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Multi-area Load Frequency Control using IP controller tuned by Tabu Search

***Abstract**. In multi area electric power systems if a large load is suddenly connected (or disconnected) to the system, or if a generating unit is suddenly disconnected by the protection equipment, there will be a long-term distortion in the power balance between that delivered by the turbines and that consumed by the loads. This imbalance is initially covered from the kinetic energy of rotating rotors of turbines, generators and motors and, as a result, the frequency in the system will change. Therefore The Load Frequency Control (LFC) problem is one of the most important subjects in the electric power system operation and control. In practical systems, the conventional PI type controllers are carried out for LFC. In order to overcome the drawbacks of the conventional PI controllers, numerous techniques have been proposed in literatures. In this paper a IP type controller is considered for LFC problem. The parameters of the proposed IP controller are tuned using Tabu Search (TS) method. A multi area electric power system with a wide range of parametric uncertainties is given to illustrate proposed method. To show effectiveness of the proposed method, a PI type controller optimized by TS is incorporated in order to comparison with the proposed IP controller. The simulation results on a multi area electric power system emphasis on the viability and feasibility of the proposed method in LFC problem.*

***Streszczenie.** Nagłe dołaczenie lub odłączenie znacznych obciążeń powoduje zakłócenia wyrażające się zmianą częstotliwości. Tradycyjne regulatory PI w systemach LFC (Load Frequency Control) nie zawsze sobie dają radę. W artykule przedstawiono wykorzystanie metody Tabu Seach do tego celu. Metodę zilustrowano na, przykładzie wielopowierzchniowej sieci rozdzielczej z dużą liczba parametrycznych niepewności. (**System kontroli zmian częstotliwości pod wpływem zmian obciążenia bazujący na metodzie Tabu Search**)*

Keywords: Multi Area Electric Power System, Load Frequency Control, Tabu Search, IP Controller
Słowa kluczowe: sieć rozdzielcza, zmiany częstotliwości, Tabu Search

Introduction

For large scale electric power systems with interconnected areas, Load Frequency Control (LFC) is important to keep the system frequency and the inter-area tie power as near to the scheduled values as possible. The input mechanical power to the generators is used to control the frequency of output electrical power and to maintain the power exchange between the areas as scheduled. A well designed and operated power system must cope with changes in the load and with system disturbances, and it should provide acceptable high level of power quality while maintaining both voltage and frequency within tolerable limits.

Many control strategies for Load Frequency Control in electric power systems have been proposed by researchers over the past decades. This extensive research is due to fact that LFC constitutes an important function of power system operation where the main objective is to regulate the output power of each generator at prescribed levels while keeping the frequency fluctuations within pre-specifies limits. A unified tuning of PID load frequency controller for power systems via internal mode control has been proposed in [1]. In this paper the tuning method is based on the two-degree-of-freedom (TDF) internal model control (IMC) design method and a PID approximation procedure. A new discrete-time sliding mode controller for load-frequency control in areas control of a power system has been presented in [2]. In this paper full-state feedback is applied for LFC not only in control areas with thermal power plants but also in control areas with hydro power plants, in spite of their non minimum phase behaviors. To enable full-state feedback, a state estimation method based on fast sampling of measured output variables has been applied. The applications of artificial neural network, genetic algorithms and optimal control to LFC have been reported in [3, 4, 5]. An adaptive decentralized load frequency control of multi-area power systems has been presented in [6]. Also the application of robust control methods for load frequency control problem has been presented in [7, 8].

This paper deals with a design method for LFC in a multi area electric power system using a IP type controller whose parameters are tuned using TS. In order to show effectiveness of the proposed method, this IP controller is compared with a PI type controller whose parameters are tuned using TS too. Simulation results show that the IP controller guarantees robust performance under a wide range of operating conditions and system uncertainties.

Apart from this introductory section, this paper is structured as follows. The system under study and system modeling are presented in section 2. IP type controller is presented in section 3. The design methodology is developed in section 4 and the simulation results are presented in section 5.

Plant model

A four-area electric power system is considered as a test system and shown in Figure 1. The block diagram for each area of interconnected areas is shown in Figure 2 [9-10].

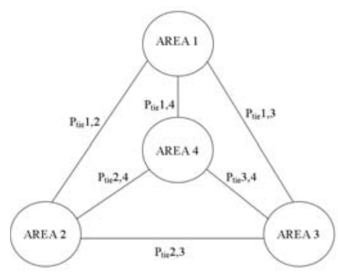


Fig.1. Four-area electric power system with interconnections

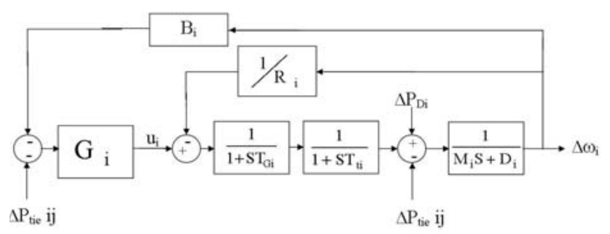


Fig.2. Block diagram for one area of system (i^{th} area)

The parameters in Figure 2 are defined as follow:

Δ: Deviation from nominal value

$M_i=2H$: Constant of inertia of i^{th} area

D_i: Damping constant of i^{th} area

R_i: Gain of speed droop feedback loop of i^{th} area

T_{ti}: Turbine Time constant of i^{th} area

T_{Gi}: Governor Time constant of i^{th} area

G_i: Controller of i^{th} area

ΔP_{Di}: Load change of i^{th} area

u_i: Reference load of i^{th} area

$B_i=(1/R_i)+D_i$: Frequency bias factor of i^{th} area

$\Delta P_{tie\,ij}$: Inter area tie power interchange from i^{th} area to j^{th} area.

Where: $i=1,2,3,4 \;\; j=1,2,3,4 \;\; and \;\; i \neq j$

The inter-area tie power interchange is as (1) [9-10].

$$\Delta P_{tie\,ij} = (\Delta\omega_i - \Delta\omega_j)(T_{ij}/s) \tag{1}$$

Where: $T_{ij} = 377(1/X_{tie\,ij})$ (for a 60 Hz system)

X_{tie-ij}: Impedance of transmission line between i and j areas

The ΔP_{tie-ij} block diagram is shown as Figure 3.

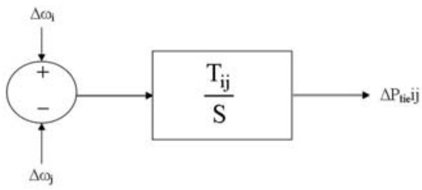


Fig.3. Block diagram of inter area tie power (ΔP_{tie-ij})

Figure 2 shows the block diagram of i^{th} area and Figure 3 shows the method of interconnection between i^{th} and j^{th} areas. The state space model of four-area interconnected power system is as (2) [9-10].

$$\begin{cases} \dot{X} = AX + BU \\ Y = CX \end{cases} \tag{2}$$

Where:

$$U = [\Delta P_{D1}\, \Delta P_{D2}\, \Delta P_{D3}\, \Delta P_{D4}\, u_1\, u_2\, u_3\, u_4]$$

$$Y = [\Delta\omega_1\, \Delta\omega_2\, \Delta\omega_3\, \Delta\omega_4\, \Delta P_{tie\,1,2}\, \Delta P_{tie\,1,3}\, \Delta P_{tie\,1,4}\, \Delta P_{tie\,2,3}\, \Delta P_{tie\,2,4}\, \Delta P_{tie\,3,4}]$$

$$X = [\Delta P_{G1}\, \Delta P_{T1}\, \Delta\omega_1\, \Delta P_{G2}\, \Delta P_{T2}\, \Delta\omega_2\, \Delta P_{G3}\, \Delta P_{T3}\, \Delta\omega_3\, \Delta P_{G4}\, \Delta P_{T4}\, \Delta\omega_4\, \Delta P_{tie\,1,2}\, \Delta P_{tie\,1,3}\, \Delta P_{tie\,1,4}\, \Delta P_{tie\,2,3}\, \Delta P_{tie\,2,4}\, \Delta P_{tie\,3,4}]$$

The matrixes ***A*** and ***B*** in (2) and the typical values of system parameters for the nominal operating condition are given in appendix. As refereed before, the IP type controller is incorporated to LFC problem. IP type controller is introduced in the next section.

It is worth to mention that in figure 2, the controller output is shown by u. in fact, the control effort signal u is summed with speed droop feedback loop signal and fed into governor. In the case of $u=u_{ref}$, the speed droop feedback loop signal plays the rule of input signal.

IP controller

As referred before, in this paper IP type controllers are considered for LFC problem. Figure 4 shows the structure of IP controller. It has some clear differences with PI controller. In the case of IP regulator, at the step input, the output of the regulator varies slowly and its magnitude is smaller than the magnitude of PI regulator at the same step input [11]. Also as shown in Figure 5, If the outputs of the both regulators are limited as the same value by physical constraints, then compared to the bandwidth of PI regulator the bandwidth of IP regulator can be extended without the saturation of the regulator output [11].

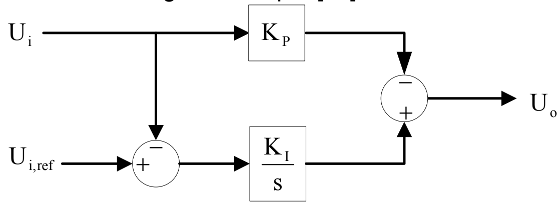


Fig.4. Structure of the IP controller

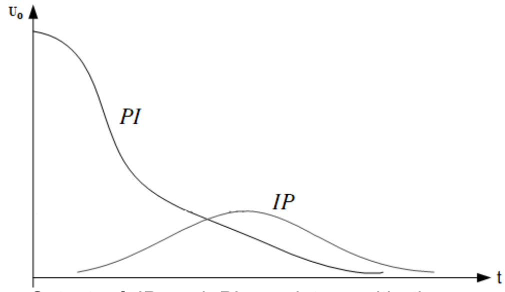


Fig.5. Output of IP and PI regulators with the same damping coefficient ($\xi = 1$) and the same band width at the same step input signal command

Design methodology

The proposed IP controller performance is evaluated on the proposed test system given in section 2. The parameters of the IP controllers are obtained using TS. In the next subsection a brief introduction about TS is presented.

Tabu search

Tabu search (TS) was first presented in its present form by Glover [12]. Many computational experiments have shown that TS has now become an established optimization technique which can compete with almost all known techniques and which - by its flexibility - can beat many classical procedures. Up to now, there is no formal explanation of this good behavior. Recently, theoretical aspects of TS have been investigated [13].

The success with TS implies often that a serious effort of modeling be done from the beginning. In TS, iterative procedure plays an important role: for most optimization problems no procedure is known in general to get directly an "optimal" solution.

The general step of an iterative procedure consists in constructing from a current solution x_i a next solution x_j *and* in checking whether one should stop there or perform another step.

In other hand, a neighborhood $N(x_i)$ is defined for each feasible solution x_i, and the next solution x_j is searched among the solutions in $N(x_j)$.

In this part we summarize the discrete TS algorithm in four steps. Assume that X is a total search space and x is a solution point sample and $f(x)$ is cost function:

1- Choose $x \in X$ to start the process.

2- Create a candidate list of non-Tabu moves in neighborhood. (x_i, $i=1,2,...,N$)

3-Find $x_{winner} \in N(x)$ such that $f(x_{winner}) < f(x_i)$, $i \neq$ winner .

4- Check the stopping criterion. If satisfied, exit the algorithm.

If not, winner $x = x_{winner}$, update Tabu List and then go to step 2.

In order to exit from algorithm, there are several criterions that are considered in our research.

1- by determining a predetermined threshold: If the value of cost function was less, algorithm would be terminated.

2- Determination of specific number of iterations.

3- If the value of the cost was remained invariable or negligible change for several iterations, algorithm would be terminated.

A didactic presentation of TS and a series of applications have been collected in [14].

IP controller tuning using TS

In this section the parameters of the proposed IP controllers are tuned using TS. The IP controller has two parameters denoted by K_P and K_I and for each area there is one IP controller. Therefore in four-area electric power system with four IP controllers, there are 8 parameters for tuning. These *K* parameters are obtained based on the TS. In section 2, the system controllers showed in Figure 2 as G_i. Here these controllers are substituted by IP controllers and the optimum values of K_P and K_I are accurately computed using TS. In optimization methods, the first step is to define a performance index for optimal search. In this study the performance index is considered as (3). In fact, the performance index is the Integral of the Time multiplied Absolute value of the Error (*ITAE*).

$$ITAE = \int_0^t t|\Delta\omega_1|dt + \int_0^t t|\Delta\omega_2|dt + \int_0^t t|\Delta\omega_3|dt + \int_0^t t|\Delta\omega_4|dt \quad (3)$$

The parameter "t" in ITAE is the simulation time. It is clear to understand that the controller with lower ITAE is better than the other controllers. To compute the optimum parameter values, a 10 % step change in ΔP_{D1} is assumed and the performance index is minimized using TS. It should be noted that TS algorithm is run several times and then optimal set of parameters is selected. The optimum values of the parameters K_P and K_I are obtained using TS and summarized in the Table 1.

Table 1. Optimum values of K_P and K_I for IP controllers

	K_P	K_I
First area IP parameters	12.0818	44.7810
Second area IP parameters	3.3793	67.6872
Third area IP parameters	1.0000	31.9223
Fourth area IP parameters	13.4795	97.3224

Results and discussions

In this section the proposed IP controller is applied to the system for LFC. In order to comparison and show effectiveness of the proposed method, the PI and I type controllers optimized by TS are designed for LFC. The optimum value of these controllers Parameters are obtained using Tabu search and summarized in the Table 2.

Table 2. Optimum values of K_P and K_I for PI and I controllers

	K_P	K_I
First area PI parameters	15.96	42.92
Second area PI parameters	2.99	59.411
Third area PI parameters	0.99	30.33
Fourth area PI parameters	10.33	90.411
First area I parameters	-	53.22
Second area I parameters	-	77.51
Third area I parameters	-	10.59
Fourth area I parameters	-	86.71

In order to study and analysis system performance under system uncertainties (controller robustness), three operating conditions are considered as follow:

i. Nominal operating condition

ii. Heavy operating condition (20% changing parameters from their typical values)

iii. Very heavy operating condition (40% changing parameters from their typical values)

In order to demonstrate the robustness performance of the proposed method, The *ITAE* is calculated following step change in the different demands (ΔP_D) at all operating conditions (Nominal, Heavy and Very heavy) and results are shown at Tables 3-4. Following step change, the IP controller has better performance than the PI and I controllers at all operating conditions.

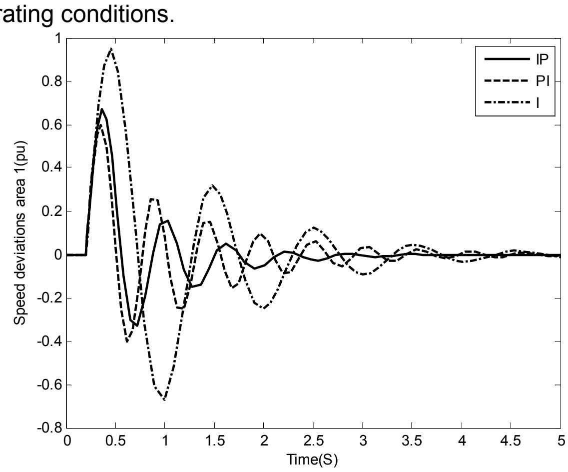
Table 3. 5% Step increase in demand of 1st area (ΔP_{D1})

	The calculated ITAE		
	IP	PI	I
Nominal operating condition	0.0022	0.0102	0.0112
Heavy operating condition	0.0042	0.0135	0.0152
Very heavy operating condition	0.0065	0.0171	0.0197

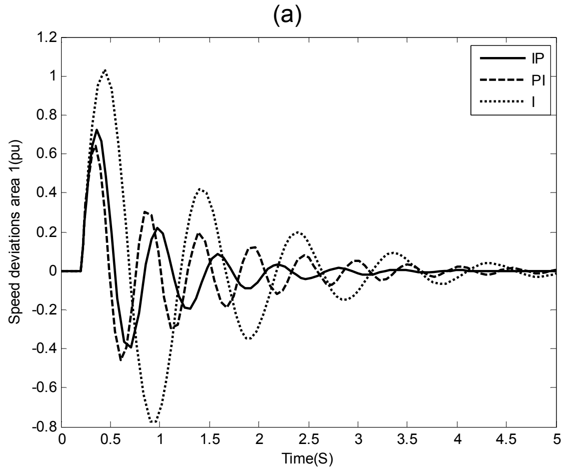
Table 4. 5% Step increase in demand of 1st area (ΔP_{D1}) and 10% step increase in demand of 3rd area (ΔP_{D3})

	The calculated ITAE		
	IP	PI	I
Nominal operating condition	0.0173	0.0188	0.0199
Heavy operating condition	0.0202	0.0323	0.0381
Very heavy operating condition	0.0243	0.0389	0.0448

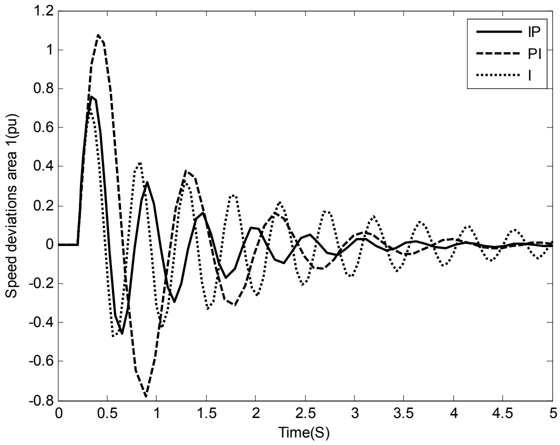
Figure 6 shows $\Delta\omega_1$ at nominal, heavy and very heavy operating conditions following 10 % step change in the demand of first area (ΔP_{D1}). It is seen that the IP controller has better performance than the other methods at all operating conditions.



(a)



(b)



(c)

Figure 6. Dynamic response $\Delta\omega_1$ following step change in demand of first area (ΔP_{D1}) - Solid (IP controller), Dashed (PI controller), Dotted (I controller) - a: Nominal b: Heavy c: Very heavy

Conclusions

In this paper a new TS based IP controller has been successfully carried out for Load Frequency Control problem. The proposed method was applied to a typical four-area electric power system containing system parametric uncertainties and various loads conditions. Simulation results demonstrated that the IP controllers capable to guarantee the robust stability and robust performance under a wide range of uncertainties and load conditions. Also, the simulation results showed that the IP controller is robust to change in the system parameters and it has better performance than the PI type controller at all operating conditions.

Appendix

The typical values of system parameters for the nominal operating condition:

1st area parameters

T_{T1}=0.035	T_{G1}=0.08	M_1=0.1667	R_1=2.4
D_1=0.0083	B_1=0.401	T_{12}=0.425	T_{13}=0.500
T_{14}= 0.400	T_{23}= 0.455	T_{24}= 0.523	T_{34}=0.600

2nd area parameters

T_{T2}=0.025	T_{G2}=0.091	M_2=0.1552	R_2=2.1
D_2=0.009	B_2=0.300	T_{12}=0.425	T_{13}=0.500
T_{14}= 0.400	T_{23}= 0.455	T_{24}= 0.523	T_{34}=0.600

3rd area parameters

T_{T3}=0.044	T_{G3}=0.072	M_3=0.178	R_3=2.9
D_3=0.0074	B_3=0.480	T_{12}=0.425	T_{13}=0.500
T_{14}= 0.400	T_{23}= 0.455	T_{24}= 0.523	T_{34}=0.600

4th area parameters

T_{T4}=0.033	T_{G4}=0.085	M_4=0.1500	R_4=1.995
D_4=0.0094	B_4=0.3908	T_{12}=0.425	T_{13}=0.500
T_{14}= 0.400	T_{23}= 0.455	T_{24}= 0.523	T_{34}=0.600

Also the matrixes A and B in (2) are as follow:

$$A=\begin{bmatrix}
\frac{-1}{T_{G1}} & 0 & \frac{-1}{R_1T_{G1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
\frac{1}{T_{T1}} & \frac{-1}{T_{T1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & \frac{1}{M_1} & \frac{-D_1}{M_1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{-1}{M_1} & \frac{-1}{M_1} & \frac{-1}{M_1} & 0 & 0 & 0\\
0 & 0 & 0 & \frac{-1}{T_{G2}} & 0 & \frac{-1}{R_2T_{G2}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & \frac{1}{T_{T2}} & \frac{-1}{T_{T2}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & \frac{1}{M_2} & \frac{-D_2}{M_2} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{M_2} & 0 & 0 & \frac{-1}{M_2} & \frac{-1}{M_2} & 0\\
0 & 0 & 0 & 0 & 0 & 0 & \frac{-1}{T_{G3}} & 0 & \frac{-1}{R_3T_{G3}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{T_{T3}} & \frac{-1}{T_{T3}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{M_3} & \frac{-D_3}{M_3} & 0 & 0 & 0 & 0 & \frac{1}{M_3} & 0 & \frac{1}{M_3} & 0 & \frac{-1}{M_3}\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{-1}{T_{G4}} & 0 & \frac{-1}{R_4T_{G4}} & 0 & 0 & 0 & 0 & 0 & 00\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{T_{T4}} & \frac{-1}{T_{T4}} & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{M_4} & \frac{-D_4}{M_4} & 0 & 0 & \frac{1}{M_4} & 0 & \frac{1}{M_4} & \frac{1}{M_4}\\
0 & 0 & T_{12} & 0 & 0 & -T_{12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & T_{13} & 0 & 0 & 0 & 0 & 0 & -T_{13} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & T_{14} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -T_{14} & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & T_{23} & 0 & 0 & -T_{23} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & T_{24} & 0 & 0 & 0 & 0 & 0 & -T_{24} & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & T_{34} & 0 & 0 & -T_{34} & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}$$

$$B = \begin{bmatrix} 0 & 0 & \frac{1}{M_1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{M_2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{M_3} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{M_4} & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{1}{T_{G1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{T_{G2}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{T_{G3}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{T_{G4}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

REFERENCES

[1] Tan W., Unified tuning of PID load frequency controller for power systems via IMC, IEEE Transactions Power Systems, 25: 1 (2010) 341-350.

[2] Vrdoljak K., Peric N., Petrovic I., Sliding mode based load-frequency control in power systems, Electric Power Systems Research, 80 (2009) 514–527.

[3] Kocaarslan I., Cam E., Fuzzy logic controller in interconnected electrical power Systems for load-frequency control, Electrical Power and Energy System, 27 (2005) 542–549.

[4] Liu F., Song Y.H., Ma J., Mai S., Lu Q., Optimal load frequency control in restructured power systems, IEE Proceedings Generation, Transmissions and Distribution, 150: 1 (2003) 87-95.

[5] *Sayed Mojtaba Shirvani Boroujeni, Babak Keyvani Boroujeni, Hamideh Delafkar and Elahe Behzadipour* "Two-Area Load Frequency Control Using IP Controller Tuned Based on Genetic Algorithms" World Applied Sciences Journal 15 (10): 1386-1390, 2011, ISSN 1818-4952, IDOSI Publications, 2011.

[6] Zribi M., Al-Rashed M., Alrifai M., Adaptive decentralized load frequency control of multi-area power systems, Electrical Power and Energy Systems, 27 (2005) 575–583.

[7] Shayeghi H., Shayanfar H.A., Malik O.P., Robust decentralized neural networks based LFC in a deregulated power system, Electric Power Systems Research, 77 (2007) 241–251.

[8] Taher S.A., Hematti R., Robust decentralized load frequency control using multi variable QFT method in deregulated power systems, American Journal Applied Sciences, 5: 7 (2008) 818-828.

[9] Wood A.J., Wollenberg B.F., Power generation, operation and control, (2003), John Wiley & Sons.

[10] Machowski, J.Bialek, J.Bumby: "Power System Dynamics. Stability and Control". John Wiley & Sons, Chichester, New York, 2008, 2009 (658 stron), ISBN 978-0-470-72558-0.

[11] Seung K.S., Control of Electric Machine Drive Systems, John Wiley & Sons, Inc. (2011) Hoboken, NewJersey.

[12] Glover F., Future Paths for Integer Programming and Links to Artificial Intelligence, Computers and Operations Research, 13 (1986), 533-549.

[13] Faigle U., Kern W., Some Convergence Results for Probabilistic Tabu Search. ORSA Journal on Computing, 4 (1992), 32-37.

[14] Glover F., Taillard E., Laguna M., de Werra D., Tabu Search, Annals of Operations Research, 41 (1993).

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