Multilevel Matrix Converter Interfacing with Generator-grid in Wind Energy System

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ABSTRACT: The SIZMC and quasi-Z-source circuits, embedded in the previous reported literature the converter topologies, allow interfacing a low-voltage generator with the grid in wind energy systems. The efficiency of the proposed converters was expected to be high due to reduced number of power electronic switches. Therefore, the reconfigured topology shown here, has lesser number of harmonics through simulation results produced with the help of SIMULINK. Also, because the topology involves IGBT bidirectional switches it is fit to be used for generator action for a turbine (wind turbines).

Key words: Wind turbines, Multilevel Converters, SIMULINK/MATLAB.

1.1 INTRODUCTION TO MULTI LEVERL CONVERTERS

Multilevel power conversion was first introduced in 1975. The generalized concept involves incorporating a higher number of active semiconductor switches to perform the power conversion in small voltage steps. There are numerous advantages to this approach when compared with conventional power conversion. The term multilevel began with the three-level converter. Subsequently, several multilevel converter topologies have been developed. However, the elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform.

1.2 MULTILEVEL CONVERTERS STRUCTURES

The term multilevel converter is used to refer to a power electronic converter that may operate in an inverter or rectifier mode. The three different major multilevel converter structures have been applied in industrial applications: cascaded H-bridges converter with separate dc sources, diode clamped, and flying capacitors. The illustrated structures can be implemented for inverter structures and rectifying operation as well.

Figure 1.1 shows the general structure of the multilevel converter system. In this case, a three-phase motor load is shown on the AC side of the converter. However,

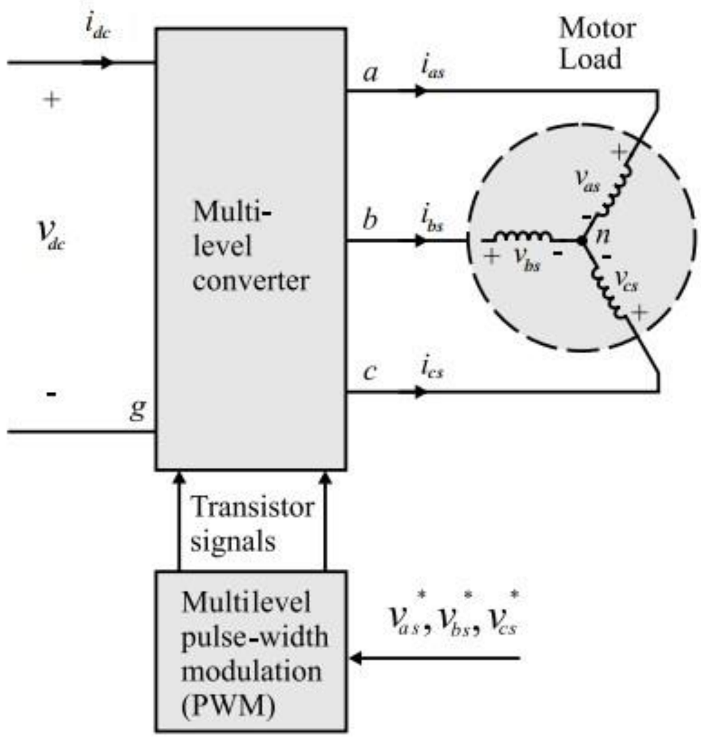


Fig. 1.1 – Multi-level Converter Structure

And may be expressed in general form as –

$$v_{as}^* = \sqrt{2}\, v_s^* \cos(\theta_c)$$

$$v_{bs}^* = \sqrt{2}\, v_s^* \cos\left(\theta_c - \frac{2\pi}{3}\right)$$

$$v_{cs}^* = \sqrt{2}\, v_s^* \cos\left(\theta_c + \frac{2\pi}{3}\right)$$

Where $v*_s$ is a voltage amplitude and θ_c is an electrical angle. To describe how the modulation is accomplished, the converter AC voltages must be defined. For convenience, a line-to-ground voltage is defined as the voltage from one of the AC points in Fig. 1.1(*a*, or *b*, or *c*) to the negative pole of the DC voltage (labelled in Fig.1.1). For example, the voltage from *a* to *g* is denoted v_{ag}

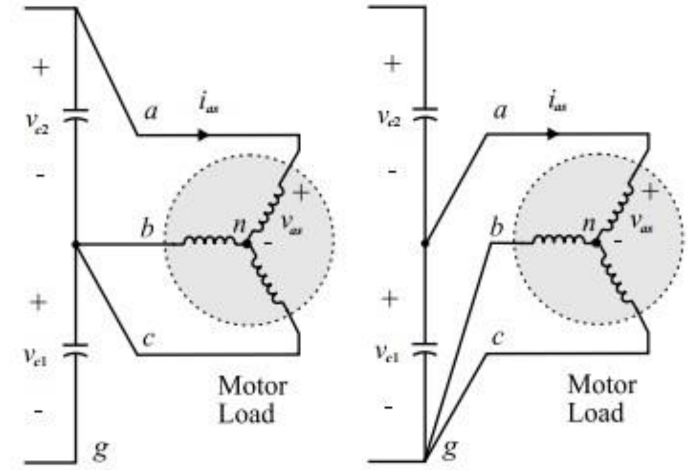


Fig. 1.2 Redundant switching state example.

Redundant switching states are states that lead to the same motor voltages, but yield different capacitor currents. As an example, consider the three-level converter redundant switching states *sw* 24 and *sw* 9 shown in Fig. 1.1. It can be shown through Eq. that either switching state will produce the same voltages on the load (assuming the capacitor voltages are nearly balanced). However, from Fig. 1.2 it can be seen that the current drawn from the capacitor bank will be different in each case. In particular, if the *a*-phase current is positive, the load will discharge the capacitor that it is connected to. In this case, the load should be connected across the capacitor with the highest voltage.

From (1.3), the magnitudes of the Fourier coefficients when normalized with respect to V_{dc} are as follows:

The conducting angles, θ_1, θ_2…….,θ_s, can be chosen such that the voltage total harmonic distortion is a minimum. Generally, these angles are chosen so that predominant lower frequency harmonics, 5th, 7th, 11th, and 13th, harmonics are eliminated. More detail on harmonic elimination techniques will be presented in the next section.

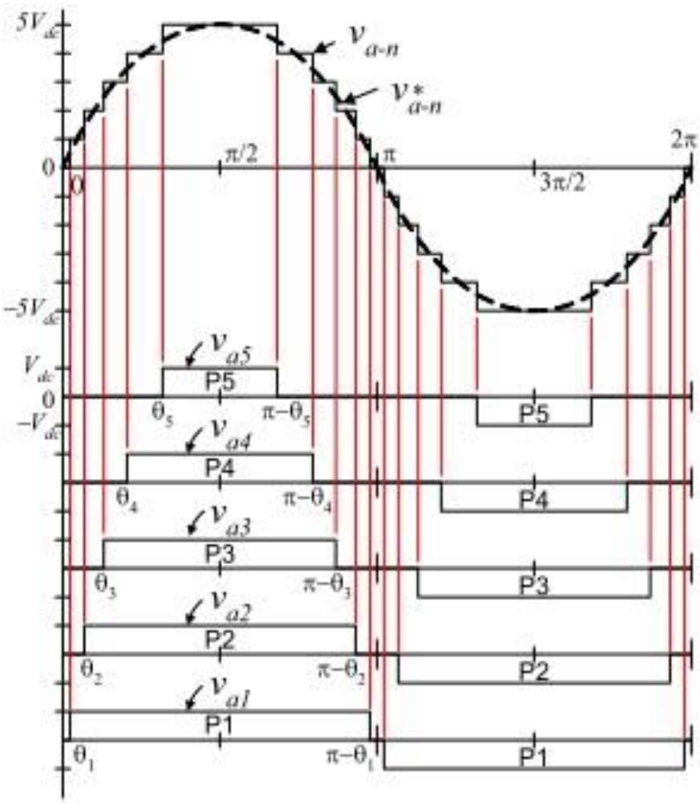


Figure 1.3. Output phase voltage waveform of an 11-level cascade inverter with 5 separate dc sources

1.3 SCHEMES FOR WIND POWER GENERATION

- **CSCFS** (Constant Speed Constant Frequency Scheme)
- **DSCFS** (Dual Speed Constant Frequency Scheme)
- **VSCFS** (Variable speed constant frequency scheme)
- **VSCF (**Variable speed constant frequency with double output)
- **VSVFS** (Variable speed variable frequency schemes)

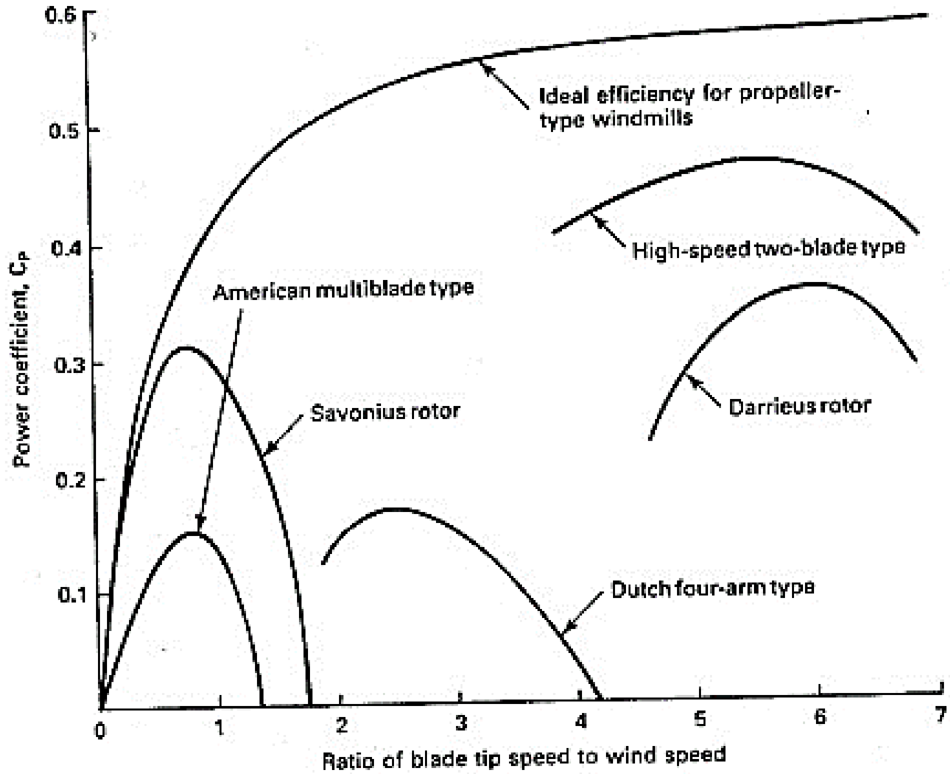


Fig. No. 1.4 Typical performance of a wind machines

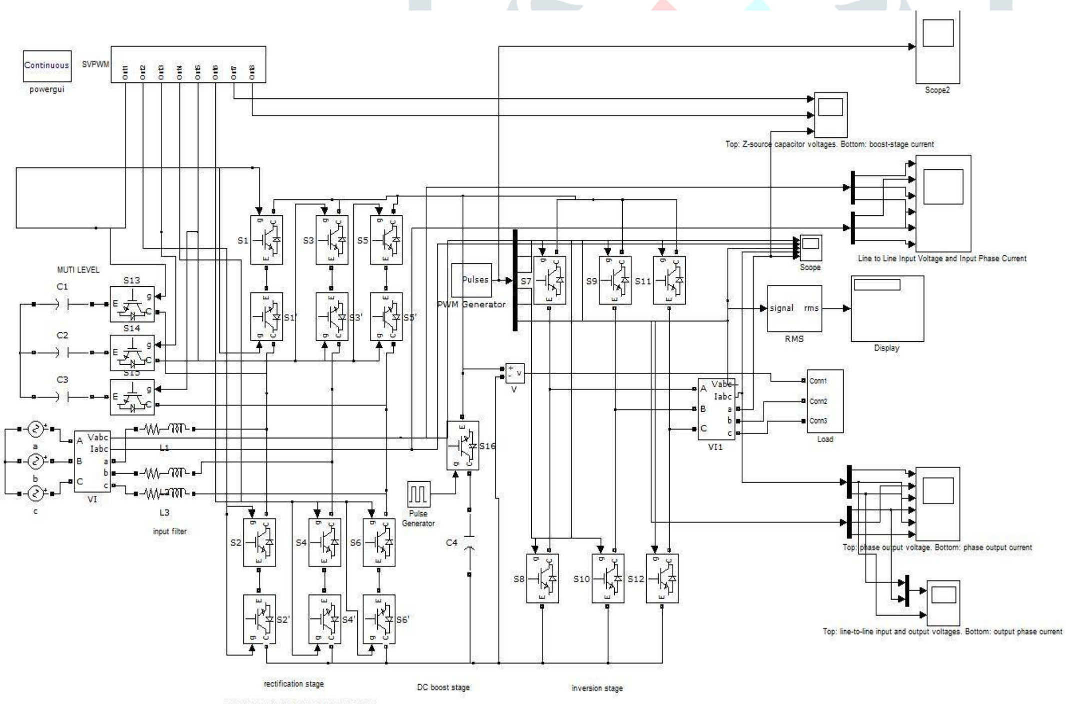


Figure. 1.5- SIMULINK MODEL OF THE PROPOSED MODEL

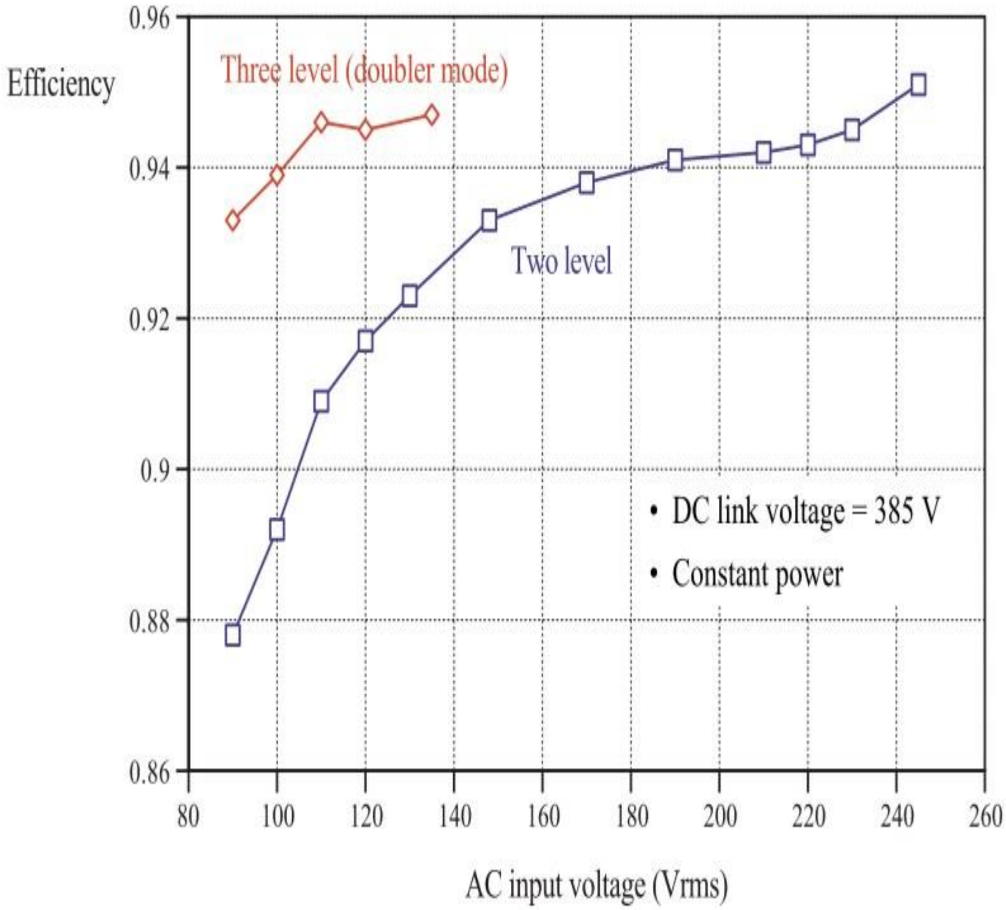
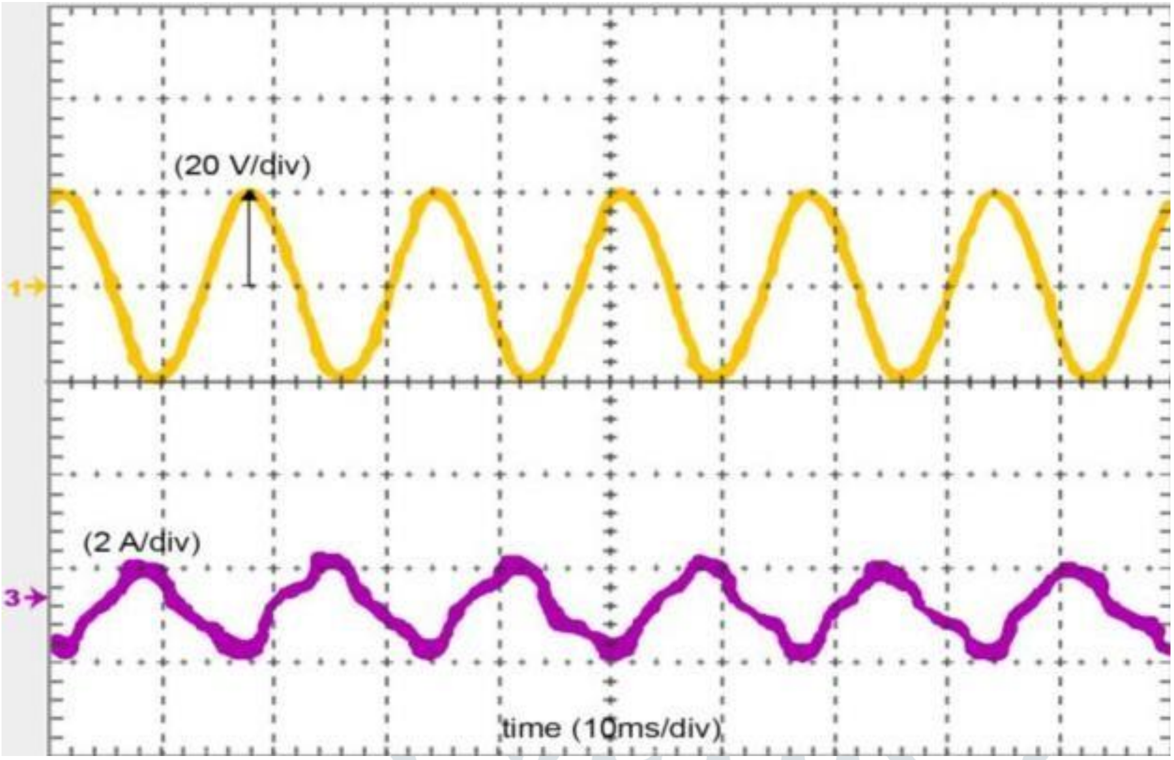


Figure 1.6 Efficiency vs. AC input voltage of 2-level and 3-level Converters

1.4 RESULT

In conclusion, an optimized design of the matrix converter input filter is a quite difficult task, since it relies on a system level approach and in the light of the new coming harmonic and EMI reduction standards it can be somehow considered an outstanding issue. The converters are reconfigured so as to keep low input voltage and derive high efficiency through high output voltage.



Top: Z-source capacitor voltages. Bottom: boost-stage voltage

1.5 CONCLUSIONS

As, the switching is an automated phenomena, the system is useful in high power applications, but switching imposes problems for dynamic systems. This area of work is yet untouched. The systems are integrated very well into the renewable energy sources, and thus must be extended to other potential renewable energies.

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