POWER QUALITY IMPROVEMENT VIA INDIRECT MATRIX CONVERTERS

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Abstract
The power quality and concern issues are growing rapidly, affecting the electricity networks, feeding nonlinear loads and generate many harmonic distortions i.e. harmonics, flicker, swells, sags and voltage interruptions resultant into increase of power losses and power interruptions resulting in poor performance of the electricity networks. Indirect Matrix Converter is considered as one of better solution for improvement of output voltage and reduction in common mode voltage. The system will offer good compensation compared to existing D- STATCOM, UPQC, Multilevel Inverters, Interleaved converters, AC-AC Matrix and conventional converters. The article discuss the indirect matrix converter stimulated using MATLAB configurations.

Keywords: Power quality improvement, Voltage Source Inverter, Indirect Matrix Converter, Three-level Space Vector modulation

1. Introduction

The converters are traditionally used in power quality improvement possess storage components. The traditional power converters normally integrated with electrical grid. It also became a major challenge incorporation of solar and wind power generation. If these are not attended, then cause voltage and current collapsing in the system i.e. heavy voltage/current variations, harmonic distortion, transient problems and power reverse [1], power flow which can cause sudden failures of sensitive electronic equipment, overheating of power transformers, and also escalate the power losses in the systems [1]. The various extensive tools have been demonstrated in the power grid [2][3][4]. But, these type of connection requires control strategy that is highly complex and has bulky storage system. The other disadvantage are reduced current levels, and hence converter is not reliable and not considered as a good solution for quality improvement [5] [6]. Hence, there is needed to go for other better converters. Matrix converters are considered as a viable to the existing grid compared to the conventional existing converters. The matrix converter is very simple with reduced size. These are more suitable and can directly interface with existing electrical power grid to the load. These excellent features have lately increased the passion and interest of researchers to examine the Matrix converter. There are two types of matrix converters: (1) conventional, and (2) indirect type [7] [8], which use almost the same or reduced number of turn-off semiconductors as the traditional matrix converter (CMC) shown in fig.1 that presents various bidirectional switches in the rectifier stage. The advantages of Indirect Matrix Converters compared to conventional converters are as follows: modulation complexity is lowered, offer safe system commutation [9], no requirement for added over-protection circuit in the grid. Despite these advantages, indirect converters possess increased number of semiconductors devices in the current path. Therefore, these matrix converters suffer more conduction losses at normal operating point. In this respect, Reverse Blocking IGBTS [10], incorporating two transistors leads to reduced dissipated power in the devices [9]. The RB-IGBTS suffers from a reduced efficiency, but now days, new RB-IGBTSs are introduced in the market. Modular multilevel converters have recently become a proper solution so that these converters can be interfaced to the existing grid or distributed energy sources because of the requirement of high voltage applications. These topologies if employed can produce sinusoidal output voltage, reduce switching stress, reducing common mode voltage as well as reducing harmonics at the output terminals. The new topology of three-phase-to-three-phase three level hybrid matrix converter is proposed due to increased voltage requirement in the distributed energy supplies. The modulation proposed for this topology will be PWM in the rectifier stage and three-vector space modulation in the inverter stage to reduce CMV and increase voltage transfer ratio and reduce harmonics.

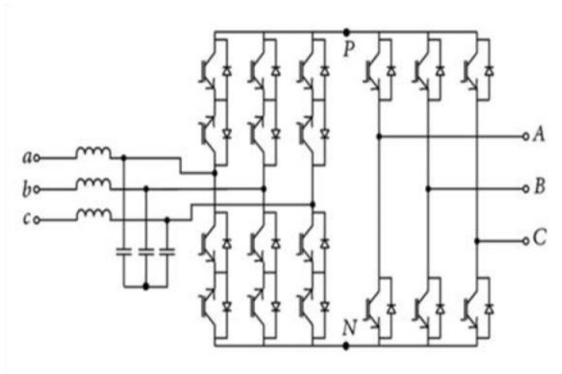

Figure 1 conventional indirect matrix

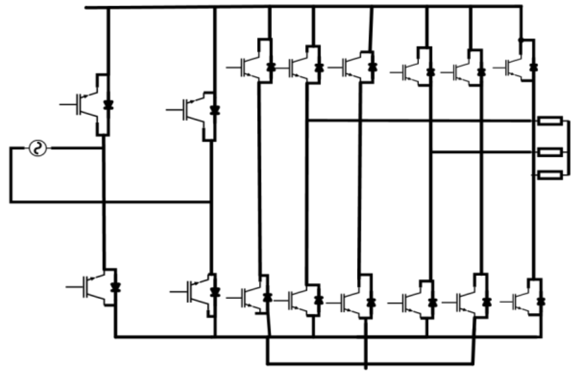

Figure 2 proposed model

From the figure.1. It is clearly shown that there is no capacitor being connected between the rectifier and the inverter stage [11]. These topologies produce low switching losses and conduction losses in comparison with conventional matrix converters. The Space Vector Pulse Width Modulation (SVPWM) algorithm was applied to this topology and it was found to reduce distorted waveforms in the output signal[12][13]. It is supported with Rutian Wang et al proposal of investigated three-phase to five-phase output MC topology to supply high quality power to heavy power industries. Pulse width modulation algorithm was presented and it resulted into low computational efforts and improved waveforms [14]. Heavy power industries are considering and incorporating them in their processing plans [15]. M. Hamouda et al demonstrated the most appropriate technology where a five-leg stage was proposed to supply two AC machines. This topology had reduced number of switching devices from twelve devices to ten devices only [15] and resulted into low switching stresses applied on the semiconductors.

2. Modelling of Pulse width modulation and SPW

A drawing of a three-level hybrid matrix converter is as shown in figure. 2. Output voltage signals are generated with the use of different switching combinations as arranged in H-bridge format producing three-level phase output voltage as Vdc,0,-Vdc as shown figure .The matrix converter will have a hybrid type on rectifier as well as in the inverter side.

3. Simulations

Two models were considered for the simulations and the results show that the proposed topology of three-level matrix converter was worthy to be considered. The output voltage was greatly improved because for the input line voltage of 400v which was considered for the model the output voltage was found to be 400 V as shown in figure.3 compared to the other model of two level matrix converter which produced around 380 Vas output voltage as shown in figure.4 with the same input voltage. Both models produced sinusoidal input voltages and improved harmonics. The common mode voltage was greatly improved for the proposed model as stipulated in the output voltage found. Three-level matrix converter with PWM in the rectifier stage and three-level vector modulation in the inverter stage, Parameters for considered for the model are as shown in Table 1 below.

Table 1. Model parameter values considered

Source voltage magnitude	230V
Source frequency	50Hz
Load frequency	50Hz
Input capacitance	12uF
Input filter resistance	0.15mH
Load resistance	50

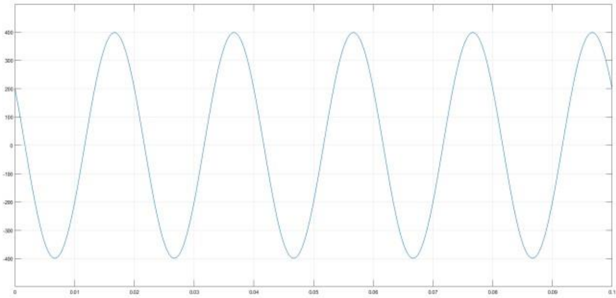

Figure 3 input line voltage for three-level matrix converter

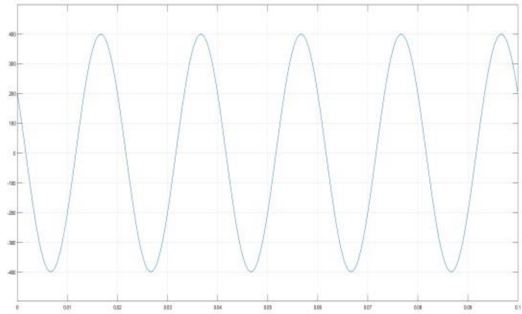

Figure 4 line input voltage for two level matrix converter

The results for three-level matrix converters are mentioned as figures. 5 and 6 showing the output line output voltage and line voltage for two level matrix converter respectively.

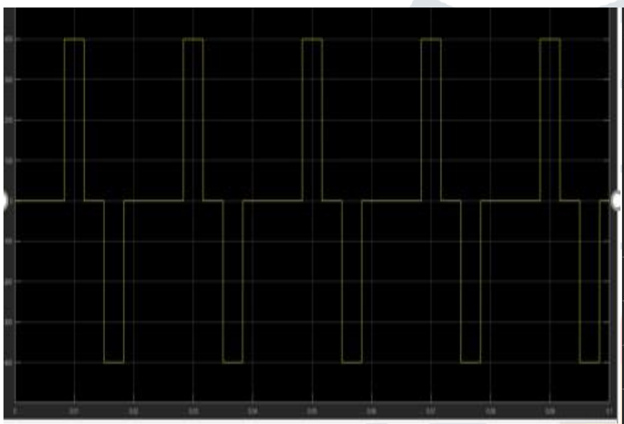

Figure 3 Output of the line voltage

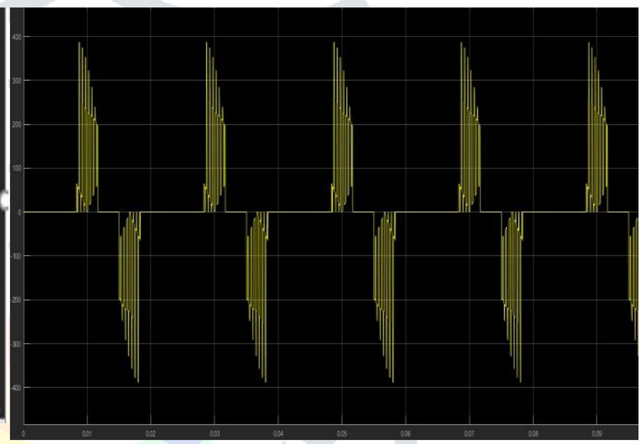

Figure 6 line output voltage for two level matrix converter

The harmonics content of three level and two level inverter is illustrated in figure. 7 and 8 of 0.01% and 0.04 % respectively.

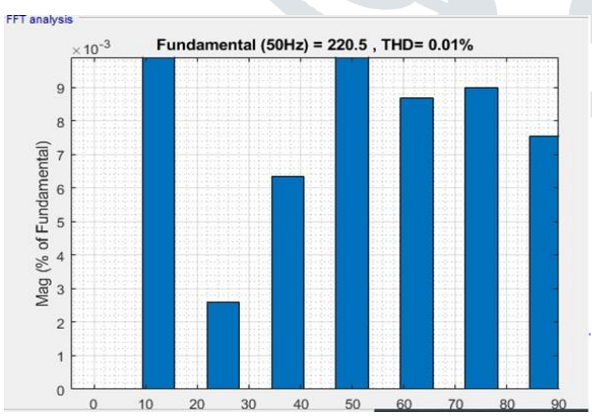

Figure 4 Harmonic content in the three-level matrix converter

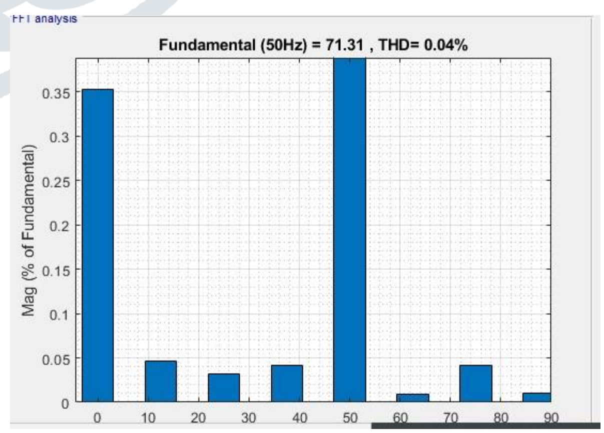

Figure 8 Harmonic content of two level matrix converter

4. Conclusion

The principle of PWM and Three-level space vector in the three-level matrix converter have been demonstrated in this paper. The proposed model has produced high quality waveforms on both the input and output that any matrix converter can produce at the required output frequency. The results found from this model are in agreement with the theoretical results as stipulated by the direct frequency converters hence matrix converters are worthy to be designed and studied in future.

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