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Power Quality Improvement by Harmonic Mitigation using Hybrid Power Filter

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Abstract:-- **This paper re presents a proper method to mitigate harmonic in distribution and transmission system to improve the power quality. This include the hybrid power filter for mitigating the harmonic in the power system, the hybrid power filter is the combination of the voltage source inverter and the passive component like a capacitor and the inductor. The drawback of the active and the passive power filter is overcome by designing the hybrid power filter, the capability of harmonic mitigation can be increased with dc link voltage of the voltage source inverter. in this two method of implementation is adopted for harmonic mitigation in power system like hybrid mode and the passive mode , in passive mode the passive component is used in series such as capacitor and inductor and in hybrid mode the voltage source inverter is used along with the LC-filter . The power quality improvement and the reactive power control is also represented in this paper The analysis and MATLAB simulation give the proper solution to mitigate the harmonic in the distribution and the transmission system to improve the power quality.**

Keywords:-- **hybrid power filters, passive power filters, power system harmonics, reactive power control., Total Harmonic Distortion, power quality, transmission and distribution network ,FFT Analysis**

I. INTRODUCTION

Today there is need of high quality power supply. Due to wide spread used of non linear load such as UPS, electronic devices, power electronic devices, PC etc the Harmonic is generated in the system. the heating of various equipment ,voltage sag ,voltage fluctuation is some of the undesirable effect will occurs in the power system due to the generation of the harmonic. Also this non linear load is responsible for the generation of the reactive power in the system so to avoid this undesirable effect on the power system and to compensate reactive power the Active power filter , passive power filter and hybrid power filter is used but out of this three power filter the passive power filter is only the series combination of the inductance and the capacitance and this passive power filter is not that much effective to mitigate the harmonic in the power system as its performance is depends on the impedance. Where as the hybrid power filter can effectively mitigate the harmonic in the distribution and transmission System. The aim of this paper is to introduce the hybrid power filter to mitigate the harmonic in distribution and transition System to improve the power quality trough the MATLAB simulation.

II. NEED OF POWER QUALITY IMPROVEMENT

There is linear and non linear load will occurs in the power system. The load that draws the current which is proportional to the applied voltage is considered as a linear load ,resistive loads is one of the example of the linear load also the incandescent lamp is the linear load . And the load in which the voltage and current are no sinusoidal is considered as a non linear load such as the computers, variable frequency drives, power electronic devices, electronic component etc, are some common example of the non linear load. and due to used of this nonlinear load there is a issue regarding a power quality. The non-sinusoidal nature developed due to presence of harmonic in current which can cause the adverse effect on the power system such as distortion in voltage waveform also the voltage fluctuation and voltage sag, various power system equipment heating. voltage distortion that can affect both the distribution system equipment as well as the transmission system equipment and also the loads

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connected to it. Power electronic include the power converters and this power converter considered as a large non linear load in the power system. The power converters are used in the industry for different purposes, such as adjustable speed drives, uninterruptable power supplies etc. When the non sinusoidal current passes through the system impedance which causes the undesirable effect such as the voltage sag and the voltage fluctuation. Hence there is a need of power quality improvement. Due to the presence of harmonic in the power system the bus bars and cables may prematurely age. Fuses and circuit breakers will not give the better performance to protect the entire system equipment. as a result of this the harmonic mitigation is necessary to improve the power quality.

III. SHUNT ACTIVE POWER FILTER

The Shunt active power filter is consist of both active and passive element this active power filter is one of the electronic filter and it consist of amplifiers so its performance can be improved with the help of amplifier. Hence the shunt active filter can remove the harmonic in the power system and remove the voltage and current distortion also compensate the reactive power in the power system. with the used of active power filter voltage fluctuation and the voltage sag can be remove .As the name indicate that the shunt active power filter means the active power filter is connected in parallel to the system. the shunt connected active power filter is used to mitigate the current harmonic and the improve the power quality .The shunt active power filter generally fabricated with help of Insulated gate bipolar transistor ,Thyristors, bipolar junction transistor , static induction thyristor ,gate turn off thyristor to compensate the harmonic component of the load current as well as the source current.

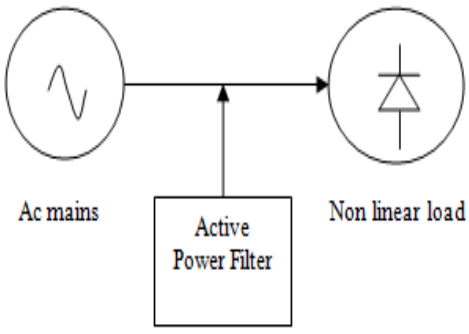

Figure 1: The block diagram of the shunt connected active power filter

This shunt connected active power filter generally used to inject the active power to compensate the voltage sag and voltage disturbances in the distribution and transmission system or grid.

IV. SHUNT PASSIVE POWER FILTER

The shunt passive power filter nothing but a series parallel combination of the passive element such the inductor ,capacitor and a resistor .Generally this type of shunt connected passive power filter can offers a low impedance path or low resistive path to the harmonic current as a result of this the harmonic current is pass through this low impedance path and so the harmonic current is diverted through shunt passive power filter network and system is free from the distortion and current harmonics and due to this maintaining the power quality. Also the system is free from voltage waveform distortion as well as the current waveform distortion proper bypassing of the current is carried out by connecting the shunt passive power filter in parallel with the harmonic producing load. There are different variety of passive filters is generally used to eliminate harmonic such as single tuned, double tuned, high pass and low pass filter, c-type filters. But out of this all type of passive filter the most commonly used filter are the single tune and double tuned passive power filter. In the shunt connected passive power filter the combination of capacitance and the inductance generally provide low impedance or resistive path for tuned harmonics but there is one drawback associated with this shunt connected passive power filter as this power filter doesn't eliminate harmonics to a greater level .Figure 2 shows the block diagram of shunt connected passive power filter in which the ac source is connected to the non linear load it can also used the six pulse or twelve pulse ac-dc converter with R-L load .This is widely used configuration or arrangement of shunt connected passive power filters.

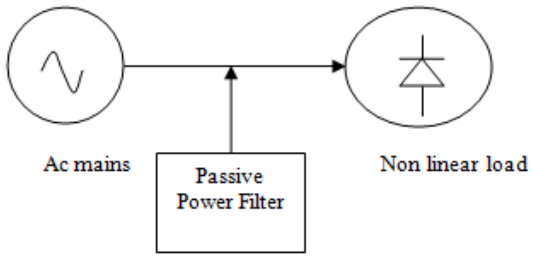

Figure 2: The block diagram of the shunt connected passive power filter

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This shunt connected passive power filter can operate as a low pass filter and high pass filter and these low pass filter and high pass filter generally eliminate the positive sequence and negative sequence current harmonics typically the shunt connected low pass filter can mitigate the5^{th} and 7^{th} harmonic and the shunt connected high pass filter can mitigate the 11^{th} harmonic This shunt connected passive power filter can more dominantly mitigate the 5th and 7th and other higher order harmonics and thus avoid to them to enter into the grid. The main reasons to divert the harmonic current in the passive power filter are the impedance available in system. As the higher be the source impedance then better performance of the passive power filter is obtained. Both a passive shunt connected filter and the passive series connected filter have a same potential solution for harmonic mitigation. Connection block diagram of series connected series active power filter is same as that of the shunt connected passive filter. In this power filter branches of passive filter is connected in series with source and the load. It can also eliminate the 5^{th} and 7^{th} and 11^{th} harmonic but in case of series passive power filter the performance of the series passive filter is not much dependent on the source impedance. But this configuration is associated with one more drawback such that their is reduction in dc bus voltage. The harmonics in distribution networks or in distribution grid or in the transition system represent the importance of the problem cause by current harmonics or the voltage harmonics in terms of power quality ,continuity of supply, steady state stability of the system .The main reasons for arising the current harmonics or the voltage harmonic in distribution system is the nonlinear loads for example the personal computer, Discharge lamps that is the mercury vapour lamp or the sodium vapour lamp generally used for the street lightning purpose and all type of power electronics based equipments and the semiconductor devices are the some frequent examples of nonlinear lads in residential, commercial, and industrial areas. The harmonics have a dominant effect on medium-voltage and Low Voltage lines due to the presence of harmonic causing load such as furnaces, ovens and rectifiers. Generally the three-phase loads generate positive sequence 1^{st},7^{th},13^{th},19^{th}….order current harmonics and negative sequence 5^{th} ,11^{th},17^{th}, 23^{rd}…..order current harmonics in the distribution system and in transmission system .Due this positive sequence and negative sequence current harmonics there is a generation of resonance condition, voltage distortion, overheating of equipment, and losses in the system and ageing of electrical equipments, etc. whereas the zero sequence current harmonic is generated because of single-phase loads, generally and the zero sequence current harmonic is 3rd, 9th, and 15th harmonic order is generated in the neutral conductor. Harmonics with order of multiple of three is the zero sequence current harmonic and this arises due to the several single-phase non linear loads and are effectively considered up in the neutral conductor due to this the harmonic current in the neutral conductor is higher than in the phase conductor and causes the neutral conductor overload, common mode neutral to earth voltages, increase of phase voltage distortion, and transformers overheating and generator overheating.

V. LITRAUTRE REVIEW

The harmonic is nothing but an integral multiple of the fundamental frequency there is several types of electronic filter this electronic filter is developed by using only resistors and capacitors or resistors and inductors. As per the connection of the inductance and capacitance connection RC single-pole filters and RL single-pole filters is developed. In resent, complex multi pole LC filters and the Hybrid filters are also developed by combining the passive filter or the resonant cell with the voltage source inverter in that generally 12 pulse or 18 pulse voltage source inverter is used. The implementation of passive power filter is generally depends on the combination of the resistance ,inductance, and capacitance and are called as passive filters, because they do not depend upon an external power supply and where as the active power filter contain the active element. In passive filter the reactive elements of the filter is inductors and capacitors. are The number of elements determines the order of the filter. Historically, the design of linear analog filter is mainly depend on the Q factor and this quality factor measure the frequency of the tuning circuit. As the requirements of telecommunications the design of filter has been developed in 1920.The Kirchhoff's law is one of the important law which is used in the design of the Low order filters by developing the transfer function and this type of analysis is usually developed only to carried out for simple filters of 1st or 2nd order due to such design there is a advantage of the simplicity of approach and the ability to easily extend to higher orders. By continued-fraction or partial-fraction expansions of the polynomial the actual element values of the passive and active and also the hybrid power filter are obtained. A different type of mathematical techniques or method is employed to analyze the behavior of a given digital filter .this paper presents a combined system of a passive filter and a small rated active filter ,both connected in series or parallel and also the

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passive power filter is integrated with voltage source inverter to obtained the hybrid power filter .The passive power filter generally remove low order harmonic. Whereas on the other hand the hybrid power filter improving the filtering characteristics of the passive filters. Due to such combination there is great reduction in rating of the active power filter and also eliminating all the harmonics and the limitation faced by using only the passive power filter, by taking into considering a practical and economical aspect of the system.

VI. HYBRID POWER FILTER TOPOLOGY

The resonant cells is the three single-phase impedances in three phases and in neutral branches of power filter are called a passive filter, and this associated with several resonance frequencies. As per the connection of the resonant cell power filter gives two groups of resonance frequencies, in which one group for the positive sequence or negative sequence components and other group for the zero-sequence components. This indicates that's the passive power filter is able to perform selective filtering of harmonics by providing low-impedance paths to current components with certain specific frequencies and sequences. The block diagram of hybrid power filter is shown in figure 3 it consist of mainly four blocks namely the grid current processing blocks this block consist of notch filter and the function of this notch filter is that it cancelling out the fundamental frequency component from the current harmonics and second one is the injected current controller block this block consist of PI controller, third one is the dc link voltage controller block , fourth one is the modulator block and , the main function of the grid current processing block is that selecting the current harmonics to be filtered from the grid current .the function of the injected current controller to sets a reference voltage for the Voltage source Inverter in order to mitigate the selected current harmonics in the distribution system. The function of the dc-link voltage controller block is that it modifies the original reference voltage of the Voltage Source Inverter by adding an extra voltage in order to keep the dc-link voltage at its normal rated value.

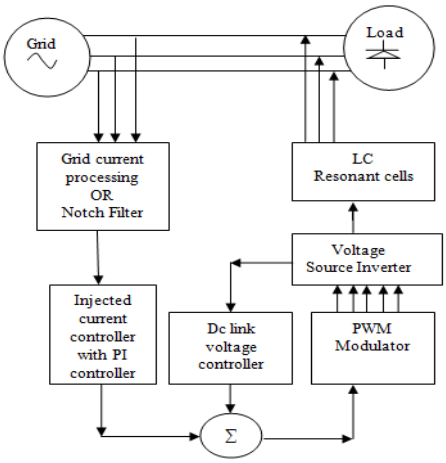

Figure 3: The block diagram of the Hybrid power filter with controlled system

And the function of the modulator to generate the switching pulses of the Voltage Source Inverter from the reference voltage of the Voltage Source Inverter and The next important part in the configuration is the voltage source inverter and the resonant cell The resonant cells that is the passive filter of the hybrid power filter provide the very low impedance path to positive sequence and negative sequence and zero sequence currents at the particular resonance frequencies therefore, to inject into the grid significant levels of harmonic currents a low dc link voltage is necessary in the Voltage Source Inverter. As the frequency goes far away from the resonance frequency then impedance offered by the resonant is also increases hence hybrid power filter can compensate only a limited range harmonics. Hence, the grid current processing block that is the notch filter selects those frequencies that are suitable to be filtered from the grid current by using signal filtering methods. As there is increase in the dc-link voltage level of voltage source inverter the harmonics mitigation range can also be increased but this increases the rating of voltage source inverter and hence cost associated to it. Also on both the parameter that is the current sensing point and the type of injected current controller the transfer function of the control system which is developed for the hybrid power filter is depends .This injected current controller developed with proportional integral controller can operate in synchronous or static reference frames .To keep the dc-link voltage to its nominal value there is exchange of active power between Voltage source inverter and the grid, this paper represent the hybrid power filter for mitigating the harmonics in

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distribution system as well as in transmission system to improve the power quality.

VII. SIMULATION MODEL

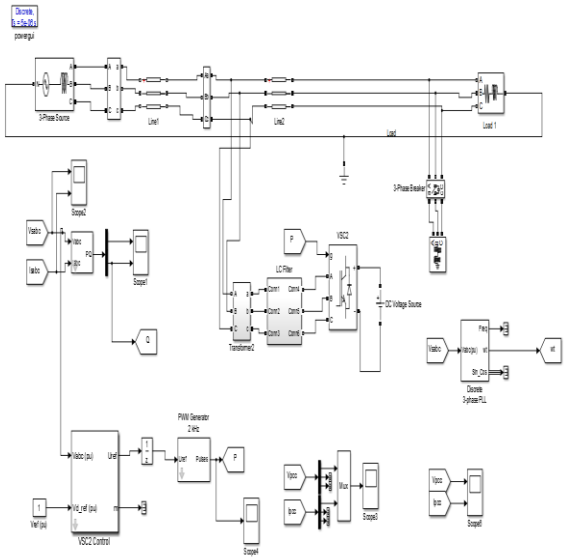

Figure 4: Simulation model of Hybrid power filter

VIII. SIMULATION RESULTS

The simulation results the proposed system is obtained by the MATLAB SIMULINK. The Total harmonic distortion of load current and voltage and also the active and reactive power is given in the results.

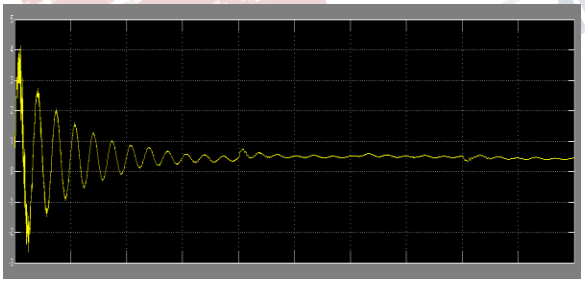

Figure 5: The Active Power

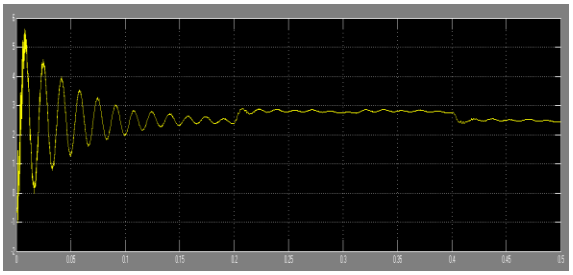

Figure 6: The Reactive Power

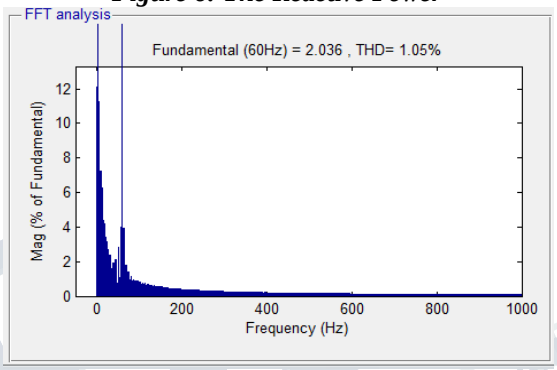

Figure 7: The FFT Analysis of load current

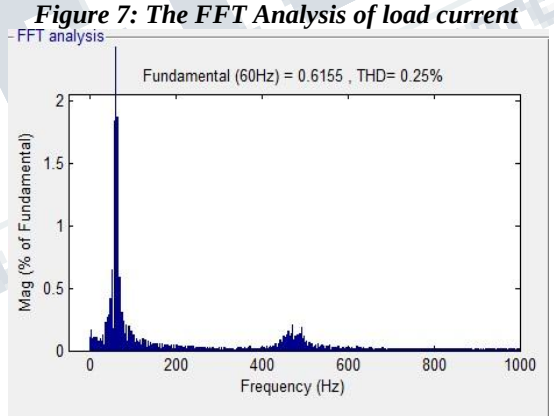

Figure 8: The FFT Analysis of Voltage

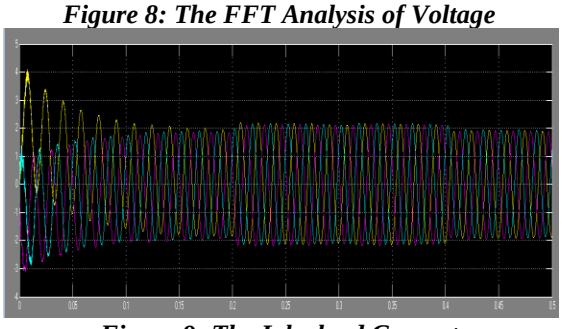

Figure 9: The Iabc load Current

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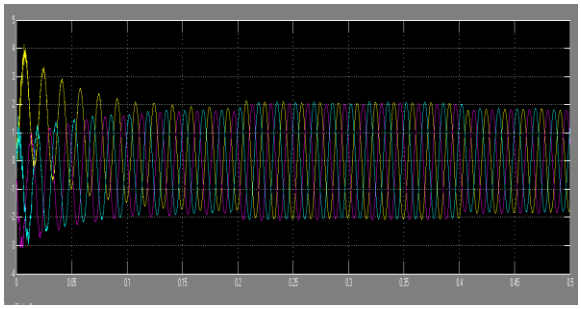

Figure 10: The Iabc Grid Gurrent

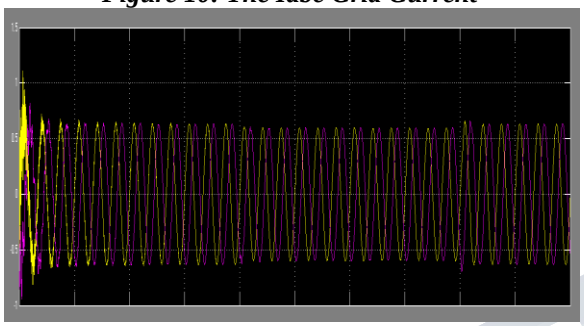

Figure 11: The Vabc Load Voltage

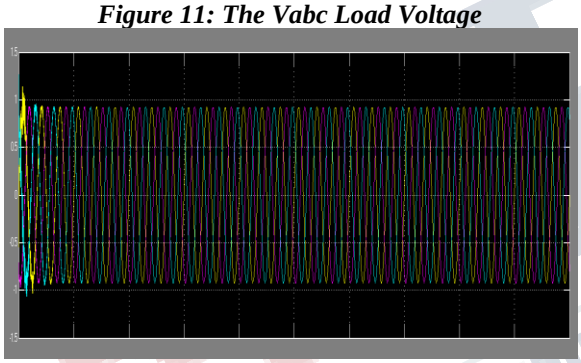

Figure 12: The Vabc Grid Voltage

IX. CONCLUSION

To improve the power quality the hybrid power filter for transmission and distribution system is presented in this paper .The MATLAB Simulation and analysis gives the better performance of the system also the FFT analysis analyzed the system behavior. The more economical system is developed by integrating the voltage source inverter with the passive filter with low dc-link voltage.

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