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REAL POWER LOSS MINIMIZATION USING FIREFLY ALGORITHM

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Abstract— Optimal reactive power flow is a special case of optimal power flow (OPF) problems. Optimization of reactive power dispatch (ORPD) is necessary for secured operation of a power system. Real power loss is minimized for achieving ORPD. Generator bus voltage magnitudes, transformer tap settings and VAR outputs from shunt compensating devices are the control parameters in ORPD. These control parameter values are adjusted for loss reduction. In this work, the newly introduced firefly algorithm is proposed for finding suitable values of the control parameters that optimizes ORPD. The firefly algorithm is based on the flashing characteristics of fireflies. The algorithm has less number of operators and can be easily implemented for any optimization problems. The proposed algorithm tested on an IEEE 30 bus system and the results are obtained.

Keywords— Optimal Reactive Power Flow (ORPF), Optimal Power Flow (OPF). Optimal Reactive Power Dispatch (ORPD), Firefly Algorithm (FA).

I. INTRODUCTION

Day to day life increase the demand of Electricity when the continuous growth of the population so nowadays the generations are not equal to the demand. Power system operations have the responsibility to ensure that sufficient power is delivered to the load reliably and economically, in order to ensure adequate delivery of power demand. The electric energy system can be operated at the desired operating level by maintaining nominal frequency, voltage profile and load flow configuration. When power system control need to maintain a continuous balance between the generation and varying load demands, while system frequency, voltage levels and security are maintained with in specified limits [1]. In general the generating electrical power must satisfy the load demand. But nowadays generating electrical energy not satisfy the demand because insufficient generation, transmission capacity expansion, over long transmission lines, and also insufficient grid facilities these are the reasons to occur on more real power loss and voltage collapse. And also these are the main problems of power system. Also these are the main reason for power demand in earlier days. The power system contains many problems these problems are solved by optimal power flow (OPF) techniques. These OPF technique first discussed by carpentier it contain the single “generation equals load plus losses”. The optimal power flow perfectly handle non-linear problems and to solve non-linear equality and inequality constraints. The main aims of optimal power flow are schedule the power system and reduce the generation cost also minimize the electrical loss in transmission system.

The loss is minimizing to improve the efficiency of the system. When the loss is reduced with the help of reallocate of reactive power generations. this achieved by generator bus voltage, transformer tap setting, VAR output from the shunt compensating devices these are the control parameter in optimal Reactive Power Dispatch (ORPD) These control parameter values are adjust for loss reduction [2].

Optimal Reactive Power Flow is a special Case of optimal power flow problem. When the optimal power flow is a basic tool in terms of protect the power system. It is a main concept for power system operation and planning. In Optimal Reactive Power Flow (ORPF) the network real power loss is minimized and voltage profile is maximized while satisfying a given system Equality and inequality constraint. Reactive power flow minimized the depending upon control variables generator bus voltage, transformer tap setting, VAR output from the shunt compensating devices are the control parameter in ORPD. Large number of conventional optimization method involved in the system such as non-convex based optimization technique are used to solve optimal reactive power flow problems but these are contain many disadvantage like numerical iteration, and take more convergence time.

The above method problems are overcome by many conventional methods used such as Genetic Algorithm (GA) [3], Tabu search [4], Evolutionary Program (EP) [5-7], Particle Swarm Optimization (PSO) [8-10], Real Coded Mixed Integer Genetic Algorithm (RMGA) [11], Differential Evolution (DE) [12], Biogeography Based Optimization (BBO) [13,14], Quantum Genetic Algorithm [15], Simulated Annealing (SA) [16], Ant Colony Optimization (ACO) [17], Artificial Bee Colony Optimization (ABC) [18], Gravitational Search Algorithm (GSA) [19], this conventional method are successfully applied optimal power flow to solve non-linear optimization problems. Even though these conventional

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methods do not always produce the better global optimal solution in quick time, and they provide a better near global optimal solution.

Firefly Algorithm is a new meta-heuristic algorithm and it has not more used in power system optimization. The firefly algorithm is based on the flashing characteristics of fireflies. The algorithm has less number of operators and can be easily implemented for any optimization problems [20, 21]. The proposed algorithm tested on IEEE-30 bus system and also these results compare to the Biogeography based Optimization and Particle Swarm Optimization. The Firefly Algorithm improves the efficiency of the system and to reduce the more real power loss also it achieved a better global optimal solution.

II. OPTIMAL POWER FLOW

Optimal power flow is a special case of optimal power flow (OPF) problems. These OPF technique first discussed by carpentier it contain the single “generation equals load plus losses”. The OPF is a very long and very toughest mathematical programming problem. Almost all mathematical programming method. That can be proceed to this problem has been attempted and it has taken develops many decades to improve computer codes that will solve. Optimal Power Flow reliably. The main aim of OPF to reduce the generation cost and electrical transmission line losses.

$$P_{\text{load}} + P_{\text{losses}} - \sum P_i = 0 \qquad (2.1)$$

These Optimal Reactive Power Dispatch (ORPD) is necessary secured operation of power system which can make control adjustment to the base or Pre-contingency operation to prevent violations in this post-contingency condition are called “Security Constrained Optimal Power flows” or SCOPF. In the OPF, there are contain many adjustable or “control” variables that be specified. A list of such parameter are include: 1) LTC transformer tap position. 2) Generator voltage.3) Phase shift transformer tap position. 4) Reactive injection for a static VAR compensator. 5) Switched capacitor settings 6) Load shedding. 7) DC line flow. These are the many control parameter these parameters use to reallocate of reactive power generation use to minimize the reactive power flow.

III. OPTIMAL REACTIVE POWER DISPATCH

The Main objective function here is to reduce the Real power loss (P_{LOSS}) in the transmission system. There are two basic approaches to loss minimization, namely the slack bus method and the summation of losses on individual lines. Sometimes it is desirable to Reduce losses in a specific area and hence, the second method which is more generic, is used in this work.

IV. PROBLEM FORMULATION

The objective of this work is to minimize the reactive power flow in a power system by reduce the real power loss and sum of load bus voltage deviation. An augmented objective function is formed with the two objective components and weights.

4.1 Objective function

The Principle of this work is to detect the optimal settings of reactive power control variables including the rating shunt of VAR compensating devices which reduce the real power loss and voltage deviation. Hence, the objective function can be expressed as

$$f = min(P_L) \qquad (4.1)$$

The total real power of the system can be calculated as follows

$$P_L = \sum_{k=1}^{N_L} G_k[V_i^2 + V_j^2 - 2V_iV_j\cos(\delta_i - \delta_j)] \qquad (4.2)$$

Where , N_L is the total number of lines in the system; G_k is the conductance of the line ‘*k*’; V_i and V_j are the magnitudes of the sending end and receiving end voltages of the line; δ_i and δ_j are angles of the end voltages.

4.2 Constraints

The minimization problem is subject to the following equality and inequality constraints.

1) Equality constraints

The equality constraint represents the load flow equations, which are given below for ith bus:

$$P_{Gi} - P_{Di} - \sum_{j-1}^{N_B} V_iV_{ij}Y_{ij}\cos(\delta_{ij} + \gamma_j - \gamma_i) = 0 \qquad (4.3)$$

$$Q_{Gi} - Q_{Di} - \sum_{j=1}^{N_B} V_iV_{ij}Y_{ij}\sin(\delta_{ij} + \gamma_j - \gamma_i) = 0 \qquad (4.4)$$

Where P_{Gi} , Q_{Gi} are the active and reactive power of ith generator, P_{Di} , Q_{Di} the active and reactive power of ith load bus, δ_{ij} the angel difference between ith&jth bus. NB: number of buses.

2) Inequality constraints

a) Reactive Power Generation Limit of SVCs

Generator voltage and reactive power of ith bus lies between their upper and lower limits as given below.

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$$Q_{ci}^{min} \leq Q_{ci} \leq Q_{ci}^{max}; i \in N_{SVC} \qquad (4.5)$$

are the minimum and maximum voltage of i^{th} generating unit and Q_{ci}^{min} , Q_{ci}^{max} are the minimum and maximum reactive power of i_{th} generating unit.

*b) **Voltage Constraints***

$$V_i^{min} \leq V_i \leq V_i^{max}; i \in N_B \qquad (4.6)$$

Where, V_i^{min} , V_i^{max} are the minimum and maximum load voltage of i_{th} unit.

*c) **Transmission line flow limit***

$$S_i \leq S_i^{max}; i \in N_l \qquad (4.7)$$

Where $S_i$the apparent power flow of i^{th} is branch and S_i^{max} is the maximum apparent power flow of i^{th} branch.

*d) **Tap position Constraints***

$$T_{pi}^{min} \leq T_{pi} \leq T_{pi}^{max}; i \in N_T \qquad (4.8)$$

Where T_{pi}^{min} , T_{pi}^{max} are the minimum and the minimum and maximum tap setting limits of i^{th} transformer.

V. FIREFLY ALGORITHM

The Firefly Algorithm was invented by Dr. Xin she yang at Cambridge University in 2008.which was inspired by mating or flashing behaviour of fireflies. This paper used to solve non-linear design problems. This technique used to reduce real power loss and improve the voltage profile and these are achieved by with help of to adjust the control parameters such as transformer tap settings and VAR outputs from shunt compensating devices are the control parameters. And this algorithm used how to determine better global optimal solutions are given below. To find global optimal solutions is achieved by help of two test functions one is singularity (or) stochastic another one is deterministic.

Stochastic method produce different solution evens the same starting point. Deterministic method produce the same set of solution of even with the same starting point. These Deterministic algorithms are to find efficient local optima. It is difficult to find the global optimal solution. So, stochastic method used to find global optimal solution. Most stochastic algorithms can be considered as meta-heuristic, and good examples are genetic algorithms (GA) and particle swarm optimization (PSO). Many modern meta-heuristic algorithms were developed based on the swarm intelligence in nature. Stochastic method has a deterministic component and a random component. Stochastic method can take many forms such as simple randomization by randomly sampling the search space or by random walks. The Firefly algorithm has proved to be much simpler both in concept and implementation.

5.1 Flashing Behaviour of fireflies

Fireflies or lightning bugs belong to a family of insects that are capable to produce natural light to attract a mate or prey. There are about two thousand firefly species which produce short and rhythmic flashes. These flashes often appear to be in a unique pattern and produce an amazing sight in the tropical areas during summer. The intensity (I) of flashes decreases as the distance (r) increases and thus most fireflies can communicate only up to several hundred meters. In the implementation of the algorithm, the flashing light is formulated in such a way that it gets involved with the objective function to be optimized.

5.2 Fireflies Basic Rules

The fireflies characteristics are the following three rules are given list.

- Every fireflies are unisex so that one firefly is attracted to remaining fireflies regardless of their sex.
- Attractiveness is proportional to their light intensity thus for compare any two flashing fireflies the low brighter one will move towards the higher brighter one. The attractiveness is directly proportional to the brightness and they are both decrease as their distance increases. If no one is brighter than a specified firefly, it moves erratic.
- The brightness or light intensity of a firefly is find by the landscape of the objective function to be optimized.

5.3 Algorithm

Step 1: Start the program
Step 2: Enter the load system input data
Step 3: The Generate initial population of fireflies x_i (i = 1, 2, ..., n)
Step 4: To determine Light intensity I_i at x_i is determined By $f(x_i)$
Step 5: Set the iteration count iter=1
Step 6: To calculate ith firefly for i = 1 : n all n fireflies
Step 7: To calculate jth firefly for j = 1 : n all n fireflies
Step 8: To check if (Ij> Ii), Migrate firefly i towards j in d-dimension; end if
Step 9: To calculate attractiveness, when Attractiveness Varies with distance r.
Step10: To Evaluate new solutions and update light Intensity
Step11: end for j

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Step12: end for i
Step13: Rank the fireflies and find the current best
Step14: To evaluate Iter=Iter+1
Step15: Check Iter >Iter max; the condition no means go to step 4.
Step16: Print the results
Step17: Stop the program.

5.4 Implementation of Fire Fly Algorithm

The following are the steps used in the implementation of fire fly algorithm for optimal reactive power dispatch is explained as follows

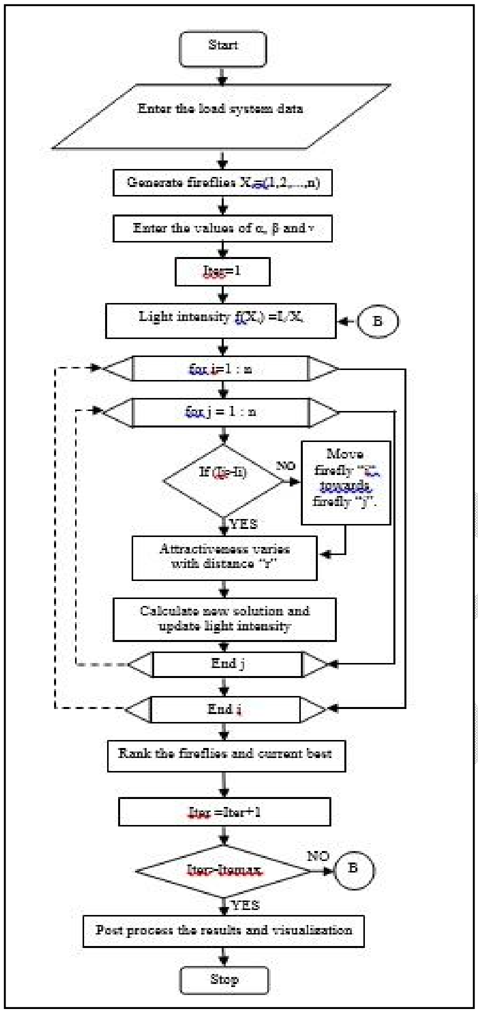

Fig 1: Flowchart

Step 1: Form an initial generation of *NP* fireflies in a random manner respecting the limits of search space, each fire fly is a vector of control variables i.e. [Vg1, Vg2, Vg3...Vgn; Tp1, Tp2, Tp3,.; Qsvc1, Qsvc2, Qsvc3...Qsvcn].

Step 2: light intensity is directly proportional to objective function. In this case light intensity is taken as the objective function value itself. Calculate the fitness function values (light intensity) of all candidate solution by running the NR load flow.

Step 3: Compare the intensity of a randomly selected firefly against the intensity of other firefly in the population. if the intensity is smaller, then move the firefly towards the other with high brightness. The attractiveness is also varied. The movement is governed by the following equation.

$$x_i = x_i + \beta_0 e^{-\gamma r_{ij}^2}\left(x_j - x_i\right) + \alpha\epsilon$$

Here, i is the fire fly with less brightness and moving towards j, the one with more brightness. In the equation, β_0 is the attractiveness and r_{ij} is the distance, α is a random number in (0, 1) and value of ϵ lies in (-1, 1).

Step 4: Return to step 2 until stopping criteria has been achieved. The global best fly is also recorded.

VI. NUMERICAL RESULTS AND DISCUSSIONS

The performance of the proposed Firefly algorithm based reactive power optimization method is tested on the any size IEEE bus system. The algorithm is implemented using MATLAB program and a Core 2 Dio, 2.8 MHz, 2GB RAM based PC is for the simulation purpose.

The control variables are Generator bus voltage magnitudes, transformer tap settings and VAR outputs from shunt compensating devices are the control parameters in optimal power flow problems. These control parameter values are adjusted for loss reduction are shown in table 1

Table 1 : Control Variable Limit.

Sl No	Control Variable	Limit
1	Generator voltage (V_{Gi})	(0.9-1.1) p.u.
2	Tap setting (T_{Pi})	(0.9-1.1) p.u.
3	MVAR by static Compensators (Q_{svc})	(0-10) MVAR

The test system taken has six generating units connected to buses 1, 2, 5, 8, 11 and 13. There are 4 regulating transformers connected between bus numbers 6-9, 6-10, 4-12 and 27-28. Two shunt compensators are connected in bus numbers 10 and 24. The system is interconnected by 41

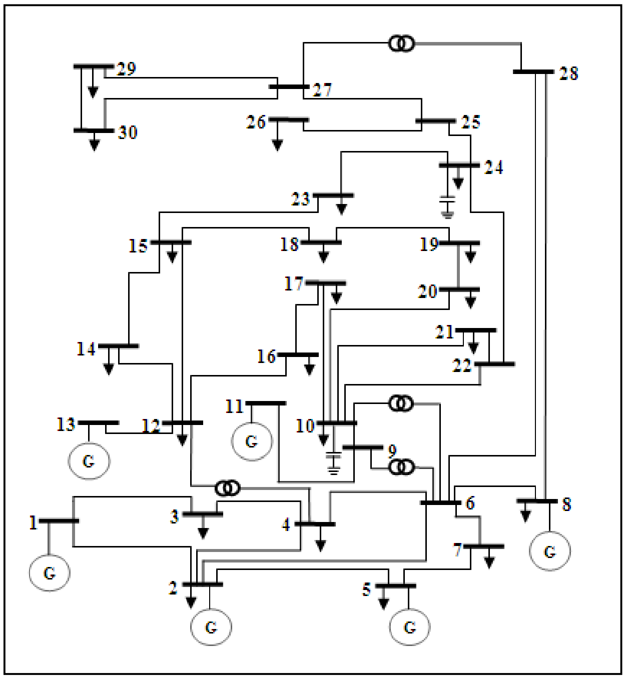

Fig 2 : Single Line Diagram of Standard IEEE-30 Bus System

6.1 Minimization of Real Power Loss

The real power transmission loss minimization is the major component of reactive power optimization and it needs more attention. This case takes only the real power loss minimization as the objective function. The optimal control variables of the overall system obtained by FFA algorithm for this case are shown in table 2.

Table 2: Optimal Parameter Values

Sl no	Parameter	Initial value	Optimal Value [FFA]
1	V_{G1}	1.05	1.1000
2	V_{G2}	1.04	1.0967
3	V_{G5}	1.01	1.0850
4	V_{G8}	1.01	1.0895
5	V_{G11}	1.05	1.0930
6	V_{G13}	1.05	1.0969
7	T_{6-9}	1.078	1.0478
8	T_{6-10}	1.069	0.9439
9	T_{4-12}	1.032	1.0318
10	T_{27-28}	1.068	1.0044
11	Q_{10}	0.0	5.3399
12	Q_{24}	0.0	6.6341

In this case the FFA algorithm better optimizes both real power loss and voltage deviation as shown in table 3. The reduction in loss indicated by FFA algorithm is highly encouraging and it is only 4.7106 MW.

Table 3 : Minimization of objective terms

Sl no	Parameter	Initial value	FFA	BBO [1]	PSO [1]
1	P_{loss}	5.744	4.7106	4.9650	5.09219
2	VD	1.4753	0.0918	2.1410	-

The good convergence characteristics of Firefly Algorithm In the objective of real power loss minimization is plotted in fig 3

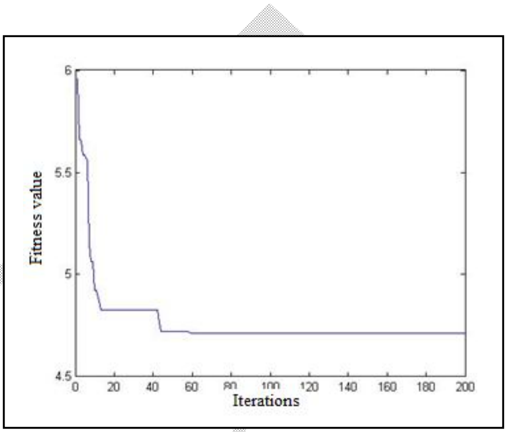

Fig 3 : Convergence characteristics of FA

Voltage magnitudes of buses 14 to 30 were less than 1.0 p.u. before alteration of the control parameters. Figure 4 depicts that all the load bus voltages are brought to nearly 1.0 p.u.

Fig 4 : Voltage profile improvement

VII. CONCLUSION

In this paper, a nature Inspired FA optimization algorithm is proposed to solve reduce real power loss using reactive power flow problem. The performance of the proposed algorithm for solving ORPF problems is explained using IEEE-30 bus system. The established results are compared to those of conventional algorithms like BBO and PSO. The test results clearly shown that FA are more efficiency and high quality solution. The projected FA is more used for large system as is evident from IEEE-30 bus system. From all simulation results it may finally find that among the three algorithms Firefly algorithm capable to reduce real power loss and achieve better global optimal solution. This paper shows that such outstanding results with to reduce real power loss shows that makes the proposed Firefly algorithm optimization technique is better in dealing with power system optimization problems.

References

[1] Mamandur KRC, Chenoweth RD. Optimal control of reactive power flow for improvements in voltage profiles and for real power loss minimization. IEEE Trans Power ApparatSyst 1981;PAS-100(7):3185–93.

[2] Mansour MO, Abdel-Rahman TM. Non-linear VAR optimization. Using decomposition and coordination. IEEE Trans Power Apparat Syst 1984;PAS-103(2):246–55.

[3] Iba K. Reactive power optimization by genetic algorithm. IEEE Trans Power Syst 1994;9(2):685–92.

[4] Gan D, Qu Z, Cai H. Large-scale VAR optimization and planning by Tabu search.Elect Power Syst Res 1996;39:195–204.

[5] Lai LL, Ma JT. Application of evolutionary programming to Reactive power planning-comparison with nonlinear programming approach. IEEE Trans Power Syst 1997;12(1):198–206.

[6] Swain AK, Morris AK. A novel hybrid evolutionary programming method for function optimization. In: Proc 2000 congress on evolutionary computation, vol. 1, July 2000. p. 699–705.

[7] Abido MA, Bakhashwain JM. Optimal VAR dispatch using a multiobjective evolutionary algorithm. Int J Elect Power Energy Syst 2005;27(1):13–20.

[8] Yoshida H, Kawata K, Fukuyama Y, Takayama S, Nakanishi Y. A particle swarm optimization for reactive power and voltage control considering voltage security assessment. IEEE Trans Power Syst2000;15(4):1232–9.

[9] Esmin AAA, Lambert-Torres G, de Souza ACZ. A hybrid particle swarm optimization applied to loss power minimization. IEEE Trans Power Syst 2005;20(2):859–66

[10] Vlachogiannis JG, Lee KY. A comparative study on particle swarm optimization for optimal steady-state performance of power systems. IEEE Trans Power Syst 2006;21(4):1718–28.

[11] Gaing Z, Huang HS. Real-coded mixed integer genetic algorithm for constrained optimal power flow. In: IEEE TENCON region 10 conference, 2004, vol. 3, November 2004. p. 323–6.

[12] M. Varadarajan, K.S. Swarup, “Differential Evolutionary Algorithm for Optimal Reactive Power Dispatch, Electrical Power & Energy Systems Vol. 30, No. 8, pp. 435–441, October 2008.

[13] Simon D. Biogeography-based optimization. IEEE Trans EvolutComput 2008;12(6):702–13.

[14] P.K. Roy, S.P. Ghoshal, S.S. Thakur, “Optimal VAR Control for Improvements in Voltage Profiles and for Real Power Loss Minimization using Biogeography Based Optimization”, Electrical Power and Energy Systems, Vol. 43, No.1, pp. 830–838, December 2012.

[15] Lee JC, Lin WM, Liao GC, Tsao TP. Quantum genetic algorithm for dynamic economic dispatch with valve-point effects and including wind power system. Int J Elect Power Energy Syst 2011;33(2):189–97.

[16] Hsiao YT, Chiang HD, “Applying Network Window Schema and a Simulated Annealing Technique to Optimal VAR Planning in Large-Scale Power Systems”, Electric Power Systems Research,Vol. 22, No. 1, pp.18, January 2000.

[17] Pothiya S, Ngamroo I, Kongprawechnon W, “Ant Colony Optimisation for Economic Dispatch Problem with Non-smooth Cost Functions”, Electric Power & Energy Systems, Vol. 32, No. 5, pp. 478–487, June 2010.

[18] Kursat Ayan, Ulas kilic, “Artificial Bee Colony Algorithm Solution for Optimal Reactive Power Flow”, Applied Soft Computing, Vol.12, No. 5, pp. 1477–1482, May 2012.

[19] Serhat Duman, Ugur Guvenc, Yusuf Sonmez, Nuran Yorukeren, “Optimal Power Flow Using Gravitational Search Algorithm”, Energy Conversion and Management, Vol. 59, pp.86–95, July 2012.

[20] X. S. Yang, “Firefly algorithm, stochastic test functions and design optimisation,” International Journal of Bio-Inspired Computation, vol. 2, no. 2, pp. 78–84, 2010.

[21] MohdHerwan Sulaiman, Hamdan Daniyal MohdWazir Mustafa “Modified Firefly Algorithm in Solving Economic Dispatch Problems with Practical Constraints” 2012 IEEE International Conference on Power and Energy (PECon), 2-5 December 2012, Kota Kinabalu Sabah, Malaysia.