Research Paper Engineering

# A REVIEW ON POWER SYSTEM HARMONICS


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**ABSTRACT**

Harmonic distortion is not a new phenomenon on power systems. It has already been a major concerned during the history of ac electric power systems. Harmonic currents, generated by non-linear electronic loads, increase power system heat losses and power bills of end-users. As the new generations are more tilting towards the power electronics equipment, so it has become increasingly necessary to address their influence while making any additions or changes to a changes. However if the system is properly sized to handle the power demands of the load, there is a low probability that harmonics will cause a problem with the power system.

**KEYWORDS** Harmonics, THD

**I.Introduction**

Harmonics can be treated as if the mathematical model of the real world. Harmonic distortion is caused by nonlinear devices in power system. Non linear load are those loads whose resistance or impedance are not remain fixed to the applied voltage, which is the main source of producing harmonics. When a waveform is identical from one cycle to another cycle it can be treated as a sum of series of pure sine wave which in turn is an integral multiple of sine wave. Each element of the power system must be examined for its sensitivity to harmonics as a basis for recommendations on the allowable levels. The main effects of harmonics within the power system are,

- Due to resonance the net harmonic effect may be amplified.
- Efficiency of the electrical appliances may decreases or increases.
- Malfunctioning of the system equipment
- Ageing of the insulation plant

**II.Harmonic effect on modern power system**

Harmonics are a distortion of the normal electrical current waveform, generally transmitted by nonlinear loads. Switch-mode power supplies (SMPS), variable speed motors and drives,

Personal computers, laser printers, battery chargers and UPSs are examples of nonlinear loads.

**The effects of voltage distortion into three general categories**

- Thermal stress
- Insulation stress
- Load disruption

Most of the power system can accommodate to certain amount of harmonic content but will experience problem when it becomes a significant component in power system. When these higher frequency component flow through the power system they may leads to following power system problem

- Over heating of electrical distribution equipment
- Generator failures
- False tripping of circuit breaker
- Metering error
- Crest factor problem
- Lower system power factor resulting excess billing
- Malfunctioning of the equipment
- Telephone and communication system noise.
- Decrease in the life span

**III. Technical view of harmonics**

Harmonics are currents or voltages with frequencies that are integer multiples of the

fundamental power frequency. If the fundamental frequency becomes 50Hz then second harmonics and third harmonics are 100Hz and 150Hz respectively. When these frequencies are prevalent the transformer becomes mechanically resonant to these higher order harmonics and hence creates buzzing sound due to this harmonics. Harmonic frequency from 3rd order to 25$^{th}$ order is most common range of power disturbances.

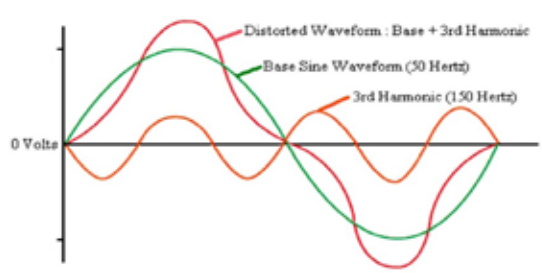



**Fig-1 Harmonic distortion of Electrical wave form**

**Figure 1 shows the harmonic distortion of electrical wave form which basically consist of 1st harmonic and 3rd harmonic of a 50Hz power system.**

**a. RMS value**
Harmonic quantities are generally expressed in terms of their RMS values because heating effect depends upon the distorted wave. For a sinusoidal wave the rms value is the maximum value divided by 2.

**b. Total harmonic distortion**
Total harmonic distortion determines the thermal effect of all the harmonics.THD is defined as the ratio of RMS value of harmonics to the rms value of fundamental and multiplied by 100. THD of voltage is usually less than 5% and the current is usually from few cycles to more than 100%.

**c. Effects**
Harmonic effect may be short term or long term. Short term harmonics are more dangerous and sometimes lead to high voltage fluctuation. Long term harmonics are basically in the form of heating and the main affected area are :

- Vibration and noise
- Over heating of capacitor
- Heating of cable and equipment
- Interference on control circuit

## IV. Harmonic impacts

**a. Impact on motor**
Most of the motors that are used for industrial purposes are Variable frequency drives in nature. As we know that it deals with hysteresis and eddy current losses & being the functions of frequency, these losses increases and raises the temperature.

The harmonics are of three types, Positive, Negative & Zero harmonics. The positive harmonics follow the fundamental frequency components; Negative harmonics opposite to positive & Zero harmonics being neutral to both. The interaction between the positive and negative harmonics sets-up torsional oscillations on the motor shaft. If the frequency of oscillations coincide with the original frequency of machine then it gets further amplified which might result in damage of machine shaft. Hence proper analysis has to done on it while employing these Motors.

**b. Impact on transformer**
The transformers also do have the same problem as motors. The non-sinusoidal supply to it, increases the eddy current losses in it. The eddy current loss varies in square to the frequencies as result of which the operating temperature increases due to harmonics.

**c. Impact on capacitor bank**
The capacitor banks are used to counter the harmonic effects up to some extent in the power system. These capacitors are designed such that it can operate at a maximum of 110% of their rated voltage and 135% of its kVAR rating. As we know that the capacitive reactance is inversely proportional to the frequency, so the unfiltered harmonic component in the network gets stored in the capacitor. It basically acts as a sink to harmonics. However it also has its own limitations.

## V. Factors to reduce the harmonic impacts

**a. In line reactors**
A simple method to control harmonic distortion generated by adjustable speed drives involve a relatively small reactor inserted at the line input side of the drive. It is one of the best method of PWM drive.

**b. Zigzag transformers**
It is generally used to control the zero sequence current by offering a low impedance path. It can shunt about 50 percent of the third harmonic current in addition to main circuit conductor. The largest zero sequencing harmonic will nearly always be 3rd harmonics due to heavy use of computers.

**c. Over sizing the neutral wiring**
The neutral wiring should always be specified to be the same capacity as the power wiring, or larger.

**d. Use of K-rated transfoermer**
K-rated transformers are not used to handle harmonics, but they can handle the heat generated by harmonic currents and are very efficient when used under their K-factor value.

K-factor generally lies between 1 to 50. Special care care must be taken while selecting the k-rated transformer as it is going to affect the cost and safety factor. General transformer basically has a k-factor of 1.

## VI. Conclusion

Harmonic can have significant effect on the power quality. Although harmonic effects are very low but they generally affect the power system reliability. An understanding of the causes, potential effects and mitigation means for harmonics can help to prevent harmonic related problems at the design stage and reduce the probability of undesired effects occurring on start-up.

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