THD Analysis of Three Phase SPWM Inverter

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Abstract: This paper offers the simulation of three phase inverter in MATLAB/Simulink using Sinusoidal Pulse Width Modulation scheme. The generated triangular carrier wave is compared with the sine wave which is kept at reference. The modulation index is varied from 0.5 to 1 by changing the amplitude of the modulating signal. In SPWM technique, the amplitude is constant but the duty cycle is varied a width of the pulse also differed for each period. The width of the pulses is modulated to provide triggering signals to the semiconductor switches (IGBTs) connected in the inverter. In this way of output voltage is accurate controlled and THD also reduced and also increase the efficiency of the inverter. This type of control strategies is mostly used in industrial motor controlling scheme.

Keywords: MATLAB/Simulink, Three phase inverter, SPWM, Modulation index.

I. INTRODUCTION

With the growth in technology, we find AC power applications at the maximum when compared with DC power, so we are in need to convert the DC power into AC power which is done with the help of inverters. The inverters are mostly used power electronics switches like MOSFET and IGBT, the inverter gate circuits are control the turn on and turn off characteristics of inverter switches and the inverter input DC voltage is fixed but not controllable, a variable inverter output voltage is obtained by varying the gain of the converter which is achieved by Pulse Width Modulation technique control. Normally the carrier waves and reference waves are compared with help of comparator the comparator output is called the gate signal of inverter circuit. The inverter gain is the ratio of AC output voltage to DC input voltage.

II. SINUSOIDAL PULSE WIDTH MODULATION (SPWM)

The Sinusoidal pulse width modulation of each pulse width are differed in proportion to the amplitude of the sine wave evaluated at the centre of the similar pulse. The triggering signals are produced by comparing a triangular carrier wave with a sinusoidal reference wave of frequency Fc and Fr respectively. The reference frequency Fr defines the inverter output frequency f, and its peak amplitude Ac controls the Modulation Ratio (Ac/Ac) and the Vc is rms output voltage. A high frequency carrier wave Vc is compared to a reference signal Vr taking the desired frequency through a comparator. When the sinusoidal wave has a higher magnitude, output is high otherwise it is low. The comparator output is processed in a gate pulse generator in such a way that the output voltage wave has a pulse width in agreement with comparator pulse width. The inverter switching gate pulses are two type switching schemes are Unipolar and Bipolar voltage switching. In unipolar control mode the triangular carrier wave is either in the upper or lower polarity range of changes and the SPWM wave lies only in the polar Range. Bipolar control mode the triangular
carrier wave lies in continuous range between both upper and lower polarity and SPWM wave lies between upper and lower changes.

Fig 1. a) Unipolar switching

Fig 1. b) Bipolar switching

III. THREE PHASE INVERTERS

Mostly the three phase inverters are used industrial applications because variable frequency operations. Sinusoidal pulse width modulations are used to control the three phase inverter. 120 mode the carrier wave is compare to three sinusoidal reference waves.

The inverter dc voltage $V_{dc}$ is fixed and it has three phase leg each legs are consisting pare of IGBTs. The inverter IGBTs are controlled by using of SPWM techniques the SPWM of sinusoidal wave determine the inverter fundamental frequency and the triangular wave is desired the inverter switching frequency the each switches conducts 180 degrees. When T3 is ON condition R is connected to upper terminal of DC supply voltage. When T6 is ON condition R is connected to the lower terminal of input voltage. The each mode operate 60 degrees totally six mode of operations in inverter. The line and phase output voltage are measured across the RL load. And the Simulink model are show in figure 3.

The inverter DC input voltage is kept 415V and the load resistor, inductor values are chosen to be 2.2 ohm and 6.5 mH.

Fig 3. Three phase inverter simulation circuit

the three phase inverter gate pulses are shown in Figure 4a,b,c. The carrier wave frequency is kept 1000 Hz whereas for reference sine wave, it is 50 Hz.
Fig 4. a) Gate pulses for T1

Fig 4. b) Gate pulses for T3

Fig 4. c) Gate pulses for T5

For T5, T1 and T3, the gate signals are just the inverse of T2, T6 and T4 respectively. This is done by adding a NOT gate after each comparator and then the resultant signal is given to the remaining three switches.

Fig 5. Inverter output waveform

IV. TOTAL HARMONIC DISTORTION ANALYSIS

Total Harmonic Distortion values are analyzed with help of FFT analysis by varying the modulation index from 0.5 to 1.
<table>
<thead>
<tr>
<th>S.NO</th>
<th>MODULATION INDEX</th>
<th>THD(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.5</td>
<td>130.25</td>
</tr>
<tr>
<td>2.</td>
<td>0.6</td>
<td>119.17</td>
</tr>
<tr>
<td>3.</td>
<td>0.75</td>
<td>100.10</td>
</tr>
<tr>
<td>4.</td>
<td>0.8</td>
<td>96.82</td>
</tr>
<tr>
<td>5.</td>
<td>0.95</td>
<td>80.21</td>
</tr>
<tr>
<td>6.</td>
<td>1.0</td>
<td>71.77</td>
</tr>
</tbody>
</table>

Table 1: harmonics analysis

V. CONCLUSION

The three phase inverter with sinusoidal pulse width modulation simulation work is done help of MATLAB/Simulink. The THD (total harmonic distortion) values are calculated for different modulation index from 0.5 to 1.0. The above results are show the reducing harmonic content values. Commonly the sinusoidal pulse width modulation techniques are used to provide the gate signal to switches in three phase inverter.

VI. REFERENCES


