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Implementation of OPF and LINEAR FUZZY controller in Power system load flow analysis

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ABSTRACT

In the present predicament, power prices are increasing extra rapidly in the generation and distribution sectors. This article seeks to analyze the models and approaches by which we evaluate static behavior at the frequency components of power distribution systems. Through controlling the assembly's reactive force movement, reliability improvement is obtained. Various literature suggests various methods / initiatives to maximize the dependability of the transmission system whilst also positioning Physical count and trying to organize physical inventory count, one of the disadvantages being that they sometimes take into account the usual system condition. FACTS controllers can flexibly control power flow in frameworks. In this article, power flow efficiency is assessed as well as power flow control intervals studied based more on FACTS equilibrium model. This paper provides a FACTS implementation POPF method.

Key words: FACTS, PFC,POPF, Power Systems

1. INTRODUCTION

A drastic change happens internationally on the power supply market. Two explanations for this remarkable transition are economic economics, scarcer natural resources and an ever-increasing oil demand. Against this context of rapid progress, the expansion programs of numerous utilities preventing the licensing and construction of new transmission lines and power generation units thwarten a range of well-established environment, land-use and regulatory pressures. Detailed review of alternatives for the maximization of properties with a high degree of efficiency and stability showed the path of power electronics [1]. Modern technology and electronic energy technologies are widely recognized as substituting for conventional approaches, usually focused on low response density and reduced maintenance costs in electromechanical systems.

Awaiting recently, there was careful adaptation of electric power impedances, a perform actions generator, in addition to changes in terminal voltage tap regulations AC distribution network. Order and shunt characteristic impedance are often necessary for successful line impedance correction. FACTS [2] technology is of special importance to the analysis of the business company as it provides new possibilities for power management and increases the reliability of existing, current and updated lines. The feasibility of regulating current through the line at acceptable expense helps established lines to expand the ability of broad drivers and to enable one FACTS controller to work under usual and variable conditions with sufficient electricity.

1.1 Benifits of utilizing facts devices:

The advantages of using FACTS tools can be described as follows in electricity distribution systems [3]:

- Better use of current properties of the electricity network.
- Improved efficiency and quality of the distribution networks.
- Improved reliability of complex and intermittent system and loop flow elimination.
- Improved product efficiency for key sectors.
- Economic advantages increased usage of the infrastructure of the electricity network. The performance of various facts devices under different conditions is shown in Table-1.

Table 1: Techinicalbenifits of the main FACTS device [4]

Device	LFC	VOLTAGEC ONTROL	TRANSIENT STABILITY	DYNAMIC STABILITY
SVC	GOOD	BEST	GOOD	BETTER
STATE COM	GOOD	BEST	BETTER	BETTER
TCSC	BETTER	GOOD	BEST	BETTER
UPFC	BEST	BEST	BETTER	BETTER

2 Power flow analysis

Planning, improved performance and further expansion of electrical systems requires research into load flows, short circuits and structural components under existing conditions.

In any bus you can obtain stable equilibrium by load flow checks, voltage levels and angles. The voltages of both the bus will be held to a certain level [5]. That is quite critical. The true and reactionary supply voltage can be measured for every line if the tension of the bus and its vantage points are ascertained with a transfer function. The losses in that certain line could even be determined by the discrepancy between receiving and transmitting voltage controls. One of the main benefits is the accuracy of the Newton Raphson method for convergence. Convergence is independent of the frequency and form of control mechanism on the computer and the network size, relative to non-Newton Raphson [12].

2.1 The Newton Raphson algorithm

The Newton Raphson proved most effective in large-scale power flow model due to its good agreements in order. The Newton Raphson algorithm of power flow is expressed in the following [11]

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = -\begin{bmatrix} \Delta P/\Delta\theta & \Delta P/(\Delta v/v) \\ \Delta Q/\Delta\theta & \Delta Q/(\Delta v/v) \end{bmatrix} \begin{bmatrix} \Delta\theta \\ (\Delta v/v) \end{bmatrix}$$

It is important to find out that the correction phrase "secure Vm" is separated by the expression "healthy Vm" to account for the possibility that the Jacobic language "secure Vm," "healthy Vm," "safe Vm" is compounded by "safe Vm." In the figure 1 among both buses k and m, recognize the first integrated element. 1 [6], the terms of the agreement of Jacobian are set out below:

For k≠m.

$$\frac{\partial P_{k,l}}{\partial \theta_{k,l}} = V_k V_m \left[G_{km} \sin(\theta_k - \theta_m) - B_{km} \cos(\theta_k - \theta_m)\right]$$

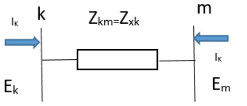

Figure :1 Equivalent Impedance

$$\frac{\partial P_{k,i}}{\partial V_{m,i}/V_{m,i}} = V_k V_m \left[G_{km} \cos(\theta_k - \theta_m) - B_{km} \sin(\theta_k - \theta_m)\right]$$

$$\frac{\partial Q_{k,i}}{\partial \theta_{m,i}} = -\frac{\partial P_{k,i}}{\partial V_{m,i}/V_{m,i}}$$

$$\frac{\partial Q_{k,i}}{\partial V_{m,i}/V_{m,i}} = \frac{\partial P_{k,i}}{\partial \theta_{m,i}}$$

2.2 Power flow model facts devices

The alternate UPFC algorithm consists of three coordinated parallel voltage levels for steady state work of voltage regulator. A big, unified water pump is part of the UPFC substitute network. In figure 2 you can see a circuit for this counterpart [7].

UPFC frequency originates from the following:

$$E_{vR} = V_{vR}(\cos\delta_{vR} + j\sin\delta_{vR})$$

$$E_{cR} = V_{cR}(\cos\delta_{cR} + j\sin\delta_{cR})$$

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Where VvR and βvR represent the manageable magnitude of the voltage of the shunt converter (VvRmin / VvR / VvRmax) and of phase angle(0). A conversion voltage source VcR and µcR phase angles (alternativamente vcR / additionally to vcR max) and (0 alternatively − CR − otherwise) are regulated between limitations which involve both. The injected voltage series phase angle determines the control mode for power flow [10]. The UPFC changes terminal stress if µcR is compatible with the nodal stress angle. The active power flow, acting as a phase switch, is regulated when¨cR is¨square¨. Where µR is squared with an angle of current of the line, the active flow of power is controlled and the variable series is compensated. UPFC operate as a combination of energy supply, with errors at any other µcR value having a possible compensator and phase shifter [8]. The voltage to be controlled is determined by the magnitude of the injection voltage. The actual and reactive power equations are based in Figure 2 on the comparable circuits:

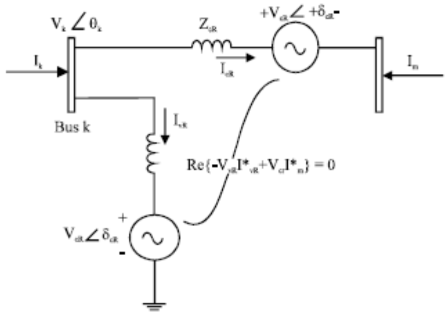

Figure 2: Unified power flow controller equivalent circuit

At bus k:

$$\begin{aligned} P_k &= V_k^2 G_{kk} + V_k V_m [G_{km}\cos(\theta_k - \theta_m) + B_{km}\sin(\theta_k - \theta_m)] \\ &+ V_k V_{cR}[G_{km}\cos(\theta_k - \delta_{cR}) + B_{km}\sin(\theta_k - \delta_{cR})] \\ &+ V_k V_{vR}[G_{vR}\cos(\theta_k - \delta_{vR}) + B_{vR}\sin(\theta_k - \delta_{vR})] \end{aligned}$$

$$\begin{aligned}Q_k &= -V_k^2 B_{kk} + V_k V_m [G_{km}\sin(\theta_k-\theta_m) - B_{km}\cos(\theta_k-\theta_m)]\\ &+V_k V_{cR}[G_{km}\sin(\theta_k-\delta_{cR}) - B_{km}\cos(\theta_k-\delta_{cR})]\\ &+V_k V_{vR}[G_{vR}\sin(\theta_k-\delta_{vR}) - B_{vR}\cos(\theta_k-\delta_{vR})]\end{aligned}$$

At bus m:

$$\begin{aligned}P_m &= V_m^2 G_{mm} + V_m V_k [G_{mk}\cos(\theta_m-\theta_k) + B_{mk}\sin(\theta_m-\theta_k)]\\ &+V_m V_{cR}[G_{mm}\cos(\theta_m-\delta_{cR}) + B_{mm}\sin(\theta_m-\delta_{cR})]\end{aligned}$$

$$\begin{aligned}Q_m &= -V_m^2 B_{mm} + V_m V_k [G_{mk}\sin(\theta_m-\theta_k) - B_{mk}\cos(\theta_m-\theta_k)]\\ &+V_m V_{cR}[G_{mm}\sin(\theta_m-\delta_{cR}) - B_{mm}\cos(\theta_m-\delta_{cR})]\end{aligned}$$

2.3 Series converter

$$\begin{aligned}P_{cR} &= V_{cR}^2 G_{mm} + V_{cR} V_k [G_{km}\cos(\delta_{cR}-\theta_k) + B_{km}\sin(\delta_{cR}-\theta_k)]\\ &+V_{cR} V_m[G_{mm}\cos(\delta_{cR}-\theta_m) + B_{mm}\sin(\delta_{cR}-\theta_m)]\end{aligned}$$

$$\begin{aligned}Q_{cR} &= -V_{cR}^2 B_{mm} + V_{cR} V_k [G_{km}\sin(\delta_{cR}-\theta_k) - B_{km}\cos(\delta_{cR}-\theta_k)]\\ &+V_{cR} V_m[G_{mm}\sin(\delta_{cR}-\theta_m) - B_{mm}\cos(\delta_{cR}-\theta_m)]\end{aligned}$$

2.4 Shunt converter

$$P_{vR} = -V_{vR}^2 G_{vR} + V_{vR} V_k [G_{vR}\cos(\delta_{vR}-\theta_k) + B_{vR}\sin(\delta_{vR}-\theta_k)]$$

$$Q_{vR} = V_{vR}^2 B_{vR} + V_{vR} V_k [G_{vR}\sin(\delta_{vR}-\theta_k) - B_{vR}\cos(\delta_{vR}-\theta_k)]$$

The most effective tool in FACTS is a voltage-controlled controller (UPFC). It may change the three controller parameters concurrently or independently: bus voltage, power transmission reaction and two bus step angle. UPFC achieves so by in-phase voltage modulation, square stress, and compensatory harm shunt. UPFC is the most robust and versatile electronic control device for controlling and regulating electrical power distribution in transmission systems. It provides major possible benefits for vertical and horizontal lines service [9]. The UPFC was designed to control and adaptively compensate real-time ac transmission systems, providing multi-functional versatility to solve many power industry issues. Under traditional transmitting and delivery principles, The UPFC can collectively or exclusively control all voltage control variables for each distribution system. Unlike most of the other detectors, actual and responsive generated voltage throughout the sector can be primarily managed [13].

3 SIMULATION OF IEEE 9 BUS SYSTEM

An IEEE 9 bus frame was built to view the electricity flow without the distribution network, in the Matlab / simulink context. The role of the FACTS system is chosen depending on the local extreme rarity index in this setting. The design methods are displayed in the table 2 below.

Table 2: Sensitivity index for IEEE 9 bus systems

Line Number	From Bus	To Bus	Sensitivity index
1	1	4	-0.005538
2	4	5	-0.01644
3	5	7	0.0565
4	2	7	-0.001916
5	7	8	0.000373
6	8	9	-0.004958
7	3	9	1.0588
8	6	9	-0.026910
9	4	6	-0.05458

As can be seen from table above line 7 of bus 3 to bus 9, the FACTS system has been linked between such buses. This segment displays the effects of the IEEE-9 bus network simulation with and without the FACTS tools.

Table 3: Power Flow Of IEEE 9 Bus system without UPFC device

Frombus	Without UPFC	
	ACTIVE POWER (MW)	REACTIVE POWER(MVAR)
1-4	71.97	26.58
4-5	41.12	31.92
7-5	84.13	-3.72
2-7	162.13	6.48
7-8	76.41	7.01
9-8	24.07	13.52
3-9	84.79	-10.99
9-6	59.32	-4.80
4-6	30.85	9.12

The overall power loss from IEEE 9 bus load flow without Dc microgrid is P = 4.55 MW and Q = 48.06 MVAR. Table 3, shows the IEEE-9 bus system power flow analysis at different bus system..

Table 4: power flow of IEEE bus system with and without UPFC device

From Bus	WithOut UPFC		With UPFC	
	Active power(MW)	Reactive Power(MVAR)	Active power(MW)	Reactive Power(MVAR)
1-4	71.97	26.58	72.0	26.08
4-5	41.12	31.92	41.19	31.52
7-5	84.13	-3.72	84.07	-3.21
2-7	162.13	6.48	162.79	9.69
7-8	76.41	7.01	76.45	6.38
9-8	24.07	13.52	24.02	14.18
3-9	84.79	-10.99	84.79	-8.57
9-6	59.32	-4.80	59.35	-3.90
4-6	30.85	9.12	30.81	8.32

From the load flow of IEEE9 bus with UPFC the total power loss is P=4.58MW and Q=52.74MVAR as shown in table 4.

Table 5: Result without UPFC included in Bus 3

Parameter	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
$V_{M\ (p.u)}$	1.1	1	1	0.9944	0.9752	1	1.01	0.998	1
$V_{A\ (deg)}$	0	-2.04	-4.75	-4.82	-5.82	-5.9	-6.02	-6.2	-6.23

Table 6: Result with UPFC included in Bus 3

Parameter	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
$V_{M\ (p.u)}$	1.1	1	1	0.9917	0.9745	1	1.02	0.996	1
$V_{A\ (deg)}$	0	-1.76	-1.76	-3.19	-4.93	-5.92	-6.22	-6.26	-6.43

UPFC is used to keep this same reactive current from UPFC to bus 4 at 40 MW and 2 MVar, also including, to offset the transmission line from bus 3 to bus 4. Additionally, the UPFC shunt transmitter is designed to regulate nodal voltage at 1 p.u on bus 3. Active power to bus 3 actually increases by 32 percent. Table 5 and table 6, shows the bus maximum voltages at different busses measured at fault condition with and without UPFC controller. The increase represents the UPFC sequence converter's wide operating volume. Thus we can see from the above study that, in the sense of traditional transmission and distribution principles, the Upfc may regulate asynchronously or selectively all parameters influencing transmission line strength (voltage, expected loudness and phase angle), and the unified adjective indicates this specific ability.

4. CONCLUSION

At project completion, we introduced the IEEE 9-bus FACTS, UPFC and SSSC transmission line devices. UPFC's basic laws are being reviewed. A UPFC power flow model was checked, and updated contingency analysis equations were shown to help the device work better. Research findings, however, are not as predominant as expected when the FACTS system is ready in power plants' IEEE 9-bus system. Therefore, the possible aim of this research is to achieve optimum vehicle configuration and to pursue influential efficiency in these multi-bus networks. Furthermore, the cost function should also be included, where the cost of total energy production must be further reduced.

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