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A BIDIRECTIONAL SWITCH BASED HIGH EFFICIENCY RESONANT CONVERTER FOR PHOTOVOLTAIC APPLICATION

G. Gurumoorthy*[1] & S. Pandiarajan[2]
[*1&2]Asst.professor, Department of Electrical and Electronics Engineering, M.I.E.T Engineering College, Trichy

ABSTRACT

Push-Pull converter is discussed. A push-pull converter is suitable for photovoltaic applications, because the step up ratio of high frequency transformer is high. The proposed push-pull converter also decreases the switching loss using soft switching techniques. The voltage doublers circuit reduce the turn's ratio of the transformer. MOSFETs as a switching device due to its high power rating and high switch speed. This paper discusses about a new type of resonant converter that provides voltage regulation through Pulse width Modulation (PWM) control by adding a secondary side bi-directional switch to the resonant converter for wide range of input voltage which is more suitable for Photovoltaic applications.

Keywords: *Zero Voltage Switching, Zero Current Switching, Photo voltaic, Pulse Width Modulation.*

I. INTRODUCTION

1.1.General

Photovoltaic (PV) energy is the fastest growing renewable energy source. Its non-pollutant, direct power conversion characteristics make the entire system more competitive than traditional energy sources. The power conditioning system (PCS) required for the PV application must be efficient and less in cost. There are plenty of isolated topologies available. Among them, half bridge, full bridge and push pull are prominent topologies. These topologies are simple in construction and more economical. Topologies are modified, So that they can have efficient power tracking from the PV panel. The performance of these topologies is characterized in graphical representation. The topology is designed so as to have high voltage gain, for that a bidirectional switch is provided at the high voltage side of the transformer. The bidirectional switch is formed by connecting two MOSFETs drain terminals together. Single driver unit is required to operate the switch. The switching frequency of the bidirectional switch will be twice that of the resonant frequency.

1.2 Push pull converter

Push pull topology is an ideal choice for dc-dc converter for multiple reasons. The most important reason is the isolation between source and output provided by magnetic in the transformer. Another deciding factor is the simplicity of switching. By only having to turn on one switch at a time, timing issues become less critical. The increased dependence on energy sources and limited availability of fossil fuels has led to the exploration of new and renewable energy resources. Among various renewable energy resources, Photovoltaic power is one of the emerging industries that is reliable and is steadily growing due to decrease in prices. Large efforts are being taken worldwide to reduce the cost of electronics devices used in PV Power generation system with increased performance and efficiency. PV power generation system is the Power Conditioning Systems (PCSs) whose major function is to convert one form of electric power to another as required by the utility grid and to track maximum power from the PV module.

1.3 High frequency push-pulltransformer

High frequency transformer of push pull converter can handle more power than forward converter. Because push pull converter operate in two quadrants of B-H curve. On the other hand forward converter operate only in one quadrant of B-H curve. Designing magnetic components form the backbone of a good switching power supply.

Their proper electrical and physical designs have a large effect on the reliable operation of every switching power supply. Furthermore, the design of magnetic components take considerable time as there are many decisions to be made: core material, core shape and type of conductor, to mention a few. A specific method was followed for the design of the HF transformer. It comprises a center tap primary winding and a secondary center tap winding. The primary and secondary are each divided into two 3-turn windings and the transformer turn's ratio is 1:1. The primary was wound using copper foil in order to achieve good coupling and minimize leakage inductance and skin effect that is prevalent in cylindrical copper conductors.

1.4 Maximum power point tracking (MPPT)

Maximum Power Point Tracking (MPPT) is very important in solar power system because it minimizes the solar array cost by decreasing the number of solar modules required to achieve the desired output power. MPPT is a device that looks for the maximum power point of a source and keeps it operating in that point. Since, the PV is not always operating in its maximum power point, but with the use of an MPPT it is possible to force the PV to extract the maximum power at the given irradiance level. We used P&O MPPT algorithm due to its simplicity and easy of implementation. This technique is easily implemented by an algorithm using the power-voltage characteristics of the PV module. Knowing that at the right and the left of the maximum power point the power decrease, the converters duty cycle is changed depending on the last change in power and if the duty cycle was increased or decreased.

This technique operates in the boundaries of the MPPT. The MPPT algorithm developed for this application is responsible for deploying the necessary adjustment in the Push-Pull Converter's duty cycle so that the optimum voltage is achieved, thus allowing maximum power delivery to the load the P&O, MPPT algorithm varying the push-pull converter duty cycle to obtain the maximum power delivered by PV panel.

1.5 Literature survey

This section deals with the related works done for the proposed system. Thomas LaBella [1] proposed a bidirectional switch based on isolated resonant converter for PV application. The regulation of voltage can be combined by the application through a fixed-frequency PWM control along with LLC converters by adding a bidirectional switch at secondary side of the isolation transformer. D. Cao, proposed a half bridge micro-inverter for single phase grid connected PV system with continuous input current and reduced transformer turns ratio [2]. A transformer less single phase topology with maximum power point tracking (MPPT) is introduced by D.Meneses [3]. Z.Liang [4] implemented a dual mode resonant converter topology for parallel connected dc module integrated converter (MIC). An LLC converter with substantial resonant inductance for wide input voltage regulation is established by R.Beiranvand [5]. T.-H.Hsia [6] proposed an interleaved soft switching (zero voltage and zero current switching) technique.

A forward flyback converter using dual constant on-time modulating for wide input voltage regulation is proposed by W.Yu [7]. Q. Li and P.Wolfs [8] described the three different DC link configurations for module integrated topologies. The wide output voltage range with optimized design procedure of LLC resonant converter is examined by R.Beiranvandet [9]. B.Gu [10] established a transformer with less topology and with two split ac-coupled inductors which work separately for negative and positive half grid cycle. F.Musavi [11] developed an LLC resonant converter for battery charging applications with wide output voltage range that eliminates both low and high frequency current ripples.

An improved LLC converter utilizing two series transformers for changing the magnetizing inductance to reduce magnetizing current is developed by H.Hu [12]. The leakage inductance energy recovery for the isolation transformer of interleaved flyback converter is modelled by G.Jun-yin [13]. Fariborz Musavi [14] have addressed the limitations of LLC converter, implemented the current mode control and optimization of burst mode operation for current regulation. Y.Chen [15] proposed a design method of wide output range constant current LLC resonant converter. B.-G.Chung and K.-H.Yoon [16] developed a converter with two resonant tank circuits and auxiliary switches to get the high voltage gain characteristics with wide input voltage and load. A fixed frequency zero voltage switching three-level DC/DC resonant converter with phase-shift control between the primary and secondary sides of the transformer is designed by F.can and P.Barbosa [17] to make the converter work at a fixed switching frequency. T.LaBella [18] established an active-clamp fly back converter using Gallium Nitride based MOSFETs for reducing the losses that occur during dead time. M.M.Jovanovic [19] proposed a high-frequency quasi-resonant buck converter using graphical state-plane technique. B.Yang [20] developed a LLC resonant converter for front end DC/DC conversion.

II. METHODOLOGY

2.1 Proposed block diagram

The proposed block diagram the operation of a Push-Pull converter is utilized in PV ac module systems because of the fact that it has only few components and isolation between the PV modules and the ac grid line. Therefore, the push-pull converter is used with a voltage doublers which can decrease turn ratio of the transformer.

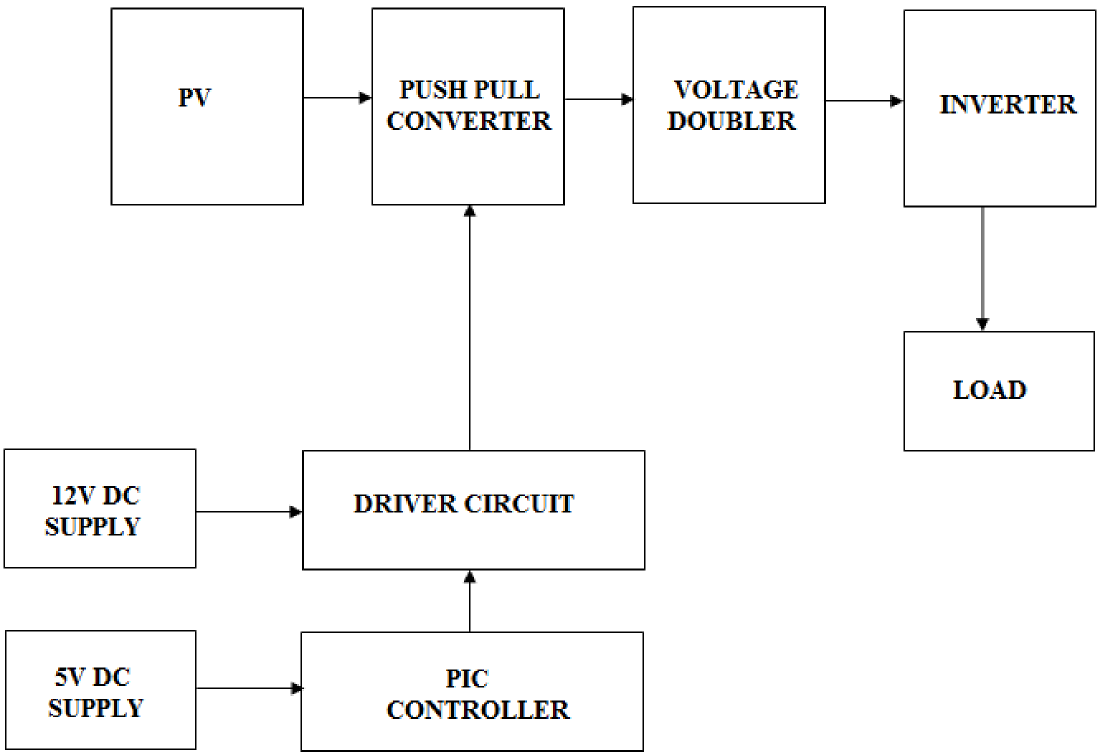

Figure: 2.2 Proposed block diagram

The driver circuit is provides isolation between control circuit and power circuit. It provides amplified voltage and current to the device.

III. SIMULATION RESULTS AND DISCUSSION

In this paper, the comparative study of the isolated resonant topologies is proposed. Based on the performance, the Push pull topology has high voltage gain than the remaining topologies. The requirement of switches and elements will be low when compared with the other two (half bridge and full bridge) topologies. Hence, it results low switching losses, low cost and higher efficiency. The performance of half bridge converter is low when compared with full and push pull topology. So the desired features can be obtained through push pull arrangement for tracking power from the PV module. Hence the push pull topology can be used widely in PV applications.

The simulation results of the proposed topologies represents the input voltage and output voltage of the isolated resonant topologies the output voltage and current of the isolated resonant topologies (half full and push pull). Here the input voltage of these topologies has taken as 24V. The input voltage and corresponding output voltage for these topologies are shown in the Table 5.

3.1 Existing simulation diagram

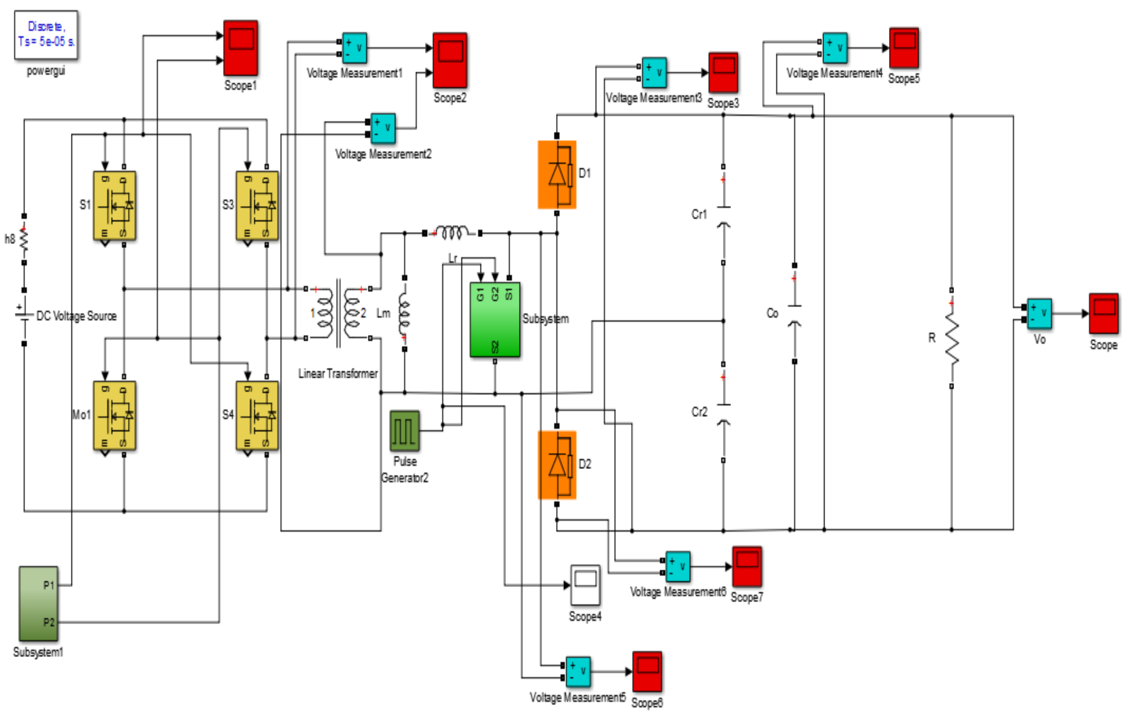

Fig 3.1 Existing simulation diagram

3.2 Proposed simulation diagram

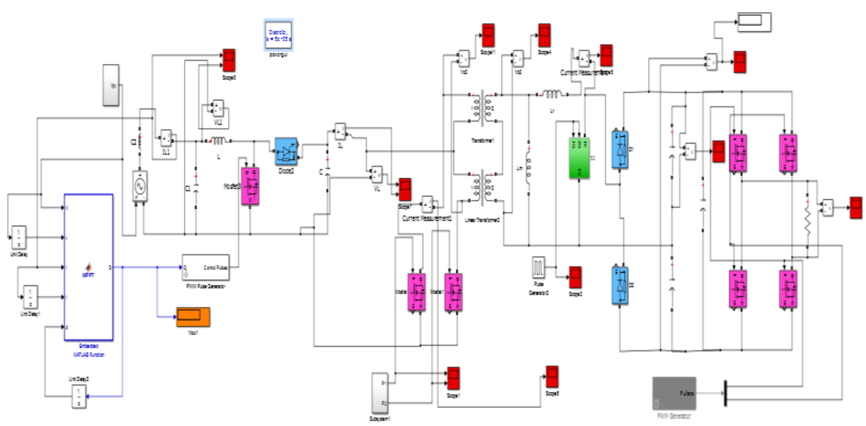

Fig.3.2Proposed Simulation Diagram

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IV. OUTPUT WAVEFORM

4.1. Input voltage

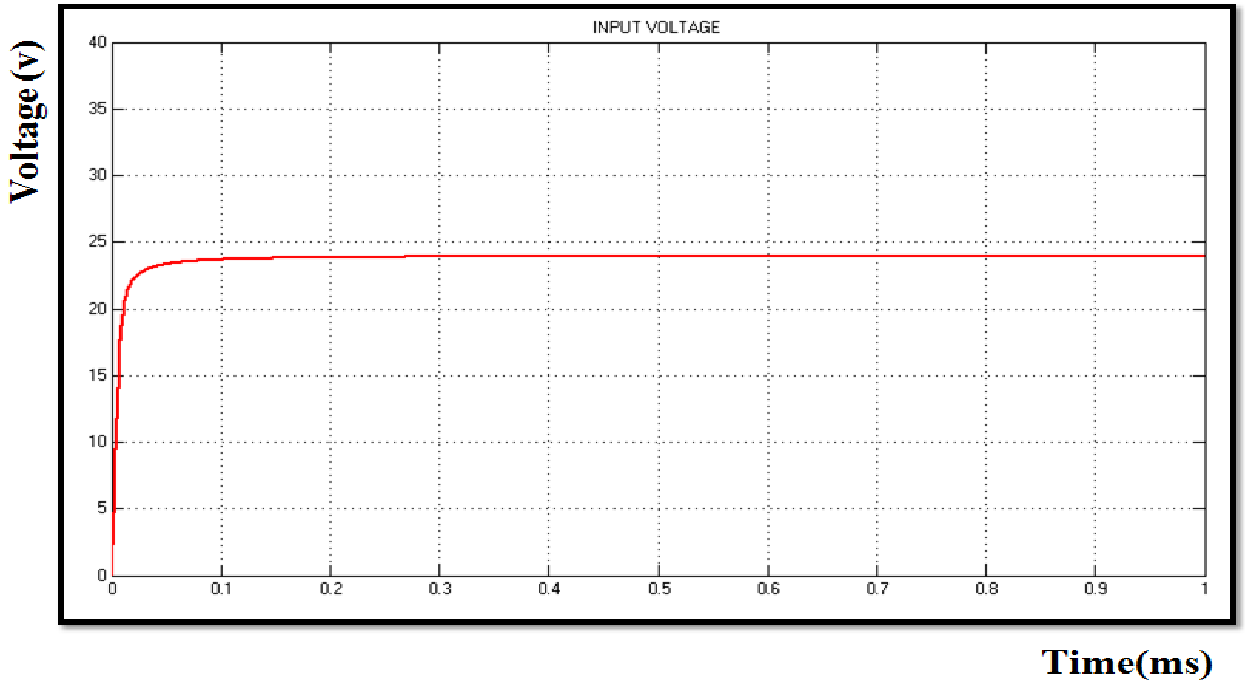

Fig4.1.Input voltage

4.2.Output voltage

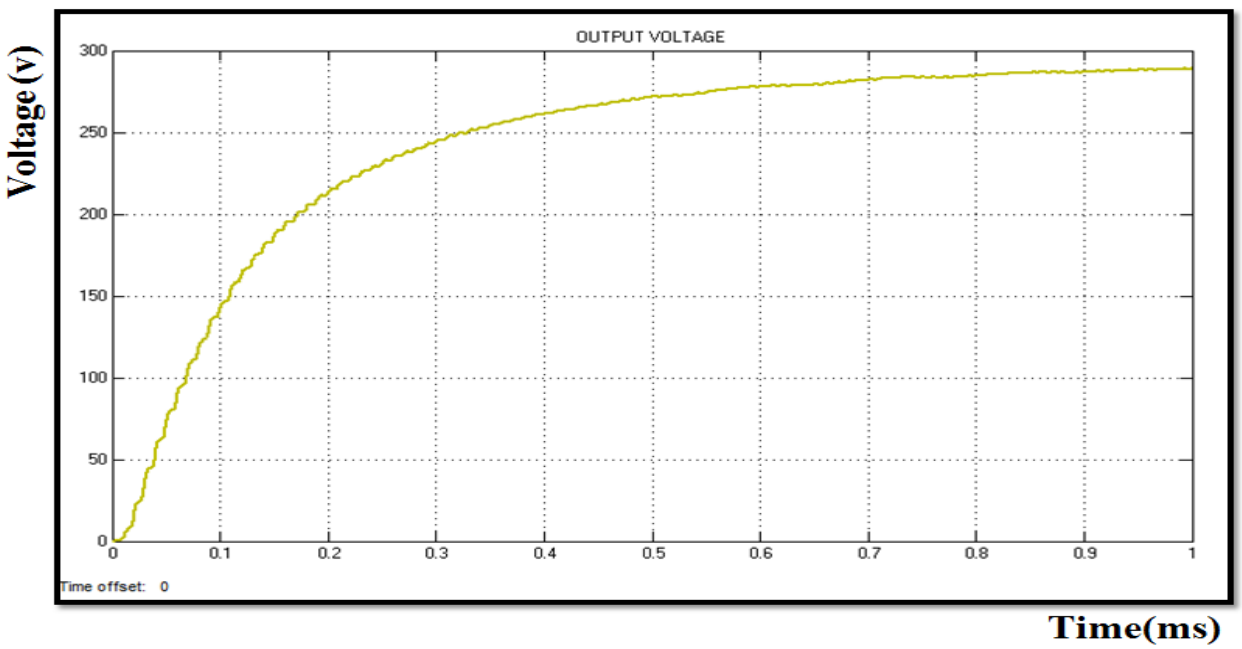

Fig.4.2.Output voltage

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4.3. Inverter output voltage

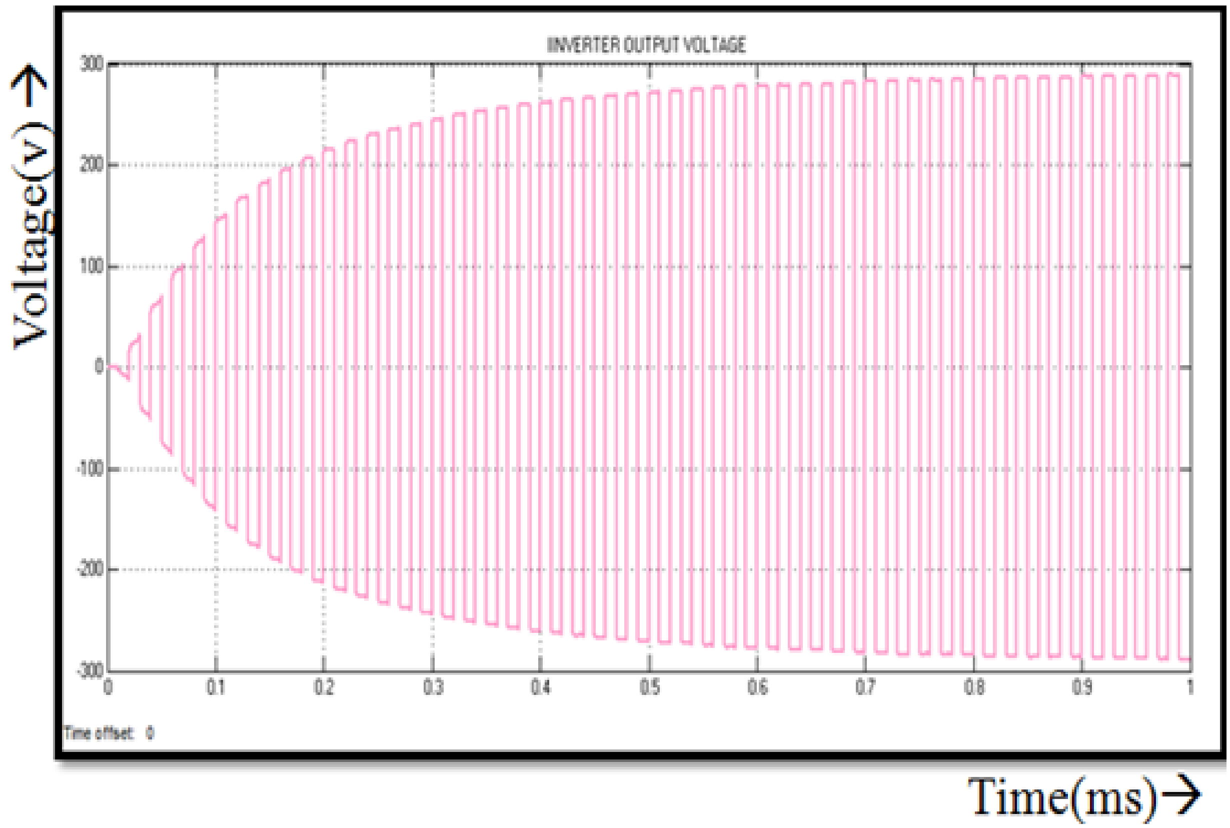

Fig.4.3.Inverter Outputvoltage

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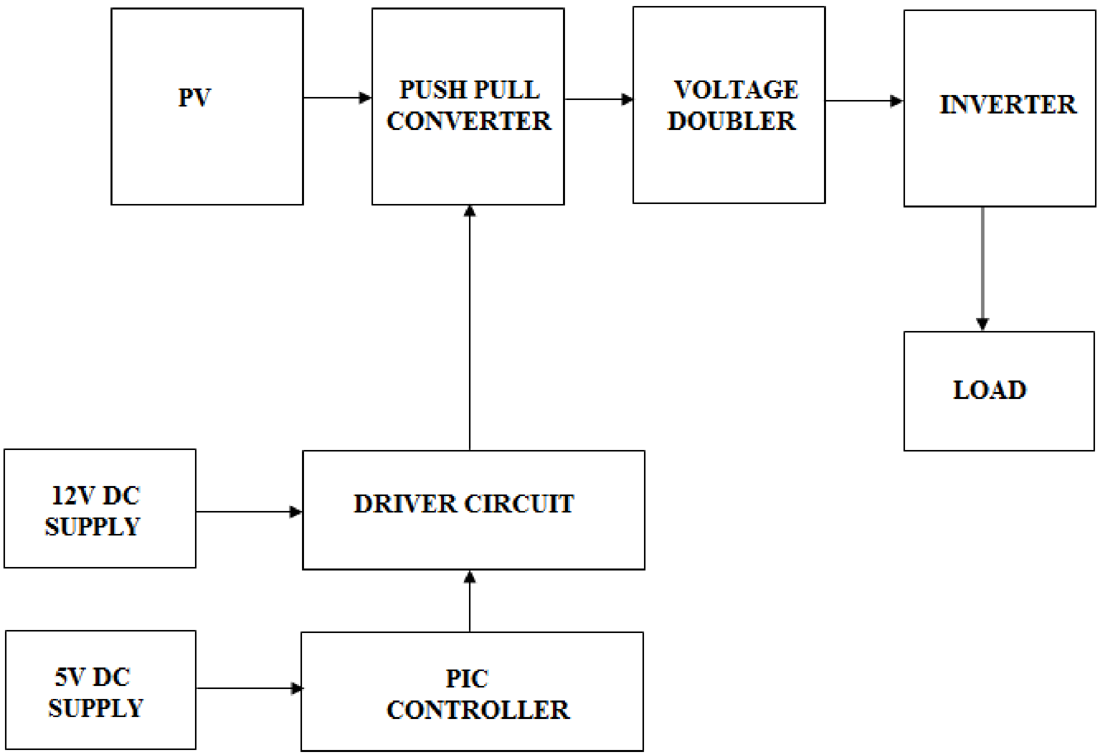
V. HARDWARE REQUIREMENTS

5.1. Hardware block diagram



VI. HARDWARE KIT IMAGE

The hardware kit for push pull converter is designed and tested on 10.8V DC supply. The output of push pull converter is connected to inverter to check the performance of he designed push pull converter. Push pull converter circuit consists of Power MOSFET, diode, inductor, capacitor and Transformer. The Power MOSFET in the circuit is driven by driver circuit which is energized by the microcontroller unit. The control circuit has PIC Microcontroller, Voltage regulator, Capacitor, Resistor, Transistor.

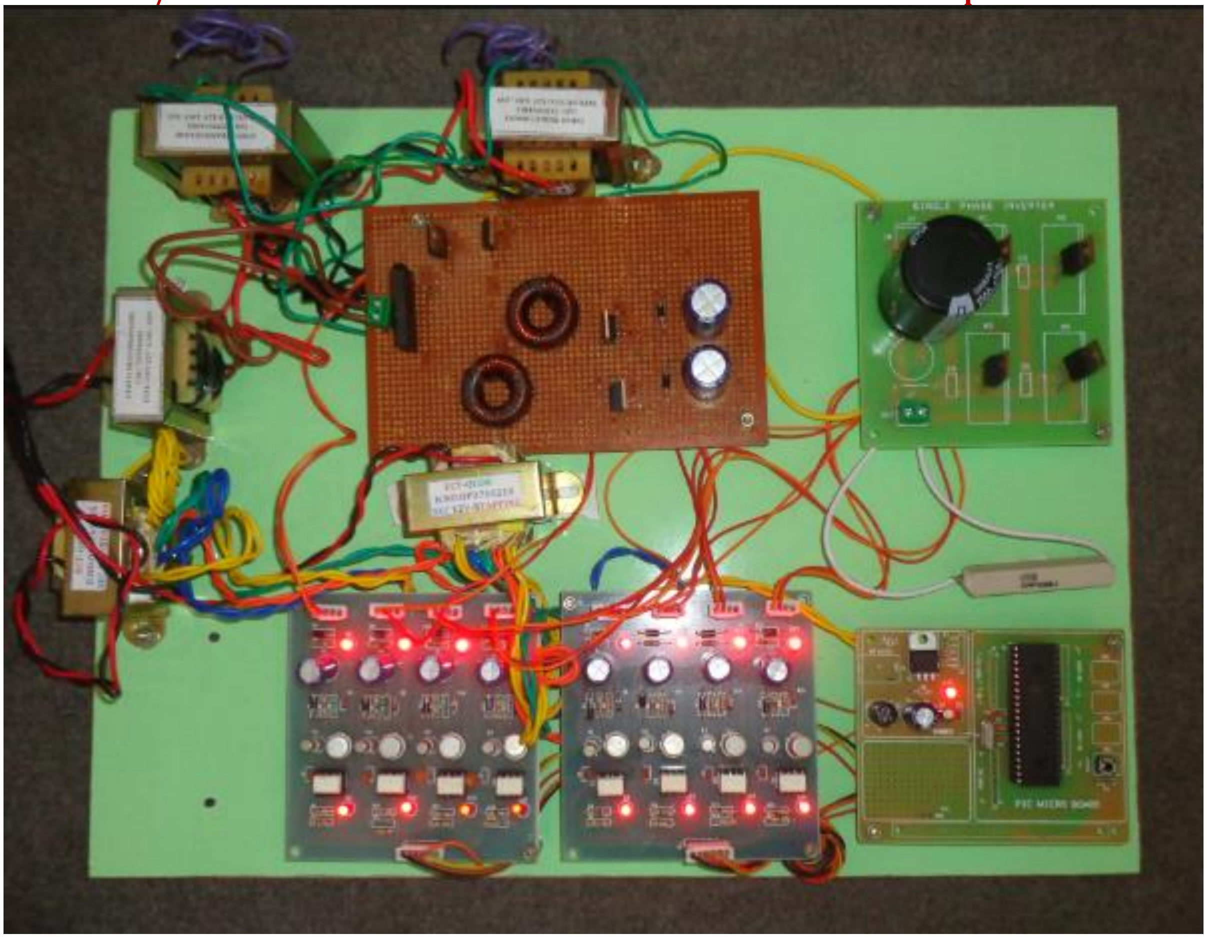


Figure: 6.1 Hardware module of proposed converter

Oscillator crystal or external clock input. Oscillator crystal input or external clock source input. ST buffer when configured in RC mode otherwise CMOS. External clock source input. Always associated with pin function OSC1 (OSC1/CLKI, OSC2/CLKO pins).

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Figure: 6.3 Hardware module with DSO

The input of 230V AC supply is step down to 12V AC by using the step down transformer and then it is converted to DC by using rectifier circuit. The capacitor act as filter to reduce the harmonics and by using voltage regulator LM7805 a constant input supply of 5v given to PIC microcontroller. The output from controller connected to driver circuit and also fed as the input to the push pull converter. The MOSFET switch is energized by driver circuit and it starts conducting.

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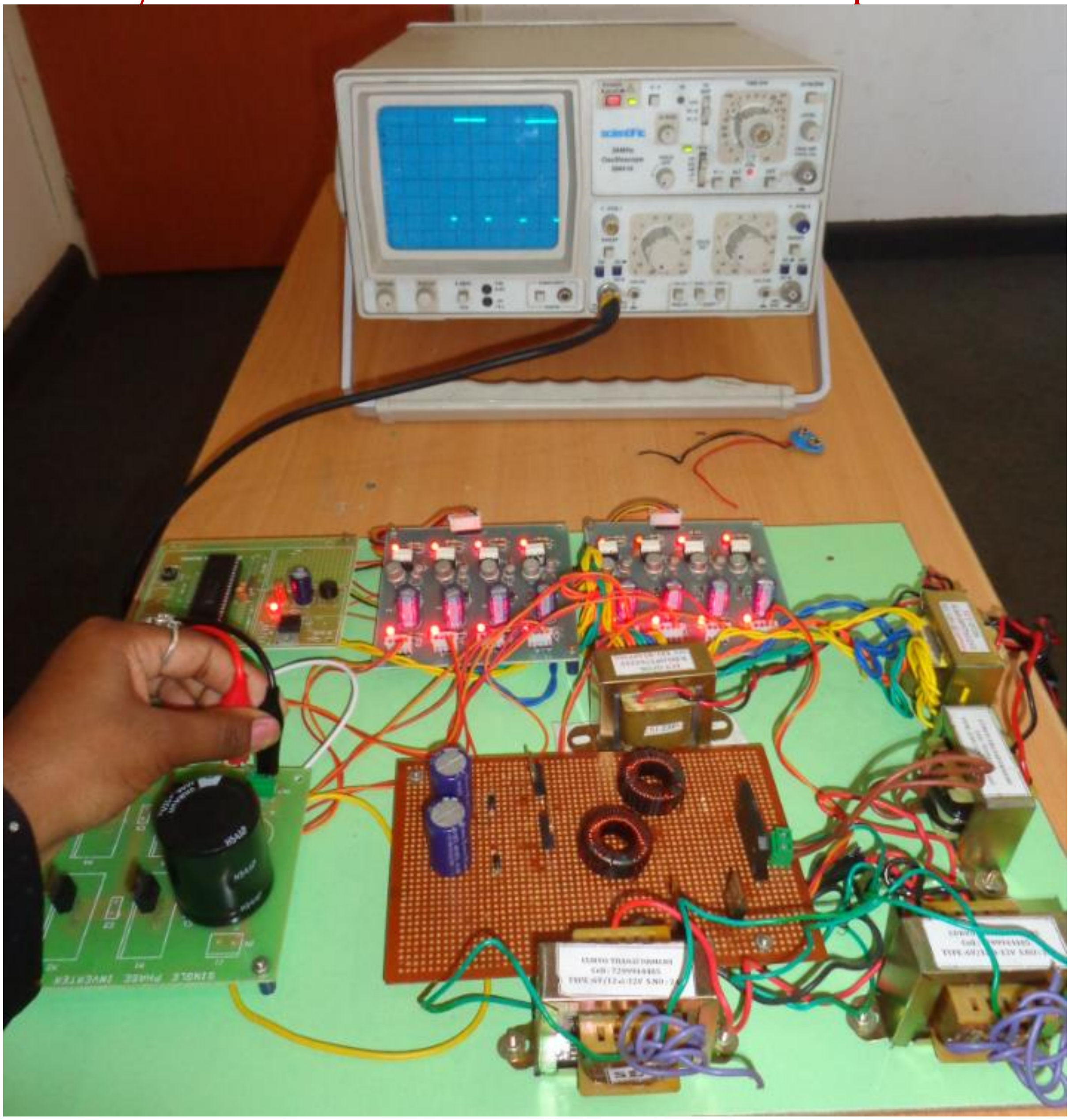

Figure: 6.2 Hardware module with CRO

VII. CONCLUSION

The simulation results simulated by MATLAB and hardware results taken by digital stage output (DSO) are compared. The 12V DC supply is given to the proposed push pull converter and the output voltage is stepped up to 115VAC. The results of software and hardware are similar. It is noted that the voltage of the proposed push pull converter is 115V AC which is greater than the existing system. The proposed push–pull converter decreases the switching loss.

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