An Integrated IoT LabVIEW Based Fuzzy-PLC Controller for Automation of Boiler

S Boobalan 1, S Gobinath2, A Dharmalingam3, A Jayaprakash 4, M Poovarasann 5, K Poovendan 6
Assistant Professor, Department Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology1,2
UG Scholar, Department Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology3,4,5,6

Abstract. The proposed prototype, to develop and automate and controlling of steam outlet from the boiler unit in the Power Plants using Fuzzy logic-based PLC Controller. The set point of the steam outlet could be decided by the Fuzzy Logic Controller. Automation is a growing technology in almost all fields and It reduces the man power and time complexity in all the way to the thermal power plant also. It reduces the risk of making mistakes and avoid any danger. The details of the load is collected from P.T and then given to the LabVIEW. The data about the load requirements, peak load data requirements ae once fed into the LabVIEW. The LabVIEW sends signals to the PLC and steam outlet is controlled by Servo Motor. The steam outlet set point is measured and controlled by fuzzy logic with the help to PLC controller. Based on alternator current and voltage signal the fuzzy logic will decide the steam outlet set point. If in case the load requirement is higher or lower, the changes in the coal input and the water requirement are changed by means Fuzzy logic control. The steam valve sensor closes or opens the valve by servo motor using the variable frequency drive that is connected to the PLC. Depending upon the load, to the steam turbine. The PLC is connected to the ethernet by means in LabVIEW, in which the data are collected are given to the authorized person in the control room. If in case required the data can be used to store the data in the cloud for future use.

Index Terms— Boiler Automation, PLC Controller, HMI, LabVIEW, Fuzzy Logic Controller, IOT, ThingSpeak.

I. INTRODUCTION

The market for automated systems that can work more proficiently has increased to deliver better quality products. In the case of a steam boiler factory, proper production control and proper temperature monitoring are frequently needed. Therefore, manual plant management turned out to be a laborious one for the job. The suggested concept design of boiler automation was introduced to achieve the goals identified with the automation control system: creation of processes, enhancement of management level and high-performance method.

The boiler automation systems are very necessary to keep human employees from making mistakes. A variety of reports on the boiler automation system have been performed since. Automation was performed in the manufacturing field using different techniques. T. Karuppiah and Dr. Azha built a framework for power plant boiler automation by using microcontroller and GSM technology[2]. The temperature of the device in their proposed design is regulated by alternator production. The central water tank has an ultrasonic sensor for monitoring water pressure. In every boiler pipe there is a certain temperature sensor which controls the machine temperature. The GSM module is used to give details to the user. Udaykumar S. Kulkarni & Venkat N. Ghodke have suggested a boiler automation system utilizing FPGA & GSM[3]. A principal water tank is attached to many boilers in their planned configuration. Water level sensor & temperature controls are used for monitoring main tank water level & boiler temperature. GSM cell phone is used to provide present temperature knowledge in every boiler. VHDL (VHSIC Hardware Definition Language) is used and introduced in Field Programmable Gate Array (FPGA) equipment. Aaron James et. Al . suggested a boiler automation framework for a power station utilizing a distributed control system (DCS)[4]. The device is typically used up to about as a water tube boiler. Three hundred bar or around as a strong steam boiler. Thirty windows. With the assistance of DCS, the steam production from the steam header covers the required temperature by means of a good temperature sensor. The roles have not yet been explicitly established for this framework, however.
This research addresses the concept and testing of an integrated programmable logical controller (PLC) for the fuzzy logic system. The chosen system is part of the IQ-F MITSUBISHI sequence, while code in Ladder Diagram has been created. The fuzzy controller is of the form Mamdani and is used for servomotor operation. The validation of the built software module and its viability to handle this form of control algorithm are contrasted with a LabVIEW fuzzy controller. Fuzzy means "not visible, distinct or true, blurred." A kind of depiction of information relevant to notation that cannot be strictly specified but relies on its meaning. A fugitive logic controller imitates the way information is managed by human operators.

A Fuzzy adds a series of control laws that can vary and sometimes contradict each other to the simulation. A sequence of answer rules developed by the professional operator[5] are used by the fluid logic control[6]. The quantizer moves the knowledge from the sensor to a way which can be used by the fluid logic system.

LabVIEW uses an interactive programming framework to imagine all facets of the design, including equipment, calculations, and debugging. This shows simplifies the incorporation of each vendor's measuring equipment, reflects a dynamic diagram structure, integrates data processing algorithms, and creates unique user interfaces. Classic Control proved long enough to do machine control function, but it is based on an exact mathematical model of the program and is not a basic mathematical operation.

The fuzzy logic is able to simulate incorrect or imprecise structures, as opposed to conventional logic systems. The fluoridated logic strategy presents a easier, cheaper and more efficient alternative with strong benefits over modern technology. At present, LabVIEW simplifies the implementations of technology, process management, analysis, manufacturing usage and calculation. Thanks to the fact that LabVIEW lacks the programming language's simplicity coupled with built-in monitoring, measurement and control tools[8][9]. Through utilizing the interactive LabVIEW system to communicate with real-world signals, data are processed for relevant evidence and findings are exchanged. Take LabVIEW then to build a control framework that appends to fudge logic and which is more flexible than normal traditional regulation for device parameter variance, and the advantages of fogging are [10][11].

### 2. BLOCK DIAGRAM

The following diagram is the main block diagram of proposed An Integrated IoT LabVIEW Based Fuzzy- PLC Controller for Automation of Boiler

![Block diagram of proposed An Integrated IoT LabVIEW Based Fuzzy- PLC Controller for Automation of Boiler](image)

In the proposed system LabVIEW plays an important role as measurements i.e. Data Acquisition, Analysis, Monitoring and Controlling. For automating the steam valve in requirement with the load demand, it need to get an output from the generator. So the Potential Transformer is connected at the Generator side, to measure the current load demand. Then the P.T is connected as input to the LabVIEW.

The Fuzzy-Logic is built on the LabVIEW. The Fuzzy-logics is like adding an thinking ability to the PLC. The Fuzzy-logics keeps on monitoring the P.T input. When the Load demand rises the Fuzzy-logics decides how much angle to open the steam valve to rotate and when demand reduces the steam valve is closed in based on the demand. This change in angle is sent to the PLC through OPC Server. OPC stands for Open Platform Communication. The PLC receives data through the OPC from LabVIEW, and it is mapped on the Position control of the Ladder Logics. So the PLC sent data to the servo amplifier and turns the motor to the required angle for the steam flow to steam turbine.

To monitor the changes of the steam valve, IOT is introduced on the LabVIEW to monitor the process remotely. The LabVIEW
sends information such as VOLTAGE, CURRENT, POWER, STEAM VALVE ANGLE, RPM (of the generator) to the cloud database. This database from the cloud can be monitored on various platforms.

In currently major industries are using human manpower and their knowledge-based supervising of change it setpoint in manually. In this proposed prototype project has the option to it automatically using artificial network. Further the setpoint also chosen by the artificially by sing intelligent technique using LabVIEW.

3. DESIGN AND IMPLEMENTATION

The construction of a Fuzzy logic controller is an essential phase in boiler automation and the required process variable must be defined before beginning automation or constructing a Fuzzy logic controller. Sometimes "linguistic words" are used when defining the value of the factors in the input equation. For eg, error and actual location are two language words that can be used as input variables easily specified. To order to monitor the device, the blurry output must be used. Over recent decades, the usage in the fields of power electronics, control systems and positioning systems of multiple software technologies such as hybrid [1, 2] or Artificial Intelligence has increasingly increased. A broad data base and knowledge of control methods are required to explain the conceptual framework to facilitate decision taking in order to apply such implementation methods. The fugitive logic [3, 4] is one of these approaches, which is important to strengthen the classical logic and is essentially a assertion that can be interpreted as a logical value of 1 or 0.

The LabView Fuzzy Logic Toolkit is put in the LabVIEW development framework software section. The Fuzzy Logic Toolkit is a GUI, a digital user interface, in true LabView form. Fuzzy logic is an expert framework and process management mechanism rule-based decision taking tool. The philosophy of Fuzzy varies from the standard Boolean logic since Fuzzy theory allows partial membership. The Fuzzy Logic utilizes descriptive, vocabulary definitions for the management of systems. The data are collected by a blurry sensor in order to handle or manipulate a specific device in real time. The outputs of the fuzzy controller are easily performed through analog hardware DAQ to monitor the operation in real time. To interactively build a fuzzy framework using the Fuzzy Program Builder. For the programming of fuzzy programs, using Fuzzy Logic VIs.

The following diagram shows the fuzzy logic controller, which is designed in LabVIEW.
Fig. 2. Building the Fuzzy-Logic Control using NI LabVIEW

Fig. 3. Fuzzy system Designer
The above diagram shows the fuzzy membership function for speed of alternator and valve position. As per the real-time process variable the sigmoidal membership function is chosen as best one. Through this membership function, the real-world process easily captured because of the boiler process.

Fig. 4. Fuzzy system Rules
The above picture is the Realtime snapshot of the fuzzy rules system designer. There are 14 rules has been framed based the operating procedure of the boiler. If the rules are designed in such manner that the system is going to yield good result. So, the rules are very most important thing to control the process. There are 14 rules here is used to manipulate the input and output variable and it is used to control the output using fuzzy controller.

Fig. 5 shows the Testing system of the boiler automation. Once the rules were fixed and framed in fuzzy designer system, the system itself has the ability to simulate the output process. By using this advance feature, this will leads to help to design a controller in a better manner. Before applying to the real-time process, it could help to simulate the entire controlled process and error correction. By using this feature, we could able to adjust and fine tune the rules and membership function values and factors. So it will leads to improve the controller output efficiency. The following Fig. 5. Shows the Test system Design.
Fig. 5. Test System of Fuzzy Rules Based System

Fig 6. Fuzzy Logic Controller in LabVIEW

The above picture shows the entire Fuzzy Logic Controller system, which is designed in LabVIEW.

4. PLC PROGRAM

PLC-Programmable Logic Controller is the field controller is used to control the steam valve with the help of servo motor. So PLC is need to get the input control signal LabVIEW. This is the important step is required to control the entire process. Before connecting PLC to labVIEW, PLC itself to get programmed to monitor the its input card and output card signal status. For that the PLC needs to program itself to monitor those signals.

The proposed prototype project we have used Mitsubishi FX5CPU PLC Controller. The PLC is configured for the entire process using GX Works 3 Environment.
5. HUMAN MACHINE INTERFACE

HMI- Human Machine Interface is the system to operate and monitor the process easily. The GOT 2000 series Mitsubishi is used here to monitor the input and output variable. There is a separate program is needed to program the HMI system. Before Monitoring the variable such as Speed of the alternator, Temperature, Steam valve position, it requires the register need to allocate it first. Then it could map with the PLC Program, which is already programmed in PLC Controller. The following fig.8. Shows the HMI Front panel Screen. Fig. 8. HMI Program in GOT 2000 Mitsubishi HMI Based on the operating condition, it could have the two cases like manual mode and automatic mode. In automatic mode selection the operator who is handling the boiler system, who couldn’t able to change the process variable. The system itself is going to process it based the rules, which is already fed into the system in LabVIEW. But in manual mode the operator, who could able to change the process variable based on the real-time condition. The following fig.9 Shows the /manual mode operation.
Based on the real-time condition the operator could able to change the process variable based on the operation. This is the additional feature included in the proposed project prototype.

6. OPC: OPEN PLATFORM COMMUNICATION

OPC: Open Platform Communication is the software which is used to communicate the two different hardware’s. NI OPC is used in this project to communicate the and sharing the information between LabVIEW and Mitsubishi PLC in a single platform. Fig.10.

OPC communication between NI LabVIEW and Mitsubishi PLC Field controller.

The above procedure is almost playing an important role in his proposed project. Because the fuzzy logic controller is designed the LabVIEW need to send a control signal and receives the field physical sensor values, so that both the PLC controller and LabVIEW is need to communicate each other. So that purpose OPC Server is required to communicate each other.
Fig. 10. OPC Server Configuration
7. RESULTS AND DISCUSSIONS

The following sections are the real-time graphs which is really designed a fuzzy logic controller and the output response are drawn using IOT Sever.

![IOT Interface using LabVIEW using Thinspeak Server](image1)

**Fig.11. IOT Interface using LabVIEW using Thinspeak Server**

ThingSpeak Server is used here to monitor the input and output process variable of the boiler system. These values are Alternator speed and Temperature, Alternator voltage, Current, etc. These process variables are measured using corresponding sensors using LabVIEW and through the LabVIEW the data’s were sent to ThingSpeak Server for IOT enabled system.

![IOT Server Data Monitoring system](image2)

**Fig.11. IOT Server Data Monitoring system**

Thus, the above Fig 11 shows the real time datas of the alternator. By using this we could able to monitor the health and process of the boiler in remote. This syste yields the good profit at end case. Because we could able to do predict the problem as well as we could able to increase the health of the alternator.
8. CONCLUSION
In this proposed prototype we have automated the steam valve in the Thermal Power Plants by using servo motor coupled with valve, based on demand of load using Fuzzy-Logics build on LabVIEW. Here the pneumatic control valve is replaced by using servo motor. The servo motor is used here to achieve accurate position control of the steam valve in requirement with the load demand.

9. FUTURE WORKS
Even though this system has more capable to achieve good result. Further Complete Automation of Boiler including Water level monitoring, coal intake, temperature control needs to introducing the Artificial Intelligence (AI) for the controlling of steam valve. And Controlling of the Boiler and the Steam valve through cloud computing. Temperature control of boiler using thermal camera for better study of Boiler.

10. REFERENCES
1. PENG, G.L. and LIU, Z.G., 2006. Boiler control system with PLC [J]. Electric Power Automation Equipment
2. Conrad, D.A. and Muldoon, D.P., 1995. Design and application of a PC/PLC utility boiler control system. In INSTRUM CONTROL AUTOM POWER IND, PROC (Vol. 38, pp. 351-362).
3. Xu, L., Jiang, Y., Wang, J., Gao, T. and De, X., 2008, July. Design of fuzzy-PID controller based on prediction model and its realization in PLC. In 2008 Chinese Control and Decision Conference (pp. 3808-3811).
4. Weibin, C. and Qingjian, M., 2010, October. Based on PLC temperature PID-Fuzzy control system design and simulation. In 2010 International Conference on Information, Networking and Automation (ICINA) Vol. 2, pp. V2-417.
5. Shuisheng, C. and Qingjian, M., 2011. Based on PLC Temperature PID-fuzzy Control System Design and Simulation [J]. Journal of Agricultural Mechanization Research
6. YU, H.Y., JING, F., SONG, Q.K. and CHEN, S.S., 2003. Fuzzy-control in the Combustion System of Burning Coal Boiler
7. Thepsatorn, P., Numsomran, A., Tipsuwanporn, V. and Teanthong, T., 2006, October. DC motor speed control using fuzzy logic based on LabVIEW. In 2006 SICE-ICASE International Joint Conference pp. 3617-3620.
8. Pei, F. and Yang, W.S., 2004. Design and Application of Fuzzy Logic Controller Based on LabVIEW. Control and Instruments In Chemical Industry, 31(1), pp.41-43.
9. Jin, M.L. and Ho, M.C., 2009. Labview-based fuzzy controller design of a lighting control system. Journal of marine science and technology, 17(2), pp.116-121.
10. Zhao, B.C., An, L. and Liu, X.H., 2006. Design and simulation of fuzzy logic controller based on LabVIEW. Control Engineering of China, 12, pp.49-52.
11. Gowthaman, E., Saravanan, S., Naveenbalu, K., Aravind, S. and Naveen, S., 2016, November. Performance analysis of hybrid fuzzy-PID controller action on boiler drum level control. In 2016 Online International Conference on Green Engineering and Technologies (IC-GET) (pp. 1-6).
12. Kar, P.P. and Saikia, P., 2013. Performance of different control strategies for boiler drum level control using LabVIEW
13. Wang, J., Song, A.J. and Zhu, Q.X., 2011. Adaptive PID temperature controller based on fuzzy logic. In Applied Mechanics and Materials (Vol. 55, pp. 1455-1458).