

Implementation of MATLAB-GUI based Fuzzy Logic Controllers for Liquid Level Control System

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Abstract

This paper presents the design and implementation of MATLAB graphical user interface (GUI) based fuzzy and integrated fuzzy logic controllers (IFLC) for liquid level control system. The control algorithms are developed in MATLAB. The fuzzy tool box in MATLAB is used to design fuzzy logic controller. An indigenously designed AD-DA board is interfaced to PC through PCI DIOT card to acquire signals from sensor and send control output to the actuator. The GUI designed for the present study is used to control liquid level in real-time mode. Also, the simulation study of PIDC, FLC and IFLC is carried out. Simulation models are created using the MATLAB/SIMULINK software. The liquid level is acquired by PC and displayed on GUI. The control action is sent to the control valve to maintain the liquid level at desired set point. The inflow of the water is controlled by varying the opening and closing of inlet valve. The proposed GUI not only compares the simulation and real-time results of PIDC, FLC, and IFLC controllers but also allows user to test and tune the controller of interest. The step input of 15cm and staircase input of 15cm, 30cm and 45cm are applied. From both the studies it is observed that for step and staircase, the performance of IFLC is better in terms of faster settling-time, lesser rise-time, and with no steady state error.

Keywords: MATLAB/GUIDE, GUI, Simulink, FLC, Liquid Level, Control System.

1. Introduction

An user interface is the point of contact or method of interaction between a person and a computer or computer program. It is the method used by the computer and the user to exchange information. A GUI incorporates graphic objects such as windows, icons, buttons and menus. Selecting or activating these objects, in some way, usually causes an action to occur is described in Duane Hanselman and Bruce Littlefield [1]. MATLAB which stands for MATrix LABoratory, is a very powerful technical language for mathematical programming. It has a very extensive library of predefined programs or functions designed to help engineers and scientists to solve their problems in a faster and less painful way is presented in Kirani Singh Y. and Chaudhuri B. B. [2]. It has a number of toolboxes for different subjects of study. The present day professional version of MATLAB has the graphical and GUI features. The GUIDE toolbox, provided in MATLAB, to design user friendly interfaces is presented in Amos Gilat [3]. Literature survey reveals that GUIs are designed and developed to measure, control, and analyze the different process parameters such as speed, flow, position, temperature, level etc.

The GUI for DC motor speed control is designed in Visual Basic software package in Mohd Fuaad R. and Mariam Md Ghazaly [4]. This GUI compares the time specification performances between conventional controller and artificial intelligent controller in position control of a DC motor. Control of liquid level in tanks and fluid flow between tanks is a fundamental requirement in almost all process industries like waste water, chemical, petrochemical, pharmaceutical, food, beverages etc. The liquid level control in a spherical tank is investigated in Nithya S *et al* [5]. They used PI type controller, tuned by Ziegler-Nichols method, with internal model control (IMC) based settings to control liquid level. They used ADAM's data acquisition module for real time control of liquid level and algorithms implemented in MATLAB.

The SCADA control via programmable logic controller for a liquid level control system with a Sugeno type fuzzy logic controller is proposed in Zafer Aydogmus [6]. The control algorithms are simulated using MATLAB/SIMULINK to achieve the parameters of the membership functions. The simulation and real time results obtained with a good degree of accuracy. The PID controllers are commonly used in industries

for nearly a century due to their simplicity, efficiency and flexibility. The control of nonlinear process in industries has turned the attention towards designing of intelligent controllers such as fuzzy logic controller is investigated in Arivalahan R *et al* [7]. They employed fuzzy logic controller to nonlinear conical shape tank. The simulation work is also carried out by servo and regulatory operations on the nonlinear conical tank process. They found that FLC tracks the set point with fewer oscillations and results are compared with PI controller. The evolving of two types i.e., fuzzy and classical PID liquid level controllers and examined whether they are better able to handle modeling uncertainties. A two stage strategy is employed to design the synthesis fuzzy and classical PID controller. The simulation is carried out by using MATLAB/SIMULINK is investigated in Berk P *et al* [8]. They proposed that the fuzzy logic controller is useful for controlling the nonlinear parameter. The PIC16F84A microcontroller investigation on liquid level control is described in Khaled Reza *et al* [9]. They proposed microcontroller based automated water level sensing and controlling in a wired and wireless environment. The system indicates the amount of water in the tank that can support global water systems for remote water monitoring and sends information to the cellular phones over the network.

The fuzzy logic controller for spherical tank liquid level control was investigated in Sakthivel G. T. [10]. The real time control of liquid level designed and implemented in MATLAB using VMAT-01 data acquisition module. The fuzzy logic controller designed for nonlinear processes is reported in Dharamniwas *et al* [11]. The experimental real time studies show that the fuzzy logic controller performs better with no overshoot, faster settling time, better set point tracking and produces lower performance indices like integral square error (ISE) when compared with the PI controller. The difficulty of water tank level control system is often operates under unstable condition such as above the set point level or below the set point. The unstable condition normally contributes to damage of devices and equipments of a process plant. To simulate such systems, the virtual model developed using Microsoft Visual Basic 6.0 and the conventional P and PID controllers are implemented in Maziyah Mat Noh *et al* [12].

From the literature it is found that very less work has been reported on implementation of MATLAB-GUI for process control. Some of the authors reported that, for their application, GUI was designed by using Visual Basic software package. In which the design and implementation of controllers is

bit difficult task as every task is to be programmed and no powerful built-in functions available. Also, the literature shows fuzzy logic controllers are suitable for nonlinear process systems. This has motivated authors to undertake the present research work to design and implement MATLAB-GUI based fuzzy logic controllers for liquid level control.

2. Process System Model

Figure 1 shows the tank model, reported in Satean T A and Santi Wanganiparnto [13], Zafer Aydogmus [6], and Sharad K T and Gagandeep K [14], used for the present investigation. The model consists of 100cm height rectangular tank fitted with an inlet and outlet valves.

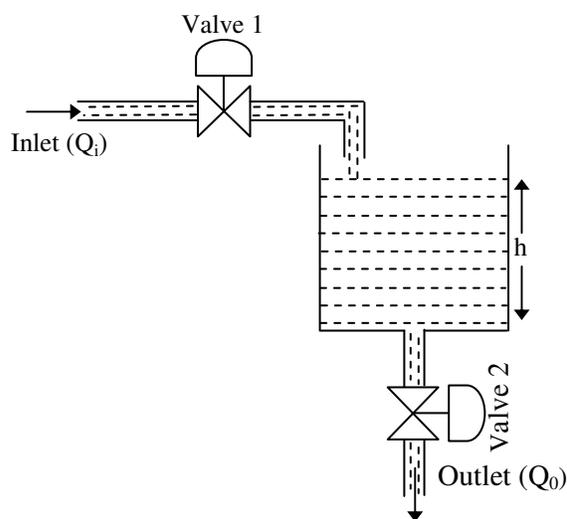


Fig. 1. Tank model

Here the relation between inlet and outlet flow rates is expressed as,

$$Q_i - Q_o = A (dh/dt) \dots \dots \dots (1)$$

where,

- Q_i - Inlet flow rate
- Q_o - Outlet flow rate
- A - Cross sectional area of tank
- h - Liquid height in a tank

The flow rate of water through the hole/ orifice, according to the Bernoulli equation, is given by

$$Q_o = Ca\sqrt{2gh} \dots \dots \dots (2)$$

where,

- C - Discharge coefficient of the outlet valve
- a - Cross sectional area of outlet orifice
- g - Gravitational constant equal to 9.8m/s²

Substituting for Q_o in equation (1), we get,

$$Q_i - Ca\sqrt{(2gh)} = A(dh/dt)$$

$$dh/dt = (Q_i/A - (Ca\sqrt{(2gh)})) / \dots\dots\dots (3)$$

The change in level in a tank with respect to time is given by

$$dh(t)/dt = Q_i/A(h(t)) - (Ca\sqrt{(2gh)})/A(h(t)) \dots\dots\dots (4)$$

Equation (4) is used to design the tank model in MATLAB/ SIMULINK. Fig. 2 shows the SIMULINK tank model of liquid level control system using integrated fuzzy logic controller. The liquid level is first sensed from the tank block in the SIMULINK model with initial conditions. The measured level is compared with the set value by using summer block. The error and change-in-error are applied to the integrated fuzzy logic controller. The water level in tank is controlled by controlling the inflow of water to the tank. The rate of inflow is adjusted with an actuator (control valve) depending on the control action issued by the GUI. The controller's scaling factors, membership functions and PID constants are assigned from the present GUI. The Scope block in figure shows the response of the controller. Also, the present GUI retrieves the simulations responses and is displayed on axes component of the GUI.

Graphical User Interface (GUI)

The GUI developed for the liquid level control system using fuzzy logic controllers is shown in Fig. 3. This GUI is divided into two parts. The first part of the GUI is used to simulate the process variable and second part is used to perform real time control of process variable. The GUI has drop-down menus such as *Real Time*, *Simulations*, and *Analysis*. These menus are used to guide the user to control liquid level. The GUI allows user to select and tune the controllers for real-time and simulation studies as well. The menus provided in this GUI are self-explanatory as their names describe the function to be performed. On invoking the GUI, all menus and the *Set Point*, *Present Level* and *Controller Selected* are displayed on the GUI, and also the DIOT card is initialized for hardware interface. The GUI allows user to tune controller of interest. The GUI is very interactive between user and the process. After initialization of DIOT card, the GUI prompts user to enter the set point for the process and by clicking on *Control* button the control process starts with PID as the default controller. If the user selects FLC or IFLC, the corresponding controller will control the process. The performance graph of controller is displayed on the axis component of the GUI. An option is provided to the user to select step or staircase input for the selected controller under *Real Time* drop-down menu.

Fig. 2 shows the invoked SIMULINK model when the simulation is selected in the GUI *Main Menu*.

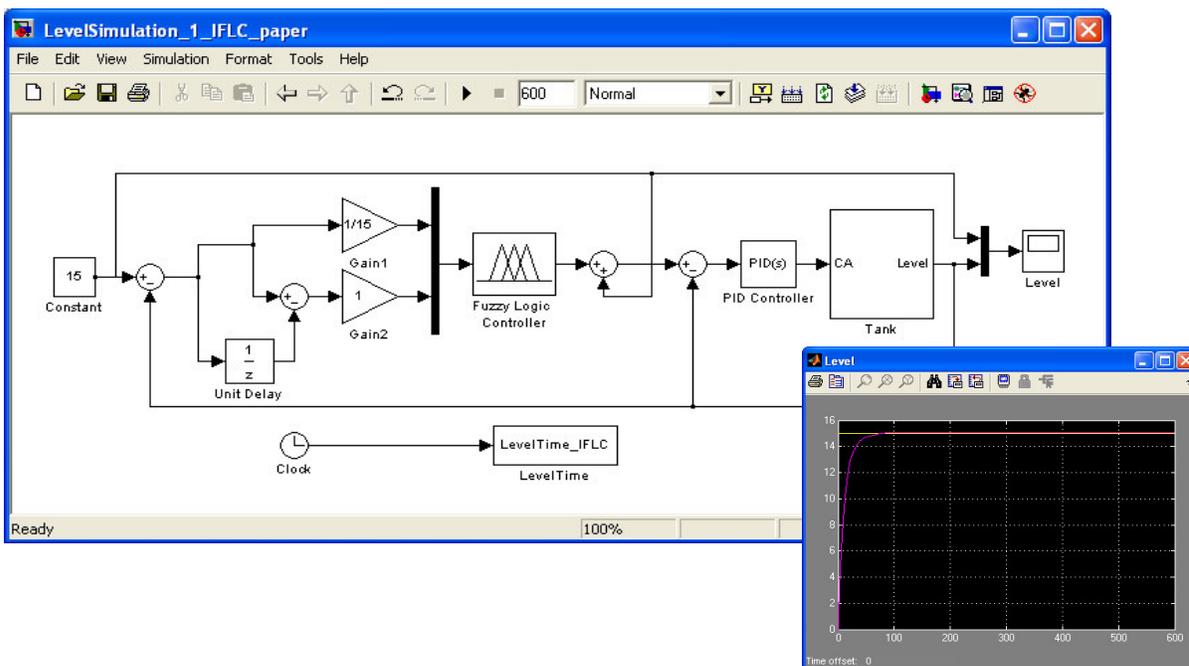


Fig. 2. MATLAB/SIMULINK model for liquid level control system using IFLC

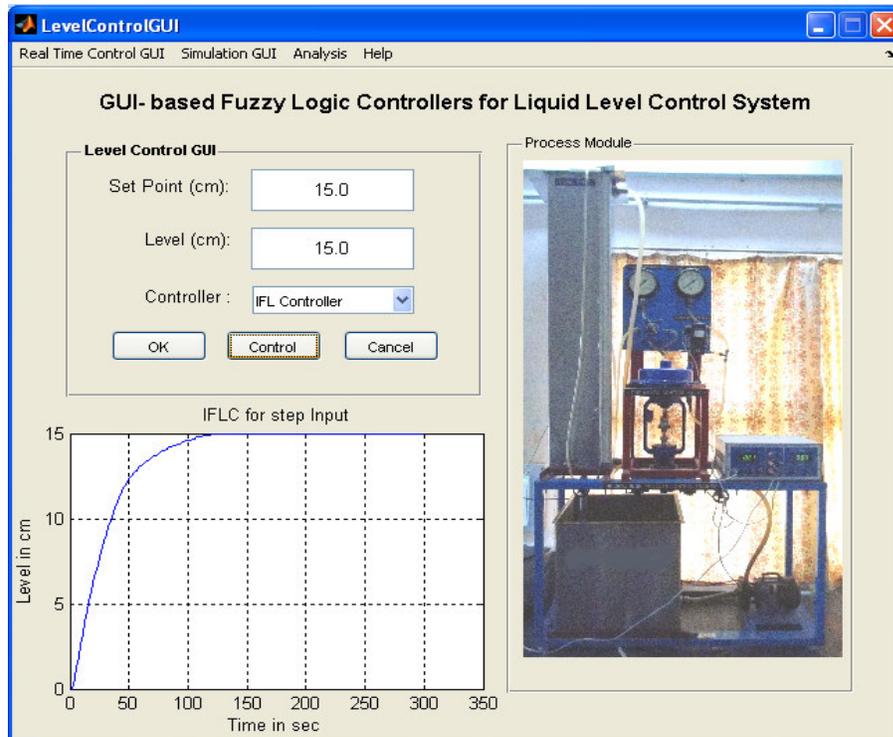


Fig. 3. MATLAB-GUI for liquid level control system

On invoking the simulation, particular controller is chosen from the *Main Menu*. By clicking on the particular simulation menu, the MATLAB/SIMULINK model is opened and it can be interacted with GUI. The simulation model parameters can be set by the GUI and results are displayed on axis component of the GUI. The *Analysis* menu provides facility to view both real-time and simulation results on axis components on the GUI. Also, user can store the responses in the hard disk for future reference. Finally, like every computer application offers the capability to open and save the data files, the present GUI also opens and saves the data files.

3. Hardware Details

The hardware scheme of MATLAB-GUI based liquid level control system using fuzzy logic controller is shown in Fig. 4. It consists of the following hardware:

- i) Differential Pressure Transducer (DPT)
- ii) Excitation Source
- iii) Instrumentation Amplifier
- iv) AD-DA board

v) PCI-1751 DIOT Card

vi) V/I and I/P Converters

Differential Pressure Transducer (DPT)

The SX05DN level sensor of SenSym make [15] is used to measure the liquid level. It is strain gauge type sensor. Strain gauges are pasted on the diaphragm. The resistances of the strain gauges change when the pressure is exerted on the diaphragm. The four strain gauges are connected in Wheatstone bridge form. The bridge is excited with a stable +5V DC voltage. The change in resistance is converted in to change in voltage. The sensor is provided with two ports for applying either single ended or differential pressure. In this application, one port is closed, and another is connected to the bottom of the tank for single ended measurement. The specifications of the sensor are tabulated in Table 1.

Excitation Source

DPT sensor is a strain gage type sensor. It changes resistance with a change in liquid level. In order to convert the change in resistance of the sensor to the corresponding change in voltage, a constant excitation

voltage of +5V is generated using ICs LM329, LM308, and 2N2222 transistor. LM329, a precision voltage

components. Sensor produces a small differential output voltage of 1.5mV/cm liquid height. So an

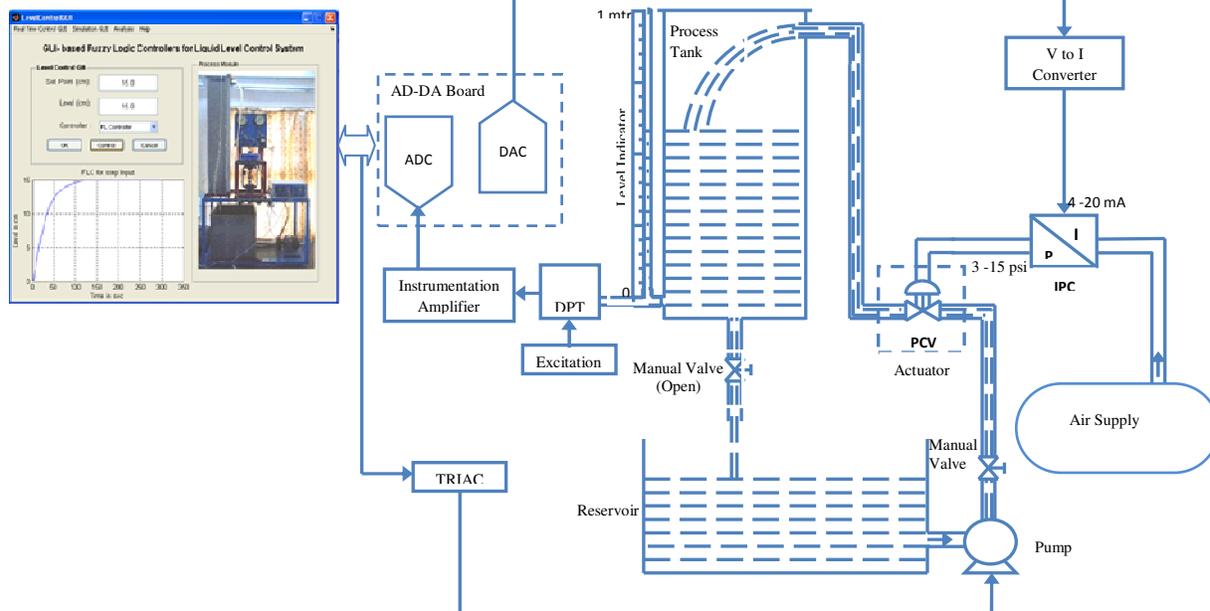


Fig. 4. Block diagram of MATLAB-GUI based liquid level control system

source, produces 6.9V which is dropped down to +5V and connected to non-inverting input of op-amp LM308. The op-amp with a transistor at the output provides the enough current to the bridge. With a +5V excitation voltage, the sensor will produce an output of 1.5mV/cm.

instrumentation amplifier is used to amplify and convert in to single ended voltage compatible to be sampled by the on-board ADC of AD-DA board. A gain of 10 is set for the amplifier to get 15mV/cm.

Table. 1. Specifications of DPT

Parameter	Unit
Operating pressure range	0-5 psid
Input	Absolute and differential (Gage)
Supply voltage	+12V DC (max)
Sensitivity	3mV/V/psid
Full scale span	75mV
Type	Integrated Circuit Pressure Sensor
Package	Plastic DIP
Typical weight	4-5 gms
Make	SenSym
Part No.	SX05DN

Instrumentation Amplifier

The sensor produces 3mV/V/psid. This differential voltage is amplified by using instrumentation amplifier. In the present study AD620 is used as an instrumentation amplifier [16]. This provides 100dB CMRR, which is low noise amplifier with fewer

AD-DA Board

In the present work, authors have indigenously designed the AD-DA board [17] for data acquisition. This board contains Analog Devices make 12-bit analog to digital converter and Burr-Brown make 12-bit digital to analog converter. Each has the following specifications.

Analog to digital converter specifications

- Analog Devices AD1674
- Complete monolithic IC with 12-bit resolution and 10μsec sampling time
- AC and DC specified and tested unipolar and bipolar inputs ±5V, ±10V, 0V-10V, 0V-20V input ranges

Digital to analog converter specifications

- Burr-Brown DAC7541A
- Low cost, 12-bit four quadrant multiplying digital to analog converter
- Single +5V to +15V supply
- Relative accuracy of ±1LSB = ±0.024% of FSR

PCI-1751 DIOT Card

The ADVANTECH make PCI-1751 DIOT card [18] is used. It has 48 digital I/O lines and three 16-bit counter/timers. This card uses high density small computer system interface (SCSI), 68 pin connector for easy and reliable connections to field devices. This card is inserted in the PCI slot of personal computer. The personal computer used for the work has the following specifications: OS Windows XP-SP3, Intel Core2Duo CPU E700 @2.66GHz with MATLAB® 7(R2010a) Version.

V/I and I/P Converters

The control voltage generated from computer is converted into current by using V/I converter. The 0-5V is converted in to industrial standard 4-20mA for I/P converter. The pneumatic signal (air) from the compressor is applied to the valve through I/P converter. The GT2108ED is used as I/P converter [19] in the present work. The pneumatic signal (3-15psi) will control the opening and closing of control valve. The complete circuit diagram of proposed liquid level control system is given in Fig. 5.

4. Software Details

The software for the present application is developed in the MATLAB® platform [20]. The GUI and control algorithms are developed and implemented for liquid level control. The modern controllers such as FLC and IFLC are developed. The simulation of the liquid level control system is performed in MATLAB/SIMULINK software. SIMULINK models of three controllers (PIDC, FLC and IFLC) are created and simulated through present GUI.

Fuzzy Logic Controllers

Fuzzy logic controllers (FLCs) are special expert systems. Fuzzy control leads to a higher degree of automation for complex ill-structured process parameters. Control can range from complex tasks typical in robotics which requires a multitude of coordinate actions, to simple goals such as maintaining a prescribed state of a single variable. Fuzzy controllers are more robust than conventional controllers. The block diagram of fuzzy logic controller is shown in Fig. 6.

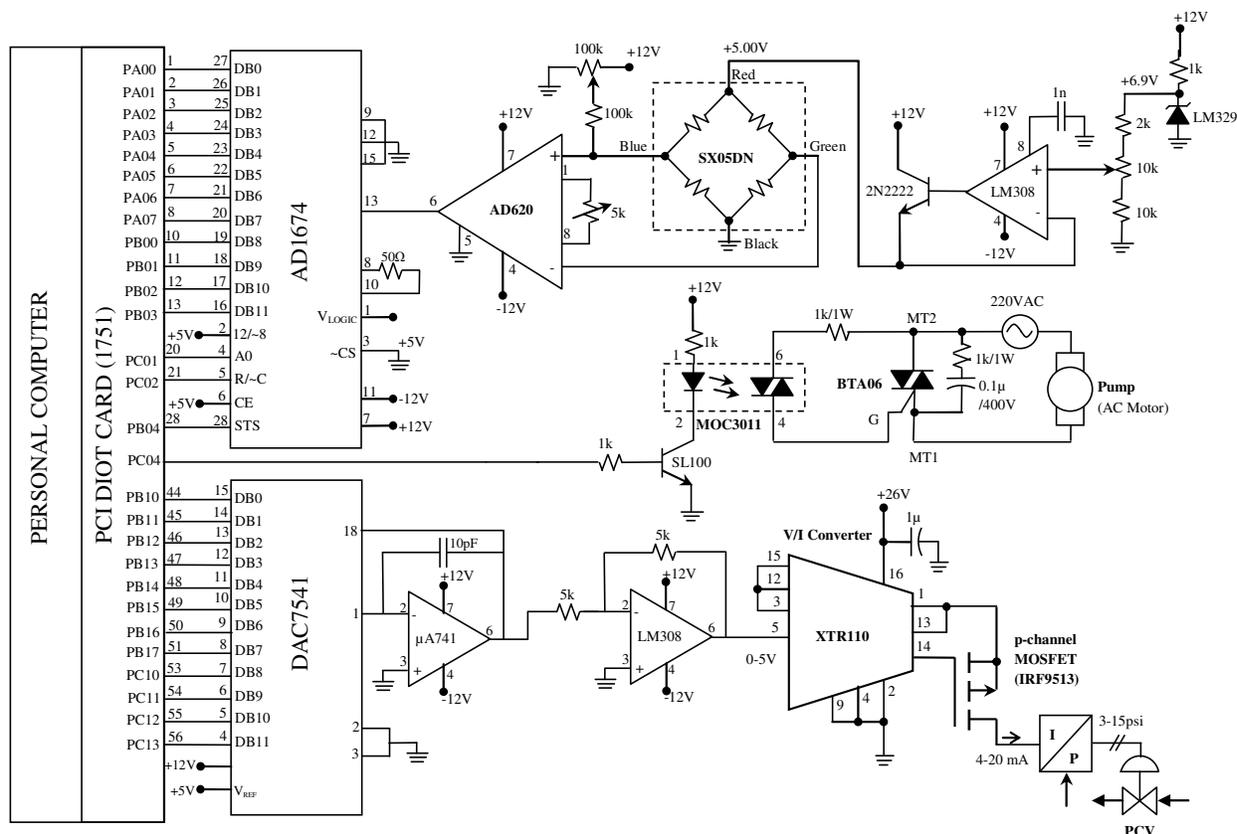


Fig. 5. Complete circuit diagram of liquid level control system

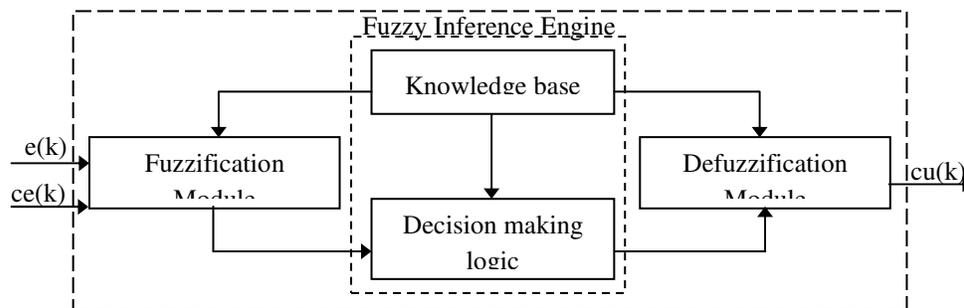


Fig. 6. Block diagram of fuzzy logic controller

It consists of fuzzification module, rule base or knowledge base, decision making logic, and defuzzification module. Fuzzification module performs a scale transformation, which maps the physical values of the current state variable into a normalized universe of discourse. It also maps the normalized values of the control output variable onto its physical domain.

The fuzzification module which converts crisp value of a process state variable in to a fuzzy set, in order to make it compatible with the fuzzy set representation of the process state variable in the rule antecedent. The basic function of the rule base is to provide the necessary information for the process functioning of the fuzzification module, the rule base, and the defuzzification module. Defuzzification module converts the set of modified control output values into a single point wise value which maps the control output onto its physical domain [21-23]. The rule base for the fuzzy logic controllers is shown in Table 2.

Table 2. Fuzzy rule base

ce	NL	NM	NS	ZE	PS	PM	PL
e	NL	NL	NL	NL	NM	NS	ZE
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
NS	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	ZE	PS	PM	PL	PL	PL	PL

The fuzzy logic controllers can be easily designed by using sophisticated software package like MATLAB®. MATLAB provides fuzzy toolbox, which provides fuzzy editor GUI by which any type of membership function and number of fuzzy membership function can be selected. Fig. 7 shows the fuzzy GUI for error and change-in-error inputs. Fig. 8 shows the fuzzy GUI for control action output and Fig. 9 shows the fuzzy rule base editor [1].

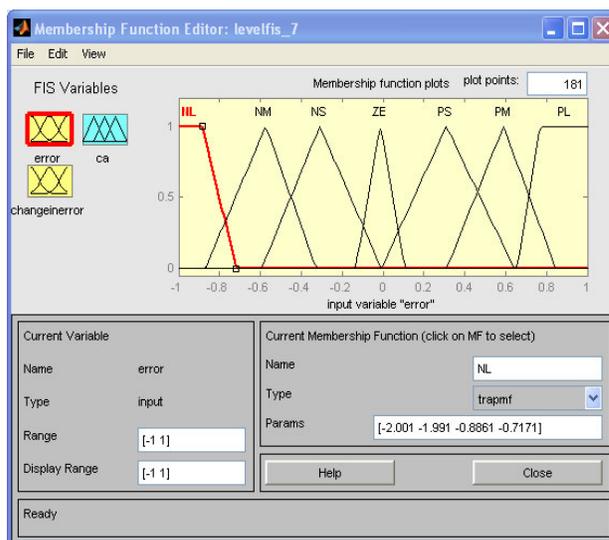


Fig. 7. Seven-member triangular function for error and change-in-error

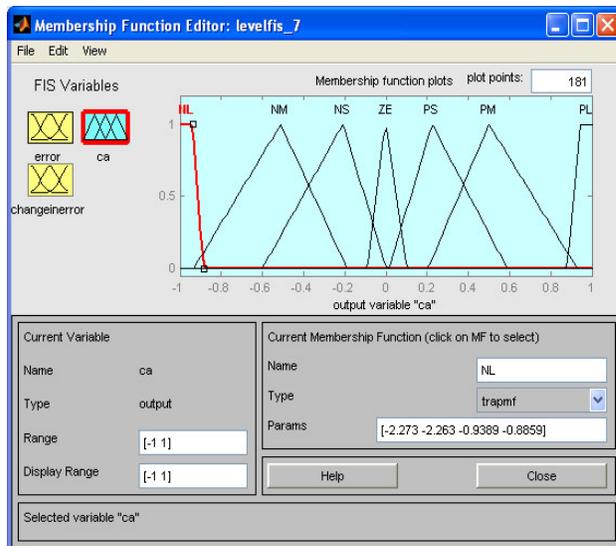


Fig. 8. Seven-member triangular function for control action

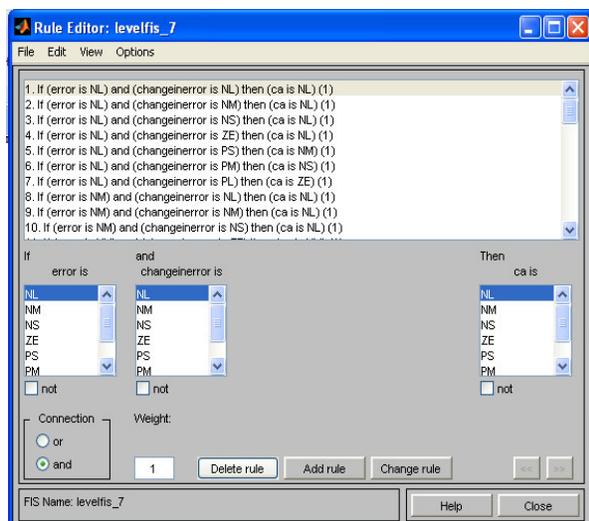


Fig. 9. Rule base editor

Flowchart

Figure 10 shows the detailed flowchart of MATLAB-GUI based fuzzy logic controller for liquid level control. The system software first initializes the DIOT card and invokes the GUI. The software has two sections. One is real-time and another is simulation section. Either of the sections can be selected by the GUI shown in Fig. 3. The detailed functionality of the GUI is already discussed in section 2.1.

5. Experimental Results

In the present application MATLAB-GUI has been employed to study the real-time and simulation results. Both results are discussed below. Here the simulation is carried out only for the tank system not for the entire system. The GUI designed for the present application is very useful tool to study the liquid level control system. The responses from the real-time and simulation are obtained and displayed on this GUI. The SIMULINK model block parameters (gain block, constant block, PID block, fuzzy block etc) are assigned through present GUI. Also, by using the proposed GUI, the SIMULINK model can be invoked and results are retrieved and displayed on the GUI.

Real-Time Experimental Results

Figures 11 and 12 show the real-time responses of step, and staircase inputs. A step input of 0-15cm is applied. From the experimental results it is found that the IFLC has faster settling time. For non linear parameters such as level, the integrated fuzzy logic controller gives the best performance. Also, the performance of integrated fuzzy logic controller is tested for step variation i.e., from 0 to 15cm, 15 to 30cm, and 30 to 45cm.

Simulation Results

Figures 13 and 14 show the simulation results obtained by the GUI for step and staircase inputs respectively. The level has been set to 15cm, 30cm, and 45cm at time $t = 0, 300, \& 600$ seconds respectively. The real-time and simulation results are similar. Table 3 shows the comparative study of PIDC, FLC and IFLC controllers for stair case input of 15cm in real-time mode.

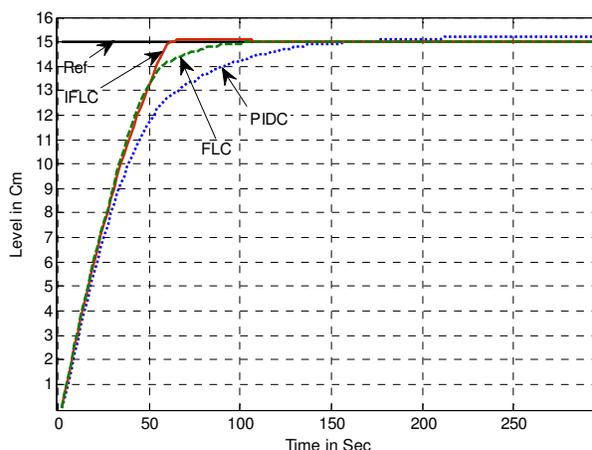


Fig. 11. Real-time: responses of PIDC, FLC & IFLC for step input of 15cm

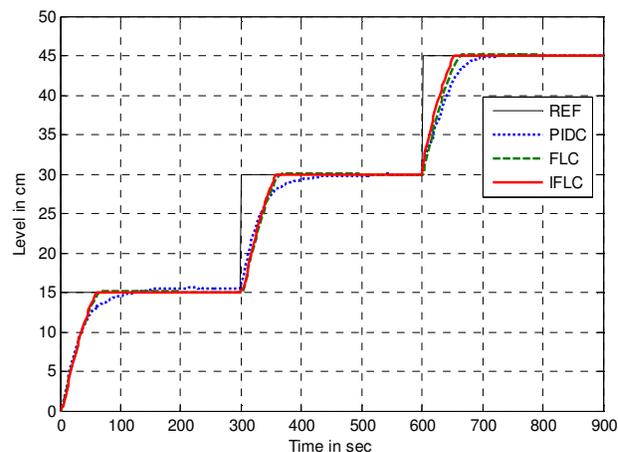


Fig. 12. Real-time: response of PIDC, FLC & IFLC for staircase input

6. Conclusions

In this paper the application of MATLAB-GUI for analysis and design of liquid level control system using FLC and IFLC is investigated. The GUI approach to the control system makes the system user friendly in nature. The various functionalities are added to the GUI. The GUI allows user to interact with the process in both real-time and simulation modes. The simulation

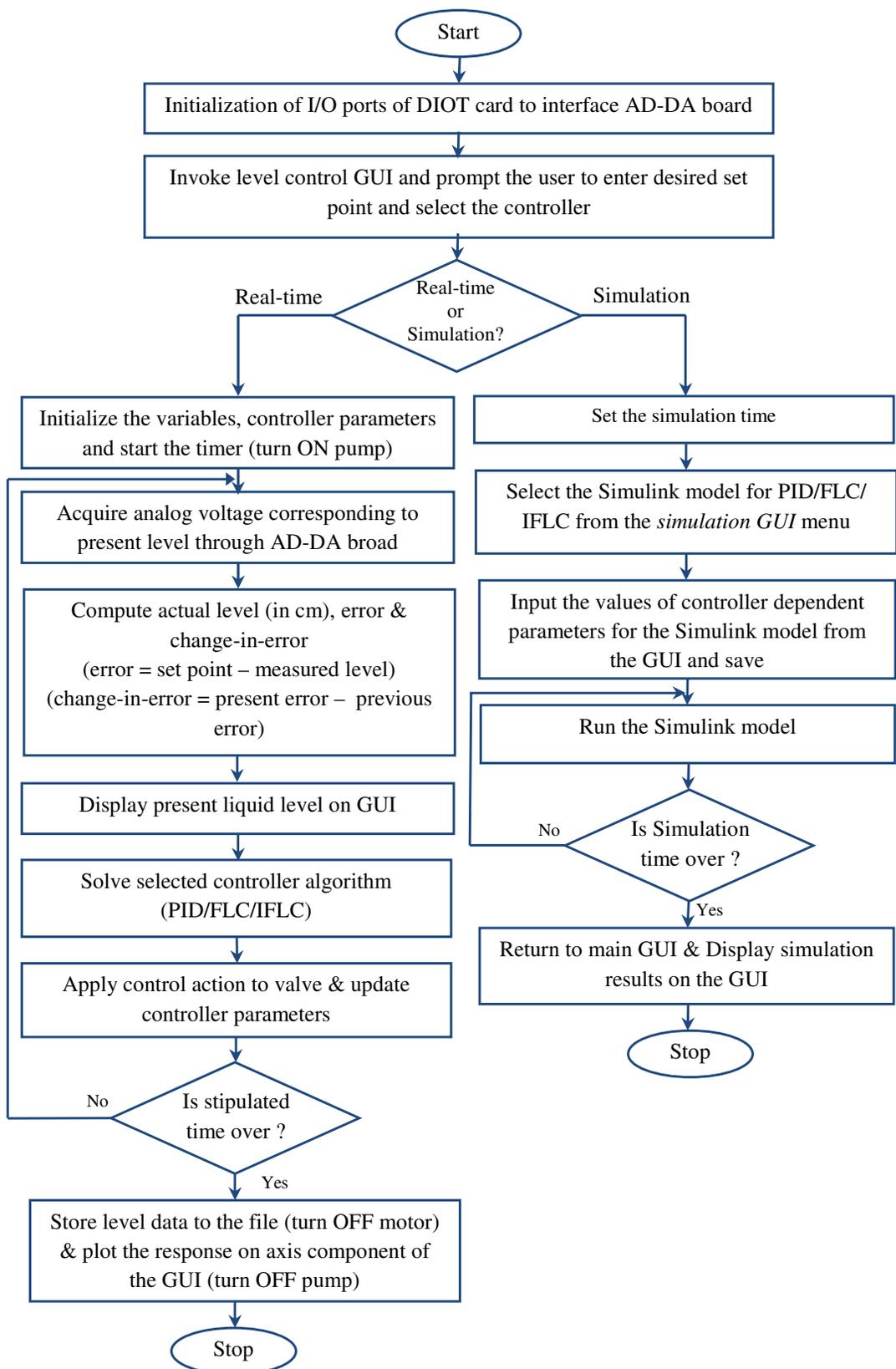


Fig. 10. Flowchart of GUI liquid control system

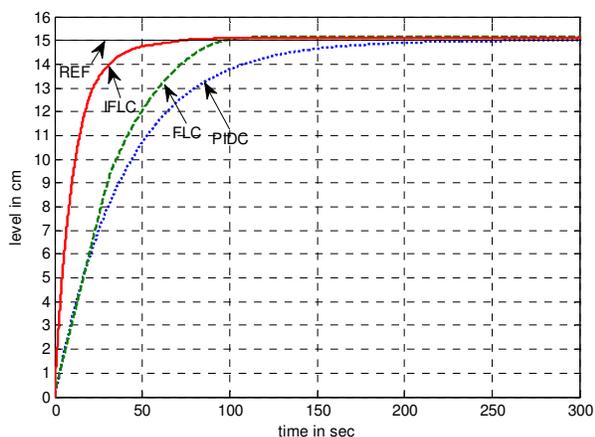


Fig. 13. Simulation: Responses of PIDC, FLC & IFLC for step input of 15cm

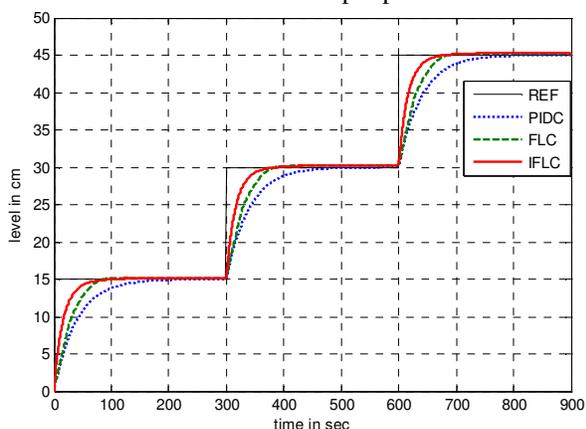


Fig. 14. Simulation: Responses of PIDC, FLC & IFLC for staircase input of 15cm

Table. 3. Comparative study of PIDC, FLC & IFLC (Real-time)

Liquid Level→		0 – 15 cm	15 – 30 cm	30 – 45 cm
Performance indices ↓	Controller↓			
Rise Time (sec)	PIDC	67.39	67.60	68.00
	FLC	52.77	51.30	51.80
	IFLC	52.68	51.28	46.30
Settling Time (sec)	PIDC	120.50	130.00	124.00
	FLC	63.73	62.10	64.10
	IFLC	63.72	62.00	57.20
Overshoot (%)	PIDC	3.3	0.6	0.6
	FLC	0.6	0.6	0.6
	IFLC	0.6	0.6	0.6

results are also displayed on the GUI to compare with the real-time results. The obtained results are compared and in both the cases controllers exhibit good degree of accuracy. The design and tuning of controller such as PIDC, FLC and IFLC is made easier by the use of present GUI. The menus provided on the GUI are self-explanatory and no specific commands need to run the

process. From the GUI based control system it is found that no skilled technical knowledge is required to operate the process. From the experimental results IFLC is the best among the three controllers in simulation and real-time as well. The designed control system is tested for step and staircase inputs with equal step size.

Acknowledgement

The authors would like to thank University Grants Commission (UGC), New Delhi, India for providing financial assistance to carry out this project work successfully.

References

- [1] Duane Hanselman & Bruce Littlefield, *Mastering MATLAB* (Pearson Education, South Asia) 2008.
- [2] Kirani Singh Y & Chaudhuri B B, *MATLAB Programming* (PHI Learning Pvt. Ltd., New Delhi) 2013.
- [3] Amos Gilat, *MATLAB –An Introduction with Applications* (Wiley India Pvt. Ltd., New Delhi) 2013.
- [4] Mohd Fuaad Rehmat & Mariam Md Ghazaly, Performance comparison between PID and fuzzy logic controller in position control system of DC servomotor, *J Teknologi*, **45** (D) (2006), 1-17.
- [5] Nithya S, Sivakumaran N, Balasubramanian T & Anantharaman N, Model based controller design for a spherical tank process in real time, *Int J Simulation, Systems, Science & Technology*, **9** (4) (2008), 25-31.
- [6] Zafer Aydogmus, Implementation of a fuzzy based level control using SCADA, *Expert Systems with Applications*, **36** (2009), 6593-6597.
- [7] Arivalahan R, Hosimin Thilagar & S Devaraj D, Investigation of fuzzy logic controller for conical tank process, *European J Scientific Research*, **92** (2), 2012, 191-202.
- [8] Berk P, Stajanko D, Vindis P, Mursec B & Lakota M, Synthesis water level control by fuzzy logic, *J Achievements in Materials and Manufacturing Engineering*, **45** (2) (2011), 204-210.
- [9] Khaled Reza, M S Shah Ahsanuzamam, Md Tariq & Mohsin Reza S M, Microcontroller based automated water level sensing and controlling design and implementation issue, *Proc World Congress on Engineering and Computer Science* (San Francisco, USA) 2010, 20-22.

- [10] Sakthivel G T, Anandhi S, Natarajan P, Design of fuzzy logic controller for a spherical tank system and its real time implementation, *Int J Engineering Research and Applications*, **1 (3)** (2011), 934-940.
- [11] Dharamniwas, Aziz Ahmad, Varun Edhu & Umesh Gupta, Liquid level control by using fuzzy logic controller, *Int J Advances in Engineering & Technology*, **4 (1)** (2012), 537-549.
- [12] Maziyah Mat Noh, Muhammad Najib, Nurhanium Saadah & Abdullah, Simulator of water tank level control system using PID controller, in *Int Conf on Water Resources Hydraulics & Hydrology* (University of Cambridge, UK) 2008.
- [13] Satean Tuny Asirrut & Santi Wanganipparnto, Level control in horizontal tank by fuzzy PID cascade controller, *World Aca Sci, Eng and Tech*, **25** (2007), 78-82.
- [14] Sharad Kumar Tiwari & Gagandeep Kaur, Analysis of fuzzy PID and immune PID controller for three tank liquid level control, *Int J Soft Computing and Engineering*, **1 (4)** (2011), 185-189.
- [15] SenSym SX05DN -ICPT Datasheet at www.sensortech.com
- [16] AD620 Datasheet at www.analog.com
- [17] Immanuel J, Parvathi C S, Shrimanth Sudheer L & Bhaskar P, MATLAB graphical user interface based fuzzy logic controllers for liquid level control system, *Sensors & Transducers*, **148** (1) (2013), 57-62.
- [18] ADVANTECH PCI-1751 DIOT card at www.advantech.com
- [19] GT2108ED Datasheet at www.conoflow.com/pdf/products/gt210.pdf
- [20] MATLAB® at www.mathworks.com
- [21] Driankov H, Hellendroon & Reinfrank M, *An Introduction to Fuzzy Logic Control* (Narosa Publishing House, New Delhi) 2001.
- [22] L. Shrimanth Sudheer, Sudheer, Immanuel J, P. Bhaskar, Parvathi C. S, ARM7 Microcontroller based fuzzy logic controller for liquid level control system, *International Journal of Electronics and Communication Engineering & Technology*, **4(2)**, 217-224, March-April 2013.
- [23] Immanuel J., Parvathi C. S., P. Bhaskar, and L.S. Sudheer, Design and development of real time MATLAB-GUI based fuzzy logic controllers for DC motor speed control system, *International Journal of Electronics Engineering*, **3(1)**, 133-139, 2011.



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