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# A Study of PI Controller Based Unified Power Quality Conditioner

**Anil Bharti**[1],
Department of Electrical Engineering, ,
M.M.M,E.C
Gorakhpur – 273010, India

**Rajat Varshney**[2]
Department of Electronics & Instrumentation Engineering, INVERTIS UNIVERSITY,
Bareilly – 243123, India

**Dr S.K.Srivastva**[3]
Department of Electrical Engineering
M.M.M,E.C
Gorakhpur – 273010, India

***Abstract- The Unified Power Quality Conditioner is the combination of the STATCOM and SSSC, we can say it is the most advanced controlling FACT device over the all basic power system parameter, transition voltage harmonics compensation, impedance and phase angle held with the use of UPQC. It has been used very frequently amongst the all other power flow techniques, but at the same time it is one of the most expensive controlling techniques. The fundamental arrangement of UPQC is define as there is two voltage source inverter which are connected through a common DC storage capacitor and it has been connect to the power system via a coupling transformer. First voltage source inverter is used in shunt with the transmission system with the help of shunt transformer. On the other hand second voltage source inverter is used in series with the help of series transformer.***

***Present work investigates PI controller as concerned to UPQC application for power quality improvement. The UPQC is studied and its advantages over conventional APFs and UPFC are discussed in detail. The relevant simulations are carried out using MATLAB/ Simulink.***

Keywords—***UPQC, Power Quality***

## I. INTRODUCTION

Power electronics is playing an important role in transmission and utilization of electrical power due to its capability of processing electric power in most efficient and cost-effective way. However, the nonlinear characteristics of power electronic devices give rise to two important limitations; they generate harmonics and draw lagging current from the utility. In recent years, UPQC is prove to be an all in one device for active power conditioning to compensate both harmonics as well as reactive power. UPQC is an advanced version of unified power flow controller (UPFC). The performance of UPQC mainly depends upon how quickly and accurately compensation signals are derived. The UPQC mitigates harmonics and provides reactive power to the power systems network so as to improve the power factor close to unity.**[1],[4] ,[5]**

The UPQC is a combination of shunt active and series active power filters connected through a dc bus.**[2]** The shunt active filter of UPQC acts as a current source for injecting compensating current through a shunt transformer, whereas, the series active filter acts as a voltage source for feeding compensating voltage through a series transformer.

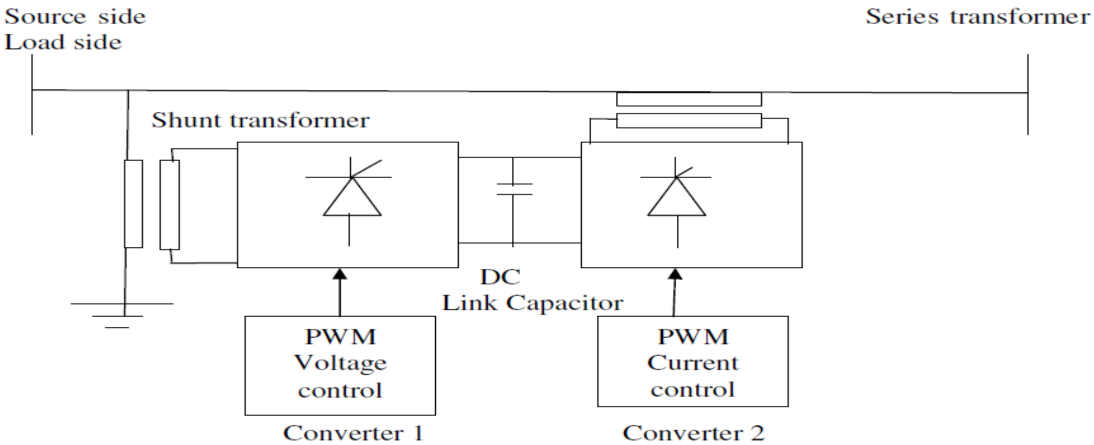



**Fig.1:** Basic structure of UPQC using back to back

## II. CIRCUIT DESCRIPTION

When PI based controller is used, the dc link voltage is sensed at regular intervals and is compared with a reference value. The error signal thus derived is processed in a PI controller. A limit is put on the output of the controller to ensure that the shunt active power filter supplies active power of the load through the series active power filter **[3].**

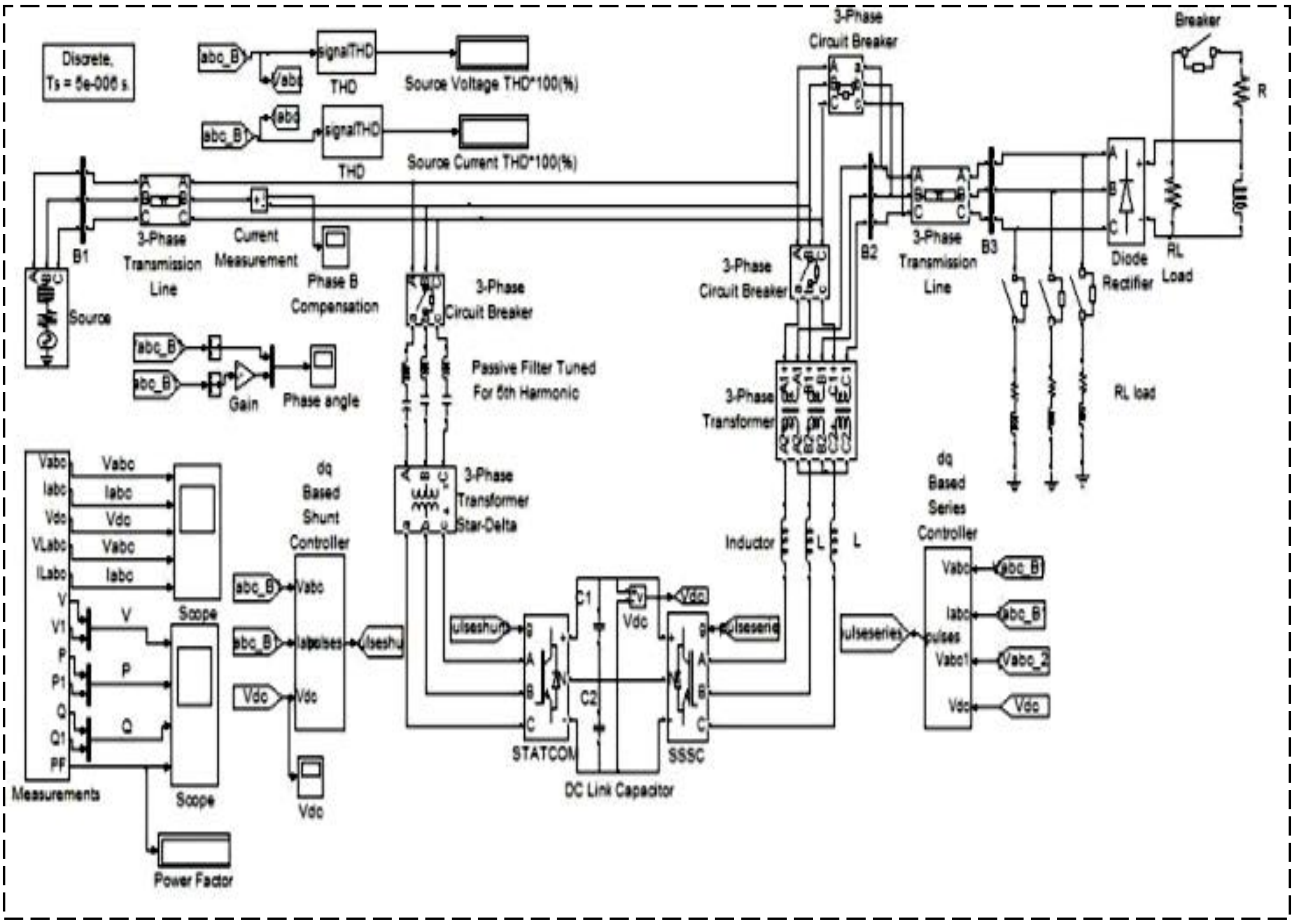



**Fig. 2:** showing simulation for UPQC

**1. Shunt Controller/STATCOM in MATLAB**

It is an integral part of the converter present in STATCOM to operate voltage control mode. Its function is to operate the rectifier power switches so as to maintain a fixed dc voltage in the dc link and to generate a fundamental output voltage waveform with demanded magnitude and phase angle in synchronism with the sinusoidal system which forces the reactive power exchange required for compensation.**[4][7]**

**2. Series Converter/SSSC Model in MATLAB**

A SSSC is a solid-state voltage source inverter, which generates a controllable AC voltage source, and connected in series to power Transmission lines in a power system. The injected voltage ($v_q$) is in quadrature with the line current *I*, and emulates an inductive or a capacitive reactance so as to influence the power flow in the transmission lines. The compensation level can be controlled dynamically by changing the magnitude and polarity of $v_q$ and the device can be operated both in capacitive and inductive mode. The main features of control system are:**[6]**

1. There is a phase-locked loop (PLL) which synchronizes measured positive-sequence component of the current with self generated current. The quadrature axis and direct axis components Sequence of voltages $v_a$ ,$v_b$ and the dc voltage $v_{dc}$ of the AC 3-Ø voltages and currents being used to compare with the help of output of the PLL.
2. The ac and dc voltage regulators which compute the both two components of the converter voltage ($_{vdcnv}$ and $_{vqcnv}$) required obtaining the desired dc voltage ($_{vdcref}$) and the injected voltage ($_{vqref}$).
3. The change in injected voltage is performed by the means of a Voltage-sourced converter (VSC) connected on the secondary side of a coupling transformer. The VSC uses forced-commutated power electronic devices (e.g. IGBTs or IGCTs, GTOs,) to synthesize a voltage $v_{cnv}$ from a dc voltage source. A capacitor connected on the dc side of the VSC acts as a dc voltage source.

**III.RESULT AND ANALYSIS**

When the transmission line is without UPQC, the real and reactive power flow cannot be controlled. The active power flow through line which is controlled by UPQC. Transmission capability of the existing transmission line is highly improved with the presence of UPQC. The value of difference between the sending end real power and receiving end real power is high in the transmission line without UPQC. This is due to the increase in transmission losses, which are minimized with the help of UPQC. We have seen the improve result in Fig (a), (b), (c), and (d) where time is define from 0 to 0.4 in which for 0 to 0.1 the result are without UPQC and have great loses on the other hand 0.1 to 0.4 are with UPQC which have improved result .It is also help to improving power factor of the transmission line. As shown in Fig. 6, without UPQC, power factor of the transmission line is 0.83 but as UPQC switched, the power factor increases to 0.96.

Before compensation when UPQC not connected, source current THD is 30.70%, due to non linear *RL* load. The dominant harmonic is $5^{th}$ harmonic and its magnitude is 29.5% of fundamental component. Source current THD after compensation when UPQC connected at 0.1s and PI controller used, source current THD is reduced to 3.94%

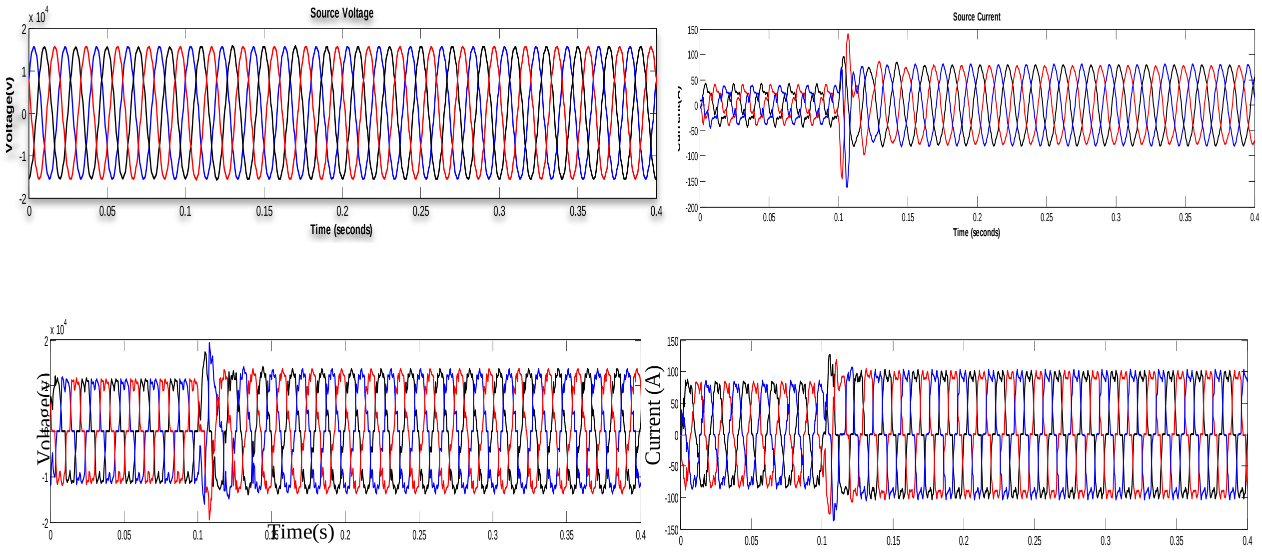
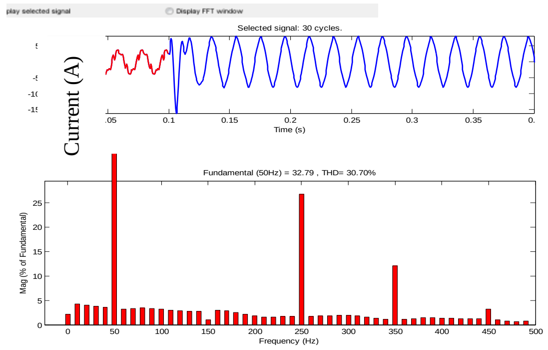



**Fig.3:** Simulated results of UPQC (a) source voltage (b) source current (c) load voltage (d) load current



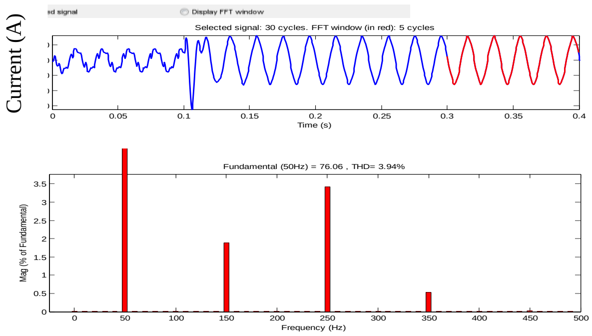




**Fig.4:** Total harmonic distortion (THD) distorted source current THD**Fig.5:** Compensated source current THD

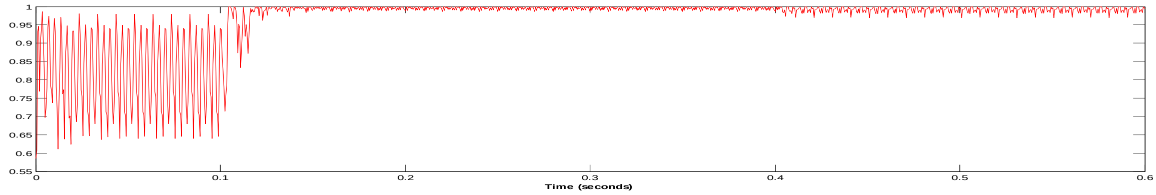



**Fig.6:** power factor

## IV. CONCLUSION

This work presents control and performance of UPQC intended for installation on a transmission line with the help of PI controller. A control system is simulated in switching and unbalanced condition with shunt inverter and series inverter in open loop phase angle control mode. Simulation results show the effectiveness of UPQC in active filtering and controlling real and reactive power through the line.AC voltage regulation and power factor of the transmission line also improved. This work presents an improvement result in the real and reactive power flow via the transmission line with UPQC using PI controller when compared to the system without UPQC.

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