

Power System Transient Stability Transmission Line Improvement with STATCOM Positioning

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ABSTRACT: Flexible AC transmission systems (FACTS) controllers have been mainly used to solve various power system control problems. Many controllers of Flexible AC Transmission Systems (FACTS) like SVC, STATCOM, Unified Power Flow Controller (UPFC), PWM asynchronous dc link, Thyristor-Controlled Series Capacitor (TCSC) and PWM Series Static VAR compensator gives stabilized voltage support. So they can be placed at the mid-point of the transmission line, which has been proven by the late E.W. Kimbark, as the optimum location for shunt capacitor compensation. This paper deals with the position of a shunt FACTS device (STATCOM) other than mid-point on transmission line to improve transient stability with predefined real power flow.

KEYWORDS: FACTS, simulation, Modelling, STATCOM, Transient Stability, MATLAB.

I. INTRODUCTION

Recent development of power electronics introduces the use of FACTS devices in power systems. FACTS devices are capable of controlling the network condition in a very fast manner and this unique feature of FACTS devices can be exploited to improve the transient stability of a system. Reactive power compensation is an important issue in electrical power systems and shunt FACTS devices play an important role in controlling the reactive power flow to the power network and hence the system voltage fluctuations and transient stability. The flexible AC transmission system (FACTS) are now recognized as a viable solution for controlling transmission voltage, power flow, dynamic response ,etc. and represent a new era for transmission systems. It uses high-current power electronic devices to control the voltage, power flow, etc. of a transmission system. FACTS devices are very effective and capable of increasing the power transfer capability of a line, if the thermal limit permits, while maintaining the same degree of stability. SVC and STATCOM are members of FACTS family that are connected in shunt with the system. Even though the primary purpose of shunt FACTS devices is to support bus voltage by injecting (or absorbing) reactive power, they are also capable of improving the transient stability by increasing (decreasing) the power transfer capability when the machine angle increases (decreases), which is achieved by operating the shunt FACTS devices in capacitive (inductive) mode. Previous works on the topic prove that shunt FACTS devices give maximum benefit from their stabilized voltage support when sited at the mid-point of the transmission line. The proof of maximum increase in power transfer capability is based on the simplified model of the line neglecting line resistance and capacitance. However, for long transmission lines, when the actual model of the line is considered, the results may deviate significantly from those found for the simplified model. The primary objective of our project is to find the maximum power and the corresponding location of the shunt FACTS devices when the actual line model is considered. Based on the simplified line model it has been proved that the centre or midpoint of a transmission line is the optimal location for shunt FACTS devices. When the actual model of the line is considered, it is found that the FACTS device needs to be placed slightly off-centre to get the highest possible benefit. To facilitate the same the objectives have been listed below as:-

1. To find the maximum power and the corresponding location of the shunt FACTS devices when the actual line model is considered.
2. To compare the optimal location obtained for both the simplified and actual line model of a 345kV, 450km line.
3. To compare the power-angle characteristics and stability for both simplified and actual line model.

4. To find the optimal location of shunt FACTS device when a 5-bus system is considered. Haque, M.H. [1] investigated the effects of the actual line model on the optimal location of shunt FACTS devices to get the highest possible benefit. IEEE Task Force [3] presents the results of Task Force 3 of the IEEE’s FACTS Working Group of the DC and FACTS Subcommittee which had the assignment to establish appropriate definitions of FACTS-related terminology. FACTS are an evolving technology-based solution envisioned to help the utility industry to deal with changes in the power delivery. Kimbark, E.W. [8] has dealt with raising the stability limit of a power system examined with respect to their employment at or near the electrical center of a two-machine system. New concept of current gain, voltage gain are defined and illustrated. Shunt devices are most effective when connected at the electrical centre of a transmission system and their effectiveness falls off rapidly when a change in the transmission system throws them off-centre. Kazerani, B.T. [10] studied how FACTS devices derive maximum benefit from their stabilized voltage support when sited at the mid-point of the transmission line. The power transfer capacity is increased to twice that of the uncompensated line. The mid-point sitting is also most effective in reactive power control. The transmission line must be operating below the thermal limit and the transient stability limit. Tan, Y.L [11] suggested a novel method for the analysis of the effectiveness of an SVC and a STATCOM of the same KVar rating for first-swing stability enhancement is presented and the concept is demonstrated with a numerical example. The analysis shows that the STATCOM is superior to the SVC for first-swing stability enhancement. Siddhartha Panda, Ramnarayan N. Patel[11] investigated about the Shunt Flexible AC Transmission System (FACTS) devices, when placed at the mid-point of a long transmission line, play an important role in controlling the reactive power flow to the power network and hence both the system voltage fluctuations and transient stability. This paper deals with the location of a shunt FACTS device to improve transient stability in a long transmission line with predefined direction of real power flow. It has been observed that the FACTS devices, when placed slightly off-centre towards sending-end, give better performance in improving transient stability and the location.

II. TRANSMISSION LINE MODEL

In this paper, the transmission line is modeled by a two-port, four terminal networks as shown.



Figure 1: Two port four terminal model of a transmission line.

Transmission lines are operated with a balanced three phase load; the analysis can therefore proceed on a per phase basis. A transmission line on a per phase basis can be regarded as a two port network, wherein the sending end voltage V_s and current I_s are related to the receiving end voltage V_r and current I_r through ABCD constants as

$$V_S = AV_R + BI_R \quad (1)$$

$$I_S = CV_R + DI_R \quad (2)$$

Electrical systems are constantly changing industry, where there is a field. Power industry to lower prices and better power efficiency are restructuring to meet more users. As they are interconnected power systems are becoming more complex. Load demand increases linearly with the increase in users. Transfer capability limit of stability within the system since the event, due to economic reasons, need to ensure power system stability and reliability. Different types

of rotor angle stability of power system stability, frequency stability and voltage stability [11] have been classified as. Fig-1 power system stability [1] shows the classification.

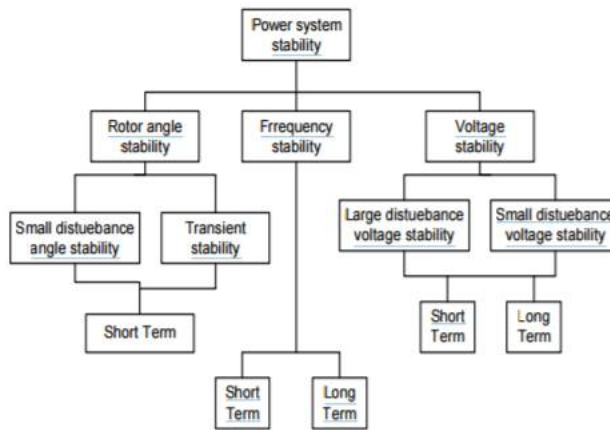


Fig-2: Classification of power system stability

Power outages rise against the catastrophic economic operation system during the inter-relations, and strategic coverage and improved reliability are becoming more complex. Transmission network reinforcement and to avoid environmental objections include the capital costs are now under more stress than ever before. These trends need to operate close to the stability limit is a system, and disturbances of the system is more vulnerable electrical fast transient and dynamic stability problems. Utility companies operating security limit the risk of engineers to perform off-line transient stability simulation face a huge number. These limits again for on-line dynamic security monitoring control center are used throughout the energy management system.

III. SIMULINK MODEL

Power system stabilizers (PSS) have been extensively used as supplementary excitation controllers to damp out the low frequency oscillations and enhance the overall system stability. Fixed structure stabilizers have practical applications and generally provide acceptable dynamic performance. There have been arguments that these controllers, being tuned for one nominal operating condition, provide suboptimal performance when there are variations in the system load. There are two main approaches to stabilize a power system over a wide range of operating conditions, namely robust control. This block is used to damp out the rotor oscillations of the synchronous machine by controlling its excitation. This has the input as speed deviation from machine block and output in form of stabilization voltage for the excitation system block (Figure 3).

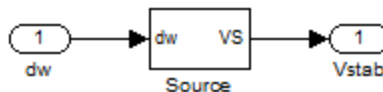


Figure 3: Power System Stabilizer

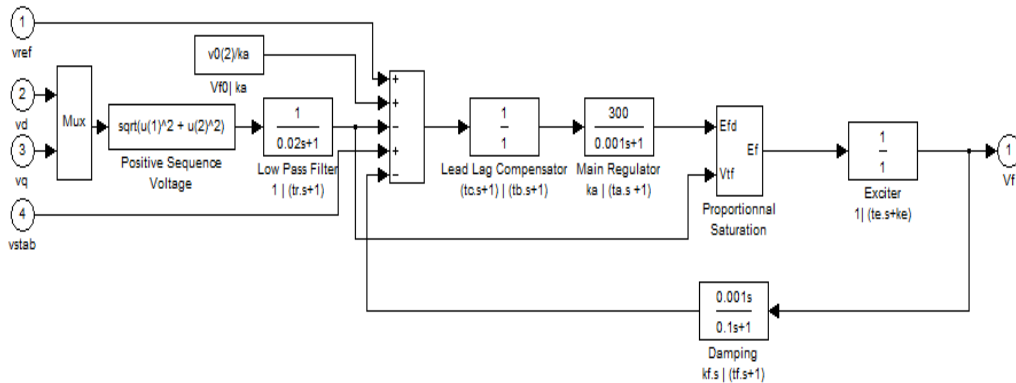


Figure 4:Excitation System

IV. SIMULINK RESULT

Previous works on the subject sited at the mid-point of the transmission line when the constant voltage shunt devices supporting facts prove that the maximum benefit. Evidence of increased stability and maximum power transfer capability of the line model is based on a simplified version of neglecting line resistance and capacitance. Based on the simple model of a transmission line or the center line between facts combined shunt -series has proven to be the optimal location in the equipment. Line is the actual model, the fact that the highest possible return device [3] should be placed slightly off-center to get that is found. Sitting mid-point of reactive power control is most effective. Transmission line transient stability and thermal limits must be operating below the threshold. Increase STATCOM first swing stability analysis [5] SVC is better than the shows. Siddhartha Panda, Ram Narayan N. Patel [10] placed at the mid-point of a long transmission line, the shunt Flexible AC Transmission Systems (FACTS) devices investigated regarding, for power networks play an important role in controlling reactive power flow and both voltage fluctuations and transient stability within the system. This paper predefined direction of real power flow in a long transmission line to improve transient stability is also related to the placement of a shunt FACTS device. It is placed slightly offcenter toward the sending end when the FACTS devices, delivering better performance in improving transient stability and space that has been seen.

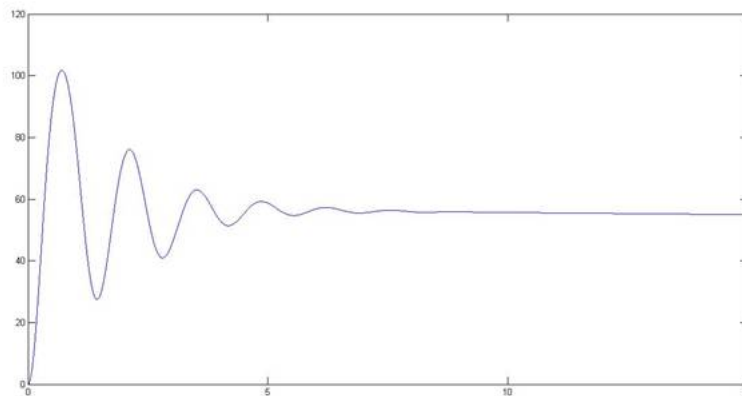


Figure 5: L-G fault without STATCOM

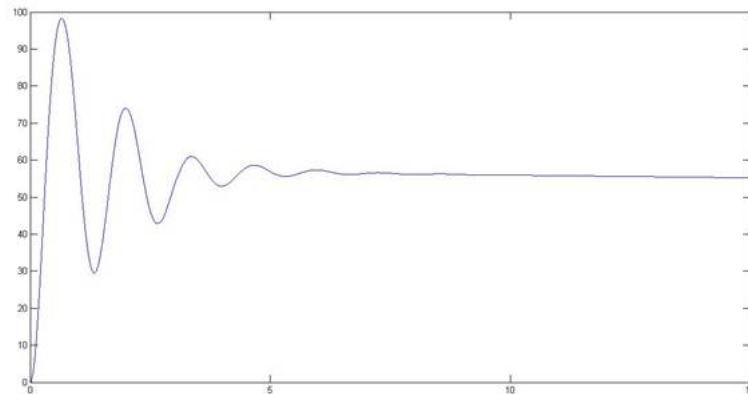


Figure 6: L-G fault with STATCOM

V. CONCLUSION

It has been found that the shunt FACTS device needs to be placed slightly off-centre to get highest possible benefit when the power flows in the particular direction. The optimal location from the centre point depends on the line resistance and increase almost linearly as the R/X ratio of the line is increased. The results found in this paper would be useful in selecting the best location for various shunt FACTS devices to get the highest possible benefit when the pattern of power flow of the line is known. It is also found that some of the results obtained or conclusions made for the simplified line model are not valid for the actual line model, especially when the FACTS device is placed at the midpoint. In the future, FACTS devices could be installed on a wide scale by electrical utilities in an attempt to control the power flows through their networks. It is also recognized as a viable solution for controlling transmission voltage, power flow, and dynamic response.

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