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A LABVIEW® AND FUZZY LOGIC BASED PID CONTROLLER TUNING FOR PRECISION HEATER POWER CONTROL

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Abstract: PID based power controls are popular in precision power control for heaters in industrial as well as research systems where temperature should not vary from the set values. While PID parameters could be set manually for the purpose in simple systems where the environment is safe and system is not complicated with interlinked multi peripheral systems, it is not the case where close human interventions is not possible and multiple subsystems are interlinked . While a remote operated GUI based system can solve the safety angle of operating such systems, the best suited will be one where a LabVIEW® and fuzzy logic based software and hardwares are incorporated in the total operation of the system. Described here is a software and hardware set up where Modbus protocol and LabVIEW® application software using PID and fuzzy logic tool kit are used to automate the process to provide a more precise and hassle free control over the heater temperatures .The fuzzy logic controller will control the parameters thereby completely automating the temperature control system.
Key Words: KEY WORDS: PID, LabVIEW®, Fuzzy Logic, Modbus protocol

I. INTRODUCTION

A thyristor based PID controlled power supply, Model PID-723of Libratherm Instruments, with Switching and Analog output 4 to 20mA, is used for this experiment. Thirteen numbers of K type thermocouples of temperature range 0-12000C are embedded as sensors for the system set up. The system requirement is temperature stability of ± 1 degree Celsius at 800^0C. Currently, the monitoring and tunning operation of the temperature controller is carried out manually using its keypad for the PID controllers, while the motivation of the development of this GUI is for remote monitoring and operating with easier user convenience

A. Advantages of LabVIEW®, Modbus transmission protocol and Fuzzy Logic

LabVIEW®: It has Graphical user interface, Drag and drop built-in functions, Reduces cost and preserve investment, Flexibility and scalability, Connectivity and instrument control, Compiled language for fast execution, etc.LabVIEW programs are designed to facilitate data analysis, as well as to offer numerous display options. LabVIEW can communicate with hardware like GPIB, PXI, VXI, RS-232 and RS-485 devices. Modbus transmission protocol: It was developed by Gould Modicon (now AEG) for process control systems. In contrast to the many other buses discussed, no interface is defined in this scheme. The user can therefore choose between RS-422, RS-485 or 20 mA current loops, all of which are suitable for the transmission rates, which the protocol defines. Although the Modbus is relatively slow in comparison with other buses it has the advantage of wide acceptance among instrument manufacturers and users. About 20 to 30 manufacturers produce equipments with Modbus protocol. Fuzzy Logic: Fuzzy logic (FL) is used to develop the Fuzzy code for the models which are nonlinear or inexact.It is an approach to control various engineering problems FL simulates the logical thinking through knowledge base and to take decisions accordingly. It uses “IF X AND Y THEN Z” technique for solving engineering problems.

II. HARDWARE SET UP

There are three main components for hardware setup: PID-723, RS-485 to RS-232 converter and PC.Schematic diagram of the temperature monitor system showing the block of I/O interfaces shown in the Fig 1.

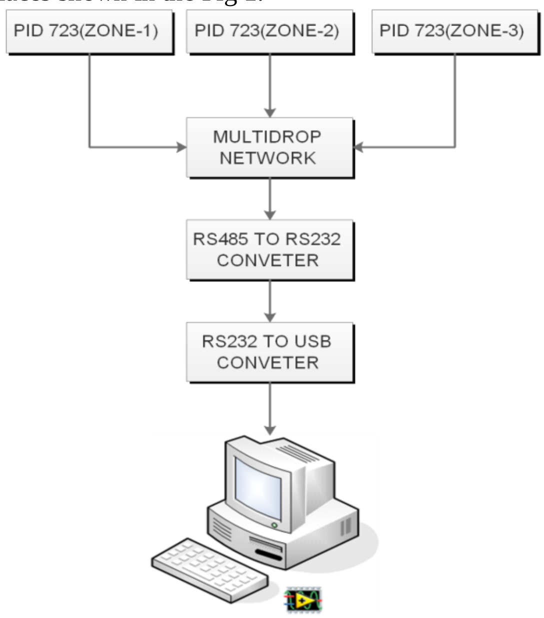


Fig.1.Schematic diagram of the temperature monitor system showing the block of I/O interfaces.

III. 1 PID-723 CONTROLLER IN Multidrop network

Model PID-723 of Libratherm Instruments Microcontroller based PID Temperature Controller with Switching and Analog output (4 to 20mA) is used for temperature measurement. It has input as ‘K’ type thermocouple for 0 to

12000C display range. PC interfacing is done by two wire RS 485 MODBUS RTU protocol. In the new hardware set up three PID Controllers are connected in Multi drop network (Fig 2). The I/O control of the temperature controller is established via a standard serial interface coupled to the PC through a RS-485 to RS-232 and RS-232-to-USB interface using two wire twisted pair cable. LabVIEWTM tools like web-publishing tool, structure palette, string, VISA palette and PID and fuzzy logic tool kit have been used to design this graphical user interface. The temperature control is designed to be controlled either from the control panel or from a remote PC but not from both at the same time.

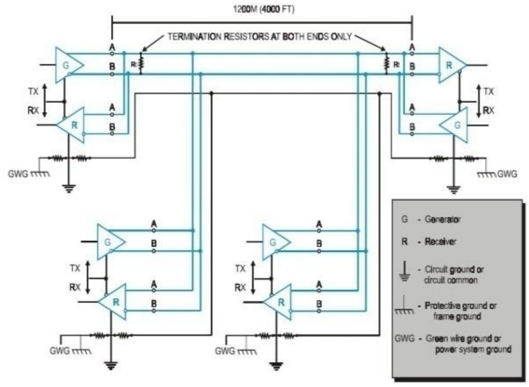


Fig. 2 2-wire multi-drop network (Ref No: 7)

IV. II.2 RS-485 to RS-232 converter

RS-485 permits a ‘multi drop’ network connection on 2 wires and allows reliable serial data communication for distances of up to 1200 m and data rates of up to 10 Mbps same as RS-422. Up to 32 lines of transceivers could be connected on the same line Block diagram (Fig 3) illustrates the RS-485 to RS-232 converter connections. Interface converters can also be used to increase the effective distance between two RS-232 devices. RS-232/485 interface converters are very similar and provide bidirectional full-duplex conversion for synchronous or asynchronous transfer between RS-232 and RS-485 ports (ref 7).

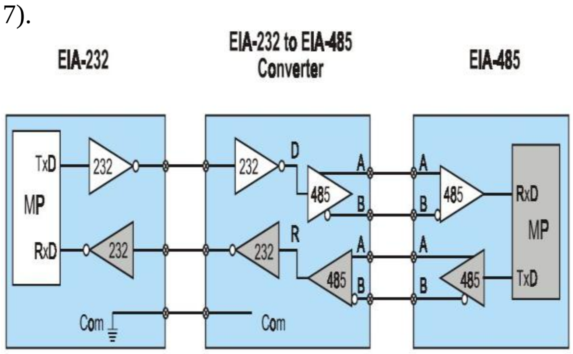


Fig.3 Internal diagram of RS-485 to RS-232 converter (Ref No: 7)

V. THE PROGRAMMING 1PID TUNING WITH FUZZY LOGIC USING LABVIEW.

Fuzzy controller is the main component of the system. It includes the fuzzification, de- fuzzification and rule base. The knowledge base contains the experienced knowledge of the user of the flow process station. Data base contains membership function of every linguistic variable. Control rules are described by the data base. Fuzzy PID tunning can be done using PID and Fuzzy logic toolkit which are available in the website of M/s National Instruments. The fuzzy controller which is discussed below is developed on the fuzzy system designer in LabVIEW®. The block diagram of the fuzzy logic controller with PID controller is shown in the Fig.9.

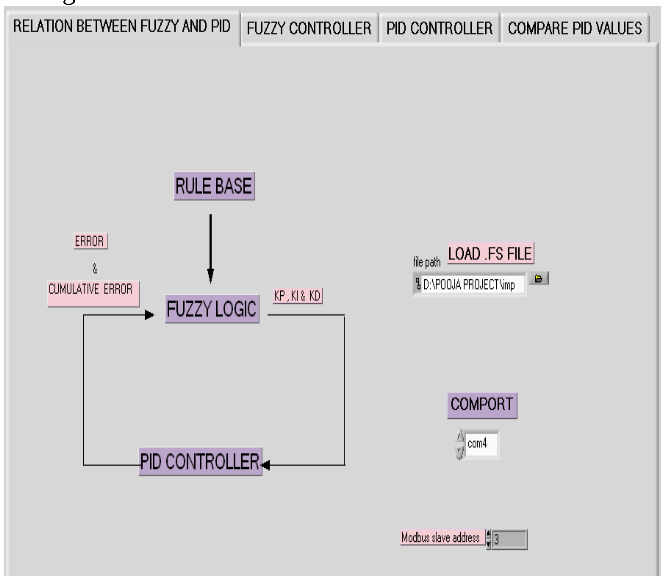


Fig.4 General structure Block Diagram of Fuzzy logic

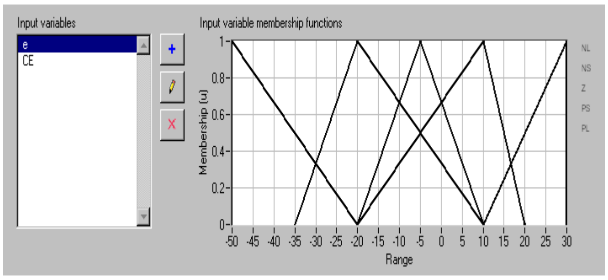
By using this toolkit the PID tunning can be done in the following steps:

A. Fuzzification

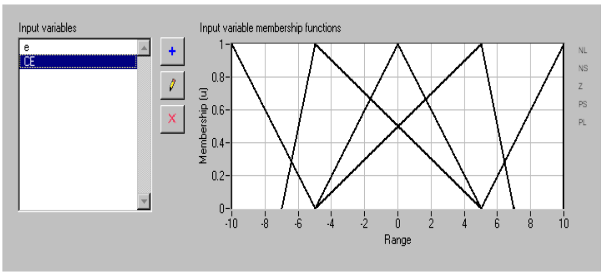
The accurate input will become fuzzyfied input in the fuzzification. Two sets of fuzzy input variables are defined in this case ‘error’ and ‘cumulative error’. These inputscontain 5triangular membership functions which are shown in figure-5.Three sets of the fuzzy output variables are defined in this case for PID gains kp, ki and kd. These outputs contain 7triangular membership functions which are shown in the Fig6. The error ranges from -51 to +24 and the fuzzy subset are Negative Large, Negative small, Zero, Positive small, and Positive Large termed as NL, NS, Z, PS, PL respectively. The cumulative error ranges from -10 to 10.The quantization factor and the scaling factor play an important role in the performance of the fuzzy controller. The range of kp, is set as 1 to 20,ki as 1 to 10 and kd as 1 to 10 and the fuzzy subsets are Positive Very Large, Positive Large, Positive medium large, Positive medium, Positive medium small, Positive small, and Positive very small termed as PVL, PL, PML, PM, PMS, PS, PVS respectively.

B. Defuzzyfication.

De- fuzzification again transforms the fuzzy quantity into accurate quantity. Defuzzyfication is carried out in this project using thecenter of Area method. The controller has been tested using PID and fuzzy logic toolkit using LabVIEW.

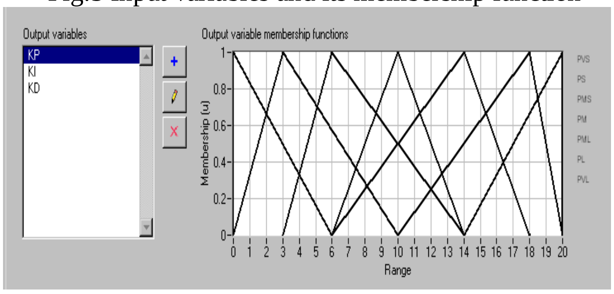


Error

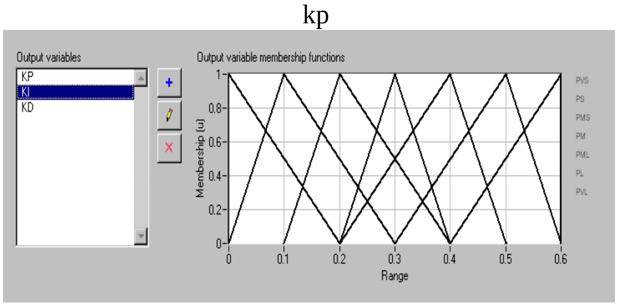


Cumulative error

Fig.5 Input variables and its membership function



kp



Ki &kd

Fig.6 Output variables and its membership function

VI. CONTROL BASE RULES

The control rules are framed to achieve the best performance of the fuzzy controller. 147 control rules are adopted in this project to control the PID tunning parameters. Using this control rules FuzzyPID.fis is created. The membership function as defined above with the mentioned fuzzy subsets and control rules together form the fuzzy controller. The fig.7 shows the rules of the fuzzy system. The rule base characterizes the control goals and controls the policies of the domain experts by means of a set of linguistic control rules. The knowledge base defines the rules for the desired relationship between the input and output. It comprises knowledge of the application domain and the attendant control goals. It consists of a data base and a linguistic (fuzzy) control rule base.

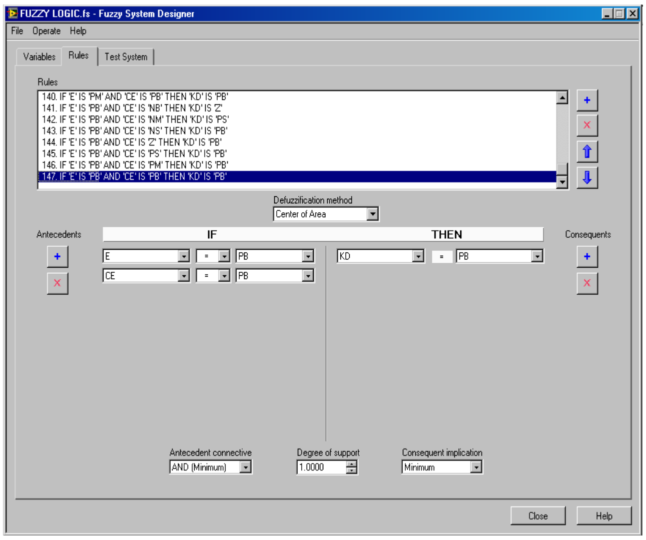


Fig.7 fuzzy rules

VII. TESTING AND OBSERVATION OF THE FUZZY SYSTEM

Testing will show the rules which are invoked for the resulting output values of kp, ki and kd. By trial and error method the test result can be modified. The fig.8 shows one of the test results of the PID tunning using fuzzy logic.

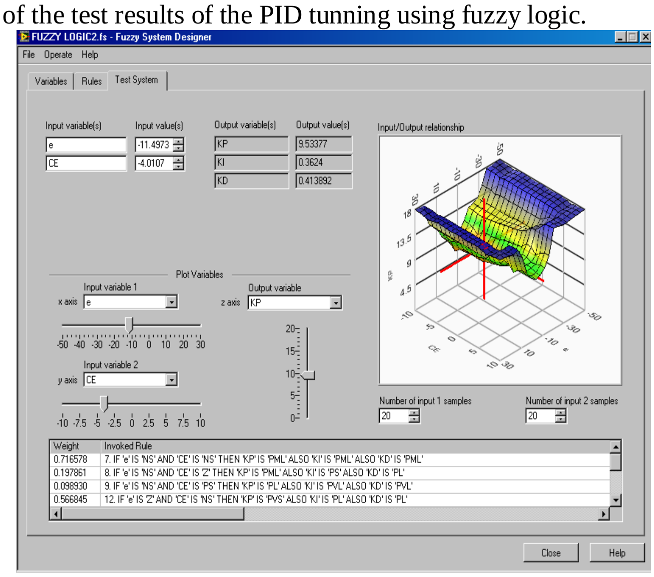


Fig.8 fuzzy test system

VIII. CONCLUSION

The user interface for monitoring parameters of PID temperature controller was designed in LabVIEW™ software and tested successfully and the system works in standalone mode. The test results obtained from the PID tunning show better gains compared to other tuning methods. The comparison can be done by providing virtual PID controllers to both sets of gain and comparing the values of the output. Current consumption through fuzzy logic PID tunning is less compared to normal PID tunning. The fig shows the comparison chart between the unturned and tuned gains of the controller. The output of the fuzzy controller gives precise control inputs on current flow which will in turn make precision control on the set temperature. The fuzzy logic can be modified for more precision. As a low cost alternative one can develop hardware having signal conditioning and design own PID controller in LabVIEW™.

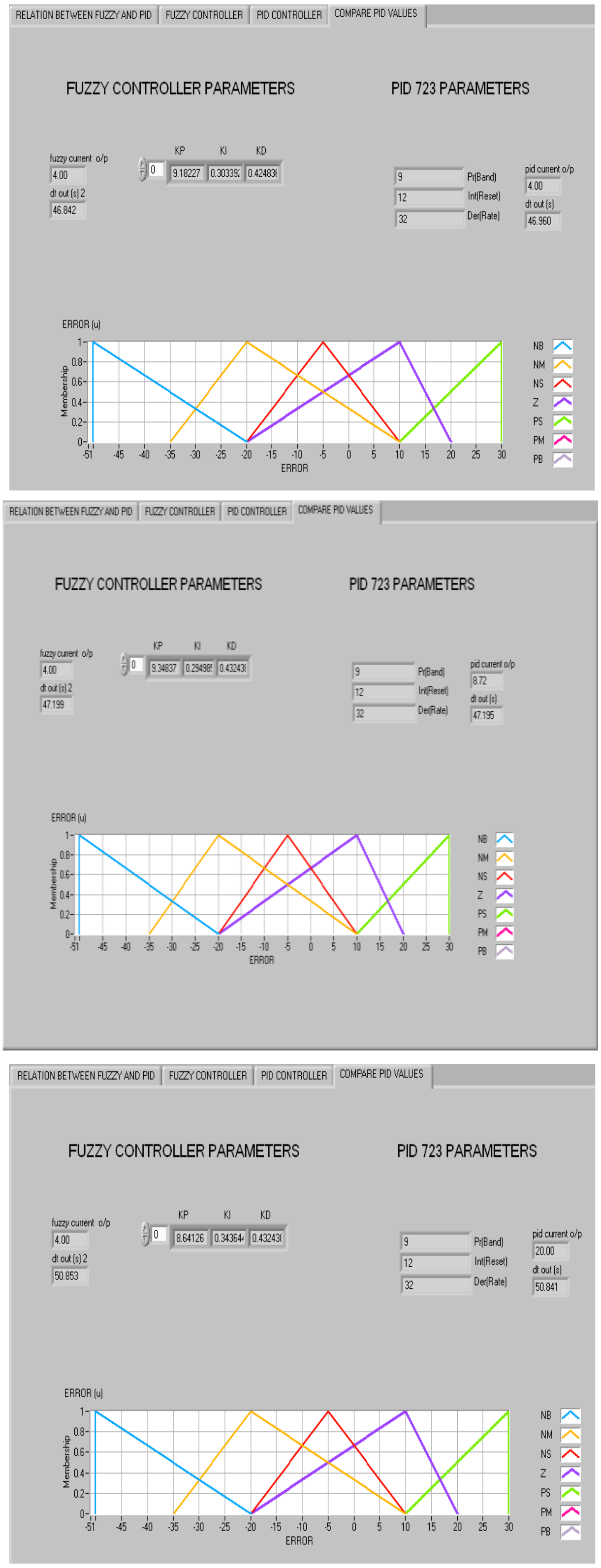


Fig.9 results of PID tunning using fuzzy logic

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