STUDY ON CURRENT HARMONIC`S MITIGATION USING HYSTERESIS CURRENT CONTROLLER TECHNIQUE

Gopika Agarwal[1]

Abstract:

Power Quality problems are emerging as most important issues for today's power system engineers. Major use of power electronics devices has increased the harmonics disturbances in power systems. These harmonics are basically due to presence of non-linear load in power system. These loads draw harmonic and reactive power components of current and voltage from main supply. Basically Current Harmonics are generated by these nonlinear loads due to nonlinear currents of load, for example drives of adjustable speed, static power supply, UPS etc. To reduce the effects of harmonics, voltage and current compensator is required. Among different types of compensators Shunt Active Power Filters (SAPF) has better harmonics compensation. This article includes the introduction of hysteresis control technique which was applied to compensate the current harmonics in power system.

Key words: Harmonics, Shunt Active Power Filter, hysteresis current control technique.

I. INTRODUCTION

Due to fast growth in semiconductor industry, the use of power converters and power electronics devices is increasing day by day. But these devices are nonlinear in nature therefore they are also the main reason of power harmonics in power system. Figure 1 presents a layout of power system having source voltage V_S , nonlinear load current i_{L1} contains harmonics. The harmonics in the line current i_s generates a non-linear voltage drop ΔV in the line impedance, which in turns distorts the load voltage $V_{L.}$ Due to distorted load voltage linear load current i_{L2} also becomes non sinusoidal.

[1] Assistant Professor, Electrical and Electronics Engineering Dept. KIT, Rooma, Kanpur, U.P., India

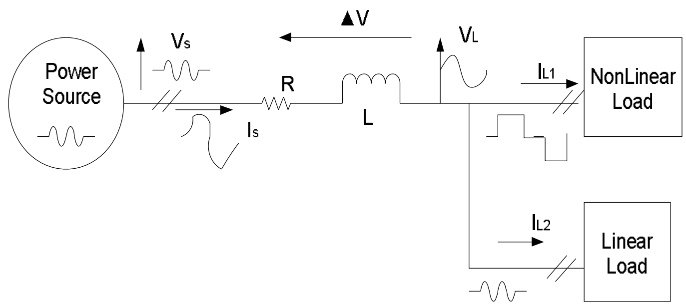

Fig. 1 Power System with nonlinear Load

The presence of Harmonics in power system is the basic reason of power losses in the distribution system, interference in the communication system and also the equipment failure. It also causes the operation failure of electronic equipment as they are very sensitive and work with very low energy levels. Because of these problems, end consumers are facing the power quality problems and also the voltage at different buses of power system will also get distorted.Initially the Passive filters were used to compensate the harmonic current problems, but due to some limitations like Background distortion can overload filter, interaction with distribution capacitor banks, system resonance problems, poor filtering characteristics, leading power factor, sensitive to capacitor switching. To overcome these limitations recent efforts have been done in the development of Active Filters. (Figure-2)

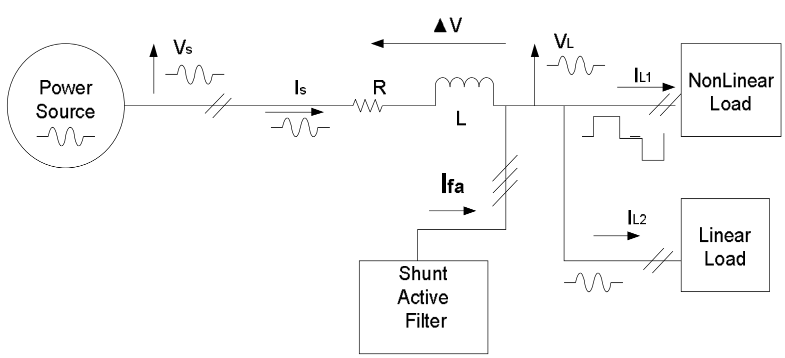

Fig. 2- Power system with non-linear load and a shunt active filter.

II. HARMONICS

Every nonlinear load is capable of creating harmonics with the exception of the incandescent light bulb that is basically linear in nature. Nature of the nonlinear loads is discussed in previous chapter. Each nonlinear load generates harmonics but, the content of harmonics varies from load to load and each load responds differently to the effects of harmonics. Based upon the above theory table-1 shows the order of harmonics generated by nonlinear loads.

Table-1

Load /harmonic order	**1**	**3**	**5**	**7**	**9**	**11**	**13**	**15**
6 pulse rectifier	100	-	17	11	-	5	3	-
12 pulse rectifier	100	-	3	2	-	5	3	-
18 pulse rectifier	100	-	3	2	-	1	0.5	-
24 pulse rectifier	100	-	3	2	-	1	0.5	-
Electronic Computer	100	56	33	11	5	4	2	1

III. SHUNT ACTIVE FILTER

The shunt Active filter is connected in parallel to nonlinear load, to cancel the reactive and harmonic currents from the nonlinear load, to make current sinusoidal. In shunt active filter a current controlled voltage source inverter is used in order to generate the compensating current i_c* which is injected into the power source grid. This current cancels all the harmonics components which are drawn by nonlinear load and maintain the line current sinusoidal. Figure 3 represents the schematic diagram of a shunt active filter for a three phase power system. It can compensate current and improve power factor correction. It contains the voltage source inverter with capacitor on DC side. The reference currents (i_{ca}*, i_{cb}*, i_{cc}*, i_{cn}*) are calculated from the measured values of phase voltages (v_a, v_b, v_c) and the load currents (i_a, i_b, i_c). This reference current are used by inverter to produce the compensation currents (i_{ca}, i_{cb}, i_{cc}, i_{cn}).

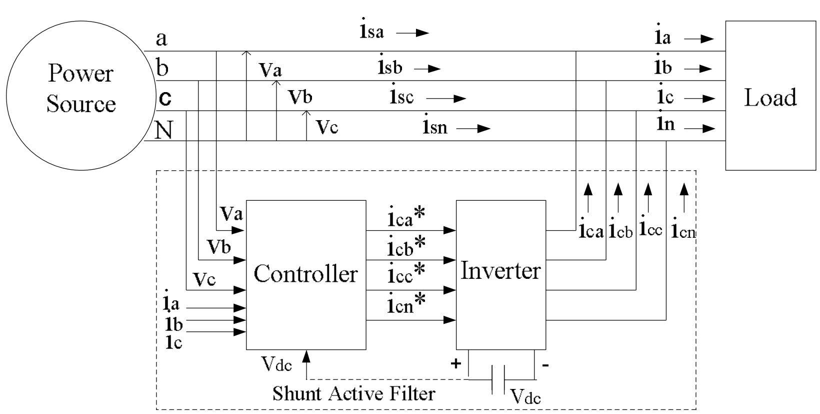

Fig. 3- Shunt Active Filter

The main reason of the active filteris to compensate the current harmonics from harmonics producing loads. Along with that it is also use to compensate voltage harmonics and voltage imbalance. The basic principle of current harmonics compensation in shown in figure 4.

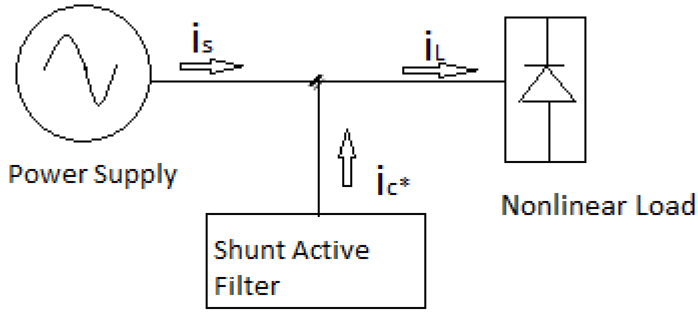

Fig. 4 - Basic principle of current harmonics compensation.

Harmonic current compensation using active filter is performed in a closed loop manner. The active filter injects the compensating current i_c* to the line in the power system. Thus the source current is equal to the load and filter current. This can be given by following equation:

$$\boldsymbol{i_l + i_c^* = i_s}$$

IV. HYSTERESIS CURRENT CONTROL TECHNIQUE

Hysteresis band control is basically a feedback current control method, where the actual current continuously tracks the command current in the hysteresis band. In this method a reference sine wave current wave is compared with the actual phase current wave.

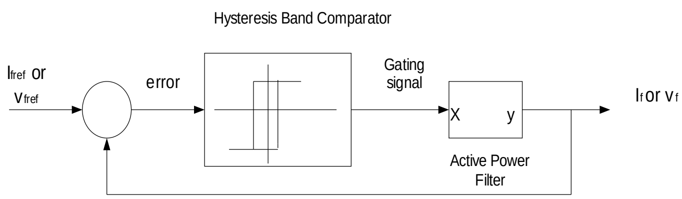

Fig. 5 Hysteresis Current Control

This method is implemented to generate the pulses for voltage source inverter which is inbuilt in the Shunt active filter. This method controls the switches of the voltage source inverter asynchronously in order to ramp the current through the inductor up and down, so that it can follows the reference current. Hysteresis current control is the easiest control method to implement in the real time. The working of this control technique depends upon the hysteresis band.

Figure 6 illustrates the ramping of the current between the two limits where the upper limit is the sum of reference current and the maximum error or the difference between the upper limit and the reference current and for the lower hysteresis limit; it is the subtraction of the reference current and the minimum error. Supposing the value for the minimum and maxi um error should be the same. As a result, the hysteresis bandwidth is equal to two times of error.

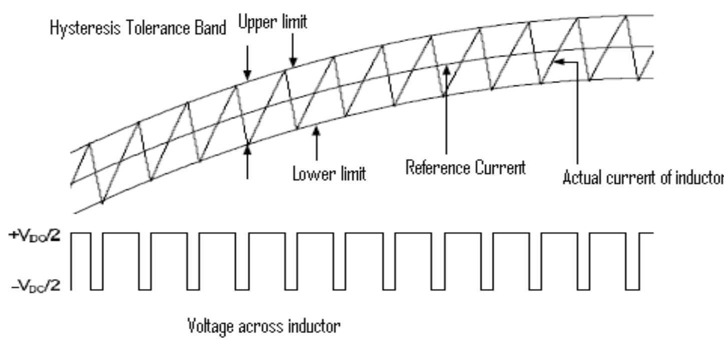

Fig. 6 Hysteresis Band and Generation of Pulses

When the current exceeds the upper limit of hysteresis band then the upper switch in the inverter bridge in turned off and lower switch is turned on, and the current starts decreasing. As the current crosses the lower band limit, the lower switch is turned off and upper switch is turned on. This method provide excellent dynamic properties and also easy to implement. There are some drawbacks which are as follows:

1. During the fundamental period, the resulting frequency changes which leads to irregular operation of the inverter.
2. When the zero voltage vector is applied, then the load is disconnected at several instant over fundamental period of output voltage

V. CONCLUSION

The objective of this article was to study the Hysteresis Current Control Technique briefly. Using this technique we are able to compensate the harmonics caused by three phase non linear loads. The instantaneous reactive and active theory is very much effective for Shunt Active Filter. By using Hysteresis current control technique harmonics are compensated to good extent.

Reference

1. Acha, E., Agelidis, V., Anaya, O., & Miller, T. J. E. (2001). *Power electronic control in electrical systems*. Elsevier.
2. Bose, B. K. (1990). An adaptive hysteresis-band current control technique of a voltage-fed PWM inverter for machine drive system. *IEEE Transactions on industrial electronics*, *37*(5), 402-408.
3. Chandra, A., Singh, B., Singh, B. N., & Al-Haddad, K. (2000). An improved control algorithm of shunt active filter for voltage regulation, harmonic elimination, power-factor correction, and balancing of nonlinear loads. *IEEE Transactions on Power Electronics*, *15*(3), 495-507.
4. da Silva, E. S., Martins, M. P., Coelho, E. A. A., de Freitas, L. C., Vieira, J. B., & Farias, V. J. (2002). Soft-single-switched boost PRC using UC3854 and special hysteresis current control technique. In *Power Electronics Specialists Conference, 2002. pesc 02. 2002 IEEE 33rd Annual* (Vol. 3, pp. 1369-1374). IEEE.
5. Jain, S. K., Agrawal, P., & Gupta, H. O. (2002). Fuzzy logic controlled shunt active power filter for power quality improvement. *IEE Proceedings-Electric Power Applications*, *149*(5), 317-328.
6. Jin, C. (2013). *Theory of nonlinear propagation of high harmonics generated in a gaseous medium*. Springer Science & Business Media.