Review on Harmonics And Methods To Reduce Them

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Abstract- *In power system non-linear loads are the major source of harmonics. These loads impose various reactive-power demands that may compensate in a manner to improve the power factor and efficiently delivers the active power to various loads. It results in harmonic distortion and relevant problems, for reducing the quality of electrical power and its performance of power system. In this paper, from various equipment's and devices the nature of harmonics that exists in the operation, the ways of eliminating harmonics and its effects have been discussed in this paper. The paper also reviews the strategies and pros and cons of elimination of harmonics followed in the literature and introduced new hybrid optimization methods to eliminate them in multilevel inverters. The hybrid optimization which is proposed a optimum switching angle at a faster convergence rate which may calculate the switching angles and lookup tables were used, which may lead us to find the near optimum switching angle and lower rate coverage.*

Keywords- Harmonics, Power System, Optimization, Total Harmonic Distortion.

I. INTRODUCTION

HE last three decades shows, various methodologies and techniques were proposed for sustainable power quality. One of the major parameters which effects the power quality is harmonics, it is of great value for industrial field, because of distortion, heating and disturbance effects that may cause. In addition, the changes in resonance always causes voltage and current magnification in equipment. Only odd harmonics will be produce because of electrical equipment's, normally when it works. During malfunction, transient conditions or single-phase rectification etc, may occur.

The advancement of power electronic components such as triacs, IGBT, thyristors, GTO, power transistor etc, have a major roles on industrial world. These developed components are used to convert inject harmonic currents on draw non-sinusoidal current and electrical network from utility grids, thus contribution to power system for degradation of power quality in distribution or industrial power system.

On this paper discussing sources of harmonics their effects and methodologies that is proposed to eliminate or compensate harmonics and inverters in power system.

II. SOURCES OF HARMONICS

Here we are discussing the definition of harmonics and total harmonic distortion, after that we would discuss about source of harmonics. A source that is power supply would always be sinusoidal voltage at every industrial and residential location.

2.1 Review Stage

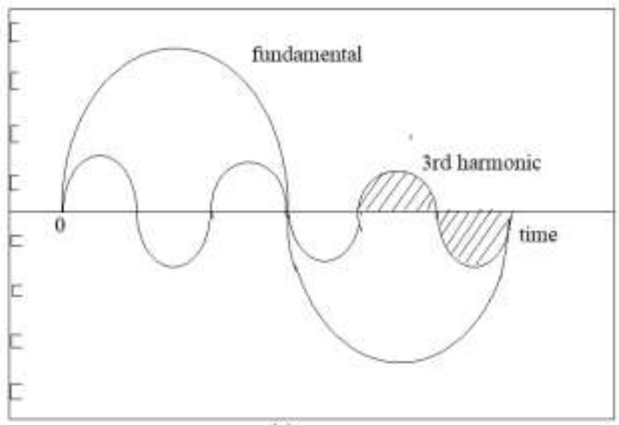
Detailed submission guidelines can be found on the author resources Web pages. Author resource guidelines are specific But, at the utility point it is difficult to preserve such a condition due to various reasons. The conversion of voltage and current waveforms from sinusoidal is known as harmonics distortion. Harmonic component of a periodic waveform has frequency and integral multiple of the fundamental fret waveform as shown in fig below.

Frequency of harmonic component $f_H = L*F$

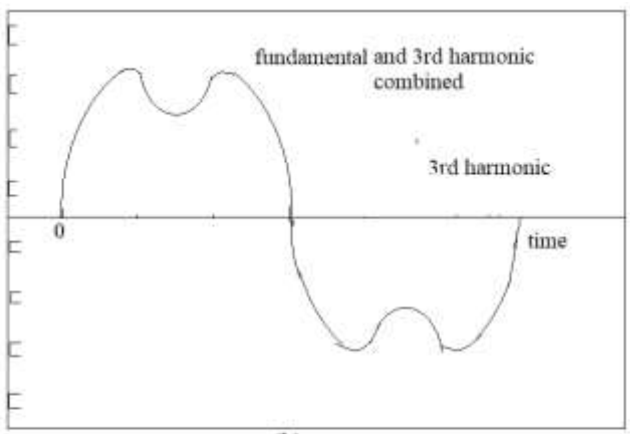
Where,

F – fundamental frequency Hz.
L – integer (order of harmonics).

If the power supply frequency of 50 Hz, then second harmonics frequency is 100 Hz and third harmonic is 150 Hz. A harmonic of infinite order contains distorted wave. And the amplitude od distorted wave increases and decreases with harmonic frequency. According to IEEE 519 standard the total harmonic distortion (THD) for general system muct be less then 5%. The total harmonic distortion of the current is expressed below,



(a)



(b)

Fig 1. (a) Fundamental and third harmonics
(b) Fundamental and third harmonic combined.

$THD\% = (I_2^2+I_3^2+\ldots\ldots..+I_n^2)0.5*100/I_1$

Total harmonic distortion (THD) can also be denoted as distortion factor (DF), harmonic factor (HF) etc.

Current and voltage harmonics are produced by non-linear loads which are connected to the power system. Non linear load is said, when its impedance changes with respect to time. The major sources of harmonics in power system are:

- Rectifiers (AC-DC Converters).
- Inverters (DC-AC Convertors).
- Cycloconverters
- Choppers (DC-DC Converters).
- Ballast inductor.
- Switched mode power supplies (SMPS).
- Uninterrupted power suppliers (UPS).
- Fluorescent lights (CFL).
- Television sets.
- Static VAR compensators.
- Personal computers.
- Variable frequency motor drives (VFD).
- Synchronous machines.
- Power transformer.
- Induction machine.
- Pulse-burst heating.
- Motor-soft start units.
- Soldering equipment.
- Battery chargers
- Mercury-vapour or high-pressure sodium lamps.
- Refrigerators.
- Machines
- Freezers.
- Air-conditioning device.
- Printers.
- FAX machines

Considering from many sources, harmonics listed above few of them are major sources have been discussed briefly.

1.1 Static Var Compensators

On long transmission line, at the ends or near by sources of fluctuating power, static var compensators are being used to control the voltage of power system. 1% of the 11^{th} harmonic current are produced by thyristor controlled reactor.

- **Power converters**

Dc side and ac side rectifiers presents higher inductance. Hence dc current is almost constant and converter acts as an harmonic voltage source on the side of ac circuit. The number of pulse depends upon the harmonics produced by the pulse convertors. In this case the harmonic components of pulse converter is given by the expression,

H = LP+/-1

Where,

H – order of harmonic component.

L – integer.

P – number of pulses.

- **Transformer**

Due to the characteristics, of saturation and hysteresis, the transformers in steady state may produce small level of current harmonic. When transformers are energized initially high level of harmonics are produced, which may be as high as 60% of the transformers rated current.

- **Effects of Harmonics**

The problems occurred due to harmonics on the power equipment or components are.

- **Conductors**

Generally, heat is produced in current carrying conductors due to IR^2 losses. An increment in harmonic orders may produce an increase in skin effect. As the skin effect increases the IR^2 losses tends to produce which may result in over heating of the conductors. Because of proximity effect heating of conductors may also emerge, and effect influenced by the magnetic field of current harmonics in the adjacent conductors.

- **Transformers**

Frequency is directly proportional to the eddy current losses. Hence, the increment in harmonic order there will be a increase in eddy current losses takes place for transformer. In addition, the skin effect, and eddy current losses in the transformer would be reduced. This increment in temperature will results in increment in loss of life of the insulation of transformer which may be determined by the hot spot temperature reached by the winding.

- **Capacitance**

To improve the power factor, use of capacitors has a significant influence on harmonic levels. The decrement in capacitive reactance with increment in frequency of harmonics. So, because of the incremental flow of current, the capacitors may get overloaded and the electric stress may impose higher. Suppose, the resonance condition (i.e. inductive reactance and capacitive reactance becomes equal to each other) occurs in circuit, then impedance of the circuit get decreased, causing destructive damage to the parts as well as the capacitors.

- **Circuit Breaker and Fuses**

In circuit breaker low level faults can be high due to degree of harmonic load current. And for load distortion, high di/dt rating at the zero crossing of sinusoidal waveform make the interruption difficult. Hence, malfunction of circuits breaker may occur due to harmonic load current may lead.

- **Lights**

The decrement in life of incandescent lamp gets worse as the distorted power supply. If the life of lamp gets decreased by 47% it is because of the lamp operated at 105% rated voltage. In case of discharge lamps, the audible noises are the main problem due to harmonic current. In fixtures with capacitors, ballast inductor together with the capacitors and lamp may present a resonance problem.

- **Rotating Machines**

Operational frequency of a electric machine depends upon the losses produced in it. For an inverter generating high harmonic frequencies, for induction motor core and stray losses becomes significant. The reduction in life is due to the increment in temperature in the windings of the rotating machine. Pulsating torque are produced by the interaction of air gap flux density and the fluxes produced by the harmonic's currents on the rotor. Audible noises are produced due to the difference between the harmonic frequencies. Other problems in rotating machine is due to the harmonic and equipment fatigue, bearing wear out, etc.

- **Telephone Interferences**

The greater problem with power system harmonics is that they cause greater fundamental frequency because human hearing is sensitive and telephone response peak is near about 1 KHz. Capacitive, inductive and conductive interferences may take place between telephone lines and a power line.

- **methods to eliminate harmonics**

In this section, there is various elimination or compensation techniques for harmonic is being handled in literature for inverters have been discussed briefly, and their advantages and disadvantages.

For single pulse-width modulation inverters are used for vector-optimized harmonic elimination, considering dc link ripple for optimized switching angle calculation for finite dc link capacitor. The output voltage quarter wave symmetry is not assumed because pulse position is not fixed. In application the size of the capacitor is required for optimization, ripple capacitor filter is introduced for lower order harmonics to flow in the ac load. These harmonics of lower order is eliminated and reduced for capacitor filter size. The pulse-width modulation converters act as additionally as an active power filter for power factor correction. The main drawback of this method is that, it does not consider about the THD factor.

In fuzzy multi-objective technique integrated with (DE) Differential Evolution has been applied to optimize total harmonics distortion and power factor. An attempt for incrementing power factor may result in increase in THD. Kind of these problems are solved through this approach.

Multi-objective in the sense of total harmonic distortion and power factor has been optimized keeping harmonic distortion within limits. The advantages for initial parameter values are DE are finding global minimum regardless, few control parameters and fast convergence.

For five level inverter half-wave symmetry selective harmonic elimination method is being implemented with varying modulation index of range 0 to 1.15. from modulation index of 0.8, twelve group of solutions were obtained for modulation, even harmonics can be automatically eliminated in both the half wave and quarter wave symmetry model. The half wave symmetry allows the phase of variation of the harmonics with the fundamental whereas only 0- or 180-degree phase shift may be provided by quarter wave symmetry. Half wave symmetry can generate more solutions the that of asymmetry method and quarter wave symmetrical method. But more no. of equations more complexity increases. To calculate switching angles for eleven level inverters shuffled frog leaping algorithm is utilized. At low modulation indices, optimal solutions for selecting harmonic elimination problem was obtained. The main advantage of meta-heuristic SFLA includes fewer great capability and control parameters for global search and easy implementation. And the main disadvantage is that, this method is an offline method and separate lookup table is required.

By composite observer method the voltage harmonics in single phase inverter was reduced by this. To extract the quadrature signal from periodic wave to in phase form of contain harmonics composite observer was used. For feedback control the inverter was modelled with the system with harmonics being fundamental component and noise of a periodic waveform to be the required output. Feed forward procedure series compensation is used for harmonic voltage drop in the filter inductor. The main difficulty with feed forward compensation is filter inductance, delay is not precisely known and effective series resistance is known. The method for reducing THD cannot be applied to reduce selective harmonics.

With phase coordinates active power filter was developed to mitigate harmonics in. filtering current is performed by this method. It can handle unbalanced voltage source and distorted voltage source. Phase-lock loop method and Least square fitting curve method were utilized for determining the reference currents. With in the application of APC – abc THD may reduce by 18 times.

III. PROPOSED METHOD

Various harmonic elimination or compensating techniques were adopted in the last few decades, and have been reviewed. Based on these surveys a new methodology to control distortion of harmonics in multilevel inverter is introduced. In the selected method proposed harmonics were eliminated with pulse width modulation technique to reduce the harmonics and implemented by means of particle swarm optimization-back propagation algorithm. The PSO-BPA calculates method that switching angles requires for the inverter online. So the separate look-up table is required for this method. The main advantage of the proposed optimization method is to minimize harmonic distortion are: 1. Convergence rate, 2. Faster convergence rate and accuracy at global optimal is higher, 3. Real-time solving of harmonics elimination equation, 4. More chance of escaping from local minima.

IV. CONCLUSION

in non-liner loads of power system sources of harmonic distortions that can occur in it with associated problem were discussed briefly. To compensate harmonics for inverters that were followed and various methodology is completely review on this literature was done. Based on this review a latest hybrid optimistic method called PSO-BPA to eliminate harmonics by calculation switching angles online for harmonic elimination of pulse-width-modulation technique of multi-level inverter is mentioned in this paper.

V. CONCLUSION

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

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