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Matlab Design and Simulation of AGC and AVR for Multi Area Power System and Demand Side Management

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ABSTRACT

This paper deals with the automatic generation control (AGC) of interconnected thermal systems with combination of the automatic voltage control (AVR) and Demand Side Management (DSM). In this particular work thermal unit is considered with four area concept. The primary purpose of the AGC is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighboring systems are maintained. Any mismatch between generation and demand causes the system frequency to deviate from scheduled value. In this paper DSM scheme is also considered. Demand side management is normally used to reduce the total load demand of power systems during periods of peak demands in order to maintain the security of the system

Index Terms*—Automatic Generation Control (AGC), Automatic Voltage Regulator (AVR), Area Control Error (ACE), Economic Dispatch, Frequency Response, Voltage Response, Power System Operation, Tieline Control, Scheduled Loading Availability (SLA).*

I. INTRODUCTION

The AGC problem, which is the major requirement in parallel operation of several interconnected systems, is one of very important subjects in power system studies [1]. In this paper, the power system with four areas connected through tie-lines is considered in Matlab/Simulink environment. The perturbation of frequencies at the areas and resulting tie-line power flows arise due to unpredictable load variations that cause mismatch between the generated and demanded powers. The objective of AGC is to minimize the transient deviations and to provide zero steady state errors of these variables in a very short time [2] – [5].The generator excitation system maintains generator voltage and controls the reactive power flow. The generator excitation of older system may be provided through slip rings and brushes by means of DC generators mounted on the same shaft as the rotor of the synchronous machine. A change in the real power demand affects essentially the frequency, whereas a change in the reactive power affects mainly the voltage magnitude. The interaction between voltage and frequency controls is generally weak enough to justify their analysis separately. The sources of reactive power are generators, capacitors, and reactors.

SYSTEM INVESTIGATED

The AGC system investigated consists of four generating areas. Area 1, Area 2, Area 3 & Area 4 of different sizes is reheat thermal systems [1]. An automatic voltage regulator for an excited AC generator comprising at least one controlled rectifier for conducting the field current of the generator, a trigger signal supplying means for supplying a trigger signal to the controlled rectifier when the controlled rectifier is forward biased, a voltage detection circuit for detecting the output voltage of the generator, an inhibiting circuit for inhibiting turn-on of the controlled rectifier when the instantaneous value of the voltage detection circuit exceeds a predetermined voltage, characterized in that the voltage detection circuit comprises a phase shifting circuit receiving and shifting the phase of the output voltage of the generator. A multiarea interconnected system is represented in a ring fashion and in a longitudinal manner.

Automatic voltage regulator

- *Amplifier model*

The excitation system amplifier may be magnetic amplifier, rotating amplifier, or modern electronic amplifier. The amplifier is represented by a gain K_A and a time constant T_A and the transfer function is

$$\frac{V_R(S)}{V_e(s)} = \frac{K_A}{1 + sT_A}$$

- *Generator field model*

The transfer function relating the generator terminal voltage to its field voltage can be represented by a gain K_G and a time constant T_G and the transfer function is

$$\frac{V_t(S)}{V_F(s)} = \frac{K_G}{1 + sT_G} \qquad \frac{V_S(S)}{V_t(s)} = \frac{K_R}{1 + sT_R}$$

- *Sensor model*

The voltage is sensed through a potential transformer and, in one form, it is rectified through a bridge rectifier. The sensor is modeled by a simple first order transfer function, is given by…..
Where K_R is sensor gain constant and T_R be Sensor time constant.

COMBINED AVR AND AVR LOOPS

The AVR and AGC Loops are not in the truest sense no interacting; *cross coupling does exist* and can some time troublesome. There is little if any coupling from AGC to AVR loop, but interaction exist in the opposite direction [12] .We understand this readily by realizing that control action in the AVR loop affect the magnitude of generated emf E′. As the internal emf determines the magnitude of real power. It is clear that changes in AVR loop must felt in AGC loop. However, the AVR loop is much faster than the AGC loop and there is tendency for AVR dynamics to settle down before they can make themselves in slower AGC channel.
If we include small effect of voltage on real power, we obtained following liberalized equation:

$$\Delta P_e = P_S\,\Delta\delta + K_2 E'$$

Where K_2 is change in electrical power for small change in stator emf and Ps is synchronizing power coefficient. Also including the small effect of rotor angle upon generator terminal voltage, We may write

$$\Delta V_t = K_5\,\Delta\delta + K_6 E'$$

Where K_5 is change in terminal voltage for small change in rotor angle at constant stator emf and K_6 is change in terminal voltage for small change in stator emf at constant rotor angle.Finally, modifying the generator field transfer function to include effect of rotor angle we may express the stator emf as

$$E' = \frac{K_g}{1 + T_g}\left(V_f - K_4\,\Delta\delta\right)$$

DEMAND SIDE MANAGEMENT

The total amount of real power in network emanates from generator stations, the location and size of which are fixed. The generation must be equal to demand at each moment and since this power must be divided between generators in unique ratio, in order to achieve the economic operation. We conclude that individual generator output must be closely maintained at predetermined set point. But it does not happen. Sometimes demand is very large than generation and some time surplus power in a duration of 24 hrs. It is important to remember that demand undergo slow but wide changes throughout the 24 hr of the day.
Here problem for management is in demand side. Demand side can be managed by controlling tariff in demand side. This is called Demand Side Management and this can deal with two points as

- AGC, AVR and Frequency Availability Based Tariff.
- AGC, AVR and Availability of Scheduled Loading.

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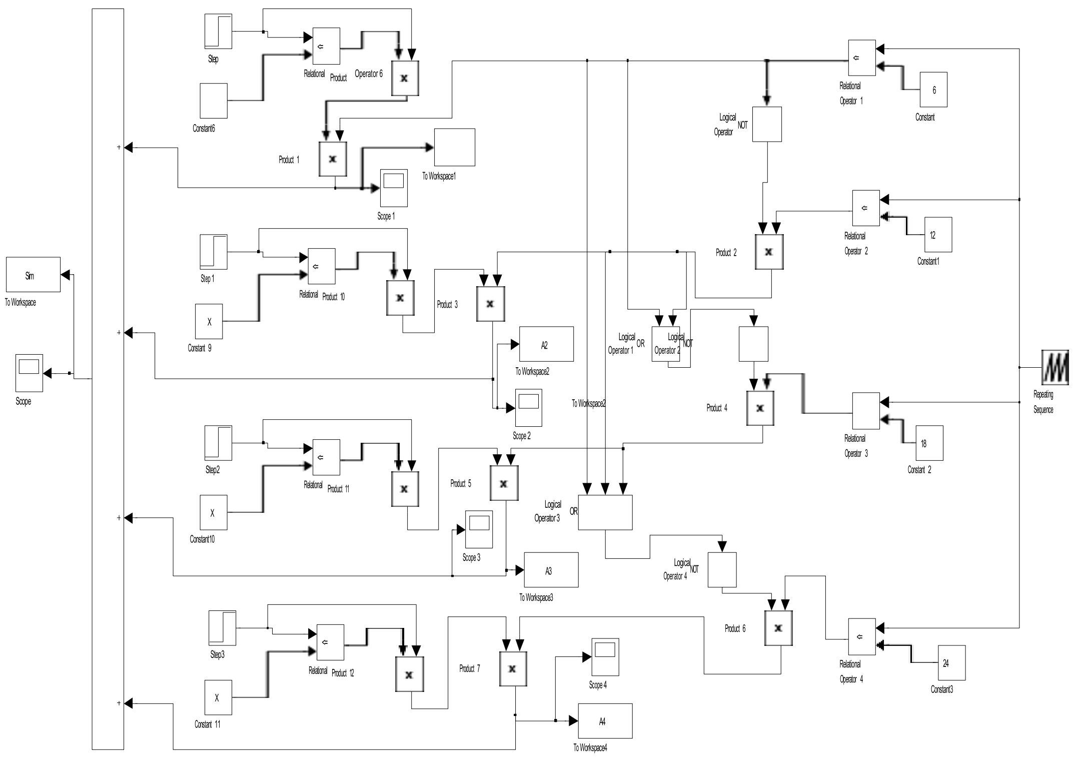
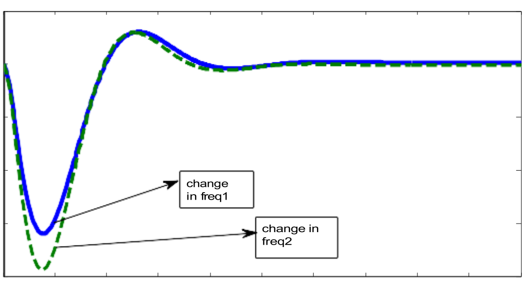


II. DESIGN AND SIMULATION

The testing was completed using the MATLAB Simulink tool. Testing was done on each of the individual blocks of the AGC system. Tests were 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 was the addition of the scopes that would be used to measure the outputs of the system. The inputs for each of the tests were varied to allow for more data. The simulink block diagram representation is shown in Fig. 2. The frequency Vs time responses for interconnected system of Area 1 with area 2,3,4 is shown in Fig. 4, Fig. 5, Fig. 6 respectively. Similarly interconnection of Area 2 with Area 3, 4 is shown in Fig. 7, Fig. 8, and interconnection of Area 3 with Area 4 is shown in Fig. 9.



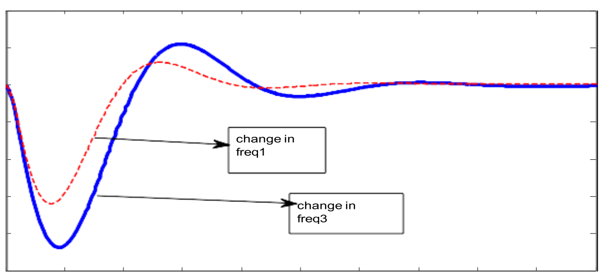
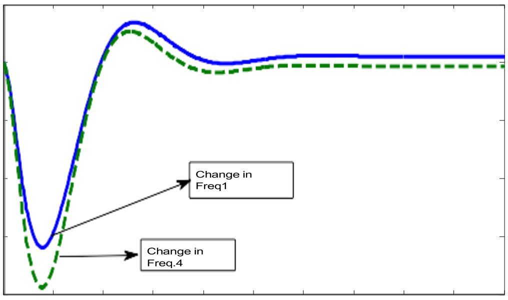


Fig. 4: AGC and AVR response for Area1 & 2 Systems Fig. 5: AGC and AVR response for Area1 & 3 Systems.



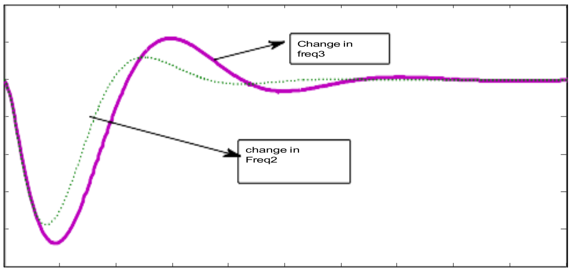
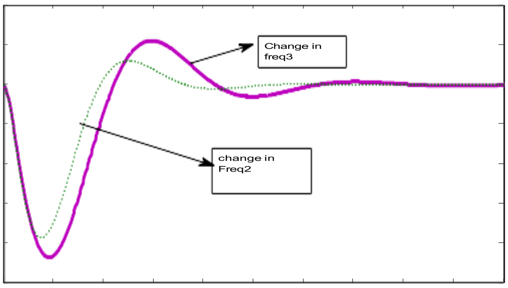


Fig. 6: AGC and AVR Response Area 1 & 4 System. Fig. 7: AGC and AVR Response Area 2& 3 System



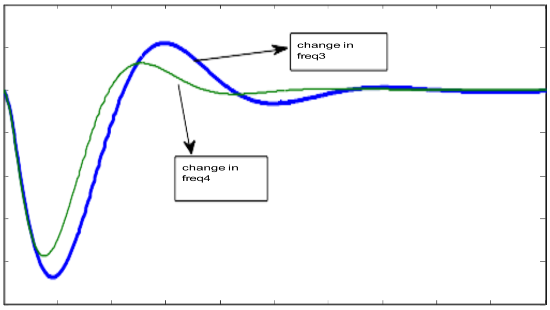
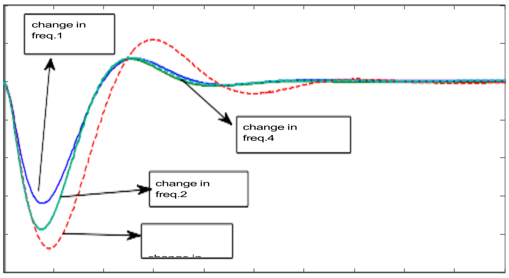


Fig. 8: AGC and AVR response Area 2 & 4 System. Fig. 9: AGC and AVR Response Area 3 & 4 System



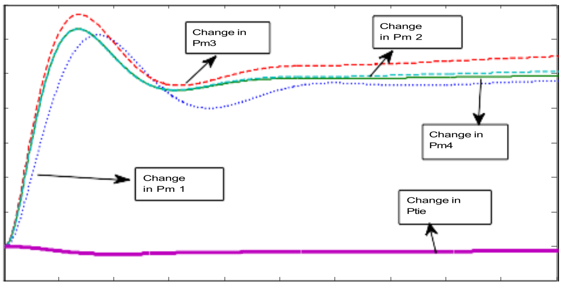


Fig. 10: AGC and AVR Response Area 1,2,3 &4 for Four Area System Fig. 11: Combined Loop of AGC and AVR for Four Areas System

III. CONCLUSION

In this paper attempt is made to develop AGC scheme with AVR and DSM. In this scheme coupling between AGC and AVR is employed and interaction between frequency and voltage exists and cross coupling does exist. AVR loop affect the magnitude of generated emf E´ as the internal emf determines the magnitude of real power. It is concluded that changes in AVR loop is felt in AGC loop. It is concluded that the generation must be equal to demand at each moment, since this power must be divided between generators in unique ratio, in order to achieve the economic operation..

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