Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 11, November -2017

Reactive Power Compensation in Distribution System using D-STATCOM

Akansha Reddy[1], Amit Goswami[2]

[1]Department of EEE, DIMAT, Raipur, India
[2]Department of EEE, DIMAT, Raipur, India

Abstract — *D-STATCOM is a custom power device which is used in distribution system to control the flow of reactive power. The load compensation by shunt connected compensator are fast executed and maintains unity power factor while load balancing reducing line losses. D-STATCOM injects a current in to the system to correct the voltage sag and swell. The control of the Voltage Source Converter (VSC) is done with the help of SVPWM. The SVPWM switching algorithm has reduced commutation losses, lower harmonic distortion and has better amplitude modulation index. There is an increasing trend of using space vector PWM (SVPWM) as easier digital realization and better dc bus utilization can be obtained. The proposed and implementation of SVPWM in VSC of D-STATCOM using PI controller is designed and simulated using MATLAB/SIMULINK software.*

Keywords- *Distribution static compensator (DSTATCOM), voltage source convertor (VSC), Total Harmonic Distortion (T.H.D), Control techniques (SVPWM), reactive power.*

I. INTRODUCTION

The FACTS devices enhance the quality of power and provides reliable control over transmission parameters, like line impedance, voltage and phase angle between the sending end and receiving end voltage. Whereas the custom power devices provides value addition which involves the application of high power electronic controllers to distribution systems and provides cost effective solution for the compensation of reactive power. DSTATCOM, DVR, UPQC are most widely used custom power devices. D-STATCOM provides cost effective solution for the compensation of reactive power [1]. The concept of FACTS refers to a family of power electronics based devices which enhance AC system stability and controllability and increase the power transfer capability. In this paper Distributed Static compensator (D-STATCOM) is used as main custom power device. A D-STATCOM is a shunt connected VSI fed power electronic device used to mitigate the harmonics and power quality problems. It eliminates the harmonics from source current and balances them to provide reactive power compensation for improving the power factor and also for regulation of load bus voltage. The performance of D-STATCOM depends upon different control algorithms used for reference current generation and firing pulse generation strategy to VSI [2]. The D-STATCOM can exchange active and reactive power with the distribution system by varying the phase angle and amplitude of convertor voltage with respect to the line terminal voltage [3].In this work modified space vector switching modulation technique is implemented which works in αβ frame.

II. DESIGN OF D-STATCOM

A D-STATCOM systematically depicted in Figure.1, consists of a two level self-commutated Voltage Source Convertor (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. This configuration allows device to generate or absorb controllable active and reactive power. The VSC converts the DC voltage across the storage device into a set of three phase ac output voltages .The converted voltages are in phase with the AC system through the reactance of coupling transformer. The effective control of active and reactive power exchanges between the D-STATCOM and the ac system can be made by suitable adjustment of phase and magnitude of the D-STATCOM output voltages. Three phase voltage source convertor (VSC) act as the D-STATCOM which consist of six insulated gate bipolar transistor (IGBT) and anti-parallel diodes are connected to each IGBT [4]. DC side of voltage source convertor (VSC) consist of a capacitor which is used to maintain constant voltage for switching operation of the IGBT switches. The DC capacitor does not provide any reactive power compensation. L_f is connected on the ac side of the voltage source convertor for compensating high frequency component of compensating current [5]. Storage capacitor, C_{dc} does not exchange any active power between load and the D-STATCOM. Breaker is used to observe the performance of the D-STATCOM before and after compensation.

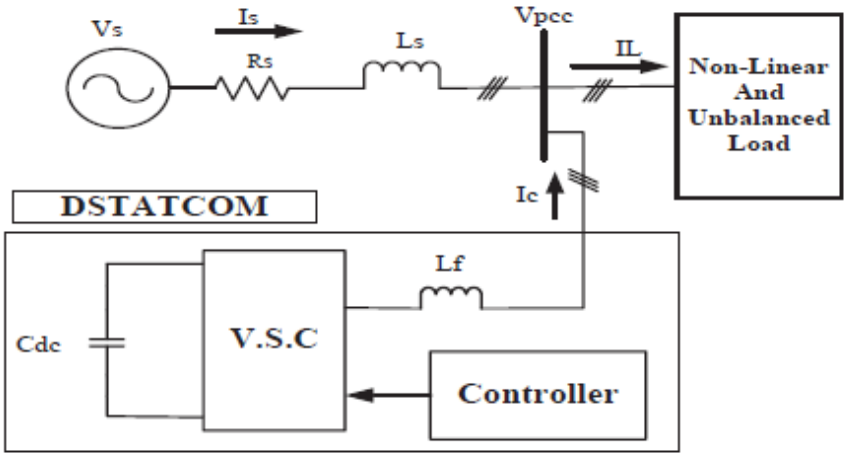


Figure.1:*Schematic Representation of D-STATCOM*

The shunt connected VSC has three distinct purposes:

- Compensation of reactive power and voltage regulation
- Power factor correction
- Current harmonic elimination

The shunt injected current is controlled by adjusting the output voltage of the convertor and is given by,

$$I_{sh} = I_L - I_S = I_L - \left(\frac{V_{th} - V_L}{Z_{th}} \right) \quad (1)$$

$$I_{sh} \angle \eta = I_L \angle -\theta - \frac{V_{th}}{Z_{th}} \angle (\delta - \beta) + \frac{V_L}{Z_{th}} \angle -\beta \quad (2)$$

The effectiveness of D-STATCOM in correcting voltage sag depends on the value of Z_{th} or fault level of the load bus.

III. VOLTAGE SOURCE CONVERTOR

A Voltage source convertor is a power electronics device which generates sinusoidal voltage with any required magnitude, frequency and phase angle. They are basically used to mitigate voltage dips. The VSC converts DC voltage across the storage device into set of three-phase ac output voltages which are in phase and coupled through reactance of coupling transformer to the AC system. They completely replace the voltage or inject the 'missing voltage'. The missing voltage is defined as the difference between the 'nominal voltage' and the actual voltage.

IV.SPACE VECTOR PWM (SV-PWM) CONTROL TECHNIQUE

The space vector modulation is an algorithm for the control of pulse width modulation (PWM) and provides less THD and better power factor. Space vector modulation provides algorithm for multi-phase AC generation. The space vector PWM method consider each of the three modulating voltages as a single identity taken in account simultaneously in a two dimensional reference frame ($\alpha\beta$).The main objective of this technique is to generate PWM load line voltages that are average and equal to a given or load reference load line voltages. It realizes the slow rotating voltage space vector (corresponding to fundamental component of output voltage) from six active state voltage vectors and two null state vectors. The active state voltage vectors have magnitude $V_{dc,}$ pointing along a fixed direction whereas null state vectors have a zero magnitude [6].In order to integrate the reference signal , one or more zero switching vectors are preferred for the sampling period.

4.1. Principle of Space Vector PWM:

The topology of three phase voltage source invertor is shown in Figure.2.Eight possible switching combinations are generated by the switching network. Switches S_1 to S_6 used for shaping the output .Total six out of the eight topologies produces a non-zero output and called as non-zero switching states and topologies which produces zero output voltage and called as zero switching states.

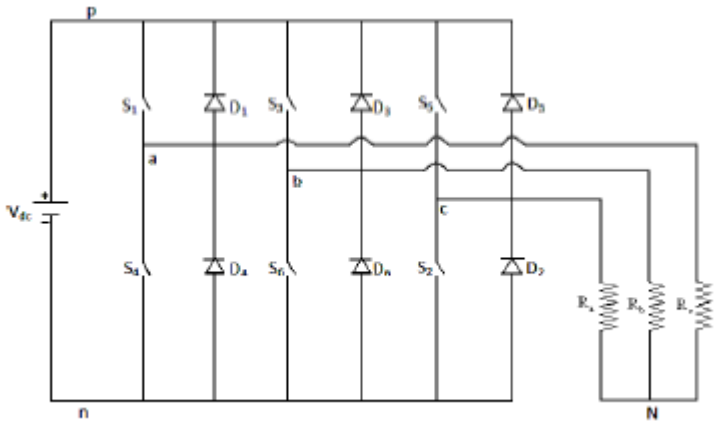


Figure.2:*Three phase Voltage Source Invertor*

The main advantage of SVPWM is that there is degree of freedom of space vector placement in a switching cycle which improves the harmonic performance of the system. A balanced three phase sinusoidal waveform is obtained when the reference vector is rotating in the $\alpha\beta$ frame. The eight voltage vectors V_0 to V_7 corresponding to switches S_1 to S_6 with line to neutral voltages and line to line voltages is shown in Table.1.

Table.1 *Switching vectors, phase voltages, output line-line voltages*

Voltage vectors	Switching vectors			Line to neutral voltage			Line to line voltage		
	A	B	C	V_{an}	V_{bn}	V_{cn}	V_{ab}	V_{bc}	V_0
V_0	0	0	0	0	0	0	0	0	0
V_1	1	0	0	2/3	-1/3	-1/3	1	0	-1
V_2	1	1	0	1/3	1/3	-2/3	0	1	-1
V_3	0	1	0	-1/3	2/3	-1/3	-1	1	0
V_4	0	1	1	-2/3	1/3	1/3	-1	0	1
V_5	0	0	1	-1/3	1/3	2/3	0	-1	1
V_6	1	0	1	1/3	-2/3	1/3	1	-1	0
V_7	1	1	1	0	0	0	0	0	0

In order to implement Space vector modulation, the voltage equations in the abc reference frame can be transformed to the stationary dq reference frame consisting of horizontal (d) and vertical (q).

4.2. Steps for the implementation of Space Vector PWM:

There are three basic steps for the implementation of space vector technique.

- Determine voltages V_d, V_q, V_{ref} and angle (α).
- Determine time duration T_1 , T_2 ,T_0
- Determine switching time of each switch.

V.CONTROLLER SCHEME

The control scheme is implemented to achieve constant magnitude voltage at the point where sensitive load under disturbances is connected. This system measures the rms voltage at the load point and no reactive measurements are required. The VSC switching strategy is based on space vector PWM. The controller input is an error signal which is obtained from reference voltage and measures rms terminal voltage. The error produced is processed by a PI controller, the output of which is angle δ , which in turn is provided to the PWM signal generator. The PI controller processes the

error signal and generates the required angle to drive the error to zero .As a result of which the load rms voltage is brought back to the reference voltage [4].

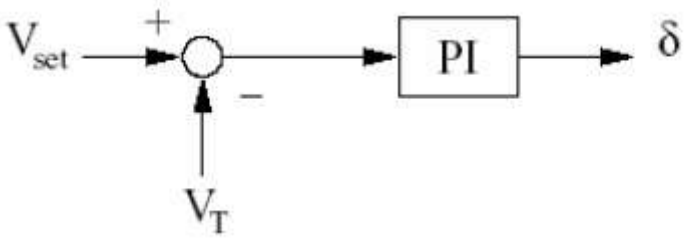


Figure.3.*PI control for reactive power compensation*

VI.SIMULATION AND RESULTS

A. Uncompensated Line

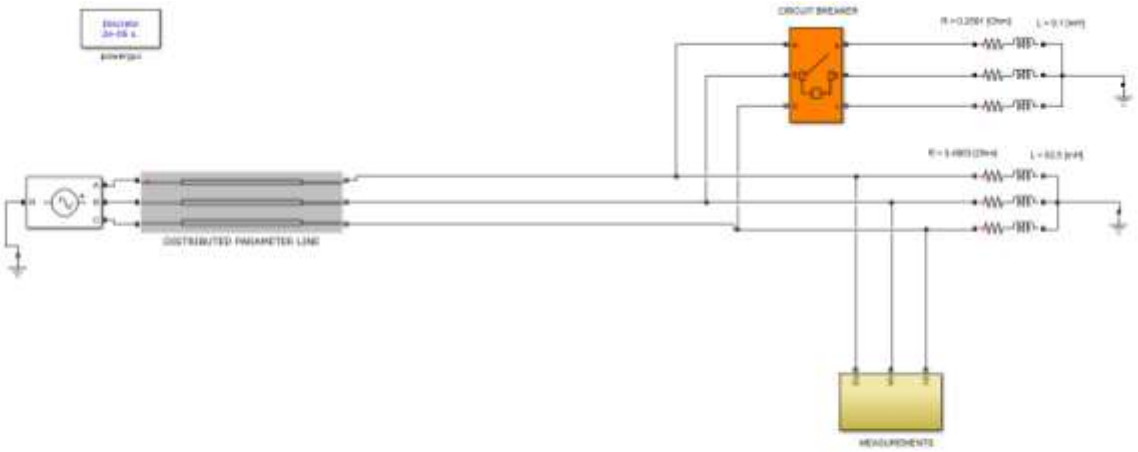
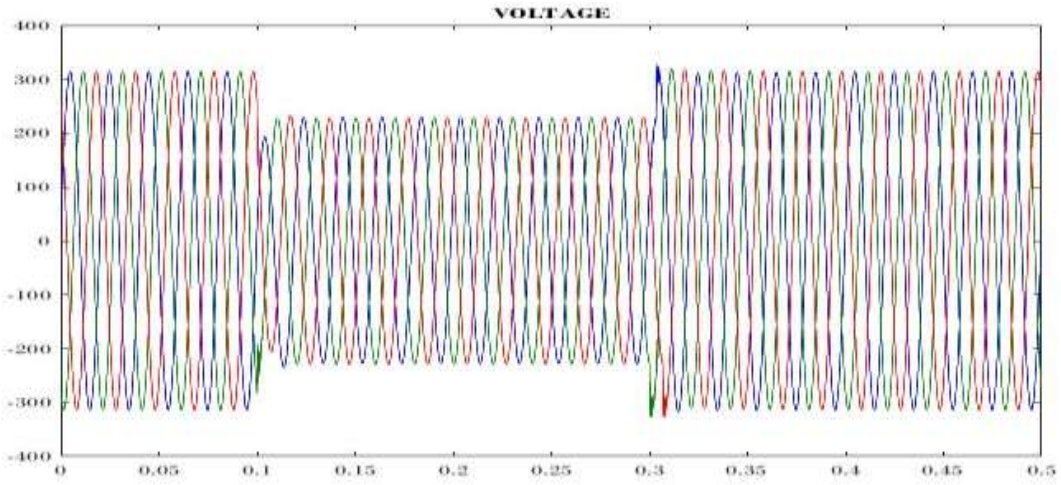


Figure.4.*Simulink model of uncompensated line with RL load*

Initially from Figure.4 we have considered the case of RL load which is connected to the line. After 0.1 seconds, the circuit breaker closes and the load gets connected to the line .Due to this load we obtain certain results in voltage, current and magnitude of voltage waveform. The voltage waveform gets reduced and current rises high because of the load which receives large power from the supply side.



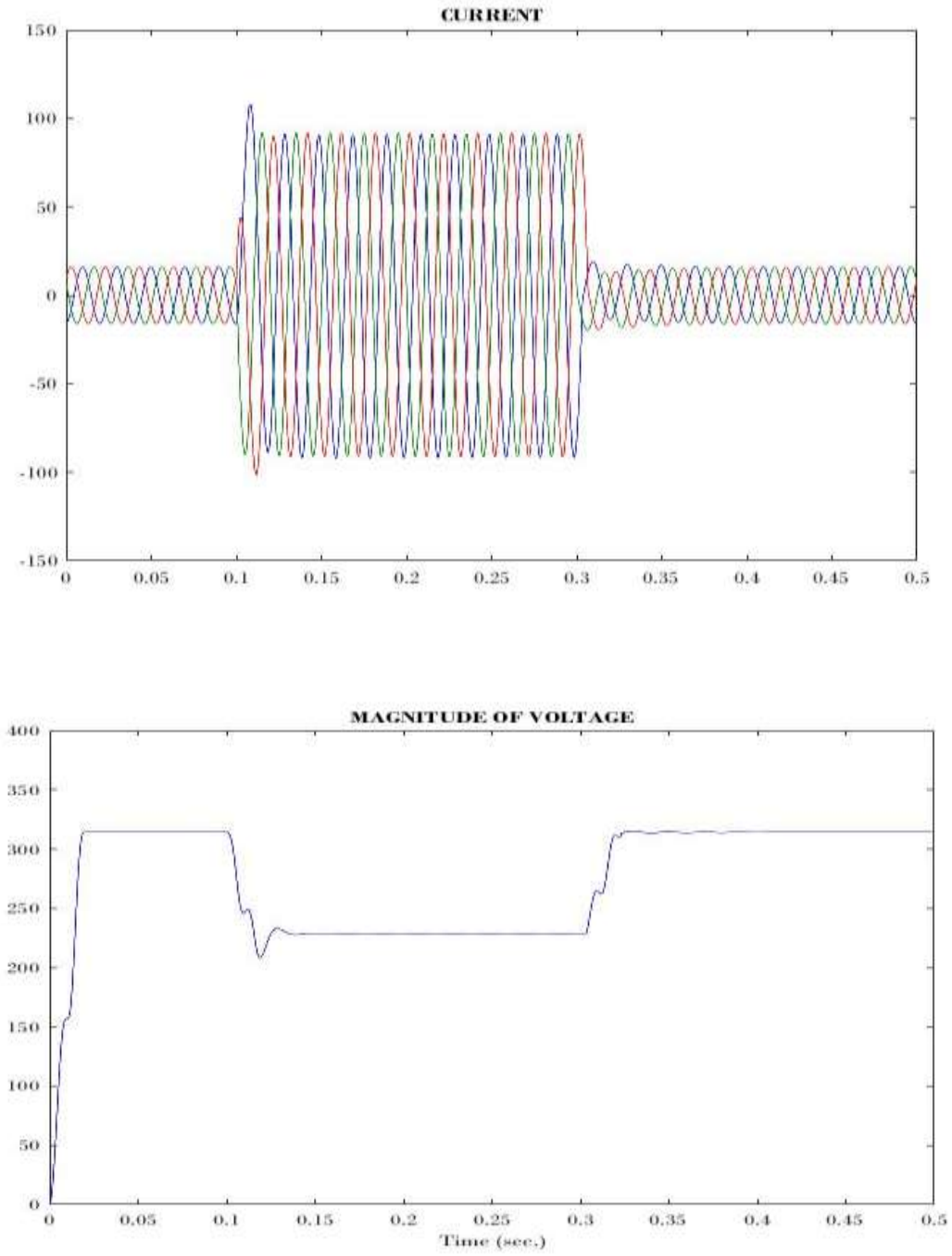


Figure.5.*Waveform of Voltage, current and Magnitude of Voltage*

B. Compensated Line

Considering that the D-STATCOM is connected in shunt with the line. Initially from figure.6 there is fixed load connected to the line. After 0.1 seconds the circuit breaker gets closed and the load is applied to the line which results in fewer drops in voltage due to the injection of reactive power by the D-STATCOM. The waveform results shows variation in voltage waveform in which the magnitude of voltage has been improved to some extent and current waveform gets reduced.

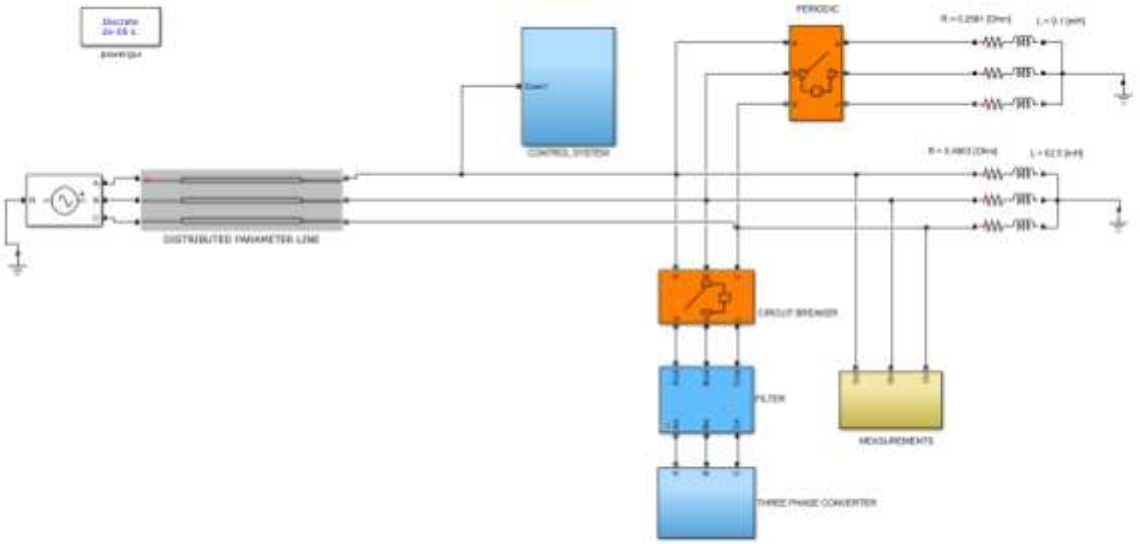
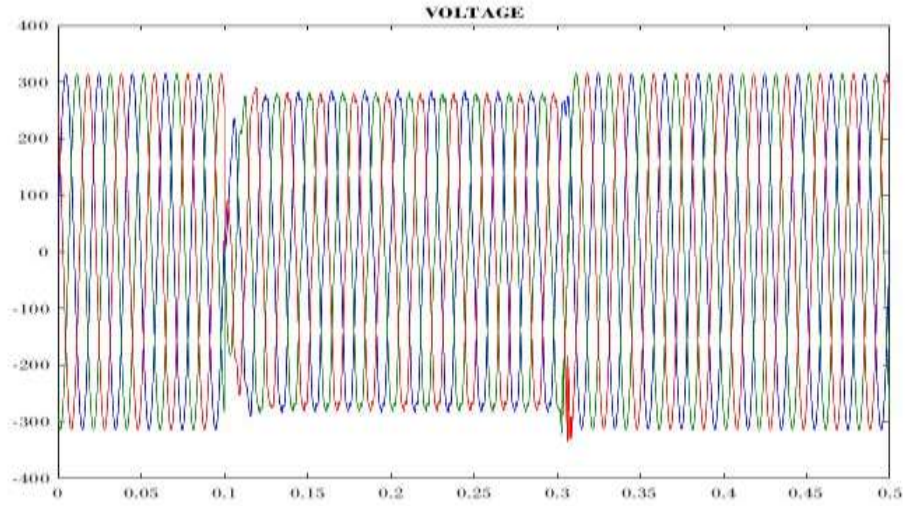
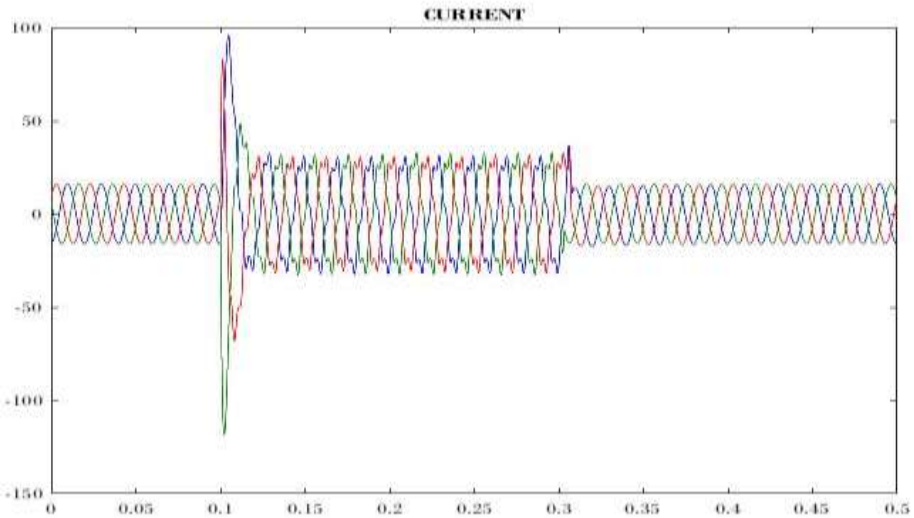


Figure.6.*Simulink model of compensated line with RL load*





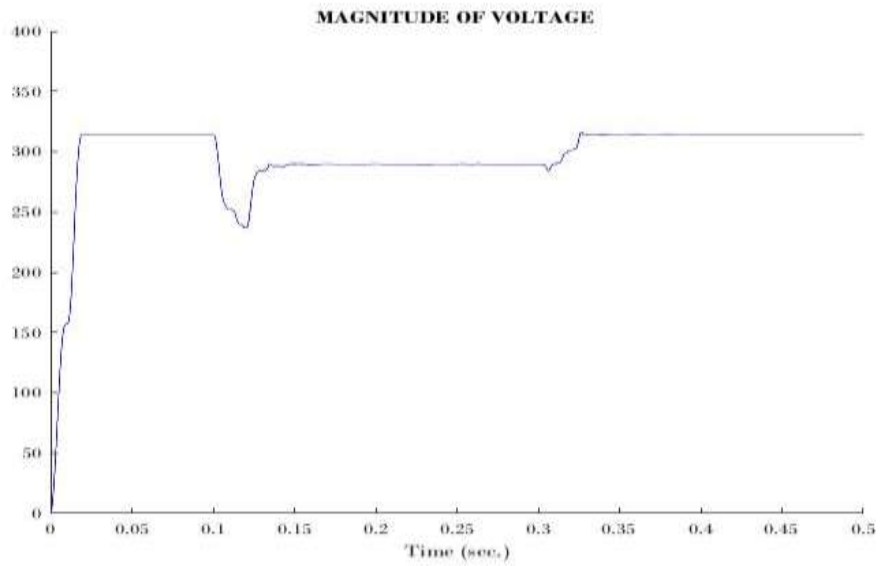


Figure.7.*Waveform of Voltage, Current and Magnitude of Voltage*

VII.BENEFITS OF D-STATCOM

- Quick response to system disturbances.
- Provides smooth voltage control over different operating conditions.
- Achievement of Dynamic voltage control in the distribution system.
- Transient stability is provided in the system
- Ability to control reactive and active power

VIII.CONCLUSION

In this paper, study and discussion about the custom power device D-STATCOM and its usefulness in compensation of reactive power is done. This device acts as voltage source convertor which is implemented at the load side of the system to improve the voltage profile of the system and thereby reducing the power losses. The response of the D-STATCOM is fast as compared to conventional reactive power control devices.

REFERENCES

[1] Kiran Kumar Pinapatruni and Krishna Mohan L."DQ based Control of DSTATCOM for Power Quality Improvement",VSRD- IJEECE.vol2(5),2012,207-227.
[2] N.G.Hingorani, "Introducing Custom Power ." IEEE Spectrum,vol.32,no.6,pp.41-48,1995.
[3] B.Singh and J.Solanki, " A Comparison of Control Algorithms for DSTATCOM," IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS,vol.56,no.7,pp.2738-2745,2009.
[4] K.Padiyar,Facts Controller in Power Transmission and Distribution .New Age International, 2007.
[5] N.G.Hingorani and L.Gyugi,Understanding Facts :Concepts and Technology of Flexible AC transmission Systems.Wiley-IEEE press,2000.
[6] K.Vinoth Kumar,Prawin Angel Michael,Joseph P.John and Dr.S.Suresh Kumar, ' Simulation and comparison of Spwm and Svpwm Control for Three Phase Invertor" ARPN Journal of Engineering and Applied Sciences vol.5,no.7.July 2010,PP.61-74
[7] K.Mounika ,B.Kiran Babu , "Sinusoidal and Space Vector Pulse Width Modulation for Invertor" International Journal of Engineering Trends and Technology (IJETT)-vol.4 issue4-April 2013.pp 1012-1017.
[8] Mr.Deepak G.Pagar,Prof.S.S.Khule,"Implementation of Space Vector PWM for Hybrid DSTATCOM".International Research Journal of Engineering and Technology (IRJET)-vol.04 issue7-July 2017pp2395-0056.
[9] R.C.Dugan,M.F.McGranaghan and H.W.Beaty ,"Electrical power system quality ," New York,NY:McGraw-Hill,c1996,vol.1,1996.Eason.
[10] Chandan Kumar, M.V.Manoj Kumar,Mahesh K.Mishra, " A Control Scheme to Enhance DSTATCOM Operation in Power Distribution System",PEDG 2015,6th International Symposium on 22-25 June 2015 ,Aachen,pp.1-6,DOI : 10.1109/PEDG:2015.7223034,IEEE.

