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Multiobjective Load Frequency Control using Particle Swarm Optimization

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Abstract

This research presents analysis on practical model for multi objective load frequency control (LFC) of interconnected two-area power system. Load frequency control is used to regulate electrical power supply in two-area power system and changes the system frequency and tie-line load. When there is changes in load, the system frequency will be interrupted and control action need to be address instantaneously in order to maintain the system stability. The LFC needs to be tuned accurately so that the performance of the system can be optimized. In this study, particle swarm optimization (PSO) algorithms were applied in multi objective LFC of two-area power system to get the optimum value of PID parameter. Weighted sum approach was employed to provide multiple solution point by varying the weight. Non-dominated point in Pareto front has been chosen as optimum PID gains which contribute to minimum overshoot value and fast frequency response of the system. There are two objective function considered for this study and has been categorized as performance criterions which are Integral of Time Multiplied Absolute Error (ITAE) and Integral of Time Weighted Squared Error (ITSE). Hence, by implementing optimization method using PSO, optimum PID parameters which able to give the best performance in terms of less settling time and minimum peak overshoot value in the frequency deviation response will be verified.

Keywords: *Load Frequency Control (LFC), Particle Swarm Optimization (PSO), Multiobjective Optimization, PID*

Abstrak

Kertas kajian ini menyediakan analisis berkenaan mengoptimumkan berbilang objektif bagi kawalan frequensi beban untuk dua kawasan tersaling hubung di rangkaian sistem kuasa. Kawalan frekuensi beban digunakan untuk mengawal selia bekalan kuasa elektrik di dua kawasan sistem kuasa dengan menukar frekuensi beban sistem dan beban di antara dua talian kuasa. Apabila berlaku perubahan pada beban penjana, frekuensi sistem akan turut terjejas dan tindakan kawalan perlu bertindak secepat mungkin untuk mengekalkan kestabilan sistem kuasa. Prestasi kawalan sistem kuasa perlu ditala dengan tepat supaya prestasi sistem dapat dioptimumkan. Dalam projek ini, Particle Swarm Optimization (PSO) algoritma digunakan untuk mendapat parameter pengawal PID yang optimum bagi kawalan frekuensi beban di dua kawasan sistem kuasa. Teknik jumlah pemberat diaplikasi untuk mendapatkan pelbagai penyelesaian dengan menaikkan pemberat. Susunan tidak perusa dalam lengkungan Pareto di pilih sebagai gandaan PID yang optimum dimana dapat menghasilkan kurang lajakan maksimum dan respon frekuensi yang cepat. Dua fungsi objektif dipertimbangkan dalam kajian ini dan dikategorikan sebagai kritetia prestasi ITAE dan ITSE. Oleh itu, dengan melaksankaan kaedah pengoptimuman, prestasi kawalan frekuensi beban boleh dioptimumkan melalui pengoptimuman parameter pengawal PID.

Introduction

The electrical power system is an interconnection of many important components which ensure successful transmission of power over a certain region or large area. Proper coordination between the generation, transmission and distribution elements of the system is important for successful and stability of the interconnected power system (Naidu, Mokhlis & Bakar, 2014). Along the transportation of electricity, both active and reactive power must be maintained balance between generating and load demand to ensure system stability (Kumar, Malik, & Hope, 1985). Generally in power system, system frequency depends on balance of the active power where else voltage depends on reactive power.
For large scale interconnected power system, one of the aspect need to be considered is capable of the system to supply high quality and reliable power to consumers. The controller of the power system plays important role to uphold the uninterrupted balance between generation and changes of load demand besides to maintain the system frequency and the tie line power within allowable limit. The variation of load in power system effect the power supply quality, therefore it must resolved as soon as possible to avoid frequency deviation from the schedule value which can result to power system stability issue.

Problem statement

Generally, in a large power plant, load frequency control is used to maintain the frequency and tie-line power within permissible limit. Frequency of a system will be interrupted when load generation balance is not maintained. When there are different between power generated and load demand, frequency fluctuation will occur. If load demand is increase, frequency of the system will decrease. Therefore, control strategy is needed to act as fast as possible for any deviation in frequency to avoid system instability.
Generator should capable to settle the deviation in frequency with minimum settling time and less maximum overshoot. PID controllers are applied in LFC to improve the transient response so as to reduce error amplitude with each oscillation which finally settled to a final set value. Conventionally, the controller parameter are obtained by trial and error approach which may consume more time in optimizing the controller parameter and not practical in complex power system which involves few objective. Taking into consideration the effort required and time consumed, it is necessary to go for an advanced method which includes optimization algorithm based on natural processes.

In this respect, a multi objective optimization technique is crucially needed to provide the optimum PID parameter. In this report, non-dominated sorting approach is investigated to obtain the optimum value for controller parameter in order to achieve best system performance for frequency response in term of settling time and less peak overshoots.

The purpose of this research paper is to :-

a) To model inter-connected Load Frequency Control (LFC) for two area power system.
b) To apply Particle Swarm Optimization (PSO) algorithm for multi objective load frequency control of two area power system
c) To determine optimal PID parameter of load frequency control based on minimum settling time and overshoot using proposed optimization technique.

Literature Review

Power supply systems are considered extremely non-linear and complex with different dynamic response and characteristic. Several interconnected generating units supplied power to variety of loads across the massive geographical area through tie-lines. Due to this, it is very much needed to monitor and ensure power system perform well during usual and unusual operations. However, due to constant change in load, frequency, voltage and other environment disturbance these tasks are challenging (Astrom, K. J., & Hagglund, T, 2001). In a power system, active and reactive powers are two important factors that need to be considered. This is because instability in frequency may result to power system disturbance. Active power is related to system frequency while the reactive power is related to voltage magnitude where it is less sensitive to frequency. Thus, load frequency control is introduced to control frequency and real power.

Load frequency control in interconnected power system is very essential in modern electrical power systems to provide a reliable supply to their customers. It is used to restore the system frequency if there are any load changes and maintain the tie line power to a desired value. Tie-line can be referred as transmission lines that are connected between areas in different geographical location. Through this tie-line the power will be shared among different location/regions. Imbalance between load demand and generation will cause the system frequency to be affected where the frequency will be decrease if load demand is greater than power generated. The changes in the load demand is uncontrollable due to it being on the consumer side but the imbalance between load demand and power generated can be rectified as soon as possible by managing the governor speed on the generator side.

Load frequency control (LFC) and automatic voltage regulator (AVR) is two common equipment in generator interconnected power system as exhibit in Fig. 1. The general diagram of load frequency control and voltage regulator of synchronous generator consists of a frequency sensor and automatic voltage sensor to detect any small changes in frequency and voltage in load demand. These sensors will produce signal to the controller which is the load frequency control and automatic voltage regulator to react as soon as possible to uphold the voltage and frequency within specific limit. When there are small changes in rotor angle, due to changes in speed of the generator, frequency will affect the real power generated.

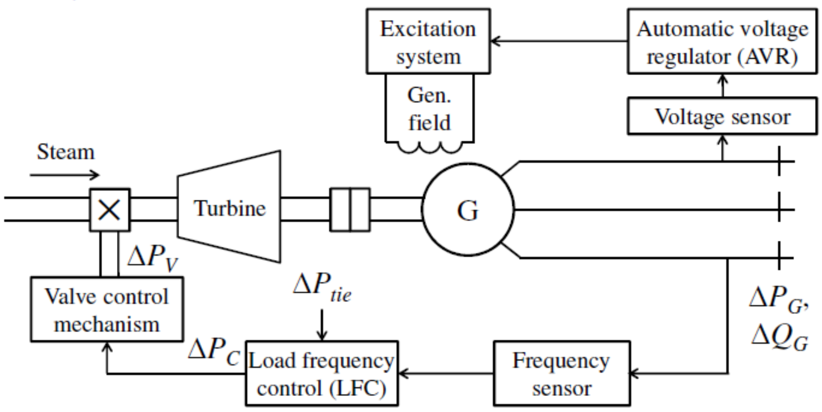

Fig. 1 LFC and AVR schematic diagram in synchronous generator (Saadat,1999)

Load Frequency Control

Load frequency control is used to maintain the system frequency and the interconnected tie-line power very close to permissible limit. Numerous studies have been conducted over the years in relation to load frequency control to achieve the best method to preserve the frequency and tie-line interchange between the areas at rated value. The non-linearity and dynamic characteristic of the system have encouraged researches to keep on improving on the modeling and design of LFC (Bevrani, 2009). There are many methods and approaches have been applied by researches to optimize the LFC performance.

Among various types of load frequency controllers, the most commonly used known as conventional proportional integral (PI) controller. However, in PI controller, usually 'I" control parameter are tuned, and it is unable to give good dynamic performance for various load and system changes situation. Many researches have been carried out in the past about the load frequency control. In literature, there are few control strategies that have been suggested based on the conventional linear control theory (A.Kumar, O.P.Malik, G.S.Hope, 1995). These controllers maybe inappropriate in some operating condition due to the complexity of the power system such as nonlinear load characteristic and variable operating points. Researches found that conventional type controller scheme incapable to reach a high degree of control performances (Unbehauen, H., Keuchel, U., Kocaarslan, 1991). Typical methods applied for tuning include Ziegler-Nichols ultimate-cycle tuning and many other traditional techniques but this method doesn't promise optimal PID parameter (Ziegler & Nichols, 1993).

PID Controllers are most accepted due to their simplicity and reliability. They are able to provide robust and reliable performance for most systems and the PID parameters are tuned to ensure a satisfactory close loop performance (Kim,D.H.,Park,J.I, 2005). Transient response of a system is improved by using PID controller by minimizing the overshoot and settling time of a system (Astrom, K. J., & Hagglund, T, 2001). Generally, almost all control loops in process industries use PID control algorithm and act as cornerstone for many advance control algorithm and strategies. To ensure the best performance of a control loop, the PID controller needs for proper tuning. Artificial bee colony optimization has been applied to obtain the optimal value of the PID controller parameters (Naidu, K., Mokhlis, H., & Bakar, A. H. A, 2014). Area control error or knows as (ACE) act as input signal to the controller and which has been measured in order to satisfy the load frequency control objective which is the controller parameters gain that has been identified depending on the control area characteristic

When there are minor changes in the angle of the rotor δ, it will affect the frequency and tie-line real power which is measured as error Δδ. Prime mover is controllable part which controls the torque due to error signal in frequency, Δf and ΔPtie. Prime mover receives real power signal ΔPv either to increase or decrease the torque in order to bring back the Δf and ΔPtie to the desired range by changing the generator's output, ΔPg. For better understanding, design and analyze of the control system, mathematical modeling is necessary in the form of transfer function or state variable. According to (Hadi, 1999) both method used need to be linearized for generator model, load model, prime mover model and governor model.

Design of two-area system

Two-area power system can be defined as combination of two single area power systems which is interconnected through power line known as tie-line. Each area consists of governor, turbine and generator connected through tie-line that allows flow of power between each other. Since they are interconnected, both areas will contribute the impact of frequency changes and power flow in each area. When there are changes in power in any area, there will be increased in generation in all the areas linked to change in tie-line power and drop in frequency. Contrast to normal operation state, where the demand of each area will be fulfilled at normal frequency and changes in load will be absorb by each area. Controller like PID usually used to fulfill certain minimum requirement with regards to voltage and frequency. The most challenging part in two-area power system is the frequencies that vary in each area and need to be stabilized within certain limit. Besides that, is to provide sharing of load between generator proportionally and to keep the tie-line power exchange within allowable limit.

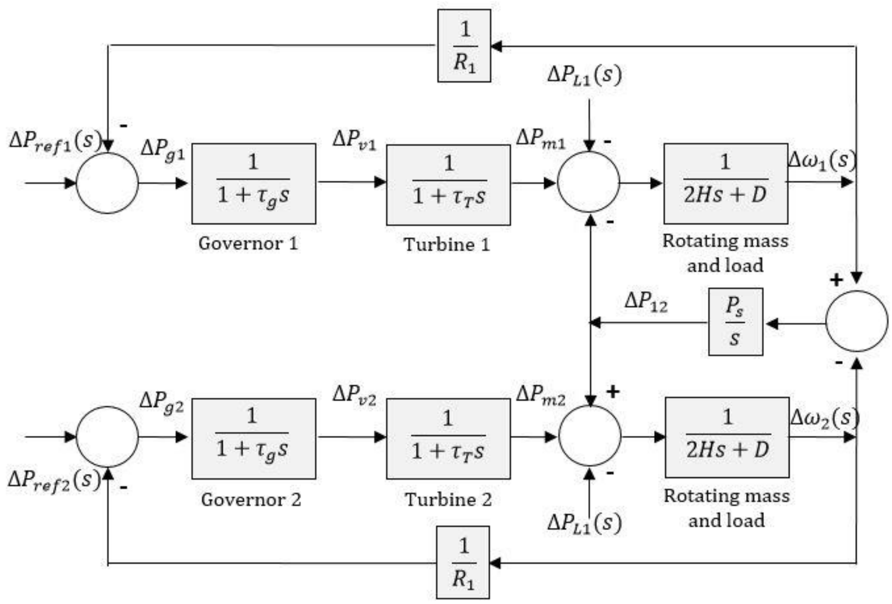

Fig. 2. Block diagram of load frequency control (LFC) for two-area power system (Saadat, 1999)

Fig. 2 above illustrate block diagram for load frequency for two-area power system. Based on the figure,

$\Delta P_{ref1}(s)$	=	Reference real power signal for area 1 in time domain
$\Delta P_{ref2}(s)$	=	Reference real power signal for area 2 in time domain
ΔP_{v1}	=	Real power command signal for area 1
ΔP_{v2}	=	Real power command signal for area 2
ΔP_{m1}	=	Changes in mechanical power for area 1
ΔP_{m2}	=	Changes in mechanical power for area 2
ΔP_{12}	=	Tie-line power changes within area 1 and 2
$\Delta \omega_1(s)$	=	Changes in frequency deviation in area 1
$\Delta \omega_2(s)$	=	Changes in frequency deviation in area 2
$\Delta P_{L1}(s)$	=	Load changes in area 1
$\Delta P_{L2}(s)$	=	Load changes in area 2

Optimization Techniques

Optimization is a widely applied technique in operational research that has been used in various types of applications. It is aim to obtain the maximum or minimum value of an objective subject to certain constrains (Pike-Burke, C). In modern days, there are many optimization techniques which have been applied to attain the greatest performance for power system controller (Kothari, 2012). In general, optimization is a method to find the optimum solution of a specific objective function.

In current situation, tremendous development in computer software lead researcher to utilize computer resources to deal with optimization problem. Looking at the history, huge number of optimization techniques have been used to solve various complicated problem for instance in economic load dispatch, load frequency control, reactive power dispatch, sizing PV system and many more on the list (Abdul Aziz, Sulaiman, Musirin, & Shaari, 2013). Researchers have gain interest in intelligent based techniques due to potential of the search mechanism which tune the controller based on fitness function that has been evaluated (Naidu, Mokhlis & Bakar, 2014).

Artificial intelligent (AI) techniques have also become practical as a substitute method to replace the current conventional method in solving complex problems in many areas. AI is considered one of the intelligent techniques which categorize under computational intelligent (CI) hierarchy and consist of three main branches namely artificial neural network (ANN), fuzzy logic and evolutionary algorithm.

Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) has been developed by Kennedy and Eberhart way back in 1995 as evolutionary computational method. It's also known as population based optimization. Its algorithm develop from swarm intelligent and it is based on study movement behavior of bird and fish flock (Kavya, M., & Rao, G. S, 2015). It can be applied to solve various type of optimization problem. Similar to evolutionary algorithms, PSO algorithm perform search using population of particles which corresponding to individuals. Simultaneously, each particle will be a potential solution in the swarm, (Rao, R. N., & Reddy, P. R. K., 2015). Looking at PSO algorithm, all particles will fly in multidimensional search space and each particle adjusts its position according to its own experience and neighbourhood experience.

This method features many advantages such as fast, simple and can be programmed in few lines. Its simplicity of implementation and don't need gradient information. Compare to other optimization method, PSO has memory where each particle will memorizes its best solution known as global best (gbest). In additional, another advantage of PSO is that the original population of PSO is maintained, so it's not necessary to apply operator to the population which is save in time and memory storage (Rao & Reddy, 2015). We can say that, PSO population based optimization method is depends on practical cooperation between particles.

Coordinate of each particle will be keep track in the solution space which is associated with the best solution (fitness) that has attain so far by that particle. This value's known as personal best, pbest. Beside that, another best value that track by PSO is the best value obtain so far by any particle in the neighbourhood of that particle and identify as global best, gbest. Basically, PSO concept based on the accelerating of each particle toward its pbest and gbest position, with random weighted acceleration at each time step, (Kavya, M., & Rao, G. S, 2015) as shown in Fig 3.

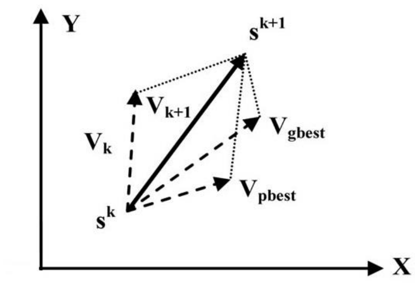

Fig. 3. Accelerating of each particle toward its pbest and gbest position

Where;

S^k: Present search point

S^{k+1} : Modify search point

V^k : Present velocity

V^{k+1}: Modify velocity

V_{pbest} : Velocity depends on pbest

V_{gbest} : Velocity depends on gbest

There two major equations in PSO algorithm which is:-

Velocity modification equation:

$$V_i^{k+1} = wv_i^k + c_1 rand_1 \times (pbest_i - s_i^k) + c_2 rand_2 \times (gbest_i - s_i^k)$$

Where, v_i^k are the velocity of agent i at iteration k, c_1 and c_2 are two position constants called acceleration constant. $rand_i$ is known as random number from 0-1, where else $pbest_i$ is p-best of agent i. Present position of agent i at iteration k is s_i^k. $gbest_i$ is gbest of the group. The inertial movements for the particle are kept by inertia weight 'w'. It is actually the influence of previous velocity to current velocity, whereby the algorithm has the tendency to extend the search space and ability to explore the new area. Inertia weight of 'w' can be expressed by following equation:-

$$W = W_{max} - \frac{(W_{max} - W_{min}) * \text{present iteration}}{\text{maximum iteration}}$$

In velocity equation, there are three terms to be identify which is:-

i. wv_i^k is identify as inertia component that gives a memory of the previous direction which means the movement of the immediate past

ii. $c_1 rand_1 \times (pbest_i - s_i^k)$ is called as cognitive component. It's act as particle memory of the position that was best for the particle.

iii. $c_2 rand_2 \times (gbest_i - s_i^k)$ is recognize as social component. The reason particle moves towards the best position establish so far by the swarm.

Once each particle velocity calculation is done, it followed by position update using position update equation as shown below.

$$s_i^{k+1} = s_i^k + v_i^{k+1}$$

where,

s_i^k and s_i^{k+1} are current and update position respectively. v_i^{k+1} is called as update velocity. General flowchart for PSO algorithm is shown in Fig. 4.

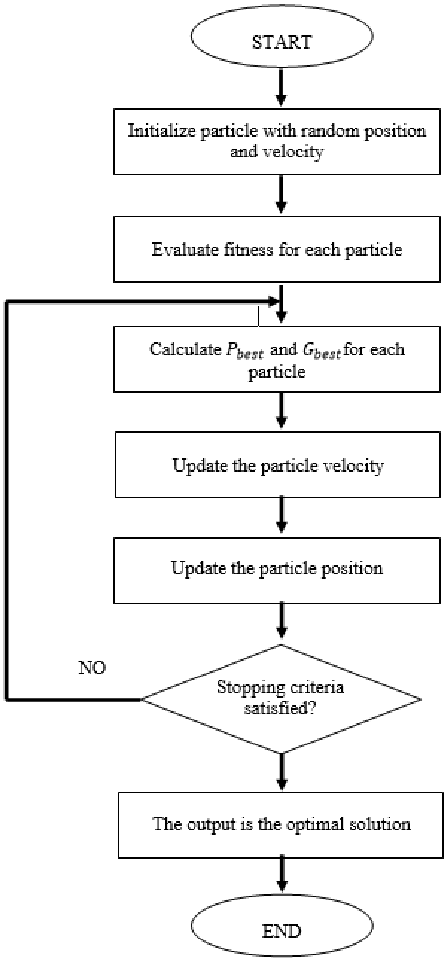

Fig. 4: Flowchart for PSO algorithm

Multi-objective optimization

Multi-objective formulations (MO) have been employed in many areas such as engineering, science and economic. In the real world application, many optimization problems engage with more than one objective to be optimized. Most of the engineering problems objectives are usually conflicting, such as maximizing of a performance, minimizing of cost, maximize reliability and many more. It is also known as optimization of conflicting objectives.

Multi-objective is associated with mathematical optimization problems involving two or more objectives function to be optimized at the same time. Usually, in some cases a single solution would not satisfy both objective functions and the optimal solution of one objective will not necessary be the best solution for other objective. Therefore, different solutions will produce trade-offs between different objectives and a set of solutions is required to represent the optimal solutions of all objectives (Sumathi & Kumar, 2016). According to (Tammam, Aboelela, Moustafam, 2012), an acceptable solution to a multi-objective problem is to evaluate a set of solution, whereby each of solution satisfies the objectives at an tolerable level without being dominated by any other solution.

The main objective of multi-objective is to find the multiple Pareto optimal solution for two or more conflict objective (Deb, Pratap, Agarwal, Meyarivan, 2002). This algorithm has become a popular among researcher and an engineer because it uses population based approach and gives various solutions in iteration and evolves a new population of solution in each iteration. As single objective optimization, multi objective optimization also has the same purpose either to minimize f(x) or maximize f(x) from objective function.

Non-dominated Set

In modern day application, when there are two objective functions to be optimized, Pareto front has been applied to get better solution in various filed such as engineering, science, business and many more. Study shows that optimizing a solution based on one single objective will not provide an optimal solution regarding the other objectives. Therefore, two main goals in a multi objective optimization are:-

- To find a number of solutions nearest to the Pareto-optimal front
- To find a set of solutions as diverse as possible

Solutions that lie along the line are known as non-dominated solution while those lie inside the line are dominated solutions. This is due to there is always another solution on the line that has at least one objective that is better. Pareto-optimal front and its corresponding value are shown in Fig. 5. The line indicates the Pareto optimal front and solution on it called Pareto-optimal solution. Pareto-optimal solutions are known as non-dominated. Therefore, it is essential in multi objective optimization to locate the best solutions as close as possible to the Pareto front and as far along it as possible.

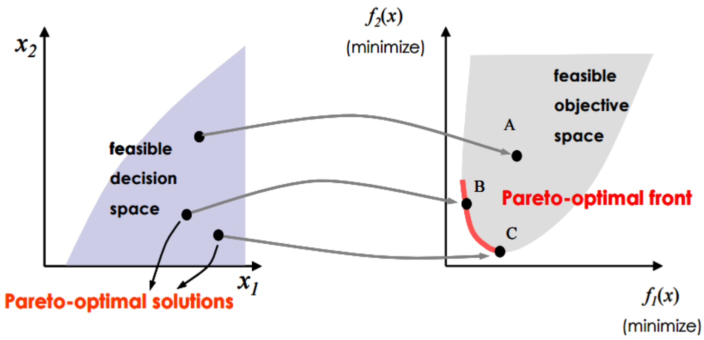

Fig. 5. Pareto optimal front and corresponding value as Pareto optimal solutions

A solution $x^{(1)}$ is said to dominate the other solution $x^{(2)}$, if both conditions 1 and 2 are true:

1) The solution $x^{(1)}$ is no worse that $x^{(2)}$ in all objectives
2) The solution $x^{(1)}$ is strictly better than $x^{(2)}$ in at least one objective

Pareto front, non-dominated and dominated solution in two objective functions can be observed in Fig. 6.

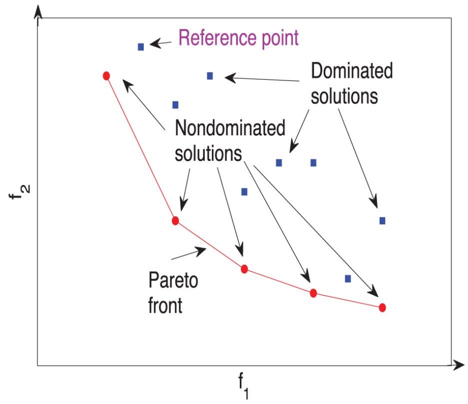

Fig. 6. Pareto front, non-dominated and dominated solution in two objective function

Results and Discussion

A two area interconnected power system are considered for this study. Simulation for multi-objective load frequency control using Particle Swarm Optimization carried out by MATLAB 8.3, SIMULINK R2014a software run on PC of i5 processor with 2.4 GHz speed and RAM of 8GB. For multi area LFC system the population size is chosen as 40 and the maximum number of iteration for optimization are 50. Besides that, the best value of constriction factor c1 and c2 are taken as C_1=C_2=2 and W_{max} = 0.9 and W_{min} = 0.4.

In order to test the implementation of multi objective PSO algorithm in LFC, there are two different optimization cases in which the controller with the proposed algorithm was employed. In all cases, PID controller parameters are tuned simultaneously for both areas and frequency response of the system are observed. In this paper, tabled step load of 10% applied in area 1 alone. Further studies can be done by applying step load of 10% in both areas to test the robustness of the system.

Since the study involved two areas, therefore two PID controllers are used in the simulation. Each PID controller have three parameters which are proportional (Kp), integral (Ki) and derivative (Kd) gain. In order to obtain the optimum parameters of PID controller, the codes for the PSO algorithm are written by using MATLAB M-file integrated with two area LFC simulink block. With optimized parameters based on PSO algorithm, the proposed proportional-integral-derivative PID controller's of the LFC can achieve lower settling time value and less maximum overshoot value in frequency deviation response.

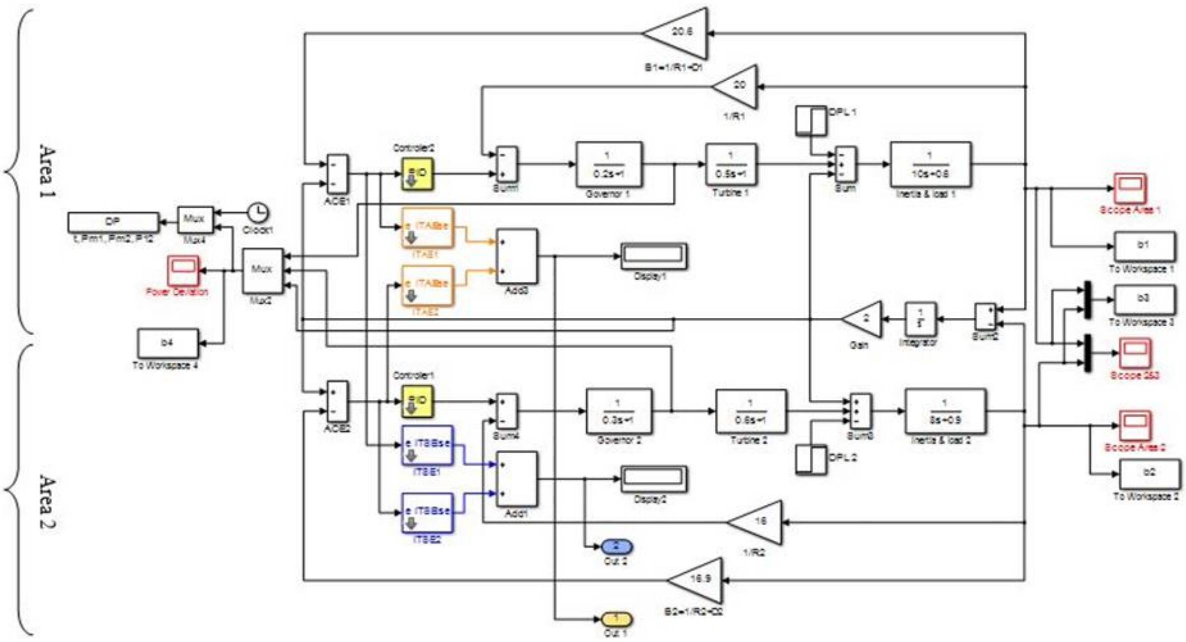

Fig. 7. Simulation block for two areas system Load Frequency Control

In this study, weighted sum technique is applied to obtain the Pareto front for two objectives. This method believed to be one of the simplest and most practical approaches solving multi objective optimization (Naidu, Mokhlis & Bakar, 2014). At the end of the analysis, non-dominated Pareto point can be obtained from Pareto optimal solutions. In order to get proper weighted value, the weighted sum value of w1 and w2 is varied from 1 to 0 with step 0.1. For each weighted value, the PSO algorithm is executed for 10 times to produce the Pareto point. The z1 represent objective function 1 and z2 is objective function 2. The value of z1 and z2 are recorded in table based on the best x value. The graph for objective 1 (z1) versus objective 2 (z2) for all the weightage set is plotted. Based on non-dominated values obtain, the optimized parameter for PID controllers can be retrieved.

Case I - Step Load Change in Area 1

Step load change of 10% is applied in Area 1 initially to test and evaluate the effectiveness of the optimized controller. The weightage set is varied in the range of 0-1 with step size 0.1. To obtain the non dominated point, all the values of z1 and z2 from all weighted sum varying from 0-1 has been plotted on a single graph as seen in Fig. 4.7.

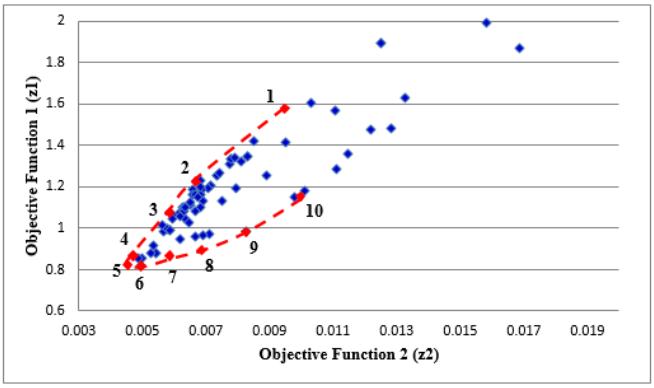

Fig. 8. Non-dominated points for step load of 10% in Area 1

Table 1. Optimum PID parameters and System performance from non-dominated points with step load in Area 1

Non-dominated point	w1	w2	z1	z2	Area 1			Area 2			System Performance (Area 1)		System Performance (Area 2)	
					Kp1	*Ki1*	*Kd1*	*Kp2*	*Ki2*	*Kd2*	Settling Time (s)	Maximum Overshoot (Hz)	Settling Time (s)	Maximum Overshoot (Hz)
1	0.2	0.8	1.5769	0.0095	1.882	0.56	0.6582	1.6725	0.216	0.9908	17.9625	0.0001	29.4121	0
2	1	0	1.227	0.0067	2	0.7325	0.4942	1.4594	0.2	2	17.257	0.0002	29.5152	0
3	1	0	1.0775	0.0059	2	0.7872	0.5066	1.146	0.274	0.9895	14.361	0.0002	28.9254	0
4	0.9	0.1	0.8645	0.0047	2	0.9013	0.4873	1.6856	0.2	2	15.8134	0.0004	29.3468	0
5	0.7	0.3	0.824	0.0045	2	0.8608	0.5329	2	0.2	1.6844	15.9495	0.0002	29.1695	0
6	0.5	0.5	0.8167	0.0049	2	0.7687	0.5793	1.8654	0.429	0.9975	12.7787	0.0001	27.977	0
7	0.2	0.8	0.8645	0.0059	2	0.6908	0.5364	1.9902	0.5515	0.7559	6.2856	0.0001	27.4646	0
8	0.3	0.7	0.8926	0.0069	1.9313	0.6305	0.5013	1.5591	0.7821	1.3538	6.5948	0.0001	26.2124	0
9	0.6	0.4	0.9844	0.0082	2	0.5515	0.5698	2	1.5315	0.8231	8.3514	0	27.1082	0
10	0.1	0.9	1.1538	0.01	2	0.4989	0.545	2	2	0.6899	9.6053	0	27.529	0

System performance of optimized controller based on non-dominated points with step load of 10% applied in area 1 shown in Table 1. The result shows that when step load in area 1 alone, the transient response of the system is within the limit. The lowest settling time for area 1 is 6.2856s and area 2 is 26.2124s. The maximum overshoot for area 1 and area 2 is 0.0004Hz and 0.0000Hz respectively. It indicates that the frequency deviation step response in area 1 changes according to the load demand.

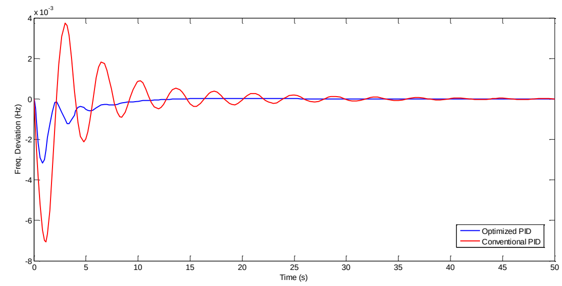

Fig. 9. Frequency Deviation in Area 1 with step load at Area 1

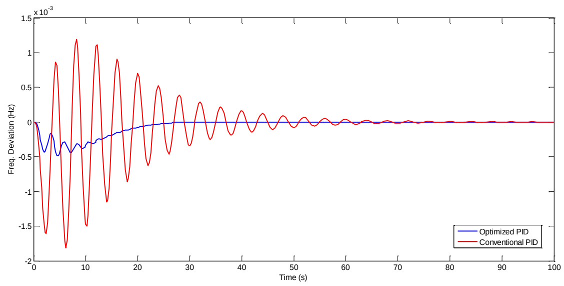

Fig. 10. Frequency Deviation in Area 2 with step load at Area 1

The optimized PID gain from non-dominated point shows that the controller is able to response well during step load change. Mechanical power change in area 1, 2 and tie-line power deviation when 10% step load at area 1 are shown in Fig. 11. The increase in load at area 1 is met by increase in generation ΔP_m1. It shows that tie -line power change reduces to zero quickly with less oscillation contrast to conventional PID as can be observed in Fig. 12.

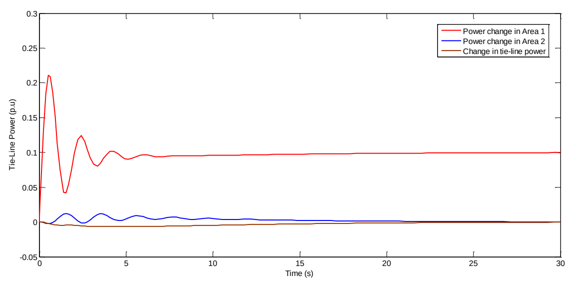

Fig. 11. Power deviation step response for optimized PID

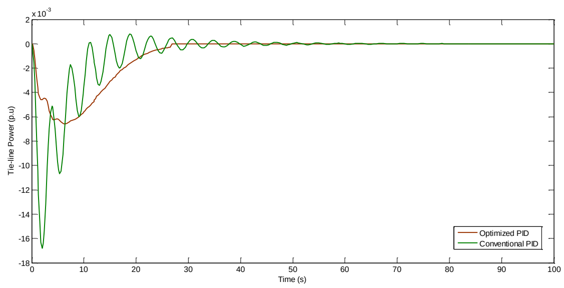

Fig. 12. Tie-line power changes with step load in Area 1

It is clearly shows that proposed controller outperforms the conventional PID controller. The weighted sum PSO based PID controller is able to settle the system with minimize overshoot value and settling time with less oscillation.

Conclusion

Power generation and load balancing is the most major requirement in power system. The increasing complexity of power system made it as challenging task to come up with proper controllers which assure stability of power system. PID controllers are known to be best control solution and if it is perfectly tuned will outperform almost any other control option. However, the challenging part is in finding the gain values for optimum performance.

In this report, two area inter-connected load frequency control are model using Matlab Simulink. Multi objective optimization using weighted sum approach is used to optimize the PID controller's parameter of the load frequency control. The nature inspired PSO algorithm is applied to tune the controllers. The frequency deviation and tie-line power deviation is observed and the result of the system performance in terms of settling time and overshoot value are presented.

Since, the study is on two area system, two PID controllers have been used to initiate the control action as quick as possible to retain the desired value by applying performance criterion as objective function. It is designed to optimize a composite set of objective functions. Analysis was carried out to identify the optimum PID parameter based on dominated and non-dominated points. The point's lies along the Pareto front are identified as non-dominated point and optimum solution for PID parameter.

Comparison has been carried out between optimized PID and conventional PID. Optimized PID based on non-dominated point was able to outperform the conventional PID controller. The effect of the load demand on system performance is observed by applying step load in area 1 alone and both areas. The step respond of the system corresponds well according to the load demand with minimum oscillation. It is shown analytically and graphically that the proposed controller gives better control performance by minimizing settling time and maximum overshoot. The PSO algorithm has proven to be effective dealing with multi objective optimization.

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