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Survey Paper on IEEE 14-bus System with FACTS Technology

Rajesh Kumar, Prof. Prashant Garg, Prof. Balram Yadav

M. Tech. Scholar, Department of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India

Assistant Professor, Department of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India

Head of Department, Department of Electrical and Electronics Engineering, SCOPE College of Engineering, Bhopal, India

ABSTRACT: Now-a-days the Flexible AC Transmission Systems (FACTS) is very popular and essential device in power systems. After introducing the FACTS technology, power flow along the transmission lines becomes more flexible and controllable. Several FACTS-devices have been introduced for various applications in power system. Among a variety of FACTS controllers, Unified Power Flow Controller (UPFC) is the most powerful and versatile device. The UPFC is a device which can control the flow of real and reactive power by injection of a voltage in series with the transmission line. Both the magnitude and the phase angle of the voltage can be varied independently.

KEYWORDS: IEEE 14 bus System, UPFC, FACTS Technology, MATLAB Simulink

I. INTRODUCTION

Power Generation and Transmission is a complex process, wherever power is to be transferred, the two main components are active and reactive power. In a three phase ac power system active and reactive power flows from the generating station to the load through different transmission lines and networks buses. The active and reactive power flow in transmission line is called power flow or load flow. Power flow studies provide a systematic mathematical approach for determination of various bus voltages, there phase angle, active and reactive power flows through different lines, generators and loads at steady state condition. Power flow analysis is also used to determine the steady state operating condition of a power system. For the planning and operation of power distribution system, Power flow analysis is used. It is very important to control the power flow along the transmission line. Thus to control and improve the performance of ac power systems, we need the various different types compensators. The continuing rapid development of high-power semiconductor technology now makes it possible to control electrical power systems by means of power electronic devices [1,2]. These devices constitute an emerging technology called FACTS (flexible alternating current transmission systems) [2, 3]. The FACTS technology opens up new opportunities for controlling the both types of powers and enhancing the usable capacity of present transmission systems. The possibility that power through a line can be controlled enables a large potential of increasing the capacity of lines. This opportunity is arises through the ability of FACTS controllers to adjust the power system electrical parameters including series and shunt impedances, current, voltage, phase angle, and the damping oscillations etc. The implementation of such equipments requires the different power electronics-based compensators and controllers [5].The FACTS devices use various power electronics devices such as Thyristors , Gate turn offs(GTO), Insulated gate bipolar transistors(IGBT), Insulated Gate Commutated thyristors (IGCT),they can be controlled very fast as well as different control algorithms adapted to various situations. FACTS technology has a lots of benefits, such as greater power flow control ability, increased the loading of existing transmission circuits, damping of power system oscillations, has less bed impact on environmental and , has the less cost than other alternative techniques of transmission system is used.

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The UPFC is one of the most versatile devices. It cannot only perform the functions of the static synchronous compensator (STATCOM), thyristor switched capacitor (TSC) thyristor controlled reactor (TCR), and the phase angle regulator but also provides additional flexibility by combining some of the functions of the above controllers [1]. The main function of the UPFC is to control the flow of real and reactive power by injection of a voltage in series with the transmission line. Both the magnitude as well as the phase angle of the voltage can be varied independently. Real and reactive power flow control can allow for power flow in prescribed routes, transmission lines loading is closer to their thermal limits and can be utilized for improving transient and small signal stability of the power system.

II. LITERATURE REVIEW

M. Venkateswara Reddy et al. [1], this paper deals with the design and simulation of standard IEEE 14 bus system with IPFC. As a suggested solution to effective load sharing between the transmission lines, The interline power flow controller will transfers the power demand from above loaded line to less loaded transmission line. The proposed IPFC was connected between 2, 3 and3, 4 buses of standard IEEE 14 bus system. In this paper, two five level inverter based IPFC connected to the main IEEE system was presented. The system was designed in mat lab/Simulink and explained the effectiveness of power transmission with and without presence of IPFC.

The demand of electric power is increasing day by day. This situation has necessitated a review of the traditional power system concepts and practices to achieve greater operating flexibility and better utilization of existing power systems. During the last two decades, various high-power semiconductor device and control technologies have been introduced [1]. The various thyristor circuits used in to generate and control the reactive power [2].These technologies have been instrumental in the broad application of high voltage DC and AC transmissions. They have already made a significant impact on AC transmission via the increasing use of thyristor controlled static VAR compensators (SVCs).The UPFC is the one of most powerful Facts device, introduced by Gyugyi, L et al. [3].Various mathematical model of UPFC has been introduced depend upon various purpose of application. For the Power system stability studies the UPFC current injection model is used, which improve the dynamic performance of the system [4]. In this model the shunt compensation of UPFC is controlled to maintain the system bus voltage and the two components of UPFC series voltage, which are in phase voltage and quadrature voltage, are coordinated to respond to the power variations of the line. In case of static performance the power injection model is used. This is particularly the case in the area of power flow analysis where, two very constrained models have been published [5]. The sending and receiving ends of the UPFC are decoupled. The active and reactive power loads in the PQ bus and the voltage magnitude at the PV bus are set at the values to be controlled by the UPFC. The active power injected into the PV bus has the same value as the active power extracted in the PQ bus since the UPFC and coupling transformers are assumed to be lossless [6]. Takes the approach of modeling the UPFC as a series reactance together with a set of active and reactive nodal power injections at each end of the series reactance. These powers are expressed as function of terminal, nodal voltages, and the output voltage of the series source which represents the UPFC series converter. The UPFC injection model has implemented into a full Newton-Raphson program by adding the UPFC power injections model and by derivatives the elements of jacobian matrix with respect to the AC network state variables, i.e. nodal voltage magnitude and angles, at the appropriate locations in the mismatch vector and Jacobian matrix. The mismatch vectors original dimension and Jacobian matrix are not altered at all. The UPFC stability to regulating power flow through a transmission line and to minimize power losses, without generation re-scheduling, is shown by numeric examples. The attraction of this formulation is that it can be implemented very easily in existing power flow programs. Another model of UPFC in terms of power flow control is presented in [7]. In that model state variables of UPFC are incorporated inside the Jacobian matrix and mismatch equations, leading to vary the iterative solutions. UPFC controls the active and reactive power simultaneously and the voltage magnitude also. At initial conditions a set of analytical equations has been derived to provide UPFC. The losses of the UPFC coupling transformers have taken into account. UPFC have the capability to regulate the power flow and minimizing the power losses simultaneously [8].

M Tomay and A.M. Vuralin the power injection model of (UPFC) the operational losses also taken into account and the effects of UPFC location on different power system parameters are entirely investigated. A general sequential power flow algorithm based on an injection model of FACTS devices has been presented in. The algorithm is compatible with Newton Raphson and decoupled algorithms. It is important to ascertain the location for placement of

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UPFC which is suitable for various contingencies. An effective placement strategy for UPFC is proposed. The method uses Line Stability index which is sensitive to line flow to screen down the possible locations for UPFC.

III. FACTS CONTROLLER

Flexible AC Transmission System (FACTS): Alternating current transmission systems incorporating power electronic-based and other static controllers to enhance controllability and increase power transfer capability. The various basic applications of FACTS-devices are:

- Power flow control
- Increase of transmission capability
- Voltage control
- Reactive power compensation, stability improvement
- Power quality improvement
- Power conditioning.

The fig 1.1 is for classification of FACTS Controllers Based on power electronic devices. In this fig, left hand side column of FACTS-devices employs the use of thyristor valves or converters. This valves or converters are well known since several years. They have low switching frequency and low losses. The devices of the right hand side column of the fig has more advanced technology of voltage source converters based mainly on Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristors (IGCT). Pulse width modulation technique is used to control the magnitude and phase of the voltage.

By the means of flexible and rapid control over the AC transmission parameters and network topology, FACTS technology can facilitate the power control, enhance the power transfer capacity, decrease the line losses and generation costs, and improve the stability and security of the power system. FACTS technology opens up new opportunities for controlling and enhancing the useable capacity of present, as well as new upgraded lines. FACTS are an evolving technology and can boost power transfer capability by 20–30% by increasing the flexibility of the systems. By providing added flexibility, FACTS device offers continuous control of power flow or voltage, against daily load changes or change in network topologies.

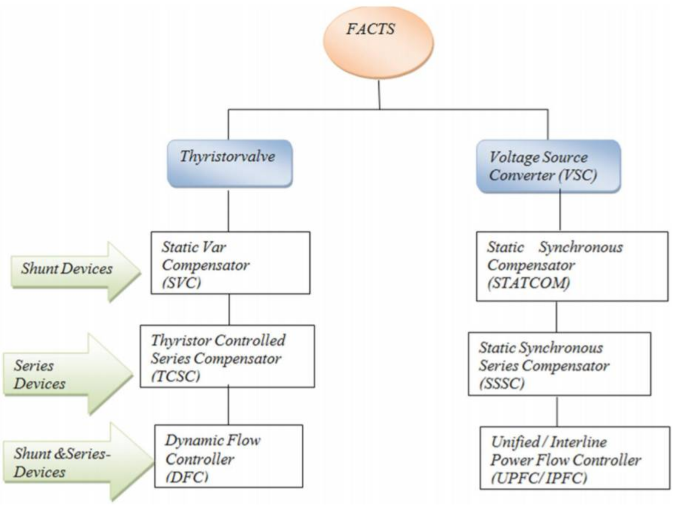

Figure 1: Overview Of major FACTS devices in terms of on power electronic devices

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Classification of FACTS Controllers

In general, FACTS controllers can be divided into four categories [1-4]:

- Series Controllers
- Shunt Controllers
- Combined series-series Controllers
- Combined series-shunt Controllers

Depending on the power electronic devices used in the control, the FACTS controllers can be classified as [1, 3]:

- Variable impedance type
- Voltage Source Converter (VSC) type

The variable impedance type controllers include:

- Static VAR Compensator (SVC), (shunt connected)
- Thyristor Controlled Series Capacitor or Compensator (TCSC) (series connected)
- Thyristor Controlled Phase Shifting Transformer (TCPST) or Static PST (combined shunt and series)

The VSC based FACTS controllers include:

- Static Synchronous Compensator (STATCOM) (shunt connected)
- Static Synchronous Series Compensator (SSSC) (series connected)
- Interline Power Flow Controller (IPFC) (combined series-series)
- Unified Power Flow Controller (UPFC) (combined shunt-series)

IV. PROPOSED METHODOLOGY

The UPFC is the most powerful and versatile FACTS-equipment used to control the power flow and stability of the power system. UPFC can be act static as well as dynamic condition also. Static is an analysis at the steady state condition and dynamic is an analysis at the transient condition such as faults occurs in transmission system. This chapter described about basic principle of UPFC and load flow analysis.

Operation of UPFC

The UPFC is a device which can control simultaneously all three parameters of line power flow (line impedance, voltage and phase angle) .It is a one of the FACTS family that used to optimum power flow in transmission. The UPFC is a combination of static synchronous compensator (STATCOM) and static synchronous compensator (SSSC).Both converters are operated from a common dc link with a dc storage capacitor. The real power can freely flow in either direction between the two-ac branches. Each converter can independently generate or absorb reactive power at the ac output terminals [6]. The controller provides the gating signals to the converter valves to provide the desired series voltages and simultaneously drawing the necessary shunt currents, In order to provide the required series injected voltage, the inverter requires a dc source with regenerative capabilities. The possible solution is to use the shunt inverter to support the dc bus voltage.

Advantages of UPFC

The UPFC can perform the function of STATCOM and SSSC and phase angle regulator. Besides that the UPFC also provides an additional flexibility by combining some of the function above. UPFC has also a unique capability to control real and reactive power flow simultaneously on a transmission system as well as to regulate the voltage at the bus where it’s connected. The UPFC can also increase the capability of the power flow to the load demand until its reach its limit in the short period .At the same time the UPFC also can increase the security system by increases the limit of transient stability, fault and the over load demand .Lastly the UPFC also can reduce the value of the reactive power And will optimum the real power flow through the transmission line.

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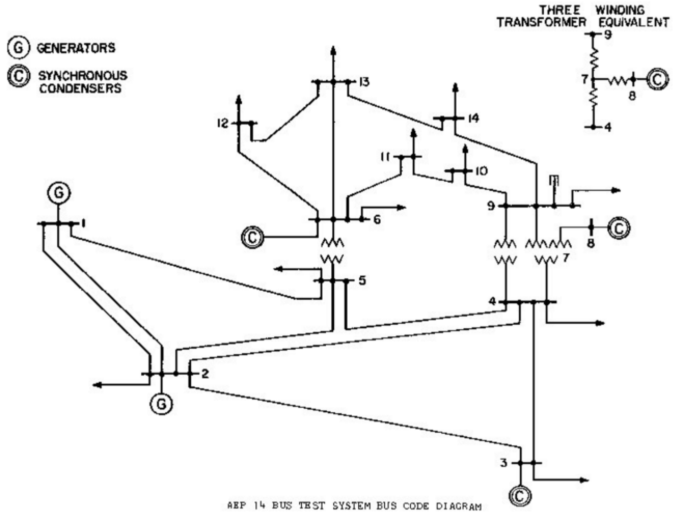

Figure .2: Flow Chart of IEEE 14 Bus Systems

V. CONCLUSION

Day by day all over the world the demand of electric power is increasing. Not only that, the demand of power by the consumer is more than the power flowing through the transmission line. In order to provide the power that achieved the consumers demand the FACTS technology introduced. The maximum loads which are used in daily life or industrial purpose are inductive type. This type of load are consumed the reactive power. To control and regulate the active and reactive power the various FACTS device are used. The UPFC is most promising device among the entire FACTS device. The UPFC can control transmission voltage, impedance, and phase angle. The UPFC can also enhance the real and reactive power capacity of the system.

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