ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

Overview of Reduction of Harmonics in Flexible Power Electronic Transformer

Sonali Raj
M. Tech (Power System), Nit Patna, Patna, India

Abstract: This paper introduces modulation techniques to reduce harmonics in Flexible Power Electronic Transformer. The proposed FPET is power electronic based transformer which has enough flexibility to satisfy future needs of power electronic centralized systems. The main feature of the FPET is the independent operation of modules each of which contains one port and connected to a common dc link. Each port can be considered as input or output, because bidirectional power flow is provided. More harmonic component in the input current of FPET has been compared to the similar circuits topologies proposed for multilevel PET. PSM i.e. PHASE SHIFT MODULATION technique will be applied to FPET to control voltage and reduce harmonics. SPWM, SIGMA DELTA MODULATION, and HYSTERESIS BAND CONTROL MODULATION techniques would be used to reduce THD of voltage and current waveforms of FPET.

Keywords: DC Source, IGBT, Inverter, Cycloconverter, LC-Filter, Modulation Techniques, BI-Directional Power Flow, HFIT.

I. INTRODUCTION

FPET

FPET is flexible enough to meet future needs of power electronic centralized systems. The main feature of the FPET is the independent operation of modules each of which contains one port and connected to a common dc link. Therefore, a multiport system is developed in which each port can operate independently. The modulator is a dc–ac converter and the demodulator is an ac–ac converter; both with bidirectional power flow capability. These ports can have many different characteristics, such as voltage level, frequency, phase angle, and waveform.

The multilevel PET proposed earlier and FPET have the same capability of the power factor correction and power quality enhancement. The advantage of multilevel PET over FPET is its lower harmonic components in the input current. On the other hand, FPET has the capability of the bidirectional power flow, while the multilevel PET is unidirectional. FPET has one dc link and one dc capacitor but multilevel PET has two dc links in each module. In addition, the output ports of FPET can be connected in star configuration to provide a three phase four-wire system with independent phase voltage control.

HARMONICS

Harmonic is a sinusoidal component of a periodic wave and its frequency is an integral multiple of the fundamental frequency.

These power harmonics are called ELECTRICAL POLLUTION which will degrade the quality of the power supply. They also cause disturbances to other consumers and interference in nearby communication networks, low system efficiency and poor power factor. Sources of harmonics are fast switching associated with power electronic devices, conventional sources such as electrical rotating machines, transformers and modern electronic equipments. Harmonic voltages and currents in an electric power system are a result of non-linear electric loads. Harmonic frequencies in the power grid are a frequent cause of power quality problems.

Harmonics in power systems result in increased heating in the equipment and conductors, misfiring in variable speed drives, and torque pulsations in motors. Reduction of harmonics is considered desirable.

Methods to reduce harmonics are –

PWM

Pulse Width Modulation (PWM) signals have been widely employed in power-electronic applications, generates its signal by comparing a reference signal and a high-frequency triangular carrier waveform. The switching frequency in the SPWM scheme is always fixed.

SDM

The SDM consists of an integrator and a quantizer in a feedback loop, as shown in Fig. 1. The quantizer considered here is a two-level type which the output is either +1 or -1, and its input is the integral of the difference between the input and the quantized output. That is, the quantization error. As an effect of the feedback loop, the average value at the integrator input is brought to zero.

II. OVERVIEW

In 2010, Mehran Sabahi, Ali Yazdanpanah Goharrizi, Seyed Hossein Hosseini, Mohammad Bagher Bana Sharifian, and Gevorg B. Gharehpetian [1] have proposed Flexible Power Electronic Transformer. The proposed FPET is flexible enough to satisfy desirable future needs of power electronic centralized systems. The main feature of the FPET is the independent operation of modules each of which contains one port. The advantages of the FPET are: bidirectional power flow capability of ports, module-based topology, which can be used in different forms, independent operation of ports, flexibility in power amount and direction in all ports, and double galvanic isolation between each port, as well as using only one storage element. Design simplicity and expandability (to achieve higher ratings) are other advantageous of FPET.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

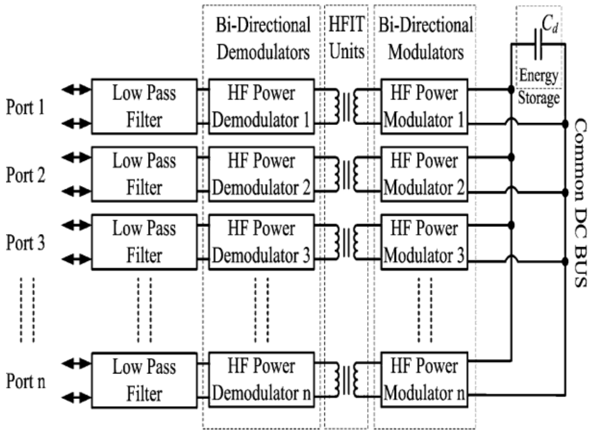

Fig. Block diagram of FPET

In this paper, the voltage regulation is performed by the FBDCI and cycloconverter using Pulse Shift Modulation (PSM) method. There are more harmonic components in the input current of FPET in comparison to the similar circuit topologies proposed in PET. Conversion efficiency of FPET is relatively low compare to PET. Efficiency regarding the number of switches is less in comparison to PET.

In 2002, Edward R. Ronan, Scott D. Sudhoff , Steven F. Glover, and Dudley L. Galloway [2], have introduced A Power Electronic-Based Distribution Transformer. This paper has introduced the architecture of a power-electronics based transformer that is insensitive to harmonics. A new kind of distribution transformer is proposed; one that can be made self-regulating, oil-free, and able to correct power quality problems**.** The transformer design proposed herein, is a three-part design that utilizes an input stage, an isolation stage, and an output stage. The three-stage topology described herein has many attractive features. First, series-tied semiconductor devices are avoided because the voltage on the individual modules is reduced to the point where series tying of devices is unnecessary. Second, because of the three-stage topology and the unique capabilities of each stage, the total stress factor is much lower than it would be for the ac/ac chopper.

In 2008, S.H. Hosseini, M.B. Sharifian , M. Sabahi , A. Yazdanpanah, G.H. Gharehpetian [3] have presented Bi-Directional Power Electronic Transformer For Induction Heating System.This proposed PET contains primary bi-directional cycloconverter switches, high frequency isolation transformer, matching coil and a parallel resonant heating system. In this paper a three phase input, single phase output direct PET (without energy storage element) induction heating device is presented. Additionally, this new topology provides higher power rating with respect to utility voltage at the load side.

Cycloconverter switches are controlled under a specific pattern to obtain three level high frequency voltage source to supply parallel resonance tank through a matching coil. Additionally, this topology can provide voltage level conversion ability; leads to obtaining desired power even at input low voltage level. Furthermore, proposed topology provides maximum output power and low output THD utilizing comparatively smaller size matching filter coil which work suitably with auto tuning of switching frequency controller. A known type of phase locked loop controller is used to adjust proper switching frequency to deliver maximum power.

In 2013, Xu She, Alex Q. Huang, and Rolando Burgos [4], have presented Review of Solid-State Transformer Technologies and Their Application in Power Distribution System. This paper has presented a comprehensive technology review of the Solid-State Transformer (SST), from components design to system application, aiming at providing a systematic review in this area. The basic idea of the SST is to achieve the voltage transformation by medium- to high-frequency isolation, therefore to potentially reduce the volume and weight of it compared with the traditional power transformer.

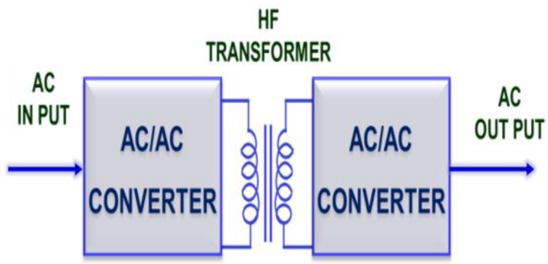

Fig. Block diagram of Solid- State Transformer

This brings promising advantages such as power flow control, voltage sag compensation, fault current limitation, and others, which are not possible for traditional transformers. Second, voltage source converters connected from the secondary terminal of the SST could readily support a regulated dc bus which could be connected to dc micro grids enabling this new micro grid architecture.

In 2012, J.R. Rodríguez [5] have presented a state of the art on electronic transformer, whose structure is based on power electronic devices and high-frequency electromagnetic induction. It has the capability to handle bidirectional flow of active and reactive power for different input-output voltage ratios and mitigate voltage disturbances and harmonic voltage and / or current. In this paper, it has been described that evolutions of electronic transformers as a generational change in the traditional distribution transformers, with the advantage of control added capacity for the benefit of users and the electric network. In such applications where the magnitude of the output voltage is directly represented by the level of LVBUS, it is quite beneficial the addition of adaptive feed-forward control, which is an effective technique to mitigate the effects on the output of system affected by disturbances at the entrance, through a new variable that dynamically modifies the width of the pulses PWM input to variations in the DC bus. But, it cannot be as efficient as a line frequency transformer operating at full load. Given the complex nature of electronic transformer, initially this may not be as reliable as a traditional transformer, but like all systems, the reliability will increase as the technology matures.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

In 2007, S.H. Hosseini, M. Sabahi, A.Y. Goharrizi [6] has proposed Multi-function zero-voltage and zero-current switching phase shift modulation converter using a cycloconverter with bi-directional switches. A novel voltage source full-bridge DC-DC converter with phase shift modulation using a high-frequency cycloconverter have been proposed in this paper. Both zero-voltage and zero-current switching (ZVZCS) commutation for full-bridge active power switches and zero-voltage switching operation for cycloconverter bi-directional switches are obtained. Soft switching operation is provided in a wide range of voltage regulation without utilising an auxiliary inductor in the primary side of an isolating transformer. However, this topology has some disadvantages such as complex controller and power circuit structure. Practically, the output voltage ripple can considerably increase especially in high-power applications. On the other hand, implementation of a high-frequency IT encounters some difficulties at high-power levels.

In 2010, Yu Du, Seunghun Baek, Subhashish Bhattacharya, Alex Q. Huang [7] have presented High-voltage High-frequency Transformer Design for a 7.2kV to 120V/240V 20kVA Solid State Transformer. Three cascaded 6.7kVA high-voltage high-frequency transformers operating at 3kHz are employed to convert voltage from 3800V high voltage DC link of each cascaded stage to 400V low voltage DC link. The magnetic core materials were reviewed and compared in this paper for the high voltage and high frequency transformer in SST applications. The amorphous core material is selected to build the 3kHz 6.7kVA transformer prototype, due to its acceptable specific loss, good mechanical strength and relatively low cost. The partial discharge issue and the performance of proposed insulation structure should be evaluated in the future work. In 2008, Hisayuki Sugimura, Sang-Pil Mun, Soon-Kurl Kwon, Tomokazu Mishima, Mutsuo Nakaoka [8] have proposed Direct AC-AC Resonant Converter using One-Chip Reverse Blocking IGBT-Based Bidirectional Switches for HF Induction Heaters. This paper deals with a novel type soft switching utility frequency AC- high frequency AC converter using asymmetrical PWM bidirectional active switches which can be defined as high frequency resonant matrix converter. This power frequency changer can directly convert utility frequency AC power to high frequency AC power ranging more than 20kHz up to 100kHz. Only one active edge resonant capacitor-assisted soft switching high frequency load resonant cyclo-converter is based on asymmetrical duty cycle PWM strategy. This series load resonant cycloconverter incorporating bidirectional active power switches is developed and implemented for high efficiency consumer induction heated food cooking appliances.

In 2013, G.Sudha Rani ,Rasool Ahemmed.SK , N.Lavanya [9] have proposed Implementation of Modified Reference PWM for Reducing the Harmonics in Inverters by using Matlab/Simulink. This paper attempts to analyse the dominant harmonics present in sinusoidal PWM inverter output with AC source. A new technique for reducing this harmonics in PWM inverter output by modifying the reference waveform is proposed, by using MATLAB simulations. SPWM is a very simple technique for harmonic reduction. In this technique pulse magnitude will be constant and only pulse time (width) can be changed. In this paper, the popular sinusoidal PWM technique with a control scheme, which can reduce any two dominant lower order harmonics at a time, is proposed. Since there is no hardware requirement here, the scheme is reliable and economical. Furthermore, by using the multilevel inverters we can improve the THD in future.

In 1997, K. M. Rahman, M. Rezwan Khan, M. A. Choudhury, and M. A. Rahman [10] have introduced Variable-Band Hysteresis Current Controllers for PWM Voltage-Source Inverters. In this paper, two new controllers are proposed. One is a mixed-mode controller of sinusoidal band added to a fixed band, and the other is an equidistant-band current controller. Performances of the proposed controllers are compared with the performances of the conventional fixed-band and sinusoidal-band controllers. The equidistant-band controllers can be applied to drives at steady-state condition (where the load current power factor is high) without additional lockout circuits since the MSF can be limited by selection of the lateral distance. The mixed-band controller is useful because of its lower average frequency. It also provides uniform switching frequencies for highly inductive (low power factor) loads such as motor drives during starting period.

III. CONCLUSION

Based on the requirement of a flexible power conversion system, FPET is proposed to facilitate many requirements that are expected in power electronic and distribution systems. The dc link plays a significant role to provide energy balance, power management in the circuit and independent operation of ports. Through comparative study, it came to know that FPET has more harmonic component in the input current in comparison to the similar circuit topologies proposed for PET. PHASE SHIFT MODULATION has been used to regulate voltage of FPET.

IV. 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 SPWM, Series connection of transformers with some PHASE DISPLACEMENT.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 7, July 2015

REFERENCES

1. Mehran Sabahi, Ali Yazdanpanah Goharrizi, Seyed Hossein Hosseini, Mohammad Bagher Bana Sharifian, Gevorg B. Gharehpetian, “Flexible Power Electronic Transformer”, IEEE Transaction on Power Electronics, vol. 25, no. 8, August 2010.
2. Edward R. Ronan, Scott D. Sudhoff , Steven F. Glover, and Dudley L. Galloway, “A Power Electronic-Based Distribution Transformer”, IEEE Transaction on Power Delivery, vol. 17, no. 2, April 2002.
3. S.H. Hosseini, M.B. Sharifian , M. Sabahi , A. Yazdanpanah, G.H. Gharehpetian, “Bi-Directional Power Electronic Transformer For Induction Heating Systems”, in Proc. Can. Conf. Electr. Comput. Eng., May 4–7, 2008.
4. Xu She, Alex Q. Huang, and Rolando Burgos, “Review of Solid-State Transformer Technologies and Their Application in Power Distribution Systems”, IEEE Journal in power electronics, vol.1, no. 3, September 2013.
5. J.R. Rodríguez, E. L. Moreno-Goytia, V. Venegas R ,L“State of the Art, Modeling and Simulation of an Advanced Power Electronics Transformer”, IEEE Journal, 2012.
6. S. H. Hosseini, M. Sabahi, and A. Y. Goharrizi, “Multi-function zerovoltage and zero-current switching phase shift modulation converter using a cycloconverter with bidirectional switches,” IET Power Electron. JNL,vol. 1, no. 2, June 2008.
7. Yu Du, Seunghun Baek, Subhashish Bhattacharya, Alex Q. Huang,” High-voltage High-frequency Transformer Design for a 7.2kV to 120V/240V 20kVA Solid State Transformer”, IECON - 36th Annual Conference on IEEE Industrial Electronics Society, pp. 493 – 498, 2010.
8. Hisayuki Sugimura,Sang-Pil Mun, Soon-Kurl, Tomokazu Mishima, Mutsuo Nakaoka,”Direct AC-AC Resonant Converter using One-Chip Reverse Blocking IGBT-Based Bidirectional Switches for HF Induction Heaters”,IEEE Conference, 2008.
9. G.Sudha Rani ,Rasool Ahemmed.SK , N.Lavanya, ”Implementation of Modified Reference PWM for Reducing the Harmonics in Inverters by using Matlab/Simulink”, IJAREEIE, Vol. 2, Issue 4, April 2013.
10. K. M. Rahman, M. Rezwan Khan, M. A. Choudhury, and M. A. Rahman,” Variable-Band Hysteresis Current Controllers for PWM Voltage-Source Inverters”, IEEE Transaction on Power Electronics, Vol. 12, No. 6, November 1997.

BIOGRAPHY

SONALI RAJ was born at Patna, Bihar in 1990. She received the B.Tech degree in Electrical & Electronics Engg, from R.G.P.V. University, Bhopal, and the M.Tech degree in Power System from NIT Patna.