Microcontroller controlled H bridge Mosfet dual converter and PWM Inverters for Automatic Generation Control in Multi Area Power

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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.

Index Terms—: *Multi area power generation, Fuzzy logic, Matlab, Data Aequitsiton tool box, Dual converter***.**

1. INTRODUCTION

(I) Fuzzy Logic:- Fuzzy logic is a form of multivalued logic in which the truth values of variables can be any real number between 0 and 1. It is used to treat the concept of partial truth, where the truth value can lie between completely true and completely false. In contrast, in Boolean logic, the truth values of variables can only be the integer values 0 or 1. It is based on the observation that people make decisions on the basis of imprecise and non-numerical information; fuzzy models or sets are mathematical means for representing uncertainty and imprecise information, hence the term fuzzy. These models have the ability to recognize, present, manipulate, interpret and use data and information that is vague and uncertain.

Fuzzy logic has been applied to many areas, from control theory to artificial intelligence. Fuzzy logic begins with and builds on a series of human language rules provided by the user. The fuzzy systems convert these rules into their mathematical equivalents. This simplifies the work of the system designer

and the computer and leads to much more accurate representations of the behavior of systems in the real world.

Additional advantages of fuzzy logic are its simplicity and flexibility. Fuzzy logic can handle problems with inaccurate and incomplete data and model nonlinear functions of any complexity. "If you don't have a good plant model, or if the system changes, fuzzy provides a better solution than traditional control techniques," said Bob Varley, senior systems engineer at Harris Corp., an aerospace company in Palm Bay, Florida. You can create a fuzzy system that matches any set of input / output data. The Fuzzy Logic Toolbox makes this particularly easy by providing adaptive techniques such as adaptive neuro-fuzzy inference systems (ANFIS) and fuzzy subtractive clustering.

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

(II) Automatic Generation Control of Multi Area Power System

One of the most important components in the daily operation of a power grid is the planning and control of the generation. This feature is the primary concern of the Energy Control Center and is largely provided by an Automatic Generation Control (AGC) program implemented as part of the Energy Management System (EMS).

Although the process is highly automated, dispatchers in the power system can interact with it by monitoring its results and entering data that reflect current operating conditions. In general, power supply systems are interconnected to ensure safe and economical operation. The connection is typically divided into a control area, each of which consists of one or more energy supply companies. Control areas are connected by transmission lines, commonly referred to as trunk lines, and the power flowing between control areas is referred to as trunk line exchange power. One of the main tasks of each control area is to provide enough generation to meet its customers' load needs, either with its own generation sources or with electricity obtained from other control areas.

The main part of the operation and control of the power supply system is to guarantee a continuous power supply of acceptable quality to all consumers in the power grid. The system is in balance when there is a balance between the electricity demand and the electricity generated.

(III) Interconnected Power Systems

From a practical point of view, the frequency control problem of interconnected regions is more important than the frequency control of isolated (individual) regions. However, in order to understand the theory and concepts of interconnected systems, knowledge of a single region is equally important. In fact, all power systems are now connected to the environment and the problem of automatic power control is becoming a common cause. The basic operating principles of the interconnection of power supply systems are listed below.

• Under normal operating conditions, each control area should strive to bear its own load, but the predetermined portion of the other member's load is not agreed by both parties.
• Each control area must agree to use mutual adjustment and control strategies and devices under normal and abnormal conditions.

(IV) Need of Intelligent Control Techniques

The intelligent control technology has made the implementation of the AGC power supply system considerably easier. Power supply systems are more complex today and have to be operated in unsafe and less structured environments. Therefore, the safe, economical and stable operation of power supply systems requires improved and innovative control methods. The intelligent control technology adapts well to changing conditions and can make quick decisions by dealing with inaccurate information. Some of these techniques are rule-based logic programming; model-based thinking, fuzzy sets, artificial neural networks, evolutionary programming and genetic algorithms. In this work, fuzzy logic controller (FLC) technology was used to connect the AGC of power supply systems. This fuzzy controller has many advantages in the results of the controller theory.

II. OBJECTIVE OF STUDY

[1.] Design & development of an automated hybrid algorithm for generation control of multi area, different type power generation systems.
[2.] Use of advanced artificial intelligence algorithms such as combination of Artificial Neural Network (ANN) & Fuzzy Logic to optimize power generation cost & environmental impact.

[3.] Development of an automatic prioritization scheme based on load, Cost to optimize choice of renewable/non renewable generation & optimal generation by fuel based power generation systems.
[4.] Our proposed system will not only cater, to power generation control of similar kind of generation system, but also of dissimilar type of generation systems.
[5.] Use of biologically inspired algorithm such as Wolf or Bat in conjunction with traditional prediction techniques, to allow forecast of load schedule, & optimize power generation.
[6.] Development of intelligence in system to counter maximum power limits & dramatic power changes in renewable energy systems as they are heavily dependent on natural phenomenon & weather.
[7.] As compared previous studies, our work will comprise of working Simulink/Matlab model, having a blend of renewable & non renewable generation system, & with different cost of their operation, various load scenarios etc.

III. LITERATURE REVIEW

In this paper, a number of decentralized and centralized PI and Model Predictive Control (MPC) based algorithms for the purposes of automatic generation control (AGC) in MTG (Multi-Terminal HVDC) networks have been proposed. The use of voltage sets has also been suggested as an additional control variable to improve performance. The paper discusses how this approach can improve the allocation of secondary reserves and help achieve the EU energy targets for 2030 and beyond. [1]
In this paper, the gravity search algorithm is used to obtain optimal gains of the PIDF controller for the problem of automatic generation control (AGC). The first GSA is presented in detail and therefore the examined power supply system is examined. The results of the simulation underline the effectiveness of the GSA. The PIDF controller coordinated by the GSA has been urgently proposed for automatic generation control. [2]
The paper looks at a multi-stage power supply system with wind power generation in area 1. The emergency situations of a sudden generation loss and a sudden load loss are simulated for a two-area system, one of the areas having a wind turbine generator. The results show that the frequency deviation and the voltage profiles are within the limits in both situations. Coordinated performance planning is required to keep system parameters under control. [3]
In this paper, the ACO-based fuzzy controller is applied to the SEDC motor. The fuzzy rules are optimized offline, while the parameters of the fuzzy controller are set online. Compared to the Hybrid Fuzzy ACA Controller, ACA and Fuzzy Logic Controller, the Hybrid Fuzzy-ACA Controller is not only more robust, but can also achieve better static and dynamic system performance. [4]
A simulation study of one 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 a frequency drift after a load disturbance and is mainly due to the mismatch between the electrical load and the mechanical input into the turbine. [5]
In this work a type 1 fuzzy controller is used to control the load frequency of the single-range thermal power plant without reheating. A load load disturbance of 1% is applied to the load requirement of the power plant and analyzes the system reactions with regard to settling time, peak overshoot and peak undershoot. It is therefore necessary to keep the system frequency constant. [6]
This paper was ratified with a novel FPID controller optimized for the DECRPSO algorithm that is used in both areas of an interconnected hydrothermal power system to minimize ACE. In order to achieve better control of the performance and frequency deviation of the connecting line, the gains of the FPID controller are optimized by PSO, CRPSO and hybrid DECRPSO algorithms. [7]
In this work the optimal load frequency control (LFC) of interconnected power supply systems is examined. The influence of the LFC control method on the fluctuations caused by step load disturbances is examined. The effect of the LFC controller is also analyzed. The PID controller parameters (Proportional-Integral Derivative) of the examined LFC model are optimized by various techniques. An application of a new approach based on the hybrid genetic algorithm and particle swarm optimization (HGA-PSO) to solve the LFC problem is being developed. The proposed hybrid GAPSO algorithm is first applied to the two-zone network and then extended to the large three-area 9-unit network model. The comparative study shows the validity and potential of the proposed approach and its robustness for solving the optimal LFC problem. [8]
The present article developed a new approach to the LFC of a single area power system as an extension of the TDF-IMC scheme. The inner and outer loop controllers were calculated using a predictive model, which was observed from the responses and performance

indexes, that the proposed configuration with the nominal and disturbed parameters performed better. In addition, it has been observed that the proposed scheme provides better transient and steady state performance in external load disturbance. [9]

The comparison of the settling times of the MSMA power supply system using ADRC and PID as secondary controllers is shown in Table 1. The table shows that the settling time using ADRC is shorter compared to the PID controller. Not only the settling time, but also the overshoot / undershoot remain very short when using an ADRC controller, which is shown in Fig. 8 to 25. The settling time remains the same for both the ADRC and the PID controller for different load changes in the power supply system. [10]

This article examines the performance of the automatic generation control of a three-surface thermal power system. To demonstrate the effectiveness of the proposed controller, an evolutionary controller (genetic algorithm for tuning the integer controller) is used. AGC with load tracking is treated as an ancillary service that has been essential for maintaining adequate electrical system reliability in recent years. The structure of electricity suppliers around the world has changed fundamentally. [11]

In this article, an electrical energy management system has been proposed that implements a model for predicting total power consumption. This model was created using the fuzzy logic method. Several individual houses were instrumented to emphasize the importance of the forecast model. Finally, the system proposed here offers security guarantees, particularly during the disconnection of the AC line. [12]

Green energy targets for the coming decades advocate a high penetration of wind energy in the main energy matrix, which poses a fire risk for the stability and reliability of modern power grids if their integration aspects are not assessed in advance. The real-time balance of supply and demand or the automatic generation control is a challenging task in the modern power grid when it is permeated with unpredictable and variable wind power. [13]

In this study, a fuzzy logic control approach is used for load frequency control of an isolated system and for an interconnected power supply system with a turbine system without reheating. The proposed fuzzy controller is said to perform better than the PID controllers reported in the literature. This mismatch must be corrected by a load frequency control (LFC), which is defined as regulating the power output of generators within a tolerable range. [14]

In this article, the different optimization techniques for automatic generation control are presented. From the discussion above it appears that all techniques have their particular advantages since GA is a simple technique that is suitable for problems with fewer dimensions. BF has a global search function. ANN is based on adaptive learning without programming. Conventional controls are easy to implement, but take more time and result in large frequency deviations. [15]

IV. METHODOLOGY

Procedure Block Diagram

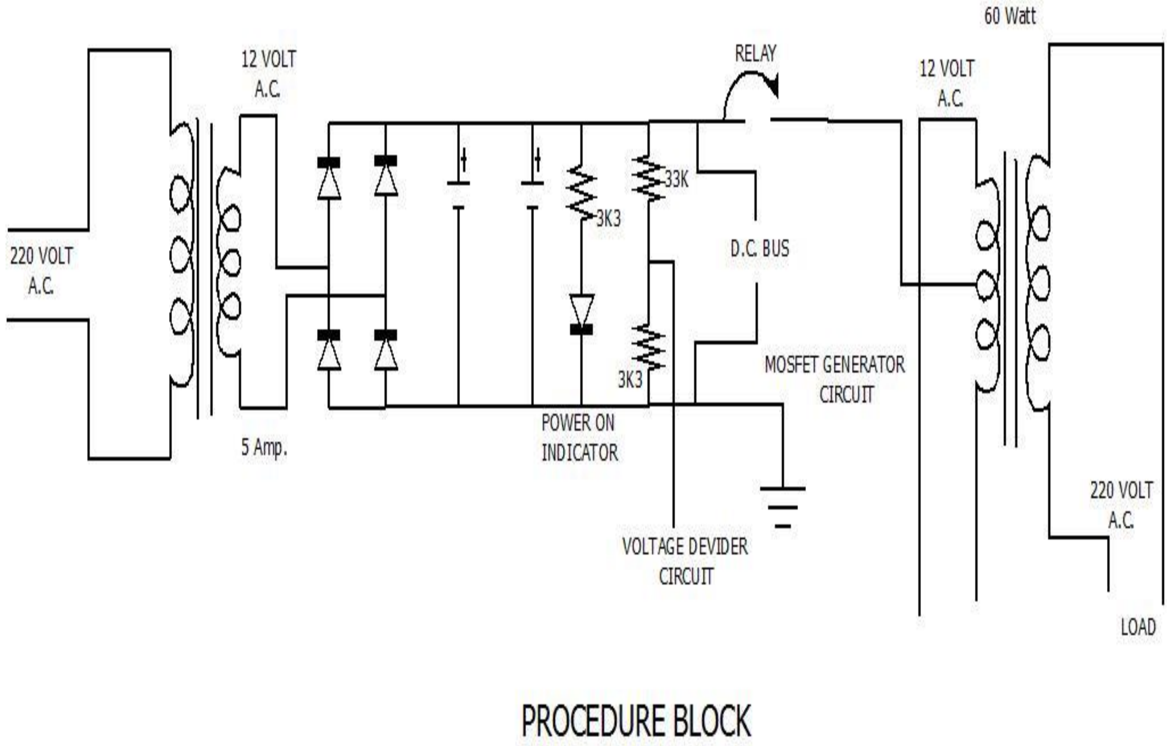


Fig 1.1 Procedure Block Diagram

PWM Invertor Flow Chart

In this flow chart we can see 1st code is start then portb is equal to zero. Then f0 to f7 of port b is equal to zero then after delay of 5 milli second f0, f2, f4, f6 of port b is equal to 1 and f1, f3, f5, f7 of port b is equal to zero. Then after delay of 5 milli second f0 to f7 of port b is equal to zero. Then after delay of 5 milli second f0, f2, f4, f6 of port b is equal to zero and f1, f3, f5, f7 of port b is equal to 1. Then after delay of 5 milli second algorithm will be stop and repeat again.

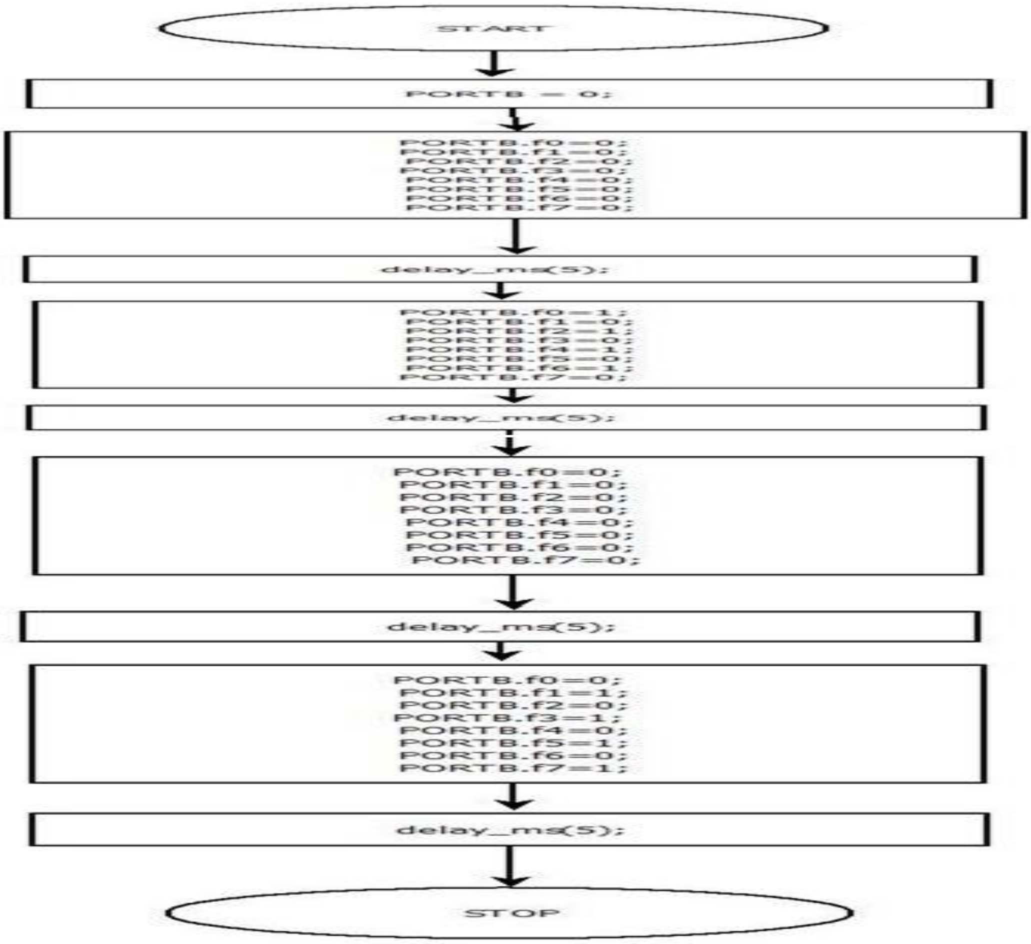
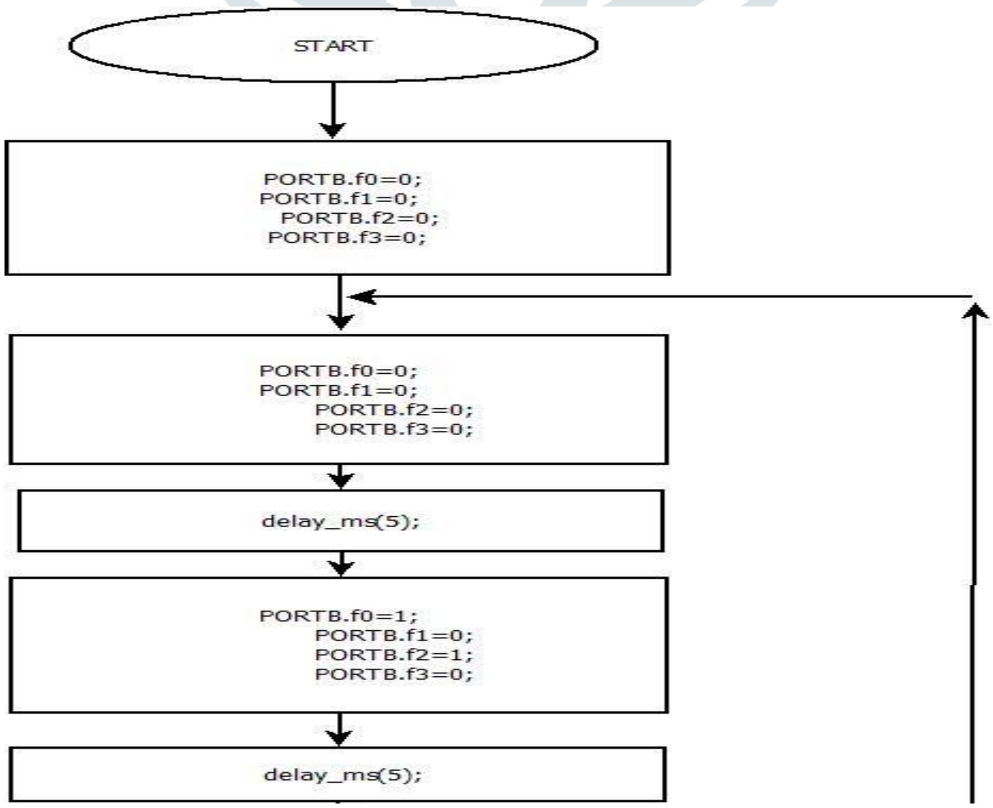


Fig 1.2 PWM Flow Chart

Dual H Bridge Flow Chart



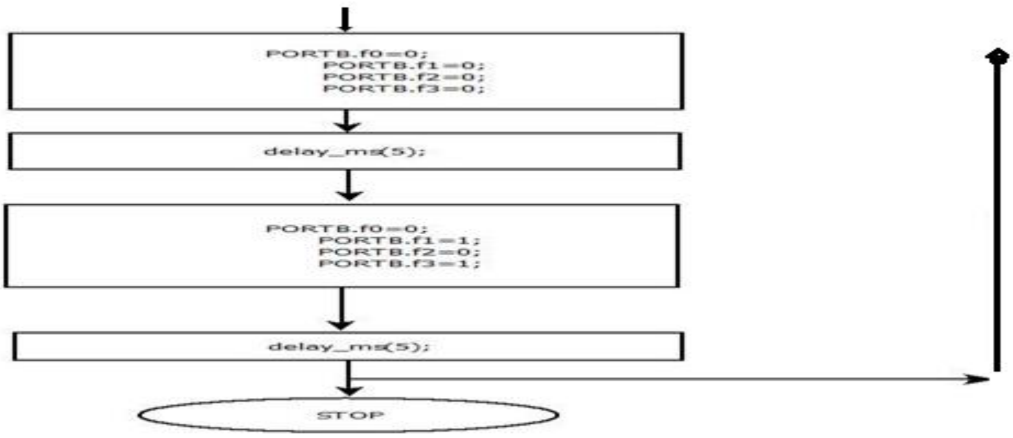


Fig: 1.3 H Bridge Flow Chart

In this flow chart we can see 1st main code is start then f0 to f3 of port B is equal to zero. Then after delay of 5 milli second f0 and f2 of port B is equal to 1 and f1 and f3 of port B is equal to zero. Then after delay of 5 milli second f0, f1, f2, f3 of port B is equal to zero. Then after delay of 5 milli second f0 and f2 of port B is zero and f1, f3 of port B is equal to 1. Then algorithm repeats.

V. RESULT

Hardware Image

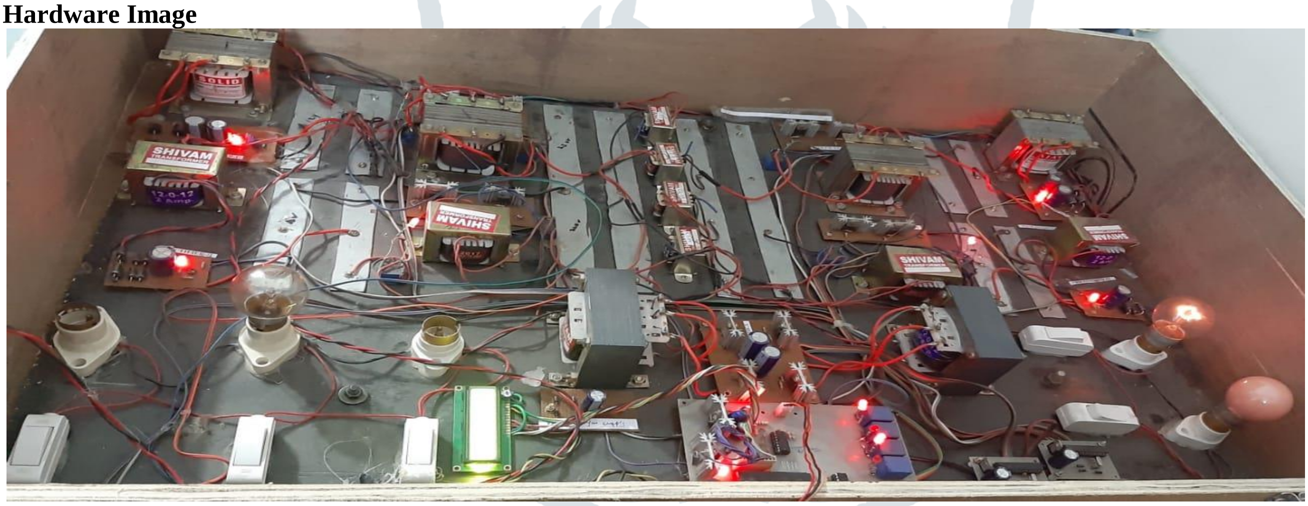


Fig 5.1 Hardware Image

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

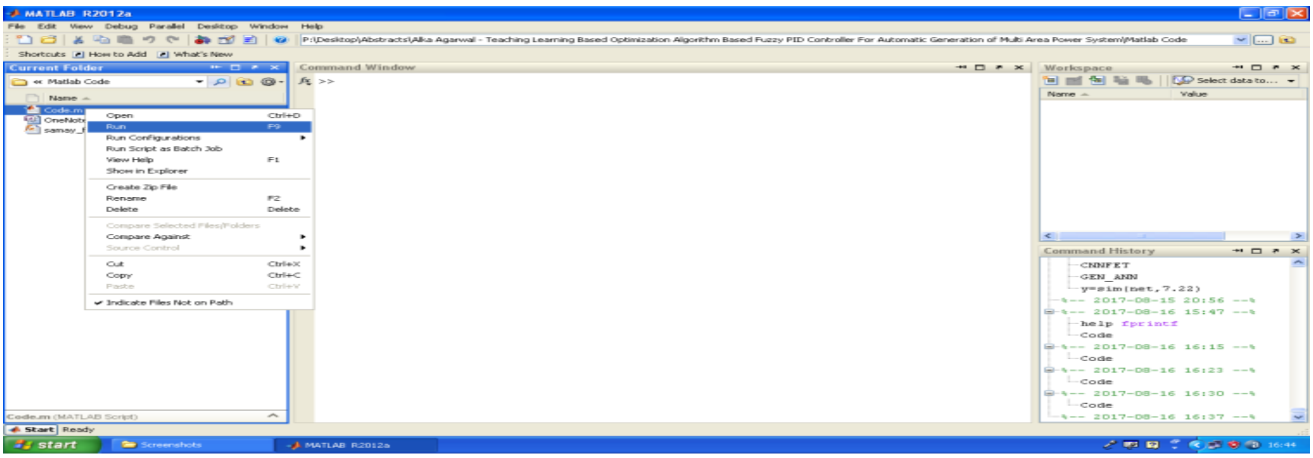


Fig 5.2 Run Main Code

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

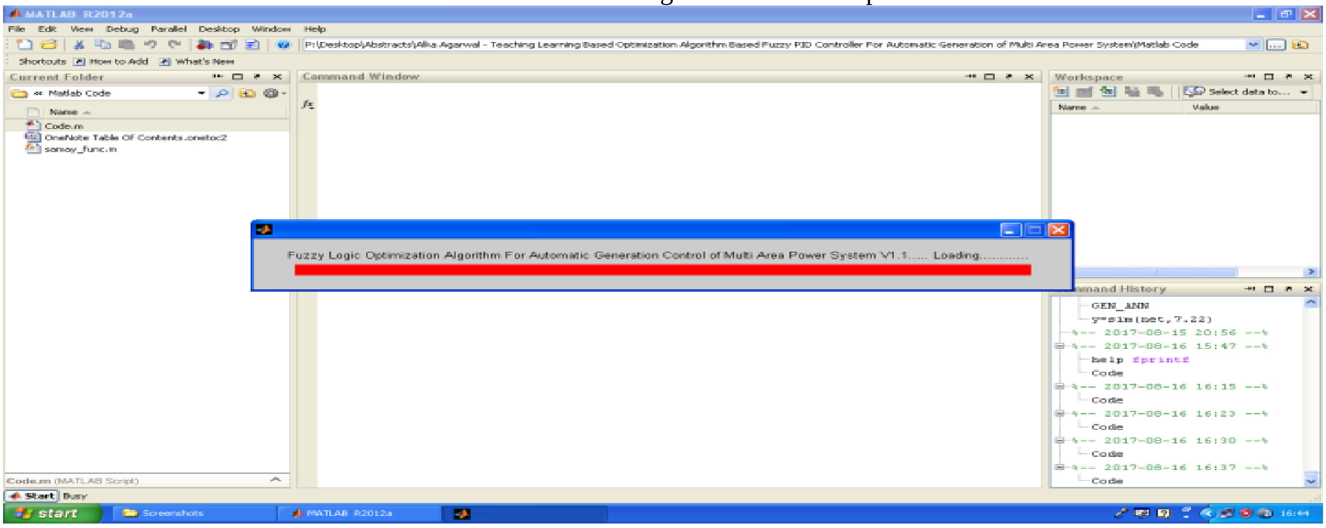


Fig 5.3 loading window

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.

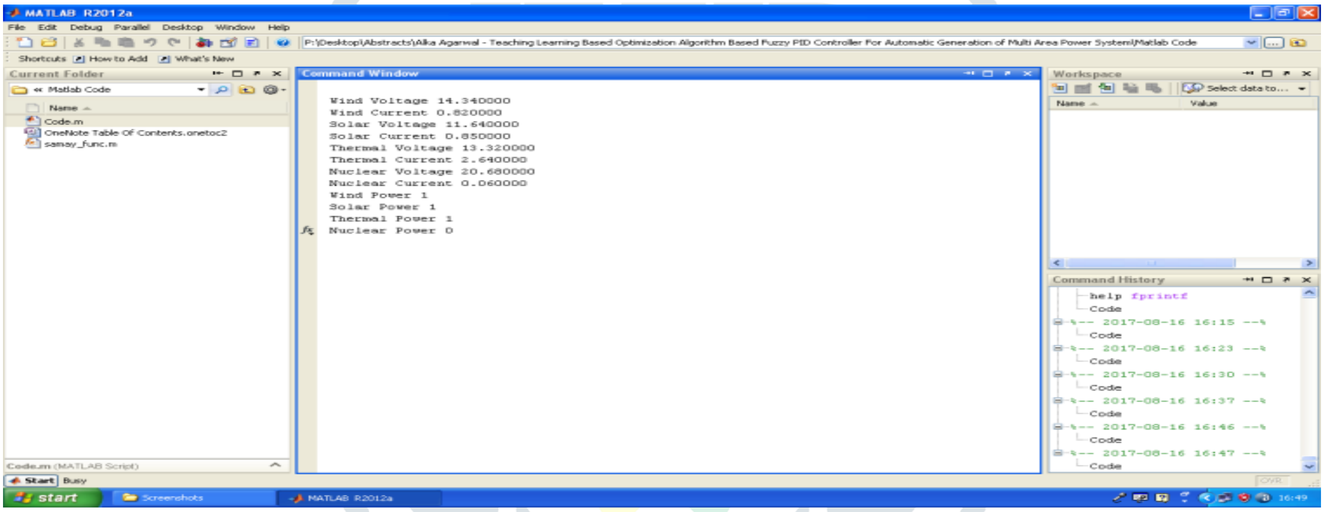


Fig 5.4 Voltage and current values from different power plant

In this window we can see different voltage and current from the different power plants.When 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.

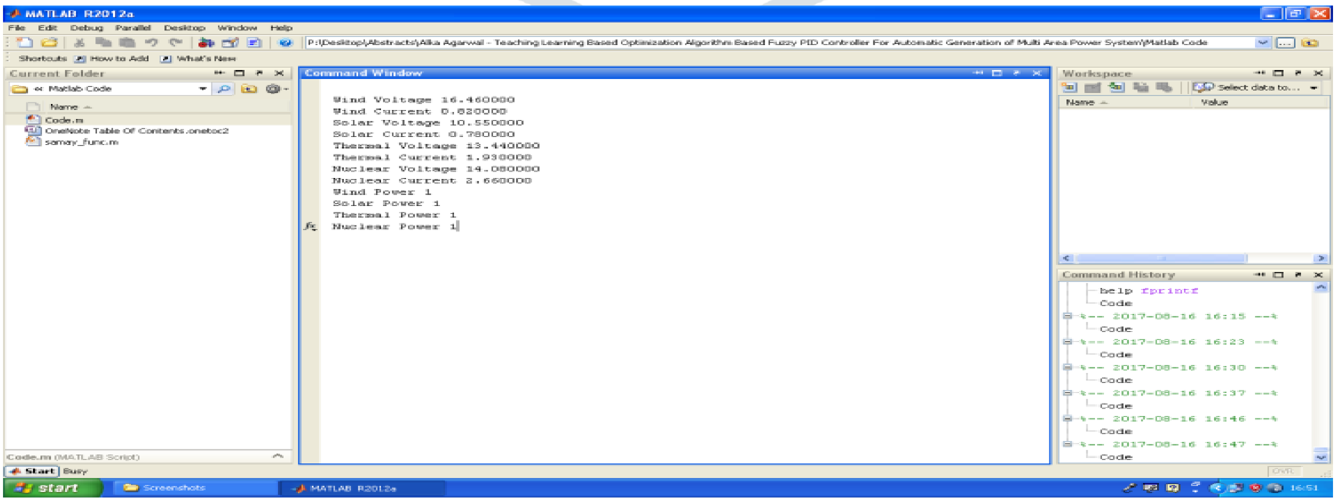


Fig 5.5 Voltage and current values from different power plant

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

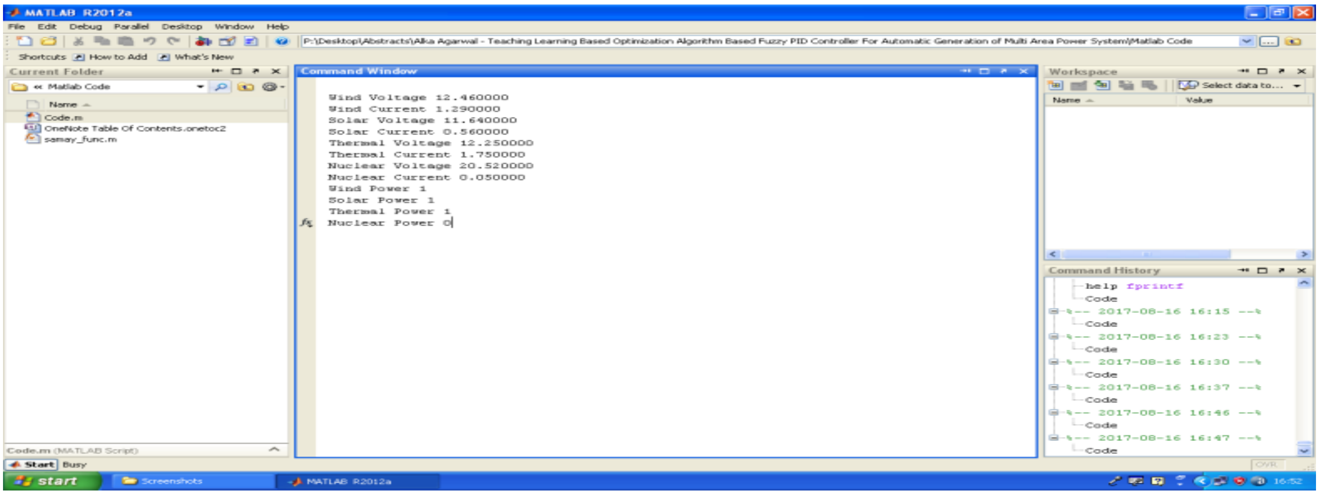


Fig 5.6 Voltage and current values from different power plant

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.

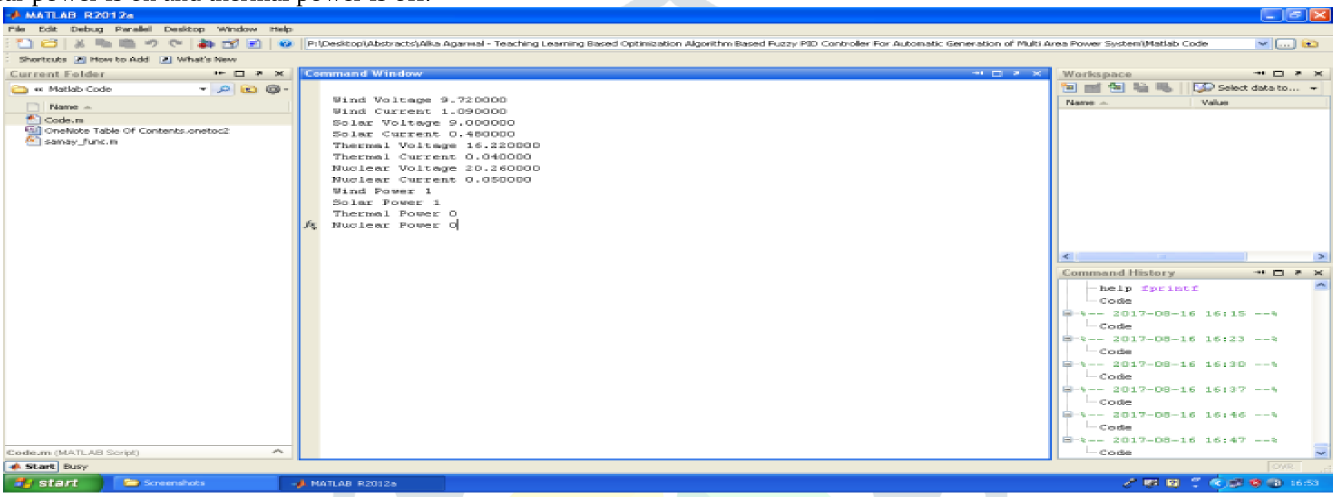


Fig 5.7 Voltage and current values from different power plant

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: 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: 2 Observation of voltage & current of various power generation stations

VI. Conclusion and Future Scope

Conclusion

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.

FUTURE SCOPES

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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