International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

# Implementation of Automation System for Level with Flexibility

**Godhini Prathyusha**[†*]

[†]Department of Instrumentation & USIC, S.K. University, Anantapur, Andhra Pradesh, India

Accepted 05 Dec 2015, Available online 11 Dec 2015, **Vol.5, No.6 (Dec 2015)**

***Abstract***

*Applications that require level control are often meet in industry. In this paper a low cost application for level control in a tank using ardiuno mega 2560 was designed and developed. Level control is implemented by using Ultrasonic sensor HCSR04 and software Fuzzy with PID is applied to this system. This study includes level control using a PID controller and Fuzzy logic implemented on Arduino. The general purpose process is to ensure a desired level in a closed loop safety operational function. The developed hardware and software successfully implemented and tested with prototype system and the results are evaluated. The system is satisfactorily working with an accuracy of ± 0.03cm.*

***Keywords:*** *Ultrasonic sensor HCSR04, Level, PID, FUZZY, DC motor*

## 1. Introduction

[1]The requirement for electronic signal processing circuitry can be used to make the ultrasonic sensor an intelligent device. Ultrasonic sensors can be designed to provide point level control, continuous monitoring or both. Due to the presence of a controller and relatively low power consumption, there is also capability for serial communication from to other computing devices making this a good technique for adjusting calibration and filtering of the sensor signal, remote wireless monitoring or plant network communications. The ultrasonic sensor enjoys wide popularity due to the powerful mix of low price and high functionality (Daniel K. Fisher, Ruixiu Sui, 2013).

In this paper three Ultrasonic sensors are used for the controlling of different shapes of container level like rectangle, cylinder, and cone. Typical measurement and control of different containers by unique implementation of arduino based automation of level using Fuzzy with PID software.

## 2. Hardware

The block diagram of an Ardiuno based ultrasonic type level measurement is shown in figure 1 consisting of the following units. They are:

a) Ultrasonic sensor HCSR04
b) Arduino mega 2560
c) Driver circuit
d) DC motor
e) PC

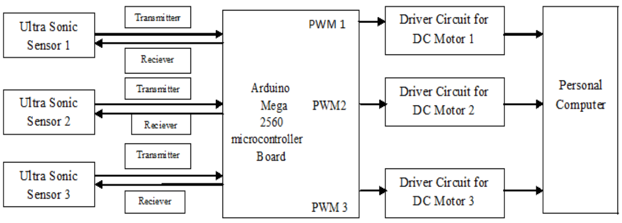



**Fig.1** Block diagram of level measurement and control using ultrasonic sensor

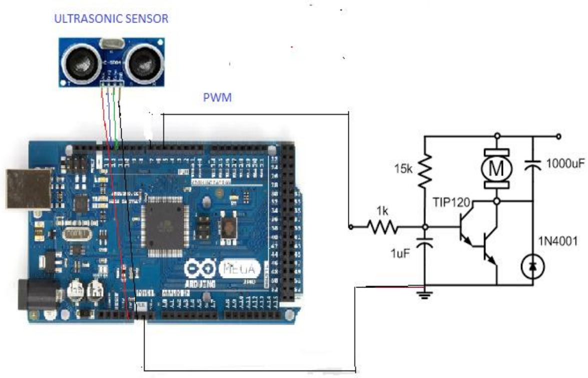



**Fig.2** Circuit diagram of level measurement and control using ultrasonic sensor

The GUIs are developed by processing software using java programming language. The GUIs are different for different shape of the level container, which we selected that will be displayed in the form of GUI. The GUI consists of set value, measured value, slides, figure for the selected shape and total setup snapshot and finally the controlled buttons.

*Corresponding author: **Godhini Prathyusha**

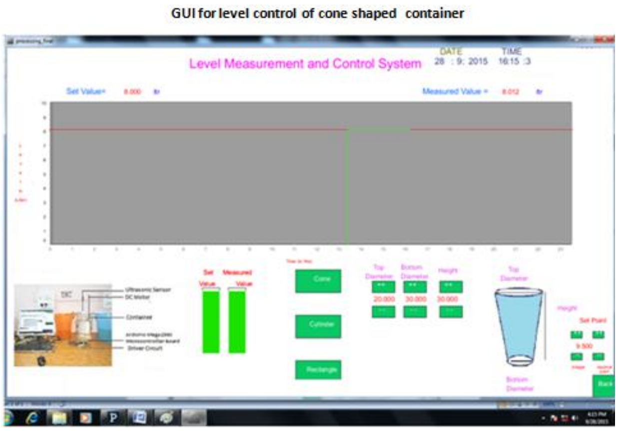



**Fig.3** GUI for level control of cone shaped

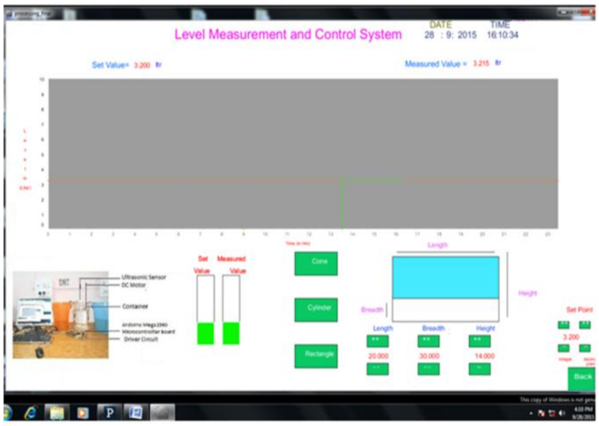



**Fig.4** GUI for level control of rectangle shaped

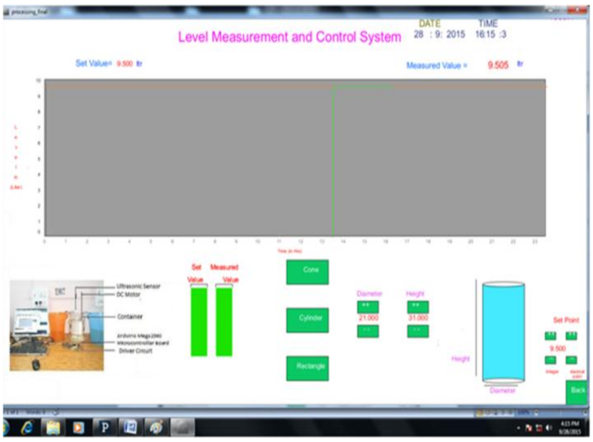



**Fig.5** GUI for level control of cone shaped

**Fig.6** Snapshot for complete system of level measurement and control using ultrasonic sensor

*2.1 Ultrasonic sensor*

**Fig.7** Ultrasonic sensor (HCSR04)

Ultrasonic level sensors are used for non-contact level sensing of highly viscous liquids, as well as bulk solids. They are also widely used in water treatment applications for pump control and open channel flow measurement. The sensors emit high frequency (20 kHz to 200 kHz) acoustic waves that are reflected back to and detected by the emitting transducer. Ultrasonic level sensors are also affected by the changing speed of sound due to moisture, temperature, and pressures(Shakharov, S.A. Kuznetsov, B.D.Zaitsev, I.E. Kuznetsova and S.G.Joshi, 2003]. Turbulence, foam, steam, chemical mists (vapors), and changes in the concentration of the process material also affect the ultrasonic sensor's response. Turbulence and foam prevent the sound wave from being properly reflected to the sensor; steam and chemical mists and vapors distort or absorb the sound wave and variations in concentration cause changes in the amount of energy in the sound wave that is reflected back to the sensor (Sabuj Das Gupta, and Islam Md. Shahinu, 2012). Stilling wells and wave guides are used to prevent errors caused by these factors. Proper mounting of the transducer is required to ensure best response to reflected sound. In addition, the hopper, bin, or tank should be relatively free of obstacles such as weldments, brackets, or ladders to minimise false returns and the resulting erroneous response, although most modern systems have sufficiently "intelligent" echo processing to make engineering changes largely unnecessary except where an intrusion blocks the "line of sight" of the transducer to the target. Since the ultrasonic transducer is used both for transmitting and receiving the acoustic energy, it is subject to a period of mechanical vibration known as "ringing". This vibration must attenuate (stop) before the echoed signal can be processed. The net result is a distance from the face of the transducer that is blind and cannot detect an object(Barrett, Steven F., 2010). It is known as the "blanking zone", typically 150mm – 1m, depending on the range of the transducer.

*2.2 Arduino mega 2560 microcontroller*

Microcontrollers are widely used in many commercial and industrial applications. In the present work we used Arduino mega 2560 microcontroller and it operates on +5V with 16 MHz and the final output of the level measurement after processing presented on pc. The operation of the level measurement system is very simple and is sensed by the Ultrasonic sensor HCSR04 . The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically .Out of 54 Digital I/O pins 15 provide PWM output.

*2.3 Driver circuit*

The TIP120 is an NPN Power Darlington Transistor. It can be used with an Arduino to drive motors, turn lights on, and drive other high power gadgets.The TIP120 acts as a power broker or gatekeeper between the Arduino realm and the high power realm composed of the PC fan and its battery pack. The Arduino can tell the TIP120 how much power to pass from the external battery pack to the PC fan but the Arduino does not share any of its power or share pins with the PC fan or its batteries. The TIP120 is the go in between.The TIP120 has three pins. One is called Base, which we will connect to the Arduino PWM pins. Through the Base pin, the Arduino can tell the TIP120 how much power to supply to the motor from the external battery pack. That's it. The TIP120 does the heavy lifting while Arduino sits back and gives orders through one of its PWM pins to the TIP120 Base pin telling it how much power to pass to the motor. The TIP120 has to then pass the requested power from the external power to the motor based on Arduino's request. As the name implies, a level controller is an instrument used to control the level. The level controller takes an input from a ultrasonic sensor and has an output that is connected to a control element such as a water pumping motor. To accurately control process level without extensive operator involvement, level control system relies upon a controller, which accepts a level sensor such as an ultrasonic sensor as input. It compares the actual level to the desired control level, or set point, and provides an output to a control element. The controller is one part of the entire control system, and the whole system should be analyzed in selecting the proper controller.

The following items should be considered when selecting a controller:

- Type of input sensor (Ultrasonic Sensor)and level range
- Type of output required (SSR, analog output)
- Control algorithm needed (Fuzzy, PID)
- Number and type of outputs (DC motor, limit)

*2.4 DC Motor*

A DC Motor which operates with +12V by 1Amp power supply for pumping the liquid. It consists of one inlet and one outlet for maintaining the level in a tank by pumping water. In this work the motor controlled by a controller line of PWM which is operates with +5V/+12V by using Fuzzy with PID software. The application software for the present work developed through communication interfacing with PC and USB .One advantage of it is, its operating voltage is +5V same as controller. It has two sets of line drivers for transferring and receiving data.

## 3. Software

*3.1 PID Control*

The proportional integral derivative (PID) controller is the most common form of feedback used in the control systems. It can be used for various Industrial applications. One of the applications used here is to control the speed of the DC motor. Controlling the speed of a DC motors is very important as any small change can lead to instability of the closed loop system. The aim of this paper is to show how DC motor can be controlled by using a Fuzzy with PID controller using Arduino. DC Motor will be interfaced using an Arduino board. Arduino Uno board plays the role of low cost data acquisition board. The speed of the DC motor will be set by PWM in the board creating a software program for PID Controller. Arduino will in turn pass this speed to the DC motor using a PWM pins on the Arduino Uno board. DC motor will move with the speed set by the user in Arduino. The speed of the dc motor will be controlled by depending on the difference between set level and measured level. the output of the measured level is sent to the PID Controller in Arduino board. PID Controller compares the actual level of the tank and set level ,it controls the speed of the DC motor with the PWM. PID Controller will try to minimize the error and bring the motor to the set point of the level value . PID (Proportional, Integral, Derivative) control is a widely-used method to achieve and maintain a process set point. (Mann G. K.I., Hu B.G.Gosine R.G, 1999). The PID control equation may be expressed in various ways, but a general formulation is:

$$\text{Drive} = kP * \text{Error} + kI * \Sigma\, \text{Error} + kD * \frac{dp}{dt} \qquad (1)$$

*3.2 Fuzzy Logic*

To ensure a controlled environment, the proposed automation system is required to measure temperature accurately with high resolution. A higher measured resolution would provide more time for initiating an accurate and the conditional statement between fuzzy input variable (present level) and fuzzy output variable (motor speed). A level control system consists of a sensor, actuator, and microcontroller(M. Sugeno,1985). Fuzzy Logic has been employed to control level by varying ON-time of motor. The actual level is read and compared with the corresponding to set-point level (Hassan B.Kazemian, 2001). The error-count is used to trigger the Fuzzy Inference process. This develops an overall power for motor control that maintains the level of container to the set value.

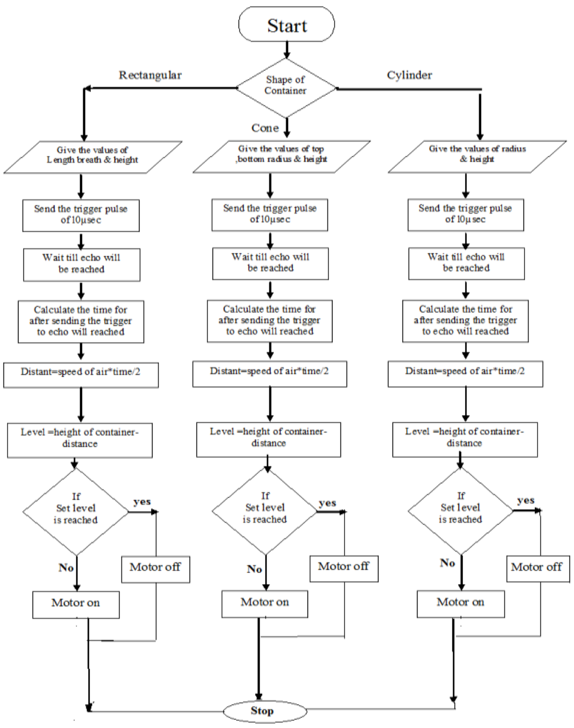
### *3.3 Algorithm*

1) Initialization.
2) Select the shape of the container
3) Send the trigger pulse of 10μsec time
4) Initialize the timer of microcontroller.
5) Wait till echo will be reached.
6) Timer is off.
7) Calculate distance

$$d = \frac{\textbf{Speed} * \textbf{Time}}{\textbf{2}} \quad (2)$$

8) By using Tip120 through PWM driver of controller control the motors for controlling the level of the tank.
9) If level of the tank reached set point the motor will be off.
10) If the level of measured tank greater than the set point, then the water will be pumped outside.

### *3.4 Flow chart for level measurement and control using Ultrasonic sensor*

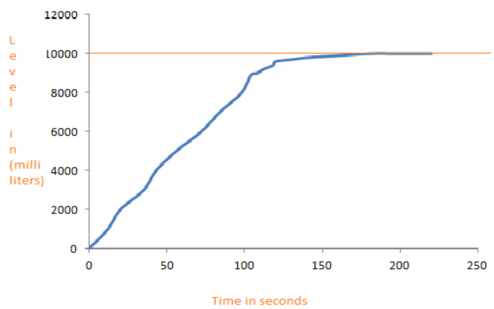



## Results and conclusions

The prototype liquid level measurement system was successfully developed and implemented. The test measurement is compared with standard values. We observe that the results are in good agreement with the standard values as tabulated in table 1 and corresponding graph is shown in figure 6. But though the instrument cost is very less and the accurate with ± 0.03cm . The results are shown in Table 1 and the corresponding calibrated curve of Level measurement is shown in Graph 1.

**Table 1** Experimental values

| S.NO | Time in seconds | Level in milliliters |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 12 | 1000 |
| 3 | 20 | 2000 |
| 4 | 35 | 3000 |
| 5 | 43 | 4000 |
| 6 | 56 | 5000 |
| 7 | 72 | 6000 |
| 8 | 84 | 7000 |
| 9 | 98 | 8000 |
| 10 | 104 | 8900 |
| 11 | 108 | 9000 |
| 12 | 112 | 9200 |
| 13 | 118 | 9400 |
| 14 | 120 | 9600 |
| 15 | 130 | 9700 |
| 16 | 140 | 9800 |
| 17 | 160 | 9900 |
| 18 | 180 | 10000 |
| 19 | 200 | 10000 |
| 20 | 210 | 10000 |
| 21 | 220 | 10000 |




**Graph.1** Time (sec) versus level (ml)

## References

Daniel K. Fisher, Ruixiu Sui (2013), An inexpensive open - source ultrasonic sensing system for monitoring liquid levels ,*CIGR Journal,* Vol.15, No.4, Shakharov, S.A. Kuznetsov, B.D.Zaitsev, I.E. Kuznetsova and S.G.Joshi, Liquid (2003)Liquid level sensor using ultrasonic Lamb waves, Ultrasonic, Volume41, Issue 4, Pages 319-322.

Sabuj Das Gupta, and Islam Md. Shahinu (2012), Design and Implementation of Water Depth Measurement and object

Detection Model using Ultrasonic Signal System, *International Journal of Engineering Research and Development,* e-ISSN:2278-067X,p-ISSN: 2278-800X, Volume 4, Issue 3 , PP.62-69

Barrett, Steven F. (2010), Arduino Microcontroller, *Processing for Everyone. Morgan & Claypool, 325* pp. ISBN: 9781608454389. Available online at UCSD library.

Mann G. K.I., Hu B.G.Gosine R.G, (1999), Analysis of direct fuzzy PID controller structures, *IEEE Trans on Systems, Man and Cybernetics.* Vo1.29, pp. 371-388.

M. Sugeno, (1985), Industrial applications of fuzzy control, Amsterdam, *The Netherlands: Elsevier*

Hassan B.Kazemian, (2001), Development of an intelligent Fuzzy Controller, *IEEE International Fuzzy Systems Conference.* Vol.1, , pp. 517–520