Optimal Reactive Power Insertion & Allocation To The Iraqi Super Grid 400 Kv Network Applying Genetic Algorithm Technology

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ABSTRACT: The aim of this paper is to find the optimal location and the reactive power needed to be inserted in the 400 Kv super grid Iraqi network , so as to reduce the losses in the network and reaching the optimum power flow . A Genetic Algorithm calculation method is applied and the Optimum Power Flow program is applied to calculate and find the power flow distribution in the network . A comparison can be set to find the change in the network parameters before and after allocation of the reactive power injection nodes , also noticing the improvement in the power factor of the power flows in the T.L's .
KEY WORDS: Power factor improvement, Participation factor, Genetic Algorithm, Switching capacitor Type ,Optimum Power Flow Program , Iraqi 400 Kv network .

1. INTRODUCTION

During the peak load periods especially in winter and summer as a result of increasing needs for inductive power due to high inductive loading and to improve power factor for the transmission system and to avoid the resultant losses accused by the current for long distances. For this purpose, the use of capacitors in system with special circuit breakers to convey the capacitive current will be necessary [1, 2].

Locating circuit breakers to the capacitor is not possible unless convey the same capacitive current rating or higher value from it.

Insertion of capacitors to the transmission line network is possible in self-transformers 400/132/11 KV.

On 11kv side, we use it is because of the increase in inductive power on 132kv side. Therefore, we can see the increase in voltage on 132kv side clearly.

The following notes are noted on connection of capacitors in transmission lines

A) Avoid switching off transformer and capacitor in work because of resonance phenomenon in which the impedance of XC and XL are equal and occurs a short circuit on coils of transformers and damage them and also avoid switch on transformer again with a connected capacitor because of the same phenomenon.

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B) Inserting capacitor in work or out of work (such as 20MVAR) that will cause a large sudden change in voltage magnitude.

C)In transformers 132/33/11 kV, it is noted that output power from the transformer must be greater than the value of the required capacitor to improve the voltage and avoiding transformer working on leading p. f. [3] .

D) Adding capacitor to the tertiary on 11 kV side in self-transformers will increase the current on 132 kV side.

2. POWER FACTOR CORRECTION

Capacitors offer a means of improving system power factor and helping to correct the above conditions by reducing the reactive kilovar load carried by the utility system [4, 5].

3. CAPACITORS OR VOLTAGE REGULATORS

Shunt capacitors provide some voltage rise and can do so at a lower cost than a line regulator. Sample calculations are shown in the following sections.

However, for some load conditions, the voltage rise offered by capacitors may be excessive and cause problems for customers' connected equipment. Higher cost regulators offer a means for maintaining more constant system voltage. The combination of regulators and capacitors provides the best of both worlds [6, 9].

4. OPTIMAL CAPACITOR PLACEMENT

Before determining the capacitor location, using exciting power flow methods (Newton _Raphson methods) to study the need for such operation.

Bus participation factors are used to select the candidate buses for the subsequent VAR source placement. The buses with higher participation factors are selected first, and they are considered in the second stage where the genetic algorithm technique is employed to optimize the location, and size of VAR sources [4].

5. GENETIC ALGORITHM OPTIMIZATION

To solve the optimization problem, formulated in (A) the genetic algorithm was used, a technique inspired by the principle of evolution. The description of GA theory can be found in [7].

GA uses a "Chromosomal" representation which requires the solution to be coded as a GA used in this paper is as follows:

First, the initial population of Ns randomly constructed solutions (strings) is generated. Within this population new solutions are obtained during the genetic Cycle using crossover and mutation operators. Crossover produces a new finite length string. The basic structure solution (off spring) forms a randomly selected pair of parent solutions providing the inheritance of some basic properties of the parents in the offspring.

Mutation results in slight changes in the offspring structure and maintains diversity of solutions [8, 10].

Each new solution is decoded and its objective function (fitness) values are estimated.

These values are a measure of the quality which is used to compare different solutions. The comparison is fulfilled by a selection procedure that decides which solution is better: the newly obtained one or the worst solution in the population. The better solution joins the population and the worse one is discarded. If the population contains equivalent solutions following selection, redundancies are eliminated and the population size decreases. After Nrep repetitions of the crossover-selection sequence, new random constructed solutions are generated to replenish the shrunken population, and a new genetic cycle is started. The GA is terminated after Nc genetic cycles. The final population contains the best solution achieved [11].

The crossover operator is aimed at producing a new solution (string) which inherits some properties of both parent solutions by combining parts of their strings. A two-point (fragment) crossover is adopted in which elements belonging to the fragment defined by two randomly chosen crossover sites are copied from the first parent and elements located out of the fragment, from the second parent. Mutation provides slight changes in the string by incrementing or decrementing by 1 the randomly chosen number from this string with some given probability [12].

6. A POWER NETWORK CASE STUDY

A 10- generator case (the system of Iraq) with 22 bus bars is taken to illustrate the proposed algorithm to correction power factor problem.

As in the previous section the same procedures will be computed to get the reduced total cost.

Figure(1) down below presents the schematic of 22 bus transmission system.

The Newton – Raphson, of the system, and the load flow the system before placing the capacitors are presented in Tables (1)

To improve power factor, the method of Participation factor is performed by computing the Jacobian Matrix reduction JR to analyze the stability of the voltage. This can be made by computing the eigen values and eigenvectors for JR matrix, where the values of eigen values give a proximate for the voltage instability at the load level, and from this we can determine the Participation Factor for the buses of the system, and the buses that have the minimum eigen values are selected and large PF values are used to inject the capacitors in the buses.

Tables (2) below present the results buses and the Participation factor for these buses:

From the results of the participation factor, the 10 candidate locations in the system are selected for placing the capacitors, (Table (3)).

After the best candidate buses are obtained, the next step is to get the optimal sizes for the capacitors to place them in these buses, this is done by using the ***Genetic Algorithm (GA).*** And to achieve this target, we need to building an initial population and getting the fitness function and determined the number of generations. At initial, random population are selected and the encoding of the chromosomes of the population use integer values (because each chromosome will present the number of capacitors that will be injected to system). Each of chromosome is added to the buses data array to the field of **Qsht** (which present the field of capacitors) and compute the power losses for the system.

The value of power losses will be multiplied by the cost of energy and will be added to the price of capacitors and their maintenance to give the fitness function. So, to get the perfect power factor we must get the best chromosome that has the minimum fitness function.

$$\text{Fit. Fun.} = P_d / \sqrt{\ } (P_d\text{^}2 + (Q_d - Q_{sh})^2)$$

P_d= load active power (MW)

Q_d= load reactive power (MVAR)

Q_{sh}=added reactive power (MVAR)

Table (3) presents the location of candidate capacitors and their optimal sizes which are obtained from the GA and Tables (4), (5) below present the final results to get the reduced total generation costs.

8 . Conclusions :

On comparing the Iraqi network data presented in tables (1),(5),for the same load data , there is an improvement in the generating system power factor,also reduction in the generated power.

$S_{gen.}$=4618.651+j1026.448 Mva before correc.

$S_{gen.}$=3173.154+j600.2690 Mva after correc.

and the injected reactive power is of 80 Mvar. at the selected network nodes .This will helps greatly improving the total network operating conditions.

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Table (1) Power Flow Solution By Newton-Raphson before placing the capacitors

Maximum Power Mismatch = 6.38099e-007
No. of Iterations = 10
No reactive power injections at the nodes

Bus No.	Voltage Mag	Angle Degree	Generation MW	Generation Mvar
1	1.020	0.000	-1121.349	223.221
2	1.018	1.520	0.000	0.000
3	1.020	6.417	1320.000	88.710
4	1.070	11.837	318.000	86.934
5	1.058	13.511	260.000	89.215
6	1.022	11.161	0.000	0.000
7	1.040	11.631	660.000	-53.439
8	1.025	8.112	0.000	0.000
9	0.971	12.379	0.000	0.000
10	0.977	13.271	0.000	0.000
11	0.974	11.998	0.000	0.000
12	0.990	16.783	492.000	52.635
13	0.993	12.011	0.000	0.000
14	1.000	15.155	1200.000	155.428
15	0.988	20.938	0.000	0.000
16	0.984	13.932	0.000	0.000
17	1.001	13.676	0.000	0.000
18	1.000	22.387	840.000	186.857
19	0.964	22.271	0.000	0.000
20	1.020	23.581	250.000	60.922
21	1.040	25.479	400.000	135.965
22	0.967	12.248	0.000	0.000
Total			4618.651	1026.448

Table (2) Participation factor for The Selected Buses

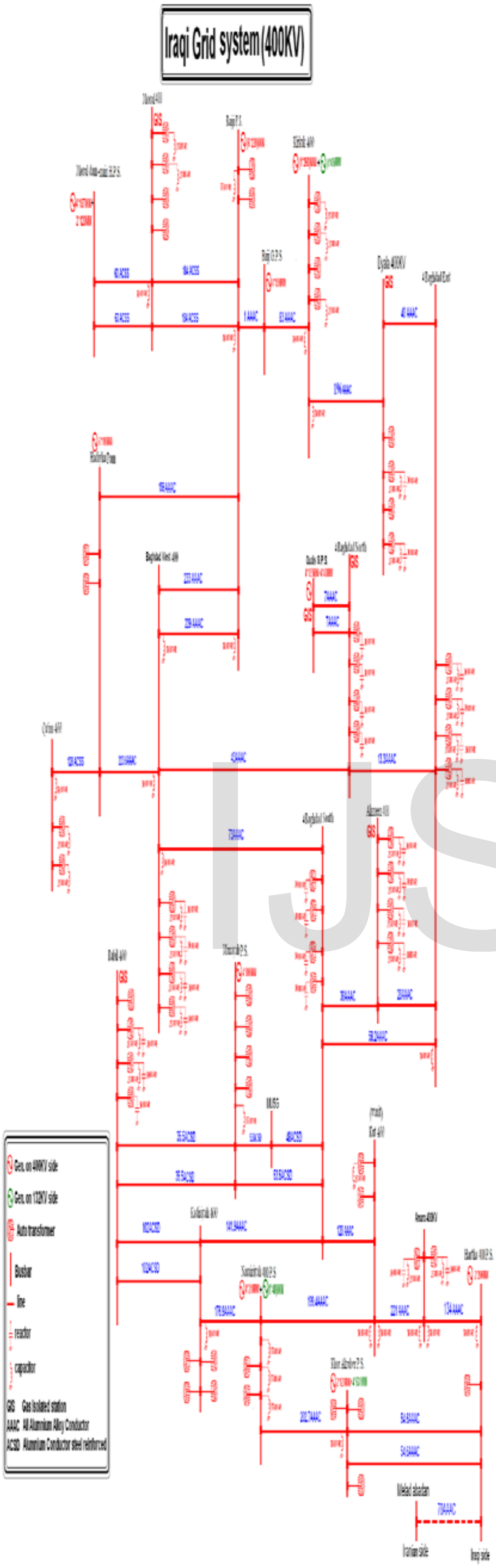
Bus No.	Participation Factor
2	0.0025
6	0.1344
8	0.0025
9	0.1344
10	0.0836
11	0.0374
13	0.0836
15	0.1514
16	0.1623
17	0.1500
19	0.0374
22	0.3115

Table (3) Switching Capacitors allocations and Their optimal Sizes

Optimal Capacitor Allocations	Optimal Size of Capacitors (MVAR)
6	11
9	7
10	15
11	2
13	9
15	5
16	13
17	6
19	11
22	1

Table (4) Optimal Dispatch of Generation and Lambda of The System

Optimal capacitor locations (bus No.)	Power factor before adding capacitor	Power factor after adding capacitor
6	0.7832	0.9810
9	0.7654	0.9273
10	0.7693	0.9345
11	0.8012	0.9675
13	0.8321	0.9543
15	0.8110	0.9686
16	0.7956	0.9439
17	0.7564	0.9554



Figure(1) The Iraqi 400 Kv super grid network

Table (5) Power Flow Solution by Newton-Raphson after placing the capacitors

Maximum Power Mismatch = 7.87172e-007
No. of Iterations = 10
After Reactive Power Injection & their locations

BB No	Volt. Mag p.u.	Volt. Angle Deg.	Gen. Act. Pow. MW	Gen. Reac. Pow. Mvar	Injec. Reac. Pow. Mvar
1	1.020	0.000	187.04	3.596	0.000
2	1.019	-0.246	0.000	0.000	0.000
3	1.020	0.414	348.00	-49.847	0.000
4	1.070	5.497	400.00	64.665	0.000
5	1.058	5.516	300.00	84.714	0.000
6	1.022	-1.270	0.000	0.000	11.00
7	1.040	-0.733	449.00	-67.958	0.000
8	1.025	-4.252	0.000	0.000	0.000
9	0.976	-1.516	0.000	0.000	7.000
10	0.984	-2.556	0.000	0.000	15.00
11	0.979	-2.542	0.000	0.000	2.000
12	0.990	1.649	355.00	40.907	0.000
13	0.996	-0.004	0.000	0.000	9.000
14	1.000	-3.541	125.00	117.08	0.000
15	1.009	0.348	0.000	0.000	5.000
16	0.991	-2.797	0.000	0.000	13.00
17	1.006	-3.651	0.000	0.000	6.000
18	1.020	1.119	368.82	212.46	0.000
19	0.994	1.018	0.000	0.000	11.00
20	1.040	2.247	300.00	50.125	0.000
21	1.060	3.637	339.00	144.51	0.000
22	0.974	-2.829	0.000	0.000	1.000
Total			3173.1	600.26	80.00