WATER LEVEL CONTROL BY USING FUZZY LOGIC CONTROLLER

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Abstract: Level control is immensely important in many process industries.In this work, a simple coupled tank system is used to maintain the water level in the second tank at a constant level when there is liquid flow in and liquid flow out in the first tank and liquid flow out of the second tank .The liquids in the coupled tank system requires to be pumped from first tank to the second tank and stored in the second tank . This paper presents the advantages of a Fuzzy Logic Controller and it is is applied to a water level control system. The paper also presented a low cost hardware model and practical procedure for controlling the water level in the tank. At first the mathematical model of the coupled tank process was implemented by using Labview software.Then the Labview simulation are coordinated based on this developed mathematical model.

Keywords: Fuzzy logic controller; Fuzzy Inference System; Coupled tank system; LABVIEW simulink;

I. INTRODUCTION

In certain industrial processes,water level control problem is often required.Water level control is a very composite system due to its nonlinear nature of the system.The best industrial process known PID controller is widely used for cotrollimg the liquid level because of its simplicity,high reliability and robustness but generally they are delineated for linear systems. Ziegler-Nichols and Cohen-Coon methods have been used to tune a PID controller for a particular operating point.When the operating point is changed beyond the linearized region,the PID controller parameters need to be tuned again.In this case Fuzzy logic controllers are effectually applied to non-linear systems because of the presence of their non-linear structural characteristics.Chemical process industries and petroleum industries experienced many challenging control problems due to their nonlinearity, unreliability and time varying behavior of the parameters.To overcome these type of difficulties, Fuzzylogic controller was implemented.In the coupled tank system, liquid level has to be controlled and flow between the two tanks must be maintained. Flow and level contol is the heart and soul of the chemical engineering.

II.EXPERIMENTAL SETUP OF COUPLED-TANK SYSTEM

The following figure shows that two interacting tanks are connected in series.The inflow Qi into the tank1 and outflow Q2 is out of tank2. The liquid level or height in both the tanks are h1 and h2.The liquid level h1 in tank1 influence the liquid level h2 in tank2.This water level variation depends on the input flow rate and output flow rate of the liquid.The output flow rate Q2 varies the square root of the height h2,so that higher the water level faster the flow out of the tank.If the output flow rate is greater than the input flow rate ,the water level will drop and if the output flow rate is less than the input flow rate,the water level will rise.This process is known as self regulation. The liquid level in second tank ie, h2 is maintained at some constant value by flowing through the liquid into the tank1.In case of an interacting process, the dynamics of tank1 is being influenced by the dynamics of tank 2 and the opposite is also true because the flowrate depends on the difference between the liquid levels in both the tanks.

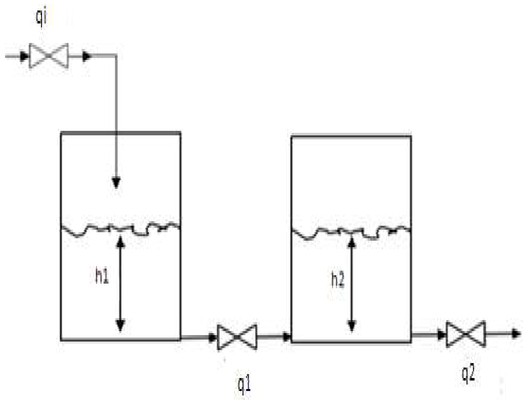


Fig2.1 Coupled Tank System

II. CONTROLLER DESIGN

Table1.Fuzzy rules of the coupled tank system

Tank2 error / dH/dTin tank2	Large negative	Some negative	None	Some positive	Large positive
Fast negative	No change	Some positive	Medium positive	Large positive	Large positive
Slow negative	Some positive	No change	Some positive	Medium positive	Large positive
Zero	Large Negative	Some negative	No change	Some positive	Large positive
Slow positive	Large Negative	Medium negative	Some negative	No change	Some positive
Fast positive	Large Negative	Large Negative	Medium negative	Some negative	No change

The membership functions that are used by the Fuzzy Controller are triangular and trapezoidal. The two inputs are ‘dH/dT tank2’ and‘Tank2 error’ which is ranging from -0.01 to 0.01 and -0.5 to 0.5 respectively. The output is ‘Flow change’which ranges from -0.05 to 0.05.The fuzzy membership of input dH/dT tank2 are Fast negative, Slow negative, Zero, Slow positive and Fast negative. Similarly fuzzy membership of input ‘Tank2 error’ is Large negative, Some negative, None, Some positive and Large negative. The fuzzy membership of output ‘Flow change’ are Large negative, Medium negative,Some negative, No change, Some positive, Medium positive and Large positive.

Table 2 shows the input ‘dH/dT Tank 2’of the coupled tank which ranges from -0.01 to 0.01

Table2.Crisp range table for the input dH/dT Tank2

Fuzzy variable	**MF used**	**Crisp input range**
Large negative	**Trapezoidal**	**-0.5 to -0.1**
Some negative	**Triangular**	**-0.3 to 0**
None	**Triangular**	**-0.1 to 0.1**
Some positive	**Triangular**	**0 to 0.3**
Large positive	**Trapezoidal**	**0.1 to 0.5**

Table 3 shows the input 'Tank2 error 'which ranges from-0.5 to 0.5.

Table 3. Crisp range Table for the input Tank2 error

Fuzzy variable	MF used	Crisp input range
Fast negative	**Trapezoidal**	**-0.01to -0.00266**
Slow negative	**Triangular**	**-0.0066 to 0**
Zero	**Triangular**	**-0.00266 to0.00266**
Slow positive	**Triangular**	**0 to 0.0066**
Fast negative	**Trapezoidal**	**0.00266 to 0.01**

Table 4 shows the output 'flow change' which ranges from -0.05 to 0.05.

Table 4. Crisp Range Table for output 'Flow change'

Fuzzy variable	MF used	Crisp output range
Large negative	**Triangular**	**-0.05 to -0.03**
Medium negative	**Triangular**	**-0.05 to -0.01**
Some neg	**Triangular**	**-0.03 to 0**
No change	**Triangular**	**-0.01 to 0.01**
Some positive	**Triangular**	**0 to 0.03**
Medium positive	**Triangular**	**0.01 to 0.05**
Large positive	**Triangular**	**0.03 to 0.05**

III. Simulation With Fuzzy Logic Controller

The MAMDANI fuzzy inference system is used. There are two inputs. They are Tank2 error in liquid level dH/dT and rate of change of liquid level in Tank2 and one output parameter is output flow change.5 membeship functions for two inputs ,7 membership functions for one output and total 25 fuzzy rules for each input and output. Triangular and trapezoidal membership functions are selected to fuzzify the inputs and output variables.

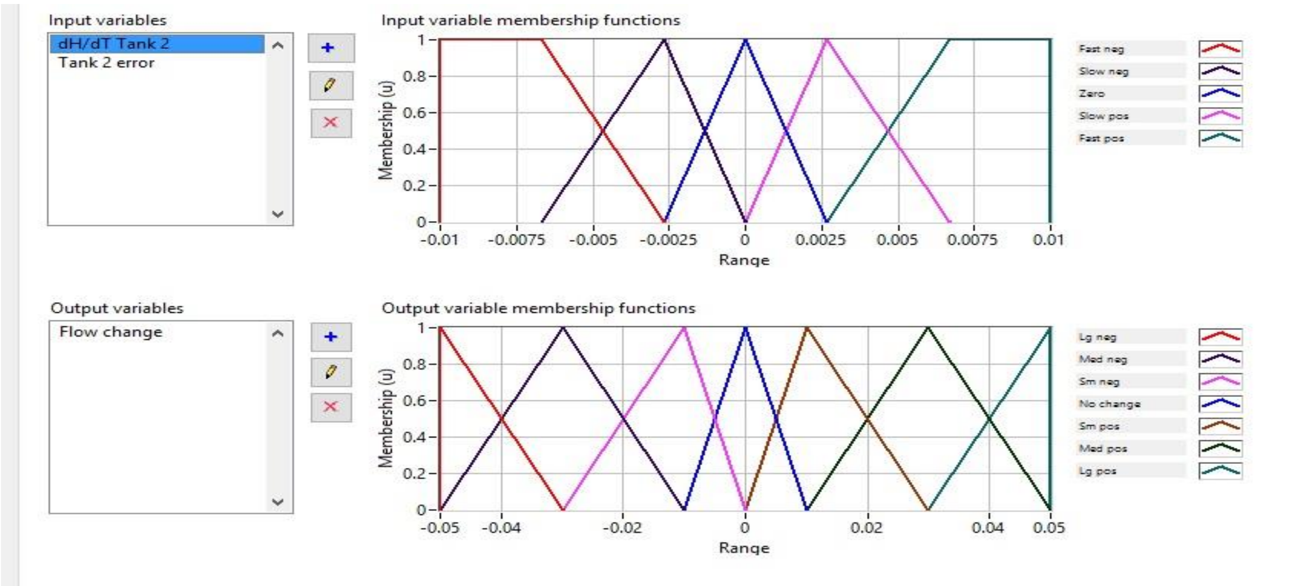


Fig3.2: Fuzzyfication of input variable dH/dT of Tank 2 and output variable

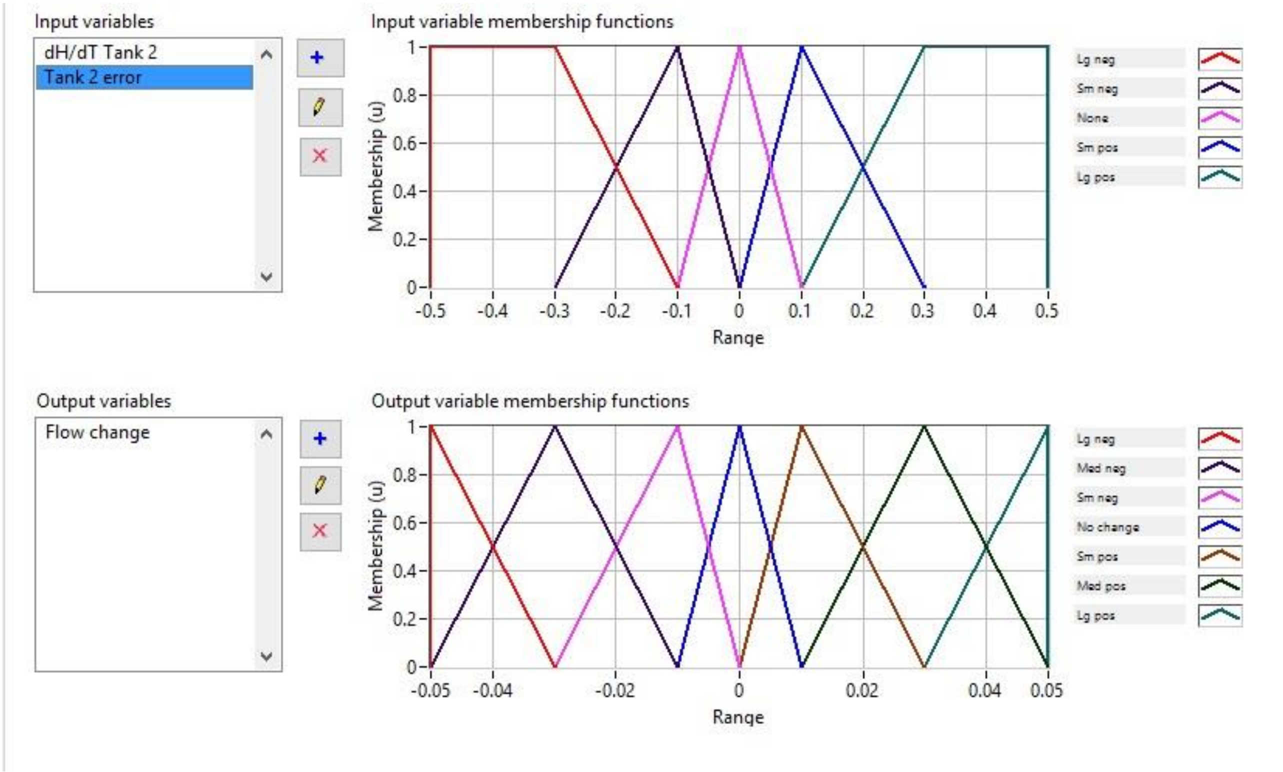


Fig3.3: Fuzzyfication of input varible Error in Tank 2 and ouput variable Flow Change

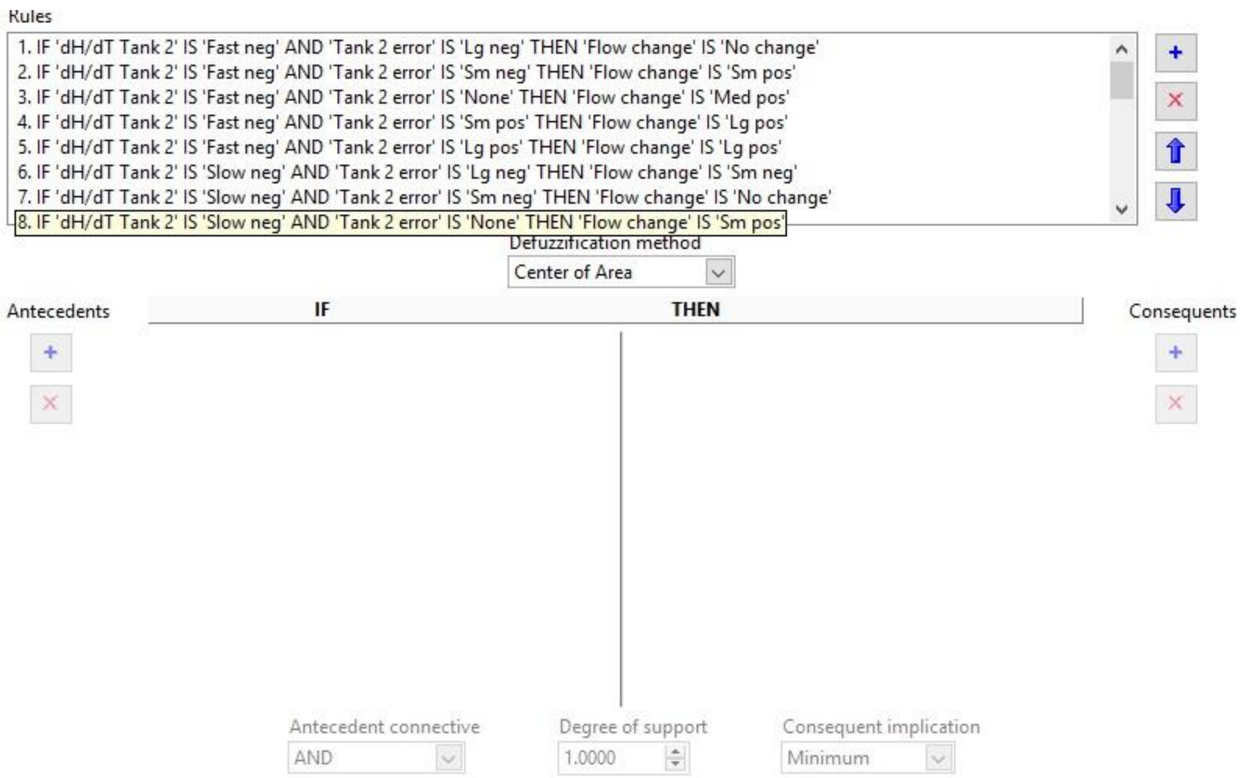


Fig3.4: Rule viewer

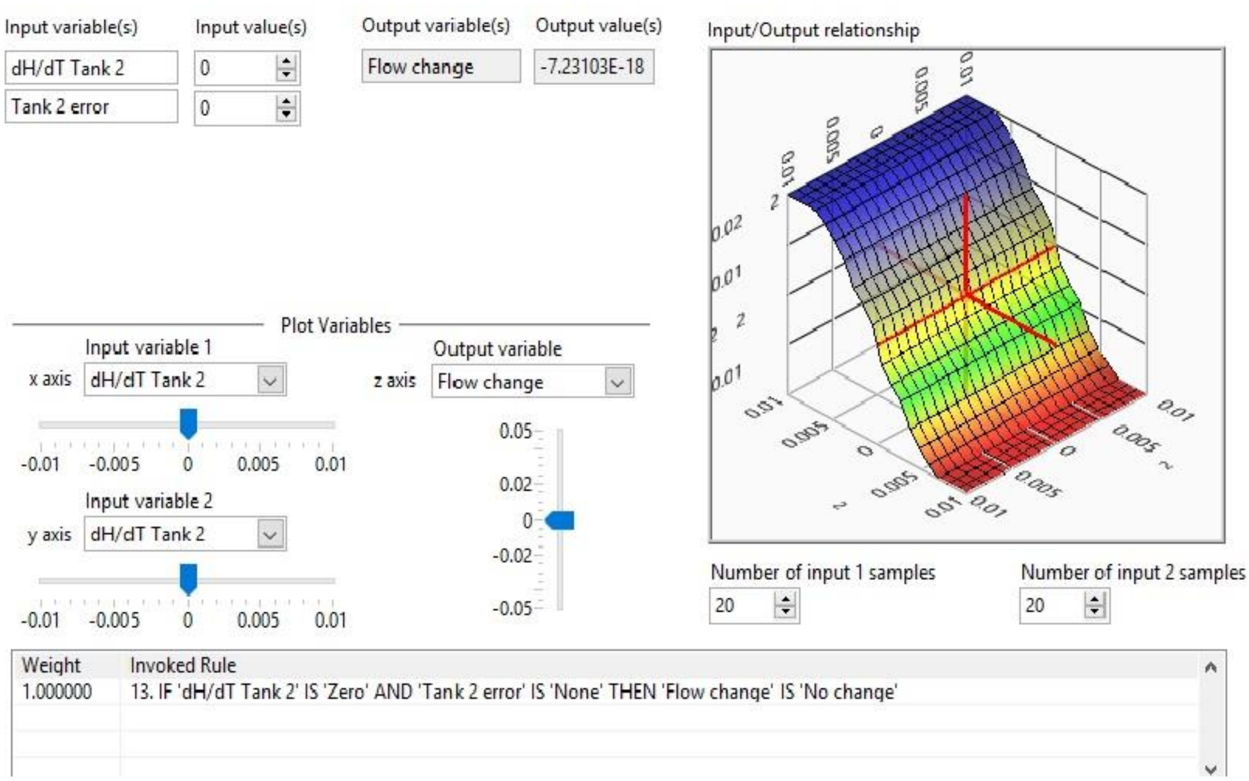


Fig3.5: Surface viewer

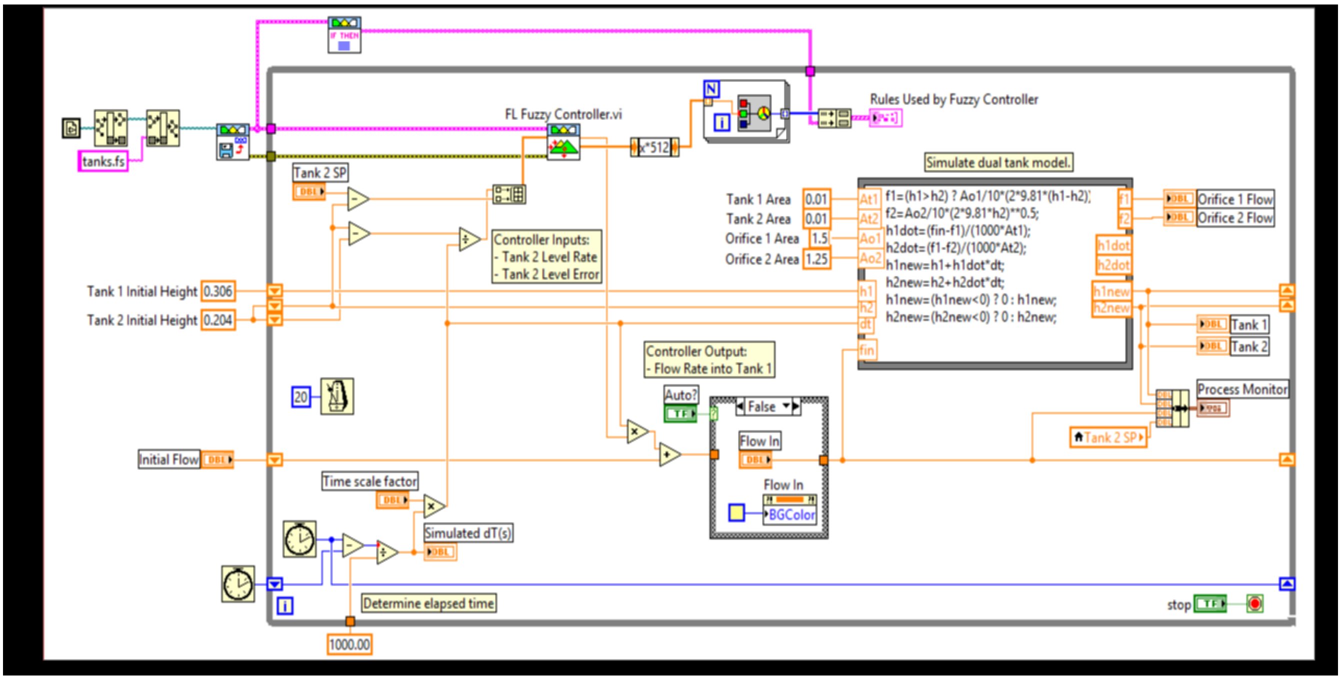


Fig3.6: Labview Simulink block diagram

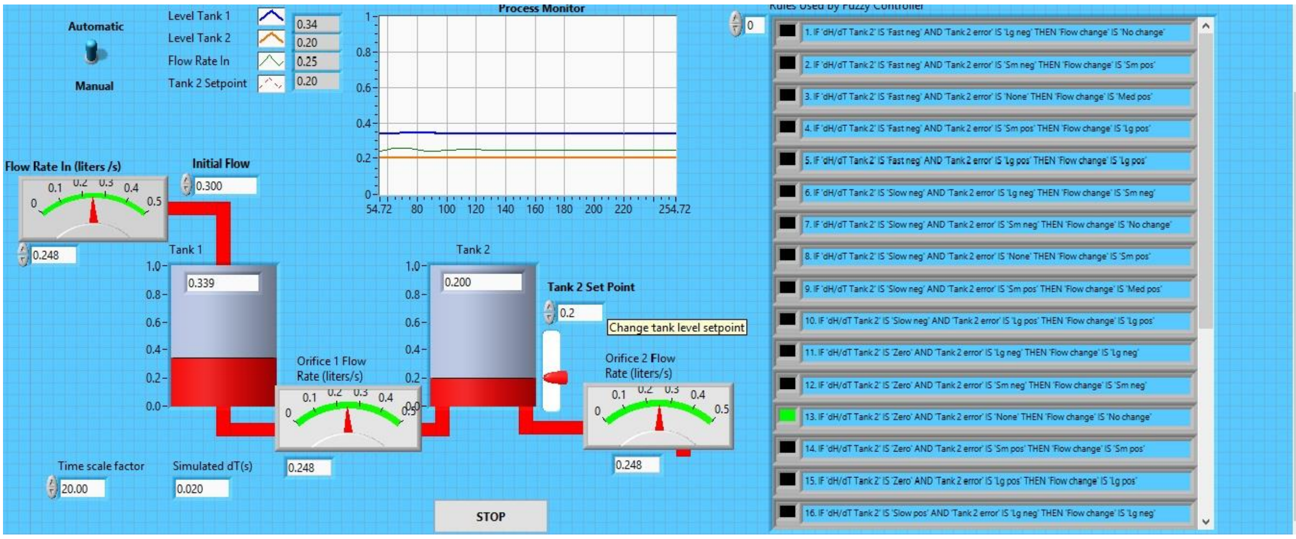
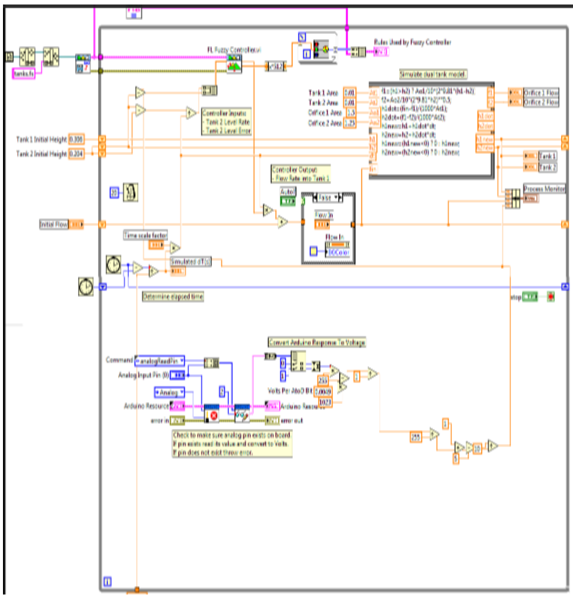


Fig3.7: Front panel

LIFA: The Lab VIEW Interface for Arduino or simply LIFA is a Toolkit that permits developers to acquire data from the microcontroller unit like Arduino and process the data in the Lab VIEW Graphical Programming environment.LIFA software enables lab VIEW directly to talk to the Arduino. To communicate between Lab VIEW and Arduino a program called LIFA base must be deployed to the Arduino. It is written in processing language and run in Arduino IED.



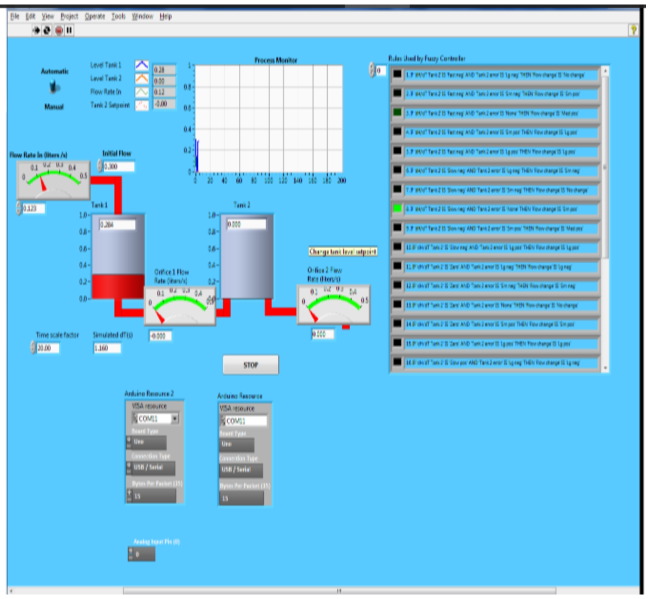
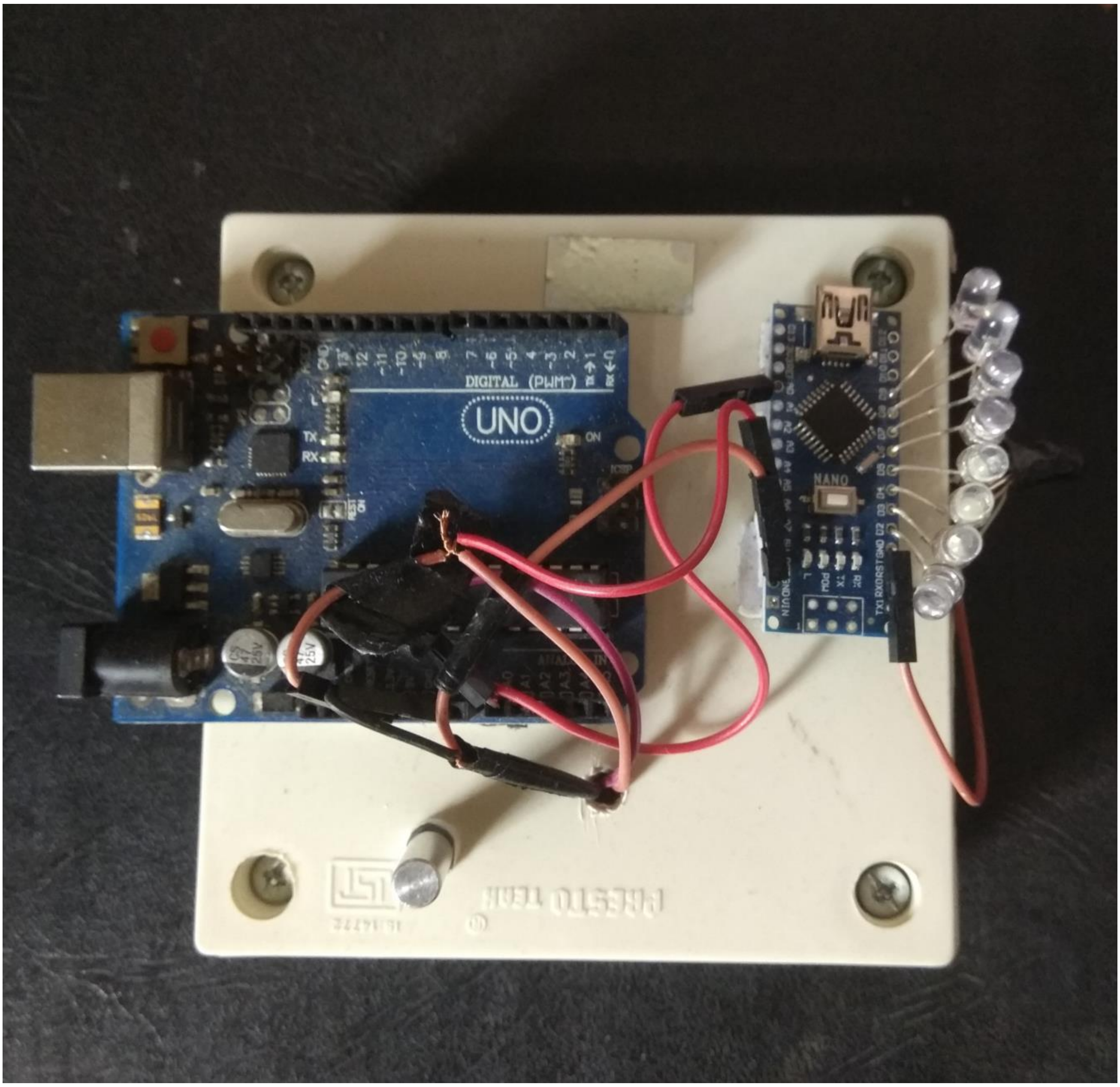


Fig3.8:Block diagram panel

Fig3.9:Front panel

IV. HARDWARE IMPLEMENTATION

In the system,there is some hardware got implemented.For this we use Arduino UNO and Arduino NANO as microcontroller unit.A potentiometer of 22K and connect it to the analog pin Ao of the arduino UNO.As the arduino receive the analog signal,it send it to the V.I program through LIFA software.This allows to divide the potential in the range of (0-5)V.Now this potential is sampled and finally quantized for analog to digital conversion.This quantized value act as the set point of the system.Therefore by regulating the potentiometer can able to set the set point of the system manually.In the output section, there are LED bulb arrays as an indication of the tank level.These LED’s are connected to an another controller Arduino NANO,which gives the visual information of the tank level of the user.These LED’s are controlled and mapped with the tank height.VI program named as ‘analog write’.



V. Conclusion

Based on the LabVIEW simulation,Fuzzy-Logic Controller is easily implemented and simulated successfully. This Fuzzy controller on water level control problem results are satisfactory and promising.The Fuzzy Logic Controller can be easily programmed by using some simple algorithm into many industrial process controllers.Response of this Fuzzy Logic Controller is better than any conventional cotrollers.This control approach can be usually used in firmentation.The future scope of this work as the fuzzy controller can be implemented for more than two water level as adaptive Fuzzy

Controller give fast response and high intelligence.Fuzzy Controller can also be implimented in a microcontroller or microprocessor unit with an additional set of fuzzy rules for more accurate control. We can also develop the mathematical model of coupled tank system by using some intelligent control methods such as genetic algorithm,artificial neural network.

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