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Robust Load Frequency Regulation In a New Distributed Generation Environment

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Abstract--**A new approach based on μ-synthesis technique is proposed for the design of robust load frequency controller in response to the new technical demand for load frequency regulation in a competitive distributed generation power system. The siting of numerous generator units in distribution feeders is being encouraged by the current deregulation of the industry is likely to have an impact on the Load Frequency Control (LFC) operation of the existing power systems.**

In this approach the overall power system will be divided to some distribution areas. Each area is modeled as a collection of distributed generators to supply the area-load. The area is responsible to perform its own LFC by using an independent robust controller. An example for a distribution area is given to illustrate the proposed approach. The resulting controller is shown to minimize the effect of disturbances and achieve acceptable frequency regulation in presence of uncertainties and load variation.

Index Terms--**Load frequency control, Robust control, Multi-machine power system, μ-synthesis, Distributed generation.**

I. Introduction

CURRENTLY, the electric power industry is in transition from large, vertically integrated utilities providing power at regulated rates to an industry that will incorporate competitive companies selling unbundled power at lower rates. On the other hand with increasing the various demands the number of small and large generators in private or regular format is increased. These changes introduce a set of significant uncertainties in power system control and operation, especially on LFC problem solution. The classical LFC based on the conventional Area Control Error (ACE) [1] is difficult to implement in the new structure and comes the need for novel control strategies to maintain the reliability and eliminates the frequency error (Δf).

Under current organizations, several notable approaches based on classical, optimal, adaptive and robust control theorems have already been proposed. The H∞-based method for an area with two generator units is given in [2]. [3] has proposed the flexible neural network based load frequency controller for the same example. [4-9] discuss on some general issues for solution of LFC problem for multi-machine power system after deregulation. [10] has addressed some technical and economic issues associated with integrating numerous small scale generators in to the distribution system, in a competitive electric market. The impacts of distributed generation by siting of numerous independent generators on stability of power system frequency are shown in this reference.

This paper addresses the new design of robust load frequency controller based on μ -synthesis technique developed by Doyle [11-12], for interconnected large-scale electric power systems for a possible structure in the new multi-machine environment. The new power system structure consists of a collection of control areas interconnected through high voltage transmission lines or tie-lines. Each control area has its own load frequency controller and is responsible for tracking its own load and honoring tie-line power exchange contracts with its neighbors.

Therefore, according to this scenario the large scale power system is divided to some distribution areas and the area-system is modeled as a collection of independent generator units to supplying the area-load. In the proposed strategy one generator unit is responsible for tracking the load and hence performing the load frequency control task by securing as much transmission and generation capacity as needed. We will discuss on area example including three generator units and we will show that designed controller guarantees robust stability and robust performance for a wide range of operating conditions. The preliminary steps of this work are presented in [6-7, 13].

This paper is organized as follows. Section 2 describes an area model with three generator units, as an example. The synthesis methodology for the given structure is presented in section 3. Section 4 demonstrates the effectiveness of proposed scheme by some simulation results.

II. MODEL DESCRIPTION

A typical multi-generator distribution area is shown in Fig. 1. In this example the Generator unit 2 (Gunit 2) and Generator unit 3 (Gunit 3) are the main supplier for area-load and Generator unit 1 (Gunit 1) is considered to LFC responsibility. In other word the area delivers firm power from Gunit 2 and Gunit 3, and enough power from Gunit 1 to supply its load and support the LFC task. Generator units produce electric power that is delivered to the load either directly or through the transmission unit (Tunit). In a deregulated power system, Gunit 1, Gunit 2 and Gunit 3, can be corresponded to three independent Generator company (Genco), and, Tunit corresponds to a Transmission company (Transco). In deregulated environment the load management

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and LFC task may be done by Independent System Operator (ISO) [4] or Distribution company (Disco) [3].

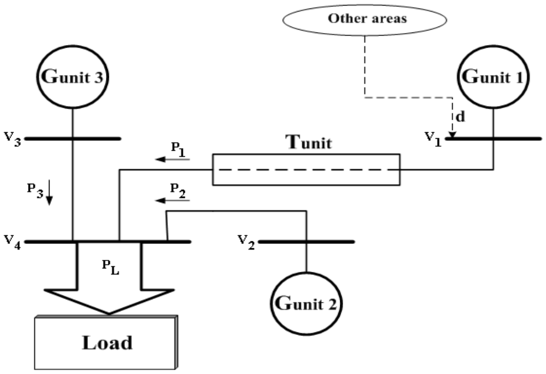


Fig. 1. A distributed generation area

The objective is supplying power to area load at a nominal frequency. In case of a load disturbance Gunit 1 will adjust its output accordingly to track the load changes and maintain the energy balance. Connections of this area to other areas are considered as disturbances (*d*). For simplicity assume that each Gunit has one generator. The linearized dynamics of the generators are given by:

$$\frac{2H_1}{f_0}\frac{d\Delta f_1}{dt} = \Delta P_{M1} - \Delta P_1 - d - D_1\Delta f_1$$

$$\frac{2H_i}{f_0}\frac{d\Delta f_i}{dt} = \Delta P_{Mi} - \Delta P_i - D_i\Delta f_i \ ; \quad i = 2,3 \qquad (1)$$

$$\frac{d\Delta\delta_i}{dt} = 2\pi\Delta f_i \ ; \quad i = 1,2,3$$

where

Δ : deviation from nominal value

H_i : constant of inertia

D_i : Damping constant

f_o : nominal frequency

f_i : frequency

δ_i : rotor angle

P_M : turbine (mechanical) power

d : disturbance (power quantity).

The generators are equipped with a speed governor. The simplest models of speed governors and turbines associated with generator *i* are given by:

$$\frac{d\Delta P_{Vi}}{dt} = -\frac{1}{T_{Hi}}\Delta P_{Vi} + \frac{K_{Hi}}{T_{Hi}}\left(\Delta P_{refi} - \frac{1}{R_i}\Delta f_i\right)$$

$$\frac{d\Delta P_{Mi}}{dt} = -\frac{1}{T_{Mi}}\Delta P_{Mi} + \frac{K_{Mi}}{T_{Mi}}\Delta P_{Vi} \ ; \quad i = 1,2,3 \qquad (2)$$

where

P_V : steam valve power

T_M and T_H : time constants of turbine and governor

K_M and K_H : gains of turbine and governor

R_i : droop characteristic

P_{refi} : reference setpoint (control input)

Assuming $\Delta\delta_{ij} = \Delta\delta_i - \Delta\delta_j$ and T_i is equal to synchronizing power coefficient of line *i* connected to the load bus (bus 4), we can obtain the state space model of given area as:

$$\dot{x} = Ax + Bu + Fw \qquad (3)$$

where:

$$x^T = \begin{bmatrix}\Delta f_1 & \Delta P_{M1} & \Delta P_{V1} & \Delta\delta_{12} & \Delta f_2 & \Delta P_{M2} & \Delta P_{V2} & \Delta\delta_{13} & \Delta f_1 & \Delta P_{M1} & \Delta P_{V1}\end{bmatrix}$$

$$w^T = \begin{bmatrix}\Delta P_L & d\end{bmatrix}; \ u = \Delta P_{ref1}$$

$$A = \begin{bmatrix}
-D_1T_{P1} & T_{P1} & 0 & -\frac{\alpha T_{P1}}{T_3} & 0 & 0 & 0 & -\frac{\alpha T_{P1}}{T_2} & 0 & 0 & 0 \\
0 & -\frac{1}{T_{M1}} & \frac{K_{M1}}{T_{M1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\frac{K_{H1}}{R_1T_{H1}} & 0 & -\frac{1}{T_{H1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
2\pi & 0 & 0 & 0 & -2\pi & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & T_{P2}T_2 - \frac{\alpha T_{P2}T_2}{T_1T_3} & -D_2T_{P2} & T_{P2} & 0 & -\frac{\alpha T_{P2}}{T_1} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & -\frac{1}{T_{M2}} & \frac{K_{M2}}{T_{M2}} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & -\frac{K_{H2}}{R_2T_{H2}} & 0 & -\frac{1}{T_{H2}} & 0 & 0 & 0 & 0 \\
2\pi & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -2\pi & 0 & 0 \\
0 & 0 & 0 & T_{P3}T_3 - \frac{\alpha T_{P3}}{T_1} & 0 & 0 & 0 & -\frac{\alpha T_{P3}T_3}{T_1T_2} & -D_3T_{P3} & T_{P3} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{1}{T_{M3}} & \frac{K_{M3}}{T_{M3}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{K_{H3}}{R_3T_{H3}} & 0 & -\frac{1}{T_{H3}}
\end{bmatrix}$$

$$B^T = \begin{bmatrix}0 & 0 & \frac{K_{H1}}{T_{H1}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\end{bmatrix}$$

$$F^T = \begin{bmatrix}-\frac{\alpha T_{P1}}{T_2T_3} & 0 & 0 & 0 & -\frac{\alpha T_{P2}}{T_1T_3} & 0 & 0 & 0 & -\frac{\alpha T_{P3}}{T_1T_2} & 0 & 0 \\ -T_{P1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\end{bmatrix}$$

$$\alpha = \frac{T_1T_2T_3}{(T_i + T_2 + T_3)}, T_{Pi} = \frac{f_0}{2H_i}$$

III. DESIGN METHODOLOGY

A. Proposed framework

The objective is to formulate the LFC problem as a μ-control design problem. The state-space model is based on (3), however to meeting our design goals, (3) needs to be augmented to include the rotor angle of Gunit 1 since one of objectives of LFC problem is to guarantee that the frequency will return to its nominal value following a step disturbance. Hence, the state vector becomes:

$$x^T = \begin{bmatrix}\Delta f_1 & \Delta P_{M1} & \Delta P_{V1} & \Delta\delta_{12} & \Delta f_2 & \Delta P_{M2} & \Delta P_{V2} & \Delta\delta_{13} & \Delta f_1 & \Delta P_{M1} & \Delta P_{V1} & \Delta\delta_1\end{bmatrix}$$

The augmented nominal system has the following state-space model:

$$G_0: \quad \dot{x} = \bar{A}x + \bar{B}u + \bar{F}w \qquad (4)$$

where

$$\bar{A} = \begin{bmatrix}A & 0_{11\times 1} \\ 2\pi & 0_{1\times 11}\end{bmatrix}; \bar{B} = \begin{bmatrix}B \\ 0\end{bmatrix}; \bar{F} = \begin{bmatrix}F \\ 0\end{bmatrix}.$$

Analogously to the traditional area control error (ACE), let the output system variable as follow:

$$y = Cx + Ew \tag{5}$$

where

$C = [\beta_1 \;\; 0 \;\; 0 \;\; 1 \;\; \beta_2 \;\; 0 \;\; 0 \;\; 1 \;\; \beta_3 \;\; 0 \;\; 0 \;\; 1]$, $E = [1 \;\; 0]$

and $\beta_i = D_i + 1/R_i$ is the frequency response characteristic of unit i.

We now proceed to design a robust controller using the μ-synthesis approach. The objective is to design a controller that will result in a stable closed-loop system and minimize the effects of the worst disturbances or exogenous inputs on the output variable. To achieve our objectives and according to μ-synthesis requirements we have proposed the control strategy as shown in Fig. 2. In fact this figure shows the main framework and synthesis strategy for obtaining desired controller.

It is notable that in model of power system there are several uncertainties because of parameter variations, model linearization and unmodeled dynamics due to some approximations. However to keep the complexity of the controllers reasonably low, depending on the given area power system, we can focus on the most important uncertainty. The uncertainties in power system can be modeled as multiplicative and/or additive uncertainties [14]. In Fig. 2 the Δu block models the uncertainty as a multiplicative type and W_u is associated weighting function.

According to requirement performance and practical constraint on control action, three fictitious uncertainties W_{P1}, W_{P2} and W_{P3} are added to power system model. The W_{P1} on the control input sets a limit on the allowed control signal to penalize fast change and large overshoot in the control action. This is necessary in order to guarantee implement ability of the resulting controller.

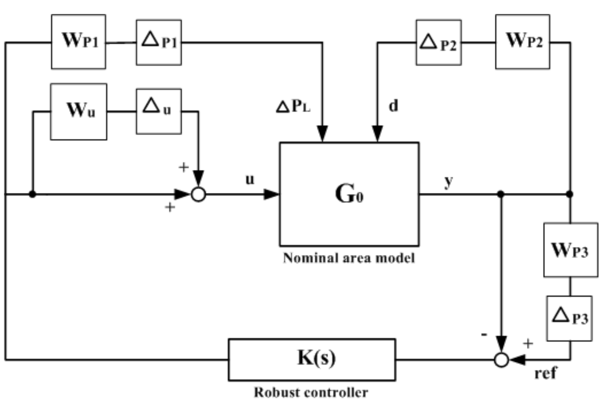


Fig. 2. The synthesis framework

The weights W_{P2} and W_{P3} at the output sets the performance goal e.t. tracking/regulation on the output area control signal. Further more it is notable that in order to reject disturbances and to good tracking property, W_{P2} and W_{P3} must be such select that singular value of sensitivity transfer function from control input u to output y be reduced at low frequencies [15]. Δp_1, Δp_2 and Δp_3 are uncertainty blocks associated with W_{P1}, W_{P2} and W_{P3} respectively. We can redraw the Fig. 2 as a standard M-△ configuration, which is shown in Fig. 3.

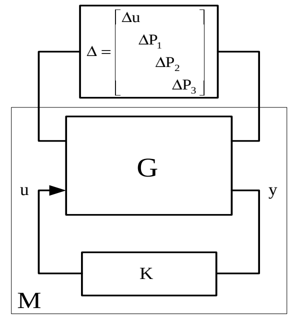


Fig. 3. M-△ configuration.

G includes the nominal model of area power system, associated weighting functions and scaling factors. The block labeled M, consists of G and controller K. Now, the synthesis problem is designing the robust controller K. Based on the μ-synthesis, the robust stability and performance holds for a given M-△ configuration (Fig. 3), if and only if

$$\inf_{K} \sup_{\omega \in R} \mu[M(j\omega)] < 1. \tag{6}$$

Using the performance robustness condition and the well-known upper bound for μ, the robust synthesis problem reduces to determine

$$\min_{K} \inf_{D} \sup_{\omega} \bar{\sigma}(D\, M(j\omega) D^{-1}),$$

or equivalently $\quad \min_{K,D} \left\| D\, M(G,K)(j\omega) D^{-1} \right\|_{\infty}$,

by iteratively solving for D and K (D-K iteration algorithm) [16]. Here D is any positive definite symmetric matrix with appropriate dimension and $\bar{\sigma}(.)$ denotes the maximum singular value of a matrix. For deeper insights into the theory, the interested reader is referred to [11-12, 16].

The controller found by this procedure is typically of a high order. In order to decrease the complexity of computation, appropriated model reduction techniques might be applied to the obtained controller model. The proposed strategy guarantees the robust performance and robust stability for closed-loop system.

In summary, the proposed method consists of the following steps:

Step 1: Identify the uncertainty blocks and associated weighting functions for the given area, according to dynamic model, practical limits and performance requirements, as shown in Fig. 2.

Step 2: Isolate the uncertainties from nominal model, generate Δp_1, Δp_2, Δp_3 and Δu blocks; and performing M-△ feedback configuration (formulate the robust stability and performance).

Step 3: Start the D-K iteration using μ-synthesis toolbox [16] to obtain the optimal controller.

Step 4: Reduce the order of result controller by utilizing the standard model reduction techniques and apply μ-analysis to closed loop system with reduced controller to check whether or not upper bound of μ remains less than one.

B. Apply to area example

B. 1 Design objectives The system is shown in (4) is unstable. Calculation the eigenvalue sensitivity of matrix $\overline{A}$ in (4) to the parameters shows that the unstable mode is most sensitive to H_1 . Therefore in this paper, our focus (in viewpoint of uncertainty) is concentrated on variation of H_1 parameter or per unit inertia constant related to Gunit 1.

This uncertainty in Fig. 2 is modeled as an unstructured multiplicative uncertainty. In this figure W_u represent the fixed weighting function containing all the information available about the H_1 variation corresponds to Gunit 1.

For the problem at hand (Fig. 1), we have set our objectives (robust stability and performance) as follow:

1-Holding stability in presence of H_1 variation between 4 and 10; $4 \le H_1 \le 10$. The nominal value is $H_1 = 6$.

2-Holding stability and desired reference tracking for $0 \le \Delta P_L(\%) \le 10$.

3-Minimizing the effectiveness of input step disturbance from outside area (*d*).

4-Maintaining acceptable overshoot and settling time on frequency deviation and power changing at Gunits' terminals.

5- Set reasonable limit on control action signal in change speed and amplitude viewpoint.

B. 2 Selection of weighting functions According to Fig. 2, now we must choose necessary uncertainty blocks and associated weighting functions. As it is mentioned in previous section, we can consider the specified uncertainty in power system area as a multiplicative uncertainty (W_u) associated with nominal model $G_0(s)$.

Let $\hat{G}(s)$ denote the transfer function from the control input *u* to control output *y* at operating points other than nominal point ($H_1 = 6.$). Following a practice common in robust control, we will represent this transfer function as

$$\hat{G}(s) = G_0(s)(1 + \Delta_u(s)W_u(s)) . \tag{7}$$

Then the multiplicative uncertainty block can be expressed as

$$\left|\Delta_u(s)W_u(s)\right| = \left|[\hat{G}(s) - G_0(s)]G_0(s)^{-1}\right| \ ; \ G_0(s) \ne 0 . \tag{8}$$

$W_u(s)$ is fixed weighting function containing all the information available about the frequency distribution of the uncertainty, and where $\Delta_u(s)$ is stable transfer function representing model uncertainty. Furthermore, without loss of generality (by absorbing any scaling factor into $W_u(s)$ if necessary), it can be assumed that

$$\left\|\Delta_u(s)\right\|_\infty = sup_\omega\left|\Delta_u(s)\right| \le 1 \tag{9}$$

Thus, $W_u(s)$ is such that its respective magnitude Bode plot covers the Bode plot of all possible plants. Some sample uncertainties corresponding to different values of H_1 are shown in Fig. 4. We can see that multiplicative uncertainties have a peak around the 4 rad/s. This peak becomes larger and steeper as the H_1 decreases. Based on this figure, the following multiplicative uncertainty weight was chosen for control design:

$$W_u(s) = \frac{1.5s^2}{s^2 + 0.6s + 10} \tag{10}$$

The magnitude frequency responses of $W_u(s)$ is also shown in Fig. 4. This figure clearly show that attempting to cover the sharp peak around the 4 rad/s will result in large gaps between the weight and uncertainty at other frequencies, introducing conservatism at that frequency range. On the other hand, a tighter fit at all frequencies using higher order transfer function will result in high-order controller. The weight (10) used in our design provides a good tradeoff between robustness and controller complexity.

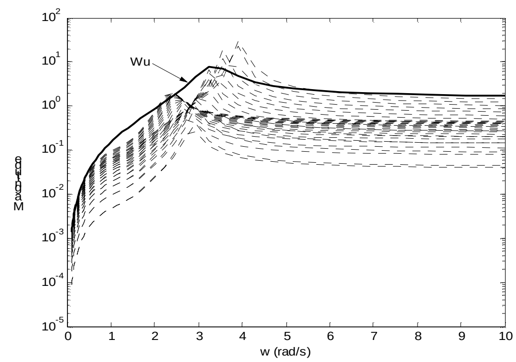


Fig. 4. Uncertainty due to changes of H_1 .

The robust controller *K(s)* must be computed to meet design objectives. An important issue in regard to selection of the weights is the degree to which they can guarantee the satisfaction of design objectives. For the problem at hand a suitable set of performance weighting functions is:

$$W_{p1}(s) = \frac{0.05s + 10^{-5}}{500s + 0.01} \ , \ W_{p2}(s) = \frac{0.35s + 0.1}{s + 10^{-4}} \ , \ W_{p3}(s) = \frac{0.2s + 4\times 10^{-6}}{300s + 1}$$

The selection of W_{P1} , W_{P2} and W_{P3} entails a trade off among different performance requirements, particularly good area control error minimization versus peak control action. The weight on the control input W_{P1} was chosen that penalize fast change and large overshoot in the control input. The weights on input disturbance from other areas (W_{P2}) and output error (W_{P3}) were chosen close to an integrator at low frequencies in order to get disturbance rejection, good tracking and zero steady-state error.

Finally, we know that to reject disturbances and to track command signal property, it is required that singular value of sensitivity function be reduced at low frequencies, W_{P2} and W_{P3} be such select that this condition satisfied. More details on how these weighting functions are chosen, is given in [13, 15]. Our next task is to isolate the uncertainties from the nominal plant model and redraw the system in the standard M- Δ configuration. Having setup our robust synthesis problem in terms of the standard μ-theory, we used the μ-analysis and synthesis toolbox [16], to obtain a solution.

The controller K(s) is found at the end of the Three D-K iteration yielding the value of about 0.9992 on the upper bound on μ, thus guaranteeing robust performance. The resulting controller has a high order (24*th*). The controller is reduced to a 8*th* order with no performance degradation, using the standard Hankel Norm reduction. The state space realization of the reduced order controller is:

$$\begin{aligned} \dot{\hat{x}} &= A_k \hat{x} + B_k y \\ u &= C_k \hat{x} + D_k y \end{aligned} \qquad (11)$$

where

$$A_k = \begin{bmatrix} -67.46 & 45.999 & -22.019 & 0.7718 & -0.6737 & 0.0015 & -0.0283 & -0.2112 \\ -45.999 & -152.44 & 111.96 & -22.958 & 11.968 & -280.2 & 54.238 & 3.8787 \\ 22.019 & 111.96 & -83.326 & 21.011 & -9.8533 & 0.02315 & -0.4519 & -3.2096 \\ 77.178 & 22.958 & -21.011 & -1.7743 & 2.9453 & -0.0064 & 0.1060 & 0.8603 \\ 0.6737 & 11.968 & -9.8533 & -2.9453 & -7.9094 & 0.0237 & -1.3222 & -3.7082 \\ -0.0015 & -0.028 & 0.0232 & 0.0064 & 0.0237 & -0.0001 & 0.0272 & 0.0129 \\ -0.02827 & -0.5424 & 0.4519 & 0.106 & 1.3222 & -0.0272 & -0.0306 & -1.7090 \\ 0.2112 & 3.8787 & -3.2096 & -0.8603 & -3.7082 & 0.01295 & 1.7090 & -2.2472 \end{bmatrix},$$

$$B_k = [2.6624 \quad 32.16 \quad -21.183 \quad -1.7825 \quad -1.3023 \quad 0.003 \quad 0.0563 \quad -0.4137]^T,$$
$$C_k = [2.6624 \quad -32.16 \quad 21.183 \quad -1.7825 \quad 1.3023 \quad -0.003 \quad 0.0563 \quad 0.4137],$$
$$D_k = [0].$$

The Bode plots of the full-order controller and the reduced-order controller are shown in Fig. 5.

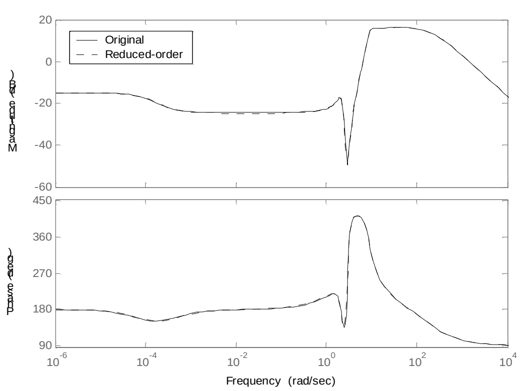


Fig. 5. Bode plots comparison of full-order controller (original) and the reduced-order controller.

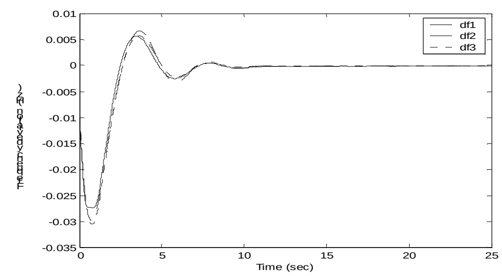
IV. SIMULATION RESULTS

In order to demonstrate the effectiveness of the proposed method, some simulations were carried out. In these simulations, the proposed load frequency controller described in section 3 was applied to the multi-machine power system described in section 2. Data is given in Table 1.

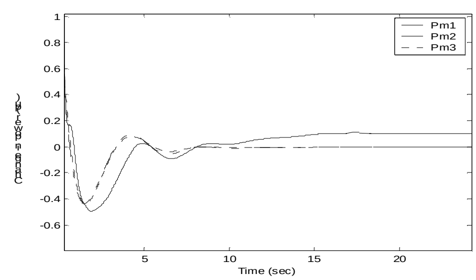
Figure 6 shows the frequency deviation, power change at Gunits and control action signal, following a 10% increase in the area load. In Fig. 6(a) *df1*, *df2* and *df3* are corresponded to Δf_1, Δf_2 and Δf_3 at Gunit 1, Gunit 2 and Gunit 3, respectively. At steady-state the frequency is back to its nominal value.

TABLE I
DATA FOR SIMULATION

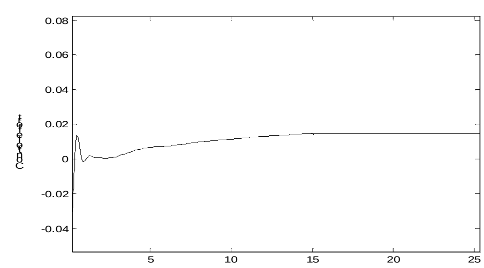
Quantity	*Gunit 1*	*Gunit 2*	*Gunit 3*
Rating (MW)	1000	800	600
Constant of Inertia: H(sec)	6	6	6
Damping: D (pu MW/Hz)	0.02	0.015	0.012
Droop characteristic:R(%)	4	5	5
Generator's: $T_P = (2H/f_0)^{-1}$	5	5	5
Turbine's Time Constant: T_M	0.5	0.5	0.5
Governor's Time Constant: T_H	0.2	0.1	0.15
Gains: K_M, K_H	1	1	1
Synchronizing coefficients: T_i	0.2	0.1	0.15



(a)



(b)



(c)

Fig. 6. (a) Frequency deviation, (b) Change in power supplied to area, and, (c) Control action signal, following a 10% load increase.

Fig. 6(b) shows the change in power coming to the area from Gunits. This figure Shows power is initially coming from all Gunits to respond to the load increase which will result in a frequency drop that is sensed by the speed governors of all machines. But after few seconds and at steady-state the additional power is coming from Gunit 1 and other generator units do not contribute to the LFC problem solution. Fig. 6(c) shows the according control action signal.

Fig. 7 demonstrates the out side disturbance rejection property of closed loop system. This figure shows the frequency deviation at Gunits following a step disturbance of d=0.01 pu to area from other area at t=15s. Power system is started up with a 10% area-load increase, already.

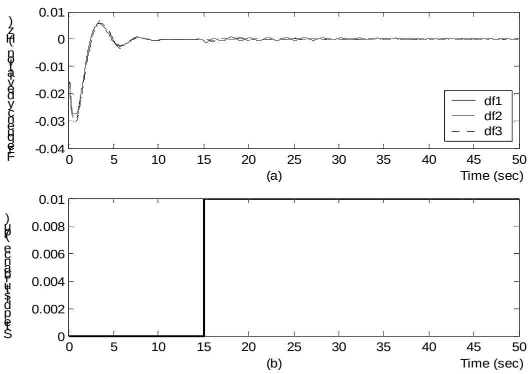


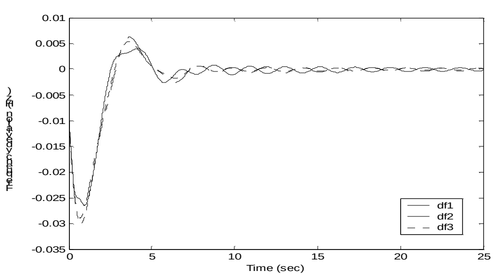
Fig. 7. Frequency deviation at Gunits if: $\Delta P_L = +10\%\ ; t \in [0\ \ 45]s$ and $d = 0.01\ pu\ ; t \in [15\ \ 45]s$.

Finally, figures 8 presents the robustness of closed loop power system in presence of H_1 variation (for worst cases) and area-load change, simultaneously. Fig. 8a shows the frequency deviation at Gunits for:

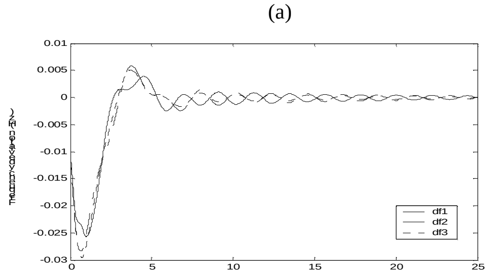
$$H_1 = H_{1min} = 4,\ \Delta P_L = +10\%\ \ ;\ \ t \in [0\ \ 25]s$$

and Fig. 8b shows the same responses for:

$$H_1 = H_{1max} = 10,\ \Delta P_L = +10\%\ \ ;\ \ t \in [0\ \ 25]s$$



(a)



(b)

Fig. 14. Frequency deviation at Gunits for:

(a) $H_1 = H_{1\,min} = 4,\ \Delta P_L = +10\%\ \ ;\ \ t \in [0\ \ 25]s$

(b) $H_1 = H_{1\,max} = 10,\ \Delta P_L = +10\%\ \ ;\ \ t \in [0\ \ 25]s$

V. CONCLUSION

In this paper a new method for robust load frequency controllers using μ-synthesis in a distributed generation power system has been proposed. Design strategy includes enough flexibility to setting the desired level of stability and performance, and, considering the practical constraint by introducing appropriate uncertainties.

The proposed method was applied to a typical multi-generator power system. Simulation results demonstrated that the designed controller is capable to guarantee the robust stability and robust performance such as precise reference frequency tracking and disturbance attenuation under a wide range of parameter variation and area-load conditions. In summary because of the flexibility of synthesis procedure to modeling uncertainty, possibility of direct formulation of performance objectives and practical constraints, the proposed control strategy can be chosen as an appropriate control scenario for competitive distributed generation power systems.

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