Cascaded Hybrid Seven Level Inverter with Different Modulation Techniques for Asynchronous Motor

Ankur Chourasiya, Poonam Chouksey, Nayna Bhargava, S. P. Phulambrikar

Abstract- This paper presents a symmetric cascaded hybrid 7 level multilevel inverter using different switching techniques i.e. phase disposition pulse width modulation, degree modulated pulse generator and hybrid mixed switching technique. This paper presents comparison between motor output and THD of Asymmetrical Cascaded hybrid 7 level Multilevel Inverter (MLI) using different modulation techniques. These control schemes is applied to 7 level Asymmetrical Cascaded hybrid Multilevel Inverter (CHMLI). Different topologies of multilevel inverter have been reported in the literature, but this work mainly focuses on the asymmetrical cascaded hybrid multilevel inverter circuit with reduced number of switches and input DC sources. THD and motor output are analyzed in FFT window. The results are observed by MATLAB/SIMULINK software.

keywords- Asymmetrical CHMLI, Mixed switching, Degree modulated pulse generator , PDPWM.

1. INTRODUCTION

Inverter is a device that converts electrical power from DC to AC form using electronic circuits. Generally simple inverter gives 2 or 3 level output voltage. The inverters with number of voltage level equal to three or above that are known as multilevel inverter. MLI are capable of producing high power high voltage as the unequal voltage sources of of MLI allows to reach high voltage wiyh low harmonics without the use of transformer.MLI is a latest alternative to implement low frequency based inverter with low output voltage distortion. Basic Multilevel topologies are of 3 types shown in below:

- Diode clamped inverter
- Flying capacitor inverter
- Cascaded

Figure 1.1 Multilevel inverter topologies

2. CASCADED H-BRIDGE MLI

Cascaded H-Bridge (CHB) configuration has recently become very popular in high-power AC supplies and adjustable-speed drive applications. A cascade multilevel inverter consists of a series of H-bridge (single-phase full bridge) inverter units in each of its three phases. Each H-bridge unit has its personal dc source, which for an induction motor would be a battery unit, fuel cell or solar cell. Each SDC (separate D.C. source) is associated with a single-phase full-bridge inverter. The ac terminal voltage of different level inverters is connected in series. Through different combinations of the four switches, S1,S2,S3 & S4, each converter level can generate three different voltage outputs, \( +V_{dc}, -V_{dc} \) and zero. The AC outputs of different full-bridge converters in the same phase are connected in series such that the synthesized voltage waveform is the sum of the individual converter outputs, Note that the number of output-phase voltage levels is defined in different way from those of the two previous converters (i.e. flying capacitor and diode clamped). In
these topologies the number of output-phase voltage levels is defined by $m=2N+1$, where $N$ is the number of DC sources.

A seven-level cascaded converter, for example, consists of three DC sources and three full bridge converters. Minimum harmonic distortion can be obtained by controlling the conducting angles at different converters levels. Each H-bridge unit generates a quasi-square waveform by phase shifting its positive and negative phase legs’ switching timings. Every switching device always conduct for 180° or half cycle regardless of the pulse width of a quasi-square wave. These switching methods make all of the switching devices current stress equal. In the motoring mode a power flows from the batteries through the cascade inverter to the motor.

In the charging mode, the cascade converters act as rectifiers, and power flows from the charger (ac source) to the batteries. The cascade converters can also act as rectifiers to help recover the kinetic energy of the vehicle if regenerative braking is used. The cascade inverter can also be used in parallel HEV configurations. This new converter can avoid extra clamping diodes or voltage balancing capacitors.

The combination of the 180° conducting method and the pattern-swapping scheme make the cascade inverter’s voltage and current stresses the same and battery voltage balanced.

Figure 2.4 shows the basic block of cascade H-bridge Multi-level inverter and its associated switching instants. As shown it consists of a DC source and. The switching states for four power devices are constant i.e., When S1 is on, S2 cannot be on and vice versa, similarly with S3 or S4.

### 3.1 H-BRIDGE MLI USING HYBRID MIXED SWITCHING SCHEME

Seven level hybrid cascaded multilevel inverter with a mixed pulse width modulation method is designed by reducing a number of switches.

A simulation diagram using a mixed switching scheme of Seven-level HMLI with asynchronous motor are shown in a figure 3.1 using MATLAB/SIMULINK.

![Figure 3.1 Seven-level HMLI using hybrid mixed switching scheme simulation diagram with asynchronous motor](image)

The simulation block diagram has seven level cascaded hybrid multilevel inverter with asynchronous motor is...
shown in Fig-3.1 These are combination two types inverter: first one is H-bridge inverter and other is two conventional inverter. The conventional inverter is acting as the main inverter and H bridge inverter is acting as the auxiliary inverter.

### 3.1.1 HYBRID MIXED SWITCHING SCHEME

Table:5.1. Pulse Generation Formula in seven level HMLI.

<table>
<thead>
<tr>
<th>Sn</th>
<th>Hybrid PWM mixing operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>A1</td>
</tr>
<tr>
<td>S2</td>
<td>A1</td>
</tr>
<tr>
<td>S3</td>
<td>A3</td>
</tr>
<tr>
<td>S4</td>
<td>A3</td>
</tr>
<tr>
<td>S6</td>
<td>PWM*{(A2<em>A1)+(A2</em>A1)}</td>
</tr>
<tr>
<td>S5</td>
<td>PWM+{(A2<em>A1)+(A2</em>A1)}</td>
</tr>
<tr>
<td>S6</td>
<td>PWM*{(A2<em>A1)+(A2</em>A1)}</td>
</tr>
<tr>
<td>S6</td>
<td>PWM+{(A2<em>A1)+(A2</em>A1)}</td>
</tr>
</tbody>
</table>

These pulses are given for eight switches. Two conventional inverter has a S1, S2, S3, S4 and H-bridge inverter has four pulse S6, S5, S6, S6. By using these modulation technique to have controlled seven level output voltage Then seven level output voltage of Hybrid multilevel inverter is produce in asynchronous motor drives & parameters of the motor are analysis in a output figure 4.2.

### 3.2. H-BRIDGE MLI USING DEGREE MODULATED PULSE GENERATOR (DMPG) SWITCHING SCHEME

In seven levels H bridge MLI total eight switches and two batteries are uses to control the output voltage. IN multilevel inverter with unequal voltage sources are utilize to generate same number of voltage level per phase. The MLI consist of full bridge cell for maximum voltage and half bridge cell for intermediate voltage. When MLI fed an induction motor drive system, to reduce harmonics losses and saving energy. In topology we have generated 7 level voltage as 0V, 100V, 200V and 300V.

A simulation diagram using degree modulated pulse generator (DMPG) switching scheme of Seven-level HMLI with asynchronous motor are shown in a figure 3.2 using MATLAB/SIMULINK.

Figure-3.2.1 Using degree modulated pulse generator (DMPG) switching scheme of Seven-level HMLI with asynchronous motor
3.2.1 DEGREE MODULATED PULSE GENERATOR (DMPG) SWITCHING SCHEME

The switching technique here used is degree modulated pulse generated to identification and reference angle generation. We have generated a switching pulse to obtain staircase output voltage which resembles nearly equal to sine wave. For different switching angles the power circuit behaves defiantly producing different waveform. To obtain equal step firing a 7 level output is divided into equal segment.

3.3 H-BRIDGE MLI USING PHASE DISPOSITION (PD) PWM SWITCHING SCHEME.

The simulation circuit for asymmetric cascaded 7 level with induction motor is shown in fig 3.3.1 CHMLI 7 level has two unequal magnitude DC sources and 8 power switches are used.

A simulation diagram using phase disposition (PD) PWM switching scheme of Seven-level HMLI with asynchronous motor are shown in a figure 3.3 using MATLAB/SIMULINK.
4. SIMULATION RESULTS

Figure 4.1: Output voltage waveform for Seven-level HMLI using hybrid mixed switching scheme

Show the above figure-4.1 MATLAB simulation result for a seven level inverter with hybrid mixed switching scheme. Multilevel carrier based pulse width modulation methods are used in these inverter topologies.

Figure 4.2: FFT analysis for Seven-level HMLI using hybrid mixed switching scheme

Figure 4.3: Motor output of seven-level HMLI using hybrid mixed switching scheme

Figure 4.4: Output voltage of Seven-level HMLI using degree modulated pulse generator (DMPG) switching scheme

Show the above figure MATLAB simulation result for a seven level inverter with equal step firing using degree modulation switching scheme.
Figure 4.5 FFT analysis for Seven-level HMLI using degree modulated pulse generator (DMPG) switching scheme

Figure 4.6: Motor output of seven-level HMLI using degree modulated pulse generator (DMPG) switching scheme

Figure 4.7 Output voltage waveform for Seven-level HMLI using phase disposition (PD) PWM switching scheme

The output voltage waveform of 7 level CHMLI with capacitor start run motor induction motor is shown in fig 4.7

Figure 4.8 FFT analysis for Seven-level HMLI using phase disposition (PD) PWM switching scheme
Figure 4.9: Motor output of seven-level HMLI using phase disposition (PD) PWM switching scheme

Table no. 3: Steady state value for Induction Motor

<table>
<thead>
<tr>
<th>HMLI using switching scheme</th>
<th>Time to reached Steady state value of Main winding current (sec)</th>
<th>Time to reached Steady state value of Rotor Speed (sec)</th>
<th>Time to reached Steady state value of Electromagnetic Torque (sec)</th>
<th>THD</th>
</tr>
</thead>
<tbody>
<tr>
<td>mixed switching</td>
<td>0.25 sec</td>
<td>0.25 sec</td>
<td>0.25 sec</td>
<td>11.53%</td>
</tr>
<tr>
<td>degree modulated</td>
<td>0.2 sec.</td>
<td>0.25 sec</td>
<td>0.2 sec</td>
<td>22.89%</td>
</tr>
<tr>
<td>phase disposition</td>
<td>0.2 sec.</td>
<td>0.2 sec.</td>
<td>0.2 sec</td>
<td>9.76%</td>
</tr>
</tbody>
</table>

Table no. 4: Variation of Induction Motor Parameters

<table>
<thead>
<tr>
<th>HMLI using switching scheme</th>
<th>Main winding current (Amp)</th>
<th>Rotor speed (rad/sec)</th>
<th>Electromagnetic Torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mixed switching</td>
<td>6.5</td>
<td>151</td>
<td>3.8</td>
</tr>
<tr>
<td>degree modulated</td>
<td>9.2</td>
<td>151</td>
<td>6.8</td>
</tr>
<tr>
<td>phase disposition</td>
<td>6.7</td>
<td>157</td>
<td>4.7</td>
</tr>
</tbody>
</table>

All simulation results are shown in above table no. 3 and table no. 4 respectively.

5. CONCLUSION

The paper deals with a comparison of cascaded 7 level multilevel inverters for Asynchronous motor using different modulation techniques i.e. phase disposition pulse width modulation, degree modulated pulse generator and hybrid mixed switching technique. Indeed, asymmetrical 7 level multilevel inverter have been compared in order to find an optimum motor speed, torque and main winding current with lower switching losses, Total harmonic distortion and optimized output voltage quality. The asymmetric cascaded 7 level inverter gives optimum motor output and reduced THD using pulse width modulation technique. The steady state condition of motor output has reached earlier in case of asymmetrical cascaded 7 level inverter using pulse width modulation (phase disposition) as compared to other two techniques.

6. REFERENCES


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