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Power Flow Problem Reduced Using Unified Power Flow Controller

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Abstract: ***Modern power systems are designed to operate efficiently to supply power on demand to various load centers with high reliability. The generating stations are often located at distant locations for economic, environmental and safety reasons. Power flow analysis is concerned with describing the operating state of an entire power system, by which we mean a network of generators, transmission lines, and loads that could represent an area as small as a municipality or as large as several states. Given certain known quantities—typically, the amount of power generated and consumed at different locations—power flow analysis allows one to determine other quantities. The most important of these quantities are the voltages at locations throughout the transmission system, which, for alternating current (A.C.), consist of both a magnitude and a time element or phase angle. Once the voltages are known, the currents flowing through every transmission link can be easily calculated. 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. Many FACTS-devices have been introduced for various applications in power system.***

Keywords: MATLAB, UPFC, STATCOM, SSSC Voltage Regulator

1. Introduction

Power Generation and Transmission is a very 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. It is also called 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. It is very important to control the power flow along the transmission line. So it is to control and improve the performance of ac power systems, we need the various different types compensators. The compensator are both analog and digital type. In analog compensator are very large size, complex construction , high cost and its operation is also complex. So we use generally digital compensator. The digital compensator are development of high-power semiconductor technology now makes it possible to control electrical power systems by means of power electronic devices. These devices constitute an emerging technology called FACTS. The control of power and upgraded lines can be effectively done by Flexible alternating current transmission systems (FACTS) technology. It is essential to improve electric power utilization in today's highly complex and interconnected power systems, while still maintaining reliability and security. 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 controller to adjust the power system electrical parameters including series and shunt impedance ,current, voltage, phase angle, and the damping oscillations etc. 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.[1]

2. Problem of Power Flow

Problem of Power is not about harmonic only, but is about the distortion to the supply voltage and its effects on the equipment connected to it either directly or indirectly. There are many types of problems (disturbances) which may affect the power quality. Some of these problems are severe but rare while others could be not that critical however they are more frequent. Among the electric power quality problems, the following are distinguished: transients, harmonics, sags, swells, flicker, unbalances notches, frequency variations and high-frequency noise. Some of these power quality problems are investigated in more depth showing causes and effects of such problems and some recommendations on how to eliminate them[2].

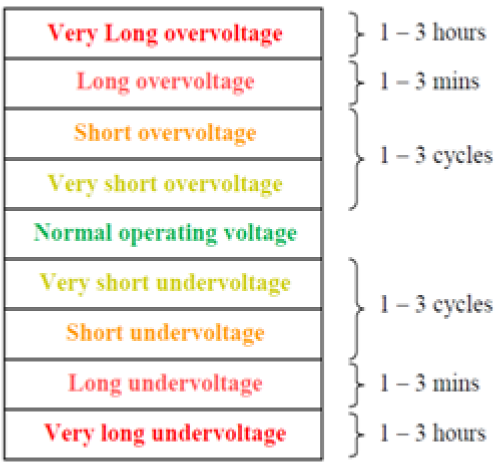

Figure 1: Magnitude-duration for classification of PQ events

3. Power Flow Problem Improvement Using Facts Devices

Flexible AC Transmission System (FACTS)is 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:

1. power flow control
2. increase of transmission capability
3. voltage control
4. reactive power compensation, stability improvement
5. Power quality improvement
6. Power conditioning.

The fig 2 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. They have high modulation frequency.

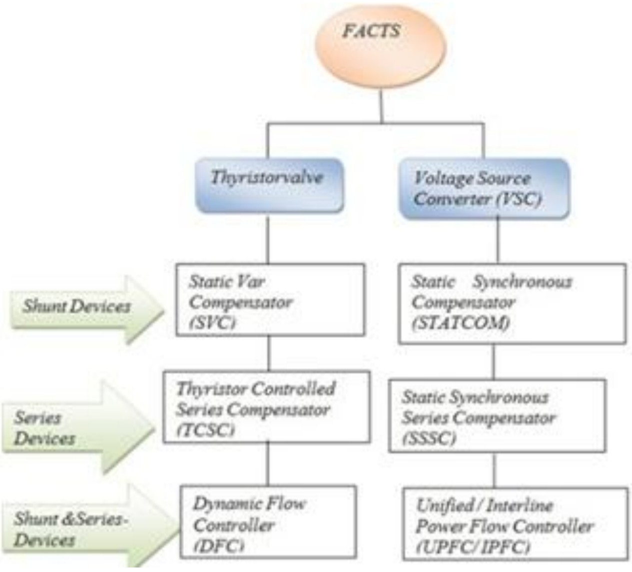

Figure 2: Overview Of major FACTS devices in terms of on power electronic devices.

4. Unified Power Flow Controller

UPFC is the versatile voltage source FACTS device that is capable of controlling transmission system parameters. It consists of two voltage source inverter connected back-to-back through a common dc link as shown in Fig.3. This arrangement function as an ideal ac to ac converter in which the real power can flow in either direction between ac sides of two inverters. Due to different functions of two inverters in the system, inverter 1 is referred as exciter and inverter 2 as booster.[3] The reactive power on the two ac sides of inverter can be controlled independently.

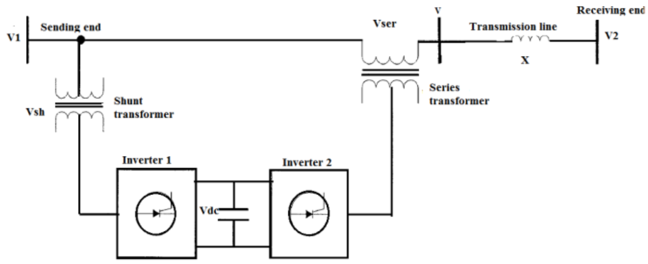

Figure 3: Schematic diagram of a UPFC system

Analysis of Series Part

The series injected voltage is split into two orthogonal components as shown in Fig.4.The components of the injected voltage are in-phase and quadrature with the reference. The two components are normalized by introducing new parameters β and γ which represent the injected voltage.

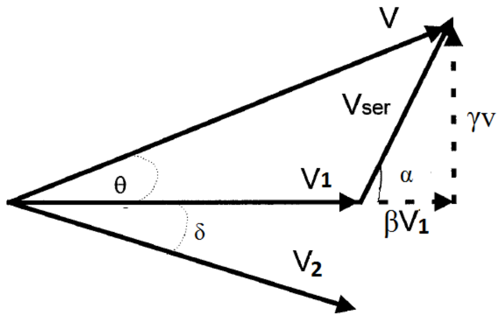

Figure 4: UPFC vector diagram of series part

Analysis of Shunt Part

Real power exchanged between shunt inverter and the ac system is determined by the level of quadrature component of inverter output voltage (ξ).This power must be balanced by the real power demand of series inverter. The reactive power generated or absorbed by the shunt inverter is controlled by the in-phase component of inverter output voltage (η). Vector diagram of shunt part of UPFC is shown in Fig. 5.

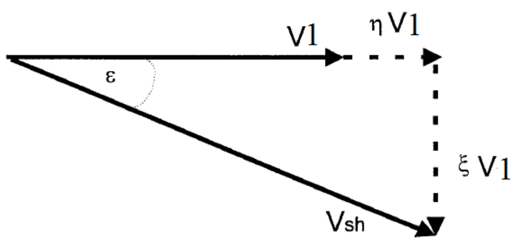

Figure 5: UPFC vector diagram of shunt part

Control of UPFC

UPFC is important type of FACTS family. It is a combination both series and shunt type of FACTS. It control are two type

1. Shunt control
2. Series control

Shunt Control

The shunt part of the UPFC supply the real power demand of the series inverter and support the system bus voltage. The real and reactive power of shunt part is given by,

$$P_{sh} = (V1^2/X_{sh})\xi \quad (1)$$

$$Q_{sh} = -(V1^2/X_{sh})\eta \quad (2)$$

Where,
ξ = in-phase shunt inverter voltage
η = quadrature shunt inverter voltage

The control parameters of the shunt inverter ξ and η are obtained as,

$$\xi = (X_{sh}/V_1^2)P_{ex} \quad (3)$$

$$\eta = -(X_{sh}/V_1^2)\, Q_{sh} \quad (4)$$

Where,
$P_{ex} = P_{sh}$ is the real power exchanged between the series inverter and the AC system.
In this paper, a fuzzy-like PI is used to control the operation of the shunt inverter. Pex or Psh is used to define ξ. The bus voltage deviation is used to define η.

Series Control

By considering series compensation voltage Vser and considering the vector diagram of series inverter per-unit change of real and reactive power flow of series inserted voltage components are expressed as,

$$\Delta P=\beta\sin\delta+\gamma\cos\delta \quad (5)$$

$$\Delta Q=\gamma2+\gamma\sin\delta+(2-\cos\delta)\beta+\beta2 \quad (6)$$

The values of β and γ corresponding to the desired change of the real and reactive power may be obtained by solving Eq.(5) and Eq.(6).

$$\beta = V_{ser}\cos\delta \quad (7)$$

$$\gamma = V_{ser}\sin\delta \quad (8)$$

The series compensation voltage will control line current and line voltage at the UPFC right side. These limits are given mainly at maximum inserted voltage. Controller should find an appropriate operating point within the system feasible limits before control limit is exceeded. The solution depends on the system operating conditions, and neuro fuzzy techniques are inherently advantageous in such a decision-making process. The per unit change in real and reactive power in transmission system can be rewritten as

$$\Delta P=V_{ser}\sin(\delta+\alpha) \quad (9)$$

$$\Delta Q=V_{ser}^2-V_{ser}\cos(\delta+\alpha) + 2V_{ser}\cos\alpha \quad (10)$$

5. Result and Conclusion

In power system transmission it is desirable to maintain the magnitude of voltage, angle of phase and impedance of line . Therefore, to control of power from one end to other end, in this concept of power flow control and voltage injection is applied. The UPFC is a device which can control simultaneously all three parameters of line power flow (impedance of line , voltage and phase angle). The UPFC combines together the features of the Static Synchronous Series Compensator (SSSC) and the Static Synchronous Compensator (STATCOM). Fig. 6 show the simulation diagram of Unified Power Flow Control(UPFC).

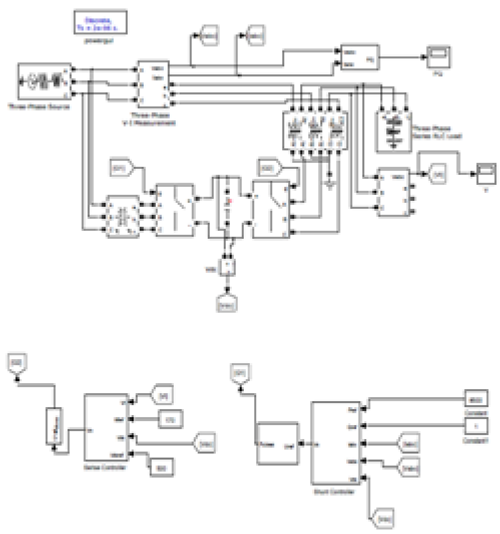

Figure 6: Simulation modal of UPFC

These two devices are two Voltage Source Inverters (VSI's) connected respectively in with the series transmission line through a series transformer and in shunt with the transmission line through a shunt transformer, connected to each other by a common dc link. It is a storage capacitor. The shunt inverter is used for voltage regulation at the point of connection injecting an opportune reactive power flow into the line and to balance the real power flow exchanged between the series inverter and the transmission line. The series inverter is used to control the real and reactive line power flow inserting an opportune voltage with controlled magnitude and phase in series with the transmission line. In simulation modal we analysis that when fault come and these device are not connected active and reactive power are shown in below fig.7

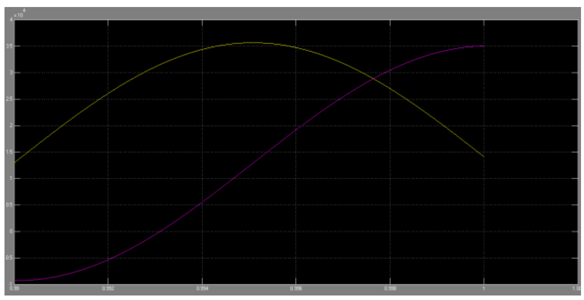

Figure 7: Active and reactive power when fault come on circuit which UPFC connected.

So when UPFC are connected it has increase the strength of both active and reactive power. Which has shown on fig.8 as below.

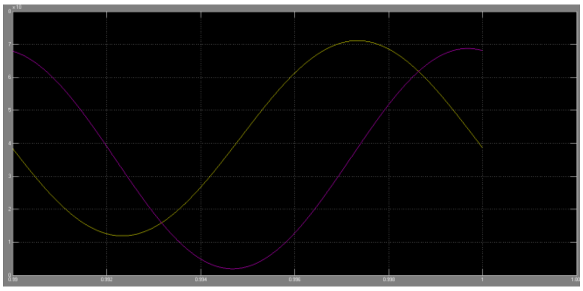

Figure 8: Active and reactive power when fault come on circuit which UPFC connected

References

[1] N. G. Hingorani, "Power Electronics in Electric Utilities: Role of Power Electronics in Future Power Systems", Proceedings of the IEEE, Vol.76, NO. 4, pp 481-482, April 1988.CIGRE, "FACTS Overview", IEEE Power Engineering Society, 95 TP 108, April 1995.
[2] Abraham olatoke "investigations of power quality problems in modern buildings".School of Engineering and Design, Brunel University,2011.
[3] B.Gopinath, S.Suresh Kumar, Juvan Michael 'Unified Power Flow Controller (UPFC) for Dynamic Stability in Power System using Modern Control Techniques''2013.
[4] Abhijit Chakrabarti & Sunita Halder, "Power System Analysis Operation and Control". Prentice Hall of India Pvt. Limited, New Delhi, 2006.
[5] Z. T. Faur, "Effects of FACTS Devices on Static Voltage Collapse", Master Thesis, University of Waterloo, Ontario, Canada, 1996.
[6] K.R. Padiyar, "FACTS controllers in power transmission and distribution,"New Age Int. Publisher, 2007.
[7] Gyugyi, L, "A Unified Power Flow Control Concept for Flexible AC Transmission Systems," IEE Proceedings-C, Volume-139, No.4, (July 1992).
[8] T. J. E. Miller, "Reactive Power Control in Electric Systems", John Wiley & Sons, 1982.
[9] Hadi Saadat, "Power System analysis", Tata Macgraw-hill Edition, 2002.
[10] G.W.Stagg, A.H.El-Abiad, "Computer methods in power system analysis", 1968 McGraw Hill.
[11] Chapman, D.; Power Quality Application Guide - The Cost of Poor Power Quality; Copper Development Association; Version 0b November 2001.
[12] Chiang, T. K.; Law, C. K.; To, V.; Kwan, H. F. 'Power Quality case studies; CLP Power's Experience'. Proceedings of Symposium on Power Quality and You. Managing pollution in Electric Supply Systems, May 2002.
[13] L. Gyugyi, "Solid-State Synchronous Voltage Sources for Dynamic Compensation and Real-Time Control of AC Transmission Lines",Emerging Practices In Technology, IEEE Standards Press, Vol. 9, pp. 904 – 911, April 1993.
[14] Abdul Haleem, Ravireddy Malgireddy, "Power Flow Control with Static Synchronous Series Compensator (SSSC)", International Conference on Science and Engineering (ICSE), 2011, ISBN: 978-981-08-7931-0.