ARM Based Temperature Control for Electrical Furnace using Fuzzy logic

Soma Dhanvanthari M[#1], Smt. Phanisri Ch[*2]

[#]*Electronics and communication Engineering, JNTU Kakinada University*
GVP college of engineering, Visakhapatnam, AP, India
[1]maganthi.dhana@gmail.com

[*]*Smt. Phanisri Ch[2]*
Electronics and communication Engineering, JNTU Kakinada University
GVP college of engineering, Visakhapatnam, AP, India
[2]phanisrich@gmail.com

***Abstract*— In order to control the temperature of the electrical furnace more efficiently and accurately, fuzzy logic is used. Accuracy of the temperature control depends upon the membership functions of the fuzzy logic. In this paper ARM 7 microcontroller is used to control the temperature.**

***Keywords*— FLS.**

I. INTRODUCTION

Temperature controllers are needed in any situation requiring a given temperature be kept stable. This can be in a situation where an object is required to be heated, cooled or both and to remain at the target temperature (set point), regardless of the changing environment around it. Temperature controllers are used in a wide variety of industries to manage manufacturing processes or operations.

There are several reasons for using automatic temperature controls for electrical furnace applications. For some processes, it is necessary to control the product temperature to within fairly close limits to avoid the product or material being processed being spoilt. Steam flashing from boiling tanks is a nuisance that not only produces unpleasant environmental conditions, but can also damage the fabric of the building. Automatic temperature controls can keep hot tanks just below boiling temperature. Also for economy, quality and consistency of production, saving in manpower, comfort control, safety and to optimize rates of production in industrial processes boiler temperature control is necessary.

The reason for developing concepts of fuzzy logic control on classical control theory is that the classical control theory usually requires a mathematical model. The inaccuracy of mathematical modelling of the plants degrades the performance of the controller, especially for non-linear and complex control problems.

In 1973, Lotfi Zadeh, a Professor at the University of California, Berkley proposed the concept of linguistic or fuzzy variables like temperature, defined by fuzzy sets and linguistic values such as hot and cold.

Fuzzy logic control do not require mathematical models of the plants information and expert knowledge into control signals and are preferred over traditional approaches such as optimal and adaptive control techniques.

II. FUZZY LOGIC

A fuzzy logic system (FLS) can be defined as the nonlinear mapping of an input data set to a scalar output data set. FLS consists of four main parts: fuzzifier, rules, inference engine, and defuzzifier. These components and the general architecture of a FLS system are shown in fig 1.

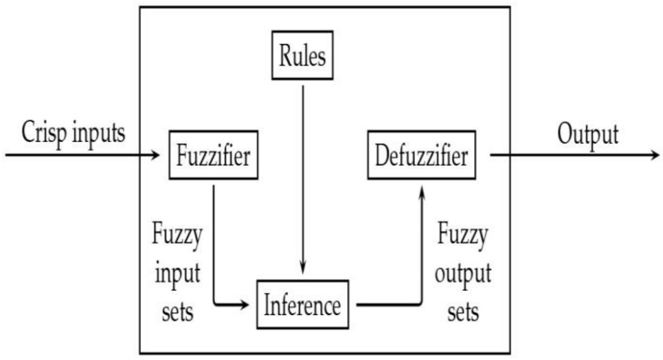

Fig 1: Fuzzy Logic System

The processes of Fuzzy Logic is explained as follows, firstly a crisp set of input data is collected and converted to a fuzzy set using fuzzy linguistic variable, fuzzy linguistic terms and membership functions. This step is known as fuzzification. After fuzzification, inference is made with the set of rules. Finally the resulting fuzzy output set is mapped to a crisp output set using membership functions in the defuzzification processes.

1. LINGUISTIC VARIABLES

Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms.

2. MEMBERSHIP FUNCTION

Membership functions are used in the fuzzification and defuzzification steps of a FLS, to map the non-fuzzy input values to fuzzy linguistic terms and vice versa. A membership function is used to quantify a linguistic term. Note that, an important characteristic of fuzzy logic is that a numerical value does not have to be fuzzified using only one membership function. In other words, a value can belong to multiple sets at the same time.

3. FUZZY RULSE

In a FLS, a rule base is constructed to control the output variable. A fuzzy rule is a simple IF-THEN rule with a condition and a conclusion. In Table 1, fuzzy rules for controlling the temperature of electric furnace in Figure 3 are listed. Table 2 shows the matrix representation of the fuzzy rules for the said FLS. Row captions in the matrix contain the values that current temperature can take, column captions contain the values for target temperature, and each cell is the resulting command when the input variables take the values in that row and column. For instance, the cell (3, 4) in the matrix can be read as follows: If temperature is cold and target is warm then command is heat.

Table 1: Sample fuzzy rules for electric furnace

1	IF (temperature is cold OR too-cold) AND (target is warm) THEN command is heat
2	IF (temperature is hot OR too-hot) AND (target is warm) THEN command is cool
3	IF (temperature is warm) AND (target is warm) THEN command is no-change

Table 2: Fuzzy matrix

Temperature /target	too-cold	Cold	warm	hot	too-hot
too-cold	no-change	heat	heat	heat	heat
cold	cool	no-change	heat	heat	heat
warm	cool	cool	no-change	heat	heat
hot	cool	cool	cool	no-change	heat
too-hot	cool	cool	cool	cool	no-change

III. BLOCK DIAGRAM

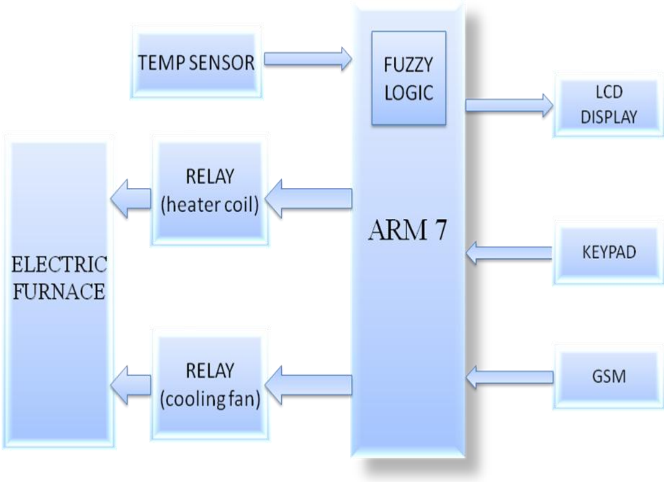

Fig. 2 Block Diagram of the Proposed System

IV. FEATURES OF MICROCONTROLLER

ARM7 LPC2148 has the following features which are required for monitoring agriculture environment

1. 16/32- bit ARM7 TDMI-S microcontroller
2. In-system programming / In-Application programming (ISP/IAP)
3. 40kB of on-chip static RAM and 512kB of on-chip flash memory
4. Two 10-bit ADCs provide a total of 14 analog inputs, with conversion time as low as 2.44μs per channel
5. Multiple serial interfaces including two UARTs
6. 48 of 5V tolerant fast general purpose I/O pins
7. CPU operating voltage range of 3.0V to 3.6V (±10%) with 5V tolerant I/O

V. INTERFACING SENSORS TO MICROCONTROLLER

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. The temperature sensor has three terminals as shown in figure 3. The V_{cc} pin is given a supply voltage of 5V DC. The ground pin is grounded. The supply voltage is taken from the microcontroller V_{cc} pin and the ground pin of the sensor is connected to the ground pin of the microcontroller. The data pin is connected to the channel-1 of the inbuilt ADC using port pin P0.29. The sensor gives electrical output in terms of voltage proportional to the temperature (^{0}C). In order to make the temperature water resistant it was covered with a mseal.

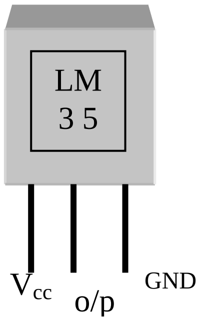

Fig 3: LM35

VI. INTERFACING HEATER COIL AND DC FAN USING RELAYS

Heater and dc fan are interfaced to the output ports P0.6 and P0.7 of the ARM7. Heater coil and DC fan are connected at the feedback part. Based on fuzzy rules command output signal will be generated. Here the heater coil is operated with AC and fan is operated with DC 5v. So a relay circuit is used. Relay is used as connecting switch. Relay on only when there will be an output from the ports P0.6 and 5V DC supply to the fan then only fan will be activated shown in Fig 4, similarly when there will an AC voltage from the supply and output from the port P0.7 then only heater coil will be activated shown in Fig 5

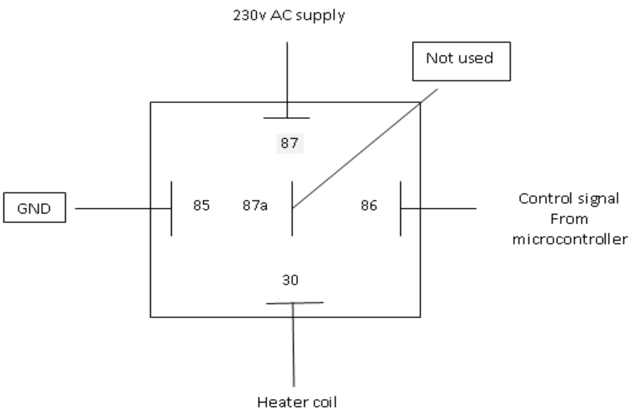

Fig 4: Interfacing of heater coil to relay circuit

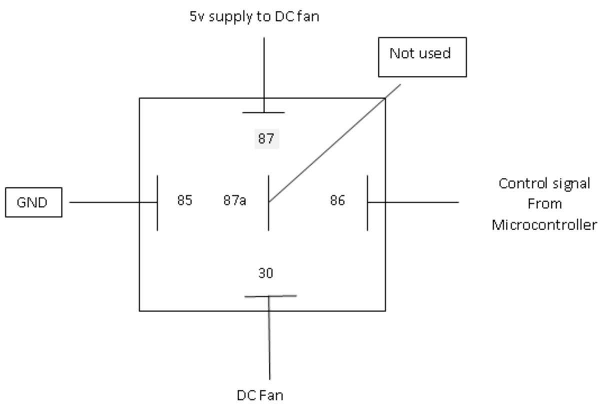

Fig 5: Interfacing of DC fan to relay circuit

VII. INTERFACING OF GSM MODULE

GSM is a digital mobile telephony system. GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

The GSM module is communicate the microcontroller with mobile phones through UART. To communicate over UART or USART, we just need three basic signals which are namely, RXD (receive), TXD (transmit), GND (common ground) as shown in Fig 6.

GSM modem interfacing with microcontroller for SMS control of industrial equipments. The sending SMS through GSM modem when interfaced with microcontroller or PC is much simpler as compared with sending SMS through UART.

Text message may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller i.e., TxD, RxD and GND. In this scheme RTS and CTS signals of serial port interface of GSM Modem are connected with each other.

The transmit signal of serial port of microcontroller is connected with transmit signal (TxD) of the serial interface of GSM Modem while receive signal of microcontroller serial port is connected with receive signal (RxD) of serial interface of GSM Modem.

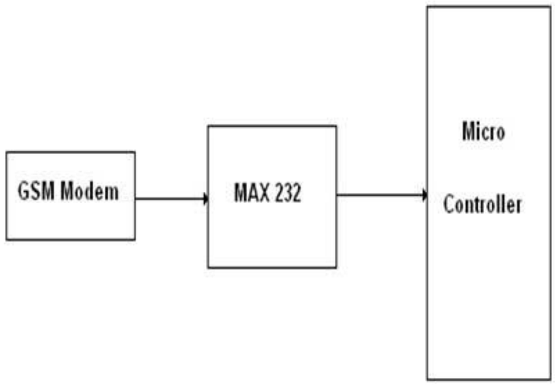

Fig 6: Interfacing GSM module to microcontroller

VIII. INTERFACING LCD TO MICROCONTROLLER

A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information such as text and integers. Its major features are lightweight construction, and portability. The sensor values are displayed continuously on LCD. Four data lines are used to send data on the LCD. When RS=0 and EN pin is made high to low command is sent to LCD. When RS=1 and EN pin is made high to low data is sent to LCD. V_{EE} is used to adjust contrast. The pin connections to microcontroller are shown in figure 7.

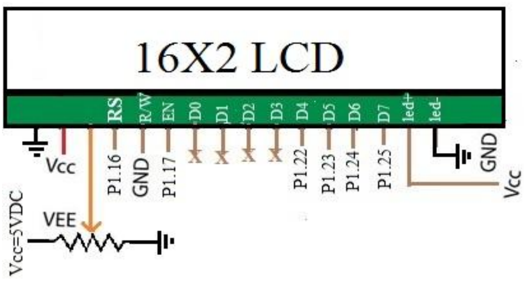

Fig 7: Pin connections of LCD to LPC2148

IX. SOFTWARE USED

For programming keilµ4 and for dumping the code flash magic are used.

X. RESULTS AND CONCLUSION

An embedded system is developed to control the temperature of the electrical furnace more efficiently and accurately by using fuzzy logic system. A fuzzy based closed loop temperature control system have been developed and successfully demonstrated. The system has been designed for maintaining the temperature at any desired value. The membership function can be modified to achieve any desired temperature. The use of fuzzy logic provides very fast response and reliable operation.

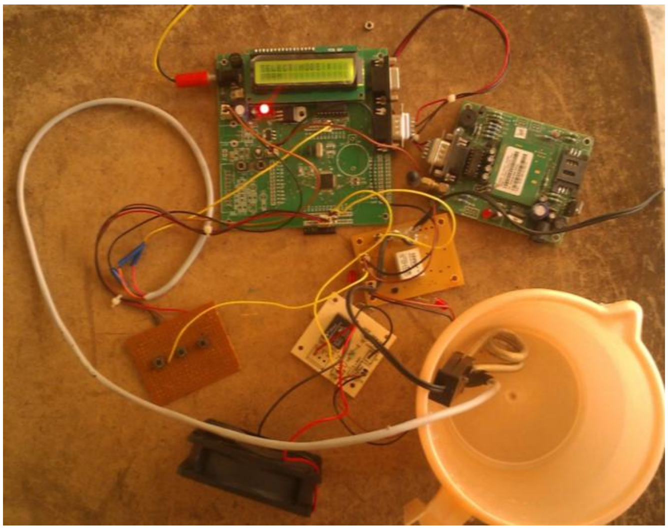

Fig. 9 Overall view of implemented system

XI. REFERENCES

1. Wang Suzhen, Shao Mingwei "temperature gathering and fuzzy control system of electrical furnace based on the ARM" International Conference on Measuring Technology and Mechatronics Automation 2011.
2. J. Mendel. Fuzzy logic systems for engineering: a tutorial. Proceedings of the IEEE, 83(3):345{377, Mar 1995.
3. Isizoh A. N, Okide S.O, Anazia A.E, Ogu C.D, "Temperature Control System Using Fuzzy Logic Technique" International Journal of Advanced Research in Artificial Intelligence 2012
4. Om Prakash Verma, Himanshu Gupta, "Fuzzy Logic Based Water Bath Temperature Control System" International Journal of Advanced Research in Computer Science and Software Engineering April 2012.
5. Anabik Shome, Dr. S.Denis Ashok, " Fuzzy Logic Approach for Boiler Temperature & Water Level Control" International Journal of Scientific & Engineering Research, Volume 3, Issue 6, June-2012
6. Sheroz Khan, I. Adam, A. H. M. Zahirul Alam, Mohd Rafiqul Islam, and Othman O. Khalifa, "Rule-Based Fuzzy Logic Controller with Adaptable Reference" International Journal of Electrical and Computer Engineering 3:5 2008.
7. Deepak Bharadwaj and L.N Das "Design and Development and Hardware Implementation of Fuzzy Knowledge Based Intelligent Temperature Control System" International Journal of Engineering Science and Technology.
8. NXP Semiconductor, LPC2148 microcontroller user manual, http://www.nxp.com/UM10139.pdf, pp.1-94, 147-162, 206-244, 273-293, April, 2011
9. LM 35 data sheet, http://www.ti.com /product/lm35, pp.1-13, November, 2000.

