Inverter based Welding Machine

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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 possess 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.

Key words: Welding Electrode's, Arc Welding, Equipment Fabrication, Transformer, Inverter

I. INTRODUCTION

Welding method for arc consists of heating the Secondly, the making welding flow of electrons of an electric arc metal surfaces of the parts to be attached to their plastic hotness from side to side channel of tall AC or DC electric flow of electrons. The electric arc is ignition between the electrode and the pieces at small potential differences range as 10-40 V at tall flow of electrons range as 5-2000 A. The manual-metal arc welding with consumables electrodes appearance about 30% of each welding systems the physical welding tools utilize the far above the ground frequency inverters to offer far above the ground ability flow of electrons through action. Frequency range for inverter is between 20 to 100 kHz from side to side by using semiconductors tools like MOSFET and IGBT transistors for process. In this document a Half Bridge far above the ground frequency inverter is used to offer a fitting flow of electrons on welding tip. The expected equivalence welding apparatus gives the steady PWM for heavy IGBT of its inverter and pedals the output welding flow of electrons by turn-off on or off of IGBT switches. So it cannot adjust fit the excellence of welding flow of electrons to path the setting welding flow of electrons. In The other control method, the output welding current controlled by changing the duty cycle of PWM. The changes Based on the mistake among the principles of reaction output welding flow of electrons and the location current applied to a checker.

II. BLOCK DIAGRAM FOR INVERTER WELDING APPARATUS

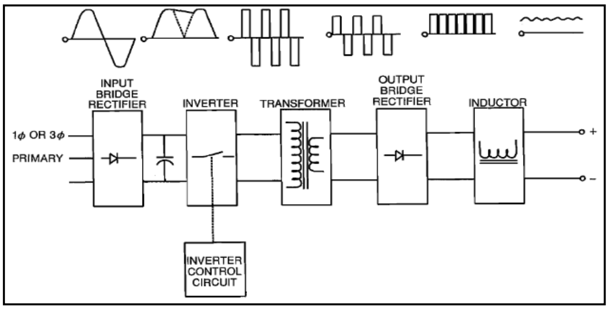


Fig. 1: Block Diagram for Inverter Welding Apparatus

The potential difference on capacitors C is equivalent by half V_{dc} and connects on the other offer transistors in firewood. A direct trail is used to manage the output flow of electrons of welding tool. The three-stage bridge rectifier circuit has three-legs, with each phase being connected to one of the three phase voltages .The rectifier unit, at the input, is used to rectify the three stage AC voltage into a direct current capacitor store.

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 frequency AC 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 as follows:

- Security (Lonely / Non Lonely)
- Output power (a few topologies are restricted in power)
- Input and output potential difference (lesser, superior or upturned, numerous outputs etc)
- Charge (associated to digit of control tools)

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 driving circuitry for the welding circuit. In full bridge topology, the transformer primary voltage is zero volts when all four switches are off. To keep away from a short circuit, and thus the breakdown of the switch, on time of Switch1 must not go beyond with the turn on time for *S2*. The same condition applies to *S3*and *S4*.The full bridge route is used in far above the ground power applications. The benefit of a full bridge in excess of a half bridge is so as to, the potential difference forced across the main is a square wave of ±*V*, instead of ± *half of V dc* for the half bridge.

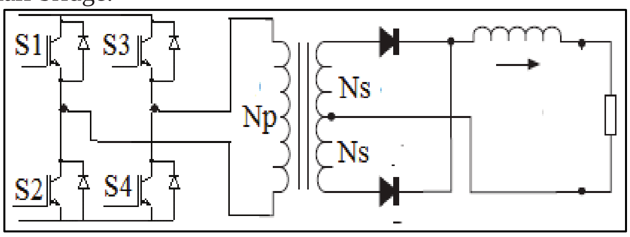


Fig. 2: Full Bridge Converter Circuit

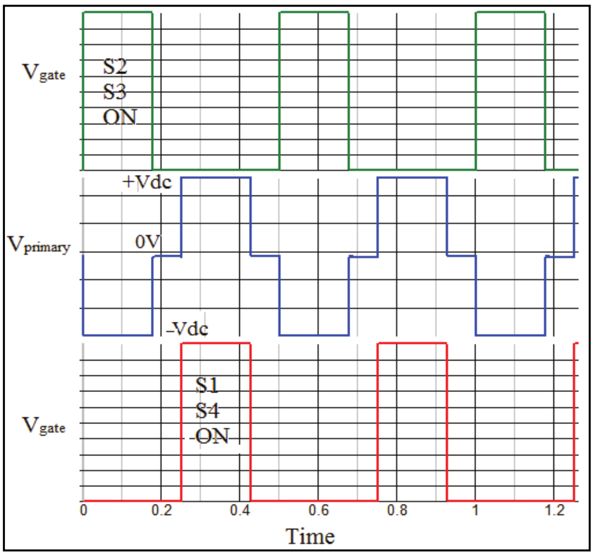


Fig. 3: Output Waveform of Inverter

In the complete bridge, the transformer's major turns have to be two times those of the half bridge as the main winding must maintain two times the potential difference. The tip and RMS flow of electrons are half of the half bridge since, the transformer main chains two times the voltage as compared to the half bridge. With two times the main turns but half the RMS current, the size of the full-bridge transformer is the same to which of the half bridge at identical output powers. The transformer main voltage is 0V when each four switches are off.

The turn on times of SWITCH 1 and SWITCH 2 must not be overlap with each for not permit breakdown. Do same for the SWITCH 3 and SWITCH 4.The. The benefit of a complete bridge is that the potential difference forced across the main is a square wave of ±V, instead of ±half of Vdc for the half bridge.

III. 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 magnetic components. 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 push pull 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.

IV. Simulation of Welding Machine in MATLAB-2013

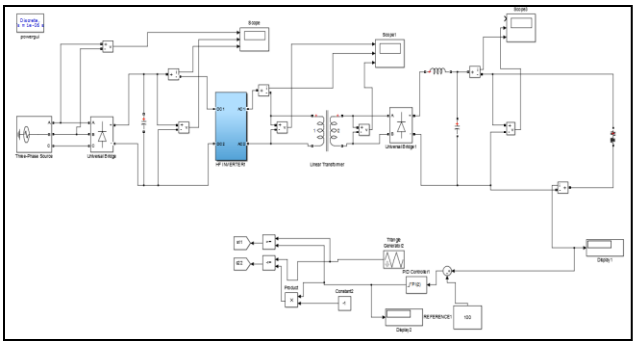


Fig. 4: Simulation Welding Circuit in Constant Current Mode Of 3-Phase, 60volt, 100 Ampere

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%.

A. *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 5 of output voltage.

For single supply:

Ac input, 230volt, 50 Hz supply, Output voltage of full bridge rectifier is: √2 *230 =325.26volt (Rms voltage)

For 3-phase supply:

For input voltage 415 volt,

Ph-ph voltage is 415/√3=239.88 volt.

Rms value of voltage = √2 *415=585.15 volt (phase voltage)

Output rectified voltage is =415 * √2/√3=339.25 volt (line voltage)

Output Voltage waveforms of value 339VOLT (DC)

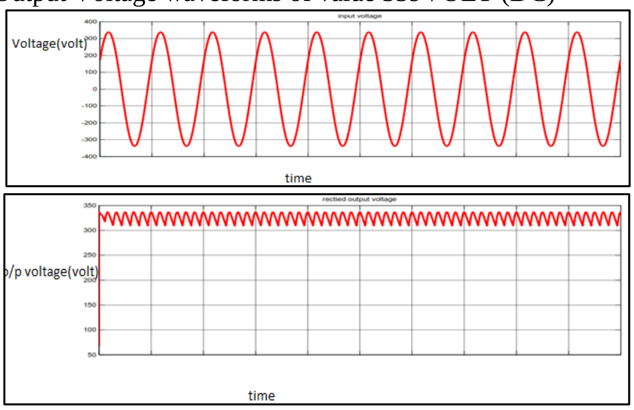


Fig. 5: Waveforms of Output Voltage for 3-Phase Rectified Voltage

V. Simulations Results of Output Voltage (60V DC) & Output Current (100AMP)

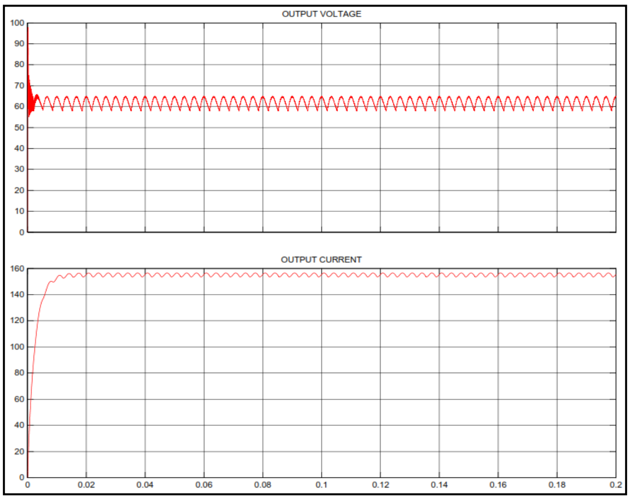


Fig. 6: Output Waveform of Load Voltage & Load Current of Welding Machine

As shown in above figure.6 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.

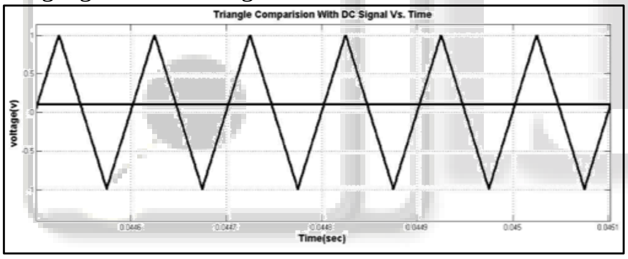


Fig. 7: Triangular Comparison with Dc Signal

– 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.

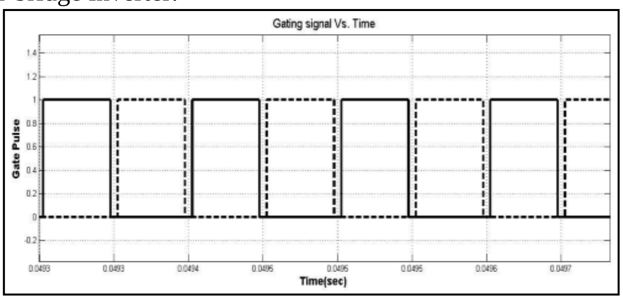


Fig. 8: Gate Pulse of H-Bridge Inverter

Welding scheme with h-bridge inverter using PSIM for Constant Current Condition

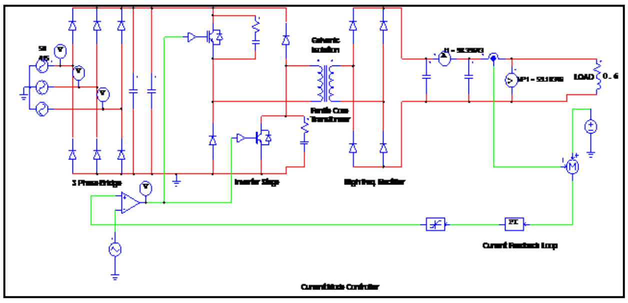
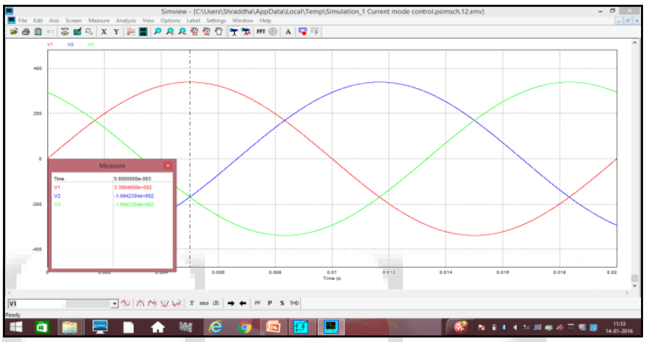


Fig. 9: Simulation Circuit of Welding Circuit with PSIM Software

In this simulation circuit, as shown in figure.9, 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 & Output Current (60V DC, 100AMP)*

VI. Driver Circuit Used in Welding Circuit

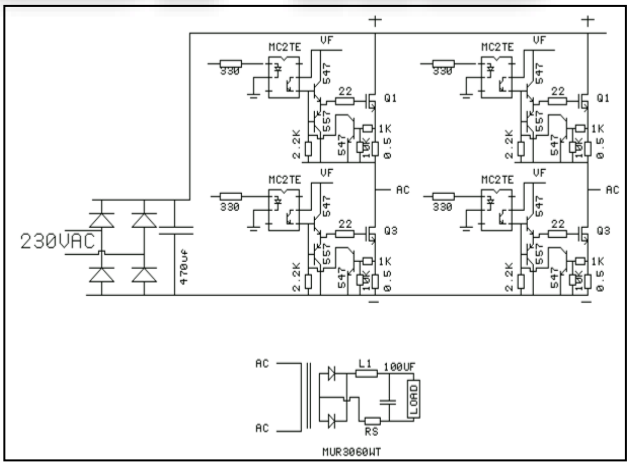


Fig. 10: Driver Circuit of Welding Machine

Components used in this driver circuit:

1) Bridge rectifier, (25 Ampere fast recovery diode)
2) Transistor (BC547), (BC557)
3) Op to 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.

To complete isolation between input and output, Opto couplers are provided in circuits. For protection from high voltage, low level noises and surge of voltage, we can provide isolation and that could be produces errors in the output. Opto couplers also provide interface between different voltage levels. Current at inside of circuit of an Opto coupler as like Photo diode, LDR, photo transistor and LASCR.

A. *Ratings of IGBT (60N100)*

1) *Current rating of IGBT*

Output Current Io= Rms value of current *safety factor
=60 * 2
=120 Amp

2) *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.

VII. DRIVER CIRCUIT USING PIC 18F4720 CONTROLLER FOR CLOSED LOOP CONTROL

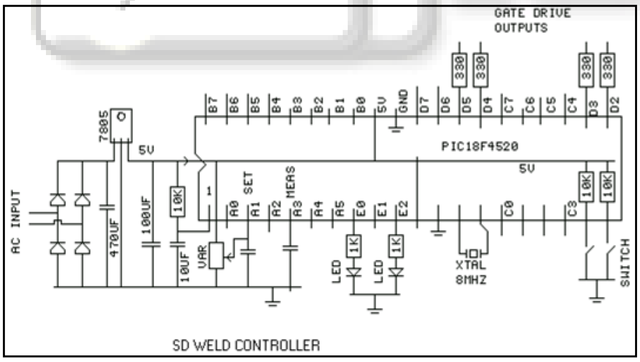
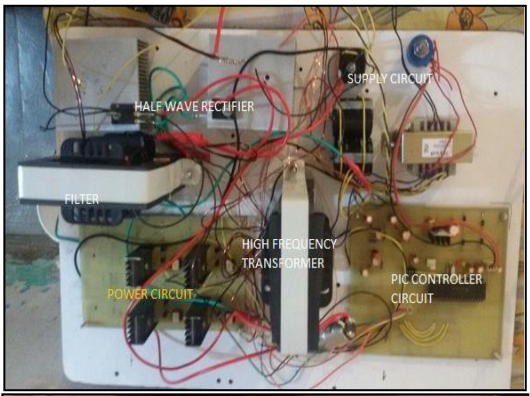


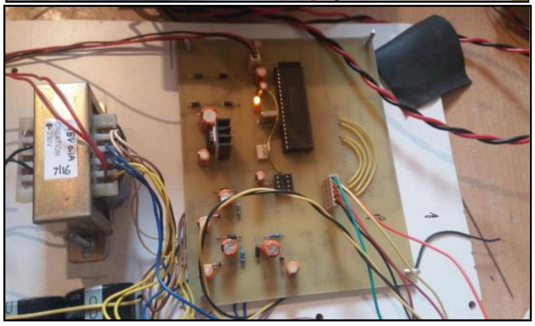
Fig. 11: Driver Circuit Using Pic Controller

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 .11 of driver circuit.

VIII. HARDWARE IMPLEMENTATION OF 20AMP. ELECTRONIC WELDING MACHINE

A. *Welding Machine Hardware*

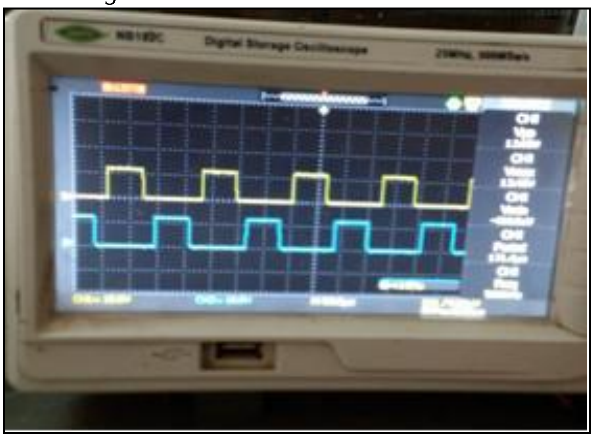


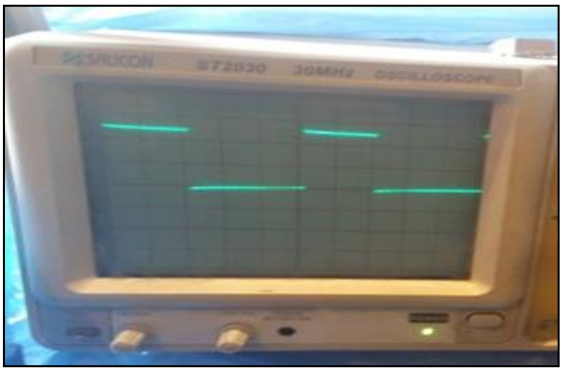


The converter in the hardware testing requires separate heat sinks for each power module. The IGBT, full bridge rectifier, and the input AC/DC converter were all replaced on separate heat sinks. The heat sinks should be integrated for the compactness of the system. In this inverter welding circuit compared to conventionally welding circuit, it uses the transformer which provides high frequency in an inverter welder, so we get more efficiently at large frequencies; so from this, the inverter gives a much lesser size of transformer. Size and weight can be minimized. Power taken by transformer is decreased and efficiency will increase. Due to the superior frequency of the current, an inverter welder gives a smother arc. By using software, we can analyse voltage and current constantly and it can set at the time of welding process.

B. *Hardware Results*

1) *Switching Pulses*

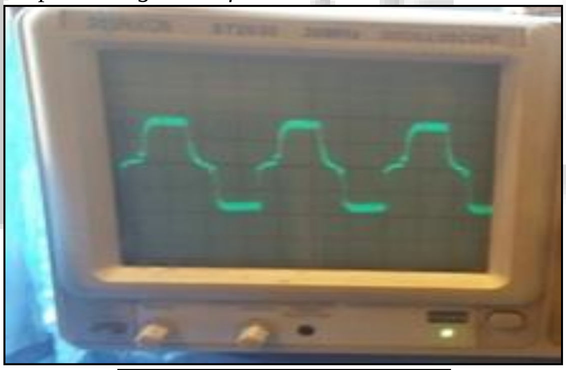


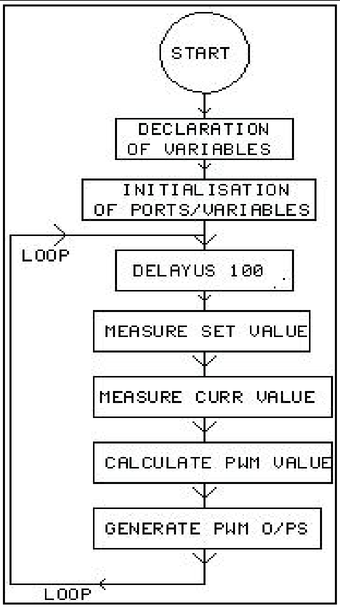


When IGBT1 IS ON,

2) *WHEN IGBT2 IS ON,*

3) *Output Voltage Waveforms*





Flow Chart of Electronic Welding Machine

IX. CONCLUSION

In this analysis, PIC controller is introduced to run the single phase inverter. Control of inverter switch is used the PWM technique in this method. This method is better to other methods for improving the output waves. PSIM and matlab-2013 is used to simulate the system and compared the experimental results. The experienced inverter is weighed down at a range of ac loads 11w, 15w and 26w.

REFERENCES

[1] ”A novel inverter for arc welding machines”, IEEE-transactions on industrial electronics, Volume-62, March-2015.

[2] Jian Min Jian -A simple Inverter for Arc welding Machines with current doubler rectifier”, IEEE- 23 February - year 2011.

[3] ”Device selection guide for half bridge welding machine”-fairchild semiconductor.com

[4] J.Borka and M.Horvath -”A new simple, low cost modular arrangement of high power factor for both DC and AC welding “-IEEE ISIE,volume-54,year-1999,

[5] Sakabe, T. Kashima, T. Mita andT. Araya, “Inverter-controlled arc welding equipment”, *Welding international*, 1, pp.629-638.

[6] ” A new PSFB converter-based inverter arc welding machine with high power density and high efficiency”, ht t p: //j our na l s. t ubi t a k. gov. t r /e l e kt, 7th november, 2014.

[7] ”A 6kw electronic welder control circuit“-IEEE-1998.

[8] L.Malesani, P.Mattavelli, L.Rossetto, P.Tenti,W.Marin, A.Pollmann, “Electronic welder with high-frequency resonant inverter”-*IEEE Trans. Industry applications*,vo1.31, n.2, pp.273,279, 1995.

[9] L.Malesani, P.Mattavelli, L.Rossetto, P.Tenti,W.Marin, A.Pollmann, “Electronic welder with high-frequency resonant inverter”- *IEEE Trans. Industry applications*,vo1.31, n.2, pp.273,279, 1995.