International Journal of Software & Hardware Research in Engineering
ISSN No: 2347-4890 Volume 2 Issue 9, September 2014

Analysis and Simulation Three-Phase Inverter

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ABSTRACT

The objective of this paper is to obtain a three-phase ac square wave output, which is obtained by a 3-phase inverter. An inverter receives dc supply for its input and produces an ac output. Here the dc input to the 3-phase inverter is obtained by constant dc source. The inverter circuit consists of six MOFET for dc to ac conversion. Simulation of 3-phase inverter was done in MATLAB.

Keywords

Multi-level inverter, Simulink, Matlab, THD.

1. INTRODUCTION

A device that converts dc power into ac power at desired output voltage and frequency is called an inverter. Inverters can be broadly classified into two types; voltage source inverters and current source inverters. A voltage source inverter has stiff dc voltage source at its input terminals. A current source inverter is fed from a stiff dc current source.

VSIs using transistors, like BJTs, MOSFETs, IGBTs or SITs, can be turned off by the control of their base current. Switching-off of the devices with the help of their gate or base currents is called self-commutation. So the self-commutated inverters using GTOs and transistors do not require additional commutation circuitry. This reduces the complexity and cost of the self-commutated inverter circuits and at the same time, enhances the reliability of their operation.

The three-phase inverters are used in industrial applications for providing variable frequency AC supply. The input is taken from a battery or DC supply and the output is a three-phase AC supply of desired frequency. An elementary three-phase inverter is of bridge type and consists of six controlled switches.

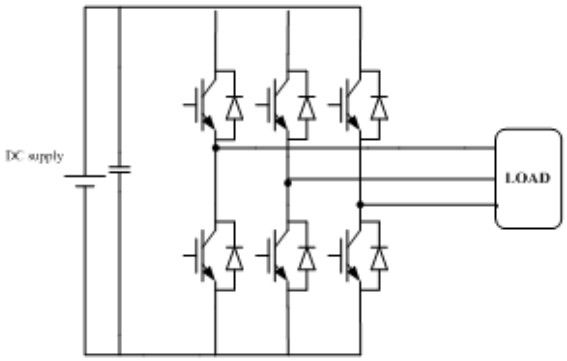

Fig 1: Three phase inverter

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.

2. SIMULATION ANALYSIS

Three-phase inverter has two mode of operation, namely 180˚ conduction mode inverter and 120˚ conduction mode inverter.

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2.1 Three-phase 180˚ conduction mode inverter

A three-phase 180˚ conduction mode bridge-type inverter model built up of six MOSFETs, 450V DC supply, star-connected load of 300Ω, six pulse generators, and measurement blocks in shown simulation model in Fig.2. In this inverter, each MOSFET conducts for 180˚ and hence it is known as three-phase 180˚ voltage source inverter. The MOSFET pair in each arm, i.e. M1 and M4, M3 and M6, and M5 and M2 conducts for a time interval 180˚. It implies that M1 conducts for 180˚ and then M4 conducts for 180˚, and so on. Table 6.1 illustrates the switching pattern for 180˚ mode inverter. It can be seen from table-1 that in every step of 60˚ duration, only three switches are conducting, i.e. one from the upper group and two from the lower group or two from the upper group and one from the lower group.

Table 1: Switching pattern for 180˚ mode three-phase VSI.

Angle	ON Switches	OFF Switches
0˚-60˚	M1, M5, M6	M2, M3, M4
60˚-120˚	M1, M2, M6	M3, M4, M5
120˚-180˚	M1, M2, M3	M4, M5, M6
180˚-240˚	M2, M3, M4	M1, M5, M6
240˚-300˚	M3, M4, M5	M1, M2, M6
300˚-360˚	M4, M5, M6	M1, M2, M3

The three-phase 180˚ mode VSI model shown in Fig.2 is simulated from 0 to 0.1 s. the parameters of pulse generator block G1 are taken as follows: amplitude-5, period-0.02 s, pulse width-50%, and phase delay-0 s is taken so that the output voltage waveform is of frequency 50Hz (1/50 = 0.02). The pulse width of 50% is taken so that the MOSFET M1 conducts from 0 to 0.01 s, i.e. 0˚ to 180˚. As 0 to 0.02 s is equivalent to 0˚ to 360˚, the delay of 0.01 s means 180˚ delay in electrical angle. Similarly, the phase delay for G2 is 0.01s, i.e. 180˚. The output voltage waveform of the three phases obtained after simulating the model Fig.4. It can be observed from Fig.4 that the first phase has phase angle of 60˚, the second phase -120˚, and third phase 120˚.

Below fig. shows the simulation model for three-phase inverter.

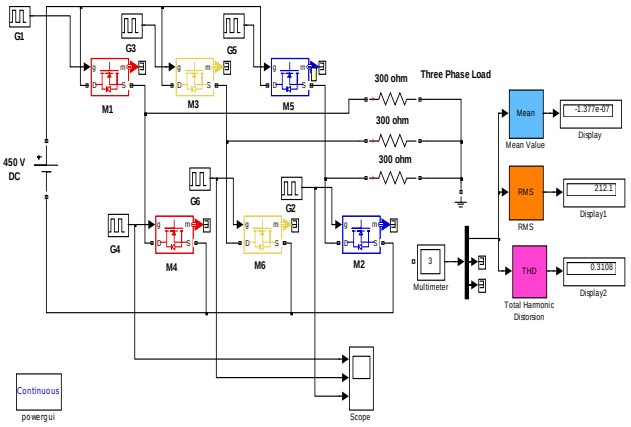

Fig. 2 Simulation model for three-phase inverter with 180˚ conduction mode.

The following parameters are measured for the first phase as can be seen in fig.2:

1. V_{avg} = -5.884×10-12V, i.e., almost zero
2. V_{Rms}=212.1V
3. THD=0.3108

Fig. 3 Gate pulses of M4, M6, and M2

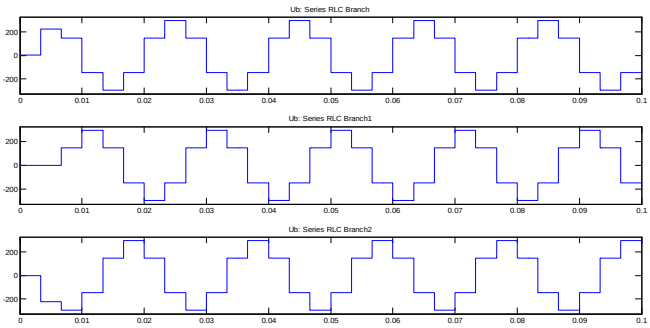

Fig.4 output voltage waveform of three-phases

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2.2 Three-phase 120˚ conduction mode inverter

The model of a three-phase 120˚ VSI containing a 450V DC source, six MOSFETs and pulse generators, 300Ω star-connected load, and measuring blocks is shown in fig. 5. In case of a 120˚ mode VSI, each switch conducts for 120˚ of a cycle. Like 180˚ mode, the 120˚ mode inverter also requires six steps of 60˚ duration for completing one cycle of output AC voltage waveform. In this inverter, M1 conducts for 120˚ and for the next period of 60˚, neither M1 nor M4 conducts. Now, M4 is turned ON at 180˚ and it conducts for a period of 120˚, i.e., from 180˚ to 300˚. At 300˚, M4 stops conducting and 60˚ interval elapses before M1 is turned ON again at 360˚. In the bottom row, M3 is turned ON at 120˚ and it conducts for a period of 120˚ and then it is turned OFF. At 300˚, M6 is turned ON and it conducts for 120˚. After the 60˚ interval elapse, M3is turned ON again. The sequences if firing the six MOSFET switches is same as that for the 180˚mode inverter. In this case, in each step only two switches conduct, i.e., one from upper group and one from the lower group.

Table-2: Switching pattern for 120˚ mode three-phase VSI

Angle	ON Switches	OFF Switches
0˚-60˚	M1, M6	M2, M3, M4, M6
60˚-120˚	M1, M2	M2, M3, M4, M5
120˚-180˚	M2, M3	M1, M4, M5, M6
180˚-240˚	M3, M4	M1, M2, M5, M6
240˚-300˚	M4, M5	M1, M2, M3,M6
300˚-360˚	M5, M6	M1, M2, M3, M4

The model shown in fig.5 is simulated from 0 to 0.1 s. The parameters set for pulse generator block G1 are as follows: Amplitude-5, period-0.02s, pulse width-33.34%, and phase delay-0 s. A period of 0.02 s is taken so as to get a 50Hz waveform at the output and a pulse width of 33.34% is taken for G1 because M1 conducts from 0˚ to 120˚, i.e., 0 to 0.0067 s. Similarly, the phase delay for G2 is 0.01/3 s, for G3 is 0.02/3 s, for G4 is 0.01 s, for G5 is 0.04/3 s, and for G6, it is 0.05/3 s, all other parameters remaining the same. The delays are set according to the conduction angle given in table-2 for each switch. The gate pulses given to switches M1, M3, and M5 are shown in fig.6. It can be observed that each switch conducts for 120˚. The output voltage and current waveforms of the three phases are shown in fig.7. It can be observed that the first phase has a phase angle of 0˚, second phase has a phase angle of 120˚, and the third phase has a phase angle of -120˚.

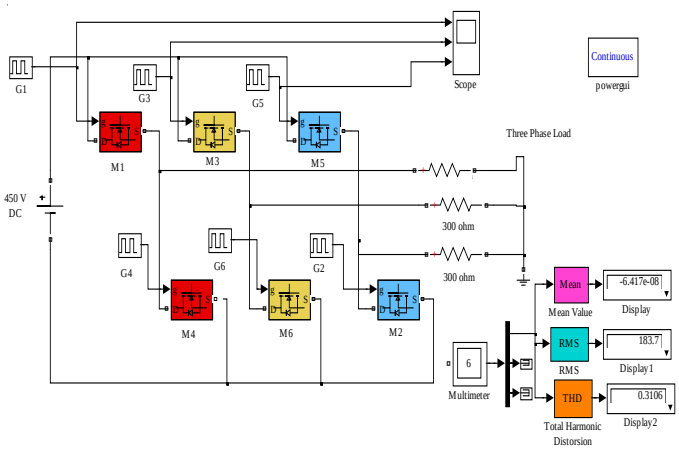

Fig.5 Simulation model for three-phase inverter with 120˚ conduction mode.

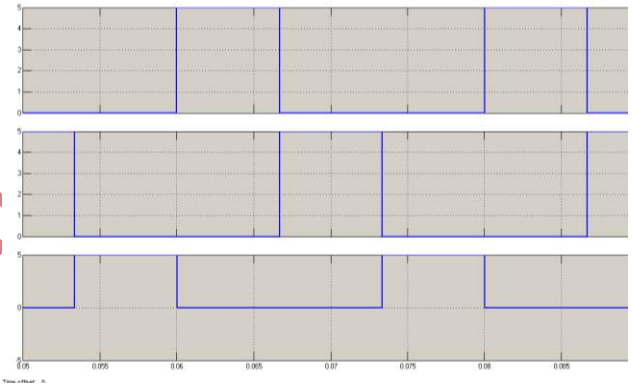

Fig.6 Gate pulses of M1, M3 and M5

The following parameters are measured for the first phase as can be seen in fig. 6.

1. Vavg = -3.342×10-11
2. Vrms = 183.7V
3. THD = 0.3106

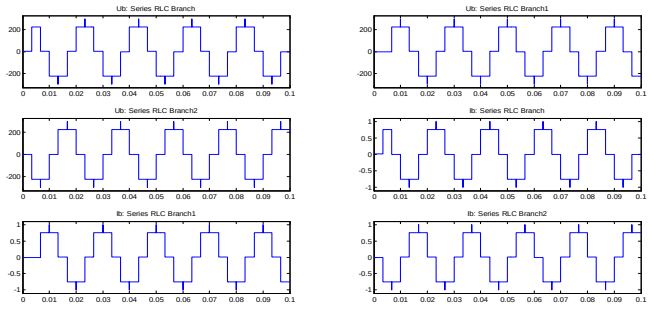

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Fig.7 Output voltage and current waveform of the three phases.

3. CONCLUSION

The simulation of the inverters namely conventional three and two level carried out. THD more in two level inverter, which will be overcome by three level inverter. The load current for three level inverter are much more sinusoidal and improvement in the line current waveform.

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