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Automatic Generation Control Issues in Power System Operation after Deregulation Review

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Abstract : This paper deals with load frequency control of interconnected power system before and after the deregulation. In this particular work two area concepts is considered. The primary purpose of the AGC (automatic generation control) or LFC (loud frequency control) is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighbouring systems are maintained. Any mismatch between generation and demand causes the system frequency to deviate from schedule value. Thus frequency deviation may lead to system collapse. Further, in a restructured power system, the engineering aspects of planning and operation have to be reformulated although essential ideas remain the same. The traditional power system is subdivided according to geographical size into utilities, control areas, pools and coordinating councils. Utilities typically own generation, transmission and possibly, distribution over a wide geographical area. In the competitive market structure various tasks which are normally carried out within the traditional system are separated so that these tasks can be open to competition whenever practical and profitable. This process is called "Unbundling". The traditional AGC two area systems is modified to take into account the role of AGC as an ancillary service and system performance has been evaluated.

Keywords: automatic Generation Control, load frequency Control, area Control Error Area Participation Factor.

I. Introduction

In recent years, power system restructuring has been a worldwide trend with the introduction of competitive of market system under deregulation. Also, major changes have been introduced into the structure of electric power utilities all around the world. The reason for this was to improve the efficiency in the operation of power system by means of deregulating the industry and opening it up to private competition. In this new frame work, consumers will have an opportunity to make a choice among competing providers of electric energy. The net effect of such changes will mean that the transmission, generation and distribution system must now adapt to a new set of rules dictated by open markets. In power system, any sudden load perturbations cause the deviations of tie- line exchanges and the frequency fluctuations. So, the load frequency control (LFC) and automatic generation control (AGC) is very important issues in power system operation and control for supplying sufficient and reliable electric power with good quality. The main goal of AGC of power system within specified tolerance is to maintain the frequency of each area and tie-line power flow by adjusting the MW outputs of AGC generators so as to accommodate fluctuating load demands. Automatic generation control (AGC) in a multi area interconnected power system has four principal objectives when operating in either the so-called normal and preventive operating states:

- Matching total system generation to total system load.
- Regulating system electrical frequency error to zero.
- Distributing system generation amongst control areas so that net area tie flows match net area tie flow schedules.
- Distributing area generation amongst area generation sources so that the area operating costs are minimized, subject to appropriate security and environmental constraints.

Power system loads and losses are sensitive to frequency. Data captured right after frequency disturbances indicate that their aggregate initial change is in the same direction as the frequency change. Once a generating unit is tripped or a block of load is added to the system, the power mismatch is initially compensated by an extraction of kinetic energy from system inertial storage which causes a declining system frequency. As frequency decreases, the power taken by load decreases. Equilibrium for large is often obtained When the frequency sensitivity reduction of loads balances the output power of the tripped unit or that delivered to the added block of load at the resulting (new) frequency. If this effect halts the frequency decline it usually does so in less than 2 seconds. If the mismatch is large enough to cause the frequency to deviate beyond the governor dead band of generating units, their output will be increased by governor action. For such mismatches, equilibrium is obtained when the reduction in the power taken by load plus the increased generation due to governor action compensates for the mismatch. Such equilibrium is normally obtained within a dozen seconds after the tripping of a unit or connection of the additional load.

A. Operating Environment

Since the end product is simulation, the operating environment is not applicable.

B. ASSUMPTIONS

1. We assumed the basic block diagram for a two area AGC system.
2. We assumed the system is in normal operating state.
3. The loss of a generating unit will not be considered.
4. We also extend this block diagram up to 4 generating units.

C. LIMITATIONS

1. The area control error or the power interchange between areas must be equal to zero at least one time for every 10 minutes.
2. The average power interchange between areas must be zero in ten minutes period and follow limits of the generation system
3. Power interchange between areas must be returned to zero in 10 minutes.
4. Corrective actions must be accommodating within one minute of a disturbance.

II. OPEN LOOP AGC SYSTEM FOR SINGLE AREA SYSTEM

In the present system the coordinator must also project which units should operated in subsequent periods. Unit commitment programs are used to fulfil this function. Operating capacity additions must be planned in advance given the fact that it may take from 1 to 10 hours to restart all available steam plants, for example. Other conditions, such as hydro storage facilities, may require that weekly concerns be included (for example, start the week with full storage, end the week with no storage, and pump the storage full over the weekend). At present, energy management systems and various utility control centres respond to their anticipated demand and perform economic dispatch and unit commitment. The units under the jurisdiction of a particular EMS or a control center generally schedule their own units for the prepared upon power exchange with neighbouring companies. Tie-line flow scheduling among different companies is done bilaterally without any overall systemwide coordination. Frequency deviates and error is continuously exists in the system. This frequency error must be removed.

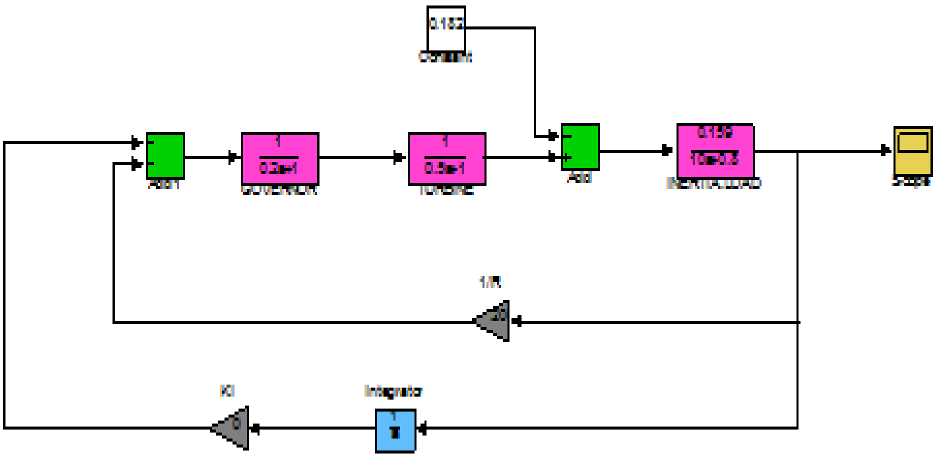
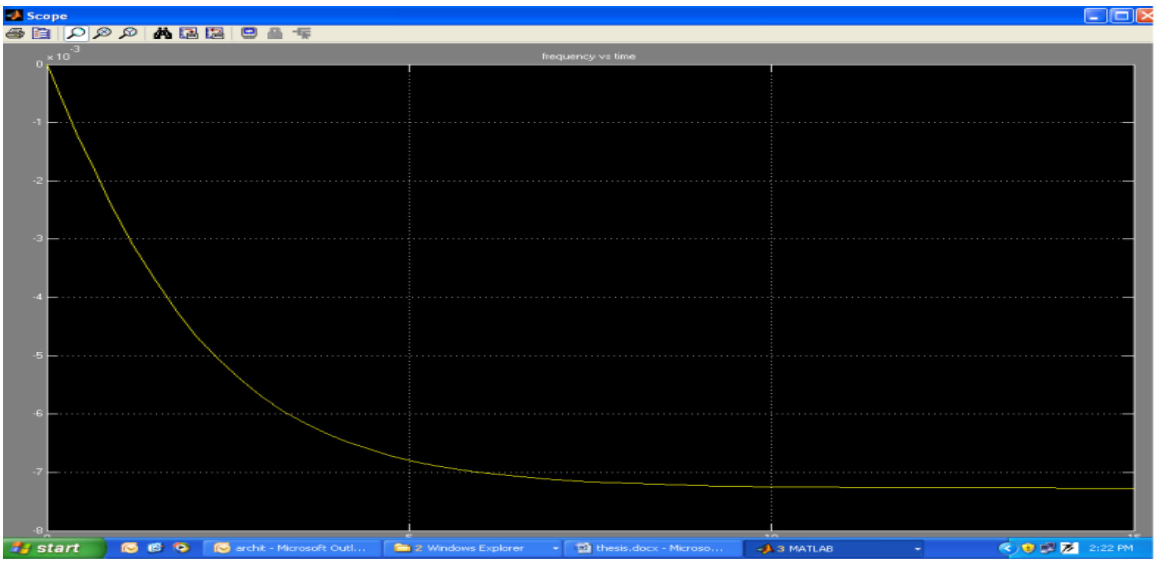


Fig. 2.1 Open Loop AGC single Area System



Time (seconds)

Fig 2.2 Response for open loop single area

It is found from graph that with open loop if demand changes to 0.180 pu, a steady state error exists in frequency of 0.008 unit.

III. CLOSE LOOP AGC FOR SINGLE AREA SYSTEM

System frequency specifications are rather stringent and, therefore, so much change infrequency cannot be tolerated. In fact, it is expected that the steady change in frequency cannot be tolerated. In fact, it is expected that the steady change in frequency will be zero. While steady state frequency can be brought back to the scheduled value by adjusting speed changer setting, the system could undergo intolerable dynamic frequency changes with change in load. It leads to the natural suggestion that the speed changer setting be adjusted automatically by monitoring the frequency changes. For this purpose, a signal from ΔF is fed through an integrator to the speed changer. The closed loop AGC system is shown in figure

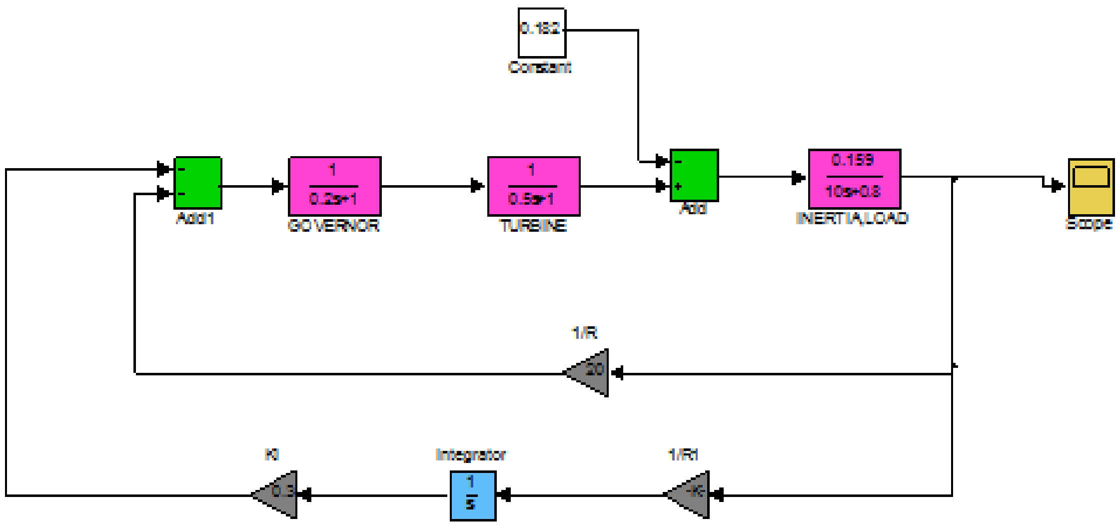
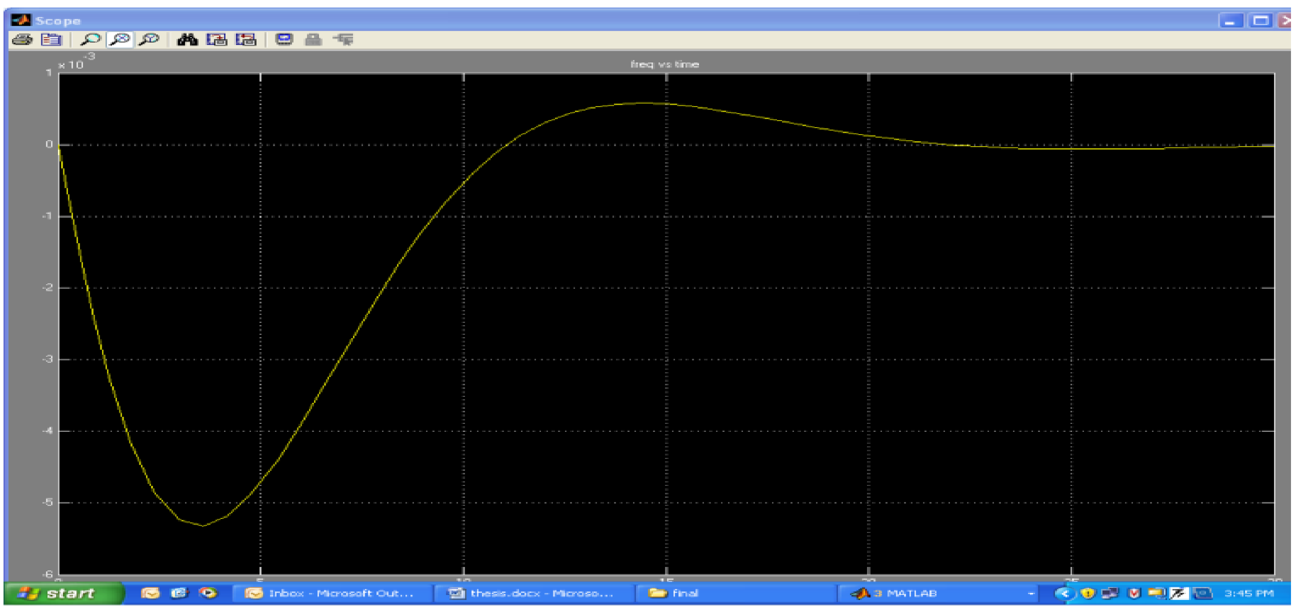


Fig. 3.1 Close loop AGC system for single area

As there are several GENCOs and DISCOs in the deregulated structure, a DISCO has the freedom to have a contract with any GENCO for transaction of power. A DISCO may have a contract with a GENCO in another control area. Such transactions are called "bilateral transactions." All the transactions have to be cleared through an impartial entity called an independent system operator (ISO). The ISO has to control a number of so-called "ancillary services", one of which is AGC. The frequency response is as shown:



Time (seconds)

Fig. 3.2 Response for close loop AGC system

It is concluded that the system now modifies to a proportional plus integral controller, which, as is well known from control theory, gives zero steady state error, i.e. Δf(steady state) = 0.

Among these ancillary services is the Automatic Generation Control(AGC). In the new scenario, a DISCO can contract individually with a GENCO for power and these transactions will be made under the supervision of ISO. The entities that will wheel this power between GENCOs and DISCOs have been designated as TRANSCOs. A DISCO may have a contract with a GENCO in another control area. Such transactions are called "bilateral transactions."

A. AGC System in Restructured Environment

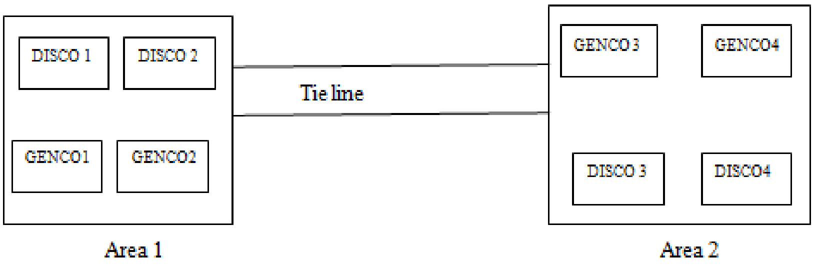


Fig. 3.3 Schematic of a 2 area system in restructured environment

B. Case 1

In this case I consider a two area system with one GENCO and one DISCO in each area as shown in figure below. This case is to be considered as a simplified case for a complete two area AGC system in restructured environment.

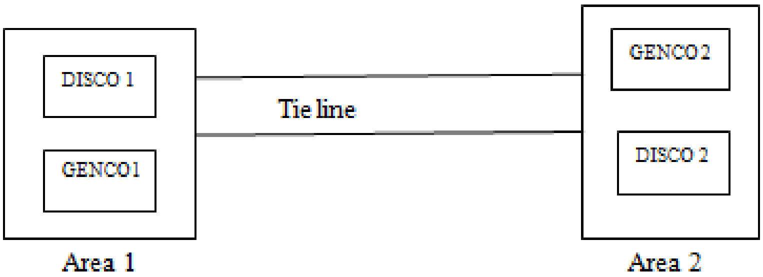


Fig. 3.4 Schematic of a 2 area system in restructured environment

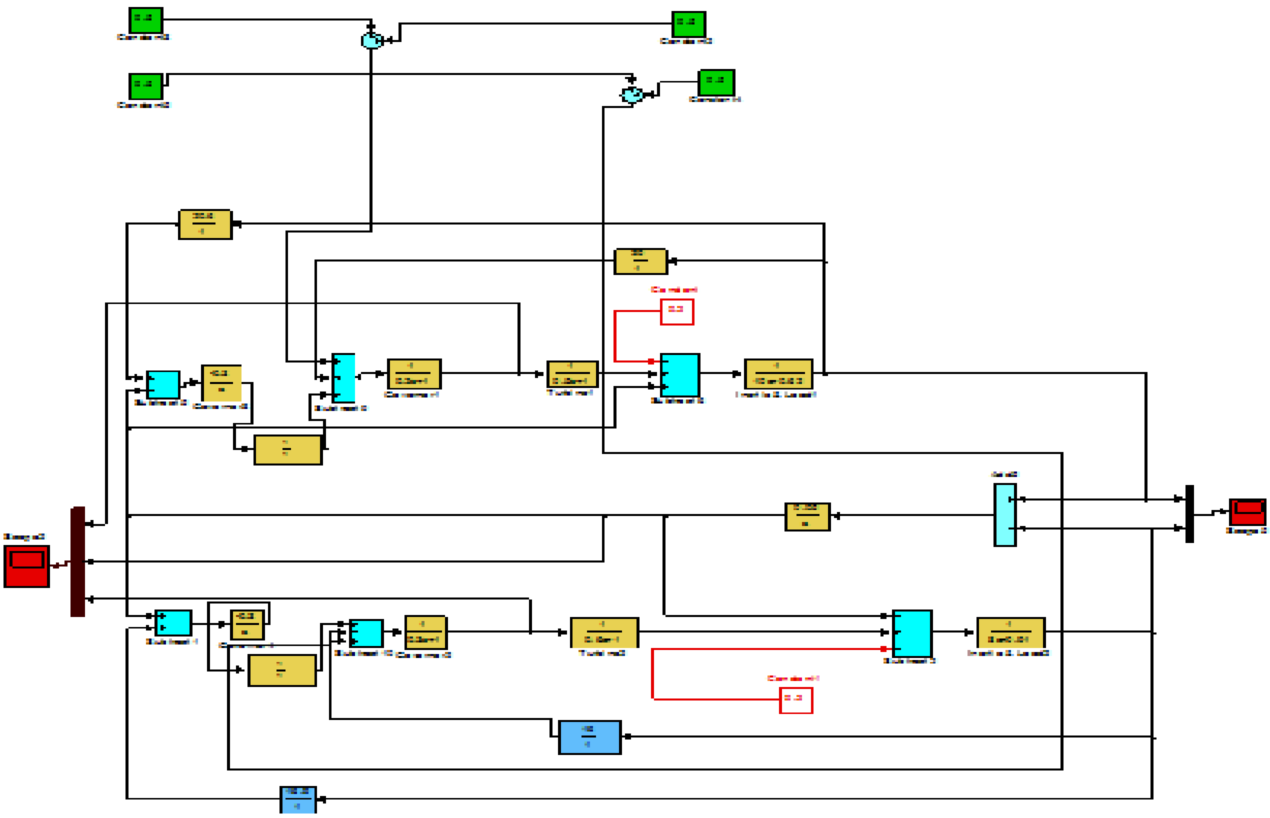
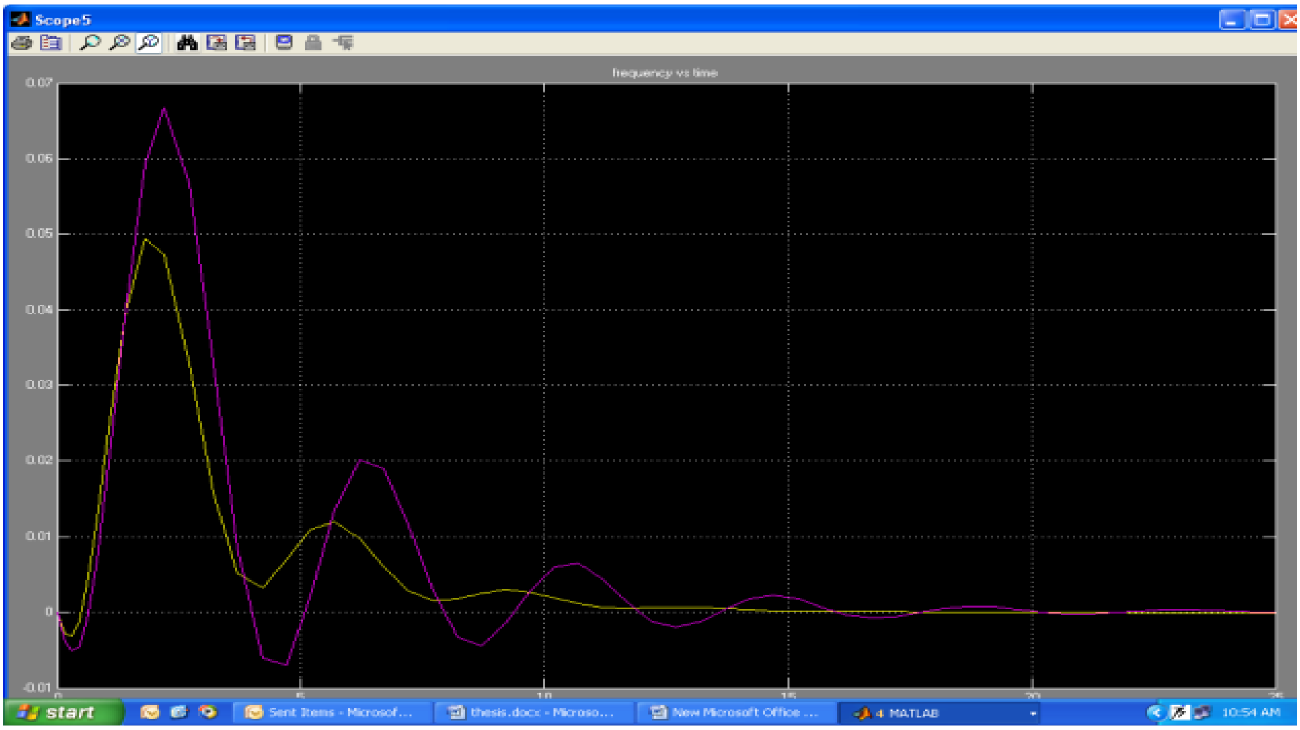


Figure 3.5 AGC model for two area system in restructured environment

In this case all the participation factors of a distribution participation matrix is considered as 0.5, that is both the distribution companies demand equally from their GENCO and both the ACE participation factors are considered as 1.0 and as no distribution company demands power from GENCO of another area, therefore, tie line power flow is zero as shown in results below.



Time (seconds)

Figure 3.6 Frequency Response for two area AGC system in restructured environment

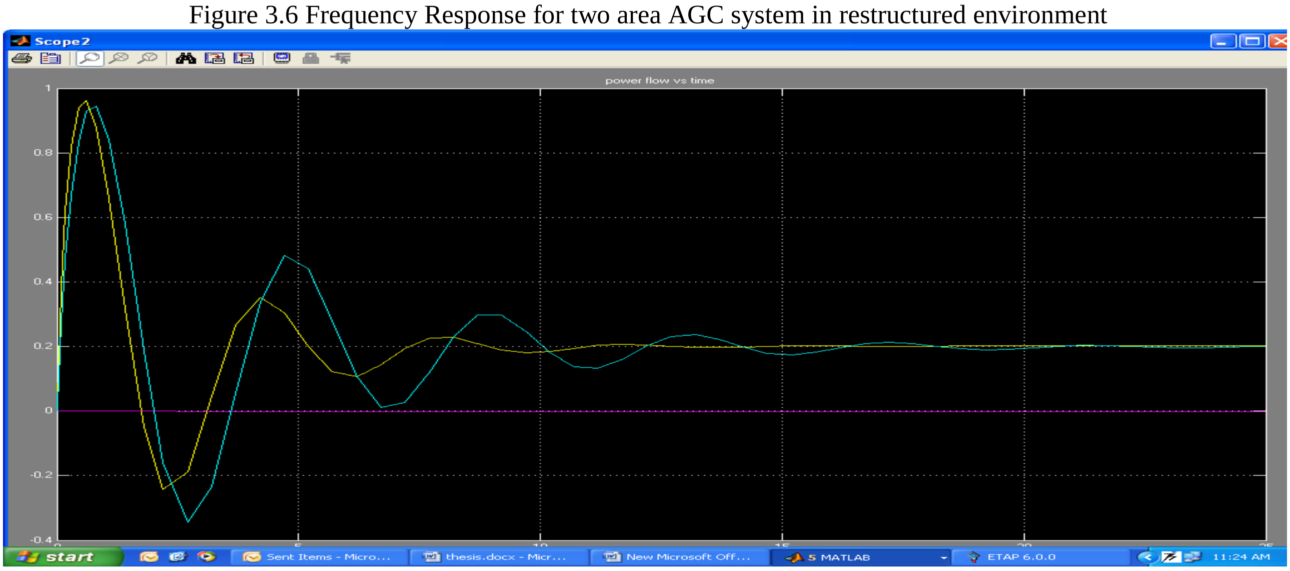


Figure 3.7 Power Responses for two area AGC system in restructured environment

IV CONCLUSION

AGC provides a relatively simple, yet extremely effective method of adjusting generation to minimize frequency deviations and regulate tie –line flows. This important role will continue in restructured electricity markets. However some important modifications are necessary to cater for bilateral contracts that span control areas. Bilateral contracts can exist between DISCOs in one control area and GENCOs in other control areas. The scheduled flow on a tie line between two control areas must exactly match the net some of the contracts that exist between market participants on opposite sides of the tie line (taking account of contract directions). If a contract is adjusted, the scheduled tie line flow must be adjusted accordingly. The concept of “Disco Partition Matrix” (DPM) is introduced in this work. The DPM provides a compact yet precise way of summarizing bilateral contractual arrangements. The modelling of AGC in a restructured environment must take account of the information flow relating to bilateral contracts. Clearly, contracts must be communicated between DISCOs and GENCOs. However it is also important that information regarding contracts is taken into account in establishing/ adjusting the tie line set points. In This paper attempt is made to make a scheme for automatic generation control within a restructured environment considering effects of contracts between DISCOs and GENCOs to make power system network in normal state.

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