



## DESIGNING A POWER SUPPLY FOR INVERTER WELDING MACHINE

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**Abstract:** This project is about the designing a power supply for Inverter based Welding Machine with desire output current and using efficient way for the best use of the users like fabrication workers and industrial users. This project is used for the making of economical machine for better market version of market product with using DSP for better controlling of output current and output voltage. Which is better than normal welding machines. The fixed Output Current and Output Voltage are gained with high speed DSP using different timers and interrupt. It has easy control of temperature and other parameters because of DSP. The inverter make the welding machine more conventional economical and efficient than Normal Welding machines. The efficiency is more than 88%.

**Key Words – Rectifier, Transformer, IGBT, Inverter, Filter.**

### I. INTRODUCTION

The main trend in development of welding sources is an increase of the degree of interaction between the control object (welding arc, molten electrode metal and weld pool) and power supply. This makes it possible to improve the quality of the welding joint formation. The basic requirements for power supplies for manual arc welding are related to the need for easy arc ignition and stability of its burning. Also, the task exists of elimination of the possible “sticking” of the electrode to the work piece when trying to ignite the arc.

At the same time, the issues of the influence of the power supply on the mains, the influence of the quality of electricity on the quality of welding, including owing to the mutual influence of the sources, are often not concerned at all. Therefore, in the context of rising energy prices and introduction of standards for electromagnetic compatibility (EMC) of technical equipment, the actual task is to ensure EMC, improve energy efficiency and technical and economic parameters of welding equipment.

In the world without metals we are nearly nothing and for metals joint and cutting we need heavy tools and heavy power supply for it. The metals like aluminum and iron they are so solid and strong but also the core of the things like machines, buildings and vehicles an when it comes to connecting these metal we need welding machine for permanent joints and longer lifetime of the joint. For this time the welding is the best way of connecting of metals. But the normal welding machine they are very heavy and bulky so that they cannot be portable. The arc welding is one of the most used welding method for better experience and long term works. This paper is about the basic fundamentals of designing a power supply for inverter welding machine and its overview.

### II. LITERATURE REVIEW

With invention of short electric arcs by Humphry Davy in 1800 and continues electric arc by Vasily Petrov in 1802, possible practical applications came into mind including welding. After several efforts Arc Welding was first developed by Nikolia Benardos in 1881. In 1905 Russian scientist Vladimir Mitkevich proposed the usage of three-phase electric arc for welding. In 1919, alternating current welding was invented by C.J. Holslag but did not become popular for another decade. Competing welding processes such as resistance welding and oxyfuel welding were developed during this time as well; but both, especially the latter, faced stiff competition from arc welding especially after metal coverings (flux) for the electrode, to stabilize the arc and shield the base material from impurities, continued to be developed [6], [9]-[13].

During World War I welding started to be used in shipbuilding in Great 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 [1]-[5].

During the 1920s, major advances were made in welding technology, including the 1920 introduction of automatic welding in which electrode wire was continuously fed. Shielding gas became a subject receiving much attention as scientists attempted to protect welds from the effects of oxygen and nitrogen in the atmosphere. During the following decade, further advances allowed for the welding of reactive metals such as 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.

When developing welding sources, the objectives are to achieve high-power density, high efficiency, flexible output voltage-current characteristic (V-I characteristic), etc., but little attention is paid to the EMC of the supply with the power mains. EMC means:

- ✓ Harmonic distortion of the input current (THD – Total Harmonic Distortion);
- ✓ Power factor (PF), calculated in accordance with the IEEE 1459-2010 standard;
- ✓ Level of high-frequency noise, etc.

Due to the high harmonics ratio in the input current, welding supplies are not entirely correct to be referred to energy-saving equipment. An analysis of the circuitry of welding inverter supplies was carried out, including from the standpoint of electromagnetic compatibility. It is but obvious that inverter supplies are characterized by large distortions of the input current than supplies with low-frequency transformers. Here the ways of increasing the technological efficiency of welding power supplies are outlined, but there is practically no attention paid to electromagnetic compatibility issues. At the same time, according to the information, electric welding equipment is about 65 % of potential sources of electromagnetic interference [8].

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 current power supplies and 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. This is important because in manual welding, 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, and as a result, are most often used for automated welding processes such as gas metal arc welding, flux cored arc welding, and submerged arc welding. In these processes, arc length is kept constant, since any fluctuation in the distance between the wire and the base material is quickly rectified by a large change in current [6], [7].

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 general, the positively charged anode will have a greater heat concentration (around 60%). For stick welding in general, DC+ polarity is most commonly used. It produces a good bead profile with a higher level of penetration. DC- polarity results in less penetration and a higher electrode melt-off rate. It is sometimes used, for example, on thin sheet metal in an attempt to prevent burn-through. With few exceptions, electrode-positive (reversed polarity) results in deeper penetration. Electrode-negative (straight polarity) results in faster melt-off of the electrode and, therefore, faster deposition rate. Non-consumable electrode processes, such as gas tungsten arc welding, can use either type of direct current (DC), 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 electrode makes deeper welds. Alternating current rapidly moves between these two, resulting in medium-penetration welds [14] – [19].

### III. WORKING PRINCIPLE

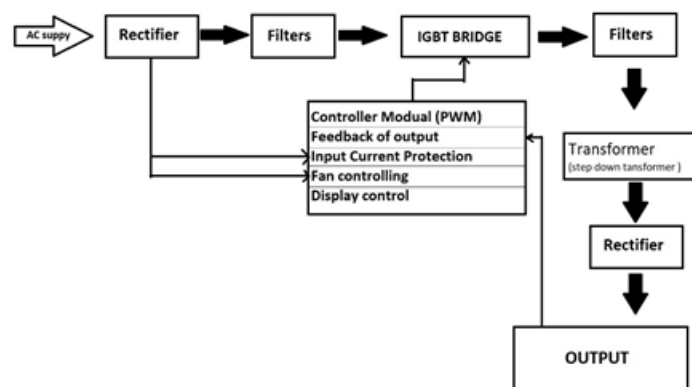


Figure 1: Block diagram

The block diagram shows (Figure - 1) the first part ac supply which is a normal AC supply of 230 V and 50 Hz frequency. The range of the AC supply is 180-240 voltage. The normal range of the welding machines are nearly 4 to 6 kilowatts. The rectifier parts rectifier is basically converter which converts AC form to receive in terms of power supply bridge rectifier design to withstand up to nearly 40 to 50 amperes for safety purpose and the output of this rectifier will not be pure DC. It will be fluctuating DC so we have to filter it out for filtering process the most suitable filters are LC filters which contain inductors and capacitors. Capacitor is for filtering the voltage and inductors are mainly used for current filter so the combination of this both inductor and capacitor is most suitable for such a condition. Usually the filter cannot remove all the ripples in the DC and in normal range 5% of ripples can be good for the designing and efficiency purpose.

The third block IGBT bridge which is full bridge topology in which the 2 paths are created with help of PWM switching and to convert DC supply to the High frequency AC supply it can be square waves or sine waves whatever the need is. The DC supply now converted in to AC but with higher frequency. The usual range of this frequency is more than 10 kilo hertz and in this project it is nearly 50 kilo hertz.

The PWM pulses will be generated with help of microcontroller. The microcontroller uses the different timers to make counting according to the clock of the controller and through that we can achieve different range of frequency with help of digital controller. This controller will also control the different feedback of the welding machine like input surge protection and fan controlling using feedback from output current. After certain level of current the controller will automatically turn on the fan for the cooling process of the IGBT and other devices because the heating can cause the low efficiency in result and sometime damage components. The feedback of the output is most important in the circuit control as it help to give the constant output for example the current is set for the 150 ampere and we need to change the metal for welding when the base material changes the small change in the resistance will be make big change in the current change so the feedback from the output sending to the controller and the duty cycle of IGBT changes accordingly. Thus we are getting the constant output current. The controller also controls the display of the machine to show the output.

#### IV. CIRCUIT DESCRIPTION

The old machines were using the analog circuits for this purposes but the digital method are more beneficial and faster than analogs. The filters now makes the output of the IGBT Bridge more clean for better efficiency and it gives to the transformer.

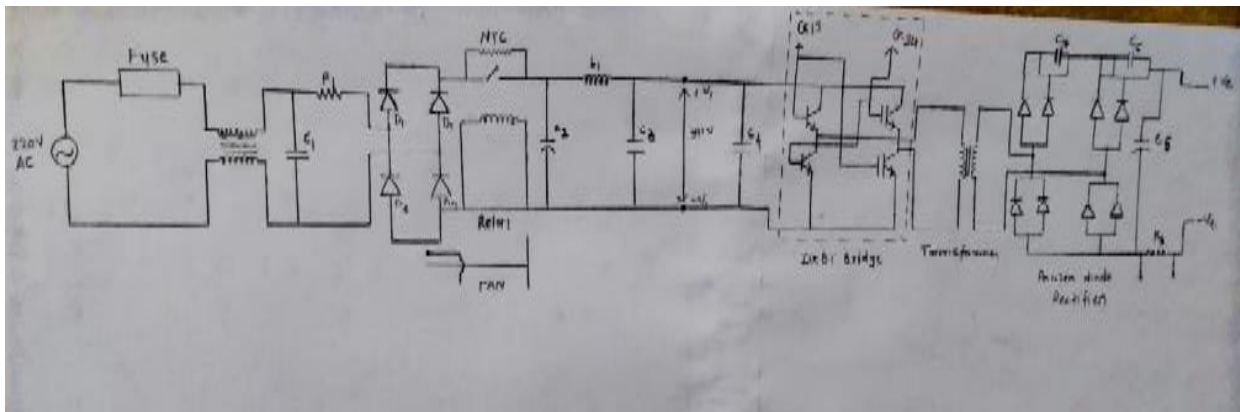


Figure 2: Circuit Diagram

The step down transformer which brings the voltage of the AC output from the IGBT (Figure – 2) and the IGBT delivers the high frequency which can be in square wave or sine wave but higher frequency make sure to cut more flux in small amount of copper and reduces the voltage nearly sixth of the main supply to get desired current in the secondary winding which is because of the high cycle per second. The transformer gives the high current low voltage supply in output but still in AC mode. The transformer having high ratio of turns and it delivers the voltage low but the power is always remains constant in both side so the voltage are low but the current are rises and by that high current output is delivered from the transformer.

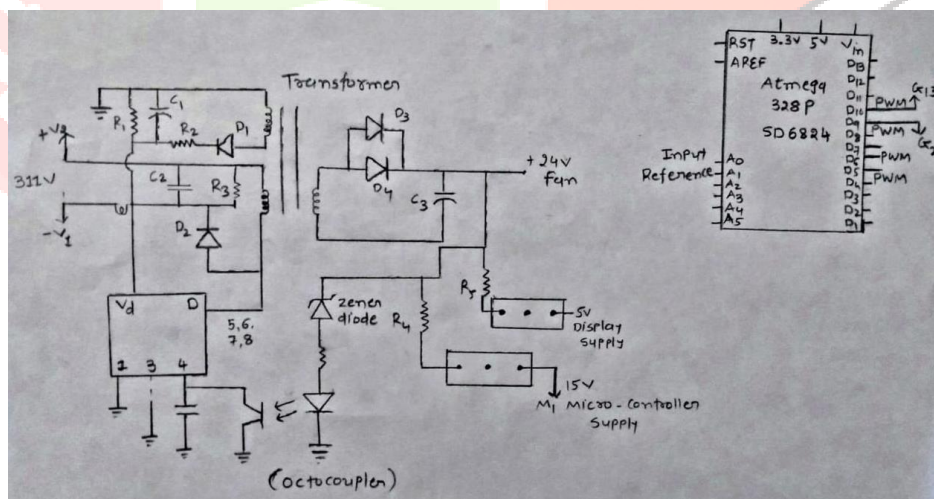


Figure 3: Control Circuit

The high current AC supply applies to the power diode rectifier. These power diodes having high breakdown voltage and as they are made to withstand high power applications without getting any damage, these rectifier gives us the DC supply but low voltage range near to 24-26 v and high current range nearly 200 amperes or more according to the need of the output.

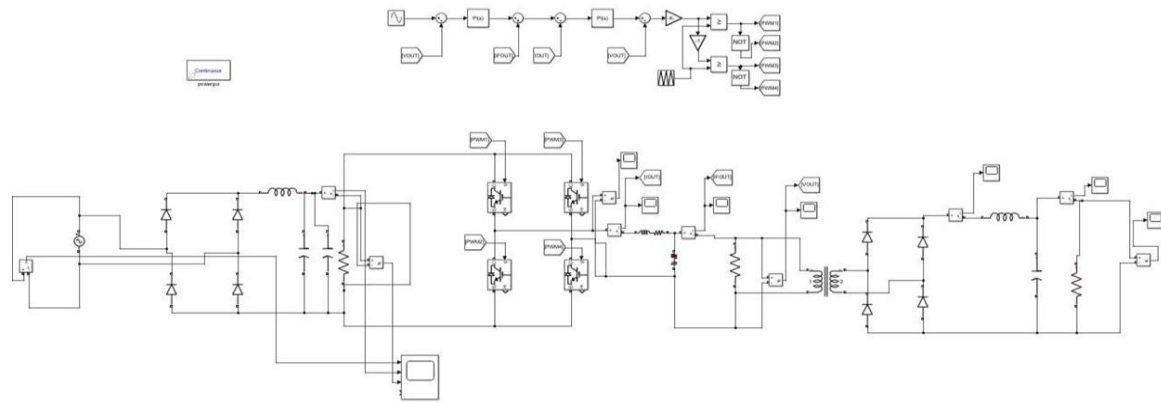
The heat sinks are designed to make the component's cooling process faster. When heat occurs in any component it made loss. Lower efficiency can be caused by heat also. Permanent damage of the components is possible. Calculation of heat sink is necessary to avoid the random size of heat sink because the bigger size will make the circuit more bulky unnecessarily.

There is one special part in the circuit or the whole project is called low voltage power supply this low voltage power supply take power from direct line AC supply. Through different types of ICs (Figure – 3) and transformer we can get different types of DC supply for low voltages for power supply of microcontroller, power supply for fan and display smaller other components which need and extra DC supply. All these necessary supplies are obtained through this low voltage supply circuit.

#### V.SIMULATION AND RESULTS

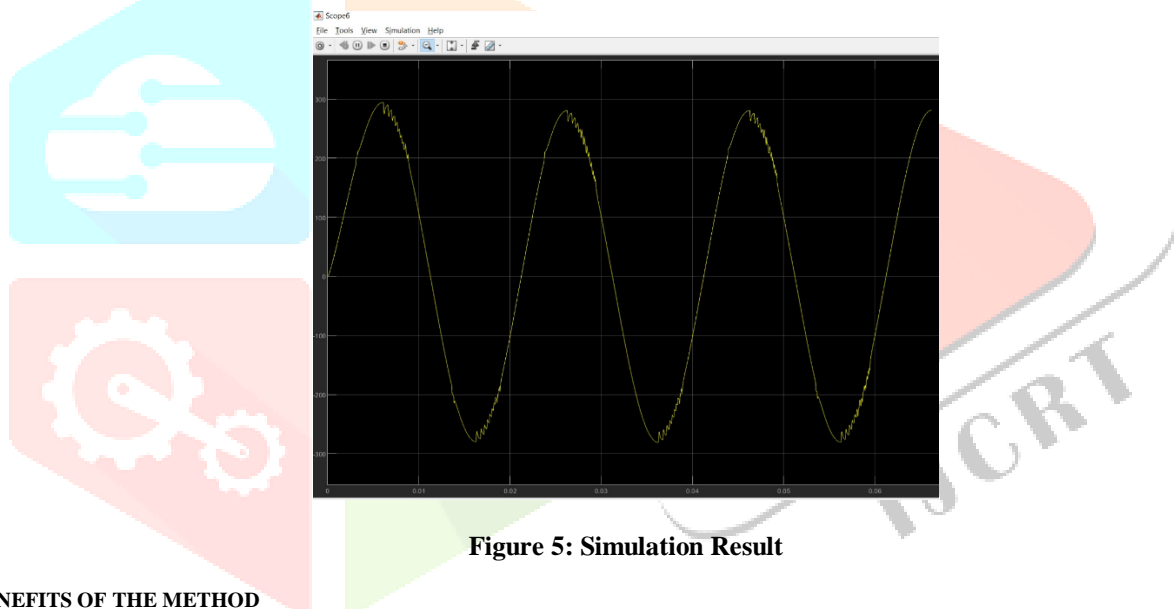
The MATLAB software is used for simulation purpose. In the circuit (Figure - 4) we can see the AC supply is connected to the rectifier (full bridge) connected. Full bridge topology in rectifier give the highest efficiency. The filter we have used LC filter the

value of the filter is set to give 5% ripple in the DC output which is more conventional. The resistor in the circuit is just for measuring the output across the point in real circuit it isn't necessary.



**Figure 4: Simulation Circuit**

The output of the rectifier is sent to the IGBT and which can be seen connected to the PWM pins which are created with different arithmetic and used for creating a SVPWM pulses in full bridge topology and the 1-3 IGBT conduct at once and other two at once this give the output to the transformer (Figure - 5) . The transformer is set to input voltage at 300 volts and 4.8kw power the secondary winding is set for 26 volts and same power at the current in primary winding gives nearly 20 ampere and in secondary winding it is near to the 200 ampere as per normal condition with losses counted. The rectifier after the transformer gives the output DC supply and the filtering of the output is done for the less fluctuation of the current in final output.



**Figure 5: Simulation Result**

## VI. BENEFITS OF THE METHOD

- This circuit include different power electronics part which is more efficient and smaller size in compare to normal components and it require less maintenance.
- Higher efficiency will result in low losses and there for running cost will be low.
- The inverter method is easy and reliable for controlling the output aspect so this circuit is easy to control.
- The digital part of the controlling circuit is most efficient as if now and it is faster than analog circuits and by changing the program we can get the different output as well so it can give a wider range of output without changing whole circuit.
- The higher frequency range which is nearly 50khz can cause the small transformer so smaller transformer can be used having less copper and smaller core so the cost will be low and the weight of the machine will reduce.

## VII. CONCLUSION

In this research paper the method for designing a power supply for inverter welding machine is a closed loop method and it controls full bridge inverter with SVPWM method for high efficiency with low cost product which are efficient reliable and more flexible than the conventional welding machine and the digital control of the machine gives the easy control and flexibility in output range of the machine. Conventional welding machines are inefficient and heavy weighed, which is the main reason why this inverter method we should choose while designing the machine.

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**REFERENCES**

- [1] Nabeel Sabri Altanneh, Akin Uslu, Mehmet Timur Aydmir 2019 Design of a Series Resonant Converter GMAW Welding Machine by using the Harmonic Current Technique for Power Transfer. MDPI Electronic Journal 2019, 8, 205. 1-17.
  - [2] Christian Klumpner, Mathew Corbridge, A two stage power converter for Welding Applications with Increased Efficiency and Reduced Filtering. UK IEEE.org.
  - [3] Chuntian Li, Changhua Du, Huibin Xu, Yi Luo, Al. 2011 The Design and study of GMAW Inverter Power Based on DSCCS. Elsevier Procedia Engineering 15: 1098 – 1102.
  - [4] Ovbiagele U, Obaitan B, 2015. Design and Construction of an Inverter Type 3KVA, 50 Hz, Single Phase Arc Welding Machine, International Journal of Scientific & Engineering Research, Volume 6, Issue 5, May 2015. 931 – 942.
  - [5] Ertugrul Kocaaga, Gokhan Sen, Sinan Kivrak, 2019. Design and Implementation of 400 A Industrial Inverter Welding Machine. International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS) Volume 8, Issue 2, February 2019, ISSN: 2278 - 2540, 147 – 152.
  - [6] EDWARD J. OSHABEN Bachelor of Science in Electrical Engineering Case Western Reserve University May, 2005. DC-DC Power Converter Design for Application in Welding Power Source for the Retail Market
  - [7] Jayasheela Deepa Jabavathi, HabeebullahSait Department of Electrical and Electronics Engineering, University College of Engineering Tiruchirappalli-620024, India Design of a single chip PWM Driver Circuit for Inverter Welding Power Source.
  - [8] V. Burlaka, E. Lavrova, S. Podnebennaya, I. Zakharova, “Development of Single-phase High Power Factor Inverter Welding Sources”, Eastern European Journal of Enterprise Technologies, ISSN: 1729 – 3774, pp 18-24, 4/1(88) 2017.
  - [9] Inverter DC MMA ARC Welding Machine, Operational Manual by ARPP Engineers.
  - [10] IGBT Inverter Welder, User’s Manual, Modle: MMA 120k/140k/160k/180k/201k.
  - [11] [https://en.wikipedia.org/wiki/Arc\\_welding](https://en.wikipedia.org/wiki/Arc_welding)
  - [12] <https://ijcrt.org/papers/IJCRT1812498.pdf>
  - [13] <https://www.machinedesign.com/fastening-joining/article/21812878/welding>
  - [14] <https://www.researchgate.net/publication/305728923>
- DESIGN AND CONSTRUCTION OF A WELDING MACHINE WITH A VARIABLE CURRENT SELECTOR**
- [15] <https://www.wilhelmsen.com/globalassets/marine-products/welding/documents/wilhelmsen-ships-service---unitor-welding-handbook.pdf>
  - [16] <https://www.researchgate.net/publication/333685429> Design and Construction of an Electric Arc Welding Machine's Transformer
  - [17] <https://www.ijtsrd.com/papers/ijtsrd18784.pdf>
  - [18] <https://site.ieee.org/gms-pes/files/2014/11/Transformer-Design-and-Design-Parameters.pdf>
  - [19] [https://www.infineon.com/dgdl/Infineon-Discrete\\_IGBT\\_Datasheet\\_Explanation-AN-v01\\_00-EN.pdf?fileId=5546d462501ee6fd015023070b8b306d#:~:text=VCEsat%20represents%20the%20voltage%20drop,and%20at%20several%20junction%20temperatures.&text=IGBT%20devices%20of%20traditional%20PT,coefficient%20even%20at%20nominal%20currents.](https://www.infineon.com/dgdl/Infineon-Discrete_IGBT_Datasheet_Explanation-AN-v01_00-EN.pdf?fileId=5546d462501ee6fd015023070b8b306d#:~:text=VCEsat%20represents%20the%20voltage%20drop,and%20at%20several%20junction%20temperatures.&text=IGBT%20devices%20of%20traditional%20PT,coefficient%20even%20at%20nominal%20currents.)