International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 7(C); July 2018; Page No. 14051-14054
DOI: http://dx.doi.org/10.24327/ijcar.2018.14054.2535

Research Article

ENHANCING THE PERFORMANCE OF POWER SYSTEM TRANSMISSION NETWORK

Bhupendra DagaduGangurde and Shridhar S Khule

Matoshri College of Engineering & Research Centre Eklahare, Nasik, Maharashtra, India – 425406

ARTICLE INFO

Article History:

Received 25th April, 2018
Received in revised form 13th May, 2018 Accepted 7th June, 2018
Published online 28th July, 2018

Key words:

FACTS-Flexible AC Transmission System devices, TCSC-Thyristor Controlled Series Compensator UPFC-Unified Power Flow Controller, PSS-Power System Stabilizers,

ABSTRACT

Today's energy scenario, demands a significant change in the transmission network. As the demand for electrical energy increases day by day, new sources for generation of electrical energy are being probed. This increased generation of electrical energy must ultimately reach the end consumers. This can be done by installing new transmission lines. But, the planning of new transmission lines is inhibited by various factors like right of way, ecological elements and increased expense of installation. Therefore, the increased generated power has to be transferred to the end consumers only with the existing transmission lines. This has led to the transmission lines operating nearer to the thermal limits and voltage limits more often. Hence, the existing transmission lines are prone to stability limit violations. Generally, the problems of voltage collapse and black outs are increasing. Moreover, the reactive power compensation is also the need of the hour. This decreases the transmission line losses effectively. The increased power transfer in the existing transmission lines is also affected by the network constraints. The other scenario that has to be viewed in the transmission sector is the policy of deregulation practiced in the present power system. Deregulation of the power industry has led to the transformation of electricity into commodity. In earlier days, power industry was under monopoly and the pricing was fixed by the Government policy. Due to privatization of power sector, different private sectors are interested in delivering power to the end consumers at low cost along with reliability and quality. This leads to the congestion in transmission lines. The problem of congestion has to be tackled by the transmission system. The significant change in the present-day transmission system has led to the increased power transfer in the existing transmission lines without violating the stability limits.

A forty-eight pulse STATCOM evolved on two level gate turn-off thyristor based voltage source converters (GTO-VSCs) topology to be operated at fundamental frequency switching modulation is employed to have higher voltage gain in the midpoint of the transmission line enabling to achieve reasonable power gain in the system.

INTRODUCTION

The introduction presents a picture of the structure of today's power system. It also portrays a reasonable picture about the different challenges that are confronted by the present-day transmission framework.

Today's power system is a complex system that consists of power generation system, transmission system and distribution system. The present-day transmission system is a nonlinear interconnected network. As the nature of the electrical load changes day by day, the consumption of electrical power also varies. Also, with the increase in population, the demand for electrical energy increases with too many folds. To meet the growing demand of electric power, the generation capacity has to be increased.

Corresponding author:* **Bhupendra DagaduGangurde
Matoshri College of Engineering & Research Centre
Eklahare, Nasik, Maharashtra, India – 425406

But in recent years, the increased cost of building new transmission lines with constraints on right of way and environmental factors has demanded the operation of the existing transmission lines to carry the amount of increased generated power. This has led to the operation of existing transmission lines to their maximum limits. Due to these factors, the transmission system faces different challenges. The challenges that the transmission system faces today, are voltage stability, transient stability, minimization of transmission losses, congestion management, voltage regulation and reactive power support.

These challenges are addressed in the forthcoming sections and the possible ways to meet out the challenges are also discussed in the proposed thesis. By addressing these challenges effectively, the performance of the transmission system can be increased considerably.

The inability of the power system to supply the reactive power or by an excessive absorption of reactive power is termed as voltage collapse. Therefore, voltage collapse happens due to reactive power and it is strongly affected by the load behaviour (i.e. constant Q for varying voltages).

Voltage stability refers to the ability of a power system to maintain steady voltages at all buses in the system and maintain or restore equilibrium between load demand and load supply from its given initial operating conditions, after it has been subjected to a disturbance. Instability may result due to progressive voltage rises or falls at some buses. The cause for voltage instability are the loss of load in an area, possible tripping of transmission lines and other elements of their protective systems which can lead to cascading outages. Voltage collapse is more complex than voltage instability. It is a process in which blackout of the power system occurs due to the abnormal sequence of events. Sometimes it also leads to abnormally low voltages in a significant part of the power system. The main symptoms of voltage collapse are low voltage profiles, heavy reactive power flows, inadequate reactive support and heavily loaded systems. Transient Stability is the study of the power system following a major disturbance. If the rotor angle of the synchronous alternator deviates from its limit, due to the disturbance, then it is termed as transient instability. The load angle of the alternator has to regain its original position, when the disturbance is cleared. This state of returning to the original state by the load angle is called transient stability. The disturbance is caused by a fault that occurs in the system. When the fault is cleared, the system should regain to its original state.

Dynamic stability is defined as the ability of a power system to maintain stability under continuous small disturbances (also known as small signal stability). These small disturbances occur due to random fluctuations in loads and generation levels. These random variations can lead to catastrophic failure in an interconnected power system, as this may force the rotor angle to increase steadily. Now–a-days the electric power industry is undergoing tremendous changes in its structure and governance. Deregulation of power industry has led to the new power framework in which electricity is considered as a commodity. In the previous set up, monopolistic framework, electricity supply is considered as a public service. Due to deregulation and open economy policy of the government, the investors own transaction permissions from the government to sell their generated power. These investors have to follow certain guidelines framed by the government. In deregulation environment the problem of congestion is more prone. When a transmission line transfers more power than its permissible limit, then it is said to be congested. Congestion takes place, when the transmission lines are not sufficient to transfer the power, according to market desires. Thus, congestion management is a tool which efficiently makes use of the power available without violating the system constraints. Congestion management means the activities of the transmission system operator to relieve transmission constraints in a competitive electricity market. Congestion management refers to avoiding or relieving congestion. In a much broader sense, congestion management can be classified under two broad paradigms. One is the cost-free method and the other is the non-cost-free method. These methods employ modifying the topology of the network, installing transformer taps and operation of conventional compensation devices, e.g. phase-shifters and use of Flexible AC Transmission System devices. The cost-free measures are more advantageous, since they avoid any sort of economic discrepancy. The cost-free measures include installation of FACTS devices, especially Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC).

LITERATURE REVIEW

The In a power system disturbance is an inherent thing when it is subjected to a disturbance. During the transient period protective relays experience abnormal operating conditions.
Power System Stabilizers (PSS) can effectively be used to damp out generator electromechanical oscillations by minimizing the phase lead and lag between the synchronously rotating armature flux and the rotor. AVR along with PSS is used to enhance power system stability as stated by Dudgeon *et al* (2007). The effectiveness of AVR and PSS are investigated in their work. The operation of these two devices is interlinked with each other. The effect of these devices on system stability is discussed. Barreiros *et al* (2005) have designed a PSS using a static Artificial Neural Network. This neural network is used to tune the parameters of PSS with respect to the operating conditions. This neural PSS performed better than fixed parameter-based PSS. Fusco & Russo (2011) designed a PSS and excitation controller which has non-linear characteristics and has a satisfactory performance under different operating conditions. Power System Stabilizers (PSS) can effectively be used to damp out generator electromechanical oscillations by minimizing the phase lead and lag between the synchronously rotating armature flux and the rotor. AVR along with PSS is used to enhance power system stability as stated by Dudgeon *et al* (2007). The effectiveness of AVR and PSS are investigated in their work. The operation of these two devices is interlinked with each other. The effect of these devices on system stability is discussed. Barreiros *et al* (2005) have designed a PSS using a static Artificial Neural Network. This neural network is used to tune the parameters of PSS with respect to the operating conditions. This neural PSS performed better than fixed parameter based PSS. Fusco & Russo (2011) designed a PSS and excitation controller which has non linear characteristics and has a satisfactory performance under different operating conditions.

Congestion Management and Voltage Stability Enhancement Using Rescheduling With Facts Devices

Here emphasizes the significance of congestion management in an interconnected power network. Along with congestion management, voltage stability enhancement is also done by rescheduling of generators and FACTS devices.

All over the world, the electricity industry is converging towards a competitive framework and amarket environment is replacing the traditional monopolistic scenery in the electricity industry. In the regulated framework, electricity supply is considered as a public service to the electric energy industry. Congestion results, when power flows in the transmission line are higher than allowed by the operating reliability limits. In a competitive electricity market, congestion occurs, when the transmission network is unable to accommodate all of the desired transactions due to violation of system operating limits. Congestion takes place, when the transmission lines are not sufficient to transfer the power, according to market desires as stated by Shahidehpour *et al* (2002). Thus, congestion management is a tool which efficiently makes use of the power available without violating the system constraints. Congestion management means the activities of the transmission system operator to relieve transmission constraints in a competitive electricity market. Singh *et al* (2014) stated that congestion management refers to avoiding or relieving congestion. In a much broader sense, congestion management can be classified under two broad paradigms. One is the cost-free method and the other is the non-cost-free method. These methods employ modifying the topology of the network, installing transformer taps and operation of conventional compensation devices, e.g. phase-shifters and use of FACTS devices. The cost free measures are more advantageous, since they avoid any sort of economic discrepancy. The cost free measures include installation of FACTS devices, especially Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC). FACTS devices can be classified into three categories: series controller, shunt controller and combined series-shunt controller. The series controllers like Thyristor Controlled Series Compensator (TCSC), Static Synchronous Series Compensator (SSSC) and Thyristor Controlled Phase Angle Regulator (TCPAR) are used in alleviating line overloads and increasing transfer capability by controlling the power flow. The shunt controllers such as SVC (static var compensator) and STATCOM (static synchronous compensator) can be employed to compensate voltages by injecting, directly or indirectly, reactive power at the low voltage buses. The combined series– shunt controllers such as UPFC (unified power flow controller) can be used in the system to release the power flow congestion as well as support voltages. The use of FACTS combined with optimization methodologies is one of the leading techniques in the present power scenario that is capable of efficiently curtailing congestion. Effective power flow control through FACTS applied to the transmission congestion could improve the transfer capacity and also it could limit the voltage stability and voltage security constraints. Thus, FACTS devices, play a very important role in reducing the congestion costs by their optimal location. FACTS devices can be used to improve the loadability of the transmission system, transient stability, power oscillation damping, decreases line losses, voltage stability enhancement, etc. The non-cost free measures include generation rescheduling and the curtailment of load transactions. Here, system operator re-dispatches power generation in such a way, that resulting power flow does not overload any line. According to cardell (2007), Every generation unit can bid an increase or decrease for its production in a similar manner as this is done on a balancing market, while the responsibility of system operator is to select bids in an efficient way. Somehow, a counter trade approach based congestion management can be viewed as a simplified optimal power flow problem, where optimization variables are used to redispatch the active power production. The objective function is to keep the cost minimum related to this active power re-dispatch. Congestion management is basically a non-linear program involving a lot of variables which could be solved using optimization algorithms. This chapter submits a method to solve the congestion management with the help of stability indexes. The Line Voltage Stability Index (LVSI) and Maximum Power Stability Index (MPSI) values are measured for all the transmission lines connected in the system. RuhaizadIshak *et al* (2014) in his work used the MPSI index for optimal placement and sizing of distribute generators. The capability of voltage and power transfer in the lines has been determined by these indexes. The congested lines are identified from the priority values of the Stability Indexes. The congestion occurred in the system is being reduced by generator rescheduling and by connecting FACTS devices. In this chapter, SVC and TCSC are employed for limiting the overload in the transmission lines. The generation rescheduling and the addition of FACTS devices are achieved by implementing an optimization algorithm. Based on the stability index calculation, fuel cost minimization and power loss minimization have been done.

CONCLUSION

Today's fast changing energy scenario and policies of government in energy sector has led to an enormous leap in the advancement of power sector in India. The increased generation of power has to reach the door steps of the end consumers with quality and reliability at minimum cost. Many challenges are to be met in fulfilling this dream. In this paper, an attempt has been made to transfer the increased power to the end consumers using FACTS devices. The installation of FACTS devices in developing country like India helps to improve the transmission system with great economy. FACTS installation also helps to improve the stability and reliability of the transmission system. FACTS devices reduce the transmission cost by reducing the losses in the transmission line.

This paper focuses on the role of FACTS devices in enhancing the performance of the transmission system, an attempt has been made to improve the characteristics of the existing transmission system such as voltage stability, transient stability, voltage regulation and congestion management using FACTS devices. By improving these characteristics of the existing transmission system increased power transfer with reduced power losses is possible. The reliability of the power supply is also increased with improved voltage regulation. Overall the performance of the transmission system is increased using FACTS devices.

This work presents a method to relieve congestion using generation rescheduling with and without FACTS devices. The enhancement of the voltage stability is also being discussed. The congestion in the transmission lines has been found using stability indexes. This proposed work suggests that the congestion management with FACTS provides better resultscompared with rescheduling without FACTS devices. The proposed technique can also be applied to large scale power systems.

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How to cite this article:

Bhupendra DagaduGangurde and Shridhar S Khule (2018) 'Enhancing the Performance of Power System Transmission Network', *International Journal of Current Advanced Research,* 07(7), pp. 14051-14054.
DOI: http://dx.doi.org/10.24327/ijcar.2018.14054.2535

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