

AN OPTIMAL LOCATION OF A CAPACITIVE REACTANCE COMPENSATOR IN ELECTRIC POWER SYSTEMS

Ahmad N. Al- Husban

Al Balqa Applied university, Faculty of Engineering Technology, Amman, Jordan, PO box 377 *Amman, 11947, Jordan*
* E-mail: drahusban2008@yahoo.com

Abstract

The paper presents detailed fast control characteristics and continuous compensation capability; Flexible AC Transmission System (FACTS) devices have been researched and adopted in power engineering area. It can increase dynamic stability, and improve power quality. It can also increase utilization of lowest cost generation. FACTS device is to control the power flow actively; it can transfer power flow from one line to another within its capability.

The optimal location and parameters of Unified Power Flow Controllers (UPFCs) in electrical power systems is studied. The location of FACTS devices in the power system are obtained on the basis of static and/or dynamic performances, the best locations are in the line congested or near that line. The paper focuses on the operation of the FACTS device under fault that may cause other transmission lines to be overflowed

The proposed algorithm in this paper is tested and verified on the 9 bus system by using ATP simulation program.

Keywords: Power quality, Sag, FACTS, IEEE-9 bus system.

1. Introduction

In recent years, power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. The continuous grow of electric demand requires building new generating units and transmission circuits.

These requirements are becoming more difficult because of economic and environmental reasons. Also, conventional devices with fixed or mechanically switchable component have low control speed, high wearing and require frequent.

The operation of an AC transmission system is generally constrained by limitations of one or more network parameters (such as: line impedance) and operating variables (such as voltages and currents) J.B.Choo *et al*. (2004). As a result, the power line is unable to direct power flow among generating stations. To increase the power transfer capability of transmission systems, minimize the transmission losses, to support a good voltage profile and to retain system stability under large disturbances.

The main objectives of FACTS are; to increase transmission capacity of lines, control power flow over designated transmission, electronically and statically, without need of operator's actions and without need of mechanical manipulations or conventional breakers switching (C.Kim *et al.* 2005).

It is well known that shunt and series compensation can be used to increase the maximum transfer capabilities of power networks. With the improvements in current voltage handling capabilities of power electric devices that have allowed for the development of FACTS, the possibility has arisen of using different types of controllers for efficient shunt and series compensation.

More recently, various types of controllers for shunt and series compensation, based on voltage source inverters (VSIs), Shunt and Series Static Synchronous Compensators (STATCOMs and SSSCs) and Unified Power Flow Controllers (UPFCs), have been proposed and developed.

The optimal location of Flexible AC Transmission Systems (FACTS) in multimachine power system using Genetic Algorithm, the objective is to obtain the bus voltages of the system within healthy limits, A capacitive reactance compensator is the FACT device chosen for the proposed algorithm, the location of FACT devices and their rated values are optimized simultaneously (C.Kim *et al*. 2005; H.Fujita *et al* 2006; E.M.Farahani & S.Afsharnia 2006).

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The proposed algorithm in this paper is tested and verified on the 9 bus system by using ATP simulation program.

2. Power System Problem

The nonlinear characteristics of various office and industrial equipment connected to the power grid could cause electrical disturbances leading to poor power quality. These electrical disturbances could destroy certain sensitive equipment connected to the grid or in some cases could cause them to malfunction.

All electronic equipment when connected to the power system can actually generate electrical disturbances, which can adversely affect other equipment within the power network. Heavy industrial equipment such as nonlinear variable speed drives powered through power electronic converters cause the power disturbances. The transient problems such as sags and swells when repeatedly experienced can damage electronic equipment connected to the network (A. Kumar 2007).

Both electric utilities and end users of electrical power are becoming increasingly concerned about the quality of electric power. There are many reasons for this growing concern such as; the use of microprocessor-based controls and power electronic devices. In fact many loads are sensitive to different types of disturbances.

Any power problem is manifested in voltage, current, or frequency deviations. A failure or misoperation of customer equipment means that there is a power quality problem.

3. Power System Modeling

In the case of a no-loss line, voltage magnitude at receiving end is the same as voltage magnitude at sending end:

$$V_s=V_r=V. \qquad (1)$$

Transmission results in a phase lag δ that depends on line reactance X.

As it is a no-loss line, active power P is the same at any point of the line:

$$P_s=P_r=P$$

$$= (V\cos(\delta/2))((2V\sin(\delta/2))/X)$$

$$=(V^2 \sin\delta)/X \qquad (2)$$

The reactive power at sending end is the opposite of reactive power at receiving end:

$$Q_s=-Q_r=Q$$

$$=(V\sin(\delta/2))((2V\sin(\delta/2))/X)$$

$$=(V^2(1-\cos\delta))/X \qquad (3)$$

As δ is very small angle, active power mainly depends on δ whereas reactive power mainly depends on voltage magnitude.

FACTS for series compensation modify line impedance Fig.(1) : the total transmission system reactance X is decreased so as to increase the transmittable active power. However, more reactive power must be provided.

$$P = (V^2 \sin\delta)/(X-X_c) \qquad (4)$$

$$Q = (V^2(1-\cos\delta))/(X-X_c) \qquad (5)$$

4. Capacitive Reactance Compensator

It is a capacitive reactance compensator which consists of a series capacitor bank shunted by thyristor controlled reactor TCR, in order to provide a smoothly variable series capacitive reactance X_C and connected to series capacitor bank reactance X_{C1eq}. ATCSC components are given in Fig.2.

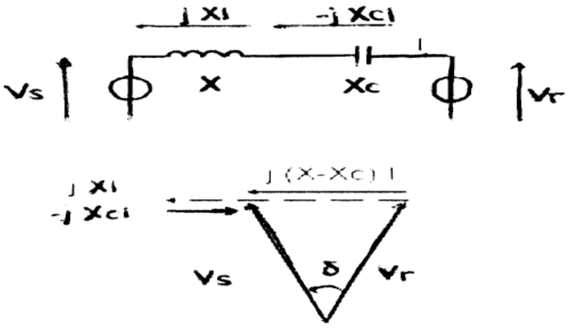

Figure.1 Series FACTS

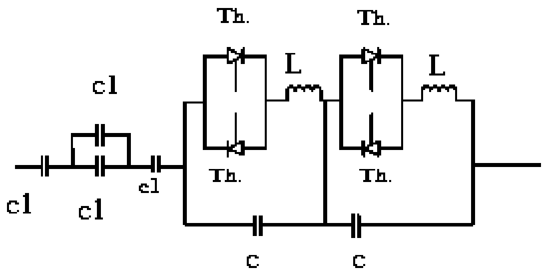

Figure.2 Capacitive Reactance Compensator

In a capacitive reactance compensator the following equation is used:

$P = (V^2 \sin\delta)/(X-X_c) + X_{C1eq} V^2 \sin\delta \cos\delta$ **(6)**
$Q = (V^2(1-\cos\delta))/(X-X_c) + X_{C1eq} V^2 \sin^2\delta$ (7)

5. Numerical Simulation

In this section the IEEE power system is discussed (S. Gerbex *et al* 2003; A. Kumar 2007; K. Lokanadham 2010; H.O. Bansal et al. 2010).

Fig.3 shows 9 bus system under study and Fig.4 shows the block diagram of closed loop control system used to control of power quality problem (sag problem) by using advanced FACTS devices. A simple and efficient model for optimizing the location of FACTS devices used for improving power quality by controlling the device parameters.

The optimal location of the devices in the network must be ascertained and then, the settings of the control parameters optimized. The best locations are in the line need to improve power quality or near that line. ATP simulation program is used.

Fig.5 shows the voltage at bus 8 at normal state from 0 to 0.2 sec. (voltage=5250volt). When generator connected to bus 2 (G2) is out of service from 0.2 to 0.4 sec. (voltage=1600volt) and when connected a capacitive reactance compensator at bus 8 from 0.4 to 0.6 sec. and the voltage increased to the normal state (voltage=5250volt).

Fig.6 shows the voltage at bus 6 at normal state from 0 to 0.2 sec. (voltage=3600volt) and when generator connected to bus 1(G1) is out of service from 0.2 to 0.4 sec. (voltage=1333volt). When connected a capacitive reactance compensator at bus 6 from 0.4 to 0.6 sec. and the voltage increased to the normal state (voltage=**3**600volt).

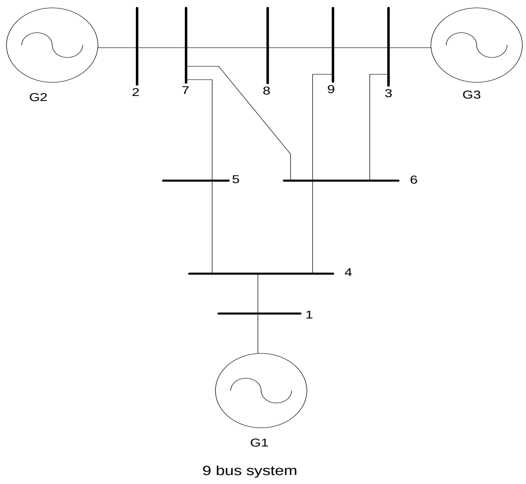

Figure.3 9bus system

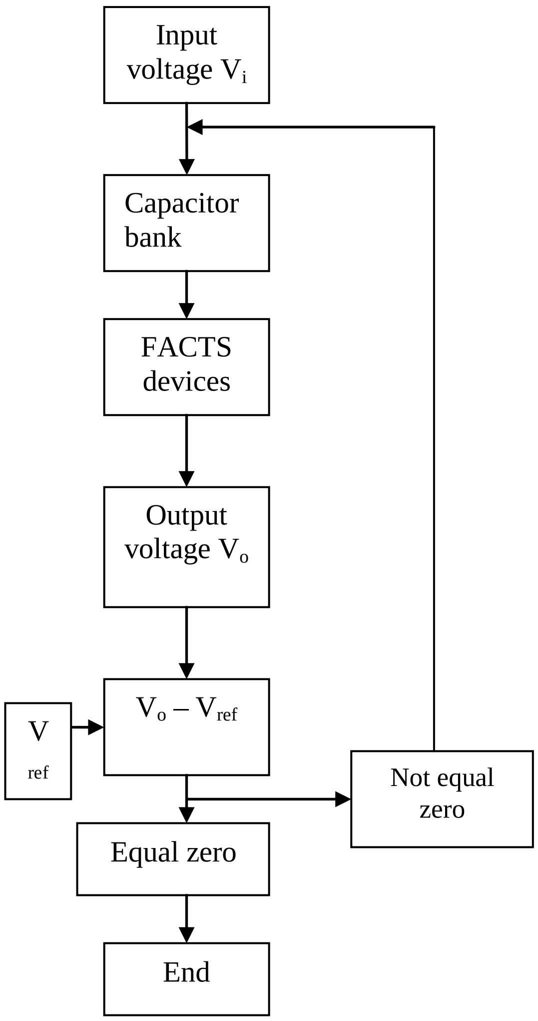

Figure.4 The block diagram of closed loop control system

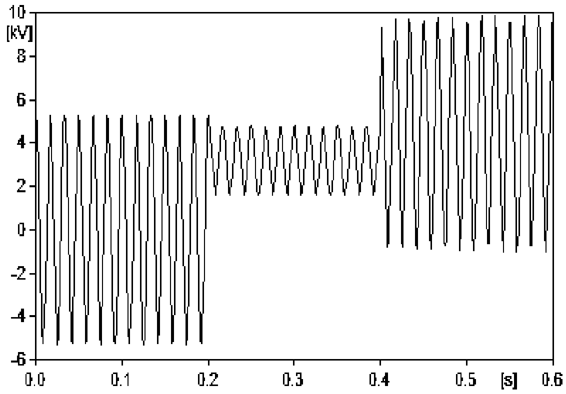

Figure.5 The voltage Response at bus 8

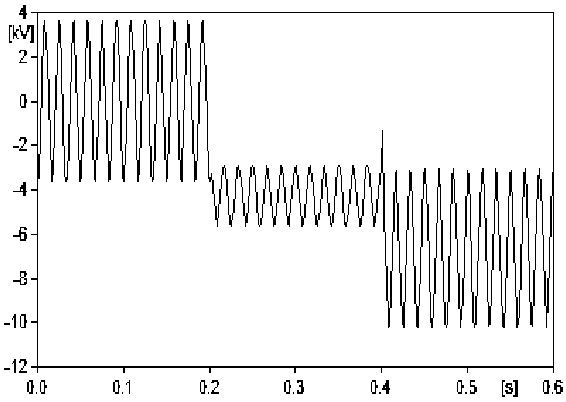

Figure.6 The voltage response at bus 6.

6. Conclusion

In this paper, a capacitive reactance compensator is only used to study for the 9 bus power system. The optimal location to connect FACTS is the bus need to improve power quality; the ATP simulation program can be used.

The Alternative Transient Program (ATP) techniques use power flow calculation has several advantages such as fast calculation, possibility of determination of the margin of power quality problem.

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