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Harmonic Analysis of VFD's

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Abstract: *VFD's are the power electronic control devices that provide unique and beneficial opportunities for AC induction motors control. VFD's offer process control through speed variation and starting control for motors. VFD's convert/rectify voltage from a constant frequency alternating current (AC) power system to create a direct current (DC) voltage link, and then electronically invert the DC voltage link to create a variable voltage variable frequency output. While doing this conversion the supply is rectified and inverted using power semiconductor devices. This conversion process generates harmonics in the line current waveform and power gets polluted.*

Keywords: *Variable frequency drives, Total harmonic distortion, Power harmonic analyzer.*

I. Introduction

The harmonic distortion depends on the network impedance, the technology used in the VFD incoming rectifier and the impedance values of the components used in the VFD power circuit. The most commonly used frequency converter is of a type called pulse width modulation (PWM). This uses a 6-pulse diode rectifier. Many manufacturers are using inductances to reduce the harmonic distortion level. With the inductances, the typical THD (total harmonic distortion in current) value is around 30%. Without the inductance, it can be 70% to 120%. Industries with heavy motor load and VFDs generate harmonics and thus pollute the power. It also affects other consumers also. Therefore consumers are required to evaluate the impact of their plants on the power system. For this reason, it is necessary to measure harmonics at the Point of Common Coupling (PCC).
Three phase ac power supply is rectified into dc voltage by the rectifier unit and smoothed by a bank of smoothing capacitors. These smoothing capacitors act as a constant voltage source for the inverter stage of the VFD. Hence the name voltage source inverter type of VFD. The dc bus voltage is inverted using pulse-width modulation strategies and fed into the induction motor. The output frequency of the inverter is controlled by a control circuit to meet different load conditions. Theses VFD's area major source of the harmonics in the power system and thereby pollute power. VFD's control speed of the motor over the entire load range. Therefore for harmonic mitigation VFD's must be analyzed taking into account load variation.

II. Harmonic analysis of VFD

Variable Frequency Drives (VFD's) have grown rapidly in their usage in recent years because of many advantages. An unfortunate side effect of their usage however, is the introduction of harmonic distortion in the power system. As a non-linear load, a VFD draws current in a non-sinusoidal manner, rich in harmonic components. These harmonics flow through the power system where they can distort the supply voltage, overload electrical distribution equipment (such as transformers) and resonate with power factor correction capacitors among other issues.
In Harmonic Spectrum of VFD:

- Lower harmonic orders have the higher magnitudes
- Magnitudes should decline as the harmonic order increases

If the harmonic spectrum exhibits abnormal magnitudes, it is a good sign of harmonic resonance typically caused by interaction with Power Factor Correction Capacitors. The following VFDs were analyzed and 5th harmonic component was recorded at various frequencies. Harmonic signatures of the VFD were taken at different frequencies. Equipment taken under consideration is a Cooling Tower Fan motor, Make- Marathon, V= 415 V, F = 50 Hz, kW =18.5,HP =25, RPM =1460, % Eff =90.5, P.F =0.85 Amp =33.5
VFD details: Model Power Flex 700, Make Allen Bradley, Normal duty Power= 30 Kw 40 HP, Heavy duty Power = 22 kW 30 HP, Input 3 Ph. - 47- 63 Hz, AC voltage Range =342 - 440 V, Amp = 53, Output 3 Ph. 0-400 Hz, AC voltage Range 0- 400, Base Hz = 50, Continuous Amp =56, 1 Min over Load Amp =64, 3 sec Overload Amp =86

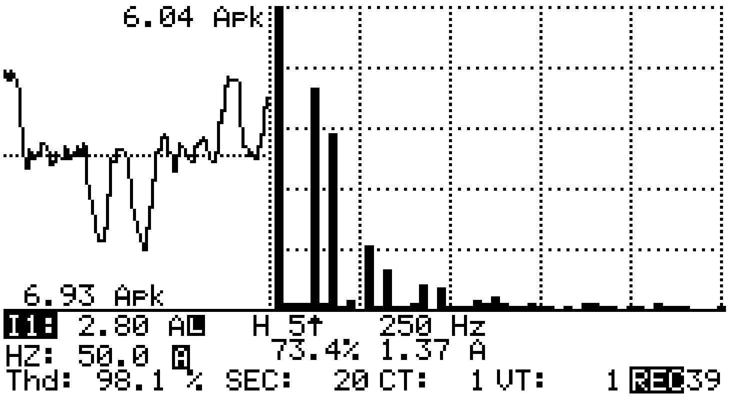

Fig 1 : Harmonic signature at 20 Hz

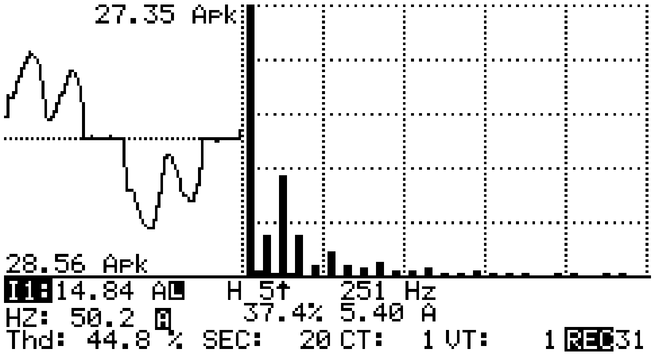

Fig 2: Harmonic signature at 40 Hz

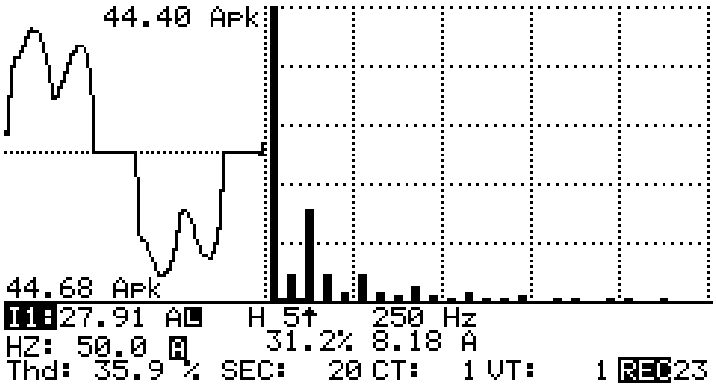

Fig 3: Harmonic signature at 50 Hz

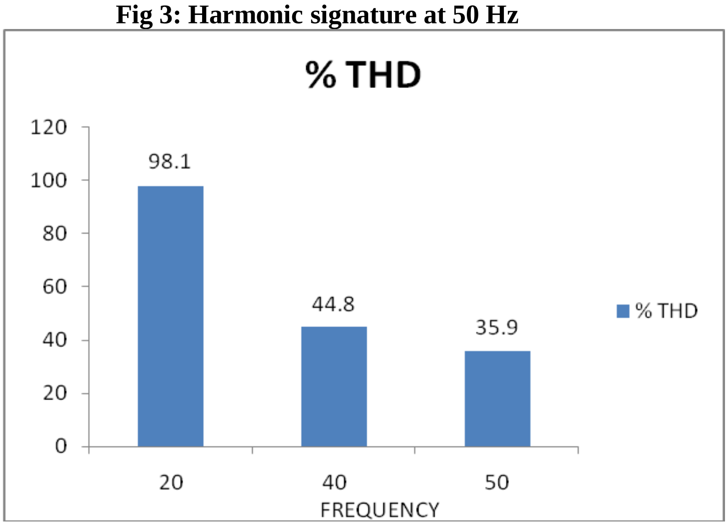

Fig 4: %THD Vs Frequency in Hz

Fig. 5 Photograph of actual experimental set up

III. Conclusion

- In all the VFDs, %THD falls with the increase in frequency.
- In all the cases, 5^{th} harmonic component was the highest one.
- As the harmonic order increases its value decreases i.e. 7^{th} , 11^{th} and so on all the components are smaller than 5^{th} harmonic component. Thus there is no harmonic resonance

IV. Future Scope

Based on the work done filter can be designed to mitigate harmonics generated by the variable frequency drives considering the variations introduced in the THD % age because of variation in thefrequency of the drive.

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