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IMPROVE DYNAMIC PERFORMANCE OF ALFC OF MULTI-AREA THERMAL POWER SYSTEM BY USING GAS-TURBINE

Tejram Singh Saini[*] , Vaibhav Shukla[**], and Mukul Chanakya[***]

Abstract: This paper is based on the two different Load Frequency Control (LFC) techniques of multi area system in which, one technique is based on PID controller and other is based on the PID controller with Gas Turbine Unit. In the thermal power plant steam turbine extracts thermal energy from the pressurized steam and rotates the shaft of the generator so the control of the turbine is very important for speed control. The uncontrolled acceleration generator can lead to over speed trip so the nozzle valve that control the flow of steam fail to operate properly. If this failure occurs, the turbine may continue acceleration until it will damaged. Although the load is always varying, so that load frequency control is done by PID controller and PID controller with Gas Turbine Unit. In these study three Non-Reheated Thermal systems is connected through the Tie-Line. Gas Turbine Unit with PID controller provides better performance, high efficiency and guarantees a superior transient response and littler settling time

Key Words: Proportional-Integral-Derivative controller, Integral Controller, Gas Turbine Unit, Automatic Load-Frequency Control, Tie-Line Power

1. INTRODUCTION

In present power system main problem is to maintain the frequency control operation of an interconnected power system and provide good electric. The main object of the LFC is maintaining the balance between the generated power and load demand of the connected power system. The Load frequency control (LFC) loop and the automatic voltage regulator (AVR) loop come under AGC. In LFC system, when frequency decreases then the speed of the turbine is decreased. The rotor angle control open the in-let steam valve and more steam enter to the Turbine and maintain the frequency as per load variation. In AVR system when the voltage increase or decrease then it gives a signal to reactive power control (Q-control) and it gives signal to excitation system. The excitation system increase or decrease its voltage as per requirement. The other objective of the LFC is to maintain the frequency deviation steady state error remains zero. So the feedback controller is designed in such a way that the load flow and the frequency is remain under desirable values. In the thermal power system, load frequency control is realized by PID controller and PID controller with GT Unit. Gas Turbine unit with a most extreme capacity can be connected not just

[*] PG Student, Electrical Engineering Department, Lovely Professional University, Punjab, India
Email: tejramsinghsaini@yanoo.com

[**] PG Student, Electrical Engineering Department, Lovely Professional University, Punjab, India
Email: shukla.vaibhav@ymail.com

[***] Assistant Professor, Electrical Engineering Department, Lovely Professional University, Punjab, India
Email: mukul.17092@lpu.co.in

as a quick vitality compensate for huge loads additionally to minimize the frequency and tie-line power variation, that make it economic system.

A Thermal Power Plant consists of these parts:-

1.1 Steam-Generator/Boiler

1.2 RO/DM Plant

1.3 Fuel Plant

1.4 T/G (Turbine/Generator) Area

T/G system is having combination of Turbine and Generator. A Steam Generator generates super-heated steam and feed it to Turbine. A steam turbine rotates with generator and generates the electric power. A block diagram of thermal power plant is shown in the figure below

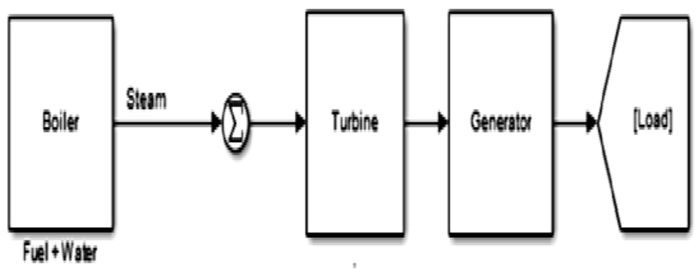

Fig.1: Block diagram of thermal power plant

2. PID CONTROLLER

A PID controller is stand for Proportional Integral Derivative. These three terms are summed to ascertain yield of the PID controller. We defined the U (t) as the controller output of the PID controller is given by-

$$U(t) = K_p\, e(t) + K_i \int_0^t e(t) + K_d \frac{d}{dx}\, e(t)$$

K_p = Proportional gain

K_i= Integral gain

K_d = Derivative gain

$e\ (t)$ = Present error.

Now, we explain of all these three term one by one as given below-

The PID controller circuit diagram is shown in the figure below-

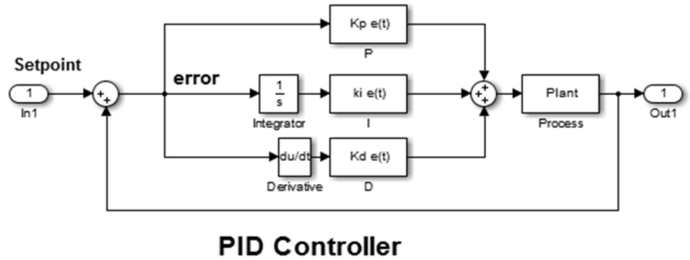

Fig.2 Transfer function model of PID controller

3. TURBINE -GOVERNOR OR CONTROLLER

Here we discuss the steam turbine controller from old to new controller. The controllers are given below as-

3.1 Mechanical Governor (UG-20)

In the Mechanical Governor, we set the droop and speed manually during operation of the turbine. The control action is slow of the Mechanical Governor. Due to its slow control action, the steam turbine tripped many times.

3.2 Electronic Analog Governor (2301A)

Electronic Analog Governor is panel mounted automatic Analog-Controller. In this, we set the droop and speed only one time during testing or commission of the turbine soits control action response is high.

3.3 Electronic Digital Governor or Distributed Control System (DCS) (505, 505E & EGCP)

An Electronic Digital Governor is panel mounted Digital-Controller. In this Digital controller need programming to operation of the turbine. In the Digital Governor, we set droop, speed and required parameters. It is also works in auto mode. This is latest technology and gives a better response as compared to Mechanical Governor and Electronic Analog Governor.

3.4 Gas Turbine (GT) Unit

To guarantee a superior quality and higher dependable Power supply to the purchasers, the control information necessities must be repaid with Distributed Generators (DG) to upgrade zero frequency deviations, zero tie-line power deviations in a speedier way. Gas Turbines which is considered as one of the DGs have higher productivity and the lower greenhouse emanations contrasted with other energy sources and quick beginning capacity which empowers them to be utilized even as peaking units that react to crest requests.

4. DESIGN METHOLOGY

4.1 Governor Model

A sudden change in a load of any area in the interconnected power system make the cause of deviation in frequency of all area as well as change in flow of tie line power. The Governor open or close inlet steam-valve according to load variation and maintained the frequency up to steady state operation. Governor model consist these following parts-

- Speed Governor
- Hydraulic Amplifier
- Linkage Mechanism
- Speed Changer

The speed governor output dP_g is the difference between the change in input power or reference power dP_g and $dP_c - \frac{1}{R}df$ the power as given below-

$$dP_g = dP_c - \frac{1}{R}df$$

Taking Laplace transform on both side-

$$dP_g(\mathrm{s}) = dP_c(s) - \frac{1}{R} dF(s)$$

Consider the linear relationship between the dP_g and dP_v, So

$$dP_V(\mathrm{s}) = \left[\frac{1}{1 + T_g S} . dP_g(s)\right]$$

4.2 Turbine Model

Turbine model is the ratio of the *Laplace Transformed* of incremental change in the mechanical power turbine output $dP_m(s)$ over the *Laplace Transformed* of incremental change in steam valve opening position $dP_v(s)$.

The Turbine model's transfer function is given as-

$$G_T(\mathrm{S}) = \frac{dP_m(s)}{dP_v(s)} = \frac{1}{1+T_t S}$$

above equation, the transfer function is given by-

$$G_T(s) = dP_g(s) = \frac{K_t}{1+T_t S} . dX_E(s) \qquad [since\ dP_t(s) = dP_m(s) = dP_g(s)]$$

The combined transfer function of the steam turbine and the speed-governor mechanism as given below-

$$dP_m(s) = \frac{K_g K_t}{(1+T_t S)(1+T_g S)} \times [dP_c(s) - \frac{1}{R} . dF(s)]$$

4.3 Generator-Load Model

The generator-load model provides the relation between the change in frequency (df) as a result of the change in generation power (dP_g) when the load changes by a small amount (dP_d).

$$dF(s) = \frac{K_p}{1+T_p S} . [dP_m(s) - dP_d(s)]$$

Where $T_p = \frac{2H.}{f^0}$ is the power system time constant and the power system gain is given by $K_p = \frac{1}{B}$.

So, the complete block diagram of the P/S Load Frequency Control is shown in the figure below as-

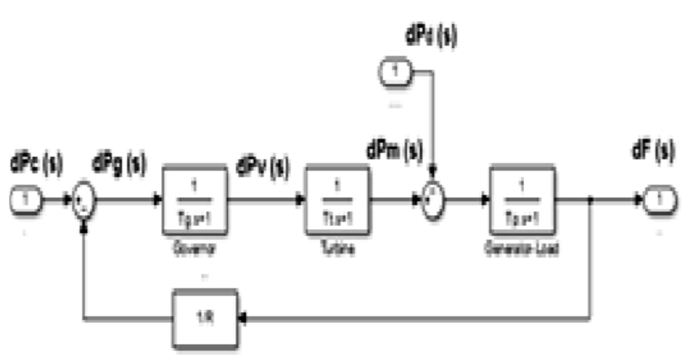

Fig.3: Complete Transfer function model of isolated power system

4.4 Gas Turbine Unit Model

A GT unit's exchange capacity model is appeared in fig.4 that is a standout amongst the most generally utilized element models and has likewise been utilized as a part of this system. Gas Turbines have the favorable circumstances like fast start-up/close-down, lesser weight and size, expense of establishment is less, low capital cost, Black-begin capacity, high productivity requires less wrenching force, toxin discharge control and so on., When the heap is all of a sudden expanded the rate drops rapidly however the controller responds and builds the fuel stream to a greatest of 100%, subsequently enhancing the proficiency of the system.

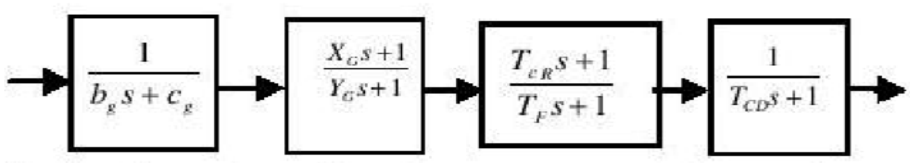

Fig.4 Transfer function model of GT Unit

5. A MULTI-AREA THERMAL POWER SYSTEM:

Interconnected Thermal System can be divided in to many control Area, those are connected by tie lines. The load deviation in any area of the interconnected P/S makes the cause of deviation in frequency of all area as well as change in flow of tie line power. So this extended p/s is divided into many number of LFC (load frequency control) areas those are connected to the Transmission line and are called pool system and its operation is called pool operation.

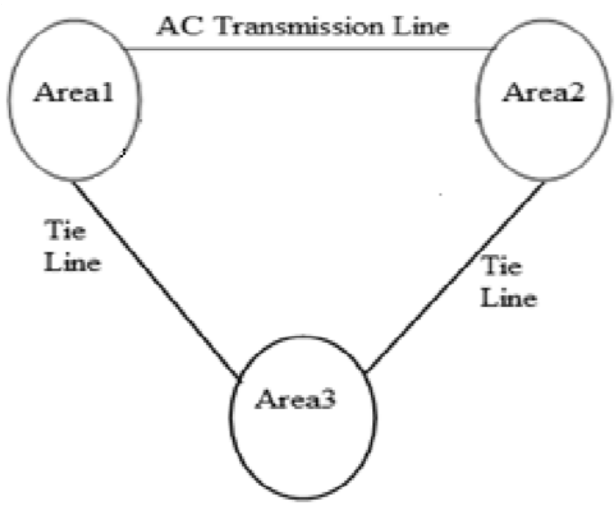

Fig. 5: Block diagram of Three-area power system

In the multi-area P/S, a group of generators are internally closely and synchronously connected to each other. The Load Frequency Control (LFC) loop shows the overall system called as the control area. AGC is a combination of the LFC (load frequency control) and AVR (automatic voltage regulator). The active power (P) is dependent on the internal angle (δ) and independent of the bus voltage magnitude |V|. The bus voltage is dependent on the machine excitation system and hence on reactive power Q and its independent of machine angle (δ).

The Models are given below-

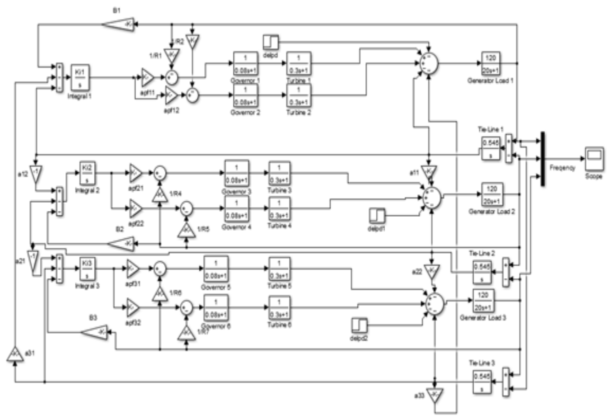

Fig.6: Three area thermal power system without GT Unit

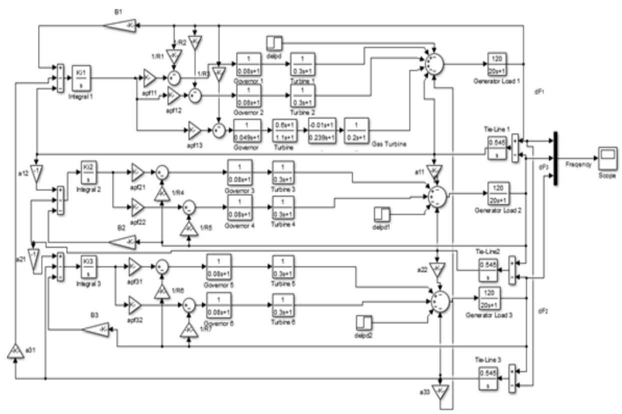

Fig.7: Three area thermal power system with GT Unit

6. SIMULATION RESULT AND DISCUSION

A LFC model of three- area power system is shown in the fig.6 and Fig.7. This paper present the three areas thermal interconnected P/S, which is developed by using different types of controller as Integral controller, PID controller and Gas Turbine Unit in MATLAB environment, and we get the better result of load frequency control. Two types of Simulink models are developed in this paper one is without Gas Turbine Unit and second is with Gas Turbine Unit, and analyze the results. The PID controller with Gas Turbine Unit provides best dynamic result of them. Plots of frequency deviation for thermal are obtained by 1% change of load in system frequency dF_1, dF_2, dF_3 and Tie-Line power (P_{tie}) as shown in the figures below respectively.

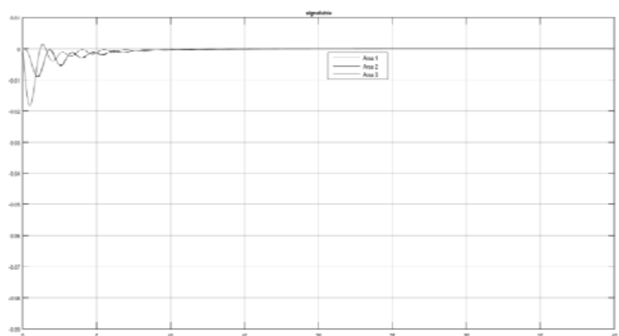

Fig.8: Frequency deviations with Integral controller alone

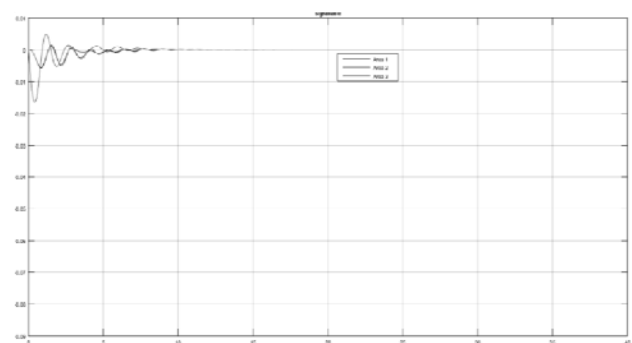

Fig.9: Frequency deviations with Integral controller and GT Unit

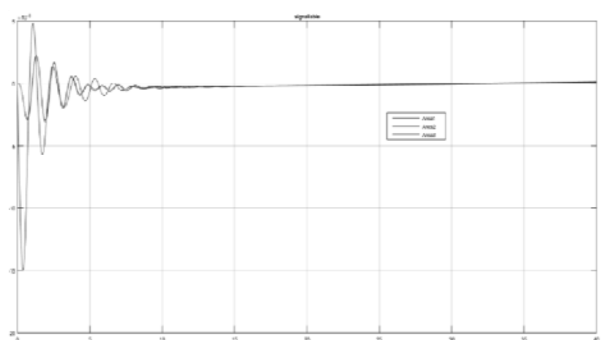

Fig.10: Frequency deviations with PID controller alone

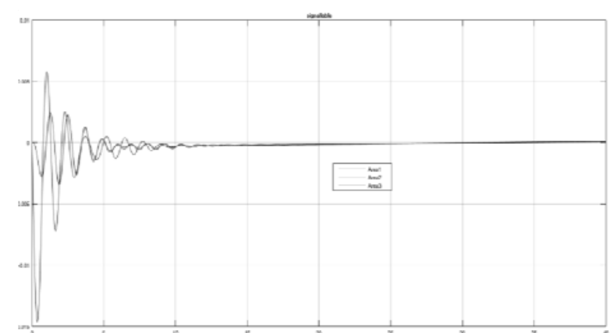

Fig.11: Frequency deviations with PID controller and GT Unit

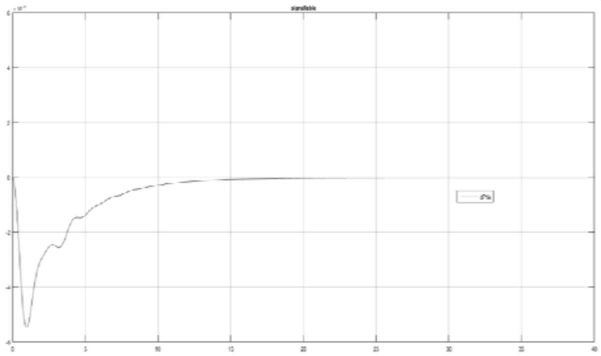

Fig.12: Tie-Line Power with Integral Controller alone

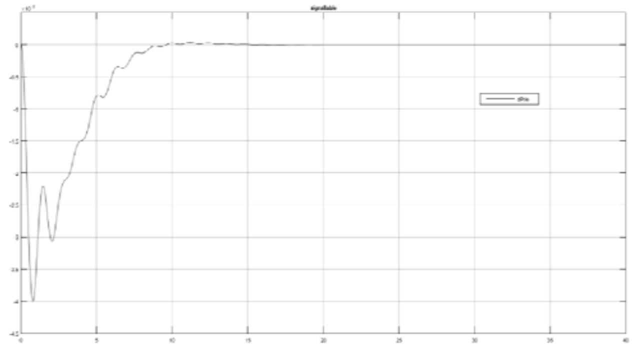

Fig.13: Tie-Line Power deviations with Integral controller and GT Unit

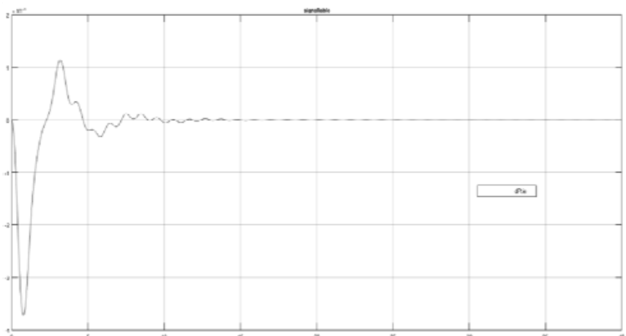

Fig.14: Tie-Line Power deviations with PID controller alone

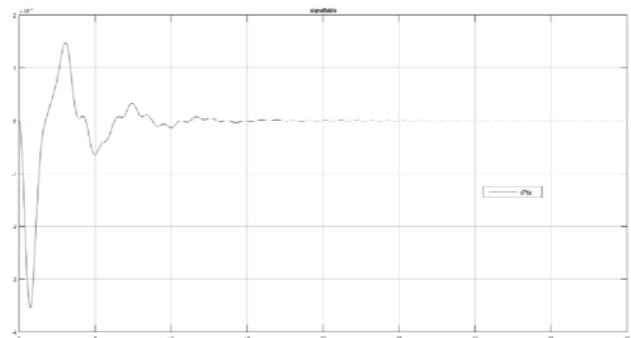

Fig.15: Tie-Line Power deviations with PID controller and GT Unit

Table-1
Comparision of Settling Time

Controller	*df in Area1*	*df in Area2*	*df in Area3*	$dP_{Tie\text{-}Line}$
Integral	10	11	11	15
Integral & GT unit	9	8	8	12
PID	8	7	7	11
PID & GT unit	7	6	6	10

Table-2
Comparision of Peak Overshoots

Controller	*df in Area1*	*df in Area2*	*df in Area3*	*dPTie-Line*
Integral	-0.0195	-0.0090	-0.0091	-0.00055
Integral & GT unit	-0.0171	-0.0052	-0.0053	-0.00041
PID	-0.0150	-0.0038	-0.0039	-0.0037
PID & GT unit	-0.0140	-0.0033	-0.0034	-0.0033

7. CONCLUSION

This is important to maintain the power frequency and flow of inter area tie-line power as possible as up to a given values in interconnected P/S. Model of the three-area interconnected P/S has been developed with different area characteristics. The use of the Integral and PID controller with Gas Turbine Unit can improve the dynamic performance. The error is calculated by Integral and PID controller that is the difference of measured and desired value of the variables. So, PID controller tries to minimize error by process value adjusting. It is seen that if the proper tuning of PID controller is completed, the area frequency could brought back to its pre-defined value with acceptable tolerance. From the above design technique which is based on Integral controller, PID controller along with Gas Turbine Unit for LFC (Load Frequency Control) in a three area interconnected P/S is become successful to reduce the settling time and maximum overshoot value up to desired limit**.**

References

[1] K. Sabahi, M.A. Nekoui, M. Teshnehlab, M. Aliyari, and M. Mansouri, “Load frequency control in interconnected power system using modified dynamic neural networks,” Proceedings of the 15th Mediterranean Conference on Control & Automation, T26-011, 2007.

[2] P.Venkatasubramanian, S.Abraham Lincon, “Area Requirement based Load Frequency Controller using Artificial Bee Colony Algorithm for a Two Area Interconnected Power System with GT Unit”, International Journal of Computer Applications (0975 – 8887) Volume 69– No.5, May 2013

[3] V.D.M. Kumar, “Intelligent controllers for automatic generation control”, IEEE Region 10 International Conference on Global Connectivity in Energy, Computer, Communication and Control, TENCON ‘98, vol. 2, pp. 557-574, 1998.

[4] C.S. Chang and W. Fu “Area load frequency control using fuzzy gain scheduling of PI controllers,” Electrical Power and Energy Systems, vol. 42, no. 2, pp. 145-152, 1997.

[5]] G.Karthikeyan, S.Ramya, Dr .Chandrasekar” Load frequency control for three area system with time delays using fuzzy logic controller” IJESAT,2012, Volume-2, Issue-3, 612 – 618.

[6] Surya Prakash, S.K. Sinha, “Load frequency control of three area interconnected hydro-thermal reheat power system using artificial intelligence and PI controllers”.

[7]] H.D. Mathur and H.V. Manjunath, “Study of dynamic performance of thermal units with asynchronous tie-lines using fuzzy based controller,” Journal of Electrical Systems, vol. 3-3, pp. 124-130, 2007

[8] Kocaarslan I., and Cam E, fuzzy logic controller in interconnected electrical Power system for load-frequency control, Int.J.of Electrical systems

[9] Jaleeliu .N, Vanslyck .L.S, Eward .D.N, Fink .L.H, Hoffmann .A.G “Understanding Automatic generation control”. IEEE Tran power systems 1992; 7(3): 1106-12

[10]] Ismail H. Altas, JelleNeyens “A Fuzzy Logic Load-Frequency Controller for Power Systems, IJEST, April 26-27, 2006.

[11] K. P. Singh Parmar, S. Majhi, D. P. Kothari, “Optimal Load Frequency Control of an Interconnected Power System”, MIT International Journal of Electrical and Instrumentation

[12] Wen Tan, “Unified tuning of PID load frequency controller for power system via IMC”,IEEE Trans. Power Systems, vol. 25, no. 1, pp. 341-350, 2010

[13] Pan C.T., Liaw .C.M. “An adaptive controller for power system LFC”. IEEE Transpower systems 1989, 4(1), 122-8.