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Modeling and Simulation of DSTATCOM for Power Quality Enhancement in Distribution System

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ABSTRACT: This paper presents the systematic procedure of the modelling and simulation of a Distribution STATCOM (D-STATCOM) for power quality problems with unbalanced load a based on four different Pulse Width Modulation techniques. Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipment's. The major problems dealt here is the voltage, swell and with unbalanced loads. To solve this problem, custom power devices are used. One of those devices is the Distribution STATCOM (D-STATCOM), which is the most efficient and effective modern custom power device used in power distribution networks. D-STATCOM injects a current in to the system to correct the voltage sag, swell and unbalanced load. The control of the Voltage Source Converter (VSC) is done with the help of SPWM, SVPWM, sub-harmonic PWM and Triangular PWM. The proposed D-STATCOM is modelled and simulated using MATLAB/SIMULINK software.

KEYWORDS: Distribution STATCOM (DSTATCOM), MATLAB/ SIMULINK, Power quality problems.

I.POWER QUALITY PROBLEMS

The power disturbances occur on all electrical systems, the sensitivity of today's sophisticated electronic devices make them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause scrambled data, interrupted communications, a frozen mouse, system crashes and equipment failure etc [2]. A power voltage spike can damage valuable components. Power quality problems encompass a wide range of disturbances such as voltage sags, swells, flickers, harmonic distortion, impulse transients, and interruptions.

II.DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Fig.1, consists of a two-level Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power [7].

The D-STATCOM has been utilized mainly for regulation of voltage, correction of power factor and elimination of current harmonics. Such a device is employed to provide continuous voltage regulation using an indirectly controlled converter. In this paper, the D-STATCOM is used to regulate the voltage at the point of connection. The control is based on sinusoidal PWM and only requires the measurement of the rms voltage at the load point.

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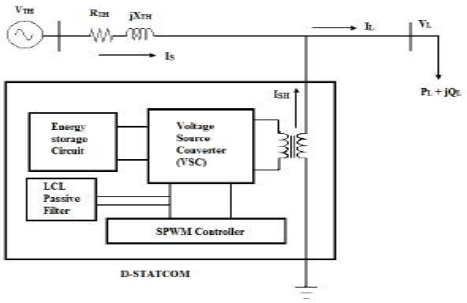

Fig.1.Schematic diagram of D-STATCOM.

The shunt injected current Ish can be written as,

$$I_{SH}=I_L-I_S$$

Where $I_S=\frac{V_{TH}-V_L}{Z_{TH}}$

Therefore

$$I_{SH}=I_L-I_S=I_L-\frac{V_{TH}-V_L}{Z_{TH}}$$

Or

$$I_{SH}\angle\eta = I_L\angle-\theta-\frac{V_{TH}}{Z_{TH}}\angle(\delta-\beta)+\frac{V_L}{Z_{TH}}\angle-\beta$$

The complex power injection of the D-STATCOM cab be expressed as

$$S_{SH}=V_L I_{SH}$$

It may be mentioned that the effectiveness of the D-STATCOM in correcting voltage sag depends on the value of ZTH or fault level of the load bus. When the shunt injected current ISH is kept in quadrature with VL, the desired voltage correction can be achieved without injecting any active power into the system. On the other hand, when the value of ISH is minimized, the same voltage correction can be achieved with minimum apparent power injection into the system.

III.METHODOLOGY

To enhance the performance of distribution system, D-STATCOM was connected to the distribution system. D-STATCOM was designed using MATLAB - SIMULINK version R2010b [6].
D-STATCOM Simulations and Results for THD Total harmonic distortion, or THD, is the summation of all harmonic components of the Voltage or current waveform compared against the fundamental component of the voltage or current wave:

IV.SIMULATION MODEL AND RESULTS

DSTATCOM for mitigating power quality problems like UPF, ZVR and load balancing in 3-phase 4-wire distribution network.4 leg inverter is used for the compensation purpose and .synchronous reference frame theory based controller is used for the control of DSTATCOM.

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a. Simulation model without DSTATCOM.

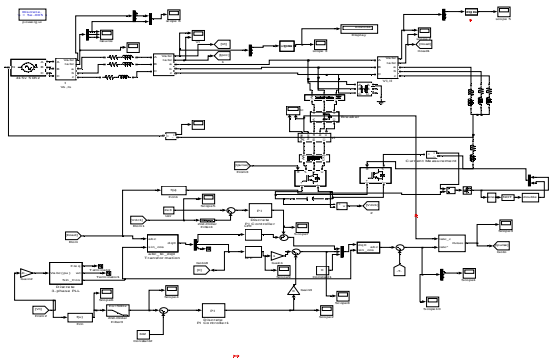

Fig.2. Simulation model of without DSTATCOM.

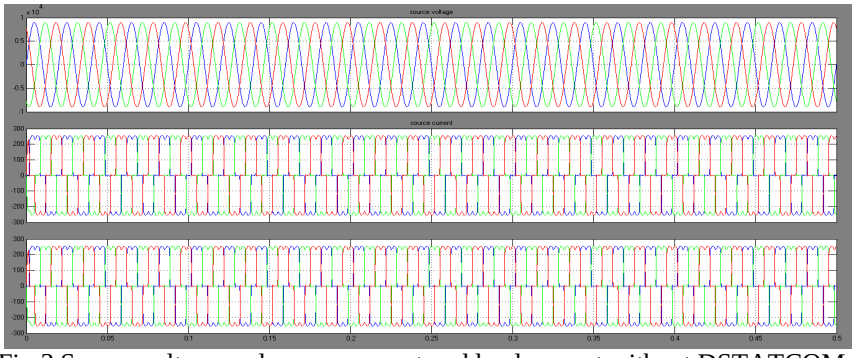

Fig.3.Source voltage and source current and load current without DSTATCOM.

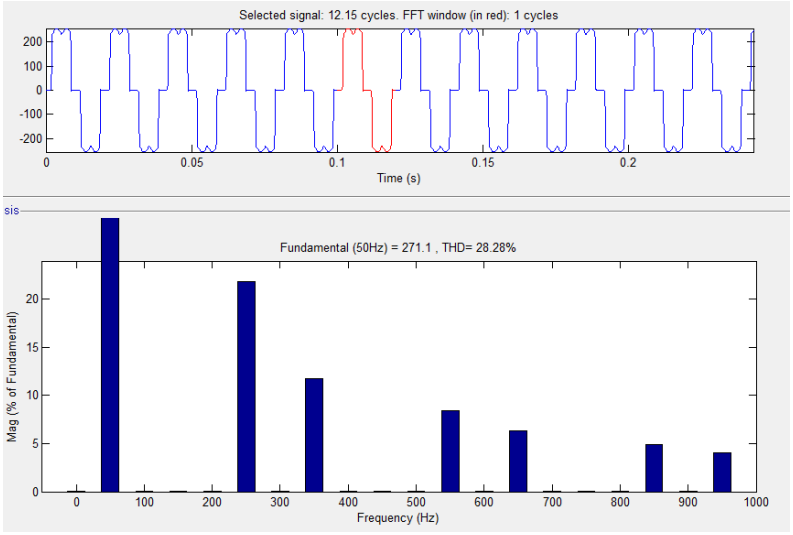

Fig.4.Total harmonic distortion for without DSTATCOM.

Fig.2.shows the Matlab/Simulation diagram of the without DSTATCOM,Fig.3.shows the sourec Voltage and current, load current.Fig.4. shows the source current THD for Without DSTATCOM.

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2. COMPARISON OF DIFFERENT PWM TECHNIQUES WITH DIFFERENT DISTURBANCES

b. Carrier based PWM simulation model:

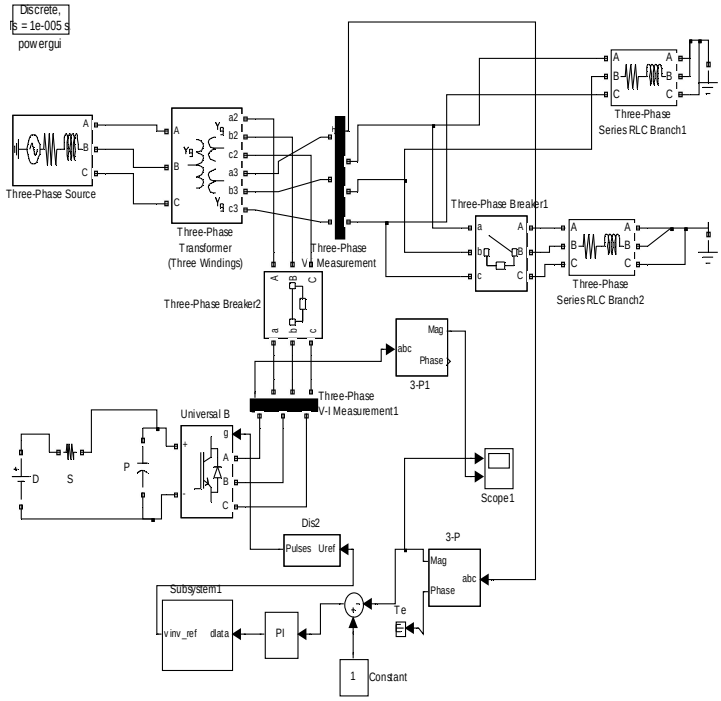

Fig.5.Simulation model of with DSTATCOM control of carrier based PWM.

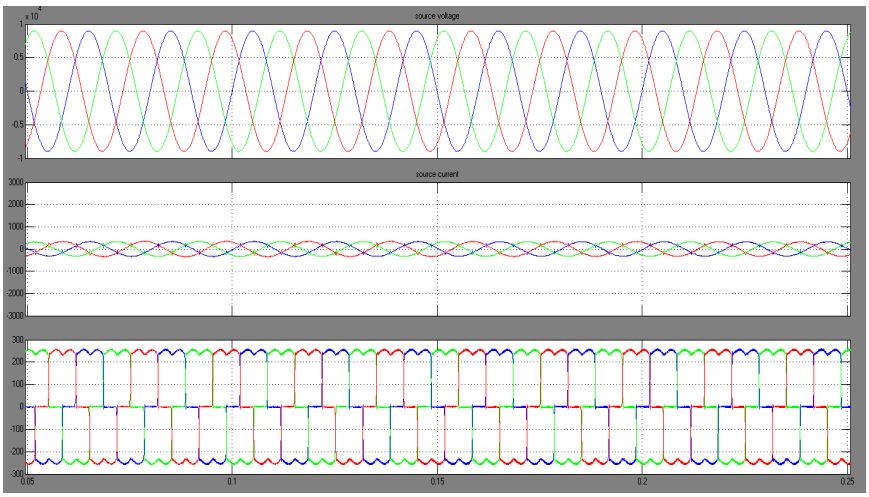

Fig.6.Source voltage and source current and load current with DSTATCOM.

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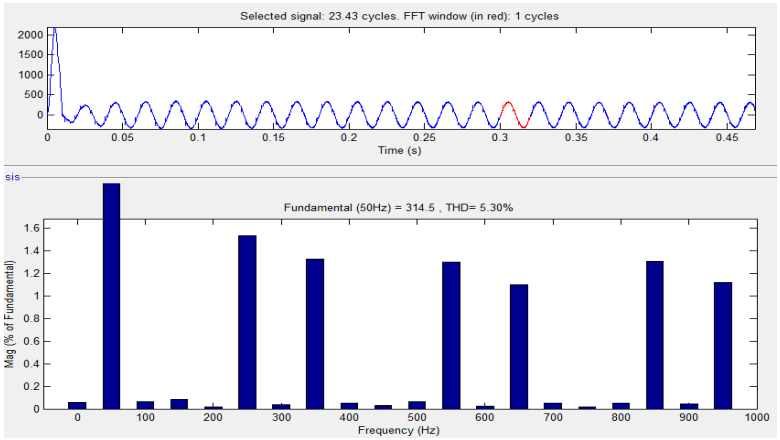

Fig.7. Total harmonic distortion for with DSTATCOM for carrire baseed PWM.

Fig.5.shows the Matlab/Simulation diagram of the with DSTATCOM,Fig.6.shows the sourec Voltage and current, load current.Fig.7. shows the source current THD for With DSTATCOM for carrire based PWM.

c. Sinusoidal PWM:

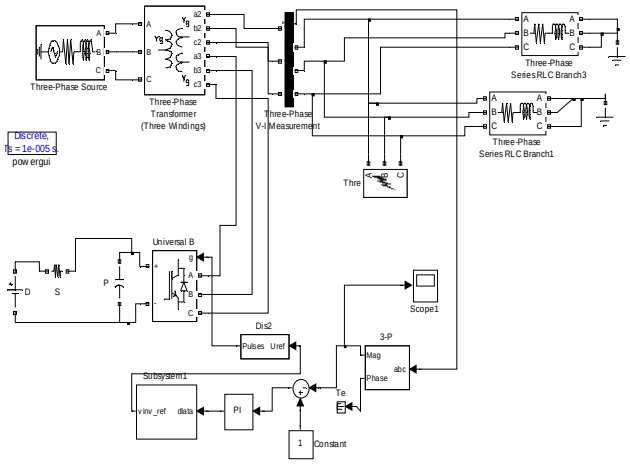

Fig.8. Simulation model of with DSTATCOM control of sinusoidal PWM.

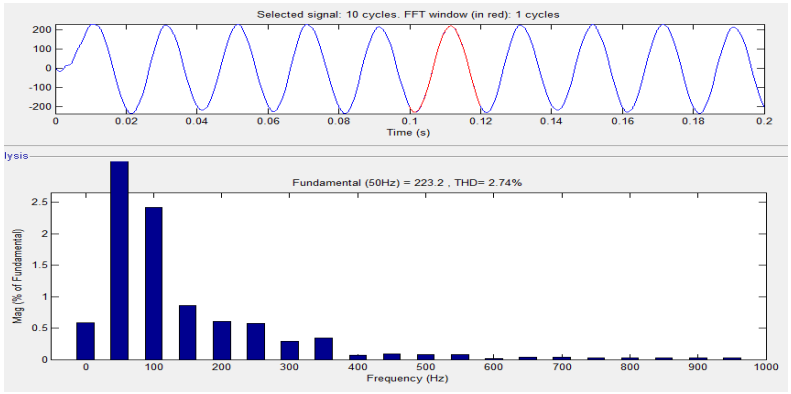

Fig.9. Sources current Total harmonic distortion with DSTATCOM for sinusoidal PWM.

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Fig.8.shows the Matlab/Simulation diagram of the with DSTATCOM control of sinusoidal PWM,Fig.9. shows the source current THD for With DSTATCOM.

D.Sub-harmonics PWM:

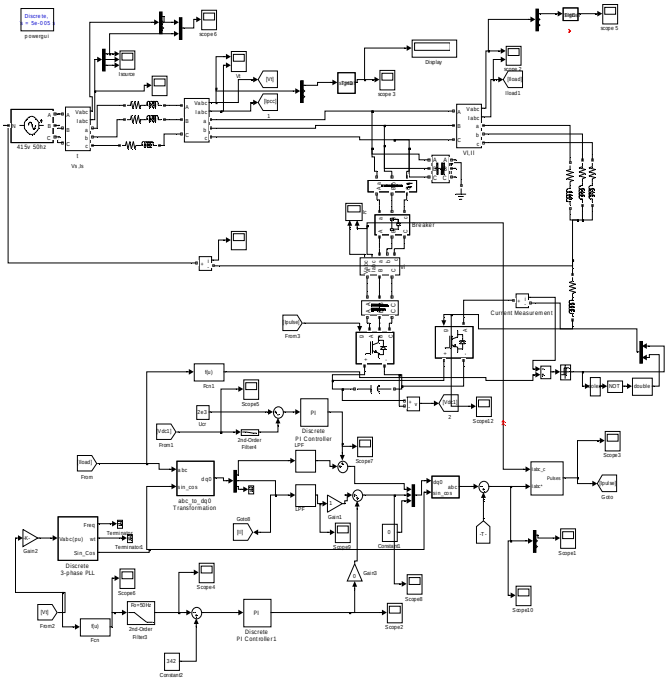

Fig.10. Simulation model of with DSTATCOM control of Sub-harmonics based PWM.

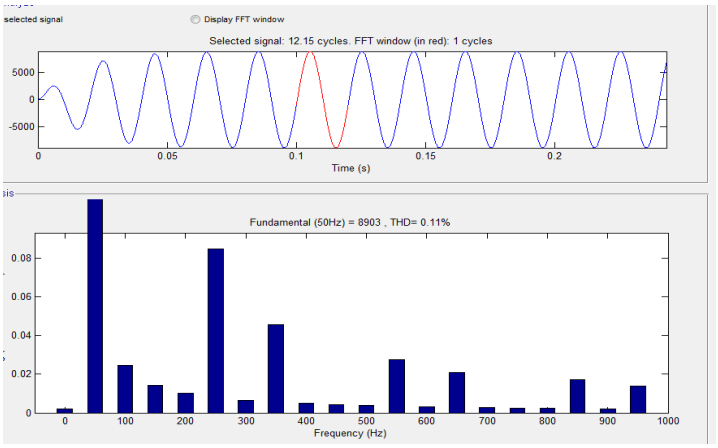

Fig.11. Source current Total harmonic distortion with DSTATCOM for sub-harmonics based PWM.

Fig.10.shows the Matlab/Simulation diagram of the with DSTATCOM control of sub-harmonics based PWM, Fig.11. shows the source current THD for With DSTATCOM.

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e.Space Vector PWM

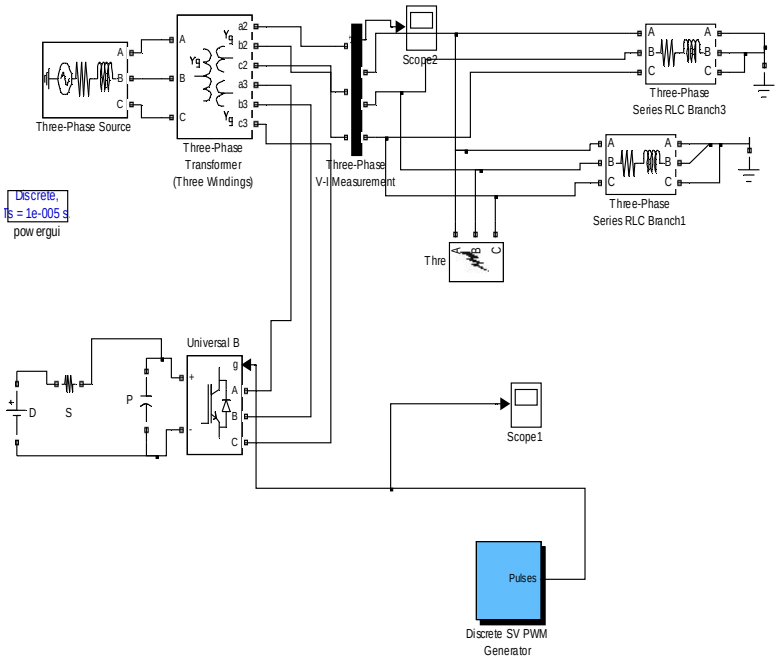

Fig.12. Simulation model of with DSTATCOM control of space vector based PWM.

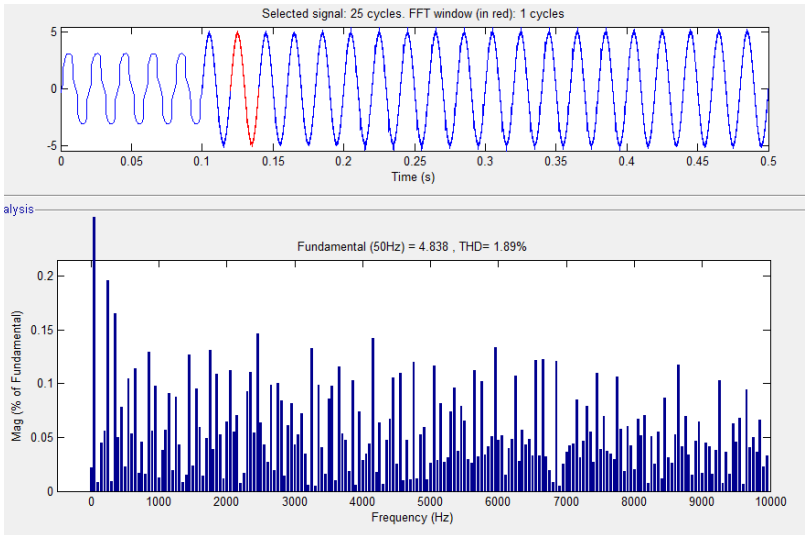

Fig.13. Source current Total harmonic distortion with DSTATCOM for Space Vector based PWM.

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Table 1. Comparision table of PWMs

Types of PWMs	**THD (%)**
Sinusoidal PWM	5.30
Carrier based/Triangular PWM	2.74
Sub-harmonic PWM	1.89
SVPWM	0.11

V.CONCLUSION

This paper has presented the power quality problem such as total harmonic distortion in the distribution system and simulation technique of a D-STATCOM. The simulation results with different PWMs show that, by adding LCL Passive filter to D-STATCOM, the THD reduced within the IEEE STD 519-1992. The power factors may also increase close to unity. Thus, it can be concluded that by adding D-STATCOM with LCL filter and SVPWM the power quality is improved and THD is reduced.

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