International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

Unified Active Power Filter for Plow flow control

G. Rambabu & D. Jayanth Kumar
Assistant Professor, ADAMS Engineering College, T.S, INDIA

Abstract- *This paper manages the simulation of a Unified Active Power Filter went for inspecting its capacity in enhancing power quality in a power dispersion systems. The UAPF output demonstrates includes two 12 pulse inverters which are associated in series and in shunt to the system. A summed up sinusoidal pulse width modulation exchanging system is created in the proposed controller outline for quick control activity of the UAPF. Results were completed utilizing the MATLAB to approve the execution of the UAPF demonstrate. Simulation comes about confirm the capacities of the UAPF in performing voltage sag remuneration, flicker diminishment, voltage unbalance alleviation, UPS mode, control stream control and harmonic end. An examination of the UAPF with other custom power devices demonstrates that the UAPF gives a superior execution in control quality alleviation.*

I. INTRODUCTION

An expanding interest for high caliber, solid electrical power and an expanding number of twisting loads have driven an expanded attention to control quality both by clients and utilities [1]. For control quality change, the improvement of energy electronic gadgets, for example, adaptable AC transmission system and custom power systems have presented a rising branch of innovation giving the power system flexible new control capacities [2].

When all is said in done, FACTS devices are utilized as a part of transmission control though custom power devices are utilized for circulation control. Since the presentation of FACTS and custom power idea, devices, for example, bound together power-stream controller (UPFC), synchronous static compensator (STATCOM), dynamic voltage restorer (DVR), strong state exchange switch, and strong state blame current limiter are created for enhancing power quality and dependability of a system [3].

Propelled control and enhanced semiconductor exchanging of these devices have accomplished another period for control quality alleviation.

Examinations have been done to think about the viability of these devices in control quality moderation, for example, sag remuneration, harmonics disposal, unbalance compensation, receptive power compensation, stream control, control factor amendment and flash lessening [4]. These devices have been produced for moderating particular power-quality issues.

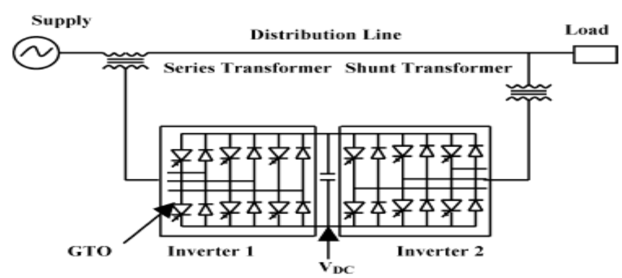

Fig.1. Basic configuration of UAPF

For instance, UPFC functions admirably for power flow control. DVR, which goes about as an series compensator, is utilized for voltage sag compensation. STATCOM, which is a shunt compensator, is utilized for responsive power and voltage sag compensation [5]. The STATCOM and DVR are helpful for remunerating a specific sort of energy quality issue and in this manner, it is important to build up another sort of Unified Active Power Filter (UAPF) which can alleviate a more extensive scope of energy quality issues [6]. By utilizing a bound together approach of series shunt compensators it is conceivable to make up for an assortment of energy quality issues in a circulation framework including hang remuneration, glimmer decrease, unbalance voltage moderation, and power-flow control.

Notwithstanding, very little work has been done in the improvement of a UAPF. The goal of this paper is to investigate the abilities of a UAPF in alleviating power-quality issues. The proposed model of the UAPF considers the utilization of two 12 pulse inverters [7].

The demonstrating and simulation of the UAPF has been completed utilizing the outstanding MATLAB.

II. MODELLING & PRINCIPLE OPERATION

The UAPF is a mix of series and shunt voltage source inverters and its fundamental design is appeared in Fig. 1.The fundamental segments of the UAPF are two 12 pulse voltage source inverters made out of constrained commutated control semiconductor switches, commonly gate turn off (GTO) thyristor valves. One voltage source inverter is associated in series with the line through a series of arrangement infusion transformers, while the other is associated in shunt with the line through an arrangement of shunt transformers.

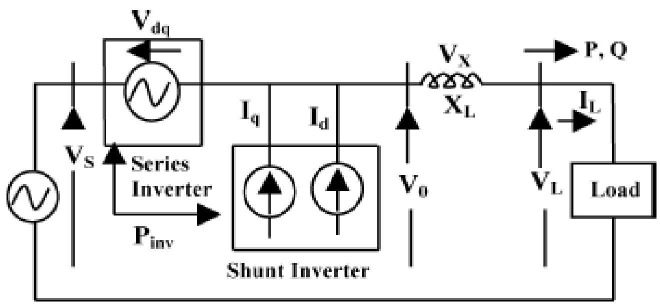

Fig.2: Principle operation of UAPF

The dc terminals of the two inverters are associated together and their normal dc voltage depends on a capacitor bank. The UAPF is practically like the UPFC, yet the main contrasts are that the UPFC inverters are in shunt series association and it is utilized as a part of transmission frameworks while the UAPF inverter in series shunt association and it is utilized as a part of dissemination systems.

The standard operation of a UAPF is depicted by first alluding to the model appeared in Fig. 2. As said before, the UAPF comprises of a shunt associated inverter and a series associated inverter. The series associated inverter infuses a voltage Vdq in arrangement with the appropriation line, which thus changes the voltage Vx over the dissemination line reactance Xl, consequently changing the current and the power move through the circulation line.

The current infused by the shunt inverter has a real or direct segment Id, which can be in stage or in inverse stage with the line and a receptive or quadrature segment Iq, which is in quadrature with the line voltage, in this way imitating an inductive or a capacitive reactance at the purpose of association with the dissemination line. The responsive current can be freely controlled which thusly will manage the line voltage.

The UAPF acts as a perfect air conditioning to AC inverter, in which the trading of real power at the terminal of one inverter to the terminal of the other inverter is through the regular dc connect capacitor. It ought to be noticed that the shunt inverter is controlled so as to give decisively the appropriate measure of real power at its dc terminal to meet the real power needs of the series inverter and to direct the dc voltage of the dc transport. In this manner, real power is retained from or conveyed to the dissemination line through the shunt associated inverter, which infuses a current at the purpose of association.

Along these lines, UAPF incorporates the elements of both series and shunt associated inverters which creates or ingests receptive energy to manage voltage extent and current flow at the AC terminal, separately.

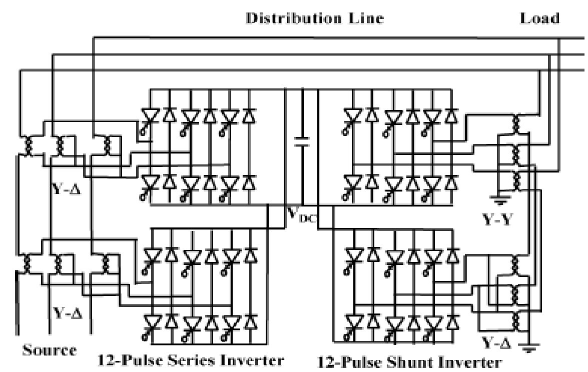

Fig.3. Simulation model of UAPF using 12-pulse series and shunt inverters

III. SIMULATION MODEL

Simulation model of the UAPF which has been produced utilizing MATLAB. The UAPF comprise of two 12 pulse inverters in which one 12 pulse inverter is associated in series and the other 12 pulse inverter is associated in shunt. The series and shunt blend of inverters comprises of a two-level, three-stage, 24 self-commutated GTO switches with non-parallel diodes. This valve blend and its capacity to go about as a rectifier or as an inverter with immediate current flows in positive or negative bearing, separately, is the fundamental voltage source converter idea.

The shunt associated inverter is associated with the load by methods for two arrangements of three single-stage transformers which are of Y-Y and Y-Δ designs to evade stage move of other than the request of harmonics in the optional of the transformers, which may bring about vast flowing current because of regular center of motion. The stage to nonpartisan consonant voltages of Y-Y associated optional, other than the request of 12n+1, i.e., fifth, seventh, seventeenth, nineteenth.

Are inverse to those of the stage to stage harmonic voltages of Y-Δ associated optional and with 1/3 times the sufficiency. Accordingly, the yield voltage of shunt inverter would be a 12 pulse wave shape, with symphonious request. In any case, the series associated inverter is associated with the source by methods for two arrangements of three single-stage transformers which are of Y-Δ design. This is on account of, typically Y - associated optional windings permit the infusion of positive, negative and zero succession voltages, while the delta associated auxiliary windings permit just the infusion of positive and negative arrangement voltages. The delta association forestalls zero succession flows going into the system from the inverter.

The essential windings of all the single-stage transformers are associated in arrangement with a specific end goal to stay away from harmonics circulating current. The spillage reactance's of the every one of the transformers are kept low in order to keep an expansive voltage drop. The 22/4.6-kv step down

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transformers with spillage reactance of 0.01 for each unit are considered.

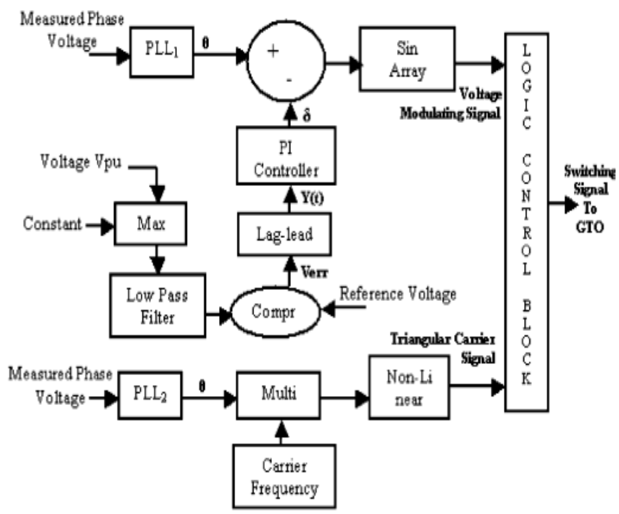

Fig.4. Shunt inverter control system

Two consecutive 6-pulse inverters are used to make up the 12 pulse inverter and the phase shift between these two inverters is calculated and found to be 30 degrees by using the phase shift displacement angle formula which is given by, where 2π/6m is the number of the 6-pulse inverters used. The capacitor plays an important role in the UAPF operation by acting as a dc source to provide reactive power to the load and to regulate the dc voltage. The size of the dc capacitor considered in this simulation is 3340 microf.

IV. CONTROL SYSTEM OF UAPF

The control arrangement of the UAPF can be partitioned into two sections, to be specific a shunt inverter controller and an series inverter controller, in which they control the shunt current and the series infused voltage, separately. At the point when the series and the shunt associated inverters work as remain solitary devices, they trade solely receptive power at their terminals. The series associated inverter infuses a voltage in quadrature with the line current in this way copying an inductive or a capacitive reactance in arrangement with the line. The shunt associated inverter, in any case, infuses a responsive current, in this way additionally copying a reactance at the purpose of association. While working both series and shunt-associated inverters together as a UAPF, the series infused voltage can be at any point concerning the line current. The trading of real power flow can be between the terminals of series and shunt associated inverters through the regular dc connect capacitor.

Shunt Inverter Controller of UAPF:

The controller of a shunt inverter is used to operate the voltage source inverter such a way that the phase angle between the inverter voltage and the line voltage is dramatically adjusted so that the shunt inverter generates or absorbs reactive power at the point of connection of the system [8]. Fig. 4 illustrates the control design of the shunt inverter together with sinusoidal pulse width modulated (SPWM) switching implemented in MATLAB.

In the voltage control loop, the measured three-phase voltages are fed to the phase locked loop (PLL1) in order to detect the phase angles and angular positions of the voltages.

The PLL1 is responsible for providing the voltage synchronizing signal with an angle. The measured voltage in per unit and a constant are fed into a maximum block to calculate the maximum voltage signal which is then passed through the first order low pass filter to attenuate the voltage transients. The signal is then compared with a reference voltage. A voltage error is observed and is fed to the voltage lag-lead function block, in which the output Y(t) is fed to the proportional integral (PI) control block. The output of the PI controller is the angle order, which gives either a leading or lagging phase angle which is necessary to adjust the voltage of the capacitor.

The angle order represents the shift between the system voltage and the voltage generated by the shunt inverter. The angle order combined with voltage synchronizing signal q becomes the voltage modulating signal in which its magnitude and phase are controlled.

The phase-locked loop (PLL2) also provides a voltage synchronizing signal which is multiplied by a carrier frequency of 1.65 kHz, which is 33 times the system operating frequency so as to convert the carrier ramp signal into the triangular carrier signal whose amplitude is fixed between -1 to + 1. In the SPWM technique, the triangular carrier signal is compared with the voltage-modulating signal so as to obtain the firing signals of the GTOS. The zero crossings of the voltage ramps fire/block the GTOs, depending on the displacement angle. If displacement angle =0, the shunt inverter output voltage is said to be in phase with the ac system voltage. However, if there is an error between the reference voltage and the system voltage in per unit, that is, V p.u < V ref, then the displacement angle >0 and the shunt inverter voltage lags behind the ac system voltage thus causing real power flow into the shunt inverter. Consequently, the dc capacitor voltage will increase, thus causing an increase in the ac output voltage of the shunt inverter.

The increase in ac output voltage causes a reduction in the error voltage until, V p.u = V ref. If V p.u > V ref, then the displacement angle <0 and the shunt inverter voltage leads the ac voltage thus causing real power flow into the system.

Consequently, the dc capacitor voltage will decrease, thus using a decrease in the ac output voltage of the shunt inverter and a reduction in the error voltage until V p.u = V ref.

Series Inverter Controller of UAPF

In the series inverter, the spwm technique is also used to control the magnitude and phase of the ac voltage by synchronizing the GTO's switching to the ac system voltages. The control for the series inverter are almost similar to that of the shunt inverter, but

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the only difference is that in the series inverter voltage control loop, the measured phase currents are input to the PLL1 in order to generate the synchronizing signals. The series inverter injected voltages are kept in quadrature with the line currents to provide series compensation, whereas in the shunt inverter injected currents are kept in quadrature with the line voltage. In the series inverter control, the generation of the displacement angle and the generation of the triangular carrier signal and the voltage modulating signal is similar to that of the shunt inverter. In general, the overall controller function is the same to that of the shunt inverter controller.

V. MODELLING OF CASE STUDY AND RESULTS

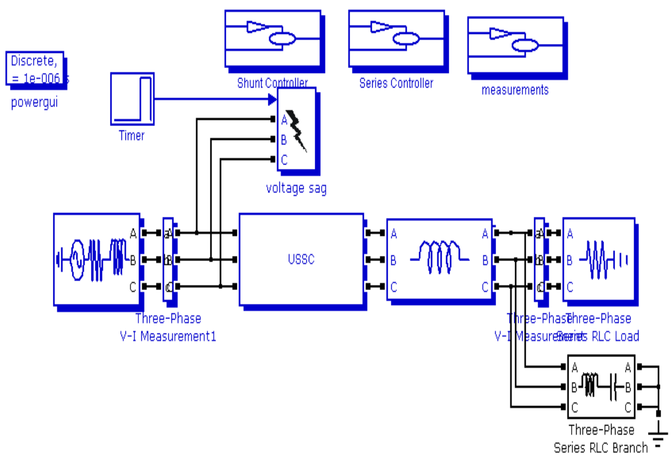
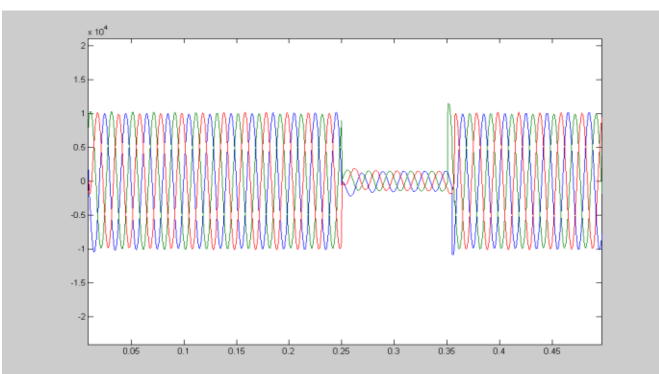


Fig.5: Simulink model of UAPF



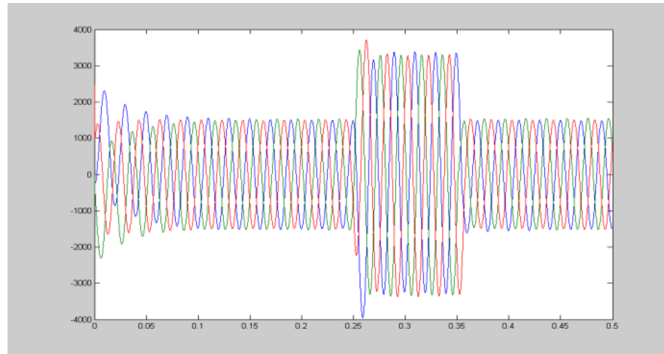


Fig.6: source voltage and current

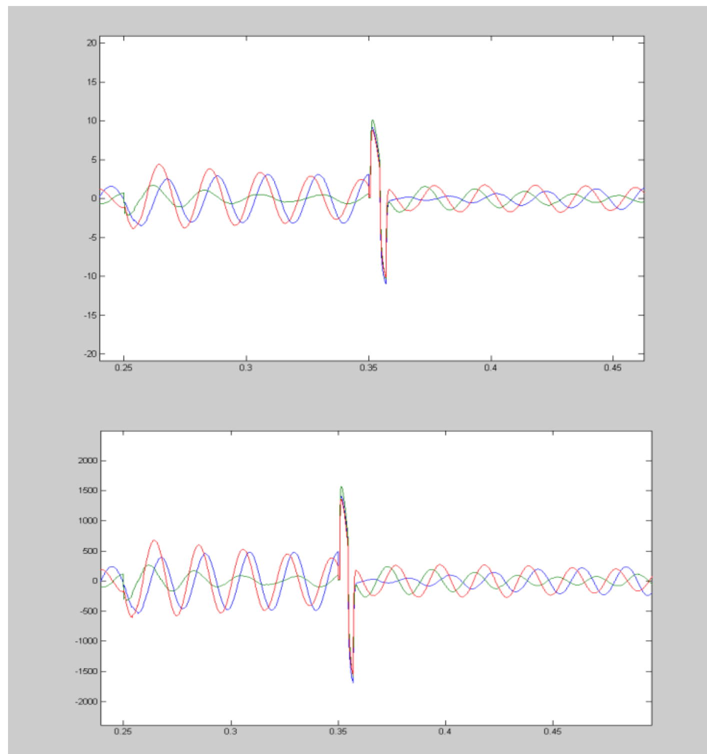


Fig.7: Load voltage and current

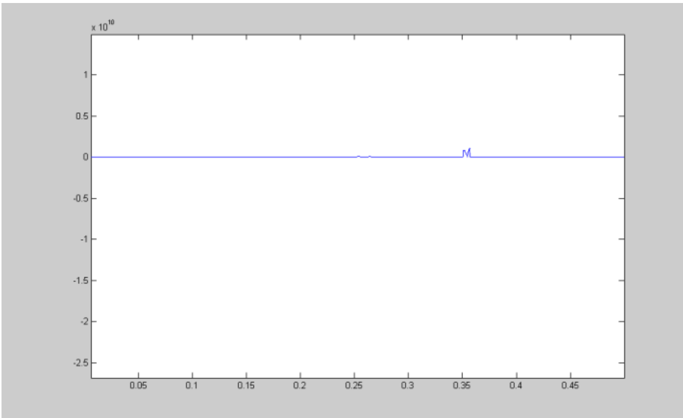


Fig.8: Active power Compensation

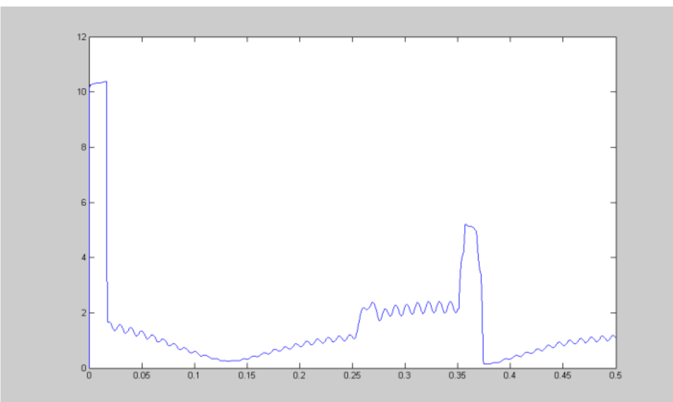


Fig.9: RMS voltage

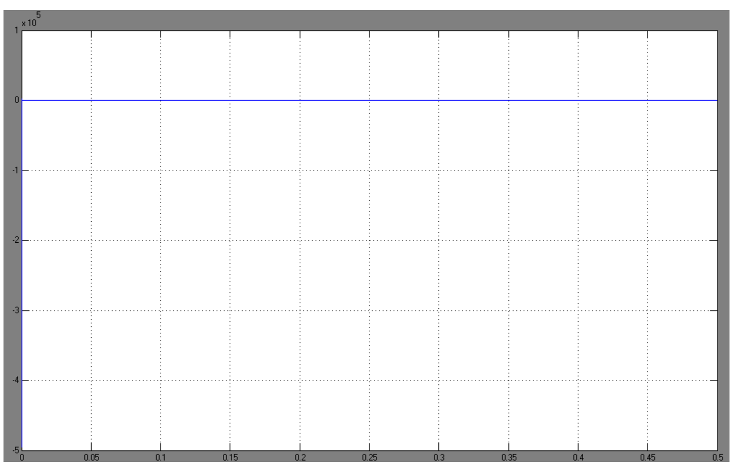


Fig.10: THD Value

VI. CONCLUSION

A brought together way to deal with the relief of different power quality issues has been researched by utilizing UAPF. The two level, UAPF fusing 12 pulse series and shunt associated inverters has been displayed in MATLAB and another SPWM-based control conspire has been executed to control the GTO's of the inverters. Simulation results have been done to assess the execution of the UAPF under different working conditions and power-quality unsettling influences. Results comes about demonstrate that the UAPF can perform voltage sag remuneration, flicker lessening, voltage unbalance alleviation, UPS mode and power flow control. It was additionally monitored that harmonics created by the UAPF can be altogether decreased by embeddings an inactive channel into the system. A correlation is made between the UAPF and the other custom power systems, for example, D-STATCOM and DVR as far as their abilities in control quality relief. It is demonstrated that the UAPF gives a superior execution in control quality moderation, particularly in voltage sag compensation and power flow control, and furthermore give more power-quality arrangements when contrasted with the D-STATCOM and DVR.

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Author's Profile

G. Rambabu
Assistant Professor, ADAMS Engineering College, T.S, INDIA

D. Jayanth Kumar
Assistant Professor, ADAMS Engineering College, T.S, INDIA