Parallel Connected 12 Pulse Rectifier using Inter Phase Transformer

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Abstract

This paper presents simulation and analysis of twelve pulse rectifier transformer unit configured in series and also in parallel to have higher current capability and reduced harmonics, which creates the current imbalance and hence circulating current can be observed with parallel connection. Balanced current can be achieved with the introduction of Inter Phase Transformer (IPT) while paralleling two six pulse rectifier in rectifier transformer unit. PSCAD is used for performing all the simulations.

Keywords: Circulating Current, Harmonics, Inter Phase Transformer

1. Introduction

Twelve pulse drives are frequently applied in applications such as heating, ventilating and air conditioning because of its harmonic reduction capability. To gain higher current capability with reduction of harmonic in 12 pulse rectifiers, two 6 pulse rectifiers are connected in parallel. In case of source imbalance between two six pulse bridges leads to current imbalance and causes circulating current which can be avoided using inter phase transformer or inter balance transformer. An inter phase transformer absorbs voltage difference between DC voltage of instant and current imbalance can be avoided.

2. Series Configuration of 12 Pulse Rectifier

This simulation circuit shown below consist of a three phase-three winding transformer with two 6-Pulse rectifier connected in series employing 12 pulse configurations, forming a Transformer Rectifier Unit (TRU)⁹.

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Figure 2. Output voltage.

Figure 3. Output Current.

Figure 4. THD for Series configuration.

Figure 5. IHD for series configuration.

Figure 6. Parallel Configuration of transformer rectifier assembly.

Figure 7. Output Voltage.

Figure (4) and (5) shows total harmonic distortion and Individual harmonic distortion up to 15\textsuperscript{th} order for series configuration where 11\textsuperscript{th} order of harmonic is 7.34\% and 13\textsuperscript{th} order of harmonic is 4.39\% and total distortion is 8.7\%\textsuperscript{6}.

3. Parallel Configuration of 12 Pulse Rectifier

To have better current capability and reduced harmonic parallel connection of two six pulse rectifier is further simulated and analyzed. However, their parallel operation is more complicated due to fluctuations in DC voltages\textsuperscript{1}. In case of source imbalance or firing angle imbalance between six pulse bridge comprising 12 pulse rectifier leads to circulating current. To analyze this 3\% source imbalance is created in source of six pulse bridges\textsuperscript{3,10}.
Figure 8. Output Current with source imbalance.

Current imbalance due to source imbalance can be observed from Figure 8. Due to source imbalance current in one set of rectifier (i1) will be more than current flowing in rectifier set two (i2) which is supplying less voltages. Therefore some amount of circulating current will flow which is undesirable.

Figure 9. THD for Parallel configuration.

Figure 10. IHD for Parallel configuration.

Figure 11. Parallel Configuration of transformer rectifier assembly with IPT.

Figure 12. Output Voltage.

get reduced with this parallel configuration which can be analyzed from Figure (9) and (10). Total harmonic distortion is reduced to 6.37% and also IHD for 11th order is 5.7% and for 13th it is 2.65%.

Two or more rectifier systems with displaced ripple voltages can be connected in parallel through an Interphase Transformer (IPT), which absorbs difference between DC voltages of individual systems. Again with 3% source voltage imbalance and with introduction of interphase transformer system is simulated and analyzed.
Analysis of Figure (11) and (13) shows that systems can be connected in parallel without any circulating current, if their DC voltages are equal at any instant, i.e., if their average values are equal and ripple voltages coincide, which can be achieved with the use of IPT.

4. Conclusion

From simulation results it can be analyzed that parallel combination of two or more rectifier system increases current carrying capability as well as reduces content of harmonics but introduces current imbalance at the output which further can be avoided using interphase transformer.

5. References

3. Hink KM. Harmonic mitigation of 12-pulse drives with unbalanced input line voltages. MTE Corporation.