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Analysis of Single Area System

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***Abstract* – This is known as free governor operation.ΔPL, the change in load demand. Let us consider a simple situation in which the speed changer has a fixed setting (ΔPref, the change in speed changer setting, and ΔThe work shows that there are two important incremental inputs to the load frequency control system - In the given condition, the block diagram will be simplified as Considering Ts < TTG << TP 1, the dynamic response which is giving the change in frequency as a function of the time for a step change in load can be obtained as follows≅and KSKTG where G(s) = KP/(1+sTP) and H(s) =1/R.**

Therefore, we can say that the LFC system posses inherently steady state error for a step input of load change provided that the reference setting remains unchanged.

Consider now the steady effect of changing speed changer setting with load demand remaining fixed. Similar to the previous condition, letting Ts < TTG << TP 1, the simplified block diagram and transfer function becomes≅and KSKTG Where G(s) = KP/(1+sTP) and H(s) =1/R

Following the same procedure as case A, the steady state change in frequency due to change in reference setting will have similar expression: PL, the steady state frequency change is obtained by superposition, i.e.ΔPref while the load demand changes by ΔIf the speed change setting is changed by According to the above equation, the frequency change caused by load demand can be compensated by changing the setting of the speed changer, i.e. f = 0.Δ, for f is fed through an integrator to the speed changer resulting in the block diagram configuration shown below.ΔTherefore, for this purpose, a signal from Now, the analysis on input-output relation results Neglecting TS and TTG /both have << 1, the above equation becomes,≅Tp/ and KSKTG.

Key Words: load demand, incremental inputs, dynamic response, steady state.

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INTRODUCTION

Here we find that the steady state change in frequency has been reduced to zero by the addition of the integral controller. In central load frequency control of a given control area, the change (error) in frequency is known as Area Control Error (ACE). The additional signal fed back in the modified control scheme presented above is the integral of ACE. From the above analysis, it is clear that proportional integral and derivative control strategy can be applied for load frequency control. While proportional control is inherent in the feedback through the governor mechanism itself, derivative control when introduced improves transient performance and ensures better margin of stability for the system.

The selection of the gain controller /in the secondary LFC/ should be such that i. control loop must be stable, ii. Frequency error should return to zero
COMPOSITE SYSTEM IN A SINGLE CONTROL AREA: The composite power/frequency characteristics of a power system thus depends on the combined effect of the droops of all generator speed governors. It also depends on the frequency characteristics of all the loads in the system. where Meq /equivalent generator/ MΣ= PL is given byΔFor a system with n generators and a composite load-damping constant of D, the steady-state frequency deviation following a load change.

REVIEW OF LITERATURE:

An extended power system can be divided into a number of load frequency control areas interconnected by means of tie lines in order i. to get commercial benefit from neighboring systems ii. to meet sudden requirement of electric power and improve reliability iv. Reduce in installed capacity. The major disadvantages are control system becomes complex and any disturbance in one system is reflected in the other area. The control objective now is to regulate the frequency of each area and to simultaneously regulate the tie line power as per inter-area power contracts. As in the case of frequency, PI controller will be installed so as to give zero steady state error in tie line power flow as compared to the contracted power.

Power transported out of area A is given by where, are power angles of equivalent machines of the two areas. 2, the incremental tie line power can be expressed asδ1 and δFor incremental changes in Where T12 is synchronizing coefficient. F 2), the above equation can be written asΔf1 and ΔSince incremental power angles are integrals of incremental frequencies (Similarly the incremental tie line power out of area B is given by the block diagram of the system based on the above analysis is given below. The steady state response of this two area system can be determined as follows. PL2). ΔPL1 and ΔPref2) and there are step load changes in both areas (ΔPref1 and ΔConsider the speed changer position is fixed (Pm1 ssΔThe turbine input change (& Pm2 ss) due to the valve opening by the regulation characteristics in the two areas in steady state condition becomes ,Δ Fss ;ΔPm1 ss = -(1/R1) Δ FssΔPm2 ss = - (1/R2) Δ Under this condition & Solving for steady state frequency and tie line power, we get & 1 = D1βWhere + 1/R1 2 = D2$\beta$and + 1/R

We thus conclude from the preceding analysis that the two area system, just as in the case of a single area system in the uncontrolled mode, has a steady state error but to a lesser extent and the tie line power deviation and frequency deviation exhibit oscillations that are damped out latter. Hence, in interconnected operation to avoid these deviations and also to enable each area control the changes in such a fashion that it absorbs its own load change in steady state, area control error signals should be sent to reference (speed changer) in the two areas respectively as follows Using laplace transform The general block diagram for a two area system can now be developed as shown below.

MATERIAL AND METHOD:

This is known as free governor operation.ΔPL, the change in load demand. Let us consider a simple situation in which the speed changer has a fixed setting (ΔPref, the change in speed changer setting, and ΔThe above model shows that there are two important incremental inputs to the load frequency control system In the given condition, the block diagram will be simplified as
Considering Ts < TTG << TP 1, the dynamic response which is giving the change in frequency as a function of the time for a step change in load can be obtained as follows$\cong$and KSKTG where G(s) = KP/(1+sTP) and H(s) =1/R.
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Industrial and domestic loads, both, require real and reactive power. Hence, generators have to produce both real and reactive power. Reactive power is required to excite various types of electrical equipment as well as transmission network.

Basically, the reactive power transmitted over a line a great impact on the voltage profile. Hence, by controlling the production, absorption and flow of reactive power at all levels in the system, the control of voltage levels is accomplished.

For efficient and reliable operation of power systems, the control of voltage and reactive power should satisfy the following objectives; Voltage at the terminals of all equipment in the system are within acceptable limits. The reactive power flow is minimized so as to reduce losses to a practical minimum. Important generators of reactive power are over-excited synchronous machines capacitor banks, the capacitance of overhead lines and cables Static var compensators Important consumers of reactive power are inductive static loads, shunt reactors, inductance of overhead lines and cables under-excited synchronous machines, Transformer inductances, induction motors Static var compensators for some of these, the reactive power is easy to control, while for others it is practically impossible. The most important devices for reactive power and voltage control are described hereafter. Generators are often operated at constant voltage by using an AVR which senses the terminal voltage level and adjusts the excitation to maintain constant terminal voltage also maintain the reactive output at the required level. The main purpose of the excitation system of a synchronous machine which may be either DC excitation, AC excitation or Brushless excitation scheme is to feed the field winding with direct current so that the main flux in the rotor is generated. The relation between terminal voltage and induced voltage of alternator can be expressed as Under different loading conditions especially when there is constant real power and variable reactive power demand, the terminal voltage will vary. Consider that the current is operating at unity power factor and hence, no reactive power generation at the alternator. For there is any change in reactive power demand, the alternator acts to supply the demand, if there is no any other device to respond. If excitation is not changed depending on the condition, the terminal voltage of the alternator deviate from the desired value. This in turn, affects the voltage distribution in the system. In order to avoid this problem the excitation of the alternator has to take action accordingly. To understand how voltage can be maintained using excitation system, consider the following schematic diagram The function of important components and their transfer function is given below Potential transformer: It gives a sample of terminal voltage, VT Differencing device: at the feedback point, Vref e∆- VT = e, where kA∆eA = kA ∆Error amplifier: It demodulates and amplifies the error signal is amplifier gain. SCR power amplifier and exciter field: It provides the necessary power amplification to the signal for controlling the exciter field. ie is the change in exciter field current. If∆where ie. The transfer∆ef = kA ∆1A change in field current produce k volt change in the output, then function of the exciter using laplace can be expressed as ef∆Alternator: Its field is excited by the main exciter voltage. Under no-load it produces a voltage proportional to field current. The input voltage signal to the generator field, when applied to the circuit results in the following Kirch off's voltage equation.... v, then∆If the output voltage changes by where Lfa is the mutual inductance between the field and stator phase winding. Hence, the transfer function for the generator block will be the voltage regulator loop can be represented by the following block diagram the cascaded transfer function blocks can be combined into single block Shunt Reactors: are used to compensate for the effects of line capacitance, particularly to limit voltage rise on open circuit or light load.

Shunt Capacitors: supply reactive power and boost local voltages. They are used throughout the system and are applied in a wide range of sizes.

Synchronous condenser: is a synchronous machine running without a prime mover or a mechanical load. By controlling the field excitation, it can be made to either generate or absorb reactive power. Static var compensators (SVCs): may be comprised of two different elements, i.e TCR and TSC. By delaying the firing of the thyristors, a continuous control of the current through the reactor can be obtained, with the reactive power consumption varying between 0 and V2/X.

By combining the TCR with a suitable number of capacitor banks, a continuous control of the reactive power can be achieved by a combination of capacitor bank switching and control of reactor current. The control system of the SVC controls the reactive output so that the voltage magnitude of the controlled node is kept constant. The economic dispatch problem consists in allocating the total demand among generating units so that the production cost is minimized. Generating units have different production costs depending on the prime energy source used to produce electricity (mainly coal, oil, natural gas, uranium, and water stored in reservoirs). In addition to continuous decisions on how to allocate the demand among generating units, the economics of electricity generation also requires the calculation of an optimum time schedule for the start-up and shutdown costs of the generating units. (since the units' start-up or shutdown costs can be significant, on/off scheduling decisions must be optimally coordinated with the ED of the continuous generation outputs.

Each generating unit is assigned a function, Ci(PGi), characterizing its generating cost in $/h in terms of the power produced in MW, PGi, during 1hr. This function is obtained by multiplying the heat rate curve, expressing the fuel consumed to produce 1MW during 1hr, by the cost of the fuel consumed during that hour. /Note that the heat rate is a measure of the energy efficiency of the generating unit/.

Considering n generating units, the total production cost is where Pgi is unit generation level If the system total demand is PD total and all generating units contribute to supply this demand, total production or generation must be the ED problem consists of minimizing the total cost with respect to the unit generation output subject to the above power balance, and to the generating unit operational limits Using the method of Lagrange multipliers, neglecting losses and generating limits for simplicity, G(P) where F(P) is objective function for minimization and G(P) is equality constraint. Therefore,λ) = F(P) + λwe have L(P, The necessary conditions are given as Hence, we get at the optimum.λThe above equation states that at the optimum all the generating stations operate the same incremental cost for optimum economy and their incremental production cost is equal to the Lagrange multiplier In addition to the load should be taken up always at the lowest incremental cost, it must be ensured that the generations so determined are within their capacities. Under this circumstance, the Lagrange function becomes where new multipliers, are incorporated, corresponding to the minimum and maximum power outputs of each generating unit. The first-order necessary optimality conditions become

Hence, the marginal cost will be operated at equal incremental cost if the generation is within the limits. Otherwise, the generation has to be kept constant at the capacity limit for that unit and eliminated from further optimum calculations. Electric power transmission or "high voltage electric transmission" is the bulk transfer of electrical energy, from generating power plants to substations located near to population centers. This is distinct from the local wiring between high voltage substations and customers, which is typically referred to as electricity distribution. In this process, some part of electric energy is lost as transmission and distribution loss. The size of the power systems increased enormously, with long transmission lines connecting several power generating stations extending over large geographical areas transferring power to several load centers.

CONCLUSION:

With this development, it has become necessary to consider not only the incremental fuel costs but also incremental transmission losses incurred in these line while power is transmitted. Here, the previous equality constraint is modified by including losses and the Lagrange function becomes Applying the necessary conditions for the minimum L is equal to the incremental cost of the received power.λ. This constant λ must be constant for all generators and equal to λThe sum of the incremental production cost of power at any plant i and the incremental transmission losses incurred due to generation Pi at bus i charged at the rate of One of the most important, simple but approximate methods of expressing transmission loss as a function of generator powers is through B-coefficients. This method uses the fact that under normal operating condition the transmission loss is quadratic in the injected bus real powers. where Pi and Pj are real power injection at bus i and j, and Bij is loss coefficients. Substituting this to the previous first derivative equation, we get If the incremental costs are represented by a linear relationship following a quadratic characteristics, then ICi(PGi) = ciPi + di Substituting PGi = Pi + Pdi, and simplifying for Pi, the above equation can be solved iteratively by assuming initial values of Pi . Iterations are stopped when Pis converge within a specified accuracy.λFor any particular value of It should be understood that losses can be considered not only as a constraint but also as objective function

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