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Analysis Of IEEE 14-Bus System And Improvement Of Power Quality By Using Series And Parallel Facts Devices

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Abstract: *Power quality is one of the major concerns in the power system. The power quality problem occurred due to a non-linear load in the distribution network and its severe impact on sensitive loads. To overcome this problem, the new series, parallel FACTS device use. The Interline Power Flow Controller (IPFC) is a VSC based Flexible AC Transmission System (FACTS) controller for series compensation with the unique capability of power flow management among the multiple transmission lines in the transmission system. Due to disturbance, the electromechanical oscillations will present in the transmission system and these oscillations should damp out using IPFC. The performance of the considered IEEE 14 bus system is analyzed in terms of oscillations using IPFC. The conventional Proportional Integral controller with Interline Power Flow Controller (IPFC) is used to damp oscillations. In this work, we will be applying the fuzzy PI controller in combination with the Unified Power Flow Controller (UPFC) for better performance and to improve the overall THD of the existing PI IPFC system. This paper presents the comparison of IPFC and UPFC as well as the modeling of the IEEE 14 bus system and their performance analysis.*

Keywords: *Flexible AC Transmission System (FACTS), Interline Power Flow Controller (IPFC), Unified Power Flow Controller (UPFC), fuzzy PI controller.*

I. Introduction

Modern power systems are highly complex and are designed as such to fulfill the growing demands of power with better power quality. High technology nowadays is being used for controlling power flow. Due to this, power quality is improved. Modern technology and new constructions of transmission lines are also needed for improving power system security, profitability, and reliability. Voltage collapse occurs when power systems are heavily loaded, faulted, or have reactive power shortages. Voltage collapse is system instability and it occurs due to many power system components. Reactive power imbalance occurs when the system is faulted, heavily loaded and voltage fluctuation is there.The investigates the performance of series-series.

(Interline Power Flow Controller) and series-shunt (Unified Power Flow Controller) FACTS controllers by compensating real and reactive power flow. For analysis, the IEEE14 Bus system is used.

Shunt compensation is used in all high voltage, EHV systems to supply reactive power and improve voltage profile. Series compensation is used to increase transmission line capacity, system stability, etc.

IEEE 14 bus system considered for analysis is shown in Fig.1. This system includes five T-G units with IEEE type-1 exciters14 buses, three transformers, and twenty AC transmission lines. This system has 11 loads totaling. Bus 1 is selected as a slack bus. The generator G1 is considered as reference. The three synchronous compensators are considered as generators to meet the demand of real power by loads. The generators are modeled with both P and Q limits as standard PV buses, loads are considered as constant PQ loads.

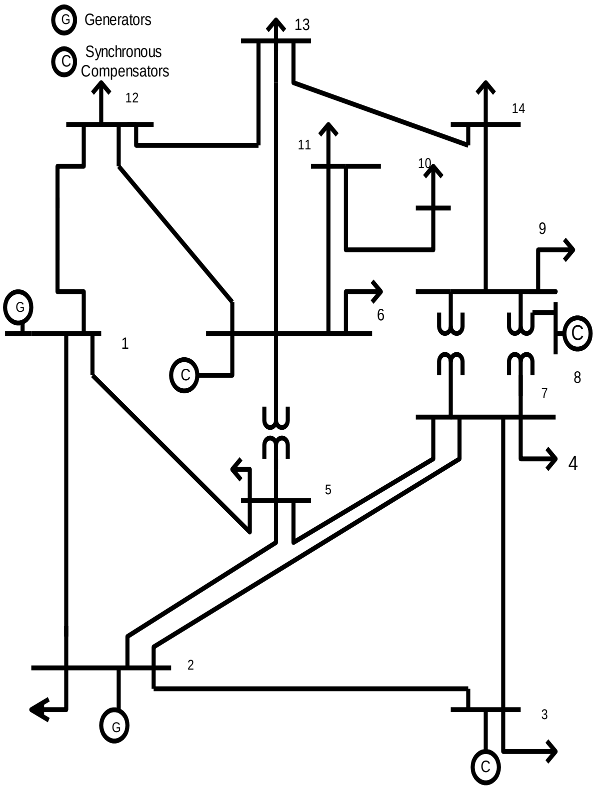

Fig.1. IEEE 14 Bus Power Network understudy

A. Benefits for FACTS Controllers

- Secure loading of transmission lines nearer to their thermal limits.
- Increased dynamic and transient grid stability.
- It allows more active power in present lines by reducing reactive power flow in the line.
- Access to lower production cost.
- Environmental benefits.
- Upgrade of transmission lines.
- Reduce RP flows, thus allowing the lines to carry more active power.
- Loop flow control.
- Power System Stability Improvement Using FACTS Devices.

II. Facts Controllers Can Be Divided Into Four Categories

- Shunt controller-SVC and STATCOM,
- Series controller-TCSC, SSSC, and TCPAR
- Series-series-IPFC
- Series-shunt- UPFC

A. Series Controllers

Series Controllers consist of capacitors or reactors which introduce voltage in series with the line.

- Static Synchronous Series Compensator (SSSC)
- Thyristor Controlled Series Capacitor (TCSC)
- Thyristor switched series capacitor (TSSC)
- Thyristor-switched series reactor (TSSR)
- Thyristor-controlled series reactor (TCSR)

B. Shunt Controllers

Shunt controllers consist of variable impedance devices like capacitors or reactors which introduce current in series with the line.

- Static Synchronous compensator (STATCOM)
- Static VAR Compensator (SVC)

- Thyristor Controlled Reactor (TCR)
- Thyristor Switched Reactor (TSR)
- Thyristor Switched Capacitor (TSC)
- Mechanically Switched Capacitor (MSC)
- Harmonic Filter

C. Series-Series-IPFC

It is a combination of series controllers or a unified controller. The objective of introducing this controller is to address the problem of compensating a number of transmission lines connected at a substation The Interline Power Flow Controller (IPFC) provides, in addition to the facility for independently controllable reactive (series) compensation of each individual line, a capability to directly transfer or exchange real power between the compensated lines.

D. Series-Parallel-UPFC

Unified Power Flow Controller (UPFC) is the most versatile device designed based on the concept of a combined series-shunt FACTS Controller. It has the ability to simultaneously control all the transmission parameters affecting the power flow of a transmission line i.e. voltage, line impedance, and phase angle.

III. Different Technique Stages Of Operation

On the basis of the literature view we analyze the different technique which is divided into 4 stages which are as follows:

A. Stage-I

In this technique, IPFC & UPFC is one of the latest generation flexible AC transmission systems (FACTS) controller used to control power flows of multiple transmission lines. The main objective is a detailed study of a real and reactive power coordination controller (IPFC & UPFC). The basic control for the IPFC is such that the series converter of the UPFC controls the transmission line real/reactive power flow and the shunt converter of the (IPFC & UPFC) controls the bus voltage/shunt reactive power and the DC link capacitor voltage. Because of the common link, any inverter within the (IPFC & UPFC) is able to transfer real power to any other and thereby facilitate real power transfer among the lines of the transmission system. Since each inverter is able to provide reactive compensation, the (IPFC & UPFC) is able to carry out an overall real and reactive power compensation of the total transmission system.

In this study, the control and performance of UPFC intended for installation on a transmission line. Simulation results show the effectiveness of UPFC in controlling real and reactive power through the line. Also, with UPFC in the transmission line, results in improvement of transient stability of the system, which is an added advantage along with the power flow control, improved Plant Utilization Factor, better Voltage Profile. The work has been carried out by placing the Multiple FACTS devices is placed in suitable places to minimize the power losses in the IEEE bus system and to improve the voltage profile, reduction in power losses. The referred analysis was based upon the shunt and series real power balance when the converters' losses are neglected.

B. Stage-II

In this technique, a Comparison of the performance of IPFC (series-series) and UPFC (series-shunt) FACTS controllers for voltage stability enhancement and improvement of power (real and reactive power) transfer capability has been presented. The power profile has been studied for an uncompensated system. Results obtained for the uncompensated system are then compared with the results obtained after compensating the system using IPFC (series-series) and UPFC (series-shunt) FACTS devices. A system with the inclusion of the above (IPFC and UPFC) FACTS devices in improving the voltage stability and power profile.

The voltage stability enhancement and power profile improvement by IPFC and UPFC FACTS devices are presented. The real and reactive power of the system is compared with and without the presence of IPFC and UPFC in the system. Then the performance of series-series (IPFC) and series-shunt (UPFC) FACTS compensators are compared. It is seen from the above simulation results that both the power flow and voltage profiles are improved with the addition of the above compensating devices. IPFC provides compensation from a capacitor value as low as 150µF but gives better performance at capacitor rating 1300µF after which its performance (power profile and voltage profile) deteriorates. UPFC will give a desirable performance (real power 2.375MW, reactive power 3.35MVAR and receiving end voltage 4.7KV) at capacitor rating 250µF. But IPFC fails to give any impressive performance beyond this point. If the rating of the capacitor is increased then the cost of the equipment is also increased. So, after comparing the performances of series-series(IPFC) and series-shunt(UPFC) FACTS devices it can be concluded that desirable performance is obtained with the addition of UPFC(series-shunt) to the system for a capacitor value of 250µF.

C. Stage-III

In this technique, a comparison study between the applications of the unified power flow controller (UPFC) and the interline power flow controller (IPFC) in optimal power flow (OPF) control. The performance of the UPFC and the IPFC is compared from the viewpoint of the total active power losses.

UPFC and the IPFC are powerful tools for power flow regulation, by which the transfer capability of the transmission line can be increased significantly. Combined with the generating bus voltage adjustment, the OPF incorporating either FACTS device can effectively minimize the overall generating cost without active power generation dispatching. In case an IPFC is incorporated to control the active and reactive power flows in a chosen transmission line, the effectiveness varies with the location of the IPFC series VSC without the branch power flow constraints. The capacity of the UPFC is usually significantly larger than that of the IPFC to achieve a similar.

D. Stage-IV

In this technique, Electric drive performance is highly influenced by the potential of the controller employed. This paper investigates the application of a fuzzy logic controller for the speed control of Field oriented PMSM. The Fuzzy Logic is based on the speed error and change of error measured as the difference between the motor speed and the reference speed. The Fuzzy Logic controller performance is also compared to a PI controller. It's been observed that the Fuzzy Logic controller gives a better response PMSM drive as compared to the PI controller.

The fuzzy logic speed controller based closed-loop vector control of The powerPMSM drive system has been proposed. The fuzzy logic speed controller was used in the speed loop, and it helped to improve the system performance. A performance comparison of the fuzzy control based PMSM drive system and the conventional PI controller based drive system is also provided in the simulation. The higher efficiency and better dynamic response of the proposed method as compared with the traditional method over a wide range of load variation. The result defines high efficiency and high dynamic performance of the proposed fuzzy control based PMSM drive system. It's apparent that when using the PI speed controller, there are evident torque, speed and three-phase current fluctuation when starting, and it takes more time to reach steady-state. It leads to a significant drop in speed waveform when increasing the load suddenly, and cannot recover steady-state in a short period of time; When using fuzzy logic speed controller, the motor torque, speed and three-phase current waveforms are smooth, and there are no overshoots, and then it takes a shorter time to reach steady-state, so it can recover steady-state in a short time when increasing the load suddenly.

PID controllers are designed to enhance the trajectory tracking performance of a flexible link robot. Firstly, a PI controller is used where conventional Ziegler –Nichols method adjusts the controller parameters. In addition, the Fuzzy PID controller is designed in which fuzzy rules are utilized on-line to tune the PID controller parameters based on the current value of error and its first time-derivative.

PID controllers are done to improve the tracking performance of a flexible link robot. As shown in the simulation, the fuzzy PID controller has better performance. Fuzzy PID with the LOM defuzzification method improves the reference signal tracking error of the closed-loop system. The experimental results are presented which confirm the supervisory of the fuzzy PID controller.

IV. Conclusion

From the analysis of all 4 stages, it is concluded from the first 2 stages, it is clear that both IPFC and UPFC are balanced the real and reactive respectively as well as the converters' losses are neglected. There is a considerable improvement in real and reactive power with a change in capacitance value. At the capacitor rating 250μF series-shunt (UPFC) FACTS device is seen to give optimum performance and in the case of a series-series (IPFC) FACTS device at the capacitor rating of 1300μF gives best results. But increased capacitor rating means an increase in the cost of the equipment. So, we can conclude that UPFC gives better performance (power profile) when compared to IPFC for a given operating condition with much low value of capacitance.
After that from next 2 stages conclude that when we analyze the performance of PI controller there are some disadvantages like time delay, response time is more but when we use FUZZY-PI then these all drawbacks are neglected because Fuzzy-PI updates its parameter on each control cycle on a different range and give the quick response.

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