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Optimization of Voltage Stability of Transmission line using UPQC

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***Abstract*: The most important topic for electrical engineering is power quality in past few years. Power quality problem is an occurrence as a nonstandard voltage, current or frequency. One of the major problems is the voltage sag. With the waste development in power electronics technology have made it possible to mitigate power quality problems. This paper presents power quality problem such as voltage sag. Compensating devices such as STATCOM, tap changing transformer, UPQC and DVR are available to mitigate voltage sag problems. This paper first gives an introduction to power quality problems for a UPQC and power electronics controllers for voltage sag mitigation. Thereafter the operation and elements in UPQC is described. Modeling and simulation of proposed UPQC is implemented in MATLAB/SIMULINK.**

I. INTRODUCTION

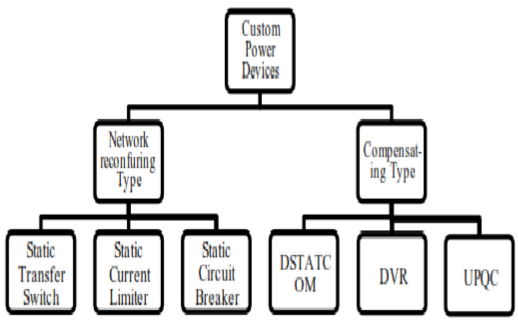
An electric power system is a network of electrical components used to supply, transmit and use electric power. However, with a fast increasing number power electronics devices of applications of industry electronics connected to the distribution systems today, including nonlinear, switching, reactive, single-phase and unbalanced three-phase loads, a complex problem of power quality evolved characterized by the voltage and current harmonics, unbalances, voltage sag, voltage swell.[1] Voltage balance at a load can be made by reactive power injection at the load side point of common coupling.[2] So as far as concern Unified power quality conditioner is used to control active power.

Harmonics are of having frequencies that are integer multiples order of the frequency at which the supply system is operate and designed for that as known as the fundamental frequency which is usually 50 or 60 Hz. The harmonic originates in the nonlinear loads characteristics of devices and also on loads connected to the power system.[3]

Voltage sags are the consideration power problems. Sags are short-term damps in voltage and can causes damage or interrupt sensitive equipments such as adjustable-speed drives, relays and robots.

The various causes for sag includes, like rural location remote from power source, Long distance from a distribution transformer with interposed loads, Unbalanced load on a three phase system and Short circuit faults. As a results of this and also similar problems like voltage dip, voltage swell and distortion content there arises a critical issue of Power Quality.[4,5]

FACTS devices are played very important role to mitigate such problems and to give better switching over AC transmission parameters. The FACTS technology is not a single high - power controller, but rather a collection of controllers, which can be applied individually with other equipments to control one or more than one of correlated system parameters like series and shunt impedance, voltage, current, phase angle etc.



In general, FACTS Controllers can be divided into four categories:

- Series Controllers
- Shunt Controllers

- Combined Series-Series Controllers
- Combined Series-Shunt Controllers

A. Basic Configuration of UPQC

The main work of the series active filter is harmonic reduction between a sub transmission system and a distribution system. The basic configuration of a general UPQC consisting of the combination of a series active and shunt active filter shows in Fig. 1.

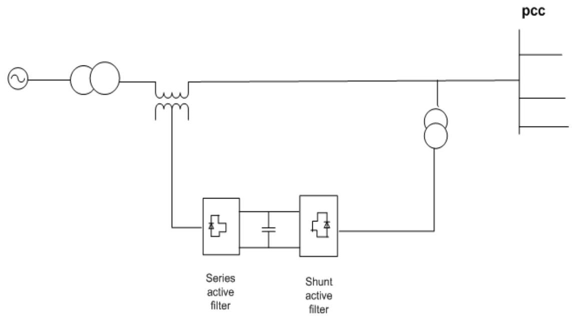


Fig. 1: Schematic of the UPQC

The main work of the shunt filter is to absorb current harmonics, compensation of reactive power and negative sequence current and control the DC link voltage between both active filters.[8]

II. PROPOSED SYSTEM

A. Single Line Diagram of the UPQC Test System

It was observed from the literature survey that, the field of power quality and custom power devices plays an important role in power system. UPQC is one of the custom power device used in distribution system for the improvement of power quality. Different type of controller namely fuzzy, hysteresis, PI and PID are reported in literature to compensate various PQ problems. In this work, PI controller is used for controlling the UPQC. In this system, the generating unit is of 13kV, 50 Hz. Test System employed to carry out the simulations concerning the UPQC actuation. The output from generating unit is fed to the primary of the three winding transformer. Further two parallel feeders of 11kV each are drawn. In one of the feeders UPQC is connected and other feeder is kept as it is. For this system ASD load is considered and different fault conditions LL, LLG and LLLG are tested on this system. PI controller is used for the control section. The single line diagram of test system of UPQC is shown in Fig. 2. It is composed by a 11kV, 50Hz, generating system feeding two transmission lines through a three winding transformer connected in Y/DELTA/DELTA, 13/115/115kV. Such transmission lines feed two secondary transmission lines through the transformers connected in DELTA/Y, 115/11kV.[9]

These two secondary transmission systems feed the two distribution networks through the transformers connected in Y/Y, 11kV/440V. To verify the working of UPQC for voltage compensation three phase balanced fault is applied at point x at resistance 0.01 for time duration of 0.1s. The UPQC is simulated to be in operation only for the duration of fault.

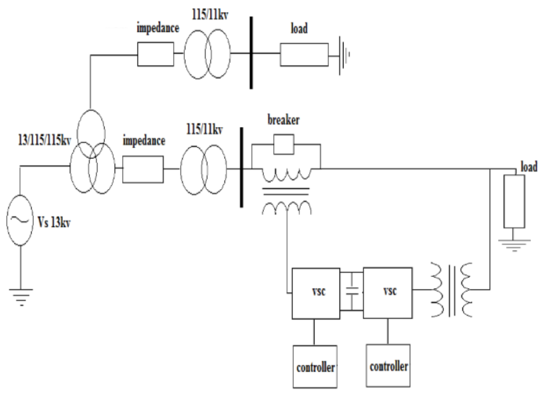


Fig. 2: Circuit model of UPQC test System

B. Design of PI Controller

A PI controller is a proportional gain which is in parallel with an integrator; both in series with a lead controller. The proportional is a gain provides fast error response. The integrator drives the system to a steady-state error. PI controller is one of the most widely sought after controller in industry as it is the simplest to design.

Fig. 3 PI controller "P" is Proportional control in which the output varies based on how far you are from your target. The error is multiplied by a negative (for reverse action) proportional constant P and added to the current output. P represents the band over which a controller's output is proportional to the error of the system, e.g. for a heater, a controller with a proportional band of 10˚ C and a set point of 100˚ C would have an output of 100 percentage up to 90˚ C, 50 percentage at 95˚ C and 10 percentage at 99˚ C. If the temperature overshoots the set point value, the heating power will cut back further. Proportional only control can provide a stable process temperature but there will always be an error between the required set point and the actual process temperature.

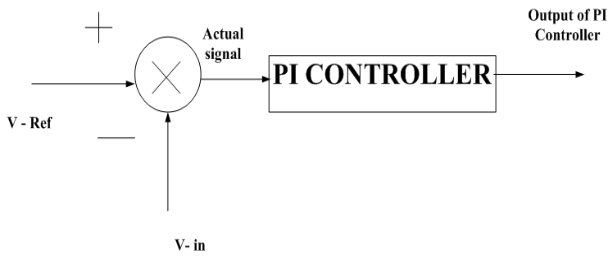


Fig. 3: PI controller

III. MATHEMATICAL MODELING

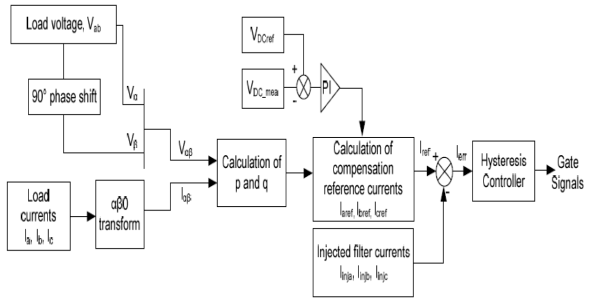


Fig. 4: Proposed APF controller

The most important disadvantage of IRPT theory is that voltage harmonics in supply voltages (so load voltages) result in increased THD content. This can cause the incorrect calculation of reference current. To overcome this problem, only one load voltage measurement is performed. With the use of the measured value, 90° phase shifted virtual voltage is generated as shown in Fig. 4[6]. The generation of this virtual voltage depends on the detection of zero crossing of phase-to-phases voltage of A and B phases. With the zero crossing detection, frequency compensation is made on virtual voltage. The unbalances between measured load voltages are eliminated using this control approach.

$$V_\alpha = V_{ab} \quad (1)$$

$$V_\beta = V_{ab}(-90^o) \quad (2)$$

The basic principle of the compensator will be considered, concerning the α axis instantaneous current on the load side. The instantaneous active and reactive currents are divided into the following two kinds of instantaneous currents, respectively:

$$i_\alpha = \frac{V_\alpha}{V_\alpha^2 + V_\beta^2}\bar{p} + \frac{V_\alpha}{V_\alpha^2 + V_\beta^2}\tilde{p} + \frac{-V_\beta}{V_\alpha^2 + V_\beta^2}\bar{q} + \frac{-V_\beta}{V_\alpha^2 + V_\beta^2}\tilde{q} \quad (3)$$

Where $\bar{p}$ and $\tilde{p}$ are the DC and AC components of the instantaneous real power and $\bar{q}$ and $\tilde{q}$ are the DC and AC components of the instantaneous imaginary power.

IV. RESULT ANALYSIS

The operation of the simulation model shown is described as first the reference voltages and the reference currents are generated and then the reference voltages are compared with the actual load voltages and the reference currents are compared with the actual source currents and then the error signals are given to the hysteresis controllers for generating the switching signals for the switches of series active power filter and the shunt active power filter and the generated pulses are then given to the series and shunt APF's and accordingly the switches are turned on and off to compensate for the voltage and current harmonics the supply voltage, supply current and injected current waveforms of the line current before the shunt current and after the shunt current injection. The overall simulation run time is 0.8 sec. the control strategy is started after 0.1 sec. After 0.8 sec the PI controller acted to settle the reference DC link voltage and current from the shunt converter injected to make the supply current sinusoidal. It is observed that after the control strategy started the wave shape of the line current at the input side is improved in term of the harmonic distortion. It is also observed that the supply voltage does not affect.

An ideal three-phase sinusoidal supply voltage is applied to the non-linear load injecting current and voltage harmonics into the system.

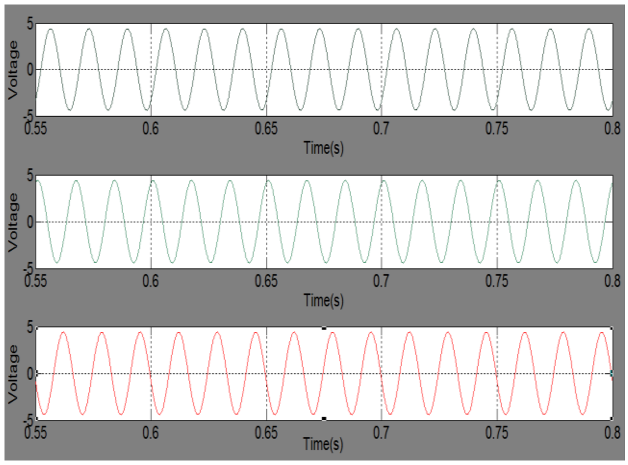


Fig. 5: Without compensation load voltage for UPQC

Fig. 5 shows without compensation the load voltage remain affected throughout the operation.

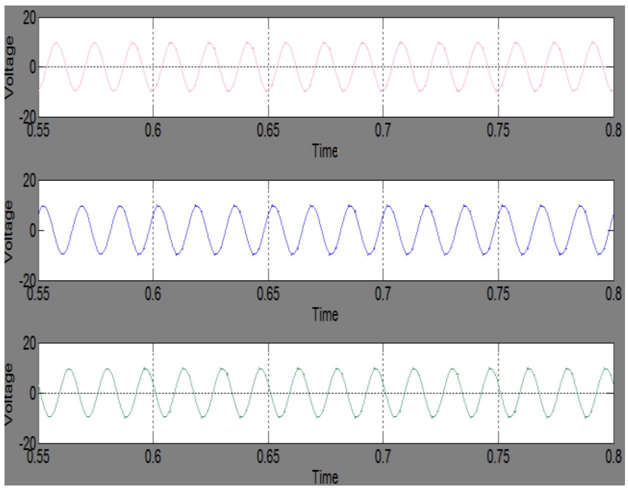


Fig. 6: With compensation load voltage for UPQC

The load voltage after compensation is presented in Fig. 6 that indicates the current becomes sinusoidal. Here the load voltage is after applying Unified Power Quality Conditioner.

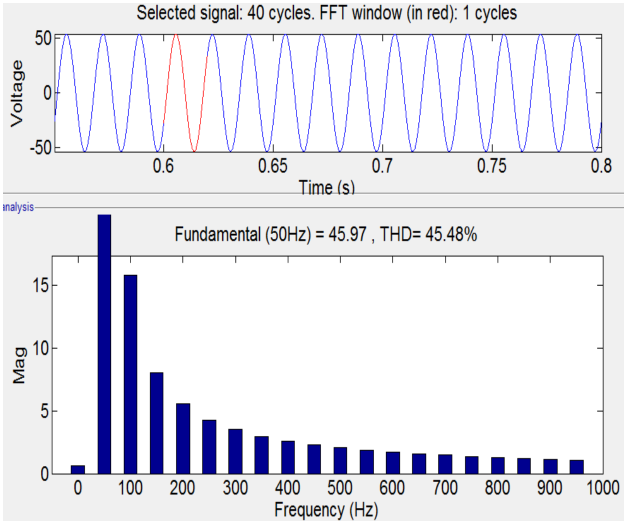


Fig. 7: Without compensation FFT analysis for load voltage for UPQC

FFT analysis without applying Unified Power Quality Conditioner shows that the THD is 45.48 percentage at load side as shown in Fig. 7.

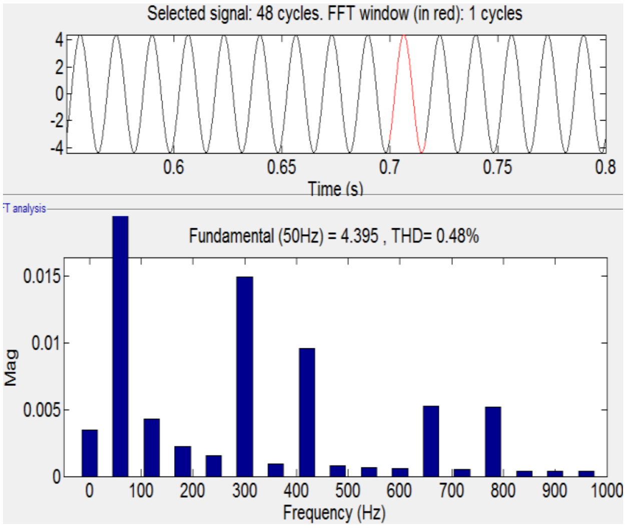


Fig. 8: With compensation FFT analysis for load voltage for UPQC

FFT analysis with applying Unified Power Quality Conditioner shows that the THD is 0.48 percentage at load side shows Fig. 8.

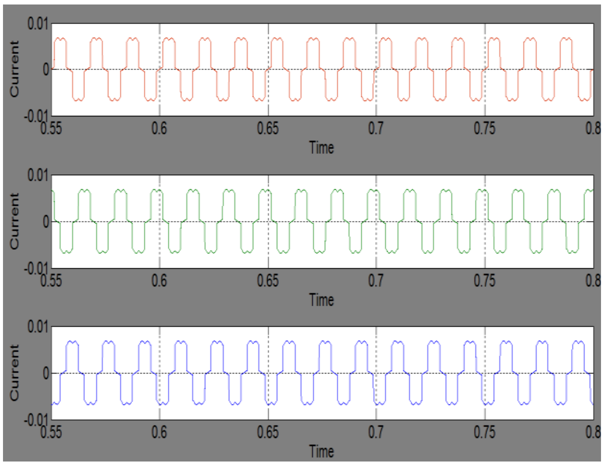


Fig. 9: Without compensation load current for UPQC

Fig. 9 shows without compensation the load current remain affected throughout the operation. Here there is disturbance and the results obtained are before applying Unified Power Quality Conditioner.

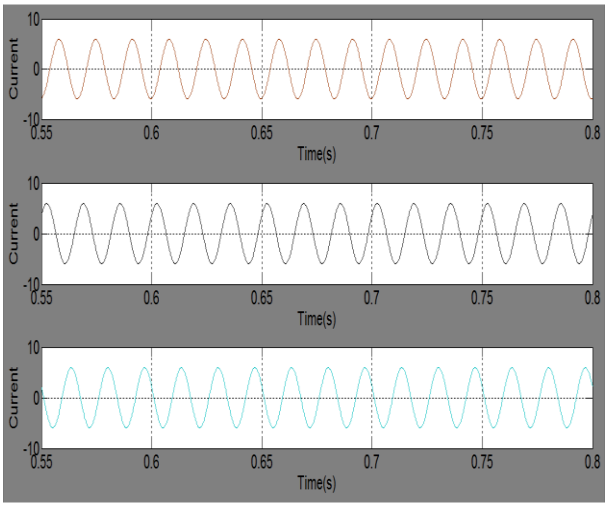


Fig. 10: With compensation load current for UPQC

The load current after compensation is presented in Fig. 10 that indicates the current becomes sinusoidal. Here the waveform are sinusoidal and the results obtained are after applying Unified Power Quality Conditioner.

V. CONCLUSION

With a fast increasing number of applications of industry electronics connected to the distribution systems today, including nonlinear, switching, reactive, single-phase and unbalanced three-phase loads, a complex problem of power quality evolved is characterized by the voltage and current harmonics, unbalances, low Power Factor (PF). In recent years active methods for power quality control have become more attractive compared with passive ones due to their fast response, smaller size and higher performance. The simulation shows that the UPQC performance is satisfactory in mitigating voltage sags.

This research presents the simulation results also shows that the UPQC compensates the sags quickly and provides excellent voltage regulation. The UPQC handles both balanced and unbalanced situations without any difficulties and injects the appropriate voltage component to correct rapidly any abnormality in the supply voltage to keep the load voltage balanced and constant at the nominal value.

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