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Consequences of Harmonics and Ways to Reduce Them: A Comprehensive Review

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Abstract:
This articleprovides a description of harmonics in power system and explain different methods for reduction of harmonics issues in non-linear devices that generateharmonics which reduces the output power. Therefore, it is necessary to study other harmonics problems and introduce suitable techniques to reduce harmonics, effective way to use filters, fundamentals of harmonics distortion and filterdesignes and then added to the panelin order to reduce distortion.

I. Introduction:

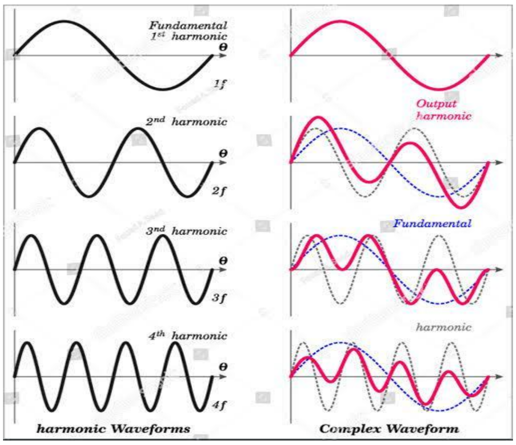
Usually when we look at the power system at that time an alternating current flowing through charging circuit is explained in terms of frequency and its amplitude. In the harmonics component of AC system defined as the sinusoidal component of an alternating signal with a frequency equals to integral multiple of fundamental system frequency[1].

Total harmonics distortion is the sum total of fundamental frequency and harmonic current when the harmonics is multiple of fundamental frequency[3]. If we consider, harmonics of voltage and current waveforms to be better, than compensating for this sinewave.

Fh={h}*{fundamental frequency}

Where "h" is an integer.

Then, considering the first harmonic of the system and



the frequency of the line become the cosine of the frequency of third harmonic[5]

F3=(3*50)=150Hz

And same is true forthe fifth harmonic equation,

F5=(5*50)=250H,

and seventh harmonic equation,

F7=(7*50)=350Hz

Harmonious analysis of electrical system must take into account the effect of harmonic creating load[5]. Harmonic system design, trouble shooting and so on, lot of research has been used to solve the problem.

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Due to the singlephase electronic Load, harmonics which are odd multiples of fundamental frequency are generally dangerous majorly triple harmonics that have frequency in multipletriple andare well balanced in the neutral on secondary side of delta-wye transformer and causes very high neutral currents drawn in the secondary side. Triple harmonic is generated in the primary winding of the conventional Transformers leading to high losses in the transformer.

The5th & 7th harmonic contents are the major causes of heating power losses and distortion in three-phase power distribution[4].

II. Causes of Harmonics in Power System

The voltage supply is sinusoidal even though the typical behaviour of a non-linear loadis that they consume distortedform of current wavewhere as the most electrical components only generate odd harmonics[7]. For each device, changes due tothe consumption of operating power, the background voltage distortion and the source resistance changes due to these current distortions. Most common type of causes are given below.

1. Single Phase Load

In power systems, the components of electronic equipment are powered by the voltage. Electronic component, rectifier, is used for the conversion of AC power (for internal use) into DC power. Such equipment'sare made up of-:

- Computers,recorders, CD/DVD players
- Digital micro oven, printers
- Electronic lightings, Adjustable speed driver.

2. Three phase loads

In this type of high powerloads,a three phase rectifieris used.In most of the cases, capacitors are used for low power application conductor lubricants and containers are used from large rectifier[2]. Especially in industrial applications and three-phase energy. Some equipment are-:

- SVCS, large UPS's
- Arc furnaceand Adjustable Speed Drive(ASD)

3. Harmonics Generated by Transformers

Saturation in the transformer cores can be from any one of the two following cases:

- When the transformer is overrated on power basis.
- When the transformer is overrated on voltage basis.

In powers system, the transformers generates harmonics in a bulk. Structure ofa transformer is usually done optimal use of magnetic core material, which leads to maximum magnetic flux density at steady state. Such a design of the maximum magnetic flux when the main material exhibits a high density of magnetic flux.

4. Harmonic Generated by Rotating Machines

In the practical and economical design of an electrical machine are also results in the generation of harmonic inthe power system. For rotary machine, magnetic driving force is composed of two components at different frequencies[4]. The negative sequence are coupled to the normal frequency on rotating machine, where the space harmonics are created by imperfections of distributed winding.

5. Power Converter Harmonics

The harmonics is most comprehensive source of power distribution system, when use of electric air conditioning in which the parameters like voltage and frequency are changed in order to adapta specific industrial processes, is a converter by switching 50Hz to 60Hz to a DC power source, electronic converts can be classified as trouble shooting into following-

<u>High Performance Transformers:</u> They are used in the metallurgical industry to transmit high-voltage direct current (HDVC) system.

<u>MediumPower Converters</u>:Used in the speed control of motor manufacturing industries and in the railway industries.

<u>SmallPower Converters</u>: They are used in home appliances and household equipment such as radios, television and personal devices a compute another example is a charger.

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Reduction of Harmonics

There are various methods in which harmonic content can be reduced, in order to meet standard regulation limits. Here are some of the most popular methods in which we can reduce harmonics.

1. DC Choke

It is series inductor on DC sideof a bridge circuit on AFD endat front. The DC choke and the line reactor are similar in many ways,although the percentage of total harmonic distortion (THD) is a little less. The DC choke offers more reduction mainly of the 5th and 7th harmonics[4]. The mains reactor is superior in higher order harmonics, therefore in terms of compliance with the IEEE guidelines, the DC choke and the line reactor are similar. If a DC inductor is applied to all AFDs, the IEEE guidelines can be followed if up to 14% to 38% of the system loads are AFD, depending on- (i) Stiffness (ii)load linearity (iii) measure of inductance.A harmonious analysis is required to ensure this amenability with the guidelines provided by the IEEE.

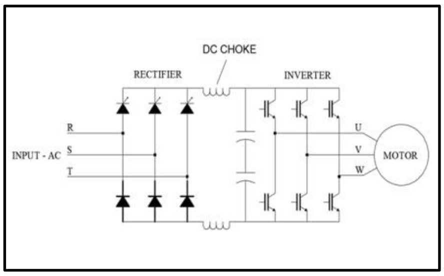

fig 1. DC Choke

Advantages

• Integrated in AFD

• Can cause a little fall in the voltage and the current harmonicvalues.

• The voltage drop is low when compared to an equivalent line reactor.

Disadvantages

• Low protection when compared to other AFD input methods.

• Harmonic level cannot be lowered belowIEEE 519 1992 guideline

• In most of the AFDs, this option is not included such as SVX9000.

The impedance is generally determined by the design.

2.Line Reactor

A line reactor is nothing but a series of inductors in a 3-phase side ofAFD. If AFDs are applied by a line reactor, it might be possible to fulfill the instructions provided by the IEEE where only 14% to 38% ofthe system loads are AFDs, depending on the hardness of the line reactance values[4]. The line reactance is mainly available in percentage impedance of about 1-5%. The SVX9000 comes with a standard input impedance of about 3%and with the exception of the Compact NEMA Type 1,which is designed in a M3bhousing.A harmonious analysis is necessary to ensure compliance with the instructions provided by the IEEE.

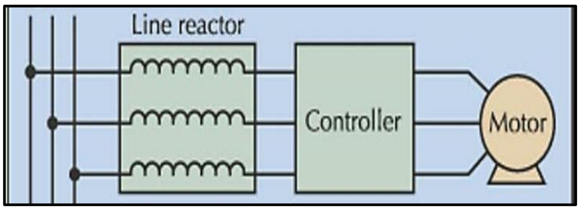

fig 2. Line Reactor

Advantages

• Cheap

• May cause mild lowering of the voltage harmonic as well as the current harmonic.

• Available in different percentage impedance value.

• Providesextra entry safety forthe AFD

as well as its line transient semiconductor.

Disadvantages

• Detached mounting or the larger AFD box may be required

• The harmonic level cannot be reduced as under IEEE 519-1992 guideline

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3.Harmonic trap filter

Harmonic trap filteris generally used along with a line reactorand are placed in every single AFD load.

In this,a L-Cis filter installed in a bypass arrangement of an AFD, and they're tuned slightly below 5th harmonic, which is mostly responsible for the harmonic distortion. A signifierquantity of seventh harmonicdistortion is observed. More filters along with this can be used to adjust the harmonics which are of higher order.

Extra care is demandedin the application of a harmonic trap filterthanin other methods, as they tends to filterthewhole distribution systems for more harmonious components.

AFD charges are added unfiltered, and thepreviously installed filter might become overloaded. The line reactor is used in conjunction with the filter in order to reduce the risk of this happening andin order to improve the filter action.

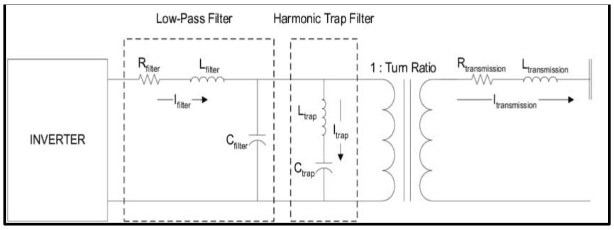

fig 3. Harmonic trap filter

Advantages

• Permits a greater percentage of AFDsystem load than those inline reactor and the choke.

Disadvantages

• Expensive

• Requires separated mounting

• May not decrease the harmonious levelbelow the instructions provided by IEEE 519-1992.

• Filter overloading needs to be avoided

4.Broadband filter

Theseare the filters which arevery similar to the filter traps, but have a great difference in their designs. While trap filter are joint in parallel with the AFD, the Broadband filter are joint in series with the AFD and bearings full AFD stream. [4]This change provides additional protection AFD current input part. Broadband filter not required Tuning, improving the power factor of the system and minimizing everything- harmonic frequencieswhich also includes the 3rd harmonic.Avoiding system resonances and the import of external harmonics.

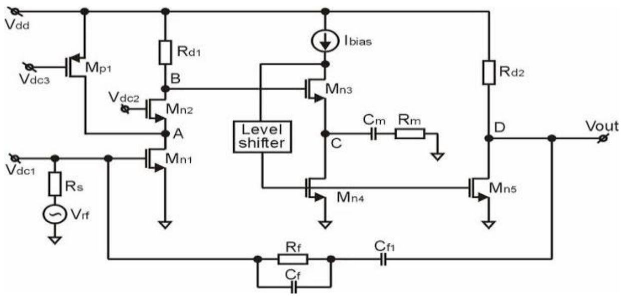

fig 4. Broadband filter

Advantages

• Enables larger percentage of the AFD system load than reactor lines and handcuffs.

• Provide improved input safety forthe AFD and its semiconductors. (From line crossings)

• Provide additional safetyto the AFD power consumption.

• Provide factor correction

Disadvantages

• Expensive

• Special assembly

• May not decrease the harmonics according toth IEEE 519-1992 instructions.

• Can lead to performance factors under load condition.

• Requires modifications to match the AFD using internal-line chokes, such as: SVX9000

5.Active filter

In this method sophisticated electronic and an IGBT power unitis used in order to injectan even and opposite harmonics across the system performance and to erase those generated by other devices. These filters track nonlinear current that require non-linear loads (such as AFD) and generate electronically adjusted and cancel harmonic destruction currents.

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Active filter is non-resonant and can easily be connected in parallel with the system load.

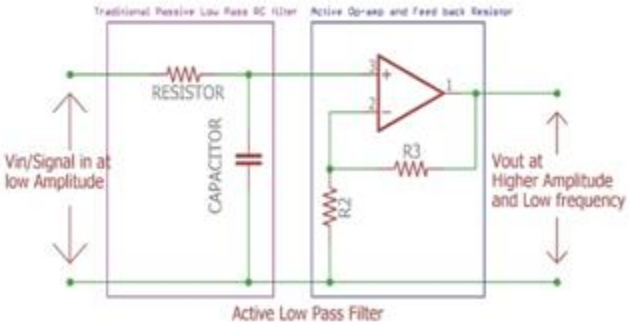

fig 5. Active low pass filter

<u>Advantages</u>

• Guaranteedmatching with IEEE 519-1992. (Adjustable)

• Damage cancellation of harmonics 2 to 51

• No serial connection allows easy installation without major system installation repairs

• Provides VAR current, improving power factor system

<u>Disadvantages</u>

• Expensive than other methods because of(i)High performance (ii) power monitoring section.

• Input semiconductorsof the filteris exposed tothe line transitions.

6.Capacitor switched filter

One more type of filtering method is the capacitor method, which is widely available in recent years. Standard Active Built-in Filters The on-board capacitor overcomes some problems, while some are equipped with interesting new features. Capacitor filters require additional capacitors or inductors, and their cut frequencyis set to a typical accuracy of ± 0.2% at an external clock frequency. This allow for consistentfilter designs using a cost-effective crystal controlled oscillator or filter whose closing frequency is available in a broad range by simply changing the frequency cycle. The capacitor filter can alsobe operated with lower sensitivity tothe temperature changes.

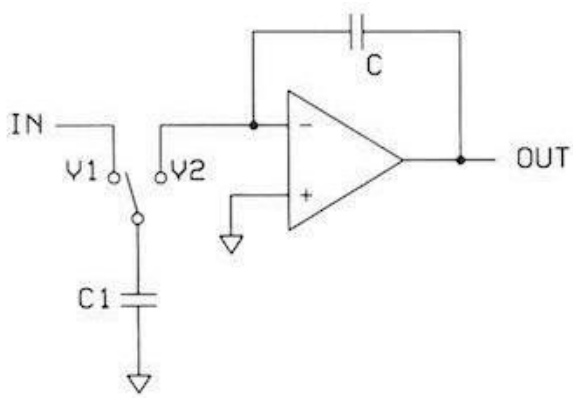

fig 6. Switched Capacitor Filter

Conclusion

There is very adverse effect of harmonics in the system, specially the presence of the 5th and the 7th harmonics. Also, the elements and the equipment of the system have a very important effect on the harmonic performances. It is essential to study a harmonic distortion in a system not only in order to assess its performance but also to improve it. Understanding the difficulties of the electrical system will help in the implementation along with the right solutions. You need to be very careful while studying harmonious problems in any part of the power system.

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