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Modeling and Simulation of a Novel Three-phase Multilevel Inverter with Induction Motor Drive

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Abstract- This paper proposes asymmetrical three-phase multi string nine-level inverter for various distributed energy resources DERs application. The simplified multi level inverter requires only eight switches which reduces number of power devices and passive components, and control circuitry when compared to conventional cascaded H-bridge CCHB multilevel inverter. The proposed topology has advantages like smaller filter size, and lower electromagnetic interference. Output harmonics are also reduced and hence total harmonic distortion is reduced. The proposed topology is implemented to Induction Motor Drive. The result of the proposed system was obtained through Matlab/Simulink software.

Index Terms- Multilevel inverter, distributed energy resources**.**

1. INTRODUCTION

The ever-increasing energy consumption, fossil fuels soaring costs and exhaustible nature, and worsening global environment have created a booming interest in the development of environmentally friendly distributed energy resources(DERs).some of the DERs are photovoltaic (PV), wind power, micro turbines, and fuel cells. For delivering premium electric power in terms of high efficiency, reliability, and power quality, integrating interface converters of DERs into the micro grid system has become a critical issue. DERs usually supply a dc voltage that varies in a wide range according to various load conditions. Thus, a dc/ac power processing interface is required.

Since past decade, multilevel inverters have drawn increasing attention because of their promising applications in power systems and industrial drives. They can be efficiently used in the distributed energy systems in which, output ac voltage is obtained by connecting dc sources at input side of the inverters.

The multilevel inverters offer several advantages like nearly sinusoidal output-voltage waveforms, output current with better harmonic profile, less stressing of electronic components owing to decreased voltages, switching losses that are lower than those of conventional two-level inverters, a smaller filter size, and lower EMI, all of which make them cheaper, lighter, and more compact.

Various topologies for multilevel inverters have been proposed over the years. Common ones are diode-clamped, flying capacitor, cascaded H-bridge. Among these three, cascaded H-bridge has a modular structure and requires least number of components as compared to other two topologies, and as a result, it is widely used for many applications in electrical engineering.

2. PROPOSED TOPOLOGY

Three phase multi string nine-level inverter is proposed for dc/ac power conversion. The newly constructed inverter topology offer strong advantages such as improved output waveforms, smaller filter size, and lower EMI and total harmonics distortion (THD). The proposed three-phase nine-level inverter was developed from the basic single phase five-level inverter and single phase nine-level inverter.

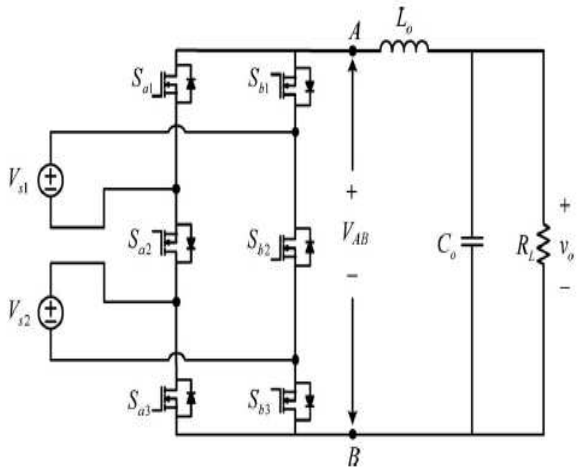

Fig. 1 Basic five-level inverter

The basic single-phase five level inverter topology used in this study is shown in Figure. 1. and the switching function of the switch is defined as follows

$$Saj = 1, Saj\ ON$$
$$Saj = 0, Saj\ OFF$$
$$Sbj = 1, Sbj\ ON$$
$$Sbj = 0, Sbj\ OFF$$

Where j = 1, 2, 3

The five output voltage levels of the multi level inverter stage are described below.
1) When switches *Sa*2, *Sb*1, and *Sb*3 are ON then output voltage is Vs1+Vs2. If Vs1=Vs2=Vs then voltage is 2Vs.
2) When switches *Sa*2, *Sb*1, and *Sa*3 are ON then output voltage is Vs1 or switches *Sa*2, Sa1, and *Sb*3 are ON then output voltage is Vs2. If Vs1=Vs2=Vs then voltage is Vs in each switching combination.
3) When the left or right switching leg is ON, output voltage is 0.
4) When switches *Sa*1, *Sb*2, and *Sb*3 are ON then output voltage is −Vs1 or when switches *Sa*3, *Sb*1, and *Sb*2 are ON then output voltage is –Vs2. If Vs1=Vs2=Vs then voltage is –Vs in each switching combination.
5) When switches *Sa*1, Sa3, and *Sb*2 are ON, then output voltage is – (Vs1+Vs2). If Vs1=Vs2=Vs then voltage is −2Vs.

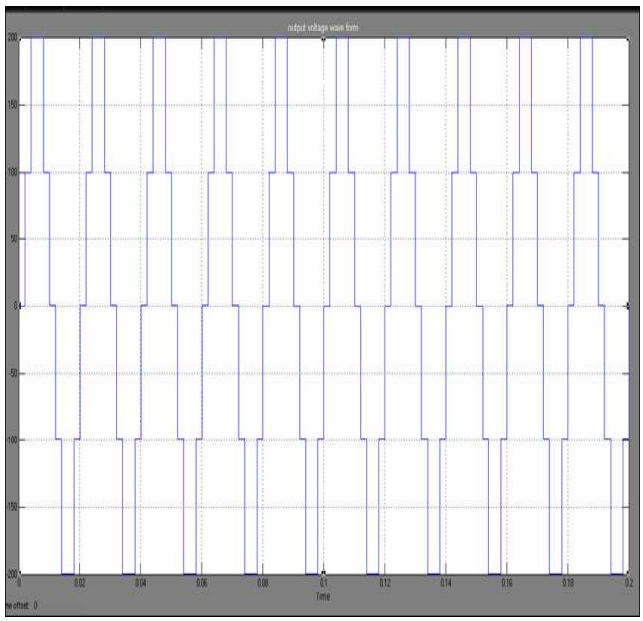

Fig. 3 Output voltage waveform of five level inverter.

3. MATLAB/SIMULINK MODEL & SIMULATION RESULTS

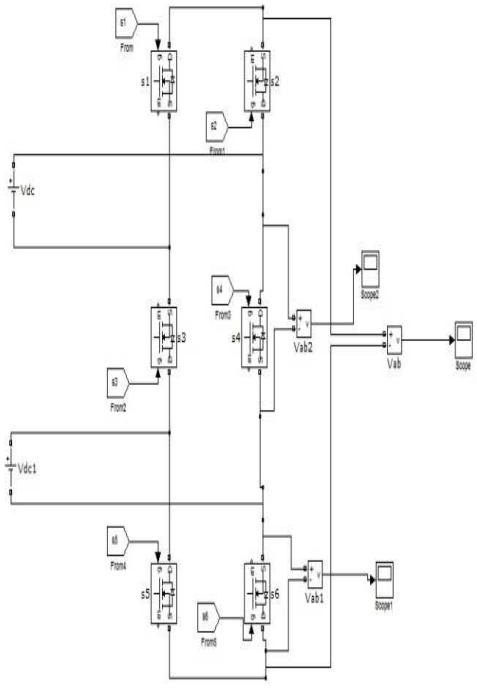

Fig. 2 Simulation circuit of Five Level Inverter

The basic 5 level simulation circuit, Figure 2 is an inverter with combination six switches. Based on the selection of switches in the circuit output voltage is obtained. Figure 3 shows the five level output voltage of multi string inverter.

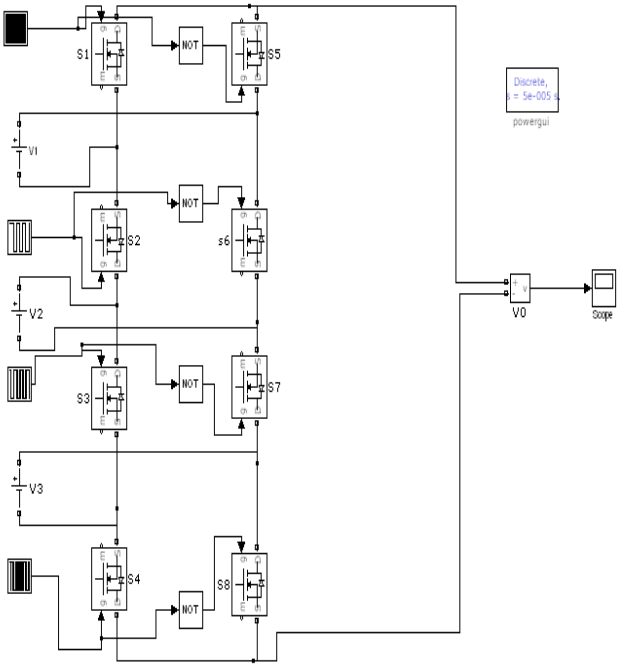

Fig. 4 Simulation circuit of nine level inverter

Figure 4 shows the Matlab/Simulink Model of Nine Level Multistring Inverter with constant DC Sources and Figure 5 shows the nine level output voltage of multi string based nine level inverter, whenever more levels we get pure sinusoidal nature voltage, less harmonics.

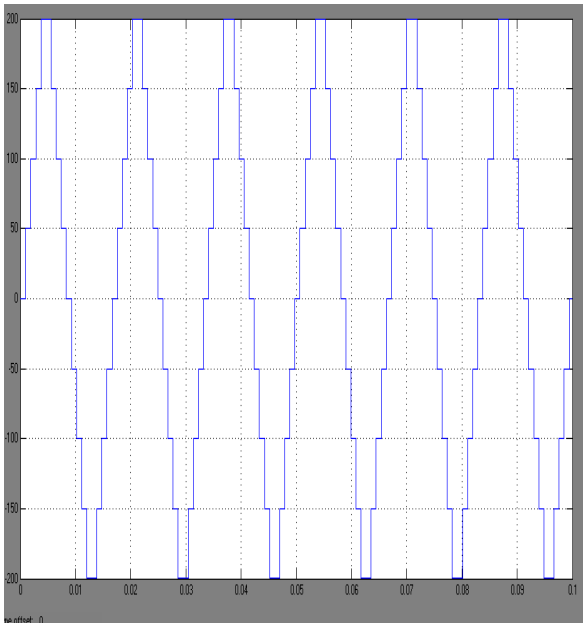

Fig. 5 Output voltage waveform of nine level inverter

Figure 6 shows the Matlab/Simulink Model of Three Phase Multistring based Multilevel Inverter with R-load. Figure 7, shows the three phase output voltage of three phase multi string Nine level inverter.

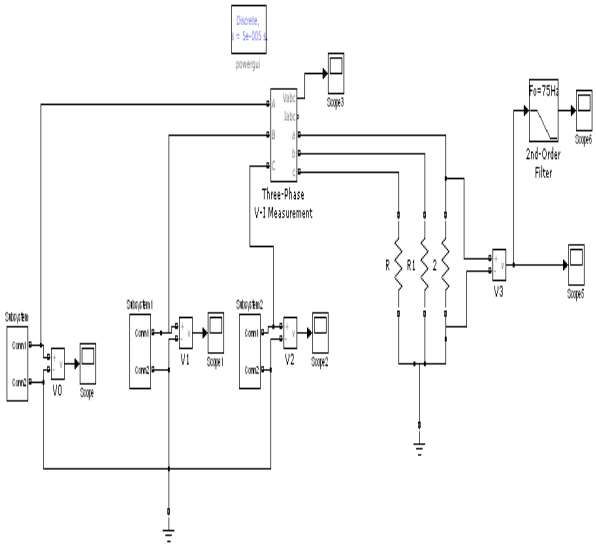

Fig. 6 Matlab/Simulink Model of Three Phase nine level Inverter

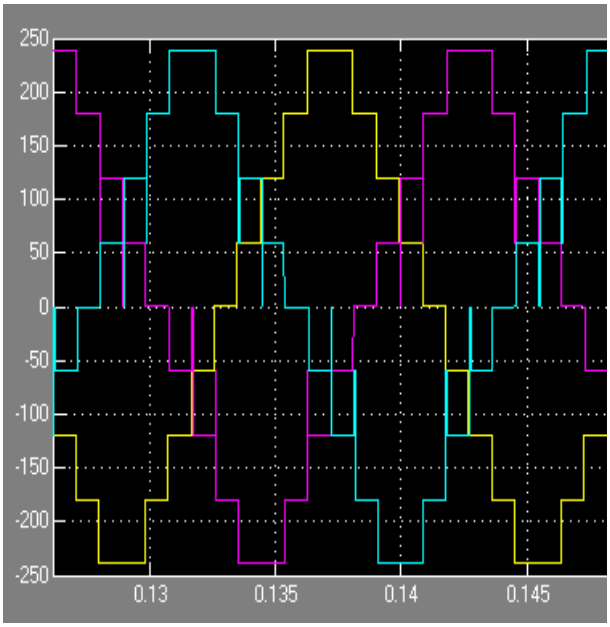

Fig. 7 Three phase voltage of nine level inverter

Figure 8 shows THD Analysis of Multistring Based Nine Level Output Voltage, without filter configuration we get THD is 13.84%.
Figure 9 shows THD Analysis of Multistring Based Nine Level Output Voltage, with filter configuration we get THD is 2.58%.

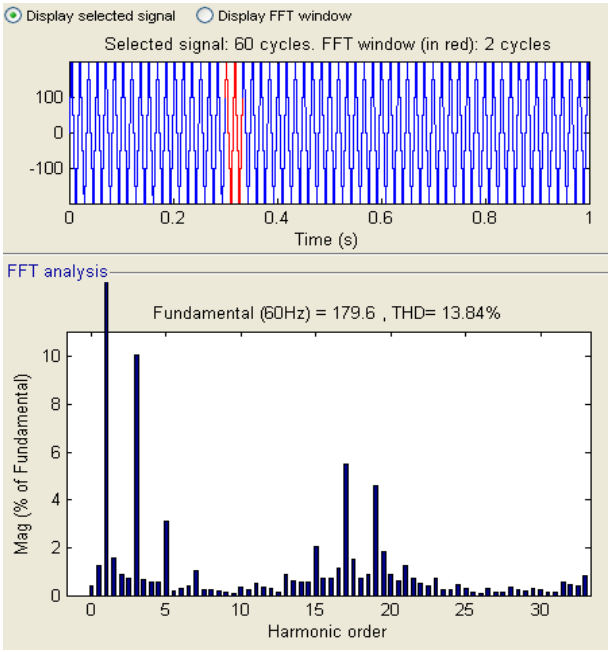

Fig. 8 THD Analysis of Nine Level Voltage without filter

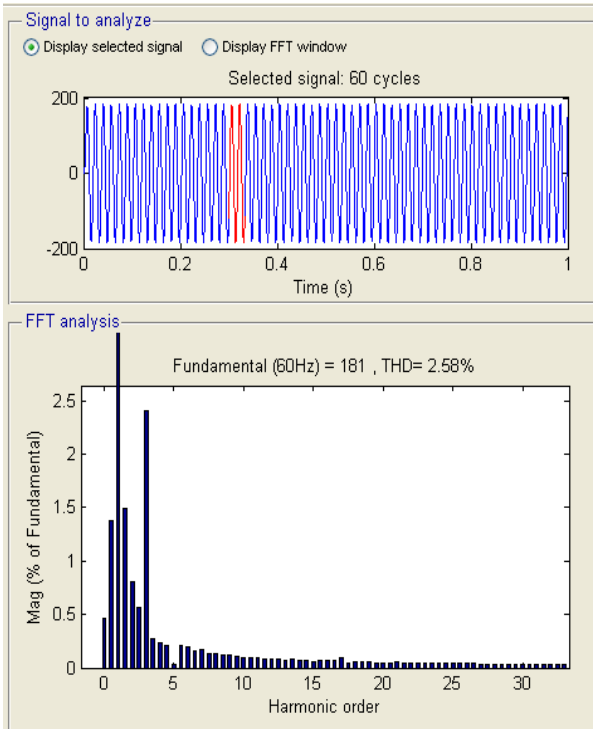

Fig. 9 THD Analysis of Nine Level Output Voltage with filter

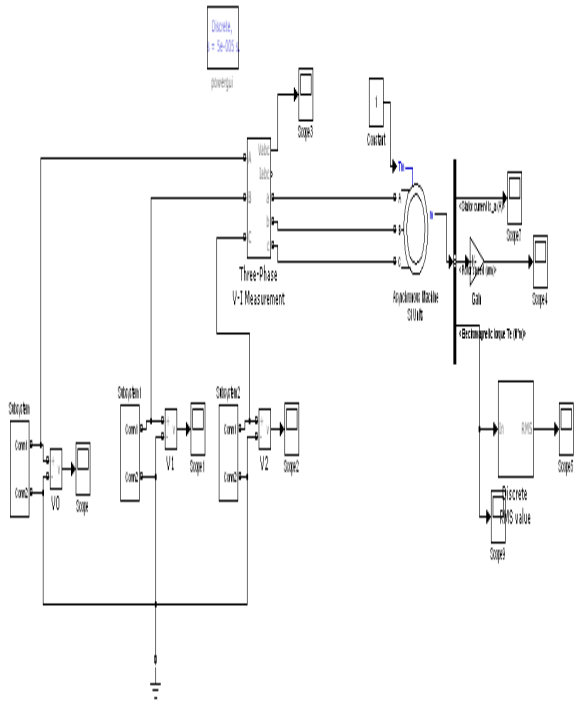

Fig. 10 Matlab/Simulink Model of three phase multi string nine level inverter with Induction motor drive

Figure 10 shows the Simulation circuit for three phase multi string nine level inverter with Induction motor drive, to check the outcome performance of the drive. Figure 11, 12, 13 shows the high performance induction motor drive characteristics Stator Current, Speed, Torque respectively.

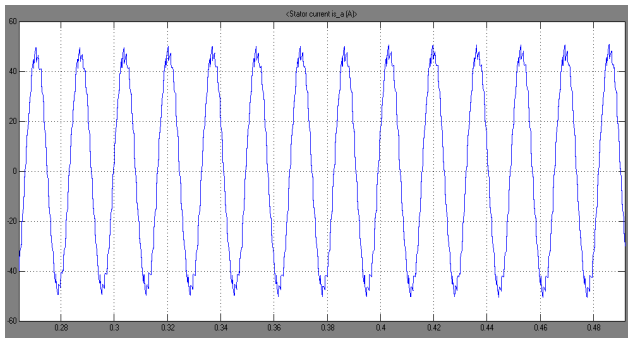

Fig. 11 Waveform of stator current output

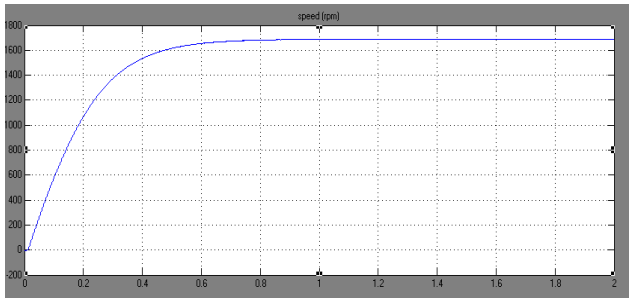

Fig. 12 Waveform of speed output

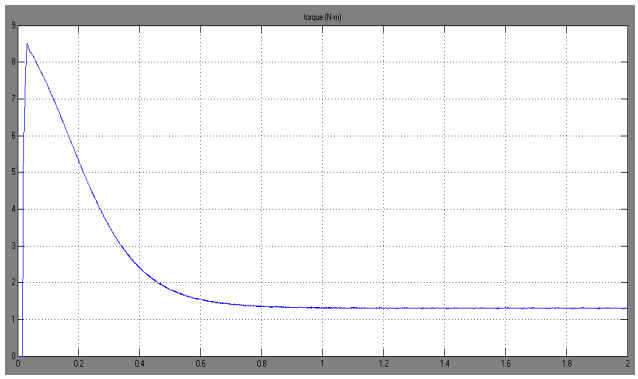

Fig. 13 Waveform of Torque Output

4. CONCLUSION

A Novel Asymmetrical three-phase nine-level inverter is proposed in this paper. The proposed converter produces more voltage levels with less number of switches which reduces the cost and complexity of the circuit. The proposed circuit is applied to Induction Motor Drive to check the performance of entire system. Simulation results are shown. THD also reduced with filter in the converter circuit.

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