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Enhancement of Power Quality Using Active Power Filters

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Abstract- This paper introduces the terminology and various issues related to 'power quality'. The interest in power quality is explained in the context of a number of much wider developments in power engineering: deregulation of the electricity industry, increased customer-demands, and the integration of renewable energy sources. After an introduction of the different terminology two power quality disturbances are discussed in detail: voltage dips and harmonic distortion. For each of these two disturbances, a number of other issues are briefly discussed, which are characterization, origin, mitigation, and the need for future research. Shunt, hybrid and series active power filters are described showing their compensation characteristics and principles of operation. Different power circuits topologies and control scheme for each type of active power filter are analyzed.

Index Terms- Power quality, voltage sag voltage Swell, voltage fluctuations, Active filters.

I. Introduction

The proliferation of microelectronics processors in a wide range of equipments, from home VCRs and digital clocks to automated industrial assembly lines and hospital diagnostics systems, has increased the vulnerability of such equipment to power quality problems [1]. These problems include a variety of electrical disturbances,which may originate in several ways and have different effects on various kinds of sensitive loads. What were once considered minor variations in power, usually unnoticed in the operation of conventional equipment,may now bring whole factories to standstill. As a result of this vulnerability, increasing numbers of industrial and commercial facilities are trying to protect themselves by investing in more sophisticate equipment to improve power quality [2]. Moreover, the proliferation of nonlinear loads with large rated power has increased the contamination level in voltages and currents waveforms,forcing to improve the compensation characteristics required to satisfy more stringent harmonics standard [3],[4].Between the different technical options available to improve power quality, active power filters have proved to be an important alternative to compensate for current and voltage disturbances in power distribution systems [5],[6], [7]. Different active power filters topologies have been presented in the technical literature, [8] [9] and many of them are already available in the market [1], [2].This paper will focus in the analysis of which to use with their compensation characteristics. Shunt active power filters, series active topologies, and hybrid schemes will be presented and analyzed. The control scheme characteristics for shunt and series schemes will also be discussed. Finally, steady state and transient results for dynamic compensation, obtained from simulated and experimental setup will be presented.

I.I MPORTANCE OF POWER QUALITY:

Power quality is an increasingly important issue for all businesses. Problems with powering and grounding can cause data and processing errors that affect production and service quality.

Lost production: Each time production is interrupted, your business loses the margin on the product that is not manufactured and sold.

Damaged product: Interruptions cadamage a partially complete product, cause the items to be rerun or scrapped.

Maintenance: Reacting to a voltage disruption can involve restoring production, diagnosing and correcting the problem, clean up and repair, disposing of damaged products and, in some cases, environment costs.

Hidden costs: If the impact of voltage sag is a control error, a product defect may be discovered after customer delivery. The costs of losing repeat sales, product recalls and negative public relations can be significant and hard to quantify.

A recent study by IBM showed that power quality problems cost U.S. businesses more than $15 billion a year. That's an average of $79,000 for each company.

II. Power Quality

"Power quality" is defined as "the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of the equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment.

Power quality has become a strategic issue for the following reasons:

1. The economic necessity for businesses to increase their competitiveness.
2. The widespread use of equipment which is sensitive to voltage disturbances and /or generates disturbances itself.
3. The deregulation of the electricity market.

In this context, it is essential for the utility and the customers to prevent and detect power quality problems and to have solutions available to fix them.

4. The power quality correction and harmonic filtering system give solution to solve the problems of harmonic disturbances and voltage fluctuations.

Power Quality Glossary:

Although specialists use complex equations for precise descriptions and analysis, the following definitions are adequate for most discussions
with your local utility account managers, distribution engineers, and PQ consultants and vendors.

Harmonic distortion. Continuous or sporadic distortions of the 60-hertz (Hz) voltage sine waveform, usually caused by microprocessor based loads in the building such as computer power supplies, lighting ballasts, and electronic adjustable speed drives. Harmonics can also be transmitted from an energy user down the block. These can cause telecommunications or computer interference; overheating in motors, transformers, or neutral conductors; decreased motor performance; deterioration of power factor–correction capacitors; or erratic operation of breakers, fuses, and relays.

Interruption, momentary. A very short loss of utility power that lasts up to 2 seconds, usually caused by the utility switching operations to isolate a nearby electrical problem.

Interruption, temporary. A loss of utility power lasting from 2 seconds to 2 minutes, caused by a nearby short circuit due to something like animals, wet insulators, or accidents. Corrected by automated utility switching.

Long-term outage. A loss of utility power lasting more than 2 minutes due to major local, area, or regional electrical events.

Noise. Sporadic voltage changes consisting of frequencies higher than the normal 60-Hz power frequency due to any number of causes, including arc welders, loose wiring, and nearby radio and TV transmitters.

Sag. A short-term decrease in voltage lasting anywhere from milliseconds up to a few seconds. Sags starve a machine of the electricity
it needs to function, causing computer crashes or equipment lock-ups. Usually caused by equipment start-up—such as elevators,
heating and air-conditioning equipment, compressors, and copy machines—or nearby short circuits on the utility system.

Spike. A very brief (nanoseconds to milliseconds) change in voltage ranging from tens to thousands of volts. Can be produced by utility and customer equipment operations, nearby lightning strikes, falling tree limbs on power lines, and even static discharges.

Surge. A short-term increase in voltage, lasting up to a few seconds. They are due either to customer equipment operation, such as air conditioners or motors switching on and off, or to utility activities, such as capacitor switching.

Transient. A sudden momentary change in voltage. Also called a spike.

III. VOLTAGE SAG

Voltage sag is a sudden reduction (between 10% and 90%) of the voltage magnitude at a point in the electric System and lasting from 0.5 cycles to few seconds. Either switching operations or any type of faults as well as fault clearing process can cause a voltage dip. Switching like those associated with a temporary disconnection of the supply or flow of heavy currents associated with the starting of large motor loads is the most common. These events maybe originated at the utility side or at the customer site.

IV. HORMONIC ELIMINATION TECHNIQUES

To avoid the ill effects of harmonics on the operation of sensitive equipments, it is necessary to keep harmonic contents below safe limit by installing filter at load end. The simplest way of eliminating harmonics of different orders is to install filters at the location generated by different loads are connected in two ways in power system network.

1.SERIES CONNECTED FILTERS: Such type of filters are connected in series with power system network and offer high impedance at turning frequencies high impedance offered by filters allow very little harmonics are passed. The drawback of series filters are high cost, because the rating of filter component required is rated full load current.

2.SHUNT CONNECTED FILTERS: It is most commonly used filters in A.C. power system network and offers very low impedance path to harmonics. Shunt type of filters are cheaper than series type because the shunt connected filters are designed for graded insulation levels which makes the components cheaper than the series filter components.

Following are the different techniques used to eliminate harmonics of different orders to keep harmonic distortion within permissible limit.

PASSIVE FILTERS:

These are LC resonating or parallel resonating circuits which offer very high or low impedance at tuning frequency. These filters are resistive at tuned frequency, capacitive at below tuned frequencies and inductive beyond tuned frequency.

TYPES OF PASSIVE FILTERS:

1.Series passive filters: These are connected in series and offers very high impedance to different harmonics at tuned frequency, because of its very high cost such type of filters are not used.

2.Shunt passive filters: These are connected between line and earth and offer very low impedance at resonant frequency. Hence particular harmonic or harmonics directed to earth and prevented from passing further. The high pass shunt filters are connected to the point of common coupling block all over the harmonic frequency and passes all higher frequency.

SHUNT ACTIVE FILTER

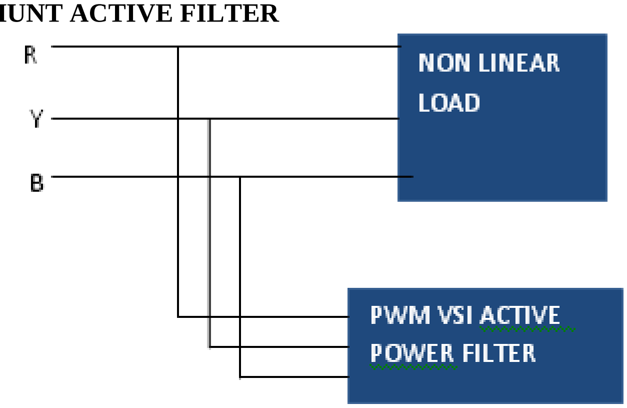
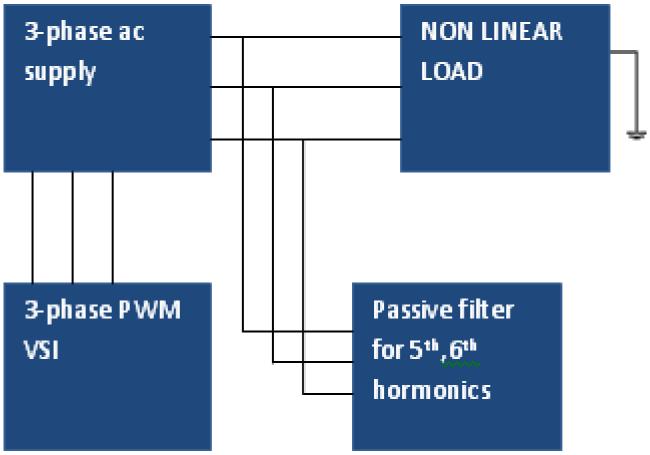


Fig 1: Shunt Active Filter

SERIES ACTIVE FILTER



VOLTAGE FLUCTUATIONS

Voltage fluctuations are changes or swings in the steady-state voltage above or below the designated input range for a piece of equipment. Fluctuations include both sags and swells.

Causes:

Large equipment start-up or shutdown; sudden change in load; improper wiring; or grounding; utility protection devices

Vulnerable equipment:

Computers; fax machines; variable frequency drives; CNC machines; extruders; motors

Effects:

Data errors; memory loss; equipment shutdown; flickering lights; motors stalling/stopping; reduced motor life.

V. SIMULATION REPRESENTATION

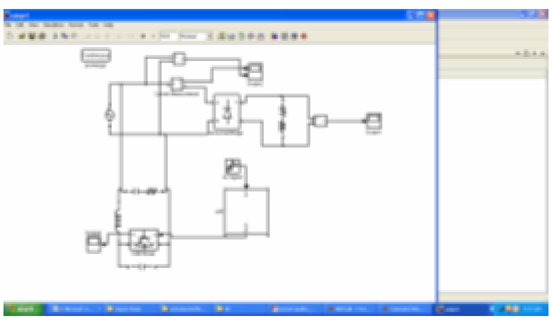


Fig 2 single phase active filter

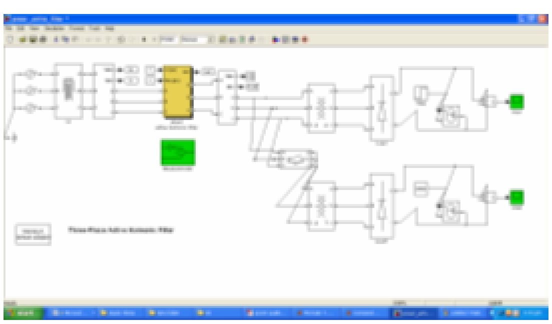


Fig 3 Three phase Active harmonic filter

VI. SIMULATION RESULTS

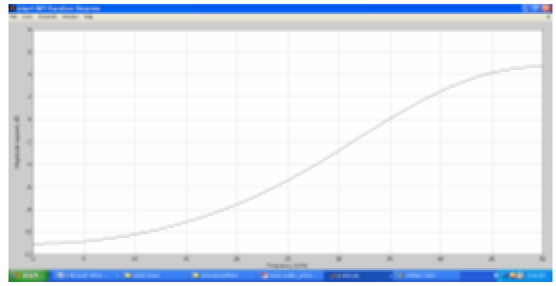


Fig 4 Active power filter equalizer

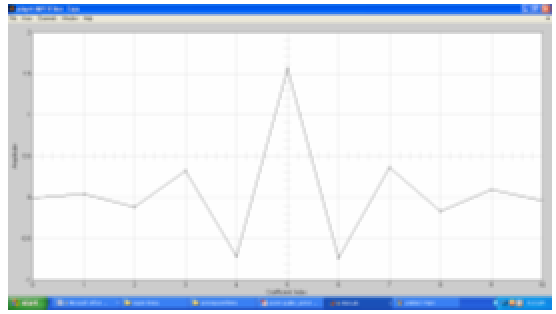


Fig 5 Active power filter amplitude

Fig 6 Source voltage and source current

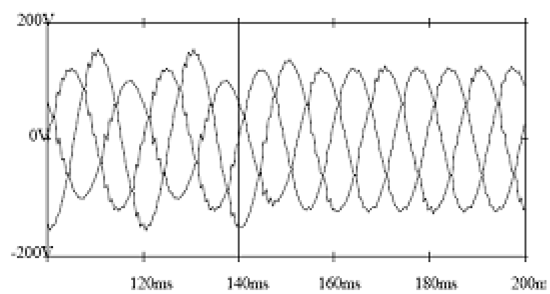


Fig 7 Simulated waveforms for voltage unbalance compensation. Phase to neutral voltages at the load terminals before and after series compensation. (Current harmonic compensator not operating).

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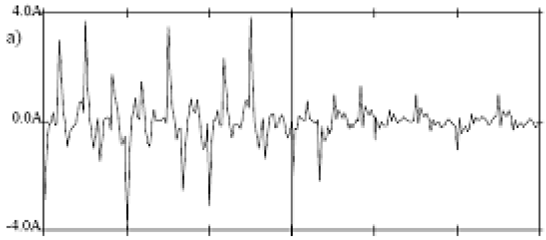
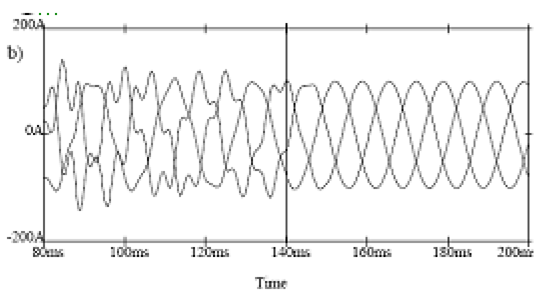


Fig 8 Simulated waveforms for current harmonic compensation. a) Neutral current flowing to the ac mains before and after compensation. b) Line currents flowing to the ac mains before and after compensation. (Voltage unbalance compensator not operating).



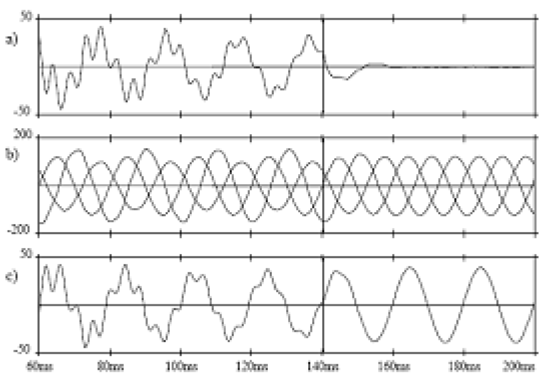


Fig 9 Simulated results for voltage unbalance and current harmonic compensation, before and after compensation. a) Ac mains neutral current. b) Phase to neutral load voltages.c) Ac source line current.

VII. CONCLUSION

In this paper the use and advantages of applying active power filters to compensation power distribution systems has been presented. The principles of operation of shunt, series, Also, a brief description of the state of the art in the active power filter market has been described. The shunt active power filter performance under fault power distribution system was discussed. Simulation results proved the viability of using active power filters to compensate active power filters.

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