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STUDY OF DYNAMIC PERFORMANCE OF TWO-AREA RESTRUCTURED POWER SYSTEM IN THE PRECENCE OF DISTRIBUTED GENERATION

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ABSTRACT
Due to the restructuring of power systems, the systems studied in this paper, an interconnected hydrothermal two-area power system is intended to be connected via a Tie-line. Here, the use of distributed generation, we are trying to improve the dynamic performance of the system including improvement in the frequency variations of areas and tie-line power between areas. Using local produce energy can be replaced the increased demand caused by the development and changing consumption patterns without suffering the high cost of line feed. Here, distributed generation is considered a thermal power plant close to the load of thermal area. The two-area power system is placed under fault condition (in this case, change the load step of 1%), and circuit simulation are presented. The simulation results show that the dynamic performance of system is improved variability in the frequency and tie-line power is reduced and thus about the stability of the restructured system is increased.

KEYWORDS: Distributed Generation, energy, solar energy, Restructured Power System.

INTRODUCTION
Large scale power systems are normally composed of coherent groups but independent generators that are connected through tie-line. These independent power units in a geographic area, called an area. Today, the movement of power systems from the traditional structure into the restructured system, and also tend to use new and renewable energy is caused to considered the small production units. (Srinivasa Rao *et al*., 2009). Small production units that once installed at strategic points of system near the load centers are called DG, including gas turbines, micro turbines, fuel cells, solar energy, etc. although the local power plants may never replace by main production centers, but can be combined with other production units in the network. Using local produce energy can be replaced by the increased demand caused by the development and changing consumption patterns without suffering the high cost of line feed. In an operational interconnected power system production power are normally composed of gas, hydro and thermal production power. (Srinivasa Rao *et al*., 2009). Actually, DG plays an important role in the performance of distribution companies, structure and design of them. DG technologies, benefits and impact in the electricity are caused to be considered in the design of distribution companies as an appropriate and reliable option. On the other hand, because of the demand for energy during peak times (when the market price is high), DG can provide additional load imposed on the network with energy supply and involved effectively reduction load with local power supply. (Srinivasa Rao *et al*., 2009).

This way, the validity and reliability of the power supply is also improved and has made significant investment made in the deployment of distributed generation. In most countries, DG constitutes about 10% of installed power generation capacity. There are numerous definitions for distributed generation systems, but basic and common sense can be paraphrased as: distributed generation are small plants with capacities between 15 kW to 25 kW for the charging station close to the consumer and provide network and load requirements and this power stations are displayed with abbreviation mark DG. (Iran power encyclopedia, 2010, Srinivasa Rao *et al.*, 2007). What power system designers have interested to centralized generation, they are supplying large electrical load, increasing the thermal efficiently, reduce operating costs and investment costs per kWh produced. There are losses at all levels of the power systems such as generation, transmission and distribution, and 75% of losses occur in distribution networks. This is due to the high amount of current lines because of the low voltage in distribution networks and also the radial structure of the networks. Therefore, reduce distribution networks losses is very important. Due to competition and restructuring in power systems is expected that small generation units (DGs) has increasing role in the future of these systems. Generally, each type of energy production at relatively low capacities regardless of the technology used in its production process, it is a form of distributed generation, that taking place in power consumption or near it (mainly in the power distribution networks). (Iran power encyclopedia, 2010, Srinivasa Rao *et al.*, 2007). The use of distributed generation, the connection of these units to the power grids, can delay the construction of new lines; with generate and

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transmit more power increase network efficiency, reduce network overloaded feeders, reduce network transmission paths, reduce network losses so the importance of the use of distributed generation in distribution systems, technical and economic point of view remarkable. (Iran power encyclopedia, 2010, Srinivasa Rao *et al*., 2007). Generally, the various types of distributed generation units, are different depending on the type, nominal capacity and also prices. The use of distributed generation is possible along with the use of large power grids. Traditional structures of power systems are divided into three parts: generation, transmission and distribution. Today, especially in the developed countries, traditional structure has changed considerably, by creating the centers of electric energy production known as the DGs, by providing energy near the centers of consumption and take into consideration the competition and restructuring of power systems, emphasis on the protection of environment, efforts to increase productively and better utilization of fossil energy sources and the approach to the use of renewable energy and new energy sources. (Iran power encyclopedia, 2010).

The main factors that led to special attention to be DG in recent decades as follows: need to restructure the electricity industry, power quality and reliability problems, global economic growth and population, rapid technological developments and emerging high-efficiency technologies, pollution air and the environment caused by burning fossil fuels in the technologies that had low efficiency and also produce high pollution, need to save energy consumption due to the decline of fossil fuel resources. Types of distributed generators, gas generators and small gas turbines have the highest chance for the global market perspective. (Iran power encyclopedia, 2010). Long transmission networks are seriously vulnerable despite all their benefits. Floods, earthquakes, landslides, heavy rain snow, storm, hostile threats and technical problems are the elements of a long list of factors threatening networks. These threats are not limited to poor countries and countries in terms of security, economy and technology are among the most advanced countries. Networks are at risk of injury. (Iran power encyclopedia, 2010). Assignment great power plants require a lot of capital; but it is possible that people with little money to build a small power plant and also thereby in addition affecting production, to find a job to return soon. The construction of these plants can be reduced losses in peak time and provided the bulk of the country's needs. Partnership and attracting investment potential in small-scale, avoid the losses of the transmission and distribution networks, reducing the need for investment in the transmission and distribution, eliminating the problems of land nature in transition plants, preparation of passive defense, ease and speed of installation at commissioning the possibility of localizing and native build generators and reducing environmental pollution are the benefits of this plant. (Iran power encyclopedia, 2010).

MATERIALS AND METHODS

Here, according to the model proposed for multi-area power system. For instance, have been investigated the impact of distributed generation on an interconnected power system with dividing into control areas that are connected by tie-lines. In each control area, all manufacturers are intended to form a coherent group. Power system under consideration in this study, typically is considered a power system consist of two areas that is shown in Figure 1. Detailed block diagram of the system with all parameters is given in Figure 2. (Srinivasa Rao *et al.*, 2007) Each area provides the required contribution and transmission lines may provide the flow of power regions. Therefore, the load's deviation in each of the areas, affect frequencies of other areas and also transmission lines. Due to this, the control system of each area requires information about the status of transmission in all areas, in order to delivering local frequency to its steady state, in restructured environment, each power system, provides control items such as frequency, as an ancillary service. (Noroozian, 1997, Srinivasa Rao *et al.*, 2007).

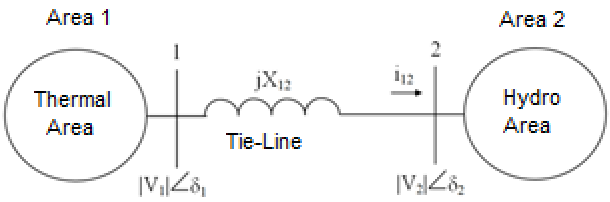

Figure 1: The two-area interconnected power system

Automatic generation control system under study, the combination of two areas is an interconnected system. Area 1, including a thermal system and area 2 includes a hydro system that is connected by a tie-line with reactance X12. (Noroozian, 1997, Srinivasa Rao *et al.*, 2007)

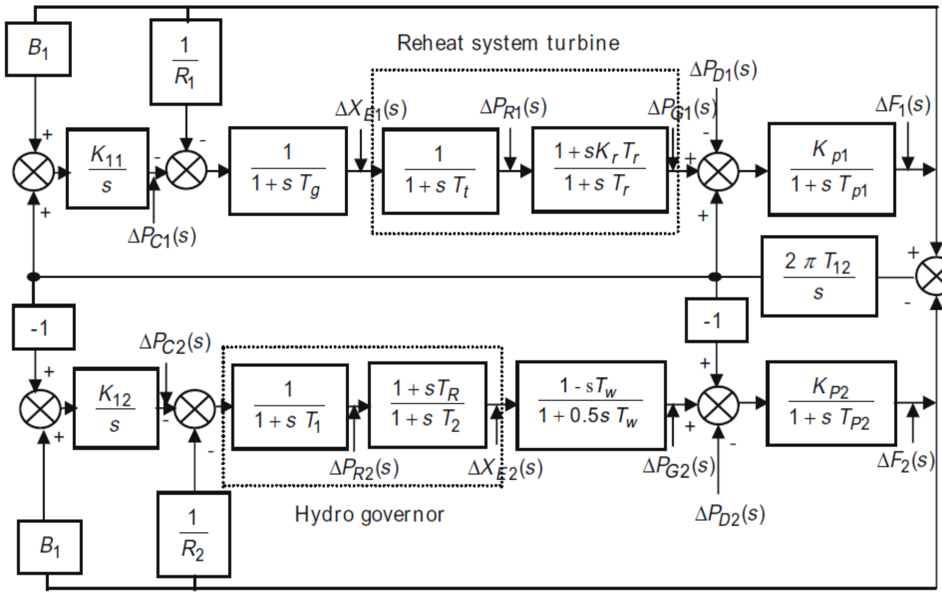

Figure 2: Two-area interconnected hydrothermal system

Specifications of the system, shown in figure 2, are below. (Noroozian, 1997, Srinivasa Rao *et al.*, 2007, Bamasak, 2005)

TP_2, TP_1 = Time constants of the power system
KP_2, KP_1 = Gains of the power system
T_T = Turbine time constant
T_G = Time constant of the thermal area governor
T_W = Time constant of water
T_2, T_1, TR = Time constant of the hydro area governor
R_2, R_1 = Speed setting parameter of governor respectively for thermal area and hydro area (a_{12}= $-PR_1/PR_2$)
PR_2, PR_1 = Relative capacitors capacity
B_2, B_1 = Frequency bias factor respectively for thermal and hydro area
KI_2, KI_1 = integral gains respectively for thermal and hydro area
For the system studied, the optimal values of the integral gain settings for each of the thermal or hydro areas, with the use of smart controllers such as fuzzy logic controller and genetic algorithms are shown in table 1. (Srinivasa Rao *et al.*, 2009)

Table 1. The optimal values of the integral gain settings

area	Integral gains
thermal	**KI1=0.0650**
hydro	**KI2 =0.0470**

In this section, first, the model of distributed generation will be added to the model shown in figure 1. Then, the dynamic responses of the system will be studied in terms of error conditions. In figure 3, two-area interconnected

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hydrothermal power system model with consideration of distributed generation is shown. Chosen DG is considered a thermal generator.

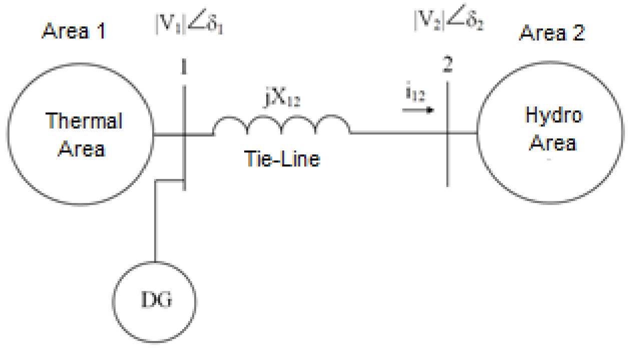

Figure 3: Two-area interconnected hydrothermal power system in the present of DG

Block diagram of figure 3 is shown in Figure 4. The model of distributed generation in the thermal area is added to Figure 2.

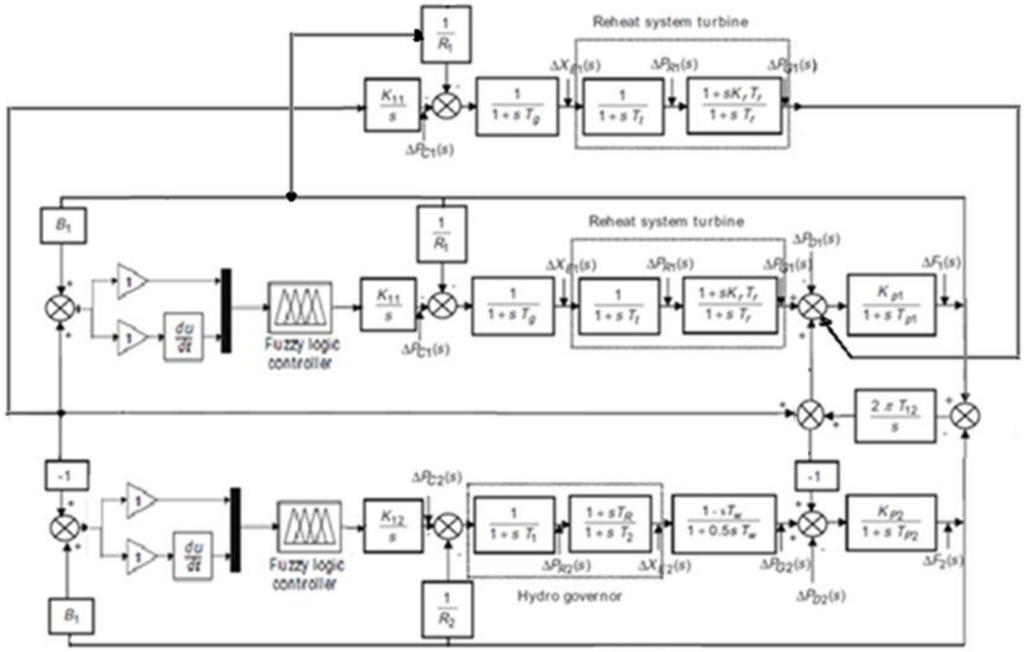

Figure 4: block diagram of two-area interconnected hydrothermal power system in the presence of DG

RESULTS AND DISCUSSION

According to the difficulties and limitations of construction hydro's power plants, thermal power plants are generally used as distributed generation. Here, also distributed generation has been considered a thermal power plant close to thermal area of two-area interconnected power system that is shown in Figure 3. Then the dynamic response of the system to change the load step of 1% in one of the areas will be obtained. The numerical values of the parameters depend on distributed generation unit is as follows:

Tt = 0.15 s, Tg = 0.04 s, Tr = 2.5 s, R_1, R_2 = 1.2 Hz/pu MW

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In a deregulated power system, the presence of distributed generation, with increased load, distributed generation by increasing production compensates the lack of load. If the load generated by DG unable to fully compensate the lack of load, this lack moved through the tie-line to the power grid and will be compensated by other area. This is due to the sudden change of load was not fully transferred to the power grid and frequency variations and tie-line power with less intensity occur in the restructured power networks. Thus, the stability of the restructured power system increases.
Simulation results of power system studied with regard to distributed generation close to load, into the step change of load in the thermal area, are shown in Figure 5 to 7. Figure 5 and 6, respectively, frequency variations of the first and second area, and in Figure 7, changes in tie-line power between two areas into step change in the thermal area. In the presence of distributed generation in comparison to the same mode for power system in the absence of distributed generation is shown.

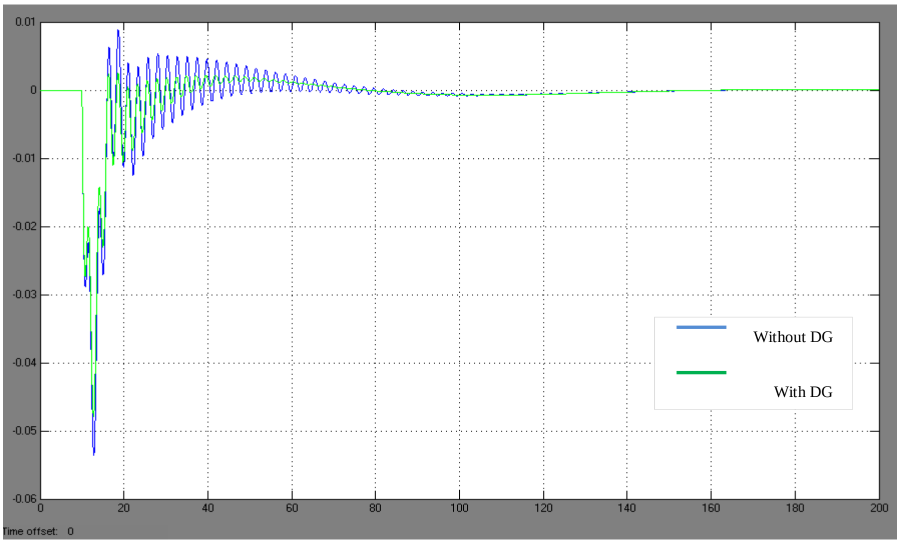

Figure 5: Frequency variations in the thermal area due to step change in the thermal area in the presence of DG

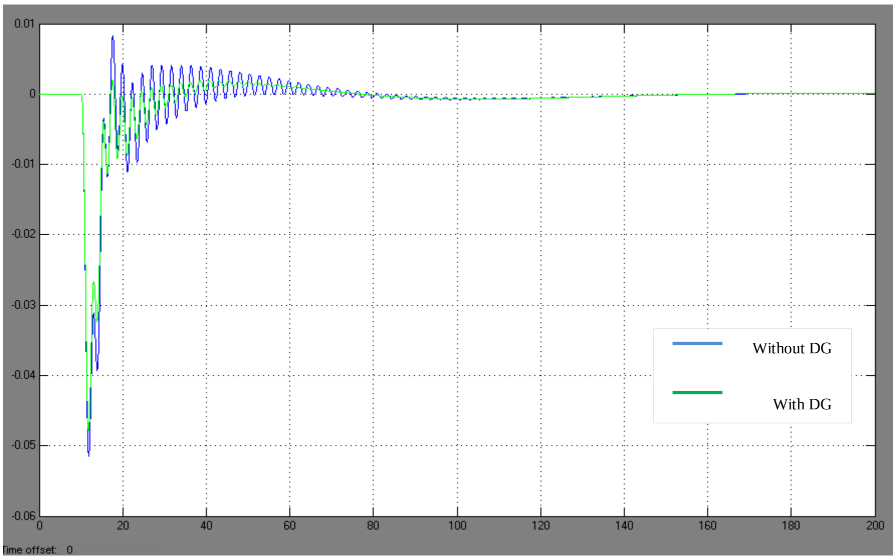

Figure 6: Frequency variations in the hydro area due to step change in the thermal area in the presence of DG

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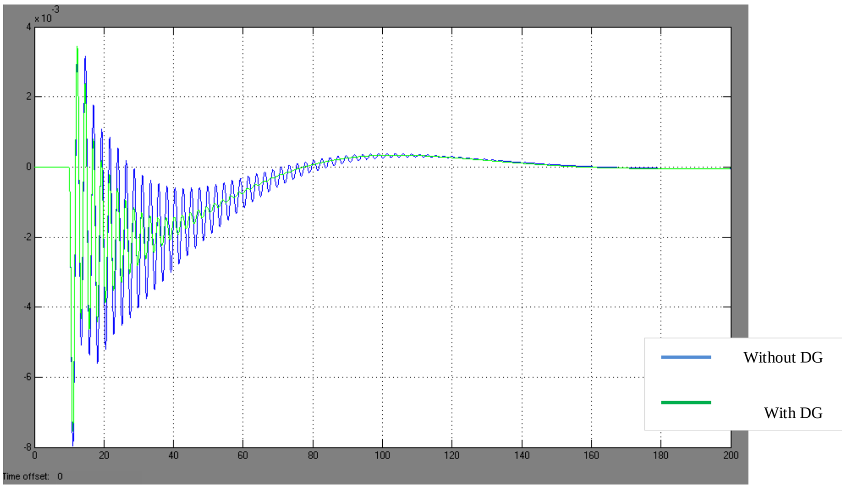

Figure 7: Changes in tie-line power due to step change in the thermal area in the presence of DG

As shown, before deployment of distributed generation, frequency changes and tie-line power had many variations. But after entering it, depending on the characteristic of DG, first, frequency and tie-line power disturbances related to changes in load disappeared and, secondly, the maximum amplitude of frequency and tie-line power changes is dramatically reduced. Here, given the choice of DG, the overshoot of frequency variations in thermal area is reduced the amount of 67% and in hydro area the amount of 72%. The amplitude of tie-line power variations approximately has 60% reduction. Also the variations of tie-line power are damped almost 60 seconds faster. Therefore, the system becomes more stable. The quality of power source is determined by voltage and frequency stability. The lowest frequency deviation and good terminal voltage response are characteristics of a reliable source of power. Simulation results, proves the impact of distributed generation in a multi-area system. Below are the most important results from this study:

- This method can reduce oscillation frequency deviation and tie-line power.
- The presences of DG contribute to the greater stability of system.
- Sitting time and peak overshoot dropped and almost no changes are transient dynamic response of system.

Simulation results show that the deployment of distributed generation, system vibrations reduces and increases the stability of restructured power system.

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