Active and Reactive Power Generation Reduction Based on Optimal location of UPFC Based on Genetic Algorithm

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Abstract

The Unified Power Flow Controller (UPFC) is a most complex power electronic device, which can simultaneously control a local bus voltage and optimize power flows in the electrical power transmission system. This paper presents the effect of installing the UPFC on the Iraqi (400 kV) grid transmission system to control the active and reactive power flow by choosing the optimal location and parameters of Unified Power Flow Controllers (UPFCs), which were specified based on the Genetic Algorithm (GA) optimization method. The objectives are improving voltage profile, reducing power losses, treating power flow in overloaded transmission lines, and reducing power generation. The steady state model of UPFC has been adopted on (400 kV) Iraq transmission lines and simulated using the MATLAB programming language. The Newton-Raphson (NR) numerical analysis method has been used for solving the load flow of the system. The practical part has been solved through Power System Simulation for Engineers (PSS\E) software Version 32.0. The Comparative results between the experimental and practical parts obtained from adopting the UPFC were too close and almost the same under different loading conditions, which are (5%, 10%, 15% and 20%) of the total load.

Keywords: Genetic Algorithm (GA), Load Flow Controller Flexible AC Transmission Systems (FACTS), Active and Reactive Power, Unified Power Flow Controller (UPFC).

تحسين توليد القدرة الحقيقية والغير فعالة باستخدام UPFC وتحديد افضل موقع بواسطةGA

سنا خالد عبد الحسن ,فراس محمد طعيمة, ياسر ناظم عبد, علي عادل اللامي

الخلاصة:

تفتح تقنية أنظمة نقل التيار المرنة (FACTS) فرصًا جديدة للتحكم في تدفق الطاقة وتعزيز القدرة القابلة للاستخدام في الوقت الحاضر ، بالإضافة إلى الخطوط الجديدة. وحدة التحكم في تدفق الطاقة الموحدة (UPFC)هي أكثر الأجهزةالإلكترونية تعقيدًا للطاقة، والتي يمكنها التحكم في وقت واحد في جهد ناقل محلي وتحسين تدفق الطاقة في نظام نقل الطاقة الكهربائية. تقدم هذه الورقة التحكم في تدفق الطاقة النشطة والتفاعلية من خلال نظام نقل الشبكة العراقي بقدرة 400 كيلو فولت عنطريق توصيل UPFC في طرف الإرسال والاستقبال. الأهداف هي تحديد نظام التحكم والأداء لـUPFC ، وهو أمر ضروري لتركيب خط النقل هذا للتحكم في تدفق الطاقة النشطة والتفاعلية. وكيف يمكن حل هذه المشكلة عن طريق اختيار الموقع الأمثل والمعلمات الخاصة بوحدات تحكم تدفق الطاقة الموحدة .(UPFCs) والذي تم تحديده بناء على طريقة تحسين الخوارزمية الجينية (GA)، تم استخدامه للبحث عن إعداد معلمات FACT المثلى والموقع بناء على تحقيق الأهداف التالية: تحسين ملف الفولتية ، وتقليل فقد الطاقة ، ومعالجة تدفق الطاقة في خطوط النقل الزائدة والحد توليد الطاقة. تم استخدامMATLAB برنامج لتنفيذ كل من برنامج GA واستخدام طريقة Newton Raphson لحل تدفق حمولة النظام تم فحص واختبار النهج المقترح على شبكة العراقية 400 كيلو فولت. تم حل الجزء العملي من خلال برنامج Power System Simulation for Engineers (PSS \ E) الإصدار 32.0. النتائج المقارنة بين الاجزاء التجريبية والعملية التي تم الحصول عليها من اعتماد ال UPFC حيث تكون قريبة جدا ومتماثلة تقريبًا في ظل ظروف تحميل مختلفة التي هي تمثل (5٪ و10٪ و15٪ و20٪) من إجمالي الحمل.

1. Introduction

In interconnected power systems, which today are very complex, there is a great need to improve utilization, while still maintaining reliability and security [1]. While some transmission lines are charged up to the limit load, others may be overloaded, which has an effect on the values of voltage and reduces system stability and security [2]. For this reason, it is very important to control the power flows along transmission lines to meet transfer of power needs [3]. In the late 1980s, the Electric Power Research, introduced a new approach to solve the problem of designing and operating power systems; the proposed concept is known as Flexible AC Transmission Systems (FACTS) [4].The main objectives of FACTS are to enhance the power transfer the capability, facilitate the power flow control and improve the security and stability of the power system. Power flow between to buses of the lossless transmission line is given by: [5]

$$P_{ij}= \frac{V_i V_j}{X_{ij}} \sin \delta_{ij} \qquad ......(1)$$

Where, $V_i$and $\delta_i$are the i^{th}bus voltage magnitude and angle,

$V_j$and $\delta_j$are thej^{th}bus voltage magnitude and angle and Xij is the line reactance [6].

Thus, from equation (1) power in the transmission line is a function of transmission line impedance, the magnitude of sending end and receiving end voltage and the phase angle between voltages. Control the active and reactive power flow in the transmission line is possible by controlling one or a combination of the power flow arrangements. The bus voltage, line impedance and phase angle in the power system can be regulated rapidly and flexibly with FACTS technology, such as Static Var Compensator (SVC) [6], Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC), etc. The Unified Power Flow Controller (UPFC) which is enables to independent control of active and reactive power in addition to improving reliability and quality of the supply [7]. The UPFC, consisting of a series and a shunt converter connected by a common dc link capacitor, can simultaneously perform the function of transmission line active/reactive power flow control in addition to UPFC bus voltage/shunt reactive power control. Under the traditional power transmission concepts, the UPFC is able to control all parameters affecting power flow in transmission line, simultaneously or selectively. [8] Otherwise, the UPFC can independently control both the active and reactive power Flow in the line, unlike all other controllers. This paper presents a possibility to control active and reactive power flow in the interconnected transmission line and set up to solve all problem resulting from overload in transmission line and improve from the performance of system by minimums line power losses, control the flow of real and reactive power by injection of a voltage in series with the transmission line.

By implement this project on 400 KV Iraqi grid on MATLAB And PSS\E can show the effect of UPFC device on load flow, line losses, rate of generation and compare the MATLAB result with practical result obtain from PSS\E under normal and contingency condition. Also limit the optimal UPFC-location and the setting parameters by using genetic algorithm to develop a novel UPFC-based line overload control in different load line, there maiming of the paper organized as follows. The basic operating principles of the UPFC, Power Flow Constraints and UPFC Control Modes are discussed in Section 2.in Section3, explained the genetic algorithm process with implemented on 400KV Iraqi grid system. In Section 4. Can notice the problem formulation. In Section 5 the simulation results in MATLAB and PSS\E programs listed in two table with and without UPFC. Conclusions are presented in Section 6.

2. Principle of Unified Power Flow Controller

A. Operating Principles of UPFC

As shown in Fig 1. the basic circuit of the UPFC arrangement [9]. Which is consists of two switching converters based on VSC valves. The two converters are connected by a common DC link. Both transformers are connected by two converters and a DC circuit represented by the capacitor. Converter 1 is primarily used to provide the active power demand of converter 2 at the common DC link terminal from the AC power system. Converter 1 can also generate or absorb reactive power at its AC terminal, which is independent of the active power transfer to (or from) the DC terminal. Converter 2 is used to generate a voltage source at the fundamental frequency with variable amplitude ($0 \leq V \leq V\text{max}$) and phase angle ($0 \leq \varphi \leq 2\pi$) [9], which is added to the AC transmission line by the series connected transformer. [11, 12]

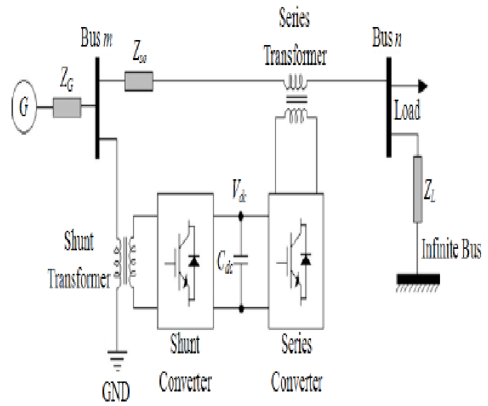

Figure (1): the basic circuit of the UPFC arrangement [13]

This voltage source can internally generate or absorb all the reactive power required by the different type of controls applied and transfers active power at its DC terminal based on basic circuit arrangement, an equivalent circuit of UPFC is established as shown in Fig.2. [10]

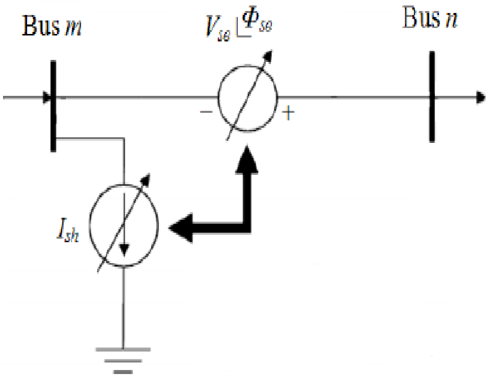

Figure (2): Equivalent circuit of UPFC device [13]

Where the phasors $\mathbf{V}_{sh}$ and $\mathbf{V}_{se}$ simples to injected shunt voltage and series voltage sources, respectively. $\boldsymbol{Z}_{sh}$ and $\boldsymbol{Z}_{se}$ are the UPFC series and shunt coupling transformer impedances, respectively.$\boldsymbol{V_m}$and $\boldsymbol{V_n}$are voltages at buses *m and n*, respectively. $\boldsymbol{I}_{sh}$ is the current through the UPFC shunt converter. The shunt converter branch active and reactive power flows,is *Psh* and *Qsh* respectively. Direction of P_{sh} and Q_{sh} power flow is from bus *m*. The currents through UPFC series converters are $I_{mn}$and I_{nm}, and the I_{mn}=− I_{nm}, and P_{sh} is the active power exchange of the shunt converter with the DC link. P_{se} is the active power exchange of the series converter with the DC link [15].

B. Power Flow Constraints of UPFC

For equivalent circuit of UPFC presented in Fig. 2, suppose$\boldsymbol{V_{sh}}= \boldsymbol{V_{sh}}\angle\theta_{sh}$,

$\boldsymbol{V_{se}}= \boldsymbol{V_{se}}\angle\theta_{se}$, $\boldsymbol{V_m}= \boldsymbol{V_m}\angle\theta_m$, $\boldsymbol{V_n}= \boldsymbol{V_n}\angle\theta_m$,;

Then the equation of active and reactive power in sending and receiving bus (k, m) respectively; [16]**,**

At bus m:

$$P_m = V_m^2 G_{mm} + V_m V_n[G_{mn}\cos(\theta_m-\theta_n) + B_{mn}\sin(\theta_m-\theta_n)] + V_m V_{se}[G_{mm}\cos(\theta_m-\delta_{se}) + B_{mm}\sin(\theta_m-\delta_{se})] \quad \ldots\ldots(2)$$

$$Q_m = -V_m^2 B_{mm} + V_m V_n[G_{mn}\sin(\theta_m-\theta_n) - B_{mn}\cos(\theta_m-\theta_n)] + V_m V_{se}[G_{mm}\sin(\theta_m-\delta_{se}) - B_{mm}\cos(\theta_m-\delta_{se})] \quad \ldots\ldots(3)$$

At bus n:

$$P_n = V_n^2 G_{nn} + V_n V_m[G_{nm}\cos(\theta_n-\theta_m) + B_{nm}\sin(\theta_n-\theta_m)] + V_n V_{se}[G_{nm}\cos(\theta_n-\delta_{se}) + B_{mn}\sin(\theta_n-\delta_{se})] + V_n V_{sh}[G_{sh}\cos(\theta_n-\delta_{sh}) + B_{sh}\sin(\theta_n-\delta_{sh})] \quad \ldots\ldots(4)$$

$$Q_n = -V_n^2 B_{nn} + V_n V_m[G_{nm}\sin(\theta_n-\theta_m) - B_{nm}\cos(\theta_n-\theta_m)] + V_n V_{se}[G_{nm}\sin(\theta_n-\delta_{se}) - B_{nm}\cos(\theta_n-\delta_{se})] + V_n V_{sh}[G_{sh}\sin(\theta_n-\delta_{sh}) + B_{sh}\cos(\theta_n-\delta_{sh})] \quad \ldots\ldots(5)$$

In addition, can calculate the value of the active and reactive power losses of the transmission system after choosing the suitable variable from the UPFC device that will be injected in the network according to following formula: [14]

$$P_L = \sum_{i=1}^{N_L} G_i\,[V_n^2 + V_m^2 - 2V_n V_m\cos(\delta_n - \delta_m)] \quad \ldots\ldots(6)$$

$$Q_L = \sum_{i=1}^{N_L} B_i\,[V_n^2 + V_m^2 - 2V_n V_m\sin(\delta_n - \delta_m)] \quad \ldots\ldots(7)$$

where:

P =Active power, MW.
Q=Reactive power, Mvar.
V_S= Supply voltage, Volt.
V_{sh}= the shunt source voltage magnitude p.u.
V_{se}= the series source voltage magnitude p.u.
δsh= the shunt source voltage angle rad.
δse= the series source voltage angle rad.
X_l= Inductive reactance of transmission line, p.u.
I_n=the current for bus n, Amp.
I_m= the current for bus m, Amp.
V_m=the voltage for bus m, volt.
V_n= the voltage for bus n, volt.
Y_{se}=the series admittance, pu.
Y_{sh}=the shunt admittance, pu.
B_{nm}=the sustenance for line between bus(n) and (m)
G_{nm}= the conductance for line between bus(n) and (m)
P_{Gi}= the real power generation for (i=46) buses, MW.
P_L=the total active power losses, MW.
Q_L= the total reactive power losses, Mvar.

C. UPFC Control Modes

1) Shunt converter

The UPFC has many possible operating modes. In particular, the shunt converter operates in such a way to inject a controllable current Ish, into the transmission line. [17]

One component of this current is determined to balance the active power of the series converter. The other components are reactive and can be set to desired reference level (inductive or capacitive) within the capability of converter. The reactive compensation control modes of the shunt converter are very similar to the STATCOM compensation. The shunt converter can be controlled in two different modes: [12]

a) VAR Control Mode.
b) Automatic Voltage Control Mode.

2) Series converter

The series inverter controls the magnitude and angle of the voltage injected in series with the line. This voltage injection is always intended to influence the flow of power on the line. However, voltage is dependent on the operating mode selected for the UPFC to control power flow. The actual value of the injected voltage can be obtained in several ways.

a) Direct Voltage Injection Mode
b) Phase Angle Shifter Emulation mode
c) Line Impedance Emulation mode
d) Automatic Power Flow Control Mode
e) Standalone shunt and series compensation

3.The Implemented 400KV Iraqi Network and Genetic Algorithm Process:

The 400 kV Iraqi grid system is implemented using the proposed Power System Simulator for Engineer (PSS/E) software and MatLab programming language.

The 400 kV Iraqi gird system in 2019 comprises of (46) bus bars, (28) load buses and (73) transmission lines. The 18 generating stations are of different MW generation and Mvar generation/absorption capabilities.

The program is the practical part of the research where its results are compared with the results obtained from the GA and know the extent of its impact on the distribution of power in a balanced and get the highest tolerance.

Where Genetic Algorithm (GA) is considered as one of the most important evolutionary algorithms based on mechanism of natural selection and genetics for solving the constrained and unconstrained optimization problems. It is worth noting that GA can search simultaneously several possible solutions without require to prior knowledge or special properties of the objective function. A GA is a simple and practical algorithm that can be easily implemented in a power system A GA have three important part, followed by, crossover rate, and mutation operations that are carried out until the best population is found and population size. [13]

In this paper the objective (fitness) function of the GA is reach to the minimum losses with maximum loadability and controller power flow. Taking into consideration the total number of UPFCs that can be inserted in a power system is limited, due to the cost of the devices and the influences on the operating characteristics of the power system. [14]

4.Problem Formulation

In Genetic Algorithm to achieve the target function the flowing constrain should be specified: [15]

a) Location of UPFC: No more than one UPFC can be installed in one branch of power-flow computations, also cannot connect UPFC device with PQ buses.
b) Control parameters: The performance of the GA depends on the control parameters such as population size, crossover probability, and mutation probability.
c) Then by implemented a and b can achieve three main functions: Minimizing the real and reactive power loss, Preserve the bus voltage within the limit and Control of the power flow in overloaded lines.

5. Simulation Results:

As previously explained, the proposed genetic algorithm (GA) and the maximum number of FACTS devices are applied to the 400 KV Iraqi grid in order to find the optimal number, size and location of UPFC devices to reach all targets: increasing line tolerance and balanced power distribution and reducing total losses in Five different cases (normal case and increase overall load in (MVA) at (5%,10%,15% and 20%).

In Table 1, Has been included the overall system loss rate and the number of transmission lines exposed to overload are included in all cases without adding UPFC to the system. Can noted that the system at the normal case (12679.21 MW) which is represent the total rate loading of the system, the active and reactive total losses to the network equal to (68.18 MW and 2079.36 Mvar) with one overload line between (KAZG-RMLG) at 83.8 % rating as shown in Table 4 in the case of without adding UPFC. These results are consistent with the practical results taken from the program. The rate of these total losses will be increase and the load ability of the transmissions line will be decreases when the system is exposed to increase in the rate of demand. This is observed when the total load increases by (5%,10%,15%,20%).

As can see in Table 1. the line between bus (KAZG-RMLG) most exposed to overload state where it appears in five cases with increase in active and reactive power losses.

Table (1) Iraqi super grid (400kV) result in MatLab and PSS/E program without UPFC

Case no.	Load	Losses	Load	Losses
Normal case	12000.400 MW 4094.7Mvar 12679.21MVA	68.181MW 2079.362 Mvar	12000MW 4094.2Mvar 12679.21MVA	69 MW 2075.7Mvar
At 5% increase	12600.420 MW 4299.43 Mvar 13313.34MVA	77.600MW 2087.406 Mvar	12600.40MW 4299.4Mvar 13313.34MVA	77.5MW 2087.8Mvar
At 10% increase	13200.440 MW 4504.170Mvar 13947.72MVA	95.324MW 2276.431 Mvar	13200.2MW 4504.2Mvar 13947.51 MVA	94.2MW 2277.1Mvar
At 15% increase	13800.460 MW 4708.905 Mvar 14581.72MVA	120.184 MW 2654.535 Mvar	13800MW 4708.4 Mvar 14581.11MVA	119.6MW 2658.9 Mvar
At 20% increase	14400.480 MW 4913.64 Mvar	158.070 MW 3274.110 Mvar	14400.2MW 4913Mvar	156.9MW 3284.1Mvar

After applying the GA on 400 KV Iraqi grid system and choosing one UPFC at normal case with optimal position which is between (NSRP-GMRL_IPP) with suitable parameters as shown in Table 3. Can notice the total active and reactive power losses will be decreases from (68.181MW to 53.512 MW) and from (2079.362 Mvar to 1900.0 Mvar). This means that there is improvement in active power losses at 23%. Where Table 2. Can show the rate improvement in active power losses in different load conditions with compare the result between MatLab and PSS/E programs.

Table (2) MATLAB and PSS\E result with GA Iraqi 400KV Super High Voltage

Case no.	MatLab result with UPFC with GA		PSSE result with UPFC with GA		Improvement in active power losses %
	Load	Losses	Load	Losses	
Normal case	12000.4MW 4094.70Mvar 12679.21MVA	53.512 MW 1900.0 Mvar	12000 MW 4094.2Mvar 12679.21MVA	53.9 MW 1900.9 Mvar	23%

At 5% increase	12600.42MW 4299.43Mvar	61.721 MW 1981.27 Mvar	12600.40MW 4299.4Mvar	61.5MW 1971.5 Mvar	20%
	13313.34MVA		13313.34MVA		
At 10% increase	13200.440MW 4504.170Mvar	79.126 MW 1988.44 Mvar	13200.2MW 4504.0Mvar	78.4MW 1988.0 Mvar	17%
	13947.72MVA		13947.51MVA		
At 15% increase	13800.460MW 4708.905 Mvar	112.413 MW 2299.69 Mvar	13800MW 4708.4 Mvar	110.05 MW 2296.1 Mvar	10%
	14581.72MVA		14581.11MVA		
At 20% increase	14400.480MW 4913.64 Mvar	141.789 MW 2789.02 Mvar	14400.2MW 4913Mvar	140.40 MW 2787.7 Mvar	13%

However, when added the UPFC to the system with optimal position selection and size by selecting optimal values by using genetic algorithms as shown in Table 3. The overload line in 400 KV Iraqi grid system has been reduced, as shown in Table 4. Which represent the overload lines rating in different load conditions with compare the result in the case of absent and present the UPFC device.

Table (3) No. of UPFC device, the position and UPFC size with GA.

Case no.	No. of UPFC	Position(with GA)	UPFC size
Normal case	1	NSRP-GMRL_IPP	P=-6.76 p.u, Q=0.70 p.u. Vcr=0.361, δcr =-0.0199 Vvr =0.560, δvr =0.0122
At 5% increase	1	NSRP-GMRL_IPP	P=-6.72 p.u, Q=1.89 p.u Vcr=0.361, δcr =-0.0199 Vvr =0.560, δvr =0.0122
At 10% increase	2	NSRP-GMRL_IPP	P=-6.84 p.u., Q=2.0 p.u. Vcr=0.36, δcr =-0.06 Vvr =0.28, δvr =0.017
		MUSG-MUSP	P=-3.40 p.u., Q=2.50 Vcr=0.2, δcr =-0.0511 Vvr =0.5, δvr =0.017
At 15% increase	4	NSRP-GMRL_IPP	P=-7.55 p.u., Q=5.50p.u. Vcr=0.60, δcr =-0.0169 Vvr =0.56, δvr =0.0102
		4BGW- BNW4	P=5.66 p.u., Q=-0.40 p.u Vcr=0.2203, δcr =-0.039 Vvr =0.979, δvr =0.0261
		MUSG-MUSP	P=-3.41 p.u, Q=-0.30 p.u Vcr =0.9, δcr =- 0.051 Vvr =0.5, δvr =0.0177
		NBJG-BAJP	P=-4.48 p.u, Q=-2.0 p.u Vcr= 0.7, δcr = - 0.0512 Vvr= 0.5, δvr = 0.01768
At 20 % increase	4	NSRP-GMRL_IPP	P=-7.80 p.u, Q=4.50 p.u Vcr= 0.60, δcr = - 0.016 Vvr= 0.55, δvr = 0.01
		4BGW- BNW4	P=-5.80 p.u, Q=4.0 p.u Vcr =0.2203, δcr = -0.034 Vvr= 0.970, δvr =0.026
		MUSG-MUSP	P=5.50 p.u, Q=-1.0 p.u Vcr =0.9, δcr =- 0.05 Vvr= 0.51, δvr = 0.017
		NBJG-BAJP	P=-0.40 p.u, Q=0.50 p.u Vcr=0.701, δcr = -0.0512 Vvr= 0.504, δvr = 0.017

Table (4) overload lines rating with UPFC with GA

	PSSE result without UPFC		PSSE result with UPFC with GA	
Case no.	**No. of overload line**	**Rating%**	**No. of overload line**	**Rating%**
Normal case	KAZG-RMLG	83.8	KAZG-RMLG	73.9
At 5% increase	4BGS-4BGC KAZG-RMLG	65.6 88.5	KAZG-RMLG	74.0
At 10% increase	4BGS-4BGC 4BGE-4AMN 4BGE-4AMN KAZG-RMLG	70.8 71 71 93.8	KAZG-RMLG	78.5
At 15% increase	BSMG-4BGS BSMG-4BGS 4BGS-4BGC 4BGE-4AMN 4BGE-4AMN 4AMN-KUTP 4AMN-KUTP KAZG-RMLG	67.8 67.8 76.3 82.5 82.5 74.6 74.6 99.6	4BGE-4AMN 4BGE-4AMN UPFC-GMRLIPP	78.2 78.2 78.0
At 20% increase	BSMG-4BGS BSMG-4BGS 4BGS-4BGC 4BGE-4AMN 4BGE-4AMN 4AMN-KUTP 4AMN-KUTP KAZG-RMLG	75.6 75.6 82 94.4 94.4 97.3 97.3 107.4	4BGE-4AMN 4BGE-4AMN 4AMN-KUTP 4AMN-KUTP UPFC-GMRLIPP	88.6 88.6 84.8 84.8 79.9

Where adding the UPFC device according to GA and limit the optimal position, No. of UPFC device and the setting parameters which are using in all case as shown in Table 5.

Table (5) Appropriate Parameters Used in GA code

Parameters	**Value**
Number of generations	100
population size	50
Crossover fraction	0.8
Fitness limit	$1e^{-12}$
Time limit	∞

The addition of UPFC can also reduce from the rate of the total real power generation (Pg.) in MW and reactive power generation (Qg) in Mvar in all cases as shown in Fig 4. and 5, In addition to a decreasing the stress on the lines overloaded by the permissible limits.

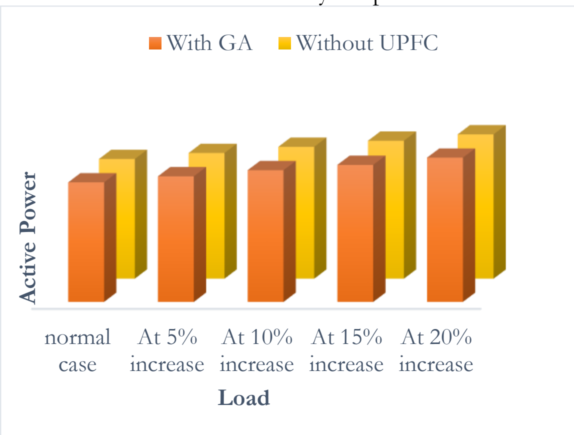

Figure (4) Reduction in the active power generation after adding the UPFC with GA

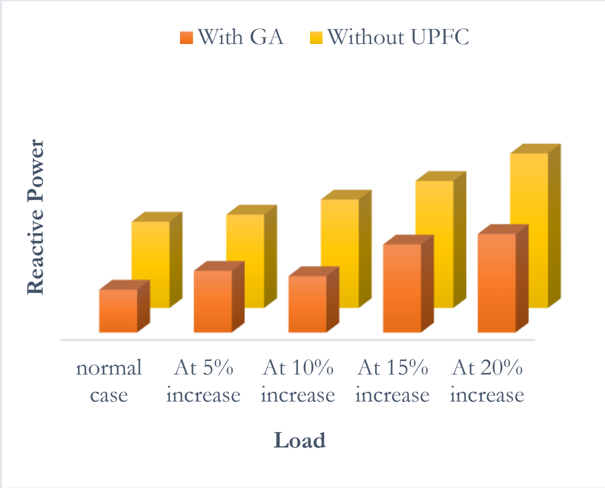

Figure (5) Reduction in the reactive power generation after adding the UPFC with GA

On the other hand in order to distinguish between the presence and absence the UPFC device in Iraqi network at 20 % increase in the total load Fig 6 and 7 represented using contour properties in PSS/E programs.

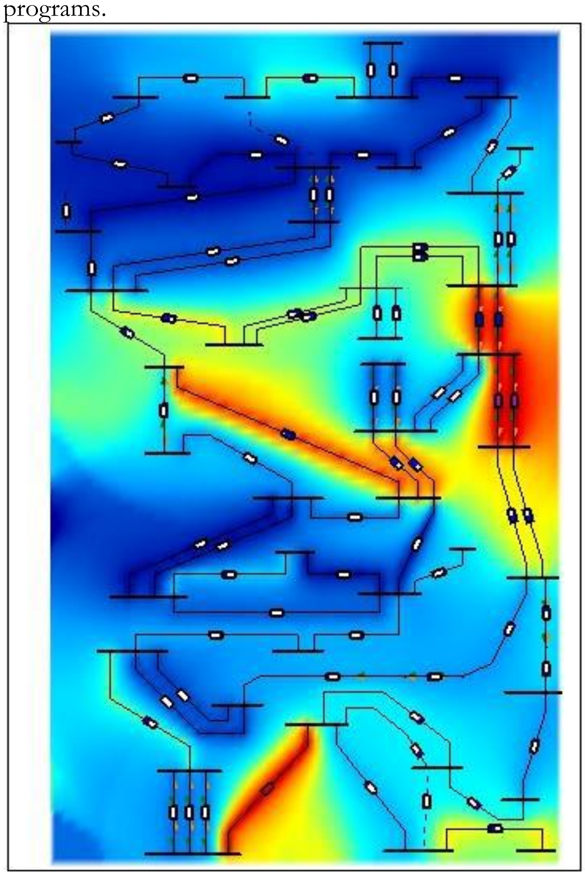

Figure (6) The loading in Iraqi grid (400kV) transmission line without UPFC device

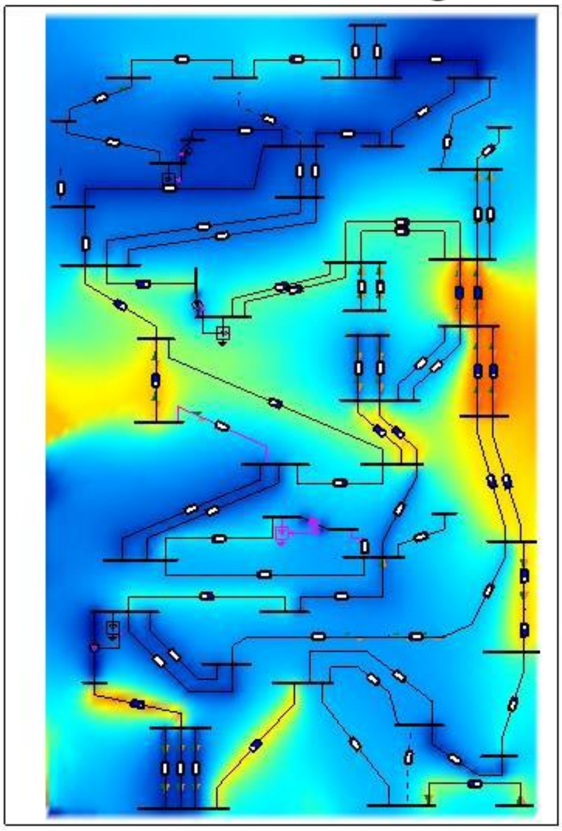

Figure (7) The loading in Iraqi grid (400kV) transmission line with UPFC device

In addition, can be described the implementing of GA technique as in the following step: [16]

Step 1: Introduction for optimization the controlling data like the number of populations size, crossover probability, mutation probability, generation number at the maximum rate, number of iterations. Also, must be defined all power system data and the parameters of UPFC device.

Step 2: Generation a first populations for individuals, this process implemented according to its optimizing variables, including the UPFC location, and the size of the UPFC device. Three chromosomes for the individual show a significate point inside the region solution of the optimization problem.

Step 3: Using the fitness function, start to determine the individual's objective inter the populations Run the program of power flow (Newton Raphson).

Step 4: The objectives data can be used to find a new population from the old populations depended on the calculations function.

Step 5: The crossover and mutation values are utilized in order to calculate a new population that will be used to select a new solution.

Step 6: The objective values are determined according to new chromosome, and using these functions into the populations.

Step 7: After that can stop the GA process and print, optimization strategy is summarized in Fig 8.

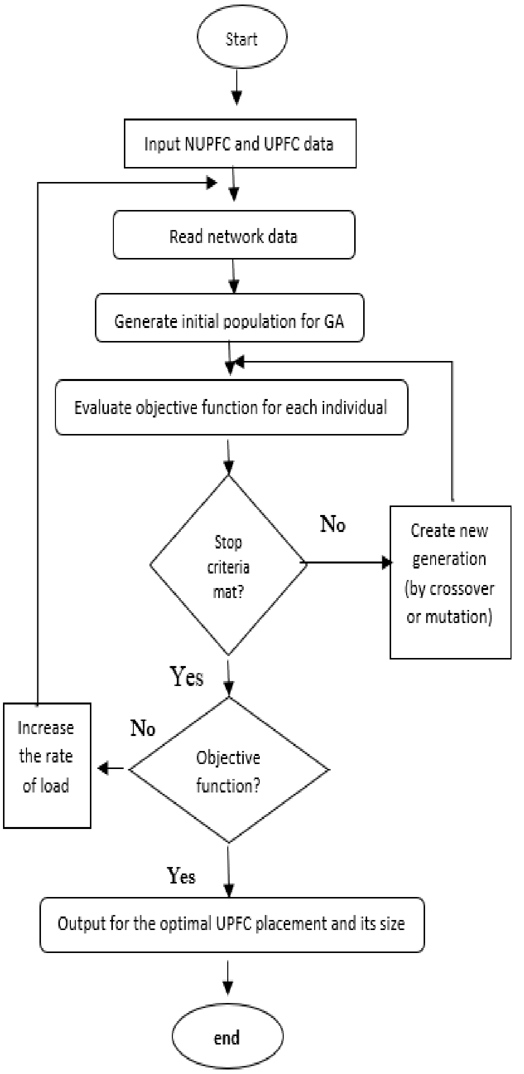

Figure (8). Optimization process flowchart of UPFC based on GA

6. Conclusion:

In this work, examine the effect of UPFC in enhancing power system performance using in the 400 KV Iraqi grid system. After applying the GA on grid system and choosing one UPFC at normal case with optimal position which is between (NSRP-GMRL_IPP). Can notice the total active and reactive power losses will be decreases from (68.181MW to 53.512 MW) and from (2079.362 Mvar to 1900.0 Mvar). This means that there is improvement in active power losses at 23%. and power transfer capability of the system is improved by making all power transfer over the transmission lines with in the normal rating.so this will make use the same line for transferring more power without any extra cost. Simultaneously the voltage profile of the system is kept with normal limit. Also due to the complexity of power systems and high cost that the installation of the UPFC device depended on the genetic algorithm (GA) it was gives better results (control the voltage magnitude, voltage phase angle, and impedance) and can get the best location and the right size with the least time this will a achieved decreases overload lines and minimizes systemic power losses. The one of the UPFC advantages is it made redistributions to the power flow, so consideration should be given when installing the UPFC, since the new path of the active and reactive power flow is the shortest path and that to avoid the increase in the active and reactive losses. So, choosing the suitable location of the UPFC is very important. In addition, UPFC controls the power at all buses in power system and keeps power under normal level. After simulating the system with and without UPFC, it clearly showed the effect in form of power reduction below new rating. UPFC regulated the power not only in the area where it was connected but in the whole power system

7. Reference

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