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Reduction of harmonics in Flexible Power Electronic Transformer

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Abstract: Reduction of harmonics is an important issue of power electronic conversion systems. This paper introduces Sinusoidal Pulse Width Modulation technique (SPWM) to reduce harmonics in Flexible Power Electronic Transformer (FPET). The simulated FPET has enough flexibility to satisfy future needs of power electronic centralized systems. More harmonic waveforms of FPET in comparison to the similar circuit topologies proposed for multilevel Power Electronic Transformer. SPWM technique will be applied to FPET to reduce these harmonics and to control voltage for the improvement of quality of power supply.
The models are designed in MATLAB/SIMULINK. SPWM technique is discussed here and applied with results to analyze less THD.

Keywords: DC Source, IGBT, INVERTER, CYCLOCONVERTER, LC-FILTER, SPWM, Bi-DIRECTIONAL POWER FLOW, HFIT.

I. INTRODUCTION

FPET is constructed based on modules and a common dc link, which is used to transfer energy between ports and isolate all ports from each other. Each module consists of three main parts, including modulator, demodulator, and high frequency isolation transformer (HFIT). The modulator is a dc–ac converter and the demodulator is an ac–ac converter. As shown in Fig. I(a), each port is composed of a full bridge dc-link inverter (FBDCI), HFIT, and a cyclo converter.

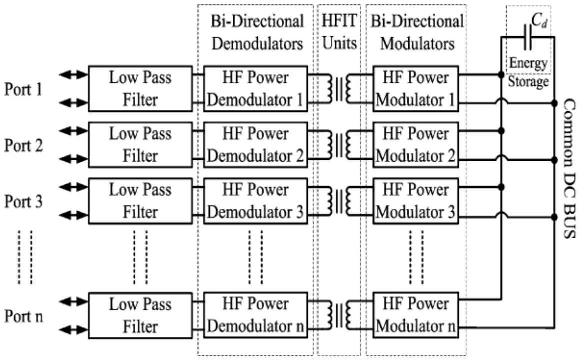

Fig. I. (a) Main concept of proposed FPET.

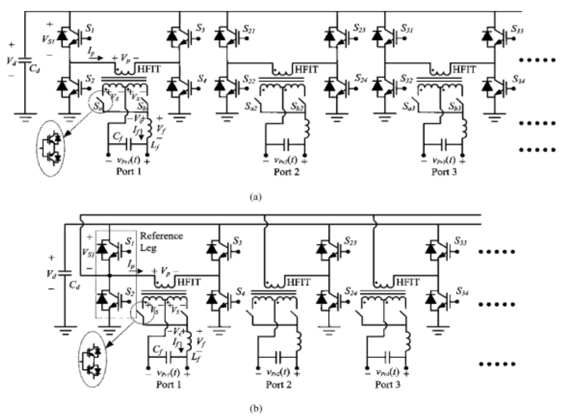

Fig.I.(b) Proposed circuit of the FPET. (a) Basic topology and (b) reduced switch topology. The FBDCI (modulator) can operate as an inverter when it converts the dc-link voltage to an ac waveform at the HFIT side. It can operate as an active rectifier when it converts the ac waveform of the HFIT to the dc-link voltage.

SINUSOIDAL PWM TECHNIQUE

Sinusoidal PWM is a common and useful technique of PWM for minimizing harmonic content and controlling output voltage waveform. In Sinusoidal Pulse Width Modulation technique, a saw tooth or triangular signal of high frequency is compared with a modulating signal of required frequency, for generating pulse for the gates of the power electronic switches of the converter.

II. SIMULATION MODEL OF FPET

First of all, one port of FPET is designed which is composed of full-bridge inverter, isolation transformer of high frequency, and a cycloconverter with L,RC-filter using pulse generator at the switches of inverter and cycloconverter as shown in fig.1. Then two ports of FPET are designed with control strategy where one of the half bridge circuits can be taken as the reference/ master leg. “Once gate pulses for the master leg (i.e., switches and) are provided, the gate pulses of the other legs (slave legs) have a phase shift respect to the master leg”. The number of semiconductor devices may be reduced to half through this control strategy as shown in fig.2. Then after five ports of FPET are designed in which upper two ports are connected in series to provide single phase voltage and lower three ports are arranged in star configuration to provide three phase controlled voltage as shown in fig.3. SPWM technique is applied to every switches of cycloconverter of one port of FPET as shown in fig.4.

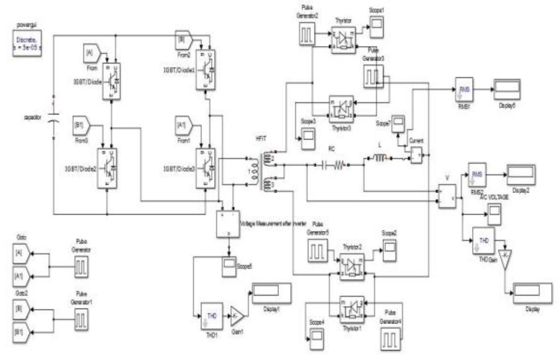

Fig.1. Simulation of one port of FPET

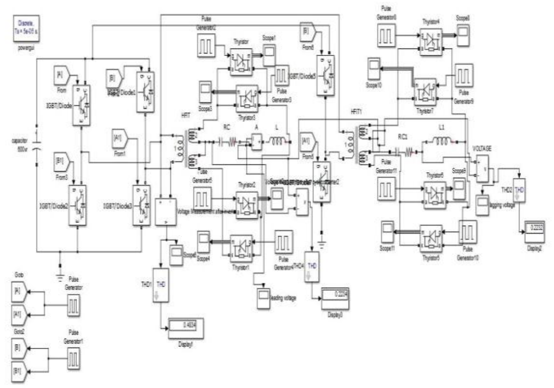

Fig.2. Simulation of two ports of FPET with control strategy.

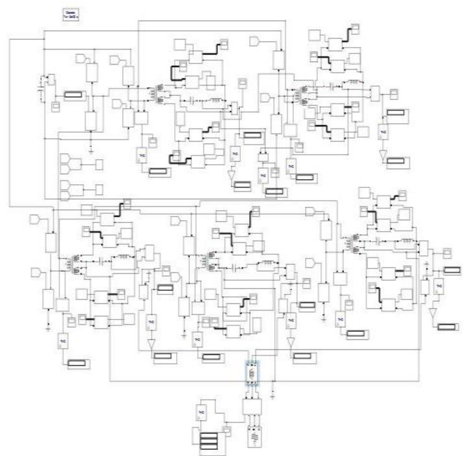

Fig. 3. Simulation of 5 ports of FPET

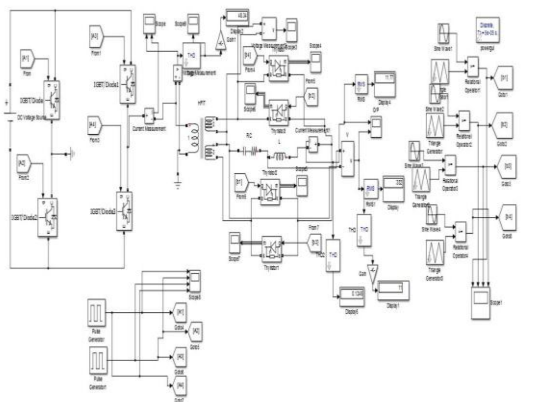

Fig.4. Simulation of one port of FPET by using SPWM technique.

III. RESULTS OF SIMULATION

Output of simulation of one or two port/s of FPET:

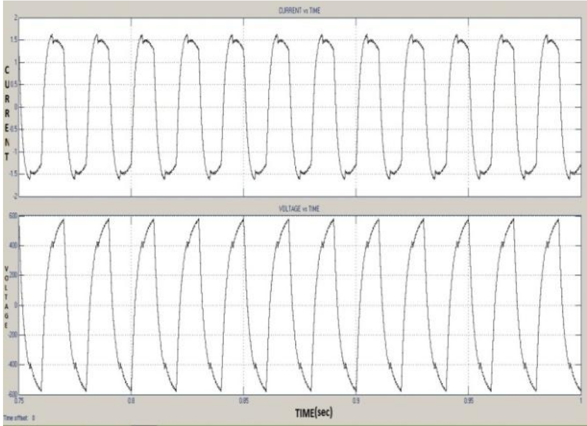

Fig.5. output at the cycloconverter side of FPET

Output of simulation of five ports of FPET:

Output of Upper Ports Single Phase FPET

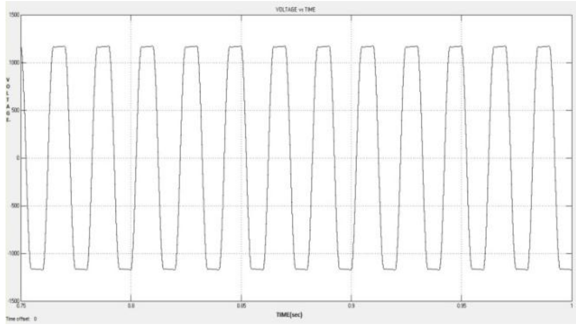

Fig.6. output of series connection of two upper output ports of FPET

Output of Lower Ports Three Phase FPET

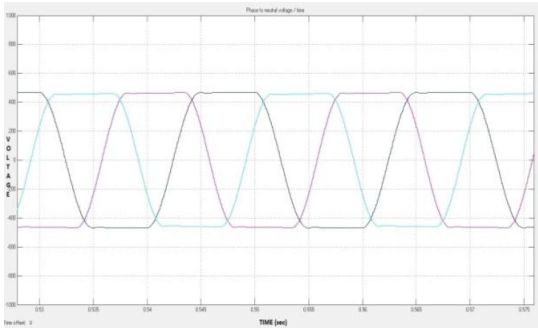

Fig.7. Phase to neutral voltage of star arranged lower ports

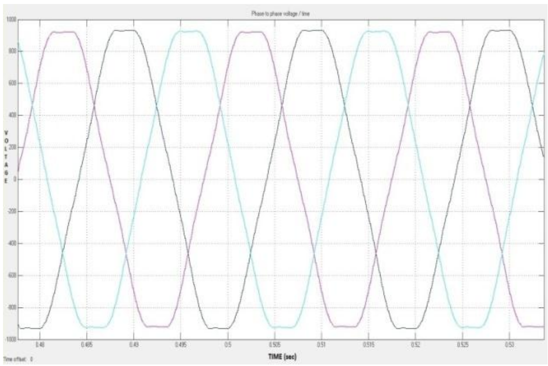

Fig.8. Phase to phase voltage of star arranged lower ports

SPECIFICATION:

PARAMETERS	VALUE
Reference Voltage, V_{ref}	600V
f_{HFIT}	2000Hz
Output voltage	414V(rms)
Output current	1.3A(rms)
THD of output voltage	22.17%
THD of output current	22.37%
Power factor	0.896

Output of simulation of FPET using SPWM technique:

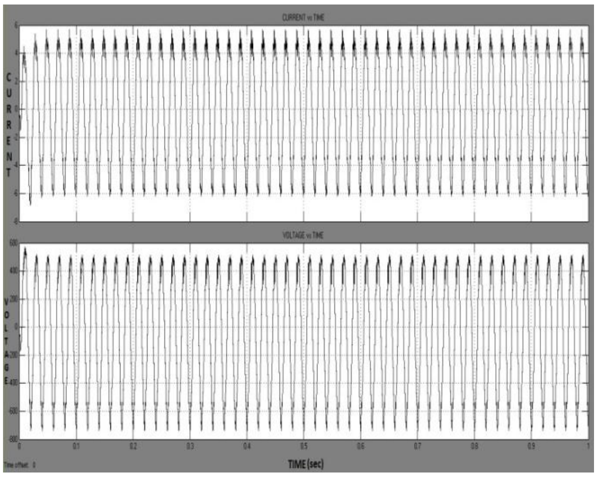

Fig.9. output of simulation of FPET using SPWM technique at the gates of cycloconverter's switches

SPECIFICATION:

PARAMETERS	VALUE
Reference Voltage, V_{ref}	600V
f_{HFIT}	2000Hz
Output Voltage	419.2V(rms)
Output Current	3.869(rms)
THD of output voltage	11.89%
THD of output current	12.67%
Power factor	0.908

IV. CONCLUSION

This paper introduces SPWM technique to reduce harmonics and to control voltage for the improvement of quality of power supply in FPET. Through comparison of their response of measured THD, it has been concluded that SPWM is a more reliable and efficient technique for less THD so that waveforms become closer to sine wave. In addition, FPET is simulated to provide different needs that are required in industrial applications and distribution systems. The simulated topology has enough flexibility to facilitate flow of power in both directions and can have a number of ports according to the requirements. It can change the output voltage waveform and frequency and can be expanded according to the requirement. It can control both real and reactive power flow. And also, three output ports of FPET are connected together in star arrangement to facilitate a control of three phase voltage to the three phase load.

V. FUTURE SCOPE

Through the implementation of modulation techniques carried out in this paper, under following activities are extracted for future work regarding this field of concern:-

1. Harmonics can be reduced by different modulation techniques such as sigma-delta modulation, delta modulation, space vector modulation, trapezoidal modulation, staircase modulation, stepper modulation, harmonic injection modulation, so that harmonics in output current waveform can be reduced to less than 5%.
2. Power factor can be improved to one by using Series connection of transformers with some PHASE DISPLACEMENT.

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BIOGRAPHIES

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