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To Voltage Sag And Swell Power Compensation With Power Stabilization Using Saf

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Abstract-

Owing to the destructive impacts of harmonic currents, the topic of reducing their impacts on power system has attracted tremendous research interests. In this regard, a shunt active power filter (SAPF) is recognized to be the most reliable instrument. It performs by first detecting the harmonic currents that are present in a harmonic-contaminated power system, and subsequently generates and injects corrective mitigation current back into the power system to cancel out all the detected harmonic currents. This means that other than the ability to generate corrective mitigation current itself, it is actually more important to make sure that the SAPF is able to operate in phase with the operating power system, so that the mitigation current can correctly be injected. Hence, proper synchronization technique needs to be integrated when designing the control algorithms of SAPF. This paper critically discusses and analyzes various types of existing phase synchronization techniques which have been applied to manage operation of SAPF; in terms of features, working principle, implementation and performance.

Keywords: active filter; control technique; harmonics mitigation; phase synchronization; power quality issues.

I. INTRODUCTION

The Power Quality issue is defined as “any occurrence manifested in voltage, current, or frequency deviations that results in breakdown, upset, failure, or mis operation of enduse equipment.” Power electronic devices are highly nonlinear though efficient, cheap and very flexible. From the supply they absorb reactive power and harmonic currents[1]. Waveform distortions will occur because of power quality pollutions. Waveform distortions results in power loss, poor system efficiency, interference with communication lines, over heating of distribution transformers, increased RMS value of supply current [3]. Passive filters and active filters are the devices used for controlling harmonic distortion. Passive filters are effective and very cheap for the elimination of harmonics. But it has a drawback of resonance, fixed compensation and they are large in size also [2]. Active power filters (APF) has a remarkable progress on analysis and design and cost effective solution. Active power filters are liable to harmonic and reactive power compensation.

Most people take the electrical supply for granted and expect it to be available at the flick of a switch. However, some businesses like share dealing houses, hospitals and continuous process lines, are so reliant on electricity that they have to provide safeguards to ensure that an emergency supply is always available. Generally, in industry, power quality is very low on the list of priorities and so very little attention is given to it, until something goes wrong. Much of the electrical equipment in an industrial facility requires high-quality electricity; it will not tolerate sags, swells, transients, or harmonics, and it certainly will not tolerate power outages, no matter how short-lived. Recognizing the limitations of grid-delivered power and the fact that 80 percent of all power quality and reliability problems occur inside end-user's facilities, it behooves all maintenance and reliability managers to understand the power quality susceptibilities within their facilities and of their key equipment. The remaining part of the paper will analyze each type of power defect with an explanation of how the problems occur and suggested preventative measures that can be considered.

II.PROPOSED METHODOLOGY- SHUNT ACTIVE POWER FILTER

Shunt active filters are widely accepted and dominant filter of choice in most industrial processes. The shunt APF structure is an attractive solution to harmonic current problems based on Voltage Source Inverter (VSI). The APF is connected at the point of common coupling in parallel and is fed from the mains [4]. The focus of the shunt active filter is to supply opposing harmonic current to the nonlinear load results in a net content. Then the supply signals remain purely fundamental [5]. Shunt active power filters also have the benefit of contributing to reactive power and balancing of three-phase currents. Several shunt active filters can be combined together for an increased power ratings to withstand higher currents.

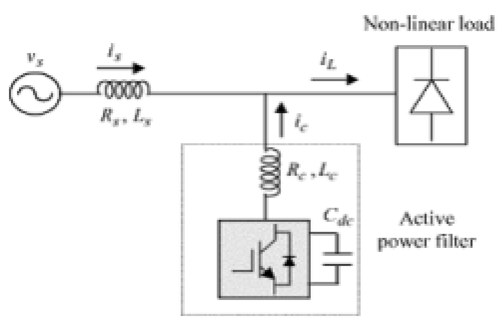

Fig 1 Shunt Active Power Filter

The APF consists of a DC link capacitor, power electronic devices. Due to nonlinear loads shunt APF acts as a current source for compensating the harmonic currents. This is achieved by "shaping" the compensation current waveform, using the Current Controlled voltage source inverter. The compensating currents are obtained by measuring the load current and subtracting from a sinusoidal reference. The main aim of shunt active power filter is to obtain a sinusoidal source current [6].

This paper presents a shunt active filter developed in the Industrial Electronics Department of the University of Minho, which uses a digital controller based on the p-q theory. Its main characteristics are the following:

- Dynamic power factor correction;

- Dynamic compensation of any harmonics currents with frequencies up to about 5 kHz; -

Dynamic zero-sequence current compensation;

- Flexible microcontroller

-based implementation;

- Only one power converter: an inverter with just a capacitor on the DC side.

- IGBT power stage capable of compensating harmonics in three-phase systems up to 75 kVA (with the developed laboratory prototype).

- Low cost system.

III. VOLTAGE SAG

- A voltage sag or voltage dip is a short duration reduction in RMS voltage which can be caused by a short circuit, overload or starting of electric motors.
- Voltage sag happens when the RMS voltage decreases between 10 and 90 percent of nominal voltage for one-half cycle to one minute.
- Some references define the duration of sag for a period of 0.5 cycles to a few seconds, and longer duration of low voltage would be called “sustained sag".
- There are several factors which cause voltage sag to happen:
- Since the electric motors draw more current when they are starting than when they are running at their rated speed, starting an electric motor can be a reason of voltage sag.
- When a line-to-ground fault occurs, there will be voltage sag until the protective switch gear operates.
- Some accidents in power lines such as lightning or falling an object can be a cause of line-to-ground fault and voltage sag as a result.
- Sudden load changes or excessive loads can cause voltage sag.
- Depending on the transformer connections, transformers energizing could be another reason for happening voltage sags.
- Voltage sags can arrive from the utility but most are caused by in-building equipment. In residential homes, we usually see voltage sags when the refrigerator, air-conditioner or furnace fan starts up.

Fig. 2 Voltage sags.

IV. VOLTAGE SWELL

a. Swell - an increase to between 1.1pu and 1.8pu in RMS voltage or current at the power frequency durations from 0.5 to 1 minute

b. In the case of a voltage swell due to a single line-to-ground (SLG) fault on the system, the result is a temporary voltage rise on the un faulted phases, which last for the duration of the fault. This is shown in the figure below:

Instantaneous Voltage Swell Due to SLG fault

a. Voltage swells can also be caused by the deenergization of a very large load.

b. It may cause breakdown of components on the power supplies of the equipment, though the effect may be a gradual, accumulative effect. It can cause control problems and hardware failure in the equipment, due to overheating that could eventually result to shutdown. Also, electronics and other sensitive equipment are prone to damage due to voltage swell.

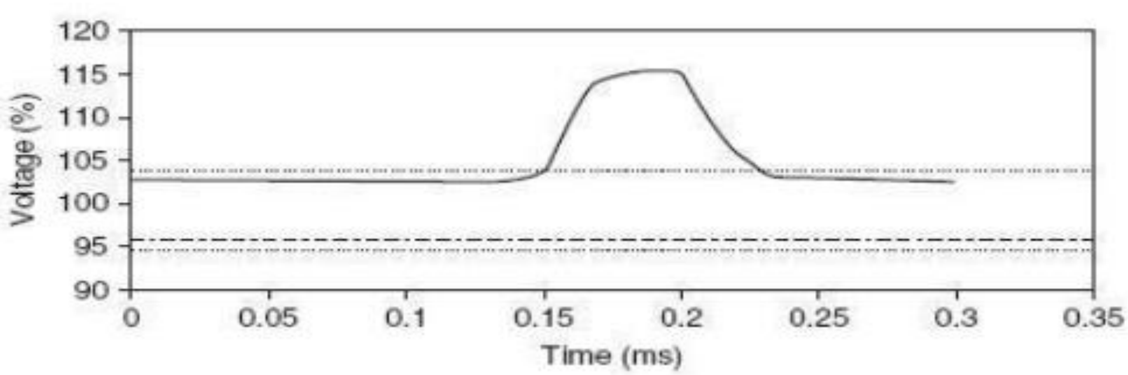

Fig 3. Voltage Swell.

Voltage dips, sags and surges Most electrical power generating authorities have an obligation to supply consumers from the grid at a constant voltage (typically within +/- 6% of nominal). However, sometimes this is not practical, particularly in rural locations. Sometimes voltage sags are caused by the power supplier during times of heavy demand, while dips are often caused by auto closers, operating within one second of fault detection.

Causes of dips, sags and surges

1. Rural location remote from power source
2. Long distance from a distribution transformer with interposed loads
3. Unreliable grid system
4. Power distributors tolerances not suitable for voltage sensitive equipment
5. Switching of heavy loads
6. Unbalanced load on a three phase system
7. Equipment not suitable for local supply

Methods of dealing with dips, sags and surges

1. Transformer with a tap changer
2. Constant voltage (ferro-resonant) transformer
3. Servo controlled voltage stabilizer
4. Switch mode power supply
5. Saturable reactor
6. Soft starters on larger electrical equipment
7. Connect larger loads to points of common coupling
8. Choose equipment with dip resilience

Symptoms of dips, sags and surges

1. Production rates fluctuates
2. Equipment does not operate correctly
3. Dimming of lighting systems
4. Variable speed drives close down to prevent damage
5. Relays and contactors drop out
6. Unreliable data in equipment test

V. SIMULATION TOOLS

Simulation is a powerful way to reduce development time and ensure the proper fulfilment of critical steps. During the development process of the shunt active filter, simulations were performed, which allowed the study of its behaviour under different operation conditions, and permitted the tuning of some controller parameters together with the optimisation of the active filter components values. There are not many simulation tools that allow working with electrical systems, power electronics and control systems, in the same integrated environment [7-12]. MATLAB/Simulink and the Power System Block set were used as simulation tools in this case and are briefly described in the following paragraphs. MATLAB/Simulink MATLAB is a high-level language oriented toward engineering and scientific applications. It has evolved over a ten-year history to become a popular, flexible, powerful, yet simple language. It has served as an effective platform for more than twenty toolboxes supporting specialized engineering and scientific applications, covering areas from symbolic computation to digital filter design, control theory, fuzzy logic, and neural nets. It is to be used interactively, and supports also the ability to define functions and scripts, and dynamically links with C and Fortran programs. Recent trends in the MATLAB language have focused on an object-oriented graphics capability that permits a rich Graphical User Interface (GUI) construction [10].

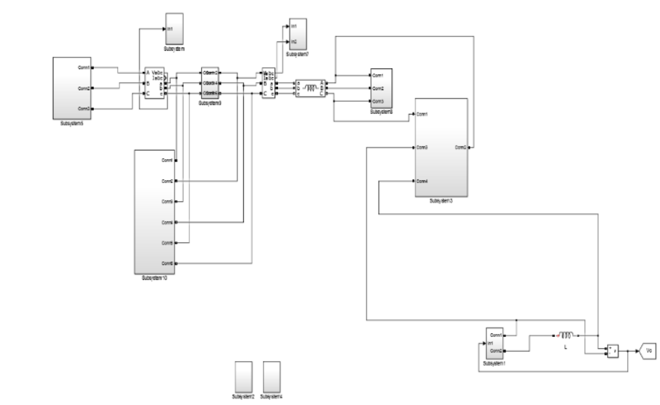

Fig 4. System modelling.

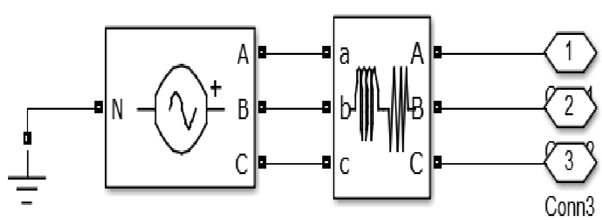

Fig 5. Source generator.

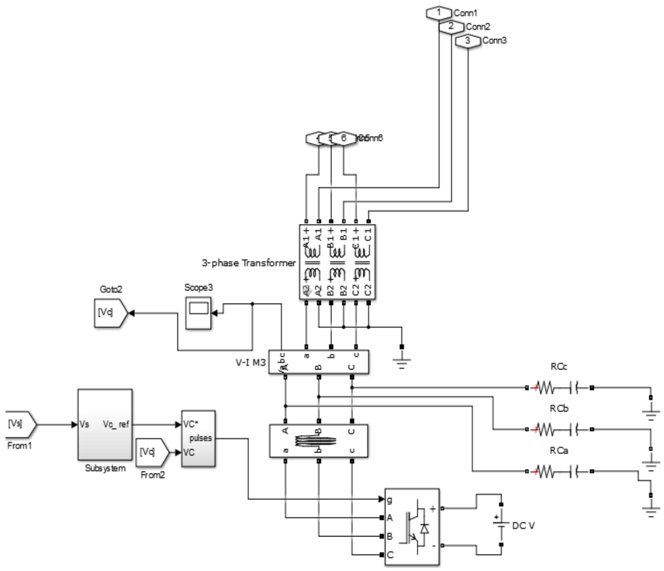

Fig 6. SAF.

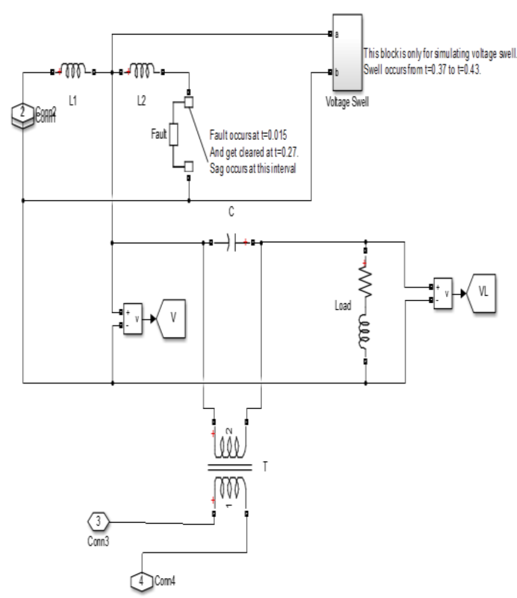

Fig 7. Sag and Swell generation.

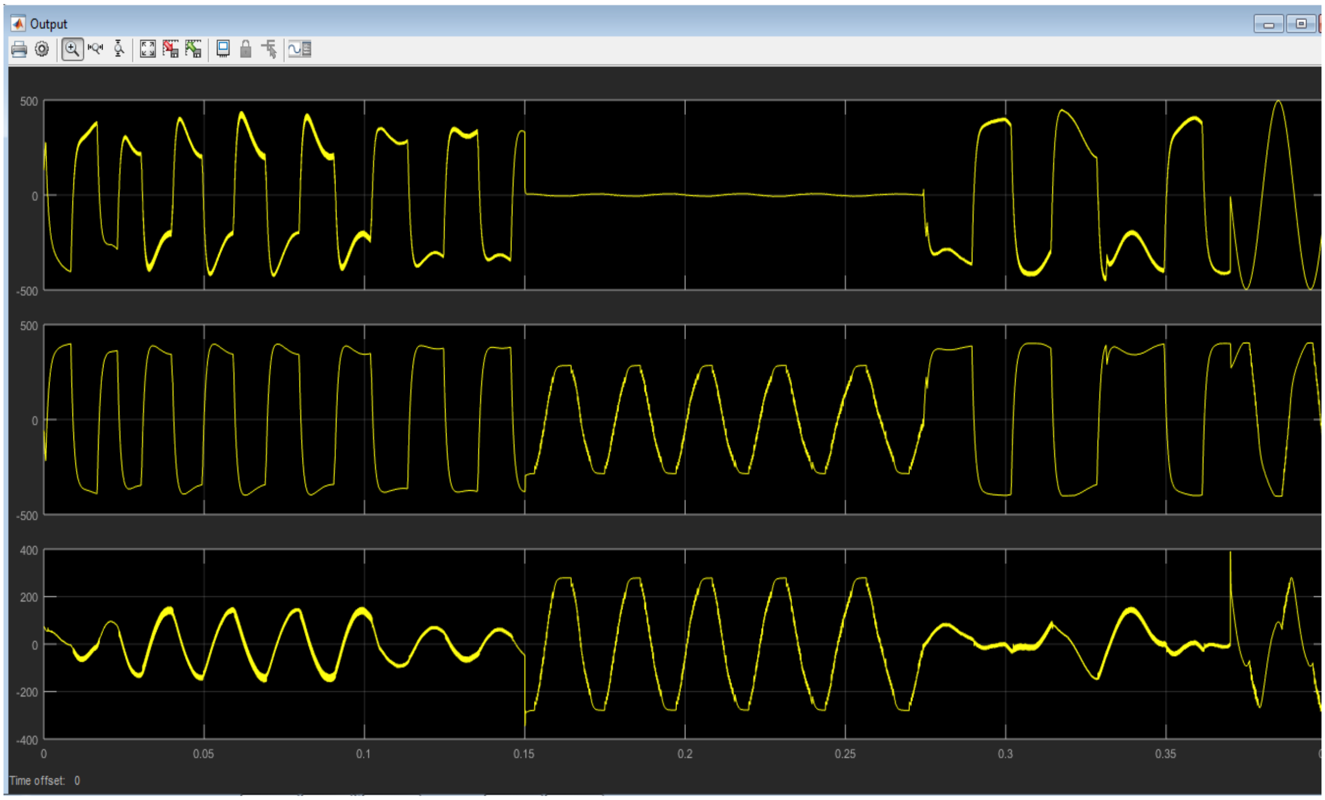

Fig 8. Sag, Swell and Compensation.

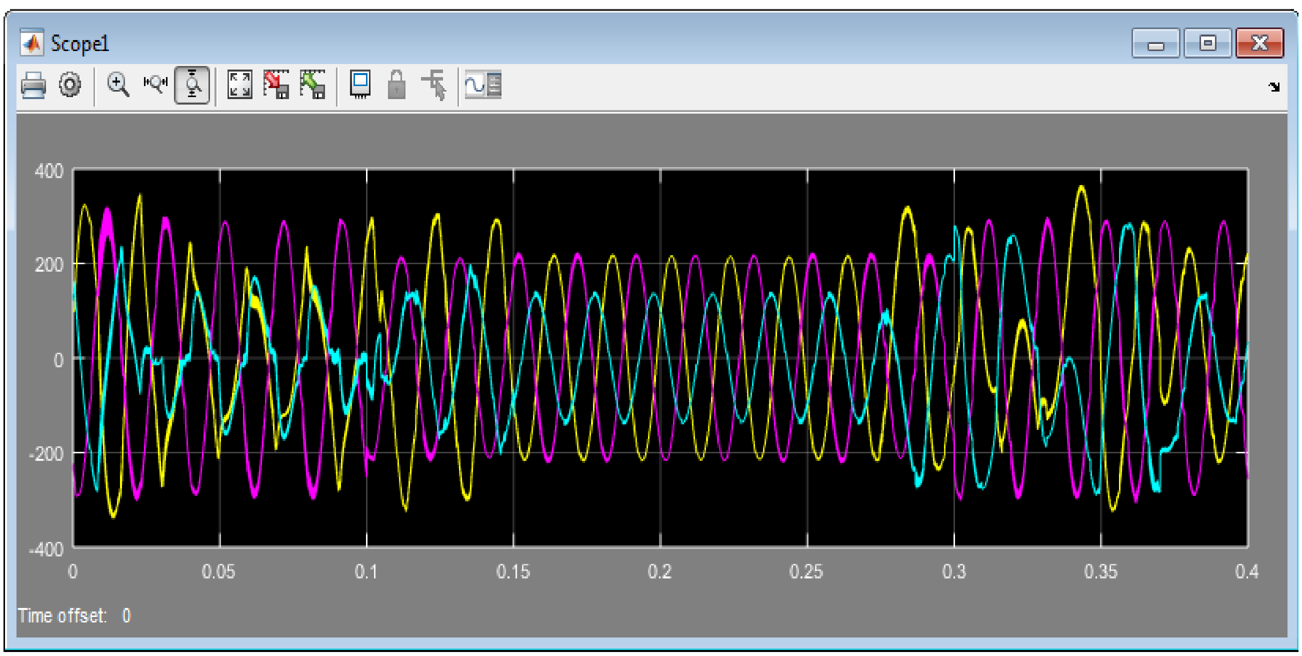

Fig 9. Effects.

VI. CONCLUSIONS

This paper presents a shunt active power filter as a reliable and cost-effective solution to power quality problems. The active filter controller is based on the p-q theory, which proved to be a powerful tool, but simple enough to allow the digital implementation of the controller using a standard and inexpensive microcontroller with minimum additional hardware. The filter presents good dynamic and steady-state response and it can be a much better solution for power factor and current harmonics compensation than the conventional approach (capacitors to correct the power factor and passive filters to compensate for current harmonics). Besides, the shunt active filter can also compensate for load current unbalances, eliminating the neutral wire current in the power lines.

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