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Enhancement In Distribution Power Quality Using D-STATCOM with Phase Faults

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Abstract

The consumers require undisturbed and steady electrical energy utilization. The power transmission lines require suffers from problems of fault occurrence abruptly which affects power quality, to maintain steady transmission of electrical energy compensation is required. In this paper, a D-STATCOM is used for the compensation in presence of faults. The 25kV, 100MVA distribution is studied in presence of faults in 3-phases. The faults are introduced in different phases, also D-STATCOM is used for both voltage and power quality compensation. The D-STATCOM is connected in parallel close to B3 feeder. The MATLAB/Simulink model is used for results.

Keywords: Power Quality; Distribution Grid; OLTC; STATCOM.

INTRODUCTION

The distribution grids uses transmission lines and power transformers to transmit power from one point to another. The power at receiving end is always lesser than the power at the transmission end due to losses incurred in transmission. The main reason behind losses is due to the resistance of the transmission lines. The power loss also varies with type of load. Also, the reactive power used by the loads above threshold generated by the source is the main reason for power losses. The power loss can be reduced or minimized with the help of compensators. The D-STATCOM is used for compensation in this paper.

The computer programs are used for the evaluation of risk factors or faults involved in production and transmission of electrical energy to distribution lines, which reduces risk and also cost involved in laying down of network. Many important factors and parameters which were previously considered neglected in complete process of production and distribution to end users are now calculated and analyzed in presence of evasive probable problems or faults using simulations in foundation phase [1-3]. The two most important and common faults which arises in electrical power systems are short circuits and grounding faults. The probability of short circuit fault is very high [4]. They can appear between the phases and as well as between the phases and the ground [5]. The short circuit faults can be broadly defined as: three phase short circuit faults, grounding faults and arc faults. The faults can arise due to many reasons and can be analysed using conventional methods or sign processing methods [6]. The sign processing methods provide excellent results by providing the frequency domain analysis of fault. For short circuit studies, the IEC 60609 is only valid standard [7].

The three phase and four wire distribution lines suffers from poor power quality problems like excessive of neutral current, unbalanced loading, and current harmonics resulting in voltage distortion. Also, there might be an increase or decrease in VAR demands due to drop or rise of load bus voltage which might result in voltage instability. The DSTATCOM used a compensation device are used in such condition to limit the variation in voltage and also increases the operational capability of power lines while keeping the power supply reliability at same level. A D-STATCOM is used here to improve the power factor and to control the voltages at terminals, at the point of common coupling (PCC) it injects current as it is a shunt connected custom power device. The voltage of a DC link capacitor in a DSTATCOM is regulated using various control algorithms and is done for load compensation. For load compensation which is based on Synchronous Reference Frame theory used for distributed generation (DG) sources, a traditional PI controller is proposed in [8]. In [9], the modified version of power balance theory has been utilized for a D-STATCOM due to simplified calculations and formulations. For voltage sag mitigation and correction of power factor it is used in [10].

The D-STATCOM got additional advantage of handling reactive current in presence of low voltages and can be modified to provide voltage and frequency support by changing energy storage devices from capacitors to batteries [11, 12]. As fuzzy logic is getting attention everywhere, fuzzy logic controllers (FLC) have been used for different applications in [13]-[17]. The FLC's takes the advantage of the fact that they doesn't require detail knowledge of the power systems. In [13], a new topology for D-STATCOM is proposed in presence of non-stiff source. The scheme enhances the current compensation and reduce the VSI ratings and interfacing filter size. When the load changes there is significant changes in voltage of dc capacitor which might influence compensation considerably [14]. A fuzzy logic method is proposed which improves transient capability of the dc link. The method immediately after the load varies, modify the proportional and integral gains of the PI controller throughout the transient period which provides significant reduction in error in dc link capacitor voltage. The simulations and designs of a D-STATCOM using fuzzy logic is presented in [15]. It carried out simulations for both linear and non-linear loads. The fuzzy controller instead of using mathematical equations uses operator's knowledge of plant. The paper [16] apply fuzzy techniques to improve voltage sag, voltage swell and interruption occurrence in a distributed power line. The paper in [17] uses a fuzzy and its hybrid fuzzy logic controller for a D-STATCOM which compensates promptly varying unbalanced and nonlinear loads. In this paper, a 25kV/100MVA distribution line is compensated with the help of D-STATCOM in presence of phase faults occurrence.

The remaining of the paper is organized as follows. The D-STATCOM working principle and distribution line parameters are given in section II. Simulations and results are given in section III. The paper is concluded in section IV.

WORKING PRINCIPLE AND SIMULATION PARAMETERS

A Distribution Static Synchronous Compensator (D-STATCOM) is utilized to compensate voltage on a 25-kV distribution line. The two feeders at 21 km and 2 km transmit power to loads connected at buses B2 and B3. At the bus B2 a shunt capacitor is utilized for power factor correction. A transformer of 25kV/600V is used to connect a 600V load to bus B3 which constitute a plant which absorbs continuously varying currents which produces voltage flicker. In order to maintain, a 0.9 lagging power factor the variable load current magnitude is modulated at a frequency of 5 Hz. The apparent power varies between 1 MVA and 5.2 MVA approximately. The varying load will allow D-STATCOM to mitigate voltage flicker problem. A three phase fault is connected in parallel between transformer of 25kV/600V and bus B3. The distribution line is shown in Fig. 1.

The variable load is constant. The programmable voltage source is used to bring the modulation of the internal voltage to be around 25-kV equivalent. On scope1 the voltage and current of phase A while controller signals are on scope 2 of the D-STATCOM. On scope3 variations of active power (P) and reactive power (Q) at bus B3 is given in 1st trace and in 2nd trace voltages at buses B1 and B3. Two modes of operations are used in D-STATCOM namely: voltage regulation and Q regulation. The injected reactive current which is modulated at 5 Hz is on trace 3 of scope 3.

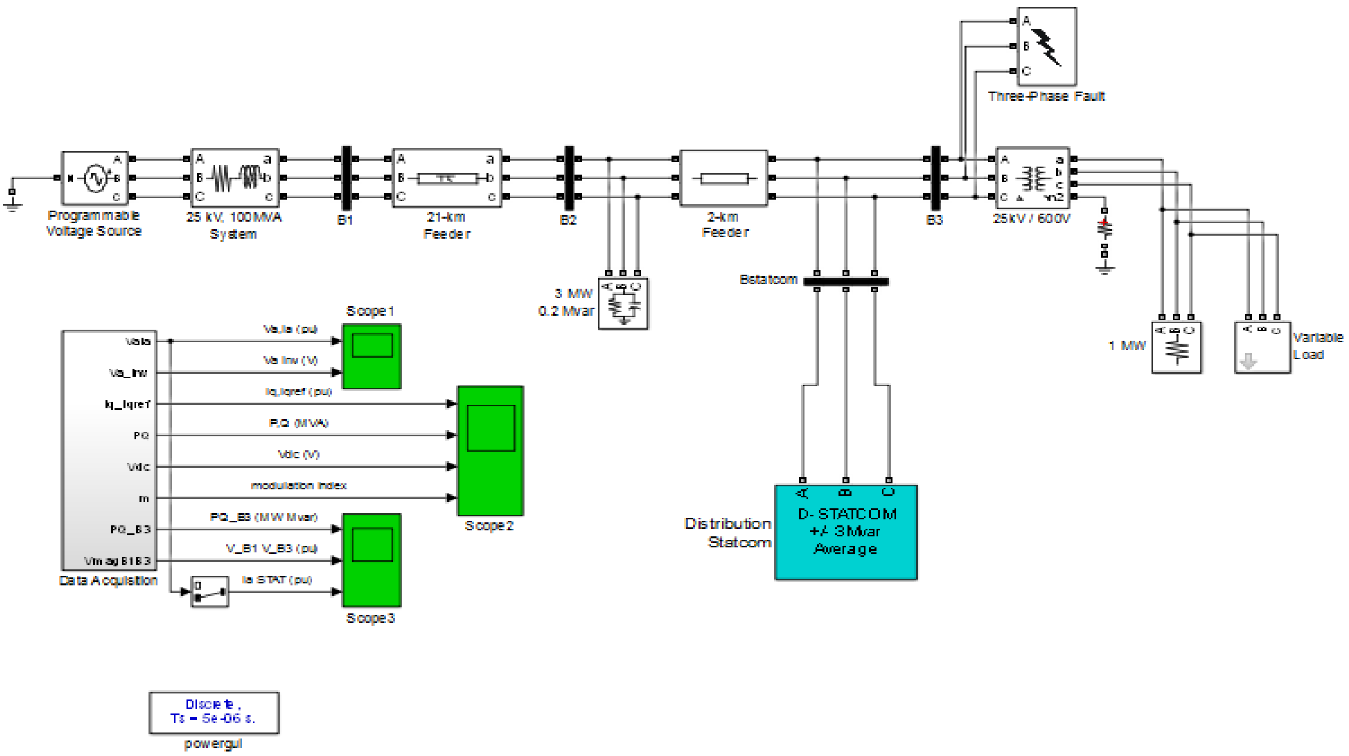


Figure 1: Distribution line with D-STATCOM and Three-phase fault.

SIMULATION AND RESULTS

A. Fault

- *Voltage Regulation*: The D-STATCOM controller is set to regulating voltage. The active power (P) and reactive power varies for time t=0.05 to t=1s and becomes constant after that at 3.8pu ad 1.5pu respectively. Voltages at bus B1 and B3 varies for time t=0.2 s to t=0.4s which is regulated by supplying injected current from D-STATCOM as shown in Fig. 2(a).

- *Q Regulation:* The D-STATCOM controller is to regulating Q. The active power (P) and reactive power varies for time t=0.05 to t=4.25s and becomes constant after that at 3.8pu ad 1.5pu respectively. Voltages at bus B1 and B3 varies for time t=0.05 to t=4.25s which bring regulation in Q as shown in Fig. 2(b).

B. Fault in phase A, B and C

- *Voltage Regulation*: The D-STATCOM controller is set to regulating voltage. The active power (P) and reactive power varies between 0 to12 pu for time t=0.05 to t=1s and becomes constant after that at 4pu ad 1pu respectively. Voltages at bus B1 and B3 varies for time t=0.5 s to t=1s below 1pu which is regulated by supplying injected current from D-STATCOM of varied amplitude. For time t=1s to 4 s, the variation in voltages at B1 and B3 is less than 0.5pu and therefore D-STATCOM injected current amplitude is also same as shown in Fig. 3(a).

Q Regulation: The D-STATCOM controller is to regulating Q. It folllows almost the same pattern as for voltage regulation, the difference is in variation of the active power (P) and reactive power, they variation is higher between time t=0.05 to t=0.07 as shown in Fig. 3(b).

C. Fault in phase A and B

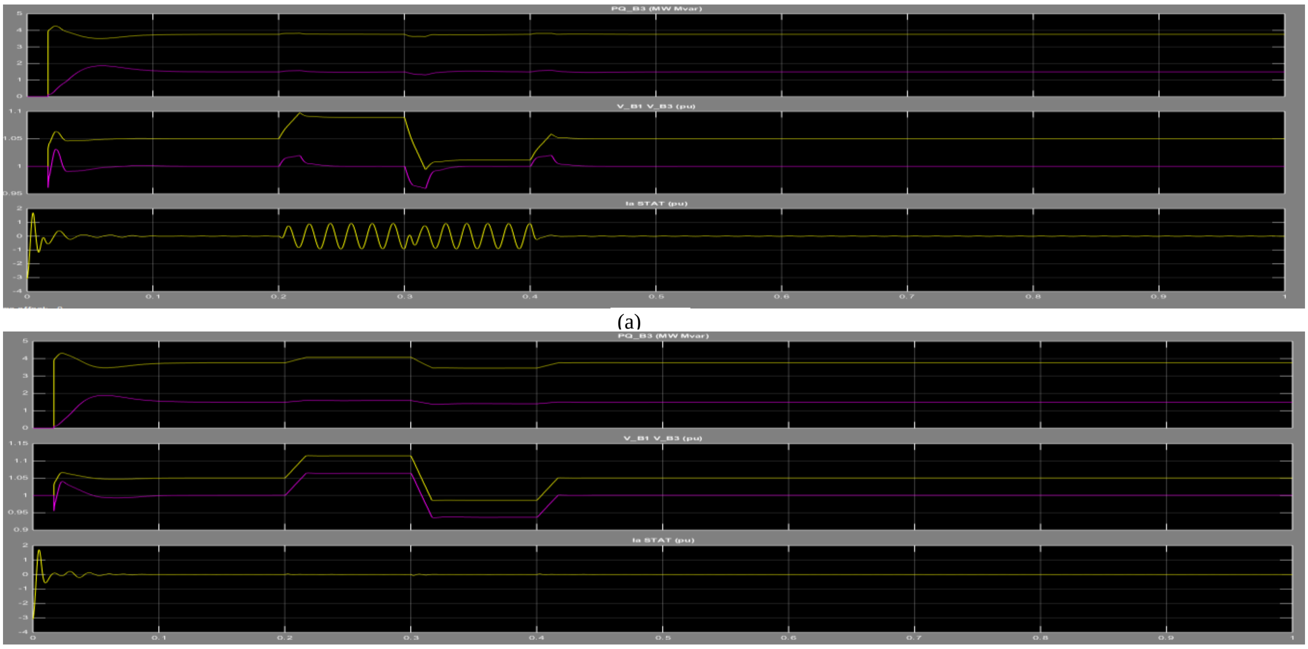
- *Voltage Regulation*: The D-STATCOM controller is set to regulating voltage. The active power (P) and reactive power varies for time t=0.05 to t=1s. The reactive power and active power varies at higher rate as around 9pu. The voltage at B3 varies between 0.6pu to 1pu. The variation in voltage at B3 is due to introduced fault near B3. The voltage is regulated by injecting current of larger amplitudes from D-STATCOM, varying from -12 pu to 12 pu as shown in Fig. 4(a).

- *Q Regulation:* The D-STATCOM controller is set to regulating Q. The pattern is same as for voltage regulation as shwon in Fig. 4(b).

D. Fault in phase A

- *Voltage Regulation*: The D-STATCOM controller is set to regulating voltage. The active power (P) and reactive power varies for time t=0.05 to t=1s. The reactive power varies at higher rate as compare to active power. The variation in reactive power is from 0 to 12 pu and voltage at B3 varies between 0.1 pu to 1pu. The variation in voltage at B3 is due to introduced fault near B3. The voltage is regulated by injecting current of larger amplitudes from D-STATCOM, varying from -12 pu to 12 pu as shown in Fig. 5(a).

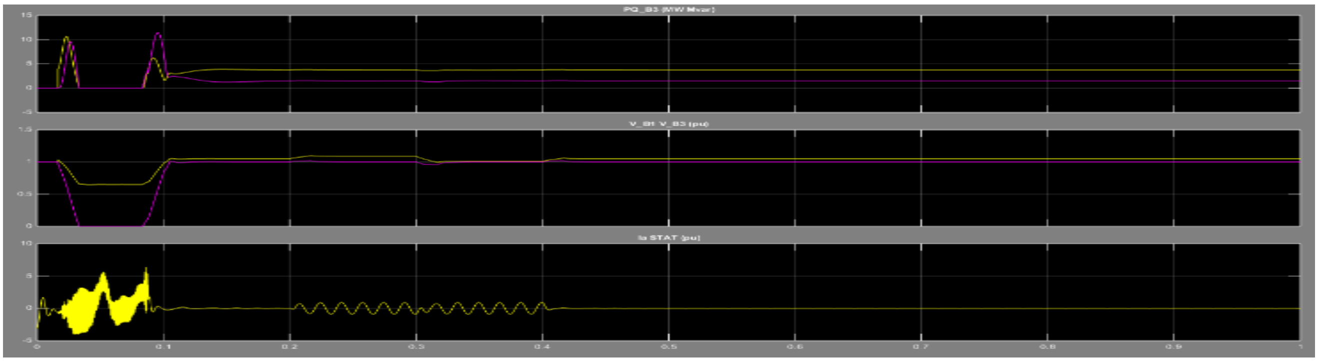
- *Q Regulation:* The D-STATCOM controller is set to regulating Q. The pattern is same as for voltage regulation as shwon in Fig. 5(b).



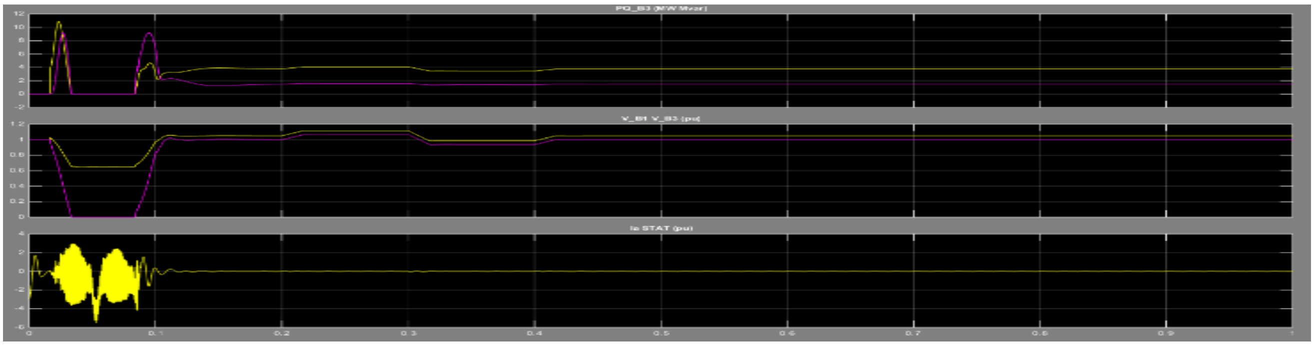
(a)

(b)

Figure 2: No fault appeared (a) Voltage Regulation and (b) Q regulation.

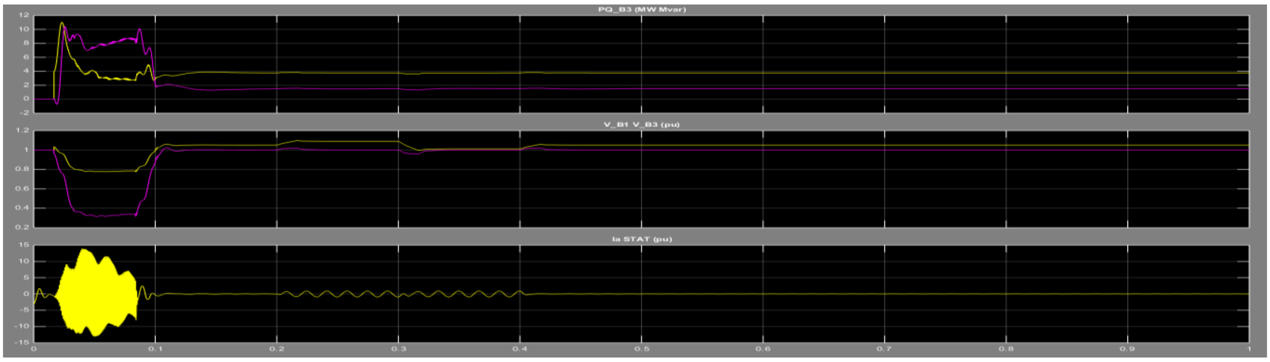


(a)

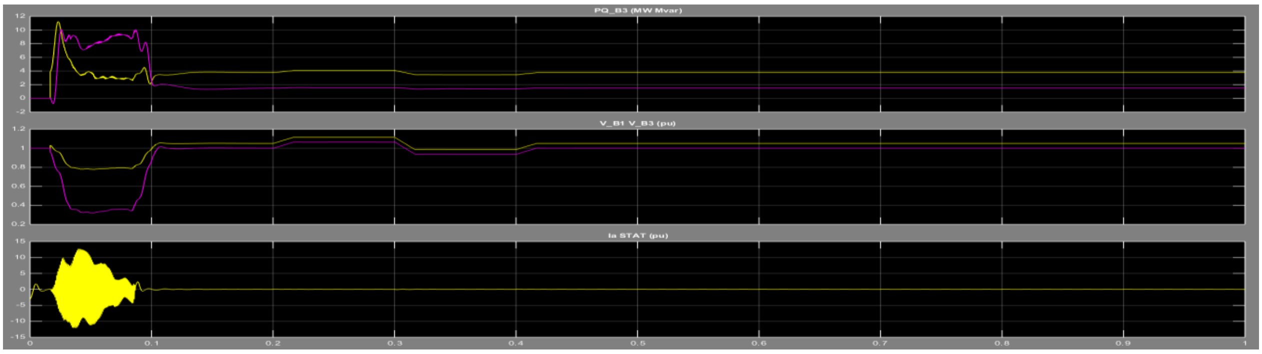


(b)

Figure 3: Fault appeared on all phases A, B and C (a) Voltage Regulation and (b) Q regulation.



(a)



(b)

Figure 4: Fault appeared on all phases A and B (a) Voltage Regulation and (b) Q regulation.

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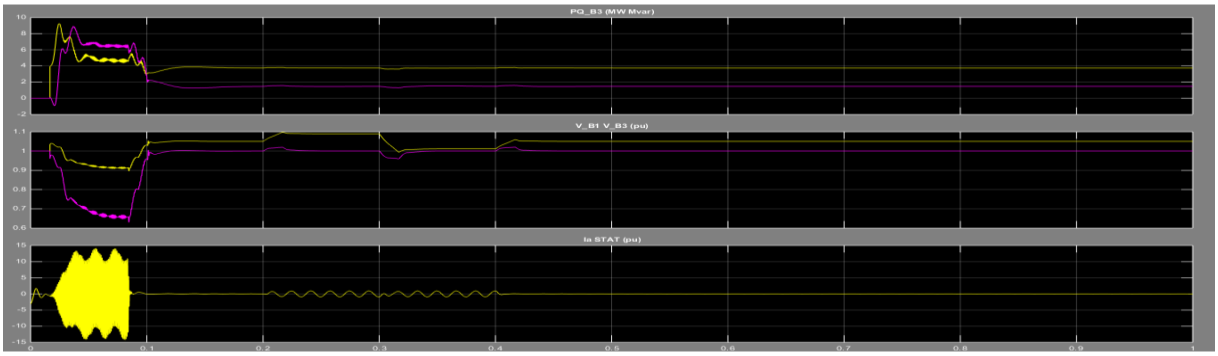
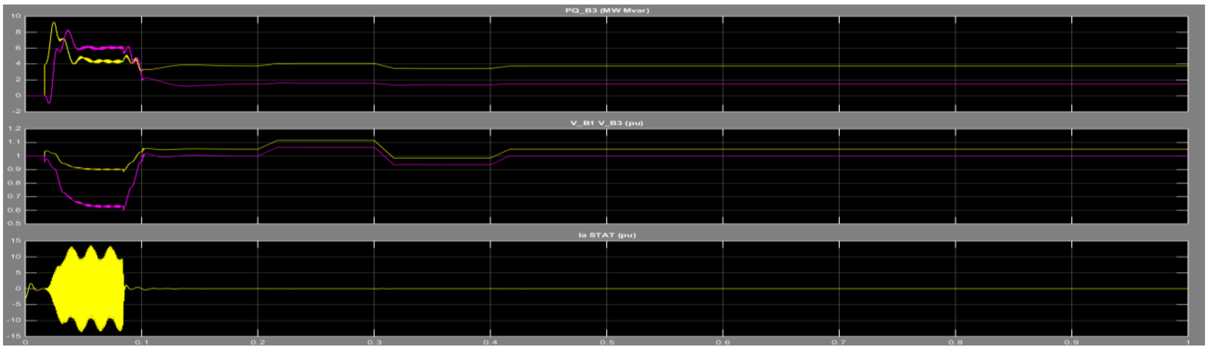


(a)



(b)

Figure 5: Fault appeared on all phases A (a) Voltage Regulation and (b) Q regulation.

CONCLUSION

In order to supply uninterrupted supply of power to end users domestic or industrial. The paper introduces faults near a load B3. The loads are introduced in all phases, combination of two and one phase. The D-STATCOM is used for compensation in presence of faults. The MATLAB/Simulink model is used to generate results of a 25kV/100MV. The results show that when faults are introduced there is variation in active power, reactive power and voltages at B3 which is compensated by D-STATCOM by injecting current parallel close to B3 feeder.

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