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Design and Simulation of DVR & DSTATCOM for Power Quality Enhancement in Distribution Networks under Various Fault Condition

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***Abstract* - Power disturbances, for instance like voltage sags, voltage swell, transients and harmonics will happen at any time and will cause adverse result to the machines or instrumentation running within the industries. As a result, it cause some disturbance and losses to the industries. Thus, we might wish to conclude the implications of the problems that followed these disturbances. By observance and analyzing, with some quantity of simulations on these events, we will gain a much better understanding regarding these power quality issues. Afterwards, we will take measures to safeguard the affected instrumentation or raise the standard of power offer. Harmonic interferences in grid, that square measure caused by harmonic manufacturing masses like diode, or thyristor convertors and cycloconverters, are serious issues to resolve. Passive filters consisting of a bank of tuned LC filters and/or a high-pass filter are wont to suppress harmonics due to a coffee initial price and high potency.**

This paper proposes to check the sources of voltage sag, the techniques of correcting the provision voltage sag in radial distribution system and reactive power compensation by 2 power electronic based mostly devices particularly DSTATCOM (Distribution Static Synchronous Compensator), and DVR (Dynamic Voltage Restorer). The paper aims to simulate and compare these devices in magnetic attraction transient programs victimization MATLAB This paper specialize in the comparison of DSTATCOM and DVR with the simulation results.

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

I. INTRODUCTION

The goals of the power system are to produce power to terminals of electrical machine, and to take care of the voltage at the instrumentation terminals in sure limits. For many years analysis and learning are focused on the primary aim. Eminence of provide was seldom a matter. A amendment in perspective passed maybe within the early 1980s. Initial in producing and industrial power systems and distribution to the general public provide, the facility quality issues appeared.

Power quality is definitely a significant concern within the present era; it becomes particularly necessary with the introduction of subtle devices, whose performance is extremely sensitive to the standard of power provide. trendy industrial processes are based mostly an outsized quantity of electronic devices like programmable logic controllers and adjustable speed drives. The electronic devices are terribly sensitive to disturbances [1] and therefore industrial masses subsided tolerant to power quality issues like voltage dips, voltage swells, and harmonics. Voltage dips are thought of one among the foremost severe disturbances to the economic instrumentation t. A paper machine will be full of disturbances of 100 percent free fall lasting for 100ms. A voltage dip of seventy fifth (of the nominal voltage) with length shorter than 100ms may end up in material loss within the vary of thousands people bucks for the semiconductors business [2]. Swells and over voltages will cause over heating tripping or maybe destruction of commercial instrumentation like motor drives. Electronic equipments are terribly sensitive masses against harmonics as a result of their management depends on either the height price or the zero crossing of the equipped voltage, that are all influenced by the harmonic distortion.

This paper analyzes the key problems within the Power Quality issues, specially keeping in mind this trend towards additional localized generations (also termed as distributed 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 replacement part into the circuit once the voltage support is needed. It's a dynamic time interval of regarding one cycle. To correct quickly for voltage spikes, sags or interruptions, the static switch will accustomed switch one or a lot of devices like electrical device, filter, alternate power line, energy storage systems etc. The static switch is employed in the alternate power cable applications. This theme requires 2 independent power lines from the utility or may be from utility and localized power generation like those just in case of distributed generating systems [4]. Such a theme will shield up to regarding eighty five take advantages of interruptions and voltage sags.

C. Energy Storage Systems:

Storage systems are often used to shield sensitive production equipments from shutdowns caused by voltagesags or short interruptions. These area unit typically DC storage systems like UPS, batteries, superconducting magnet energy storage (SMES), storage capacitors or maybe fly wheels driving DC generators [6]. The output of these devices are often equipped to the system through associate degree electrical converter on a short basis by a quick acting electronics witch. Enough energy is fed to the system to complete the energy that will be lost by the voltage sag or interruption. Just in case of utility provide backed by a localized generation this may be even higher accomplished.

D. Electronic tap changing transformer:

A voltage-regulating electrical device with associate degree electronic load faucet changer are often used with one line from the utility. It will regulate the voltage drops up to five hundredth and needs a stiff system (short circuit power to load magnitude relation of 10:1 or better). It will have the availability of coarse or swish steps supposed for infrequent voltage variations.

E. Harmonic Filters

Filters area unit employed in some instances to effectively scale back or eliminate bound harmonics [7]. If doable, it's continually preferable to use a 12-pluse or higher electrical device association, instead of a filter. Tuned harmonic filters ought to be used with caution and avoided once doable. Usually, multiple filters area unit required, every tuned to a separate harmonic. Every filter causes a parallel resonance additionally as a series resonance, and every filter slightly changes the resonances of alternative filters.

F. Constant-Voltage Transformers:

For many power quality studies, it's doable to greatly improve the sag and momentaneous interruption tolerance of a facility by protective management circuits. Constant voltage electrical device (CVTs) will be used [6] on management circuits to supply constant voltage with 3 cycle ride through, or relays and ac contactors will be given electronic coil hold-in devices to stop mis-operation from either low or interrupted voltage.

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

Frequency of the provision power is one amongst the main determinants of power quality, that affects the instrumentation performance terribly drastically. Even the main system elements like rotary engine life and interconnected-grid management are directly full of power frequency. Load frequency controller used specifically for governing power frequency beneath variable hundreds should be quick enough to create changes against any deviation. In countries like Republic of India and alternative countries of developing world, still use the controllers that are based mostly either or mechanical or electrical devices with inherent dead time and delays and from time to time additionally suffer from ageing and associated effects. In future perspective, such cont rollers will be replaced by their Digital -electronic counterparts.

IV. USE OF CUSTOM POWER DEVICES TO IMPROVE POWER QUALITY

In order to beat the issues like the ones mentioned on top of, the thought of custom power devices is introduced recently; custom power could be a strategy that is designed primarily to satisfy the wants of industrial and commercial client. The thought of custom power is to use power electronic or static controllers in the medium voltage distribution system progressing to supply reliable and high quality power to sensitive users [1]. Power electronic valves are the premise of these custom power devices like the static transfer switch, active filters and converter-based devices. Converter based power electronics devices may be divided in to 2 groups: shunt-connected and series-connected devices. The shunt connected devices is understood because the DSTATCOM and also the series device is understood because the Static Series Compensator (SSC), commercially referred to as DVR. it's also been reported in literature that each the SSC and DSTATCOM have been used to mitigate the majority the power system 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

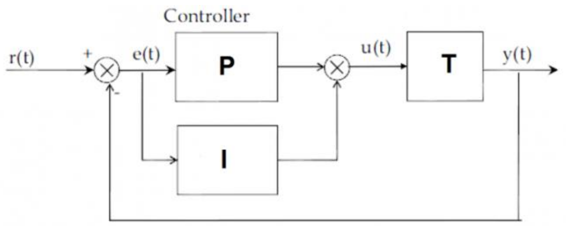


Fig.1. The PI Controller

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.

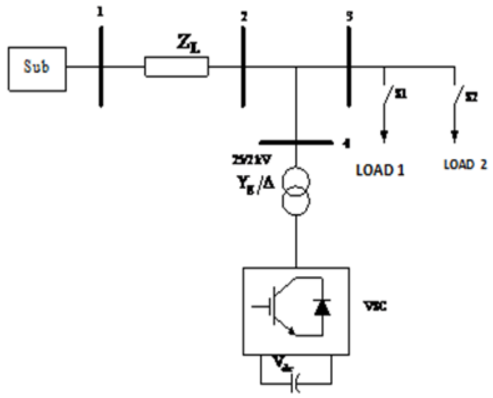


Fig 2 Single-line Diagram of the test system with DSTATCOM.

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.

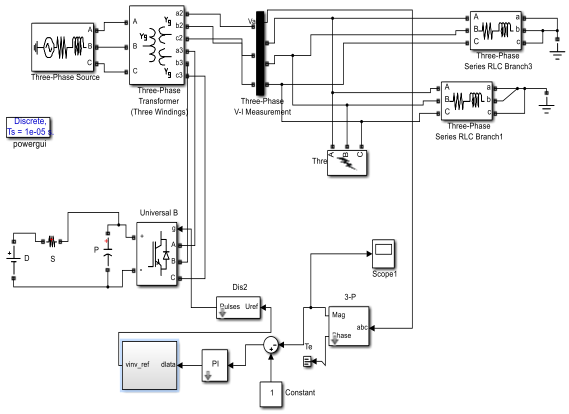


Fig.3 MATLAB Simulation model of D-STATCOM

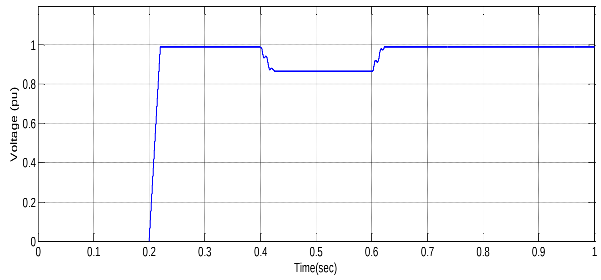


Fig.4(a) Terminal voltage when LG fault without DSTATCOM

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

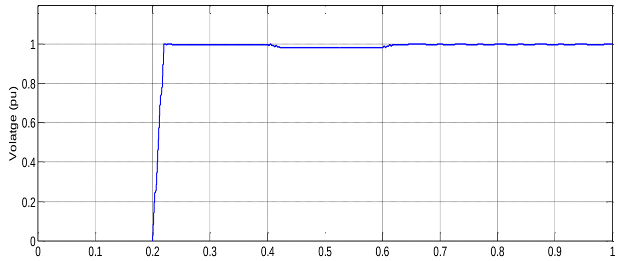


Fig.4(b) Terminal voltage when LG fault with DSTATCOM;

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.

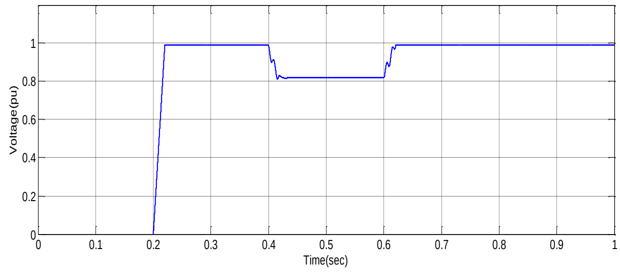


Fig.5(a) Terminal voltage when LL fault without DSTATCOM

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

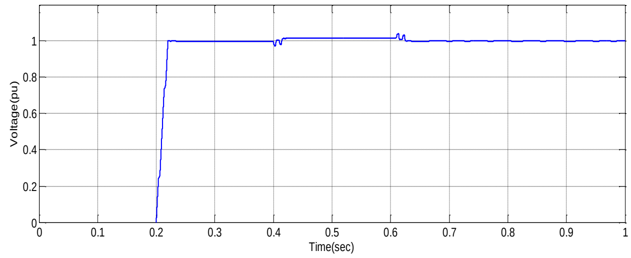


Fig.5(b) Terminal voltage when LL fault with DSTATCOM

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.

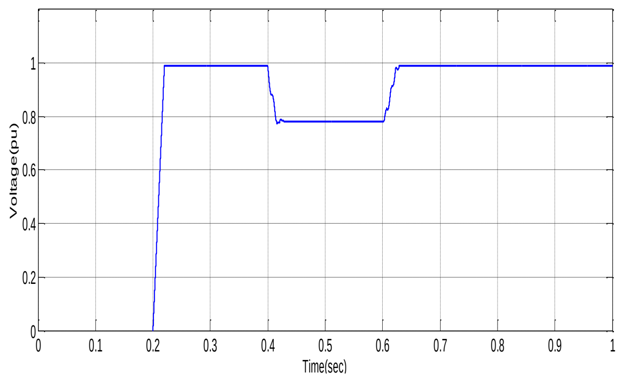


Fig.6(a) Terminal voltage when DLG fault without DSTATCOM

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

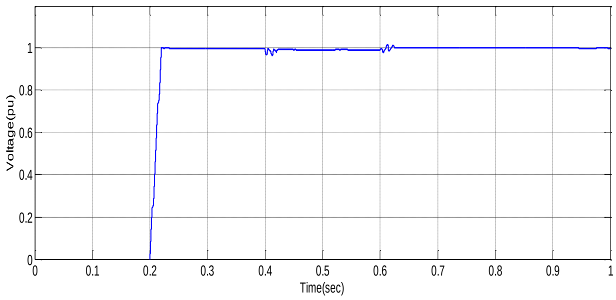


Fig.6(b) Terminal voltage when DLG fault with DSTATCOM

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.

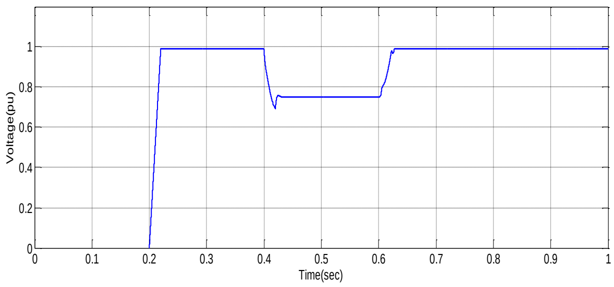


Fig.7(a) Terminal voltage when LLL fault without DSTATCOM

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.

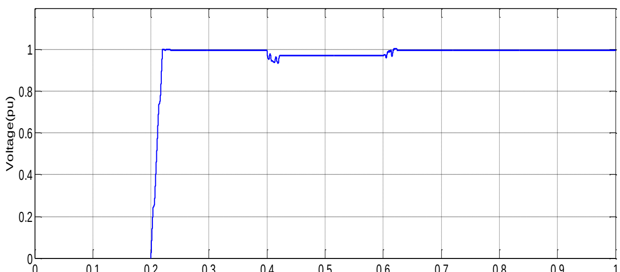


Fig.7(b) Terminal voltage when LLL fault with DSTATCOM

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.

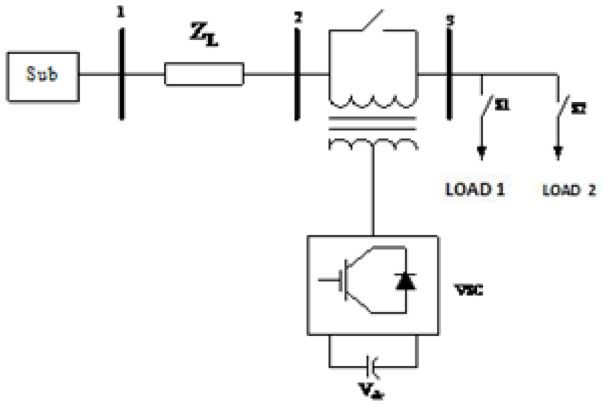


Fig 8 Single-line diagram of the test system with DVR.

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.

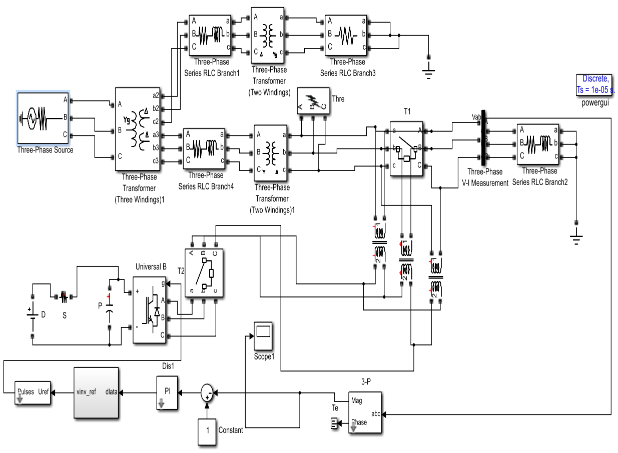


Fig.9 MATLAB Simulation model of DVR

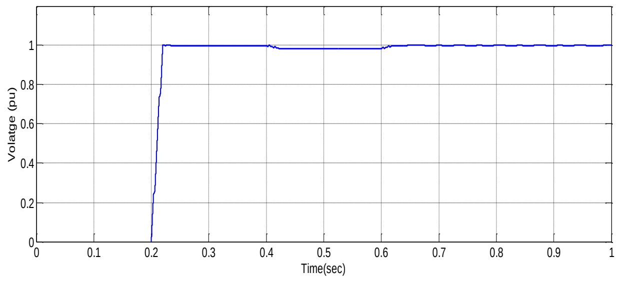


Fig.5.10(a) Terminal voltage when LG fault without DVR

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

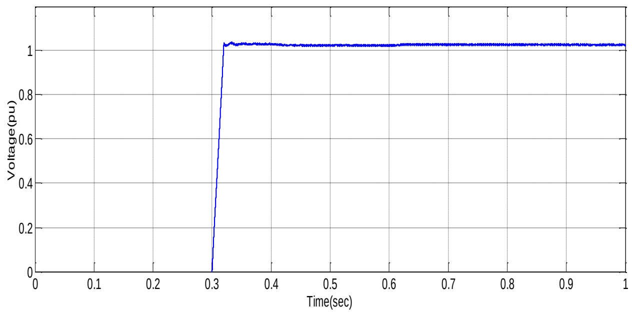


Fig.10(b) Terminal voltage when LG fault withDVR;

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.

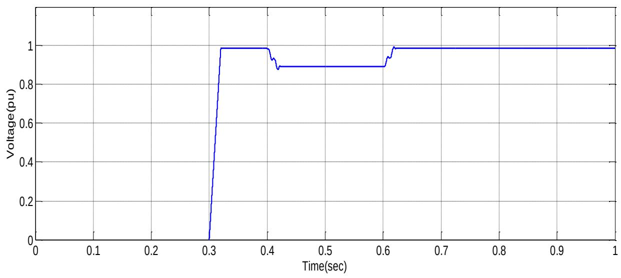
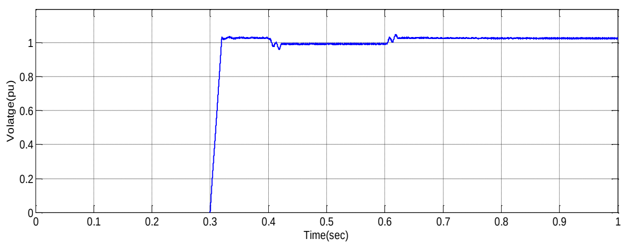


Fig.11(a) Terminal voltage when LL fault without DVR

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.

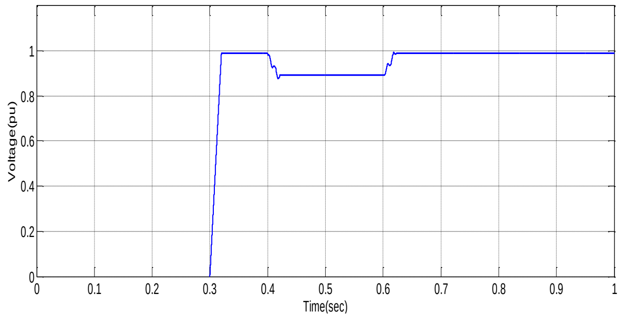


Fig.12(a) Terminal voltage when DLG fault without DVR

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

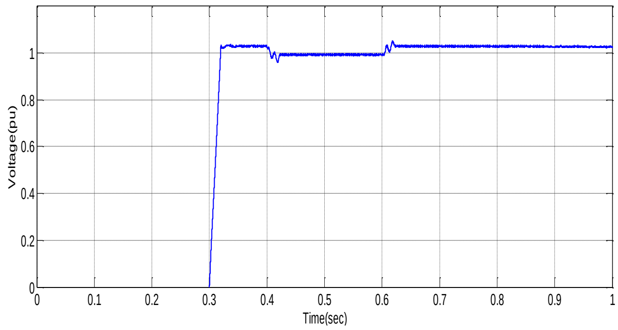


Fig.12(b) Terminal voltage when DLG fault with DVR

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.

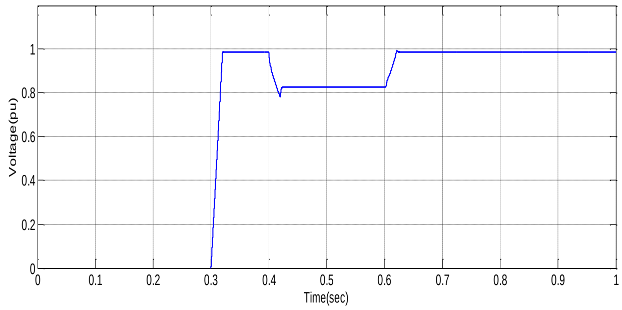


Fig.13(a) Terminal voltage when LLL fault without DVR

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.

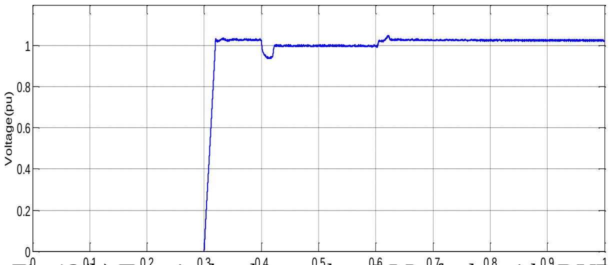


Fig.13(b) Terminal voltage when LLL fault with DVR

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

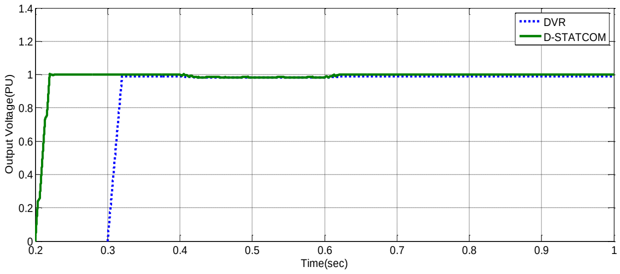


Fig.14 Terminal voltage when LG fault with DVR and D-STATCOM

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

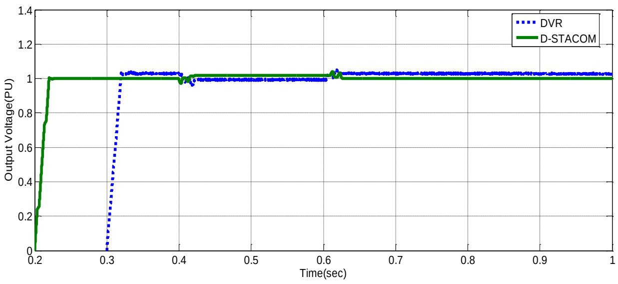


Fig.15 Terminal voltage when LLfault with DVR and D-STATCOM

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

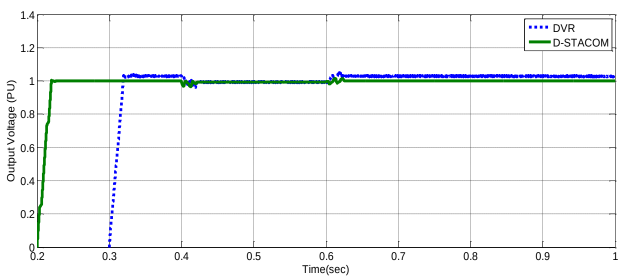


Fig.16 Terminal voltage when LLG fault with DVR and D-STATCOM

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

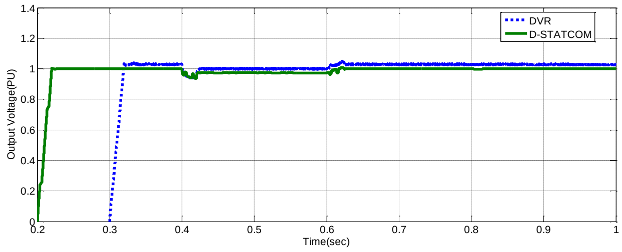


Fig.17 Terminal voltage when LLLfault with DVR and D-STATCOM

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

CONCLUSION

Predominant intention of this paper is to take a look at to find out what types of vigor disturbances are happening in power distribution method, among the many disturbances which is the most important problem and to simulate it by using help of customized power devices. Simulation outcome completed by MATLAB were compared with outcome. This paper awarded a be taught about the habits of customized energy gadgets particularly DSTATCOM, and DVR to fortify the voltage stability of distribution networks with overloading and non-linear hundreds. Simulation results exhibit that these contraptions can expand the voltage steadiness restrict. Both DVR and DSTATCOM have equal potential 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 system. Different design schemes of system could be implemented for future works. Comparisons and analysis could be carried in studying voltage sags in other design for example, mesh system. From this paper, three main custom power device simulations were established, DSTATCOM, APF and DVR. Hence from these results it is possible to model UPQC (Unified Power Quality Conditioner), which is combination of DSTATCOM and DVR to carry out in the study of voltage sag.

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