# Simulation and Design Analysis of DSTATCOM and DVR for Improving Power Quality in Distribution Networks

*Rashid Anwar*[*1], *Priyanka Maheshwari*[2], *Dr. Sanjay Jain*[3]
*M.Tech (Electrical Power System) Scholar, RKDF University Bhopal, India*[*1]
*Assistant Professor, Department of Electrical Engineering, RKDF University Bhopal, India*[2]
*Head of Department, Department of Electrical Engineering, RKDF University Bhopal, India*[3]
*rashidanwar526@gmail.com*[*1], *priyankabits4@gmail.com*[2], *jain.san12@gmail.com*[3]

***Abstract*** **- Power disturbances, as an instance like voltage sags, voltage swell, transients and harmonics will occur at any time and could reason damaging end result to the machines or instrumentation walking in the industries. As a end result, it reason a few disturbance and losses to the industries. Thus, we would want to finish the consequences of the issues that accompanied those disturbances. By observance and analyzing, with a few amount of simulations on those events, we are able to advantage a miles higher know-how concerning those electricity fine troubles. Afterwards, we are able to take measures to guard the affected instrumentation or increase the usual of electricity offer. Harmonic interferences in grid, that rectangular degree because of harmonic production hundreds like diode, or thyristor converters and cyclo converters, are severe troubles to resolve. Passive filters along with a financial institution of tuned LC filters and/or a excessive-byskip clear out out are wont to suppress harmonics because of a espresso preliminary fee and excessive potency.**

**This paper proposes to test the reassets of voltage sag, the strategies of correcting the supply voltage sag in radial distribution system and reactive power repayment with the aid of using 2 strength digital based frequently gadgets especially DSTATCOM (Distribution Static Synchronous Compensator), and DVR (Dynamic Voltage Restorer). The paper targets to simulate and examine those gadgets in magnetic enchantment temporary applications victimization MATLAB This paper specialize withinside the assessment of DSTATCOM and DVR with the simulation results.**

**Index Terms - Power Quality Problems, Power System Restructuring, Voltage Sag, DSTATCOM, DVR, MATLAB.**

## I. INTRODUCTION

The dreams of the strength gadget are to supply strength to terminals of electrical system, and to attend to the voltage on the instrumentation terminals in certain limits. For a few years evaluation and mastering are targeted at the number one aim. Eminence of offer become seldom a matter. A change in attitude handed perhaps inside the early 1980s. Initial in generating and business strength structures and distribution to the overall public offer, the ability great problems appeared. Power great is in reality a tremendous subject inside the gift era; it will become specifically important with the advent of diffused gadgets, whose overall performance is extraordinarily touchy to the usual of strength offer. ultra-modern business procedures are primarily based totally broadly speaking an oversized amount of digital gadgets like programmable good judgment controllers and adjustable velocity drives. The digital gadgets are extraordinarily touchy to disturbances [1] and consequently business hundreds subsided tolerant to strength great problems like voltage dips, voltage swells, and harmonics. Voltage dips are idea of 1 many of the major intense disturbances to the financial instrumentation t. A paper system can be complete of disturbances of a hundred percentage loose fall lasting for 100ms. A voltage dip of seventy fifth (of the nominal voltage) with duration shorter than 100ms can also additionally emerge as in fabric loss inside the range of hundreds humans greenbacks for the semiconductors business [2]. Swells and over voltages will motive over heating tripping or perhaps destruction of business instrumentation like motor drives. Electronic equipments are extraordinarily touchy hundreds towards harmonics due to their control relies upon on both the peak fee or the 0 crossing of the prepared voltage, which are all inspired through the harmonic distortion. This paper analyzes the important thing troubles inside the Power Quality problems, especifically maintaining in thoughts this fashion in the direction of extra and spread generation) and ensuing restructuring of power transmission and distribution networks. in concert of the outstanding power quality issues, the origin, consequences and mitigation techniques of voltage sag drawback has been mentioned well. The study describes the techniques of correcting the availability voltage sag in a very distribution system by 2 power physical science based mostly devices referred to as Dynamic Voltage restorer (DVR) and Distribution STATCOM (D-STATCOM).A DVR voltage in series with the system voltage and a D-STATCOM injects a current into the system to correct the voltage sag [1]. The steady state performance of each DVR and D-STATCOM is studied for varied levels of voltage sag levels.

## II. SOURCES AND EFFECTS OF POWER QUALITY PROBLEMS

The alteration in the quality of supply power can be introduced /improved at various stages; however, some of the primary sources of distortion [3] can be recognized as below:

A. Power Electronic Devices

B. IT and Office Equipments

C. Arcing Devices

D. Load Switching

E. Large Motor Starting

F. Embedded Generation

G. Electromagnetic Radiations and Cables

H. Storm and Environment Related Causes etc.

While power disturbances take place on all electrical systems, the sensitivity of today's complicated electronic devices makes them more vulnerable to the quality of power supply. For a number of susceptible devices, a momentary disorder can reason to scrambled data, broken up equipment failure etc. A power voltage point can damage precious components. Some of the ordinary power quality issues and their well-known impact are summarized in the table below:

Table1: Various power quality problems and their effects

| PARAMETERS | REFERENCE LIMITS | REFERENCE STANDARD |
|---|---|---|
| Power Frequency | Mean value of fundamental measured over 10 s: +/- 2% for 99.5% of week; | EN 50160 |
| Voltage magnitude variations | +/- 10% for 95% of week, mean 10min RMS values (LL / LN); | EN 50160 |
| Rapid voltage changes | 3% normal, 4% maximum, $P_{st}<1$, $P_{lt}<0.65$ | EN 61000-2-12 |
| Voltage Swells / dips | LV: 10-50%; Locally limited swells / dips caused by load switching: swell/dip up to 30% of V-RMS and duration up to 10ms; | EN 50160 EN 61000-6-1-2 |
| Short interruption of supply voltage | 95% reduction for 5seconds; | EN 61000-6-1 & 6-2 |
| \Long interruption of supply voltage | LV-MV: (up to 3 minutes) <10-50/year, EN 50160. | EN 50160 |
| Transient over-voltage | +/- 2KV (Line to Earth), +/- 1KV (Line to Line). 1.2KV/50KA(8/20us) Tr/TH us; | EN 61000-6-1 & 6-2 |
| Supply voltage unbalance | Positive, negative and zero sequence; 2% between Line to Line; | EN 61000-2-12 |
| Load unbalance | Positive, negative and Zero sequence, leakage currents <500Ma | EN 50160 |
| Harmonics voltage | V-THD<5%, Individual V-h <3%; | IEEE 519 |
| Harmonics current | I-THD %: as defined by ratio of I(short circuit)/I(full load); | IEEE 519 |

## III. SOLUTIONS TO POWER QUALITY PROBLEMS

There are 2 approaches to the mitigation of power quality issues. The answer to the power quality may be done from client aspect or from utility aspect [4]. 1st approach is termed load learning that ensures that the instrumentality is a smaller amount sensitive to power disturbances, permitting the operation even beneath important voltage distortion. The other solution is to put in line acquisition systems that suppress or counteracts the facility system disturbances. A versatile and versatile resolution to voltage quality issues is obtainable by active power filters. Currently they're supported PWM converters and connect with low and medium voltage distribution system in shunt or in series. Series active power filters should operate in conjunction with shunt passive filters so as to compensate load current harmonics. Shunt active power filters operate as a governable current supply and series active power filters operates as a manageable voltage supply. Each schemes area unit enforced desirable with voltage supply PWM electrical converter s [5], with a dc bus having a reactive part like a capacitance. Active power filters will perform one or additional of the functions needed to compensate power systems and up power quality.

Their performance conjointly depends on the facility rating and also the speed of response. However, with the restructuring of power sector and with shifting trend towards distributed and distributed generation, the road learning systems or utility aspect solutions can play a serious role in up the inherent provide quality; a number of the effective and economic measures may be known as following:

A. Lightening and Surge Arresters:

Arresters are planned for lightening safety of transformers, but are not adequately voltage restrictive for shielding sensitive electronic control circuits from voltage surges.

B. Thyristor Based Static Switches:

The static switch may be a versatile device for shift a alternative element into the circuit as soon as the voltage aid is needed. It's a dynamic time c program languageperiod of concerning one cycle. To accurate quick for voltage spikes, sags or interruptions, the static transfer will accustomed transfer one or a variety of gadgets like electric tool, clear out out, exchange energy line, power garage structures etc. The static transfer is hired withinside the exchange energy cable applications. This subject matter requires 2 impartial energy strains from the application or can be from application and localized energy era like the ones simply in case of disbursed producing structures [4]. Such a subject matter will guard as much as concerning 80 5 take blessings of interruptions and voltage sags.

C. Energy Storage Systems: Storage structures are frequently used to guard sensitive manufacturing equipments from shutdowns because of voltagesags or brief interruptions. These place unit generally DC garage structures like UPS, batteries, superconducting magnet power garage (SMES), garage capacitors or perhaps fly wheels using DC generators [6]. The output of those gadgets are frequently prepared to the device thru companion diploma electric converter on a brief foundation through a short performing electronics witch. Enough power is fed to the device to finish the power so that it will be misplaced through the voltage sag or interruption. Just in case of application offer subsidized through a localized era this can be even better accomplished.

D. Electronic faucet converting transformer: A voltage-regulating electric tool with companion diploma digital load tap changer are frequently used with one line from the application. It will modify the voltage drops as much as 5 hundredth and wishes a stiff device (brief circuit energy to load significance relation of 10:1 or better). It may have the supply of coarse or graceful steps intended for occasional voltage variations.

E. Harmonic Filters Filters place unit hired in a few times to efficaciously cut back or remove sure harmonics [7]. If doable, it is usually most well known to apply a 12-pluse or better electric tool association, in preference to a clear out out. Tuned harmonic filters must be used with warning and prevented as soon as doable. Usually, a couple of filters place unit required, each tuned to a separate harmonic. Every clear out out reasons a parallel Resonance moreover as a sequence resonance, and each clear out out barely adjustments the resonances of opportunity filters.

F. Constant-Voltage Transformers:

For many electricity high-satisfactory studies, it is viable to significantly enhance the sag and momentaneous interruption tolerance of a facility through defensive control circuits. Constant voltage electric device (CVTs) can be used [6] on control circuits to deliver regular voltage with three cycle journey through, or relays and ac contactors can be given digital coil hold-in gadgets to forestall mis-operation from both low or interrupted voltage.

G. Digital-Electronic and Intelligent Controllers for Load-Frequency Control:

Frequency of the supply electricity is one among the main determinants of power quality, that affects the Instrumentation overall performance extraordinarily drastically. Even the primary device factors like rotary engine lifestyles and interconnected-grid control are immediately complete of electricity frequency. Load frequency controller used specially for governing electricity frequency under variable loads must be brief sufficient to create adjustments towards any deviation. In nations like Republic of India and opportunity nations of growing world, nevertheless use the controllers which are primarily based totally on the whole both or mechanical or electric gadgets with inherent lifeless time and delays and every now and then moreover be afflicted by growing old and related effects. In destiny perspective, such cont rollers will be replaced via way of means of their Digital -digital counterparts. IV. USE OF CUSTOM POWER DEVICES TO IMPROVE POWER QUALITY In order to conquer the troubles just like the ones referred to on pinnacle of, the concept of custom electricity gadgets is delivered recently; custom electricity might be a approach this is designed mainly to meet the desires of commercial and industrial client. The concept of custom electricity is to apply electricity digital or static controllers withinside the medium voltage distribution device progressing to deliver dependable and excessive nice electricity to touchy users [1]. Power digital valves are the idea of those custom electricity gadgets just like the static transfer switch, lively filters and converter-primarily based totally gadgets. Converter primarily based totally electricity electronics gadgets can be divided in to two groups: shunt-linked and collection-linked gadgets. The shunt linked gadgets is known due to the fact the DSTATCOM and additionally the collection tool is known due to the fact the Static Series Compensator (SSC), commercially known as DVR. it is also been stated in literature that every the SSC and DSTATCOM had been used to mitigate the bulk the electricity device disturbances like voltage dips, sags, flicker unbalance and harmonics. For lower voltage sags, the load voltage magnitude can be corrected by injecting solely reactive power into the system. However, for higher voltage sags, injection of active power, additionally to reactive power, is important to correct the voltage magnitude [8]. Each DVR and DSTATCOM are capable of generating or absorbing reactive power however the active power injection of the device must be provided by an external energy supply or energy storage system. The time interval of each DVR and DSTATCOM is terribly short and is proscribed by the power electronics devices. The expected time interval is about25 ms, and that is far but a number of the traditional strategies of voltage correction like tap - changing transformers.

V. MODELING OF CUSTOM POWER DEVICES ANDSIMULATION RESULTS

As mentioned in the previous section that custom power devices could be the effective means to overcome some of the major power quality problems by the way of injecting active and/or reactive power(s) into the system [9]-[11].

This section of the paper deals with the modeling of DSTATCOM and DVR. Consequently some case studies will be taken up for analysis and performance comparison of these devices. The modeling approach adopted in the paper is graphical in nature, as opposed to mathematical models embedded in code using a high-level computer language. The well-developed graphic facilities available inan industry standard power system package, namely, MATLAB (/Simulink) [12], is used to conduct all aspectsof model implementation and to carry out extensive simulation studies.The control scheme for these devices is shown in Fig.1.

The controller input is an error signal obtained from thereference voltage and the value rms of the terminal voltage measured. Such error is processed by a PI controller andthe output is the angle δ, which is provided to the PWM signal generator. The PWM generator then generates thepulse signals to the IGBT gates of voltage source converter

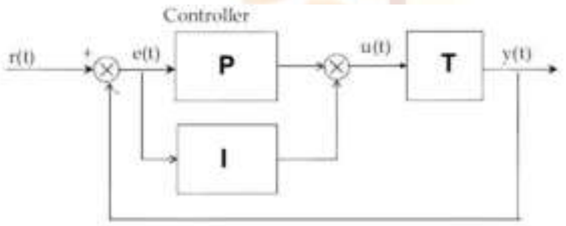



Fig.1. The PI Controller

The modeling of D-STATCOM, the simplified model is validated comparing it with the detailed model by using electromagnetic transient simulations, the well-developed graphic facilities available in an industry standard power system package, namely, MATLAB.

The test system is shown in Fig 2 is used for comparing the performance of D-STATCOM. Such a system is comprised of a 25kV, 230-MVA, 50-Hz substation, represented by a Thevenin equivalent, feeding a distribution network. And at load point a small load of resistance 0.05 ohm and inductance of 0.4806 H are connected through switches S1 and S2 respectively[9]. Performance of the devices can be obtained by opening and closing these switches and varying the terminal voltage at bus 3.

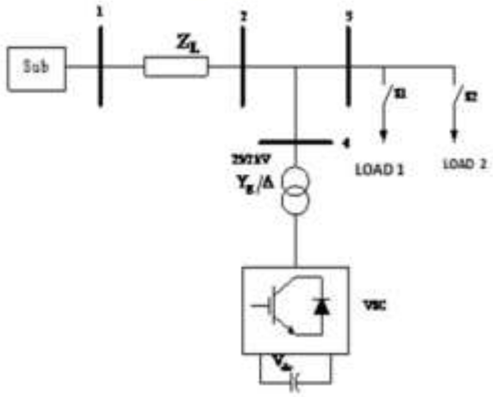



Fig 2 Single-line Diagram of the test system with DSTATCOM.

The performance of VSC based power devices acting as a voltage controller is investigated. Moreover, it is assumed that the converter is directly controlled (i.e., both the angular position and the magnitude of the output voltage are controllable by appropriate on/off signals) for this it requires measurement of the rms voltage and current at the load point[11]. Although a directly controlled converter is more difficult and expensive to implement than an indirectly controlled converter, which requires only measurement of the rms voltage at load point the former presents superior dynamic performance.

5.2.1 Simulation Procedure

The system consists of two parallel feeders with similar loads of similar ratings and static non linear load is taken. One line is connected to DSTATCOM while other one is kept as it is. The system has been analyzed under different fault conditions. The simulations of the D-STATCOM in fault condition are done using unbalanced and balanced faults. In SLG fault analysis, phase A is the faulted phase, while in DPG fault the faulted phases are phases A and B. In addition, in three-phase fault, the faulted phases are phases A, B, and phase C.

A. Simulation results for SLG fault

In this case a single line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-4(a) and Figure-4(b) respectively.

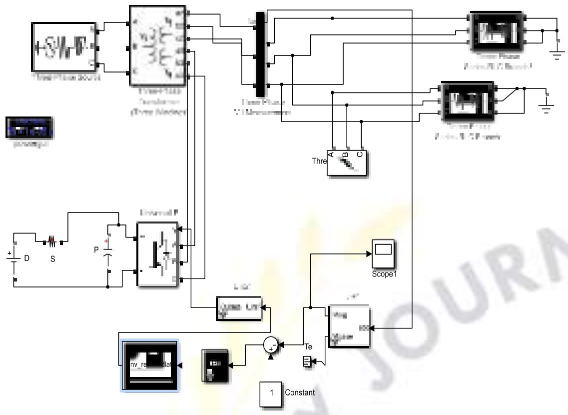



Fig.3 MATLAB Simulation model of D-STATCOM

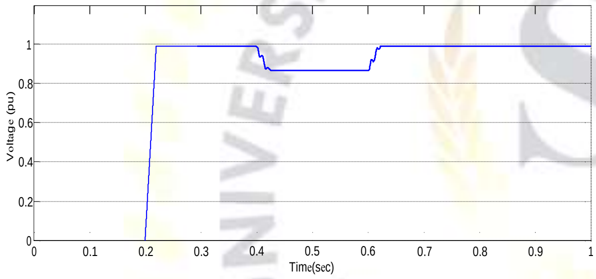



Fig.4(a) Terminal voltage when LG fault without DSTATCOM

When the Switch closes, the D-STATCOM supplies reactive power to the system. In spite of sudden load variations, the regulated rms voltage shows a reasonably smooth profile, where the transient overshoots are almost nonexistent

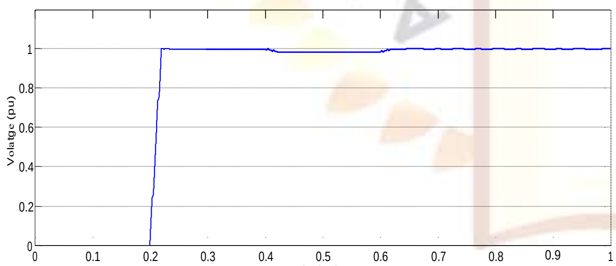



Fig.4(b) Terminal voltagewhen LG fault with DSTATCOM;

B. Simulation results for LL fault

In this case a line to line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-5(a) and Figure-5(b) respectively.

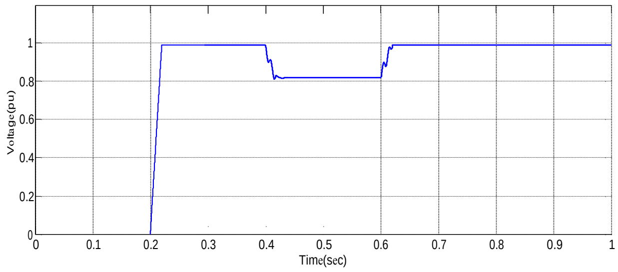



Fig.5(a) Terminal voltage when LL fault without DSTATCOM

When D-STATCOM apply to the system terminal voltage give the following wave form.

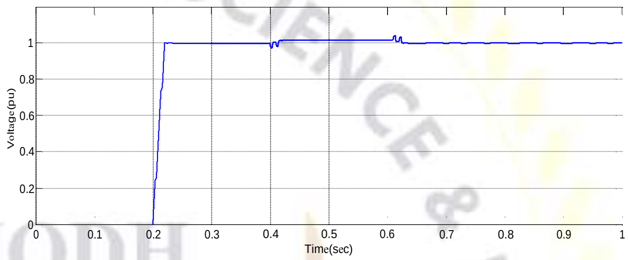



Fig.5(b) Terminal voltage when LL fault with DSTATCOM

C. Simulation results for DLG fault

In this case a double line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-6(a) and Figure-6(b) respectively.

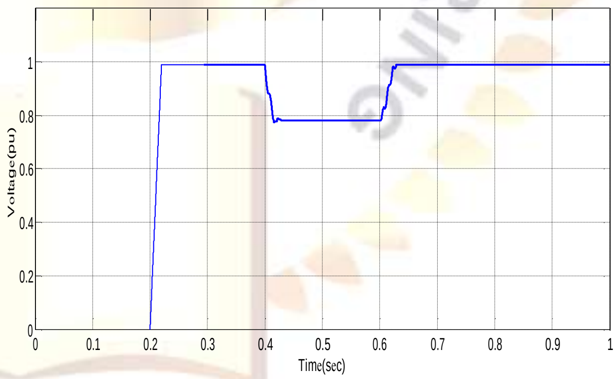



Fig.6(a) Terminal voltage when DLG fault without DSTATCOM

When D-STATCOM apply to the system terminal voltage give the following wave form.

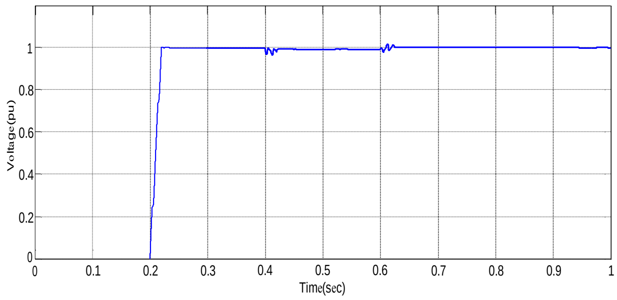



Fig.6(b) Terminal voltage when DLG fault with DSTATCOM

D. Simulation results for LLLfault

In this case a double line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-7(a) and Figure-7(b) respectively.

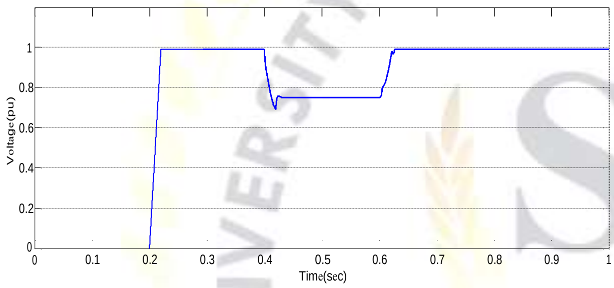



Fig.7(a) Terminal voltage when LLL fault without DSTATCOM

Fig shows that when fault is created is increasing during the fault duration in the uncompensated feeder. And the system where DSTATCOM is connected unbalancing is reduced.

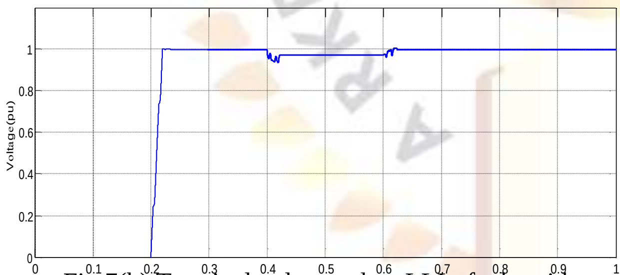



Fig.7(b) Terminal voltage when LLL fault with DSTATCOM

DVR (Dynamic Voltage Restorer)

In this section, the thesis deals with the modeling of DVR. The test system is shown in Fig 5.11 is used showing the performance of DVR. Such a system is comprised of a 13 kV, 230-MVA, 50-Hz substation, represented by a Thevenin equivalent, feeding a distribution network. And at load point a small load of resistance 0.05 ohm and inductance of 0.4806 H are connected through switches S1 and S2 respectively are connected through switches S1 and S2 respectively. Performance of the devices can be obtained by opening and closing these switches and varying the terminal voltage at bus 3.

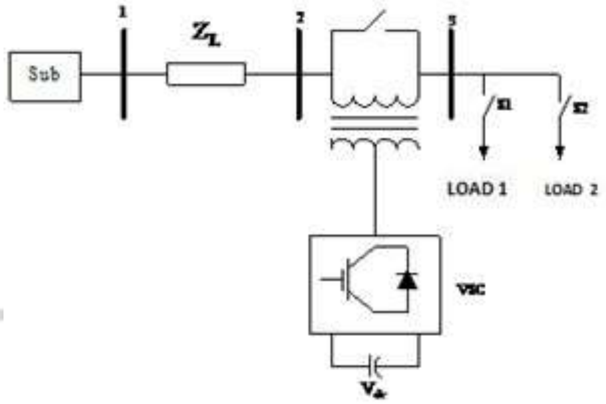



Fig 8 Single-line diagram of the test system with DVR.

5.3.1 Simulation Procedure

The test system implemented in MATLAB is employed to carry out the simulations concerning the DVR actuation is shown in Fig. 9 Such network is composed by a 13 kV, 50 Hz generation system, feeding a transmission line through an 3-winding transformer

A. Simulation results for SLG fault

In this case a single line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-10(a) and Figure-10(b) respectively.

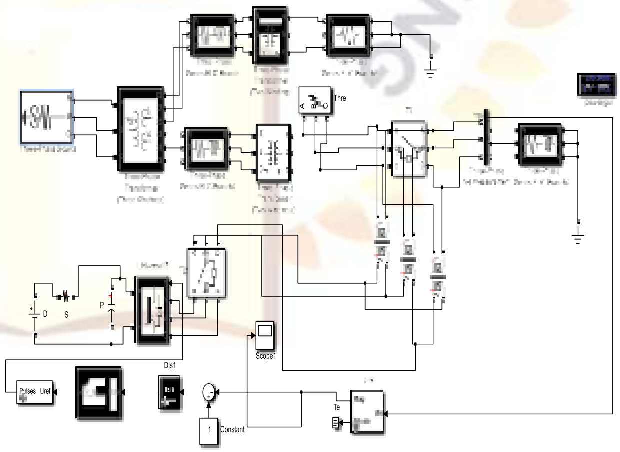


Fig.9 MATLAB Simulation model of DVR

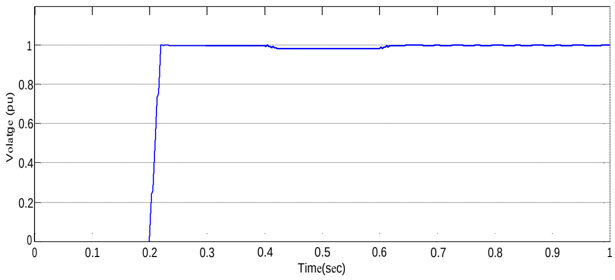



Fig.5.10(a) Terminal voltage when LG fault without DVR

When the Switch closes, the DVR supplies reactive power to the system. In spite of sudden load variations, the regulated rms voltage shows a reasonably smooth profile, where the transient overshoots are almost nonexistent

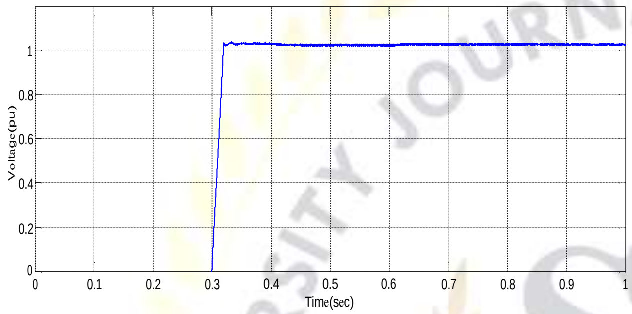



Fig.10(b) Terminal voltage when LG fault withDVR;

B. Simulation results for LL fault

In this case a line to line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-11(a) and Figure-11(b) respectively.

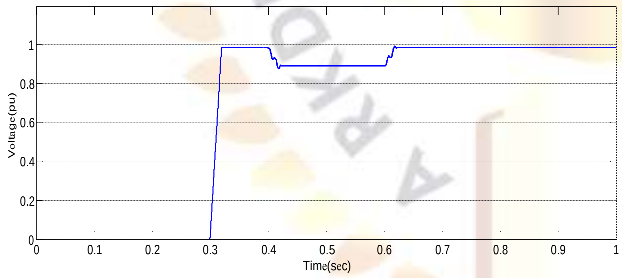
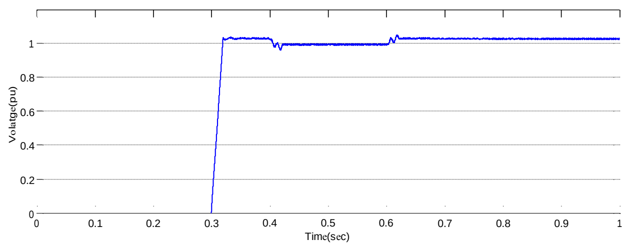



Fig.11(a) Terminal voltage when LL fault without DVR

When DVR apply to the system terminal voltage give the following wave form.




C. Simulation results for DLG fault

In this case a double line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-12(a) and Figure-12(b) respectively.

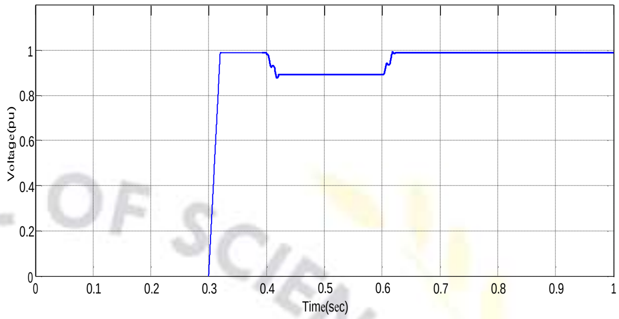



Fig.12(a) Terminal voltage when DLG fault without DVR

When DVR apply to the system terminal voltage give the following wave form.

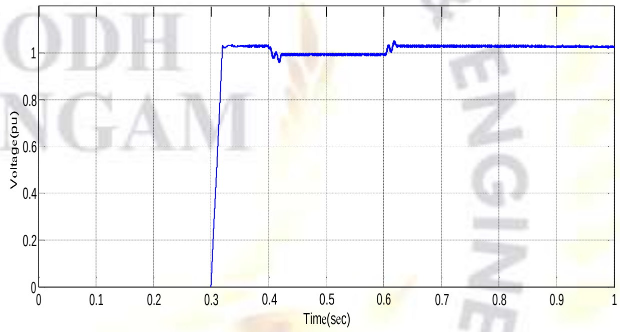



Fig.12(b) Terminal voltage when DLG fault with DVR

D. Simulation results for LLL fault

In this case a double line to ground fault is considered for one feeder and the fault resistance is 0.86 ohm. The fault is created for the period of 0.4s to 0.6s. Output waveforms of the load current with compensation and without compensation is shown in Figure-13(a) and Figure-13(b) respectively.

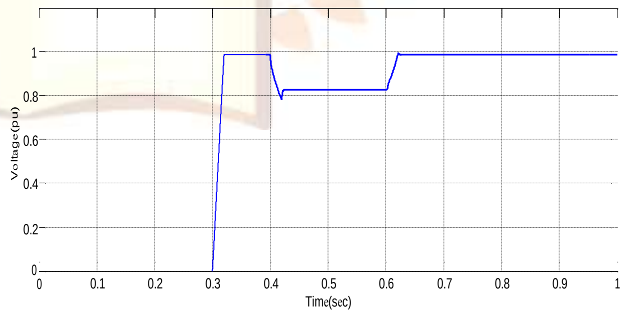



Fig.13(a) Terminal voltage when LLL fault without DVR

Fig shows that when fault is created is increasing during the fault duration in the uncompensated feeder. And the system where DVR is connected unbalancing is reduced.

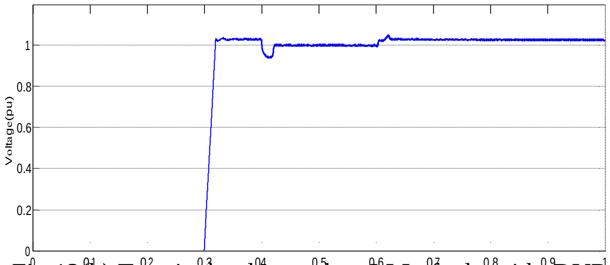



Fig.13(b) Terminal voltage when LLL fault with DVR

E. Simulation Results for SLG Fault with DVR and D-Statcom

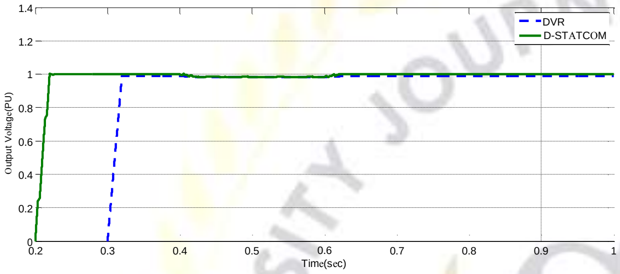



Fig.14 Terminal voltage when LG fault with DVR and D-STATCOM

Fig 14shows that whenLG fault occurs in a system D-STATCOMgive the better result as compared to DVR

F. Simulation Results for LL Fault with DVR and D-Statcom

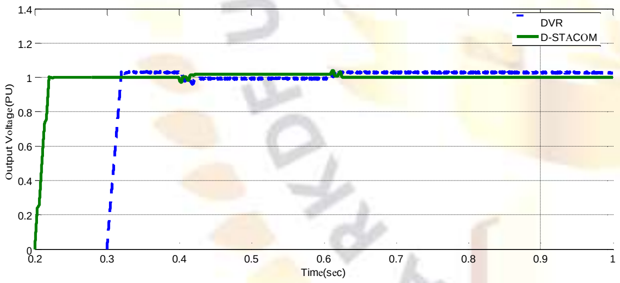



Fig.15 Terminal voltage when LLfault with DVR and D-STATCOM

Fig. 15 shows that when LL fault occurs in a system D-STATCOM give the better result as compared to DVR.

G. Simulation Results for LLG Fault with DVR and D-Statcom

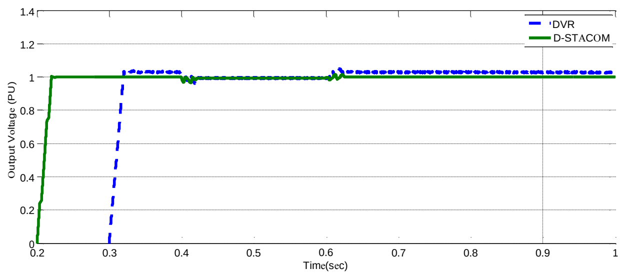



Fig.16 Terminal voltage when LLG fault with DVR and D-STATCOM

Fig.16 shows that when LLG fault occurs in a system D-STATCOM give the better result as compared to DVR

H. Simulation Results for LLL Fault with DVRand D-Statcom

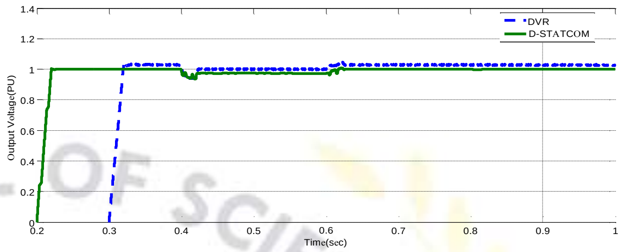



Fig.17 Terminal voltage when LLLfault with DVR and D-STATCOM

Fig. 17 shows that when LLL fault occurs in a system D-STATCOM give the better result as compared to DVR.

## CONCLUSION

Predominant purpose of this paper is to check to discover what kinds of power disturbances are taking place in energy distribution method, the various many disturbances that is the maximum critical hassle and to simulate it with the aid of using the use of assist of custom designed energy devices. Simulation final results finished with the aid of using MATLAB had been in comparison with final results. This paper provided a learn approximately the conduct of custom designed power devices especially DSTATCOM, and DVR to strengthen the voltage balance of distribution networks with overloading and non-linear hundreds. Simulation outcomes showcase that those instruments can enlarge the voltage stability restrict. Both DVR and DSTATCOM have same ability in mitigating balanced voltage sags, but DSTATCOM is superior in mitigation of voltage sags.Voltage sags analyzed in this paper was concentrated On radial distribution gadget. Different layout schemes of gadget can be applied for destiny works. Comparisons and evaluation can be carried in analyzing voltage sags in different layout for example, mesh gadget. From this paper, 3 important custom electricity tool simulations had been established, DSTATCOM, APF and DVR. Hence from those effects it's far viable to version UPQC (Unified Power Quality Conditioner), that is mixture of DSTATCOM and DVR to perform withinside the take a look at of voltage sag.

## REFERENCES

[1] John Stones and Alan Collinsion "Introduction to Power Quality" power engineering journal 2001 pages: 58-64.

[2] M.H.J. Bollen "What is Power Quality?" Electric Power Systems Research, Volume 66, Issue 1, July 2003, Pages 5-14.

[3] Ray Arnold "Solutions to Power Quality Problems" power engineering journal 2001 pages: 65-73

[4] M.H.Haque "Compensation of Distribution System Voltage Sag by DVR And DSTATCOM" Power Tech Proceedings, 2001 IEEE Porto , Volume: 1 , 10-13 Sept. 2001 Pages:5 pp. vol.1

[5] Gregory F. Reed, Masatoshi Takeda, Isao Iyoda, "Improved Power Quality Solutions using solid-state switching and Static Compensation Technologies" Power Engineering Society 1999 Winter Meeting, IEEE , Volume: 2 , 31 Jan-4 Feb 1999 Pages:1132 - 1137 vol.2

[6] Sung-Min Woo, Dae-Wook Kang, and Woo-Chol Lee "The Distribution STATCOM for Reducing the Effect of Voltage Sag and Swell" IECON'01: The 27th Annual Conference of the IEEE Industrial Electronic Society,2001

[7] ArindamGhosh, and Gerard Ledwich "Compensation of Distribution System Voltage Using DVR", IEEE Transactions on Power Delivery, Vol. 17, No. 4, October 2002.

[8] AmbraSannino, Jan Svensson, and Tomas Larsson. "Power-electronic Solutions to Power Quality Problems" Electric Power Systems Research, Volume 66, Issue 1, July 2003, Pages 71-82

[9] A. F .Huweg, S. M. Bashi- and N. Mariun "ASTATCOM Simulation Model to Improve Voltage Sag Due to Starting of High Power Induction Motor"National Power & Energy Conference, , Issue 4, July 2004, Pages 148-152 .

[10] S.V Ravi Kumarand S. Siva Nagaraju "Simulation of D-STATCOM AND DVR in Power system"Journal of Engineering and Applied Sciences, Volume 2, Issue 1, June 2007, Pages 7-13

[11] R. N. Patel, N. Ravi, D. N. Gaonkar"Utility Solutions to Power Quality Problems Institution of electrical Engineers (UK ), PEITSICON 2005, January 28-29, 2005, Pages 541-546

[12] H. Hingorani, 1996.understanding with fact devices .Second edition, Wiley & Sons, New York.

[13] D.D.Sabin ,AmbraSannino "A Summery of the Draft IEEEP1409 Custom power Application Guide "National Power & Energy Conference, , 2003, Pages 931-936 .

[14] Sankaran C. : Power Quality. CRC Press, 2001.

[15]SanninoandSvenssonJ . : A series-connected voltage source converter for voltage sag mitigation using vector control and a filter compensation algorithm. In Proc. 2000 IEEE-IAS, Vol. 4, pp. 2476–2481.

[16] IEEE Std. 1159–1995: Recommended Practice for Monitoring Electric Power Quality.

[17]Boonchiam P. and Mithuanantan N. : Understanding of Dynamic Voltage Restorers through MATLAB Simulation. Thammasat Int. J. Sc. Tech., Vol. 11, No. 3, July-ept 2006.

[18] Youssef K . : "Industrial power quality problems Electricity Distribution. IEE Conf. Pub1 No. 482,Vol: 2, 18–21 June 2001 Pages: 5 pp. vo1.2.

[19]GhoshandLedwi : Power Quality Enhancement Using Custom Power Devices. Kluwer Academic Publishers, 2002.

[20]. ChangS., Ho Y.S., and Loh P.C.: Voltage quality enhancement with power electronics based devices. In IEEE Power Engineering Society Winter Meeting, 2000, pp. 2937–2942. [21]. Kim H. : Minimal Energy Control for a Dynamic Voltage Restorer. In Proceedings of the Power Conversion Conference, Osaka, Japan, 2002, pp. 428–433.

[22]. McHattie R. : Dynamic Voltage Restorer the Customers's Perspective. In IEE Colloquium on Dynamic Voltage Restorer—Replacing Those Missing Cycles, 1998, pp. 1/1–1/5.

[23]. ChenS . , JoosG. , Lopes L. , and Guo W. : A nonlinear control method of dynamic voltage restorers. In 2002 IEEE 33rd Annual Power Electronics Specialists Conference, 2002, pp. 88– 93.

[24]. Buxton R. : Protection from voltage dips with the dynamic voltage restorer. In IEE Half Day Colloquium on Dynamic Voltage Restorers —Replacing Those Missing Cycles, 1998, pp. 3/1–3/6.

[25]. LiBH. , Choi S .S . , a n d Vi l a t h g amuwa D.M.: Design considerations on the line-side filter used in the dynamic voltage restorer. IEE Proceedings — Generation, Transmission, and Distribution, vol. 148, pp. 1–7, Jan. 2001.

[26] Chan K. : Technical and Performance Aspects of a Dynamic Voltage Restorer. In IEE Half Day Colloquium on Dynamic Voltage Restorers —Replacing Those Missing Cycles, 1998, pp. 5/1–525.

[27]. SngE .K.K. , Choi S.S, and Vilathgamuwa D.M.: Analysis of Series Compensation and DC-Link Voltage Controls of a Transformerless Self- Charging Dynamic Voltage Restorer. IEEE Transactions on Power Delivery, vol. 19, pp. 1511–1518, July 2004.

[28]. Kularatna N.: Power Electronics Design Handbook: Low-Power Components and Applications. Boston: Newnes, 1998.

[29]. Hyosung Kim, Jang -Hwan Kim, Seung -Ki Sul : A design consideration of output filters for dynamic voltage restorers. Power Electronics Specialists Conference, 2004. PESC 04.2004 IEEE 35th Annual, Volume 6, 20-25 June 2004 Page(s):4268–4272 Vo1.6

[30]. Nielsen J .G. , Newman M. , Nielsen H. , an Blabjerg F.: Control and testing of a dynamic voltage restorer (DVR) at medium voltage level. Power Electronics, IEEE Transactions on, Volume: 19, Issue: 3, May 2004, pp. 806–813.

[31]. GoleA.M. ,Sood V.K.: A Static compensator mode1 for use with electromagnetic transients simulation program. IEEE Transactions on Power Delivery, Vol 5, No 3, July 1990, pp 1398–1407.

[32]. Lai J. S ,andPeng F.Z. : Multilevel converters—A new breed of power converters. In Conf. Rec. IEEE-IAS Annu. Meeting, 1995, pp. 2348–2356.

[33]. HongyangWu , and Xiangning He : Research on PWM control of a cascade multilevel converter. Power Electronics and Motion Control Conference", 2000.Proceedings.PIEMC 2000. The Third International, Volume: 3, 15–1 8 Aug. 2000 Pages: 1099–1103, vo1. 3.

[34]. Fang M , Gardiner A I. , Mac Dougall A and Mathieson G . A . : A novel series dynamic voltage restorer for distribution systems. In 1998 International Conference on Power System Technology, 1998, pp. 38–42.

[34]. Rashid M.H.: Power Electronics Handbook. San Diego: Academic Press, 2001.

[35] Bose B.K. : Power Electronics and AC Drives. Englewood Cliffs: Prentice-Hall, 1986.