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Study of Power Quality Improvement Using UPQC

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ABSTRACT

This paper describes role of UPQC as applied to a 3P4W system to improve PQ. The Forth wire of 3P4W system is developed by means of neutral of series transformer. Neutral current which flows through neutral terminal of transformer is removed with the help of 4 leg voltage source inverter (VSI) topology for shunt part. The series transformer neutral will have 0 potential in all conditions of operation. Simulation is carried out by considering the major PQ issues like voltage, current, harmonic by connecting load which is nonlinear in nature to 3P4W scheme with UPQC. A novel control strategy of unit vector template is implemented here for designing series APF. By extending the principle of single phase PQ theory, series APF can be used for balancing the unbalanced voltage present at the load side. The PQ theory as applied to the 3 phase balanced system can even be independently used for unbalanced system.

Keywords: UPQC, VSI, APF, PCC, FACTS, PQ, PF.

I. INTRODUCTION

Current harmonic causing PQ problem in distribution system are generated at the time of their switching. The devices build on power electronics are being employed to improve PQ. A 3P4W system of distribution could be formed by facilitating a neutral wire in conjunction to 3 power lines from generation location. Unbalance load circuits is a usual problem in 3P4W distribution system that should be taken into account. The PQ can be improving by employing series and shunt APF in the system. These are 2 classes of filter are Passive and Active filters. Passive filters are comprising of L and C component which provide simplicity as well as economy to system; but they have tendency to suffer from resonance problem and get filter for every frequency and bulky. On other hand active filters comprise of IGBTs, MOSFET, and devices of storage of energy like L and C. The privilege of active filter is that they filter a specific frequency range do not resonate with the system and provide fast response. But their cost is high. The serials APF basically draw out the harmonics in voltage by providing path of large impedance path to harmonic circuits. Non - linear loads highly produce distorted current resulting into third harmonic component.

Power Quality Problems

Both the electric utilities & end users of electric power are becoming aware of quality of power that they are getting from the grid. The definitions of the PQ may be different for various types of customers. For example an electrical utility may define PQ as reliability on other hand a manufacturer of load equipment can define PQ as characteristics of power supply that enables equipment work properly. The PQ problem is defined as “Any power-problem which results in voltage, current or frequency deviation which ultimately causes failure or mal-operation of the equipment of service users”.

Following are the major problems related to power quality.

Voltage Sag

A voltage sag or dip is termed as a reduction to a low voltage (between 0.1 & 0.9 per unit RMS) at power frequency which may last from 0.5 cycles to 1 minute.

Voltage Swell

It is defined as increase in a voltage to a level (between 1.1 & 1.8 per unit RMS) at power frequency lasting from 0.5 cycles to 1minute.

Transients

These are the momentary increase in voltage and or current in a distributed electrical circuit. Transients are the short periodic events.

Harmonics

They are defined as the sinusoidal components of voltage or current at a frequency which is integer multiple of fundamental frequency.

Flickers

The spontaneous changes in load current which may lead to voltage variation of the system are called as flickers.

Sources of Poor Power Quality

A) Power electronic devices
B) IT & office equipment
C) Arcing devices such as circuit breakers
D) Switching of load
E) Switching of heavy motors
F) Embedded generation
G) Electromagnetic radiations & wires
H) Lightning, surges
I) Defective conducts & electrical devices
J) Poor power factor of large Induction motor
K) Adjustable speed drives, induction furnaces, TV receiver are major harmonic contributors.

Effects of Poor PQ

The poor quality of electrical power supply to any type of consumer will ultimately affect its economical values resulting in financial loss which are describes as follows.

1. Failure or mal-operation of connected equipment
2. Overheating of transformers, motors resulting in their decreased life-span
3. The sensitive electronic equipment like PC's control systems can get damaged.
4. There will be interference between electronic communication lines
5. The system losses are much increased
6. Existing installations are required to be oversized to meet required electrical stresses on system & thereby increasing installation & returning cost of the system
7. Many industries sometimes even need to be shut down due to PQ problems which take 4hrs to restart resulting into considerable economic loss.

II. METHODS AND MATERIAL

PQ Improvement Using UPQC

Unified power quality conditioner i.e. UPQC is one of the custom power device which gives the remedies for voltage as well as current related problems at a time. The UPQC is generally placed before load so that load voltage will be distortion free also source current is effectively compensated & almost in phase with the supply voltage.

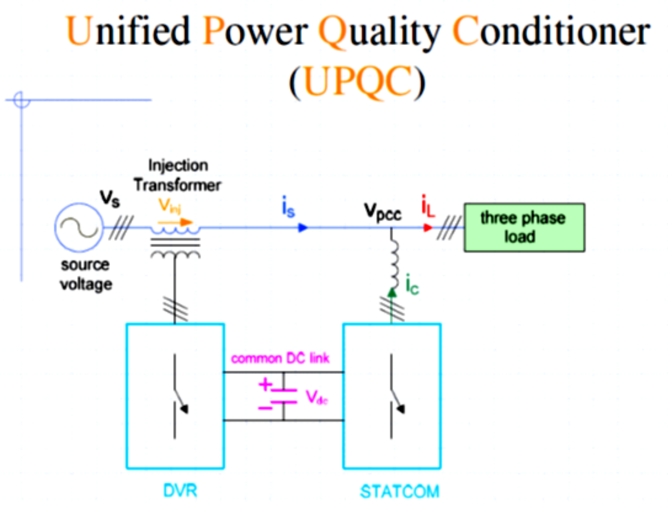

Figure 1. Block Diagram of UPQC

UPQC is the integration of shunt & series APF. Fig1 shows the block diagram of UPQC showing basic circuit arrangement of UPQC. The series part mitigates the voltage harmonics as well as any unbalance in voltage whereas shunt part of UPQC mitigates load current harmonics thereby controlling the reactive power & load current unbalances. UPQC also controls DC link voltage. Both series & shunt APF can be operated same time.

DSTATCOM & DVR

Here in this paper, UPQC fulfills the operations or functions of both DSTATCOM & DVR. Shunt APF functions like DSTATCOM whereas series APF plays role of DVR. The DVR, i.e. series APF in voltage control mode tries to make bus voltage sinusoidal for any unbalance. In current control mode, shunt APF working as DSTATCOM or UPQC tries to draw a balanced sinusoidal current from the utility bus.

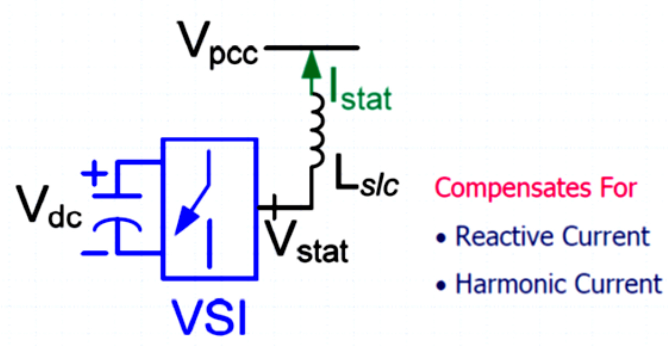

Figure 2. DSTATCOM

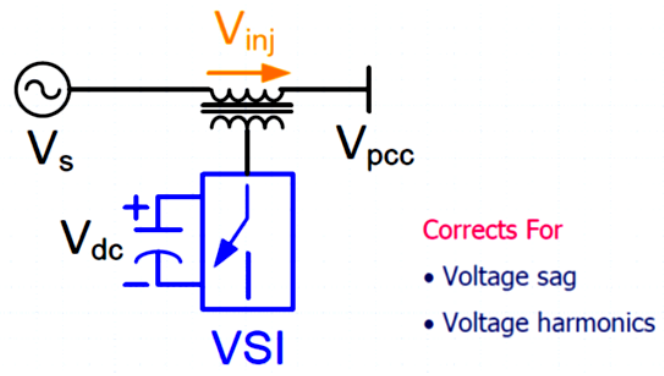

Figure 3. DVR

III. RESULTS AND DISCUSSION

Series and shunt APF performing three phase bridge inverter action

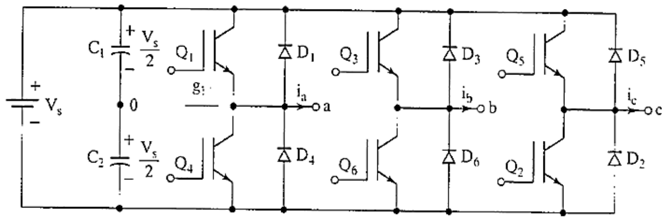

Figure 4 Three phase bridge inverter

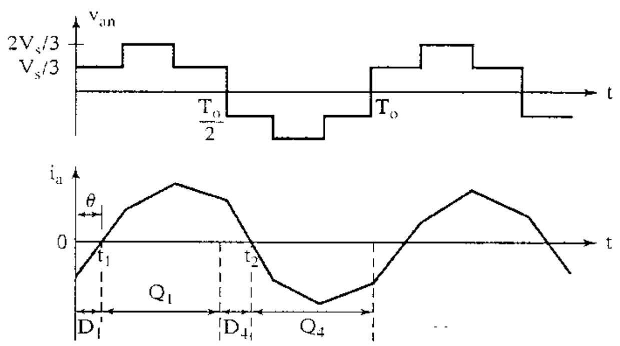

Figure 5. Three phase inverter with RL load waveforms

Fig 5. Shows typical arrangement of three phase bridge inverter which consists of six IGBT'S arranged in three pairs each containing two IGBT'S. For simplicity commutation circuitry is not shown. A three phase bridge inverter is basically a six step bridge inverter which follows a particular sequence of firings. A sine wave has cycle from 0 to 360 and total number of IGBT'S are six hence each firing has been delayed by 60 (360/6= 60), from the previous firing. Diodes shown are feedback diode. The capacitors C_1 and C_2 provide constant input dc voltage and try to eliminate harmonics coming out of inverter operations. Inverter can be operated in 180 mode or 120 mode. In project 120 mode is used. As it provides following advantages

1) Easy to understand
2) Offers proper matching between firing angle α and commutation angle γ
3) Less commutation circuitry is required
4) Provides simplicity in circuit.

In this mode IGBT'S are fired at an interval of 60 degrees in a definite sequence and each IGBT conducts for 120 degrees. The firing sequence of IGBT is Q_1,Q_2,Q_3 ,Q_4,Q_5,Q_6 and Q_1again. Q1is fired at 0 degrees, and then it conducts for 120 degrees and turned off. While Q_1 conducts from 0- 120 degrees, Q2 is fired at 60 degrees while Q3 at 120 degrees. Now Q4 is fired at 180 degrees. It is observed that Q1is commutated at wt =120 degrees and Q4 is fired at wt = 180 degrees. Hence an interval of 60 degrees is kept between each successive turn on and turns off. In this way conduction of Q1 – Q6 takes place as shown in waveforms from which sinusoidal wave is traced at the output terminals of inverter which is to be injected as voltage or current depending on type of inverter(shunt or series).

Hence series inverter as it restores the dynamic voltage is called as a DVR and shunt inverter as it compensates all current related PQ issues is called as DSTATCOM. Both DVR and DSTATCOM basically perform three phase inverting action to inject required voltage and current in the line against unbalance.

IV. CONCLUSION

In this paper, the combined operation of UPQC with DG is described in which proposed system consists of shunt & series inverter acting as STATCOM & DVR respectively. Proposed system is able to control both voltage sag & swell, voltage unbalance & current harmonics .Proper amount of voltage injected ultimately results in the right amount of active power flow to the inverter. Hence proposed system improves PQ at PCC for DG.

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