Design of Three Phase Inverter using SPWM Technique in MATLAB

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Abstract:

Nowadays an Inverter is most commonly used device in almost every field. The objective of this paper is to obtain a three-phase ac output of 3-phase inverter using SPWM technique. The Sinusoidal Pulse Width Modulation (SPWM) technique is one of the most popular PWM techniques for harmonic reduction of inverters since there are used three sine waves displaced in 1200 phase difference as reference signals for three phase inverter. An inverter converts the dc supply into ac supply. The dc input of the 3-phase inverter is obtained by constant dc source. Simulation of the 3-phase inverter using SPWM technique is done in MATLAB software.

Keywords: Three phase inverter, SPWM technique, MATLAB software, IGBT, THD.

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 dc voltage input is provided by battery, fuel cell or any other dc voltage source. In voltage source inverter (VSI) DC input voltage is normally constant and it is also not dependent on the load current which is drawn from it. The SPWM technique is the easiest modulation scheme to understand and to implement in software or hardware but this technique is unable to fully utilize the DC bus supply voltage available to the voltage source inverter. The switching devices used in inverters include BJTs, MOSFETs, IGBTs, MCTs, SITs, GTOs and SCRs. The selection of particular device depends upon power handling capacity, switching frequency and cost.

Depending upon the nature of input source, the inverters are classified into two main types:

1. Voltage Source Inverter (VSI).
2. Current Source Inverter (CSI).

In this paper we are using voltage source inverter which is further classified into two types

1. Single Phase Inverter
2. Three Phase Inverter

II. THREE PHASE INVERTER

The circuit arrangement of three phase inverter is as shown in figure below. It consists of six IGBTs i.e. T1, T2, T3, T4, T5 and T6. There are three legs of inverter, each leg consist two IGBTs like T1 & T4, T3 &T6 and T5 & T6. The three phase inverter is basically a six-step bridge inverter. A step means firing of next IGBT in the sequence thus in a cycle of 360°, firing of six IGBTs in a particular sequence forms six steps. Therefore each firing is delayed by 600 from earlier firing. It means that the IGBTs are fired at regular interval of 600 in a particular sequence to synthesize three phase voltage at the output terminals.

During this 60° interval, the commutation is ensured and possibility of short-circuiting of source due to conduction of both devices in same arm, is eliminated.

Figure 1: Three Phase Inverter
There are two modes of operation for three phase inverters
1. Three phase 180\(^\circ\) mode inverter
2. Three phase 120\(^\circ\) mode inverter
In 180\(^\circ\) mode of inverter, each IGBT conducts for 180\(^\circ\), and the IGBTs are fired at regular interval of 60\(^\circ\) in a sequence.
In 120\(^\circ\) mode, each IGBT conducts for 120\(^\circ\) and the IGBTs are fired at regular interval of 60\(^\circ\) in a sequence.

Pulse Width Modulation (PWM) Techniques
The harmonic content in the output ac voltage of the inverter can be reduced by pulse width modulation (PWM). The most commonly used PWM techniques are:
1. Signal Pulse Modulation
2. Multiple Pulse Modulation
3. Sinusoidal Pulse Modulation
4. Phase Displacement Control

Sinusoidal Pulse Width Modulation (SPWM) Technique
In this modulation technique several pulses per half cycle are used just similar to multiple pulse modulation, the pulse width is not equal for all the pulses.
The pulse width is a sinusoidal function of the angular position of the pulse in a cycle as shown in figure below.

Figure 2: Sinusoidal Pulse Width Modulation

A low-frequency sinusoidal modulating signal is compared with a high frequency triangular signal, which is called the carrier signal. The switching state is changed when the sine waveform intersects the triangular waveform. The gating signals for turning on the IGBTs are generated by comparing a high frequency career signal \(V_c\) with a sinusoidal reference signal \(V_r\) of desired frequency. The trigger pulse is generated at the intersection point of \(V_c\) and \(V_r\). The IGBT is maintained on during the interval when \(V_r > V_c\).
In fact, the comparison of \(V_c\) and \(V_r\) is carried out in comparator and when \(V_r > V_c\), the comparator output is high, otherwise it is low. By controlling the modulation index \(M = \frac{V_r}{V_c}\), the harmonic content in the output voltage is control.

III. SIMULATION:
In this Simulation we have simulated a three phase inverter by using SPWM technique. In this technique we have used SPWM for giving gate pulses to the IGBTs of the inverter. The load used for this simulation is R-L Load

![Figure 3: Simulation of three phase inverter with SPWM](image)

The various parameters of this simulation are given in following table.

<table>
<thead>
<tr>
<th>Table 1: Simulation Parameters</th>
</tr>
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<tbody>
<tr>
<td><strong>Input DC Voltage</strong></td>
</tr>
<tr>
<td><strong>Fundamental Frequency</strong></td>
</tr>
<tr>
<td><strong>Carrier Frequency</strong></td>
</tr>
<tr>
<td><strong>Load Active Power P (W)</strong></td>
</tr>
<tr>
<td><strong>Inductive Reactive power (var)</strong></td>
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</tbody>
</table>
IV. RESULT AND CONCLUSION

The simulation of three phase inverter has been done by SPWM technique successfully and the output waveform of voltage and current has obtained which is nearly equal to the sinusoidal waveform. Also the THD (voltage) has been calculated on fundamental frequency.

V. REFERENCE


4. Industrial and Power Electronics by Deodatta Shingare.