

# Three Phase 150 Degree Mode of Conduction Voltage Source Inverter using Arduino

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**Abstract**— This paper is introduced a new modification for the simplest and well-known Three Phase, six Insulated Gate Bipolar Transistors (IGBT) switch voltage source inverter (VSI). In this method, each one of the six IGBT's conducts 150 degree instead of the known 180 degree and 120 degree conduction modes. Here, 150 degree conduction mode is achieved through an Arduino board, further connected with the wye connected load through driver circuit, the output phase voltage becomes a seven-level, 12 steps waveform. In these 150 degree conduction mode, controlling the pulse has been done through the Arduino program and firing of IGBTs. Final execution on the hardware gave the same results as of during MATLAB simulation. So this 150 degree mode of conduction results into a reduction of approximately 50% of the Total Harmonic Distortion (THD). Moreover, hardware is simpler as compared to 180 degree and 120 degree conduction modes. Simulation and experimental results show the conduction of the proposed methodology.

**Keywords**—Introduction; Three Phase Inverter (150degree); MATLAB Simulink model; Arduino Uno; Driver Circuit; Experimental setup; output waveform

## I. INTRODUCTION

An inverter is a device which converts DC power into AC power at desired voltage and desired frequency. Inverters are widely used in industrial application such as UPS, FACTA device, VFD, Active power filters, High voltage direct current transmission system and inverter is most important part in Hybrid and Electric cars etc. so important in the output voltage and reduction in harmonics distortion is very important factor to be consider. A variable output voltage can be obtained by varying in the input DC voltage and maintaining the gain of the inverter constant. The inverter gain can be defined by the ration of the AC output voltage to the DC input voltage. On the other hand, if the DC input voltage is kept constant, a variable output voltage can be obtained by varying the gain of the inverter, which is normally accomplished by pulse width modulation with in inverter. The comparative results of total harmonics distortion generated at the output for conduction period of switches 120 degree conduction, 150 degree conduction and 150 degree conduction are present at the last with some another comparative issues. In IGBT based Inverter, We are need to control the switching single give to IGBTs of Hex-Bridge Module. This job can be done by Arduino Uno Board.

## II. THREE PHSE INVERTER

A.

The basic configuration of Voltage Source Inverter (VSI) is shown in fig1. Single-phase half-bridge and full-bridge configuration of VSI with square wave pole voltages have been shown in fig2. A 3-phase bridge type VSI with square wave pole voltages has been considered. The out from this inverter is to be feed to a 3-pase balance load. Fig1 shows the power circuit of the 3-phase inverter. This circuit may be identified as three single phase half-bridge inverter circuit put cross the some dc bus. The individual pole voltages of 3-phase bridge circuit are identical to the square pole voltages output by single -phase half bridge or full bridge circuit. A three phase output may also be obtained by a configuration of six controllable switches and six diodes. The gating signals and basic circuit of a three phase inverter are shown below.

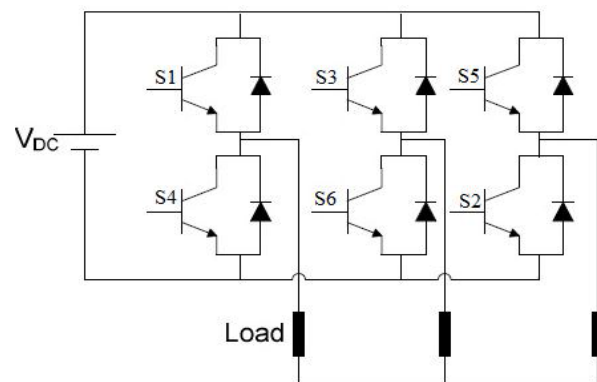


Fig1. Three Phase Inverter

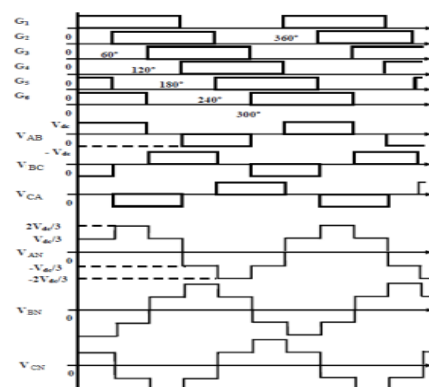


Fig2. Gating single and output voltages

The IGBT conduct in a sequence 31,123,23,234,34,345,45,456,56,561,612,12. So there are three modes of operation in one half cycles and the equivalent circuits for a Y-connected load have been shown.

### III. MATLAB SIMULINK MODEL

The Simulink model in MATLAB provides a graphical user interface, users can call the standard library module from where the necessary blocks and components are selected and are properly connected to form the dynamic system model. There is a dialog box for changing the properties of each individual component used in the module and also the system parameters as well as the configuration parameters and numerical algorithms are selected we can start the simulation program simulation of the system. Scopes are used to get the output waveform of the voltages and current and workspace is also used for the same.

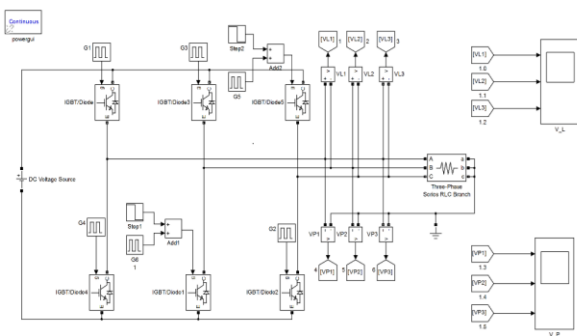


Fig 3.simulink model

We are using IGBT switch since it has a number of advantage over MOSFET and BJT. We used six IGBT/DIODE switches and star connected RL loads with the inverter. The use of filter is to reduce the distortion of output current and voltage of inverter. We used 150 degree mode of conduction and simulate in MATLAB.

#### A. Simulink result

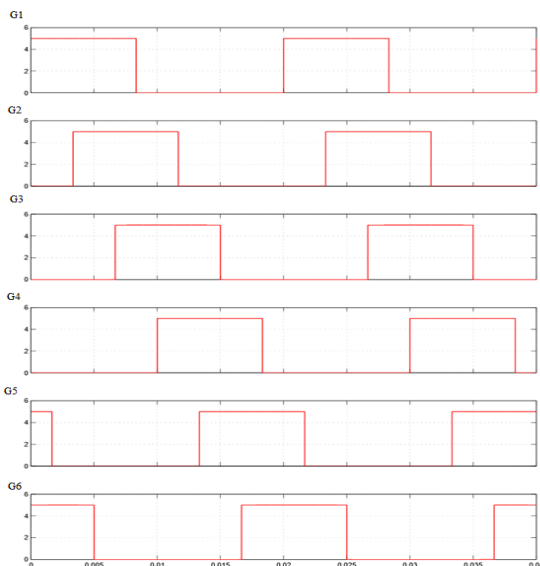


Fig4. Gate pulse

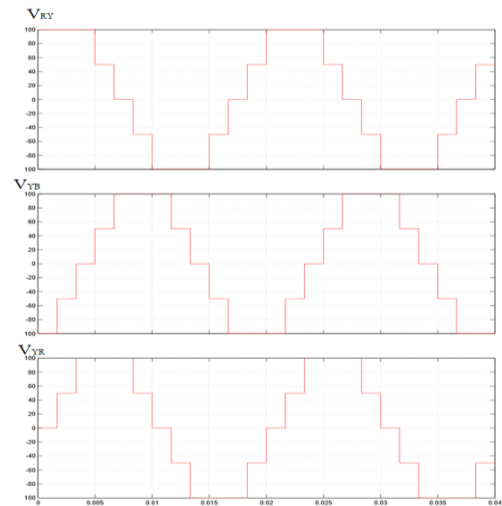


Fig5. Phase to Phase Voltage

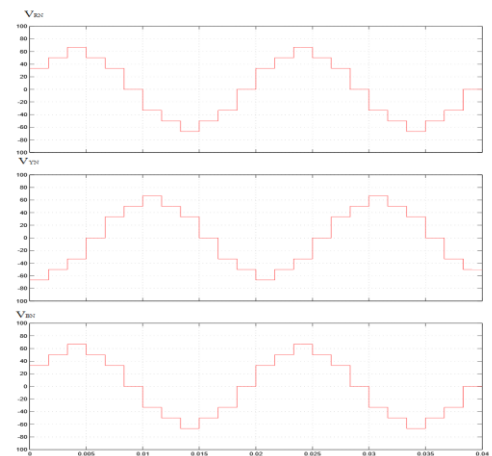


Fig6. Phase to Ground Voltage

### IV. ARDUINO

Arduino is an open-source platform used for building electronics projects. Arduino consist of both physical programmable circuit board and piece of software, or IDE that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit board, the Arduino does not need a separate piece of hardware in order to load new code onto the board- you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making to learn to program. Finally, Arduino provides a standard form factor that breaks out the function of the micro-controller into a more accessible package.

#### A. Code

So we have written the code with the help of PWM generator function for generating a three phase, six gate pluses. We have used the 1.6.7 version of the Arduino software for writing the code.

The logic of the program is simply based on the delay needed to generate gate pulse at the difference of  $30^\circ$  each.

We have uploaded the program in the Arduino UNO board and measured the various type of gate pulse on the pins mentioned in program as the output pins on Arduino board with the help of DSO. The output waveform is shown below:

**B. Arduino output gate pulse**

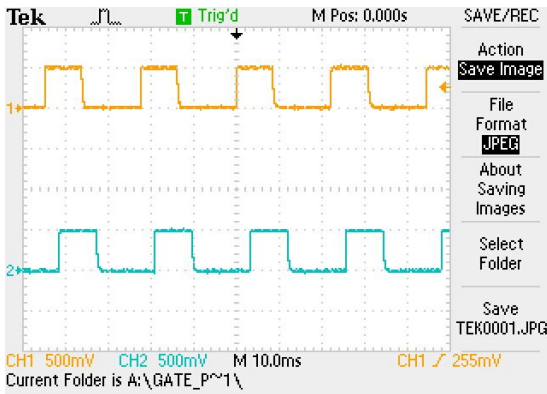


Fig7. G1-G2

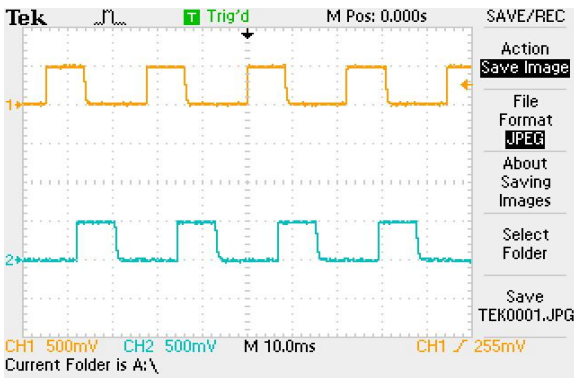


Fig8. G1-G3

**V. DRIVER CIRCUIT**

Driver circuit and isolated power supply for each gate pulse are connected parallel, the generated gate pulse with  $30^\circ$  phase shifted. Driver circuit input and output waveform are shown in fig.

The output pulse of Arduino circuit is given to the driver circuit having IC 6N137. There is need for electrical isolation between the logic level control signal and driver circuit. This isolation is provided by optocoupler inside the driver IC. Different driver ICs for top and bottom IGBT are supplied with isolated power supply. Test result shows the input and output of driver IC.

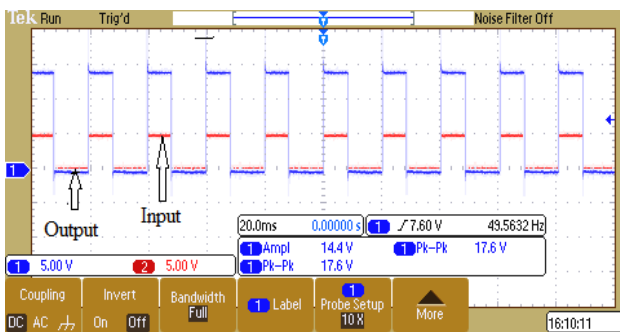


Fig9. Input and Output waveform

**VI. POWER CIRCUIT**

As per the circuit diagram, IGBTs are connected in such a way that emitter of odd number IGBTs are connected to collector of even number IGBTs respectively. Input of the each IGBT the output if the respective leg of driver circuit. Output of the power source is connected to the load. There are 3 loads of  $50\Omega$  and another three loads of  $100\Omega$ . All the six loads are of 50W. All the six loads are connected in star connection.

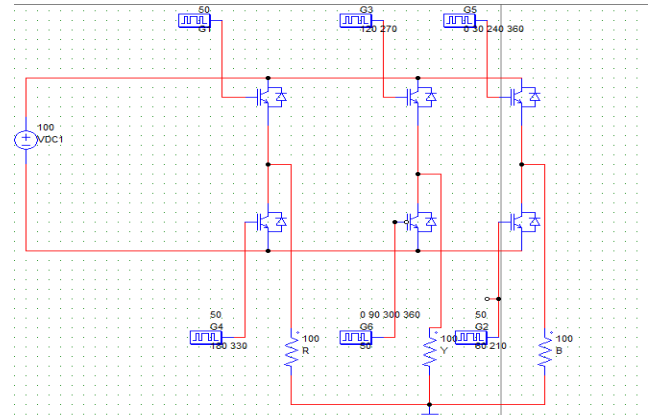


Fig10. Power circuit

**VII. EXTERNAL SETUP AND OUTPUT**

**A. Externat setup**

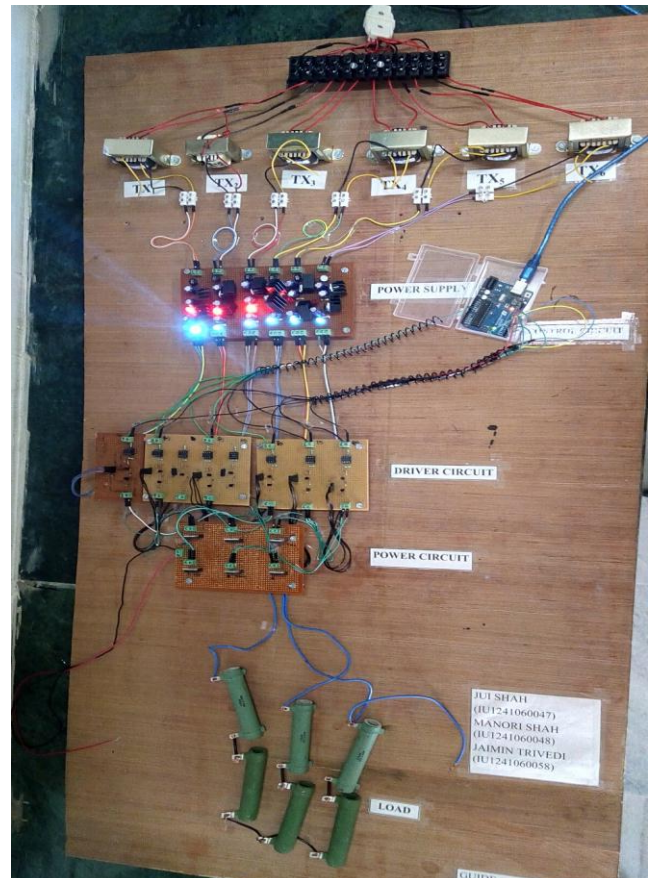


Fig11. External setup

A. output waveform

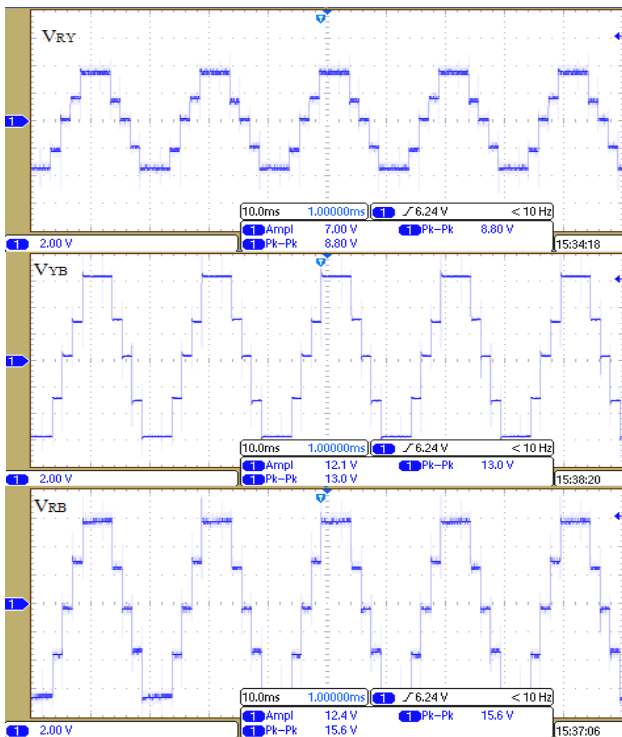


Fig12. Phase to Phase voltage

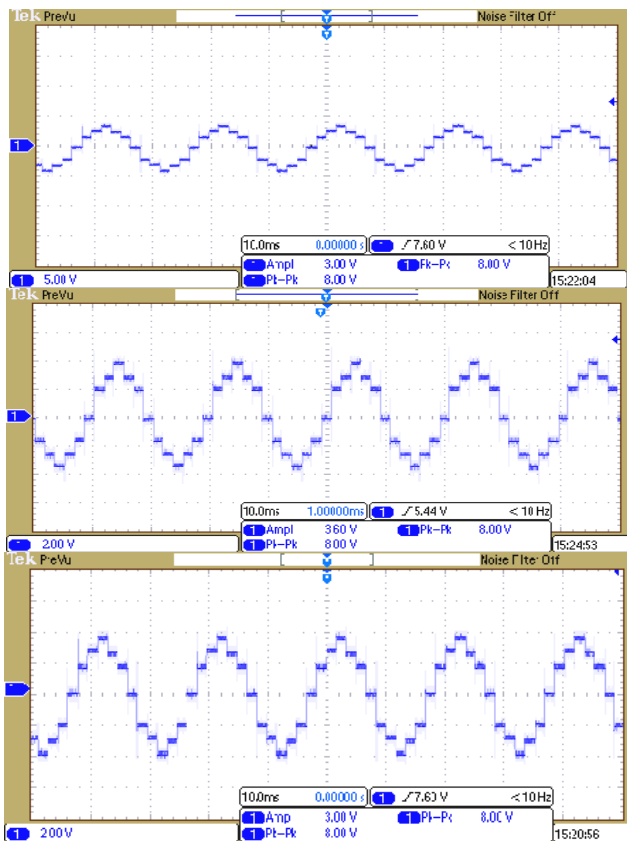


Fig13. Phase to ground

VIII. CONCLUSION

Three phase voltage source inverter in 150 degree conduction mode using Arduino controller with a star connected loads, the output phase voltage becomes a seven-level, 12 steps waveform, compared to the known only for four or three levels in 180 degree and 120 degree conduction modes respectively. This result in a reduction of the total harmonics distortion, reduction of voltage harmonics factor, and the lowest harmonic order becomes 11 rather than 5. Comprehensive study for the three conduction modes are proposed; the 150 degree inverter advantageous and increases the RMS value of output voltage, and total required VA ratings of the inverters reduces greatly over wide loads conduction. By the comparative study and simulation of different conduction mode three phase VSI, better performance is achieved 150 degree mode without adding extra component. So, on the basis of simplicity, economy, easy to implement, and less personates to total harmonics distortion at output side 150 degree is suitable topology.

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