Series Compensator for Voltage Sag Mitigation using Hysteresis Control

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Abstract: Voltage sag is a major problem in power system that must be solved. To overcome the occurrence of the voltage sag, a system that well known as Dynamic Voltage Restorer (DVR) is needed. In an electrical power system, DVR is positioned in series between a source and load. There are several DVR voltage compensating methods, such as pre-sag method, inphase method and in-phase advance compensation. DVR need synchronization time for equals phase injection voltage so it can compensate voltage sag due to short circuit current. This work employs Discrete Fourier Transform (DFT) for phase detection and hysteresis voltage control. In this project hysteresis technique PI controller is compared with PID controller.

KEYWORDS: Dynamic Voltage Restorer, PI Controller, PID, Hysteresis Controller.

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INTRODUCTION

Traditionally, a multi pulse like 6-pulse or 12-pulse inverter consisting of several voltage-source inverters connected together through zigzag arrangement of transformers is used for both harmonic and reactive power (VAR) compensations. These transformers: 1) are the most expensive equipment in the system; 2) produce about 50% of the total losses of the system; 3) occupy a large area of real estate, about 40% of the total system; 4) cause difficulties in control due to dc magnetizing and surge over voltage problems resulting from saturation of the transformers; and 5) are unreliable. Correspondingly, Pulse Width Modulated (PWM) inverters (with 10 kHz of high switching frequency) have been used for both harmonic compensation and static VAR compensation. However, the high initial and running costs have been hindering their practical use in power distribution systems.

One of the most common power quality problems today is voltage dips. A voltage dip is a short time (10 ms to 1 minute) event during which a reduction in r.m.s voltage magnitude occurs. It is often set only by two parameters, depth/magnitude and duration. The voltage dip magnitude is ranged from 10% to 90% of nominal voltage (which corresponds to 90% to 10% remaining voltage) and with duration from half a cycle to 1 min. In a three-phase system a voltage dip is by nature a three-phase phenomenon, which affects both the phase-to-ground and phase-to-phase voltages. A voltage dip is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing. Typical faults are single-phase or multiple-phase short circuits, which leads to high currents. The high current results in a voltage drop over the network impedance. At the fault location the voltage in the faulted phases drops close to zero, whereas in the non-faulted phases it remains more or less unchanged.

VOLTAGE SAG

One of the most common power quality problems today is voltage dips. A voltage dip is a short time event during which a reduction in r.m.s voltage magnitude occurs. Despite a short duration, a small deviation from the nominal voltage can result in serious disturbances.

The definition of a voltage sag is not unambiguous, and often set only by two parameters, depth/magnitude and duration. The voltage sag magnitude is ranged from 10% to 90% of nominal voltage (which corresponds to 90% to 10% remaining voltage) and for duration greater than half a cycle and less than 1 minute. The majority of voltage dips are 4-10 cycles long and with a remaining voltage of 84-90% of the nominal voltage.

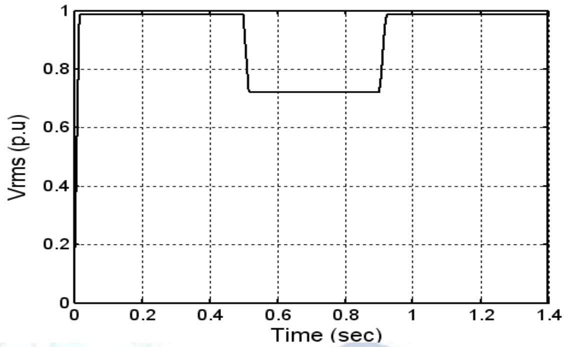

Fig.1. r.m.s voltage sag

The different types of faults increase the severity of balanced and unbalanced voltage sags. If the phase voltages during the sag have unequal magnitudes or phase relationship other than 120, the sag is considered to be unbalanced (Radhakrishna et al., 2001). The fault type, transformer connection and equipment influence the characteristics of voltage sag in each phase of a three-phase system. The voltage sags experienced by three- phase loads can be classified i.nto seven types denoted as A, B, C, D, E, F and G.

POWER QUALITY

Power quality and reliability cost the industry large amounts due to mainly sags and short-term interruptions. Distorted and unwanted voltage wave forms, too. And the main concern for the consumers of electricity was the reliability of supply. Here we define the reliability as the continuity of supply. As shown in Fig.3.1. the problem of distribution lines is divided into two major categories. First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage. If exceeds few cycle, motors, robots, servo rives and machine tools cannot provide control.

Transmission lines are exposed to the forces of nature. Furthermore, each transmission line has its load ability limit that is often determined by either stability constraints or by thermal limits or by the dielectric limits. Even though the power quality problem is distribution side problem, transmission lines are often having an impact on the quality of the power supplied. It is however to be noted that while most problems associated with the transmission systems arise due to the forces of nature or due to the interconnection of power systems, individual customers are responsible for more substantial fraction of the problems of power distribution systems.

The rapid development of power electronics technology provides exciting opportunities to develop new power system equipment for better utilization of existing systems. Since 1990, a number of devices under the term FACTS (flexible AC transmission systems) technology have been proposed and implemented. FACTS devices can be effectively used for power flow control, load sharing among parallel corridors, voltage regulation, and enhancement of transient stability and mitigation of system oscillations. By giving additional flexibility, FACTS controllers can enable a line to carry power close to its thermal rating. Mechanical switching has to be supplemented by rapid response power electronics. It may be noted that FACTS is enabling technology, and not a one-on-one substitute for mechanical switches.

VOLTAGE SOURCE INVERTER

The multilevel inverters have drawn tremendous interest in the power industry. They present a new set of features hat are well suited for use in reactive power compensation. It may be easier to produce a high-power, high-voltage inverter with the multilevel structure because of the way in which device stresses are controlled in the structure. Increasing the umber of voltage levels in the inverter without requiring higher ratings on individual devices can increase the power rating. The unique structure of multilevel voltage source inverters allows them to reach high voltages with low harmonics without the use of transformers or series-connected synchronized-switching devices. As the number of voltage levels increases, the harmonic content of the output voltage waveform decreases significantly.

The general structure of the multilevel converter is to synthesize a near sinusoidal voltage sources. As the number of level increases, the synthesized output waveform has more steps, which produce a staircase wave that approaches a desired waveform. Also, as more steps are added to the waveform, the harmonic distortion of the output wave decreases, approaching zero as the number of levels increases. As the number of levels increases, the voltage that can be spanned by summing multiple voltage levels also increases.

V. SIMULATION RESULTS

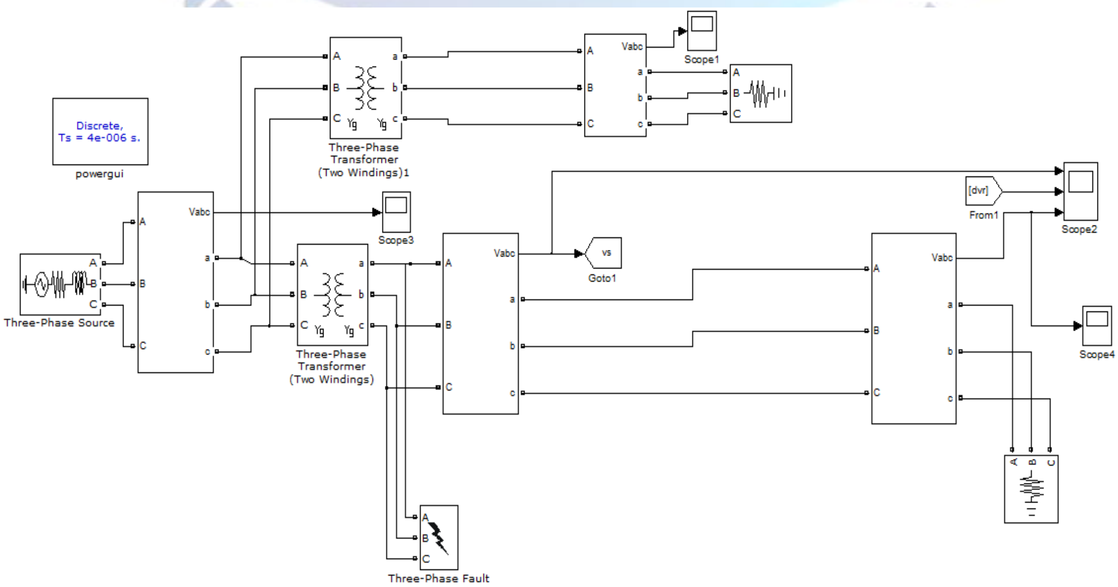

Fig 2.simulink model of uncompensated lines with inductive load

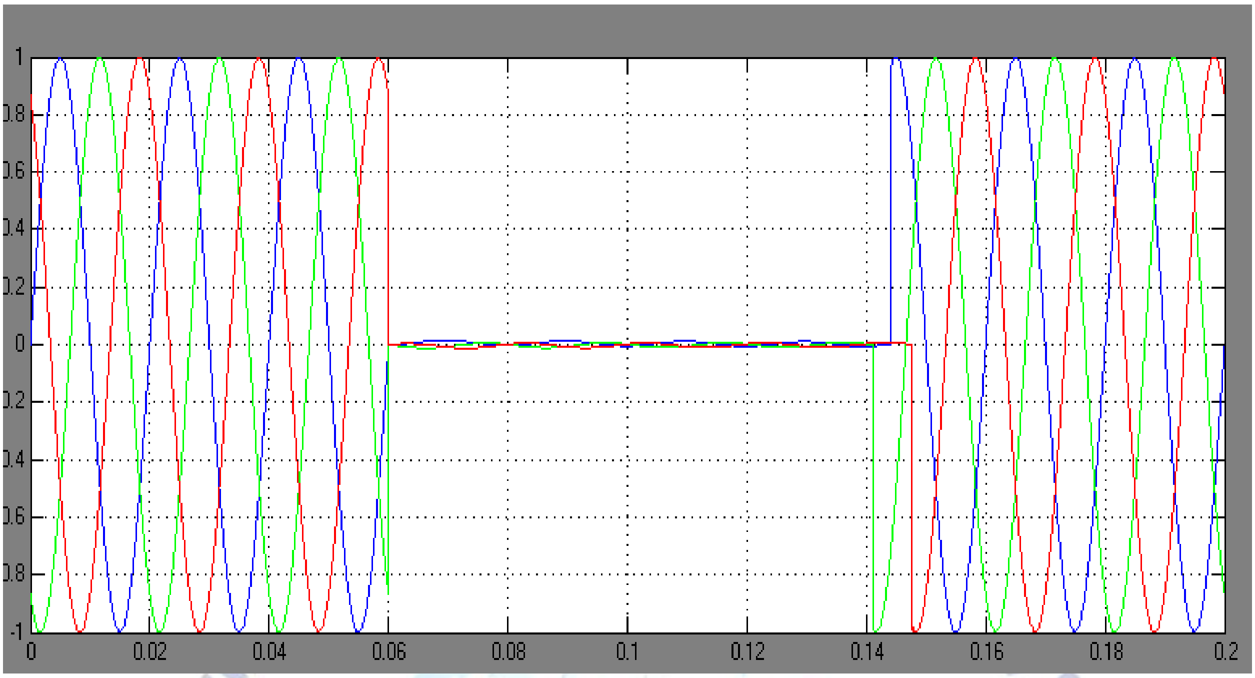

Fig 3.Load voltage with Inductive load in the uncompensated line

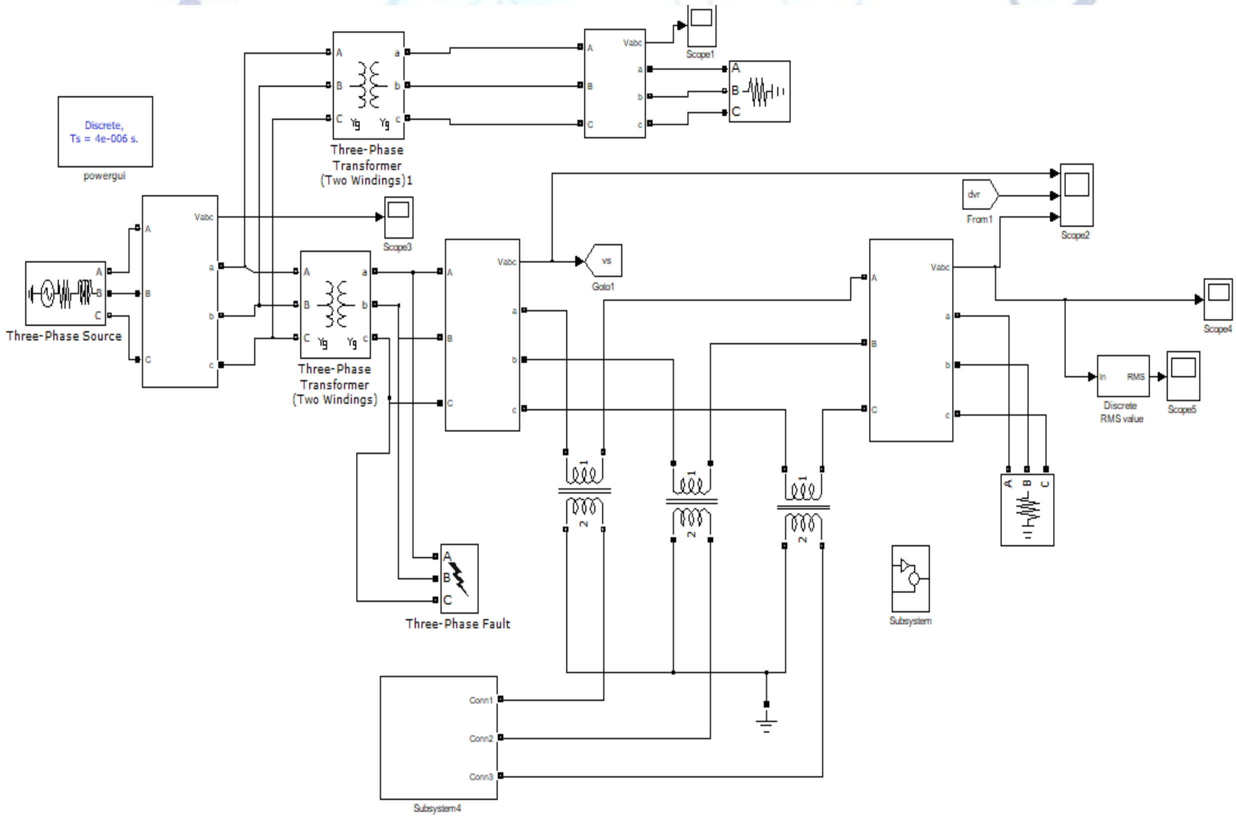

Fig 4.Simulink model of compensated line

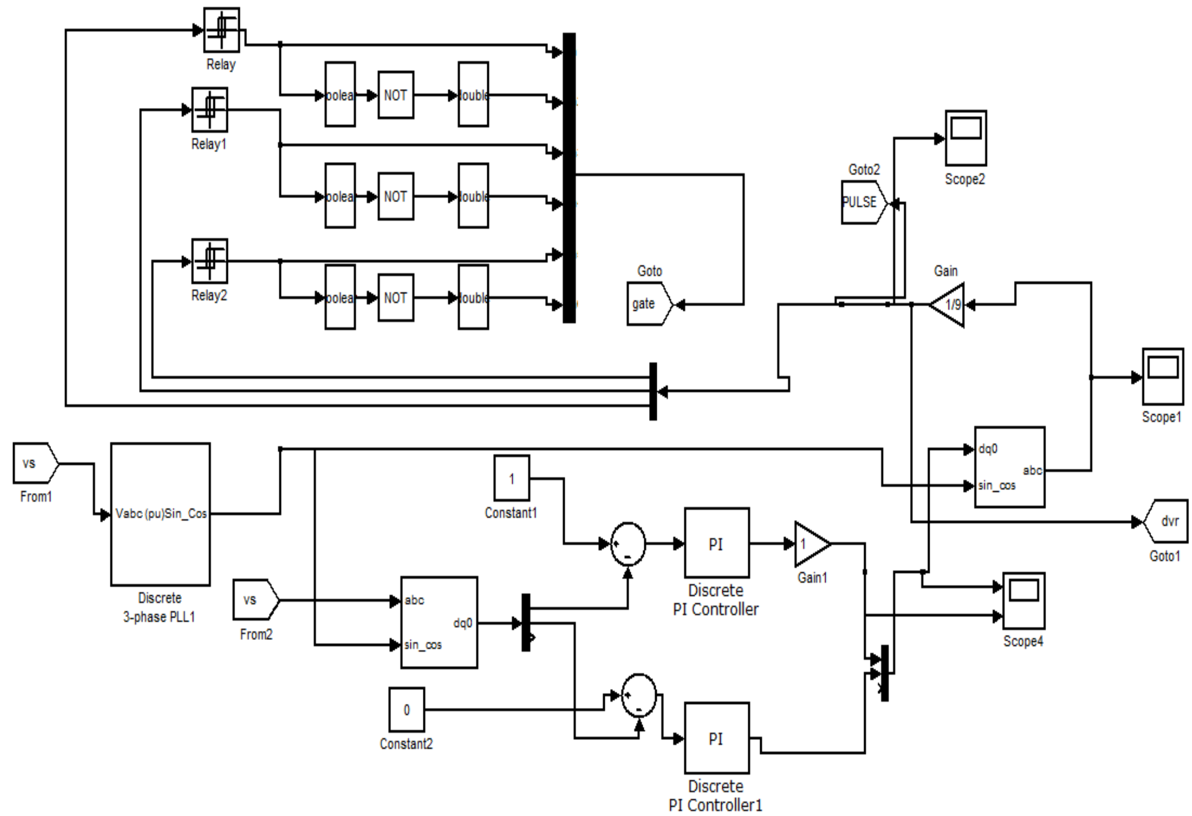

Fig 5 Hysteresis technique using PI controller

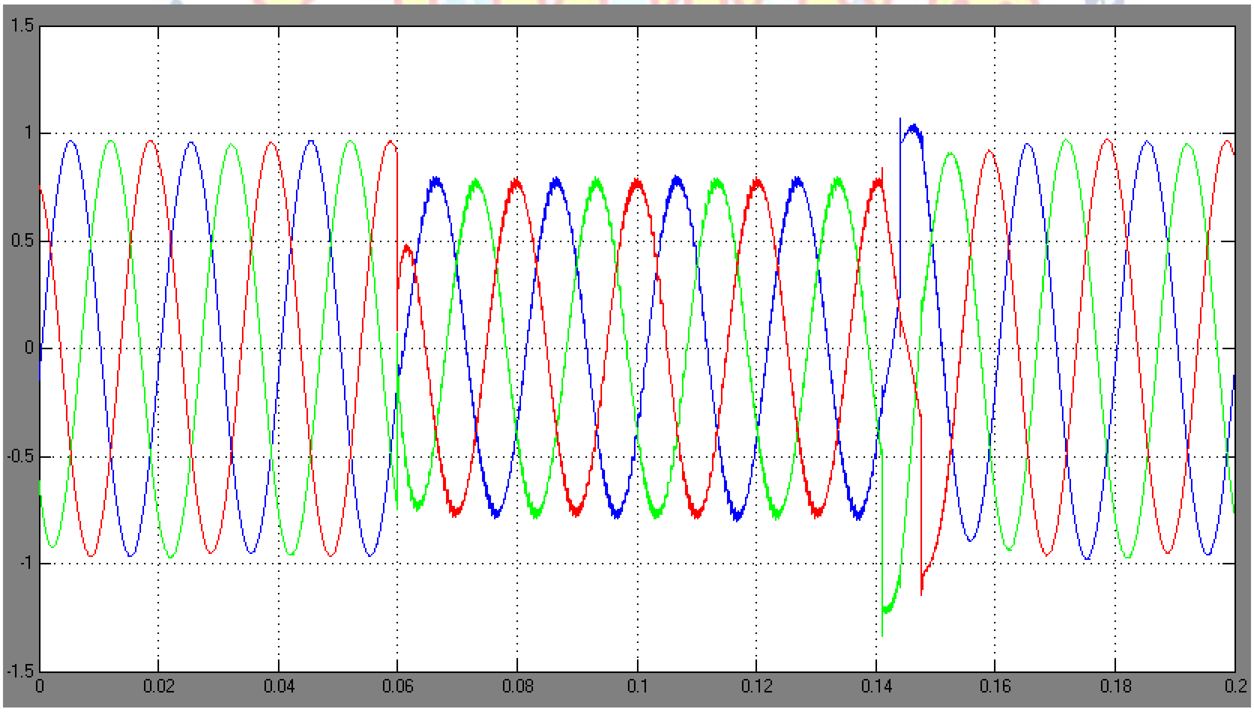

Fig 6 Compensating voltage using Hysteresis based PI controller

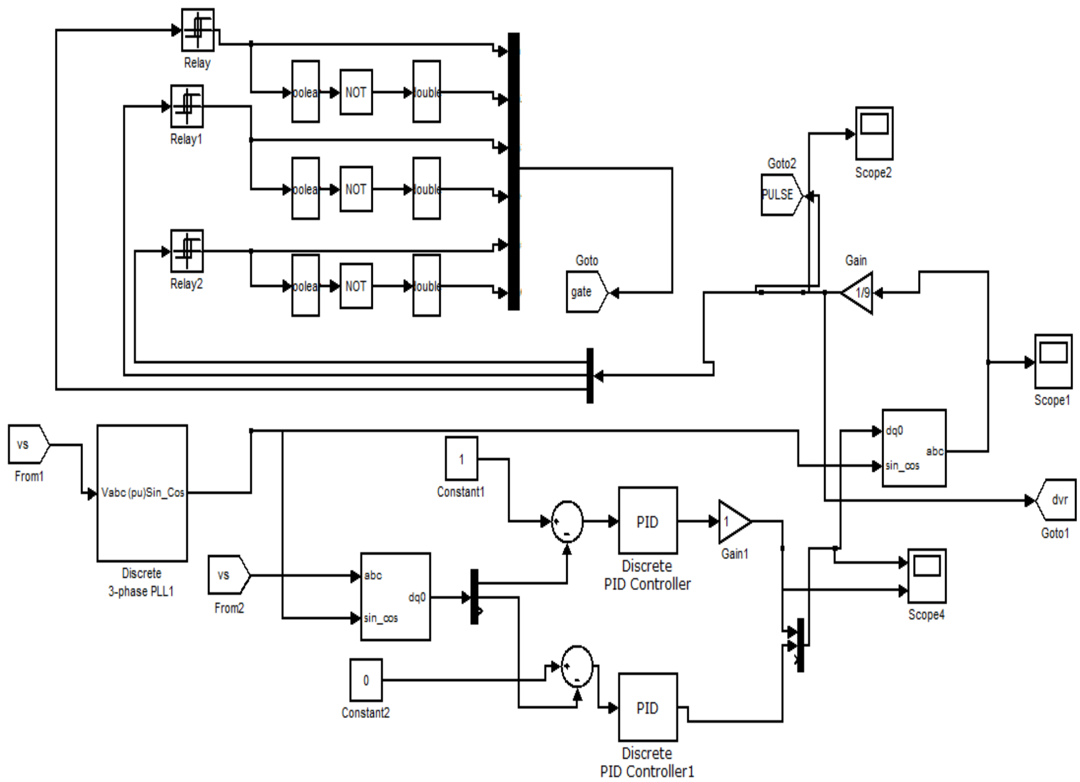

Fig 7 Hysteresis technique using PID controller

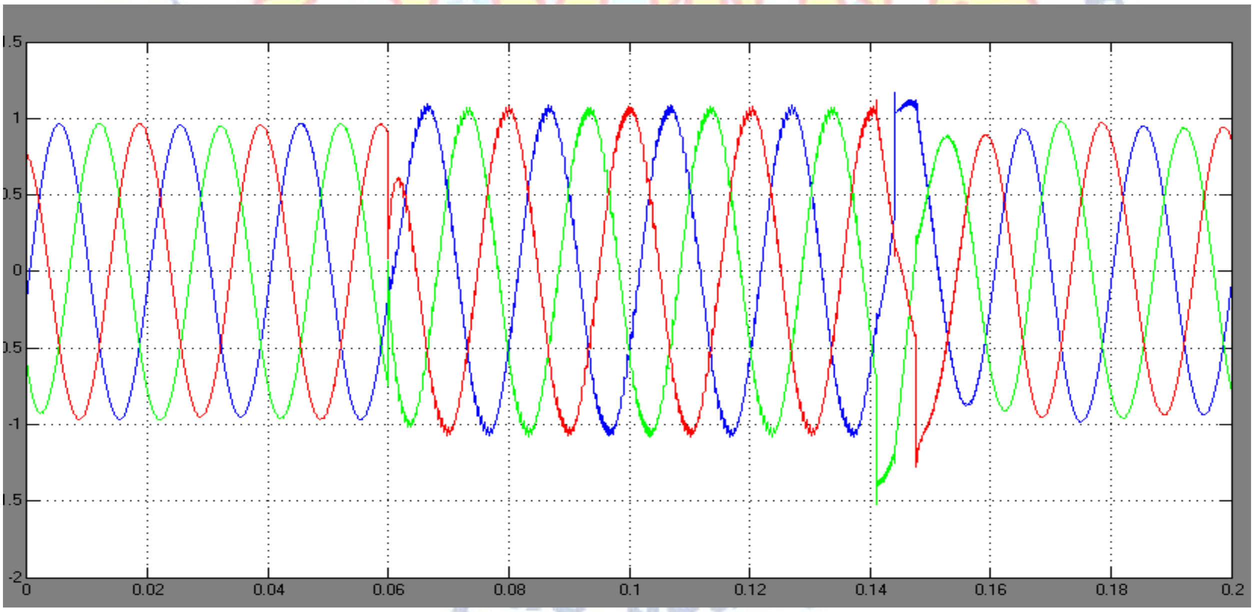

Fig 8 Compensating voltage using Hysteresis based PID controller

Table I

	Without compensation	Hysteresis with PI	Hysteresis with PID
Voltage Magnitude	Reduced to zero due to three phase fault	80% Compensated	100% Compensated

CONCLUSION

This paper presents the detailed modeling of one of the custom power products, DYNAMIC VOLTAGE RESTORER is presented using instantaneous P-Q theory, used for the control of DYNAMIC VOLTAGE RESTORER are discussed. These control algorithms are described with the help of simulation results under linear loads. The control scheme maintains the power balance at the PCC to regulate the dc capacitor voltages. PWM control scheme only requires voltage measurements. This characteristic makes it ideally suitable for low-voltage custom power applications. The control scheme was tested under a wide range of operating conditions, and it was observed to be very robust in every case. It is concluded that a DYNAMIC VOLTAGE RESTORER with Hysteresis based PID controllers will give better results.

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