HARMONICS REDUCTION USING HARMONICS INJECTION METHOD

Devika sathyaprakasan

Electrical and Electronics Engineering Department, APJ Abdul Kalam Technological University

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Abstract - *This paper presents a current harmonic injection technique to cut back harmonics from induction motor drive. Nowadays many industries victimization variable frequency drives for an induction motor. These VFD generates completely different harmonics that causes heating of motor, the introduction of EMI, malfunctioning of measure instrumentality. Harmonic distortion mostly occurs wherever loads withdrew non-sinusoidal current from the system. It is chiefly gifted wherever AC is converted into DC. The voltage provided by an influence system is mostly not a pure sine wave. It usually possesses some quantity of distortion that includes a harmonic and harmonics at that frequency.*

Key Words: Harmonic reduction, Harmonic injection, VFD, induction motor

1. INTRODUCTION

There is a large growth in industrial and domestic appliances in recent years. Power system disturbances that occur in an electrical system can cause damages to the appliances, failure of motor insulation due to overheating, and also causes reduction in efficiency of the circuit breakers. There are many issues in the power quality system. Voltage fluctuations, transients, sag, swell are the most common power quality issues encountered. Harmonics are the main power quality disturbance that can happen in a power system since the nonlinear loads are increasing. Harmonics are basically the addition of integral multiple of fundamental frequency of voltage or current along with its fundamental sinusoidal waveform. Harmonic distortion can occur due to variable frequency drives and other nonlinear loads. A nonlinear load can be defined based on its impedance changes with the applied voltage which leads the current to be not in proportion with the voltage. Nonlinear devices are those which switch on and off the current. In many appliances, AC is converted into DC for different purposes. Due to this conversion, many appliances draw current near the peak. Irrespective of applied voltage these circuits drew non-sinusoidal current which leads to current distortion. In the current scenario, almost all the equipments used causes harmonics. The statistics shows that within a decade there is an increase in harmonics from 5% to 95%.

The harmonics have the following properties:

- Lower order harmonics have the high magnitude.
- There are no even harmonics due to half-wave symmetry.
- Harmonic emission is additive in nature.

Distortion in current causes distortion in voltage. The amount of voltage distortion depends on the impedance of the system and the amount of distorted current drawn by the impedance.VFD section has a converter section which converts AC into DC, an inverter section converts DC into variable frequency AC. Both sections ie; inverter and rectifier, contain non-linear devices.

Devices used in the Converter section generate harmonics which is known as line-side harmonics and the harmonics which are generated in the inverter section are known as load side harmonics. Line side harmonics affect the power system while load side harmonics affect the load. If the current harmonics in the system increases above the critical level, the reduction in harmonics is required. AC line reactor can be used to reduce harmonic distortion, but this causes a reduction in voltage. The rectifier becomes susceptible to supply surge switches is a disadvantage of DC inductors in the application of harmonic reduction, as well as an inductor doesn't reduce the higher order harmonics efficiently.

The use of 12 pulse drive over 6 pulse drive increases the initial cost by 500%. It also increases the size due to the extra bridge and transformer. Higher the operating losses, lower the efficiency. Passive filters can be used to reduce the harmonics depending on the level of mitigation, but it increases the total cost of the installed drives as well as the losses. Third harmonic Source can be obtained through midpoint voltage of the split capacitor in DC side and inject into supply side input circuit. Additional components like capacitor and inductor required which increases size and cost. This method is limited for third harmonic injection only.

Harmonics can be reduced at the connection point of DC to AC converter. The converter is a buck-boost DC converter in series with changing polarity. Specific harmonics can be cancelled but this method makes no distinction whether harmonics are created from the converter itself or supplied by other sources to the connection point.

New technique is proposed by using three bi-directional switches as an injection device instead of using a zigzag transformer in conventional methods. The cost and size of the zigzag transformer are very high compared with three bi-directional switches.

By using this method minimum current harmonic with minimum increasing diodes power rating is present based on replacing the injecting devices by three bi-directional switches, in this case, the peak current of the diode is increased by 23.5% compared with without injection case. The line currents of a three-phase controlled converter have Total Harmonic Distortion higher than the harmonic standard limits. One of the most effective techniques to limit THD id by the circulation of third harmonic current from dc-link to the road currents.

In this paper one part controlled converter within the injection path to regulate the angle of injection current for every firing angle of the three-phase controlled converter is introduced.

IEEE standards regarding the harmonics are provided in IEEE519.IEEE 519 was firstly introduced in 1981 as an "IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters". It defines the maximum level of harmonic contents acceptable in the distribution system. The IEEE working groups of the Power Engineering Society and the Industrial Applications Society creates the guidelines for power quality that must be supplied. They have mentioned few of the limitations for industrial user to injection of harmonics.

According to the revised version of IEEE 519 in 1992, since harmonic current reflected through distribution system impedances generate harmonic voltages on the distribution side, hence the industrial system is responsible for controlling the harmonics created in the workspace. In 2004, an IEEE unit named "519 Revision Task Force (PES/T&D Harmonics WG)" was created to revise the 1992 version of IEEE 519 (Recommended Practices and needs for Harmonic management in wattage Systems) and develop an application guide IEEE 519.1 (Guide for Applying Harmonic Limits on Power Systems). In the last 20 years, there is a significant change in appliances and power system. This revision includes the change in the last 20 years with regard to harmonics, their effects on power equipment, and how they should be limited.

2. BLOCK DIAGRAM

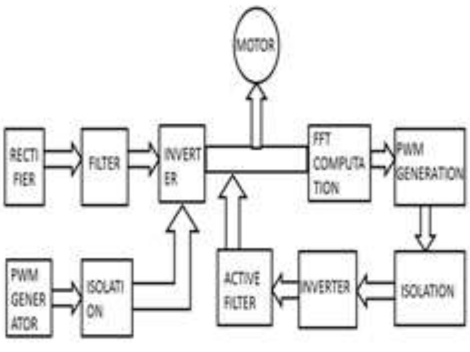

Fig-1: Block diagram

230V, 50 Hz AC input is applied to a diode-based uncontrolled rectifier which converts AC into pulsating DC. A filter is used to convert pulsating DC to smooth (ripple free) DC. Ripple free DC is applied to inverter input. An inverter is used to convert constant DC voltage into variable frequency and variable AC voltage.PWM technique is used to change the duty cycle, which resultant into variation in AC voltage irrespective of constant DC voltage. PWM generator is used to generate gate pulses to the IGBT of an inverter. Opto-isolator is used to provide the isolation between the control circuit and power circuit. Opto-isolator is used for high switching frequency. The above-described blocks are nothing but Variable Frequency Drive. VFD is used to drive Induction motor at variable speed, by varying the voltage as well as frequency.

3. SAMPLING

To implement a harmonic injection method load current signal is required. This signal is used to measure, monitor the total harmonic distortion in the current signal. The current transformer is used to monitor the current to nonlinear load. This signal filtered to remove the noise problems. Higher the sampling rates of the current signal, the higher the accuracy of harmonics characteristics. Samples of current are further processed to calculate the harmonic power compensation reference. There is a number of techniques to compensate the harmonics. This paper focuses on the FFT algorithm. The FFT calculation is performed for each cycle.

$$X\,(K) = \sum_{n=1}^{\infty} x(n)\, e^{-\frac{i2\pi kn}{m}}$$

Real part,

$$X'(K) = \sum_{n=0}^{\infty} x(n) \cos\frac{2n\pi k}{m}$$

Imaginary part,

$$X''(K) = \sum_{n=0}^{\infty} x(n) \sin\frac{2n\pi k}{m}$$

Where,
K: Harmonic order
x (n): Input current sample
M: No. of samples in one cycle
X (K): Magnitude of Kth harmonic order

$$\text{Amplitude}=\sqrt{(\text{Real part})^2 + (\text{Imaginary part})^2}$$

$$\text{Phase}=\tan^{-1}\left(\frac{imaginary}{real}\right)$$

4. VOLTAGE SOURCE INVERTER

If the input to the inverter is a dc voltage source, the inverter is called a voltage source inverter. Single phase voltage source inverters are basic inverters which produce a square shape AC output with a DC input. These inverters have simple on-off control logic and obviously, they operate at much lower frequencies. Due to a capacity of low power, they are widely used in power supplies. The voltage source inverter plays an important part in harmonics injection method. It is a single phase, full wave Inversion Bridge which is designed by using 4 switches, preferably IGBT since IGBT is naturally commutated. Each IGBT used in inverter have separate control over them and also an electrical isolation from the controller. Here we are incorporating a snubber circuit for the protection of IGBT. Snubbers are used to suppress the voltage spikes which occur in the equipment, in this case IGBT

5. PWM PULSE GENERATION

In this method, the inverter is not operating with a constant frequency. A single inverter is generating different frequency components. Pulses are generated in such a way that voltage source inverter will generate the same output waveform as that of VFD output waveform except for fundamental frequency component. The output of an inverter is injected into the VFD output with a 180 phase shift. The output of inverter will compensate the current harmonics at the output of VFD. PWM pulses are generated using the feedback of FFT computation. Higher the frequency of inverter better the current compensation

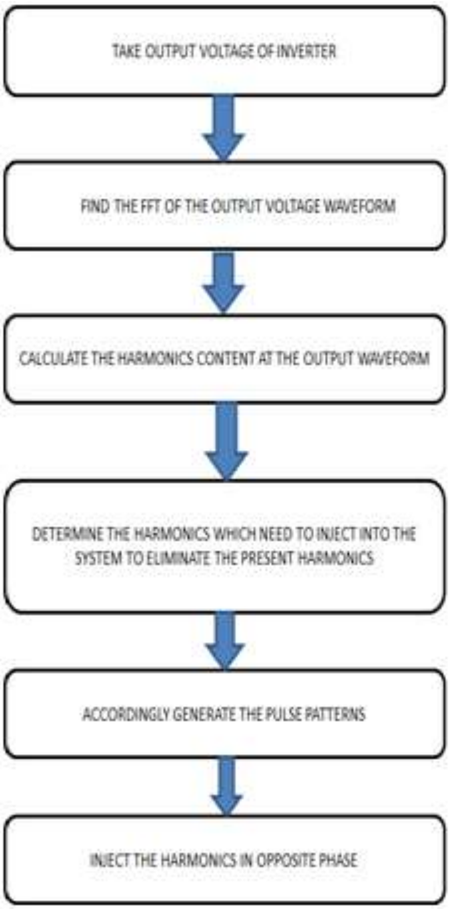

Fig-2: Flow chart

6. CONCLUSION

A current harmonic injection technique is used to cut back harmonics from induction motor drive that is discussed in this paper. VFD generates completely different harmonics that causes heating of motor, the introduction of EMI, malfunctioning of measure instrumentality. Harmonic distortion mostly occurs wherever loads withdrew non-sinusoidal current from the system. The voltage provided by an influence system is mostly not a pure sine wave.

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8. REFERENCES

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