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MITIGATION OF POWER QUALITY ISSUES IN DISTRIBUTION SYSTEM USING D-STATCOM

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ABSTRACT:
The main aim of this paper to improve the power quality for Distribution System with D-STATCOM .Power quality is the combination of voltage quality and current quality. Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The electrical power quality is more concerned issue. The main problems are stationery and transient distortions in the line voltage such as harmonics, flicker, swells, sags and voltage asymmetries.

Recently, the Power electronics controllers are gaining concern to provide the quality of power for both power suppliers and consumers. Various power filtering technology i.e. passive filters, active power filters, hybrid filters have applied from time to time for giving the solution of power quality problems to users, But could not fully satisfied them**.** The proposed D-STATCOM is modelled and simulated using MATLAB/SIMULINK software**.** Results are shown in the form of waveforms using MATLAB. The simulation is performed in MATLAB in SIMULINK environment and PSB toolboxes have been used.

KEYWORDS:-D-STATCOM,MATLAB/ SIMULINK , VSC,The control of the Voltage Source Converter (VSC) is done with the help of SPWM

INTRODUCTION:

These days, electric force frameworks are under developing anxiety, more mind boggling to work, and more precarious with unscheduled/uncontrolled force streams and higher misfortunes. The explanation for is higher interest and less era and in addition imperatives on the development of new lines. Then again, various high-voltage power frameworks are working underneath their warm evaluations due to voltage and steadiness limits. Traditional electric force conveyance frameworks, by and large, are not intended to handle the control necessities of complex, profoundly interconnected force frameworks. This circumstance requires the audit of customary force conveyance strategies and rehearses and the formation of new ideas. These strides would permit the utilization of existing lines up to their full abilities without decrease in framework solidness and security. Another reason that is compelling the survey of ordinary force exchange strategies is the propensity of present day power frameworks to take after the changing worldwide economy. Driving pattern of deregulation of electrical force showcases because of the changing worldwide economy is empowering rivalry between utilities [1].

There are numerous sorts of Custom Power gadgets. Some of these gadgets incorporate Active Power Filters (APF), Surge Arresters (SA). Battery Energy Storage Systems (BESS), Super directing Magnetic Energy Systems (SMES), Static Electronic Tap Changers (SETC), Solid State Fault Current Limiter (SSFCL), Solid-State Transfer Switches (SSTS), Static VAR Compensator (SVC), Distribution Series Capacitors (DSC), Dynamic Voltage Restorer (DVR), Distribution Static synchronous Compensators (D-STATCOM) and Uninterruptible Power Supplies (UPS) , Unified force quality conditioner (UPQC). In any case, in this work, the principle center is kept just on D-STATCOM.A DVR is based on power electronic converter, placed in series with sensitive load to protect critical loads from all supply side disturbances. The DVR is a promising and effective device for power quality enhancement due to its quick response and high reliability [2-4].

A D-STATCOM is a shunt compensator, in light of force electronic converter. It is joined in shunt at PCC to shield basic burdens from all heap side aggravations. The DSTATCOM is a powerful gadget to diminish current varieties and music from the dispersion system. The brought together power quality conditioner (UPQC), made out of a force electronic arrangement primary unit introduced in the medium-voltage/low-voltage (LV) substation, alongside a few force electronic shunt units associated near to the end clients. The arrangement and parallel units don't have a typical dc join, so their control methods are autonomous of one another [5].

POWER QUALITY PROBLEMS:

Power quality is basically the collaboration of electrical force with electrical hardware. In the event that electrical gear works accurately and dependably without being harmed or focused on, we would say that the electrical force is of good quality. Then again, if the electrical gear glitches, is inconsistent, or is harmed amid ordinary goes astray from the perfect it is hard for the other to be perfect. Voltage quality is concerned with deviations of the voltage from the perfect. The perfect voltage is a solitary recurrence sine wave of steady recurrence and consistent extent. The term voltage quality can be deciphered as the nature of the item conveyed by the utility to

Utilization, we would suspect that the force quality is poor. The best measure of force quality is the capacity of electrical gear to work in an acceptable way, given legitimate consideration and upkeep and without antagonistically influencing the operation of other electrical hardware joined with the framework [6].

THREE KEY ASPECTS OF POWER QUALITY:

"Power Quality" is an expansive term used to depict the estimation of electrical force execution. It can be separated into three key territories. Every will be talked about in the accompanying beneath[7]

• Power Factor • Harmonics • Disturbances.

DISTRIBUTION STATIC COMPENSATOR (D-STATCOM):

Distributed static compensator is a parallel voltage controller, which is schematically depicted in figure consists of a filter, VSC, a direct current energy storage gadget, a coupling transformer connected inshunt to the distribution network through a coupling transformer. The voltage source converters the direct current voltage across the storage device into a set of 3-phase ac output voltages. These voltages are in phase and coupled with the alternating current system through the reactance of the coupling transformer.

A voltage-sourced converter with PWM provides a faster control that is required for flicker mitigation purpose. A PWM operated VSC utilizing IGBTs and connected in shunt is normally referred to as "STATCOM".

A shunt-connected synchronous machine has some similarities with the STATCOM, but does not contain power electronics. The capability of the synchronous machine to supply large reactive currents enables this system to lift the voltage by 60% for at least 6 s [8].

D-STATCOM has the same structure as that of an STATCOM. It can be used in the context of FACTS at the transmission level, custom power controllers at the distribution level and in end users' electrical installations. A complicated configuration of a voltage source controller based D-STATCOM is shown in Fig. The DSTATCOM has emerged as a promising CPD to provide not only for voltage sag mitigation but a host of other PQ solutions. Important applications of it include voltage regulation, load balancing, power factor correction, harmonic filtering, and flicker mitigation. In general, the functions of DSTATCOM are reactive power compensation, harmonic elimination, along with load balancing in the distribution system in PFC and ZVR modes of operation [9].

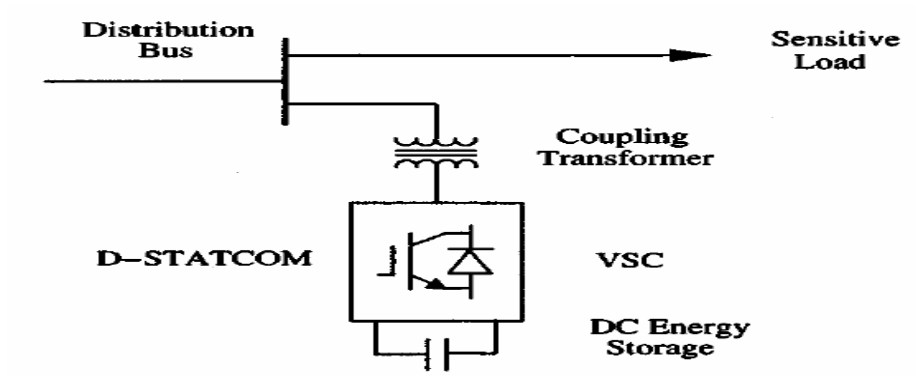


Fig 1. Schematic representation of the D-STATCOM as a custom power Device

BASIC PRINCIPLE AND OPERATION OF D-STATCOM:

A DSTATCOM is a controlled reactive source, which includes a VSC and a direct coupling link capacitor connected in parallel, capable of generating and absorbing reactive power. The principles of a DSTATCOM are based on the equivalence of the conventional rotating synchronous compensator.The alternating current terminals of the VSC are connected to the Point of Common Coupling through an inductance, which could be a filter inductance of the coupling transformer.

Fig. shows the diagram of a DSTATCOM connected to a 3 phase AC mains feeding 3 phase loads. 3 phase loads may be a lagging power factor load or an unbalanced load or mixed of these loads. For reducing ripple in compensating currents, interfacing inductors (Lf) are used at AC side of the voltage source converter A small series connected capacitor (Cf) and resistor (Rf) represent the ripple filter installed at PCC in parallel with the loads and the compensator to filter the high frequency switching noise of the voltage at PCC. The harmonics/reactive currents (iCabc) are injected by the DSTATCOM to cancel the harmonics /reactive power component of the load currents so that the source currents are harmonic free (reduction in harmonics) and load reactive power is also compensated. The rating of the switches is based on the voltage and current rating of the required compensation. For considered load of 35kVA, compensator data are given in Appendix, the rating of the VSC for reactive power compensation/harmonics elimination is found to be 25kVA (15% more reactive current from rated value) [8-10].

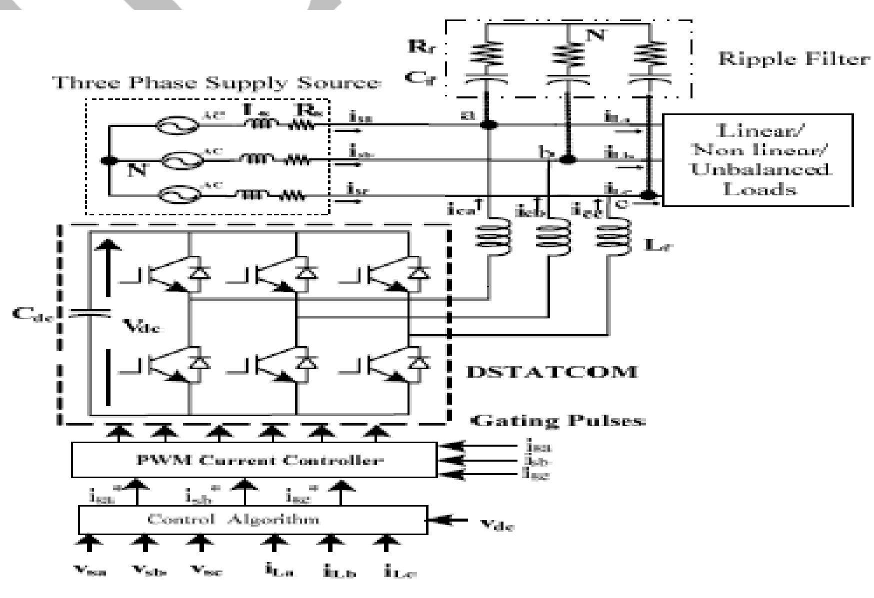


FIG 2. DSTATCOM connected to a 3 phase AC mains feeding 3 phase loads

METHODOLOGY:

SIMULINK MODEL OF D-STATCOM BASED ON SRF THEORY:

The extraction of real fundamental current component of load current by SRF theory and the performance of the DSTATCOM is controlled by SRF theory is presented in Fig. The simulation is carried out for similar load changes and unbalanced conditions. The effect of delay due to LPF used for filtering signals in d-q frame can be seen in extracted reference currents waveform in Fig. The generation of voltage templates (sine and cosine) plays an important role in calculation of reference source currents. These templates are generated using PLL and therefore the tuning of PLL is crucial. The operation of PLL slows and it also imposes some amount of delay in computation.

The D-STATCOM consists of the following components:

1. A 25kV/1.25kV coupling transformer which ensures coupling between the PWM inverter and the network.
2. A voltage-sourced PWM inverter consisting of two IGBT bridges. This twin inverter configuration produces fewer harmonic than a single bridge, resulting in smaller filters and improved dynamic response. In this case, the inverter modulation frequency is 28*60=1.68 kHz so that the first harmonics will be around 3.36 kHz.
3. LC damped filters connected at the inverter output. Resistances connected in series with capacitors providea quality factor of 40 at 60 Hz.
4. A 10000-microfarad capacitor acting as a DC voltage source for the inverter
5. A voltage regulator that controls voltage at bus B3
6. A PWM pulse generator using a modulation frequency of 1.68 kHz
7. Anti-aliasing filters used for voltage and current acquisition.

MODEL PARAMETERS:

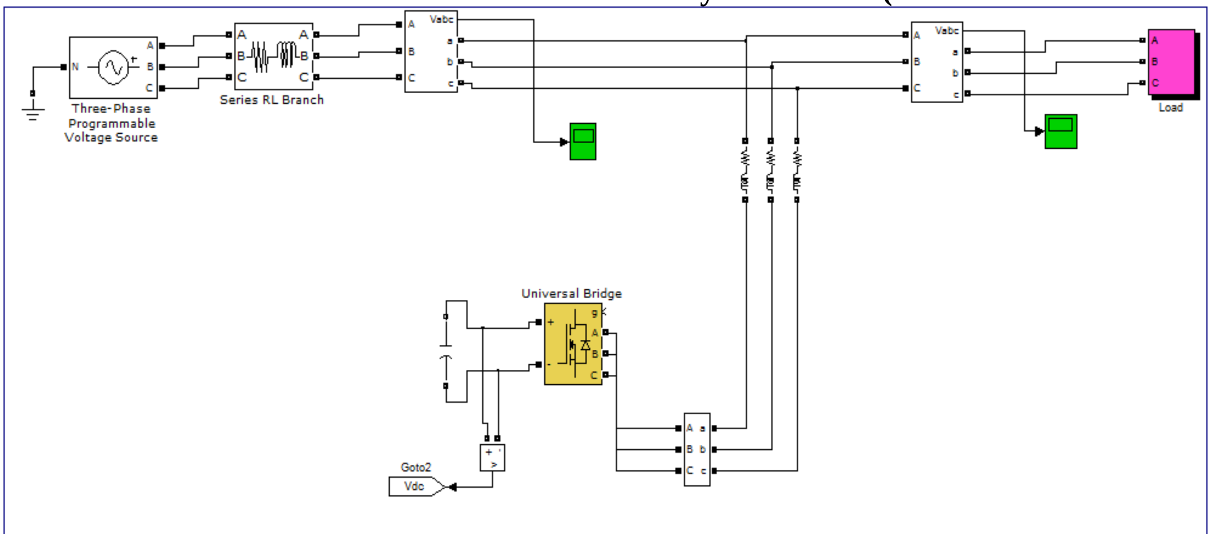
S.NO.	SYSTEM ELEMENTS	PARAMETERS
1	Source voltage	3-Phase, 25kv, 50Hz
2	Source Power	100MVA
3	Total Line Length	25Km
4	Coupling transformer	25kV/1.25kV
5	Modulation frequency	1.68 kHz
6	DC link voltage	2.4kV
7	PI Controller	Kp= 0.5,Ki =100

SIMULINK MODELS:

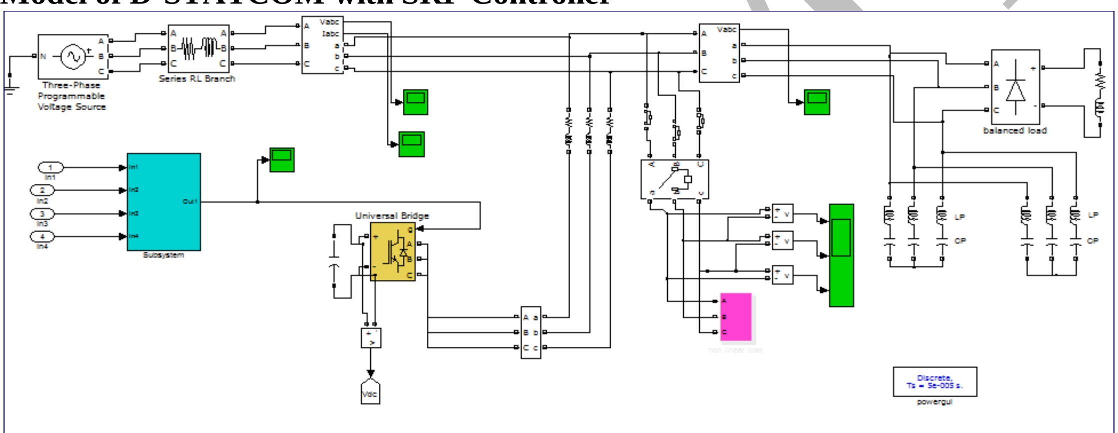
To enhance the performance of distribution system, D-STATCOM was connected to the distribution system. D-STATCOM was designed using MATLAB SIMULINK version R2009b.

Fig. shows the basic simulation model of the D-STATCOM system. The considered load is a combination of resistance and inductance connected in series for each phase. The load is star connected 32kVA at 0.8pf. The D-STATCOM model is simulated with SRF theory. Figs show the simulation models for theory. The model assembled using mathematical blocks of SIMULINK block set.

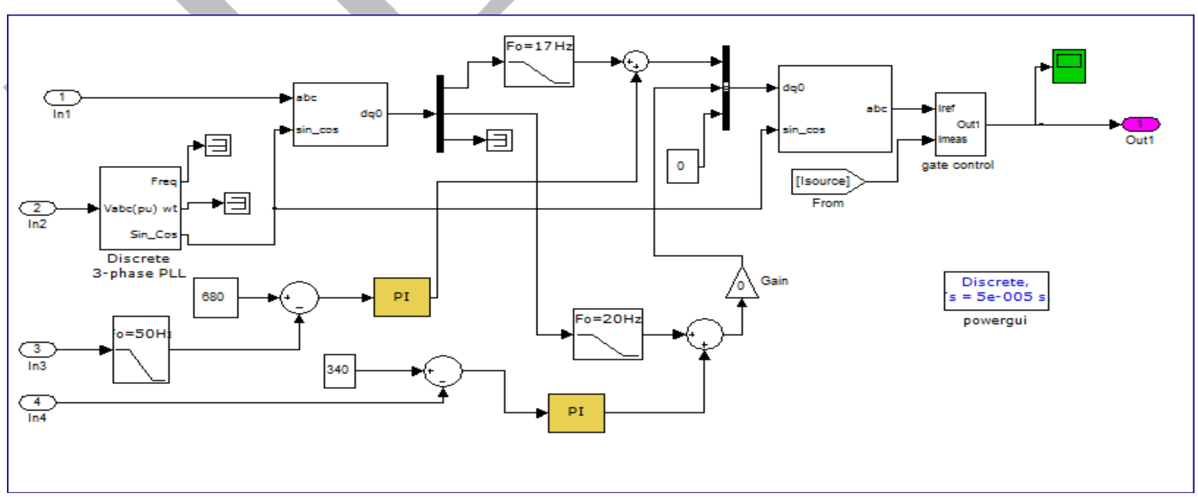
a) Model of Basic Power System (without D-STATCOM)



b) Model of D-STATCOM with SRF Controller



c) Subsystem of SRF Controller



SIMULATION RESULTS AND DISCUSSION:

The presented simulation results were obtained by using MATLAB/SIMULINK Power System Toolbox software. The load is taken as a three phase uncontrolled bridge rectifier feeding resistive load of 50Ω with line inductance of 0.7mH to reduce current spikes. The performance of DSTATCOM for PCC voltage regulation, harmonic elimination, neutral current compensation and load balancing, is shown in following graphs. It is observed that the amplitude of PCC voltage (VS) is regulated to the reference amplitude by the required reactive power compensation and that the source neutral current (ins) is maintained at nearly zero because of the zigzag transformer. The dc bus voltage of the capacitor (Vdc) of the VSC of DSTATCOM is regulated by the controller, and the dc voltage is maintained near the reference dc voltage under varying load disturbances. The total harmonic distortion (THD) of source current is observed to be less than 5%.

CONTROL OF DSTATCOM BY SRF THEORY:

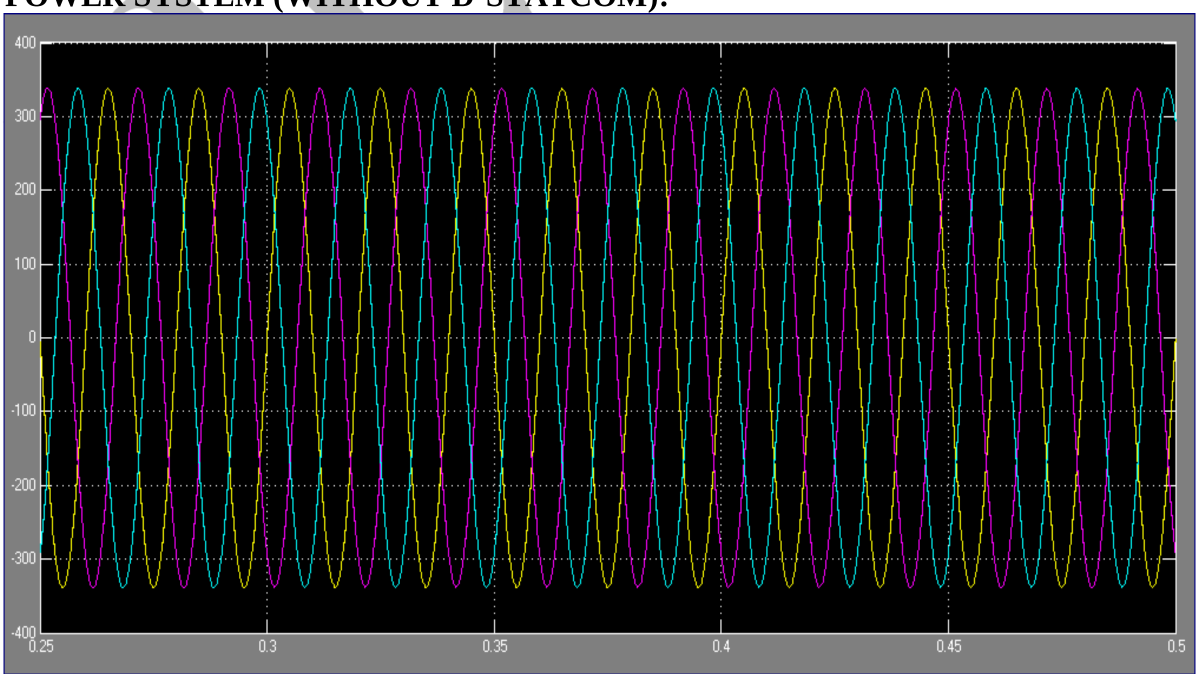
Fig. shows the extraction of real fundamental current component of load current by SRF theory and the performance of the DSTATCOM is controlled by SRF theory is presented in Fig. The simulation is carried out for similar load changes and unbalanced conditions as of previous case. The effect of delay due to LPF used for filtering signals in d-q frame can be seen in extracted reference currents waveform in Fig. The generation of voltage templates (sine and cosine) plays an important role in calculation of reference source currents. These templates are generated using PLL and therefore the tuning of PLL is crucial. The operation of PLL slows and it also imposes some amount of delay in computation.

CONTROL OF D-STATCOM BY IRPT ALGORITHM:

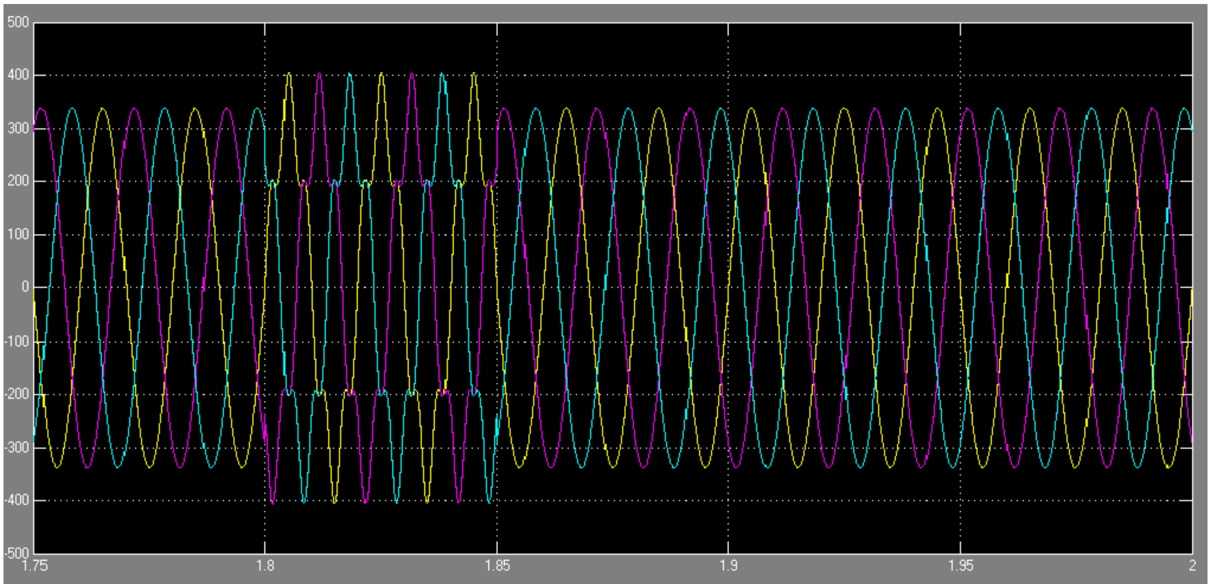
Fig. shows the dynamic performance of DSTATCO Musing the IRPT algorithm based current extractor under pure sinusoidal, asymmetric and distorted source voltage. Waveforms of extracted compensation current clearly shows that IRPT algorithm fails under asymmetric and distorted source voltage as extracted three phase compensation current of D-STATCOM is non-sinusoidal thereby will make the D-STATCOM source of disturbance itself. Since, IRPT algorithm uses voltage signals to compute instantaneous active and reactive powers.

WAVEFORM ANALYSIS:

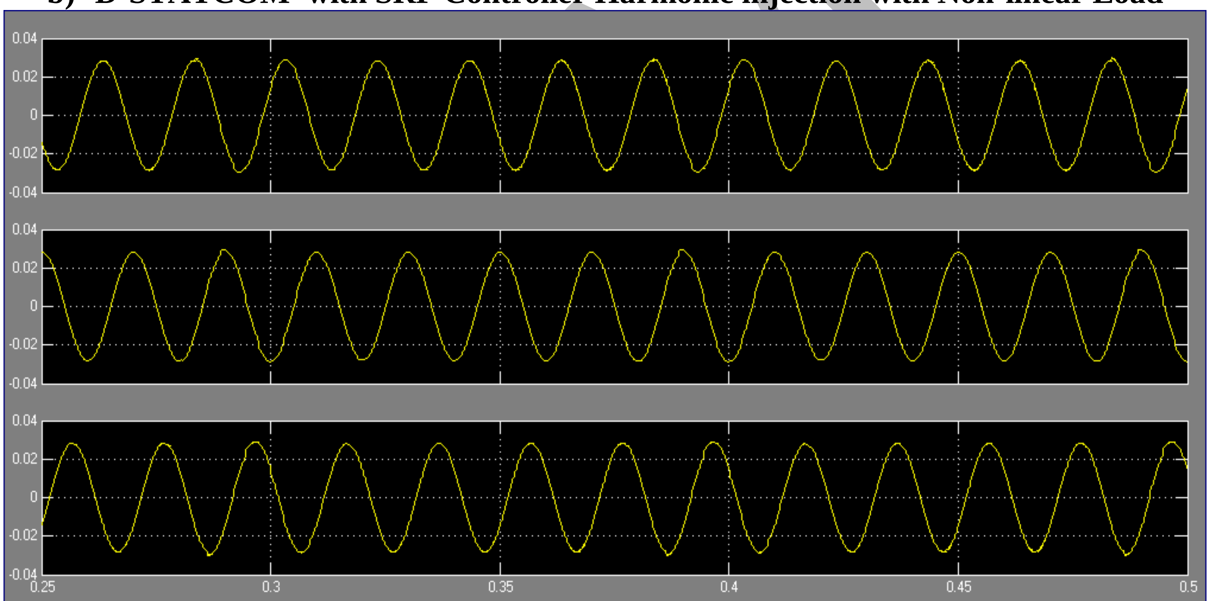
BASIC POWER SYSTEM (WITHOUT D-STATCOM):



a) Harmonic injection with Non-linear Load (without D STATCOM)



b) D-STATCOM with SRF Controller Harmonic injection with Non-linear Load



FUTURE SCOPE OF WORK:

The presented work can be extended in other following related areas:

1. Custom power devices can be tested against various loads.
2. By designing with the high Quality components and good controller the storage battery system can be integrated to the hybrid system to improve power quality which is not covered in this scope of project.
3. The major role play is that it can be supply constant power to varying loads, sag is reduced completely, and THD of the system is very less.
4. This scheme of implementation can be applied to various kinds of loads and systems in future.
5. The more advanced controllers such as fuzzy controller, artificial neutral network, AUPF, ISCT, AGCT, IGCT theories can also be used with D-STATCOM to make the system more effective.
6. Effectiveness D-STATCOM can be investigated by multi-level converters.

CONCLUSIONS:

In this research paper work has been done the power quality problems such as voltage sags, interruption, and voltage swell. The objective of work is to study the performance of D- STATCOM for mitigating voltage sag, interruption, and to improve the power quality in distribution network with non-linear load. The investigation is made on different condition for nonlinear load. In this work the investigation is composed of power system distribution system with and without D-STATCOM. Power factor comparison for source and load side. So it can be concluded that D-STATCOM effectively improves the power quality in distribution network with non-linear load.

The paper presents a comparative study on effectiveness of two approaches for determining D-STATCOM reference compensation currents. The mathematical derivation of the IRPT and SRF algorithm has been employed to demonstrate the behavior of D-STATCOM.

Simulation results show that DSTATCOM compensation strategies based on SRF algorithm is most effective in comparison with IRPT. This study can be extended to include more critical source voltage conditions for further evaluation of the effectiveness of these two compared compensation approaches. In this project "Power quality improvement in distribution system by using D-STATCOM with SRFcontroller is used instead of PI controller. Because of this advanced control we got best results compared to other controllers.

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