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Power quality improvement of 66-bus distribution system using SSC

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Abstract

This paper deals with modeling and simulation of Thirty Three Bus Distribution System(TTBDS) employing a DSSC. DSSC consists of a DC source, inverter and injection transformer. The DSSC is capable of improving the voltage profile of distribution system by injecting a voltage in series with the line .Four number of DSSCs are suggested for TTBDS to improve the voltage profile. The TTBD Systems with and without DSSC are modeled, simulated and their results are presented. The results indicate that the voltage profile is improved by using DSSC.

Keywords

Unified power flow control(UPFC), Distributed static series compensator(DSSC), Flexible AC Transmission System(FACTS), Voltage Ampere Reactive(VAR), Dynamic Voltage Regulator(DVR), Static Compensator(STATCOM).

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Contents

1. Introduction

In the last few decades, the main concerns of the power companies are about power quality issues. The index which both the demand and delivery of electrical power effect on the performance of electrical apparatus is known as power quality. From the consumer point of view, any problem occur about current, voltage or the frequency deviation that results in power failure is called power quality problems. The power quality improvement mainly affect by the power electronics devices used by consumers and used in FACTS devices. Generally, customer power devices like dynamic voltage restorer (DVR) are used in medium to low voltage levels to improve customer power quality [7].

Most serious threats for sensitive equipment in electrical grids are voltage sags (voltage dip) and swells (over voltage) [5]. These disturbances occur due to some events, e.g., short circuit in the grid, inrush currents involved with the starting of large machines, or switching operations in the grid In this paper, a Distributed static series compensator, introduced in as a new FACTS device, is used to mitigate voltage and current waveform deviation and improve power quality in a matter of seconds. The DSSC Structure is derived from the UPFC structure that is included one converter and several small independent series converters, as shown in Fig.1.1 [4, 6]. The converter is similar to the STATCOM while the series converter employs the D-FACTS concept. The DSSC has same capability as UPFC to balance the line parameters, i.e., line impedance, transmission angle, and bus voltage magnitude [4].The concept of DSSC is introduced by Zhihui Yuan in 2010 with control range of DSSC also its modeled was explained by Ahmad Jamshidi and S. Masoud Barakati in 2012 with DSSC working principle and its advantages.

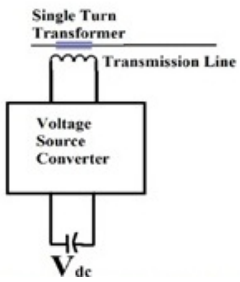

Fig. 1.1 DSSC structure

2. Dssc Principle

In the Unified Power Flow Controller (UPFC) is structured from SSSC and STATCOM. Both are coupled by DC storage capacitor via a common DC link. In comparison with UPFC, the main advantage offered by DSSC is eliminating the huge DC-link and instate using 3rd-harmonic current to active power exchange [2]. Theoretically the third, sixth, and ninth harmonic frequency can be used to exchange active power in the DSSC, which are generally zero sequence frequencies. The capacity of a transmission line to deliver power depends on its impedance. The transmission line impedance is inductive and proportional to the frequency, so the high transmission frequencies will cause high impedance. Because of this the third harmonics frequency is selected which is lowest zero sequence harmonic frequency. In the following subsections; the DSSC basic concepts are explained.

A. DC Link Elimination and Power Exchange: In the DSSC, instead of common DC link, the transmission line is used as a connection between the terminal of series converters and DC terminal of converter, for power exchange between converters [2][6]. The power theory of non-sinusoidal components is used to exchange power in DSSC. A non-sinusoidal voltage or current can be presented as the sum of sinusoidal components at different frequencies is based on Fourier series. The multiplication of current and voltage components gives the active power. Since the integral of some terms with different frequencies are zero, so the active power equation is given as:

$$P = \sum_{n=1}^{\infty} V_n I_n cos\phi_n \tag{2.1}$$

Where V_n and I_n are the voltage and current at the nth harmonic, respectively, and ϕ_n is the angle between the voltage and current at the same frequency. Equation (2.1) expresses the active power at different frequency components is independent. From the above equation (2.1) the current and voltage in one frequency has no influence on the active power at other frequencies. The active power at different frequencies is isolated from each other. So by this concept the converter in DSSC can absorb active power from the grid at the fundamental frequency and inject the current back into the grid at a harmonic frequency.

Based on this fact, a converter in DSSC can absorb the active power in one frequency and generates output power in another frequency, and also according to the amount of active power required at the fundamental frequency, the DSSC series converter generate the voltage at the harmonic frequency there by absorbing the active power from harmonic components.

As the series converters of the DSSC are single-phase, it gives the DSSC the opportunity to control current in each phase independently, which implies that both negative and zero sequence unbalanced current can be compensated. Additional controllers are supplemented to the existing DSSC controller. Their control principle is to monitor the negative and zero sequences current through the transmission line and to force them to zero.

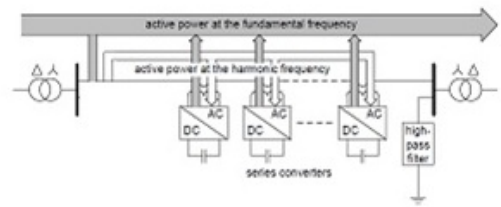

Fig.1.2 Active power exchange

The above literature does not use DSSC for distribution systems. This work proposes DSSC for TTBS. The comparison of performance of TTBS with and without DSSC is not reported in the previous papers.

3. System description

Proposed circuit Diagram of DSSC is appeared in Fig 1.3. 33 Bus system is shown in Fig 1.4.

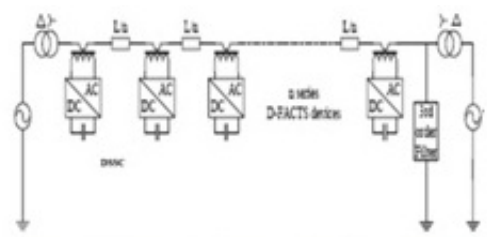

Fig. 1.3 Proposed circuit Diagram of DSSC

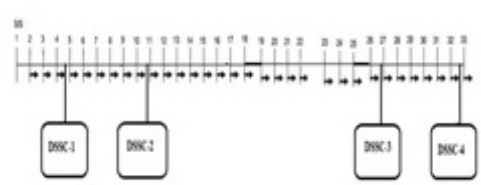

Fig. 1.4 33-Buses System of block diagram

4. Simulation Results

Circuit diagram of 33-bus system without DSSC is appeared in Fig 2.1.

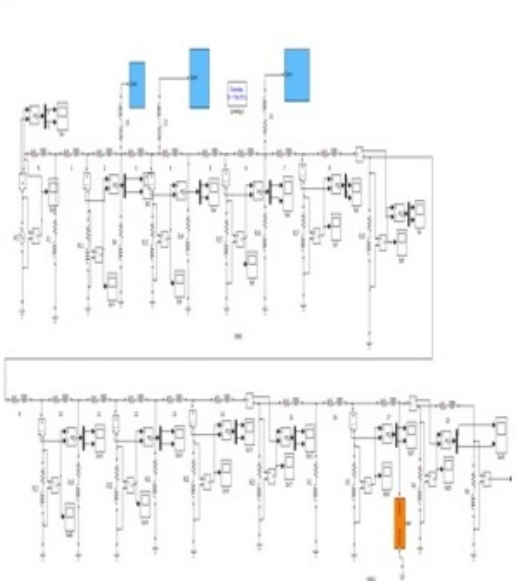

Fig 2.1 Circuit diagram of 33-bus system without DSSC

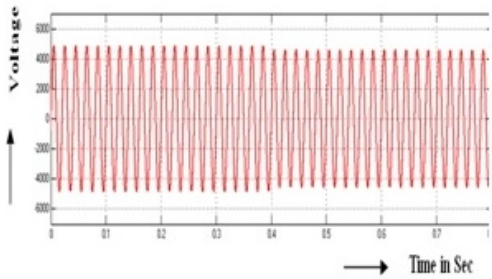

Fig 2.2 Voltage at bus-5

Voltage at bus-5 is appeared in Fig 2.2 and its value is 5000V. Real power and reactive power at bus-5 are appeared in Figs 2.3 and its value of real power is 1.17*105 MW and its value of reactive power is 2.3*104 MVAR. Without DSSC after 0.4sec second load will be on voltage, real and reactive power decreased.

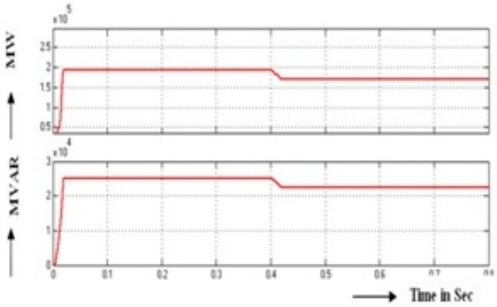

Fig 2.3 Real power and reactive power at bus-5

Voltage at bus-26 through is appeared in Fig 2.4 and its value is 4800 V. Without DSSC after 0.4sec second load will be on voltage as decreased.

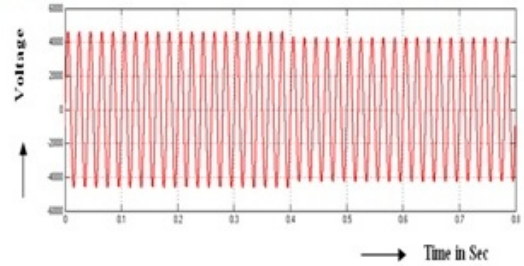

Fig 2.4 Voltage at bus-26

Real power and reactive power at bus-26 are appeared in Figs 2.5 and its value of real power is 14*104 MW and its value of reactive power is 4.4*104 MVAR. Without DSSC after 0.4sec second load will be on real nd reactive power decreased.

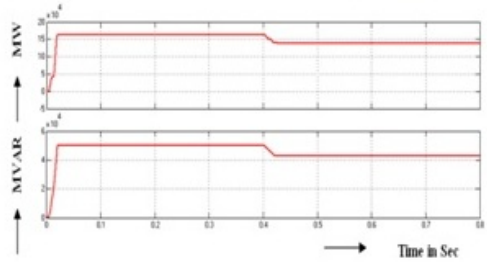

Fig 2.5 Real and reactive power at bus-26

Voltage at bus-32 is appeared in Fig 2.6 and its value is 6000 V. Without DSSC after 0.4sec second load will be on voltage as decreased.

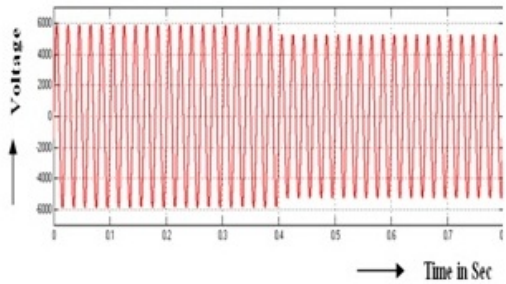

Fig 2.6 voltage at bus-32

Real power and reactive power at bus-32 are appeared in Fig 2.7 and its value of real power is 7*105 MW and its value of reactive power is 1.7*105 MVAR. Without DSSC after 0.4sec second load will be on real and reactive power decreased.

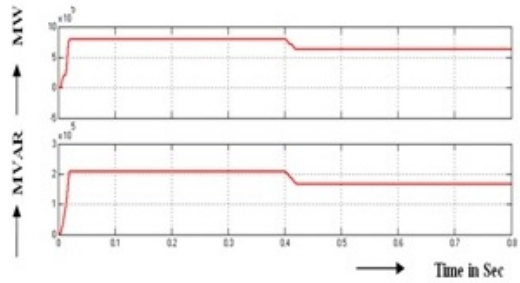

Fig 2.7 Real and reactive power at bus-32

Circuit diagram of 33-bus system with DSSC is appeared in Fig 2.8.

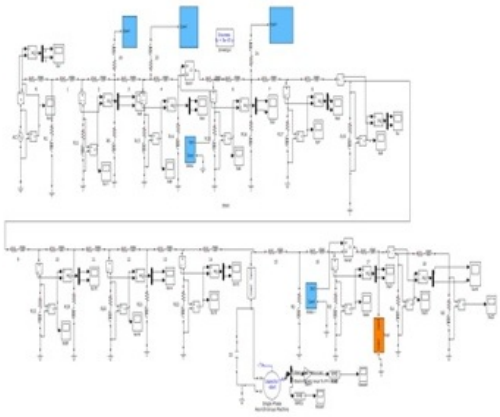

Fig 2.8 Circuit diagram of 33-bus system with DSSC

Voltage at bus-5 is appeared in Fig 2.9 and its value is 5000V. With DSSC after 0.4sec second load will be on voltage as increased.

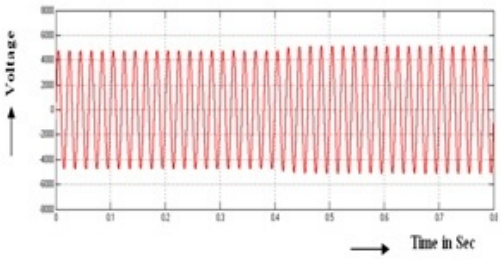

Fig 2.9 Voltage at bus-5

Real power and reactive power at bus-5 are appeared in Figs 2.10 and its value of real power is 2.1*105 MW and its value of reactive power is 2.8*104 MVAR. With DSSC after 0.4sec second load will be on real and reactive power increased.

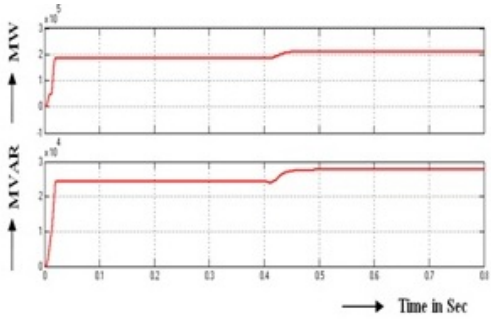

Fig 2.10 Real and reactive power at bus-5

Motor speed at bus-14is appeared in Fig 2.11 and its value is 1500 RPM.

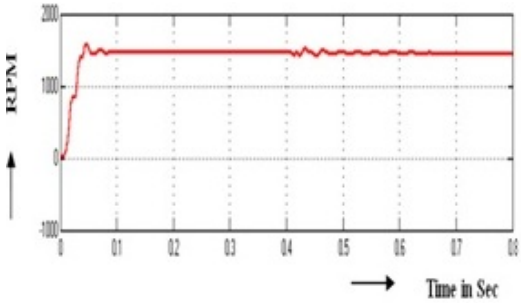

Fig 2.11 Motor speed at bus-14

Motor torque at bus-14is appeared in Fig 2.12 and its value is 99 N-m.

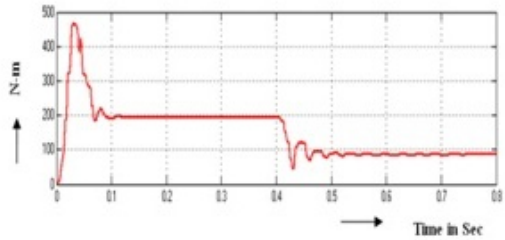

Fig 2.12 Motor torque at bus-14

Voltage at bus-26is appeared in Fig 2.13 and its value is 5000V.With DSSC after 0.4sec second load will be on voltage as increased.

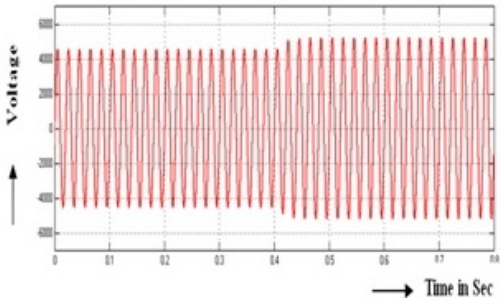

Fig 2.13 voltage at bus-26

Real power and reactive power at bus-26 are appeared in Figs 2.14 and its value of real power is 2*105 MW and its value of reactive power is 6.3*104 MVAR. With DSSC after 0.4sec second load will be on real and reactive power increased.

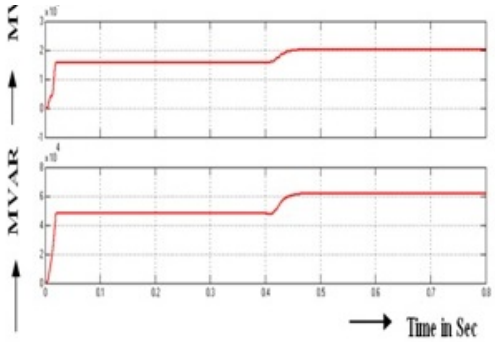

Fig 2.14 Real and reactive power at bus-26

Motor speed at bus-30is appeared in Fig 2.15 and its value is 1500 RPM.

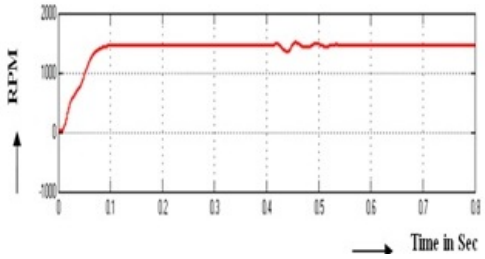

Fig 2.15 Motor speed at bus-30

Motor torque at bus-30through is appeared in Fig 2.16 and its value is 22 N-m.

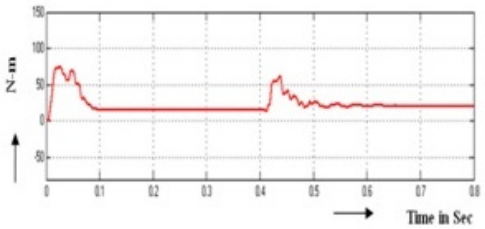

Fig 2.16 Motor torque at bus-30

Voltage at bus-32 is appeared in Fig 2.17 and its value is 6300 V. With DSSC after 0.4sec second load will be on voltage as increased.

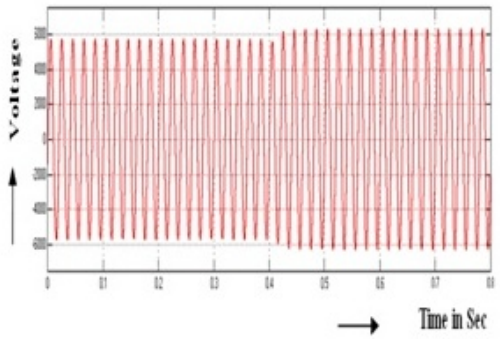

Fig 2.17 Voltage at bus-32

Real power and reactive power at bus-32 are appeared in Fig 2.18 and its value of real power is 12*105 MW and its value of reactive power is 5.5*105 MVAR. With DSSC after 0.4sec second load will be on real and reactive power increased.

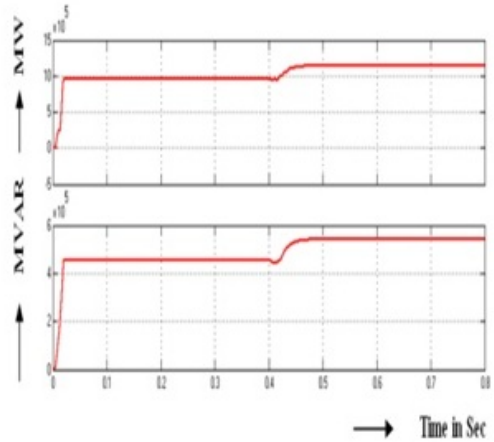

Fig 2.18 Real and reactive power at bus-32

Bus Voltage of without and with DSSC is given in Table-1. DSSC without and with voltage Bus-5 value is 4.55 to 5.51KV. The Bus 26 without and with voltage value is 4.20 to 5.15 KV. The Bus 32 without and with voltage value is 5.26 to 6.20 KV.

Table-1 Voltage of without and with dssc

BUS NO	VOLTAGE WITHOUT DSSC (KV)	VOLTAGE WITH DSSC(KV)
BUS-5	4.55	5.51
BUS-26	4.20	5.15
BUS-32	5.26	6.20

Table-2 Real and reactive power of without and with dpfc

BUS NO	Real power (MW) Without DSSC	Real power (MW) With DSSC	Reactive power(MVAR) Without DSSC	Reactive power(MVAR With DSSC
BUS-5	0.170	0.215	0.024	0.028
BUS-26	0.151	0.210	0.042	0.062
BUS-33	0.623	1.120	0.165	0.540

5. Conclusion

TTBS with and without DSSC are simulated. The results indicate that the voltage, real power and reactive power are improved by the addition of DSSC. The increase in V, P and Q are due to increase in voltage with the addition of DSSC.

DSSC has the ability to compensate the voltage sag in power and distribution lines. The disadvantage of DSSC is that the hardware cost is increased.

The present work deals with TTBS with and without DSSC. Studies on closed loop TTBS with PI and PR systems will be done in future.

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