

# Power Quality Improvement using a 28-pulse AC-DC Converter for SMPS

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**ABSTRACT:** In this paper a novel autoconnected transformer based 28-pulse ac-dc converter fed SMPS is designed to improve the power quality at the point of common coupling. It consists of two series connected 14-pulse ac-dc uncontrolled converters fed by seven phase shifted ac voltages. The behaviour of the converter is studied in MATLAB based simulation under various load conditions. It has been found that the % input ac mains current THD is less than 5% in the complete range of varying loads, with a power factor close to unity which meets the requirements of IEEE-519 standard. Thus, our proposed topology resulted in much reduction in % input mains current THD with enhanced power factor compared to conventional multi pulse ac-dc converter.

## 1. INTRODUCTION

Telecommunication power supply system requires stiffly regulated output voltages with much reduced % input ac mains current THD at the near unity power factor. In the conventional system AC supply voltage is connected to a DC-link voltage by a diode rectifier with output filter capacitor. A high frequency DC-DC converter, with regulated output voltage, is then connected in series with the Dc-link voltage. But it has high low frequency current harmonics which leads to distortion of AC supply voltage. Later on, the DC-DC converter is fed from six-pulse three phase ac-dc uncontrolled converter at the front-end that are rugged and reliable; however, the line current drawn from the utility by these converters presents high total harmonic distortion (THD) and poor power factor. These harmonics can be reduced by using multipulse ac-dc converters [1]. International power quality standards such as IEEE-519 were proposed to maintain THD and the power factor at acceptable levels [2].

Many researchers have been focusing to improve the power quality of the converters to replace the conventional ac-dc converters by improved power quality ac-dc converters that draw a nearly sinusoidal input ac mains current with unity power factor. Multipulse ac-dc converters with phase shifting technique [3] are one of the popular approaches to reduce the harmonics in medium and high power rectifier type of loads. This rectification approach has gained popularity due to its robust, rugged nature, reliability and simplicity in control. Different multipulse ac-dc converters configurations are reported in the literature [4-5] to reduce the line current harmonics. Multipulse converters have been used as an improved power quality utility interface in a variety of applications such as telecommunication power supplies, electric aircraft applications and variable frequency induction motor drives [6]. Hammond et al [7] has proposed an auto connected transformer configuration which produces multiphase output phase voltages which is not a multiple of three. It is observed that an ac-dc converter with number of phases which is not multiple of three is effective in reducing the line current harmonics.

This paper proposes a new 28-pulse ac-dc converter which is a combination of both multiphase and phase staggering technique for medium capacity SMPS. The proposed autoconnected transformer based ac-dc converter is based on multiphase technique that produces seven-phases from three-phase input supply. The advantages of the present converter approach are that it is inexpensive, reliable and energy-efficient. Moreover, the THD of ac mains current is low and the power factor is well improved. Fig.1 presents a schematic diagram of a medium capacity SMPS using a full-bridge converter that has a 6-pulse converter at the front end. For a normal 3-phase diode bridge rectifier, the power quality indices at the ac mains do not conform to IEEE 519 standard.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 11, November 2013

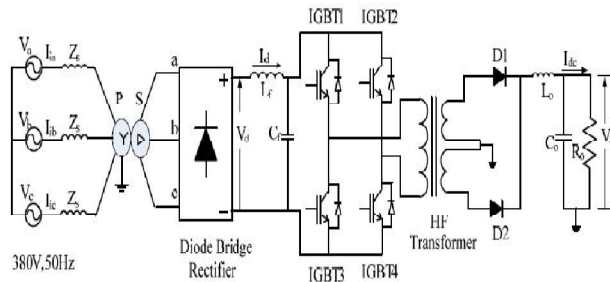


Fig. 1 Schematic diagram of a 6-pulse ac-dc Converter fed SMPS

In this paper, an autoconnected transformer based 28-pulse ac-dc converter is presented to improve the power quality at the utility interface to achieve a power factor close to unity. Design methodology of the proposed autoconnected transformer based 28-pulse ac-dc converter is included in the following sections. The operation of the ac-dc converter at constant dc load current is investigated.

## II. STRUCTURE OF THE PROPOSED SYSTEM

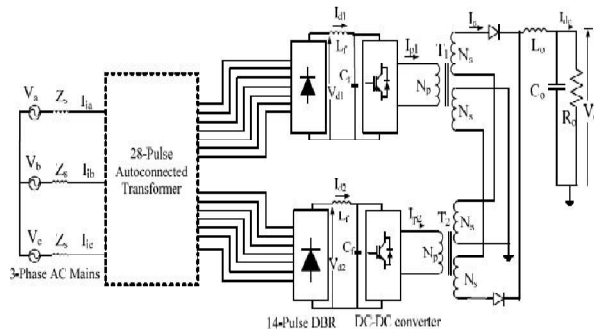


Fig.2 Structure of the overall SMPS system Configuration

Fig. 2 shows the overall system configuration. It is shown that the proposed autoconnected transformer based 28-pulse ac-dc converter is feeding a 12kW SMPS load with the isolated full-bridge dc-dc converters. The proposed autoconnected transformer secondary generates two sets of seven-phase voltage for the two seven-phase diode bridge rectifiers. The dc side of each seven-phase diode bridge rectifiers is connected to the isolated full-bridge dc-dc converters with a dc-link LC filter in between them. A dc-link LC filter ( $L_f$ ,  $C_f$ ) is placed on each of the dc-links to filter out the harmonics which are multiples of 2nd order. The electrical isolation between the input-output is provided by the high frequency transformer. Each transformer has two secondary windings, which are connected as shown in Fig. 2. The secondary winding sides of the two high frequency transformers are connected in series to achieve dc link current balancing. Thus, rectified output voltage is the sum of the secondary voltages of high frequency transformers and each secondary voltage corresponds to its respective dc output voltage of each converter.

The overall output voltage characterize a two 14-pulse ac-dc converter output consisting of the sum of the two secondary winding voltages. Further, the stresses on the devices and the conduction losses in the diodes are reduced by choosing a center-tapped connection for the high frequency transformer.

A proportional-integral (PI) controller regulates the dc output voltage and also provides gating signal to the isolated full-bridge dc-dc converter.

## III. DESIGN OF THE PROPOSED 28-PULSE AC-DC CONVERTER

The complete design of the proposed autoconnected transformer based 28-pulse ac-dc converter is presented in this section. The ac-dc converter presented here is a combination of both multiphase and phase-staggering technique. In a

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Vol. 2, Issue 11, November 2013

multiphase system all the phases are distributed at same angle resulting in elimination of harmonics. In phase-staggering ac-dc converter technique, the phase angle displacement between ac supplies connected to bridges is given as, Phase angle displacement =  $360^\circ / \text{Number of pulses}$  Fig. 3 shows the winding diagram and phasor diagram of the proposed autoconnected transformer. The phasor diagram depicts the angular position of various phasor. It means that for a 12-pulse ac-dc converter of  $30^\circ$  and for an 18-pulse ac-dc converter of  $20^\circ$  is the phase displacement between the rectifier bridges.

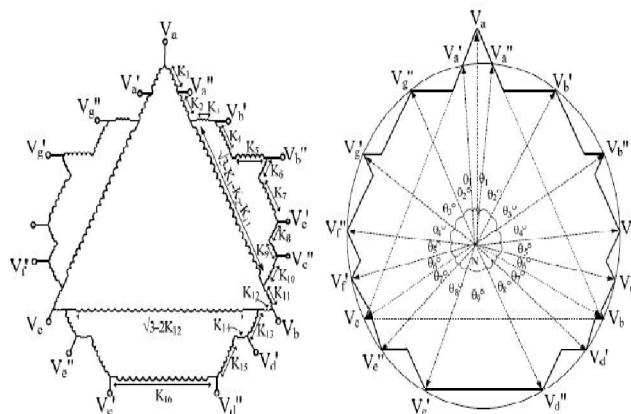


Fig. 3 Winding and phasor diagram of proposed autoconnected transformer based 28-pulse ac-dc converter.

The proposed autoconnected transformer is designed by calculating the number of turns for each winding to produce a phase shift of  $\pm 6.43^\circ$ . To calculate the number of the turns the following set of three-phase voltages and seven-phase voltages are considered.

## IV COMPARATIVE STUDY BETWEEN 6-PULSE AND 28- PULSE AC-DC CONVERTERBASED SMPS

### 1. TOTAL HARMONIC DISTORTION (THD) FOR 6-PULSE AC-DC CONVERTER:

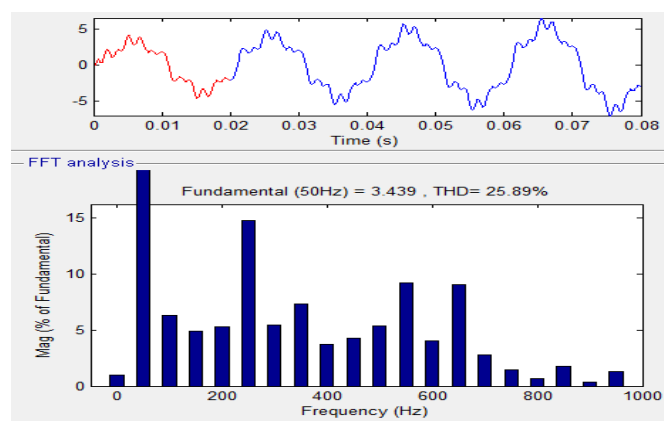


Fig.1 Input ac mains current (iia) along with its frequency spectrum for a 6-pulse ac-dc converter fed SMPS

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 2, Issue 11, November 2013

## 2. TOTAL HARMONIC DISTORTION(THD) FOR 28-PULSE AC-DC CONVERTER:

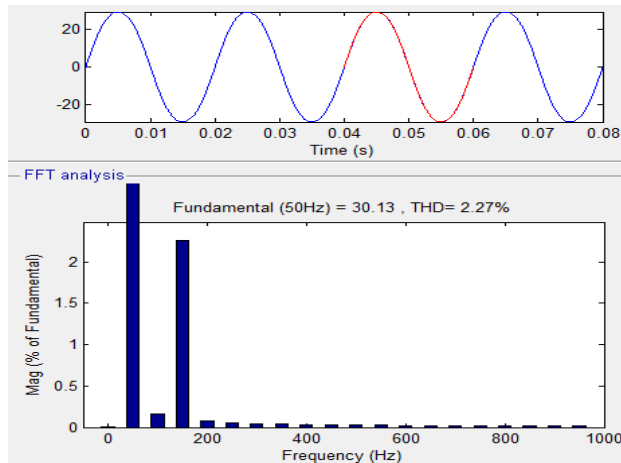


Fig.4.2 Input ac mains current (iia) along with its frequency spectrum of 28-pulse ac-dc converter fed SMPS at full load

### IV. AT LIGHT LOAD

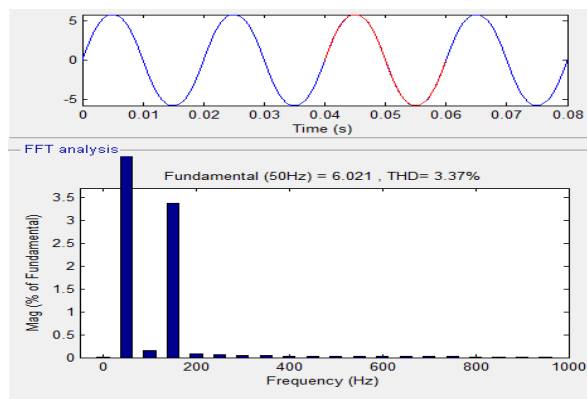


Fig.4.3 Input ac mains current (iia) along with its Frequency spectrum for 28-pulse ac-dc converter fed SMPS at light load

### V. CONCLUSION

The proposed autoconnected transformer based 28-pulse ac-dc converter feeding a 12 kW SMPS through an isolated full-bridge dc-dc converter has been modeled in SIMULINK environment with Sim Power System toolbox. The behavior of the converter is studied in MATLAB based simulation under various load conditions and also for varying leakage reactance of the autoconnected transformer. The % input ac mains current THD has been found less than 6% in the complete range of varying loads, with a power factor close to unity which meets the requirements of IEEE- 519 standard terms of THD of supply current and power factor.

### REFERENCES

1. D. A. Paice, "Power Electronic Converter Harmonic Multipulse Methods for Clean Power," IEEE Press, New York, 1996.
2. IEEE Recommended Practices and Requirements for Harmonics control in Electric Power Systems, IEEE Standard, 519, 1992.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 11, November 2013

3. Bhim Singh, Sanjay Gairola, Brij N. Singh, Ambrish Chandra, Kamal Al-Haddad, "Multipulse AC-DC Converters for improving power quality: A Review," *IEEE Trans. on Power Electronics*, vol. 23, no.1, January 2008.
4. Bhim Singh and S. Gairola , "A 40-Pulse AC-DC Converter Fed Vector-Controlled Induction Motor Drive,"*IEEE Trans.On Energy Conversion*, vol. 23, no.2, pp. 403- 411, June 2008.
5. G. R. Kamath, D. Benson, and R. Wood, "A novel autotransformer based 18-pulse rectifier circuit,"in *Proc. 2001 IEEE IECON, 2001*, pp. 795–801.