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Design and Simulation of a UPQC Based on a Phase-Locked Loop Controller with Nonlinear Loads

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Abstract*: The project implements unified power quality conditioner (UPQC) power quality improvement devices for addressing the voltage and current quality issues of sensitive loads. The UPQC contains series and shunt converters that operate through a standard dc junction. The shunt converters cleanse the nonlinear load side of current harmonics and the series converters do the same for supply-side voltage sag.*
The researched technique of generating reference signals (phase-locked loop) provides a basis for developing controllers for series converters and shunt converters. The fuzzy-logic controllers form the basis for controlling the dc link operation. The new sag indication method outperforms the dq-transformed conventional approach. The control system includes a rapid detector for sags. MATLAB/SIMULINK serves as the platform to conduct simulated tests which validate the effectiveness of this proposed system.

Keywords*: fuzzy-logic controller reference signal creation, active filter, UPQC or unified power quality conditioner*

I. Introduction

Modern electrical systems operate without performance or life-limiting breakdowns due to the electrical characteristics of power quality. The phrase describes the electrical power source and the operational effectiveness of the electrical load under its provided power. The inappropriate power delivery to an electrical load makes it vulnerable to premature failure and operational failure and complete stoppage. Electric power tends to be of poor quality from various causes which results in different kinds of problems.

Power quality (PQ) issues including the problems of flicker, imbalance and harmonics have emerged as essential concerns because distributions systems increasingly employ electronically switched nonlinear equipment. The reason behind PQ disruptions including transients and voltage sag and interruption exists due to various network problems such as lighting strikes against transmission lines and capacitor bank switching operations. The modern solution for power distribution system PQ issues involves employing customized CP devices built from VSCs for custom power.

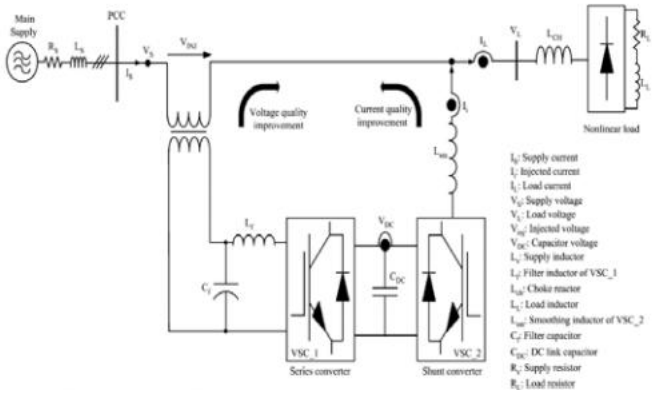

Fig 1: UPQC schematic diagram

Shunt converters operate as shunt active filters to compensate distortion and unbalance in a load which enables the transmission of balanced sinusoidal current through the feeder. A series converter also known as the dynamic voltage controls sensitive loads by maintaining exact voltage precision. The operation of power conditioners depends heavily on their control strategies. Instantaneous power theory represents the best method for generating reference signals that drive the shunt converter operation. An extended instantaneous reactive power theory in rotating reference frame basis provides both power factor correction and harmonic suppression.

II. Proposed Method

The voltage sag depth measurement becomes possible through the use of voltage sag detection methods with PLL by subtracting C(t) from the ideal voltage magnitude (4 p.u.). Examining the measured voltage value against 0.7 p.u. will determine whether voltage sag exists or not. A voltage sag detection occurs within a few milliseconds of time. Based on the suggested procedure the depth can be accurately measured yet the traditional method cannot detect the sag. The single-phase voltage sag extends 0.4 seconds while its initial detection occurs at 0.3 seconds. The voltage sag detection method together with PLL shows precision in detection and voltage balance.

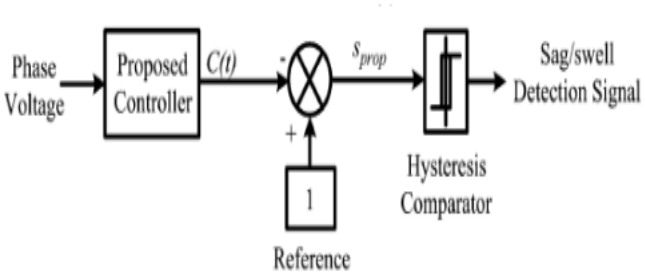

Fig 2: Sag detection method

III. Simulation Results and Discussion MATLAB

The testing of UPQC functionality to boost power quality occurs in this part. A three-phase diode bridge rectifier serves as the harmonic current-producing load through its operation and generates 22.15% THD.

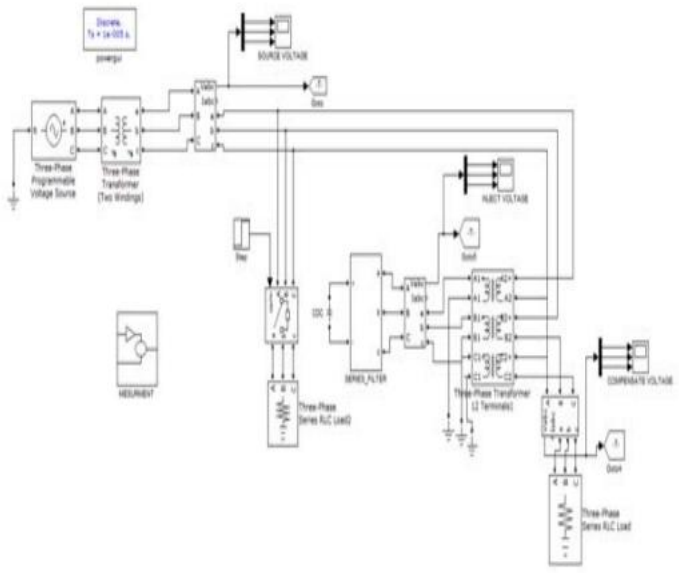

Fig 3: Series converter test system

IV. Simulation Results on Series Converter

The testing of UPQC functionality to boost power quality occurs in this part. A three-phase diode bridge rectifier serves as the harmonic current-producing load through its operation and generates 22.15% THD.

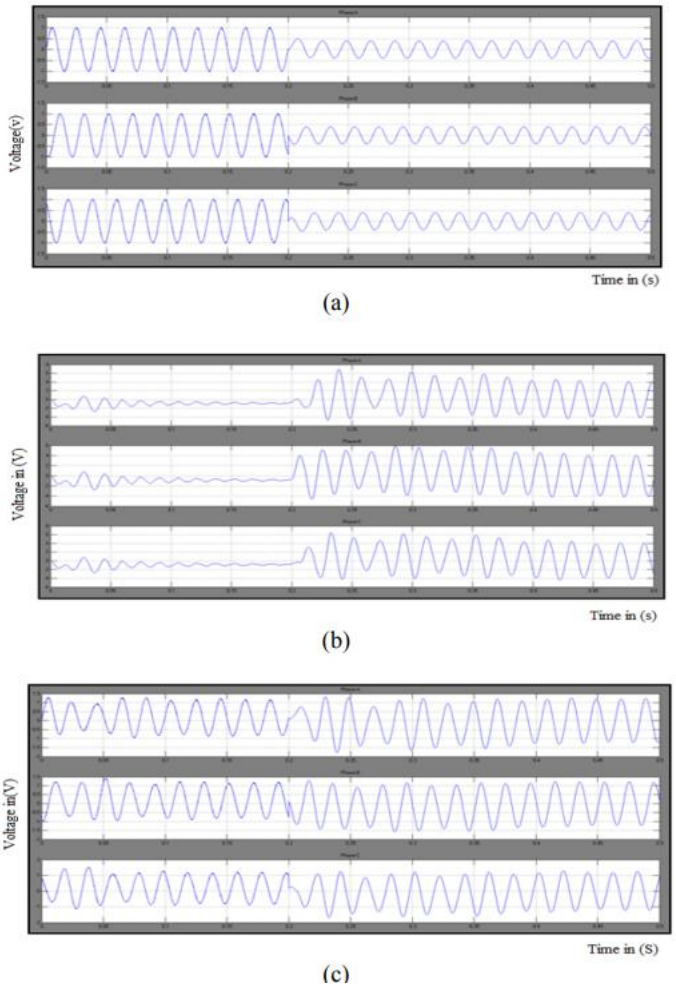

Fig 4: (a) Grid voltage (b) Inject voltage (c) Compensating voltage

V. Conclusion

The regulating voltage source converter (VSC1) applies modified PLL along with nonlinear adaptive filtering techniques and fuzzy logic control on dc-link voltages and introduces unified power quality conditioners for analysis. The new feature of the UPQC system provides fast easy signal extraction for supply voltage and load current through simple mathematical calculations. The proposed controller simplifies the number of necessary adjustments in the system. The suggested UPQC system receives its performance assessment through simulation tests of the PQ improvement mechanisms. When applying the proposed UPQC configuration it addresses various PQ stability issues at once.

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