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Power Quality Improvement of Electrical Distribution System Under Symmetrical and Unsymmetrical Faults Using D-STATCOM

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ABSTRACT:Voltage and current waveform distortion are the most vital power quality concern, because a little fluctuation with phase supply, a transient condition occurs and an unbalance within the phase voltages can cause a bigger unbalance within the phase currents. An absolutely balanced three-phase three-wire system contains only positive sequence components of voltage, current and impedance, whereas an unbalanced system contains both positive and negative sequence components of voltage and current. In a three-phase facility, the voltages at the generation side are sinusoidal and equal in magnitude with 120˚ phase difference between the phases. However, on the load side, voltages may become unbalanced because of unequal voltage magnitudes at the basic frequency, point deviations or unequal distribution of single-phase loads. This paper proposes the shunt connected, Distribution Static Synchronous Compensator (DSTATCOM) with an appropriate controlling scheme to mitigate and compensate the unbalanced load current. D-STATCOM could be a fast compensating reactive power source that's applied on the transmission or distribution system to cut back voltage variations like sags, surges, swell and flicker, together with instability which is caused by rapidly varying reactive power demand. In this paper, the planning and simulation of D-STATCOM are used to improve the standard of power under different abnormal conditions like symmetrical and unsymmetrical faults. The working efficiency is tested under different fault conditions. The DSTATCOM is designed through SIMULINK and grid Block-set toolbox available within the MATLAB program.

KEYWORDS: Power Quality, D-STATCOM, Distribution Network, Symmetrical and Unsymmetrical fault

I.INTRODUCTION

Power quality is a crucial issue in the power distribution network system. In the present day, the economic equipment is based totally on electronic components like rectifier, thyristors along with programmable sensing controllers and power electronic drives [1]. These devices are very sensitive to instabilities and find yourself less tolerant to power quality issues. Within industrial and commercial equipment, voltage sags, swell, voltage fluctuation is serious and commonest problems [1,3].

The distribution static compensator (D-STATCOM) may be a shunt connected reactive-power compensation device that's capable of generating and absorbing the reactive power and also provide voltage support to a system bus [4]. During a renewable energy system, this is often also utilized in improving the constancy of the facility system. The reactive power imbalances are often minimized through the compensation device [5, 6]. DSTATCOM is additionally capable to resolve faults problems and compensate harmonics through the aptitude of the system [5, 7].
The first D-STATCOM device was manufactured in Japan and shipped to the UK, where it has been installed adjacent to a wind farm in South West England.
The Flexible Alternating Current Transmission System (FACTS) devices provide a fast and reliable control over transmission parameters, like the voltage, line impedance and phase angle between the sending end and receiving end voltage [7, 8, 9, and 10]. On the other hand, the custom power device is used for low voltage distribution and improves the power quality due to which the system becomes reliable [11, 15]. Custom power devices are very similar to FACTS devices. The most widely known custom power devices are D-SATCOM, UPQC, DVR among which D-STATCOM provides a cost-effective solution for the compensation of reactive power [1, 6]. A FACT is a power electronic-based

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device that maintains the power quality by maintaining the better flow of power and controls the dynamic stability of the system by changing the system parameters like voltage, phase angle, impedance [13].

Solid-state Custom power devices are utilized in a power grid network to supply compensation and improve voltage profile [9]. It's mainly of three types: a) DVRs - series-connected b) distribution static compensator (DSTATCOM) shunt-connected [10] c) unified power quality conditioner (UPQC) - a permutation of series and shunt-coupled [2, 6].

II.CONFIGURATION AND OPERATIONOF DSTATCOM

A D-STATCOM could be a Voltage Source Inverter (VSI) fed power-electronic device that is connected in shunt to the system network to moderate the harmonics and power quality problems [9]. The performance of the D-STATCOM depends on different control algorithms which are used for the extraction of reference currents and to produce pulses to the gate terminals of the VSI [10]. A literature review has been performed on differing types of studies over D-STATCOM [2]. The D-STATCOM is very effective in providing load voltage regulation; however, maintaining load voltage at rated value has several unwanted effects from a customer point of view. With a voltage of 1p.u. at load point, D-STATCOM forces load to control always at rated power [3, 5]. The STATCOM employed in distribution systems is termed D-STATCOM (Distribution-STATCOM). It can exchange both active and reactive power with the distribution system by varying the amplitude and phase of the converter voltage with regard to the load terminal voltage [4, 14].

2.1 MATLAB Simulink Model of DSTATCOM

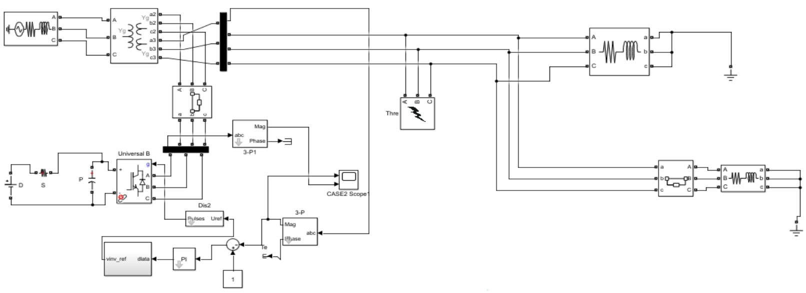

Fig. 2.1, MATLAB Simulink Model of D-STATCOM

In fig. 2.1, three phase supply 20 kV is utilized in power distribution system and non-linear load is connected as a load in power system network. Three phase distribution transformer is connected with the three phase supply voltage. DSTATCOM is a shunt connected device which is between in the power supply and non-linear load. A Fault occurs in distribution line near a load in a transmission line network. Circuit breaker is used to isolate the faulty network in power system network and which can observe the difference at the time of fault and after the compensation by D-STATCOM. The symmetrical and unsymmetrical fault study and performance is done by the given D-STATCOM Simulink model.

2.2 Controlling scheme of D-STATCOM

A controller is employed to sustain a relentless voltage magnitude at the worth of the purpose where a sensitive load is associated under system disturbances. The system simply measures the r.m.s voltage at the load point, i.e., no reactive-power measurements are required [11]. The VSC-switching strategy is based on a sinusoidal pulse width modulation (PWM). These methods offer a more efficient flexible option than the Elemental Frequency Switching (EFS) techniques preferred in FACTS applications [8]. Besides, high switching frequencies (HSF) utilized to boost the efficiency of the converter without incurring significant switching losses [14]. The input of the controller is a miscalculation signal which is obtained from the reference voltage and therefore the value r.m.s of the terminal voltage measured [16]. This error is processed by a PI controller that output is the angle Ø which is delivered to the PWM signal generator [13-16]. It's important to notice that during this case, indirectly-controlled converter, there's active and reactive power exchange with the network simultaneously: a slip-up signal is obtained by comparing the reference voltage with the r.m.s voltage measured at the load point [15]. The PI controller process the error signal generates the desired angle to drive the error to zero, i.e., the load r.m.s voltage is brought back to the reference voltage [14, 16]

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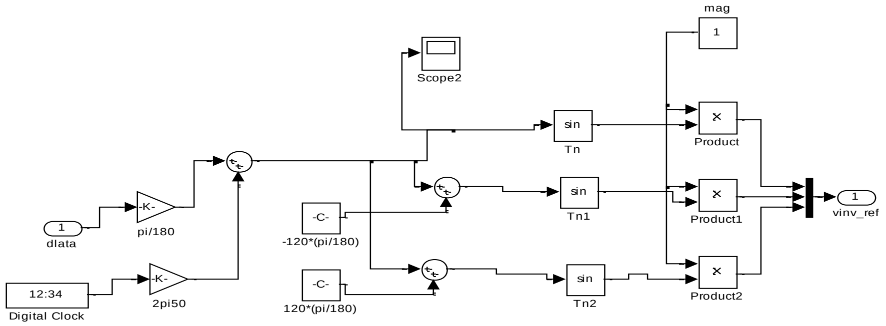

Fig. 2.2, Mathematical model of Pulse Width Modulation (PWM) Generator

The sinusoidal signal $V_{Control}$ is phase modulated by means of the angle-

$$V_A = \sin \omega t + \phi \quad (1)$$

$$V_B = \sin \omega t + \phi - \frac{2\pi}{3} \quad (2)$$

$$V_C = \sin \omega t + \phi + \frac{2\pi}{3} \quad (3)$$

The main constraints of the SPWM scheme are the amplitude-modulation indeed of signal and the FMI (frequency modulation index (M_f)) of the triangular signal. The amplitude-index (AI) is kept fixed at 1 p.u. in order to achieve the maximum fundamental voltage component at the controller output. The switching frequency (F_s) is set at the point 1080Hz. The frequency modulation index is given by-

$$M_f = \frac{F_S}{F_f} = 1080/50 \quad (4)$$

$$M_f = 21.6$$

Where, M_f is modulation index, F_S is switching frequency and F_f is fundamental frequency.

III.PERFORMANCE OF D-STATCOM SIMULINK MODEL UNDER DIFFERENT FAULT CONDITIONS

3.1 Single Line to Ground Fault (S-L-G Fault)

In case of S-L-G Fault, phase A is faulty and connected to the ground and phase B and phase C is un-faulty phase. The fault has impedance which is known as fault impedance denoted by Z_F. Phase B and phase C like as an open circuit and there is no current flow through these phases.

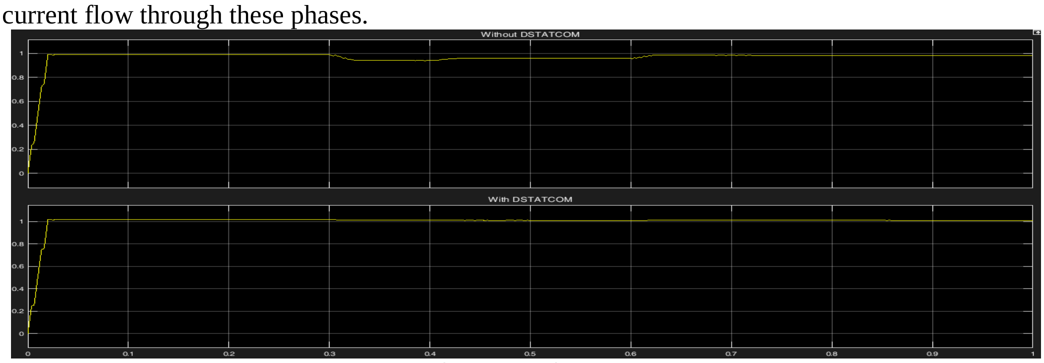

Fig. 3.1(a), S-L-G fault waveform without D-STATCOM

In fig. 3.1 (a), single line to ground (S-L-G) fault shows the result when D-STATCOM is not connected along with transmission line, the r.m.s voltage value is 0.94 p.u duration of 0.3 sec – 0.6 sec.

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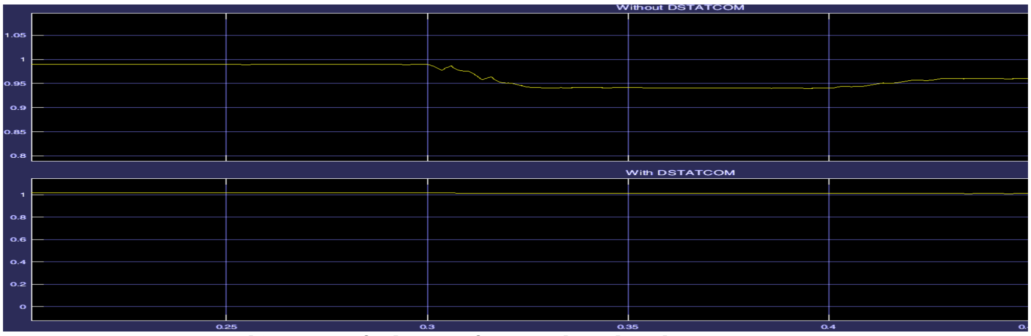

Fig. 3.1(b), S-L-G fault waveform with and without D-STATCOM

Fig. 3.1 (b) shows the rms value is 1.00 p.u when D-STATCOM is connected with the transmission line and regulates the voltage near about to 1p.u. for time period of fault and achieves the sinusoidal waveform at the load terminal in power distribution system.

3.2 Line to line fault (L-L Fault)

In case of L-L Fault, fault take place between two conductors phase B and phase C and both are short circuit; current is flow through the both phases. Fault impedance is $Z_{F.}$

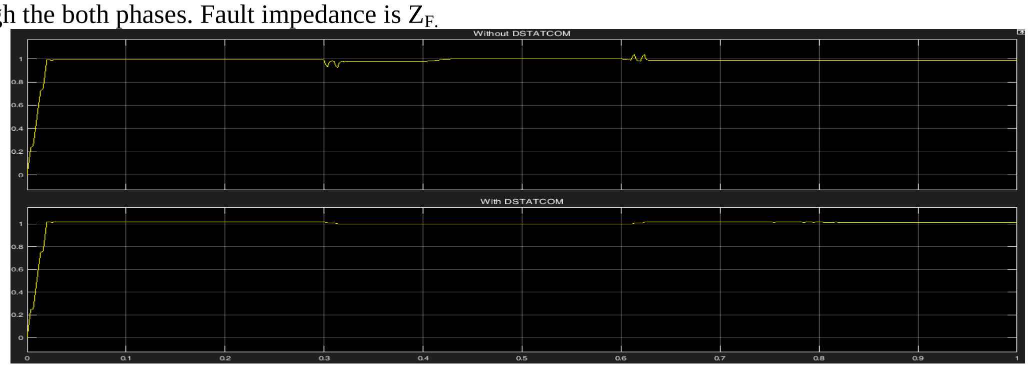

Fig 3.2 (a), L-L fault waveform with and without D-STATCOM

Fig 3.2 (a), presents the result without connected D-STATCOM along with distribution line and r.m.s voltage value is 0.92p.u which is less than 1 p.u. and the sinusoidal waveform of system is not perfectly sinusoidal.

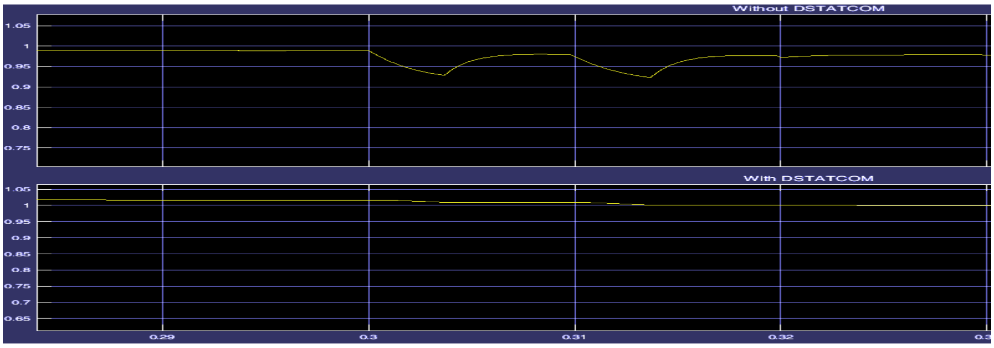

Fig 3.2 (b), L-L fault waveform with and without D-STATCOM

Fig. 3.2 (b), shows the voltage rms value is 0.92 p.u when D-STATCOM is utilize along with distribution line and regulate the voltage near to 1p.u. for duration of fault and achieves the sinusoidal waveform at the load terminal.

3.3 Double line to ground fault (LL-G Fault)

In case of LL-G Fault, phase B and phase C is short circuit and has their fault impedance value ZF, both conductors are connected to the ground after a fault through a common line and has the value of ground impedance Zg.

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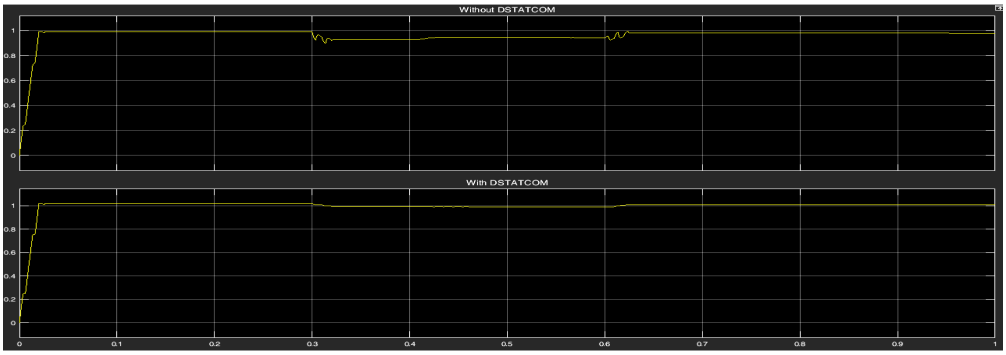

Fig 3.3 (a), LL-G fault waveform with and without D-STATCOM

Fig 3.3(a), presents the result when D-STATCOM is not used in distribution system, and shows the r.m.s voltage value is 0.90 p.u which conclude that the waveform is not sinusoidal.

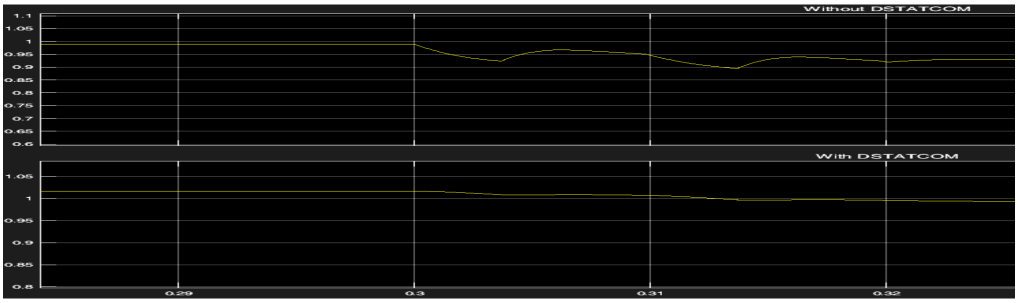

Fig 3.3 (b), LL-G fault waveform with and without D-STATCOM

Fig. 3.3 (b), shows the rms value is 1.00 p.u, when D-STATCOM is utilize along with system. D-STATCOM regulate the voltage 0.90 p.u to 1.00 per unit. Regulate voltage is 0.25 p.u duration of fault and achieved waveform is sinusoidal at the load terminal.

3.4 Three phase fault

Three phase fault is known as symmetrical fault which involves all the three phases A, B and C.

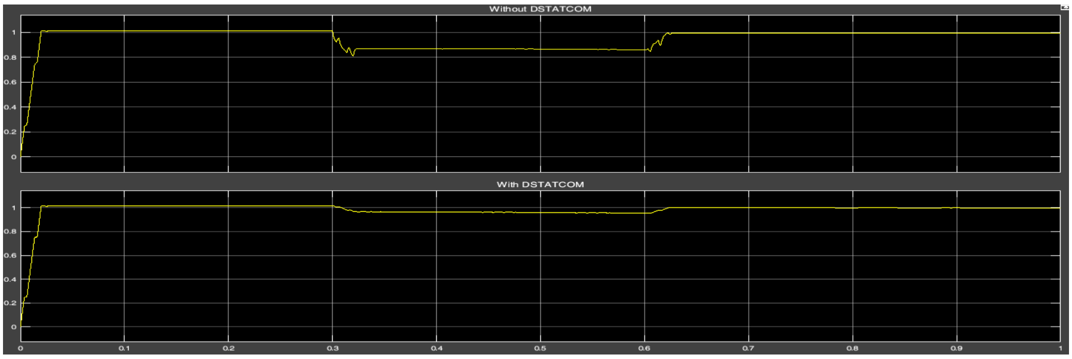

Fig 3.4 (a), Three phase fault with and without D-STATCOM

Fig 3.4 (a), presents the r.m.s voltage value is 0.80p.u duration of 0.3 sec- o.6 sec this result is achieved when D-STATCOM is not connected along with distribution line. In this case, voltage sag takes place.

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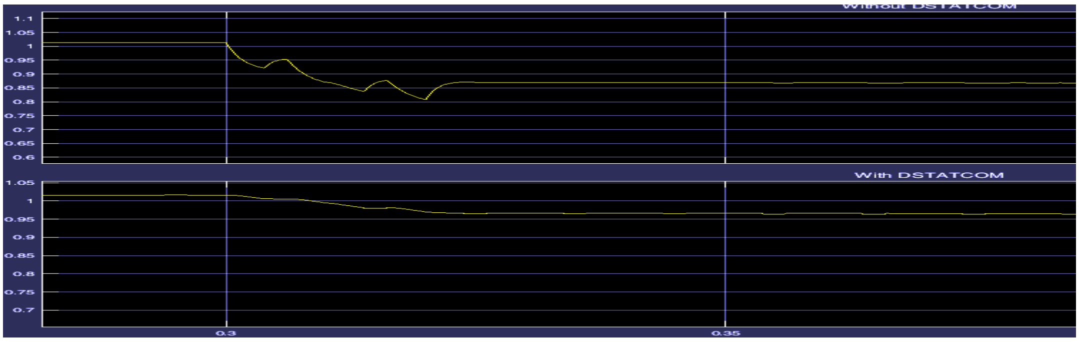

Fig 3.4 (b), Three phase fault with and without D-STATCOM

Fig. 3.4 (b) shows the rms value is 0.96 p.u when D-STATCOM is connected with system. It regulates the voltage 0.80 p.u to 0.96 per unit during fault occur time (0.3 sec - 0.6 sec). D-STATCOM is used to get sinusoidal balanced waveform at the load terminal in power distribution system.

3.5 Three phase to ground fault

In three phase fault to ground, all the phase is involves with fault and connected with ground. This fault destroys the sinusoidal wave and causes to the unbalanced condition at the near non-linear load.

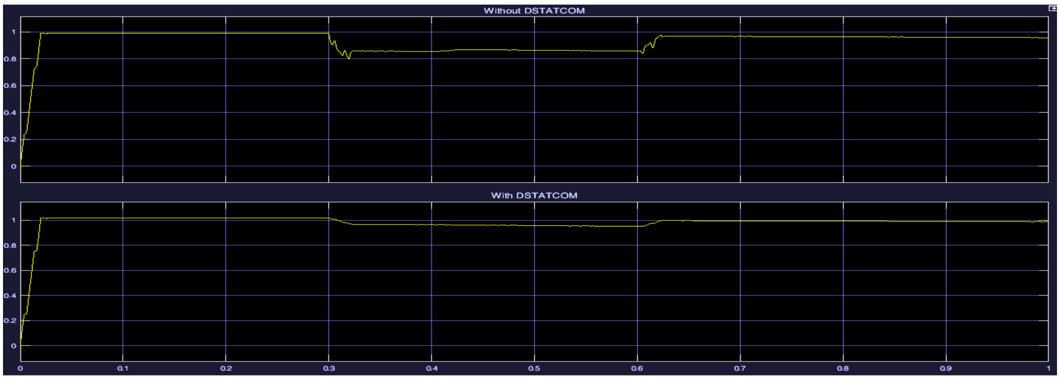

Fig 3.5 (a), Three phase to ground fault with and without D-STATCOM

Fig. 3.5 (a) presents the three phase fault to ground and result shows the r.m.s voltage value is 0.80p.u during the time 0.3 sec- 0.6 sec, this duration is fault occurring time and D-STATCOM is not connected with the distribution line, the waveform is not sinusoidal at the load terminal.

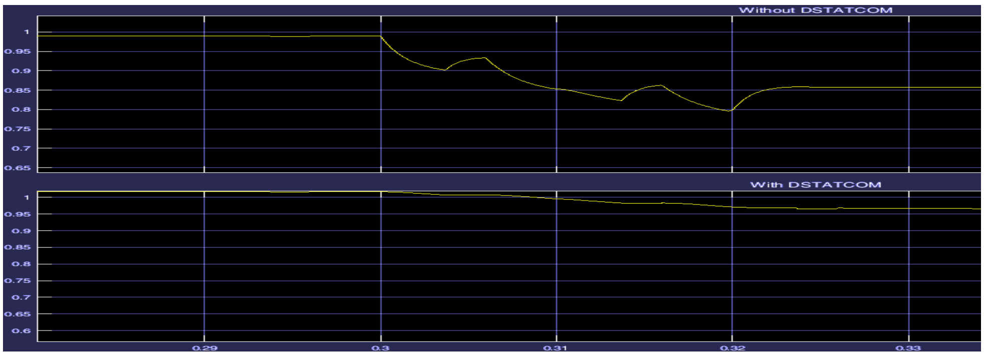

Fig 3.5 (b), Three phase to ground fault with and without D-STATCOM

Fig. 3.5 (b), shows the rms value is 0.97p.u when D-STATCOM is connected along with system; it is regulate the voltage 0.80 p.u. to 0.97p.u. D-STATCOM regulating value is 0.17 per unit during fault condition and achieved waveform is sinusoidal at the load terminal in power distribution system.

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3.6 Swell Fault Condition

In swell fault condition, a momentary increase of the voltage at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

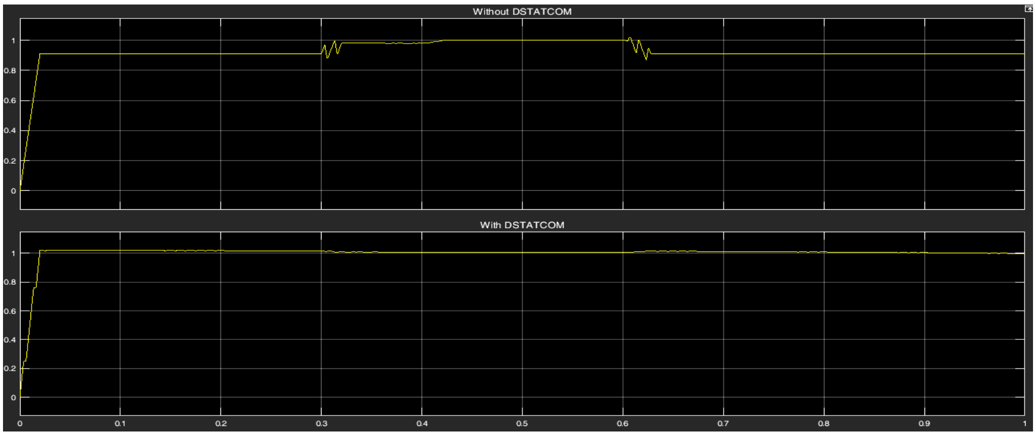

Fig 3.6 (a), Swell fault condition with and without D-STATCOM

Fig. 3.6 (a) presents the swell fault condition and result shows the r.m.s voltage value is 1.03 p.u during the time 0.3 sec- 0.6 sec, this duration is fault occurring time and D-STATCOM is not connected with the distribution line, the waveform is not sinusoidal at the load terminal.

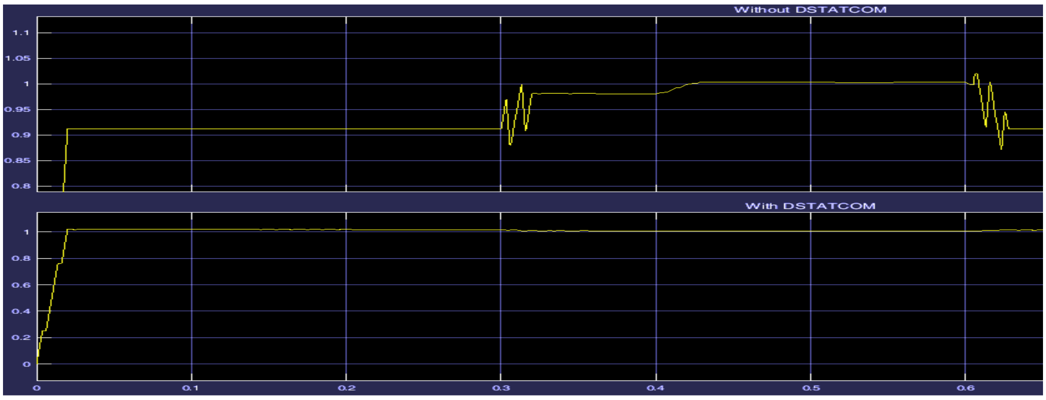

Fig 3.6 (b), Swell fault condition with and without D-STATCOM

Fig. 3.6 (b), shows the rms value is 1.03 p.u when D-STATCOM is connected along with system; it is regulate the voltage 1.03 p.u. to 1.00 p.u. D-STATCOM regulating value is 0.03 per unit during fault condition and achieved waveform is sinusoidal at the load terminal in power distribution system.

IV.RESULT AND DISCUSSION

In this paper, two different cases voltage sag and another is voltage swell. In two cases we have consider 6 different fault conditions for testing of system. Different fault conditions are 3-Phase Short Circuit Fault, 3-Phase Ground Fault, Line to Ground Fault, Line to Line Fault, Line-Line to Ground Fault and Swell Condition. The results for each fault condition are given below one by one.

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Fault Condition	Without D-STATCOM Voltage (RMS Value) p.u	With D-STATCOM Voltage (RMS Value) p.u	Power Quality Improvement (p.u.)
S-L-G Fault	0.94 p.u	1.00 p.u	0.06
L-L Fault	0.92 p.u	1.00 p.u	0.08
LL-G Fault	0.90 p.u	1.00 p.u	0.10
Three Phase Fault	0.80 p.u	0.96 p.u	0.16
Three Phase to Ground Fault	0.80 p.u	0.97 p.u	0.17
Swell Condition	1.03 p.u	1.00 p.u	0.03

V. CONCLUSION

The PWM voltage control scheme of D-STATCOM is used to manage the load voltage under the symmetrical and unsymmetrical faults, the D-STATCOM can regulate the load voltage to the required level is described during this paper. The performance of DSTATCOM has been evaluated for linear-loads and static non-linear loads. during this paper, the issues related to faults determination and appropriate DSTATCOM place and proper D-STATCOM injected reactive power rating which causes improvement of voltage profile and reduce the ability loss in facility network. Pulse width modulation control scheme is acceptable for both unbalanced load compensation and balanced RC or RL load. during this paper, the exploration of the D-STATCOM is disbursed to improvement the ability quality in power distribution networks within static linear and non-linear loads. Proportional-Integral (PI) controller is used within device to enhance system performance. The results show the satisfactory performance of DSTATCOM within the distribution system under different fault conditions and it may be concluded that DSTATCOM effectively improves the facility quality and voltage profile in power distribution system.

REFERENCES

[1] Amit Kumar, Nidhi Singh Pal and M.A.Ansari.: Mitigation Voltage Sag/Swell, Harmonic Compensation Using Self-Supported DVR", Ist IEEE International Conference on Power Electronics, intelligent Control and Energy Systems (ICPEICES-2016), pp 393-399, 2016

[2] S.M. Woo, D.W. Kang, W.C. Lee, and D.S. Hyum.: The Distribution STATCOM for Reducing the Effect of Voltage Sag and Swell, IECON’01, vol. 2, pp. 1132-1137, 2001.

[3] S.Y. Park and J.K. Park.: The Modeling and Analysis of Shunt type Custom Power Device, IEEE Power Engineering Society Winter Meeting, vol. 1, pp. 186 - 191, 2001.

[4] H.K. Chiang, B.R. Lin, K.T. Yang, and C.C. Yang.: Analysis and Implementation of a NPC-Based DSTATCOM under the Abnormal Voltage Condition, Industrial Technology 2005, International Conference on, pp. 665 – 670, December 2005.

[5] Muni, B., Rao, S., & Vithal.: SVPWM Switched DSTATCOM for Power Factor and Voltage Sag Compensation. In 2006 International Conference on Power Electronics, Drives and Energy Systems, PEDES ’06 (pp. 1–6). New Delhi, India. 2006.

[6] Kumar, C., & Mishra, M. K.: A voltage-controlled DSTATCOM for power-quality improvement, IEEE Transactions on Power Delivery, 29(3), pp-1499–1507. 2014.

[7] Geddada N, Karanki and SB, Mishra.: Synchronous reference frame based current controller with SPWM switching strategy for DSTATCOM Applications, in Proceedings of IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES) 2012, December16–19, Bengaluru, India.

[8] B.Singh , P.Jayaprakash and DP. Kothari.: A T-connected transformer and three-leg VSC based DSTATCOM for power quality improvement. Proceedings of IEEE Transactions on Power Electronics, 23, 2710–2718,2008.

[9] Bilgin HF and Ermis M.: Design and implementation of a current source converter for use in industry applications of D-STATCOM, Proceedings of IEEE Transactions on Power Electronics, 25, 1943–1957. 2010.

[10] Deben Singh M, Khumanleima Chanu L.: Power electronics technology for power quality improvement, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 4, 2073–2080. 2015. DOI: 10.15662/ijareeie.2015.0404031.

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|| Volume 10, Issue 8, August 2021 ||

| DOI:10.15662/IJAREEIE.2021.1008006 |

[11] Ghosh, A., Jindal, A.K. and Joshi, A.: Inverter Control Using Output Feedback for Power Compensating Devices, Conference on Convergent Technologies for Asia Pacific Region, 2003, pp. 48-52.

[12] B. Singh, P. Jayaprakash, and D.P. Kothari.: Three-phase four-wire dstatcom with H-bridge VSC and star/delta transformer for power quality improvement, in Proc. of INDICON 2008, Vol. 2, Dec. 2008, pp.412 - 417.

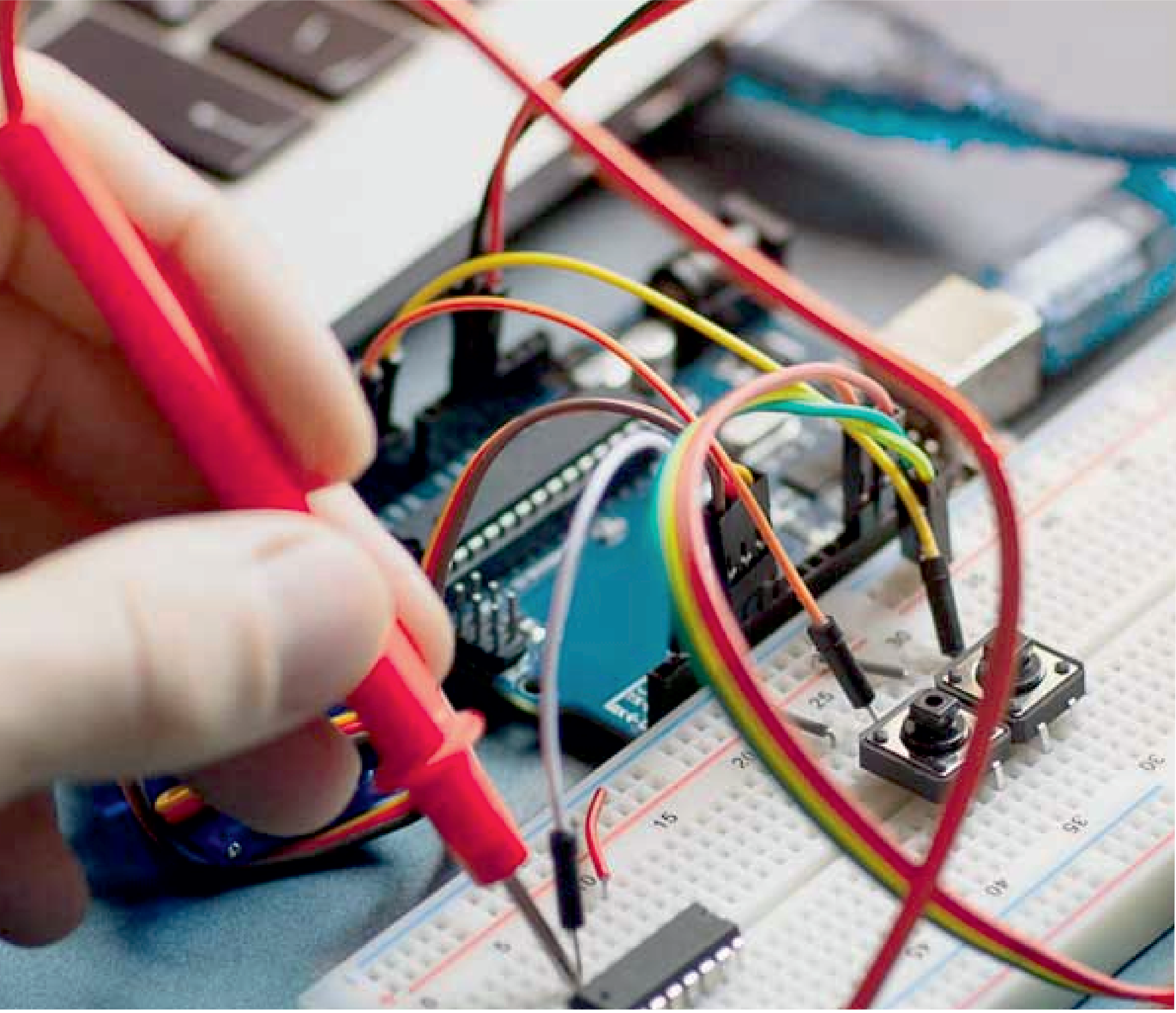
[13] P. Jayaprakash, B. Singh, and D.P. Kothari.: Three-Phase 4-Wire DSTATCOM Based on H-Bridge VSC with a Star/Hexagon Transformer for Power Quality Improvement, in Proc. of ICIIS 2008, Dec. 2008, pp.1-6.

[14] M. Tavakoli Bina,M.D. Eskandari and M. Panahlou.: Design and installation of a ±250 kVAr D-STATCOM for a distribution substation, Elsevier, Electric Power Systems Research vol73 pp.383–391,2005. doi:10.1016/j.epsr.2004.09.005.

[15] M. Tavakoli Bina, M. Eskandari, Consequence of unbalance supplying condition on a distribution static compensator, in: IEEE Power Electronics Specialists (PESC'04), vol. 8, June 2004, pp. 3900– 3904.

[16] Bhim Singh, Alka Adya, A.P. Mittal, J.R.P Gupta.: Power Quality Enhancement with DSTATCOM for Small Isolated Alternator feeding Distribution System, conference on Power Electronics and Drive Systems, vol.1, pp. 274-27, 2005.

[17] Amit Kumar, Deepak Kumar, Abhay Yadav, "Mitigation of Power Quality Problems and Harmonics Compensation Using Capacitor-Supported Dynamic Voltage Restorer (Dvr)", *Journal of Electrical Engineering (JEE),* Volume-17, 2017.



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