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Frequency Normalization using the Artificial Intelligence

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ABSTRACT: The requirement for clean energy has dramatically increased over the years due to the emission of CO₂ and the degradation of the environment by the introduction of Renewable Energy Systems (RES) into the existing power grid. This can be explained by the fact that the demand for clean energy has been caused by the introduction of RES. These systems are a step in the right direction, but they do not come without a price, since there are certain concerns about the viability of the grid as well as the system itself. To address the above stated problem, a framework is proposed using the fuzzy controller to normalize the frequency. The frequency change is introduced into the system manually to know the accuracy of the designed model to understand the rectification process. The fifty fuzzy rules were designed to normalize the frequency. The model is implemented in the MATLAB Simulink and achieved the normalization of the frequency when the system is introduced with the noise change and the results also says the same.

KEYWORDS: Frequency normalization, Fuzzy, Solar, PV thermal, Transfer function.

I. INTRODUCTION

Numerous researchers have chosen to concentrate their efforts in this area as a result of the growing global interest in renewable energy sources and the growth of the integration of such sources into the electrical grid in various parts of the world [1], [2], [3]. Applications of smart energy systems that are particularly useful include load forecasting, the forecasting of the production of renewable energy sources, energy pricing, the detection of power quality disruptions, and the detection of faults on power systems and equipment. Forecasting the production of renewable energy sources, particularly wind and solar energies, has garnered a lot of interest in recent years because to the enormous influence it has on the choices that are made about the operation and management of power systems. It is essential to have an accurate estimate of the production of renewable energy sources in order to maintain the dependability and longevity of the grid, as well as to decrease the risk and expense associated with the energy market and energy systems. This kind of forecasting will be beneficial not just to power plants and those who operate the system, but also to energy merchants and those who formulate policies.

According to the findings, an AC tie-line connection may link PV components to typical thermal power plants. We are attempting to normalise the frequency of the associated PV-Thermal control zones while the loads change in this phase of the inquiry. It has been decided to begin frequency normalisation studies for each control zone using a variety of methodologies including proportional, integral and a combination of the two depending on FL. With the least amount of overshoot, shortest settling time, and satisfactory system responses for each control zone for a specific change in loading conditions in a linked PV-Thermal system, the goal of auxiliary controllers is to realise the frequency, tie-power deviations, and ACEs of each control zone in the linked system. The outcomes of all frameworks show that the PI built FLC is fast enough to bring back the framework results to their original esteem in the smallest amount of time with dropped, to begin with, top and high damping in comparison to that observed by other FL actions. In addition, the top frequency shift in the PV control produced range is significantly more than the thermal control region. As a result, the thermal control zone has enhanced its performance in response to changing loads due to longer settling periods and acceptable compliance with restrictions.

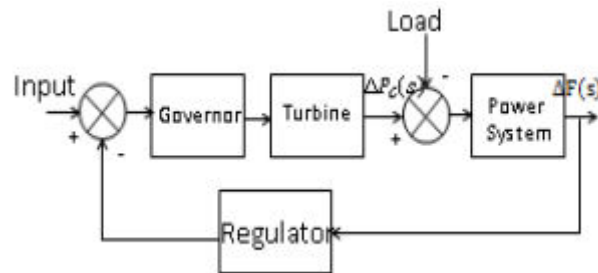


Figure 1: Power system's block diagram

The mathematical model below is the model for testing the generation system when the load disturbance is added.

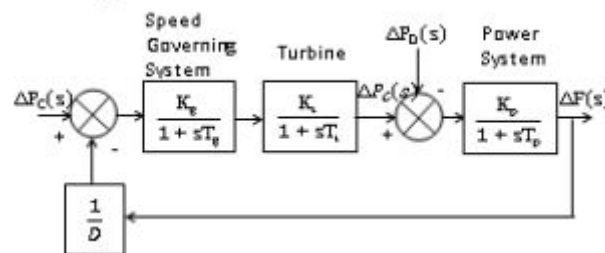


Figure 2: Generalized mathematical model for load regulation in generation station.

The organization of the paper is, the section that provides the details about the work carried out by the research scholars earlier, proposed methodology, result and discussion and last but not least conclusion.

The transfer function for the speed, governor and turbine are as follows,

$$Governor = \frac{L_h}{1 + dY_h}$$

$$Turbine = \frac{L_T}{1 + dY_T}$$

$$Generating\ power\ system = \frac{L_p}{1 + dY_p}$$

Load and the generator models is as shown in the below figure,

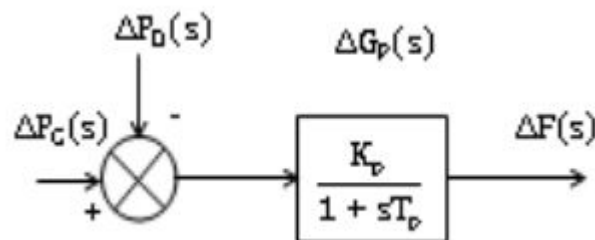


Figure 3: Generator model with respect to load.

The response from the system is provided by the below equation,

$$\Delta F(s) = \frac{-K_p * \Delta P_D(s)}{1 + sT_p + \left[\frac{K_g K_t K_p}{1 + sT_g * 1 + sT_t} \right]}$$

II. LITERATURE SURVEY

Many studies have been done on the fuzzy clustering of time series, especially in the setting of univariate analysis. Based on time series autocorrelation function estimations, [9] developed a fuzzy clustering method. Time series were categorised using this method. Inputs to the fuzzy C-means algorithm are provided. UTS characteristics were used to compute the periodogram, normalised periodogram, and logarithm of the normalised periodogram, all of which were supplied by [11]. Wavelet variances are used in a fuzzy way by [12] to group UTS. Using this method, time series with shifting patterns of variability are discovered. Extreme value analysis may be used to integrate seasonal time series. Fuzzy clustering uses time-varying parameter estimates for position, size, and shape as input characteristics. These numbers are derived via fitting an extreme value distribution to a population of randomly distributed data. [10]. One method makes use of autoregressive GARCH models, while the other relies on parameter estimation for GARCH models. Heteroskedasticity, as used by [5,] was used to sort time series. GARCH-like behaviour of series is assumed in this technique. To begin, the fuzzy C-medoids technique is fed with estimates of both unconditional and time-varying volatility. There are also other options presented. The fuzzy C-medoids approach was used in [6] to expand [7] by providing a method for fuzzy clustering of UTS. Their link was examined by this method. The quantile autocovariance function's ability to withstand lengthy tails and its absence of moment constraints are used in the technique. In light of this one, [18] creates effective strategies. Spatial time series grouping was simplified using a copula-based approach [9]. With the use of geospatial data, this approach determines the degree to which an empirical copula and a Frechet copula differ. This is a good way to compare the two copulas. Since we've only discussed feature-based clustering, it's safe to say that all the methods discussed so far are based on model parameter or residual estimates. Distance-based techniques have been proposed for fuzzy UTS clustering. The fuzzy C-means method was updated to include DTW. UTS data are averaged using a specific method used by DTW for financial time series, trimmed fuzzy clustering is described in [2]. Fuzzy C-medoids and DTW are utilised. Resilience to outlying components was achieved by lowering the number of distant series.

III. PROPOSED MODEL

The proposed model is applied on the two area, it has the speed, governor and a turbine. At the start the fuzzy controller is placed to govern the modulations of frequency change in the load. The below figure shows the two area block diagram

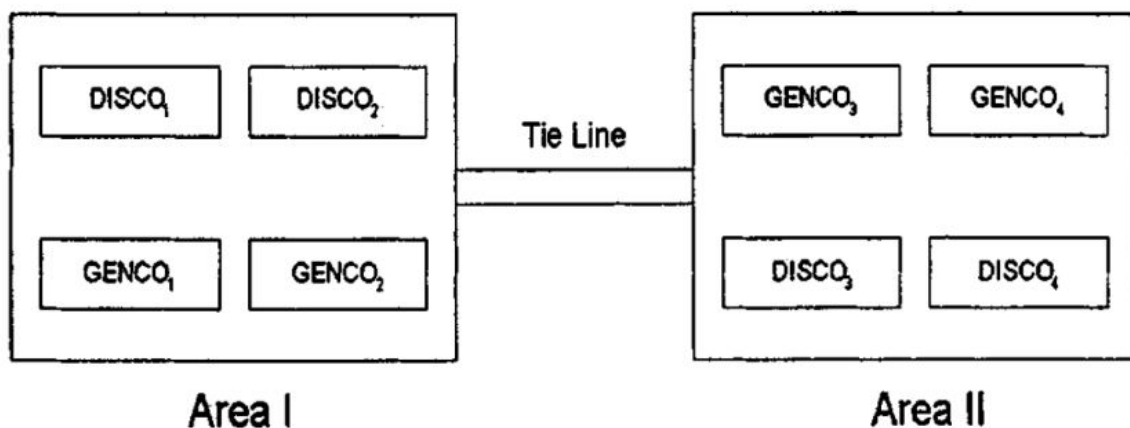


Figure 4: Two area representation.

The interconnection of the two systems with the model is as shown in the below figure

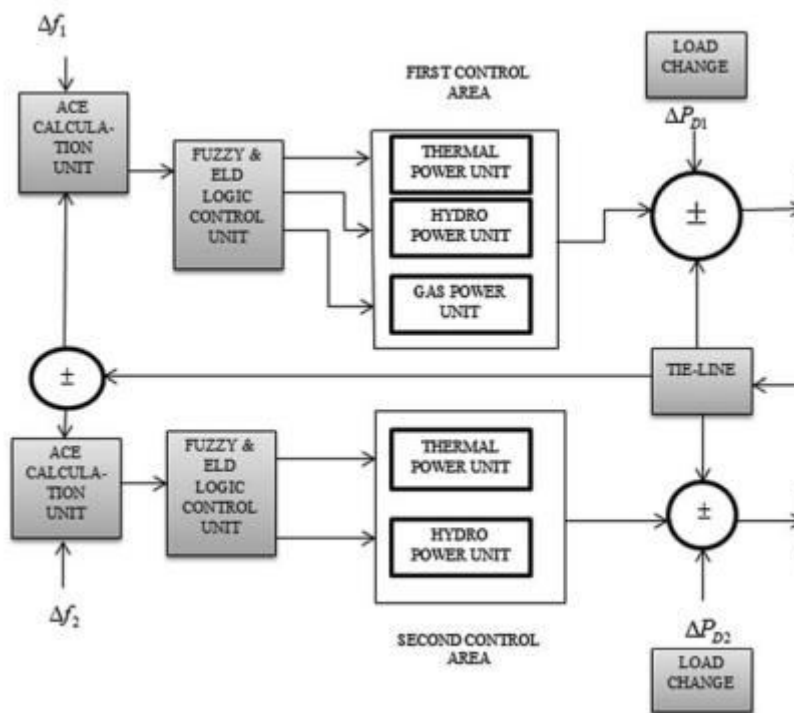


Figure 5: Power interconnection systems

Design of the fuzzy model

The proposed model using the fuzzy is as shown in the below figure,

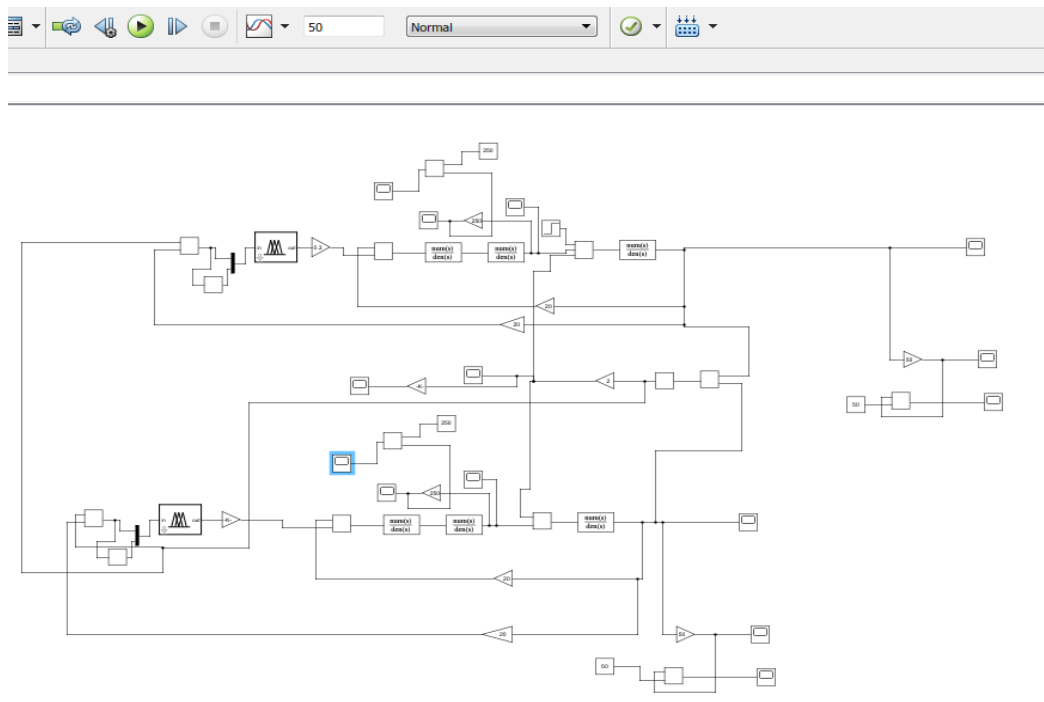


Figure 6: Proposed model for frequency normalization using Fuzzy

The basic structure for designing the fuzzy based controller is as shown in the below figure,

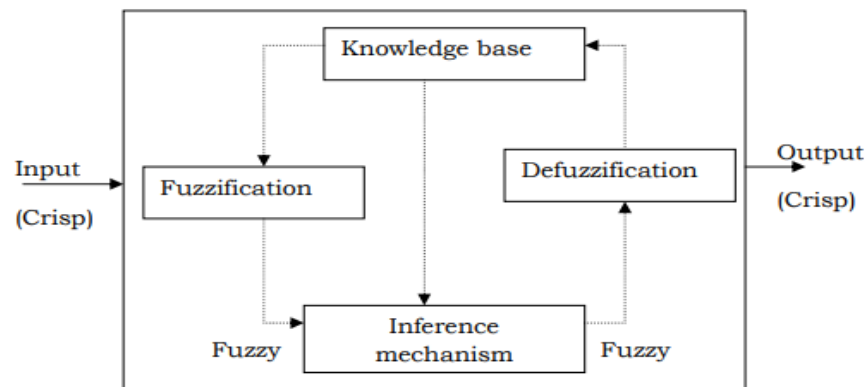


Figure 7: Structure for the fuzzy block.

For designing the fuzzy controller definition of the rules is the essential task and this sub-section provides the details of it. The model proposed employed three different methods to analyse the frequency normalization in the two area systems are given below,

1. Integral ACE and ACE in single fuzzy block
2. ACE in fuzzy block and
3. Integral ACE in one block

The standard control techniques are unable to provide the required outcomes due to the complexity and variability of the dynamic features of power systems. It is possible to use a conventional controller in lieu of an intelligent controller to get a rapid and effective dynamic response in load frequency difficulties. When compared to traditional controllers, which are known to be slower, the Fuzzy Logic Controller (FLC) may prove to be more beneficial in the resolution of large-scale controlling issues.

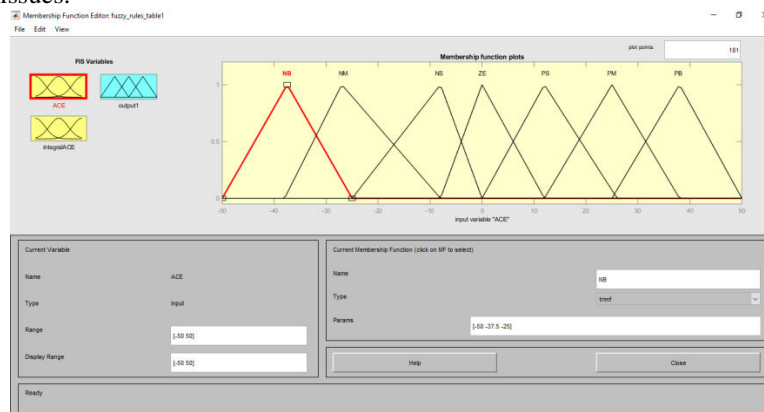


Figure 8: Membership function for the ACE and Integral ACE.

The volatility in system outputs may be kept to a minimum with the use of a fuzzy logic controller. There have been a lot of studies done on power systems using fuzzy logic controllers, and figure 2 shows that these controllers include three sections: the fuzzifier, the rule basis, and the defuzzifier. [9] provides an understanding for the many phases involved in the interference system. [10] The decision about the membership functions is made based on the input data or the data that is already accessible from the rules that are to be developed. FLC takes into consideration both the error e and the change in error de as inputs. The fuzzifier begins by first converting the two signals it receives as inputs to fuzzy numbers by employing its five membership functions. PB and PS, or Positive Big and Positive Small (PS),

Integral ACE and ACE in single fuzzy block

The block diagram for the of the proposed system is as shown in the below figure

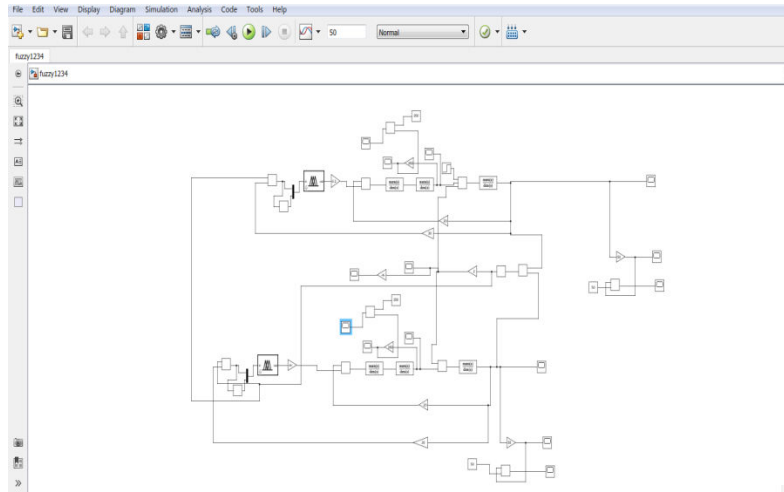


Figure 9: Integral ACE and ACE employing fuzzy.

The rules employed for designing the model is as shown in the below table,

Table 1: Table for ACE and integral ACE design of fuzzy.

		ACE				
		NB	NS	ZE	PS	PB
JACE	NB	NB	NB	NS	NS	ZE
	NS	NB	NS	NS	ZE	PS
	ZE	NS	NS	ZE	PS	PS
	PS	NS	ZE	PS	PB	PB
	PB	ZE	PS	PB	PB	PB

By using the above table had framed the fifty by performing the “AND” and “OR” while framing the rules in the fuzzylogicdesigner in the MATLAB.

Only ACE in fuzzy block

The block diagram implemented in the Simulink for the only ACE and rules framed to control the frequency change is as shown in the below figure,

Table 2: Rules framed for the ACE.

R1	IF ACE is NB THEN, ΔP_c is PB
R2	IF ACE is NM THEN, ΔP_c is PM
R3	IF ACE is NS THEN, ΔP_c is PS
R4	IF ACE is PS THEN, ΔP_c is NS
R5	IF ACE is PM THEN, ΔP_c is NM
R6	IF ACE is PB THEN, ΔP_c is NB

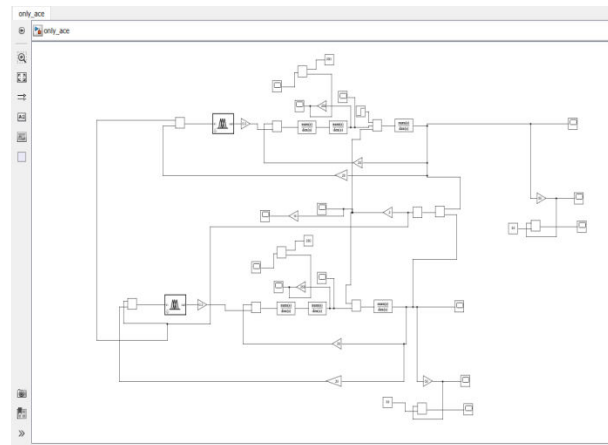


Figure 10: Proposed model using only ACE.

Only Integral ACE

The block diagram implemented in the Simulink for the only integral ACE and rules framed to control the frequency change is as shown in the below figure,

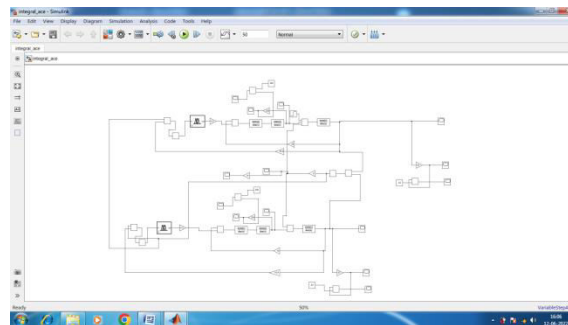


Figure 11: Integral ACE design in Simulink

Table 3: Rules framed for the design of block.

R1	IF ACE is NB, THEN, ΔP_c is PB
R2	IF ACE is NM, THEN, ΔP_c is PM
R3	IF ACE is NS, THEN, ΔP_c is PS
R4	IF ACE is PS, THEN, ΔP_c is NS
R5	IF ACE is PM, THEN, ΔP_c is NM
R6	IF ACE is PB THEN, ΔP_c is NB

V. RESULT AND DISCUSSION

The suggested design, when used in combination with economic load dispatch (also known as the unit's participation factor), has been implemented for normally multigenerating units of the linked power system's fuzzy logic controller, as can be seen in figure. MATLAB SIMULATION TOOLBOX is used to do simulations of the proposed controller.

The change in frequency (hertz) and got rectified by the fuzzy using three methods is as shown in the below figure

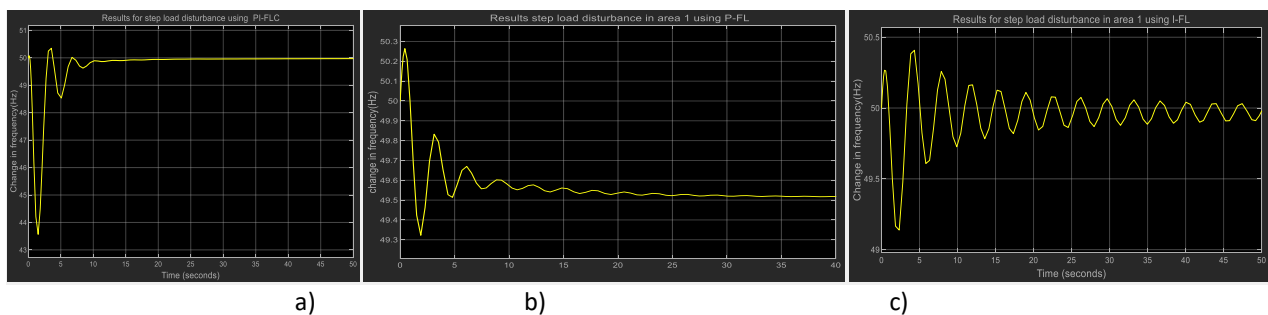


Figure 12: a) Using both integral ACE and ACE b) Only ACE c) Only integral ACE.

The change in power (Megha watts) and got rectified by the fuzzy using three methods is as shown in the below figure

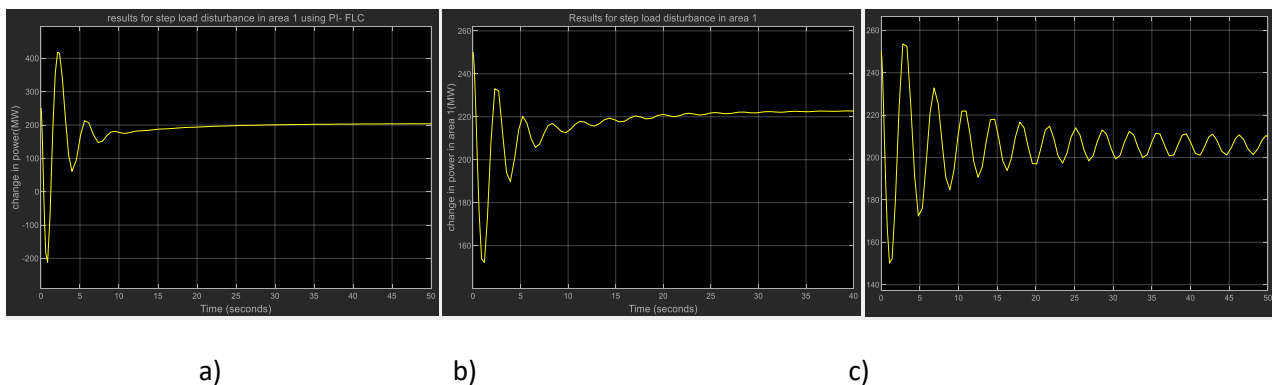


Figure 13: a) Using both integral ACE and ACE b) Only ACE c) Only integral ACE.

VI.CONCLUSION

This research examines if PV components may be added to typical thermal power facilities through AC tie-line. We're attempting to normalise the frequencies of the interconnected PV-Thermal control zones when the loads change. For frequency normalisation study, each control zone uses proportional, integral, and proportional-integral FL-based control. Auxiliary controllers aim to achieve the frequency, tie-power deviations, and ACEs of each control zone with the least overshoot, the quickest settling time, and adequate system responses for each control zone for a change in loading circumstances in a connected PV-Thermalsystem. The framework results show that the PI designed FLC is rapid enough to return the framework results to its original esteem in the shortest amount of time with lower top and high damping than other FL actions. The peak frequency shift in PV control is much larger than in thermal control. Because of extended settling periods and tolerable limits, the thermal control zone has increased performance in response to altering loads.

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