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Implementation of Process Level Control System

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Abstract: **An automatic control suitable for process level sensing and control was realized using the Ultrasonic sensor. This enabled the entire circuit to function as a threshold detector; thereby working as an ON and OFF switch. The proposed process level sensor was tested in real time application by using it to control the level of water in a tank fed by a single phase 1/2HP pump. Experimental performance results indicated that the device is quite suitable for the desired operation, since it maintained the set maximum and minimum levels of 100 litres and 10 litres respectively, by switching the pump on or off as required.**

Keywords: **Ultrasonic, level control, Automatic, Sensor, Pump, Measurement**

I. INTRODUCTION

Level measurement and control has seen considerable change over the past years – from a mechanical level measurement through to complex electronic sensors using various measuring principles. The large number of various technologies for measuring level (such as hydrostatic, reed chain, magneto resistivity, radar, ultrasound, optical and lots of more) today offers the user the likelihood to choose the foremost suitable sensor technology for his individual application. In continuous level measurement, hydrostatic pressure (also mentioned as hydrostatic level measurement) is that the principal sensor technology and measuring principle, with a market share of roughly 40 %1 by sales volume. Still considerably before ultrasound and radar technologies, hydrostatic sensors for level measurement are installed in additional than every second measuring point.

The typical process plant contains tanks, vessels, and reservoirs. The main function of these containers is to store or process materials. Accurate measurement of the contents of these containers is very vital. Usually the material in the tanks is liquid whose level must be accurately measured. It is with this and more convenience that this project was developed.

A good example of an integrating process is liquid level control, where both the flow rate of liquid into or out of a vessel is constant and therefore the other flow rate varies. If an impact valve is opened during a step-change fashion, liquid level within the vessel ramps at a rate proportional to the difference in flow rates in and out of the vessel. The following illustration shows a typical liquid level-control installation, with a process trend showing the extent response to a step-change in valve position (with the controller in manual mode, for an "open-loop" test):

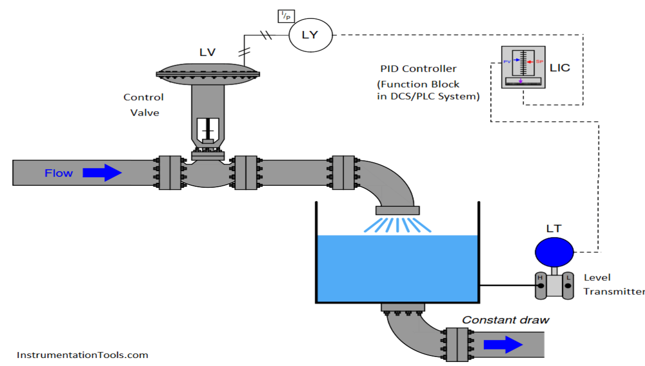

Fig.1.0: Liquid Level Controller

Image source: InstrumentTools.com

Liquid Level Measurement

Regarding the scope of this project work, it is only the techniques of measurement that are practically essential as applied that are going to be discussed.

Ultrasonic Method

An ultrasonic level measurement instrument consists of a transmitter and receiver which can be mounted on top of tank that contains the liquid to be measured. The beam is projected downwards by the transmitter and is reflected back by the surface of the liquid contained within the tank. The beam is received by the receiver. The time taken by the beam may be a measure of the space travelled by the beam. Therefore, the time 't' between transmitting and receiving a pressure pause is proportional to the distance is between the ultrasonic set and surface of the contents of the tank. (http://ecoursesonline.iasri.res.in/mod/resource/view.php?id=147116). This is as illustrated below.

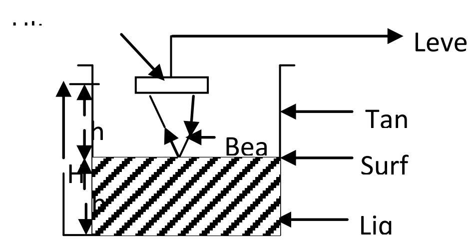

Figure 2: Measurement of Level by Ultrasonic Method

Echo Technique

Another method of measuring liquid level in vessels is to bounce a traveling wave off the surface of the liquid typically from a location at the top of the vessel the time of flight for the waves as an indicator of distance, and therefore an indicator of liquid height inside the vessel. Echo-based level instruments enjoy the distinct advantage of immunity to changes in liquid density, a factor crucial to the accurate celebration of hydra state and displacement level instruments. In this wise, they are quite comparable with float-based level measurement systems.

The single most important factors to the accuracy of an echo-based level instrument is the speed at which the wave travels on-route to the liquid surface and back. This wave propagation speed is as fundamental to the accuracy of an echo-instrument as liquid density is to the accuracy of a hydrostatic or displacer instrument. So long as this velocity is known and stable, good level measurement accuracy is achievable.

Importance of Liquid Level Measurement

Level measurement is vital within the industry because it gives information about the standard of inputs and therefore the finished product available. It enables manufacturers to understand the quantity of varied inputs, chemical, liquid, solid etc available for production and thus to work out how long they're going to operate before the next supply is due. In the petroleum and petrochemical industries, level measurement is vital in sales of crude and finished products.

Also, level measurement is important in waterworks since it allows for automatic control and packaging quantity of water. When liquid is to be sold, its volume is measured in quantity and a tag is attached accordingly.

Objectives of the Study

The overall aim is the design and implementation of a level control system with real time data acquisition and logging via internet of things

The specific objectives of the study are to:

Determine and control the water level of a process control that utilizes water;

Investigate the process of data acquisition and logging;

Remotely measure and control level of liquid in a reservoir.

Significance of the Project

An Automatic Water Level Controller (AWLC) will automatically START the pump set as soon as the water level falls below the predetermined level (usually kept half or 2/3rd tank) and shall SWITCH OFF the pump set as soon as tank is full or water level in the lower tank is at below minimum level.

II. RESEARCH METHODS

The research methodology of this research work entails calculations, component selection and design specification before the actual implementation. The design was divided into the following units for simplicity and efficiency according to the block diagram.

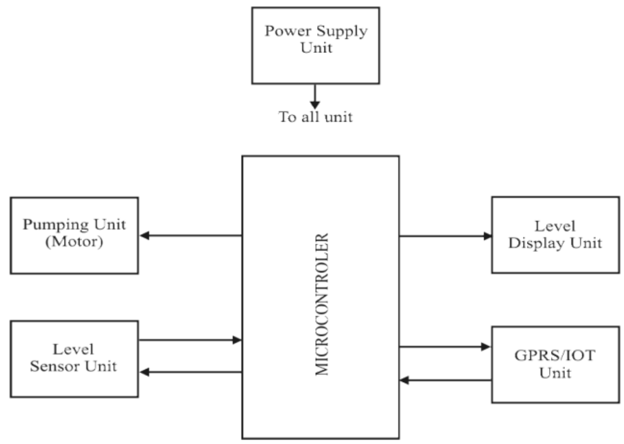

Fig. 3: *Process Level control system interfaced with IOT*

1. *The Pump Unit:* This unit represents the 220V AC Water Pump that lifts the process (water) from the storage tank into the process reservoir.
2. *Level Sensor:* The level sensor is Ultrasonic level sensor, it is a submersible pressure transmitter that has a pressure diaphragm where the inner side of the diaphragm is vented to atmospheric pressure through a vent tube in the cable and the outer side is in contact with the liquid and measuring the static pressure of the liquid column above the transmitter. This static pressure is basically caused by the weight of the fluid on top of the transmitter and is used to calculate the level of the liquid.
3. *Microcontroller:* The microcontroller (PIC16F84) takes the digital signals from the output of the analogue to digital converter (ADC), processes it and displays the value on the display circuit.
4. *The internet of things, or IoT,* is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
5. *Display:* the display used for this design is the liquid crystal display (LCD). It displays whatever has been processed by the micro controller and the display shows when the processes are above or below the set point on the liquid crystal display (LCD).
6. *Power supply unit:* the power supply unit provides the needed voltage for the circuit to operate. Power

supply is basically made up of the transformer, rectification circuit, smoothing circuit and a voltage regulation circuit.

III. SYSTEM DESIGN AND IMPLEMENTATION

A. The Level Sensor Unit

This unit measures the Process (Water) level in the Reservoir. The Requirements of the Level Sensor are:

a. It should be able to measure the process level within the specified range i.e. 0 to 100cm
b. It should be easy to use and requires less biasing components
c. The power requirements should be reasonable
d. It should be cost effective and readily available

e. The US-100 Ultrasonic sensor was used to implement the level sensor. Below are the choices for the selection of the level sensor:

f. Measuring range: 0 to 400cm, which is greater than the required specification (100cm).
g. Easy interface to the Controller and Easy principle of operation.
h. It require 5V DC to operate
i. Cost.
j. Availability.

The US-100 Ultrasonic sensor operates on the principle of transmitting sound wave and receiving the reflected wave when it meets an obstacle or there is a change in density. The sensor has a Transmitter and Receiver section. The transmitter sends the 40 kHz sound wave, when the wave encounters a change in density or an obstacle, it reflects back to the receiver section. The time taken for the wave to transmit and reflect is calculated to get the distance.

The US-100 Ultrasonic modules have FOUR (4) Pins i.e. V_{CC}, Trigger, Echo and GND PIN Respectively. When the Trigger PIN is given High (5V), the module sends the 40 kHz sound wave. When the wave reflects back to the module, the Echo outputs High (5V). The Time it takes for the echo PIN to come High is total duration for the wave travel and reflection.

Below is a mathematical illustration for the ultrasonic level sensor.

This Unit is Directly Connected to the Controller Unit i.e. PIC16F877A Microcontroller through PIN 29 and PIN 30, i.e. the Trigger and Echo PIN Respectively.

The reservoir is cylindrical in shape with the following dimensions:

Diameter: 20cm; Height: 100cm

The Velocity of sound in AIR is approximately: 360m/s

Assuming the Process level in the Reservoir is 50cm

From Velocity = Distance/Time where Distance = 50cm i.e. 0.5m; Velocity = 360m/s

Time = distance/velocity = 0.5/360 = 0.001389 seconds i.e. 1.4ms

But the Time = Time of Transmission + Time of Reflection of the sound wave

Time=1.4/2 = 0.7ms.

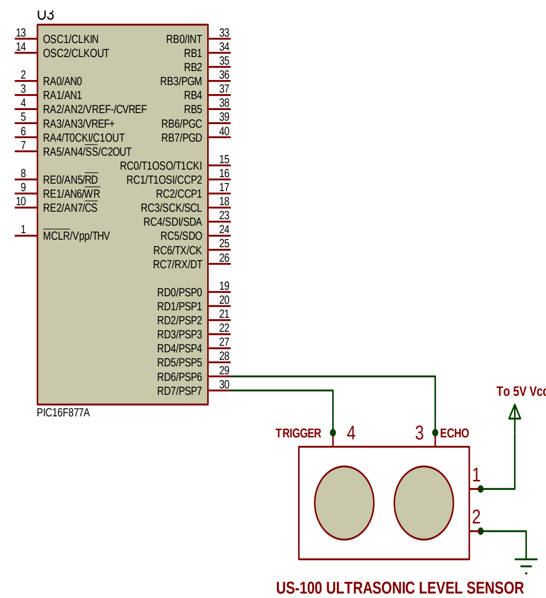

Figure 4: Level Sensor Interface with the Controller unit

B. The Pump And Pump Control Unit

The pump control element was implemented with a 220V AC 1/2hp Water pump. The final control element (FCE) Control unit is switching circuits that assist the Controller unit to switch the Pump ON and OFF. Requirement of the Switching circuit are:

a. It should not be a complex switch circuit.
b. It should be able to Power the Pump.
c. It should be easily controlled by the controller unit i.e. easy connection interface.
d. The components involved should be available and cost effective.

The transistor switching circuit was selected. It was implemented with the Following Components:

a. 12V 30A Relay
b. BC547 NPN Transistor
c. Biasing Resistor

The transistor switching circuit was selected because it meant the above requirements. This Unit is directly controlled by the Microcontroller through PIN 15. Below is the Circuit diagram of the entire Unit.

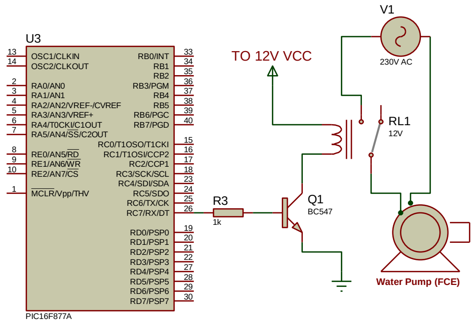

Figure 5: FCE Control Unit

IV. SOFTWARE DESIGN

The programming language used in this project is C. The embedded C program implements the system flowchart. Simply put, it reads in binary patterns from the input subsystems and sends out binary patterns that would cause the required actions to be taken by the output subsystems

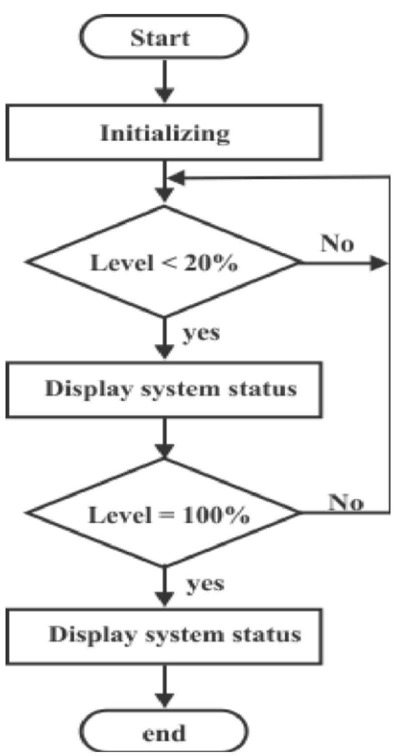

Fig. 6: Flow chart design of fingerprint access control

System Mode of Operation

This is a closed-loop system feedback system because the constant availability, inflow and outflow of liquid content within a tank depends on the operation of the sensor which triggers ON/OFF the pump switch employing a relay. The ultrasonic sensor features a trigger and an echo pin. The sensor is placed at the highest end of the (overhead) tank with its transmitter and receiver faced towards rock bottom of the tank. The ultrasonic sensor reads the space from rock bottom of the tank using ultrasonic wave transmission by the formula (distance = speed * time).

After the sensor is triggered, it sends out sound waves to the surface of the water/liquid content which obstructs the signal at whichever level and echoes back to the sensor. This echo effect enables distance measurement by allowing the Atmega read the echo pin to work out time spent between triggering and receiving of the echo.

To determine the extent of the water within the tank, the total length of the tank must be ascertained. This value would enable us calibrate our tank to suit design specifications.

The microcontroller signals the relay for automatic switching OFF of the pump when water reduces to a low level.

V. CONCLUSION

The control strategy determination is important in process engineering, it'll influence the characteristic and performance of the system. In automatic control learning, it's necessary to instill an understanding of system dynamics, comprehensive control and computational design. During observation activities, it appears that students were better trained in applying the concept of control in case studies, it is expected to be able to support the formation of better motivation, basic knowledge and skills in an integrated manner. Problem solving approach through study groups is additionally important, this is often also a chance to instill the scholar abilities in communicating, team working, and practicing professionalism.

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REFERENCE

[1] Mittal, Yash & Varshney, Aishwary & Aggarwal, Prachi & Matani, Kapil & Mittal, Vinay. (2015). Fingerprint biometric based Access Control and Classroom Attendance Management System. 1-6. 10.1109/INDICON.2015.7443699.

[2] Jack, K.E., Nwangwu, E.O., Etu, I., & Osuagwu, E.U. (2016). Design and Implementation of a Microcontroller-Based Water Level Control System with Seven Segment Display for Domestic and Laboratory Application.

[3] Jwaid Ali E, Clark S. and Ireson G. 2013 Understanding Best Practices in Control Engineering Education Using the Concept of TPACK IEEE Integrated STEM Education Conference 10 Mar. Google Scholar