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Synchronous Reference Frame Based Control Method for UPQC

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Abstract – *Power quality issues are becoming more significant now days because of the increasing number of power electronic device. In order to keep the power quality, it is necessary to introduce some compensation device. This paper deals with the Unified Power Quality Conditioner (UPQC) which is an integration of series and shunt active filter that can be used for harmonic reduction and simultaneous compensation of voltage and current related problems. This paper discusses the synchronous reference frame (SRF) based control method to mitigates the effect of voltage sag and reduces the harmonic present in the system. The proposed control method has been modeled using MATLAB/SIMULINK and simulation results are presented to validate the proposed control method.*

Key Words: Power Quality, Harmonics, Active Power Filter, Synchronous Reference Frame (SRF), UPQC etc…

1. INTRODUCTION

In recent years, with the increasing application of power electronic device which behave as a nonlinear load, power quality problems such as harmonic, voltage sag/swell and imbalance have become serious issues. With the help of FACTS device and custom power device we are capable to reduce the power quality problems. Among the custom power device UPQC is an effective device for solving the power quality problems. The main of UPQC is to mitigate the disturbance that affects the performance of load.[1]

UPQC is the combination of series and shunt active filter with a common DC link. The series active filter is connected in series with the line through a transformer to mitigate the voltage related problems and shunt active filter is connected across the load to solve current related problems.[3]

In this paper the proposed synchronous reference frame control is tested under unbalanced load condition using Matlab/Simulink software.

1.1 UPQC

UPQC is the most attractive solution for solving voltage and current related problems. It is capable of mitigating the effect of voltage sag /swell at the point of common coupling. It also prevents the harmonics present in the system.Fig.1 shows the basic configuration of UPQC.

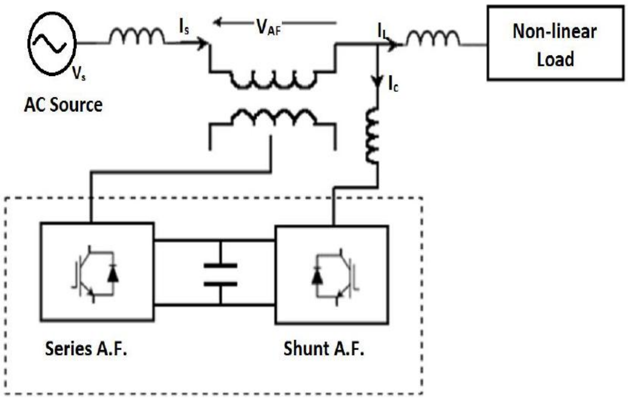

Fig -1: Basic configuration of UPQC

It contain two voltage source inverter (VSIs), connected back-to-back sharing a common DC capacitor. The series active filter is responsible for the mitigation of voltage sag and shunt active filter is responsible for the compensation of harmonics present in the system.[3][6]

2. SRF-BASED CONTROL ALGORITHM

SRF method can be used for the mitigation of power quality problems from the supply voltage and current. In the case of UPQC the voltage and current signals are transformed from a-b-c quantities to d-q frame. In the case of SRF theory d-q coordinates rotates with supply voltage.[2]

2.1 Control Algorithm for Series Active Filter

The figure below shows the control block of series active filter. The voltage at the point of common coupling is converted in to the rotating frame by using abc-dqo conversion. With the help of low pass filter (LPF) the harmonics and oscillatory components of voltage are eliminated.

The components of voltage in d-axis and q-axis are

Vsd = Vsd (dc) + Vsd (ac) (1)

Vsq = Vsq (dc) + Vsq (ac) (2)

The SRF theory is mainly used to obtain the direct and quadrature axis components of load voltage. A three phase PLL is used to synchronize the load voltage to terminal voltage. These signal are passed through the low pass filter to extract the fundamental component (Vd*, Vq*). [5]

The amplitude of the load terminal voltage is calculated from the ac voltages (VLa ,VLb ,VLc) as,

$$VL=(2/3(VLa^2+VLb^2+VLc^2))^{1/2} \quad (3)$$

The amplitude of the load terminal voltage (VL) is compared with the reference amplitude (VL*) and the output is given to the PI controller. The output of the PI controller is the added with the dc component of Vq to generate Vq*.

The resultant voltage are again converted to a-b-c co-ordinates by using reverse park transformation. The reference voltage (VLa* ,VLb* ,VLc*) and the sensed load voltage (VLa ,VLb ,VLc) are given to the hysteresis controller for generating pulse for the inverter.[5]

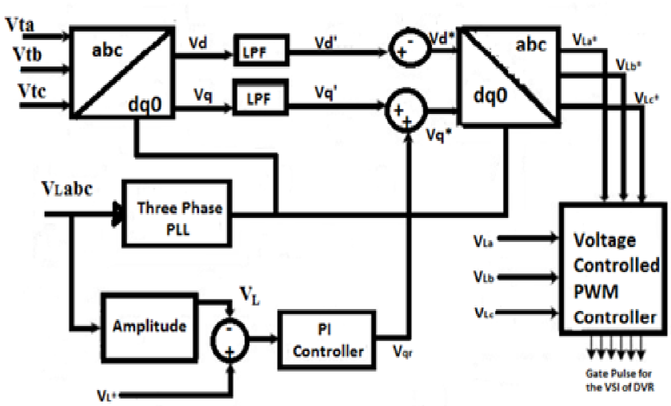

Fig -2: Control block of series active filter

2.2 Control Algorithm for Shunt Active Filter

The figure below shows the control block of shunt active filter. In this control method the inputs Va ,Vb ,Vc and iLa ,iLb ,iLc are given to the controller. A PLL is used to generate unit voltage templates. Current signals are transformed into d-q frame and again back to a-b-c frame. In order to maintain constant DC bus voltage, the error between the reference dc capacitor voltage and the sensed dc bus voltage is given to the PI controller and the output is added to the dc component of Id to generate Id*.The signals are fed to the hysteresis controller for generating pulses for the inverter.[6]

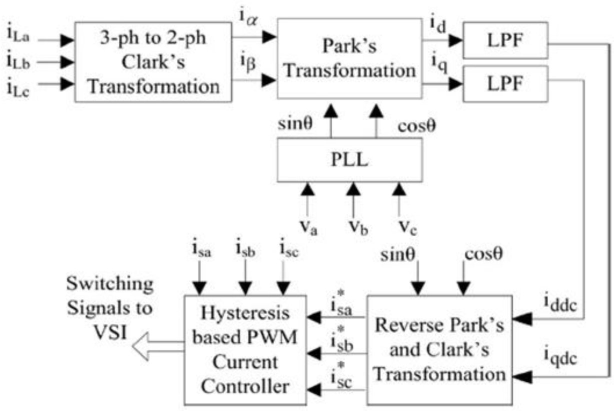

Fig -3: Control block of shunt active filter

α-β coordinates are generated, and by using θ as the transformation angle the signals are transformed from α-β to d-q frame.[6]

3. IMPLEMENTATION AND SIMULATION

3.1 Simulation model of UPQC

Figure below shows the simulation model of 3phase3wire UPQC with fault using SRF theory. In this topology a capacitor Cf is connected in series with the interfacing inductance of the shunt active filter and fault is introduced between 0.06s to 0.12s.The capacitor has the capability to supply required reactive power to the load and the active power will compensate the harmonics present in the load.

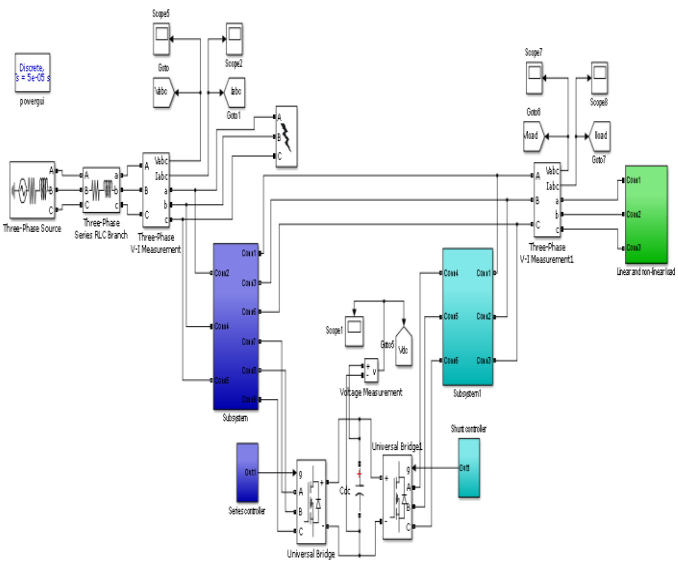

Fig -4: Simulation model of 3phase 3wire UPQC With Fault

3.1 Simulation model of series active filter

Figure below shows the simulation model of series active filter. In this synchronous reference frame theory is used for the control part. The output of the PI controller is used as the loss component of voltage.

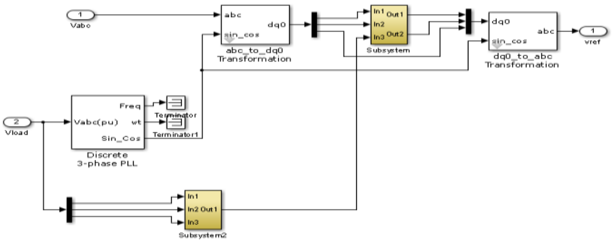

Fig -5: Simulation model of series active filter

3.1 Simulation model of series active filter

Figure below shows the simulation model of shunt active filter. In this synchronous reference frame theory is used for the control part. Reactive power compensation can be also be provided by keeping i_q component zero.

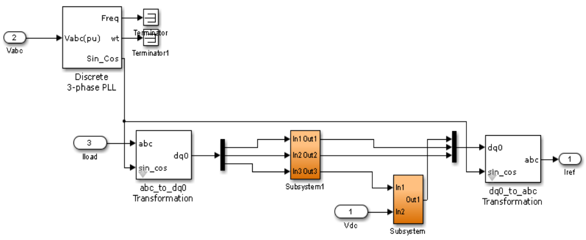

Fig -6: Simulation model of shunt active filter

4. RESULT AND DISCUSSION

A three phase fault is introduced between 0.06s to 0.12s.Due to the presence of fault the voltage gets reduced to 40% and the magnitude of the current gets increased. Figure 7 shows the waveform of source voltage with fault between 0.06s to 0.12s.Its magnitude is 320V.Due to the presence of fault 40% sag is introduced in the system and the voltage magnitude decreases to 260V.

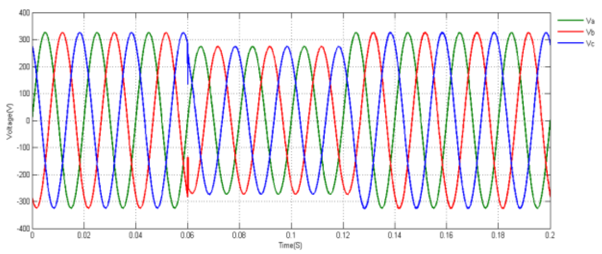

Fig -7: Source voltage

Figure 8 shows the waveform of source current with fault between 0.06s to 0.12s.Its magnitude is 20A.Due to the presence of fault the current magnitude increases to 150A.

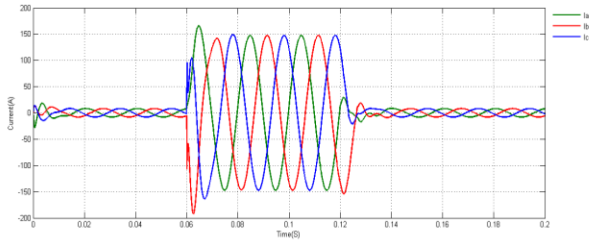

Fig -8: Source current

Figure 9 shows the waveform of injected voltage between 0.06s to 0.12s.Its magnitude is 60V and the time range between 0 to 0.2s.

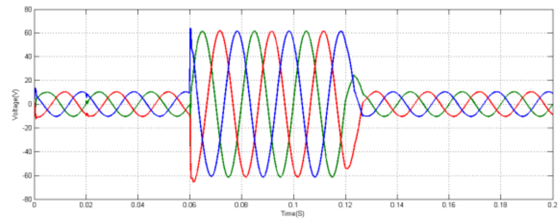

Fig -9: Injected voltage

Figure 10 shows the waveform of load voltage. Its magnitude is 320V.

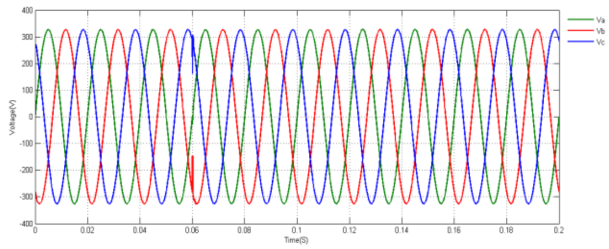

Fig -10: Load voltage

Figure 10 shows the waveform of load voltage. Its magnitude is 320V.

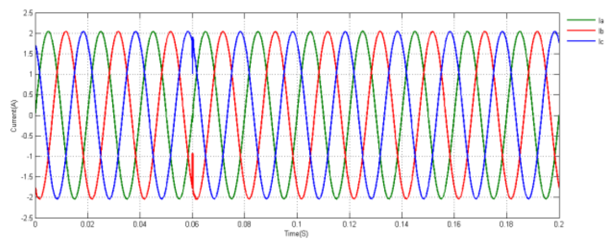

Fig -11: Load current

4.1 THD Analysis

Table -1: THD analysis between uncompensated and Compensated system

THD	Without compensation	With compensation
Phase A	9.88%	4.28%
Phase B	11.49%	4.70%
Phase C	13.03%	4.12%

5. CONCLUSIONS

Reliability of supply and power are the two important factors of any power delivery system today. Nowadays, consumers want not only the suuply, but the quality of supply is important to them. So it is necessary to solve the power quality problems. To solve this problem we are using different methods. In this paper we just introduced a device known as UPQC to solve the voltage and current related problems. From the analysis, SRF theory is efficient method to correct the abnormality in the voltage and current and also help to maintain the load voltage balanced and constant.

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BIOGRAPHIES

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