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ANALYSIS OF TOTAL HARMONICS DISTORTION USING MULTIPULSE CONVERTER

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Abstract: The work presents a deep effort towards analyzing line commutated controlled multi-pulse converters for solving the harmonic problem. The effect of increasing the number of pulses on the performance of AC to DC converters has been analyzed. For performance comparison the major factors considered are the ripple percentage, form factor and the total harmonic distortion (THD). The effects of load variation on multi-pulse AC to DC converters have also been investigated. This work presented 6, 12, 24 and 36 pulse converters.

Key Words: Multipulse converter, Harmonics distortion, Ripple counters.

1. Introduction

Three-phase controlled rectifiers have a wide range of applications, to large high voltage direct current (HVDC) transmission systems from small rectifiers. They are used for electrochemical processes, wide range of motor drives, controlled power supplies, traction equipment and other applications. The commutation process can be classified into two important categories namely: Line-commutated controlled rectifiers and Force-commutated pulse width modulated rectifiers

There are several techniques primarily adopted for the mitigation of harmonics in a 3-phase converter and multi-pulse converters fall in the same category of remedial measures. Multi pulse converters are the most fundamental solution for harmonic problem in a three-phase converter system. With the advancements in technology advances these converters and other power electronic devices with integrated magnetic featuring high input power quality and better performance would be required by many industrial, commercial applications, power supplies. The effect of increasing the number of pulses of AC to DC converters directly alters its performance parameters like ripple percentage, form factor and the total harmonic distortion.

Multipulse converters are converters providing more than six pulses of DC voltage per cycle from AC input or the converter having more steps in AC input current than that of six pulse bridge rectifier supply current. Phase shifting transformers are used to derive multipulse phase supply from three-phase AC mains using different combinations of transformer windings such as star, delta, zigzag, polygon, fork etc. In this thesis we use zigzag transformer.

The phase-shifting transformers play a key role in the multi-pulse rectifier's performance. Jiaopu et.al [1] discussed commonly used basic connections of phase-shifting transformer, such as Scott, polygon, star/delta, extended-delta and zigzag and gave the analyses and comparisons between them. Focusing on 12-pulse phase-shifting transformers, the research highlighted possible strategies from basic connections to 12-pulse phase-shifting transformers which illustrate the evolution and its basic principles which may be extended to higher pulse converters.

Singh et.al [3] analyzed the performance of multi-pulse electronic load controller for isolated asynchronous generator, as load controller conventional electronic based six pulse uncontrolled rectifier contains large content of harmonics.

A comparative study of three phase controlled multi pulse converters was presented by [4] for biomass, gas turbine, wind system based power plant, diesel, hydro, , and incorporated input current shaping of controlled rectifier using multi-pulse current shaping concept.

The author Xigeng et.al [6] introduced the realization of phase-shifting of the multi-pulse converter transformer and the method for calculating stretch phase-shifting angle, triangle voltage and the 7 number of windings and analyzed the simulation for the 30-pluse rectification system based on this transformer. Arvindan et.al [7] proposed two 24-pulse rectifier topologies based on phase shifting using conventional magnetic over PSCAD environment.

1. Controlled Rectifiers

There are two types of conversion techniques , one is uncontrolled in which diodes are implemented and other is controlled in which thyristors are implemented respectively [8].The performance improvement is achieved for total harmonics distortion (THD) in input current, DC voltage ripples and form factor. Three-phase controlled rectifiers have a wide range of applications, to large high voltage direct current (HVDC) transmission systems from small rectifiers. They are used for electrochemical processes, wide range of motor drives, controlled power supplies, traction equipment and other applications.

1.1 Three-phase Half-wave Rectifier

To control the load voltage, the half-wave rectifier uses three common-cathode thyristor arrangements. The thyristor will conduct (ON state), when the anode-to-cathode voltage V_{AK} is positive and a firing current pulse i_G is applied to the gate terminal. An angle α controls the load voltage by delaying the firing pulse.

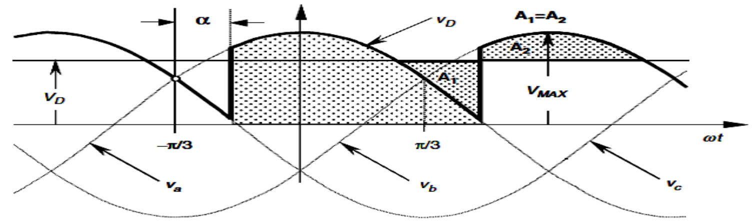

Fig 1: Instantaneous DC voltage VD, firing angle α and average dc voltage VD of half wave rectifiers.

The thyristor goes to the non-conducting condition (OFF state) when the following thyristor is switched ON, the current reached a negative value.

$$V_D = \frac{V_{Max}}{2/3\pi}\int_{-\frac{\Pi}{3}+\alpha}^{\frac{\Pi}{3}+\alpha} \cos\omega t.\, d(\omega t) \qquad (1)$$

1.2 Six-pulse or Double Star Rectifier

The thyristor side windings of the transformer shown in Fig.2, form a six-phase system, resulting in a six-pulse star point (midpoint connection). Disregarding commutation overlap, each valve conducts only during 60◦ per period.

$$V_D = \frac{V_{Max}}{\pi/3}\int_{-\frac{\Pi}{6}+\alpha}^{\frac{\Pi}{6}+\alpha} \cos\omega t.\, d(\omega t) \qquad (2)$$

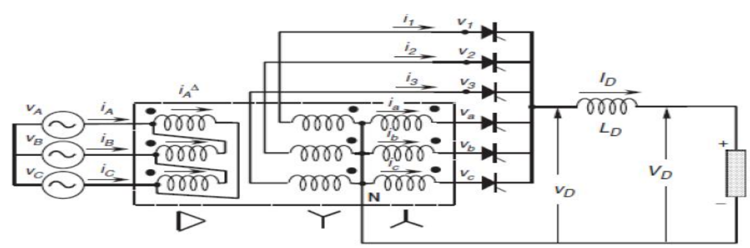

Fig 2: Six-pulse rectifier

2.3 Three-phase Full-wave Rectifier

Parallel connection via inter phase transformers permits the implementation of rectifiers for high current applications. For high voltage series connection is also possible, as shown in the full-wave rectifier of Fig.3. With this arrangement, it can be seen that the three common cathode valves generate a positive voltage with respect to the neutral, and a