MLR BASED POWER ELECTRONICS TRANSFORMER FOR POWER QUALITY IMPROVEMENT

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ABSTRACT

A new power electronic transformer (PET) based on multilevel rectifier (MLR) is proposed in this paper for power quality improvement. The main function of a conventional transformer is to transform the required voltage and at the same time provide galvanic isolation between the source and the load. However, the conventional transformers are: bulky in size, expensive and losses due to iron cores and copper windings. Hence, power electronic transformer using multilevel rectifier, isolated DC/DC converter and a DC/AC inverter conversion blocks is proposed, to provide voltage transformation, galvanic isolation, power factor correction and improvement in power quality issues, such as sag, swell and flicker. The proposed system has been simulated in MATLAB/Simulink and the power quality improvement is verified by the result obtained.

Keywords: Multilevel rectifier, Power quality issues, Power electronic transformer, DC/AC converter

I. INTRODUCTION

For many years conventional transformers are being used in electrical system to provide voltage transformation, galvanic isolation and adaptation. However, these transformers are bulky in size, heavy, high cost and also iron and copper losses are very high. And also these transformers cannot handle the ever increasing power quality issues especially in medium and high frequency applications [1,3,7]. In recent years, Advances in Semiconductor devices leads to increased use of power electronic circuits. A new transformer based on power electronic circuits is proposed. The power electronic circuits are used both in primary and secondary sides of the transformer in order to regulate the voltage sag/swell compensation and power factor correction [1-8]. PET consists of three main stages that are the input stage consisting of an AC/DC rectifier (MLR) for reducing the input side filter size and obtain less input current ripple, the isolated DC/DC converter for providing galvanic isolation and the output stage consisting of DC/AC converter usually three phase voltage source inverter for converting the DC output to AC and feeding the load.

Several PET topologies have been proposed in literature [1-8]. In some of the literatures a converter based on the three phase converter, buck converter and H-bridge converter are being proposed at the input side, as in [1]. The focus of that paper is to obtain a medium to low voltage PET using H-bridge converter. In the same manner the PET based on modular multilevel converter is proposed in [2] and the DC/DC isolation converter is realized through a series capacitor to provide a series resonance. The DC/DC converter can provide a two way flow of power [2].

In another paper [4] an AC/AC converter based on matrix converter is proposed to generate the designed output voltage from the square input voltage. The aim here is to reduce the components used in the conventional PETs. Reliability and power quality of the distribution can be significantly improved using the system. In this present work a three stage PET is proposed in which a modular five-level rectifier based on cascaded H-bridge is used in the input side of the transformer, a DC/DC isolation transformer and three phase voltage source inverter at the output side.

The arrangement shown in fig 1 depicts a block diagram of the systems which provide flexibility and functionality of the electronic transformer and also perform different power quality improvement functions together with galvanic isolation. To verify the proposed system, the PET was simulated in MATLAB/Simulink and the simulation results confirm the ability of the system to solve some power quality issues.

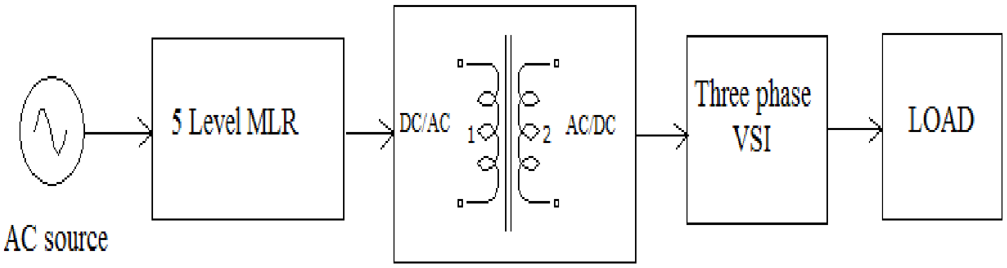


Fig. 1 Block Diagram of PET

II. INPUT-OUTPUT CONVERTERS

The topologies of the input-output converters connected to both the primary and secondary sides of the transformer respectively depend on the line characteristics of the voltage and frequency. Different architectures can be considered from the input side of the transformer, three phase AC/AC converter, single phase AC/AC converters and DC/DC converters are mostly used. However to get the high power density, less input current ripple and to reduced the input side filter a MLR is used. MLR has less components count and modular in design.

The output converter which is connected to the medium or high frequency transformer is a simple three phase voltage source inverter that is used to feed regulated power to the connected loads [3].

III. PET ARCHITECTURES

Various topologies have been presented for the realization of PET in power quality improvement. In the first architecture isolation transformer is not used but an AC/AC converter was used to transform the voltage level directly [4,7].

In the next architecture the AC waveform of the line side is changed into high or medium frequency (MF) square wave and it's coupled with secondary of MF and again demodulated to AC form by a converter as an output. Because of the lack of the energy storage it does not provide voltage sag compensation. The basic block diagram is shown in fig.2. As the size of the transformer is inversely proportional to the frequency this PET will be much smaller than the conventional transformer. So, size, weight and the stress factor of the transformer are reduced considerably.

As such the new PET is proposed which consist of three stages- input stage, isolation stage and the output stage. This PET will gives the improvement of the power quality and provide the galvanic isolation but too many power electronic converters and DC capacitors are needed here. In the first stage an AC/DC converter i.e.

five level MLR is used in mitigating the input current ripple and correcting the input power factor and regulate the primary DC bus voltage. Isolation stage is the second stage, here between primary and secondary the galvanic isolation is provided. In this stage, high frequency square wave is converted from DC voltage and coupled to the secondary of the HF or MF transformer. The output stage contains usually three phase voltage source inverter in which AC waveforms is produced and it is fed to the load.

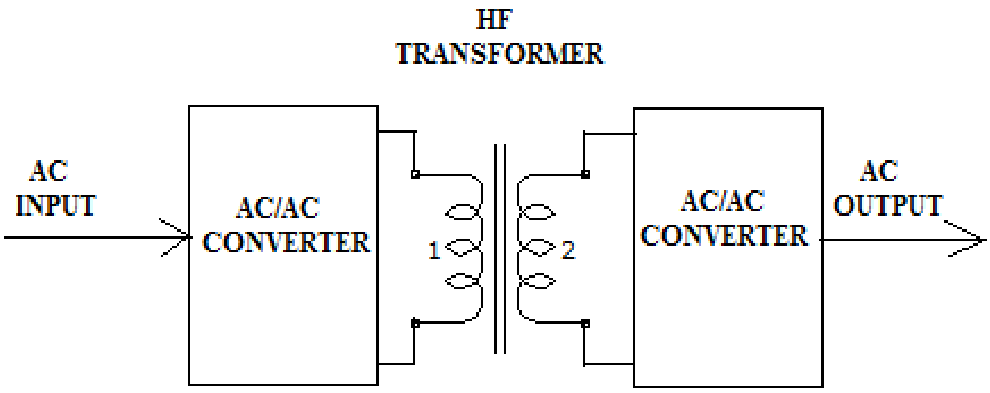


Fig. 2 PET Using HF AC-Link

IV. SIMULATION RESULTS

The complete power electronic transformer (PET) system was simulated using Matlab/Simulink and the output waveforms obtained confirmed the effectiveness of the system and its ability to solve and improve the power quality issues.

Fig. 1 shows the complete circuit diagram of the system, and Fig. 2(a), (b) &(c) depicts the input voltage Sag, DC-Link voltage and the output Voltage waveforms respectively. The Input voltage Swell, DC-Link voltage and the Output voltage waveforms are also shown in figure 3. The figures 4(a) &4(b) shows the machines speed and torque respectively. The parameters used in the simulation of the system were given in Table (1) & (2).

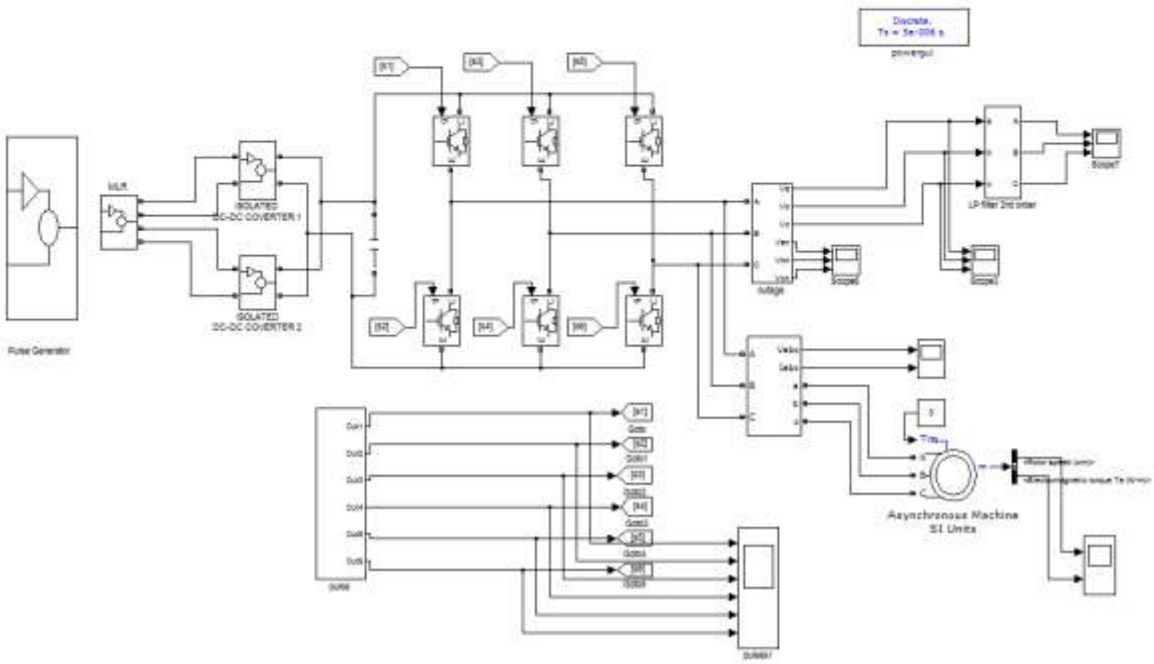
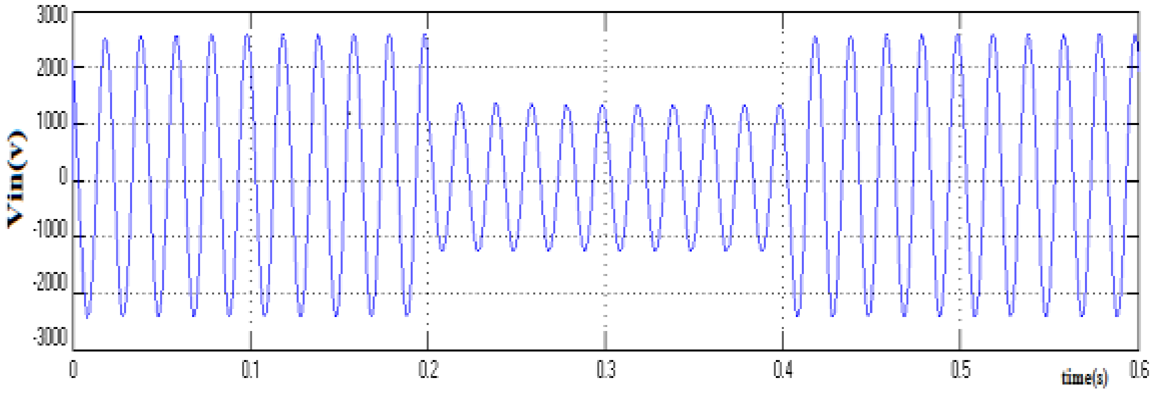
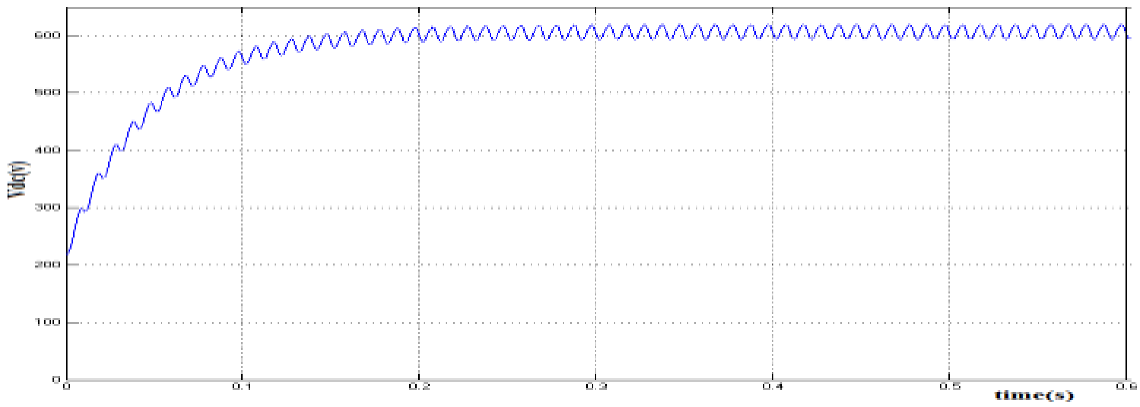


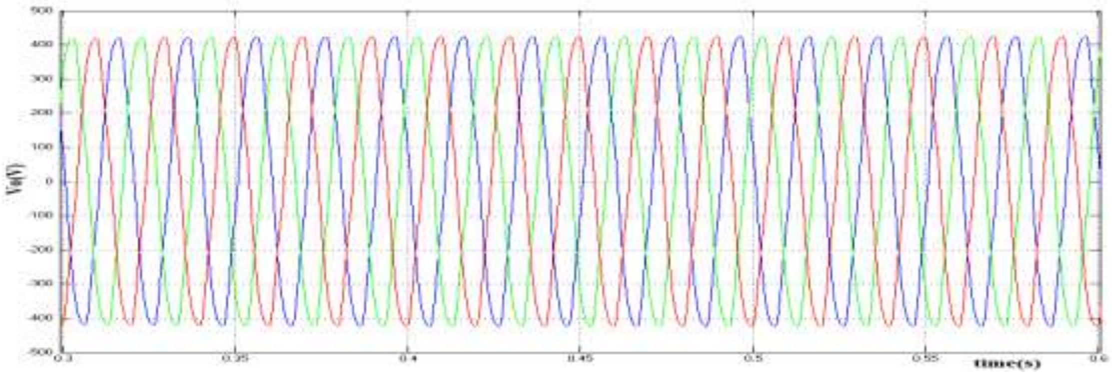
Fig. 3 Matlab/Simulink Circuit for PET



(a)

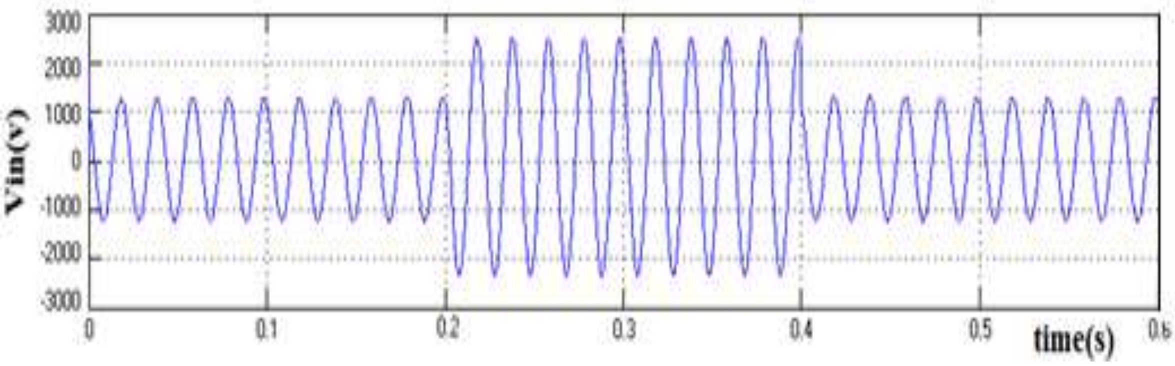


(b)

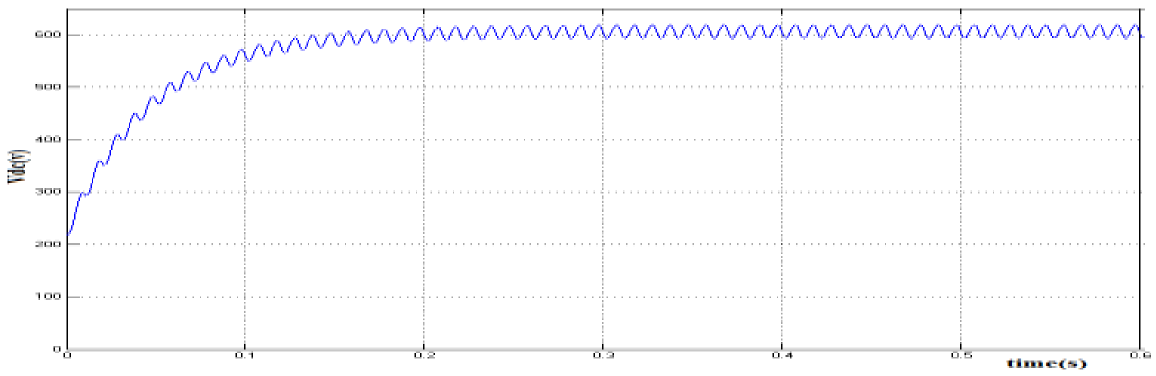


(c)

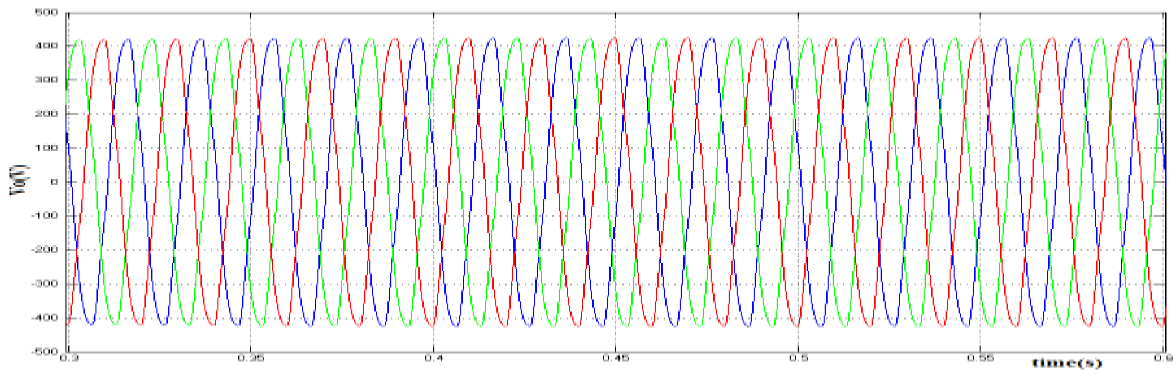
Fig. 4 (a) Input voltage Sag (b) DC-Link voltage (c) Output load voltage



(a)

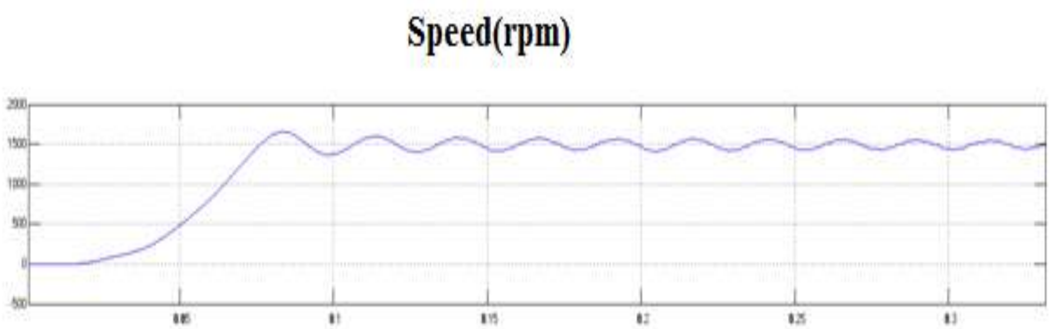


(b)

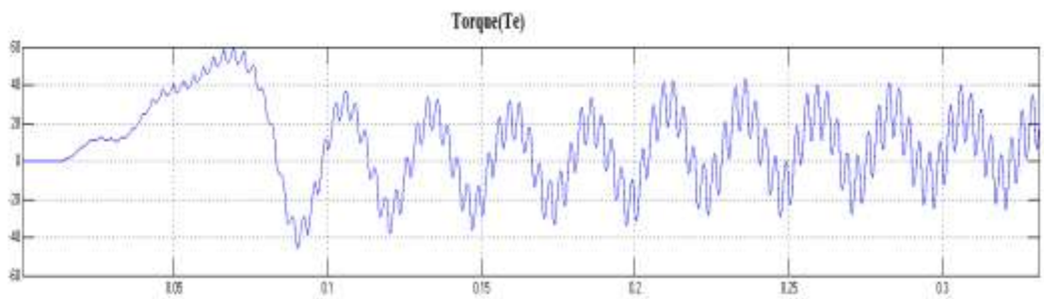


(c)

Fig. 5 (a) Input voltage Swell (b) DC-Link voltage (c) Output load voltage



(a)



(b)

Fig. 6 (a) Speed waveform (b) Torque

Table 1 System Parameters

Parameter	**Value**
Number of series MLR H-bridges at the input(N)	2
System Frequency	50Hz
Input voltage(V_{in})	2700V
Simulation period	1sec
Output voltage of DC load (V)	600V

Table 2 Machine Parameters

Parameter	***Value***
Nominal power	1100
Rs, Lls	6.03 Ω, 0.0299 H
Rr', Llr'	6.085Ω, 0.0299 H
Lm	0.4893 H
No. of poles	2
J, F	0.011787 Kg.m^2, 0.0027 Nm/s

V. CONCLUSION

In the paper, a Power Electronic Transformer (PET) using a 5-Level Multilevel rectifier from the input side is proposed. The simulation result of the system confirm the effectiveness of the system as it is able to solve and improve some power quality issues as it can be seen in the input waveforms reduces and increases from t=0.02s to 0.04s but still the PET act appropriately to adjust the voltage to the desired level at the output and also improve the power factor.

VI. ACKNOWLEDGMENT

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