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Liquid Level Control Using Fuzzy Logic in LabVIEW with ARDUINO

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Abstract: Liquid level control plays a crucial role in the industrial process control for the accurate results of the output (product). The fuzzy logic controller is the most commonly used method because of their accuracy and ease of design rules for nonlinear process control in the industrial application. The main objective of this paper is to show how liquid level of a couple tank systems can be controlled by fuzzy logic controller by using the LabVIEW software. Liquid level controller vi is interfaced with Arduino Uno board using LIFA to see the controller performance. The output of the controller is observed by one LED and buzzer.

Keywords: Couple Tank System (CTS), Fuzzy Logic Controller (FLC), Pulse Width Modulation (PWM), Virtual Instrumentation (VI), LabVIEW Interface for Arduino (LIFA).

1. Introduction

The aim of this paper is to control the liquid level of a couple tank systems. The liquid level of the second tank is controlled by using fuzzy logic controller. The liquid level of the first tank is always maintained higher than the second tank to enable continuous flow of liquid to the second tank. The simulation is done by using LabVIEW software. The liquid level is set by creation a vi with fuzzy logic controller in LabVIEW. The output of the controller is indicated by means of a LED and Buzzer through Arduino board. The set point of the liquid level is changed by using a potentiometer connected to the Arduino board.

2. Arduino Uno Board

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable modules known as shields. Some shields communicate with the Arduino board directly over various pins. Official Arduino have used the mega AVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator. An Arduino microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer. The main advantage of Arduino boards compared with the other microcontroller is that the user can program and upload it directly to the controller through Arduino IDEs. The specifications of Arduino Uno are as follows:

Microcontroller: ATmega328

Operating Voltage: 5V

Input Voltage (recommended): 7-12V

Input Voltage (limits): 6-20V
Digital I/O Pins: 14 (of which 6 provide PWM output)
Analog Input Pins:6
DC Current per I/O Pin:40 mA
DC Current for 3.3V Pin: 50 mA
Flash Memory:32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM:2 KB (ATmega328)
EEPROM :1 KB (ATmega328)
Clock Speed:16 MHz

3. PMW on Arduino

The Arduino can read analog voltages between 0 to 5 volts using analog read function. But the Arduino does not have a true analog output. As the Arduino is so fast it can take using PWM technique. PWM is a method of supplying the electrical power to the load having slow response. The Arduino is so fast that it can blink a pin on or off almost 1000 times per second. PWM pins go one step further by varying the amount of the time that the blinking pin spends High versus the time it spends Low. If it spends most of the time High, a LED connected to the pin will appear bright. If it spends most of its time Low, the LED will look dim. Because the pin is blinking much faster than our eyes can detect, the Arduino creates the illusion of true analog output.

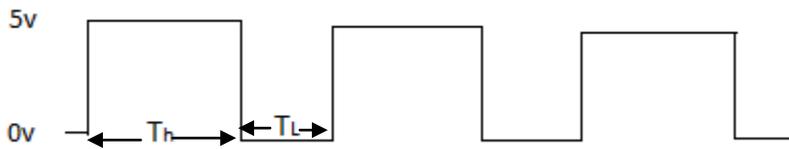


Figure 1. Variable with Pulse Train

The Arduino already contains 6PWM pins on it. The PWM output on the Arduino can be varied by varying the duty cycle from 0 to 255. The dc voltage applied to the load is controlled by varying the duty cycle. The duty cycle is given by $T_h/(T_h+T_L)$.

4. LIFA

The LIFA stands for LabVIEW Interface For Arduino. The LIFA is the way of connecting Arduino with the LabVIEW. It is a sketch for the Arduino microcontroller that acts as I/O engine that interfaces with LabVIEW vi through a serial connection. Once the information is in the LabVIEW, we can analyzed it using the Arduino hardware through LIFA from built in LabVIEW libraries. So LIFA provides us to access the digital, analog, pulse width modulation and SPI signals of the Arduino microcontroller. For this the Arduino should be connected to the system either throughUSB, serial or Bluetooth.

5. Results and discussion

The Front panel and block diagram of the liquid level system is shown in the Fig. 2 and Fig.3 below.

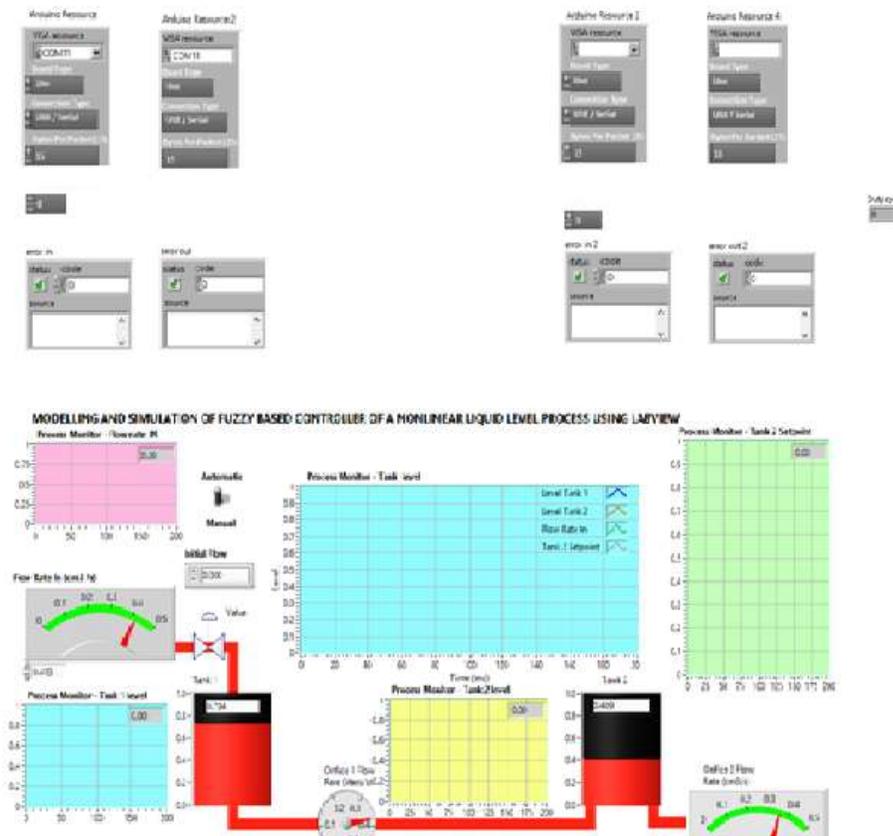


Figure2. Front Panel of the Liquid Level Process Control

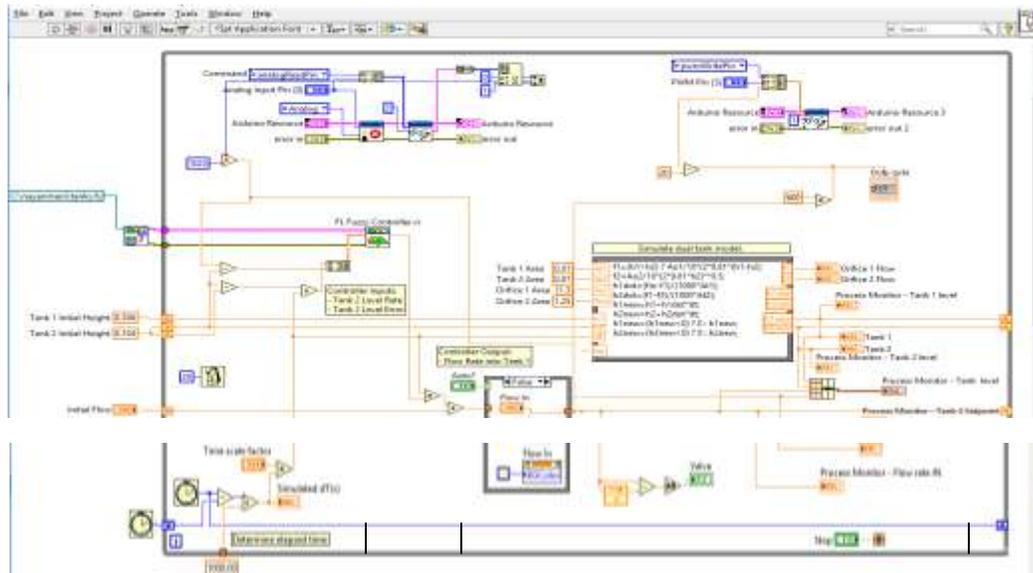


Figure 3. Block Diagram of the Liquid Level Process

The hardware implementation for the system is done using a micro controller At-mega 328. Arduino UNO R3 is used as a controller platform. The circuit is quite simple. A potentiometer, Piezzo buzzer and an LED is used for the circuit and is connected as shown in the figure below.

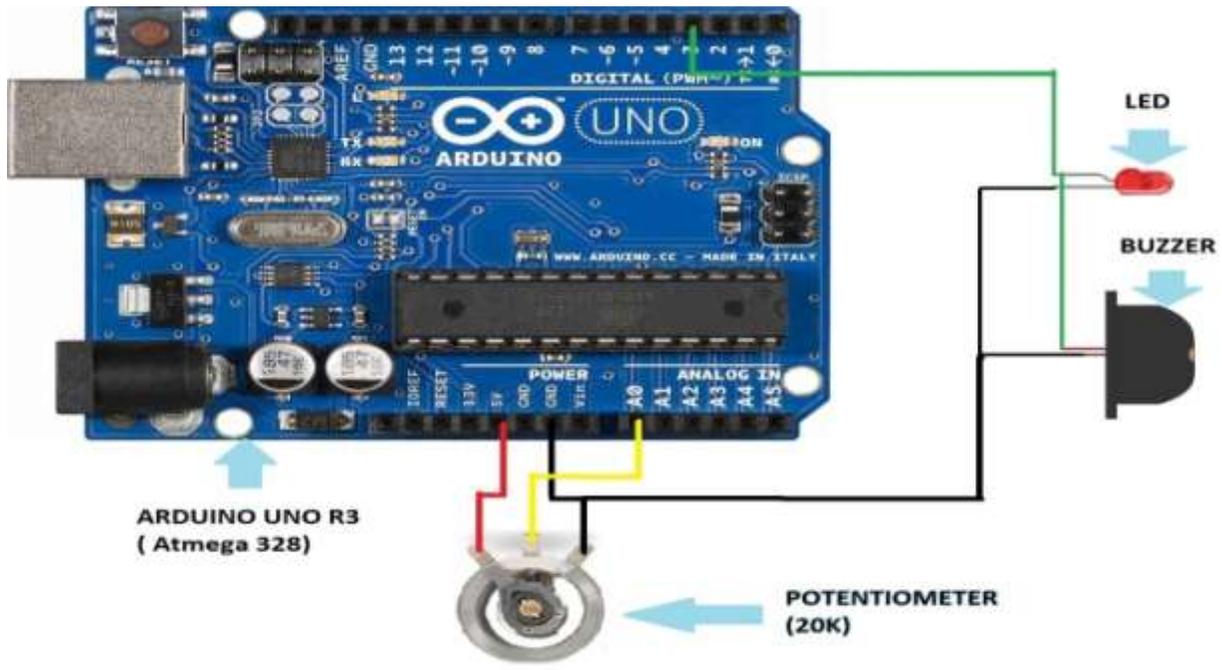


Figure 4. Circuit Diagram of the Project Hardware

Designing of the circuit is done in the software Fritzing Beta shown in Fig.5.

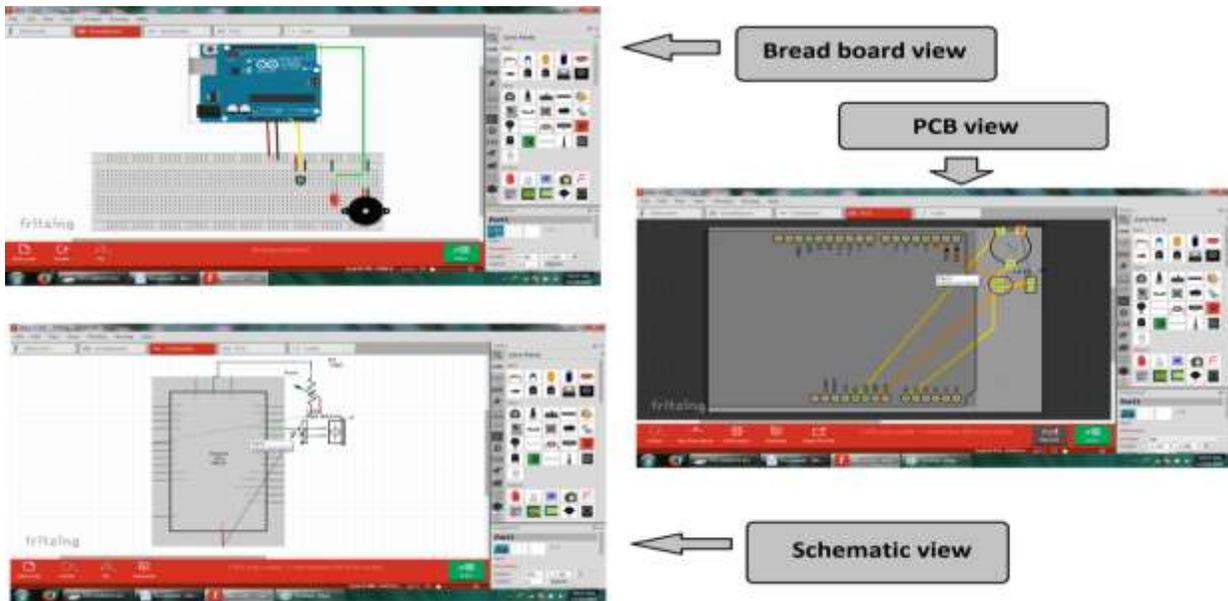


Figure 5. Fritzing Design of the Hardware

The potentiometer connected in between 5 volt and ground pin of Arduino supplies a 5 volt constant DC supply which is varied by turning the potentiometer in clockwise or anti clockwise direction. The output of the potentiometer is connected to the analog pin A0 of the Arduino. When there is a voltage at this pin of the controller platform, it immediately sensed by the controller and quantized 0-5 Volt DC in 0-1023 value. The controlled is burned with the program LIFA .It act as a mediator between LabVIEW and the Arduino hardware. LIFA fetch the data sense by the analogue pin and fed this data as the set point value of the tank. The result of which we can able to fix the set point of the tank, simply by adjusting the potentiometer.

The system acts for new set point set by the user and control the opening of control valve. The opening of this valve is again converted to a numerical value in the Lab VIEW block and is got multiplied by a calibrating factor to convert the controller zero to full opening in the range of 0-255 .This value is important because it plays an important role in controlling the final control element. This value is directly written in the PWM pin of Arduino .In our case we are using the pin no 3 of Arduino. This pin generates an output pulse which duty cycle is controlled by the output data of Lab VIEW, resulting the variation of output voltage in the final control element. In our system we simply use an LED and a Piezzo buzzer for audio-visual monitoring. The intensity and the tone of the devices got changes according the voltage level. In actual plant the FCE should be replaced be motor and pumps, which delivers liquid at different rate according to the set point. Table 1 shows the controller output in volt with different set point value and their performance.

Table 1: Observation of the Controller Output

Set point	Voltage	LED status	Buzzer
0.2	1.88 volt	Low illumination	Low sound level
0.4	2.56 volt	Medium illumination	Medium sound level
0.6	3.22 volt	High illumination	High sound level

Conclusion

This work illustrates the design and development of a LIFA based liquid level process control of couple tank system. The application of virtual instruments makes data analyzing more accurate. The system has been tested for various set point values and worked properly. So from the analysis with experimental results we can mention that the designed liquid level process established with LIFA is able to control liquid level very effectively and efficiently. This method can be implemented in the chemical process industries which can maintain the stability of the system.

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