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REVIEW: ACTIVE POWER FILTERING TECHNIQUES FOR POWER SYSTEM

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Abstract - *The term active filter is a generic one and is applied to a group of power-electronic circuits incorporating power switching devices and passive energy-storage-circuit elements, such as inductors and capacitors. The functions of these circuits vary depending on the applications. They are generally used for controlling current harmonics in supply networks at the low- to medium-voltage distribution level or for reactive power and/or voltage control at high-voltage-distribution level. In recent years there has been considerable interest in the development and applications of active filters because of the increasing concern over power quality, at both distribution and consumer levels, and the need to control reactive power and voltage stability at transmission levels. The existing approaches are classified and assessed to provide a framework of references for both researchers in this field and for generators, suppliers and consumers of electrical power who are, or may be, concerned about the problems associated with power quality and are considering installing active filters for their particular sets of problems.*

Key Words: Active power filter (APF), Power quality

1. INTRODUCTION

Centralized power generation systems face the dual constraints of shortage of fuel and want to scale back the emissions. Long distance transmission lines square measure one amongst the most causes for electric power losses. So, stress has augmented on distributed generation (DG) networks with integration of renewable energy systems into the national grid that result in potency and reduction in emissions. With the increase of the renewable energy penetration into the grid, power quality of low voltage power transmission is changing into a serious space of interest. Most of obtainable integration of renewable energy systems to the grid takes place with the help of power physics converters. The first use of the ability electronic converters is to integrate the metric weight unit to the grid in compliance with power quality standards. But, high frequency switch of inverters will inject a lot of harmonics to the systems, making major PQ issues if it's not enforced properly.

Filtering strategies like Hybrid Filtering (Combination of series passive and shunt Active Power Filter) & Inductively Active Filtering square measure the most recent development of interfacing devices between distribution offer (grid) and client appliances to beat voltage/current disturbances and improve the ability quality by compensating the reactive and harmonic power generated or absorbed by the load.

Solar is that the one amongst most promising metric weight unit sources and their penetration level to the grid is on the increase. Though the advantage of Distributed generation includes voltage support, decrease in transmission & distribution losses and improved response. PQ issues are of growing concern. This paper deals with a groundwork and development of PQ issues associated with solar integrated to the grid and also the impact of poor power quality. The affiliation topologies of filtering into the system to beat the PQ issues are mentioned.

2. Active Power Filter

2.1. Shunt active power filter

Depending on the actual application or electrical drawback to be resolved, active power filters will be enforced as shunt type, series type, or a combination of shunt and series active filters (shunt-series type). These filters may also be combined with passive filters to make hybrid power filters.

The shunt-connected active power filter as shown in Fig.1, with a self-controlled dc bus, includes a topology kind of like that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. During this case the shunt active power filter operates as a current supply injecting the harmonic elements generated by the load however phase-shifted by 180°.

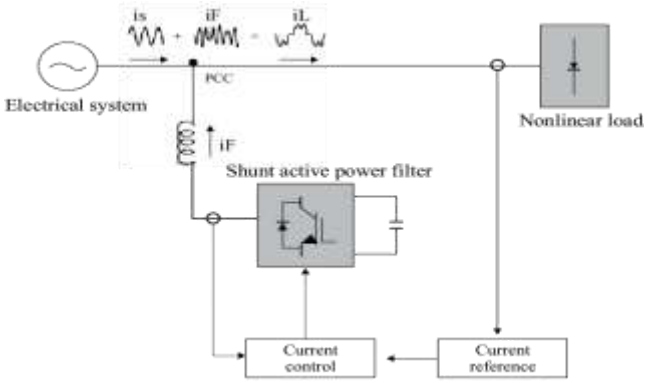

Fig-1: Series active power filter

2.2. Series active power filter

Series active power filters as shown in Fig.2 were introduced by the tip of the 1980's and operates in the main as a transformer and as a harmonic isolator between the nonlinear load and also the utility system. The series-connected filter protects the buyer from associate inadequate offer voltage quality. this kind of approach is particularly suggested for compensation of voltage unbalances associated voltage sags from the ac offer and for low-power applications and represents an economically enticing various to UPS, since no energy storage (battery) is critical and also the overall rating of the parts is smaller.

The series active filter injects a voltage part nonparallel with the provision voltage and so may be considered a controlled voltage supply, compensating voltage sags and swells on the load aspect. In several cases, series active filters work as hybrid topologies with passive LC filters. If passive LC filters area unit connected in parallel to the load, the Voltage stabilizer mistreatment series active power filter operates as a harmonic isolator, forcing the load current harmonics to flow into in the main through the passive filter instead of the ability distribution system.

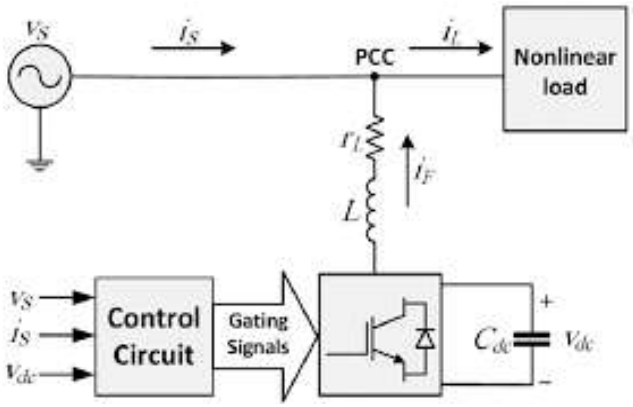

Fig-2: Series active power filter

2.3. Unified power quality conditioner

The series-shunt active filter could be a combination of the series active filter and therefore the shunt active filter. The shunt active filter is found at the load aspect and might be accustomed atone for the load harmonics. On the opposite hand, the series portion is at the supply aspect and might act as a harmonic interference filter. This topology has been referred to as the Unified Power Quality conditioner.

3. DIFFERENT TECHNIQUES FOR ACTIVE POWER FILTERING

In one in all the strategy [1] group action an energetic power filter with a solar photovoltaic (PV) generation supply, that use constant electrical converter for connecting to the network. Through this integration a double aim is fulfilled: on the one hand the power quality is improved through the compensation capability of active power filters, and on the opposite an additional contribution of active power is equipped by PV system. The facility system operation is analyzed through the instant power theory and simulated victimization MATLAB Simulink atmosphere. This can be a possible answer for the expansion designing of isolated systems, whereas the operation and maintenance prices additionally as energy losses may be reduced.

A method for dominant a vigorous power filter victimization neural networks is conferred [2]. Currently, there's a rise of voltage and current harmonics in power systems, caused by nonlinear loads. The active power filters (APFs) square measure wont to compensate the generated harmonics and to correct the load power issue. The planned management style may be a pulse dimension modulation management (PWM) with 2 blocks that embody neural networks. Neural networks estimate the reference compensation currents. On the opposite hand, a multilayer perceptron feed-forward network (trained by a backpropagation algorithm) that works as a hysteresis phenomenon band comparator is employed.

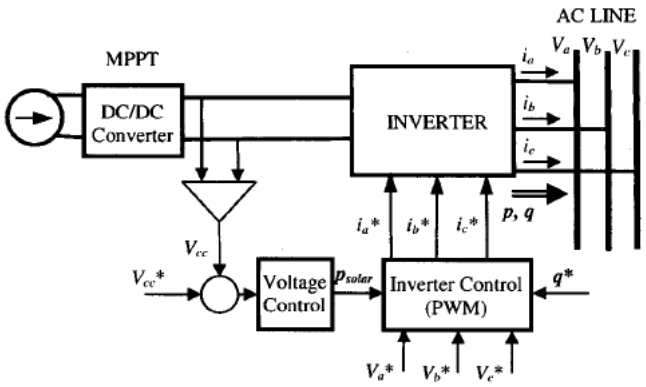

Fig-3: Basic combined scheme of an active power filter and a PV system

New management algorithmic program for a vigorous power filter (APF) to compensate harmonic and reactive power of a 3-phase thyristor bridge rectifier underneath non-ideal mains voltage eventualities was conferred [3]. Sensing load current, dc bus voltage and supply voltages reason reference currents of the APF. APF driving signals are created with these signals via a physical phenomenon band current controller. Matlab/simulink facility tool case is employed to simulate the projected system. The projected method's performance is compared with typical instant power (p–q) theory. The simulation results are conferred and mentioned showing the effectiveness of the management algorithmic program. The projected algorithmic program is found quite satisfactory to compensate the reactive power and harmonics underneath non-ideal mains voltage conditions.

A single-phase two-wire electrical converter system for photovoltaic (PV) power injection and active power filtering

(APF) with nonlinear inductance thought was projected [4]. The projected system will totally or partly perform APF, method PV power, eliminate harmonic currents, improve power issue, and take into consideration the nonlinear impact of its output filter inductance. Within the system, albeit solely the utility current is detected, each APF and most electric receptacle trailing options may be still achieved, reducing the quantity of current sensors and price considerably. To forestall output current from extraordinary switch ratings, electrical converter current is correctly controlled through a current controller and an outlined limit circle. A self-learning algorithmic rule is additionally projected to see nonlinear inductance, which might increase the accuracy of the calculable current.

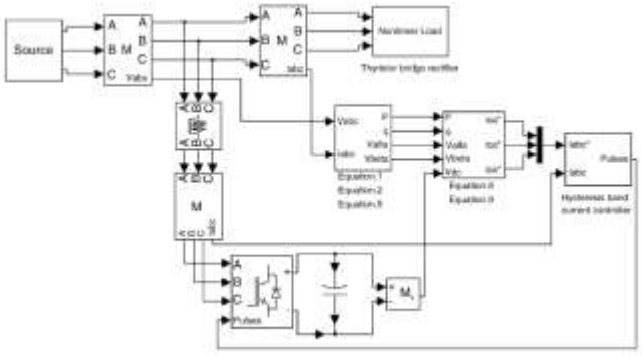

Fig-4: Schematic block diagram of three-phase shunt APF system [3]

The system will trot out PV power, compensate current harmonics, and improve power issue at the same time. Although solely a current detector is placed at the utility aspect, the required options will be still achieved. Within the style, the utility current commands area unit derived to effectively utilize the electrical converter system. A current expert is employed to guage electrical converter current to stop output power from extraordinary the switch current ratings. Additionally, a self-learning rule is additionally projected and distribution is applied to spot the nonlinear impact of the filter electrical device. A DSP chip (TMS320F240) is adopted to see the utility current-command, notice the present expert, and come through an MPPT feature in order that the management circuits of the PV electrical converter system area unit compact and programmable.

The simulation and experimental study of proportional integrator (PI) controlled DC bus voltage of 3 part shunt active power filter (APF) to enhance power quality by compensating harmonics and reactive power needed by nonlinear load is projected [5]. The compensation method relies on sensing mains currents solely, AN approach totally different from standard ways, that sometimes need harmonics or reactive var values of the load. The non-sinusoidal mains voltage downside is resolved by victimization part bolted loop (PLL) system. Pulse dimension modulation (PWM) signal generation relies on physical phenomenon management comparators to get the change signals.

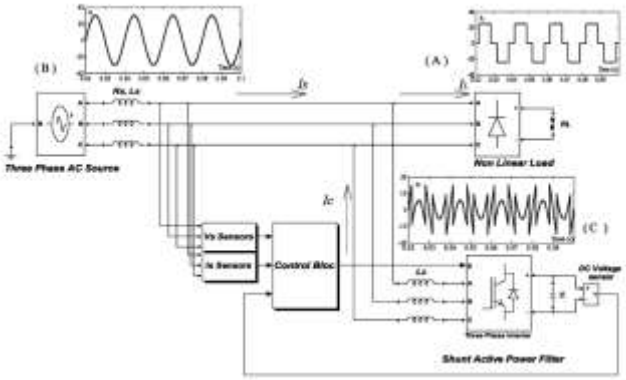

Fig-5: APF system configuration and currents waveforms [5]

The performance of the PI controller has been studied on simulation has been developed in real time method with an xPC Target system and with success tested within the laboratory to verify the simulation results. It's clear from simulation and experimental results that the compensation method is straightforward, and relies on sensing one supply voltage, electrical compensation voltage and 3 line currents solely. In spite of high frequency voltage supply wave because of this, the obtained current is synchronic with the voltage, that annihilates reactive power and harmonics area unit rejected. The total harmonics distortion (THD) of the supply current once compensation is well below five-hitter, the harmonics limit obligatory by the IEEE-519 commonplace.

One of the tactic, [6] describes adjective methodology for compensating the reactive power with a vigorous power filter (APF), that is ab initio rated for mitigation of solely the harmonic currents given by a nonlinear industrial load. It's established that, if the harmonic currents don't load the APF at the rated power, the offered power is wont to offer a neighborhood of the specified reactive power. Totally different indicators for coming up with such application area unit given, and it's established that the planned adjustive algorithmic program represents another price to the APF. The algorithmic program is much valid on a laboratory setup with a 7-kVA APF.

The planned algorithmic program compensates the reactive power if the APF electrical converter current limit isn't reached. The principle is predicated on calculation of fast d- and q-axes currents to work out by completely different suggests that the common price of reactive current (i.e., q-axis) obligatory as reference.

Active power filters (APFs) are wont to compensate harmonics, reactive current and negative sequence first harmonic current of load current drawn by nonlinear

masses. The pliability of selective compensation, if provided within the management theme, makes APF versatile device for compensation of reactive power, harmonic currents and unbalance in supply currents and their combos, relying upon the restricted rating of the voltage-source electrical converter utilized as an APF. The planned theme [7] decomposes the load current into positive and negative sequence first harmonic active parts, reactive element and harmonic parts in synchronous reference frames. The management theme performs with priority-based theme, that respects the restricted rating of the APF. The simulated ends up in MATLAB surroundings and experimental results of the developed paradigm of APF are conferred to validate the effectiveness of the planned management theme. Digital signal processor based mostly implementation of management theme is additionally elaborated for selective compensation of power-quality issues with details of developed paradigm.

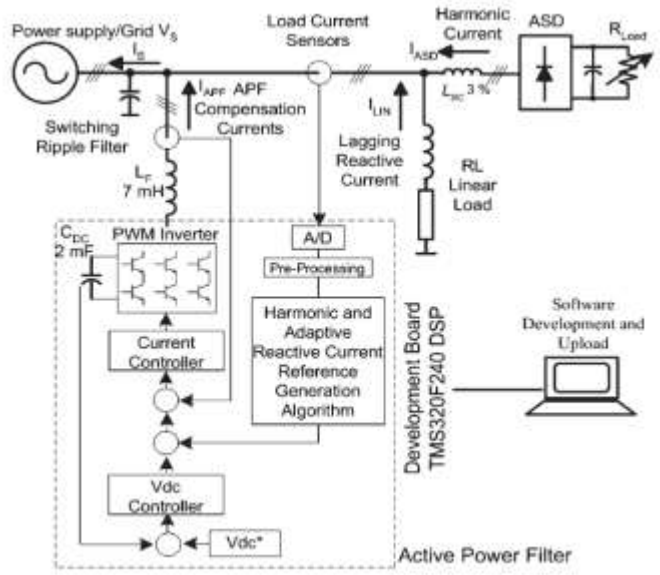

Fig-6: General diagram of the laboratory setup. The APF compensate the harmonics and the reactive power from the ASD and the RL load.

A new current decomposition technique supported SRF theory with indirect current management for prioritized selective compensation of power-quality parts has been investigated for APF. The determined performance of the active filter has incontestable the power of the planned management technique to by selection compensate the present harmonics, unbalanced loading and reactive power, supported priority to respect the restricted power capability of the VSI. Associate experimental study has been conducted and has valid the effectiveness of the planned theme. it's additionally been determined that the planned theme includes a quick response and is in a position to keep up close to curved supply current for harmonic compensation conformist to IEEE-519 commonplace and is in a position to self support the dc bus. The theme has the advantage of flexibility of choice of the power-quality indices that references could also be computed. The theme alongside indirect current management has offered automatic compensation of part lag, which might have otherwise occurred thanks to passive ripple filters etc. The theme generally could also be applicable to alternative topologies of active and hybrid power filters/conditioners. In a very shell it's suggested that below restricted power capability of the VSI of APF active power conditioner with indirect current management with prioritized theme compensation provided by the planned theme offers appropriate answer to uncertainties in grid thanks to current quality issues.

One of the techniques gift an immediate current-space-vector management [8] of a lively power filter (APF) supported a three-level neutral-point-clamped (NPC) voltage-source electrical converter. The projected methodology indirectly generates the compensation current reference by victimization a similar electrical phenomenon of the basic part victimization APF's dc-link voltage management. The projected management will by selection opt for harmonic current parts by real time quick Fourier rework to get the compensation current.

The compensation current is delineating during a rotating system with chosen shift states from a shift table enforced during a field-programmable gate array. Additionally, a 3 part four-wire APF supported a three-level neutral-point-clamped electrical converter is additionally conferred. The projected APF eliminates harmonics altogether 3 phases similarly because the neutral current. A three-phase three-wire Nonproliferation Center electrical converter system will be used as a three-phase four wire system since the split dc capacitors offer a neutral affiliation. to control and balance the split dc-capacitor voltages, a brand new management methodology employing a sign cubiform physical phenomenon controller is projected. The characteristics of the APF system with associate degree LCL-ripple filter area unit investigated and compared with ancient current management methods to judge the inherent blessings.

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To regulate and balance the split dc-capacitor voltages, a brand new management technique employing a sign cuboids physical phenomenon controller is planned. The characteristics of the APF system with AN LCL-ripple filter area unit investigated and compared with ancient current management ways to judge the inherent blessings.

An industrial controller, specifically designed for two- and three-level converters, was tailored to figure on an asymmetrical nine-level active power filter (APF) [9]. The controller is currently ready to build all needed tasks for the proper operation of the APF, like current-harmonic elimination and removal of high-frequency noise. The low switching-frequency operation of the nine-level device was a very important advantage within the application of the commercial controller. Additionally, with the nine-level filter, change losses were considerably reduced. The filter was designed to figure as voltage supply and operates as harmonic isolator, up the filtering characteristics of the passive filter. The management strategy for sleuthing current harmonics relies on the "p−q theory" and also the phase-tracking system in an exceedingly synchronous organization phase-locked loop. The dc-link voltage management is analyzed along with the impact of controller gain and delay time within the system's stability. Simulations for this application area unit displayed and experiments in an exceedingly 1-kVA model, victimization the same industrial controller, were tested, collateral the effectiveness of this new application.

A control algorithmic program for a three-phase hybrid power filter is planned [10]. It's grooved by a series active filter and a passive filter connected in parallel with the load. The management strategy is predicated on the vectorial theory twin formulation of instant reactive power, in order that the voltage wave shape injected by the active filter is ready to compensate the reactive power and therefore the load current harmonics and to balance asymmetrical masses. The planned algorithmic program conjointly improves the behavior of the passive filter. Simulations are administrated on the MATLAB-Simulink platform with totally different masses and with variation within the supply electrical resistance.

A new current controller theme for selective harmonic compensation is planned for shunt active power filters [11]. The strategy employs associate degree array of resonant current controllers, one for the elemental, and one for every harmonic, enforced in basic arrangement so as to cut back the machine effort. The planned controller style methodology is predicated on the pole-zero cancellation technique, taking under consideration the load transfer operates at every harmonic frequency. Two style ways are provided, that provide controller transfer functions with superior frequency response. The entire current controller is realized because the superposition of all individual harmonic controllers. The frequency response of the complete control system management is perfect with reference to filtering objectives, i.e. the system provides sensible overall stability and wonderful property for attention-grabbing harmonics. This conclusion is supported by experimental results on a seven. 6 kVA laboratory filter, indicating a discount in current doctorate issue from thirty four you must 2 Chronicles, whereas the best harmonic paid is that the thirty seventh harmonic current.

Modern technique proposes the effective utilization of unified power quality conditioner (UPQC) for interconnecting the PV modules to the grid exploitation power angle controller (PAC) methodology [12]. A shunt active power filter (APF) is employed to evacuate the ability from the electrical phenomenon module additionally to compensating this harmonics, load unbalance and reactive power. To accomplish this the series APF within the UPQC is employed for provision an area or whole reactive power needed by the load additionally to compensating the sag, swell, provide voltage unbalance and distortions. This is often created doable by dominant the point in time and magnitude of series injected voltage known as power angle management methodology. The reactive power and voltage compensation technique introduces a part shift between the load terminal voltage and supply voltage. The transient thanks to sudden part shift is reduced exploitation step by step introduction of series compensation voltage. The projected methodology effectively utilizes the shunt APF and series APF within the UPQC for interconnecting the PV module to the grid.

The deals with indirect current controlled shunt active power filter (APF) for up power quality by reactive power compensation and harmonic filtering [13]. The projected APF relies on a voltage supply electrical converter (VSI). The VSI is controlled by 2 loops, the voltage management loop and also the current management loop. The voltage management loop regulates the DC link electrical condenser voltage and also the current management loop uses physical phenomenon band management to form the supply current specified it's in-phase with and of identical form because the input voltage. The main advantage of the projected APF is that the reference current for power quality improvement is generated from the DC link electrical condenser voltage.

Repetitive controller (RC), which may come through zero steady-state error trailing of any amounted signal with renowned number period, offers active power filters (APFs) a promising correct current management theme to compensate the harmonic distortion caused by nonlinear hundreds. However, classical RC cannot specifically compensate periodic signals of variable frequency and would cause vital performance degradation of APFs. In one amongst the methodology, a fractional- order RC (FORC)

strategy at a set rate is projected to subsume any periodic signal of variable frequency, wherever a Lagrange-interpolation-based third delay (FD) filter is employed to approximate the factional delay things. The synthesis and analysis of FORC systems are given. The projected FORC offers quick on-line calibration of the FD and also the quick update of the coefficients, so provides APFs with a straightforward however terribly correct real time frequency-adaptive management answer to the elimination of harmonic distortions underneath grid frequency variations. A case study on a single-phase shunt APF is conducted.

4. CONCLUSIONS

In this paper, the different methodology and techniques was presented for utilization of active power filter for improvement of power quality of power system, transient improvement of power system, and minimization of affect of solar and wind integrated power system.

These paper very much useful for clear the idea about active power filter and its implementation using software approach or in simulation software. That very much helpful for students and researcher which working in field of active power filter designing.

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