Fuzzy Logic Optimization Algorithm For Automatic Generation Control of Multi Area Power System.

Alka Gupta
Research Scholar
Sangam University ,Bhilwara

Dr. Dheeraj Jain
Associate Professor
Sangam University ,Bhilwara

Dr. Archana Agarwal
Associate Professor
Sangam University ,Bhilwara

Abstract

Energy is the defining need of the 21st century & electrical energy has replaced most of the other conventional sources of the energy due to its cost, reliability & other advantages. The demand for electricity is rapidly increasing & thus integration of renewable energy generation plants in a multi area generation setup is required. This work aims at optimization of operational cost of power generation in a multi area power generation System comprised of various types of power generation setups such as non-renewable ones, Thermal & nuclear as the renewable ones such as solar or wind. The proposed work aims at development of fuzzy logic controller with corresponding embedded hardware to demonstrate multi area power generation with priority to renewable energy optimization of generation cost depending upon the varied load conditions. This work demonstrates on embedded 'C' controlled hardware controlled vid fuzzy logic implemented in Matlab over connection on RS232 port.

Keywords— Multi area power generation, Fuzzy logic, Matlab, Data Aequitsiton tool box, Dual converter.

I. Introduction

(i) Fuzzy Logic:- Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1. It is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. By contrast, in Boolean logic, the truth values of variables may only be the integer values 0 or 1. It is based on the observation that people make decisions based on imprecise and non-numerical information, fuzzy models or sets are mathematical means of representing vagueness and imprecise information, hence the term fuzzy. These models have the capability of recognising, representing, manipulating, interpreting, and utilising data and information that are vague and lack certainty.

Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. Fuzzy logic starts with and builds on a set of user-supplied human language rules. The fuzzy systems convert these rules to their mathematical equivalents. This simplifies the job of the system designer and the computer, and results in much more accurate representations of the way systems behave in the real world.

Additional benefits of fuzzy logic include its simplicity and its flexibility. Fuzzy logic can handle problems with imprecise and incomplete data, and it can model nonlinear functions of arbitrary complexity. "If you don't have a good plant model, or if the system is changing, then fuzzy will produce a better solution than conventional control techniques," says Bob Varley, a Senior Systems Engineer at Harris Corp., an aerospace company in Palm Bay, Florida. You can create a fuzzy system to match any set of input-output data. The Fuzzy Logic Toolbox makes this particularly easy by supplying adaptive techniques such as adaptive neuro-fuzzy inference systems (ANFIS) and fuzzy subtractive clustering.

Fuzzy logic models, called fuzzy inference systems, consist of a number of conditional "if-then" rules. For the designer who understands the system, these rules are easy to write, and as many rules as necessary can be supplied to describe the system adequately (although typically only a moderate number of rules are needed).

(ii) Automatic Generation Control of Multi Area Power System

One of the most important components in the daily operation of an electrical power system is the scheduling and control of generation. This function is the primary concern of the energy control centre and largely provided by an automatic generation control (AGC) program implemented as part of the energy management system (EMS).

Although the process is highly automated power system dispatchers can interact with it, by monitoring its results and inputting data that reflect the current operating conditions. In general, electrical power systems are interconnected to provide secure and economical operation. The interconnection is typically divided into control area with each consisting of one or more power utility companies. Control areas are connected by transmission lines commonly referred to as tie-lines and the power flowing between control areas is called tie-line interchange power. One of the main responsibilities of each control area is to supply sufficient generation to meet the load demand of its customers, either with its own generation sources or with power purchased from other control areas.

The main part of power system operation and control is to maintain continuous supply of power with an acceptable quality, to all the consumers in the system. The system will be in equilibrium, when there is a balance between the power demand and the power generated.

II. LITERATURE REVIEW

In this paper a number of decentralised and centralised PI and Model Predictive Control (MPC) based algorithms were proposed for the purposes of Automatic Generation Control (AGC) in Multi-Terminal HVDC (MTDC) grids. The use of voltage offsets was also proposed as an additional control variable to improve performance. The paper discusses how this approach improves the sharing of secondary reserves and could assist in achieving EU energy targets for 2030 and beyond.[1]

In this paper the gravitational search algorithm is used to obtain optimum gains of the PIDF controller for problem of automatic generation control (AGC). First GSA is illustrated in detail and therefore investigated power system under study. The results of simulation emphasize the effectiveness of the GSA. The PIDF controller which is tuned by GSA has been strongly proposed for automatic generation control. [2]

A multi-level power system is considered in the paper with wind-energy generation in area-1. The contingency situations of sudden loss of generation and sudden loss of loads are simulated for a two-area system with one of the areas having Wind-turbine generator. The results show that the frequency deviation and the voltage profiles are within the limits in the two situations. Coordinated scheduling of power is necessary to maintain the system parameters under control. [3]

This paper applies the ACO based fuzzy controller to the SEDC Motor. The fuzzy rules are optimized off line, while the parameters of the fuzzy controller are tuned on line. By a comparison the Hybrid Fuzzy ACA Controller, ACA and Fuzzy logic controller, the Hybrid Fuzzy-ACA Controller is not only more robust, but can also achieve a better static and dynamic performance of the system. [4]

A simulation study of single area, two areas and three areas as a multi system with automatic generation and control is carried out with models developed in SIMULINK MATLAB. The system experiences frequency drift following a load disturbance and it is mainly due to the mismatch between the electrical load and the mechanical input to the turbine. [5]

In this work, a type 1 fuzzy controller is used for controlling the load frequency of the single area non-reheat thermal power plant. A 1% step load perturbation is applied in the load demand of the power plant and analysis the system responses in terms of settling time, peak overshoot and peak undershoot. So, it is necessary to maintain the system frequency is to be constant. [6]

This paper is ratified with a novel hybrid DECRPSO algorithm optimized FPID controller used in both the areas of a mutually connected hydro-thermal power system to minimize the ACE. To achieve better regulation over tie-line power and frequency deviation, the gains of the FPID controller are optimized by PSO, CRPSO and hybrid DECRPSO algorithms. [7]

In this paper, the optimal load frequency control (LFC) of interconnected power systems is investigated. The impact of LFC control method on the fluctuations caused by step load disturbance is examined; also the effect of LFC controller is analyzed. The Proportional-Integral Derivative (PID) controller parameters of the investigated LFC model are optimized by different techniques. An application of new approach based on hybrid Genetic Algorithm and Particle Swarm Optimization (HGA-PSO) to solve LFC problem is developed. The proposed hybrid GAPSO algorithm is first applied to the two-area interconnected power system and then extended to the large three-area 9-unit interconnected power system model. The comparative study demonstrates the validity and the potential of the proposed approach and shows its robustness to solve the optimal LFC problem.[8]

The present article developed a new approach for the LFC of a single-area power system as an extension of the TDF-IMC scheme. The inner and outer loop controllers were computed with the help of a predictive model, observed from the responses and performance indices that the proposed configuration generates better results with the nominal and perturbed parameters. Furthermore, it was observed that the proposed scheme gives better transient and steady state performances with the external load disturbance. [9]

Comparison of the settling times of MSMA power system using ADRC and PID as secondary controllers is shown in Table 1. From the Table, it is observed that the settling time using ADRC is less compared to PID Controller. Not only settling time but also overshoots/undershoots remain very low by using an ADRC Controller which is observed from Figs 8 - 25. Settling time remains same for both the ADRC and PID controllers for different load changes in the power system. [10]

This paper investigates the performance of automatic generation control of three area thermal power system. To demonstrate the effectiveness of proposed controller, evolutionary (Genetic Algorithm for tuning of Integer controller) controller. AGC with load following is treated as an ancillary service that is essential for maintaining the electrical system reliability at an adequate level recent years, major changes have been introduced into the structure of electric power utilities all around the world.[11]

In this paper, an electrical energy management system, that implements an overall electricity consumption prediction model, was proposed. This model was established using the Fuzzy Logic method. Several individual houses were instrumented to highlight the importance of the prediction model. Finally, the system proposed here provides safety guarantees, and particularly during AC-line disconnection.[12]

Green energy targets for coming decades advocate high penetration of wind energy in main energy matrix, which pose incendiary threat to stability and reliability of modern electric grid if their integration aspects are not assessed beforehand. Real-time balancing of demand and supply or Automatic generation control is a challenging task in modern electric grid when penetrated with unpredictable and variable wind power. [13]

In this study, fuzzy logic control approach is employed for load frequency control of an isolated system as well as on an inter-connected power system with non-reheat turbine system. The proposed fuzzy controller is reported as with better performance in comparison to PID controllers reported in literature. This mismatch has to be corrected by load frequency control (LFC), which is defined as the regulation of power output of generators within a tolerable limit.[14]

In this paper, the various optimization techniques for the Automatic Generation Control are introduced. From above discussion, it is clear that all techniques are having its distinct benefits like GA is a simple technique, suitable for less dimension problems. BF has global search ability. ANN is based on adaptive learning with no need of programming. Conventional controller is simple for implementation but takes more time and gives large frequency deviation.[15]

III. METHODOLOGY

System Block Diagram

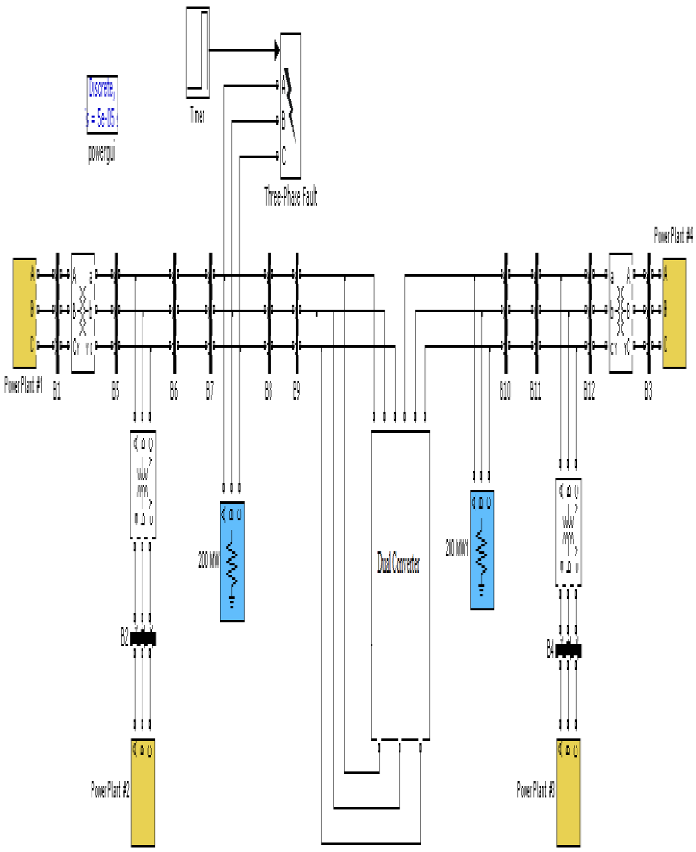

Fig: 3.1 System Block Diagram

PWM Invertor

PWM or Pulse width Modulation is used to keep the output voltage of the inverter at the rated voltage(110V AC / 220V AC) (depending on the country) irrespective of the output load.In a conventional inverter the output voltage changes according to the changes in the load.To nullify effect caused by the changing loads,the PWM inverter correct the output voltage according to the value of the load connected at the output.This is accomplished by changing the width of the switching frequency generated by the oscillator section. The AC voltage at the output depend on the width of the switching pulse.The process is achieved by feed backing a part of the inverter output to the PWM controller section (PWM controller IC).Based on this feedback voltage the PWM controller will make necessary corrections in the pulse width of the switching pulse generated at oscillator section.This change in the pulse width of the switching pulse will cancel the changes in the output voltage and the inverter output will stay constant irrespective of the load variations.

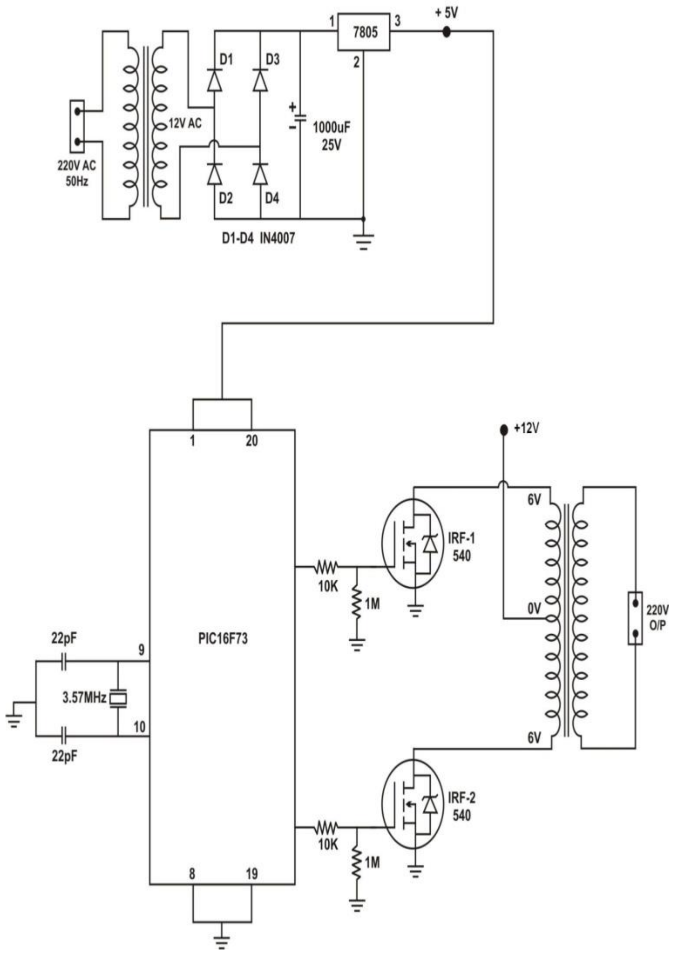

Fig: 3.2 Circuit Diagram of Pwm Inverte

IV. RESULT

In this window we can see how we run the main code by right click on the code option then click on Run.

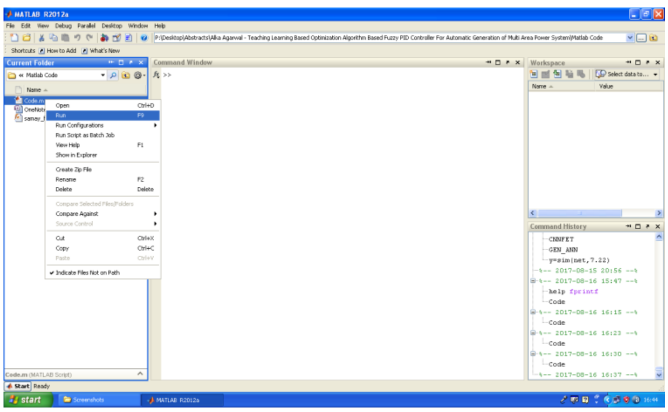

Fig 4.1 Run Main Code

In this window we can see after the click on the run button a loading window will be open.

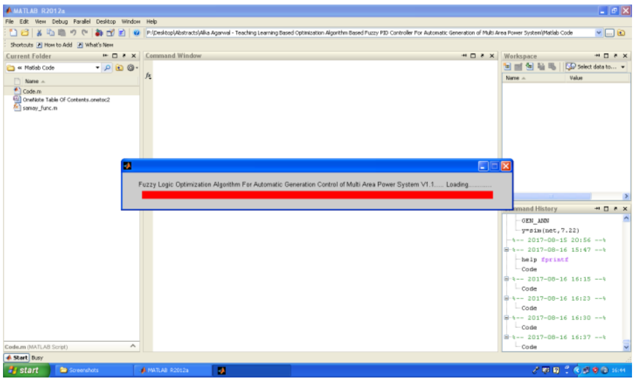

Fig 4.2 loading window

In this window we can see different voltage and current from the different power plants. When only solar power is on. When solar power, wind power and thermal power is on and nuclear power is off.

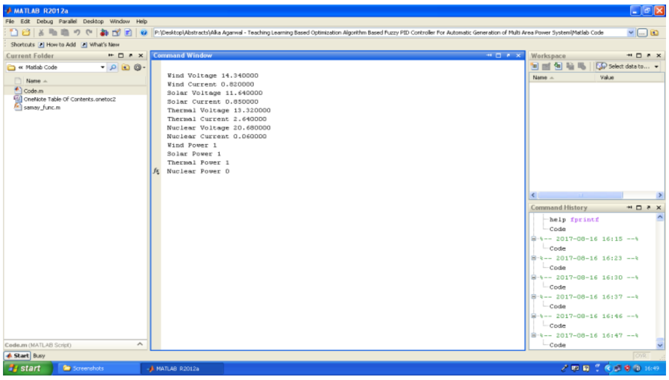

Fig 4.3 Voltage and current values from different power plant

In this window we can see different voltage and current from the different power plants.When solar power, wind power and thermal power is on and nuclear power is off. When wind power , solar power, thermal power and nuclear power is on.

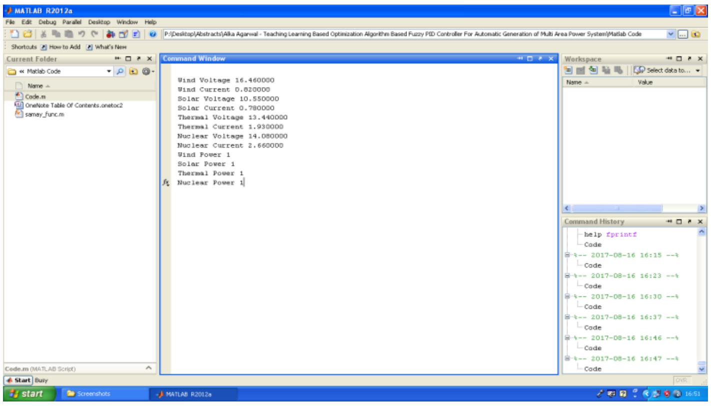

Fig 4.4 Voltage and current values from different power plant

In this window we can see different voltage and current from the different power plants. When wind power, solar power, and thermal power is on and nuclear power is off.

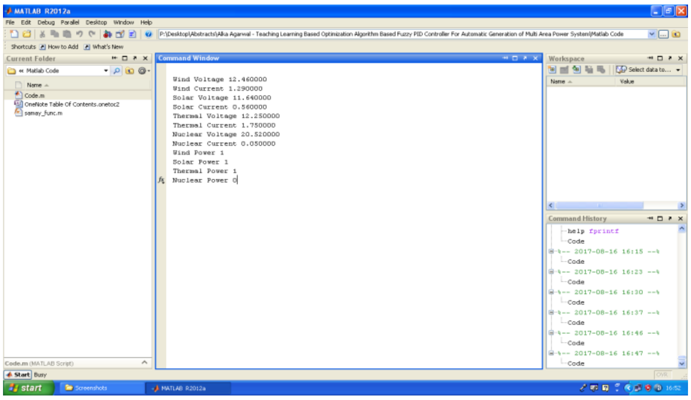

Fig 4.5 Voltage and current values from different power plant

In this window we can see different voltage and current from the different power plants. When wind power power, wind power and nuclear power is on and thermal power is off.

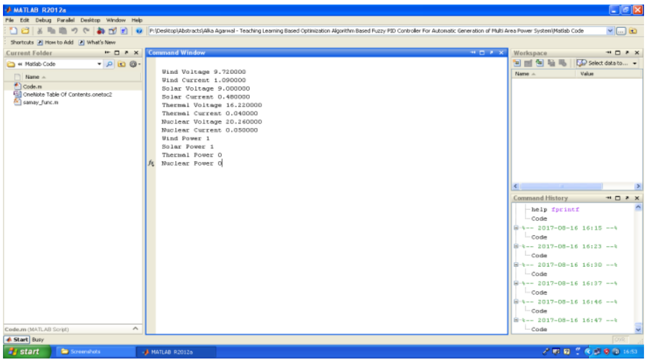

Fig 4.6 Voltage and current values from different power plant

S.No	Wind power	Solar Power	Thermal Power	Nuclear Power
1.	0.6408	5.1944	0.5259	0.6699
2.	12.8644	6.8876	0.3086	0.8836
3.	11.75	9.894	35.16	1.2408
4.	13.4972	8.229	25.9392	37.4528
5.	16.0734	9.3184	21.4375	1.0025
6.	10.5948	4.32	0.6488	1.013

Table: 4.1 Instantaneous powers of various power generations

S.No.	Wind Voltage	Wind Current	Solar Voltage	Solar Current	Thermal Voltage	Thermal Current	Nuclear Voltage	Nuclear Current
1.	16.62	0.04	12.08	0.43	17.53	0.03	22.33	0.03
2.	11.09	1.16	10.28	0.67	15.43	0.02	22.09	0.04
3.	14.34	0.82	11.64	0.85	13.32	2.64	20.68	0.06
4.	16.46	0.82	10.55	0.78	13.44	1.93	14.08	2.66
5.	12.46	1.29	11.64	0.56	12.25	1.75	20.52	0.05
6.	9.72	1.09	9.00	0.48	16.22	0.04	20.26	0.05

Table: 4.2 Observation of voltage & current of various power generation stations

V. CONCLUSIONS

The premise of this research is to optimize the cost of generation in multi area varied source power generation systems feeding combined load. As described above the system implements multiple (up to H) power generation setups by employing PWM inverters. More the over power generation setup connect to a load feeding bus or local AC bus. Also demonstrated is power sharing between various AC Buses (Local Buses) using dual converter.

The demonstration hardware setup is employs three 8 bit microcontroller from microchip for PWM generation, dual converter pulse generation & main controller acting as a slave serial unit to individually form on/off specific power generation setup according to the serial command. Successful implementation of embedded 'C' programming is demonstrated by PWM inverters & dual converter function & adherence of hardware to the predefined communication control process. Fuzzy logic controller for the proposed system has been developed in Matlab & is interfaced to the hardware over RS232 port using data equation toolbox methods. As demonstrate by the results the fuzzy controller automatically turns on or off requires power generation setups according to the load condition with prioritization of renewable energy & optimization of operational cost.

VI. FUTURE SCOPE

The author has proposed and demonstrates a multi area power generation algorithm with primary priority to renewable energy sources & also focused on cost optimization of generation station/sources. As the technology is rapidly evolving & energy crisis day by day there is continual demand in enhancements of systems cataing to multi area power generation especially micro power generation using renewable energy sores. A lot of enhancements can be introduced in the demonstrated work but the primilarily soughtones include inclusion of high speed data communication gateway over plcc & local RF repeaters to enable real time information & having between generation stations GSS, load despotch etc. to optimize generation reduce probability of faults & trips. Another important enhancement would be to include PWM control of dual converter to enable power flow quantity that control & prioritization to important load centers.

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