International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-03, June 2019

An Adaptive Approach to Mitigate Harmonics in a Distributed Power Generating System

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***Abstract*: In this paper, A 3-phase distributed power generation along with harmonics compensation technique is proposed. The techniques to combine the power generation with mitigation of harmonics using hybrid power filters. Harmonics compensating analyzation is done using various configurations of hybrid filters. The control technique based on adjustable digital system processing is proposed. The proposed current identifying method independently controls fundamental current and distribution system harmonic currents. Calculation of the harmonic compensation current is achieved by the adjustable a deep infinite impulse response digital filter. The parameters of filters are made adjustable according to the fluctuations of grid frequency. Simcape power system tool box is used to design and simulate the proposed technique. The results obtained from proposed method shows the accuracy of the proposed method.**

Keywords — ***Distributed generation, Mitigation of harmonics, hybrid filter, power quality improvement, infinite impulse response filter, grid frequency.***

I. INTRODUCTION

A continuation development in renewable energy utilization and need of consumers with affordable electricity caused to rise in interest of distributed power generation. Since few years, bulk amount distributed power generation plants using renewable energy have been developed for reduced voltage distributing load centers like solar (PV) and wind-based power sources etc. power stations using renewable energy are connected to the utilizing centers or to utility gird using DC to AC inverting schemes [1].

Supplying a quality electrical power to the consumers is highly important for the reliable and safeness operation of electrical loads. Due to nonlinear loads such as heavy variable Inductive loads, fluorescent illuminators etc., at the load centers makes the system's quality to poor and causing the system to poor performance along with damage of electrical equipment. It also increases harmonic distortion which results to rise in power loss at load centers, transmission lines etc.

Power quality is also affected with usage of distributed power stations which is caused by operating features of individual power sources. Since inverter operation is included before connecting to grid or load centers, voltage and current harmonic distortions will be increased. There are several power quality improvement techniques available, but active power filters have shown best results to compensate for voltage and current disturbances in power systems. Due to the limitations of active power filter ratings which close to load ratings [2], using active power filters are not cost affordable solution. For cost effective method for current and voltage disturbance mitigations, hybrid power filters are preferred.

An adaptive line enhancer with finite impulse response digital filter was proposed in several researches to current harmonic compensation but due to rate of convergence is slow, its applications were limited [3].

The proposed technique to compensate voltage and current harmonics in distributed power generation by using hybrid power filters. Various combinations of hybrid power filter configurations matching with distributed power generation are considered and compensation of harmonics at load side is done using adaptive notch infinite impulse response filters which provides better convergence characteristics compared to adaptive line enhancer with finite impulse response digital filters. Sim power systems tools are used to model and analyses the results.

II. DISTRIBUTED POWER GENERATION AND HYBRID POWER FILTERS

in this, power converters are used to interface renewable energy-based power units with grid. Here, power converters have voltage source, current source and active power filter modes of operation. System can be off-grid or microgrid in voltage source mode of power converters, where the frequency and ac voltage are adjusted to achieve required

 DOI : 10.35291/2454-9150.2019.0184

power quality [4]. Most of real time distributed power generating units power converters operate in current source mode, in which system is operated by injecting currents with same phase and frequency of grid voltage [5]. Mitigation of ac current and voltage harmonic distortion is done in active power mode of operation of power converters.

Hybrid power filters are the combination of active power filters and passive power filters with different combinations of shunt and series.

Shunt active power filters helps in injecting the compensating current into distributed power line to nullify harmonic currents which are due to nonlinear load conditions [6]. Series active power filters helps in generation a voltage in proportional to source current harmonics. Some examples of hybrid filter topologies are given below.

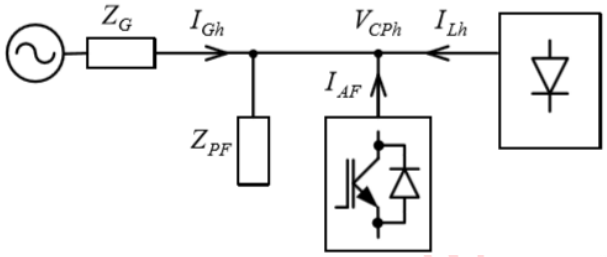

Fig.1: Hybrid power filter with the combination of shunt active power filter and shunt passive power filter.

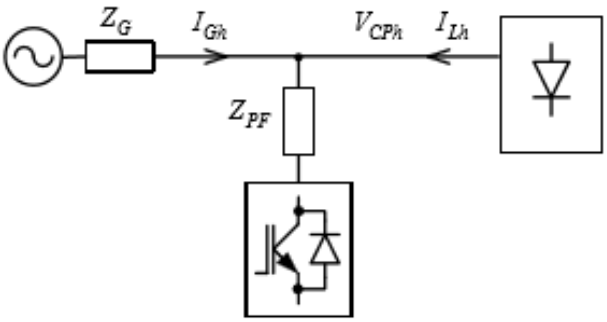

Fig.2: Hybrid power filter with series active power filter.

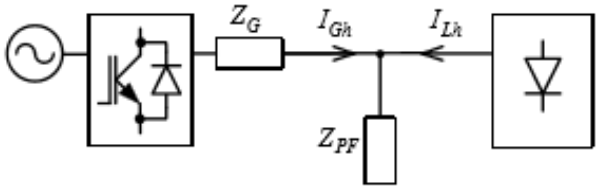

Fig.3: Hybrid power filter with combination of active shunt and active series power filter.

Whereas,

Z_G = Grid impedance given by $R_G + jwL_G$

I_{Gh} = Grid harmonic current given by

$I_{Lh} * Z_{PF} / (Z_{PF}+Z_G+R_{AF})$

I_{Lh} = Harmonic of distorted load current

III. Design in Simulink

For the mitigation of harmonics and improvement of power quality, compensating signals are produced by using frequency and time domain methods [7]. In frequency domain method, Fourier series used to analyze current distortion whereas adaptive notch Infinite Impulsive Response filter is used in time domain method.

model is designed in Simulink with sim power system tools is shown in figure no. 4 and the parameters of model are shown in a table no.1

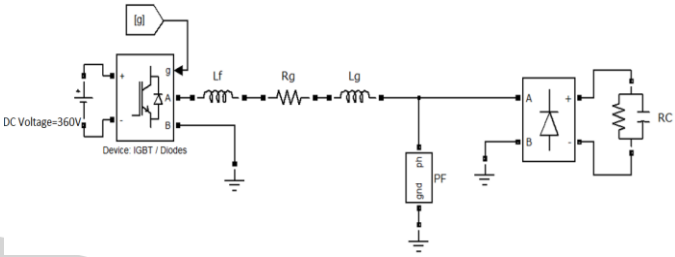

Fig 4: Simulink model

PCC Grid	Non-linear load	Linear load	Filter
DC 360V	R=4 Ohms	R=6 Ohms	C=100 µF
Rg=0.3 ohm	C=1000 µF	C=1200 µF	L=90mH
Lg=0.25mH			
Lf=1.2mH			

Table 1: Parameters of the model

IV. Simulink Results

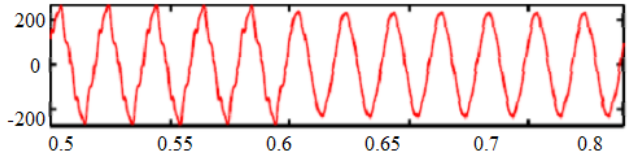

Fig.5: Grid current from simulink model

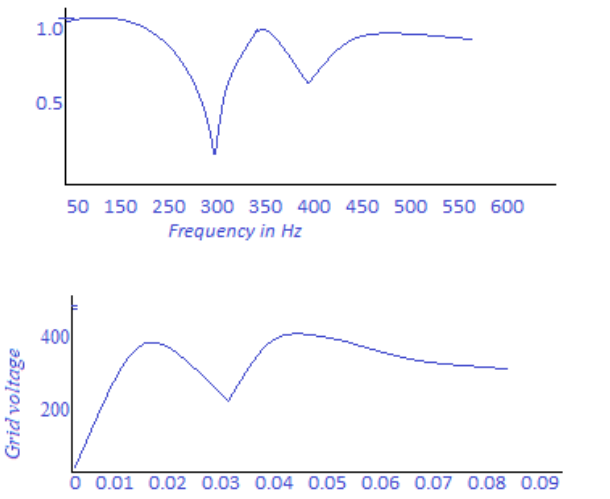

Fig.6: Frequency and grid voltage from Simulink results

 DOI : 10.35291/2454-9150.2019.0184

The obtained results from Simulink model are shown in figure no. 5 and 6.

Figure no.5 shows the grid currents at simulation step and then the harmonics mitigated output for frequency and grid voltage is shown in figure.6.

V. CONCLUSION

In this, compensation capability of voltage and current harmonic is achieved with various combination of hybrid power filters [8] in a distributed power generation unit. Sim cape power system tools were used to design in Simulink and results were as in results. Here, an adaptive approach is proposed to improve power quality by obtaining load harmonic compensation using Infinite Impulsive Response filter. It was observed that adaptive notch Infinite Impulsive Response filter can be successfully applicable to achieve mitigation of voltage and current harmonics purpose.

The performance of the proposed approach is verified with the results from Simulink and it shows the effectiveness of the proposed approach.

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