MITIGATION OF HARMONICS IN A.C.DRIVE BY USING MULTI-PULSE TRANSFORMER SOLUTION

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ABSTRACT:

With the increasing of use of power electronic controlled variable speed drives in industries, power quality distortion in electric power system has become a serious issue in recent years. In steel plants, because of presence of more number of adjustable speed electric drives, this problem is a greater concern. In this paper, the impacts of harmonic distortions due to Adjustable speed electric drives in Jindal Saw Ltd, Mundra, Gujarat, India is investigated. Harmonic measurements at various motor drives with the help of Fluke 434 power quality analyzer have been done to determine where a significant amount of harmonic currents or voltages are presented. From these measurements and subsequent calculations, the impact of harmonics is analyzed and found that the harmonic content of the motor drives to be minimized within the limits of international harmonic standards. In recently, multi pulse drive solution gained an increased attention due to their effective harmonic reduction. In this paper a phase shifting transformer has been developed for minimization of the harmonics, which is implemented in Matlab/Simulink based on real time measurement of harmonic data

***Keywords**: Adjustable Speed Drives, Harmonics, Phase shifting transformer, Powerquality, PWM Generator block,*

1 INTRODUCTION

The In modern power system, due to increase controlling technology, power quality has become a great concern. Non-linear loads, which were only 15 % of total loads in 1987,have increased to 75 % in 2012.These non-linear loads introduce harmonics into the supply system and draw non-sinusoidal currents from ac mains and cause reactive power burden ,excessive neutral current, Low power factor, Low energy efficiency ,interference by EMI and distortion of the line voltage,etc.[1,2]. The variable speed drives comes under non-linear loads and they are one of the major source of harmonics generation and power quality [problems. Harmonics are the main cause of power quality of the electrical power system. Therefore, the standard regulations and recommendations such as IEC 61000-3-2 and IEEE 519 enforce to limit the above problems [3].Filtering is a common method for suppressing harmonics [4, 5].

Inthispaper, theimpactsofharmonicdistortions duetoelectricdrives inJindal Saw Ltd, Mundra, Kutchh-Bhuj (Dist), Gujarat, India, whichismajorsupplierofsteeltomostofthe Industries/organizations in all over the world, is investigated. The harmonic measurement is done with Fluke431Apower quality analyzer. From the measured data, it is found that the harmonic content of motor drives needs to be reduced within the limits international harmonic standards. In recently multi-pulse technology gained an increased attention due to their effective harmonicreduction.Inthispaper, anadvance strategy hasbeendesignedforminimization oftheharmonicsandresultsarepresentedintermsofpercentageTHDwithout and with advance strategy. Standard AC drive topologies utilize AC-DC-AC power conversion with a three phase rectifying bridge for the AC-DC function. A three-phase diode or SCR bridge generates 6 pulse type current that is ~ 32% rich in total harmonic current distortion [2]. As ac drives proliferate, equipment system specifications limiting the amount of harmonic current injected into the grid are becoming more common and thus solicit cost effective harmonic mitigation solution

1. ANALYSIS OF HARMONICS IN STEEL PLANT

Power quality problems especially harmonic distortion associated with non-linear load such as Variable Frequency Drive (VFDs) and Induction Furnace are addressed in several papers in general, but paper deal with harmonic distortion in a steel industry is found to be very less. Hence, an attempt has been made in this paper to study harmonicanalysisofelectricmotordrivesand Induction Furnaceeffectofharmonicdistortioninthesteel plant(Figure1).Thesteelplantconsideredinthisstudyproduces 2500tonssteelperday.Theplant electricaltariffisRs.60 Lacs per Monthandmotordrives and Induction furnace aloneconsumenearly45-55%ofpower accordingtotheiroperationalload.Inthesteelindustry,themotordrivesand Induction furnace areusedindifferentpower ratings forvariousapplicationssuch asCrushers, kilncooling system, steelmillcooling, rawmillcooling, coal mill cooling,steel millclassifier,coalmill classifier,belt conveyors, hot metal heatingetc. The drivemotorrating varies from few KW to several hundred KW depending on the application.

3. HARMONIC PROFILE WITHOUT FILTER

3.1. 132 kW blower id fan

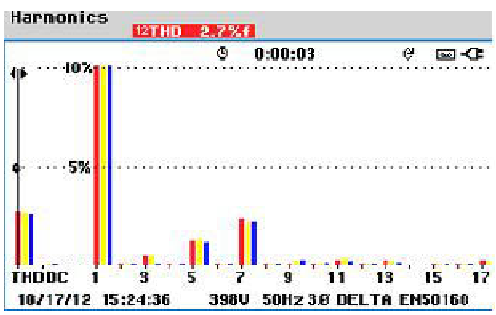

Fig.3.1 (a) Voltage harmonics of blower fan

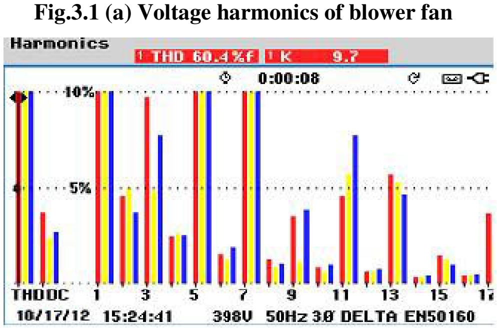

Fig.3.1 (b) Current harmonics of blower fan

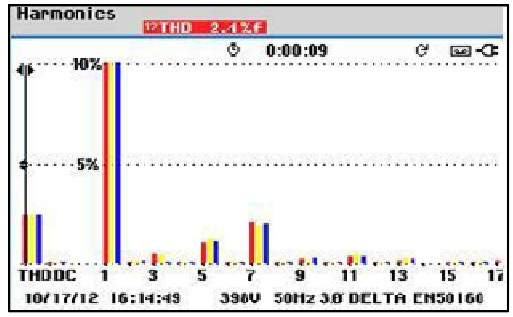

Fig.3.2 (a) Voltage harmonics of blower fan

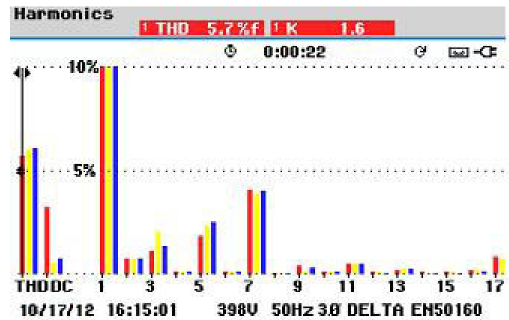

Fig.3.2 (b) Current harmonics of blower fan

4 HARMONIC MITIGATING TRANSFORMERS OR MULTIPLES DISTRIBUTION

4.1 SIX PULSE

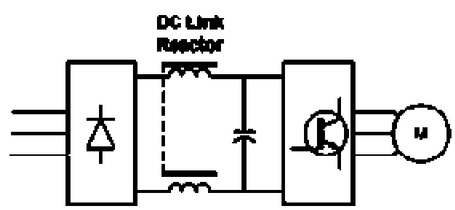

Fig 4.1 Six pulse arrangement.

4.2 TWELVE PULSE

This is similar to a 12-pulse converter, on a macroscale. If two AFDs of equal HP and load are phase shifted by feeding one AFD from a delta/wyetransformer, and feeding the second through adelta/delta transformer or a line reactor of equivalentimpedance, performance similar to 12-pulse may beachieved. The cancellation will degrade as the loadsvary from AFD to AFD, although as the load on single AFD decreases, the individual distortioncontribution percentage decreases, resulting in less ofa need for cancellation. It is possible for a facilitywith a large number of AFDs to feed twohalves ofthe distribution from phase-shifted transformers,yielding a large reduction in harmonic levels for minimal cost, and allowing a higher percentage ofAFD loads under IEEE Std 519-1992 guidelines. Multiple transformers can be used to develop different phase shifts between sources of harmonic currents. For example, two transformers with a 50Hz phase shift of 30 degrees between them will resulting cancellation of the 5th, 7th, 17th, and 19, etc. harmonics and will resemble 12 pulse drive system. Four transformers shifted by 15 degrees with respect to each other will result in a 24-pulse distribution and will significantly minimize the resulting harmonics upstream of the common bus.

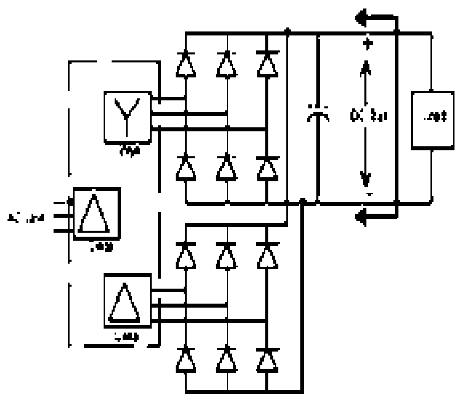

Fig.4.2 Twelve pulse transformer solution.

Advantages

- Cost may either be low or high depending on implementation
- Provides substantial reduction (50-80%) in voltage and current harmonics
- Provides increased input protection for AFD and its semiconductors from line transients

Disadvantages

- Cost may be low or high depending on implementation
- Impedance matching of phase shifted sources is critical to performance
- Maximum cancellation occurs only if drive loading is balanced
- May not reduce harmonic levels to below IEEE Std 519-1992 guidelines

4.3 EIGHTEEN PULSE (18 pulse)

This method is similar to 12-pulse converters, although instead of using two phase shifted power sources and semiconductor bridges, three are used. One manufacturer uses a specially wound autotransformer (Differential Delta) and 18 input semiconductors. When this arrangement is used, over90% of harmonic currents are canceled (Typical total harmonic current distortion of 2-3%).

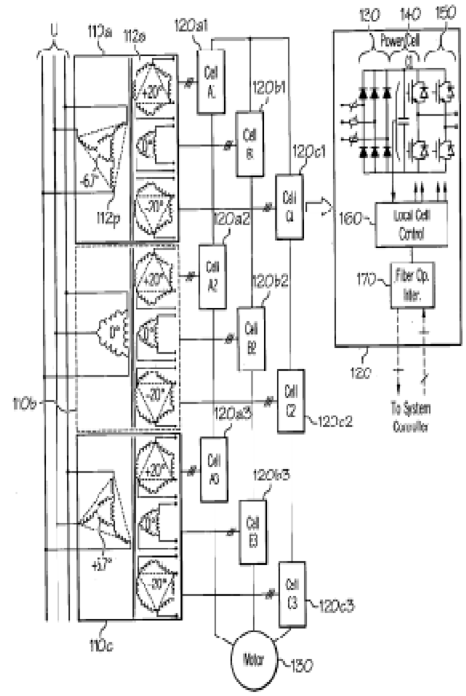

Fig. 4.3 Eighteen pulse transformer-winding connection to rectifier

Advantages

- Virtually guarantees compliance with IEEE Std 519-1992 – excellent for drives >100 HP
- Provides increased input protection for AFD and its semiconductors from line transients
- Up to 4 times the harmonic reduction of 12 pulse methods
- Smaller transformer than isolation transformer used in 12-pulse converter

Disadvantages

- Higher cost (but much better performance)

4.4 TWENTY FOUR (24) PULSE

- This method is similar to 18-pulse converters, although instead of using four phase shifted power sources and semiconductor bridges, four are used. One manufacturer uses a specially wound autotransformer (Differential Star) and 24 input semiconductors. When this arrangement is used, over 95 % of harmonic currents are canceled (Typical total harmonic current distortion of 1.2-1.5%).

Advantages

- Virtually guarantees compliance with IEEE Std 519-1992 – excellent for drives >100 HP
- • Provides increased input protection for AFD and its semiconductors from line transients

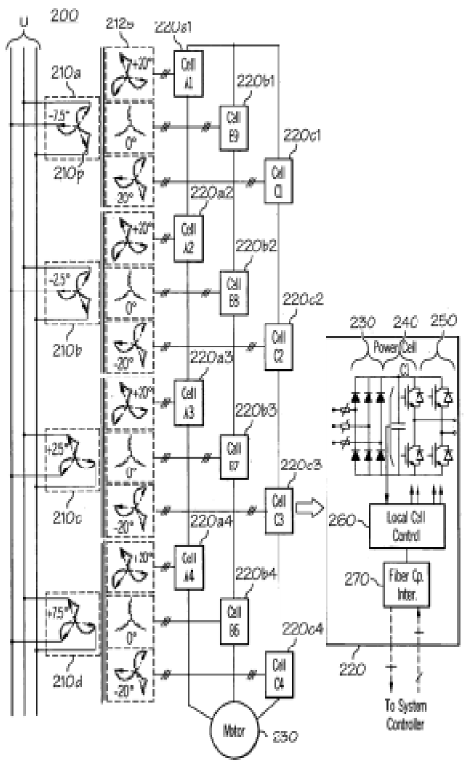

Fig. 4.4Twenty-four pulse transformer-winding connection to rectifier

5. TEST AND SIMULATION RESULT

5.1 Six pulse simulation model

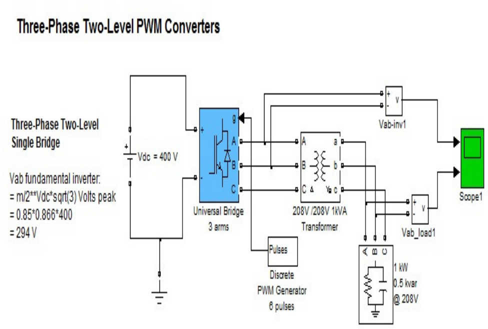

Fig 5.1 Six pulse simulation model

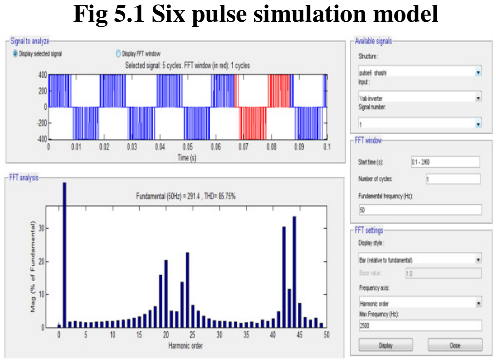

Fig 5.2 Six pulse voltage THD

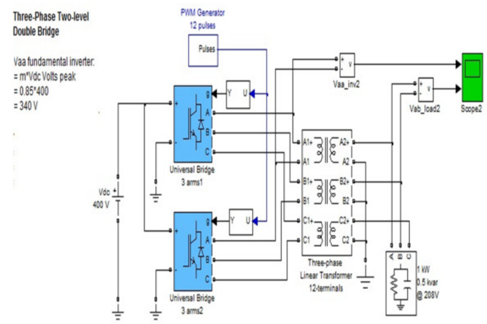

Fig 5.4 Twelve pulse simulation model

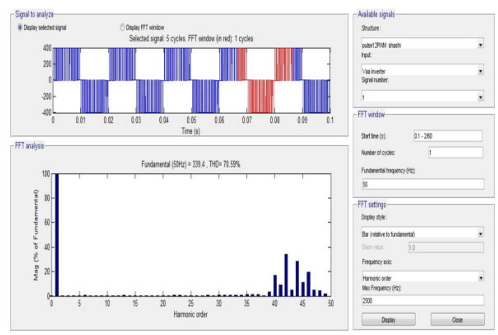

Fig 5.5 Twelve pulse voltage THD

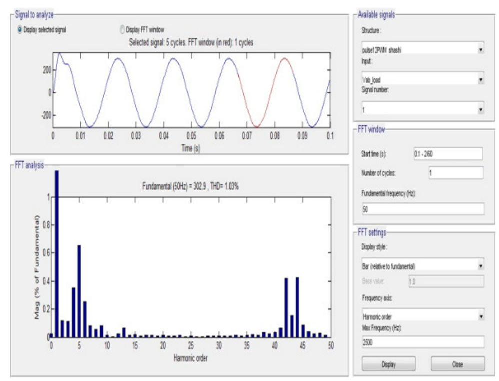

Fig 5.6 Twelve pulse current THD

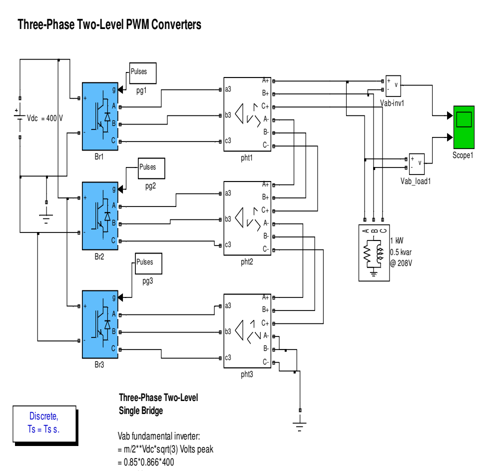

Fig 5.7 Eighteen pulse simulation

model

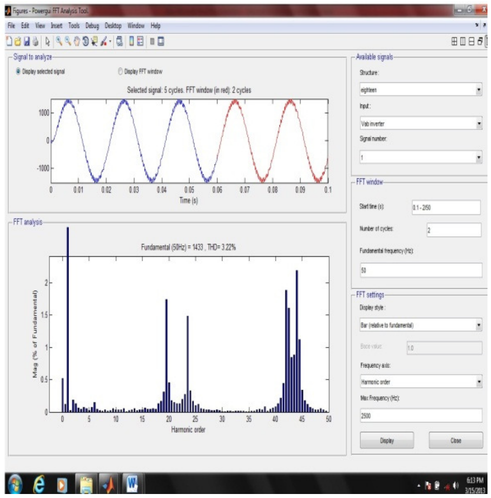

Fig 5.8 Eighteen pulse voltage THD

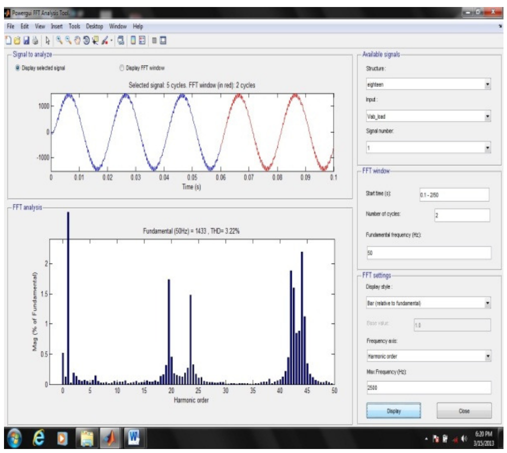

Fig 5.9 Eighteen pulse current THD

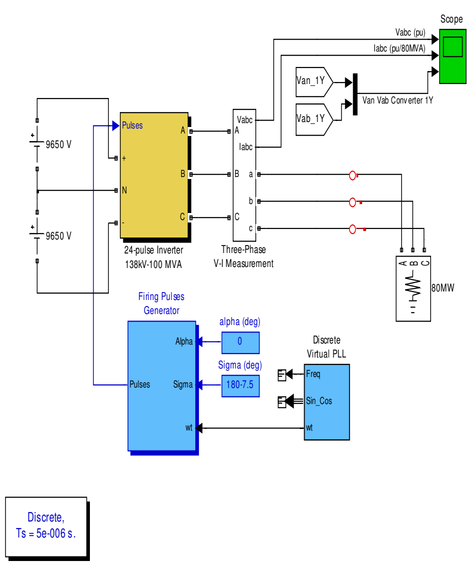

Fig 5.10 Twenty four pulse simulation model

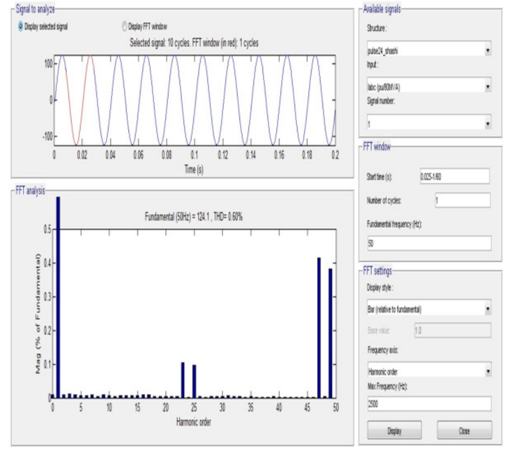

Fig 5.11 Twenty four pulse voltage THD

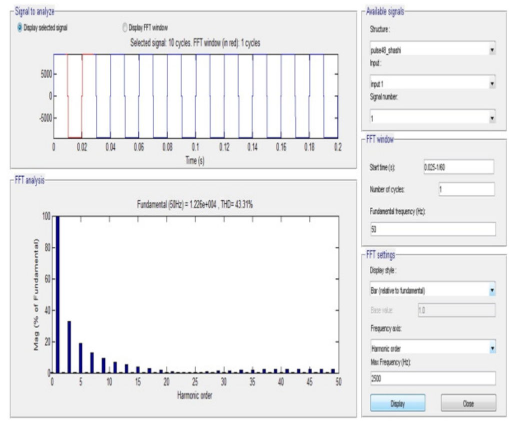

Fig 5.12 Twenty four pulse current THD

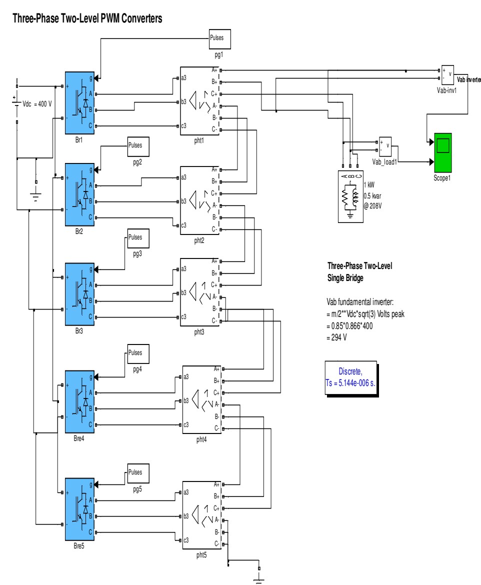

Fig 5.13 Thirty pulse simulation model

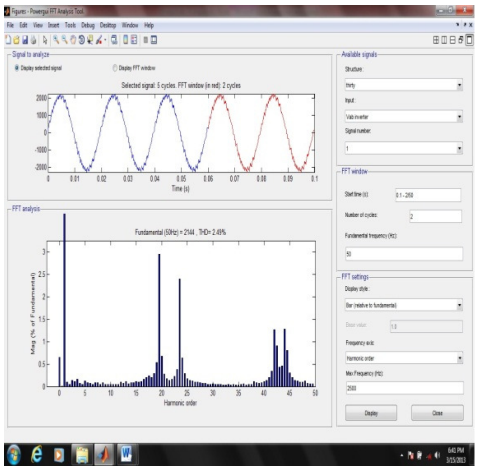

Fig 5.14 Thirty pulse voltage THD

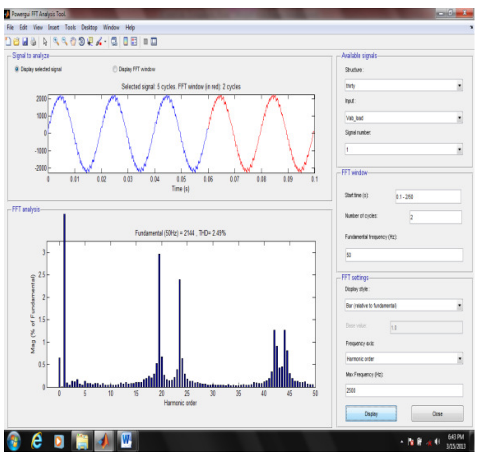

Fig 5.15 Thirty pulse current THD

6 CONCLUSIONS

This paper proposed several multi pulse based phase Autotransformers topologies to meet standard IEEE 519. Compared with other solutions, autotransformers possess such advantages as being simple, reliable, no resonance problem and relatively cost effective, as well as small physical size. The proposed AC/DC converter topologies utilizing these transformers were shown to not have current sharing problems.Working units at industrial field sites, ranging in HP sizes from 50 HP to 800 HP, are based on these topology patents [8-11]. The paper provided technical analysis and field site data on the new topologies, as well as comparison to other harmonic mitigation techniques versus horsepower size

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