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A Comparative Analysis For Power Quality Improvement Using Facts Devices In A Grid Connected Photovoltaic System

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Abstract— In a grid-connected solar system, a comparison of the Unified Power Flow Controller (UPFC) and Distributed Power Flow Controller (DPFC) is made. The main model is a grid-connected solar generation system with a boost converter and voltage source inverter (VSI). The grid side system must be meticulously monitored and managed due to power quality issues such as power oscillations, harmonic distortions, voltage sags, and swells. The use of reactive devices such as a shunt/series reactor and a shunt/series capacitor is one technique to alleviate these power quality issues. The downside of using these reactive elements is the occurrence of sub-synchronous resonance. So to overcome the sub synchronous resonance we are connecting the UPFC and DPFC to the grid connected photo voltaic cell and analyzed the best performance among them.

Keywords— Power Quality issues, Harmonics Distortion, Voltage sags, Power factor.

I. Introduction

The increased usage of non-linear loads is causing a slew of unfavourable effects in power system operation. The most important of them are the harmonic components in current and voltage waveforms. Passive filters have traditionally been used to remove line current harmonics. They do, however, introduce resonance into the power supply and are hefty. As a result, active power line conditioners have gained in popularity over passive filters since they correct for both harmonics and reactive power at the same time.

The topology of an active power filter can be connected in series, shunt, or a combination of both. Because most industrial applications require current harmonic correction, shunt active filters are more popular than series active filters. To boost the efficiency of active filters, various types of active filters have been proposed.

II. Literature survey

"Harmonic interaction between a large number of distributed power inverters and the distribution network,"
by Johan H. R. Enslin and Peter J. M. Heskes.
The harmonic interaction between a large number of distributed power inverters and the distribution network was discussed in this . The purpose of this article is to investigate the phenomenon of harmonic interference in huge populations of these inverters, as well as to compare the network interactions of various inverter topologies and control options.

"Sharing of nonlinear load in parallel-connected three-phase converters,"
UffeBorup, Frede Blaabjerg, and Prasad N. Enjeti
The sharing of linear and nonlinear loads in three-phase power converters connected in parallel with no communication between converters is discussed. The challenge that emerges when two converters with harmonic correction are coupled in parallel is the subject of this paper.

"Implementation and performance of cooperative control of shunt active filters for harmonic damping throughout a power distribution system," Pichai Jintakosonwit Hideaki Fujita, Hirofumi Akagi, and Satoshi Ogasawara, "Implementation and performance of cooperative control of shunt active filters for harmonic damping throughout a power distribution system,"
For harmonic dampening throughout a power distribution system, this work presents cooperative control of multipleactive filters based on voltage detection. A genuine distribution system's configuration would alter based on system operation and/or fault conditions. Shunt capacitors and loads are also connected to or unplugged from the distribution system on an individual basis.

Pedro Rodrguez, Josep Pou, Joan Bergas, J. Ignacio Candela, Rolando P. Burgos, and DushanBoroyevich
"Controlling power converters with a decoupled double synchronous reference frame PLL."
Under unbalanced and distorted conditions, the detection of the fundamental-frequency positive-sequence component of the utility voltage was shown. It presents a positive-sequence detector based on a new decoupled double synchronous reference frame phase-locked loop (PLL), which eliminates the detection faults of traditional synchronous reference frame PLLs altogether. This is accomplished by changing the utility voltage's positive and negative sequence components into a double SRF, from which a decoupling network is built to cleanly extract and separate the positive and negative sequence components.

SoerenBaekhoejKjaer, John K. Pedersen, and Frede Blaabjerg,[5] SoerenBaekhoejKjaer, John K. Pedersen, and Frede Blaabjerg
Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules is presented in the paper "A Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules." Inverter solutions for connecting photovoltaic (PV) modules to a single-phase grid are the focus of this article. The inverters are classified into four categories: 1) the number of power processing stages in cascade; 2) the kind of power decoupling between the PV module(s) and the single-phase grid; 3) whether or not they use a transformer (line or high frequency); and 4) the type of grid-connected power stage

"Overview of control and grid synchronisation for distributed power generation systems,"
by F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, [6].
The structures for the DPGS based on fuel cells, solar panels, and wind turbines are discussed in this study. Furthermore, the grid-side converter's control structures are explored, as well as the possibility of compensating for low-order harmonics. Control solutions for grid faults are also discussed. The study concludes with a review of synchronisation mechanisms and a discussion of their value in control.

III.POWER QUALITY AND ITS PROBLEMS

Electric grids and systems are dynamic systems with many moving parts. Unexpected or rapid fluctuations in currents and voltages are a common problem with these systems. The varied types of linear and non-linear loads to which they are coupled are primarily responsible for these variations. Aside from that, there are several forms of mishaps that might occur on the grid. Electric grids are polluted with varied harmonic currents and voltages due to the rising use of power semiconductors in the majority of industrial and home procedures. These harmonics have a negative impact on the proper operation of most grid-connected equipment, as well as resulting in significant financial losses. For harmonic difficulties, there have been many traditional and recent solutions offered in the literature. The harmonic problem is one of the topics covered in this chapter.

Frequencies of 50 or 60 Hz are used in power systems. Certain loads, on the other hand, generate currents and voltages at integer multiples of the fundamental frequency of 50 or 60 Hz. Harmonic distortion is a type of electric pollution that includes these frequency components. In a power system, there are two kinds of harmonics. Harmonics that are synced together. Harmonics that are asynchronous Sinusoids with frequencies multiples of the fundamental frequency are referred to as synchronous harmonics. Harmonic number is a term used to describe the multiplication factor. There are two types of synchronous harmonics. When the harmonic frequency is less than the fundamental frequency, this is referred to as sub-harmonics. When the harmonic frequency exceeds the fundamental frequency, the term "super harmonics" is used.

Harmonics are a type of sound that is produced by the interaction.

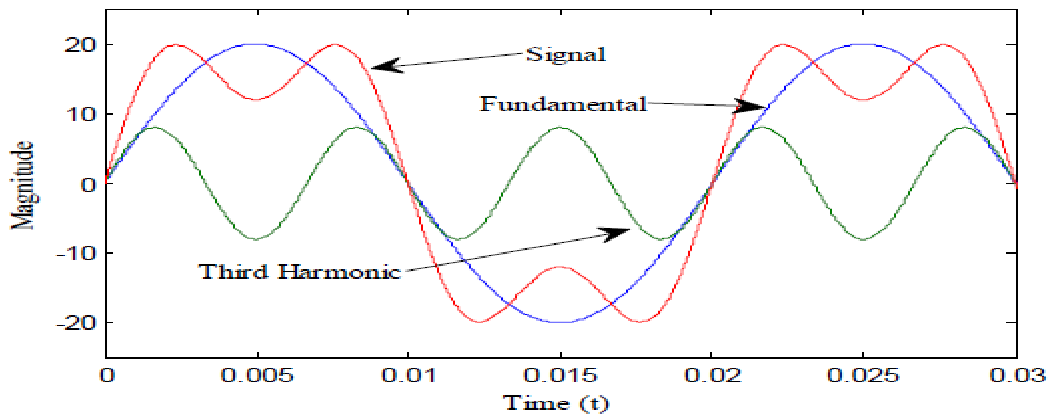


Fig. 3.1 Harmonic Content of a Signal and its Fundamental.

Harmonic currents will flow into the utility feeder, potentially causing a variety of issues. Power factor correction capacitors may trap them, overloading or causing resonant over-voltages. They can cause computer, telephone, motor, and power supply difficulties, as well as transformer failures due to eddy current losses. Installing series LC filters resonant at the troublesome frequencies may be used to trap harmonic currents. When compared to the source impedance at the resonant frequency, these filters should be constructed to offer low impedance. But there's a "gotcha" this time. If a 7th harmonic series resonance filter is installed, it will likewise have a 7th harmonic series resonance.

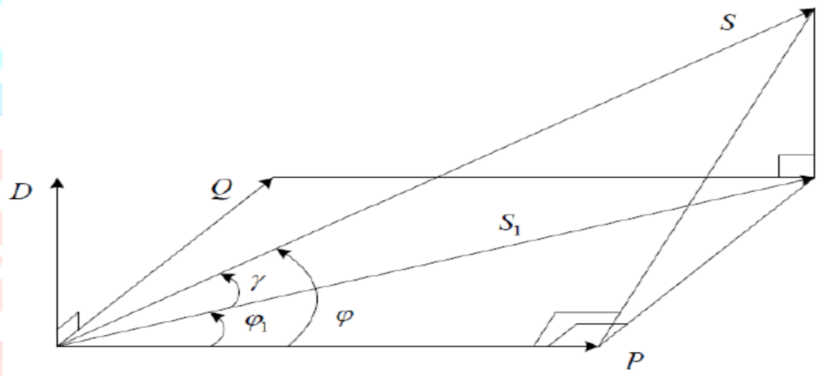


Fig. 3.2 Fresnel Representation of the Power

Three Sources of Harmonic Current

Harmonic currents are injected by non-linear loads, which is the main cause of harmonics. Because they don't need to be controlled and have a lengthy life span at a low cost, diode bridges are the most non-linear loads found in power applications. Other harmonic-producing loads include:

'Industrial equipment' is a type of equipment used in the manufacturing industry (welding machines, arc furnaces, induction furnaces, rectifiers).

Computers, photocopiers, etc.) are examples of office equipment.

Devices used in the home (TVs, microwave ovens, neon lighting, and so on).

Power inverters are a type of inverter that converts electrical energy into electrical energy.

When operating in the saturation zone, power transformers are also considered nonlinear loads that generate harmonics.

Harmonic currents flow into the electrical grid when non-linear loads are fed. Harmonics are created when current harmonics expand into feeding impedances (transformers and grid).

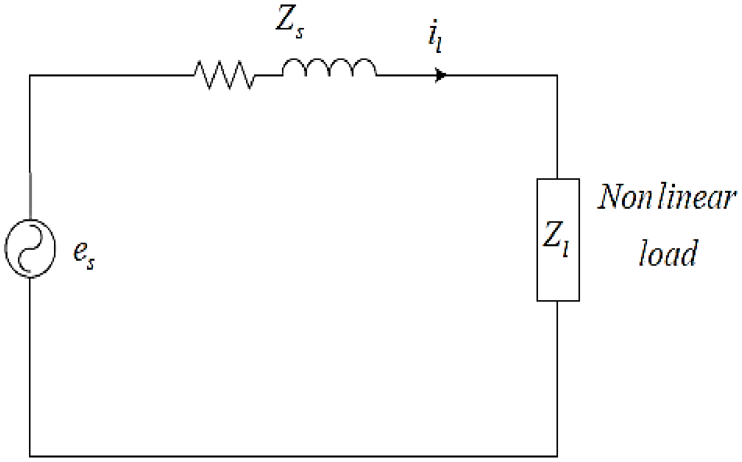


Fig. 3.3 Equivalent Circuit Per Phase of a Non-Linear Load Connected to the Grid

Series Active Power Filter (Series APF)

The Series Active Power Filter is a type of active power filter that is used to reduce the amount (Series APF)

The series APF's goal is to change the grid's impedance at a local level. It is a harmonic voltage source that cancels grid voltage perturbations or those caused by harmonic current circulation into the grid impedance. The harmonic currents created by the loads, however, cannot be compensated by series APFs.

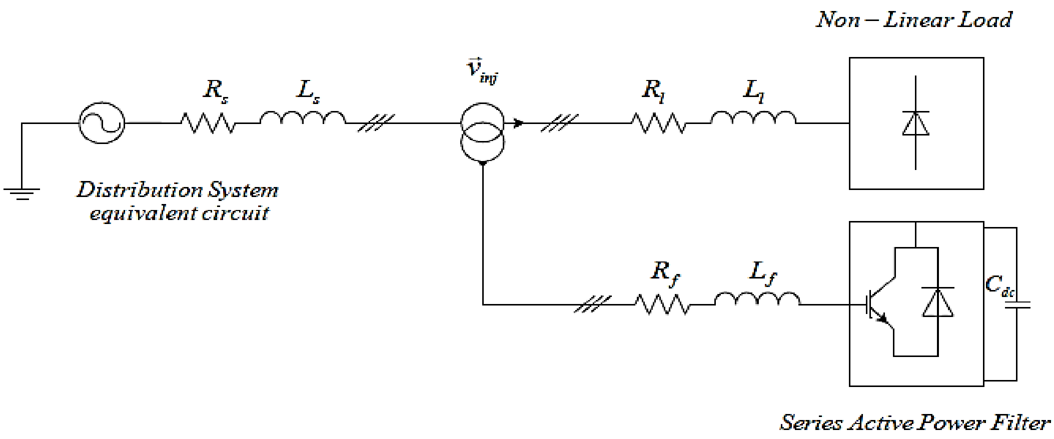


Fig. 3.4 Series Active Power Filter Connected to the Grid

Shunt Active Power Filter (SAPF)

The SAPFs are wired in parallel with the harmonic generators. They should be able to inject the harmonic currents absorbed by the pollution loads in real time. As a result, the grid current will be sinusoidal.

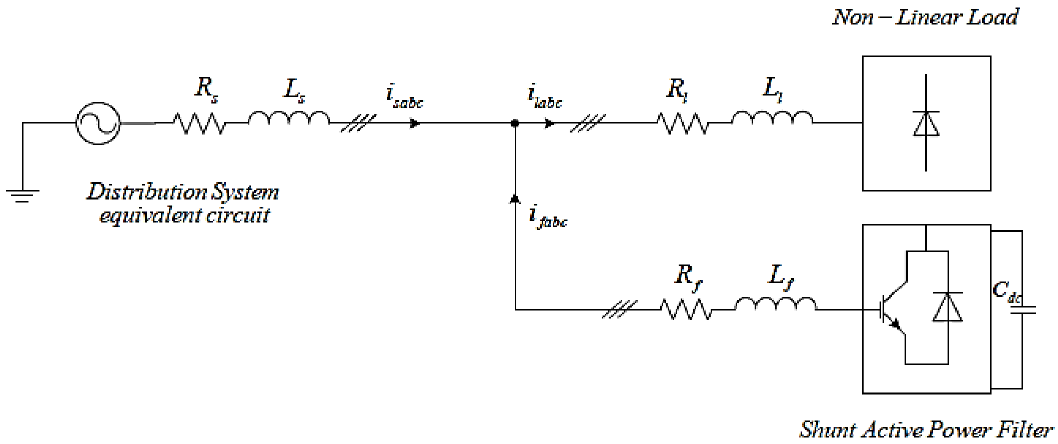


Fig. 3.5 Shunt APF Connected in Parallel with Non-Linear Load

Combination of Parallel and Series APF (UPF)

illustrates the parallel and series connection of two APFs, often known as (Unified Power Quality Conditioner). The benefits of the two APF types, series and parallel, are combined in this structure. As a result, sinusoidal source current and voltage can be achieved concurrently.

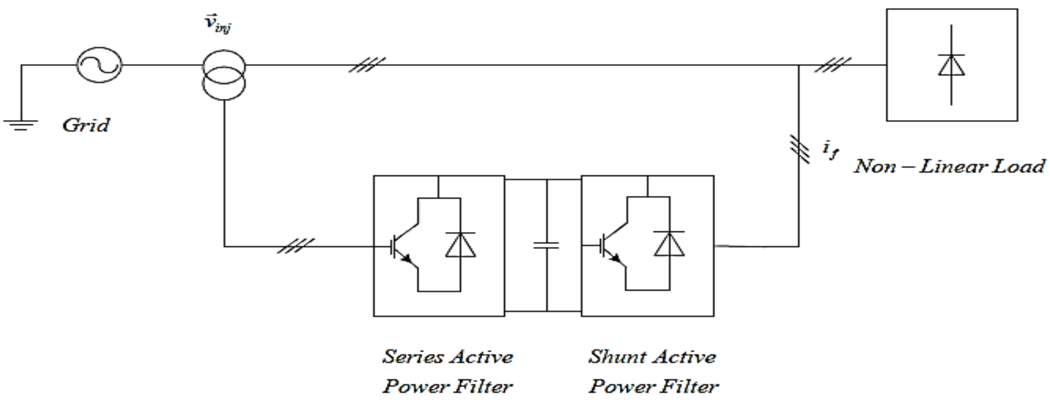


Fig. 3.6 Unified Power Quality Conditioner's Diagram

PROPOSED UPFC AND DPFC SYSTEM

Decentralized renewable energy generation is required to meet the ongoing increase in electrical energy while maintaining a clean environment. Increased energy use has the potential to overburden the distribution infrastructure and power plants, resulting in reduced electricity availability, security, and quality. Integration of the utility grid with renewable energy technologies such as solar, wind, and hydro is the only way to solve this problem. Depending on the availability of renewable energy sources, the grid1 can be connected to a renewable energy system. Solar power generating systems have recently gotten increasing attention since solar energy is more abundant, more efficient, and more benign than traditional power generation systems such as fossil fuel, coal, or nuclear. PV systems are still in use.

The instantaneous active and reactive power theory (p-q), introduced by Akagi et al in 1983, has been used to build the majority of APFs. It was originally designed for three-phase systems without a neutral wire, but Watanabe and Aredes later improved it for three-phase four-wire systems. The method involves converting distorted currents from the three-phase frame abc to the bi-phase stationary frame. The basic idea is that nonlinear controlled loads can be used to compensate for harmonic currents caused by nonlinear loads in the power system. The p-q hypothesis is founded on a collection of 31 time-domain instantaneous powers. The Clarke (or-) transformation is used to change the three-phase supply voltages.

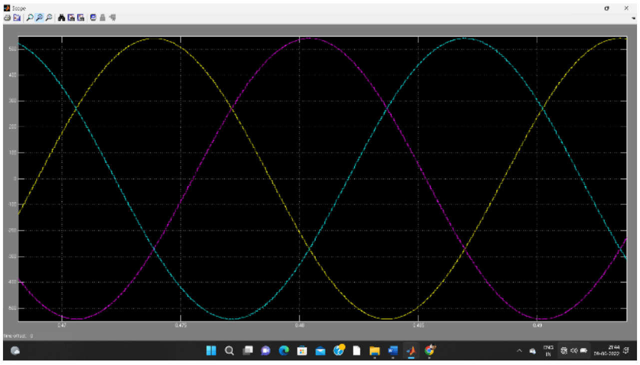
MATLAB

Simulink is a programme that allows you to model, simulate, and analyse dynamical systems. It can be used to describe linear and nonlinear systems in continuous time, sampled time, or a combination of the two. Simulink has a graphical user interface (GUI) for constructing models as block diagrams with mouse click-and-drag actions. Because models are hierarchical, we can use both top-down and bottom-up approaches to create them. We can look at the system at a high level, then double-click on blocks to descend down the levels and get more model information. This method reveals how a model is organised and how its components interact. After we've defined a model, we may simulate it using one of several integration techniques available from the Simulink menus or by writing our own.

The simulation results can be imported into the MATLAB workspace for further analysis and display. Simulink can be used to investigate the behaviour of a variety of real-world dynamic systems, such as electrical circuits, shock absorbers, braking systems, and a variety of other electrical, mechanical, and thermodynamic systems.

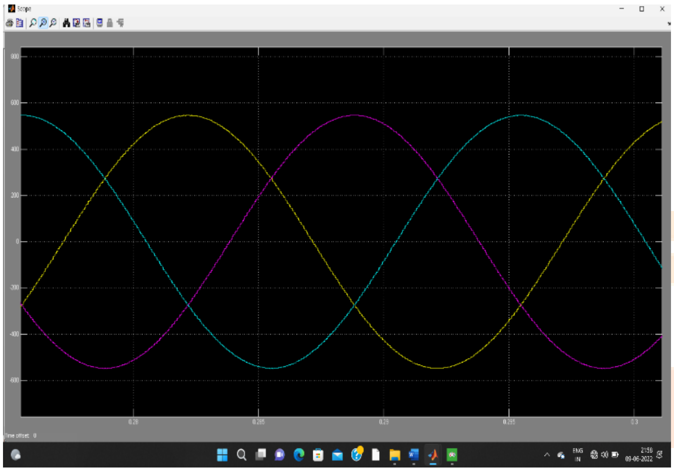
Simulating a dynamic system with Simulink is a two-step process. Using Simulink's model editor, we first develop a graphical model of the system to be emulated. The model displays the system's inputs, states, and outputs as time-dependent mathematical relationships. Then we use Simulink to replicate the system's behaviour over a given time period. Simulink runs the simulation based on the data you entered into the model.

V. OUTPUT

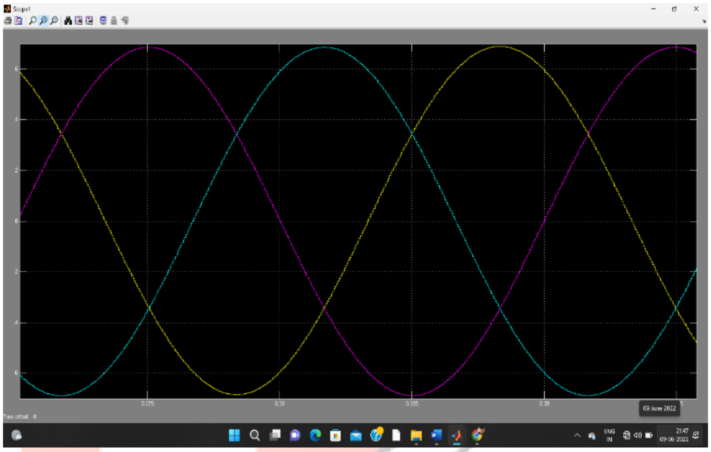


UPFC Voltage Waveforms

UPFC Current Waveforms



DPFC Voltage Waveforms



DPFC Current Waveforms

VI. CONCLUSION

The DPFC control system is investigated and provided. Individual control of each converter is part of the control scheme. The shunt converter has a three-phase and a single-phase converter, as well as a control system for each section of the shunt converter. In each phase of the transmission line, the series converter is a single phase converter. The central control's sole purpose is to provide reference voltages to the series and shunt converters. In the MATLAB/SIMULINK environment, the DPFC model was constructed and simulated.

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