

# Analysis on AGC of Interconnected Power System using Integral Controller

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**Abstract**— The algorithm to find the optimal location of STATCOM based on particle swarm optimization (PSO) has been developed. The effect of this device on line flows and bus voltage profile has been studied by Newton-Raphson method placing STATCOM at random location and placing them optimally with optimal ratings dictated by PSO. The effectiveness of developed algorithm has been tested on IEEE 14 bus and IEEE 30 bus systems using MATLAB 7.1.0 software. The results obtained are quite encouraging and will be useful in electrical restructuring.

**Key words:** LFC, AVR, PSO, STATCOM, POWER SYSTEM

## I. INTRODUCTION

This paper gives the analysis of automatic generation control using integral controller in interconnected power system. It is known that, when load increase above a certain limit it causes many undesirable changes in system. This change in load result in frequency variation and voltage variation which degrade the system performance. And also When the load increase turbine speed decrease before the governor adjust the turbine speed .As the change in the value of speed decrease the error signal become smaller and the positions of governor valve get close to the required position, to maintain constant. However the constant speed will not be the set point .So to overcome all these problem an integral controller is used which automatically adjust the generation to restore frequency to its nominal value.

## II. MATHEMATICAL MODEL

The basic function of integral controller is to make zero steady state error ( $\Delta f=0$ ).For maintaining the frequency the power difference between power produced by the generator and power required by the load is eliminated, this function is carried by load frequency control (LFC).And for maintaining the voltage the excitation of generator is controlled, this is done by automatic voltage control (AVR).

Thus, this paper gives an idea that by using integral controller there is the reduction in the frequency or speed deviation, which make the power system to operate properly to get the desired result under the changing load condition .In support of our result, we make use of Simulink model, root locus, and the Routh-Hurwitz stability criterion in this paper. From the Simulink we have seen that the proposed control approach achieves better control result than other controller. Simulation result show that the proposed integral controller approach can be effectively suppress exogenous disturbance in steady state.

In an interconnected power system, different areas are connected with each other via tie-lines. When the frequencies in two areas are different, a power exchange occurs through the tie-line that connected the two areas. The tie-line connections can be modelled as shown in Figure 1. The Laplace transform representation of the block diagram in Figure 1 is given by

$$\Delta P_{tie\ ij}(s) = \frac{1}{s} T_{ij}(\Delta F_i(s) - \Delta F_j(s)) \tag{1}$$

Where  $\Delta P_{tie\ ij}$  is tie-line exchange power between areas  $i$  and  $j$ , and  $T_{ij}$  is the tie-line synchronizing torque coefficient between area  $i$  and  $j$  [2]. From Figure 1, we can see that the tie-line power error is the integral of the frequency difference between the two areas

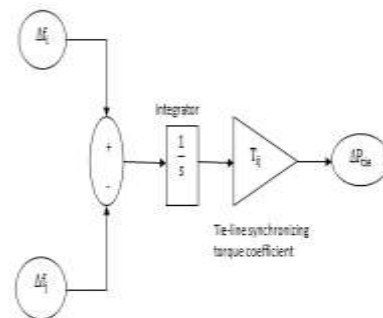


Fig. 1: Block Diagram of the Tie-Lines

## III. SIMULINK MODELS & RESULTS

Extensive testing is involved in the completion of this paper. Not only the final automatic generation control block diagram, but also the intermediate steps in the development of that block diagram have been tested. The testing of AGC system is done in MATLAB. The testing is completed using the MATLAB Simulink tool. Testing is done on each of the individual blocks of the AGC system. Tests are also conducted on the uncontrolled AGC system, and the integrator controlled system. Each test included inserting the block diagram into Simulink and plugging in the values for each of the parameters. Also involved is the addition of the scopes that would be used to measure the outputs of the system. The testing forms and the completed testing forms are included in this report. The analysis of simulink models and their result for interconnected electrical power system is done. The simulink models with or without using integral controller for single area and two area interconnected electric power system are given as following:

## IV. SIMULINK MODEL FOR SINGLE AREA

A Simulink model has been constructed for isolated uncontrolled power system as shown in figure 2.

Turbine time constant ( $T\tau$ )=0.5s,

Speed regulator time constant ( $\tau_g$ )=0.2s,

Generator inertia constant ( $H$ ) = 10s,

Speed regulation rate( $R$ )=20,

To obtain the step response and time domain performance specifications, we use the following commands

PL=0.2; numc= [0.1 0.7 1];

Denc= [1 7.08 10.56 20.8];

T=0:02:10; c=-PL\*step (num,den,t);  
Figure (2), plot (t,c),xlabel('t,sec'),ylabel('pu')  
Title ('Frequency deviation step response'), grid

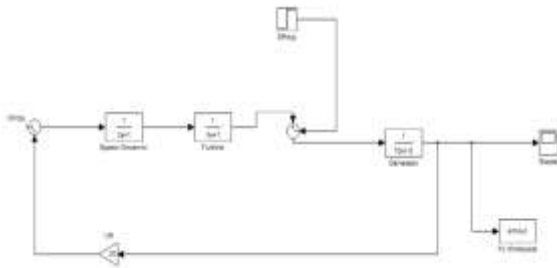


Fig. 2: Simulink Model for Uncontrolled Isolated Area

V. SIMULINK MODEL RESULT OF SINGLE AREA

The results of the model constructed for isolated uncontrolled power system are shown in figure 3.

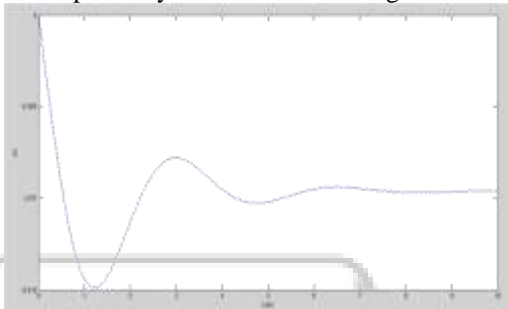


Fig. 3: Simulink dynamic response of change in frequency without controller

This figure show the affection of the load on the frequency curve in this case the frequency curve goes down proportional with the amount of change in the load applied to the system.

It has been observed that both the responses match with each other, also the steady-state frequency deviation  $\Delta f$  (steady state) is -0.0240Hz and frequency returns to its steady value in approximately 6 second.

VI. SIMULINK MODEL WITH INTEGRAL CONTROLLER (SINGLE AREA)

In this, to check the system stability in case added an integral term (controlled or compensated term) to stop on the situation of the change in the frequency at a constant disturbance.

A Simulink model named is constructed as shown in figure 4.

Turbine time constant ( $T\tau$ ) = 0.5s,  
Speed regulator time constant ( $\tau_g$ ) = 0.2s,  
Generator inertia constant (H) = 10s,  
Speed regulation rate (R) = 20,

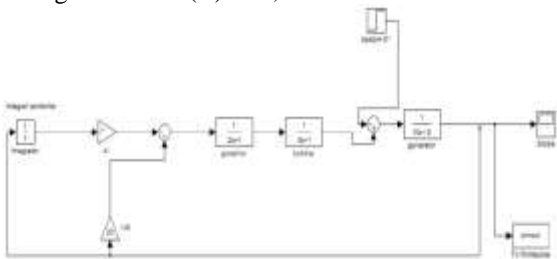


Fig. 4: Simulink Model with Integral Controller (single area)

By applied the previous values to the Simulink diagram and make the change in the gain It is noticed that frequency behaviour affected by the overshoots instantaneously and the goes to stability by using the integral controller.

To find the response, we using the following commands

PL=0.2;  
KL=7;  
Num=[0.1 0.7 1 0];  
Den= [1 7.08 10.56 20.8KI];  
T=0:02:12;  
C=-PL\*step (num,den,t);  
Plot (t,c),grid  
Xlabel('t,sec'),ylabel('pu')  
Title ('Frequency deviation step response')

VII. SIMULINK MODEL RESULT OF SINGLE AREA WITH INTEGRAL CONTROLLER

The step response is shown in figure 5.

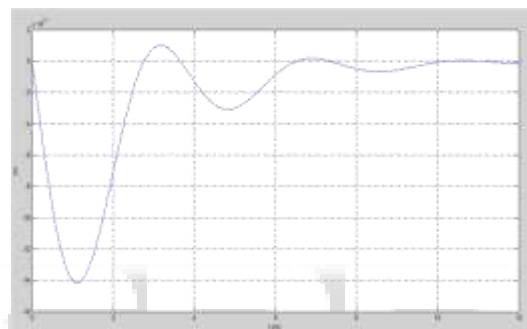


Fig. 5: Simulink Dynamic Response of change in frequency with integral control action

From the step response it has been observed that the steady state frequency deviation is zero, and the frequency returns to its nominal value in approximately 10 second.

VIII. SIMULINK MODEL OF TWO AREA SYSTEM

Area	1	2
Speed Regulation	R1=0.05	R2=0.0625
Frequency- sens. Load coeff.	D1=0.6	D2=0.9
Inertia constant	H1=5	H2=4
Base power	1000MVA	1000MVA
Governor time constant	0.2 sec	0.3sec
Turbine time constant	0.5sec	0.6sec

Tabel. 1:

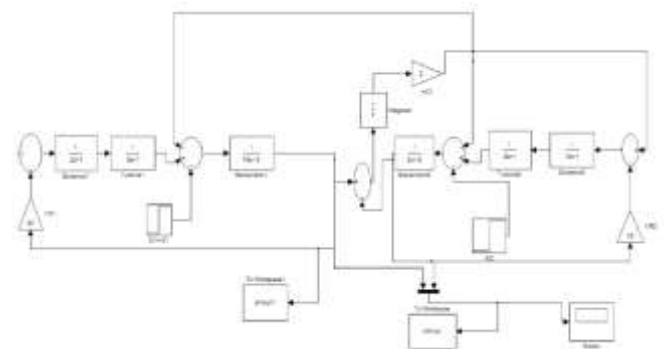


Fig. 6: Simulink model of two area

A two-area system connected by a tie line has the following parameters on a 1000 MVA common base. A change of power in area has been met by the increase in generation in both areas associated with changes in the tie-line power and a reduction in frequency. A simple control strategy for the normal mode is as

#### IX. SIMULINK MODEL RESULT OF TWO AREA WITHOUT INTEGRAL CONTROLLER

Frequency deviation step response for two areas is as: The figure 7 shows the affection of load on the frequency curve. In this case the frequency curve goes down proportional with the amount of change in load applied to the system for two areas.

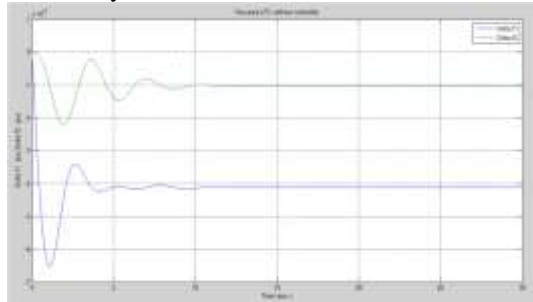


Fig. 7: Simulink dynamic response of change in frequency without controller

#### X. SIMULINK MODEL OF TWO AREA SYSTEM WITH INTEGRAL CONTROLLER

Simulink model for the two areas system with the inclusion of the ACEs and obtain the frequency and the power response for each area.

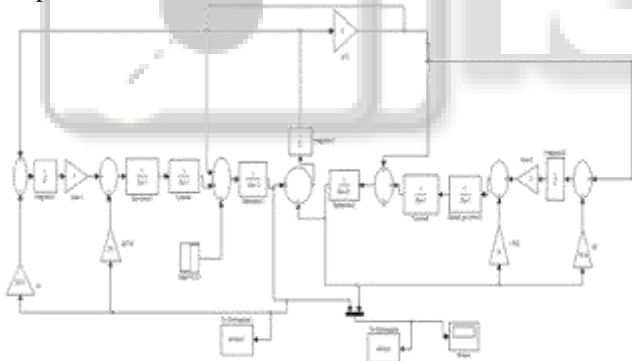


Fig. 8: Simulink model of two area with integral controller By applying the previous values to the simulink diagram and make the changes in the gain it has been noticed that frequency behaviour affected by the overshoots instantaneously and the goes to the stability by using the integral controller.

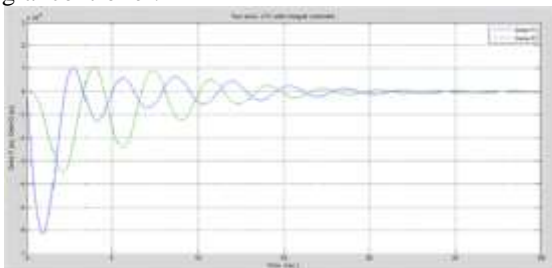


Fig. 9: simulink dynamic response of change in frequency with integral controller

As seen from the figure 9, the frequency deviation returns to zero with a settling time of approximately 20 seconds.

#### XI. CONCLUSIONS

This paper includes the simulink models for one area and two area, with or without using integral controller. This work shows that by using integral controller in one area and two area interconnected power system the frequency is restored to its nominal value to get the optimum result.

From the uncontrolled and controlled simulation of the single area and two area load frequency control its clear that the effect of the integrator term on the overshoot and the stability of the system by changing in the load disturbance the integration term reduces the overshoot time and also the value over the shoot.

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