single phase full wave (full bridge type) .DC input voltage and AC output voltage. This inverter controlled by using (PWM) and pulses produced by (PIC16F877) micro-controller. As shown in Figure (4.3).

At X-axis shown the time and at Y-axis shown the voltage , and the relation between them is clear in the Figure(4.3).

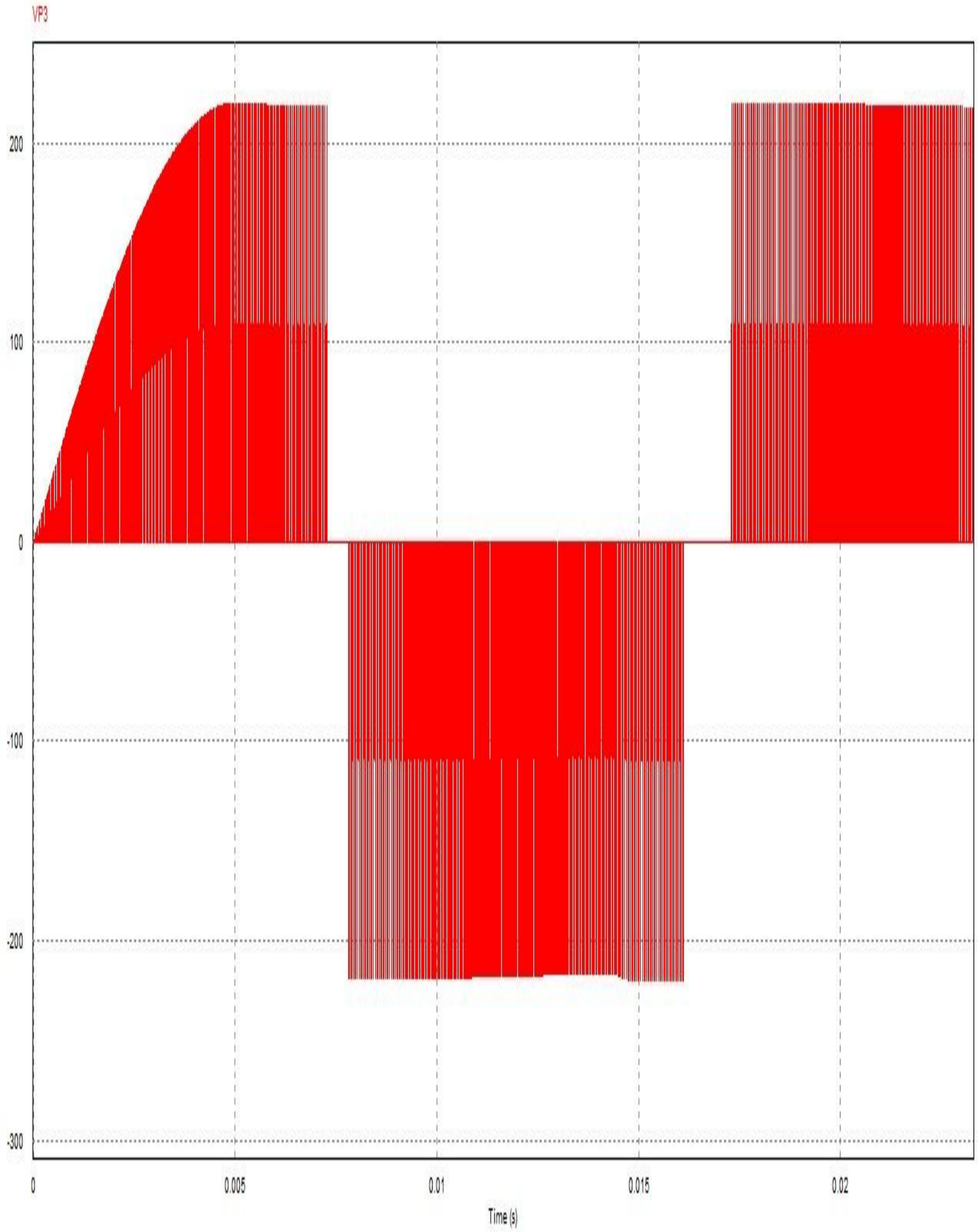


Figure (4.3) inverter output wave by using PWM

4.4.3 High Frequency Transformer output:-

This transformer is step down voltage and step up current ratio (1:4) as shown in figure (4.4).

At X-axis shown the time and at Y-axis shown the voltage , and the relation between them is clear in the Figure(4.4).

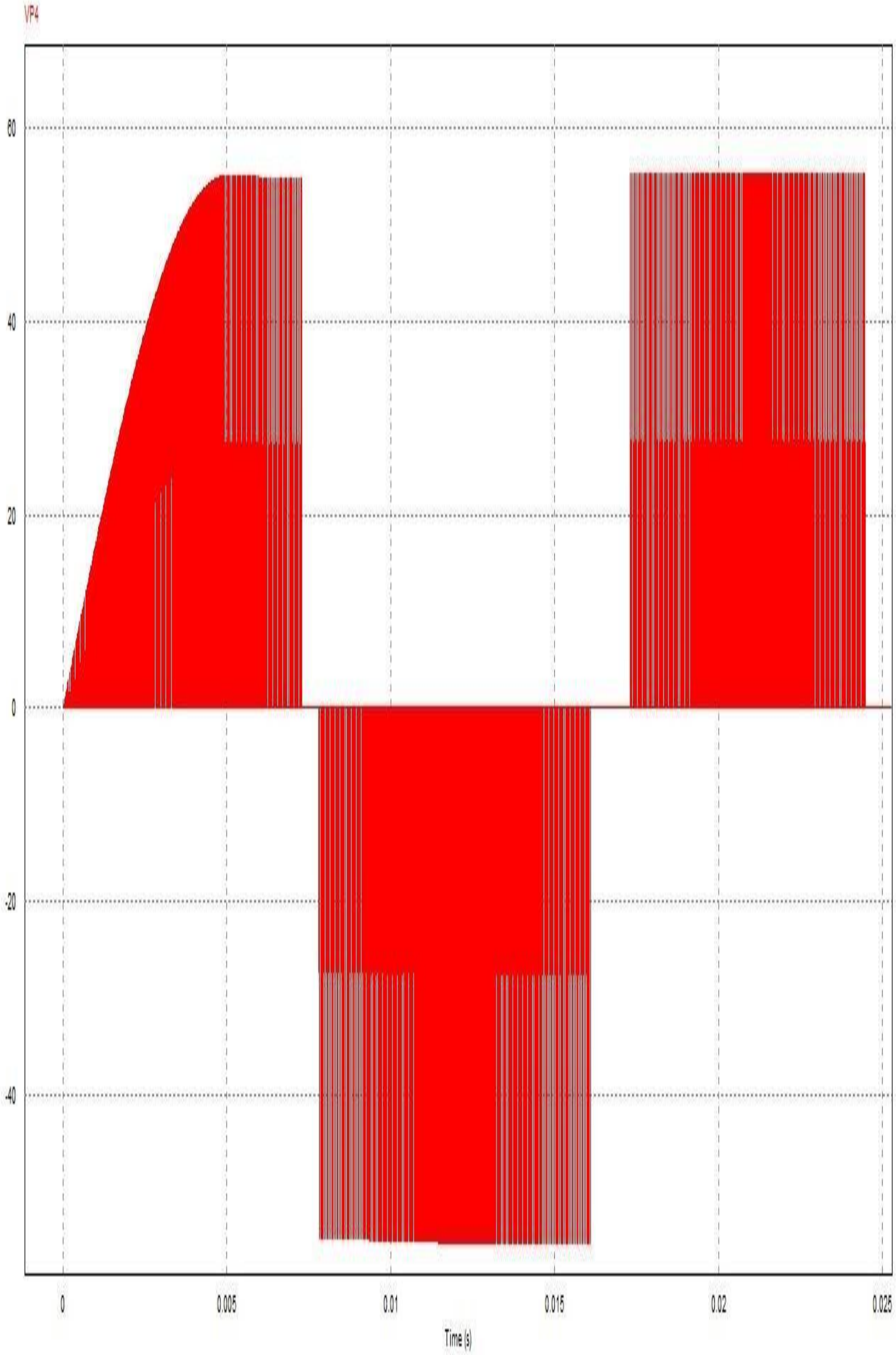


Figure (4.4) high frequency transformer output wave

4.4.4 Second Rectifier output:-

This rectifier is similar to the first rectifier in that it is full bridge type .It's output has been filtered by using smoothing Inductance as shown in Figure (4.5). At X-axis shown the time and at Y-axis shown the voltage

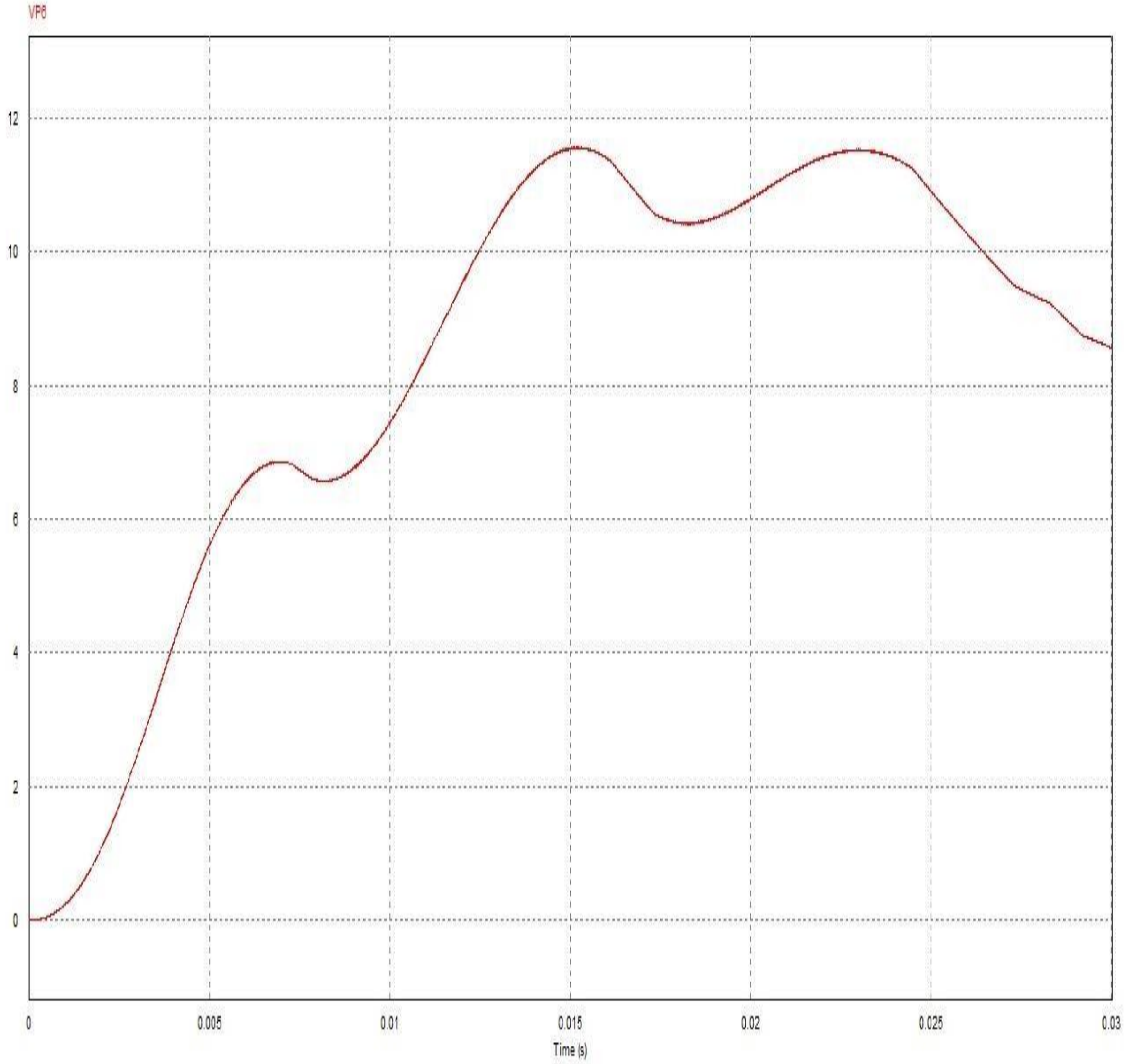


Figure (4.5) second rectifier output after filtering

4.5 Inverter circuit design by using PROTEUS program:

The inverter circuit of single phase full bridge was designed by four (MOSFET) , four signal amplifier (IR 2112) type , micro-controller (PIC458f) type and two circuits for protect micro-controller from reverse power as shown in Figure(4.6).

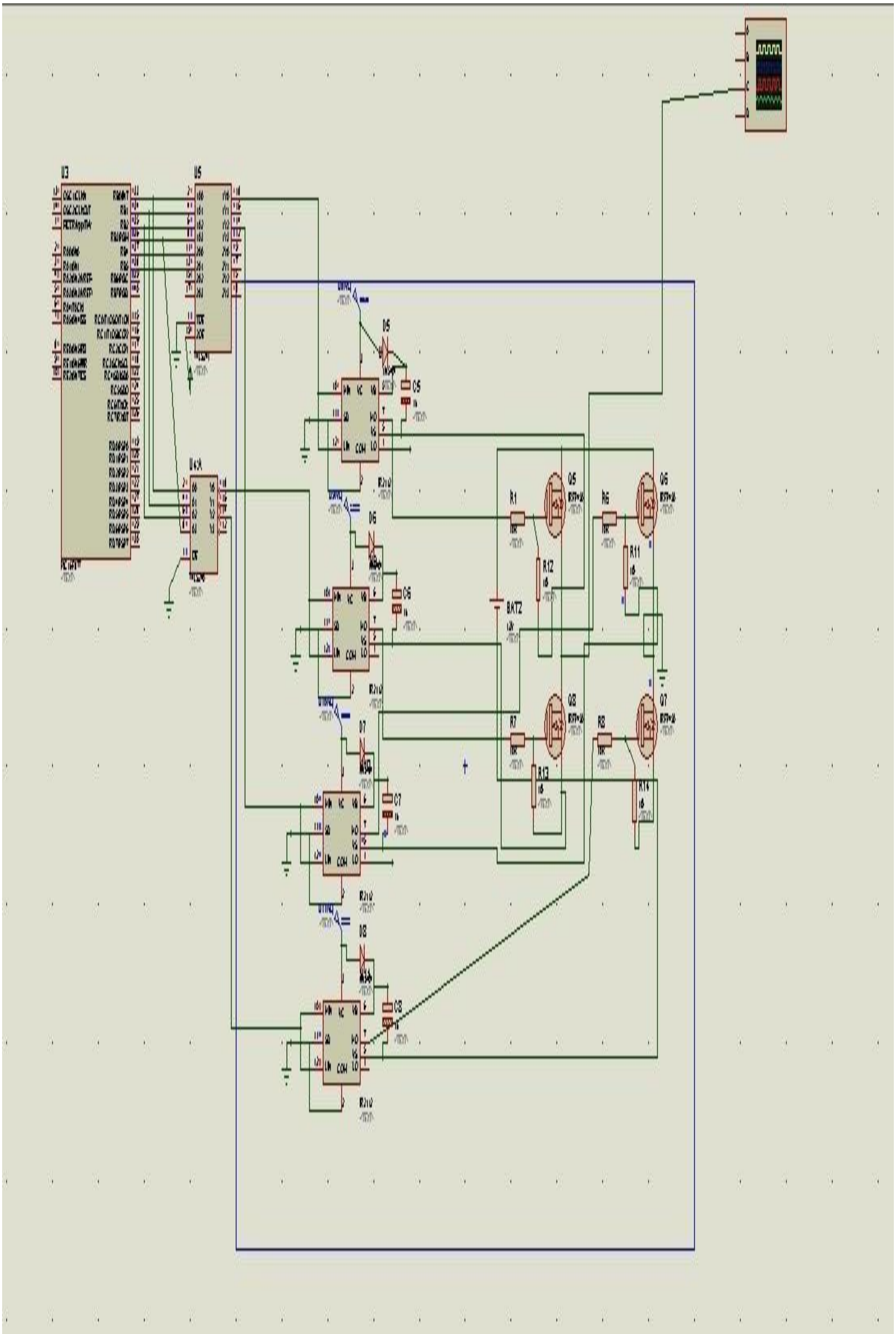
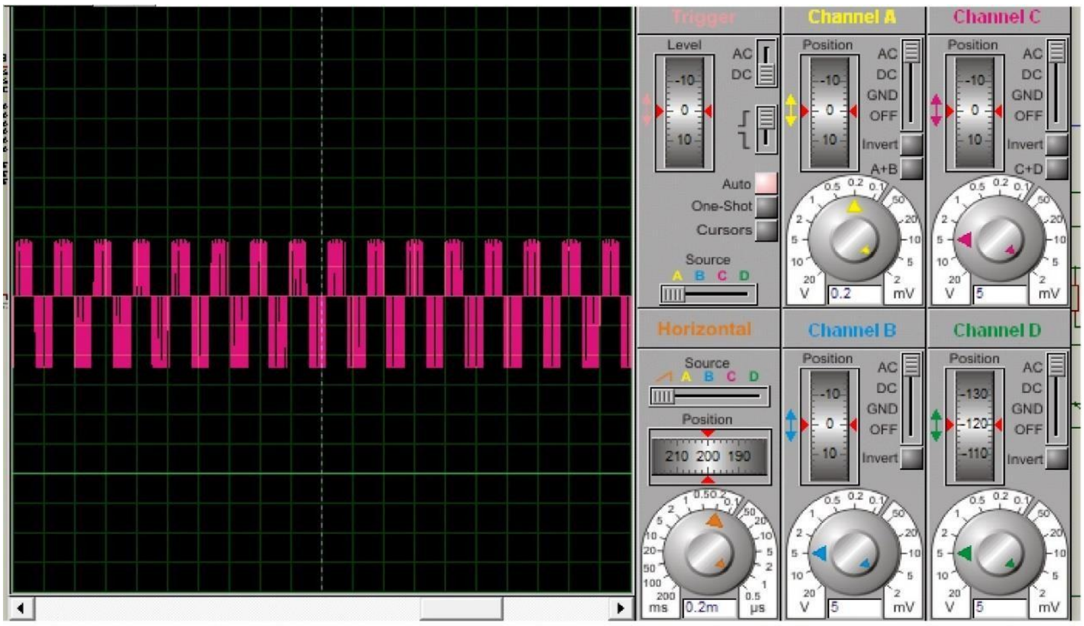


Figure (4.6) inverter circuit by PROTEUS program

4.5.1 Inverter Output:-

Figure (4.7) bellow inverter output wave .The output wave is squire at 10KHZ frequency



Welding voltage and current drawn depends on the diameter of welding wire used the table shows that

The table (4.1) it shows the amount of output voltage and direct current drawn

Cable diameter(mm)	Current(Ampere)	Voltage(volt)
1.59	70-150	10-20
2.38	125-225	15-20
3.18	225-360	25-40
3.97	360-450	40-55

CHAPTER FIVE

CONCOULSIONS & RECOMMENDATIONS

5.1 Conclusions:-

From previous studies we found that all the welding machines available in the market are conventional machine input and output current is ac current, its large size and heavy weight machine and a few efficient .When implementation of this project will solve this problems by designing an electronic welding machine with light weight and small size and high efficiency so as to benefit from the power electronics science.

In this project was the design the circuit of electronic welding machine and simulated by PSIM (power simulation) program, and it was extracted input and output results of each component of the system and all of the system

Use micro-controller (PIC16F877) after programmed by C language, the (MIKROC) program allowed the production of pulses (PWM) for transistors.

This project represents a benefit and a practical application of the power electronics science.

5.2 Recommendation:-

-provide inverter components required for its application in practice.

-Work on the development of conventional welding machines, and so by taking advantage of power electronics science, and increase the degree of safety.

- Project development to higher levels through the use of (IGBT) to achieve greater energy

- entry simulation programs more in the curriculum.

- It is not designed (DC Inverter welder) practical design Due to lack of availability of the manufacturer's printed circuit cards (PCB) and to narrow search time as well as the scarcity of certain components in the Sudanese markets such as gate drive (Gate drive IR2112).

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[5] ADIL H. Muhammad, MPhil **High** Frequency Transformer, Design and Modeling using Finite Elements Technique.