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DESIGN AND SIMULATION OF ELECTRONIC WELDING MACHINE USING H-BRIDGE INVERTER AND USING 8051 CONTROLLER.

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Abstract:-Welding serves a variety of purposes across domains. Machinery and equipments fabricated, pipeline and manifold welding, structural welding, offshore welding and ornament welding are examples of welding that take place in business and industry.Welding equipment has become of the most important tools that a producer cans posses hence the need to design and construct an arc welding machine. In this paper, authors designed and constructed 3-phase electronic welding machine of 10 kHz switching frequency with arc welding as application.

To solve the problem of weight and size of conventional arc welding machine an inverter circuit is also designed.

Keywords:-welding electodes, arcwelding, equipment fabrication, transformer, inverter.

1 .INTRODUCTION:-

The arc welding process consists of heating theSecondly, the outputwelding current of an electric arcmetal surfaces of the parts to be joined to their plasticTemperature through passage of high AC or DC electriccurrent. The electric arc (that is discharge into a gas) isignition between the electrode and the pieces at lowvoltage drops (10-40 V) at high currents (5-2000 A).The manual-metal arc welding with consumableelectrodes (sticks) form approximately 30% of allwelding systems the manual welding machines usethe high frequency inverters to provide high capacitycurrents during operation. The inverter operationfrequency is between 20-100 kHz through the use of semiconductors devices with power performances(MOSFET and IGBT transistors). In this paper a HalfBridge high frequency inverter is used to provide anappropriate current on welding point. The conventional analog welding machine generates thesteady PWM for driving IGBT of its inverter andcontrols the output welding current by turning on or offof IGBT switches. So it cannot regulate well thequality of welding current to track the setting weldingCurrent .

In The other control method, the outputwelding current controlled by changing the duty cycle ofPWM. The changes Based on the error between thevalues of feedback output welding current and the setting current applied to a controller. The requirementsfor a good DC-arc welding machine can be explained asthe following: Firstly, an output welding current easilyachieves the setting welding current at first welding. Secondly, the output welding current of an electric arc must be maintained constant during welding process.

3. BLOCK DIAGRAM OF INVERTER WELDING MACHINE

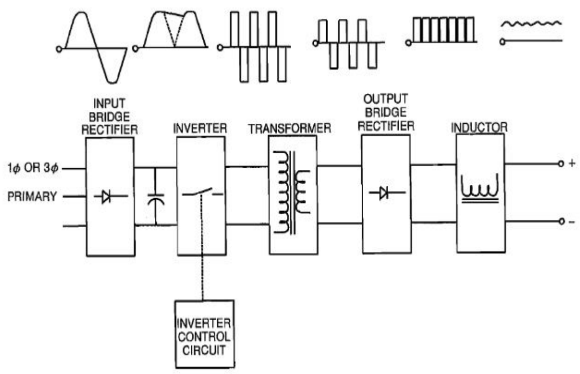


Figure.1 block diagram of inverter welding machine

The AC input voltage rectified by input AC/DCrectifier and applied to high frequency inverter device like.The voltage drops on capacitors C is equalwith 1/2Vdc and connects alternatively transistors insticks. A control circuit is used to control the outputcurrent of welding machine.The three-phase bridge rectifier circuit has three-legs, with each phase being connected to one of the three phase voltages as shown in Figure.2 The rectifier unit, at the input, is used to rectify the three phase AC voltage into a dc capacitor bank.

Three most common symmetrical types of converters are used in welding process.

1.Push pull converter
2.Half bridge converter
3.Full bridge converter

To obtain a better understanding of the topology, both half bridge and full bridge converter circuit were implemented .The controller main function of this unit is to produce a medium frequencyAC signal, which is fed to a single phase transformer. It is important to decide proper inverter topology to be used in the converter base operation. Important factors for the selection of the topology, given in are:

- Input and output voltages (lower, higher or inverted, multiple outputs etc)
- Output power (some topologies are limited in power)
- Safety (Isolated / non isolated)
- Cost (related to number of power devices)

To obtain a better understanding of the topology, both half bridge and full bridge converter circuit were Implemented. The controller circuit developed for these topologies can also be used in the drivingcircuitry for the welding circuit. In full bridge topology,the transformer primary voltage is 0V when all four switches are off. To avoid a short circuit, and thus the breakdown of the switch, the turn on time of $S1$ must not overlap with the turn on time for $S2$. The same condition applies to $S3$ and $S4$.The full bridge circuit is used in high power applications. The advantage of a full bridge over a half bridge is that, the voltage imposed across the primary is a square wave of $\pm V$, instead of$\pm V\ dc/2$ for the half bridge.

Figure.2 full bridge converter circuit

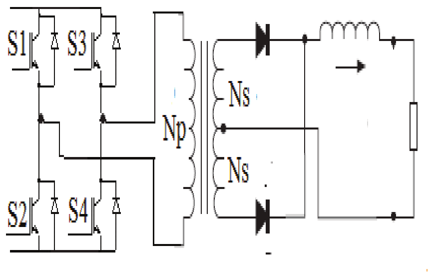
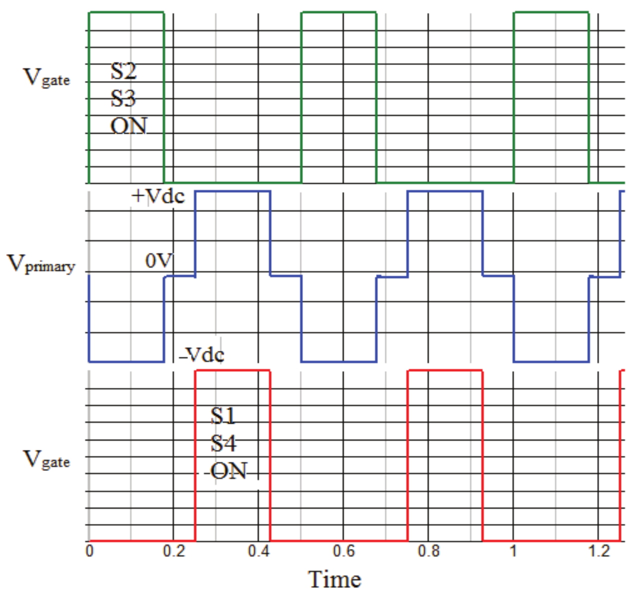


Figure.2.1 output waveform of inverter



In the full bridge, the transformer's primary turns must be twice those of the half bridge as the primary winding must sustain twice the voltage. The peak and RMS currents are half of the half bridge because, the transformer Primarysupports twice the voltage as compared to the half bridge.With twice the primary turns but half the RMS current, the size of the full-bridge transformer is identical to that of the half bridge at equal output powers.The transformer primary voltage is 0V when all four switches are off.

To avoid a short circuit, and thus the breakdown of the switch, the turn on time of *S1* must not overlap with the turn on time for *S2*. The same condition applies to *S3* and *S4*.The full bridge circuit is used in high power applications. The advantage of a full bridge over a half bridge is that, the voltage imposed across the primary is a square wave of ±*V*, instead of ±*Vdc/2* for the half bridge.

Comparison of different topologies

Selection of topology for a dc-dc converter is done, not only by input and output voltages, butalso bypower levels, voltage and current stresses of semiconductor switches and utilization of magneticcomponents.

The fly-back converter is popular in low power applications (up to 200W). Its main drawback is largersize of fly-back transformer core and high voltage stress on semiconductor switch.

The forward converter is also a single switch converter. The core size requirement is very small so it isvery popular in low and medium power applications, but because of requirement of demagnetizing winding and high voltage stress on semiconductor switch; it is not used for high power applications.

Push-pull converter is also used for medium power application.
The main drawback of pushpull converter Is potential core saturation in case of asymmetry. The half-bridge converter has a similar range of applications as the push-pull converter.
There is no danger of transformer saturation in this topology but it requires two additional capacitors to split in half dc source.

4. SIMULATION OF WELIDING MACHINE IN MATLAB-2013

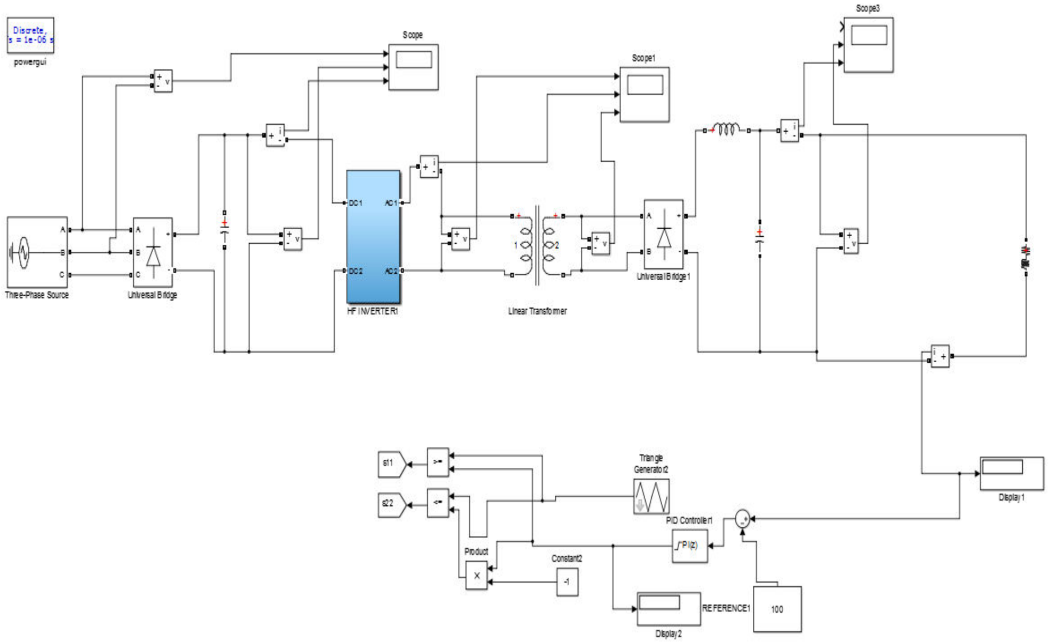


Figure.3 simulationwelding circuit in constant current mode of 3-phase, 60volt, 100 ampere

In this simulation as shown above in figure .3 we are using 3-phase, AC 415 supply voltage as input supply and to convert it to dc full bridge rectifier is used so at the output we get the voltage 340 volt as shown in calculation.DC supply is given to high frequency inverter circuit which is step down and isolated using high frequency transformer.Parameters of high frequency transformer are taken from design of transformer. Then we are using high frequency full bridge inverter and output half rectifier, and load resistance is connected as 0.6 ohm, the transformer used as given to high frequency transformer of 10 kHz. For closed loop and constant current application we are using current as feedback parameter and given to PICF184720 controller which generated PWM signals to IGBT as maintaining duty cycle 45%.

Design Calculations of input voltage:

In this simulation input supply voltage is 230volt, single phase ac supply so output of bridge rectifier is after calculation as below is 340volt (rms value) as shown in figure 3.1 of output voltage.

For single supply:

Ac input, 230volt, 50 Hz supply,

Output voltage of full bridge rectifier is: $\sqrt{2}$ *230 =325.26volt (Rms voltage)

For 3-phase supply:

For input voltage 415 volt,

Ph-ph voltage is 415/$\sqrt{3}$=239.88 volt.

Rms value of voltage = $\sqrt{2}$ *415=585.15 volt (phase voltage)

Output rectified voltage is =415 * $\sqrt{2}$/$\sqrt{3}$=339.25 volt (line voltage)

1. Output Voltage waveforms of value 339VOLT(DC)

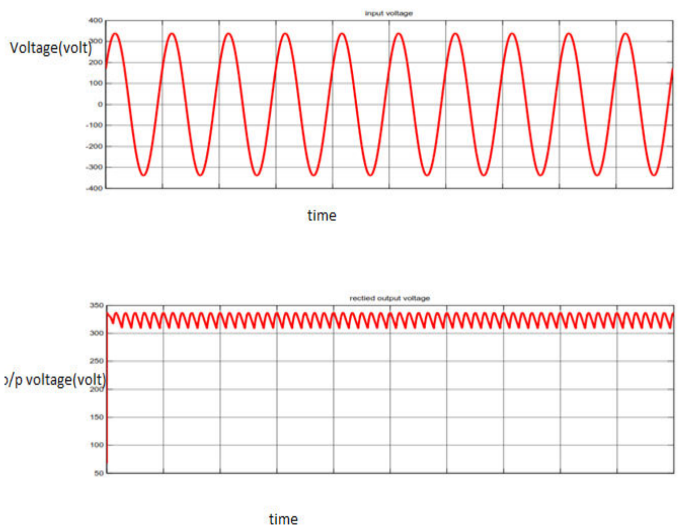


Figure.3.1 waveforms of ouput voltage for 3-phase rectified voltage

2. RESULT OF OUTPUT VOLTAGE(60V DC) AND OUTPUT CURRENT (100AMP):-

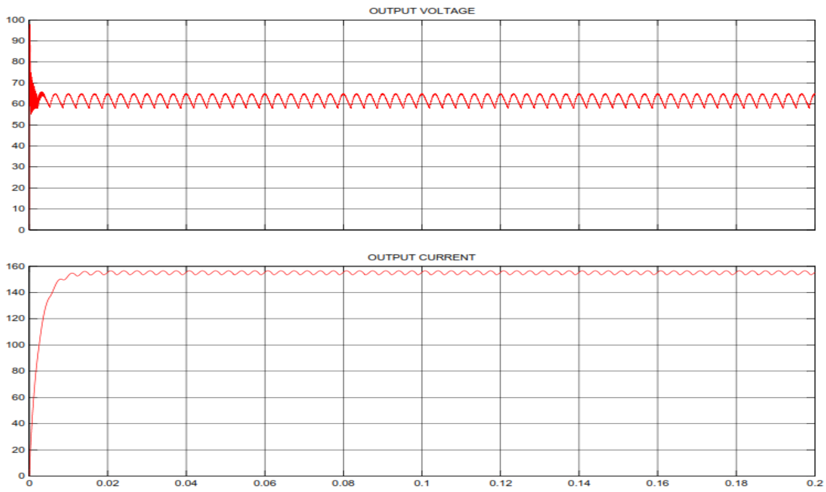


Figure.3.2 output waveform of load voltage and load current of welding machine

As shown in above figure.3 we conclude that output voltage is 60 volt and output current is 100ampere of this simulation circuit in constant current mode.

Simulation results of Triangular comparison with DC signal:

10 KHz is the switching frequency of inverter hence triangle signal of 10 KHz is compared with DC supply which gives gating signal for H-bridge inverter.

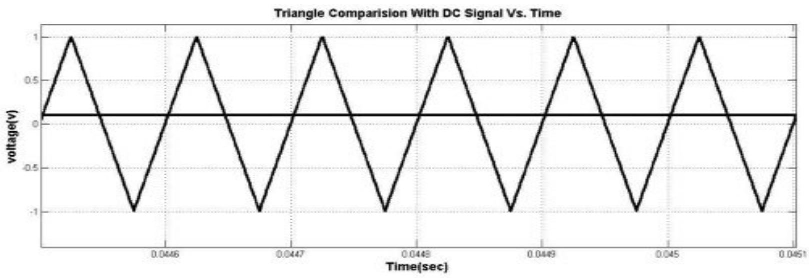


Figure.3.1 triangular comparison with dc signal

Gate Pulse for H-Bridge Inverter:
Gating signal for two diagonal of H-bridge inverter is given below with 45% duty cycle. This 5% zero period given is for dead band purpose. This will protect shortening of one leg of H-bridge inverter.

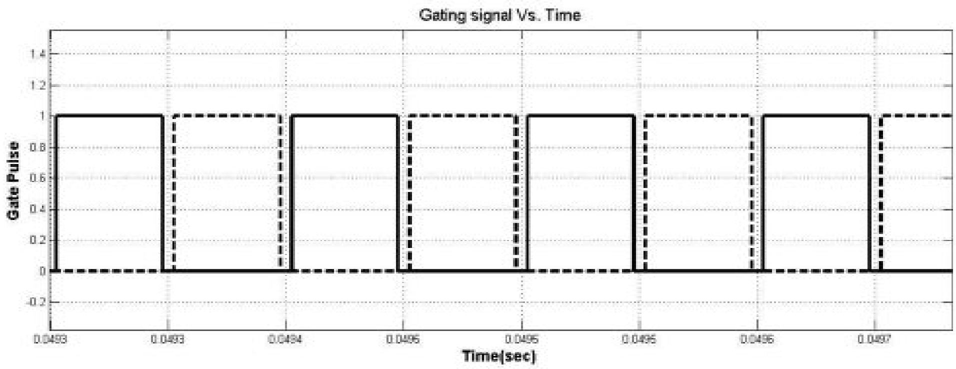


Figure.3.2 gate pulse of H-bridge inverter

SIMULATION USING PSIM:-

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1. Welding topology with h-bridge inverter in PSIM SOFTWARE:-CONSTANT CURRENT MODE

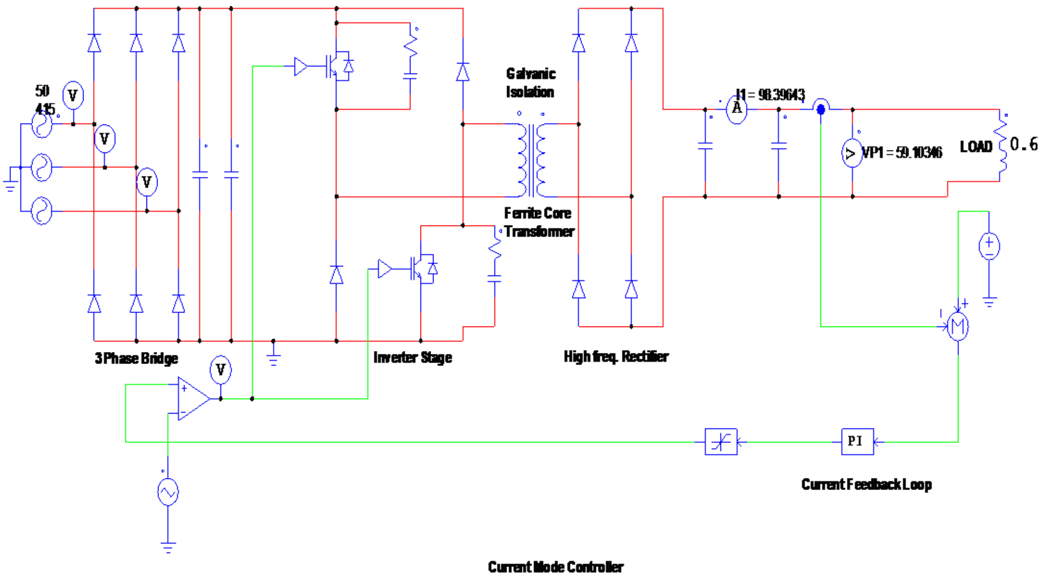
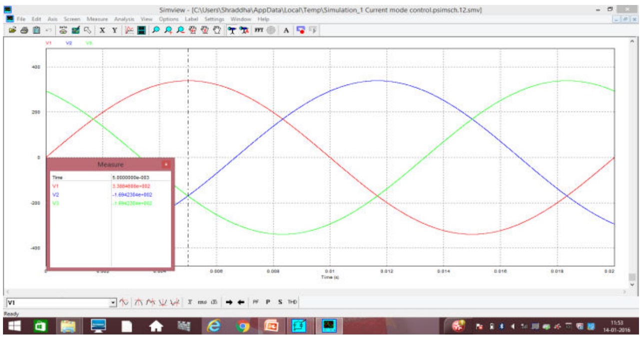


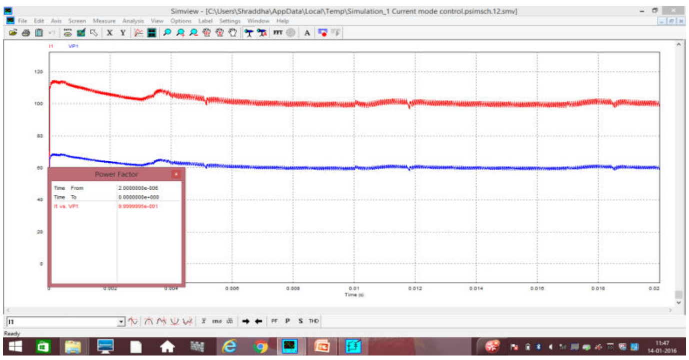
Figure.4 simulation circuit of welding circuit with PSIM SOFTWARE.

In this simulation circuit, as shown in figure.4, we are using 3-phase input as supply, 415 volt and half bridge inverter and load resistance value of 0.6 ohm and current feedback loop which is given to PI controller which is given to driver circuit in constant current mode which gives output current of 100 ampere and output voltage is 60volt.

a.INPUT VOLTAGE WAVEFORMS.



B.OUTPUT VOLTAGE AND OUTPUT CURRENT : (60V DC,100AMP)



DRIVER CIRCUIT USED IN WELDING CIRCUIT:

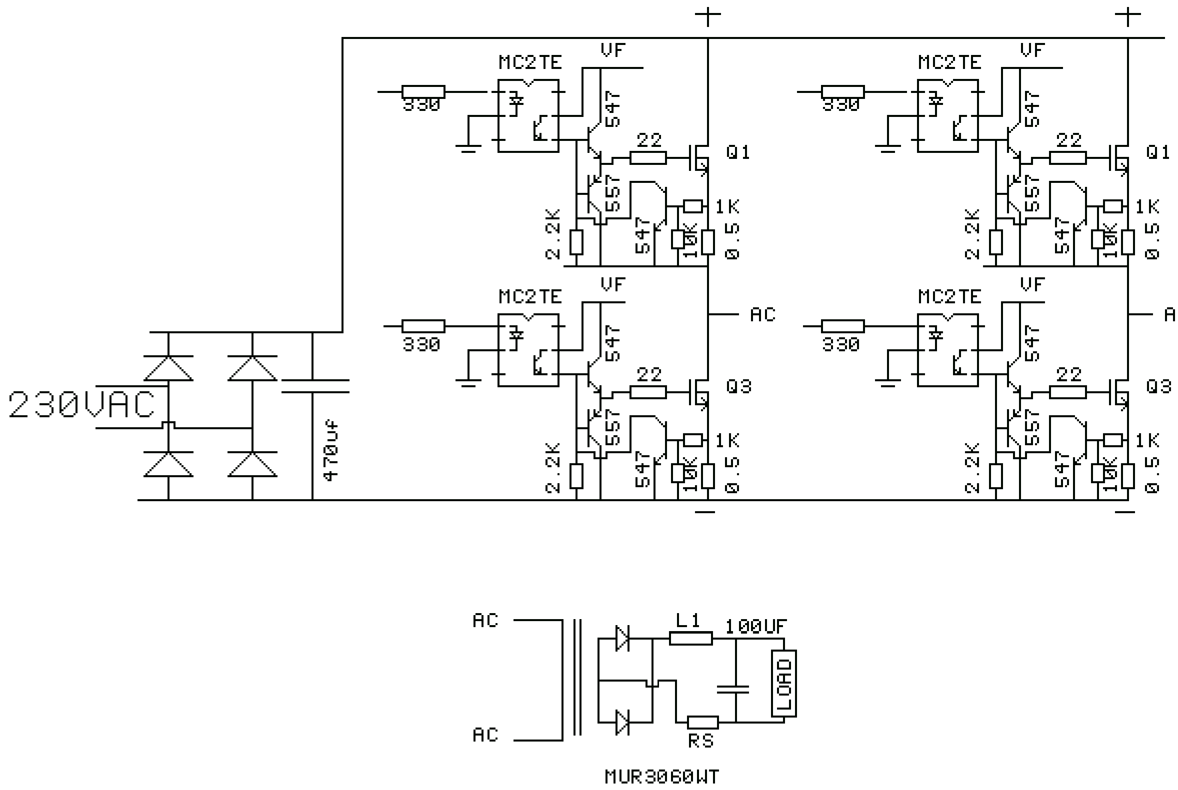


FIGURE.5 DRIVER CIRCUIT OF WELIDNG MACHINE

Components used in this driver circuit:

1. Bridge rectifier, (25 Ampere fast recovery diode)
2. Transistor (BC547), (BC557)
3. Opto isolator (MC2TE)
4. PIC18F4520 CONTROLLER
5. IGBT (60N100)
6. MUR3060 (30ampere, 600volt diode)

An isolation transformer is a transformer used to transfer electrical power from a source of alternating current (AC) power to some equipment or devices while isolating the powered device from the power source, usually for safety reasons. Isolation transformers provide galvanic isolation and are used to protect against electrical shock, to suppress electrical noise in sensitive devises, or to transfer power between two circuits which must not be connected. A transformer sold for isolation is often built with special insulation between primary and secondary, and is specified to withstand a high voltage between windings. It allows an AC signal or power to be taken from one device and fed into another without electrically connecting the two circuits.

Opto couplers are designed to complete isolation between input and output circuits. The useful purpose of isolation is to provide protect protection from high voltage, surge voltage and low level noises that could be produces errors in the output. Opto couplers also provide interface between different voltage levels. The input current of an opto coupler can be LDR, Photo diode, LASCR and photo transistor.

RATINGS OF IGBT (60N100)

1)Current rating of IGBT

Output Current Io= Rms value of current *safety factor

=60 * 2

=120 Amp

3) Voltage rating of IGBT

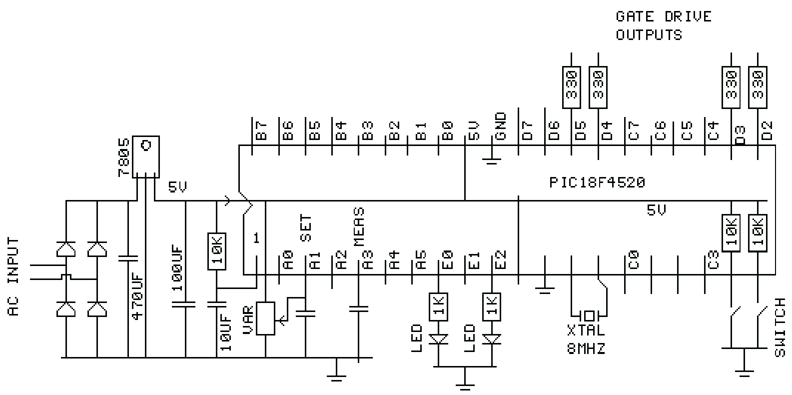
Vo= Peak value of load voltage * safety factor

= 600 * 2

=1200 volt.

We have to use IGBT which has voltage rating 1000volt. Therefore, 60n100 IGBT is selected as power device. See appendix for the detail data sheet.

DRIVER CIRCUIT USING PIC 18F4720 CONTROLLER FOR CLOSED LOOP CONTROL:



SD WELD CONTROLLER

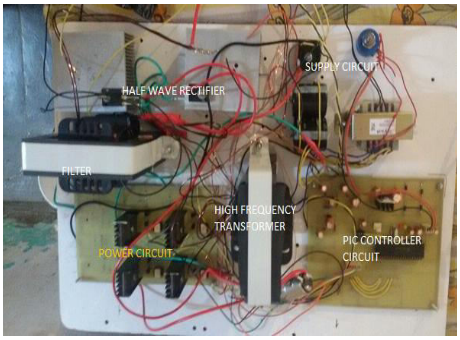
FIGURE.6 DRIVER CIRCUIT USING PIC CONTROLLER

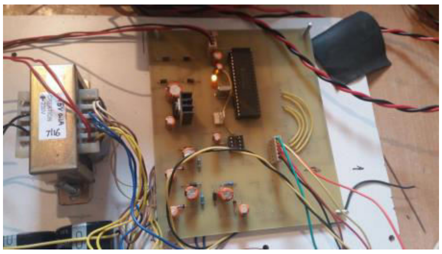
In this circuit diagram , PIC18F4520 controller pin description is given which is used for welding circuit closed loop operation. As shown in figure.6 there is one switch is connected between pin no.19 and pin no.20 for start and stop the welding operation and the crystal frequency is 8MHZ is given to pin no.13 and pin no.14. As shown in diagram IGBT gating signals is given at pin D5,D4,D3,D2 Pin.which is indicating in previous

Figure .6 of driver circuit.

HARDWAE IMPLEMENTATIN OF 20AMP. ELECTRONIC WELDING MACHINE:-

1. WELDING MACHINE HARDWARE

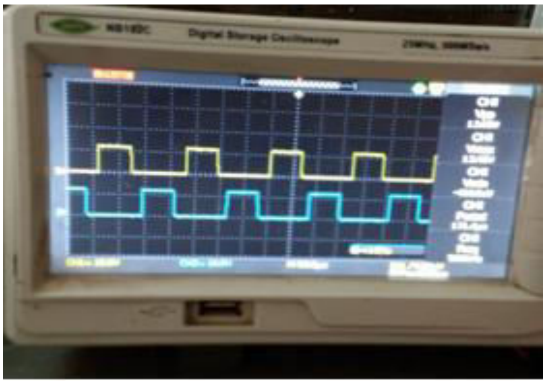




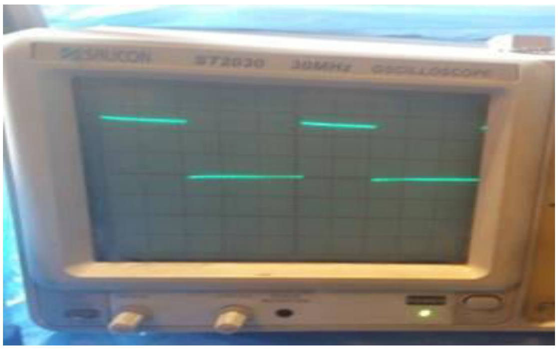
The converter in the hardware testing requires separate heat sinks for each power module. The IGBT, full bridge rectifier, and the input AC/DC converter were all replaced on separate heat sinks. The heat sinks should be integrated for the compactness of the system. In this inverter welding circuit compared to conventionally welding circuit, requires high frequency transformer with an inverter welder, this can be done more efficiently at higher frequencies; as a result, the inverter is able to use a much smaller transformer. The result is a substantial reduction in size and weight. Power consumption also decreases as the more efficient transformer loses less energy to heat. Due to the higher frequency of the output current, an inverter welder produces a smother arc when welding. Computer software constantly monitors and adjusts current and voltage during the welding process, resulting in a consistent arc.

HARDWARE RESULTS:

1. **SWITCHING PULSES:**

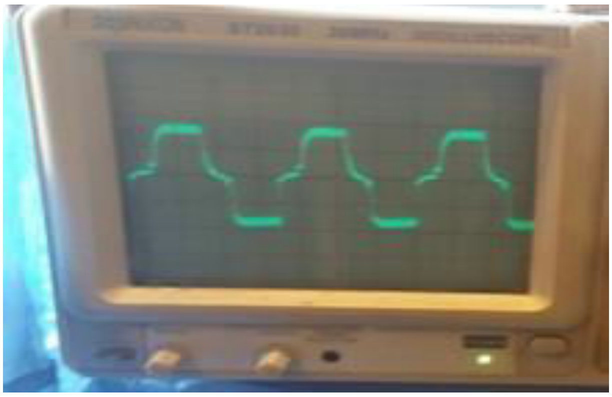


1. **when IGBT1 IS ON,**

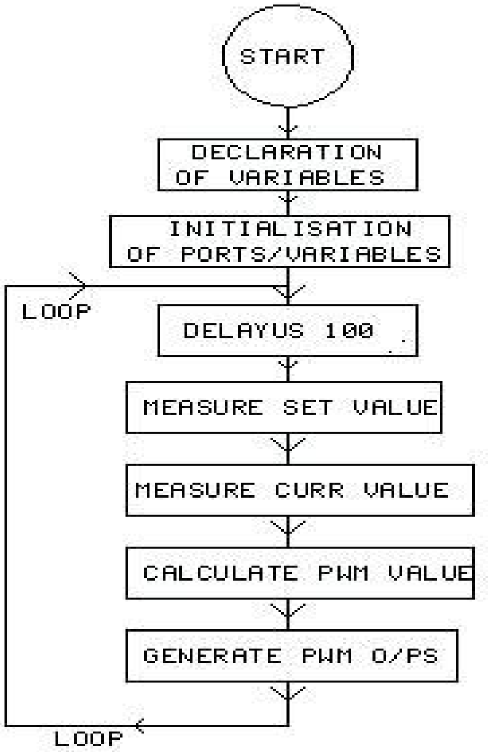


2.WHEN IGBT2 IS ON,

3.OUTPUT VOLTAGE WAVEFORMS:



Flow chart of electronic welding machine



CONCLUSION:-

1. The main task of this work is to develop and improve the control circuit for a single phase inverter the which has been implemented using PIC controller.

2. The used method to control the inverter switch is the PWM technique. This method is superior to other methods to improve the output waveforms.

3. The simulation results are performed at PSIM and matlab-2013 and compared the experimental results.

4.The tested inverter is loaded at various ac loads 11w,15w and 26w.

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