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Simulation and Implementation of Three Phase Inverter in MATLAB software

S. S. Walke, R. S. Bansod, S. S. Meshram, S. G. Ganvir, P.S. Harinkhede, P. P. Khobragade, S. R.Verma
Department of Electrical Engineering, DBACER, Nagpur, Nagpur, Maharashtra, India

ABSTRACT

Nowadays an Inverter is most commonly used device in almost every field. An inverter gives ac square wave output. The objective of this paper is to obtain a three-phase ac output of 3-phase inverter in Simulation. An inverter receives dc supply as input and generates an ac output. The dc input of 3-phase inverter is obtained by constant dc source. The inverter circuit consists of six IGBTs which are used for conversion of dc to ac supply. Simulation of 3-phase inverter is done in MATLAB software.
Keywords : Three Phase Inverter, Constant Dc Source, MATLAB Software, Simulink.

I. INTRODUCTION

An inverter is a DC to AC converter, used to convert a dc input voltage into a symmetrical ac output voltage of desired magnitude and frequency. The waveshape of output ac voltage of inverter should be sinusoidal. However, practical inverters give output voltage that are non-sinusoidal and contain harmonics. The waveshapes of output voltage are square, quasi-square or distorted sinusoidal. Inverters used in low and medium power applications normally give square or quasi-square wave output. However, in high-power applications sinusoidal waveform is required, so inverters are carefully designed to give sinusoidal output with low distortion.

The inverters are classified on the basis of nature of input source, type of commutation, configuration of circuit, waveshape of output voltage. Basically inverters are divided into two types - Voltage Source Inverter (VSI) and Current Source Inverter (CSI).

The dc voltage input to the inverter is provided by battery, fuel cell, solar cell or any other voltage source. The switching devices used in inverters include BJTs, MOSFETs, MCTs, SITs, GTOs, SCRs and IGBTs.

Inverters are widely used in various industrial and household applications such as ac drive (variable speed, ac motor controller), induction heating, stand-by power supplies, uninterruptable power supplies (UPS), battery-vehicles drives, regulated-voltage and frequency power supplies, ultrasonic wave generators, static VAR generators, active power line filters.

In inverters, a step is defined as the change of conduction from one controlled switch to another. For example, in one cycle of 360˚, each step will be of 60˚ for a six-step inverter. This implies that each controlled switch of a six-step inverter will get a control pulse at interval of 60˚ in a proper sequence so that a three phase AC voltage is synthesized at the output terminals of the inverter.

There are two patterns of supplying the controlled pulses to the inverter switches. In one pattern each switch conducts for 180˚ and in the other, it conducts for 120˚. In both these cases the control pulse is applied at an interval of 60˚ and these modes requires six controlled switches.

II. METHODS AND MATERIAL

A. Bridge Inverter

Bridge inverter are of two types:

1. Single phase bridge inverter
   i) Single phase half bridge inverter.
   ii) Single phase full bridge inverter.
2. Three phase bridge inverter

Three Phase Bridge Inverter:

The circuit arrangement of three phase bridge inverter is shown in fig (a). It employs six IGBTs which are arranged in three pairs, each is a half bridge. Thus three-phase bridge inverter is a combination of three half bridge inverters arranged side by side. The commutation circuit is not shown to maintain simplicity. The three phase bridge inverter is basically a six step bridge inverter. In a cycle (360o), firing of IGBTs in a particular sequence forms six steps. Therefore each firing is delayed by 600 from earlier firing.

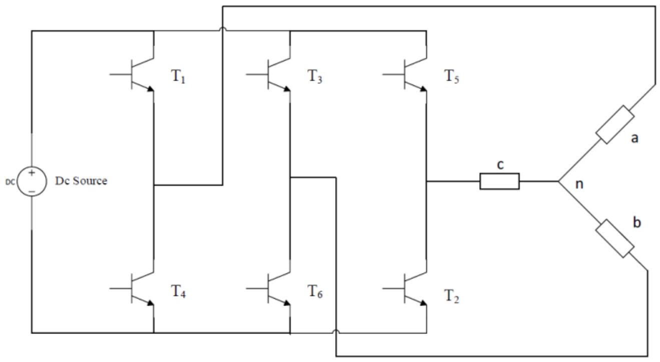

Figure 1: Three Phase Bridge Inverter

There are two modes of operation for three phase bridge inverters:

a. Three phase 1800 mode bridge inverter
b. Three phase 1200 mode bridge inverter

A. Three Phase 180^0 Mode Bridge Inverter

In this mode of inverter, each IGBT conducts for 1800, and the IGBTs are fired at regular interval of 600 in a sequence. Referring to power circuit.

Operation: It is noted be that both IGBTs in an arm i.e. S1 and S4 or S3 and S6 or S5 and S2, should not be ON simultaneously, otherwise there will be short circulating of input dc source and capacitor. If S1 is fired first, it will conduct for 1800 and then turn off. Other IGBTs in the same arm i.e. S4 must be fired after turning off of S1. Thus firing of S4 must be after 1800 from the firing of S1. The sequence of firing of IGBT is S1, S2, S3, S4, S5, S6, S1……with an interval of 600 between two successive firing. The conducting IGBT in different steps are as follows.

Table 1: Switch Conduction period for 1800 mode

Steps	I	II	III	IV	V	VI
Conducting IGBT	$T_5T_6T_1$	$T_6T_1T_2$	$T_1T_2T_3$	$T_2T_3T_4$	$T_3T_4T_5$	$T_4T_5T_6$
ωt	0 to 60^0	60^0 to 120^0	120^0 to 180^0	180^0 to 240^0	240^0 to 300^0	300^0 to 360^0
	0 to π/3	π/3 to 2π/3	2π/3 to π	π to 4π/3	4π/3 to 5π/3	5π/3 to 2π

B. Three Phase 1200 Mode Bridge Inverter

In this mode, each IGBT conducts for 1200 and the IGBTs are fired at regular interval of 600 in a sequence.

Operation: The firing sequence of IGBT is S1, S2, S3, S4, S5, S6, S1……During conduction of S1, S2 each fired at 600 and S3 is fired at 1200 and S4 fired at 1800. During this 600 interval, the commutation is ensured and possibility of short circuiting of source due to conduction of both the devices in same arm, is eliminated.

As each IGBTs conducts for 1200 after firing, two IGBTs conduct during any step of 600. The conducting IGBTs in different steps are as follows.

Table 1: Switch Conduction period for 1200 mode

Steps	I	II	III	IV	V	VI
Conducting IGBT	T_6T_1	T_1T_2	T_2T_3	T_3T_4	T_4T_5	T_5T_6
ωt	0 to 60^0	60^0 to 120^0	120^0 to 180^0	180^0 to 240^0	240^0 to 300^0	300^0 to 360^0
	0 to π/3	π/3 to 2π/3	2π/3 to π	π to 4π/3	4π/3 to 5π/3	5π/3 to 2π

B. Insulated Gate Bipolar Transistor (IGBT)

The Insulated Gate Bipolar Transistor (IGBT) is a power switching device that combines power MOSFET and bipolar technology to provide the circuit designer with a device that has power MOSFET input characteristics and bipolar transistor (BJT) output characteristics. An IGBT is basically a hybrid MOS-gated turn on/off bipolar transistor that combines the attributes of MOSFET, BJT and thyristor. An IGBT is gate turn off power semiconductor device whose electrical characteristics approach those of an ideal switch.

Why IGBT not SCR:

1. An IGBT is a voltage controlled device, the gate voltage controls the conduction. The SCR is a current control device, the gate current causes turning on of device.
2. After turning on IGBT it is not stay into ON state. Gate voltage is required to maintain it on. If gate voltage is removed it will turn off. In SCR, once it is turned on, even if gate current is removed, it remains in ON state.
3. On state voltage drop of IGBT (2-3 V) is greater than SCR(1.5-2.5 V).
4. The turn-on di/dt rating of IGBT is very high as compare to that of SCR.
5. The turn-on time of IGBT is less than that of SCR.
6. The turn-off time of IGBT (<2µsec) is much less than SCR (200µsec).

III. RESULTS AND DISCUSSION

In this MATLAB Simulation, we have made a three phase inverter by using IGBTs for inverting action. A constant DC Voltage Source is given at the input of the inverter.

There is one leg for each phase. Each leg consist of two IGBTs each conducting for 180_o. Thus the total circuit contains 6 IGBTs.

IGBT have property of conducting only if the gate signal is given to it. It will not conduct if gate voltage supply is removed from it. So we have given the gate signals to each IGBT in each leg such a way that there will be only one IGBT in one leg conducting at a time. If both IGBTs of one leg turn on at same time there will be possibility of short circuit. We used Pulse generator for supplying the gate signal to each IGBT.

Each IGBT have separate pulse generator connected to it. So total 6 Pulse generators are used in this circuit.

The Supply given is 415 volt DC supply. The load is star connected resistive load. The conduction mode is 1800 conduction mode.

The numbering to each IGBT is given according to their switching sequence.

A. 1800 mode Conduction

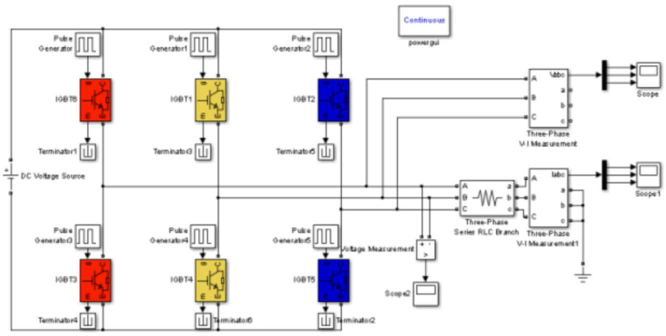

Figure 2: Simulation of three phase Inverter

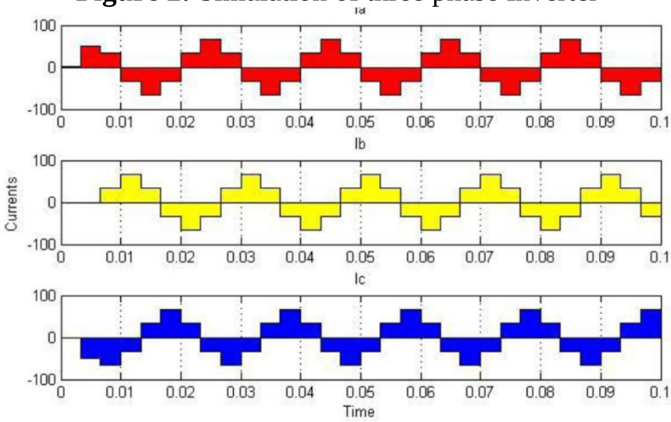

Figure 3: Output of Currents

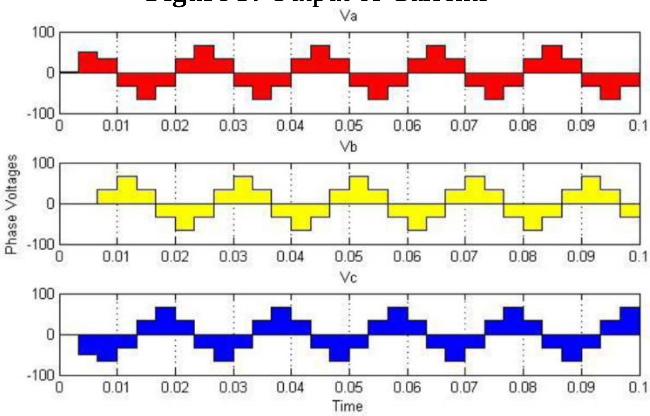

Figure 4: Output of Phase Voltages

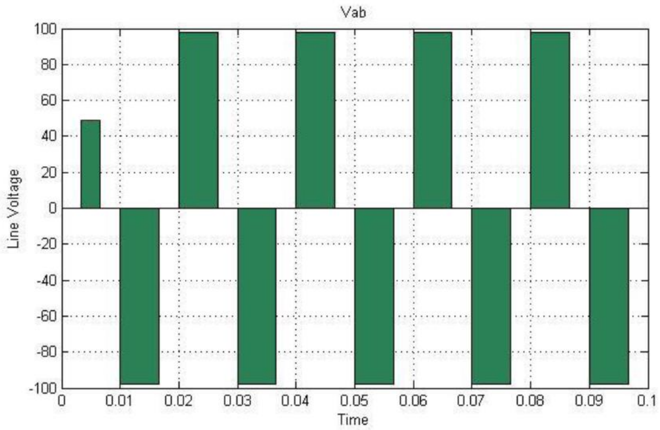

Figure 5: Output of Line Voltage

B. 1200 mode Conduction

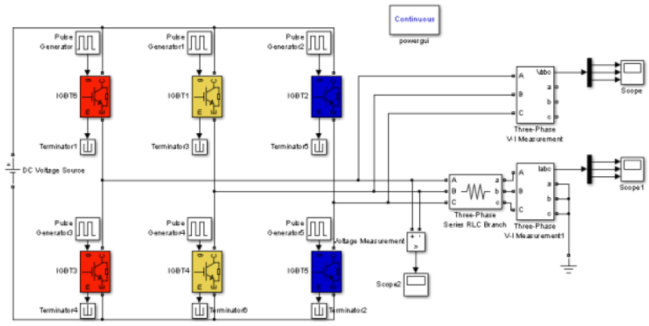

Figure 6: Simulation of three phase Inverter

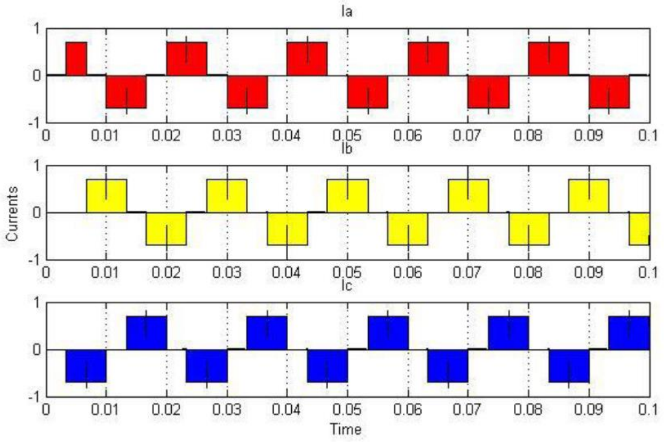

Figure 7: Output of Currents

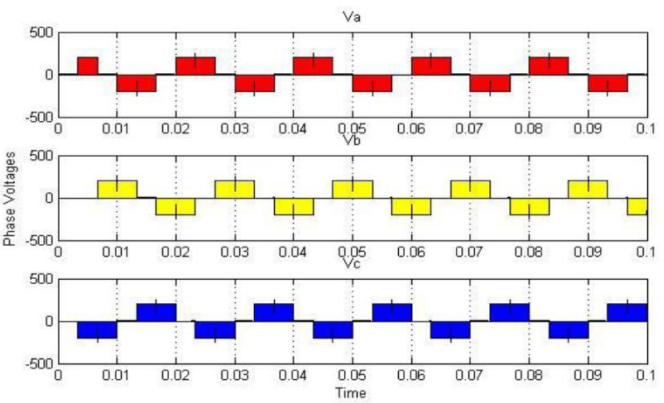

Figure 8: Output of Phase Voltages

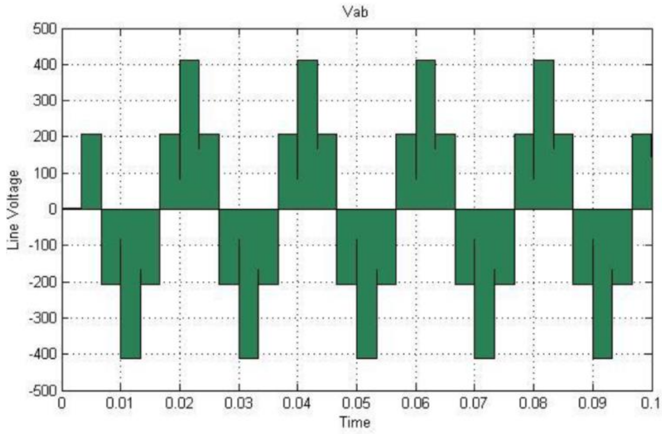

Figure 9: Output of Line Voltage

IV. CONCLUSION

The simulation of the three phase inverter has carried out. Simulation was done in two modes of operation where load is star connected resistive and the outputs of phase voltage and currents are same.

V. REFERENCES

[1]. Industrial and Power Electronics by Deodatta Shingare.
[2]. Analysis and Simulation Three-Phase Inverter by Yugal Kishor and Chitra Thakur.