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Simulation Study of Integrated Market Systems Considering Energy Sources of a Two Area Interconnected Systems in Deregulated Environment

G. Ganesan Subramanian[1], I.A.Chidambaram[2], J. Samuel Manoharan[3]
[1]*Research Scholar, Department of Electrical Engineering, Annamalai University, Annamalainagar, Tamil Nadu*
[2 3]*Professor, Department of Electronics & Communication Engineering, Bharathiyar College of Engineering & Technology, Karaikal, Pondicherry*

Abstract: ***This paper deals with a new reach of obtaining the results of various energy sources in a integrated market systems with a deregulated environment. A conventional PI controller is used for the determining optimal controller gains K_P, K_I from the performance index curves for the various cases based on integral square error criterion. The simulation results are discussed for the various regulated systems with improved dynamic response by introducing a small perturbation and dealt with the different case studies of bilateral contracts. Results reveal that two area Thermal – Thermal systems gives satisfactory operation and remains stable.***
Keywords: - Load- Frequency Control (LFC), PI controller, Energy sources, Integral square area criterion, Automatic Generation Control (AGC).

I. INTRODUCTION

In an electric power system, which is one of the most complicated systems among any non-natural systems, Load Frequency Control (LFC) has always been an important and critical issue [1-3]. Therefore, many configurations of power system model, variety of control strategies and a number of controllers have been proposed in the literature for making LFC more effective, robust, adaptive and efficient. For large scale electric power systems with interconnected areas [4] 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. Load frequency control is basic control mechanism in the power system operation.

Whenever there is variation in load demand on a generating unit, there is a momentarily an occurrence of unbalance between real-power input and output. This difference is being supplied by the stored energy of the rotating parts of the unit [11-12]. Load Frequency Control (LFC) is being used for several years as part of the Automatic Generation Control (AGC) scheme in electric power systems. One of the objectives of AGC is to maintain the system frequency at nominal value (50 Hz).

II. MODELLING OF POWER SYSTEMS IN A DEREGULATED ENVIRONMENT

A. Two area Hydro – Thermal System

Fig.1 shows the Thermal non reheat power system and Fig.2 shows Reheat Power System with GRC and GDB non-linearities [3]. The contractual power exchange between any two areas is being carried out by tie line. The amount of power transfer is directly proportional to the strength of tie line. Recently there is a voice to increase more interconnection of hydro and thermal areas rather than thermal, due to easy availability of water source. The following section describes the modeling of thermal and hydro system separately.

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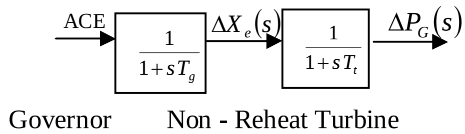


Fig.1. Thermal non-Reheat Power System

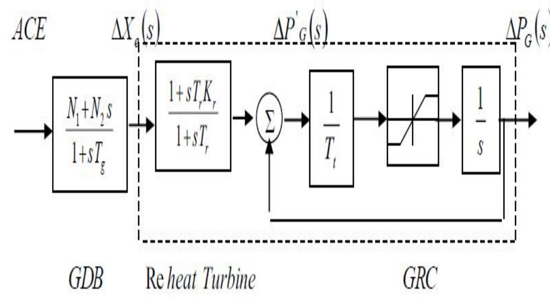


Fig.2 Transfer function of a Thermal Reheat Power System with GRC and GDB non-linearities

Simulation of the hydro-thermal model needs to develop the same. Here, transfer function model of LFC system is proposed. Each component in the LFC system is modeled in block diagram with the help of transfer function, say, governor, turbine, power system etc.

B. Two area Thermal – Diesel system

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid [5].

Proper sizing of diesel generators is critical to avoid low-load or a shortage of power. Sizing is complicated by the characteristics of modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies. The diesel electric power plants are used as Peak load plant and can be easily started or stopped at a short notice to meet the peak demand or as Mobile plants which can be mounted on trailers can be used for temporary or emergency purposes or as standby unit.

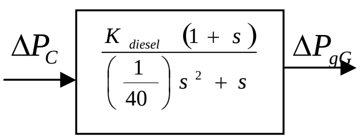


Fig.3 Transfer Function representation of a Diesel Power Plant

The diesel power plant has the following drawbacks like high operating cost, high maintenance and lubrication cost, capacity is restricted, Noise problem, cannot supply overload, unhygienic emissions and the life of the diesel power plant is less (7 to 10 years) as compared to that of a steam power plant which has a life span of 25 to 45 years.

C. Two area Thermal - Gas Power Plant system

Gas turbines are used to power aircraft, trains, ships, electrical generators, pumps, gas compressors and tanks [6]. A power station, also referred to as a power plant or power house and sometimes generating station or generating plant, is an industrial facility for the generation of electric power. Most power stations contain one or more generators, a rotating machine that converts mechanical power into electrical power. The relative motion between a magnetic field and a conductor creates an electrical current. The energy source harnessed to turn the generator varies widely. Most power stations in the world burn fossil fuels such as coal, oil, and natural gas to generate electricity. Others use nuclear power, but there is an increasing use of cleaner renewable sources such as solar, wind, wave and hydroelectric.

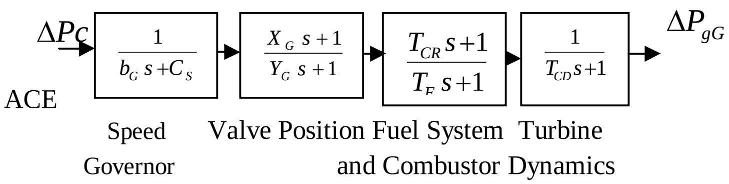


Fig.4 shows the new transfer function LFC model with single stage reheat turbine in heavy duty gas system area are considered for deregulated environment.

D. Two area Thermal – Thermal system

The model for Thermal – Thermal system interconnected power systems with integral control scheme to design optimal controllers and stability studies of these power system models have been dealt with in this area. The discrete versions of these power system models have also been obtained [13-14].

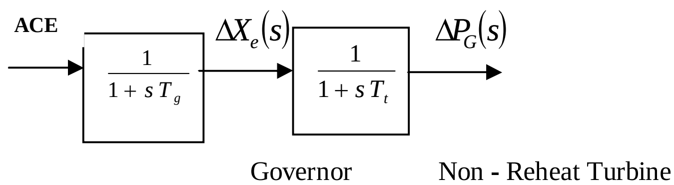


Fig.5 Transfer function of a Thermal Non-Reheat Power System

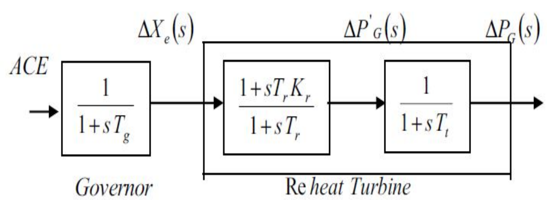


Fig.6 Transfer function of a Thermal Reheat Power System

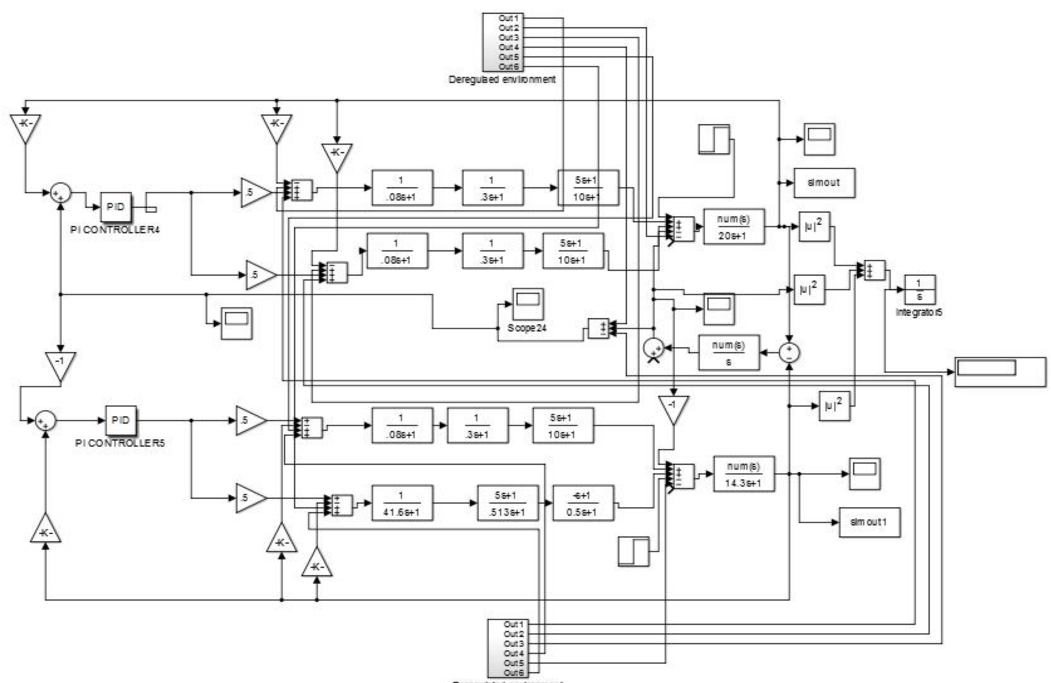


Fig.7 Simulation model of Two area Hydro – Thermal System

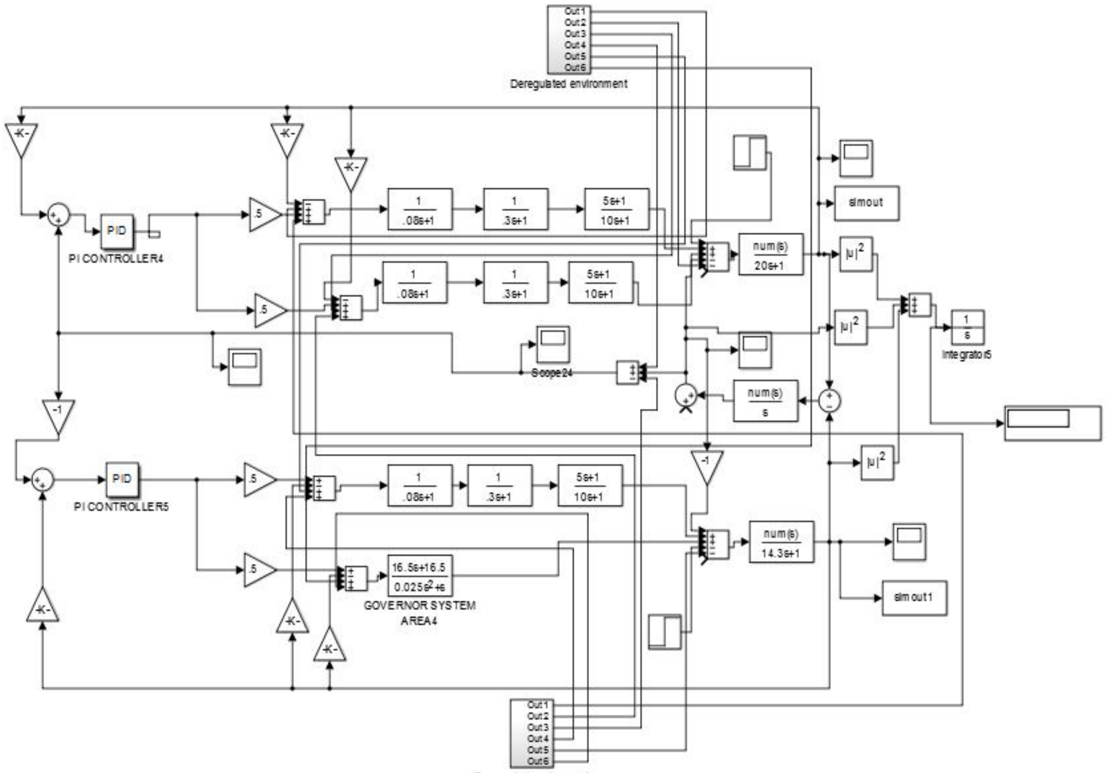


Fig.8 Simulation model of Two area Thermal - Diesel System

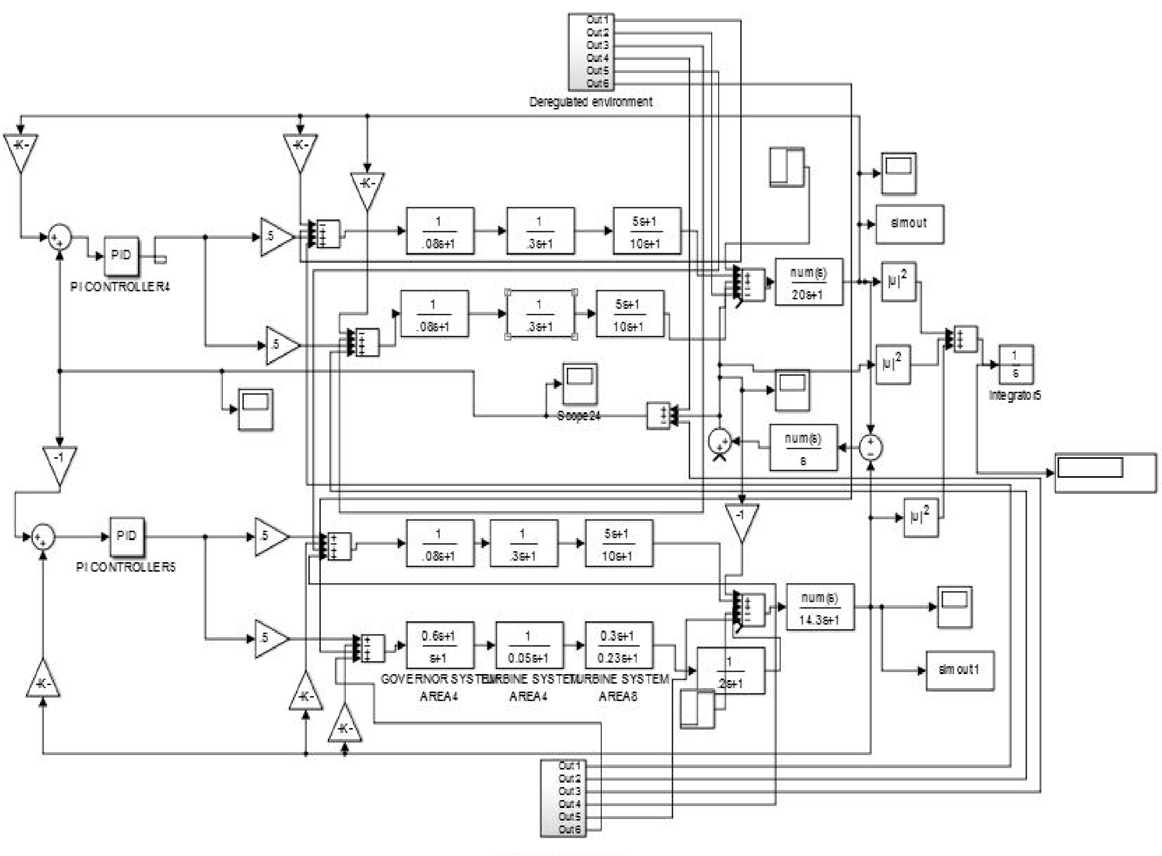


Fig.9 Simulation model of Two area Thermal - Gas System

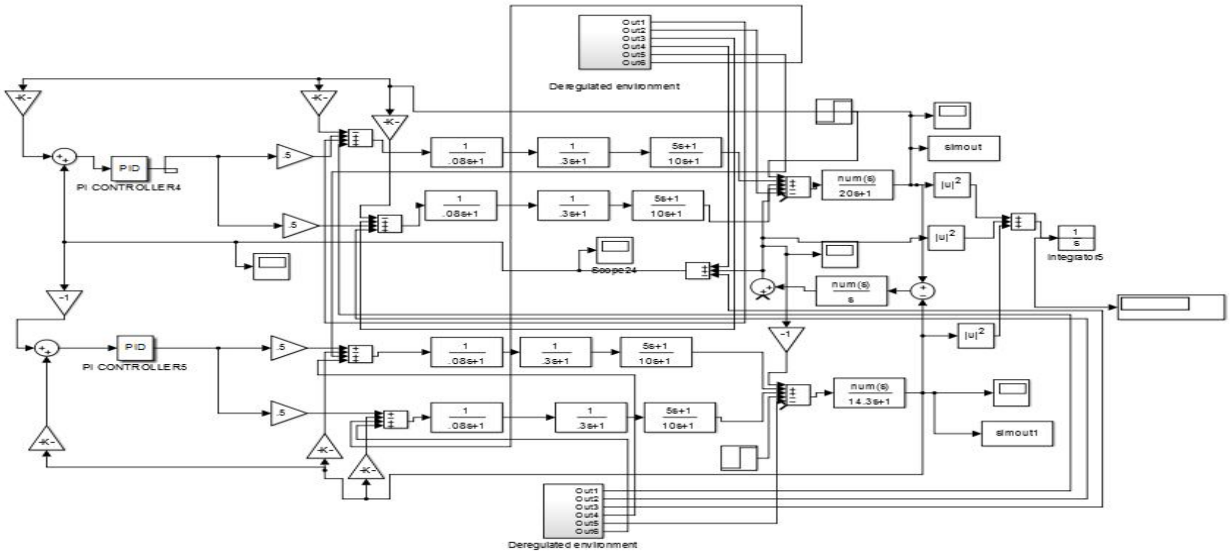


Fig.10 Simulation model of Two area Thermal – Thermal System

III. SIMULATION RESULTS AND INTERPRETATIONS

The below figures shows the two area power systems with energy sources and their fast response.

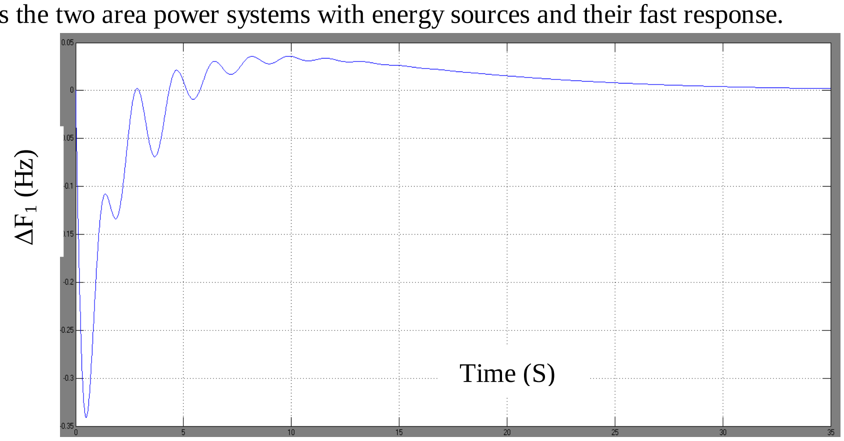


Fig. 11 ΔF_1 (Hz) vs Time (s) for two area thermal – thermal system

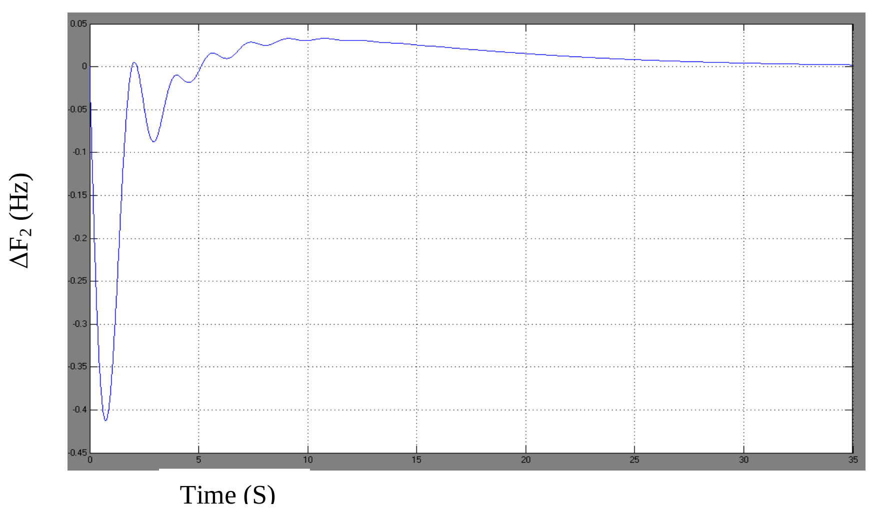
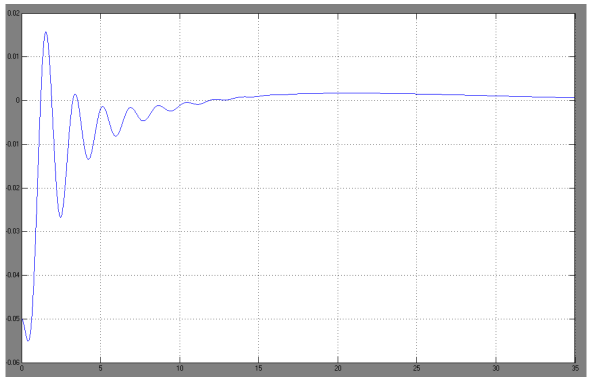


Fig. 12 ΔF_2 (Hz) vs Time (s) for two area thermal – thermal system

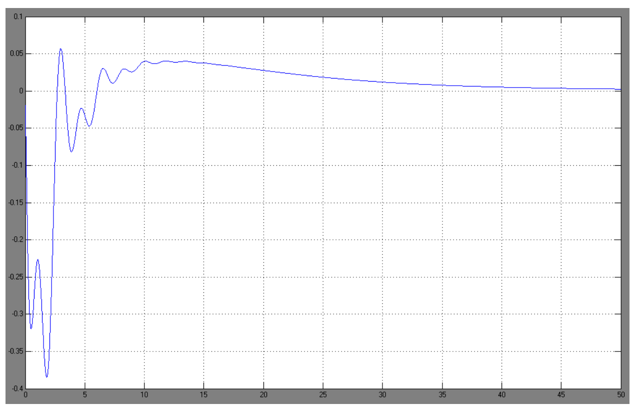
ΔP_{tie} (p.u. MW)



Time (S)

Fig. 13 ΔP_{tie} (p.u. MW) vs Time (s) for two area thermal – thermal system

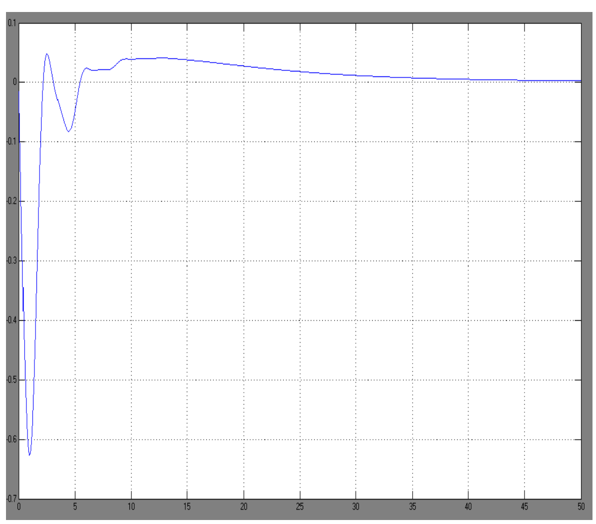
ΔF_1 (Hz)



Time (S)

Fig. 14 ΔF_1 (Hz) vs Time (s) for two area hydro – thermal system

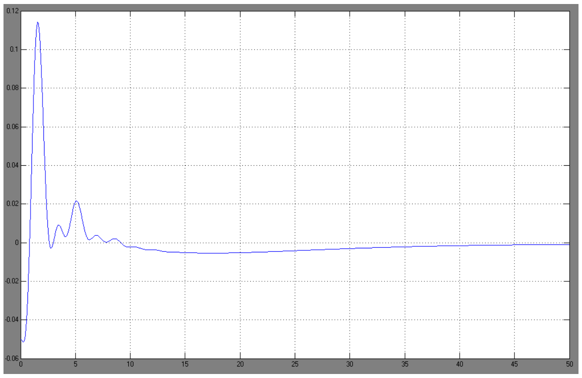
ΔF_2 (Hz)



Time (S)

Fig. 15 ΔF_2 (Hz) vs Time (s) for two area hydro – thermal system

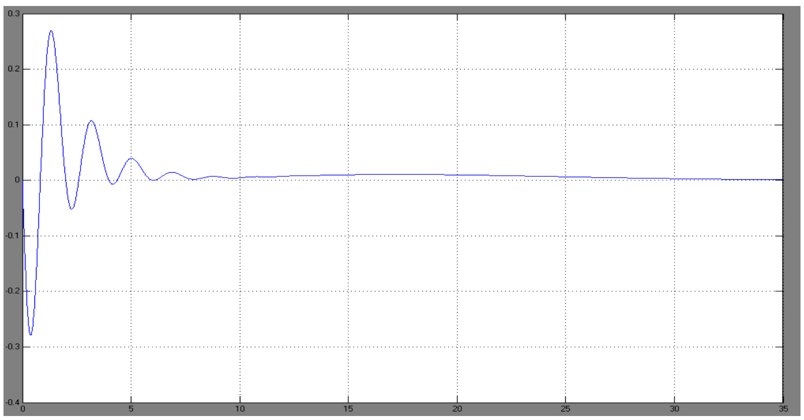
ΔP_{tie} (p.u. MW)



Time (S)

Fig. 16 ΔP_{tie} (p.u. MW) vs Time (s) for two area hydro – thermal system

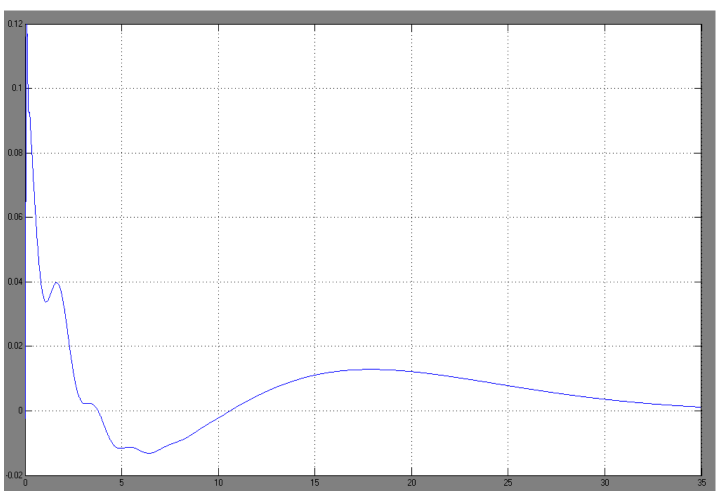
ΔF_1 (Hz)



Time (S)

Fig. 17 ΔF_1 (Hz) vs Time (s) for two area thermal – diesel system

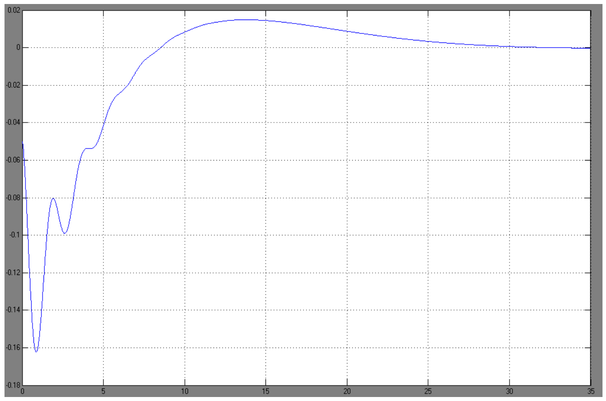
ΔF_2 (Hz)



Time (S)

Fig. 18 ΔF_2 (Hz) vs Time (s) for two area thermal – diesel system

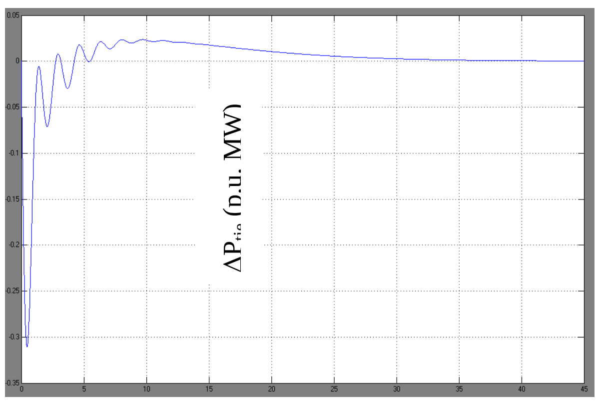
ΔP_{tie} (p.u. MW)



Time (S)

Fig. 19 ΔP_{tie} (p.u. MW) vs Time (s) for two area thermal – diesel system

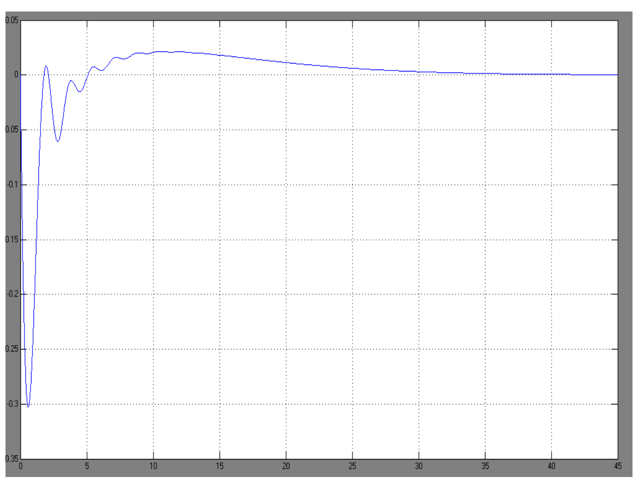
ΔF_1 (Hz)



Time (S)

Fig. 20 ΔF_1 (Hz) vs Time (s) for two area thermal – gas system

ΔF_2 (Hz)



Time (S)

Fig. 21 ΔF_2 (Hz) vs Time (s) for two area thermal – gas system

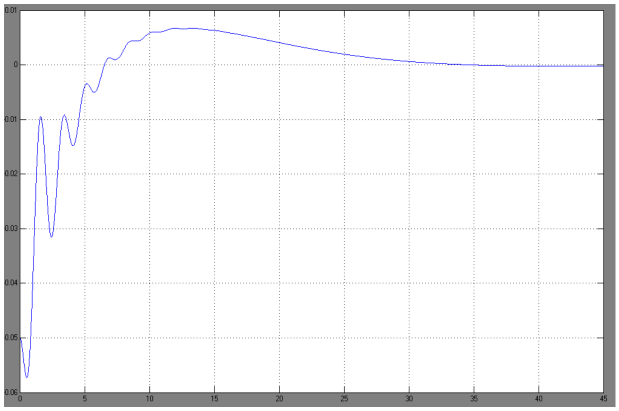


Fig. 22 ΔP_{tie} (p.u. MW) vs Time (s) for two area thermal – gas system

Table: 1 Optimum gain values for energy source of RPS in deregulated field.

Plant	Controller	Area - I		Area - II	
		K_P	K_I	K_P	K_I
Thermal – Thermal RPS with Hydro unit	PI controller	0.3884	0.232	0.1210	0.175
Thermal –Thermal RPS with Diesel unit		0.3185	0.267	0.3102	0.2903
Thermal –Thermal RPS with Gas unit		0.380	0.250	0.1216	0.168
Thermal –Thermal RPS with Thermal unit		0.3169	0.2012	0.1208	0.162

The simulation results obtained shown in Table. 1 reveals that the dynamic response of the system of the two-area interconnected Restructured Power System (RPS) with energy source ensures a better dynamic response than that of the RPS without energy source unit. Integral square Error (ISE) technique is used to obtain the optimum PID-controller gains.

IV. CONCLUSION

In transient stability analysis, the power interchange between two area system with different units has been carried out with their frequency domain study. The frequency response of two area deregulated systems supported by Thermal-Thermal units gives best and robust operation. A new version of Load frequency control with a new reach of obtaining the results of various energy sources in a integrated market systems with a deregulated environment shows that two area Thermal – Thermal systems can be suggested for all operations instead of the second area be Hydro, Diesel and Gas.

V. APPENDIX

A. Hydro – Thermal [19]

Rating of each area = 2000 MW, Base power = 2000 MVA, f^o = 60 Hz, $K_{p1} = K_{p2}$ = 120 Hz / pu MW, $T_{p1} = T_{p2}$ = 32 sec, $T_{t1} = T_{t2}$ = 0.25 sec, $T_{g1} = T_{g2}$ = 0.25 sec, $R_1 = R_2$ = 5 Hz / pu MW, $\beta_1 = \beta_2$ = 0.2083 pu MW / Hz, T_{12} = 0.5441 pu MW / Hz, a_{12} = -1, ΔP_{D1} = 0.01 pu MW

B. Thermal –Diesel [15]

K_{diesel} =16.5, X_G =0.6sec, Y_G = 1.1 sec

C. Thermal - Gas turbine [16:]

b_G = 0.049sec, C_S = 1Farad, T_{CR} = 0.01sec, T_F = 0.239sec, T_{CD} = 0.2sec

D. Thermal – Thermal [13]:

Rating of each area = 2000 MW, Base power = 2000MVA, Frequency = 60 Hz, Power System gain = K_{Pi} = 120 Hz/p.u MW, Power system time constant T_{Pi} = 20 s, Speed regulation coefficient of each area R_i = 2.4 Hz/p.u MW, Generator time constant T_{gi} = 0.08 s, Turbine time constant T_{ti} = 0.3 s, Frequency bias coefficient β_i = 0.425 p.u MW/Hz

VI. ACKNOWLEDGEMENT

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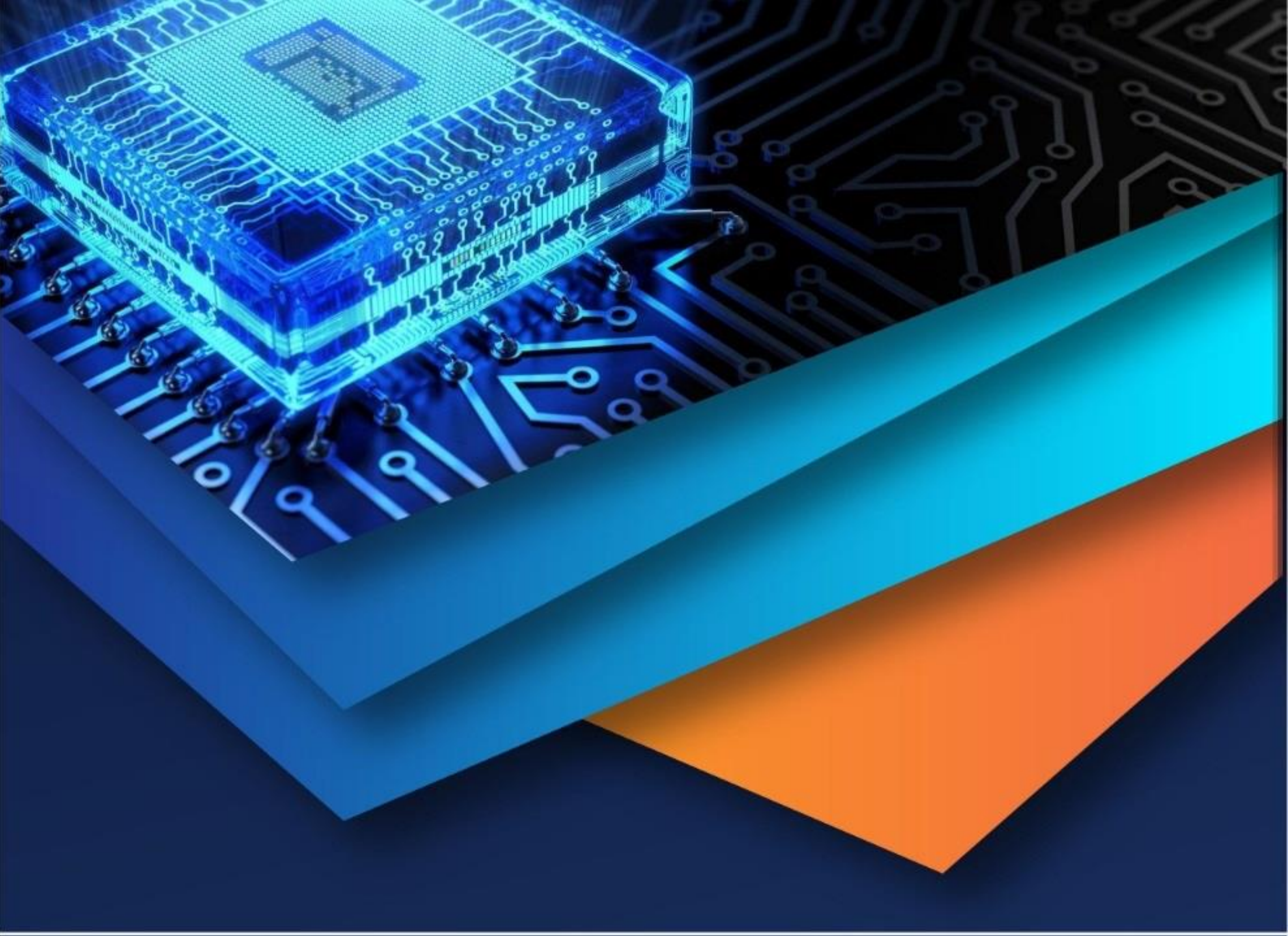
BIOGRAPHY

G. Ganesan @ Subramanian (1984) received the B.Tech degree with distinction in Electrical & Electronics Engineering, (2006) from Pondicherry University and Postgraduate Degree in Power Systems from Annamalai University in the year (2008). He is pursuing Ph.D degree at Annamalai University, Chidambaram. He is a Member in IEI, IET and life member in ISTE. He has 09 international journal publications, 20 papers in International conferences, 05 papers in National conferences. At present, He is working as an Assistant Professor in the Department of EEE, E.G.S. Pillay Engineering College at Nagapatinam. He has teaching experience of 9 years and his areas of interests are Power systems, Restructuring and Deregulation, FACTS controllers, Smart grid and Nanotechnology.

I.A.Chidambaram (1966) received Bachelor of Engineering in Electrical and Electronics Engineering (1987), Master of Engineering in Power System Engineering (1992) and Ph.D in Electrical Engineering (2007) from Annamalai University, Annamalainagar. During 1988 - 1993 he was working as Lecturer in the Department of Electrical Engineering, Annamalai University and from 2007 he is working as Professor in the Department of Electrical Engineering, Annamalai University, Annamalainagar. He has 62 international journal publications, 5 papers in International conferences, 5 papers in National conferences. He is a member of IEI, IET, ISTE and ISCA. His research interests are in Power Systems, Electrical Measurements and Controls.

J. Samuel Manoharan (1983) obtained his Bachelor's degree in Electronics and Communication Engineering (2004) from Periyar University, Salem and Master's degree (2006) in VLSI design from Karunya University, Coimbatore. He obtained his doctoral degree (2013) in Image Processing from Karunya University, Coimbatore and is currently Professor and Head of Electronics and Communication Engineering department in Bharathiyar College of Engineering and technology, Karaikal in the state of Puducherry. He has published a number of papers in referred journals and international conferences. His research interests include Medical image processing and watermarking, multi resolution approximations and Wireless sensor networks.



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