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Enhancement of Three-Phase Four-Wire UPQC Topology for Power Quality Problems-Sags and Swells

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Abstract*—The unified power quality conditioner (UPQC) is a custom power device, which mitigates voltage and current-related PQ issues in the power distribution systems. In this paper, a UPQC topology for applications with non-stiff source is proposed. The proposed topology enables UPQC to have a reduced dc-link voltage without compromising its compensation capability. This proposed topology also helps to match the dc-link voltage requirement of the shunt and series active filters of the UPQC. The topology uses a capacitor in series with the interfacing inductor of the shunt active filter, and the system neutral is connected to the negative terminal of the dc-link voltage to avoid the requirement of the fourth leg in the voltage source inverter (VSI) of the shunt active filter. The average switching frequency of the switches in the VSI also reduces, consequently the switching losses in the inverters reduce. The main purpose is to compensate for voltage imbalance,reactive power, negative sequence current and harmonics.*

Keywords *- Average switching frequency, dc-link voltage, hybrid topology, non-stiff source, UPQC.*

I. INTRODUCTION

The modern power distribution system is becoming highly vulnerable to the different power quality problems. The extensive use of nonlinear loads is further contributing to increased current and voltage harmonics issues. Furthermore, the penetration level of small/large-scale renewable energy systems based on wind energy, solar energy, fuel cell, etc., installed at distribution as well as transmission levels is increasing significantly.

To maintain the controlled power quality regulations, some kind of compensation at all the power levels is becoming a common practice. At the distribution level, UPQC is a most attractive solution to compensate several major power quality problems. The voltage sag/swell on the system is one of the most important power quality problems. The voltage sag/swell can be effectively compensated using a dynamic voltage restorer, series active filter, UPQC, etc. Among the available power quality enhancement devices, the UPQC has better sag/swell compensation capability.

With the advancement of power electronics and digital control technology, the renewable energy sources are increasingly being connected to the distribution systems. On the other hand, with the proliferation of the power electronics devices, nonlinear loads and unbalanced loads have degraded the power quality (PQ) in the power distribution network [1]. Custom power devices have been proposed for enhancing the quality and reliability of electrical power. Unified PQ conditioner is a versatile custom power device which consists of two inverters connected back-to-back and deals with both load current and supply voltage imperfections. UPQC can simultaneously act as shunt and series active power filters. The series part of the UPQC is known as dynamic voltage restorer (DVR). It is used to maintain balanced, distortion free nominal voltage at the load. The shunt part of the UPQC is known as distribution static compensator (DSTATCOM), and it is used to compensate load reactive power, harmonics and balance the load currents thereby making the source current balanced and distortion free with unity power factor.

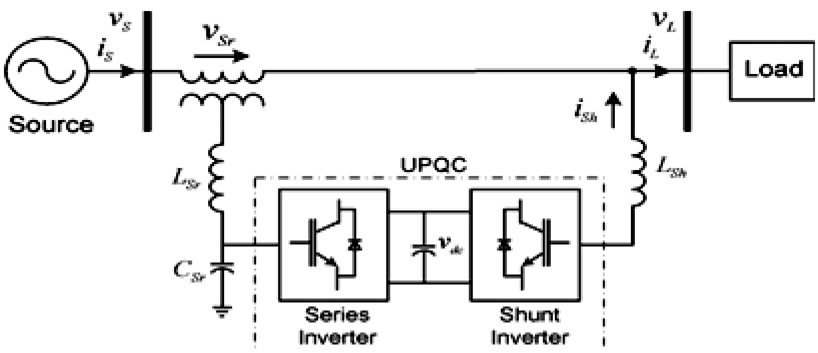

Fig.1: Single line diagram of Unified power quality conditioner (UPQC) system configuration.

II. POWER QUALITY PROBLEMS

The power disturbances occur on all electrical systems, the sensitivity of today's sophisticated electronic devices make them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause scrambled data, interrupted communications, a frozen mouse, system crashes and equipment failure etc. A power voltage spike can damage valuable components. Power quality problems encompass a wide range of disturbances such as voltage sags, swells, flickers, harmonic distortion, impulse transients, and interruptions[2].

A. Sources of Power Quality Problems

- Large motor starting
- Different faults
- Lightning

} Leads to voltage sag

- Capacitive loads
- Open circuits

} Leads to voltage swell

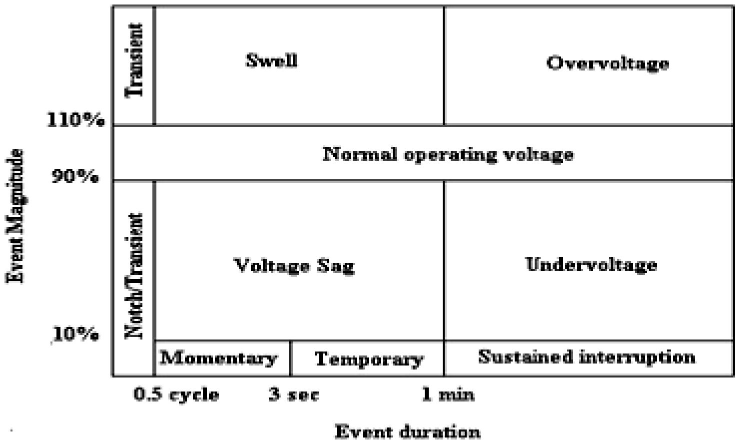

Fig.2: Percentage of Power Quality Problems

III. VOLTAGE SAG

Voltage sags and momentary power interruptions are probably the most important PQ problem affecting industrial and large commercial customers[3]. These events are usually associated with a fault at some location in the supplying power system. Interruptions occur when the fault is on the circuit supplying the customer. Voltage sags lasting only 4-5 cycles can cause a wide range of sensitive customer equipment to drop out.

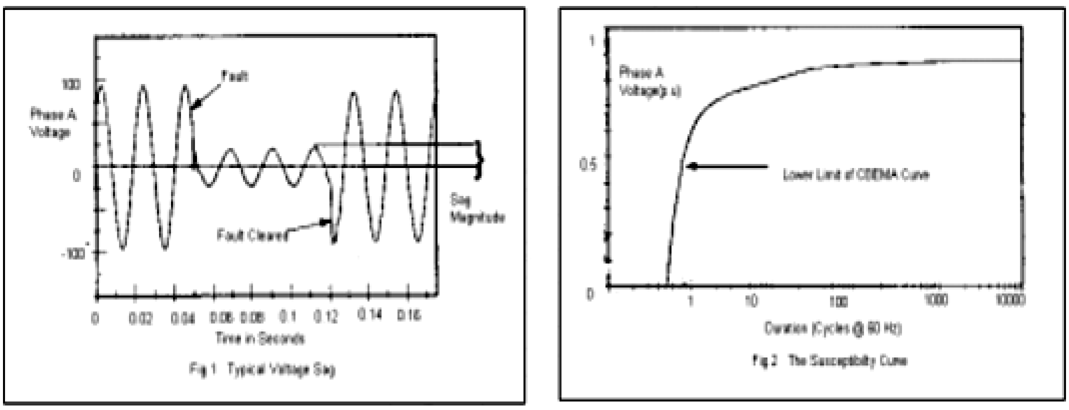

Fig.3: Example of voltage sag

IV. VOLTAGE SWELL

A swell is the reverse form of Sag, having an increase in AC Voltage for duration of 0.5 cycles to 1 minute's time. For swells, high-impedance neutral connections, sudden large load reductions, and a single-phase fault on a three phase system are common sources. Swells can cause data errors, light flickering, electrical contact degradation, and semiconductor damage in electronics causing hard server failures. Our power conditioners and UPS Solutions are common solutions for swells.

It is important to note that, much like sags, swells may not be apparent until results are seen. Having your power quality devices monitoring and logging your incoming power will help measure these events. A swell can occur due to a single line-to ground fault on the system, which can also result in a temporary voltage rise on the un faulted phases. This is especially true in ungrounded or floating ground delta systems, where the sudden change in ground reference result in a voltage rise on the ungrounded phases.

IV. UNIFIED POWER FLOW CONTROLLER

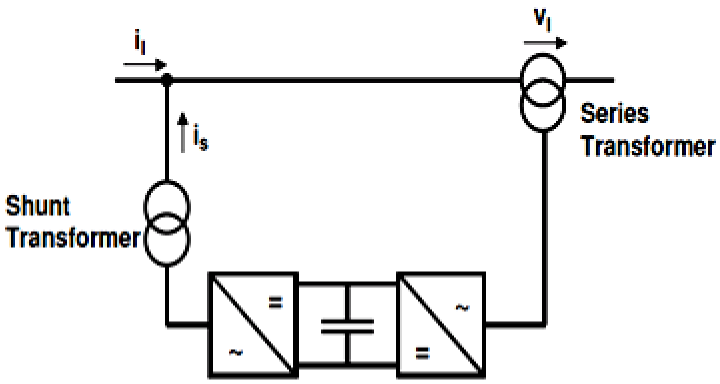

Fig.4: Principle configuration of an UPFC

The UPFC is a combination of a static compensator and static series compensation. It acts as a shunt compensating and a phase shifting device simultaneously.

The UPFC consists of a shunt and a series transformer, which are connected via two voltage source converters with a common DC-capacitor. The DC-circuit allows the active power exchange between shunt and series transformer to control the phase shift of the series voltage. This setup, as provides the full controllability for voltage and power flow. The series converter needs to be protected with a Thyristor bi-Transmission line. Due to the high efforts for the Voltage Source Converters and the protection, an UPFC is getting quite expensive, which limits the practical applications where the voltage and power flow control is required simultaneously.

A. OPERATING PRINCIPLE OF UPFC

The basic components of the UPFC are two voltage source inverters (VSI) sharing a common dc storage capacitor, and connected to the power system through coupling transformers [4]. One VSI is connected to in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer.

The series inverter is controlled to inject a symmetrical three phase voltage system (Vse), of controllable magnitude and phase angle in series with the line to control active and reactive power flows on the transmission line. So, this inverter will exchange active and reactive power with the line. The reactive power is electronically provided by the series inverter, and the active power is transmitted to the dc terminals. The shunt inverter is operated in such a way as to demand this dc terminal power (positive or negative) from the line keeping the voltage across the storage capacitor V_{dc} constant. So, the net real power absorbed from the line by the UPFC is equal only to the losses of the inverters and their transformers. The remaining capacity of the shunt inverter can be used to exchange reactive power with the line so to provide a voltage regulation at the connection point[5].

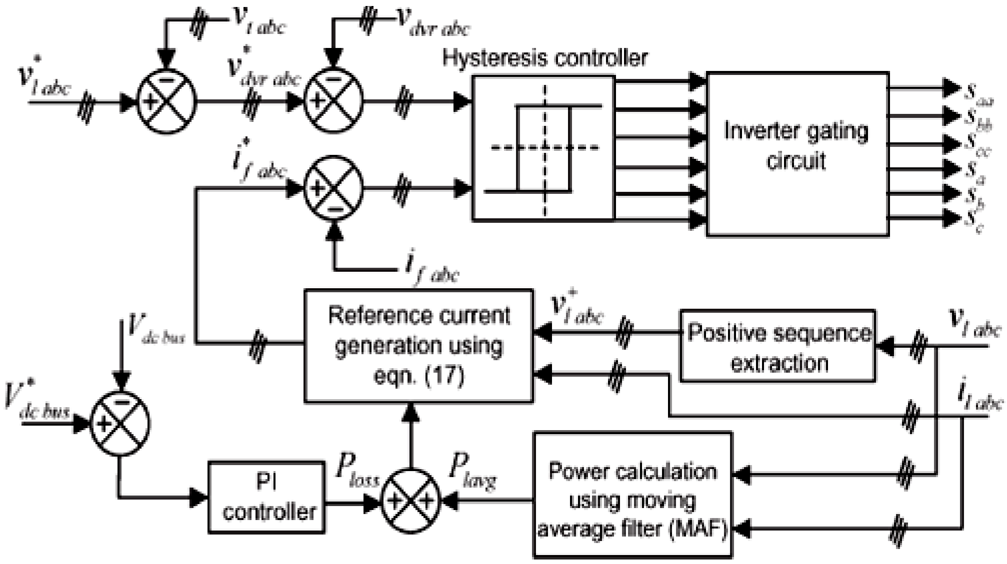

Fig.5: Control block diagram for UPQC.

V. PULSE WIDTH MODULATION

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices[6]. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs consider a waveform such as this: it is a voltage switching between 0v and 12v. It is fairly obvious that, since the voltage is at 12v for exactly as long as it is at 0v, then a 'suitable device' connected to its output will see the average voltage and think it is being fed 6v - exactly half of 12v. So by varying the width of the positive pulse - we can vary the 'average' voltage.

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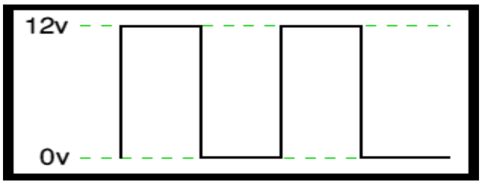
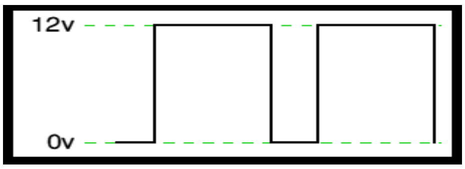
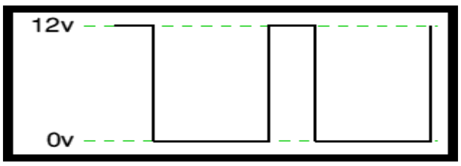


Similarly, if the switches keep the voltage at 12 for 3 times as long as at 0v, the average will be 3/4 of 12v - or 9v, as shown below



and if the output pulse of 12v lasts only 25% of the overall time , shown below



By varying - or 'modulating' - the time that the output is at 12v (i.e. the width of the positive pulse) we can alter the average voltage. So we are doing 'pulse width modulation'. I said earlier that the output had to feed 'a suitable device'. A radio would not work from this: the radio would see 12v then 0v, and would probably not work properly. However a device such as a motor will respond to the average, so PWM is a natural for motor control.

V.MODELLING OF UPQC

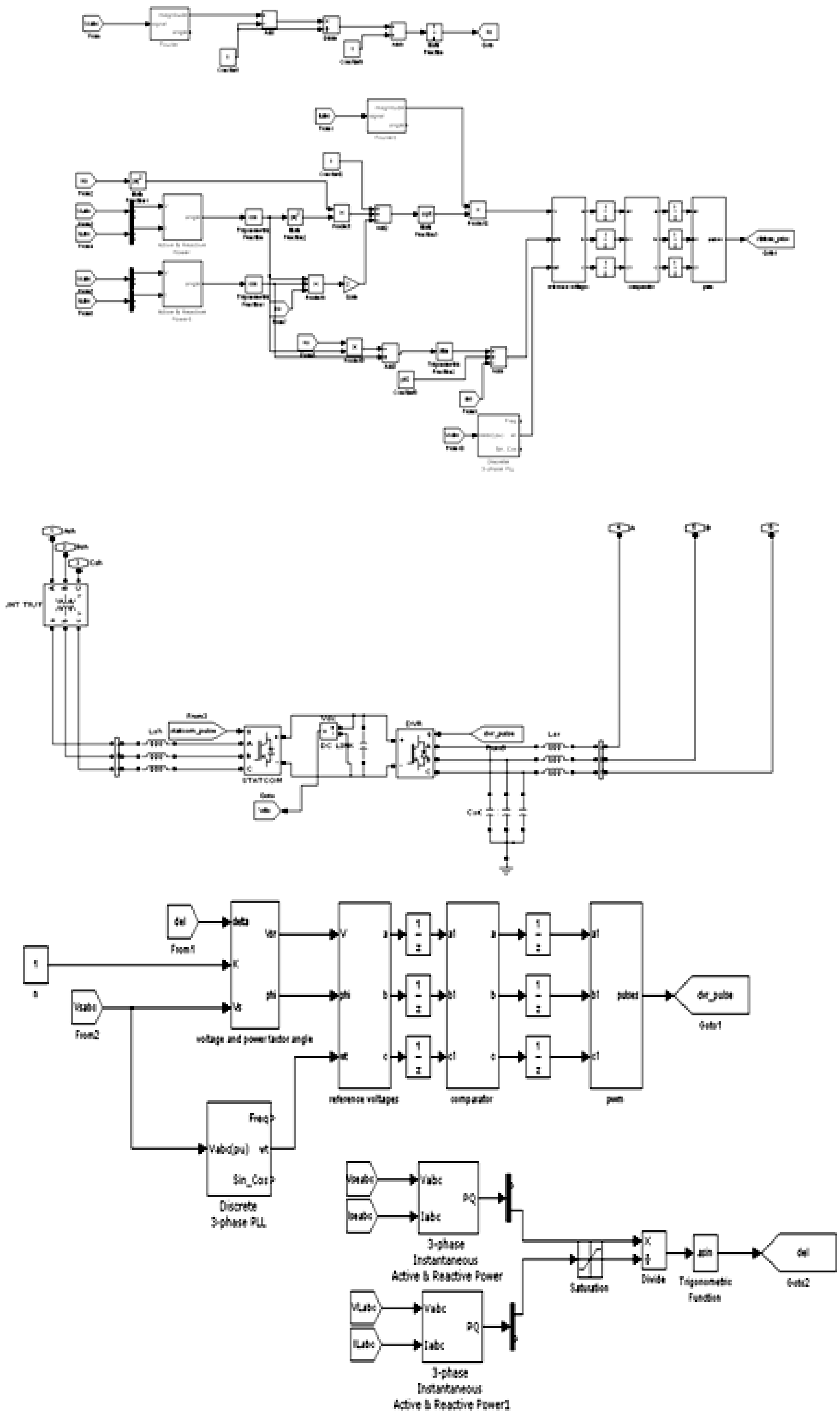


Fig.6: Simulink models

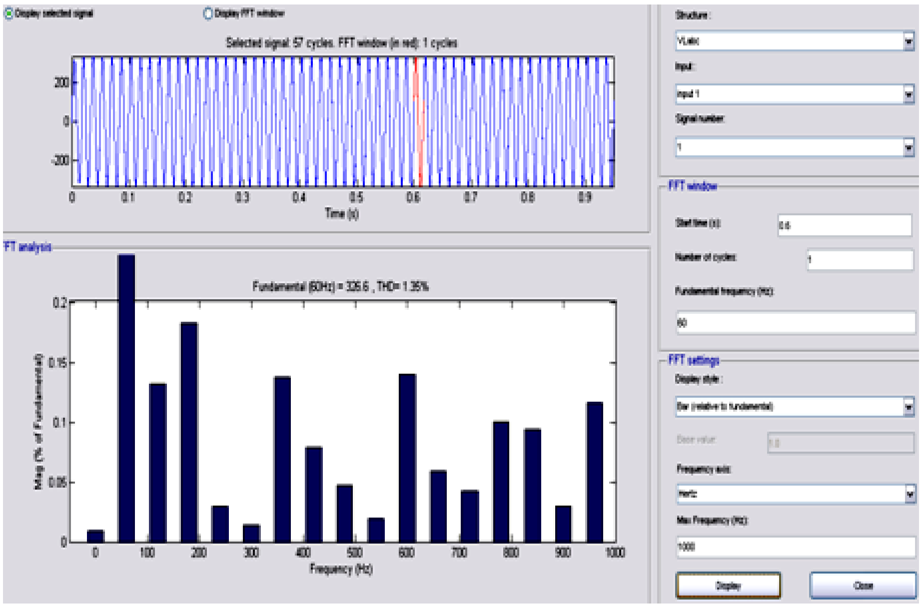


Fig.7: Total Harmonic Distortion

VI. CONCLUSION

In this paper, a new concept of controlling complex power (simultaneous active and reactive powers) through series inverter of UPQC is introduced and named as UPQC-S. The proposed concept of the UPQC-S approach is mathematically formulated and analyzed for voltage sag and swell conditions. The developed comprehensive equations for UPQC-S can be utilized to estimate the required series injection voltage and the shunt compensating current profiles (magnitude and phase angle), and the overall VA loading both under voltage sag and swell condition.

REFERENCES

[1] R. C. Dugan, M. F. McGranaghan, and H. W. Beaty, *Electrical Power Systems Quality*.. New York: McGraw-Hill, 1996, p. 265.

[2] C. Sankaran, Power Quality. Boca Raton, FL: CRC Press, 2002, p. 202.

[3] R. A. Walling, R. Saint, R. C. Dugan, J. Burke, and L. A. Kojovic, “Summary of distributed resources impact on power delivery systems,” IEEE Trans. Power Del., vol. 23, no. 3, pp. 1636–1644, Jul. 2005.

[4] L. Gyugyi, “Unified power-flow control concept for flexible AC transmission systems,” IEE – C Gene. Trans. Distr., vol. 139, no. 4, pp. 323–331, Jul. 1992.

[5] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. New York: IEEE Press, 2000, p. 432. KHADKIKAR AND CHANDRA: UPQC-S 2425

[6] V. K. Sood, HVDC and FACTS Controllers – Applications of Static Converters in Power Systems. Boston, MA: Kluwer, 2004, p. 295. [7] A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Boston, MA: Kluwer, 2002, p. 460.

