D-STATCOM for Power Quality Improvement in Distribution Power System using MATLAB Simulink

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Abstract - In today's scenario Power Quality issues are turned into a serious matter for both electric power utilities and the power system engineers. Dynamic loads are one of the major causes of power quality debasement in power transmission lines. Due to their high nonlinearity and time-varying behavior, various power quality issues like voltage variation, harmonic distortion arises in the system. Simulation of the system will be carried out using MATLAB/SIMULINK software to obtain the result. When there is an overload in the system, high current will flow through the line and the consequence voltage sag will occur. In order to improve voltage sag, D-STATCOM will connect to the system. In this paper, the performance of D-STATCOM both before and after saging will be analyzed.

Key Words: **POWER QUALITY, FACTS, D-STATCOM, HARMONICS, REACTIVE POWER.**

1. INTRODUCTION

In today's society demands for power have increased. A Modern power system is more complex and it is required to fulfill the demand with better power quality. The construction of new transmission lines and power stations increases the problem of system operation as well as the overall cost. Normally, Poor power quality is caused by power line disturbances such as impulses, voltage sag and swell, voltage and current unbalances, momentary interruption and harmonic distortions .The other major causes of poor power quality are harmonics and reactive power. The solid state control of ac power using high speed switches are the main cause of harmonics whereas dynamic loads contribute to excessive drawn of reactive power from supply. Reactive power causes an increase in the transmission losses, a decrease in power quality and the changes in the voltage amplitude at the end of the lines. Nowadays advanced technologies are being used for improving power system reliability, security, and profitability. To achieve optimum performance of the power system it is essential to control reactive power flow in the network. Reactive power flow can be controlled by using FACT's devices like distribution static compensator (D-STATCOM), Static VAR Compensator (SVC), Unified power-quality conditioner (UPQC), etc. The Flexible AC Transmission System devices (FACTS) offer a fast and reliable control over the transmission parameters, i.e. Voltage, line impedance, and phase angle between the sending and receiving end voltage [3]. On the other hand, the custom power is for low voltage distribution, and improving the poor quality and reliability of supply affecting sensitive loads. The most widely known custom power devices are UPQC, D-STATCOM, DVR among them D-STATCOM can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system[4]. D-STATCOM can be used to provide voltage regulation, power factor correction, compensation of harmonics and during transient condition provides leading or lagging reactive power to active system stability. It can exchange both active and reactive power in distribution system by changing the amplitude and phase angle of the converter with respect to the terminal voltage of the line.

1.1 DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

A static synchronous compensator (STATCOM) with a coupling transformer, an inverter, and energy storage device used in distribution system is called DSTATCOM and has configuration as the STATCOM [1]. At the transmission level, STATCOM handles only fundamental reactive power and provides voltage support, while a D-STATCOM is employed at the distribution level or at the load end for dynamic compensation [2]. D-STATCOM is a multifunctional device, it can also act as a shunt active filter, to eliminate unbalance or distortions in the source current or the supply voltage.

1.1.1 Principle of operation

A DSTATCOM is a shunt compensation device, it is connected to the point of common coupling (PCC) in the distribution system having unbalanced dynamic load, the main function of DSTATCOM is to supply the reactive power (as per requirement) to the system to regulate the voltage at the PCC. A D-STATCOM (Distribution Static Compensator) is schematically shown in Figure. It consists of 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. The VSC converts the dc voltage across the storage device into three-phase ac output voltages. These voltages are in the same phase and coupled with the ac system through reactance of the coupling transformer. The suitable adjustment of phase and magnitude of the D-STATCOM output voltages provides beneficial control of active and reactive power exchanges between the DSTATCOM and the ac system. Such type of configuration allows the device to absorb or generate controllable active and reactive power.

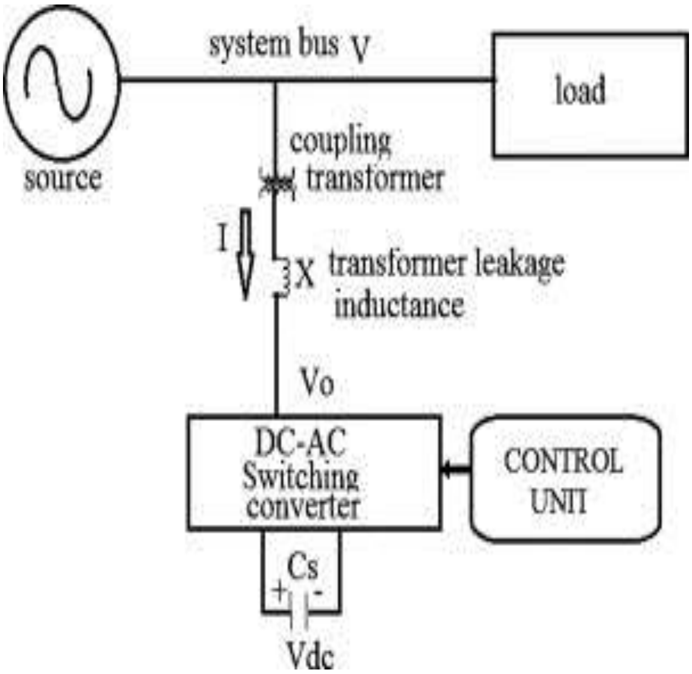


Fig -1 Schematic block diagram of DSTATCOM

If the magnitude of the DSTATCOM voltage Vc is greater than the grid voltage Vs (Vc>Vs), then the D-STATCOM supplies reactive power to the grid and will operate in the capacitive mode. If the grid voltage Vs is greater than the DSTATCOM voltage Vc (Vs>Vc), then the DSTATCOM absorbs reactive power from the grid and will operate in the inductive mode. If the grid voltage and the DSTATCOM voltage are of the same magnitude (Vc = Vs), then there will be no exchange of reactive power between the grid and the DSTATCOM and then the DSTATCOM will operate in the floating state.

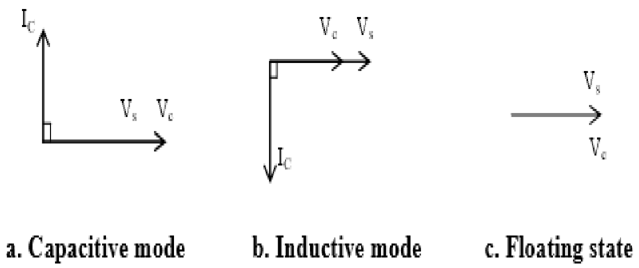


Fig -2 D-STATCOM operating modes

2. SIMULINK Result without D-STATCOM

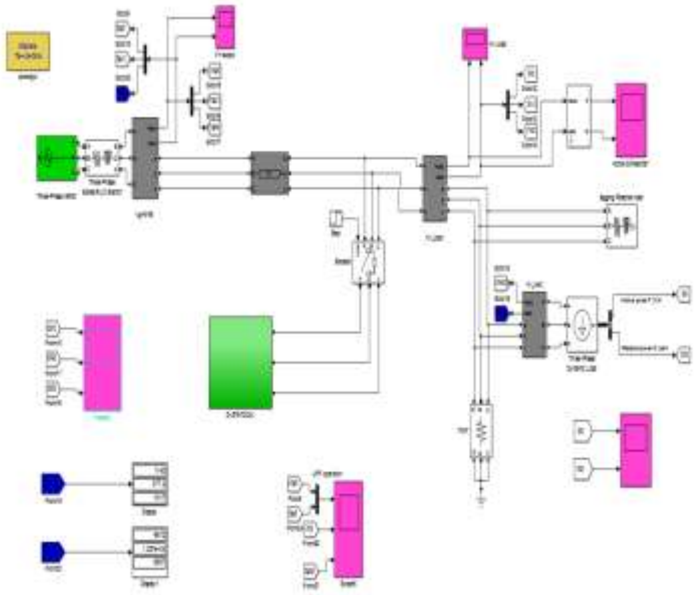


Fig -3 SIMULINK Diagram without insertion of D-STATCOM

Simulation is carried out with using the MATLAB/SIMULINK. Three Phase system is made with linear and unbalanced dynamic load.

A. Results before Compensation

Fig3. shows the results of MATLAB simulation without connecting the D-STATCOM.

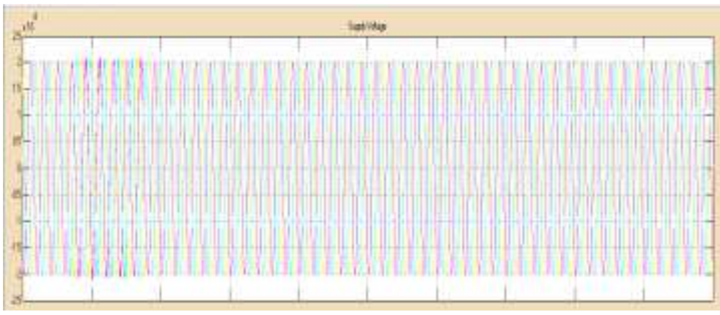


Fig -4 Supply Voltage without Compensation

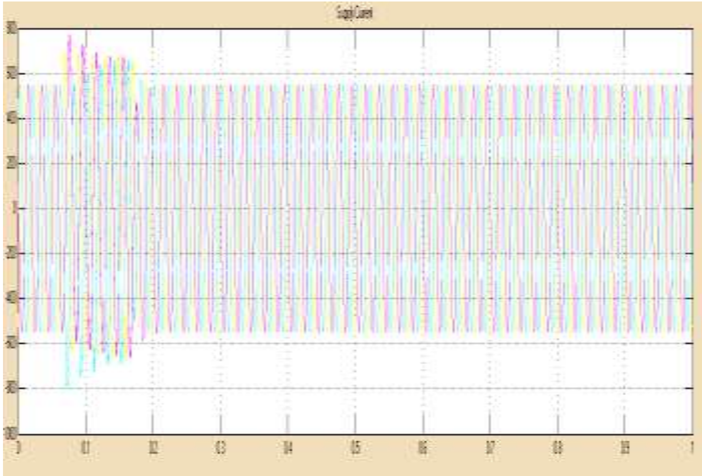


Fig -5 Supply current without Compensation

It is observed that due to unbalanced dynamic load, supply current get unbalanced and some distortion is present in their waveform.

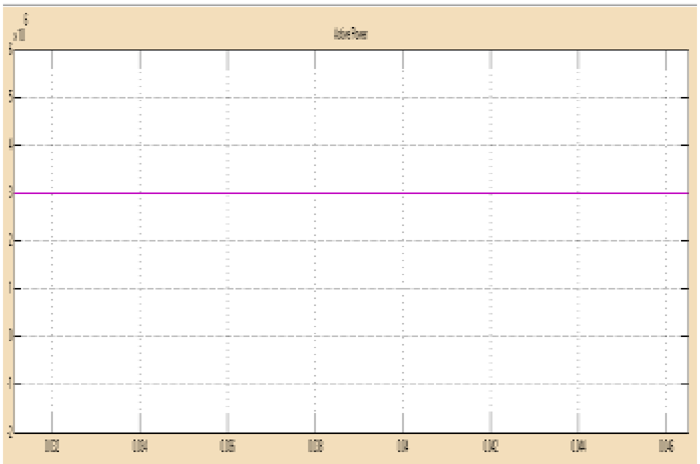


Fig -6 Active power of load side

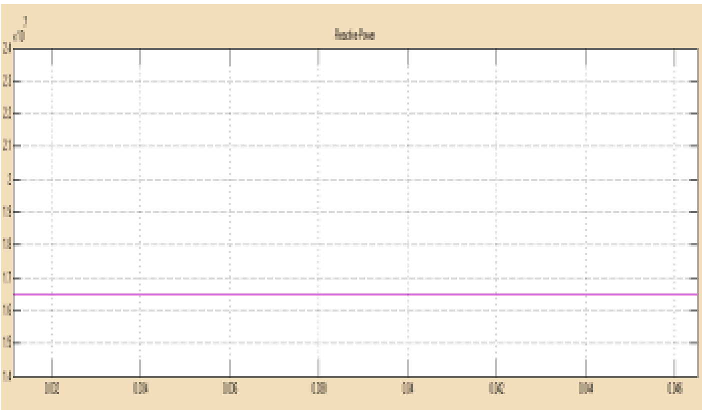


Fig – 7 Reactive power of load side

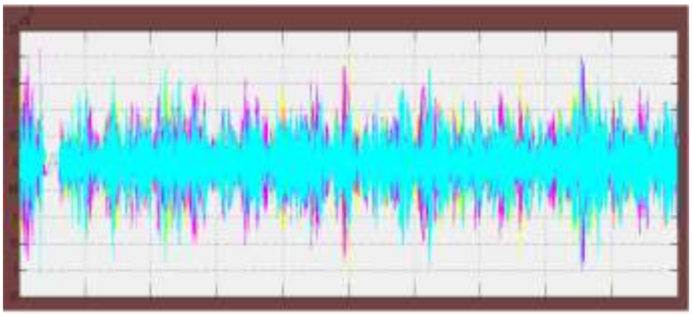


Fig - 8 Load voltage before compensation

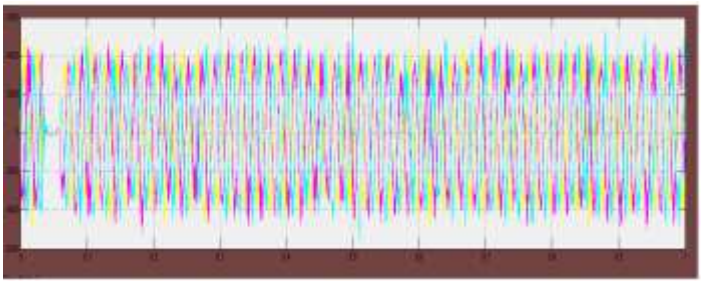


Fig - 9 Load current before compensation.

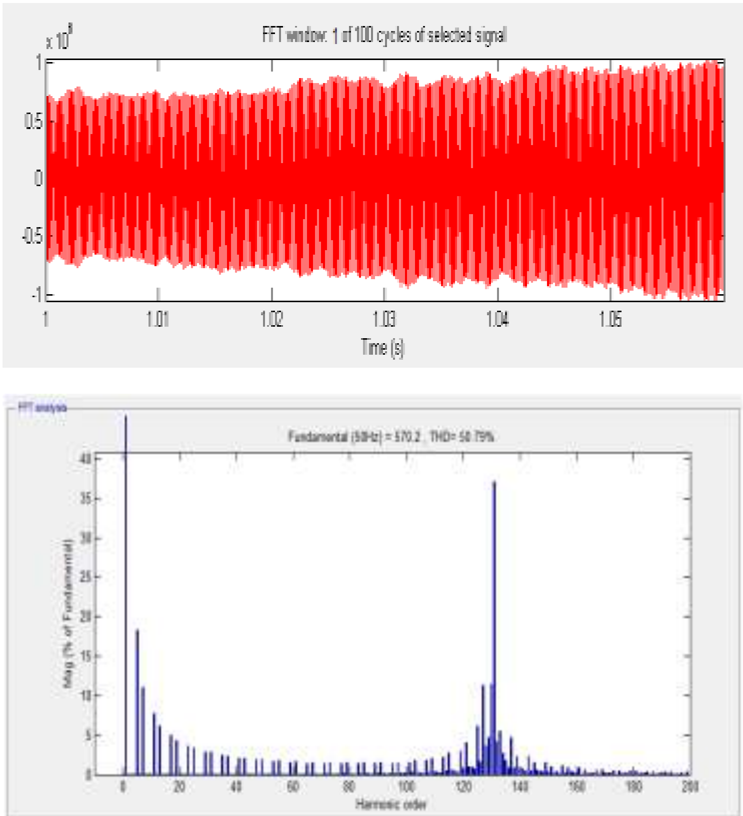


Fig – 10 The waveforms shows THD (50.79%) of fixed load and Dynamic load before Compensation

3. SIMULINK Result with D-STATCOM

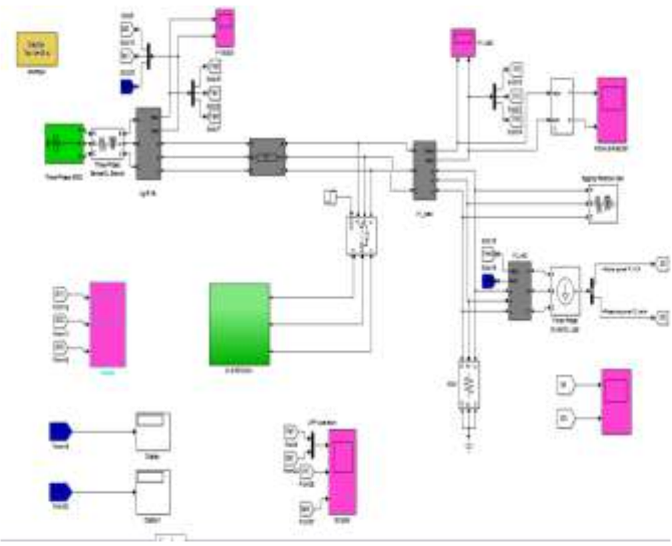


Fig – 11 SIMULINK Design Diagram with Insertion of D-STATCOM

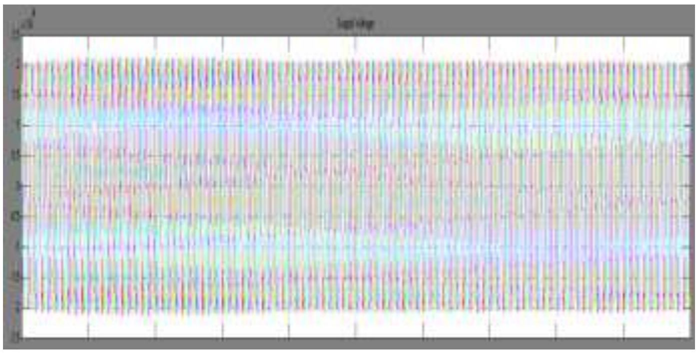


Fig – 12 voltage after the reactive power compensation

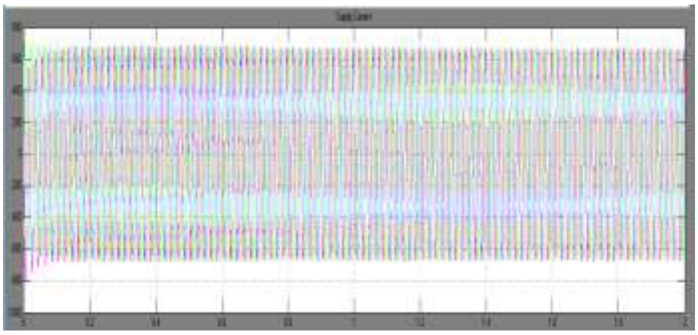


Fig – 13 Current after the reactive power compensation

After connecting DSTATCOM to the system, it is observed that voltage and current wave form are approximately sine wave, also source current and voltage are in phase with each other. So, the power factor is maintained near to unity. Total Harmonic Distortion (T.H.D) in the source current is found to be 0.23% which is very less compare to T.H.D before compensation.

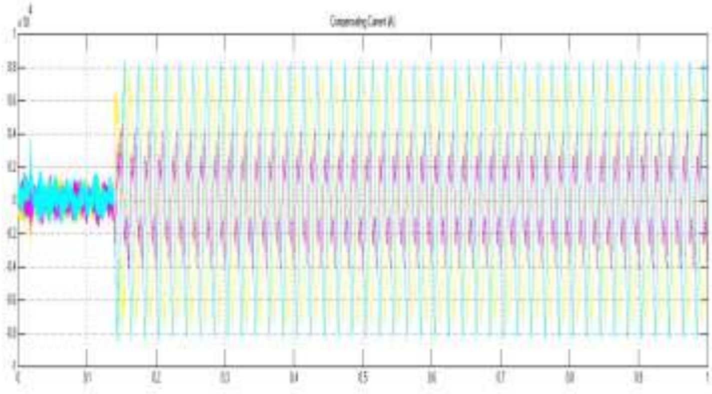
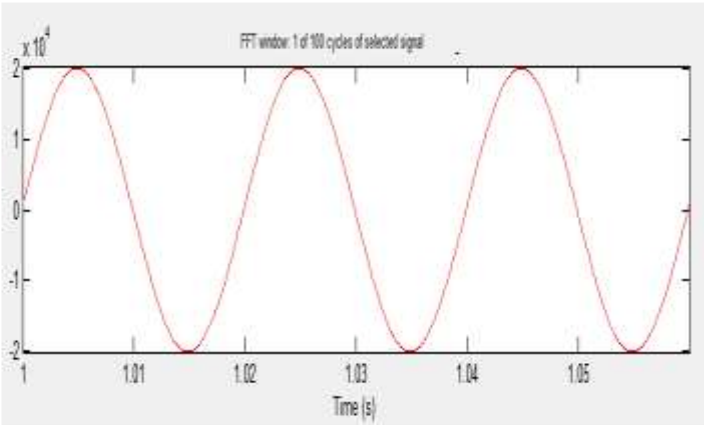


Fig – 14 Compensating Current from D-STATCOM

Figure 14 instances three-phase acclimate signals from D-STATCOM. D-STATCOM accommodates the harmonics and makes the source components to be sinusoidal.



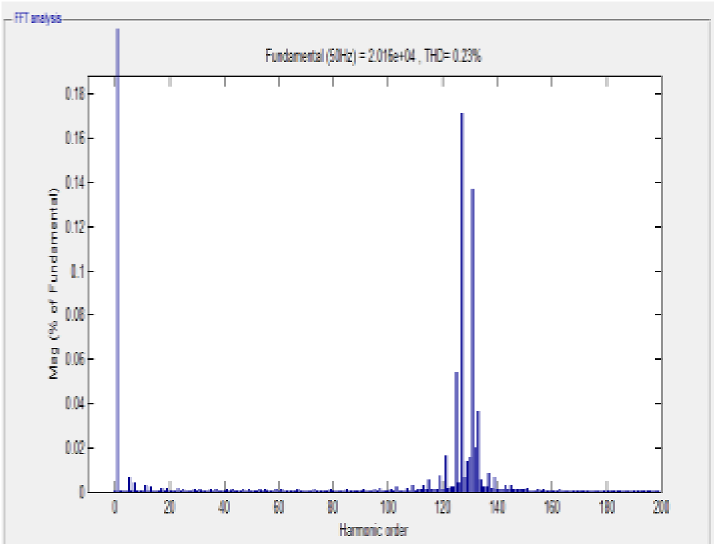


Fig – 14 The waveforms shows THD (0.23%) results of fixed load and Dynamic load with D-STATCOM.

3. CONCLUSIONS

Power quality is the major criteria in distribution system. Power quality is improved by injecting compensating current at the load side to utilize the real power maximum by the system. In this paper, modeling and analyzing of the power system is being integrated with D-STATCOM at distribution grid, at the consumer end. D-STATCOM is employed to reduce the harmonics and to compensate reactive power. Without D-STATCOM source current THD is 50.79% and then with D-STATCOM, THD has been reduced to 0.23%.

Before compensation, the unbalanced dynamic load injects harmonic currents to the source side and affects the source, due to which the waveform of source current becomes distorted. This can be overcome by using D-STATCOM by connecting as shunt at the distribution side by means of a tie reactance connected to compensate the load current. It can be concluded that D-STATCOM is an effective device for PQ improvement in the distribution system.

REFERENCES

[1] Naderi E, Hagh M, Zare K. "Determination of the performance of the distribution static compensator (dstatcom) in distribution network" In: 22nd International conference and exhibition on electricity distribution (CIRED 2013);2013.p.1–4.
[2] Mohammed Abdul Khader Aziz Biabani, Akram Jawed "Enhancement of Power Quality in Distribution System using D-Statcom" in International conference on Signal Processing, Communication, Power and Embedded System (SCOPES)-2016
[3] Kiran Kumar Pinapatruni and Krishna Mohan L, "DQ based Control of DSTATCOM for Power Quality Improvement, VSRD International Journal of Electrical, Electronics & Communication Engineering, Vol. 2 (5), 2012, 207-227.
[4] E. Praveena, Dr. P.V. Kishore et al. "Mitigation of Harmonics in Distribution System Using D - STATCOM" International Journal of Scientific & Engineering Research Volume 2, Issue 11, November-2011 ISSN 2229-5518

[5] Chandan Kumar and Mahesh K. Mishra "A Control Algorithm for Flexible Operation of DSTATCOM for Power Quality Improvement in Voltage and Current Control Mode", 2015 IEEE 6th International Symposium on Power Electronics for Distributed Generation Systems, Aachen, 22-25 June 2015 pp 1-6

[6] M. Sroor; R. M. Sharkawy; R. M. Hamouda " Dynamic performance of DSTATCOM used for voltage regulation in distribution system " International Power Engineering Conference, 2015 , Wollongong, NSW, 27-30 Sept. 2015 pp1 - 6,

[7] Noramin Ismail, 2Wan Norainin Wan Abdullah "Enhancement of Power Quality in Distribution System Using D-STATCOM", The 4th International Power Engineering and Optimization Conference, 978-1-4244-7128-7/10/$26.00 ©2010 IEEE.

[8] K. Padiyar, *FACTS Controllers in Power Transmission and Distribution*. New Age International, 2007.