© September 2015 | IJIRT | Volume 2 Issue 4 | ISSN: 2349-6002

A New Harmonic Elimination Technique Using Shunt Active Filter and PI Controller

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***Abstract*—Load compensators are used for reactive power compensation as well as harmonic compensation have the disadvantage of high cost and poor efficiency due to switching losses. So it is good to use active harmonic filters for harmonic compensation and traditional methods comprising of thyristor-switched capacitors for reactive power compensation. Existing load compensators have the capability to differentiate between the fundamental reactive component and harmonic components of the load currents ,but are complex and so they are not cost effective. In order to overcome this limitation, a shunt harmonic filter, which is capable of compensating only the harmonic components of the load current and having a simple control circuitary is proposed in this paper.**

***Index Terms*— Active Harmonic Filter, Phase Locked Loop, PI (Proportional Integral) Controller, Total Harmonic Distortion (THD),**

I. INTRODUCTION

A shunt load compensator is used for harmonic current requirement of the nonlinear load can additionally provides reactive power support for power factor correction and/or voltage regulation As the load compensator supplies the reactive component of the load current along with harmonics, it is required to be rated to carry the reactive component of the load current also. Moreover, the high bandwidth requirement of the controller which forces the compensator to supply the harmonic component of the load current necessitates the semiconductor switches to operate at high switching frequencies Operation of semiconductor devices at high switching frequency while they carry large current leads to increment in device current rating and switching losses. The increased rating makes the load compensators expensive.

The objective is to overcome this limitation is by providing compensators that act as active harmonic filters (AHFs) to compensate only for the harmonic components of the load current, while traditional methods comprising of thyristor switched capacitors/reactors are used to carry out reactive power compensation of the given load. So the converter of an AHF has to carry only the harmonic components of the load current, its current rating and the incurred power loss are less compared to that of a load compensator.

There are so many methods for harmonic elimination. Some of these methods [1],[2] require the information of the fundamental component of the grid voltage to extract the harmonics present in the source current. The grid voltage is likely to contain distortions, including multiple zero crossings, and the service of a phase-locked loop (PLL) is employed to extract the fundamental component of the grid voltage. These methods also require separate harmonic resonance generator and current controller. Some other methods [3] ,[4] except [5],[6] cannot differentiate between the reactive component and harmonic components of the load current. Some methods [7] has the flexibility to supply the harmonic components of the load and/or reactive power of the load depending on the requirement of the application and having relatively simple control structure. But optimum operation as an AHF is not guaranteed and some of them are not having the above mentioned disadvantages but having complex control circuitry [8].

In this paper, it proposes an efficient and simple control scheme for harmonic elimination using shunt active filter. It is capable of compensating only the harmonic components of the load current .So the losses can be minimized and also the cost.

II.METHODOLOGY

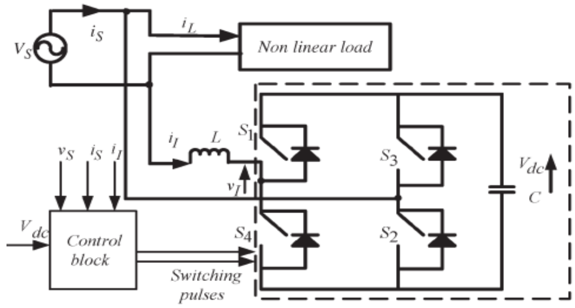

Fig 2.1: Schematic Block diagram of single phase Active Harmonic filter systems

V_s and i_s are respectively the grid voltage and grid current. V_{dc} is the DC link voltage. L is the series inductor. C is the DC link capacitor .i_I is the filter current. The switching pulses to the semiconductor switches of the filter is generated as shown below.

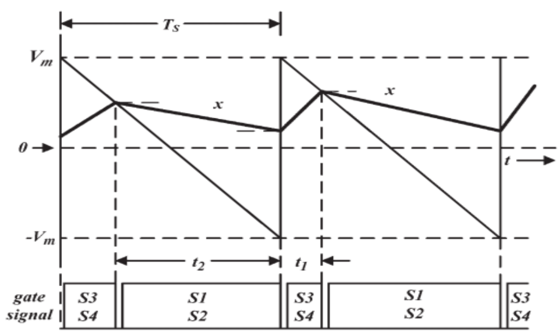

Fig 2.2:Carrier waveform (sawtooth), modulating waveform x, and gating signal

When the modulating signal x is less than the sawtooth waveform, S3 and S4 are turned on, thereby making the output voltage of the converter to be -Vdc. When x is greater than the sawtooth waveform, S1 and S2 are turned on, and the output voltage of the converter is +Vdc.

1.Conventional Method

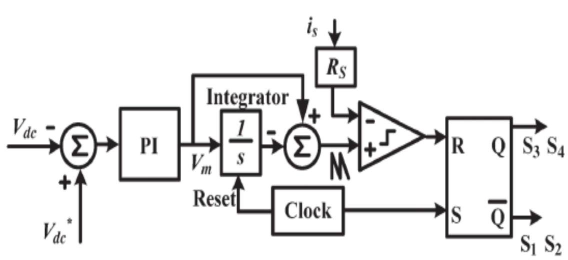

Fig 2.3:Block diagram of the controller for the conventional single-phase load compensator system

The dc link voltage V_{dc} is sensed and compared with the reference dc link voltage to generate the error between the controlled and reference functions. A PI controller processes this error signal to generate a reference signal V_m. A symmetrical saw-tooth waveform whose peak is equal to that of the reference signal V_m is generated using an integrator with a reset and an adder. Modulating signal is i_sR_s . The grid current is in phase with the grid voltage and the reactive power requirement of the nonlinear load is not supplied by the grid. The aim of the modified controller is to relieve the burden of supplying the reactive power requirement of the load from the converter. V_{dc}^* is the reference DC link voltage. R_s is the gain of the current sensor.

2.Existing Control Scheme

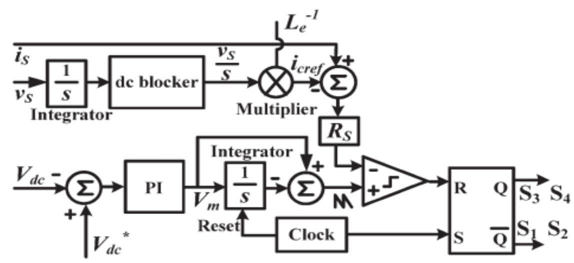

Fig 2.4: Block diagram of the controller for existing system

Modulating signal changes to $(i_s-i_{cref})R_s$. i_{cref} is the reference value of reactive current to be supplied by the source. which is obtained by finding the value of emulated inductance L_e .Which is the equivalent inductance of the Parallel combination of the non linear load and the filter. The grid current and grid voltage are not in phase. Also the additional loop makes a phase shift between the fundamental component of the grid current and converter output voltage. Now the burden of supplying the reactive power requirement of the non linear load is on the the grid not on the converter. Fig 2.5 shows the Schematic block diagram of the feedback loop which sets the value of the emulated inductance in existing method.I_{I1} is the fundamental component of filter current.I_{I1peak} is the peak value of the fundamental component of filter current.

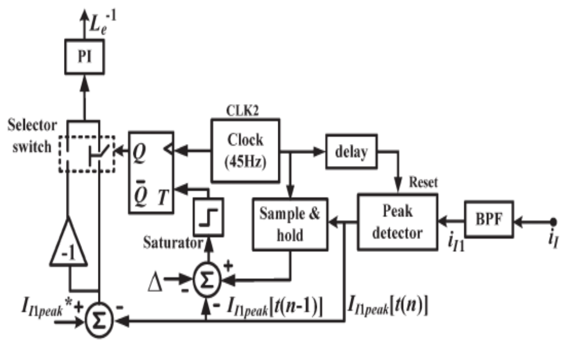

Fig 2.5: Schematic block diagram of the feedback loop which sets the value of the emulated inductance.

3. Modified Control Scheme

In the new control scheme, the circuit used to find the value of emulated inductance is changed. The new control circuit is simple compared to the existing one. Fig 2.6 shows the Schematic block diagram of the feedback loop which sets the value of the emulated inductance in the new control scheme. Q and Q_{ref} are respectively the actual and reference value of reactive current to be supplied by the source.

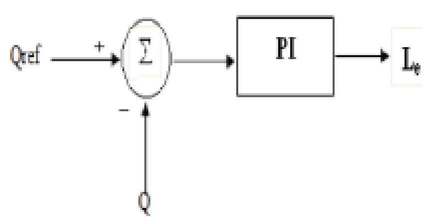

Fig 2.6: Schematic block diagram of the feedback loop which sets the value of the emulated inductance in modified method.

III.RESULT AND DISCUSSION

Total Harmonic Distortion (THD) of source current and load current for the conventional method, existing method and modified method are shown below.

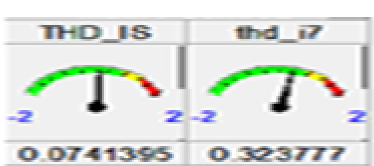

Fig 3.1: THD of source and load current for conventional method .

Fig 3.1 shows the Total Harmonic distortion of source and load current for conventional method .

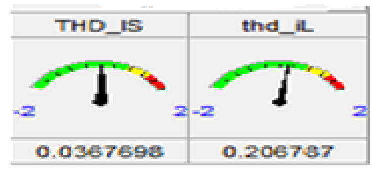

Fig 3.2: THD of source and load current for existing method.

Fig 3.2 shows the Total Harmonic distortion of source and load current for existing method. It is clear from the above two results that THD of load as well as source current are further reduced in existing method.

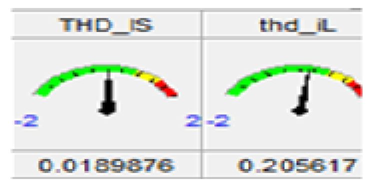

Fig 3.3: THD of source and load current for new method

The new method is capable of reducing the THD of load current and source current further when compared to the existing method.

A comparison of conventional method, existing method and new or modified method are also made by removing the PI controller in the common control loop of the three methods. The result of the above comparison is also shown below.

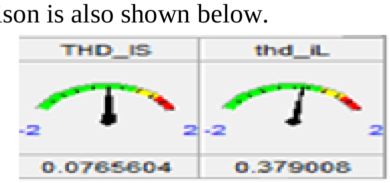

Fig 3.4: THD of source and load current for conventional method without PI Controller.

From Fig 3.4 shown above it is clear that presence PI controller will reduce the THD further.

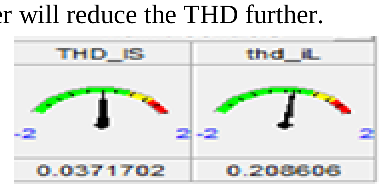

Fig 3.5: THD of source and load current for existing method without PI Controller.

On comparing results shown in Fig 3.2 and 3.5 it is clear that presence of PI controller can reduce the THD further in case of existing method also.

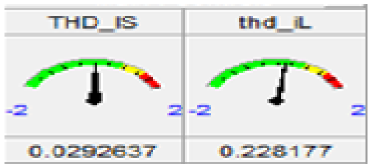

Fig 3.6: THD of source and load current for new method without PI Controller.

On comparing results shown in Fig 3.3 and 3.6 it is clear that presence of PI controller can reduce the THD further in case of modified method also.

IV.CONCLUSION

Conventional load compensators are capable of reactive power compensation along with harmonic compensation so the rating of the converter and thus the cost increases. But the existing load compensators are capable of harmonic compensation alone and thus converter rating is reduced. So it is cost effective. And when we come to the new system, with all the advantages of the existing system, the THD can further be reduced.

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