Voltage Sag Mitigation in Fifty Bus System Using D-STATCOM for Power Quality Improvement

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Abstract

The Distribution static synchronous compensator is capable of reducing the losses and improving the voltage regulation in Multi Bus systems. The Distribution static synchronous compensator injects a current into the system to reduce the losses. The Distribution static synchronous compensator is capable of enhancing the reliability and quality of power flow in low voltage distribution network. A Distribution static synchronous compensator is one of the new generation flexible AC transmission system devices with a promising feature of applications in power system. The Distribution static synchronous compensator is used to stabilize the system voltage by exchanging reactive power with the power system.
This work deals with the modeling and simulation of Fifty Bus systems with Distribution static synchronous compensator and the voltage sag is created by involving a heavy load. The sag is mitigated with Distribution static synchronous compensator. The circuit models and simulation results are presented. Voltages at various buses with and without Distribution static synchronous compensators are presented. The simulation results are compared with the analytical results. Fifty Bus System with multiple STATCOMs is modeled and simulated. The improvement in voltage stability with Distribution static synchronous compensator is presented. Voltages at various buses with and without Distribution static synchronous compensator are also discussed.

Keywords: *FACTS, D-STATCOM,UPFC,DVR*

I. INTRODUCTION

Generally Power distribution system requires maintaining of active and reactive power in terms of its supply and demand. If it is not maintained then the system fails to maintain its stability which cause system frequency will be varied and in the most possible case crumple in power system may also occur. Thus suitable voltage and power quality controllers are required in order to maintain the system stability. Nowadays power distribution system is facing increase in demand with improved power quality having greater reliability with low cost and environmental impact.

The main application of the STATCOM is Distribution Static synchronous compensator (D-STATCOM) which provides high speed control of reactive power in order to provide voltage stabilization with different types of system control. By using this the system can be protected from voltage sag/flickers caused due to variation in the reactive current demand, for a specific duration of the present condition, this controller provides lead/lag reactive power to maintain stability, power factor correction, load balancing and harmonic compensation of a particular load.

II. OPERATING PRINCIPLE

The Distribution static synchronous compensator (D-STATCOM) is a power electronic based shunt connected Flexible AC transmission system device which exchange reactive power to the load for improving the voltage stability of the load busses. The development and use of Flexible AC Transmission System (FACTS) controllers in power transmission systems had led to many applications of these controllers to improve the stability of power networks. Various flexible AC transmission system (FACTS) devices, such as static synchronous compensators (STATCOMs), static synchronous series compensators (SSSCs), and unified power flow controllers (UPFCs) are increasingly used in power systems because of their ability to stabilize power transmission systems and to improve power quality in power distribution systems. It has been reported that STATCOM can offer a number of performance advantages for reactive power control applications over the conventional SVC because of its greater reactive current output at depressed voltage, faster response, better control stability, lower harmonics and smaller size, etc Power quality is ultimately a consumer-driven issue, and the end user's point of reference takes precedence.

Therefore, the following definition of power quality is established. The ultimate reason that we are interested in power quality is economic value. There are economic impacts on utilities, their customers, and suppliers of load equipment. The quality of power can have a direct economic impact on many industrial consumers.

III. SIMULATION RESULTS

The Fifty bus system is considered for simulation studies. The Fifty bus system is simulated by using MATLAB SIMULINK. The Fifty bus system without STATCOM is shown in Figure 6.1.

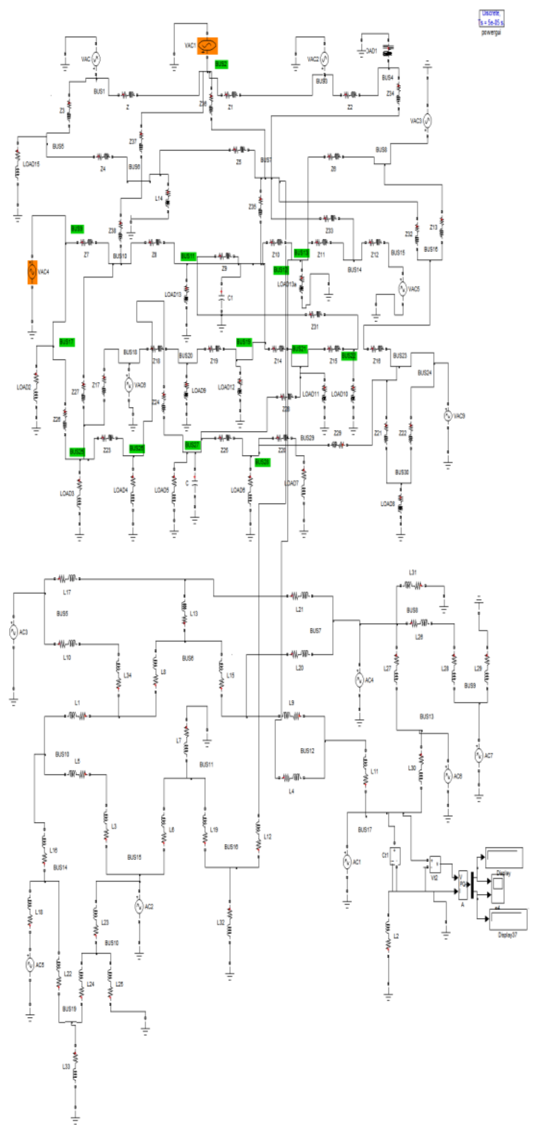

Fig 1 IEEE Fifty bus system without STATCOM

The circuit model of the fifty bus system is considered, each line represents the series impedance model and the shunt capacitance of the line is neglected because the electrical distribution system lines are the short lines. The Fifty bus system consisting of fourteen generating buses and eight load buses. The loads are connected to the respective buses. When the breaker is closed the loads are connected, the voltages at bus 4, &12 are measured.

The voltage at bus-4 is measured. The voltage across Bus-4 is shown in Figure 2. During normal operating condition the rated voltage is appeared at each Bus, the additional loads are connected after 0.2 seconds the voltage is shown in Figure 2. In the same way reactive power across Bus-4 is shown in Figure 3. The voltage drop at bus-12 is shown in Figure 4. In the same way reactive power across Bus-12 is shown in Figure 5.

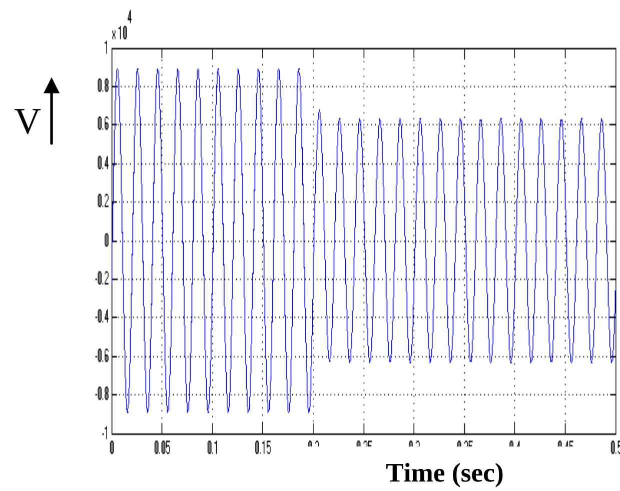

Fig 2 Voltages at Bus-4

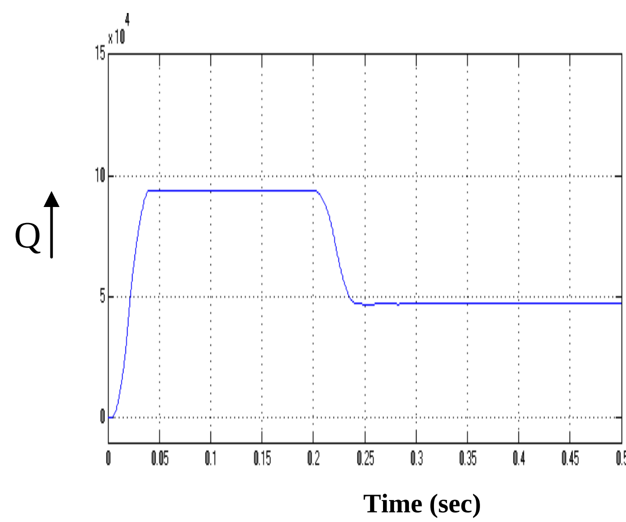

Fig 3 Reactive Power at Bus-4

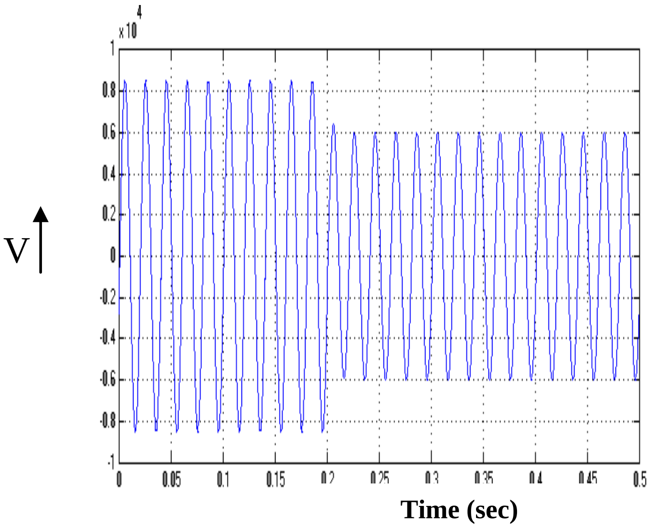

Fig 4 Voltages at Bus-12

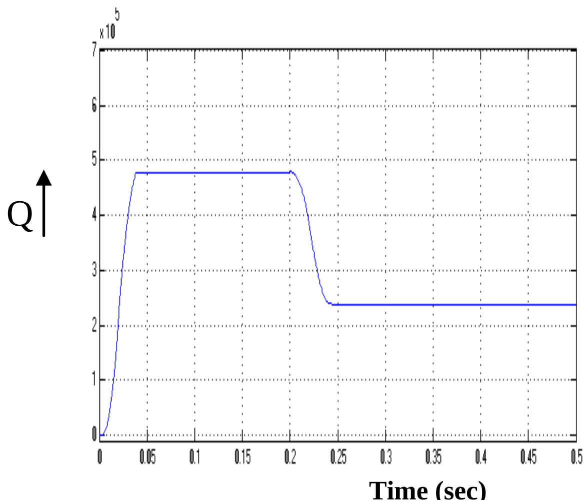

Fig 5 Reactive Power at bus-12

The circuit model of fifty bus system with Distribution static synchronous compensator is shown in Figure 6. The Distribution static synchronous compensator is connected between the Bus-13 &17. The fifty bus system consisting of fourteen generating buses and fifty load buses. The loads are connected in series with respective buses. When the breaker is closed the loads are connected, the voltages at buses 11, 13, 19,25,30,35 &45 are measured. The voltage across Bus-11 is shown in Figure 7. It can be seen that the voltage is resumed to rated voltage after 0.05 seconds by adding the Distribution static synchronous compensator in the circuit.

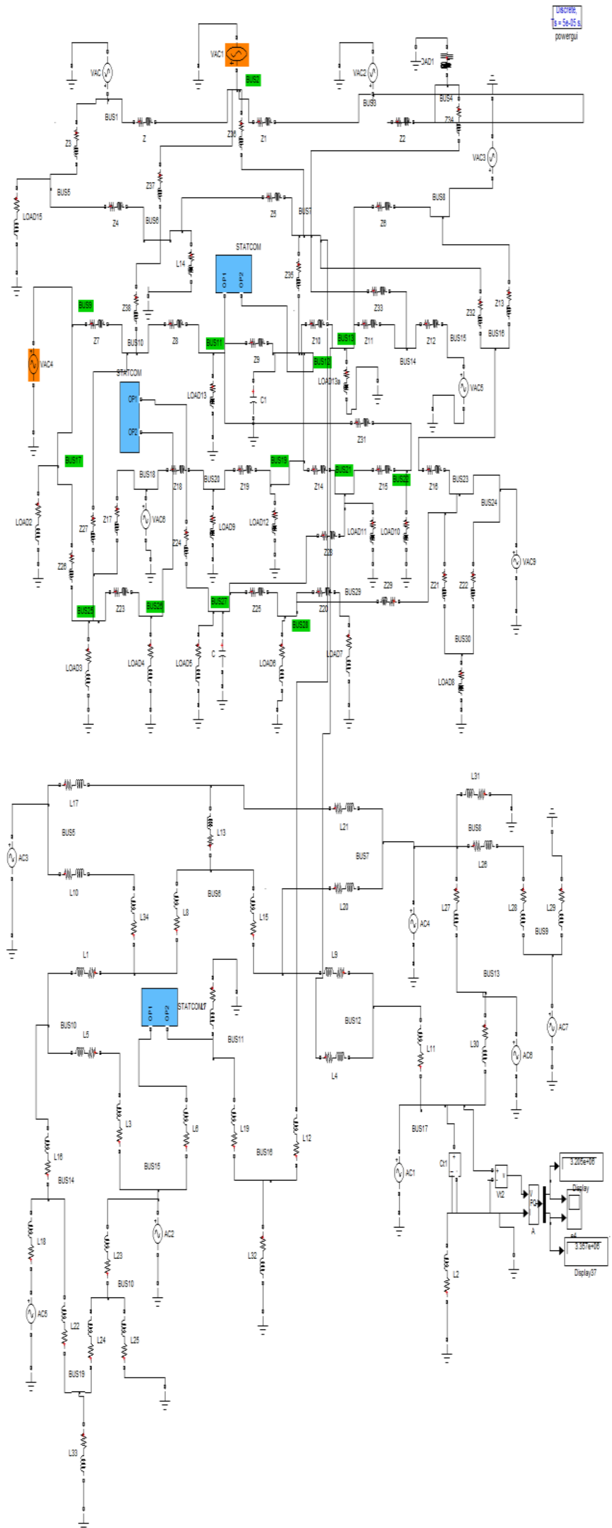

Fig 6 IEEE Fifty bus system with STATCOM

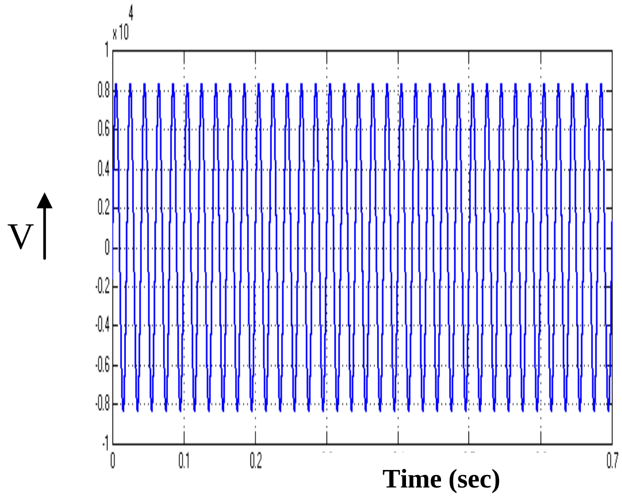

Fig 7 Voltage at bus-11

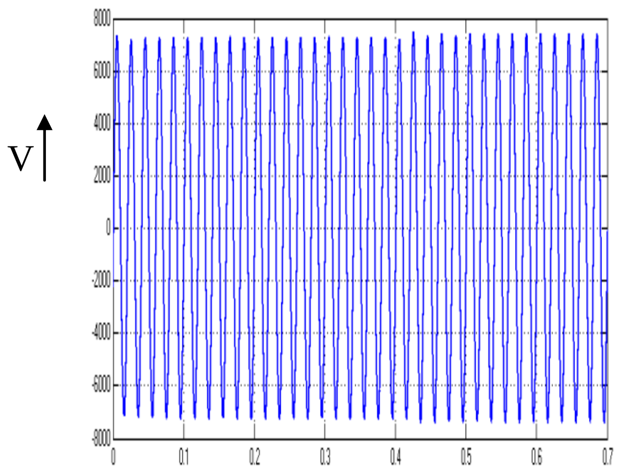

Fig 8 Voltage at bus-13

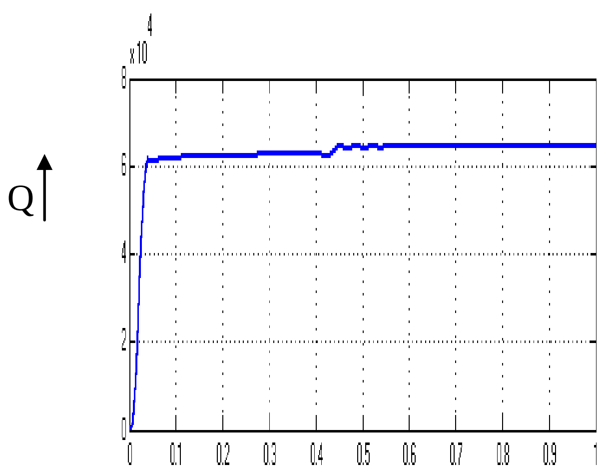

Fig 9 Reactive Power at bus 13

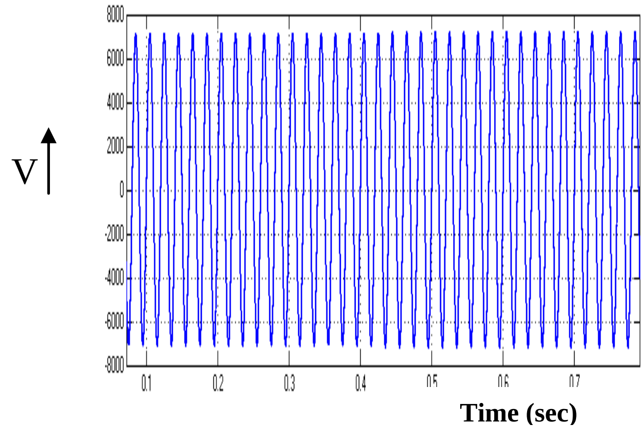

Fig 10 Voltage at bus-19

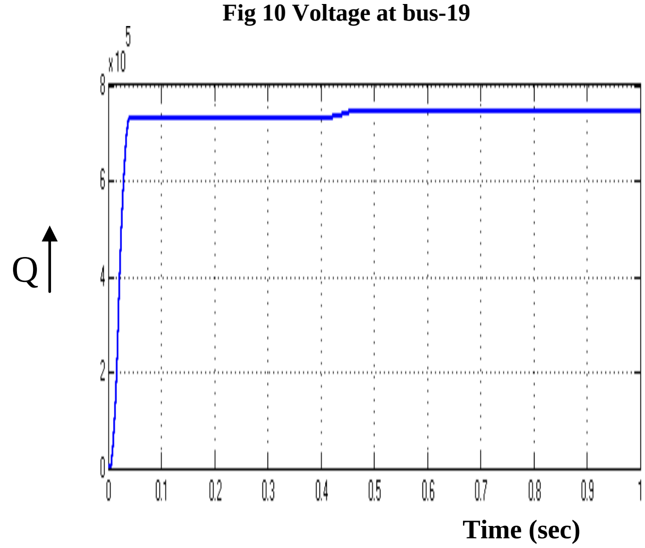

Fig 11 Reactive Power at bus 19

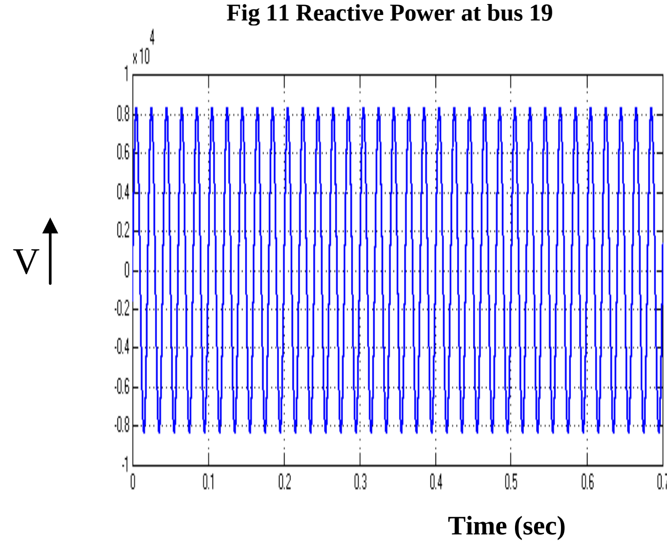

Fig 12 Voltage at bus-25

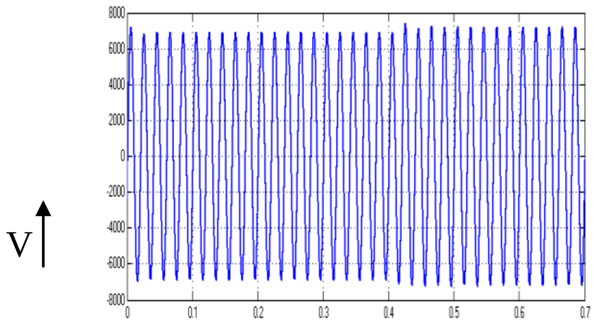

Fig 13 Voltage at bus-30

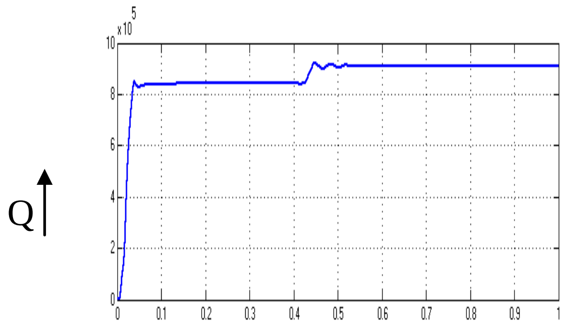

Fig 14 Reactive power at bus-30

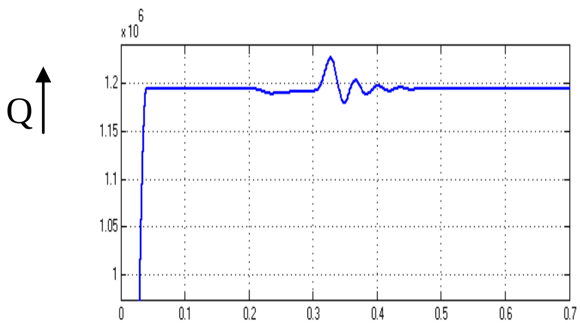

Fig 15 Reactive power at bus 35

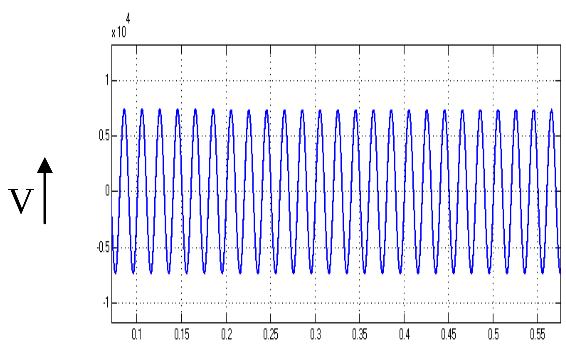

Fig 16 Voltage at bus-45

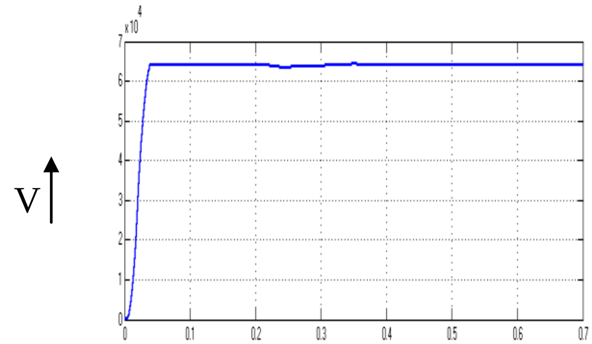

Fig 17 Reactive Power at bus 45

IV. TABLE 1

Reactive Power at different buses with and without STATCOM

BUS NO.	REACTIVE POWER WITHOUT STATCOM (MVAR)	REACTIVE POWER WITH STATCOM (MVAR)
BUS-1	0.304	0.352
BUS-2	0.301	0.348
BUS-3	1.32	1.801
BUS-4	2.210	2.788
BUS-5	2.23	2.791
BUS-6	2.27	2.810
BUS-7	2.26	2.842
BUS-8	2.241	2.846
BUS-9	2.238	2.832
BUS-10	2.861	2.989
BUS-11	2.85	3.36
BUS-12	3.23	3.25
BUS-13	2.29	2.28
BUS-14	1.971	1.998
BUS-15	1.38	1.57
BUS-16	1.86	1.89
BUS-17	2.879	2.978
BUS-18	2.798	2.861
BUS-19	2.388	2.458
BUS-20	2.386	2.451
BUS-21	2.210	2.788
BUS-22	3.612	3.629
BUS-23	2.879	2.978
BUS-24	1.971	1.998
BUS-25	3.121	3.221
BUS-26	2.843	2.856
BUS-27	1.32	1.801
BUS-29	3.35	3.36
BUS-30	2.210	2.788
BUS-31	2.23	2.791

Table 1 (Continued)

BUS NO.	REACTIVE POWER WITHOUT STATCOM (MVAR)	REACTIVE POWER WITH STATCOM (MVAR)
BUS-32	2.27	2.810
BUS-33	2.26	2.842
BUS-34	2.241	2.846
BUS-35	1.971	1.998
BUS-36	1.32	1.801
BUS-37	2.27	2.810
BUS-38	2.26	2.842
BUS-39	2.241	2.846
BUS-40	2.238	2.832
BUS-41	2.861	2.989
BUS-42	3.35	3.36
BUS-43	3.23	3.25
BUS-44	2.29	2.28
BUS-45	1.971	1.998
BUS-46	1.38	1.57
BUS-47	1.86	1.89
BUS-48	2.879	2.978
BUS-49	2.98	2.97
BUS-50	2.89	2.987

The Table 1 explains how the reactive power is decreased after adding the additional load in parallel with the load-1 after 0.2 seconds and again it resumes the rated value because of Distribution static synchronous compensator presents in the circuit. The reactive power is constant from 0 to 0.3 seconds under normal operating condition. The reactive power is decreased at 0.3 seconds due to reduction in voltage. After 0.1 seconds, the reactive power is resumed to rated value due to addition of Distribution static synchronous compensator between buses 13 & 17.

The summary of the reactive power with and without Distribution static synchronous compensator is shown in Table 1. This table explains how the reactive power is being varied with addition of the load in parallel with the load-1 at various buses with and without Distribution static synchronous compensator in the fifty bus system. The reactive power at bus-1 is measured as 0.304 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 0.352 MVAR. By comparing with and without Distribution static synchronous compensator reactive power values at bus-1, it is shown that 0.048 MVAR is been increased. The reactive powers without and with Distribution static synchronous compensator at bus-2 are 0.301MVAR and 0.348 MVAR, it is shown that MVAR is increased by 0.047. The reactive power at bus-3 is measured as 1.32 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.801 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-3 it is shown that MVAR is increased by 0.481. The reactive power at bus-4 is measured as 2.21 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.788 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-4, it is shown that MVAR is been increased by 0.578.

The reactive power at bus-5 is measured as 2.23 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.791 MVAR. By comparing with and without Distribution static synchronous compensator reactive power values at bus-5, it is shown that 0.561 MVAR is been increased. The reactive power at bus-6 is measured as 2.27 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.81 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-6, it is shown that 0.54 MVAR is been increased. The reactive power at bus-7 is measured as 2.26 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.842 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-7, it is shown that MVAR is increased by 0.582.

The reactive power at bus-8 is measured as 2.241 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.846 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-8, it is shown that MVAR is increased by 0.605. The reactive power at bus-9 is measured as 2.238 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.832 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-9, it is shown that MVAR is increased by 0.594. The reactive power at bus-10 is measured as 2.861 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.989 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-10, it is shown that MVAR is increased by 0.128.

The reactive power at bus-11 is measured as 2.85 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.36 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-11, it is shown that MVAR is increased by 0.51. The reactive power at bus-12 is measured as 3.23 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.25 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-12, it is shown that MVAR is increased by 0.02.

The reactive power at bus-13 is measured as 2.29 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.28 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-13, it is shown that MVAR is increased by 0.01. The reactive power at bus-14 is measured as 1.971 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.998 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-14, MVAR is increased by 0.027.

The reactive power at bus-15 is measured as 1.38 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.57 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-15, it is shown that MVAR is increased by 0.19. The reactive power at bus-16 is measured as 1.86 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.89 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-16, it is shown that MVAR is increased by 0.03.

The reactive power at bus-17 is measured as 2.879 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.978 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-17, it is shown that MVAR is been increased by 0.099.

The reactive power at bus-18 is measured as 2.798 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.861 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-18, it is shown that MVAR is increased by 0.063. The reactive power at bus-19 is measured as 2.388 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.458 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-19, it is shown that MVAR is increased by 0.07.

The reactive power at bus-20 is measured as 2.386 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.451 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-20, it is shown that MVAR is increased by 0.065. The reactive power at bus-21 is measured as 2.210 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.788 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-21, it is shown that MVAR is increased 0.578.

The reactive power at bus-22 is measured as 3.612 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.629 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-22, it is shown that MVAR is increased by 0.017. The reactive power at bus-23 is measured as 2.879 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.978 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-23, it is shown that MVAR is increased by 0.099.

The reactive power at bus-24 is measured as 1.971 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.998 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-24, it is shown that MVAR is increased by 0.027. The reactive power at bus-25 is measured as 3.121 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.221 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-25, it is shown that MVAR is increased by 0.01.

The reactive power at bus-26 is measured as 2.843 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.856 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-26, it is shown that MVAR is increased by 0.013. The reactive power at bus-27 is measured as 1.32 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.801 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-27, it is shown that MVAR is increased by 0.481. The reactive power at bus-29 is measured as 3.35 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.36 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-29, it is shown that MVAR is increased by 0.01.

The reactive power at bus-30 is measured as 2.210 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.788 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-30, it is shown that MVAR is increased by 0.578. The reactive power at bus-31 is measured as 2.23 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.791 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-31, it is shown that MVAR is increased by 0.561.

The reactive power at bus-32 is measured as 2.27 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.810 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-32, it is shown that MVAR is increased by 0.54. The reactive power at bus-33 is measured as 2.26 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.842 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-33, it is shown that MVAR is increased by 0.582.

The reactive power at bus-34 is measured as 2.241 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.846 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-34, it is shown that MVAR is increased by 0.605. The reactive power at bus-35 is measured as 1.971 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.998 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-35, it is shown that MVAR is increased by 0.027. The reactive power at bus-36 is measured as 1.32 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.801 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-36, it is shown that MVAR is increased by 0.481.

The reactive power at bus-37 is measured as 2.27 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.810 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-37, it is shown that MVAR is increased by 0.54. The reactive power at bus-38 is measured as 2.26 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.842 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-38, it is shown that MVAR is increased by 0.582.

The reactive power at bus-39 is measured as 2.241 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.846 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-39, it is shown that MVAR is increased by 0.605. The reactive power at bus-40 is measured as 2.238 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.832 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-40, it is shown that MVAR is increased by0.594.

The reactive power at bus-41 is measured as 2.861 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.989 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-41, it is shown that MVAR is increased by 0.128. The reactive power at bus-42 is measured as 3.35 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.36 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-42, it is shown that MVAR is increased by 0.01.

The reactive power at bus-43 is measured as 3.23 MVAR without Distribution static synchronous compensator and reactive power at the same bus with D-STATCOM is 3.25 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-43, it is shown that MVAR is increased by 0.02. The reactive power at bus-44 is measured as 2.29 MVAR without Distribution static synchronous compensator and reactive power at the same bus with D-STATCOM is 2.28 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-44, it is shown that MVAR is =increased by 0.01.

The reactive power at bus-45 is measured as 1.971 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.998 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-45, it is shown that MVAR is increased by 0.027. The reactive power at bus-46 is measured as 1.38 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.57 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-46, it is shown that MVAR is increased by 0.19.

The reactive power at bus-47 is measured as 1.86 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.89 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-47, it is shown that MVAR is increased by 0.03. The reactive power at bus-48 is measured as 2.879 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.978 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-48, it is shown that MVAR is increased by 0.099.

The reactive power at bus-49 is measured as 2.98 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.97 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-49, it is shown that MVAR is increased by 0.01. The reactive power at bus-50 is measured as 2.89 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.987 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-50, it is shown that MVAR is increased by 0.097.

V. TABLE 2

Voltage & Reactive Power at different busses with and without STATCOM

Bus No.	Reactive Power without STATCOM (MVAR)	Reactive Power with STATCOM (MVAR)	Line Voltage (volt)	STATCOM Voltage (volt)
BUS-4	2.210	2.788	3154	4260
BUS-11	2.85	3.36	3124	4503
BUS-36	1.32	1.801	3126	4551

Table 2 represents the reactive power at various buses with and without Distribution static synchronous compensator, line voltages at various buses and STATCOM voltage at various buses. The reactive power at bus-4 is measured as 2.210 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 2.788 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-4, it is shown that MVAR is increased by 0.578.

The reactive power at bus-11 is measured as 2.85 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 3.36 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-4, it is shown that MVAR is increased by 0.51. The reactive power at bus-36 is measured as 1.32 MVAR without Distribution static synchronous compensator and reactive power at the same bus with Distribution static synchronous compensator is 1.801 MVAR. By comparing the results with and without Distribution static synchronous compensator reactive power values at bus-4, it is shown that MVAR is increased by 0.481.

VI. CONCLUSION

Fifty bus system is modeled and simulated using MATLAB SIMULINK and the results are presented. The simulation results of Fiifty bus system with and without Distribution static synchronous compensator are presented. This system has improved reliability and power quality. The simulation results are in line with the predictions. Fifty bus system was modeled and simulated successfully. Three buses were identified with low voltage. STATCOMs were connected at three buses to improve the power quality.

VII.SCOPE FOR FUTURE WORK

In the present work, the Eight Bus, Fourteen Bus, Thirty Bus and Fifty Bus systems were tested with and without Distribution static synchronous compensator for shunt compensation. The software used throughout the work was MATLAB and SIMULINK. This work can also be done using PSCAD or PSIM. This concept can be extended to Sixty four bus system and the hardware may be implemented using DSP processor.

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