THE STUDY OF DYNAMIC BEHAVIOUR OF INTERLINKEDPOWER SYSTEM USING SIMULINK

Deepak Mishra[1],Sumanta Kumar Nanda[2], Sanjoy Mandal[3]

[1,2] M.Tech Student , [3]Associate Professor, Department of Electrical Engg.

ISM, Dhanbad, (India)

ABSTRACT

Practically all power system is interconnected in nature. In multi area interlinked power system the variation in load is a big obstacle .The basic intent of automatic load frequency control is to maintain total generation of system with total system requirement so that the frequency and the real power exchange with associated system are unaffected. Any dissembling between generated power and the consumed power results variation in system frequency scheduled frequency. The variation in frequency causes the system collapse, so in order to avoid such a problem we have to control the frequency variation in interlinked power system. This paper presents different Simulink results which shows the dynamic behavior of multi area interrelated power system with different conventional controller with 1% step load change, and it is found that these results are improved with the help of optimal control technique i.e. LQR method.

Keywords*: *Automatic generation control, tie line power, optimal controller, Area control error etc.

I INTRODUCTION

In previous years, largemodification have been done into the power system across the world. For the efficient and feasible operation of interlinked power system, itis required to maintain the total generation with the total demand along with system losses. Generally in present days all power systems are interconnected with their neighboring areas. In an interlinked power system the load is changes continuously so corresponding real power also changes which ultimately effect the system frequency. In orderto maintain the system frequency and real power demand the generator input must be regulated accordingly. In a large interlinked power system manual regulation of generator input is very difficult, so for this purpose there are various automatic controlling devices are used to control the generator input. These devices are basically the controllers which reduces the difference between total generation and total demand. The mismatch between total generation and total demand causes system frequency change from its schedule value, which ultimately resulting the system collapse [1-2]. Now in this paper the dynamic response of isolated power system, two area power system as well as three area power system are analyzed with PI and PID controller, these responses are improved by the use of optimal control mechanism(by LQR) [3-8]. The utilization of the advance optimal control mechanism (LQR) on power system shows that an optimal controller can provide better system response[9-14]. This paper ends with the simulation results of these controllers which shows that the dynamic behavior of power system is improved with the help of optimal control scheme in comparison to PI, PID controller[15].

II MODELLING OF POWER SYSTEM

2.1 An isolated power system with ALFC

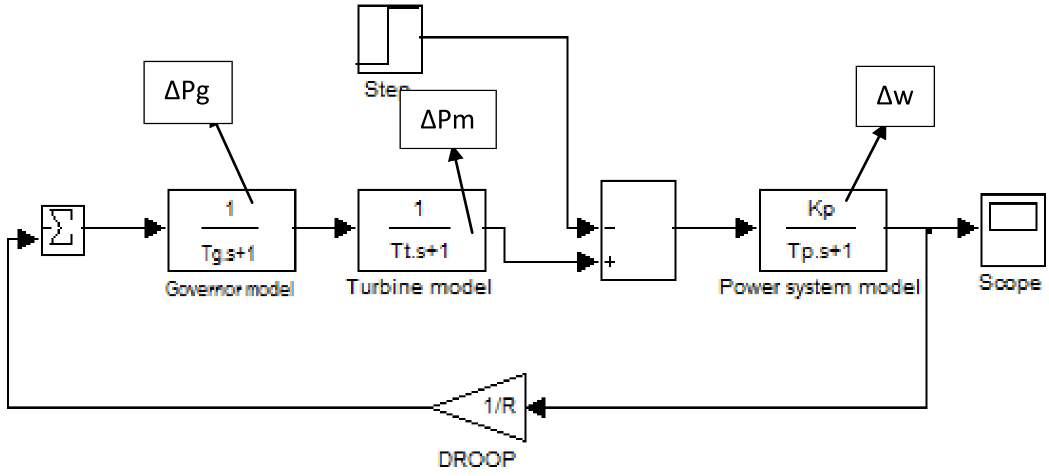


Fig .1: Single area power system without controller

Where Δwis the change in frequency for a step change in load. Here the change in frequency is not zero, so to keep frequency at its schedule value,a PI controller will be use.

2.2 Isolated power system employing Integral controller

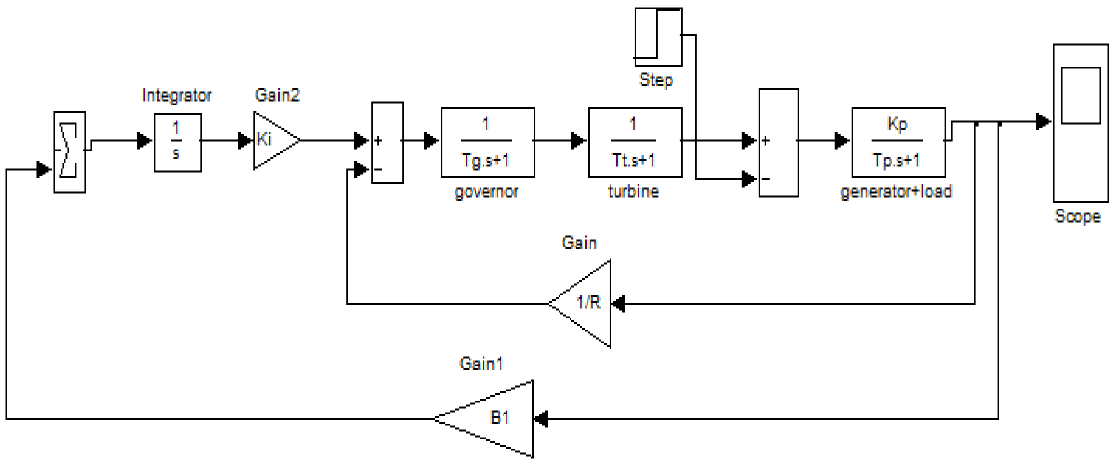


Fig.2

The automatic load frequency control loop (ALFC) is shown in fig.2.Here we use secondary loop which keeps thefrequency its nominal value. To maintain Δw=0 an integrator is used. Basically the integrator is used to measure the average error during a particularperiod of time and will remove the offset. The ability to retain its nominal value, this property of integrator is called rest action. As load on system changes continuously, so to maintain frequency at its nominal value the generation is adjusted automatically[16].

2.3 Designing of two area interlinked power system using integral controller

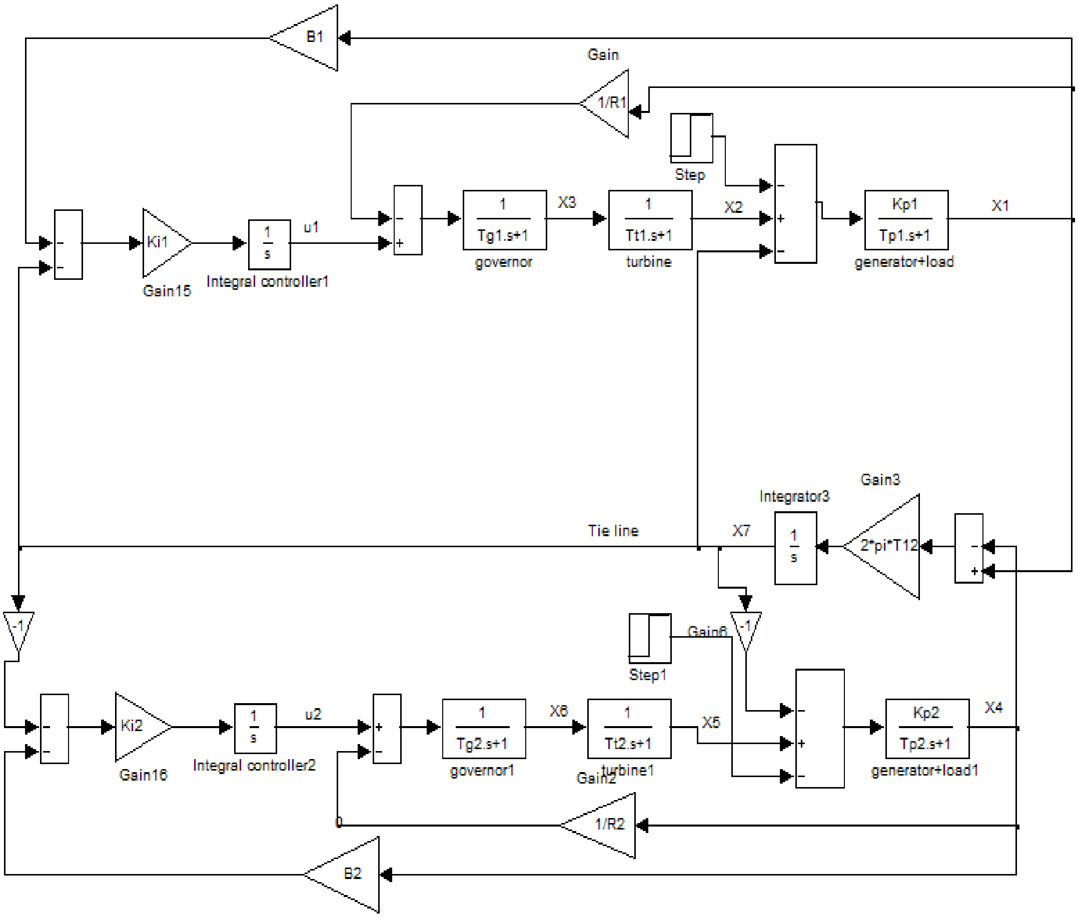


Fig.3

The block diagram representation of two interlinked power system with non-reheat turbine shown in fig.3. The two area are interconnected with the help of tie line.Both the area are provided by integral controller. There are total nine blocks which represent whole two area interconnected power system. The state equation can be formed easily with the help of transfer function of blocks. There are two controlling input namedu_1 and u_2[2] [5] [9].

Equation of controlling input is written as

For area 1

$\dot{u_1} = -Ki1(B_1 x_1 + x_7)$………………………… (1)

For area 2

$\dot{u_2} = -Ki2(B_2 x_4 - x_7)$………………………….. (2)

2.4 Linearization of two area interconnected power system using state space analysis

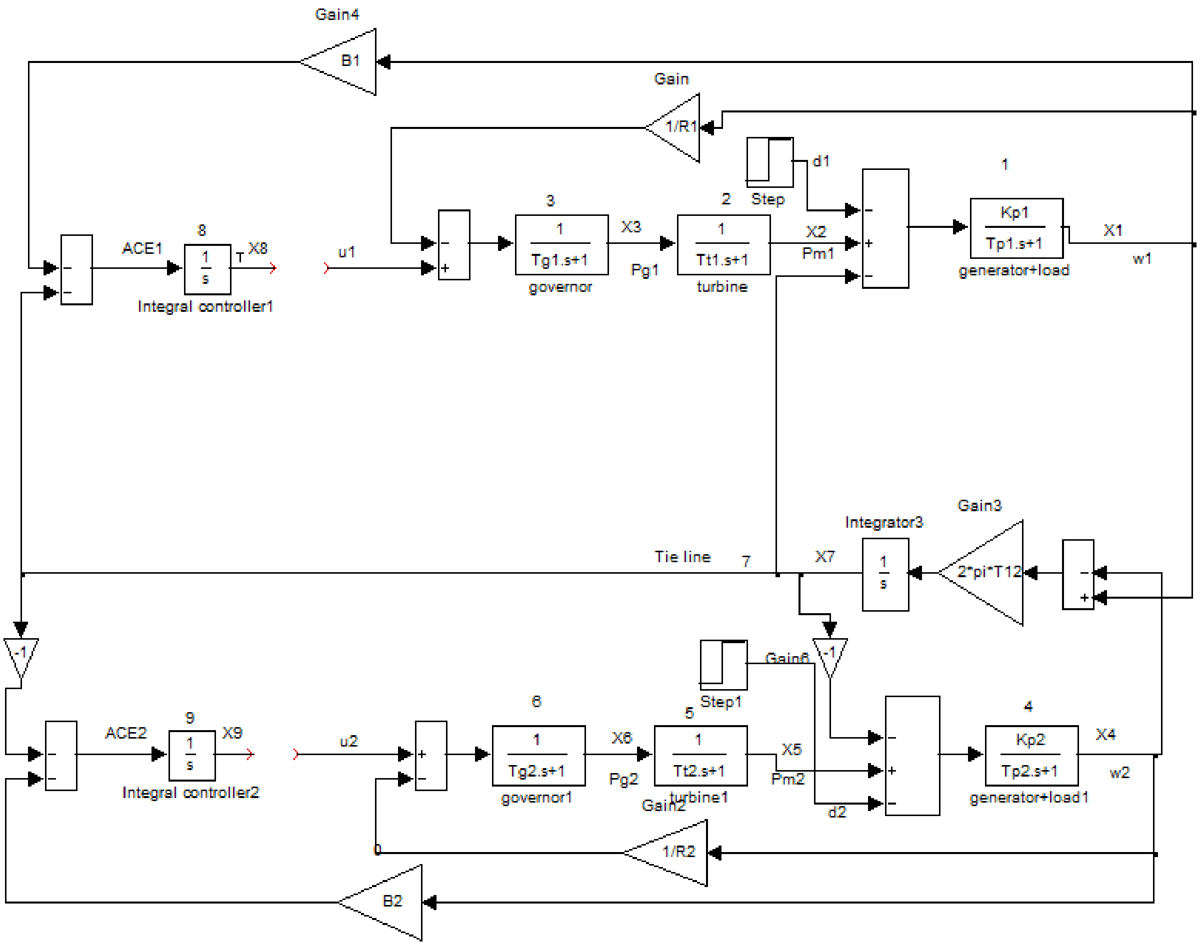


Fig.4

The generalized state space representation of two interconnected power system shown in fig.4. d1 and d2 are the disturbances in area1 and area2 respectively.

The state equations can be written as

For block 1

$x_1 + T_{p1}\dot{x}_1$= Kp1 $(x_2 - x_7 - d1)$

$\dot{x}_1$= $-\frac{1}{Tp1}x_1+\frac{Kp1}{Tp1}x_2 - \frac{Kp1}{Tp1}x_7 - \frac{Kp1}{Tp1}d1$……………………………………….. (3)

For block 2

$\dot{x_2} = -\frac{1}{Tt1}x_2 + \frac{1}{Tt1}x_3$ ………………………..……………………………………… (4)

For block 3

$\dot{x}_3 = -\frac{1}{R1\,Tg1} - \frac{1}{T_{g1}}x_3 + \frac{1}{T_{g1}}u_1$……………………………………………….. (5)

For block 4

$\dot{x}_4 = -\frac{1}{Tp1}x_4 + \frac{K_{p2}}{T_{p2}}x_{5+}\frac{K_{p2}}{T_{p2}}x_7 - \frac{K_{p2}}{T_{p2}}d2$…………………………………… (6)

For block 5

$\dot{x}_5 = -\frac{1}{T_{t2}}x_5 + \frac{1}{T_{t2}}x_6$…………………………………………………………………… (7)

For block 6

$\dot{x}_6 = -\frac{1}{R_2 T_{g2}}x_4 - \frac{1}{T_{g2}}x_6 + \frac{1}{T_{g2}}u_2$………………………………………………… (8)

For block 7

$\dot{x}_7 = 2\pi T_{12}x_1 - 2\pi T_{12}x_4$………………………………………………………… (9)

For block 8

$\dot{x}_8 = B_1 x_1 + x_7$………………………………………………………………………….. (10)

For block 9

$\dot{x}_9 = B_2 x_4 - x_7$……………………………………………………………………………. (11)

In general form these state equation can be written in single state equation

$\dot{X} = Ax + Bu + Fd$…………………………………………………………………… (12)

Where A is a matrix of order 9×9 called state matrix, B is a matrix of order 9×2 called control matrix and F is a matrix of order 9×2.

And the vector ‘x’,‘d’, ‘u’ is written as

x= $[x_1 x_2 x_3 x_4 x_5 x_6\, x_7 x_8 x_9]^T$, u =$\begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$, d=$\begin{bmatrix} d_1 \\ d_2 \end{bmatrix}$

2.5 Designing of optimal controller

The performance of system can be described in terms of cost which is to be minimized by LQR technique.

J = $\frac{1}{2}\int_0^{\infty}(x^T Qx + u^T Ru)dt$……………………………………………………………… (13)

Where ‘Q’ is ‘state weight matrix’ which is positive semi definite matrix. And ‘R’ is control semi definite symmetric weight matrix. The value of Q and R chosen according to requirement of the system.

For designing of optimal controller put

$u = -Kx$

Where feedback gain matrix 'K' is obtained by the solution of Riccati equation, which is given as

$A^T P + PA - PBR^{-1}B^T P + Q$ …………………………………………………………… (14)

$K = R^{-1}B^T P$ ……………………………………………………………………………….. (15)

The system with state feedback is given by

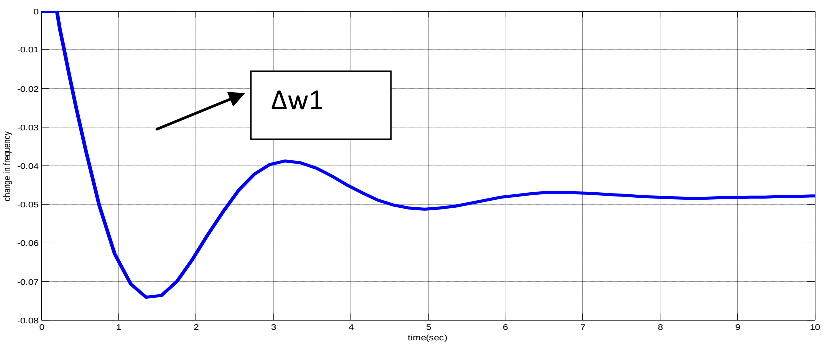
$\dot{x} = (A - BK)x$

For the stability of system the eigenvalues of $(A - BK)$ must have negative real part.

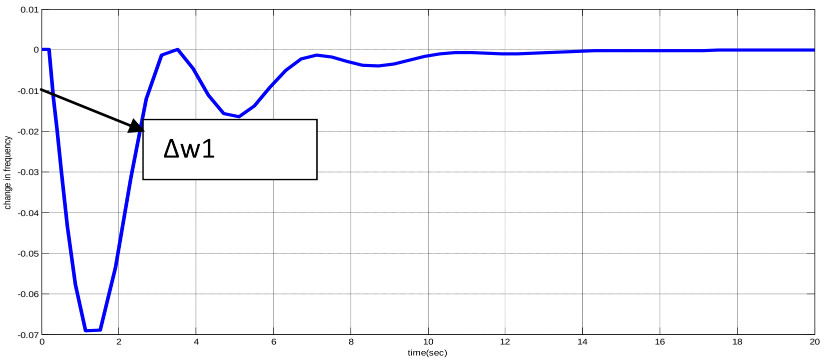
By MATLAB command $[K, P] = lqr2(A, B, Q, R)$

III SIMULATION RESULTS

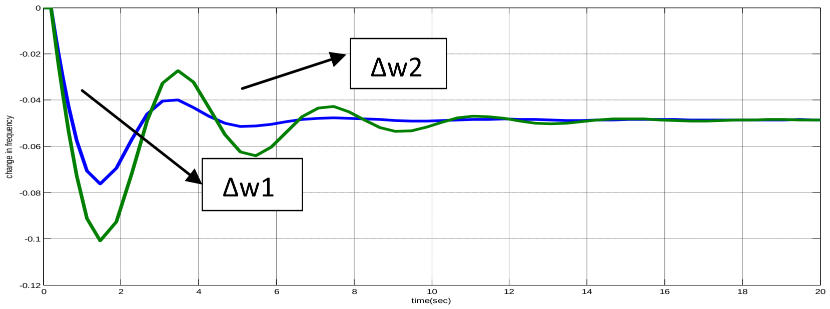
The results of Simulink are shown with PI and PID controller and the disturbance is taken as 1% for the systems. Later these results are improved by advance optimal control system.



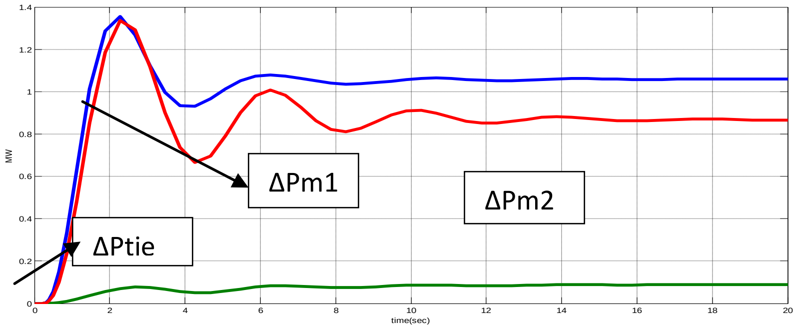
Frequency response of single area without controller



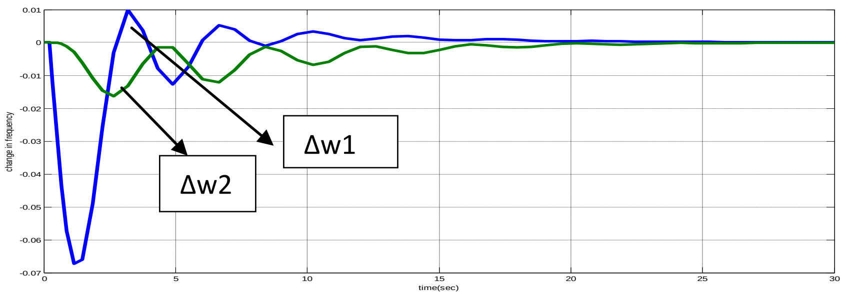
Frequency response of single area using integral controller



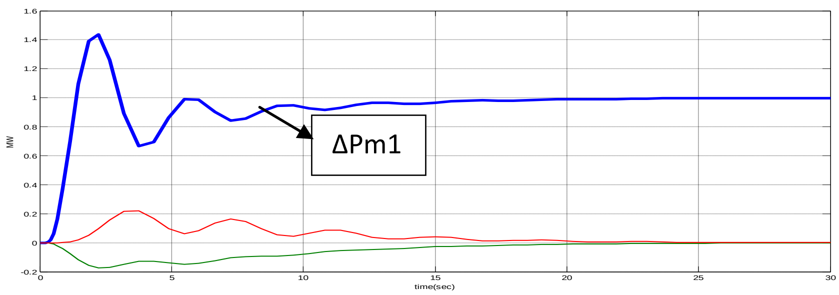
Frequency response of two area without controller



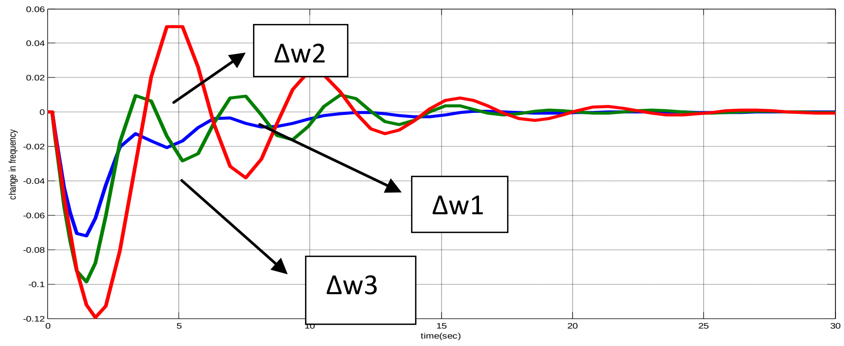
Power deviation of two area without controller



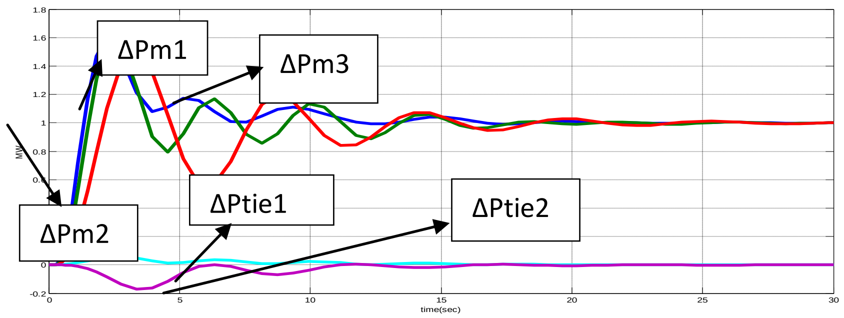
Frequency response of two interlinked power systemusing integral controller



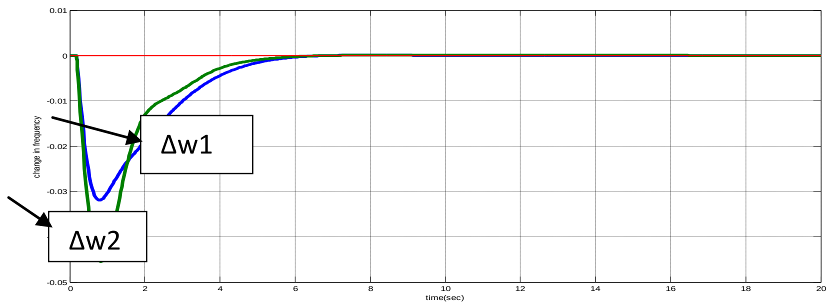
Power deviation response of two interlinked power system using integral controller



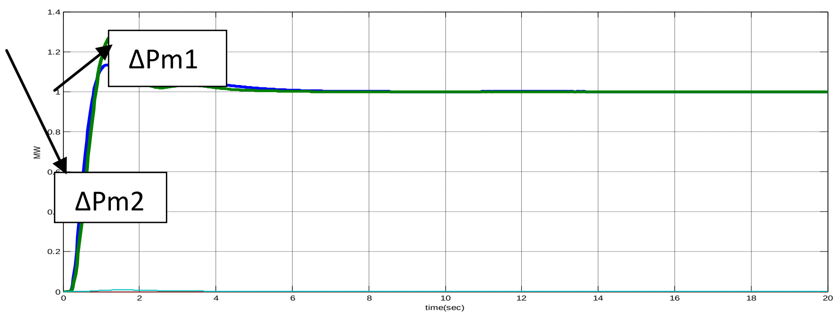
Frequency response of three interlinked power system using integral controller



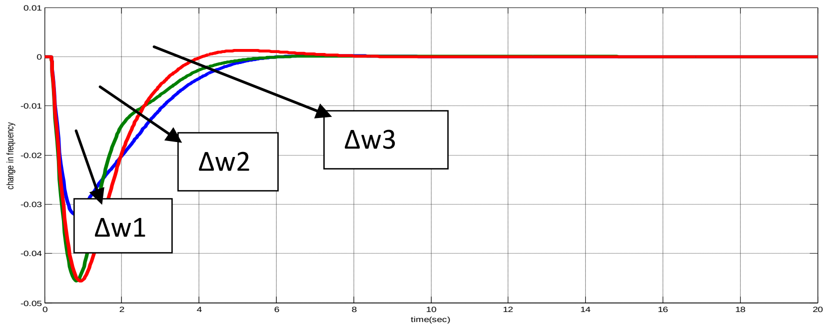
Power deviation of three interlinked power system using integral controller



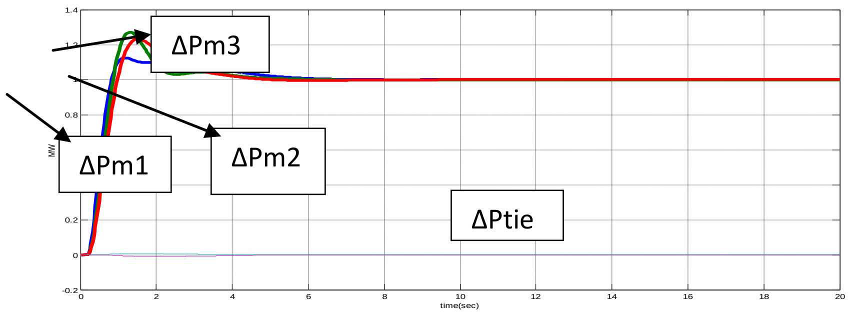
Frequency response of twointerlinked power system using PID controller



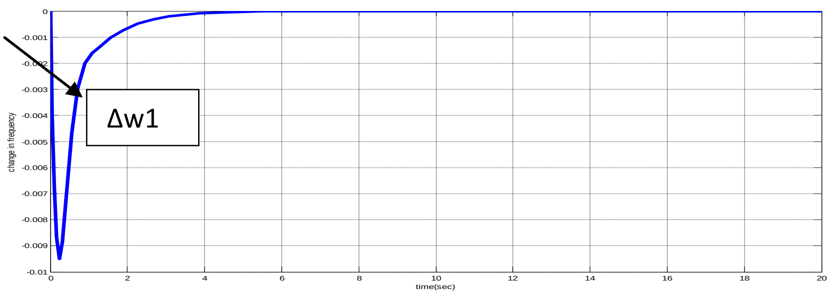
Power deviation response of two interlinked power system using with PID controller



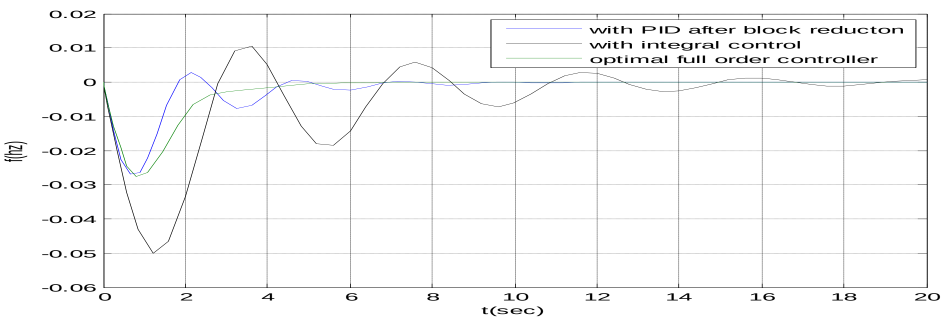
Frequency response of three interlinked power system using with PID controller



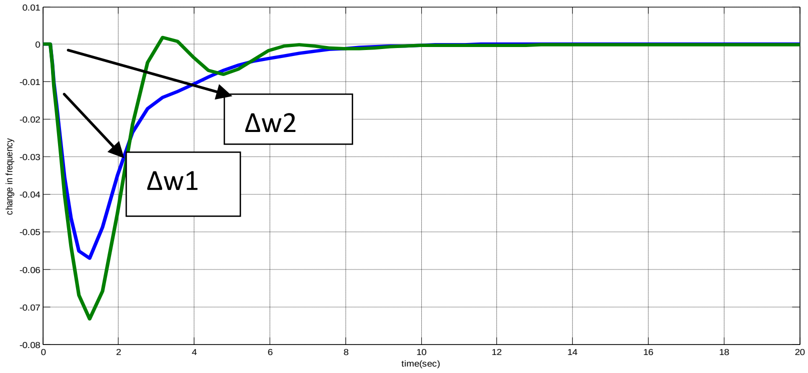
Power response of three interlinked power system using with PID controller



Frequency response of single area using optimal controller



Comparative study of simulation result (for first area)



Frequency response of two interlinked power system optimal controller (LQR technique)

IV CONCLUSIONS

In this paper the dynamic behavior of single area, two area and three area interlinked power system is examine with various controllers. It is found that PID controller gives better performance than PI controller. We have also tried to develop an optimal controller for two area interconnected power system. Finally it is concluded that LQR method gives more improved response in comparison to PI and PID controller.

Appendix:

System parameters –

$T_{g1} = 0.2$ pu

$T_{t1} = 0.5$ pu

$T_{p1} = 12.5$ pu

$K_{p1} = 1.25$ pu

$T_{g2} = 0.3$ pu

$T_{t2} = 0.6$ pu

$T_{p2} = 8.88$ pu

$K_{p2} = 1.11$ pu

2*pi*$T_{12} = 1.4$ pu

$R_1 = 0.05$ pu

$R_2 = 0.0625$ pu

$B_1 = 20.6$ pu

$B_2 = 17$ pu

For PID controller (3 area power system)

K_P	K_I	K_D
0.63	0.74	0.93
0.91	0.875	1.0
1.20	1.15	1.2

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