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AI and Traditional Techniques for Driving the response of Thermal Hydro Power Plant

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ABSTRACT

The massive demand for electricity makes it necessary to balance active power generation and load demand in order to maintain a constant system frequency and tie line power while minimizing steady-state errors. In power systems, load frequency control (LFC) is a crucial control technique intended to keep tie-line power flows and system frequency at planned levels in spite of sporadic load variations. By removing steady-state errors and reducing transient variations, LFC guarantees stable operation. In a thermal hydro power station, LFC oversees tie-line power exchanges among adjacent regions, ensuring that every region addresses its load variations independently. Advanced and reliable methods, combining conventional (PI, PID) and AI approaches (Fuzzy Logic), are utilized to improve reliability and decrease the settling time of interconnected systems following disturbances. Studies frequently concentrate on employing MATLAB/Simulink for modeling and simulation, demonstrating that the AI method (Fuzzy) surpasses conventional techniques (PI and PID) in reducing fluctuations. This development is expected to help address upcoming issues in energy production and consumption regulation.

Keywords:- AI (Fuzzy Logic) Technique, Traditional Technique (PI, PID), Thermal and Hydro System, Power, Frequency

INTRODUCTION

A power system is an intricate network that produces, transmits, and distributes electricity from power plants to consumers. It consists of three main stages: distribution (stepping down voltage for local delivery to homes and industries), transmission (high-voltage lines transporting power over long distances via substations), and generation (producing power from sources like coal, hydro, and solar). Delivering usable electrical energy from source to socket is essentially the responsibility of the entire infrastructure, which includes parts like generators, transformers, lines, and control systems. Due to factors like population growth, industrial expansion, domestic, public, and private sector uses, etc., the demand for electrical energy is rising daily. The thermal and hydro plant has been considered in order to meet this massive demand. Thermal power plants are a major source of electricity generation and are used extensively worldwide. Fossil fuels like coal and gas are burned in thermal power plants to create steam, which powers turbines. Coal-fired thermal power plants are fundamental to India's electricity generation, providing approximately 70-75% of the country's power supply, with key contributors such as NTPC and private companies managing numerous facilities, including large ones like Vindhyachal, supporting industrial and domestic demands even as the emphasis on renewable energy increases. These plants operate by combusting fuel (coal, gas, diesel) to generate steam, which rotates turbines linked to generators, generating electricity, essential for dependable, large-scale energy, despite encountering environmental issues. Hydroelectric power stations harness the potential energy of accumulated water to drive turbines, providing a renewable, affordable, and adaptable energy source. Both are essential for electricity production, yet vary greatly in fuel origin, ecological effect, and lifespan. In India, hydropower serves as a significant renewable energy resource, accounting for more than 12% of the overall

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utility-scale installed capacity, with an estimated potential of 148,700 MW. India ranks fifth globally in hydropower capacity, harnessing water from dams to power turbines, providing an affordable, renewable, and enduring energy source to satisfy electricity needs. [1-10], [18-25], [30], [40], [42-47].

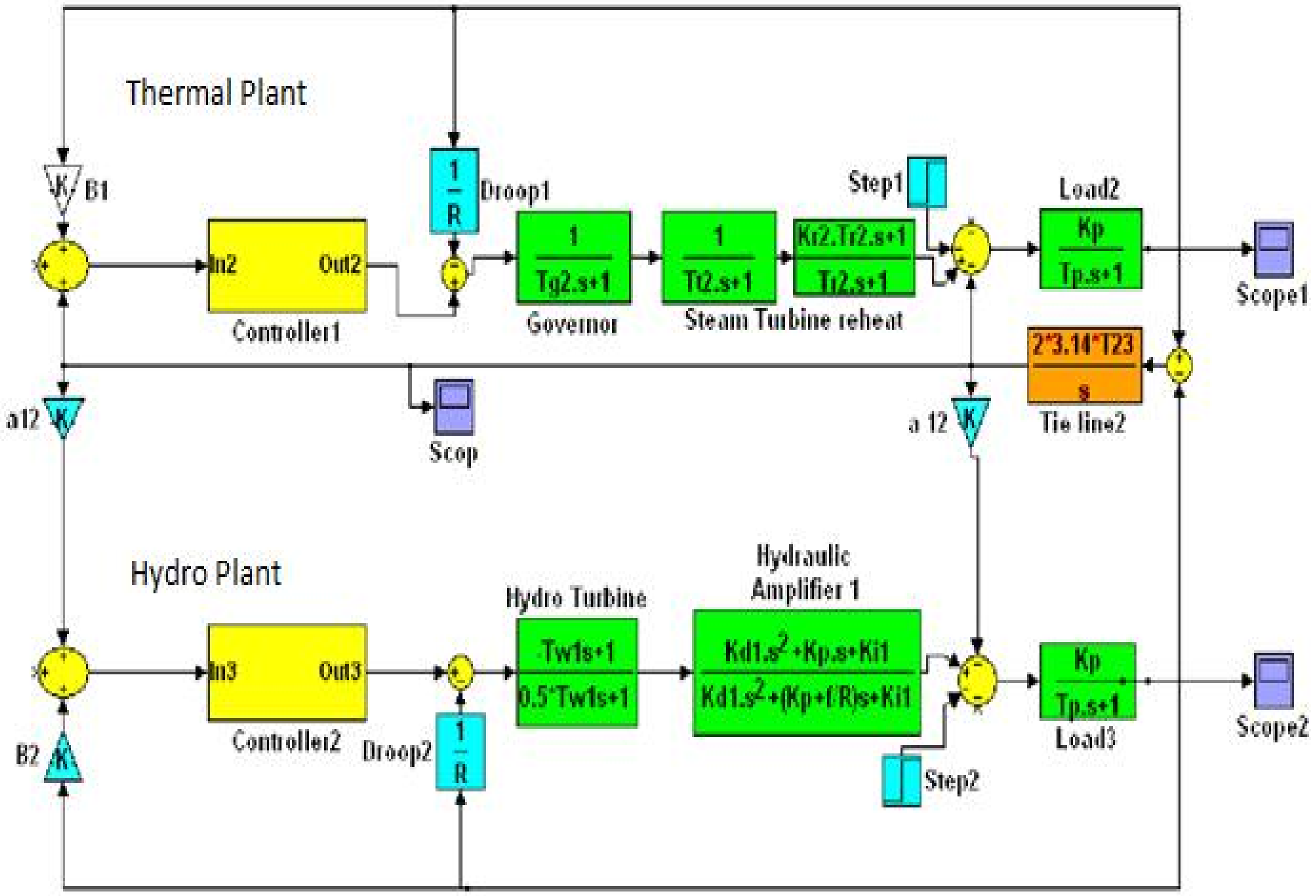

Figure 1. Transfer Function Model of Thermal Hydro Power Plant

Figure 1 depicts the thermal hydro system's transfer function model, constructed using MATLAB Simulink software. [11], [22], [25-28], [32-41].

APPLIED TECHNIQUES

Techniques plays crucial role to improve and enhance the performance of any systems. Techniques plays crucial role to improve and enhance the performance of any systems. In this paper the following traditional (PI, PID) and AI (Fuzzy Logic) technique has been applied; [11-20], [20-30].

PI TECHNIQUE

PI control represents a type of feedback regulation. It offers a quicker response time than I-only control because of the integration of the proportional action. PI control prevents the system from oscillating and can also bring the system back to its designated set point.

PID TECHNIQUE

PID technique, also referred to as a proportional-integral-derivative technique. It is a control loop mechanism based on feedback, frequently employed to oversee machines and processes needing ongoing management and automatic modification.

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FUZZY TECHNIQUE

A fuzzy method is an AI-centric, knowledge-oriented control mechanism that replicates human judgment, aimed at handling intricate, non-linear systems where accurate mathematical representations are challenging to acquire. Utilizing linguistic rules (e.g., "if temperature rises, then fan increases speed") and fuzzy logic, it analyses inputs to control systems such as braking, appliances, and industrial operations. Fuzzy logic methods function by converting uncertain inputs into a scale from 0 to 1 (partial truth) via three primary steps:

- Fuzzification: uses membership functions to convert crisp input data (such as sensor readings) into fuzzy sets.
- Fuzzy Inference Engine: Determines the proper response by applying human-like IF-THEN rules to the fuzzy inputs.
- Defuzzification: Transforms the fuzzy output back into a clear control signal that the physical system may use.

Figure 2 shown fuzzy logic system. [11-21], [24], [30-40].

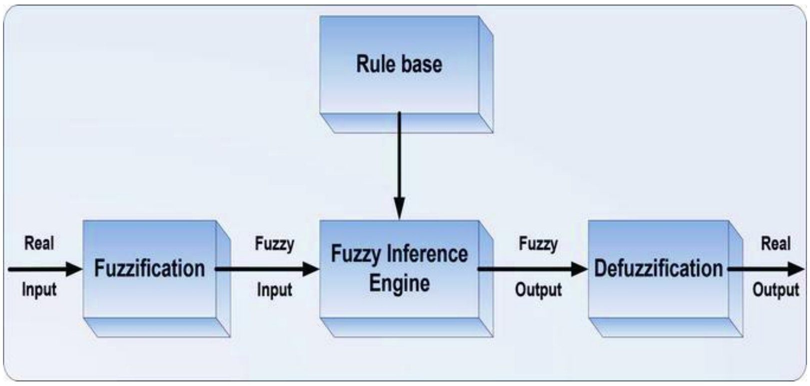

Figure 2. Fuzzy Logic System

RESULTS

The frequency response and interconnected tie line power of the corresponding resources have been examined using the established model that includes thermal and hydro power plants. Traditional techniquess (PI, PID) and AI technique (Fuzzy Logic) were used to assess the generated model's outcomes. A 0.01 p.u. step load disturbance was applied to every part of the hydro-thermal system. The frequency and tie line power response of the hydro-thermal system were shown in Figures 3 through 11.

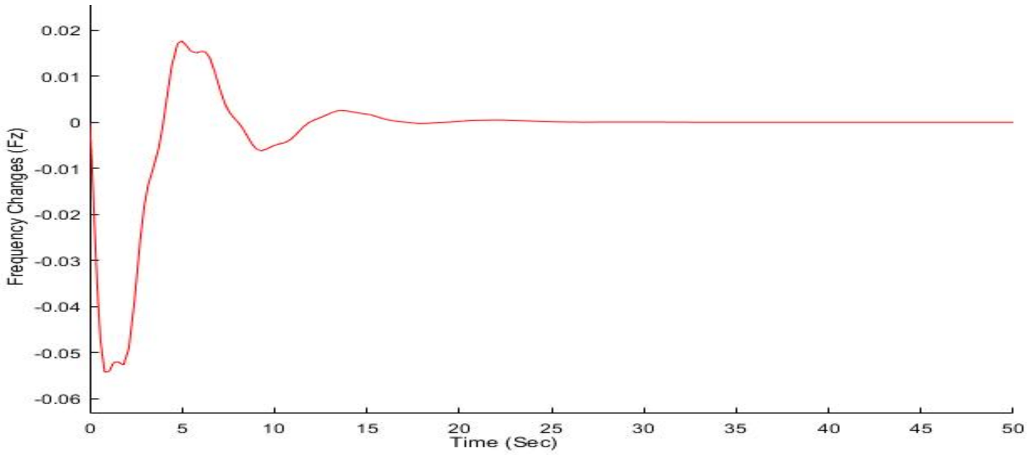

Figure 3. Frequency Changes Response of Hydro Plant by PI Technique

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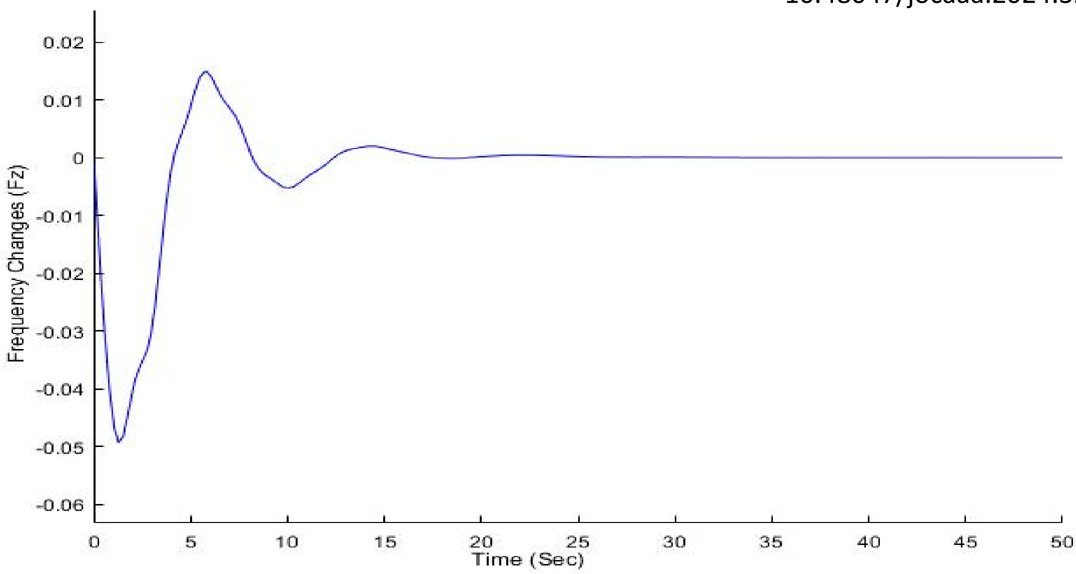

Figure 4. Frequency Changes Response of Thermal Plant by PI Technique

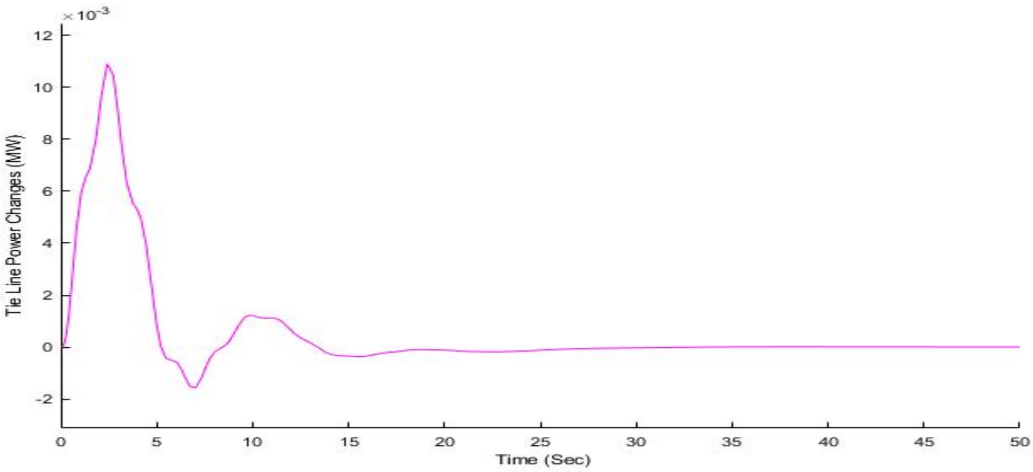

Figure 5. Tie Line Power Changes Response of Hydro-Thermal Plant PI Technique

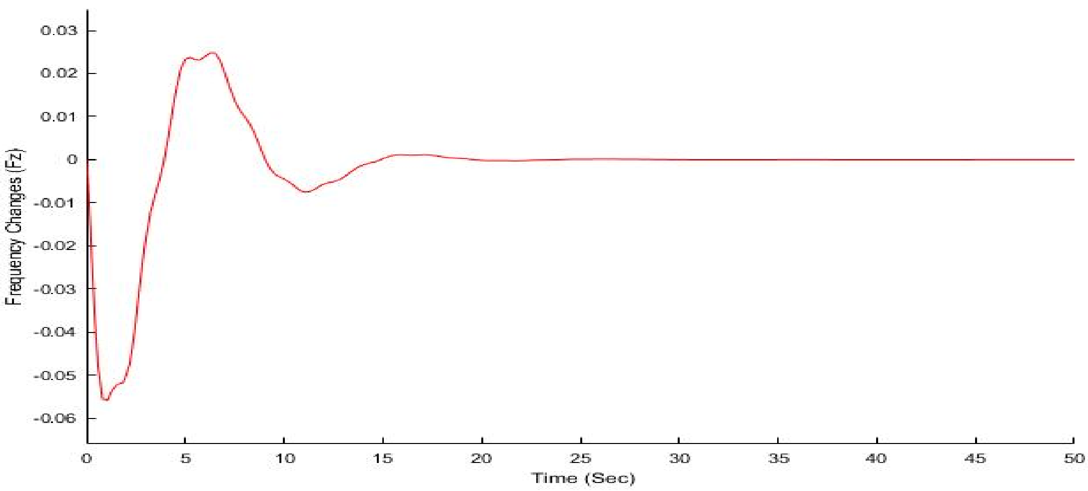

Figure 6. Frequency Changes Response of Hydro Plant by PID Technique

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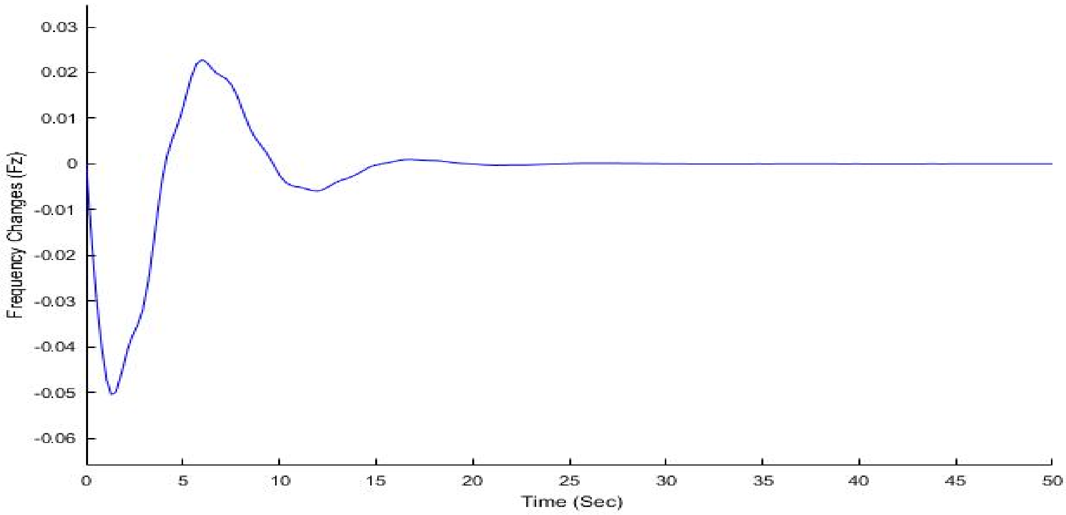

Figure 7. Frequency Changes Response of Thermal Plant by PID Technique

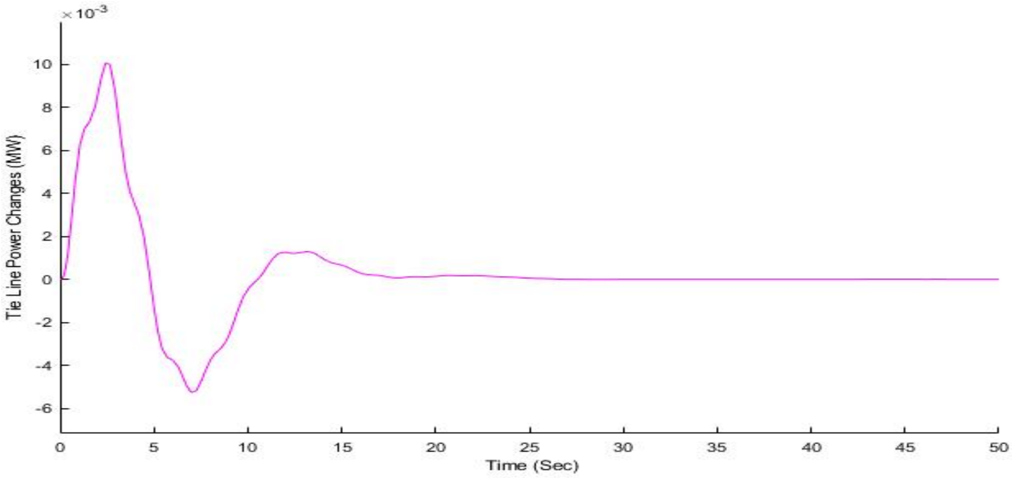

Figure 8. Tie Line Power Changes Response of Hydro-Thermal Plant PID Technique

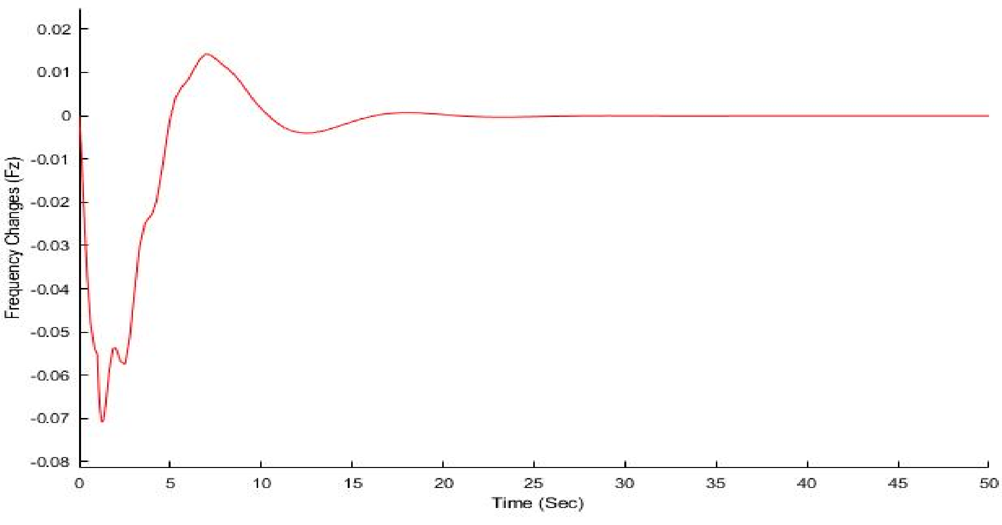

Figure 9. Frequency Changes Response of Hydro Plant by Fuzzy Technique

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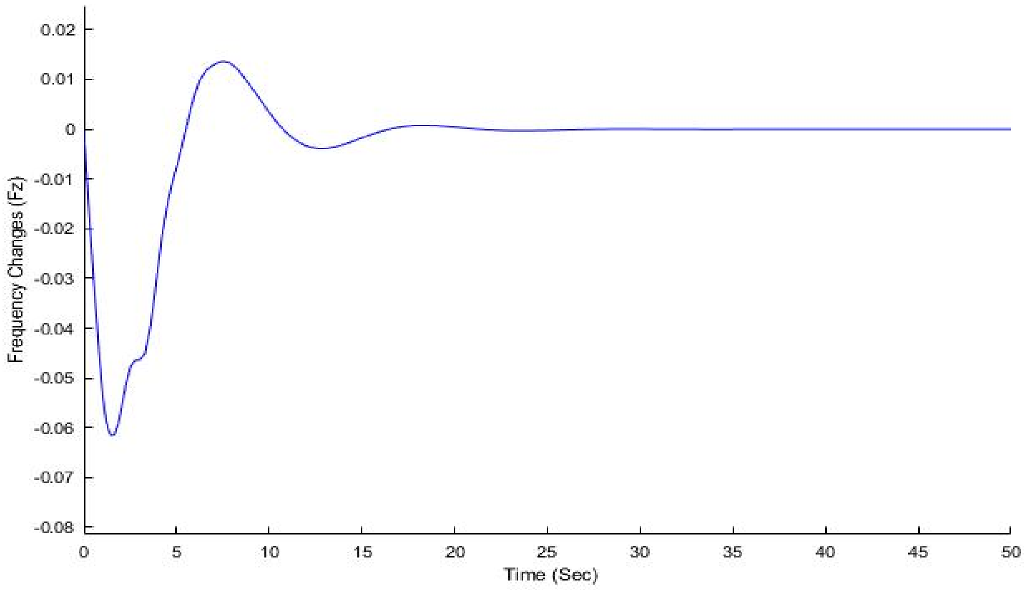

Figure 10. Frequency Changes Response of Thermal Plant by Fuzzy Technique

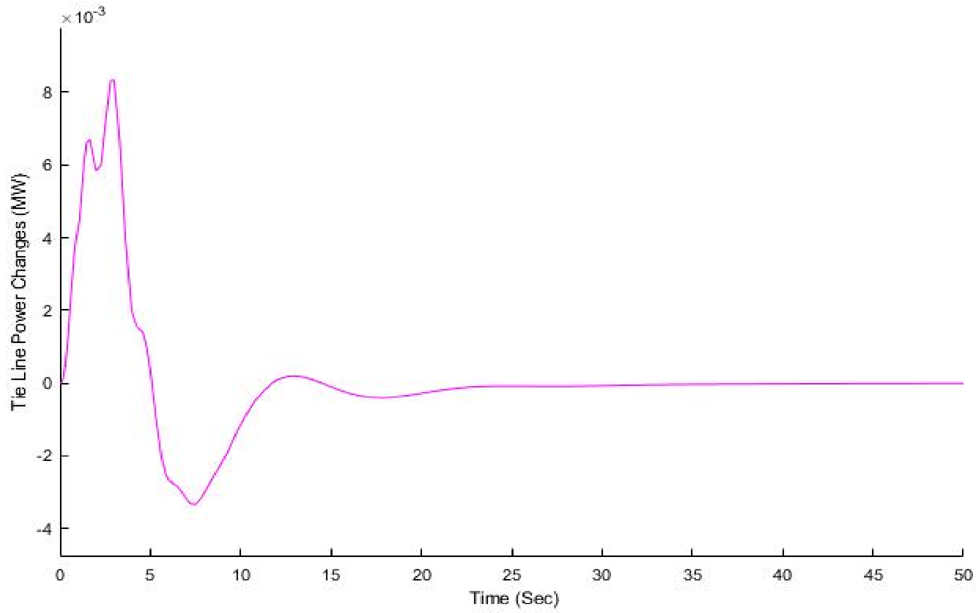

Figure 11. Tie Line Power Changes Response of Hydro-Thermal Plant Fuzzy Technique

Table 1 summarizes the hydro-thermal response results and shows that, in comparison to other methods, the Fuzzy (AI) strategy offers an efficient, effective, dependable, and quick reaction during load fluctuations.

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Table 1: Response of Thermal- Hydro System

Techniques	Settling Time (Sec)		
	Frequency Settling Time		Tie Line Power Settling Time
	Hydro Area	Thermal Area	Hydro-Thermal Area
PI Technique	23	22	22
PID Technique	22	22	21
Fuzzy (AI) Technique	21	20	20

CONCLUSION

Hydro and thermal power plants have significantly increased their contribution. Hydro-thermal systems combine hydroelectric power plants (water) and thermal power plants (coal) to improve electricity production in response to demand. This study examines the hydro-thermal system model that was developed for obtaining the response of frequency and tie line power by using traditional (PI, PID) and artificial intelligence (Fuzzy logic) techniques to meet variable load demand. The results, which are displayed in table form, show that the AI (Fuzzy) technique performs better than the traditional (PI, PID) technique by effectively minimizing disturbances in less time while meeting all system requirements. Therefore, it can be deduced that this development is expected to assist in addressing future challenges related to power generation and demand satisfaction.

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