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Power Quality Improvement Using Distribution Static Compensator

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***Abstract*-As the name implies, a distribution system is how electricity is distributed to end-users. Because distribution systems are less rigid than grid systems, a voltage drop caused by a rise in RL load might be disastrous for the whole system. As a result, DSTATCOM is an efficient solution for power systems encountering power quality issues.This research looks at one of the possible uses of the static distribution compensator (DSTATCOM) in industrial systems for reducing voltage sag. The presence of voltage sag may lead the system into an unstable state. Hence, it is necessary to mitigate the sag. SIMULINK of MATLAB software was used to create a model of DSTATCOM linked in a shunt configuration to a three-phase supply feeding RL loads. DSTATCOM might be deemed a credible solution for fixing voltage dip issues based on simulation findings. The goal of this thesis is to create a DSTATCOM for inductive and resistive circuits with slight voltage sag.**

***Keywords*: power quality issues, static distribution compensator, voltage sag**

1 INTRODUCTION

Voltage fall/dip at the load terminals is one of the most prevalent power quality issues today. A voltage dip is an occurrence that happens when the operating voltage is less than its actual rating as a result of the load using more reactive power than it is designed to. Voltage drops will impact the operation of sensitive loads, resulting in a reduction in system performance. Voltage dip is a three-phase phenomenon that occurs naturally in a three-phase system and affects both the phase-to-ground and phase-to-phase voltages in the system. A voltage dip may also be caused by a problem in the utility system, a malfunction inside the customer's facility, or a significant rise in the load current, such as when a motor is turned on or when a transformer is turned on.

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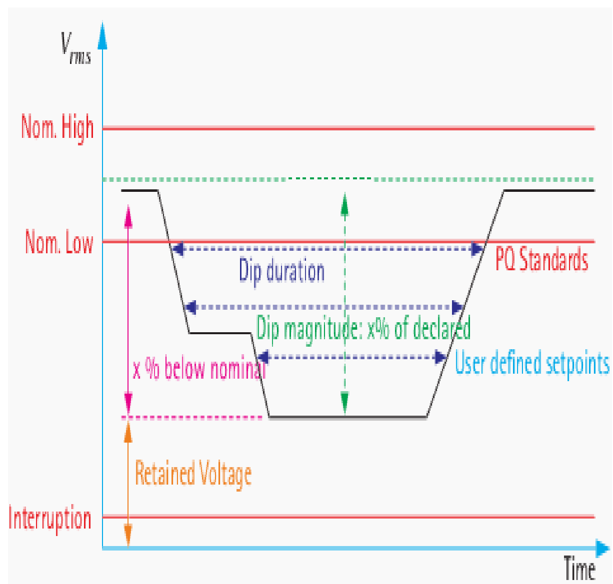

FIGURE 1 Voltage dip and its impact.

Increasing the reliability of electrical power is the driving force behind today's contemporary industry. In the recent decade, there has been significant growth in consumer awareness of the need for a stable power supply. As a result, the development of tiny distributed generating systems has received an extra boost (DG). A small number of isolated DG sets have the potential of supplying local loads, which results in an increase in the dependability of electricity while requiring an item of minimal initial capital expenditure. These systems are also becoming more important in remote places where transmission through overhead conductors or cables is impractical or prohibitive owing to excessive costs or other factors such as a lack of available land. Even in developing nations, small generating systems in rural regions, islands, steep terrains, offshore plants, aircraft, and other similar locations may be used efficiently and effectively.

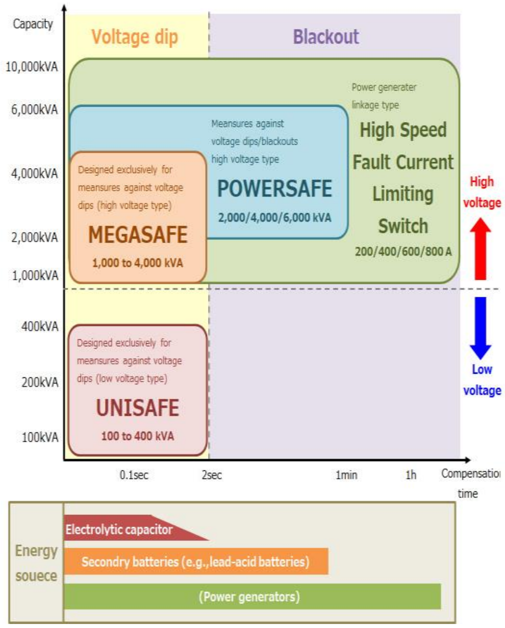

FIGURE 2 Effect of voltage fall.

These DG sets, on the other hand, may have to be de-rated if several induction motor loads are started at the same time. One option is to employ DSTATCOM in a shunt arrangement with the primary system, which allows the whole capacity of the producing sets to be used effectively.
DSTATCOM is comprised of a voltage source converter (VSC), which creates the capacitive and inductive reactive power needed by the system on an internal basis. This device's control response time is very rapid, and it has the potential of providing enough reactive power compensation to the system to which it is attached when necessary.
The use of Thyristor-based systems for reactive power compensation and voltage flicker reduction owing to arc furnace loads was suggested beforebefore the development of DSTATCOM systems.
However, because of the shortcomings of passive devices, such as fixed compensation, big size, the likelihood of resonance, and so on, the use of innovative compensators, such as DSTATCOM, to tackle these power quality concerns is becoming more widespread.
It has been recommended that DSTATCOM solve power quality issues caused by voltage fall/dip, flickers, swell, and other factors. When used in conjunction with DSTATCOM, it is intended to offer effective voltage control at the point of common coupling (PCC) and thereby avoid major voltage dips from occurring.

A. Voltage Sag

Voltage sag is an occurrence that happens when the operational voltage is less than its actual rating as a result of the load using more reactive power than it is designed to. This will have an impact on the operation of sensitive loads, resulting in a decrease in system performance. Low voltage profiles, high reactive power fluxes, insufficient reactive support, and severely loaded systems are the most common signs of voltage sag, according to the IEEE. The fall is often triggered by a single or a series of events with a low likelihood of occurring. The repercussions of a system failure may need a lengthy restoration phase, during which huge groups of consumers are left lacking supply for protracted periods of time. Schemes that mitigate against sag must rely on symptoms to detect the impending collapse and take remedial action before the collapse occurs.

II Power Quality

If the customer gets rated voltage and rated frequency without any disturbances, it is termed quality power. There are many reasons for the reduction of power quality in power systems. The following figure shows the various power quality issues.

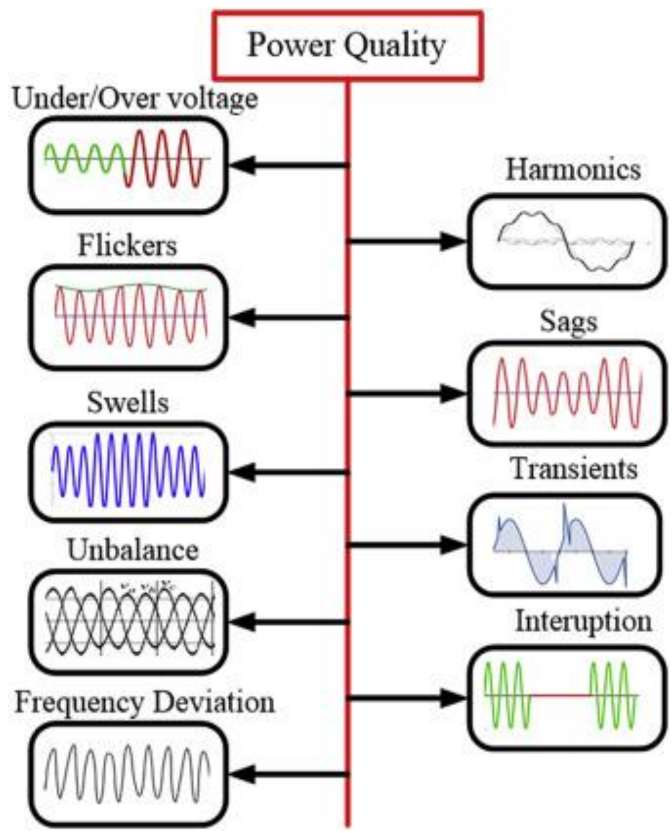

FIGURE 3 Power quality Issues.

The above figures show various power quality issues associated with the power system operation. Out of all the issues in the present work, the emphasis is shown on voltage sag-related issues.

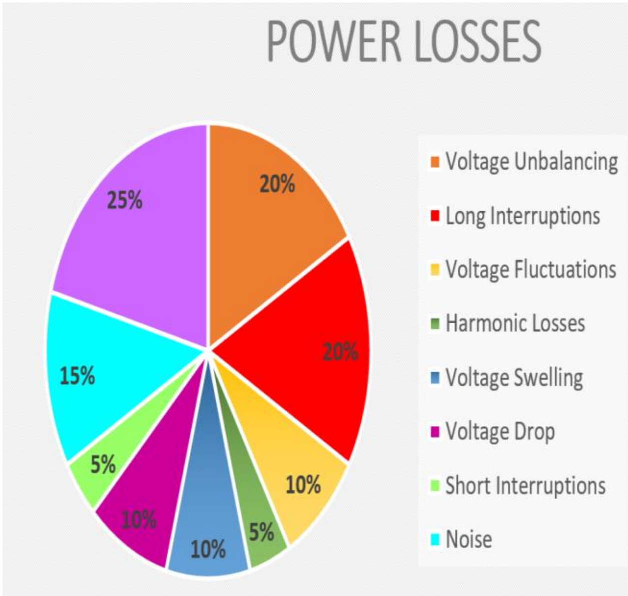

FIGURE 4 Probability of occurrence of various PQ issues.

The above figure shows the probability of various power quality issues occurrences. Voltage-related issues occupy more than 50 percent of the overall issues in power system operation.

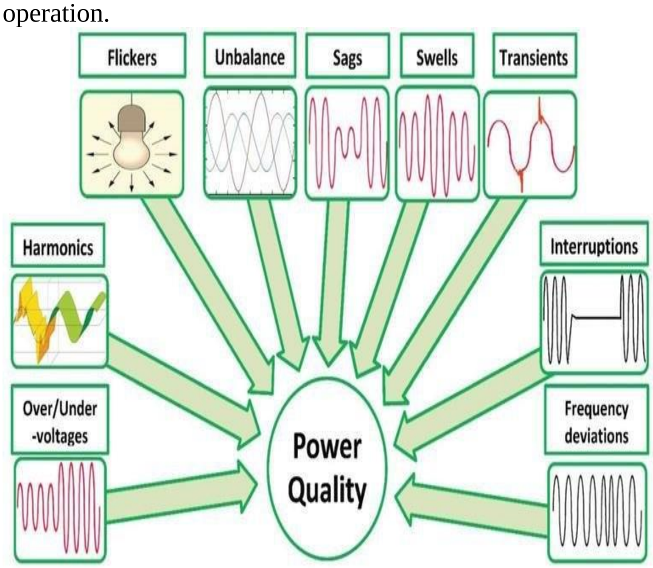

FIGURE 5 PQ events.

A. Voltage Sag/Swell

This phenomenon indicates the sudden fall or rise of the voltage waveform. This leads to the increase or decrease of the voltage magnitude than the rated voltage of the system at any point in the power system.

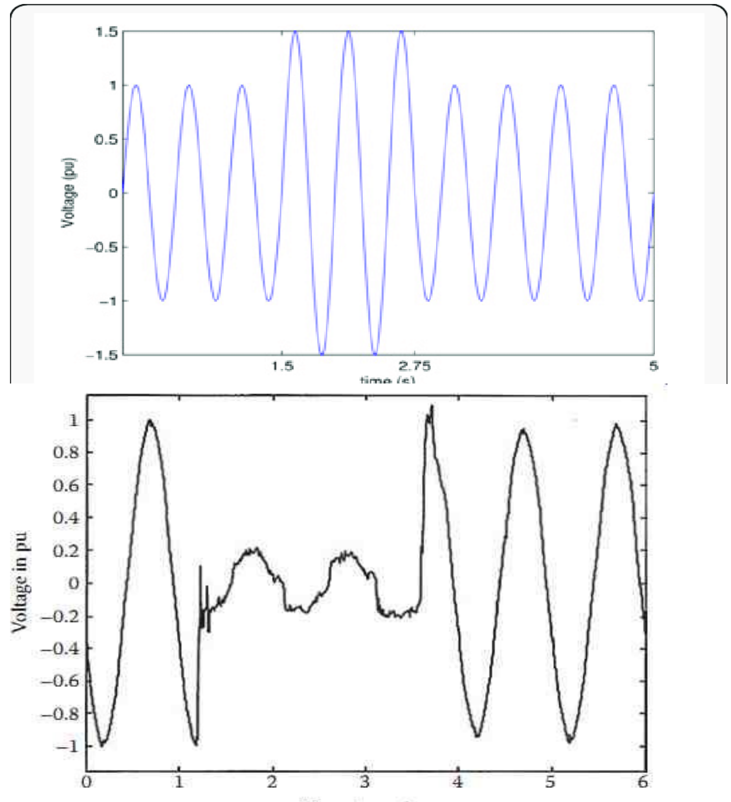

FIGURE 6 Voltage sags and swells.

B. Over voltage

It is the phenomenon of the sudden rise of the voltage magnitude to the very high values. This may lead to the failure of the insulation and may lead to the occurrences of the fault in power system.

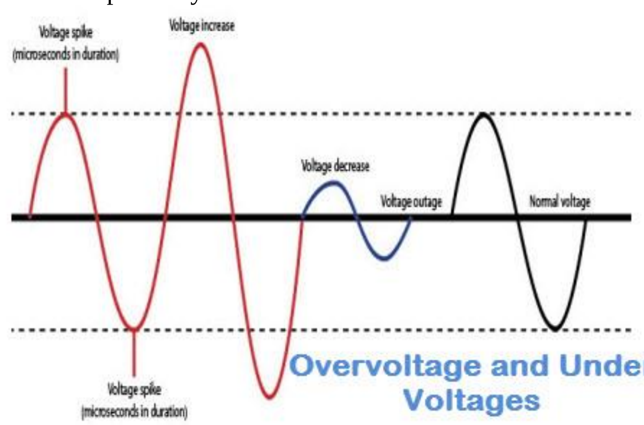

FIGURE 7 Over/Under voltage.

C. Voltage Flicker

Is is the phenomenon associated with the voltage waveform. During this there will be lot of fluctuations in voltage waveform in very short duration of time.

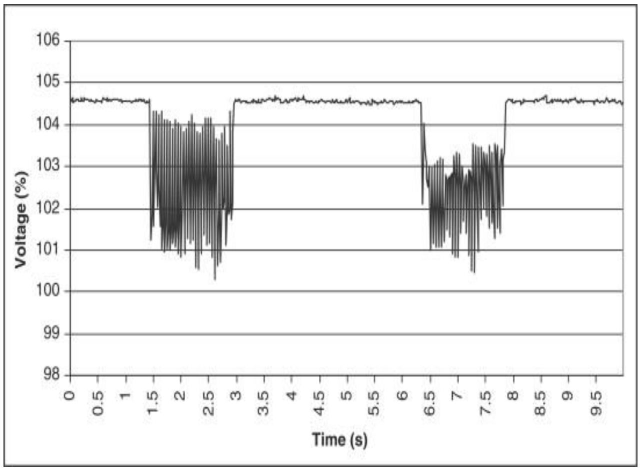

FIGURE 8 Voltage Flicker.

D. Harmonics

Presence of harmonics either in voltage or current waveform leads to the reduction of its quality. Harmonics are nothing but the integer multiples of the system operating frequency.

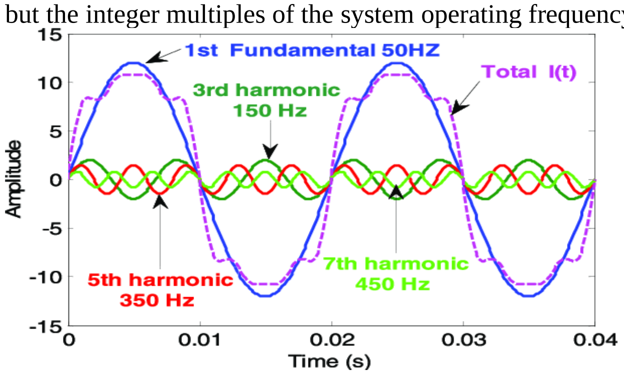

FIGURE 9 Current harmonics.

E. Transients

Transient is nothing but the sudden change in the variable. It can be a current or voltage. This may change with respect to the magnitude or the phase of the variable.

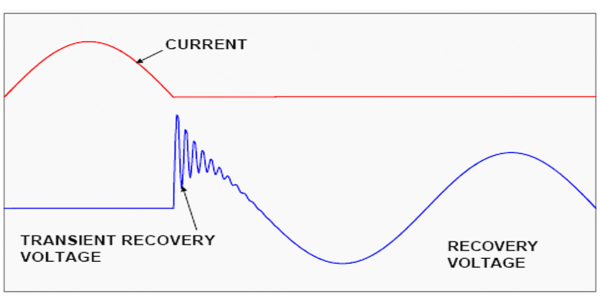

FIGURE 10 Current transient.

F. Interruptions

Interruptions of two types. Either it will be a short interruption or it is a long interruption.

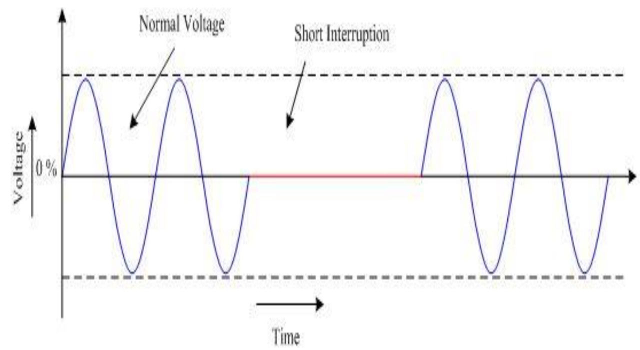

FIGURE 2 Short interruptions.

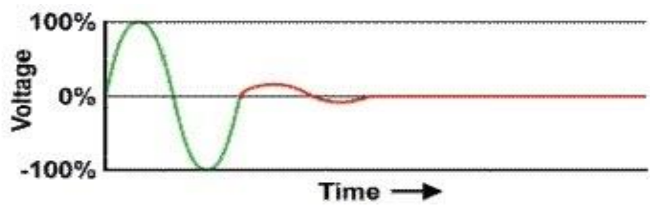

FIGURE 11 Long Interruption.

G. Power frequency variation

If the system frequency is varied, it may lead to the irregular operation of the various loads that are connected in the system. However, the major loads in the system are motors. Hence, the performance of the motors will be affected with the power frequency variations. Following figure shows the effect of power frequency variation.

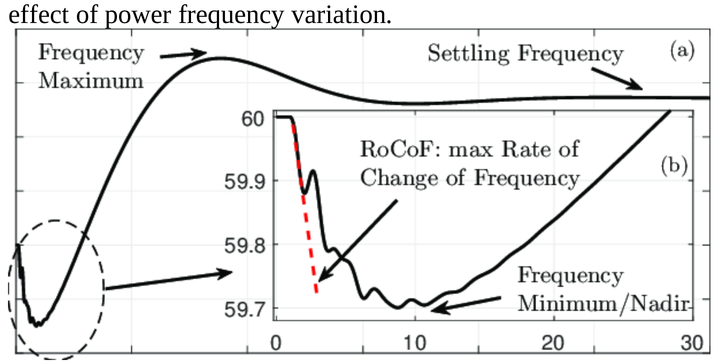

FIGURE 12 Power frequency variation.

III REACTIVE POWER COMPENSATION

We have three types of power in ac circuits. The active power, which is also called real power, which is useful to the loads. The reactive power, which is actually not used by the loads, but it is used for the compensation.

The last one is the apparent power, which is the resultant of the active and reactive powers.

The reactive power can be used for the compensation of the power system. Which means the disturbances that occur in the power system can be adjusted by using the reactive power that is available in the lines.

To implement the reactive power compensation, the devices that produce the reactive power are necessary. Following are the devices that operate with the reactive power geeration.

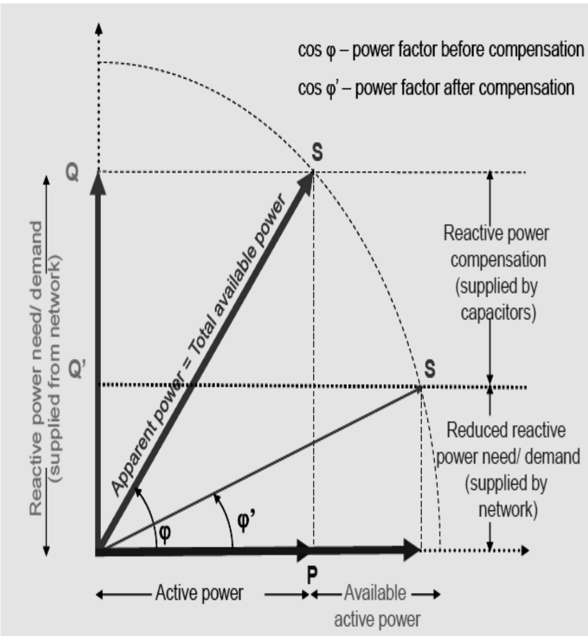

FIGURE 13 Reactive power compensation curve.

- Capacitor or bank of capacitor.
- Series compensator
- STATCOMs
    - FC
    - TCR
    - TSC
    - TCSC

IV DSTATCOM

A DSTATCOM is a

- Shunt connected compensating device.
- It is used to correct the disturbances in voltages.
- These circuits are very useful for the adjustment of voltage sags and swells.

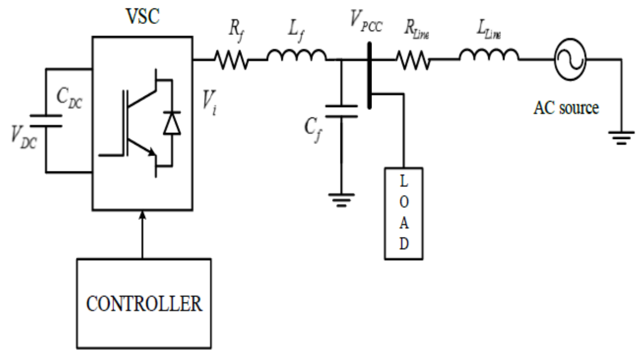

FIGURE 14 Distribution STATCOM circuit.

It consists of

- A DC voltage source
- A reference
- Converter circuit
- Controller circuit
- Reference voltage sensor arrangement
- Feedback arrangement.

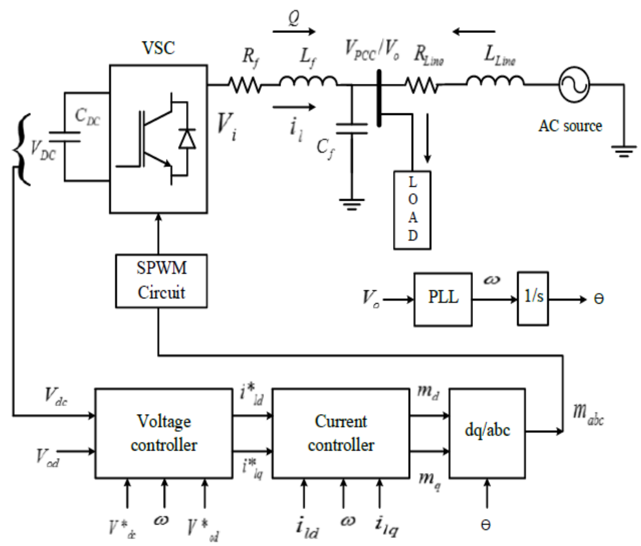

FIGURE 15 Controller circuit of DSTATCOM.

The controller circuit consists of

- Voltage controller
- Current controller
- PWM circuit
- Abc/dq transformation
- PI controller block.

V SIMULATION RESULTS

A. Specifications of DSTATCOM

In this work, the single phase mode of the operation is considered. Following are the specifications used for DSTATCOM in the present simulations.

- A fault occur at 0.015s to 0.27s, during this the voltage sag occurs
- A fault occur at 0.37s to 0.43s, during this the voltage swell occurs
- The supply voltage is 230 V rms.
- Inductive load is used in the simulation
- The step size used in the simulation is 1e-5.

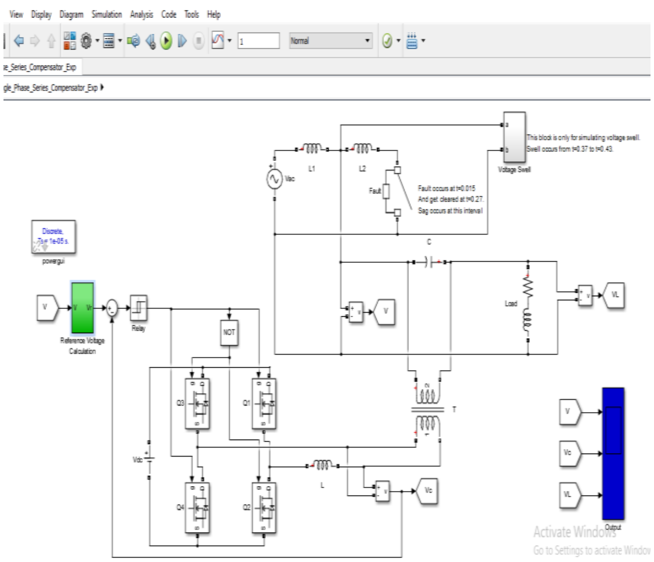

FIGURE 16 DSTATCOM simulation in SIMULINK.

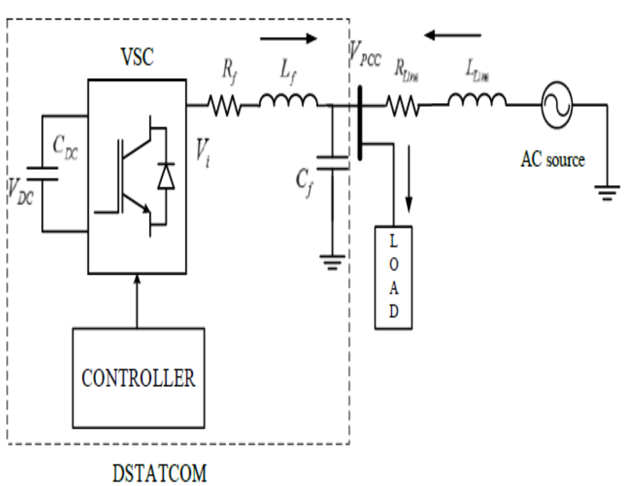

FIGURE 17 DSTATCOM Model.

B. Output waves for voltage Sag

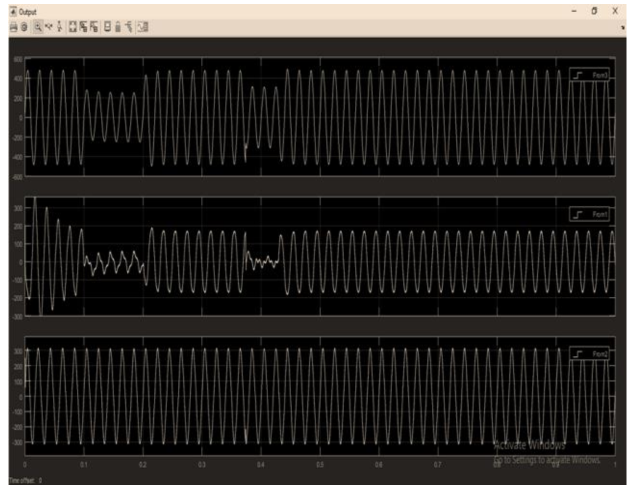

FIGURE 18 Voltage sag

C. Output waves-Only Swell

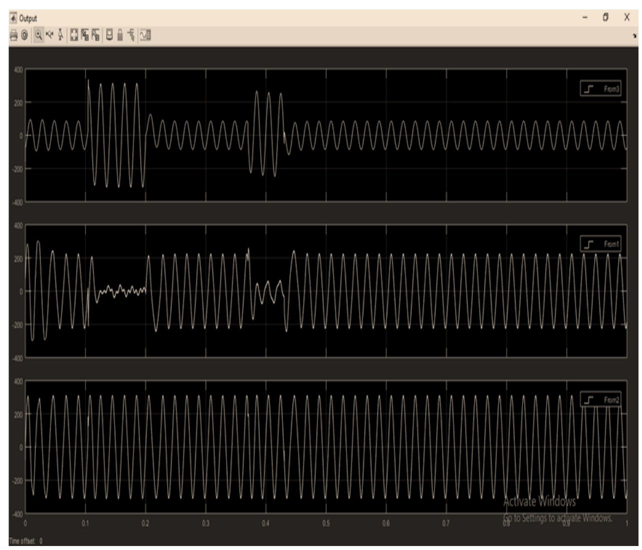

FIGURE 19 Voltage swells using DSTATCOM.

CONCLUSION

Consumers may be assured of voltage magnitudes that are near to their nominal values by using DSTATCOM. The methods of logarithmic and proportional integral (PI) control have been used to perform DC-link voltage control as well as AC side voltage control on the power grid. The findings demonstrate that both strategies are capable of achieving the control target. It is necessary to modify the control technique so that it is effective even while dealing with unequal and quasi loads.

FUTURE SCOPE

Following aspects are left as future scope of this project.
A multilevel inverter can be employed in place of conventional voltage source converter.
Advanced control schemes can be implemented with DSTATCOM.

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