IMPROVEMENT IN POWER QUALITY PROBLEMS BY UNIFIED POWER QUALITY CONDITIONER (UPQC)

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ABSTRACT

The power electronic devices due to their inherent nonlinearity draw harmonic and reactive power from the supply. In three phase systems, they could also cause unbalance and draw excessive neutral currents. The injected harmonics, reactive power burden, unbalance, and excessive neutral currents cause low system efficiency and poor power factor..The design of shunt active filter is described in .The use of the sophisticated equipment/loads at transmission and distribution level has increased considerably in recent years due to the development in the semiconductor device technology. The equipment needs clean power in order to function properly. At the same time, the switching operation of these devices generates current harmonics resulting in a polluted distribution system. The power-electronics-based devices have been used to overcome the major power quality problems Along with the increasing of concerns about the pollutions produced by fossil fuel engines to forcing the vehicle market to discover new alternatives to decrease the fossil fuel usage. Different electric vehicle and hybrid electric vehicles are viable alternatives to displace for common fleet of fossil fuel driven vehicles. Plug-in Hybrid Electric Vehicles (PHEV) are suitably to be a strong alternative to the current vehicle due to promotion in battery and hybrid electric power technologies, meet up with the financial, energy security necessity, concerns about environmental and the cost of fossil fuel . Therefore, in recent years, the numbers of PHEVs entering the market have been increasing very quickly. These vehicles could help in vehicle-to-grid (V2G) power transactions in the proposed smart grid in the near future. A survey showed that most US population drive are parked more than 95% of the day, their expectable nature can be provide successfully in V2G transactions. In V2G mode of operations, the PHEV fleet can give many grid services, such as voltage regulation management load leveling external storage for renewable energies resources and generating revenue with transaction power at different times according to variable price curves. Another important service of the PHEV is reactive power support, which has not been studied previously

In this project presents a Design of a Unified Power Quality conditioner (UPQC) connected to three phase four wire system (3P4W). The neutral of series transformer used in the fourth wire for the 3P4W system. The neutral current that may flow toward transformer neutral point is compensated by using a four-leg voltage source inverter topology for shunt part. The series transformer neutral will be at virtual zero potential during all operating conditions. In this simulation we observe the power quality problems such as unbalanced voltage and current, harmonics by connecting non linear load to 3P4W system with Unified Power Quality conditioner. A new con-

trol strategy such as unit vector template is used to design the series APF to balance the unbalanced current present in the load currents by expanding the concept of single phase P-Q theory.

Keyword: Unified power quality conditioner, Series active power filter, Shunt active power filter, Power quality

I.INTRODUCTION

Electrical power system is design to provide high quality power for satisfactory operation of various electrical equipment. However the extensive use of non-linear loads in modem power system is becoming highly vulnerable to power quality and contributing to increased power quality issues. The main issues of a poor power quality are harmonic currents, poor power factor, supply-voltage variations; etc.It has been always a challenge to maintain The quality of electric power within the acceptable limits. The adverse effects of poor power quality may result into increased power losses, abnormal and undesirable behavior of equipments, interference with nearby communication lines, and so forth. The term active power filter (APF) is a widely used terminology in the area of electric power quality improvement. APFs have made it possible to mitigate some of the major power quality problems effectively. The UPQC is one of the APF family members where shunt and series APF functionalities are integrated together to achieve superior control over several power quality problems. The function of unified power Control strategy plays a vital role in the overall performance of the power conditioner. Rapid detection of disturbance signal with high accuracy, fast processing of the reference signal and high dynamic r e s p on s e of the controller are the prime requirements for desired compensation. Generation of appropriate swi tching Pattern or gating signal with reference to command compensating signal determines the control strategy of the UPQC.

II. PROPOSED SCHEME

In proposed system easy expansion of 3P3W system to 3P4W system. The neutral current, present if any, would flow through this fourth wire toward transformer neutral point. This neutral point current can be compensated by using a split capacitor. This neutral current achievement is used the method P-Q Theory in UPQC. The UPQC consisting of the combination of a series active power filter (APF) and shunt APF.

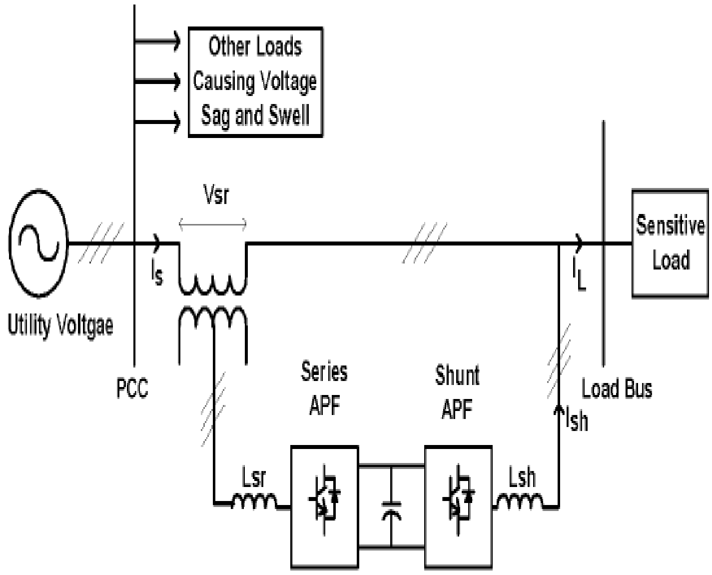

Fig1.Block Diagram of UPQC

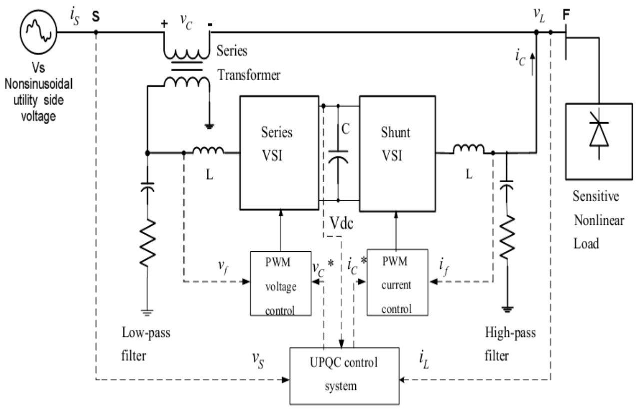

Fig2..UPQC System Connection

2.1 Existing Method

In Existing to connecting series active filters the voltage harmonic compensation, high impedance path to harmonic currents these are the main functions. All these non-linear loads draw highly distorted currents from the utility system, with their third harmonics component almost as large as the fundamental. The increasing use of non-linear loads, accompanied by an increase in associated problems concerns both electrical utilities and utility customer.

2.2 Unified Power Quality Conditioner (UPQC)

The extensive use of power electronic based equipments/loads almost in all areas, the point of common coupling (PCC) could be highly distorted. Also, the switching ON/OFF of high rated load connected to PCC may result into voltage sags or swells on the PCC. There are several sensitive loads, such as computer or microprocessor based AC/DC drive controller, with good voltage profile requirement; can function improperly or sometime can lose valuable data or in certain cases get damaged due to these voltage sag and swell conditions. One of the effective approaches is to use a unified power quality conditioner (UPQC) at PCC to protect the sensitive loads. A UPQC is a combination of shunt and series APFs, sharing a common dc link. It is a versatile device that can compensate almost all power quality problems such as voltage harmonics, voltage unbalance, voltage flickers, voltage sags & swells, current harmonics, current unbalance, reactive current. This project is based on the steady state analysis of UPQC during voltage sag and swells on the system. Aim is to maintain the load bus voltage sinusoidal and at desired constant level in all operating conditions. The major concern is the flow of active and reactive power during these conditions, as it plays an important role in selecting the KVA ratings of both shunt and series APF.

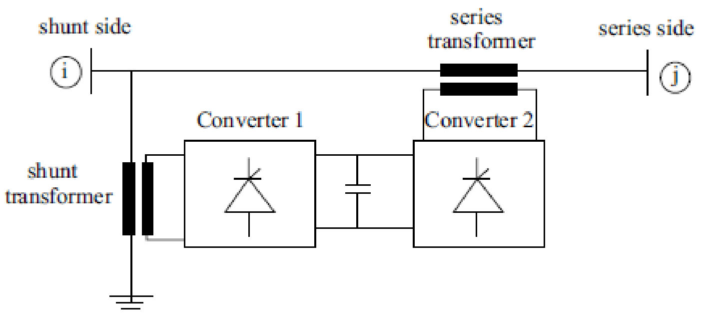

Fig 3. UPQC Inverter Arrangements

The UPQC is installed in order to protect a sensitive load from all disturbances. It consists of two voltage source inverters connected back to back, sharing a common dc link. One inverter is connected parallel with the load. It acts as shunt APF, helps in compensating load harmonic current, reactive current and maintain the dc link voltage at constant level. The second inverter is connected in series with the line using series transformers, acts as a controlled voltage source maintaining the load voltage sinusoidal and at desired constant voltage level. Major Power Quality Problems are Short Duration Voltage **Variation** Depending on the fault location and the system conditions, the fault can cause either temporary voltage drops (sags), voltage rises (swells), or a complete loss of voltage (interruptions). The duration of short voltage variations is less than 1min. These variations are caused by fault conditions, the energization of large loads which require high starting currents, or intermittent loose connections in power wiring. Voltage Sag: voltage sag (also called a “dip”) is a brief decrease in the rms line voltage of 10 to 90 percent of the nominal line-voltage. The duration of a sag is 0.5 cycle to 1 min. Common sources that contribute to voltage sags are the starting of large induction motors and utility faults.Voltage Swell: A swell is a brief increase in the rms line-voltage of 1.1 to 1.8 percent of the nominal line-voltage for duration of 0.5 cycle to 1 min. Swells can be caused by switching off a large load or energizing a large capacitor bank. Interruption: An interruption is defined as a reduction in line-voltage or current to less than

0.1 pu of the nominal, for a period of time not exceeding 1 min. Interruptions can occur due to power system faults, equipment failures and control malfunctions.

2.3 Control Strartegy

The control strategy is based on the extraction of unit vector templates from the distorted input supply. These templates will be then equivalent to pure sinusoidal signal with unity amplitude. The three phase distorted input source voltage at PCC contains fundamental component and distorted component. To get unit input voltage vectors U_S the input voltage is sensed and multiplied by equal to $(1/V_m)$ where V_m is equal to peak amplitude of fundamental input voltage. These unit input voltage vectors are taken to phase locked loop (PLL).With proper delay, the unit vector templates are generated.

$$U_a=\sin\omega t$$
$$U_b=\sin(\omega t-120^0)$$
$$U_c=\sin(\omega t+120^0)$$

Multiplying the peak amplitude of fundamental input voltage with unit vector templates gives the reference load voltage signals.

$$V^*=V_m\cdot U_{abc}$$

The measured load voltages are compared with reference load voltage signals. The error generated is then taken to a hysteresis controller to generate the required gate signals for series APF. The unit vector templates can be applied for shunt APF to compensate the harmonic current generated by non-linear load. The shunt APF is used to compensate for current harmonics as well as to maintain the dc link voltage at constant level. Reference currents and voltages are generated using Phase Locked Loop (PLL). The control strategy is based on the extraction of Unit Vector Templates from the distorted input supply. These templates will be then equivalent to pure sinusoidal signal with unity (p.u.) amplitude. The 3-ph distorted input source voltage at PCC contains fundamental component and distorted component. To get unit input voltage vectors Uabc, the input voltage is sensed and multiplied by gain equal to 1/Vm, where Vm is equal to peak amplitude of fundamental input voltage. These unit input voltage vectors are taken to phase locked loop (PLL). A controller is required to control the working of UPQC whenever any fault there for this purpose PI controller is used. For Series Inverter the magnitude of the actual voltage is compared with reference voltage (Vref).Pulse width modulation (PWM) control system is applied for inverter switching so as to generate a three phase sinusoidal voltage at the load terminals. PI controller input is an actuating signal which is the difference between the Vref and Vin. For Shunt Inverter control the magnitude of the actual current is compared with reference current (Iref).Pulse width modulation (PWM) control system is applied for inverter switching so as to generate a three phase sinusoidal current at the load terminals. Controller input is an actuating signal which is the difference between the Iref and Iin.

2.4 Plug-in hybrid electric vehicles (PHEVs)

Plug-in hybrid electric vehicles (PHEVs) potentially have the capability to fulfill the energy storage needs of the electric grid by supplying ancillary services such as reactive power compensation. A Plug-in hybrid vehicle is a

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hybrid vehicle with ability to be recharged from the grid; Figure 1.7 shows PHEV schematics. The battery is discharged while driving and then it is recharged from the grid when the vehicle is parked. The ability of re-charging allows the vehicle to be run in pure electric mode; the Department of Energy (DOE) defines All Electric Range (AER) as the distance traveled in electric mode (engine switched off) on standard driving cycles A hybrid typically has AER of 2-5 miles (3-8 km) while a PHEV can provide AER from 10 to 40 miles (16 o 64 km) kilometers PHEVs are defined PHEV-10, PHEV-20, PHEV- 30 or PHEV-40, based on the AER meaning that they could be driven for 10, 20, 30 or 40 miles (16, 32, 48, 64 km) without burning gasoline. The external charging ability also allows using battery and the electric motor more frequently and sharing more power with the engine. Thus, the engine is used at its best operating region for more time as compared to hybrid vehicle. Therefore, the PHEV can provide better fuel economy. Plug-in hybrid vehicle architecture is exactly same as a hybrid vehicle consisting of an electric drive, and engine except the size of engine is smaller, and motor and battery are bigger. A typical hybrid would carry a battery of 1-3 kWh energy where a PHEV with 30 kilometers range would require a 6 kWh battery Use of larger battery also allows reducing the engine size and giving more flexibility for tuning the engine in its best operating region. Apart from the power train requirements, a PHEV requires charging unit for the battery and interface for the grid. Plug-in hybrid electric vehicles (PHEVs) are a new and upcoming technology in the transportation and power sector. As they are defined by the IEEE, these vehicles have a battery storage system of 4 kWh or more, a means of recharging the battery from an external source, and the ability to drive at least 10miles in all electric mode [10]. These vehicles are able to run on fossil fuels, electricity, or a combination of both leading to a wide variety of advantages including reduced dependence on foreign oil, increased fuel economy, increased power efficiency, lowered greenhouse gas (GHG) emissions and vehicle-to-grid (V2G)technology. The most current example of a PHEV is the Toyota Prius. Storage is fundamental for PHEVs, hybrid and electric vehicles operation; the prospects for large scale market introduction of these vehicles are tied closely to the availability of energy storage systems that has to provide high performance, be durable and safe, and meet severe cost constraints. The electrical energy storage units must be sized so that it could store sufficient energy (kWh) and provide adequate peak power (kW) for the vehicle to have a specified acceleration performance and the capability to meet appropriate driving cycles. For those vehicle designs intended to have significant AER, the energy storage unit must store sufficient energy to satisfy the range requirement in real-world driving. In addition, the energy storage unit must meet appropriate cycle and calendar life requirements. In the case of the charge sustaining hybrid-electric vehicle using an engine as the primary energy converter and a battery for energy storage, the energy storage unit is sized by the peak power from the unit during vehicle acceleration. In most cases for the charge sustaining hybrid vehicle designs, the energy stored in the battery is considerably greater than that needed to permit the vehicle to meet appropriate driving cycles. However, the additional energy stored permits the battery to operated over a relatively narrow SOC range (often 5%–10% at most), which greatly extends the battery cycle and calendar life. In principle, determination of the weight and volume of the battery for a charge sustaining hybrid depends only on the pulse power density (W/kg) of the battery. Sizing the energy storage unit for plug-in hybrids is more complex than for charge sustaining hybrids. This is the case because of the uncertainty regarding the required all-electric range of the vehicles. In simplest terms, AER means that the hybrid vehicle can operate as a battery powered vehicle for a specified distance without ever operating the engine. In this case, the power of the electric drive system would be the same as that of the vehicle if it had been a pure electric vehicle and the energy storage requirement (kWh) would be calculated from the energy consumption (Wh/km) and the specified AER. Hence, for large AER, the battery would likely be sized by the energy requirement, and for short AER the battery would be sized by the power requirement. For plug-in hybrids, battery cycle life also becomes an important issue. The battery will be recharged from a low state-of-charge (after deep discharges); as a result, the battery cycle life requirement for plug-in hybrids will be more demanding than for an electric hybrid vehicle, and minimum of 2000–3000 cycles will be required. So both in terms of power and cycle life, the plug-in hybrid applications are more demanding for the battery than the electric hybrid vehicle. State of Charge (SOC)(%) – An expression of the present battery capacity as a percentage of maximum capacity. SOC is generally calculated using current integration to determine the change in battery capacity over time. Depth of Discharge (DOD) (%) – The percentage of battery capacity that has been discharged expressed as a percentage of maximum capacity. A discharge to at least 80 % DOD is referred to as a deep discharge.

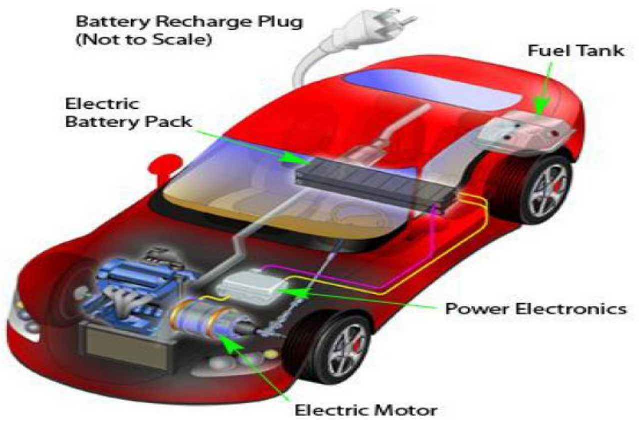

Fig 4. PHEV Arrangements

2.5 V2G Technology

The vehicle can send active and reactive power to the grid when there is a need for support by the utility. This support is called V2G, the acronym for vehicle-to-grid power transfer. It involves using the parked vehicles for distributed energy generation. Usually, a vehicle stays parked during 90-95%of their total lifetime. Therefore, the utility can benefit from this valuable asset and utilize alternative vehicle technologies, an expensive investment. EV chargers can provide the grid with the following services that can be included in V2G: Voltage support, Reactive power compensation, Harmonic filtering, Power factor regulation, load balancing. From the PHEV owner point of view, the batteries of the PHEV have to be charged overnight so the driver can drive off in the morning with a fully-charged battery. This gives opportunities for intelligent or smart charging. The coordination of the charging could be done remotely in order to shift the demand to periods of lower load consumption and thus avoiding higher peaks in electricity consumption

2.6 Simulink Software

Simulink (Simulation and Link) is an extension of MATLAB by Math works Inc. It works with MATLAB to offer modeling, simulating, and analyzing of dynamical systems under a graphical user interface (GUI) environment. The construction of a model is simplified with click-and-drag mouse operations. Simulink includes a comprehensive block library of toolboxes for both linear and nonlinear analyses. Models are hierarchical, which allow using both top-down and bottom-up approaches. As Simulink is an integral part of MATLAB, it is easy to switch back and forth during the analysis process and thus, the user may take full advantage of features offered in both environments. This tutorial presents the basic features of Simulink and is focused on control systems as it has been written for students in my control system.

III APPLICATIONS

Hybrid application an and Storage applications genrally uses UPQC system to remove power quality problems genrally occurs.In hybrid applications UPQC increases active power in circuit and removes harmonic cureents which will improve power factor and ultimately power quality

IV RESULTS

The simulation of the proposed system has been done using MATLAB/SIMULINK

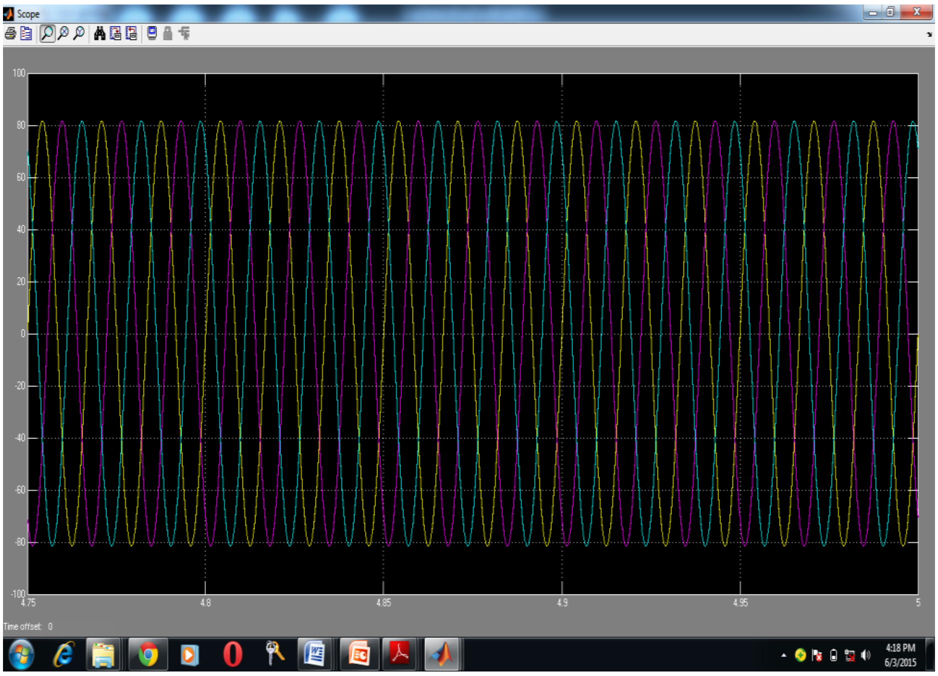

Fig 3. Input 3 Phase Voltage

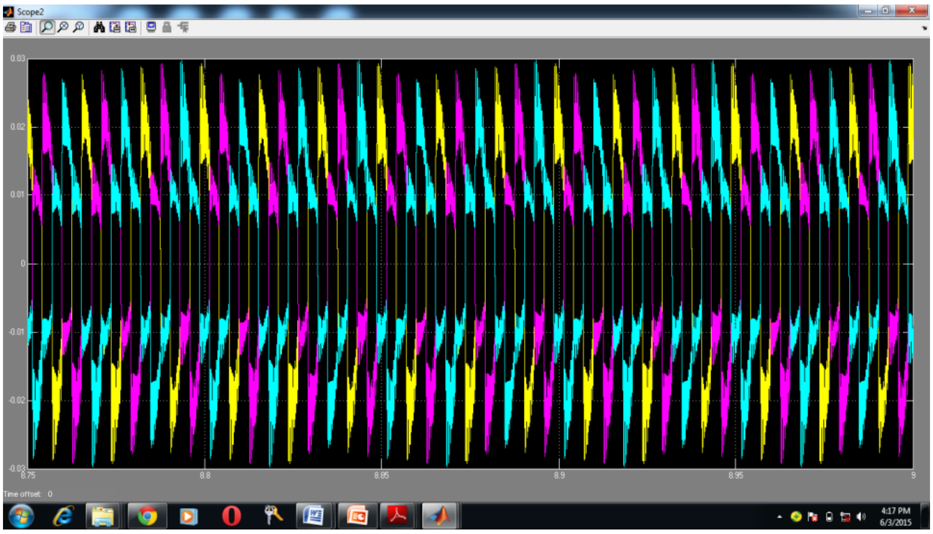

Fig 4.Distorted Output voltage due to nonlinear load

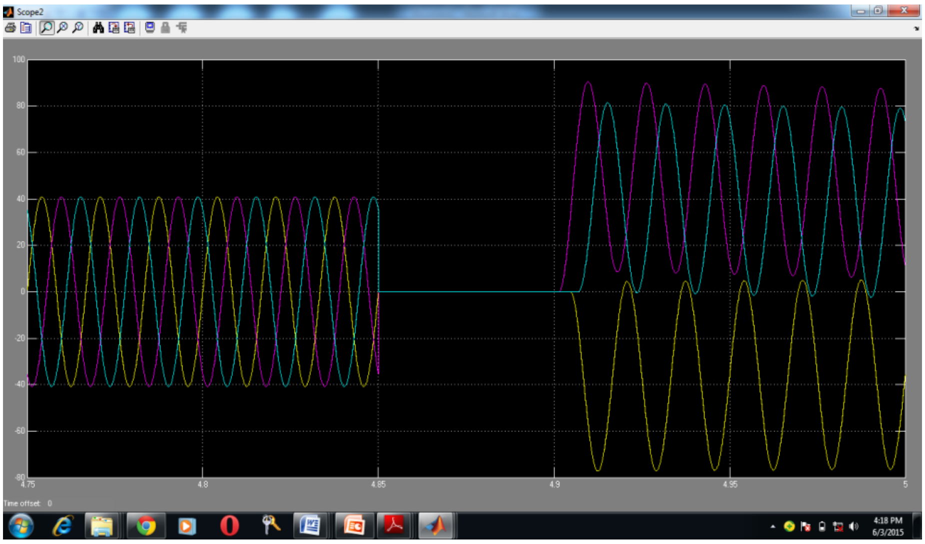

Fig 5.Output voltage with 3 phase fault

Fig 6.UPQC compensation for timer values

SYSTEM PARAMETERS

1] Three Phase Voltage Source-1 kV

2] Three Phase transformer – 10MVA, V_1rms – 10kV & V_2rms – 25k V

3] Shunt Inverter & Series Inverter (rating: 10 A), MOSFET Switches have used

4] Three Phase transformer (at output side) 10 MVA

BATTERY PARAMETERS

1] Nominal voltage – 400 V

2] Rated Capacity- 50 Ah

3] Initial SOC- 100%

4] Maximum Capacity-50.575 Ah

5] Fully Charged Voltage – 1742.1052 V

6] Nominal Discharge current – 10A

7] Internal Resistance- 2.6667 Ω

Fig 7.Without UPQC Active and Reactive power values

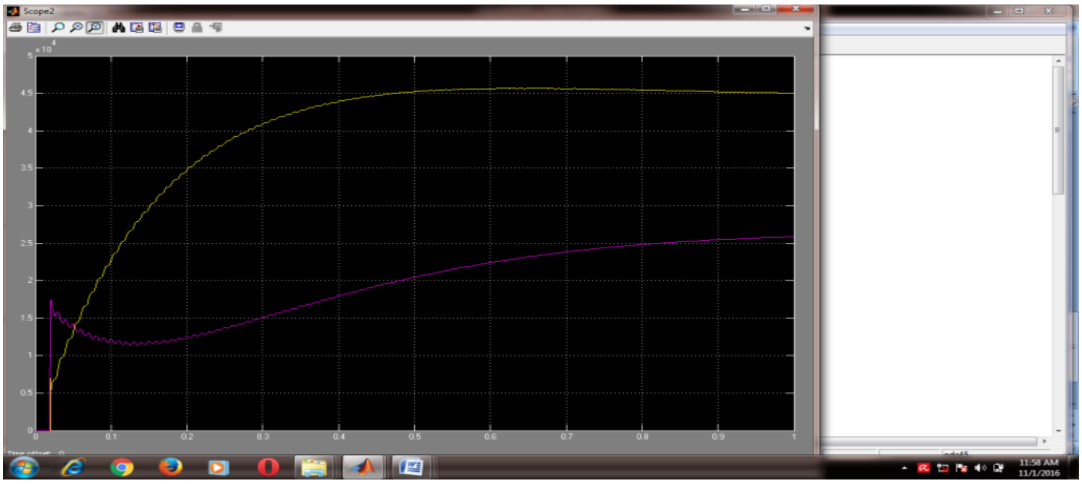

Fig 8.With UPQC Active and Reactive power values

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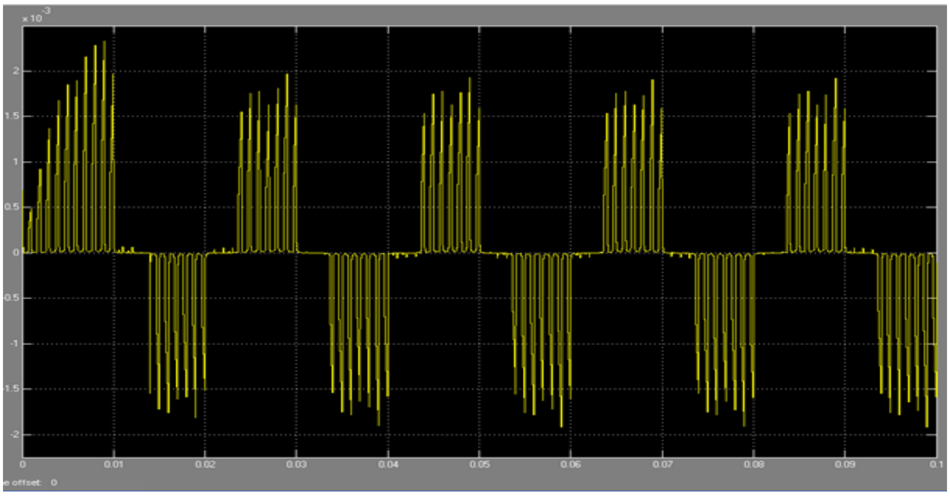

Fig 8 Series Injected voltage

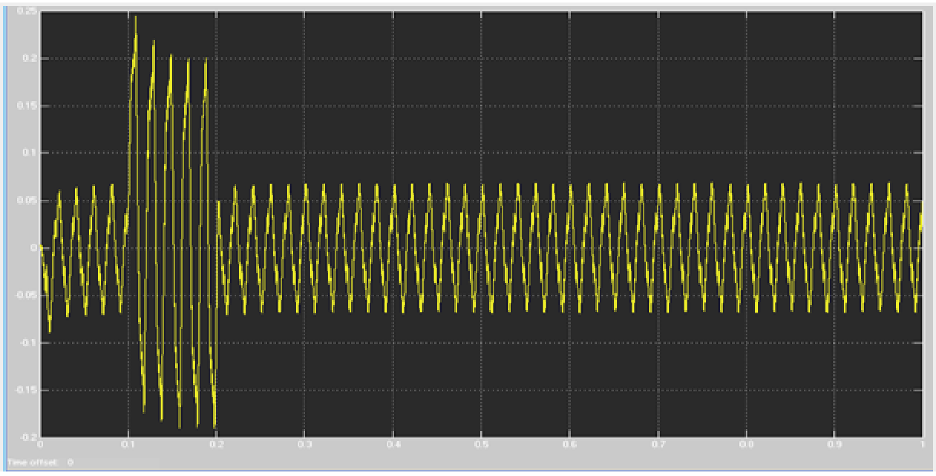

Fig 9 Shunt Injected Current

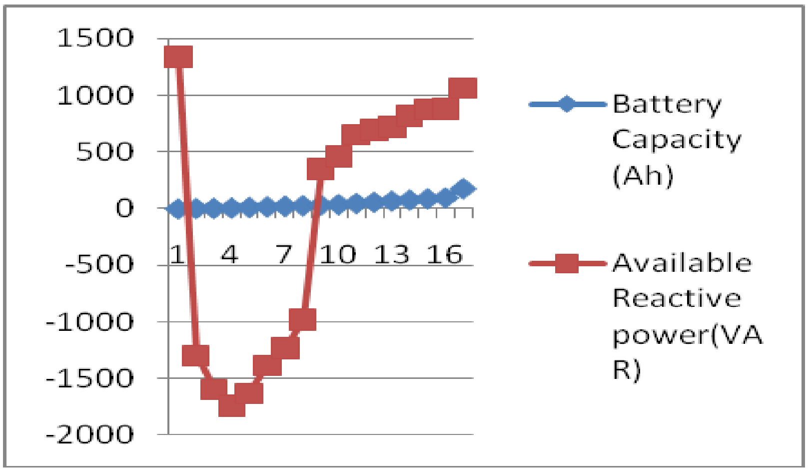

Fig 10 Reactive power available at different battery Capacity

V CONCLUSIONS

The conventional methods require the measurements of load, source, and filter currents for the shunt APF and source and injection transformer voltage for the series APF. The simulation results show that, when under unbalanced voltage conditions, the control algorithm eliminates the impact of rotor speed instability and series APF compensates the loads voltage. Recent rapid interest in renewable energy generation, especially front-end inverter-based large-scale photovoltaic and wind system, is imposing new challenges to accommodate these sources into existing Transmission/distribution system while keeping the power quality indices within acceptable limits. Thus UPQC compensates both voltage- and current-related power quality problems simultaneously. Unified Power Quality Conditioner (UPQC) is a multifunction power conditioner that can be used to compensate various voltage disturbance of the power supply, to correct voltage fluctuation, and to prevent harmonic load current from entering the power system. It is a custom power device designed to mitigate the disturbances that affect the performance of sensitive and/or critical loads. UPQC has shunt and series compensation capabilities for (voltage and current) harmonics, reactive power, voltage disturbances (including sag, swell, flicker etc.), and power-flow control.

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