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AUTOMATIC GENERATION CONTROL FOR A MULTI-AREA THERMAL SYSTEM INCORPORATING TCPS-SMES

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ABSTRACT

The power systems are widely interconnected for its applicability all over the globe. Interconnection not only enhances system reliability but also improves the system efficiency. Since the system is wide and complex, for the faithful operation, the analysis of the system is of greater importance. Frequency deviations and inter-area tie-power fluctuations from their respective scheduled values following a local load disturbance which is a source of great concern in interconnected power system operation and control.

Here two methods are proposed to minimize such deviations and thereby enhancing the performance of Automatic Generation Control (AGC) of an interconnected power system which includes Thyristor Controlled Phase Shifter (TCPS) & Superconducting Magnetic Energy Storage system (SMES) with Fuzzy Gain Scheduled (FGS) including supplementary controller for the improvement of Load Frequency Control (LFC).Therefore, the present work considers the coordinated operation of SMES and TCPS for the AGC of a two area interconnected of a thermal power system. And the system is modeled by using MATLAB/SIMULINK.

INTRODUCTION

There are volumes of research articles which have been appeared in the literature regarding Automatic Generation Control (AGC)/LFC of single area/multi area power system considering various control strategies. There are two variables of interest, namely, frequency and tie-line power exchanges.

Their variations are weighted together by a linear combination to a single variable called the Area Control Error (ACE). The AGC problem has been augmented with the valuable research contributions from time to time, like AGC regulator designs incorporating parameter variations/uncertainties, load characteristics, excitation control, and parallel ac/dc transmission links.There are different types of power plants which supply reliable and good quality of electricity to their consumers. Power plants are dependent on type of energy source. So the researchers are investigating different types of power plant. Power plants can be thermal, hydro, wind, solar, nuclear and some other type source of electricity generation.

However, the operation of AGC strategy based on a linearized model on an essentially nonlinear system does not necessarily ensure the stability of the system. Considerable attention has been paid by researchers to consider the system nonlinearities to develop a robust controller. It is shown in the literature that governor dead-band nonlinearity tends to produce continuous oscillations in the area frequency and tie-line power transient response which produces destabilizing effect on the system.The first attempt in the area of AGC has been to control the frequency of a power system via the fly wheel governor of the synchronous machine. The technique was subsequently found to be insufficient, and a supplementary control was included to the governor with the help of a signal directly proportional to the frequency deviation plus it's integral.

SUPER CONDUCTING MAGNETIC ENERGY STORAGE

Superconducting inductive coils consolidate superconductivity and magnetic energy storage concepts to store electrical energy. Other generally utilized terms for these coils are SMES coils. The primary motivation behind utilizing SMES gadgets is to store electrical energy in the attractive field of a huge curl with the goal that it can be utilized at whatever point it is required. They are principally used to supply extensive, dreary power beats, and for load leveling applications. They can likewise be utilized as a part of power systems with a specific end goal to expand the power quality.

SMES system essentially comprises of a huge curl, AC/DC converters and cooling units. The conductors utilized as a part of the coils are superconductors, and in this manner powerful cooling units should be utilized to keep up the superconductivity components of the conductors. It is attentiveness toward energy putting away and power quality issues, and SMES systems with their conceivable applications territories and promising future seen to be a decent arrangement.

INTERNAL STRUCTURE OF SMES

SMES joins these 3 fundamental standards to with proficiency store energy in an extremely superconducting loop. SMES was initially anticipated for expansive scale, load leveling, at the same time, owing to its fast release abilities, it's been upheld on power systems for beat power and system stability applications.

Superconducting attractive energy stockpiling system could be a to a great degree inconspicuous energy stockpiling system. Amid this system, a superconducting loop that is kept up at a refrigerant temperature (low temperatures underneath - 1500C) is accused of DC. The present coursing through the curl creates a powerful flux amid which power is hang on. SMES systems have the consequent components - superconducting loop, power securing system, cryogenically cooled white merchandise, thermo regulator vacuum vessel.

In a SMES system, as a consequence of the electrical current has zero resistance, the field of power once made can for all intents and purposes never debilitated unless the system breaks itself. Thus, contrasted with option systems, it loses amount measure of energy all through capacity making them horribly temperate. A moreover amazingly dependable as an aftereffect of real parts in SMES is inert. The premier vital element of SMES is that the time it takes to charge and release is to a great degree short. At this moment, SMES systems square measure basically won't to enhance power quality.

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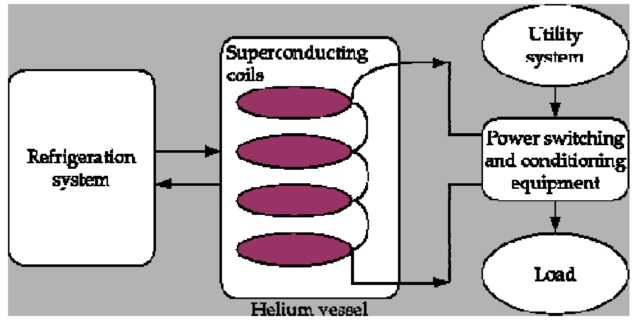

Fig.4.1 Schematic View of SMES

Fig4.1is adiagram of a commercially madeby SMES manufactured goods. The difference of the trailer-mounted and Distributed-SMES units

TCPS &SMES BASED MULTI AREA THERMAL SYSTEM WITH AGC

A definitive target of automatic generation control (AGC) is to keep up the harmony between power yield of the electrical generator and load demand in order to keep the frequency inside of as far as possible, because of the changes in the system and tie-line loading. This capacity is regularly termed as load frequency control (LFC) [1]. The power systems are broadly interconnected for its materialness everywhere throughout the globe. Interconnection upgrades system unwavering quality as well as enhances the system productivity. Subsequent to the system is wide and complex, for the devoted operation, the investigation of the system is of more noteworthy significance. Currently system turned out to be excessively mind boggling with expansion of more utilities, which might prompts a condition where supply and demand has a wide gap[2]. Because of overwhelming load condition in tie-lines by electric power exchange results in poor damping which might prompts between region swaying.

Subsequent to the loading conditions are erratic, this makes the operation more mind boggling. It has been a subject of concern, right from the earliest starting point of interconnected power system operation. In this setting, Automatic Generation Control assumes a key part in the power system operation. A few works have been completed for the AGC of interconnected power systems for most recent couple of decades

[3]-[6]. Prior works in this field proposed numerous thoughts to improve to system stability when there is sudden float in the demand. However warm power plants has got its own particular related operational imperatives, the vast majority of the proposed arrangements so far for AGC have not been actualized [7]. In any case, a couple of endeavors were made to lessen the oscillations in system frequency and tie-line power interchange.

The utilization of power electronic gadgets for power system control has been generally acknowledged as adaptable AC transmission system (FACTS) gadgets which give more adaptability in power system operation and control [1]. This additional adaptability allows the autonomous conformity of certain system variables, for example, power streams, which are not regularly controllable [7]. Thyristor-controlled phase shifter (TCPS) is a gadget that permits dispatchers to change the relative phase angle between two system voltages, in this way helping them to control real power exchanges between the two interconnected power systems. It weakens the frequency of oscillations of power stream taking after a load unsettling influence in both of the zones, too. Phase shifters additionally give series remuneration to increase stability. The fast reactions of phase shifters make them alluring for use in enhancing stability. A TCPS is required to be a compelling contraption for the tie-line power stream control of an interconnected power system.

Generally sudden changes in power prerequisite are met by motor energy of generator rotor, which adequately sodden electromechanical oscillations in power system [2]. Utilization of quick acting stockpiling gadgets in the system additionally enhances the transient execution by supplying put away energy after the sudden load bother. [8] Has proposed a control technique for TCPS to giving dynamic control of system frequency and along these lines to clammy the system frequency and tie-power oscillations by controlling the phase angle of TCPS. Creators of [10] have made an endeavor to enhance the transient execution examination in hydro-hydro system with SMES, TCPS controllers. This work gives an understanding into use of FACT gadgets particularly series joined, to moist out bury region oscillations. A lady endeavor to utilize energy stockpiling to upgrade the system execution showed up in [10], additionally considered an interconnected hydro-warm system with capacitive stockpiling gadgets and TCPS to settle low frequency swaying to enhance the transient execution of the system.

With approach of FACTs gadgets and energy stockpiling gadgets numerous exploration work are made to sodden out the tie line swaying with some of them such as TCPS, SSSC and so forth. Writing overview uncovers that the greater part of the work in connection with use of FACTS gadgets and capacity systems in AGC issues were considered independently in frequency control and tie-line power control [10-12]. In any case, there are less work gave to facilitated activity of FACTS gadgets and capacity systems. Accordingly this postulation manages an endeavor to interface warm interconnected system with Thyristor Controlled Phase Shifter (TCPS) in tie-line and in a joint effort with Superconducting Magnetic Energy Storage (SMES) system. The impact of TCPS and SMES in facilitated with two zone warm system were researched and controllers were outlined.

THYRISTOR CONTROLLED PHASE SHIFTER (TCPS)

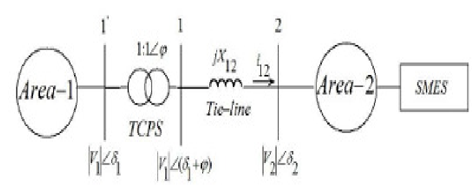

Fig. Schematic diagram of two area system with TCPS & SMES

TCPS is a device that changes the relative phase angle between the system voltages. Therefore the real power flow can be regulated to mitigate the frequency oscillations and enhance power system stability [7]. In this study, a two-area multi-unit thermal power system interconnected by a tie-line is considered. Fig .6.1 shows the schematic representation of the two-area interconnected power system considering a TCPS in series with the tie-line. TCPS is placed near Area 1. Practically, in an interconnected power system, the reactance to-resistance ratio of a tie-line is quite high and the effect of resistance on the dynamic performance is not that significant. Because of this, the resistance of the tie-line is neglected.

SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES)

The SMES unit contains a DC superconducting curl and a 12-beat converter, which are associated with framework through a Y-Δ/Y-Y transformer. The superconducting curl can be charged to a set quality from the utility matrix amid steady state operation of the power system. The DC attractive loop is joined with framework through inverter/rectifier course of action. The charged superconducting loop conducts current which is submerged in a tank containing helium. The energy exchange between the superconducting loop and the electric power system is controlled by a line commutated converter. At the point when there is a sudden ascent in the load demand, the put away energy is practically discharged through the converter to the power system as rotating current. As the senator and other control instruments begin attempting to set the power system to the new harmony condition, the curl current changes back to its introductory esteem and are comparable for sudden arrival of load [12].

SIMULATION RESULTS

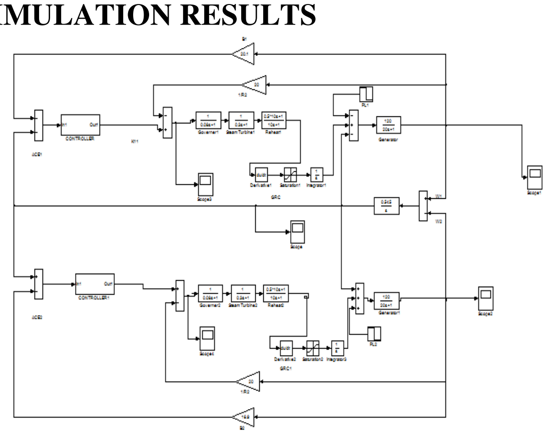

Fig.7.1 Two area thermal power system

Fig 7.1 Shows the Simulink diagram of a two area thermal power system. For a sudden load disturbance the change in frequency and change in power output and change in tie line power is shown in the following plots.

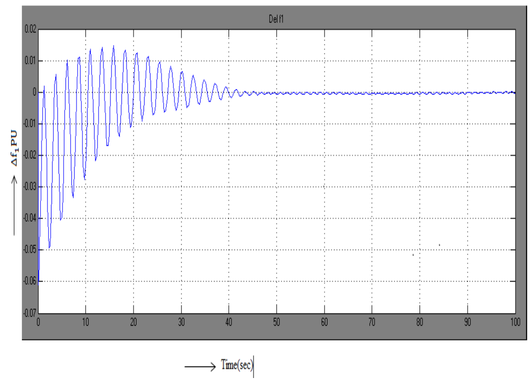

Fig.7.1.1 Deviation of frequency in area-1

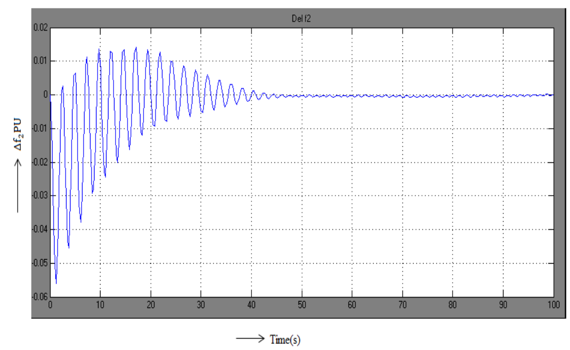

Fig.7.1.2 Deviation of frequency in area-2

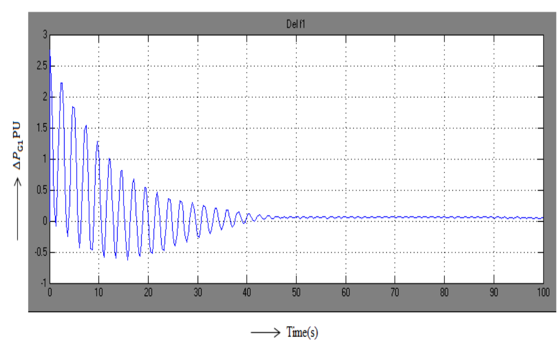

Fig.7.1.3 Change in power output of generator in area-1

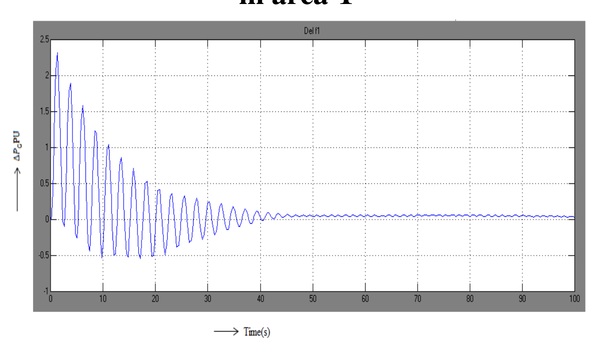

Fig.7.1.4 Change in power output of generator in area-2

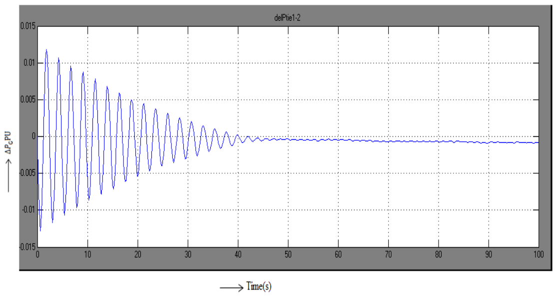

Fig.7.1.5 Tie-line power oscillations

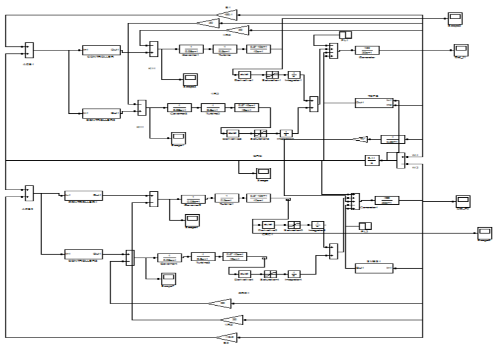

Fig.7.2 Two area thermal power system with TCPS controller in area1 and SMES Controller in area2

Fig.7.2 Shows simulink diagram of a two area thermal power system here TCPS controller are placed in area1 and SMES Controller are placed in area2.For a sudden load disturbances the change in frequency and change in power output and change in tie line power is shown in the following plots.

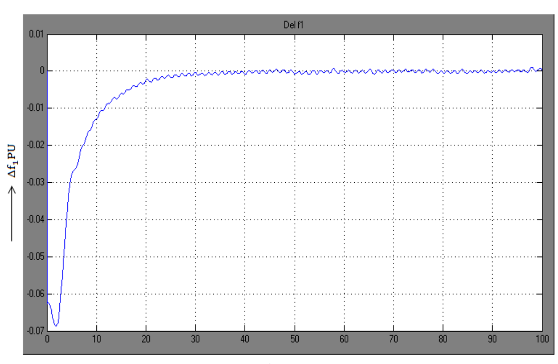

Fig.7.2.1 Deviation of frequency in area-1

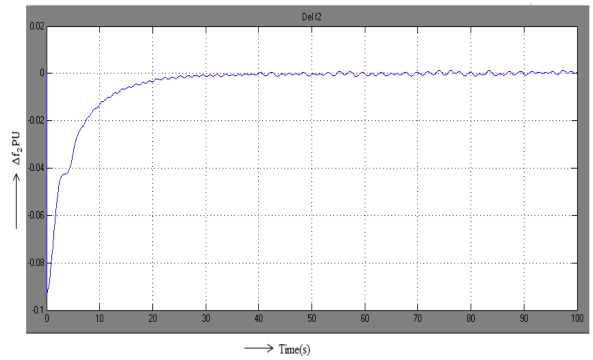

Fig.7.2.2 Deviation in frequency of area-2

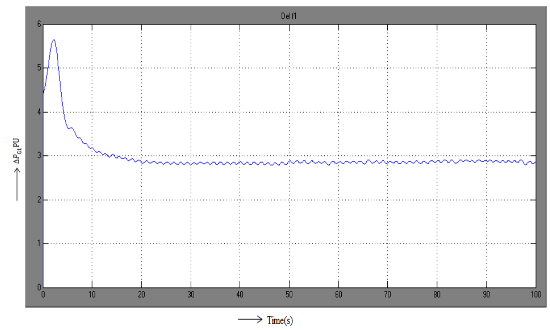

Fig.7.2.3Power output of generator in area-1

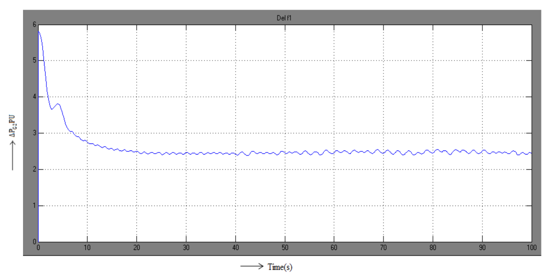

Fig.7.2.4 Power output of generator in area-2

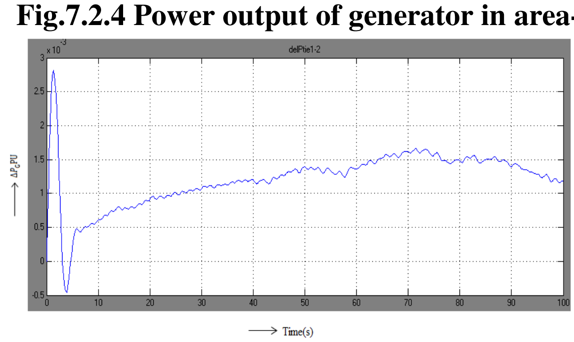

Fig.7.2.5 Waveform of deviation in tie-line power flow

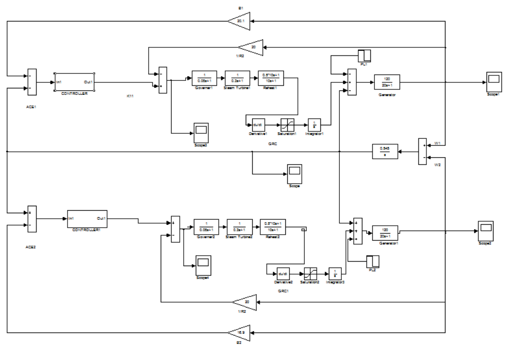

Fig.7.3 Two area thermal power system with Fuzzy controller

Fig.7.3 Shows simulink diagram of a two area thermal power system with fuzzy controller. For a sudden load disturbance the change in frequency and change in power output and change in tie line power is shown in the following plots.

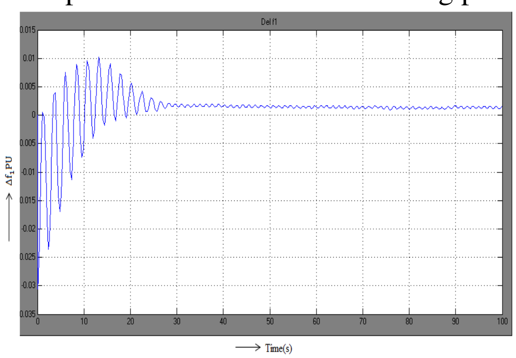

Fig.7.3.1 Deviation of frequency in area1 .

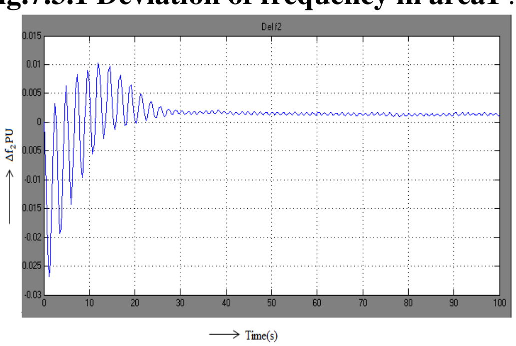

Fig.7.3.2 Deviation of frequency in area2

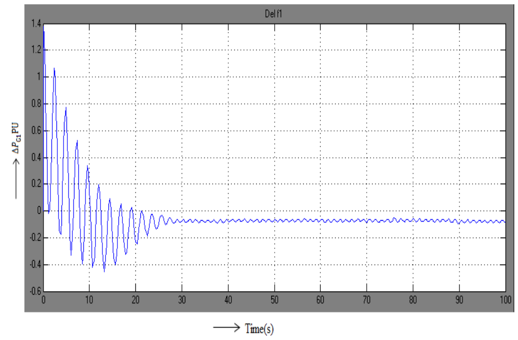

Fig.7.3.3 Change in power output of generator in area-1

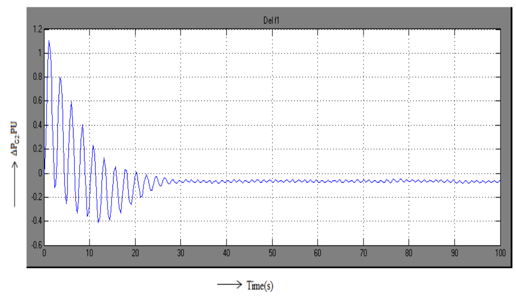

Fig.7.3.4 Change in power output of generator in area-2

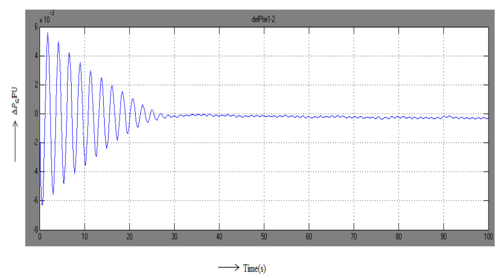

Fig.7.3.5 Tie-line power oscillations

Controllers	Peak undershoot			Peak overshoot		
	Δf_1	Δf_2	ΔP_{tie12}	Δf_1	Δf_2	ΔP_{tie12}
Without Controllers	**-0.06**	**-0.055**	**-0.012**	**0.0148**	**0.014**	**0.012**
With Conventional Controllers	**-0.069**	**-0.093**	**-0.004**	**0.0012**	**0.001**	**0.028**
Fuzzy Controller	**-0.03**	**-0.027**	**-0.0055**	**0.0102**	**0.01**	**0.0055**

Table 7.1 Dynamic response comparison in terms of peak undershoot (US) and peak overshoot (OS)

Controllers	ST of Δf_1	ST of Δf_2	ST of ΔP_{tie12}
Without Controllers	45	45	45
With conventional Controllers	40	40	40
Fuzzy Controller	30	30	30

Table 7.2 Dynamic response comparison in terms of settling time (ST)

It is observed that incorporation of SMES and TCPS units with PI controller in reheat thermal system reduces settling time greatly. As compared to TCPS unit, use of SMES unit reduces overshoot further with almost the same settling time. Instead of PI controller when FLC is used overshoot and undershoot decrease further.

CONCLUSION

PI controller is implemented as controller in each area of an interconnected power system with reheat type steam turbines for the cases with and without SMES units. The positive effects of SMES units on the dynamic response of AGC of two-area power system have been demonstrated. Simulation studies have been carried out using MATLAB platform to study the transient behaviors of the frequency of each area and tie-line power deviations due to load perturbations in one of the areas.

Further, the performance of conventional integral controller (PI) and fuzzy logic controller (FLC) in a reheat thermal system has been investigated. These controllers are designed to improve the transient performance of the interconnected systems following a disturbance in the areas. Effectiveness of the proposed controller in increasing the damping of local and inter area modes of oscillation is demonstrated in a two area interconnected power system. The dynamic system responses have been examined considering a 1% step load perturbation in either area. Also the simulation results are compared with a conventional PI controller. It is observed that incorporation of SMES and TCPS units with PI controller in reheat thermal system reduces settling time greatly. As compared to TCPS unit, use of SMES unit reduces overshoot further with almost the same settling time. Instead of PI controller when FLC is used overshoot and undershoot decrease further. Settling time also improves to some extent when TCPS and SMES units are added to the FLC. The result shows that the proposed intelligent controller is having improved dynamic response and at the same time is faster than conventional PI controller.

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