ADAPTIVE HARMONIC COMPENSATION USING SHUNT ACTIVE POWER FILTER

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Abstract

With the increasing awareness of both the costumers and utility operators of the power quality of the grid, more attention is being paid to harmonic compensation of costumers, non linear loads and harmonic damping through-out the distribution system. One of the techniques used to improve the power quality of the grid is using Shunt Active Filters (SAPF) for compensating the harmonics being injected into the systems by a specific non-linear load that is connected to the grid. An essential role is played by shunt active power filters (SAPF) in harmonic elimination as well as reactive power compensation in power systems with a large concentration of non-linear loads. The proposed topic comprises of PI controller, filter hysteresis current control loop, dc link capacitor. With the all these elements shunt active power filter reduce the total harmonic distortion. This paper successfully lowers the THD within IEEE norms and satisfactorily works to compensate current harmonics.

Index Terms: Shunt active power filter, harmonic compensation, PI controller, filter design, total harmonic distortion.

I. INTRODUCTION

Due to the proliferation electronic equipments and nonlinear loads in power distribution systems, the problem of harmonic contamination and treatment take on great significance. This harmonic interfere with sensitive electronic equipment and cause undesired power losses in electrical equipment. In order to solve and to regulate the permanent power quality problem introduced by this current harmonic generated by non linear loads such as switching power factor correction converter, converter for variable speed Ac motors drives and HVDC systems, the passive filters have been used which are simple and low cost.

However, the use of passive filter has many disadvantages such as large size, tuning and risk of resonance problem. Lately, owing to the rapid improvement in power semiconductor devices technology that makes high speed, high power switching devices such as power MOSFETs, IGBTs, IGCTs ect. Usable for the harmonic compensation modern power electronic Technology, APF have been considered as an effective solution for this issue, which has been widely used. One of the most popular active filter is the shunt active power filter (SAPF). SAPF has been researched, developed and have gradually been recognized as a workable solution to the problems created by nonlinear loads. The functioning of shunt active filter is to sense the load currents and extracts the harmonic component of the load current which the active filter must supply. This reference current is fed through a controller and then the switching signal is generated to switch the power switching devices of the active filter so that active filter will indeed produce the harmonics required by the load. Finally, the AC supply will only need to provide the fundamental component for the load resultant in a low harmonic sinusoidal supply. Generally, the effectiveness of SAPF depends on three design criteria: (i) design of power inverter;(ii)use of current controller's types (iii)methods used to obtain the reference current . The presented work was oriented mostly on the latter criterion. In order to determine harmonic and reactive component of load current, reference source current generation is needed. Thus, reference filter current can be obtained when it is subtracted from total load current. For better filter performance, generation of reference source current should be done properly. For this purpose, several methods such as pq-theory, dq transformation, multiplication with sine function and fourier transform have been introduced.

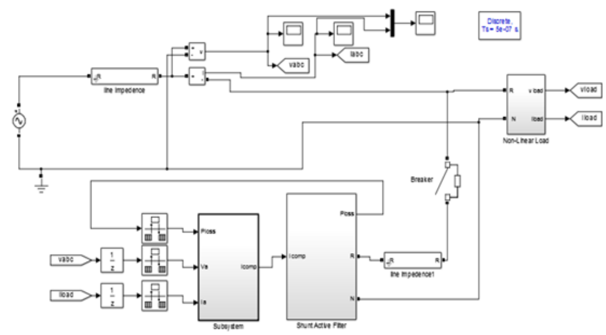
The active power is best choice to compensate reactive power. The method of removing harmonics in shunt active filter is by supplying the harmonic current to the load in opposite direction to that of supply from the mains. Hear shunt active power filter acts as the current source that supplies the compensating current that the load needs and has a phase shift of 180 deg. Because of which the harmonic currents are cancelled that from the main supply are from the filter. As per this mains current becomes pure sinusoidal. This filters are considerable to any load that generates the harmonics

Based on the basic principle of single phase shunt APF, the approximate dynamic model is derived. An adaptive sliding mode control algorithm is proposed to implement the harmonic compensation for the single phase shunt APF. This method uses the tracking error of harmonic and APF current as the control input, and adopts the tracking error of reference mode and APF output as the control objects of adaptive sliding mode. In the reference current tracking loop, a novel adaptive sliding mode controller is implemented to tracking the reference currents, thus improving harmonic eliminating performance. Simulation results demonstrate the satisfactory control performance and rapid compensation ability of the proposed controller under different conditions of the non linear load current distortion and the mutation load respectively.

II.MODELING OF ACTIVE HARMONIC CONTROLLING

In general, when the system is connected to nonlinear loads, harmonics are generated. due to these harmonics efficiency in power generation is decreased. To avoid these problems filters can be used, but it affects in economic percentage is calculated in order to reduce the harmonics. In order to detect the harmonics, additional equipment need to be provided which in turn effects the cost of the systems.

To avoid all these problems, in this method harmonic compensation is done by the active filters by modifying the control references. Here harmonics are reduced by producing a wave form which is in opposite phase with the harmonics produced. Therefore, these both wave forms when added together gets cancelled up and normal sinusoidal waveform is produced. By using these waveforms, a pulse is generated from the control circuit which is given as gate pulse to the MOSFETs in the converts circuit. The output of this converter circuit helps to control the harmonics produced. So, by controlling the function of MOSFETs harmonics can be controlled.



Circuit Diagram

III. MATHEMATICAL CLARKE TRANSFORM

The mathematical transformation called Clarke transform modifies a three-phase system to a two-phase orthogonal system with i_α and i_β components in an orthogonal reference frame and i_o the homopolar component of the system

$$i_\alpha = \frac{2}{3} . ia - \frac{(ib-ic)}{3} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$i_\beta = \frac{2(ib-ic)}{3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

$$i_o = \frac{2(ia+ib+ic)}{3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

In many applications, the homopolar component is absent or is less important. In this way, in absence of homopolar component the space vector u= $u_\alpha + ju_\beta$ represents the original three-phaseinput signal. Consider now a particular case with i_α superposed with i_a and $i_a + i_b + ic$ is zero, in the condition i_a, i_b and i_c can be transformed to i_α and i_β with following mathematical transformation

$$i_a + i_b + ic = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

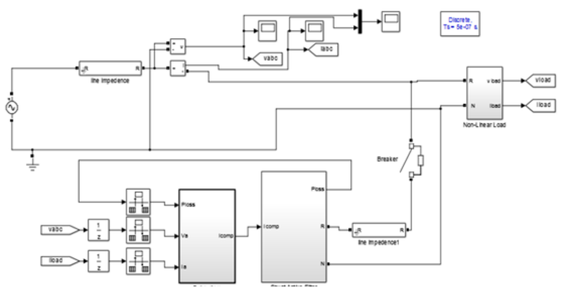
$i_\alpha = i_\beta$ ……………………………..(5)

$i_\beta = \frac{2}{3}.ia + \frac{2}{3}.ib$ ………………(6)

IV. SIMULATED AND EXPERIMENTAL RESULTS

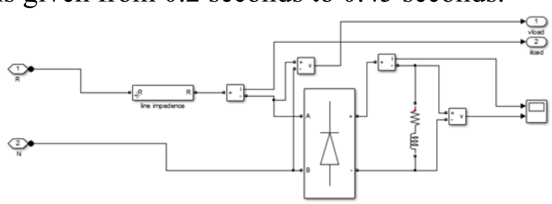
The configuration of the systems is the systems is the same as shown in figure, POC is connected voltage source with nominal 50 Hz frequency. The main grid voltage contains third and fifth harmonics voltages. Although harmonics extractions are not used in this simulation, the proposed method can still realize satisfied local load harmonic current compensation, resulted in an enhanced grid current quality with 1.45% THD. Meanwhile, when the circuit breaker is disconnected from systems, the source current is polluted with 49.2% THD.

The effectiveness of the proposed closed-loop power control strategy is verified. When the conventional open-loop power control is applied, it can be noticed that the source side current is not accurate.



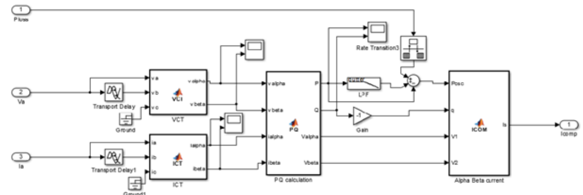
Complete Simulink Model of Active Harmonic Filtering

Here breaker is connected betweeen the systems and controller. When breaker is off controller is disconnected from circuit. The timing of breaker is given from 0.2 seconds to 0.45 seconds.



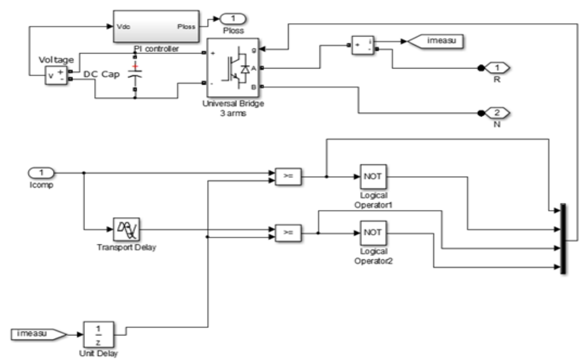
Non-Linear Loads

By connecting non-linear loads to the systems, harmonics are injected. In this simulink model diodes are considered as non-linear loads. Due to this connection of diodes, current at source side is no longer in phase with the voltage and results in harmonics.



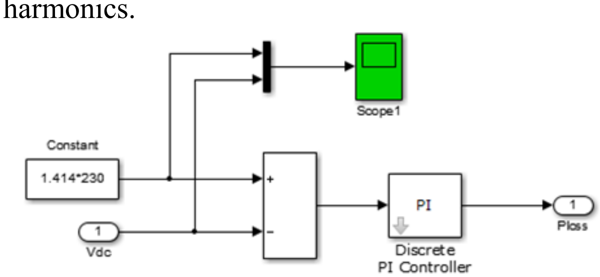
Subsystems of Active Harmonic Filtering

In this subsystems control signal is calculated which is termed as I_{comp}. This signal is derived by using of clark transformation. By this transformation real power and oscillating power can be calculated which helps to find the quality of harmonics present in the current waveform. Here α-β calculations are done in order to find active and reactive power. By use active filters oscillating quantity in active power is removed. In this model reactive power to the load supplied directly from the filter rather than supplying it from source side.

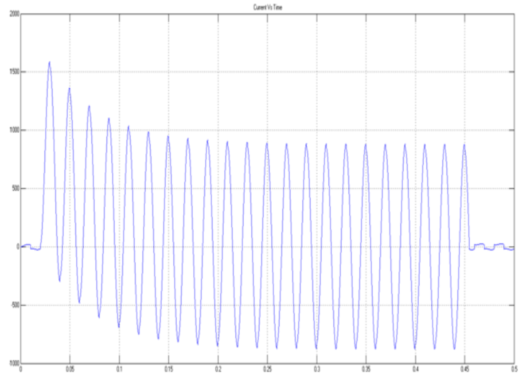


Shunt active filter

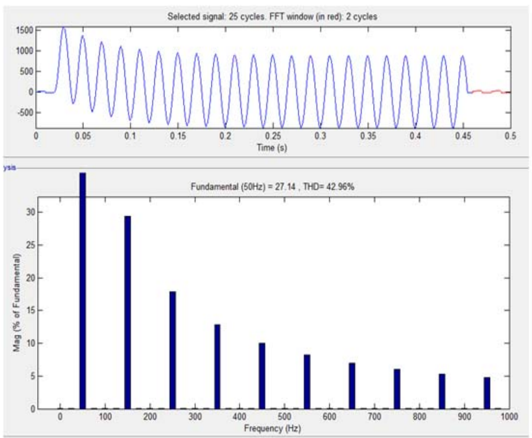
The control signal produced in the subsystems is transformed into current signal by supplying the harmonics current to the load in opposite direction to that of supply from mains. Here, shunt active power filter acts as the current source that supplies the compensating currents are cancelled that from the mains supply and from the filter. As per this mains current becomes pure sinusoidal. These filters are considerable to any load that generates the harmonics.



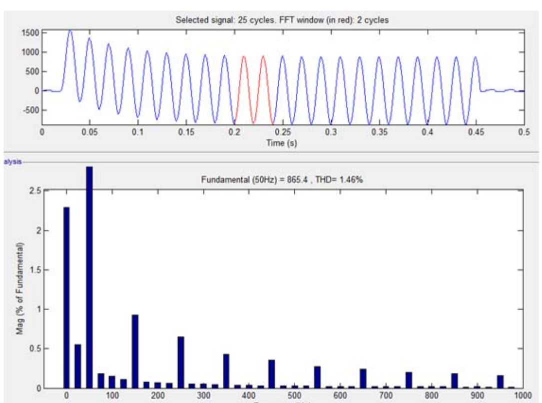
PI controller



Source current waveform



THD value before controller



THD Value after controller

CONCLUSION

In general, when the systems is connected to non-linear loads, Harmonics are generated. Due to these harmonics efficiency in power generation is decreased. To avoid these problems filters can be used, but it affects in economic point. In previous methods to reduce harmonics, initially harmonics are detected and harmonic percentage is calculated in order to reduce the harmonics in order to detect the harmonics. Additionally equipment need to be provided which in turns effects the cost of the system.

To avoid all this problems, in this method harmonic compensation is done by the DG unit by modifying the control references. Here harmonics are reduced by producing a wave form which is in opposite phase with the harmonic produced. Therefore, these both wave forms when added together gets cancelled up and normal sinusoidal wave form is produced. In order to reduce harmonic reference wave form is considered. Here both the current i.e, current at DG units and current at non linear loads are considered as reference wave forms . By using this waveforms, a pulse is generated from the control circuit which is given as gate pulse to the MOSFETs in the converter circuit of the DG unit. The output of this converter circuit helps to control the harmonic produced. So, by controlling the function of MOSFETs harmonics can be controlled.

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