Optimal Power Flow Analysis Using FACTS Devices

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Abstract- *Power flow studies are needed for planning, operation and control. Power flow studies for certain type of power system network can be carried on by using software packages without the use of manual calculation. One of the software is Power World Simulator (PWS). The subject of optimal power flow analysis has gained a lot of attention due to the high cost of electrical energy. The main objective of OPF is optimizing specific objective function such as power loss minimization and voltage profile improvement of power system by adjusting the power control variables and at the same time satisfying the equality and inequality constraints. Flexible AC Transmission System (FACTS) has been proposed as the better alternative to overcome this, as in addition to improving system performance, reliability, quality of supply and also provide environmental benefit. For determining that optimal location power world simulator(PWS) software analysis is used here .The PWS approach to the optimal power flow problem outperforms other approaches found in the literature review that have been applied to the same system, in terms of minimizing the fuel cost, minimizing the losses and also in terms of reducing the computation time. The convergence of the solution is obtained in lesser number of iterations. In this paper the standard IEEE-6 and IEEE-30 bus system has been implemented in Power world simulator.*

Keywords- Optimal Power Flow (OPF), Power world simulator (PWS).

I. INTRODUCTION

In generally Power is generated in generating station, transmitted through transmission line and then distributed to consumers. Power flow analysis is the backbone of power system analysis and design. They are necessary for planning, operation, economic scheduling and exchange of power between utilities. Transmission line is characterized by resistance, inductance, and capacitance. This will result in losses. These losses cannot be eliminated but it can be reduced. Voltage collapses typically occurs on power systems that are heavily loaded, faulted and/or have reactive power shortage. The only way to prevent the occurrence of voltage collapse is either to reduce the reactive power load or to provide the system with additional supply of reactive power before the system reaches the point of voltage collapse. [1-2]. The Optimal power flow (OPF) is the most important tool for power system planning, operation and control. The OPF problem is a nonlinear optimization problem. The OPF has been usually considered as the Minimization of an objective function representing the generation cost and/or the transmission loss minimization of the total voltage deviation at all load buses.[3-5] .The Optimal power flow (OPF) problem has been well known since 1960s. In 1962, Carpentier first introduced a generalized nonlinear programming formulation of the economic dispatch problem, including voltage, reactive power and operational constraints. Optimization is a mathematical tool to find the maximum or the minimum of a function subject to some constrains. Using lose function as objective function subjected to generator MW, transformer tapping, reactive power injection and controlled voltage as constrains. Using this we get optimal value for bus parameters such that transmission losses are minimum[6-9]. Optimal power flow (OPF) started, as one of the challenging needs for economic power system operations, in the early sixties. The importance of incorporating FACTS devices in OPF cannot be over emphasized. This importance can be realized when looking to the benefits offered by FACTS devices, the good coordination needs between them, and the need for relaxing the operating limits that stop the OPF objective optimization. Power world simulator soft ware is used to solve the OPF problem.

II. OPTIMAL POWER FLOW

Optimal power flow is sometimes referred to as security-constrained economic dispatch (SCED); most implementations of SCED include only thermal limits, and proxies for voltage limits. There are a variety of formulations with different constraints, different objective functions, and different solution methods that have been labeled optimal power flow; these are discussed in the formulations section later in this paper. Formulations that use the exact AC power flow equations are known as “ACOPF.” Simpler versions, known as DCOPF, assume all voltage magnitudes are fixed and all voltage angles are close to zero. DC stands for direct current, but is a bit of a misnomer; a DCOPF is a linearized form of a full alternating current network (ACOPF) and not a power flow solution for a direct current network. We use the general term OPF to include both ACOPF and DCOPF. The

ACOPF is often solved through decoupling, which takes advantage of the structure of the problem, where real power (P) and voltage angle (θ) are tightly coupled and voltage magnitude (V) and reactive power (Q) are tightly coupled, but the P-θ and V-Q problems are weakly coupled due to the assumptions that the phase angle differences between adjacent buses are rather small, and high-voltage transmission networks have much higher reactance compared to resistance. The decoupled OPF divides the ACOPF into two linear sub problems, one with power and voltage angle and another with voltage magnitude and reactive power. In this paper, we use the term ACOPF to refer to the full ACOPF that simultaneously optimizes real and reactive power, and decoupled OPF to refer to the decoupled problems that separately optimize real and reactive power and iterate between the two to reach an optimal solution.

A.*OPTIMAL POWER FLOW PROBLEM FORMULATION*

The objective function for the entire power system can then be written as the sum of the quadratic cost model at each generator.

Minimize: f(x, y)

$$F = \sum(ai + bipgi + cipgi^2)$$

subject to g(x, y) =0

where ngis the number of generation including the slack bus. Pgiis the generated active power at bus i. ai, bi and ci are the unit costs curve for ith generator.

The OPF problem has two types of constraints:

1) The equality constraint, g is the set of non-linear power flow equation for the power system :

$$PGi - PLi - PT(V,\delta) = 0$$

$$QGi - QLi - QT(V,\delta) = 0$$

Where PGi , QGi are the real and reactive power of the generator at bus i respectively, PLi and QLi are the real and

reactive load demand at bus i respectively, while PT and QT are the real and reactive total transmission losses

respectively.

2) The inequality constrains, h is the set of the upper and lower limit of the control variables which includes:

· Upper and lower bounds on the active generations at generator buses

· Pgimin≤Pgi ≤ Pgimax , *i* =1, ng where ng is the number of generator buses.

· Upper and lower bounds on the reactive power generations at generator buses and reactive power injection at buses with VAR compensation

III.FACTS DEVICES

Flexible transmission system is a kin to high voltage dc and related thyristors developed designed to overcome the limitations of the present mechanically controlled ac power transmission system.

Use of high speed power electronics controllers, gives 5 opportunities for increased efficiency.

- Greater control of power so that it flows in the prescribed transmission routes.
- Secure loading (but not overloading) of transmission lines to levels nearer their required limits.
- Greater ability to transfer power between controlled areas, so that the generator reserve margin-typically 18% may be reduced to 15% or less.
- Prevention of cascading outages by limiting the effects of faults and equipment failure.
- Damping of power system oscillations, which could damage equipment and or limit usable transmission capacity.

Flexible system requires tighter transmission control and efficiency management of inter-related parameters that constraints today's system including:

- Series impedance- phase angle.
- Shunt impedance- occurrence of oscillations at various below rated frequencies.
- This results in transmission line to operate near its thermal rating.

A.SHUNT COMPENSATION

By supplying reactive power near load, tension on lines, power losses minimizes and hence Improving voltage regulation. This can be achieved in three ways:

- With a capacitor
- Voltage source
- Current source

Static VAR Compensator

SVC is a shunt-connected static VAR generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system. A static VAR compensator (or SVC) is an electrical device for providing fast-acting reactive power on high-voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family voltage and stabilizing the system.

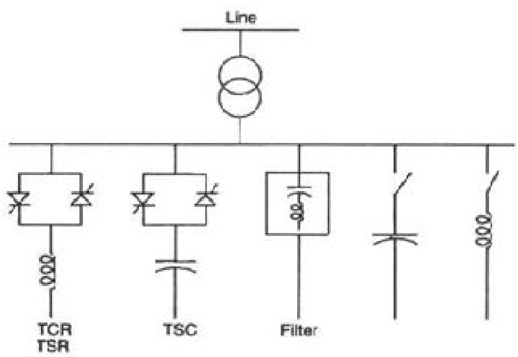

Figure 1.1Schematic diagram of SVC

Unlike a synchronous condenser which is a rotating electrical machine, a "static" VAR compensator has no significant moving parts (other than internal switchgear). Prior to the invention of the SVC, power factor compensation was the preserve of large rotating machines such as synchronous condensers or switched capacitor banks. In transmission applications, the SVC is used to regulate the grid voltage. If the power system's reactive load is capacitive (leading), the SVC will use thyristor controlled reactors to consume VAR from the system, lowering the system voltage. Under inductive (lagging) conditions, the capacitor banks are automatically switched in, thus providing a higher system voltage. By connecting the thyristor-controlled reactor, which is continuously variable, along with a capacitor bank step, the net result is continuously-variable leading or lagging power. In industrial applications, SVCs are typically placed near high and rapidly varying loads, such as arc furnaces, where they can smooth flicker voltage.

B.SERIES COMPENSATION

Here capacitors are used to decrease the equivalent reactance of a power line at a rated frequency.

Using capacitors results improves through:

Increase angular is proves of power

Improved voltage stability

Optimized power sharing between parallel circuits

Thyristor Controlled Series Compensator

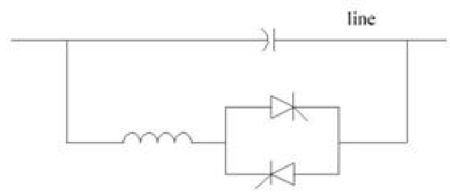

Figure 1.2 Schematic diagram of TCSC

It consists of a series capacitor bank shunted by a thyristor-controlled reactor in order to provide a smoothly variable series capacitive reactance as shown in Fig 5, the bi-directional thyristor valve that is fired with an angle α ranging between 90° and 180° with respect to the capacitor voltage. The TCSC can be operated in bypass–thyristor mode, blocked-thyristor mode and vernier mode. In bypass-thyristor mode, the thyristors are made to fully conduct with a conduction angle of 1800.Gate pulses are applied as soon as the voltage across the thyristors reaches zero and becomes positive, resulting in a continuous flow of current through the thyristor valves. The TCSC module behaves like a parallel capacitor-inductor combination. In blocked-thyristor mode, the firing pulses to the thyristor valves are blocked. If the thyristors are conducting and a blocking command is given, the thyristors turn off as soon as the current through them reaches a zero crossing. The net TCSC reactance is capacitive. The vernier mode allows the TCSC to behave either as a continuously controllable capacitive reactance or as a continuously controllable inductive reactance. It is achieved by varying the thyristor- pair firing angle in an appropriate range.

IV. POWER WORLD SIMULATOR

Power World Simulator is a user-friendly and highly interactive power system analysis and visualizations platform. It integrates many commonly performed power sysem tasks like contingency Analysis, Time-step Simulation, OPF, ATC, PVQV, Fault analysis, SCOPF, Sensitivity Analysis, Loss Analysis, Transient Stability, GIC. It is designed to operate on Microsoft windows XP/2008/7/8 Platforms.

A.POWER WORLD SIMULATOR HISTORY

Power World Simulator version 1.0 created in May 1994 at the university of Illinois Urbana-Champaign by professor Thomas Over bye (Ph.D.). The impetus for early versions was to each power system operation to non-technical audiences.

Power World Corporation was formed in 1996 with the goal of further developing and commercializing the simulator tool. The Simulator version 18 is virtually unrecognizable from the early versions of the software. It has evolved into a powerful power system analysis and visualization environment capable of solving very large systems.

B.TRAINING GOALS

It provides a better understanding of how to use Power World simulator for power system analysis and visualization. It provide techniques for building good power system models and show how these techniques can be used to analyze system issues.

C.MODES OF OPERATION

The graphical power system case editor and the power flow package are implemented in simulator's two distinct modes:

- Edit Mode
- Run Mode

EDIT MODE

The tasks performed are

- Create new power flow cases
- Modify existing cases
  Abilities
- Cases can be modified either graphically or via text displays

RUN MODE

- Stand alone power flow
- Power flow analysis tools and sensitivities
- Contigency Analysis
- Time-Step Simulation
- Optimal Power Flo(OPF)
- PV and QV Curve Tools(PVQV)
- Available Transfer Capability(ATC)
- Security Constrained OPF(SCOPF)
- Sensitivity Analysis
- Loss Analysis
- Fault Analysis
- Transient Stability
- Geomagnetically Induced Current(GIC)

V. SIMULATION RESULTS

CASE 1: IEEE-6 bus system is simulated by using the datas mentioned in the appendix, in which the total generation cost is obtained as a result shown in fig 1.3.Total generation cost before placing FACTS device is 3899472.00$/hr.

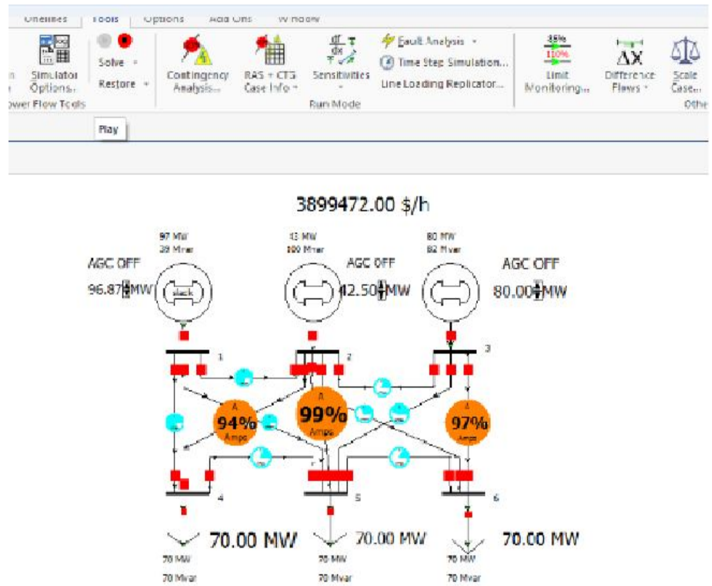

FIG 1.3: SIMULATION WITHOUT FACTS DEVICE

In this individudal generator cost is tabulated in table 1.1 and it is taken from the simulated output which is calculated using the datas mentioned in appendix.

TABLE 1.1: COST ANALYSIS WITHOUT FACTS

BUS NO	GEN POWER MW	GENERATING COST	Pmin MW	Pmax MW
1	96.9	2000716.12	50	200
2	42.5	361789.02	37.5	150
3	80.0	1536966.69	45	180

Power flows in various transmission lines is tabulated here. This variable values are obtained from the power world simulator simulation output is tabulated in table 1.2.

TABLE 1.2: POWER FLOW IN 6 BUS SYSTEM

Tx line	REAL POWER (MW)	REACTIVE POWER (MVAR)	APPARENT POWER (MVA)
1-2	28.30	-6.48	29.0
1-4	38.15	25.38	45.8
1-5	30.42	20.02	36.4
2-3	-7.56	-4.21	8.7
2-4	38.90	52.06	65.0
2-5	17.95	23.40	29.5
2-6	20.68	22.12	30.3
3-1	80.0	82.32	114.8
3-5	21.68	21.73	30.7
3-6	50.74	59.18	78
4-5	3.78	0.23	3.8
5-6	0.54	-6.29	6.3
6-5	-0.51	3.93	4.0

Total generation cost after placing FACTS device is simulated in fig 1.4 and the value is 3784487.75 $/hr.

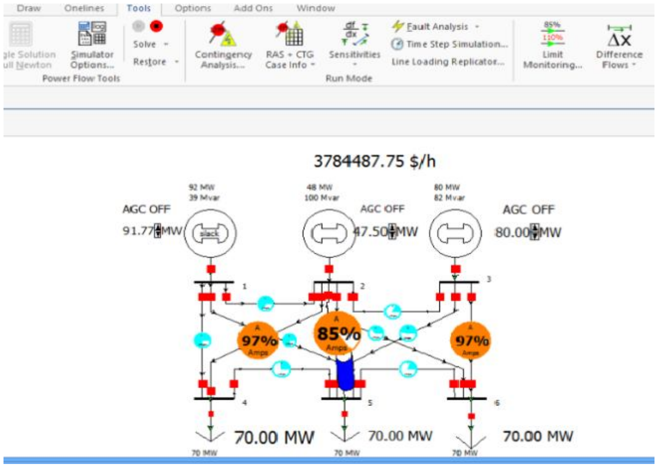

FIG 1.4: SIMULATION OUTPUT WITH FACTS DEVICE

Individual generation cost is tabulated in table 1.3 after placing FACTS device (TCSC) in the transmission line 1-2 in which the voltage magnitude is less when compared to other transmission lines.

TABLE 1.3: COST ANALYSIS WITH FACTS

BUS NO	GEN POWER (MW)	GENERATING COST	Pmin (MW)	Pmax (MW)
1	91.8	1795655.01	50	200
2	47.5	451840.75	37.5	150
3	80	1536966.69	45	180

Power flows in various transmission line is tabulated here. This variable values are obtained from the power world simulator simulation output is tabulated in table 1.4.

TABLE 1.4: POWER FLOW IN 6 BUS SYSTEM

Tx line	REAL POWER (MW)	REACTIVE POWER (MVAR)	APPARENT POWER (MVA)
1-2	25.27	-6.81	26.2
1-4	36.26	25.06	44.1
1-5	30.24	21.05	36.8
2-3	-6.27	-3.20	7.0
2-4	41.73	52.88	67.4
2-5	14.62	20.63	25.3
2-6	22.01	23.16	32
3-1	80	82.06	14.6
3-5	22.93	22.54	32.2
3-6	50.79	59.19	78
4-5	4.66	0.85	4.7
5-6	-0.76	-7.03	7.1
6-5	0.80	4.71	4.8

CASE 1: IEEE-30 bus system is simulated by using the datas mentioned in the appendix, in which the total generation cost is obtained as a result shown in fig 1.5.Total generation cost before placing FACTS device is 1429.02 $/hr.

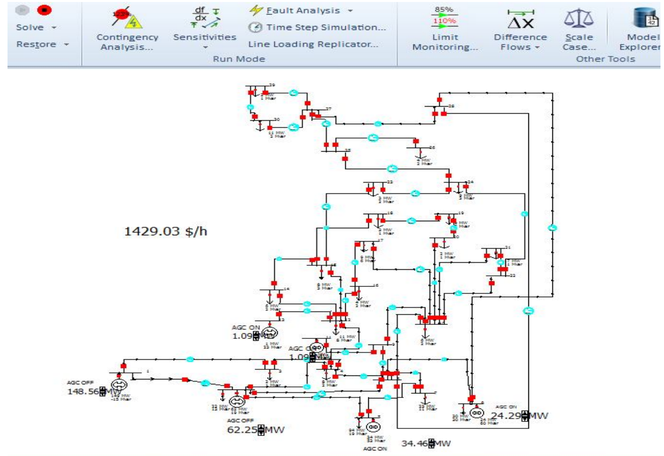

FIG 1.5: SIMULATION OUTPUT WITHOUT FACTS DEVICE (IEEE-30)

In this individudal generator cost is tabulated in table 1.5, and it is taken from the simulated output which is calculated using the datas mentioned in appendix.

TABLE 1.5: COST ANALYSIS WITHOUT FACTS

BUS NO	GEN POWER (MW)	GENERATING COST	Pmi (MW)	Pmax (MW)
1	153.8	496.17	50	200
2	57.2	257.53	20	80
5	34.5	208.69	15	50
8	24.3	183.86	10	35
11	21.6	176.55	10	30
13	11.1	103.29	12	40

Power flows in various transmission lines before placing FACTS devices. This variable values are obtained from the power world simulator simulation output is tabulated in table 1.6.

TABLE 1.6: POWER FLOW IN 30 BUS SYSTEM

x line	RE AL POWER (M W)	REAC TIVE POWER (MVA R)	APPA RENT POWER (MVA)
-2	95. 70	-30.09	100.3
-3	52. 97	-2.39	53
-4	34. 43	0.51	34.4

-5	56.93	-11.11	58
-6	42.98	-2.90	43.1
-4	49.30	-6.78	49.8
-6	37.96	-15.08	40.8
-12	37.16	6.38	37.7
-1	34.46	52.74	63
-7	-4.38	18.09	18.6
-7	27.58	-7.89	28.7
-8	17.08	-20.74	26.9
-9	15.24	5.56	16.2
-10	12.95	6	14.3
-28	6.81	-2.62	7.3
-6	-27.35	7.76	28.4
-1	24.29	6	64.7
-28	11.28	9.39	14.7
-10	36.86	18.36	41.2
-11	-21.62	-13.37	25.4
0-17	8.37	2.48	8.7
0-20	10.69	2.54	11
0-21	16.73	9.76	19.4
0-22	8.23	4.42	9.3
1-1	21.62	14.79	26.2
2-13	-1.09	-22.20	22.2
2-14	7.36	3.05	8
2-15	15.48	8.92	17.9
	4.2	5.32	6.8
2-16	2		
3-1	1.09	22.94	23
4-1	6.20	1.60	6.4
4-15	1.07	1.28	1.7
5-1	8.20	2.50	8.6
5-18	4.41	2.87	5.3
5-23	3.71	4.38	5.7
6-1	3.50	1.80	3.9
6-17	0.67	3.42	3.5
7-1	9	5.80	10.7
8-1	3.20	0.90	3.3
8-19	1.17	1.91	2.2
9-1	9.50	3.40	10.1
9-20	-8.33	-1.50	8.5
0-1	2.20	0.70	2.3
1-1	17.50	11.20	20.8
1-22	-0.92	-1.75	2
2-24	7.24	2.53	7.7
3-1	3.20	1.60	3.6
3-24	0.47	2.70	2.7
4-1	8.70	6.70	11
4-25	-1.07	-1.62	1.9
5-26	3.55	2.38	4.3
5-27	-4.64	-4.01	6.1
6-1	3.50	2.30	4.2
7-28	-18.02	-7.53	19.5

7-28	6.21	1.71	6.4
7-29	7.12	1.72	7.3
7-30	2.40	0.90	2.6
9-1	3.71	0.62	3.8
9-30	10.60	1.90	10.8

In this IEEE-30 bus system is simulated and the total generation cost is obtained after placing FACTS devices is simulated in fig 1.6.

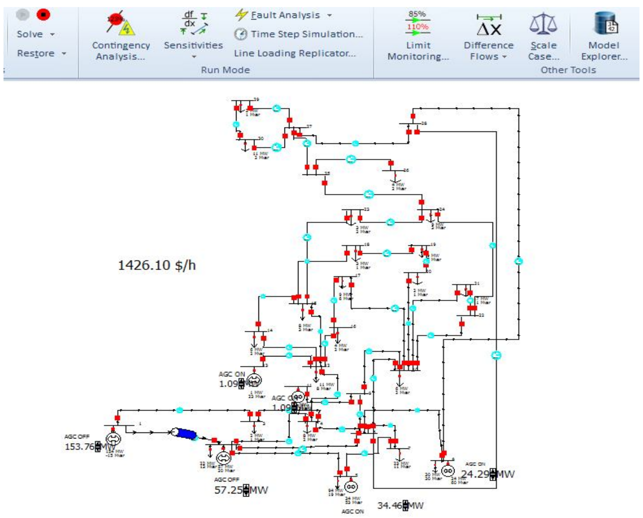

FIG 1.6: SIMULATION OUTPUT WITH FACTS DEVICE (IEEE-30)

TABLE 1.6: COST ANALYSIS WITH FACTS

BUS NO	GEN POWER (MW)	GENERATING COST	Pmin (MW)	Pmax (MW)
1	148.6	479.90	50	200
2	62.2	256.74	20	80
5	34.5	208.69	15	50
8	24.3	183.86	10	35
11	21.6	176.55	10	30
13	11.1	103.29	12	40

In this individual generation cost and generated power is calculated for each generators after placing FACTS devices is tabulated in table 1.6.

In this real , reactive and apparent power is tabulated for individual transmission lines after placing FACTS device is tabulated in table 1.7. The FACTS device used here is thyristor controlled series compensator (TCSC).

TABLE 1.7: POWER FLOW IN 30 BUS SYSTEM

Tx line	REAL POWER (MW)	REACTIVE POWER (MVAR)	APPARENT POWER (MVA)
1-2	96.11	-22.17	98.6
1-3	57.65	-2.94	57.7
2-4	32.27	1.51	32.3
2-5	56.19	-11.01	57.3
2-6	41.35	-2.48	41.1
3-4	53.75	-8.30	54.4
4-6	40.11	-15.87	43.1
4-12	37.30	6.36	37.8
5-1	34.46	52.7	63
5-7	-5.09	18.36	19.1
6-7	28.30	-8.11	29.4
6-8	17.06	-20.73	26.8
6-9	15.16	5.56	16.1
6-10	12.91	6	14.3
6-28	6.80	-2.62	7.3
7-6	-28.06	8.02	29.2
8-1	24.29	6	64.7
8-28	11.26	9.39	14.7
9-10	36.78	18.38	41.1
9-11	-21.62	-13.38	25.4
10-17	8.30	2.48	8.7
10-20	10.65	2.55	11
10-21	16.72	9.76	19.4
10-22	8.22	4.42	9.3
11-1	21.62	14.8	26.2
12-13	-1.09	-22.21	22.2
12-14	7.37	3.05	8
12-15	15.54	8.90	17.9
12-16	4.28	5.30	6.8
13-1	1.09	22.94	23
14-1	6.20	1.60	7.8
14-15	1.09	1.27	1.7
15-1	8.20	2.50	8.6
15-18	4.44	2.86	5.3
15-23	3.75	4.36	5.8
16-1	3.50	1.80	3.9
16-17	0.73	3.40	3.5
17-1	9	5.80	10.7
18-1	3.20	0.90	3.3
18-19	1.21	1.89	2.2
19-1	9.50	3.40	10.1
19-20	-8.30	-1.51	8.4
20-1	2.20	0.70	2.3
21-1	17.50	11.20	20.8
21-22	-0.92	-1.75	2
22-24	7.24	2.53	7.7
23-1	3.20	1.60	3.6
23-24	0.51	2.69	2.7
24-1	8.70	6.70	11
24-25	-1.07	-1.63	1.9
25-26	3.55	2.38	4.3
25-27	-4.61	-4.02	6.1
26-1	3.50	2.30	4.2

27-28	-17.99	-7.53	19.5
27-28	6.21	1.71	6.4
27-29	7.12	1.72	7.3
27-30	2.40	0.90	2.6
29-1	3.71	0.62	3.8
29-30	10.60	1.90	10.8

VI. CONCLUSION

In this project the attempt has been made to review optimization method which is used to solve OPF problems. Power factor is the most significant part in the utility areas. FACTS devices are preferred for improving the stability of power system. It is possible to use these devices for the control flows of active and reactive power. It also contribute to improve the limits of static, transient stability and voltage quality. Hence, as efficiency increases, voltage profile increases where the fuel cost and losses can be reduced.

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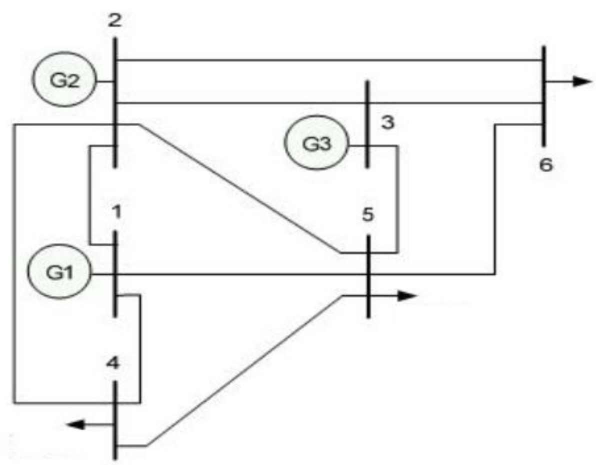
APPENDIX

CASE 1: (IEEE 6 Bus system)



BUS DATA FOR 6 BUS SYSTEM

BUS NO	V(p.u)	Pd (MW)	Qd (MVAR)	Pg (MW)	Qg (MVAR)
1	1.05	0	0	0	0
2	1.05	0	0	50	0
3	1.07	0	0	60	0
4	1	70	70	0	0
5	1	70	70	0	0
6	1	70	70	0	0

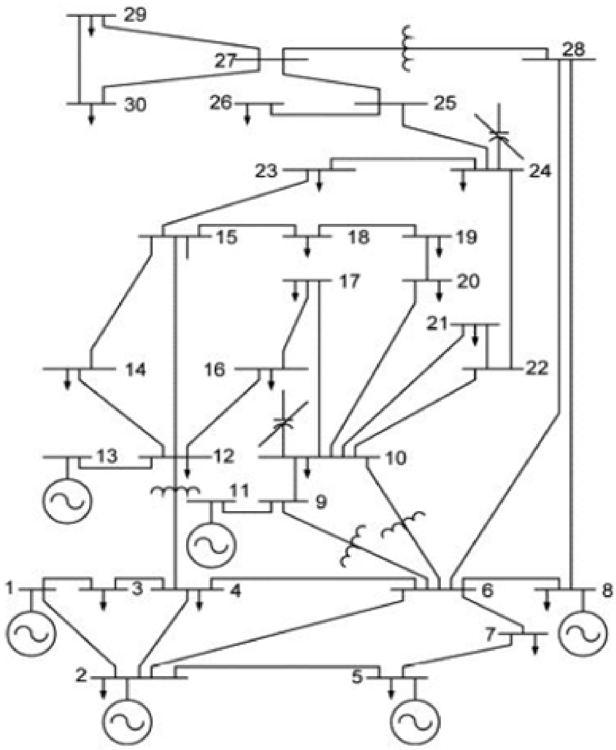
GENERATOR DATA

BUS NO	Pmin (MW)	Pmax (MW)	Qmin (MVAR)	Qmax (MVAR)
1	50	200	-20	100
2	37.5	150	-20	100
3	45	180	-15	100

TRANSMISSION LINE DATA

Tx line	R(p.u)	X(p.u)	S(p.u)	THERMAL LIMIT(MVA)
1-2	2	0.2	0.02	40
1-4	4	0.2	0.02	60
1-5	5	0.3	0.03	50
2-3	3	0.25	0.03	40
2-4	4	0.1	0.01	70
2-5	5	0.3	0.02	30
2-6	6	0.2	0.025	90
3-5	5	0.26	0.025	70
3-6	6	0.1	0.01	80
4-5	5	0.4	0.04	20
5-6	6	0.3	0.03	40

CASE 2: (IEEE 30 Bus system)



GENERATOR DATA

BUS NO	Pmin (MW)	Pmax (MW)	Qmin (MVAR)	Qmax (MVAR)
1	50	200	-20	100
2	20	80	-20	80
5	15	50	-15	80
8	10	35	-15	60
11	10	30	-10	50
13	10	40	-15	60

BUS DATA

BUS NO	V(p.u)	Pd (MW)	Qd (MVAR)	Pg (MW)	Qg (MVAR)
1	1.05	0	0	120	0
2	1.0338	21.7	12.7	62.246	0
3	1.0313	2.4	1.2	0	0
4	1.0263	7.6	1.6	0	0
5	1.0058	94.2	19	34.463	0
6	1.0208	0	0	0	0
7	1.0069	22.8	10.9	0	0
8	1.0230	30	30	24.289	0
9	1.0332	0	0	0	0
10	1.0183	5.8	2.0	021.621	0
11	1.0913	0	0	0	0
12	1.0399	11.2	7.5	28.072	0
13	1.0883	0	0	0	0
14	1.0236	6.2	1.6	0	0
15	1.0179	8.2	2.5	0	0
16	1.0235	3.5	1.8	0	0
17	1.0144	9	5.8	0	0
18	1.0057	3.2	0.9	0	0
19	1.0017	9.5	3.4	0	0
20	1.0051	2.2	0.7	0	0
21	1.0061	17.5	11.2	0	0
22	1.0069	0	0	0	0
23	1.0053	3.2	1.6	0	0
24	0.9971	8.7	6.7	0	0
25	1.0086	0	0	0	0
26	0.9908	35	2.3	0	0
27	1.0245	0	0	0	0
28	1.0156	0	0	0	0
29	1.0047	2.4	0.9	0	0
30	0.9932	10.6	1.9	0	0

TRANSMISSION LINE DATA

Tx line	R (p.u)	X (p.u)	S (p.u)	THERMAL LIMIT(MVA)
1-2	0.019	0.057	0.026	250
1-3	0.045	0.185	0.02	250
2-4	0.057	0.173	0.018	150
3-4	0.013	0.037	0.004	250
2-5	0.047	0.198	0.02	150
2-6	0.058	0.176	0.018	250
4-6	0.11	0.041	0.005	200
5-7	0.046	0.116	0.01	150
6-7	0.026	0.082	0.008	170
6-8	0.012	0.042	0.004	50
6-9	0.0	0.14	0	140
6-10	0.0	0.25	0	155
9-11	0.0	0.13	0	120
9-10	0.0	0.198	0	120
4-12	0	0.2560	0	120
12-13	0	0.1400	0	150
12-14	0.1231	0.2559	0	150
12-15	0.0662	0.1304	0	120
12-16	0.0945	0.1987	0	120
14-15	0.2210	0.1997	0	120
16-17	0.0824	0.1932	0	120
15-18	0.1070	0.2185	0	150
18-19	0.0639	0.1292	0	120
19-20	0.0340	0.0680	0	120
10-20	0.0936	0.2090	0	120
10-17	0.0324	0.0845	0	100
10-21	0.0348	0.0749	0	100
10-22	0.0727	0.1499	0	100
21-22	0.0116	0.0236	0	100
15-23	0.1000	0.2020	0	100
22-24	0.1150	0.1780	0	130
23-24	0.1320	0.2700	0	130
24-25	0.1885	0.3292	0	100
25-26	0.2544	0.3800	0	100
25-27	0.1093	0.2087	0	170
28-27	0.000	0.3960	0	100
27-29	0.2198	0.4153	0	100
27-30	0.3202	0.6027	0	100
29-30	0.2399	0.4533	0	100
6-28	0.0636	0.2000	0	170
8-28	0.0169	0.0599	0	100