Solving Optimal Reactive Power Problem by Magnetic Charged System Search Algorithm

Dr. Kanagasabai Lenin
Professor,
Department of EEE
Prasad V.Potluri Siddhartha Institute of Technology,
Kanuru, Vijayawada, Andhra Pradesh -520007.
Email: gklenin@gmail.com

Abstract – In this work Magnetic Charged System Search Algorithm (MCA) is employed to solve the optimal reactive power problem. Proposed algorithm is an improved version of the charged system Search algorithm. In Addition magnetic forces are applied adjacent to electrical forces is the important factor in the Magnetic Charged System Search Algorithm. Due to the movement of a charged particle, magnetic induction happens. This formed magnetic field forms the origin for creation of a magnetic force towards particles. In the proposed methodology, along electrical forces, magnetic forces are employed in the exploration progression. Proposed Magnetic Charged System Search Algorithm (MCA) has been tested in standard IEEE 14,300 bus test system and simulation results show the proposed algorithm reduced the real power loss considerably.

Keywords: optimal reactive power; Transmission loss, Magnetic Charged System Search

1. Introduction

Reactive power problem plays a key role in secure and economic operations of power system. Optimal reactive power problem has been solved by a various types of methods [1-6]. Nevertheless numerous scientific difficulties are found while solving problem due to an assortment of constraints. Evolutionary techniques [7-16] are applied to solve the reactive power problem, but the key problem is some algorithms stuck in local optimal solution & failed to balance the Exploration & Exploitation during the search of global solution. In this work Magnetic Charged System Search Algorithm (MCA) is utilized to solve the optimal reactive power problem. Projected algorithm is enhanced version of the charged system Search algorithm. Adding of magnetic forces adjacent to electrical forces is key factor in the projected algorithm. Due to the progression of a charged particle, magnetic induction occurs. This produced magnetic field forms the root for formation of a magnetic force towards particles. In the proposed approach, in adding to the electrical forces, magnetic forces are employed in the exploration progression. Proposed Magnetic Charged System Search Algorithm (MCA) has been tested in standard IEEE 14,300 bus test system and simulation results show the proposed algorithm reduced the real power loss considerably.

2. Problem Formulation

Objective of the problem is to reduce the true power loss:

$$\mathbf{F = P_L = \sum_{k \in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_iV_j\cos\theta_{ij}\right)} \quad (1)$$

Voltage deviation given as follows:

$$\mathbf{F = P_L + \omega_v \times Voltage\ Deviation} \quad (2)$$

Voltage deviation given by:

$$\mathbf{Voltage\ Deviation = \sum_{i=1}^{Npq} |V_i - 1|} \quad (3)$$

Constraint (Equality)

$$\mathbf{P_G = P_D + P_L} \quad (4)$$

Constraints (Inequality)

$$\mathbf{P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max}} \quad (5)$$

$$\mathbf{Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g} \quad (6)$$

$$\mathbf{V_i^{min} \le V_i \le V_i^{max}, i \in N} \quad (7)$$

$$\mathbf{T_i^{min} \le T_i \le T_i^{max}, i \in N_T} \quad (8)$$

$$Q_c^{min} \leq Q_c \leq Q_C^{max}, i \in N_C \qquad (9)$$

3. Magnetic Charged System Search Algorithm

Magnetic charged system search algorithm (MCA) is an enhanced version of the charged system Search algorithm [17]. Adding of magnetic forces adjacent to electrical forces is key factor in the projected algorithm.

Due to the progression of a charged particle, magnetic induction occurs. This produced magnetic field forms the root for formation of a magnetic force towards particles,

$$F_B = qv \times B \qquad (10)$$

Where q is the quantity of the particle's charge; B denotes the magnetic field concentration and v defines the velocity of the particle's progression in the magnetic field

Total Sum of magnitude of the forces which applied to the particle is obtained by

$$F_B = qv \times B + qE = q.(v \times B + E) \qquad (11)$$

The quantity of the magnetic force applied to every particle is obtained by,

$$F_j = q_j \sum_{i,i\neq j} \left(\frac{qi}{a^3} r_{ij} \cdot i_1 + \frac{qi}{r_{ij}^2} \cdot i_2\right) p_{ij}(X_i - X_j), \begin{cases} j = 1,2,..,N \\ i_1 = 1, i_2 = 0 \Leftrightarrow r_{ij} < a \\ i_1 = 0, i_2 = 1 \Leftrightarrow r_{ij} \geq a \end{cases} \qquad (12)$$

$$a = 0.10 \text{ X } \max(\{x_{i,max} - x_{i,min} | \, i = 1,2,..,n\}). \qquad (13)$$

Probability of i th particle Magnetic influence on j th particle is given by

$$p_{ij} = \begin{cases} 1 & \text{fit(j)} > fit(\text{i}) \\ 0 & \text{else} \end{cases} \qquad (14)$$

Attraction probability is defined as ,

$$p_{ij} = \begin{cases} 1 & \frac{\text{fit(i)} - \text{fitbest}}{\text{fit(j)} - \text{fit(i)}} > \text{random} \vee \text{fit(j)} > \text{fit(i)} \\ 0 & \text{else} \end{cases} \qquad (15)$$

The magnitude is defined by,

$$qi = \frac{\text{fit (i)} - \text{fitworst}}{\text{fitbest} - \text{fitworst}}, \quad i = 1,2, \ldots, N, \qquad (16)$$

Preliminary positions are determined arbitrarily in the exploration space

$$x_{i,j}^{(0)} = x_{i,min} + \text{rand} \cdot (x_{i,max} - x_{i,min}), i = 1,2,..,n \qquad (17)$$

Preliminary velocities of the particles is

$$v_{i,j}^{(0)} = 0, i = 1,2,..,n. \qquad (18)$$

Position and velocity are defined by,

$$X_{j,new} = \text{rand}_{j1} \cdot k_a \cdot \frac{F_j}{m_j} \cdot \Delta t^2 + \text{rand}_{j2} \cdot k_v \cdot V_{j,old} \cdot \Delta t + X_{j,old}, \qquad (19)$$

$$V_{j,new} = \frac{X_{j,new} - X_{j,old}}{\Delta t}, \qquad (20)$$

Velocity coefficient kv control the searching procedure and kv, ka are defined as,

k_v=0.5(1 − iter/iter$_{max}$), $k_a = 0.5(1 + iter/iter_{max})$ (21)

Exploration and the quick rate of convergence is balanced by rewriting the Equations (18) and (19) as

$$X_{j,new} = 0.5rand_{j1} \cdot (1 + iter/iter_{max}) \cdot \sum_{i,i\neq j} \left(\frac{qi}{a^3} r_{ij} \cdot i_1 + \frac{qi}{r_{ij}^2} \cdot i_2\right) p_{ij}(X_i - x_j) + 0.5rand_{j2} \cdot (1 + iter/iter_{max}) \cdot V_{j,old} + X_{j,old} \quad (22)$$

$$V_{j,new} = X_{j,new} - X_{j,old}, \quad (23)$$

a. Algorithm parameters are initialized
b. Evaluation of the fitness function
c. Storing the values with respect to objective function
d. Magnitude of the force of the attraction has to be computed
e. Movement to new positions and finding the rate of velocity
f. Evaluation of the objective function with new values
g. New particles will replace the old particle
h. Process will stop once the stopping criterion satisfied

4. Simulation Results

At first in standard IEEE 14 bus system the validity of the proposed Magnetic charged system search algorithm (MCA) has been tested & comparison results are presented in Table 1.

Control variables	ABCO [19]	IABCO [19]	MCA
V1	1.06	1.05	1.04
V2	1.03	1.05	1.04
V3	0.98	1.03	1.01
V6	1.05	1.05	1.03
V8	1.00	1.04	0.90
Q9	0.139	0.132	0.100
T56	0.979	0.960	0.900
T47	0.950	0.950	0.900
T49	1.014	1.007	1.000
Ploss (MW)	5.92892	5.50031	4.1824

Then IEEE 300 bus system [18] is used as test system to validate the performance of the Magnetic charged system search algorithm (MCA). Table 2 shows the comparison of real power loss obtained after optimization.

Table 2 Comparison of Real Power Loss

Parameter	Method EGA [21]	Method EEA [21]	Method CSA [20]	MCA
PLOSS (MW)	646.2998	650.6027	635.8942	615.0416

5. Conclusion

In this work Magnetic Charged System Search Algorithm (MCA) is employed to solve the optimal reactive power problem. Adding of magnetic forces adjacent to electrical forces is key factor in the projected algorithm. Due to the progression of a charged particle, magnetic induction occurs. This produced magnetic field forms the root for formation of a magnetic force towards particles. Proposed Magnetic Charged System Search Algorithm (MCA) has been tested in standard IEEE 14,300 bus test system and simulation results show the proposed algorithm reduced the real power loss considerably.

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