Harmonics Generation by Low Capacity VFD (Variable Frequency Drive), When Used In Energy Saving

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Abstract--- Seventy Percentages (70%) of electrical energy generated is consumed by three phase induction motors (3ф IM) all over the world and the demand is increasing day by day because of industrial growth. This means that if we save electrical energy consumed by 3ф IM, it can be a huge saving of energy as well as natural resources. To save energy consumed by 3ф IM a Variable Frequency Driver (VFD) is the best solution when used in a variable speed application. With the use of VFD, 3ф IM drive takes exactly the desired amount of power from the supply line. It means that power will not be lost in mechanical components. This is direct saving of electrical energy. In this paper, it is a humble effort to evaluate the harmonics generated by the VFD when used in energy conservation application. In this paper we will also give a kind of power line filters are necessary for the electronics components mounted on the same supply line. An energy conservation test setup will be made for variable flow application. The pump motor is given supply from both the VFD and direct contactor one by one. The consumed energy and harmonics generated along with Total Harmonics Distortion (THD) is measured with the help of three phase power analyzer and the results are compared internally as well as with simulation results.

Keywords: - variable Frequency Drive (VFD), Induction Motor (IM).

I. INTRODUCTION

The third-harmonic injection technique is applied to an induction motor driven by a voltage-source inverter. Variable frequency drives (VFDs) are well known harmonic sources. Be it domestic application or industry, motion control is required everywhere. The systems that are employed for this purpose are called drives. Such a system, if makes use of electric motors is known as an electrical drive. In electrical drives, use of various sensors and control algorithms is done to control the speed of the motor using suitable speed control methods. The basic block diagram of an electrical drive is shown below:

![Block diagram of an electrical drive](image)

Fig. 1: Block diagram of an electrical drive

Seventy Percentages (70%) of electrical energy generated is consumed by three phase induction motors (3ф IM) all over the world and the demand is increasing day by day because of industrial growth. This means that if we save electrical energy consumed by 3ф IM, it can be a huge saving of energy as well as natural resources. To save energy consumed by 3ф IM a Variable Frequency Driver (VFD) is the best solution when used in a variable speed application. With the use of VFD, 3ф IM drive takes exactly the desired amount of power from the supply line. It means that power will not be lost in mechanical components. This is direct saving of electrical energy.

Further the rest of paper is organized as follows: section II deals with a brief technical description of several approaches. Section III provides theoretical comparison and analysis of those approaches based on the data embedding capacity as evaluation factor. And finally section IV delivers the conclusions.

II. THEORY OF BACKGROUND

In this section explained about harmonics, Harmonic Distortion, Harmonic Spectrum.

A. Study about Harmonics

A Harmonic is a signal at a frequency that is a multiple of the fundamental or base frequency. Odd multiples (3rd, 5th, 7th.) are known as odd order harmonics and are caused by symmetrical distortion or the waveform. Even multiples (2nd, 4th, 6th.) are known as even order harmonics and are caused be asymmetric distortion. The positive and negative halves of the waveform are distorted unequally. Half wave rectifiers because even order harmonics and full wave rectifiers cause even order harmonics.

B. Need of VVVFD (VFD)

70% of the power generated is consumed by 3 phase induction motors (3ф IM), worldwide.

Population of low capacity 3ф IM is significant in industry. From speed equation of 3ф IM

\[ N_s = 120f/p \]

In industry we require variable speed motor to control various industrial parameters like flow, pressure, temperature etc. Variable voltage Variable Frequency Drive (VVVF or VFD) can be used to control the speed of 3ф IM. To control speed of 3ф IM, VFD changes frequency along with voltage to keep the flux constant. Flux is kept at knee point of the magnetic material used in 3ф IM to avoid adverse effects caused by destructive harmonics. As VFD changes voltage it offers different power to 3ф IM. Up to rated frequency VFD can run the 3ф IM at different power.

C. Circuit Diagram of VFD

Power portion of block diagram of VFD shows that the supply line is connected with a rectifier block which
converts AC supply into DC which is further getting converted into variable voltage variable frequency supply by output inverter IGBTs after proper filtration this variable voltage variable frequency supply is given to 3фIM for variable speed application. The heart of a VFD is really a power inverter a device that converts DC power to AC power.

The inverter section of a VFD typically uses a microprocessor to manage 3 bipolar pairs of semiconductor switches to synthesize three pseudo sine wave output voltages which are zero, 120, and 240 degrees apart in their phase relationships. The semiconductor switch pairs feed from the DC bus, and deliver pulses of Direct Current to each of the three phase load terminals of the drive in sequence. The microprocessor controls the pulse durations and polarity to synthesize a pseudo sine wave of variable frequency. If each one of the 3 rectifier packages is by itself large enough to support the intended load, then a single phase power source can be used, and the 2 unused diode packages can be left unterminated In practice, I connect one side of the single phase line to L1, and the other side of the single phase line to both L2 and L3 to allow these two rectifier packs to share the load. The wider voltage swings in the capacitor's charge/discharge cycle, when running on single phase, exaggerate the heating effect on the capacitor bank. This heating effect is minimized when the drive is powered from 3 phase current. So if only single phase power is available, then one very important benefit gained from using a VFD is that you don’t need a separate phase converter with its attendant cost, installation, noise, electrical inefficiencies, and eventual maintenance. And all the phase converters I am aware of have current balance problems where leg currents vary with load. Motor loads don’t like this, even if they are able to grin and bear it for a while. It is used as an energy saving.

D. Harmonic Distortion
Location Prediction is built both the sender and the receiver side Harmonic problems are becoming more apparent because more harmonic producing equipment is being applied to power systems, VFD’s, Electronic Ballasts, UPS. Additionally, in many cases, these electronic based devices can also be more sensitive to harmonics.

III. SIMULATION AND RESULTS

![Fig. 3: simulation circuit with SPWM](image)

![Fig. 4: 750 Hz Modulation index 1.0](image)

![Fig. 5: 750 Hz Modulation index 0.9](image)

![Fig. 6: 1500 Hz Modulation index 1.0](image)

![Fig. 7: 1500 Hz Modulation index 0.9](image)
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IV. CONCLUSION
As per survey we conclude that Practical implementation of VFD with 3ϕIM in energy saving mode, Finding harmonics generated by the VFD in supply line with respect to energy saved using power analyzer. The induction motor performance is affected by the harmonics in the time variation of the impressed voltage. Rectifier is a well-known non-linear load. Because of non-linearity, it produces harmonics in the supply line. The current requirement changes on the basis of load condition Amplitude and the nature of harmonic generation changes with the current drawn from the supply line.

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REFERENCES