MITIGATION OF TRANSMISSION LOSS AND IMPROVEMENT IN VOLTAGE STABILITY BY RESCHEDULING OF REACTIVE POWER THROUGH UNIFIED POWER FLOW CONTROLLER (UPFC) USING GENETIC ALGORITHM (GA)

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Abstract : This presents an algorithm for the enhancement of voltage stability subjected to operational inequality constraints by rescheduling of reactive power control variables. Amount of Reactive power which is obtained from UPFC to be injected which is determined using minimum eigen sensitivity of load flow Jacobian of the system. System voltage stability has been evaluated using continuation of power flow. Voltage instability is a quite frequent phenomenon under such a situation provide reduction of power system performance. In order to avoid voltage collapse, blackouts, power system is to be analyzed in view of voltage stability for a wide range of system operating condition. Developed algorithm has been implemented on IEEE 14-bus system.

Keywords : Unified Power Flow Controller (UPFC), Continuation Power Flow, Voltage Stability, Minimum eigen value, Voltage collapse.

I. INTRODUCTION

In the present era, power system designers (or planners) are facing more challenges in meeting the increased load demand with high reliability and minimum investment in new transmission facilities [1]. Give-up additional parallel lines and obtaining necessary right of ways or raising system operating voltages may all be prohibitive from economical and other considerations [2,3 and 4]. The demand of electrical energy is increases rapidly. Power grid upgrade, and especially the construction of new transmission lines, can't installed rapidly due to environmental considerations [5 and 6]. Due to these constraints it has become a major challenge to utilize the existing transmission line more efficiently [7]. There are two major challenge arises. The first challenge is to improve the transient and steady state stability of high voltage transmission lines [8]. The other challenge is the flexibility a deregulation energy market requires [9]. For solving the such types of above problems, a power electronics based FACTS device i.e. known as Unified Power Flow Controller (UPFC) is used.

When a power system is subjected to a sudden increase of reactive power demand following a system contingency, the additional demand is met by a reactive power reserves of generators and compensators [10]. Due to vents and lack of reactive power reserves, it may lead to voltage collapse, so causing total or partial breakdown of entire system [11]. In order to function properly, it is necessary that the voltage is kept close to nominal value throughout the entire power system [12]. The control of voltage level is realized by controlling the generation, absorption and flow of reactive power at all levels in a system which is carried out using FACTS devices [13]. FACTS devices modifying voltage magnitude, phase angle and impedance of a transmission line in a power system network [14]. This paper make use of UPFC (FACTS Device) controllers for improving voltage profiles and controlling line flows during excess load demands. Contingency analysis is carried out by increasing the load demands at each receiving end bus and removing the line out of service from the power system network [15]. The analysis of voltage stability in the power system network is carried out by computing the eigen values of the reduced Jacobian matrix during normal condition and for each case of load increments [16]. Voltage Stability Index (VSI) is calculated for all the transmission lines corresponding to the critical line outage. The line which has highest VSI value for this outage is termed as the critical line and hence gives the optimal location for placing UPFC in the network [17]. After placing UPFC on the critical line, voltage stability analysis is carried out with each transmission line in service at each case of load increments [18]. The voltage magnitudes of the severely affected buses for this critical load increment is compared with those magnitudes during the critical outage. Section-II describes concept of UPFC. Section-III presents mathematical modeling of Unified Power Flow Controller (UPFC). Section- IV describes about the problem formulation. Section-V presents developed algorithm for the solution of problem. Section-VI presents results and discussion. Section-VII describes conclusion of the paper.

II. CONCEPTS OF UPFC

The UPFC is the most powerful and versatile FACTS-equipment used to control the power flow and stability of the power system, static as well as dynamic condition [19]. It is able to control, simultaneously or selectively all the parameters affecting power flow in the transmission line (i.e. voltage, impedance & phase angle) and this unique capability is signified by the adjective "unified" in its name [20]. Unified Power Flow Controller 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 connected [21]. It consists of two switching converters connected by a common DC link and both are connected via coupling transformers to the AC transmission line [22]. The shunt converter can generate or absorb controllable reactive power and it also provides real power exchange to the series inverter to satisfy the operating control requirement [23]. Figure-1, shows the schematic diagram of a UPFC system.

The voltage magnitude of both the VSC can be controlled within their rated limits and their angle between 0° to 180°. The phase angle of series injected voltage, θ_{ser}, determines the mode of power flow control as follows [24]:

- UPFC regulates the terminal voltage of bus, if series injected voltage is in phase with nodal voltage and acts as voltage regulator.
- UPFC regulates active power flow acting as a phase shifter, if series injected voltage is in quadrature with nodal voltage, acts as phase shifter.
- UPFC regulates real power flow, if series injected voltage is in quadrature with line current angle, and acts as variable series compensator.
- At any other value of θ_{ser}, UPFC operates as a combination of the voltage regulator, phase shifter & variable series compensator.

The UPFC consists of two levels of control: Internal controller, which specifies the switching pattern of the solid-state devices within each inverter. External controller, which uses the references and system output signals to determine the control variables for each inverter.

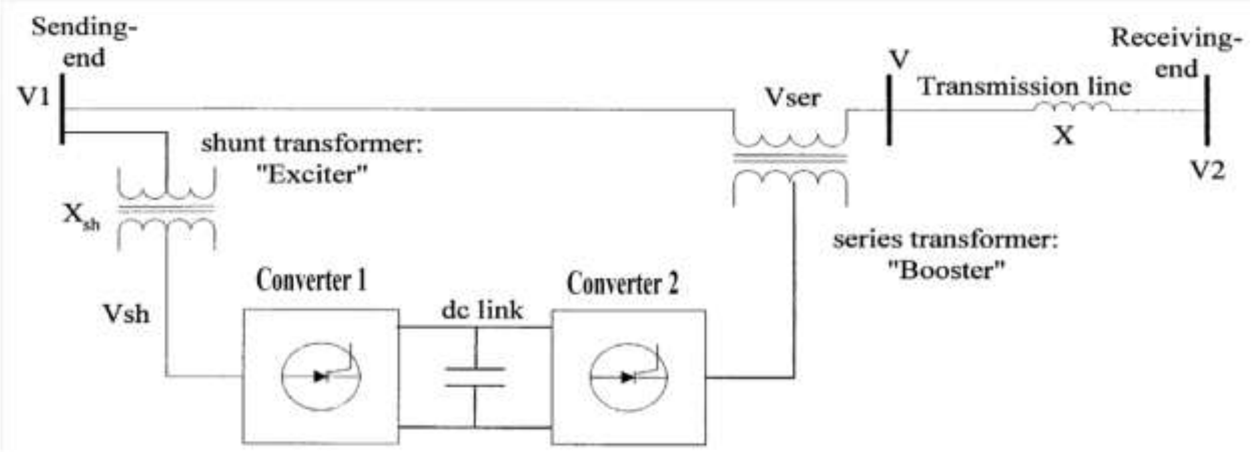

Figure 1: Schematic Diagram of a UPFC System

III. MODELING OF UPFC

Let us consider that the UPFC is lossless and the shunt inverter rating is used only for supplying the real power required by the series inverter. According to the requirement that no real power is generated or absorbed by the UPFC. The injection of power in terms of voltage and power angle, due to the insertion of UPFC in transmission line is given in following equations.

$$\boldsymbol{P_{i_{net}} = \frac{r_{ser}}{X_s} V_i V_j \sin(\theta_{ij} + \emptyset_{ser})} \tag{1}$$

$$\boldsymbol{Q_{i_{net}} = \frac{r_{ser}}{X_{sh}} V_i^2 \cos \emptyset_{ser} - \frac{V_i^2}{X_{sh}} [1 - r_{sh} \cos \emptyset_{sh}]} \tag{2}$$

However,

$$P_{j_{net}} = -P_{i_{net}} \quad \& \quad Q_{j_{net}} = -Q_{i_{net}}$$

$$\boldsymbol{P_{j_{net}} = -\frac{r_{ser}}{X_s} V_i V_j \sin(\theta_{ij} + \emptyset_{ser})} \tag{3}$$

$$\boldsymbol{Q_{j_{net}} = -\frac{r_{ser}}{X_{sh}} V_i V_j \cos(\theta_{ij} + \emptyset_{ser})} \tag{4}$$

Where, $P_{i_{net}}$, $P_{j_{net}}$, $Q_{i_{net}}$, $Q_{j_{net}}$ are the real and reactive injecting powers from bus i and bus j respectively. V_i and V_j are the injecting voltage at bus i and bus j, X_s and X_{sh} are the effective reactance offered by SSSC and STATCOM, $\boldsymbol{r_{ser}}$ is the series resistance of SSSC, Φ_{ser} *and* Φ_{sh} are the phase angle of the SSSC and STATCOM respectively.

IV. PROBLEM FORMULATION

Objectives of the paper to optimize the amount of Vars which is to be injected for maintaining steady acceptable system load bus voltage within tolerable range and minimize real & reactive power losses of the system subject to inequality constraints. To evaluate real & reactive power loss using indexes and current state voltage stability using continuation power flow and then optimized using Genetic Algorithm.

$$J = Min \sum Q_i \qquad \text{where i = 1, 2, 3, ...NB} \tag{5}$$

This objective function is evaluated based on fitness function of following indexes and inequality constraints.

A. Voltage Stability Index (F$_1$)

For maintaining the voltage stability is the major problem in a power system. Voltage stability is evaluated at each bus of the system by an indicator, L-index. At load bus j, L- index can be written as-

$$L_j = |L_j| = \left|1 - \frac{\sum_{i\varepsilon\alpha_G} C_{ij} V_i}{V_j}\right| \; j\varepsilon\alpha_L \tag{6}$$

where,

α_L = set of load buses
α_G = set of generator buses
V_i = complex voltage at generator bus i
V_j = complex voltage at load bus j
C_{ij} = elements of matrix C

The minimization of voltage stability index is the 1^{st} objective function consideration.
Where, F$_1$ = Voltage Stability Index = L$_{max}$.

B. Power Loss (F_2) in MW

The 2^{nd} objective function considering the minimization of real power loss can be expressed as-

$$F_2 = P_{loss} = \sum_{i=1}^{N_L} g_{i,j} \left[V_i^2 + V_j^2 - 2\, V_i\, V_j \cos(\delta_i - \delta_j)\right] \qquad (7)$$

where,

V_i = voltage magnitude at bus i
V_j = voltage magnitude at bus j
$g_{i,j}$ = conductance of line i,j
N_L = total number of transmission lines

C. Sensitivities of minimum eigenvalue with respect to System load

Sensitivity of minimum eigenvalue $\lambda_{\min}$ of load flow Jacobian with respect to an element a_{ij} can be written as follows:

$$\frac{\partial \lambda_{\min}}{\partial a_{ij}} = \eta_{\min i}\, \xi_{\min j} \qquad (8)$$

where,

$[a_{ij}]$- is the element of [J']
$\lambda_{\min}$ − is the minimum eigenvalue of [J'],
$\eta_{\min}^{T}$, $\xi_{\min}$ − are right and left eigenvectors corresponding to $\lambda_{\min}$,
$\eta_{\min i}$, $\xi_{\min j}$ − are respective elements of $\eta_{\min}^{T}$ and $\xi_{\min}$.

Rescheduling variables are recative control variable i.e. $Q_1, Q_2, \dots\dots, Q_n, \dots\dots, Q_{NL},$ (n≠ slack bus).
Each element of Jacobian can be assumed a function of these reactive power control variables are as follows:

$$F_3 = \partial \lambda_{\min} / \partial Q_n = \sum \eta_{\min i}\, \xi_{\min j}\, \partial a_{ij} / \partial Q_n \qquad (9)$$

D. Fitness Function

Considering all the three objective indexes from equation (6,7 and 9), the fitness function (FF) is expressed in equation (10). Fitness function,

$$F = h_1 F_1 + h_2 F_2 + h_3 F_3 \qquad (10)$$

Where $h_1, h_2,$ *and* h_3 are weighting factor of minimization of VSI objective function, weighting factor of power loss minimization objective function, weighting factor of maximization of sensitivity of change in minimum eigen value of load flow Jacobian w.r.t. change in reactive power control variable i.e. injected Vars via UPFC as objective function.

$$h_1 + h_2 + h_3 = 1 \qquad (11)$$

Inequality Constraints:

(i) Power Flow Constraints:

$$\underline{P} = \underline{f}\,(\underline{V}, \delta)$$
$$\underline{Q} = \underline{g}\,(\underline{V}, \delta) \qquad (12)$$

(ii) Reactive Power Generation Constraint:

$$Q_{g\,k} \le Q_{g\,k}^{0} \le \overline{Q}_{g\,k} \qquad \text{where } k = 1,2,3,\dots\dots\dots\dots NG \qquad (13)$$

(iii) Transmission Line constraints:

$$S_{Li} \le S_{Li}^{max} \qquad \text{where } i = 1,2,3,\dots\dots\dots\dots\dots\dots N_{TL} \qquad (14)$$

(iv) Inequality constraint on minimum eigenvalue of load flow Jacobian:

$$\lambda_{\min}{}^{0} \ge \lambda_{\min}{}^{th} \qquad (15)$$

(v) Transformer Tap constraints:

$$T_i^{min} \le T_i \le T_i^{max} \qquad \text{where } i = 1,2,3,\dots\dots\dots\dots\dots\dots N_T \qquad (16)$$

(vi) Inequality constraint on load bus voltages:

$$\underline{V}_i \le V_i^0 \le \overline{V}_i \qquad \text{where } i = NG + 1,\dots\dots\dots\dots\dots\dots NB \qquad (17)$$

The maximum reactive power of the UPFC is limited by the network power transfer. It is stressed that reactive power rescheduling is performed at current loading condition. Further, constraints as in equation no. (12) - (17) are ascertained by performing load flow solution at current operating condition (after reactive power rescheduling) and predicted loading condition (accounting reactive power rescheduling).

V. PROBLEM SOLUTION

Development of GA based algorithm to optimize the amount of Var's of UPFC to be injected for the minimization of real & reactive power and enhancement in Voltage Stability of the system is as follows.

Step-1: Data input; Reactive power control variables and system parameters (resistance, reactance, and susceptance etc.).
Step-2: Base case load flow solution is obtained using continuation power flow methodology.
Step-3: Next interval load is predicted.

Step-4: Obtain load flow solution for the predicted next interval load and execute power flow program. This process is continued until stressed condition of the system where a few load buses voilate thresshod value .
Step-5: Initialization; Generate population of size 'M' for reactive power control variables, which is obtained from the first step of the GA algorithm.

$\underline{U}_{ij} < U_{ij} < \overline{U}_{ij}$ j = 1, 2, 3, ...,NC

$U_i^0 = [u_{i\,1}^0,\ u_{i\,2}^0, u_{i\,3}^0, \dots\dots\dots, u_{i,NC}^0]^T$

Step-6: Run continuation power flow program for each vector of the population and monitor all inequality constraints eq. no. (12) - (17). If, a vector satisfies the constraints call it 'F' (feasible). Otherwise, call it 'NF' (not- feasible).

Step-7: Selection strategy applied to select appropriate load which satisfy all inequality constraints equation (12) - (17).

Step-8: Calculate indexes using eq. (6, 7 and 9) for the feasible vectors.

Step-9: Based on the value of indexes, identify the best solution vector U_{best}. This is selected as a base vector.

Step-10: Fitness function evaluate and satisfy using equation no. 10.

Step-11: Set generation count k = 1.

Step-12: Select target vector i = 1

Step-13: Apply uniform crossover to get trial vector $t_i^{(k)}$. If the trial vector satisfy inequality constraints call it 'F' otherwise, 'NF' [22].

Step-14: Select two vectors U_{r1} and U_{r2} such that base $\neq i \neq r1 \neq r2$.

Step-15: Generate a mutated vector $\rho_i^{(k)}$ subject to inequality constraints [22].

Step-16: If any component of mutated vector i.e. $\rho_i^{(k)}$ violates the bounds on decision variable u_j then apply bounce back technique and bring the violated variables within limit.

Step-17: Run continuation power flow program for each vector of the Muted solution and monitor all inequality constraints.

Step-18: Calculate objective function using eq. (5) and fix the value of Vars which is to be supplied from the UPFC.

Step-19: Evaluate real & reactive power losses, voltage stability and loadability limit of the system subjected to operational constraints.

Step-20: If convergence occurs in evaluated variables then Stop. Otherwise go to step-6.

VI. RESULTS AND DISCUSSION

IEEE 14- Bus system;

This test system consists of 3 generators, 11 load bus and 20 transmission lines. The problem is addressed for calculating the optimal injection of Var's and power rating (MVA) of UPFC by using GA. Continuation power flow program has been executed to obtain the active power, reactive power flows, load bus voltage magnitude of IEEE-14 bus system. It is desirable to keep the voltage deviations between ±5% i.e. 0.95 - 1.05pu and all inequality constraints should be within feasible limits to avoid voltage collapses during operating conditions. Load on the system increased progressively subjected to desired voltage stability limit but under stressed operating condition a few load buses voltages decreases below the desired limit as shown on Table-1. This is due to shortage of Vars which is required to keep voltages within limit at all load buses of the system. To avoid this situation additional Vars required to injected at appropriate location of the system. Table - 2 shows the transmission line power flows and losses of the IEEE 14-bus system without UPFC. The losses have been occurred at 20.02 % without FACTs devices. When we fixed the UPFC at appropriate locations then the losses have occurred at 10.98 % as shown on Table-3. Table-4 shows the power flow solution after the optimized Vars injection from two UPFC at appropriate location using Genetic Algorithm and losses have occurred at 9.39% . Table -5 shows the appropriate location and optimal amount of Vars have been injected using UPFC FACTS device, then we have seen that the power transfer capability improved. The objective of the thesis is achieved to maintain all load buses voltages within desired limit and simultaneously enhance the level of voltage stability subjected to all inequality constraints.

Table 1: Power Flow solution for IEEE 14-Bus System under stressed condition.

Total active load: 227.0073 MW
Total Reactive Load: 95.9121 MVAR
Total load: 246.4375 MVA
Voltage stability limit: 257.47 MVA

Bus No.	**Voltage Magnitude (pu)**	**Angle δ°**	P_G **(MW)**	Q_G **(MVAR)**	P_L **(MW)**	Q_L **(MVAR)**
1	1.047	0	125.74	-9.57	0	0
2	1.035	-4.983	65.810	38.76	19.2764	15.8123
3	1.013	-12.725	42.390	29.98	82.1938	24.0160
4	0.968	-10.313			42.1523	-4.8108
5	0.957	-8.774			6.0605	2.1522
6	0.823	-14.221		19.75	9.6163	9.6722
7	0.859	-13.362			0	0
8	0.798	-13.361		18.62	0	0
9	0.989	-14.939			26.0463	20.9903
10	0.973	-15.097			8.0574	8.0644
11	1.006	-14.791			2.9952	2.8738
12	0.867	-15.076			5.4737	1.7851
13	0.950	-15.156			11.9809	7.8998
14	0.845	-16.034			13.1545	7.4568

Table 2: Transmission Line Power Flows and Losses of the IEEE 14-Bus System without UPFC

Total active load: 227.0073 MW
Total Reactive Load: 95.9121 MVAR
Total load: 246.4375 MVA
Active power loss: 42.106 MW
Reactive Power Loss: 25.704 MVAR
Total Loss: 49.332 MVA
Voltage stability limit: 257.47 MVA

Line #	From Bus	To Bus	Injection Power				Line Losses	
			From		To		$I^2 Z$	
			P (MW)	Q (MVAR)	P (MW)	Q (MVAR)	P (MW)	Q (MVAR)
1	1	2	156.88	-20.4	-152.59	27.68	13.4620	6.1737
2	1	5	75.51	3.85	-72.75	2.23	8.7312	5.4502
3	2	3	73.24	3.56	-70.91	1.60	6.9215	4.6648
4	2	4	56.13	-1.55	-54.45	3.02	5.3340	2.3181
5	2	5	41.52	1.17	-40.61	-2.10	2.8258	1.3471
6	3	4	-23.29	4.47	23.66	-4.84	1.3017	0.4236
7	4	5	-61.16	15.82	61.67	-14.20	1.5240	0.7568
8	4	7	28.07	-9.68	-28.07	11.38	0	0.8187
9	4	9	16.08	-0.43	-16.08	1.73	0	0.6140
10	5	6	44.09	12.47	-44.09	-8.05	0	2.0848
11	6	11	7.35	3.56	-7.30	-3.44	0.1587	0.0524
12	6	12	7.79	2.50	-7.71	-2.35	0.1842	0.0714
13	6	13	17.75	7.22	-17.54	-6.80	0.7081	0.2051
14	7	8	0	-17.16	0	17.62	0	0.1904
15	7	9	28.07	5.78	-28.07	-4.98	0	0.3427
16	9	10	5.23	4.22	-5.21	-4.18	0.0317	0.0143
17	9	14	9.43	3.61	-9.31	-3.36	0.0150	0.0048
18	10	11	-3.79	-1.62	3.80	1.64	0.1620	0.0476
19	12	13	1.61	0.75	-1.61	-0.75	0.3651	0.1140
20	13	14	5.64	1.75	-5.59	-1.64	0.3810	0.0095
Sum			**486.15**	**19.89**	**-472.76**	**10.21**	**42.1060**	**25.7040**

Table 3: Transmission Line Power Flows and Losses of the IEEE 14-Bus System with Two UPFC

Total active load: 227.0073 MW
Total Reactive Load: 95.9121 MVAR
Total load: 246.4375 MVA
Active power loss: 22.378MW
Reactive Power Loss: 15.228 MVAR
Total Loss: 27.067 MVA
Voltage stability limit: 269.23 MVA

Line #	From Bus	To Bus	Injection Power				Line Losses	
			From		To		$I^2 Z$	
			P (MW)	Q (MVAR)	P (MW)	Q (MVAR)	P (MW)	Q (MVAR)
1	1	2	155.63	-21.65	-144.9610	87.0812	7.1546	3.6559
2	1	5	74.26	2.6	-69.1125	7.0156	4.6403	3.2274
3	2	3	71.99	2.31	-67.3645	5.0336	3.6785	2.7623
4	2	4	54.88	-2.8	-51.7275	9.5009	2.8348	1.3728
5	2	5	40.27	-0.08	-38.5795	-6.6066	1.5018	0.7977
6	3	4	-24.54	3.22	22.4770	-15.2266	0.6918	0.2508
7	4	5	-62.41	14.57	58.5865	-44.6732	0.8099	0.4482
8	4	7	26.82	-10.93	-26.6665	35.8015	0	0.4849
9	4	9	14.83	-1.68	-15.2760	5.4425	0	0.3636
10	5	6	42.84	11.22	-41.8855	-25.3253	0	1.2366
11	6	11	10.05	4.46	-6.9350	-10.8222	0.0844	0.0310
12	6	12	6.54	1.25	-7.3245	-7.3931	0.0979	0.0423
13	6	13	16.50	5.97	-16.6630	-21.3928	0.3763	0.1215
14	7	8	-1.25	-18.41	0	55.4325	0	0.1178

15	7	9	26.82	4.53	-26.6665	-15.6671	0	0.2029
16	9	10	3.98	2.97	-4.9495	-13.1503	0.0168	0.0085
17	9	14	11.78	5.43	-8.8445	-10.5706	0.0084	0.0028
18	10	11	-5.04	-2.87	3.6100	5.1594	0.0861	0.0283
19	12	13	0.36	-0.50	-1.5295	-2.3595	0.1942	0.0676
20	13	14	4.39	0.50	-5.3105	-5.1599	0.2025	0.0056
Sum			**468.7**	**0.11**	**-449.122**	**32.1210**	**22.3783**	**15.2285**

Table 4: Power Flow solution after the optimized Vars Injection from two UPFC at appropriate Location using Genetic Algorithm.

Total active load: 227.0073 MW
Total Reactive Load: 95.9121 MVAR
Total load: 246.4375 MVA
Active power loss: 20.015 MW
Reactive Power Loss: 11.623 MVAR
Total Loss: 23.145 MVA
Voltage stability limit: 272.56 MVA

Line #	**From Bus**	**To Bus**	**Injection Power**				**Line Losses**	
			From		**To**		**I^2 Z**	
			P (MW)	**Q (MVAR)**	**P (MW)**	**Q (MVAR)**	**P (MW)**	**Q (MVAR)**
1	1	2	144.3296	-17.7480	-137.331	23.8048	6.3991	2.7913
2	1	5	69.4692	3.3495	-65.475	1.9178	4.1504	2.4642
3	2	3	67.3808	3.0972	-63.819	1.3760	3.2901	2.1095
4	2	4	51.6396	-1.3485	-49.005	2.5972	2.5355	1.0483
5	2	5	38.1984	1.0179	-36.549	-1.8060	1.3432	0.6092
6	3	4	-21.4268	3.8889	21.294	-4.1624	0.6187	0.1915
7	4	5	-51.6528	15.2427	55.503	-12.2120	0.7245	0.3423
8	4	7	25.8244	-8.4216	-25.263	9.7868	0	0.3702
9	4	9	14.7936	-0.3741	-14.472	1.4878	0	0.2777
10	5	6	40.5628	10.8489	-39.681	-6.9230	0	0.9428
11	6	11	12.3200	5.8200	-6.570	-2.9584	0.0755	0.0236
12	6	12	7.1668	2.1750	-6.939	-2.0210	0.0875	0.0322
13	6	13	16.3300	6.2814	-15.786	-5.8480	0.3366	0.0927
14	7	8	0	-14.9292	0	15.1532	0	0.0862
15	7	9	25.8244	5.0286	-25.263	-4.2828	0	0.1549
16	9	10	7.8116	3.6714	-4.689	-3.5948	0.0151	0.0065
17	9	14	13.2900	4.6200	-8.379	-2.8896	0.0073	0.0022
18	10	11	-3.4868	-1.4094	3.420	1.4104	0.0769	0.0215
19	12	13	4.0392	3.3755	-1.449	-0.6450	0.1734	0.0517
20	13	14	5.1888	1.5225	-5.031	-1.4104	0.1812	0.0043
Sum			**447.258**	**17.304**	**-425.484**	**8.7810**	**20.0150**	**11.6230**

Table 5 : Power flow solution of selected transmission lines & buses before and after VARs injection based on sensitivities using UPFC FACT device for 14-bus System.

Branch	11	17
Bus No.	6 - 11	9 - 14
Power Flow without UPFC MVA	7.35 + j 3.56	9.43 + j 3.61
Power Flow with UPFC MVA	10.05 + j 4.46	11.78 + j 5.43
Power Flow with optimized UPFC MVA using Genetic Algorithm	12.32 + j 5.82	13.29 + j 4.62

VII. CONCLUSION

In this paper a novel algorithm has been developed for the injection of optimum Vars through UPFC subjected to current operating inequality constraints for the mitigation of system losses and enhancement in system voltage stability. Amount of Vars is optimized using Genetic Algorithm optimization technique and verified the results in steps using continuation of power flow technique, which has no convergence problem. It provides better improvement in all conditions (current as well as predicted). Genetic Algorithm has the ability to solve the multi-objective problem for optimal amount of Vars injection of unified power flow controller. After applying this optimization technique for optimal amount of Vars injection on transmission line through UPFC, the losses has decreases and improve the voltage profile of the system & also the power transmission capability of the line. After installing the UPFC which has least amount of Vars evaluated with GA, the voltage level of all the buses can be increased up to threshold value and losses has been reduced up to acceptable level which are shown in Table-4 subjected to all inequality constraints. Closed form algorithm has been developed, so that voltage stability of multi bus power system will be improved.

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