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Load Frequency Control By Internal Control Model (IMC) PID Controller

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ABSTRACT
The main goal of Load Frequency control (LFC) is, to maintain the real frequency and the desired power output (mw) in the interconnected power system and to control the change in tie line power between control areas. This is achieved by the use of conventional controllers. But the conventional controllers are heaving some demerits like; they are very slow in operation, they do not care about the inherent nonlinearities of different power system component, it is very hard to decide the gain of the integrator setting according to changes in the operating point. The IMC-PID controller is capable of giving better response and is applicable under different nonlinearities.

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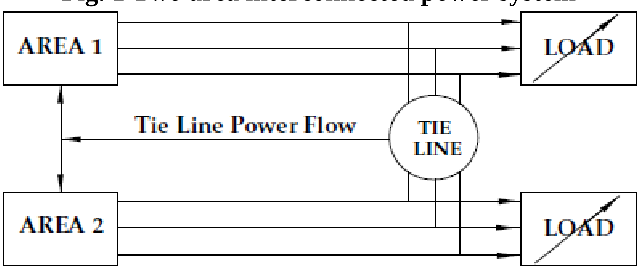
I. INTRODUCTION

In a two area interconnected power system, where the two areas are connected through tie lines, the control area are supplied by each area and the power flow is allowed by the tie lines among the areas. Whereas, the output frequencies of all the areas are affected due to a small change in load in any of the areas so as the tie line power flow are affected. So the transient situation information of all other areas is needed by the control system of each area to restore the pre defined values of tie line powers and area frequency. Each output frequency finds the information about its own area and the tie line power deviation finds the information about the other areas. Thus the load frequency control of a multi area power system generally incorporates proper control system, by which the area frequencies could brought back to its predefined value or very nearer to its predefined value so as the tie line power, when the is sudden change in load occurs.

II. TWO AREA POWER SYSTEMS

If there is interconnection exists between two control areas through tie line than that is called a two area interconnected power system. Fig. 1 shows a two area power system where each area supplies to its own area and the power flow between the areas are allowed by the tie line. In this case of two area powers system an assumption is taken that the individual areas are strong and the tie line which connects the two areas is weak. Here a single frequency is characterized throughout a single area; means the network area is ‘strong’ or ‘rigid’. There may be any numbers of control areas in an interconnected power system.

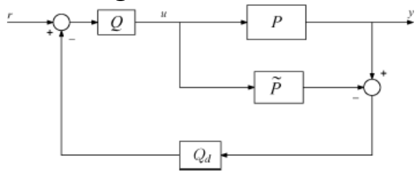
Fig. 1 Two area interconnected power system



III. IMC (Internal model control) Design

An internal model control (IMC) method is adapted for load frequency controller design. In Process control IMC is a very popular controller in Fig.2, the IMC structure is shown where the plant to be controlled is ‘P’, and the plant model is ‘Ṗ’

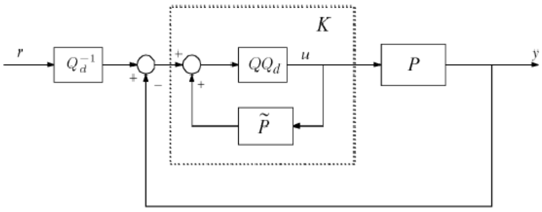
Fig. 2 IMC structure



A different unified method is described to design and tune a PID controller for load frequency control of power system with non reheat turbine. The method is applied here on the basis of internal model control. It is also applicable to multi area power systems like to a two area power system**.**

Direct implementation of IMC controller needs higher order transfer function knowledge if the model $\dot{P}$ is of higher order, which is discussed in LFC of power system. So here the IMC structure is transformed to a PID control structure.

Fig.3 IMC equivalent conventional feedback configuration



The standard technique of tuning the PID parameters from IMC controllers is that we have to expand the controller block K shown in to Malaren series. The first three terms coefficients of the Maclaurin series are the parameters of the PID controller. The procedure is obtained by the IMCTUNE package. Here a new method is approximated for any higher order PID controller in frequency domain**.**

LFC PID Design

An isolated power system with a single generator supply,

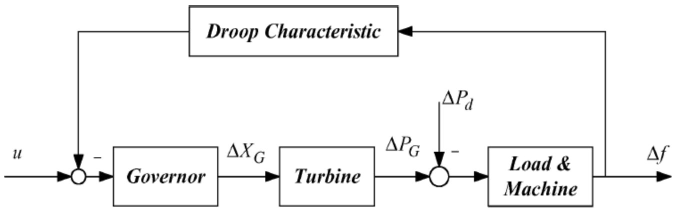


Fig.4 Linear model of a single area power system

The tuning of PID controller we know is to improve the performance of the load frequency control of power system**.** So, here we have to design a control law u = -K(s)Δf , where K(s) has the form

$$K(s) = K_p(1 + \frac{1}{T_i s} + T_d s)$$

In general, practically PID controller is implemented to reduce the noise effect. So, K(s) can be written for this case

$$K(s) = K_p(1 + \frac{1}{T_i s} + \frac{T_d s}{Ns+1})$$

Where N is called as filter constant

$$K(s) = K_p(1 + \frac{1}{T_i s} + T_d \frac{1-e^{-Ts}}{Ns+1})$$

Where 'T' is very small sampling rate

Since the load frequency control of power system considers a little change in load, it can be represented by the single area model. The drop characteristic here is the reciprocal of regulation constant "1/R" which improves the damping properties.

IV. LFC DESIGN WITHOUT DROP CHARACTERISTIC

A Non-Reheated Turbine is taken in power system. So plant with non-reheated turbine made of three different parts,

(1) A Governor with its dynamics

$$G_g(s) = \frac{1}{T_g s + 1}$$

(2) A turbine with its dynamics

$$G_t(s) = \frac{1}{T_t s + 1}$$

(3) A Load and machine with their dynamics

$$G_p(s) = \frac{K_p(s)}{T_P s + 1}$$

Now the overall open loop transfer function without any drop characteristic is

$$\tilde{P}(s) = G_p(s) G_t(s) G_g(s) = \frac{K_p}{(T_P s + 1)(T_t s + 1)(T_g s + 1)}$$

From the IMC-PID design method, as, model $\dot{P}$ is a minimum phase system, the IMC controller gets the form

$$Q(s) = P^{-1}(s) \frac{1}{(\lambda s + 1)^3} = \frac{(T_P s + 1)(T_t s + 1)(T_g s + 1)}{Kp(\lambda s + 1)^3}$$

The procedure of IMC PID controller design for the LFC of an isolated power system contains the design of IMC controller first then it is expanded to tune the PID parameters.

V. TWO AREA EXTENSION

The tuning of IMC-PID controller can be extended for load frequency control of a two area power system. The difference between LFC for single are and multi area is that in multi area case not only the area frequencies comes back to its set value but also the tie line power comes to its nominal value. In this case the Area Control Error (ACE) is used for feedback variable. Consider the model for LFC of two area power system

$$\Delta P_{tie(1,2)} = \frac{T_{12}}{s}(\Delta f_1 - \Delta f_2)$$

B_1 and B_2 both are the frequency bias coefficients and the area control errors AEC_1 and AEC_2 are defined by

$AEC_1 = \Delta P_{tie\,(1,\,2)} + B_1 \Delta f_1$

$AEC_2 = -\Delta P_{tie\,(1,\,2)} + B_2\, \Delta f_2$

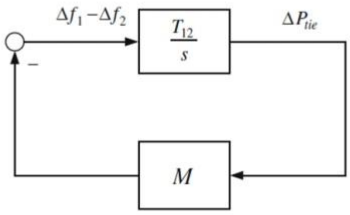


Fig.5 Equivalent closed loop system for LFC of two area power system

The load frequency control for each area could be tuned separately in this present case. Whereas, there is a tie line coupling between the areas, the tuning parameter of each area should be taken in to consideration. To give the guarantee of the stability of closed loop system when tie line is connected by tuning the decentralized controller, a closed loop system is arranged.

VI. Results of IMC-PID Controller for LFC of Two Area Power System

The dynamic responses of deviation in frequency for both the areas (Δf_1, Δf_2) and the power deviation in tie line ($\Delta P_{tie\ (1,\ 2)}$) for a power system heaving two control areas with thermal non-reheat turbines. The figures show the performances of a PID controller for LFC of power system, tuned via Internal Model Control (IMC). From figures we can clearly see that the responses are stable with very less overshoot and less settling time. So IMC-PID controller is a powerful controller which gives better stability for LFC of a two area power system.

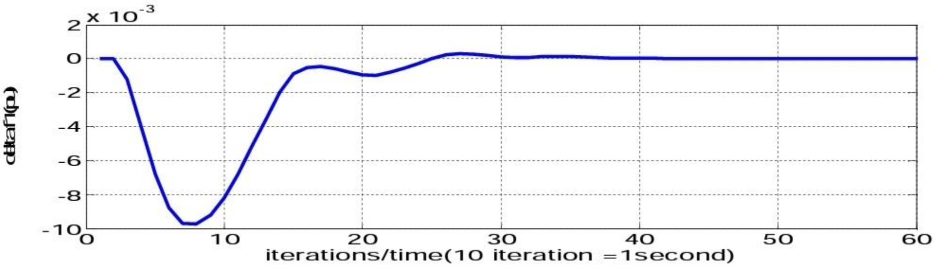


Fig 6 change in frequency V/S time in area-1 for 0.01 step load change in area-1

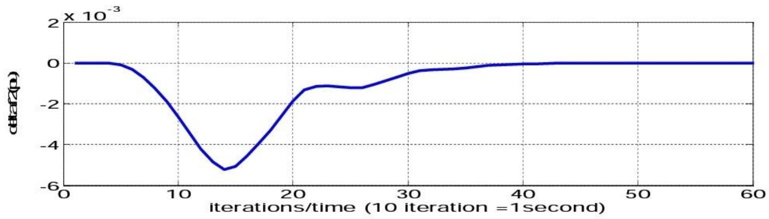


Fig 7 change in frequency V/S time in area-2 for 0.01 step load change in area-1

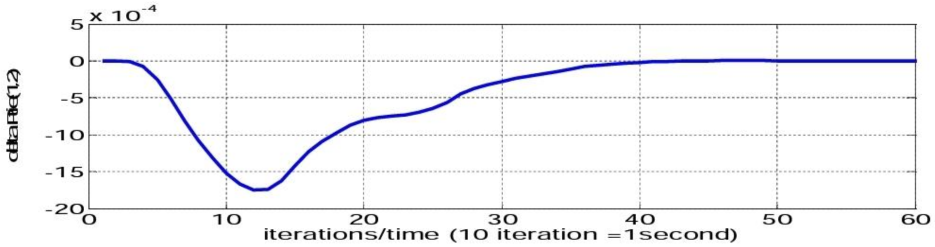


Fig 8 change in tie line power V/S time for 0.01 step load change in area-1

VII. CONCLUSION

A PID controller is designed for LFC of the proposed power system via Internal Model Control (IMC). First an IMC controller is designed, a disturbance rejection IMC controller is designed then a model equivalent to feed back (conventional controller model) model is developed. PID controller is designed on the basis of IMC controller and applied for LFC of a two are power system and well stabilized responses are obtained.

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