A Modified PSO Approach for Reactive Power Compensation in Power System Distribution Networks

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Abstract: **The power compensation is the one of the problem in distribution network. The power compensation is done by maintain the reactive power in distribution network. The power is maintain the state of the Unified power quality conditioner (UPQC). The UPAC controlled by the STATCOM or DSTATCOM. Different approaches use to maintain the power at needed level in the power distribution network the process done by MOPSO optimization method the MOPSO is the best for this process because we consider the lot of objective function to optimize the place of the UPQC. In our proposed work we find the power level in distribution network using optimization algorithm. The optimization algorithm is used to optimization the power and find which place is suitable for place the STATCOM or DSTATCOM. This is used to maintain the reactive power in distribution network.**

Keywords: **UPQC, PSO, MOPSO, STATCOM, DSTATCOM Power, Reactive, Optimization, compensation.**

I. INTRODUCTION

Power systems are large and complex electrical networks. In any power system, generations are located at few selected points and loads are distributed throughout the network. In between generations and loads, there exist transmission and distribution systems. In the power system, the system load keeps changing from time to time as shown.

Power system characteristics:

- It must gracefully control, for all intents and purposes wherever the client requests.
- It must gracefully capacity to the clients consistently.
- It must have the option to gracefully the regularly changing burden request at untouched.
- The power provided ought to be of acceptable quality.
- The power provided ought to be prudent.
- It must fulfill fundamental security necessities.

Force flow investigation is worried about depicting the working condition of a whole force framework, by which we mean a system of generators, transmission lines, and loads that could speak to a zone as little as a region or as extensive as a few states. Given certain known amounts—ordinarily, the measure of intensity produced and expended at various areas—power flow investigation permits one to decide different amounts.

The most significant of these amounts are the voltages at areas all through the transmission framework, which, for substituting current (A.C.), comprise of both an extent and a period component or stage edge. When the voltages are known, the flows flowing through each transmission connection can be effortlessly determined. Therefore the name power flow or load flow, as it is regularly brought in the business: given the measure of intensity conveyed and where it originates from, power flow investigation discloses to us how it flows to its goal.

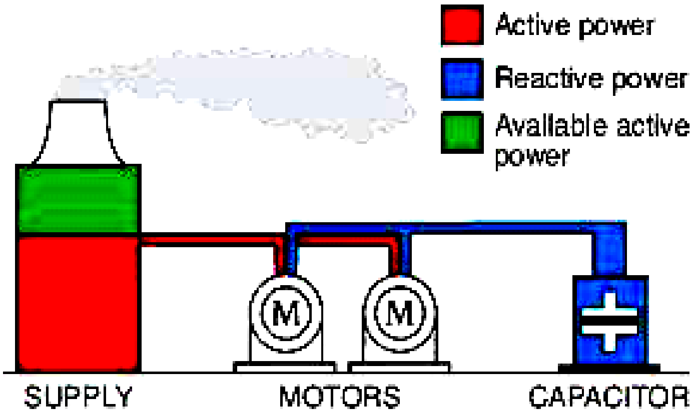


Figure 1: Active and Reactive Power

There are such huge numbers of strategy is utilizing for keep up the power flow in the distribution network side. The essential technique is the manual count. The manual figuring based system is help to distinguish low voltage are request bus and physically included the generator or every single other parameter to keep up the bus voltage. Another strategy is direct based optimization to discover the spot of the DG in bus system network. The straight based technique the direct condition is explain for discover the bus place in general bus system. The direct based optimization one of the fundamental low unpredictability strategy for flow examination. The DG spot is compuitional decreased contrast with the manual estimation.

II. METHODOLOGY

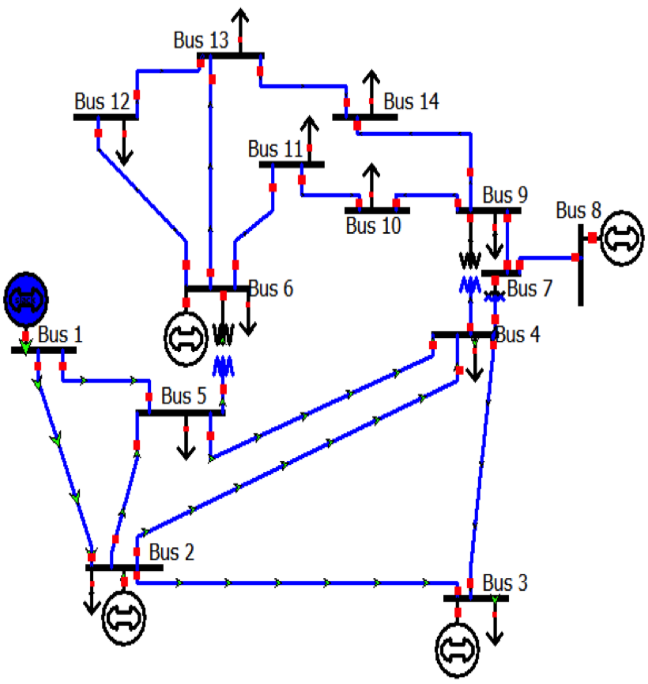


Figure 2: IEEE 14 Bus data

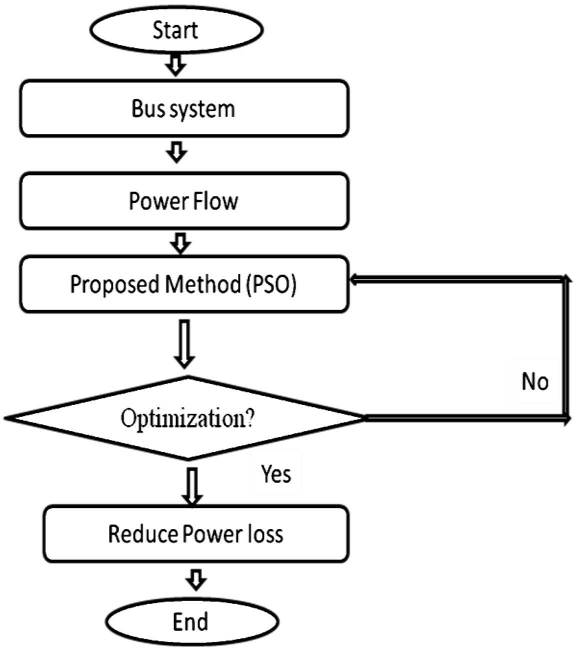


Figure 3: flow chart

i. Particle Swarm Optimization (PSO)

PSO has been created through recreation of streamlined social models. The highlights of the technique are as per the following:

a) The technique depends on investigates about multitudes, for example, fish tutoring and a herd of flying creatures.

b) It depends on a basic idea. Consequently, the calculation time is short and it requires scarcely any recollections.

c) It was initially created for nonlinear enhancement issues with persistent factors. Notwithstanding, it is effectively extended to treat issues with discrete factors. Accordingly, it is material to a MINLP with both nonstop and discrete factors, for example, VVC.

Bus dataset is presenting follow-

BData =

[1	1	1.06	0	0	0	0	0	0	0;
2	2	1.043	0	40	50.0	21.7	12.7	-40	50;
3	3	1.0	0	0	0	2.4	1.2	0	0;
4	3	1.06	0	0	0	7.6	1.6	0	0;
5	2	1.01	0	0	37.0	94.2	19.0	-40	40;
6	3	1.0	0	0	0	0.0	0.0	0	0;
7	3	1.0	0	0	0	22.8	10.9	0	0;
8	2	1.01	0	0	37.3	30.0	30.0	-10	40;
9	3	1.0	0	0	0	0.0	0.0	0	0;
10	3	1.0	0	0	19.0	5.8	2.0	0	0;
11	2	1.082	0	0	16.2	0.0	0.0	-6	24;
12	3	1.0	0	0	0	11.2	7.5	0	0;
13	2	1.071	0	0	10.6	0.0	0.0	-6	24;
14	3	1.0	0	0	0	6.2	1.6	0	0;

The active power controller aims to maintain the active power output constant at a given reference value within the permissible frequency range. The reactive power controller aims to maintain the reactive power output constant at the given reference value within the permissible voltage range.

Constraints and Variable:

```
nbus=14;
fb = linedata(:,1);
tb = linedata(:,2);
r = linedata(:,3);
x = linedata(:,4);
b = linedata(:,5);
a = linedata(:,6);
z = r + i*x;
y = 1./z;
b = i*b;
nb = max(max(fb),max(tb));
nl = length(fb);
Y = zeros(nb,nb);

busd=BData;
BMva = 100;
bus = busd(:,1);
type = busd(:,2);
V = busd(:,3);
del = busd(:,4);
Pg = busd(:,5)/BMva;
Qg = busd(:,6)/BMva;
Pl = busd(:,7)/BMva;
Ql = busd(:,8)/BMva;
Qmin = busd(:,9)/BMva;
Qmax = busd(:,10)/BMva;
P = Pg - Pl;
Q = Qg - Ql;
Psp = P;
Qsp = Q;
G = real(Y);
B = imag(Y);
```

```
pv = find(type == 2 | type == 1);
pq = find(type == 3);
npv = length(pv);
npq = length(pq);
Tol = 1;
Iter = 1;
```

Objective Functions:

- Minimization of active power loss:

  $\min f1 = \sum^{Nb-1}(Ik)^2 Rk$

- Minimization of reactive power loss:

  $\min f2 = \sum^{Nb-1}(Ik)^2 Xk$

Nb represents number of buses; Ik represents current in k^{th} branch; $Rk + jXk$ is the impedance of k^{th} branch

- Overall Objective Functions: $\boldsymbol{f = w1 * f1 + w2 * f2}$
- $w1$ and $w2$ are weight constants assigned to each objective, such that $w1 + w2 = 1$
- Here equal importance is given to both the objectives, so $\boldsymbol{w1 = 0.5}$ and $\boldsymbol{w2 = 0.5}$

Constraints:

- **Reactive power injection limit:**

Total amount of reactive power injection by the SCs should be less than the reactive power demand of the network

$$\sum_{i=1}^{nc} Q_{ci} \leq Q_{TLoad}$$

nc : total no. of SCs; Qci : reactive power injection by the SC at i^{th} node;

$QTLoad$: total reactive power demand of the distribution network

- **Node Voltage Limit:**

The magnitude of the voltage must be between the least and the peak limits

$Vmin < Vi < Vmax \qquad i = 1,2,3, \ldots Nb$

```
Gencost = [1   0.00375  20     0.2  50   200;
           2   0.0175   17.5   0.5  20   80;
           5   0.0625   10     0.3  15   50];
```

- **Fitness Evaluation based Load Flow**

For all sub-systems generated perform a load flow calculation to evaluate the proposed fitness function. A candidate solution formed by all sub-systems is better if its fitness is higher.

$$f_i = 1/\left(F_{cost} + \omega_l F_{li} + \omega_V F_{Vi}\right)$$

$$F_{Vi} = \sum_{j=1}^{nPQ} \left(\left|V_{PQij} - V_{PQij}^{\lim}\right|\right) / \left(\left|V_{PQij}^{\max} - V_{PQij}^{\min}\right|\right)$$

where f_i is fitness function for sub- systems decomposed at level i.

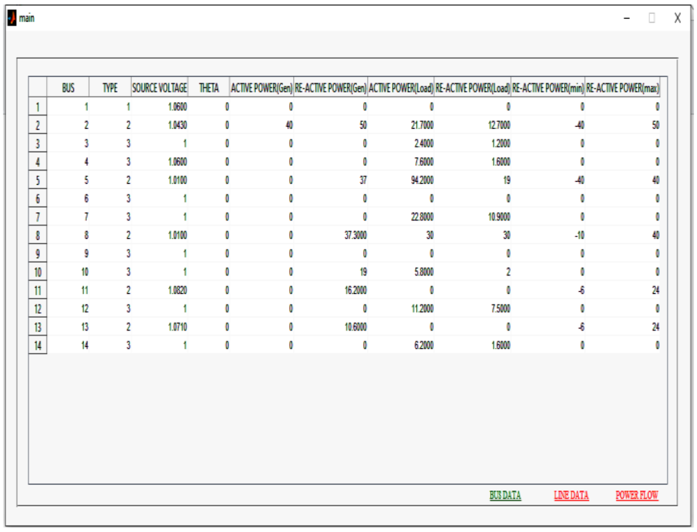
F_{li} denotes the per unit power loss generated by sub-systems at level i; F_{cost} denotes the total cost of the active power planning related to the decomposition level i; F_{Vi} denotes the sum of the normalized violations of voltages related to the sub-systems at level i.

3-Consequently under this concept, the final value of active power demand should satisfy the following equations.

$$\sum_{i=1}^{N_g}(Pg_i) = \sum_{i=1}^{part_i}(Pd_i) + ploss$$

$$Pg_i^{\min} \le Pg_i \le Pg_i^{\max}$$

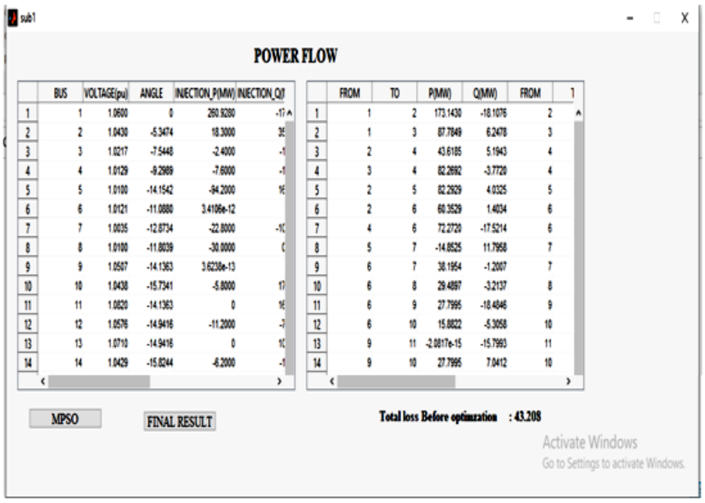
III. SIMULATION & RESULT



	BUS	TYPE	SOURCE VOLTAGE	THETA	ACTIVE POWER(Gen)	RE-ACTIVE POWER(Gen)	ACTIVE POWER(Load)	RE-ACTIVE POWER(Load)	RE-ACTIVE POWER(min)	RE-ACTIVE POWER(max)
1	1	1	1.0600	0	0	0	0	0	0	0
2	2	2	1.0430	0	40	50	21.7000	12.7000	-40	50
3	3	3	1	0	0	0	2.4000	1.2000	0	0
4	4	3	1.0600	0	0	0	7.6000	1.6000	0	0
5	5	2	1.0100	0	0	37	94.2000	19	-40	40
6	6	3	1	0	0	0	0	0	0	0
7	7	3	1	0	0	0	22.8000	10.9000	0	0
8	8	2	1.0100	0	0	37.3000	30	30	-10	40
9	9	3	1	0	0	0	0	0	0	0
10	10	3	1	0	0	19	5.8000	2	0	0
11	11	2	1.0820	0	0	16.2000	0	0	-6	24
12	12	3	1	0	0	0	11.2000	7.5000	0	0
13	13	2	1.0710	0	0	10.6000	0	0	-6	24
14	14	3	1	0	0	0	6.2000	1.6000	0	0

Figure 4: IEEE 14 Bus system data

In figure 4, all the informational collection or qualities are appearing of 14 transport framework. In which source voltage, dynamic force, responsive force regarding age, burden, min and max are appearing.



	BUS	VOLTAGE(pu)	ANGLE	INJECTION_P(MW)	INJECTION_Q(
1	1	1.0600	0	260.9280	-17
2	2	1.0430	-5.3474	18.3000	35
3	3	1.0217	-7.5448	-2.4000	-1
4	4	1.0129	-9.2989	-7.6000	-1
5	5	1.0100	-14.1542	-94.2000	16
6	6	1.0121	-11.0880	3.4106e-12	
7	7	1.0035	-12.8734	-22.8000	-10
8	8	1.0100	-11.8039	-30.0000	0
9	9	1.0507	-14.1363	3.6238e-13	
10	10	1.0438	-15.7341	-5.8000	17
11	11	1.0820	-14.1363	0	16
12	12	1.0576	-14.9416	-11.2000	-7
13	13	1.0710	-14.9416	0	10
14	14	1.0429	-15.8244	-6.2000	-1

	FROM	TO	P(MW)	Q(MW)	FROM
1	1	2	173.1430	-18.1076	2
2	1	3	87.7849	6.2478	3
3	2	4	43.6185	5.1943	4
4	3	4	82.2692	-3.7720	4
5	2	5	82.2929	4.0325	5
6	2	6	60.3529	1.4034	6
7	4	6	72.2720	-17.5214	6
8	5	7	-14.8525	11.7958	7
9	6	7	38.1954	-1.2007	7
10	6	8	29.4897	-3.2137	8
11	6	9	27.7995	-18.4846	9
12	6	10	15.8822	-5.3058	10
13	9	11	-2.0817e-15	-15.7993	11
14	9	10	27.7995	7.0412	10

Figure 5: Power loss in flow before optimization

In figure 5, indicating absolute misfortune in influence stream improvement. Here utilizing proposed approach for example molecule swarm improvement to advance receptive force.

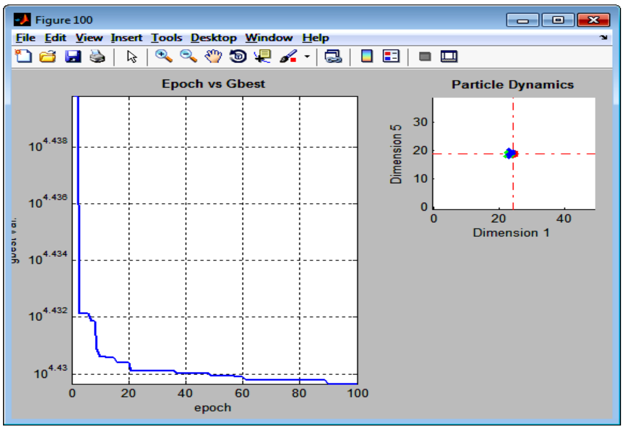


Figure 6: Proposed approach Iteration process

In figure 6, indicating emphasis approach utilizing PSO calculation, in which wellness esteem determined and Gbest versus time chart produced.

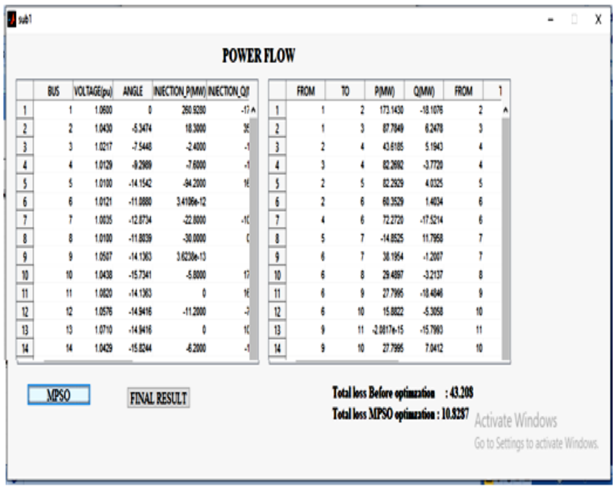


Figure 7: Average reactive power after optimization

In figure 7, absolute misfortune improvement is appearing by utilizing PSO approach. Before streamlining power misfortune is 43.208 and after advancement it gets 10.8287.

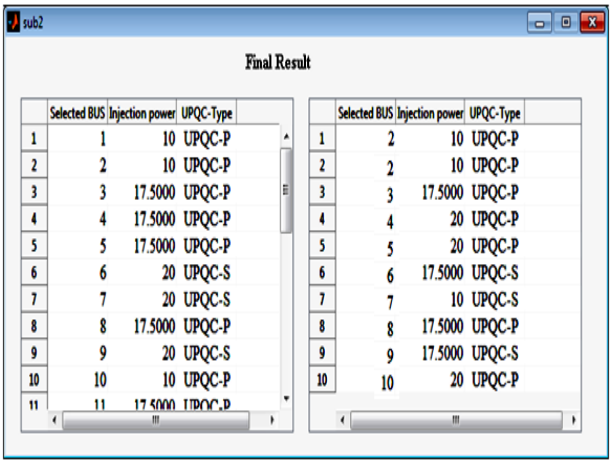


Figure 8: Final result values

In figure 8, indicating conclusive outcome esteems in information transports. Bound together force quality conditioner (UPQC), which is otherwise called the general dynamic channel. UPQC has shunt and arrangement remuneration capacities for sounds, receptive force, voltage aggravations, and force stream control.

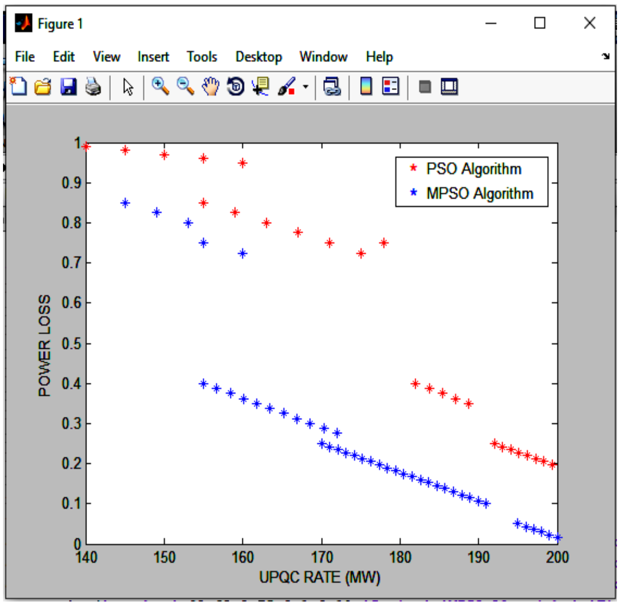


Figure 9: Power loss, PSO vs Proposed

Figure 9 indicating power misfortune versus UPQC rate in the event of particle swarm optimization (PSO) and proposed Modified PSO. Simulation results show that the power loss is optimized and minimized by using the proposed approach.

IV. CONCLUSIONS

Reactive power the board assumes a crucial job in improving force nature of the framework. The significant worry in responsive force the executive is area and amount of putting capacitor at ideal area in the spiral/work/interconnected dispersions arrange is multi-goals work with specific limitations. In proposed work we utilize the IEEE 14 transport framework for investigation the Interest reaction utilizing the MATLAB condition. In this paper proposed alter PSO based force stream is discover the interest reaction in the IEEE transport framework. Lastly determined the DG place transports and it is capacity to upgrade the force framework. Result shows that proposed work gives great outcome for pick the transports for adjusted the force stream in IEEE framework through receptive force advancement and pay.

REFERENCES

[1] K. Murugesan, M. Senthil Kumaran, J. Anitha Roseline, S. Vijayenthiran, M. Kubera Murthi and A. C. Maheswari, "DSTATCOM Using Matrix Converter for Reactive Power Compensation," *2019 Fifth International Conference on Electrical Energy Systems (ICEES)*, Chennai, India, 2019, pp. 1-6.

[2] S. Su *et al*., "Reactive power compensation using electric vehicles considering drivers' reasons," in *IET Generation, Transmission & Distribution*, vol. 12, no. 20, pp. 4407-4418, 13 11 2018

[3] A. Samir, M. Taha, M. M. Sayed and A. Ibrahim, "Efficient PV-grid system integration with PV-voltage-source converter reactive power support," in *The Journal of Engineering*, vol. 2018, no. 2, pp. 130-137, 2 2018.

[4] S. Stanković and L. Söder, "Analytical Estimation of Reactive Power Capability of a Radial Distribution System," in *IEEE Transactions on Power Systems*, vol. 33, no. 6, pp. 6131-6141, Nov. 2018.

[5] M. Moghbel, M. A. S. Masoum, A. Fereidouni and S. Deilami, "Optimal Sizing, Siting and Operation of Custom Power Devices With STATCOM and APLC Functions for Real-Time Reactive Power and Network Voltage Quality Control of Smart Grid," in *IEEE Transactions on Smart Grid*, vol. 9, no. 6, pp. 5564-5575, Nov. 2018.

[6] S. Gao, H. Wang, C. Wang, S. Gu, H. Xu and H. Ma, "Reactive power optimization of low voltage distribution network based on improved particle swarm optimization," *2017 20th International Conference on Electrical Machines and Systems (ICEMS)*, Sydney, NSW, 2017, pp. 1-5.

[7] P. Shukla and V. Mohan, "Design and Simulation of DVR & DSTATCOM for Power Quality Enhancement in Distribution Networks under Various Fault Condition", IJOSCIENCE, vol. 3, no. 1, Feb. 2017. https://doi.org/10.24113/ijoscience.v6i4.280

[8] N. S. Lakra, P. Prakash and R. C. Jha, "Power quality improvement of distribution system by reactive power compensation," *2017 International Conference on Power and Embedded Drive Control (ICPEDC)*, Chennai, 2017, pp. 415-420.

[9] P. Dong, L. Xu, Y. Lin and M. Liu, "Multi-Objective Coordinated Control of Reactive Compensation Devices Among Multiple Substations," in *IEEE Transactions on Power Systems*, vol. 33, no. 3, pp. 2395-2403, May 2017.

[10] M. Moghbel, M. A. S. Masoum, A. Fereidouni and S. Deilami, "Optimal Sizing, Siting and Operation of Custom Power Devices With STATCOM and APLC Functions for Real-Time Reactive Power and Network Voltage Quality Control of Smart Grid," in *IEEE Transactions on Smart Grid*, vol. 9, no. 6, pp. 5564-5575, Nov. 2018.

[11] A. K. Bohre, G. Agnihotri and M. Dubey, "Optimal sizing and sitting of DG with load models using soft computing techniques in practical distribution system," in *IET Generation, Transmission & Distribution*, vol. 10, no. 11, pp. 2606-2621, 4 8 2016.

[12] X. Zhang, X. Wang and X. Qi, "Reactive power optimization for distribution system with distributed generations based on AHSPSO algorithm," *2016 China International Conference on Electricity Distribution (CICED)*, Xi'an, 2016, pp. 1-4.