Simulation and Performance Analysis of Multi Source Inverter Topology for Renewable Energy Systems

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Abstract—For efficient energy conversion, multilevel inverters are playing a vital role in the micro-grid systems. In order to realize such multi level inverters, various topologies have been proposed based on their place of usage. Particularly in solar connected micro-grid systems multi level inverters are playing more importance. In this paper simulation of a novel multi source topology is discussed and its performance is evaluated. The model is developed in MATLAB Simulink and its performance is analyzed.

Keywords—Multilevel inverter, Renewable energy systems, seven level, inverter topology

I. INTRODUCTION

In medium voltage drives control, reactive power compensation and solar connected micro-grid systems multilevel inverters provides a stair case voltage waveform in order to reduce the stress on the power electronic switches as well as reducing the harmonic content in the output voltage [1-3]. In order to realize these multilevel inverters a variety of topologies have been proposed [4-9]. As the traditional topologies use more number of switching devices, new topologies are evolving. In particular for renewable energy source systems cascaded topology is preferable because of requirement of number of sources. The multi source topology requires less number of switching devices than cascaded topology [10]. As the balancing of voltage is a problem, the capacitor clamped topology is not advisable for renewable energy systems. Diode clamped topology requires more number of switches whose control circuit design is very complex.

II. MULTI SOURCE TOPOLOGY

The multi source topology for the realization of seven level inverter is shown in the figure 1. The multi source topology also requires more number of sources of less magnitude which is more suitable for renewable energy system applications in particular with solar connected micro grid systems.

To achieve maximum output voltage at the load all the three sources are to be added in series using suitable switches. In this circuit switches \(S_1, S_3, S_5, S_7\) and \(S_{10}\) should be turned ON to obtain 3V at the output in one direction which is shown in figure 2.
The output voltage is 2V by switching ON S_3, S_5, S_2, S_7 and S_10 which is shown in figure 3. Hence the bottom source and the middle sources are added together where as the top is disconnected.

![Figure 3 Equivalent circuit for obtaining 2V output.](image1)

In order to get the output voltage as V the switches S_5, S_4, S_2, S_7 and S_10 must be in ON state and the other switches must be turned OFF. Only the bottom source is supplying the load and the other sources are disconnected which is shown in the figure 4.

![Figure 4 Equivalent circuit for obtaining V output.](image2)

The load voltage will be zero when the the switches S_6, S_4, S_2, S_7 and S_10 are conducting. All the sources are disconnected from the load as shown in the figure 5. The load voltage is reversed by switchinf S_7 and S_10 OFF and switching ON S_8 and S_9.

![Figure 5 Equivalent circuit for obtaining zero output.](image3)

When the switches S_5, S_4, S_2, S_9 and S_8 are turened ON as shown in the figure 6, then the output voltage will become –V.

![Figure 6 Equivalent circuit for obtaining -V output.](image4)
The switches S₅, S₃, S₂, S₉ and S₁₀ must be turned ON to provide an output voltage of -2V. The bottom and middle sources are added together to supply the load and to provide it in opposite direction switches S₈ and S₉ are used which is represented as shown in figure 7.

The output voltage is 3V by turning ON the switches S₁, S₃, S₅, S₈ and S₉ which is shown in figure 8. In this state all the three sources are added in series to provide output voltage as 3V. The switching table is given below.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>SWITCHING TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3V</td>
</tr>
<tr>
<td>S₁</td>
<td>1</td>
</tr>
<tr>
<td>S₂</td>
<td>0</td>
</tr>
<tr>
<td>S₃</td>
<td>1</td>
</tr>
<tr>
<td>S₄</td>
<td>0</td>
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<tr>
<td>S₅</td>
<td>1</td>
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</tr>
<tr>
<td>S₇</td>
<td>1</td>
</tr>
<tr>
<td>S₈</td>
<td>0</td>
</tr>
<tr>
<td>S₉</td>
<td>0</td>
</tr>
<tr>
<td>S₁₀</td>
<td>1</td>
</tr>
</tbody>
</table>

The control signals for the operation of the converter for single phase are shown in figure 9. It requires a total number of 30 switching devices for its three phase realization.
III. RESULTS

The circuit is modelled in MATLAB Simulink environment. The waveform of phase voltages are shown in figures 10. The harmonic distortion of the phase voltage is given in figures 11.

![Figure 10 Phase voltage of seven-level inverter.](image1)

![Figure 11 Line voltage of five-level inverter.](image2)

It is observed that the switches S1-S2, S3-S4, S5-S6, S7-S8, S9-S10 pairs are complementary to each other. The switches S1-S2, S3-S4, S5-S6 has to conduct in both positive and negative half cycle of the output voltage, where as S7-S8 and S9-S10 has to conduct for only one positive half cycle.

IV. CONCLUSION

The simulation of multi source topology is discussed in this paper which is preferable for renewable energy system. From the results it is observed that, the total harmonic distortion in the output voltage is present because of only lower order harmonics in particular the third harmonic. The higher order harmonics are having less effect on the output voltage.

REFERENCES


