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Design of 2-Dof Pid Controller for Load Frequency Control of Two Area Power System using Mfo Algorithm

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Abstract: The paper endeavours to analyse the load frequency control for two area system. In this paper, two areas has been considered in which non-reheated type of turbine in both area are used and whose secondary loop consists a latest controller called 2 degree-of-freedom PID (2-DOF-PID) controller. The parameter of the this controller is been optimized by the latest meta heuristic algorithm also called Moth flame optimization algorithm (MFO) to minimize the deviation in frequency of area and tie-line power respectively. The same processes are repeated with PID controller and Integral controller whose parameters are also optimized by MFO. A comparison is made among the result of these and 2-DOF-PID controller prove its superiority over the other controller for minimizing the deviation which occurs in frequency of the area as well as the tie-line power.

Keywords : Load frequency control, 2-area power system, 2-DOF PID Controller, PID controller, Moth–Flame Optimization (MFO) algorithm, Genetic Algorithm (GA), PSO (Particle Swarm Optimization) algorithm

I. INTRODUCTION

In today's modern world, the power system is quite complex network, which considered mainly three entities called generation, transmission and distribution. The load in the system keep varying at every moment which need to kept at its prescribed value. Here load frequency control (LFC) has been introduced. LFC will control the variation in the frequency and will maintain it at its normal value. As the load varies due to which frequency will change. It will go up if load decreases and go down if load increases which leads to load frequency control. In LFC there are two loops, the primary loop and secondary loop. The primary loop is not able to settled frequency to its normal value hence we require the secondary loop. In two areas system there is tie line which transferred the power from one area to other with a view to overcoming the demand of the consumer. Tie line serve two purpose firstly it exchange power between multi area and secondary maintain the frequency of the whole system. There are hundreds of number of studies has been done for the LFC. Elgerd and Fosa are first to give their view for the robust design of controller for AGC. Various controllers for LFC are tested in [4]. The PID controller is very famous among the industry due to its robustness and simplification and its onsite adjustment facilities. The utilization of combined intelligence approach for AGC interconnected power system as discussed in [3-4]. ABC (Artificial Bee Colony) algorithm is used to modulate and regulate the AGC controller [6] because it has best and intelligent local & global search capabilities. In an interconnected power system, automatic generation control (AGC) is governed by Differential Evolution (DE) algorithm [7] which is based on PID (proportional integral derivative) and PI (proportional integral) controllers. Particle swarm optimization (PSO) method is used in many types of engineering problems and it also utilizes to address optimal regulation and tuning of AGC [9]. An approach based on the teaching learning-based optimization algorithm (TLBO) is proposed for AGC with 2-Degree freedom of - PID controller is presented in [10].From the above literature review here 2 DOF controller will be use in the for a two area system whose parameter will be optimized by the MFO algorithm.

II. SYSTEM UNDER STUDY

Here the two area systems of LFC have been discussed. Fig.1 shows the two area systems. In both area of power systems dwell with speed governing unit, turbine unit, generating unit and load unit. The input to each area is ΔP_{ref} (given to controller), ΔP_D (Load disturbance of an area) and ΔP_{tie} (Tie-line power). The output for each area are frequency deviation ΔF and Area control error (ACE). Equation for the ACE is given by -

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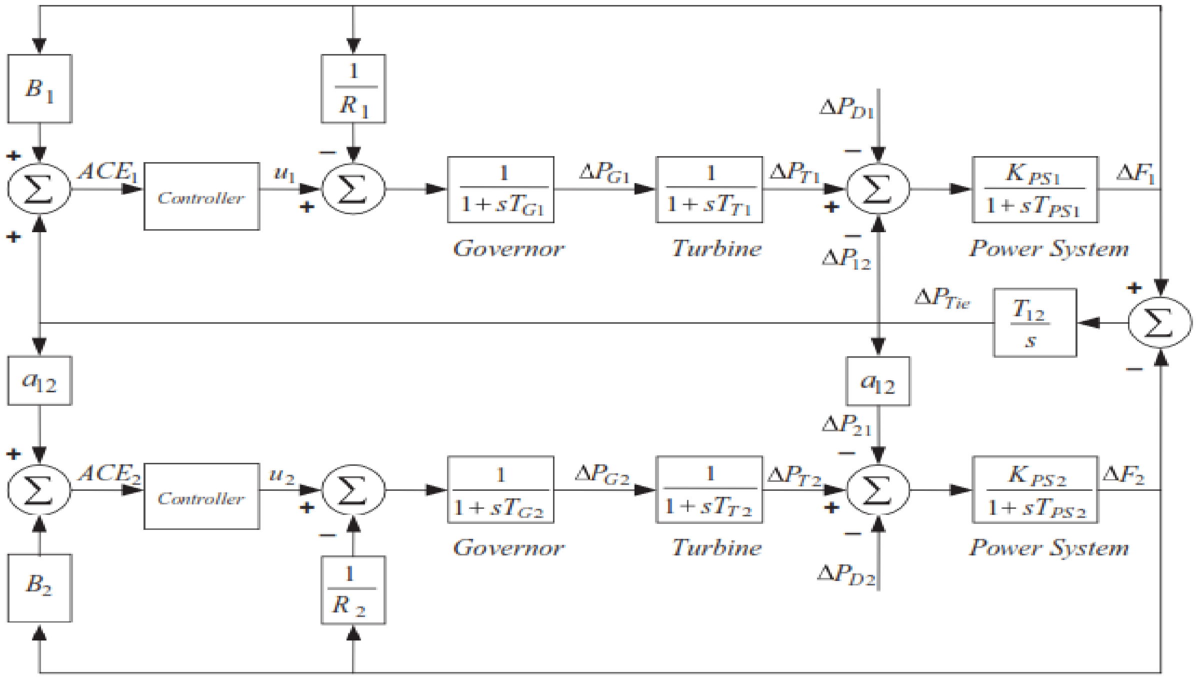

Figure :1 Two Area System

$$ACE = B\Delta F + \Delta P_{Tie} \quad (1)$$

In the above equation B stands for the frequency bias parameter. All three units of each area are denoted by a transfer function.

III. 3. 2-DEGREE OF FREEDOM PID CONTROLLER

In a control system, degree of freedom is defined as the various numbers of closed loop transfer function that is able to be adopted individually.

The purpose of designing of control system to solve the various features problem so the 2- degree of freedom or denoted as 2 DOF control system can commonly obtain more accurately than one degree of freedom system or denoted as 1 DOF system.

A 2 DOF PID controller is able to detect rapid shock or disturbance without symbolic boost of overshoot in setpoint tracking .A 2 DOF PID controllers are also advantageous in reducing the effect in the reference signal on the control system.

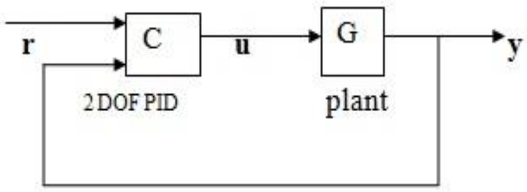

Figure 1: 2-DOF PID Controller

The above figure (2) shows a classical control architecture using a 2 DOF PID controller.

Here u represents output and its two input r & y shown in parallel form.

The transfer function to the 2-DOF PID controller has been shown below equation-

$$u = K_p(br - y) + \frac{K_i}{s}(r - y) + \frac{K_d s}{NS+1}(r - y) \quad (2)$$

Meaning of used parameters in the above equation is –

K_P - Represent proportional gain

K_i - Represent Integrator gain

K_d - Represent derivative gain

N - Represent filter gain

b - Represent set point weight on proportional term

c - Represent weight on derivative term

IV. MOTH FLOW ALGORITHM

The term optimization is nothing it is the virtue of which to find the best available technique for the appropriate issue. Past few years aka decade the complication of the questions increases day by day, so that the need of new optimization tool becomes visible more in coming days.

Now-a-days, a new algorithm named Moth Flame Optimization (MFO) algorithm used which was proposed by Mirhalili in 2015 and inspired by nature. It is fascinating to know about moth i.e. their oriented navigation method in the night by using the moon light. Most of the moths have common tendency to fly in the night. During the flight of a moth it maintains a fixed angle with respect to the moon and this particular type of navigation used by moth known as the transverse orientation for navigation.

The mathematical model to achieve these phenomena is known as the Moth-Flame-Optimization (MFO) algorithm. Both the term moths and flames explain the problem. Moth refers to the definite search operator while flame refers to the best position for moth to achieve that. Thus each moth searches around a flame and restore it in case of availability of the accurate solution in comparison of the previous one.

This MFO algorithm which estimate the global optimal of the optimization problem and it is three-tuple and can be given as

MFO = (I, P, T)

Where I related to the arbitrary number of moths and it's related fitness value. This function can be defined in mathematical form as follow the following

I: Ø $\rightarrow \{M, OM\}$

The second term P is the main function, which travel the moth to circumferences to search space. The matrix M is received by this function and it precise that matrix value and return it.

P: M $\rightarrow$ M

The third function F will reply true or false. If the termination criteria is fulfilled it reply with true signal and it reply false in the case of termination criteria is not fulfilled.

T: M $\rightarrow \{True, False\}$

There are two matrix which are ub and lb, where ub and lb define as upper and lower value of variables simultaneously.

$ub = \{u_{b_1} u_{b_2} u_{b_3} \dots \dots \dots u_{b_{n-1}} u_{b_n}\}$

Where ub_i upper shows the upper bound of the i^{th} variable.

lb = $\{lb_1 lb_2 lb_3 \dots \dots \dots lb_{n-1} lb_n\}$

Where lb_i lower shows the lower bound of the i^{th} variables.

Each moth will update its position with respect to the flame with the help of equation given below-

$M = S(M_i\ F_j) \longrightarrow M$

In the above equation M_i shows the position of the i^{th} moth and j^{th} flame which is indicated by F_j and S stands for spiral function.

S shows how a moth is flying around a flame and it can be in different space. The flames are considered as best solution and its values is store in F matrix. Fig. 3 shows the flow chart of MFO.

V. SIMULATION RESULT

It has been observed in two area system that adopted power systems are identical. Both area controllers are enhanced by the MFO in two scenarios. In the first scenario, consider the area one for which step load deviation is given and in second case step load deviation is known for area two. For both cases result is obtained. As the system is considered as identical hence the parameters will be same for both areas. The frequency of the system is 50 Hz. Two area system parameters are shown in Table 1.

Table 1: Two area system parameters

System parameter	Value
K_{ps}	105
T_{ps}	22 s
T_{sg}	0.3 s
T_T	0.5 s
Speed regulator	2.5
Bias parameters	0.326
Tie-Line Power	0.08

Case 1- When the step disturbance in given to area 1

This is the case of 2% step disturbance in area 1. System is simulated with different controller in its secondary loop and result is obtained. The values of parameters of different controllers are as follows:

Table 2: 2% step disturbance in area 1

controller	K_p	K_i	K_d	N	B	c
2DOF PID	1.907	4	4	600	10	0.07
PID	4	4	2.66	-	-	-
Integral	-	0	-	-	-	-

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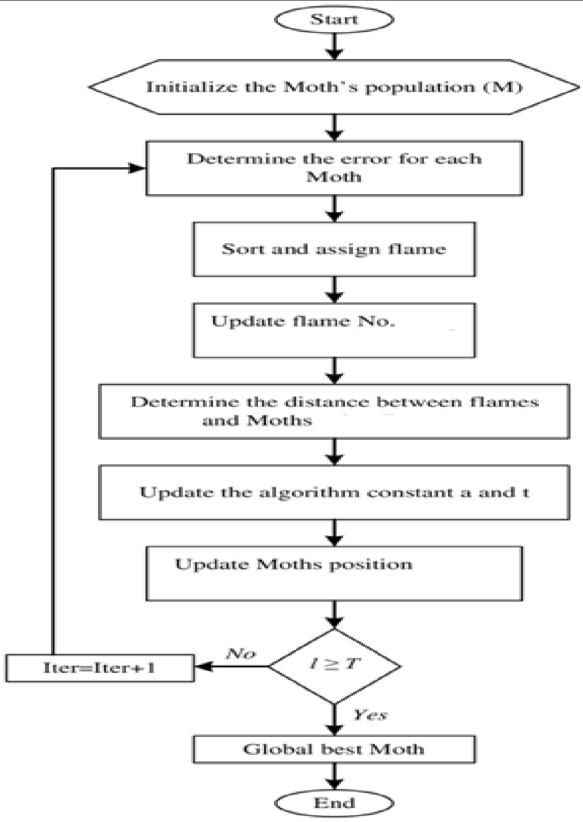


Figure 2: Flow chart of MFO

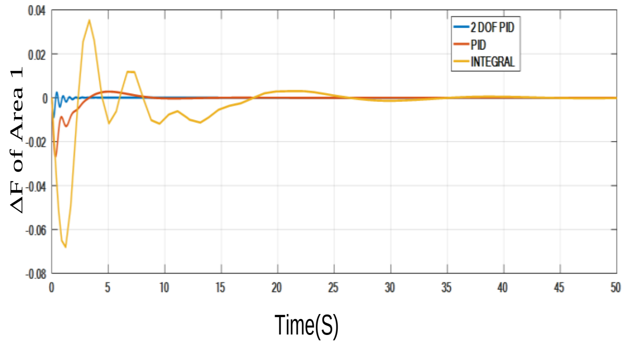


Figure 3: Frequency deviation in area 1

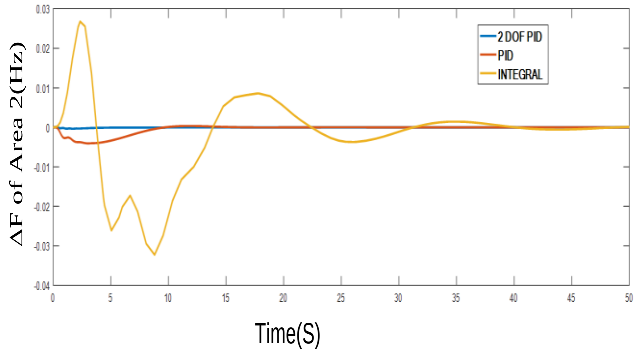
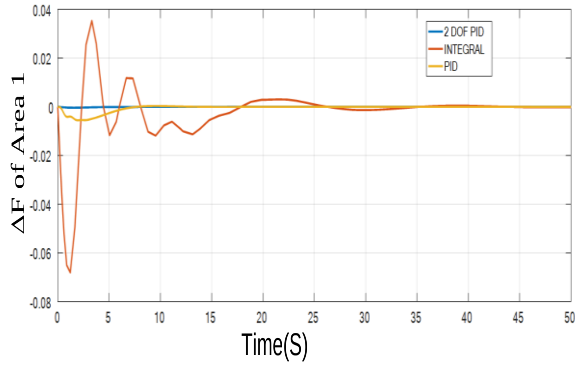


Figure 4: Frequency Deviation in area 2



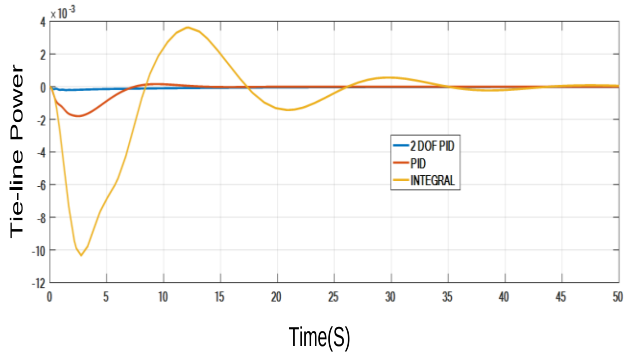


Figure 5: Deviation in the tie-line power

Case 2- When the step disturbance in given to area 2

Now this is the case of 2% step disturbance in area 2. System is simulated with different controller in its secondary loop and result is obtained. The table below shows the values of parameters of different controllers:

Table 3: 2% step disturbance in area 2

Controller	K_p	K_i	K_d	N	B	c
2DOF PID	1.8722	4	4	600	10	0.07
PID	2.7811	2.124	3.85	-	-	-
Integral	-	0.5	-	-	-	-

Figure 6: Drift of frequency in area 1

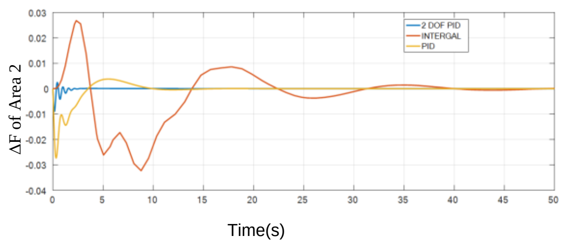


Figure 7: Drift of frequency in area 2

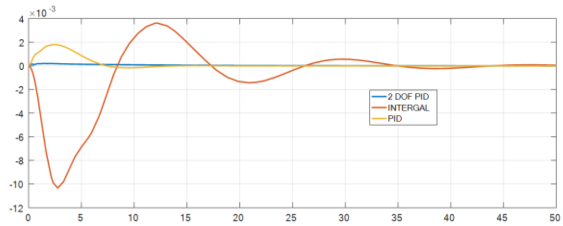


Figure 8: Deviation in the tie-line power

VI. CONCLUSION

Here we have discuss two cases when disturbance is been given in two different areas. The simulation results are shown for the both cases. It is found from the above discussed both cases that 2DOF PID controller enhanced with the help of MFO algorithm is outperform the two other traditional controller known as PID controller and integral controller . This newly controller is able to reduce the settling time, eliminated the oscillation in frequency, reduce the peak overshoot of the variable. Due to this the system with 2DOF PID controller achieves the improved performance of the whole system.

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