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Automatic Liquid Level & Temperature Monitoring and Controlling using LABVIEW and ARDUINO

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Abstract: *This paper presents an innovative prototype design for the automated temperature as well as the level monitoring and control of a Liquid tank. Automatic controls play an ever-increasing role in a human way of life. Automatic control is vast technological area with a central aim to develop control strategies that improve performance when they applied to a system. The objective of the project is to design an interactive temperature controller system using a fan and a heater, and the level controller using only pump, in a cost effective manner. Both the Fan Speed and the heater temperature change according to the error signal by implementing the Proportional Control action. The project is implemented using LabVIEW and ARDUINO.*
Keywords: *Automation, Control System, Proportional Control, LabVIEW, Arduino.*

I. Introduction

Nowadays, the demand for accurate control of process variables such as temperature and level has conquered many of industrial domains such as process heat, automotive, industrial places. One of the most important concerns involved in heat area consist in the desired temperature achievement and consumption optimization.

The concept of this paper is to create an Interactive Automatic Temperature as well as liquid level Control System to control the temperature and the level of a tank/liquid container. The circuit maintains the temperature of the system in a particular range. The fan RPM increases with increase in temperature beyond the Upper Set Point (Hot Condition) of temperature and vice versa; whereas the heater temperature increases with the decrease in temperature beyond the Lower Set Point (Cold Condition) of temperature and vice versa. For the level control, if the liquid level reaches beyond the set points, the pump will turn on/off according to the conditions. The temperature sensor used in this project is TMP35, Ultrasonic level sensor used is HCSR04 and the Arduino-Uno (Microcontroller AtMega328) board is used as the controller. The coding is done by LabVIEW2013.

II. Methodology

A. Proportional Control[1]:

The P controller is mostly used in first order processes with single energy storage to stabilize the unstable process. The main usage of the P controller is to decrease the steady state error of the system. The basic mathematical equation of proportional control is given by,

$$mv = K_p e_n + m_i$$

where, mv= manipulated variable, K_p= Proportional Gain Constant, e_n= error input [set point-process variable], m_i= initial bias.

As the proportional gain factor K_p increases, the steady state error of the system decreases. When the proportional gain will increase, it will provide smaller amplitude and phase margin, faster dynamics satisfying wider frequency band and larger sensitivity to the noise. The controller can be used only when the system has a great tolerance to a constant steady state error. In addition, it can be easily concluded that applying P controller decreases the rise time and after a certain value of reduction on the steady state error, increasing K_p only leads to overshoot of the system response. P control also causes oscillation if sufficiently aggressive in the presence of lags and/or dead time. The more lags (higher order), the more problem it leads. Plus, it directly amplifies process noise.

B. Virtual Instrumentation:

As a combination of various technologies and computer technology, virtual instrument [2] has opened up a new era of instrument technology. The basic idea of virtual instrument aims at replacing the traditional electronic instrument and gradually replacing the traditional instrument with the virtual instruments to implement some functions such as the collection, analysis, display and storage of data. According to the software development platform, virtual instrument perfectly integrates the computer hardware resources and instrument hardware. It also combines the strong data-processing capacity of computer, the measurements of instrument hardware and control capacity. Furthermore, the display, storage and analytic processing of data can be implemented through the software, and then the system control and the display of measurement data can be achieved by the interactive graphical interfaces. In addition, various functions are specified through using diagram modules. The peripheral circuit is simple and can be easily realized, which is conducive to hardware maintenance, function extension and software upgrading of the system.

C. System Operation:

1. Temperature Control:

In this project, a GUI will run on LabVIEW2013, that will continuously checking the ARDUINO board for the data (temperature) and the temperature sensor TMP35 [3] will continuously send the temperature to the ARDUINO. In the GUI, it is possible to set the upper set point of the temperature (Hot Condition) as well as the lower set point of the temperature (Cold Condition). If the room temperature increases and crosses the upper limit, an error signal will be generated that will trigger Arduino to turn on the cooling fan, and if the room temperature decreases and get below of the lower limit, it will trigger Arduino to turn on the Heater. Both the Fan Speed and the heater temperature will change according to the deviation of the process variable i.e. Temperature to the set points; thus the acting as a Proportional Controller. In this way, a temperature between the preset ranges can be maintained.

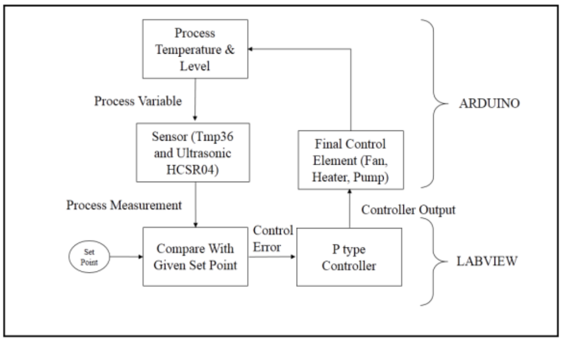
2. Level Control:

In this prototype, the ultrasonic trans-receiver [4] module HCSR04 will detect the level and the data will be processed by LabVIEW to trigger a pump. The Lower Set Point (LSP for tank empty) as well as the Upper Set Point (USP for tank full) of the water level can be altered through the GUI. When the tank height and the position of the sensor will be known to the GUI, it will start operating. Now, the water level can be maintained in two ways-

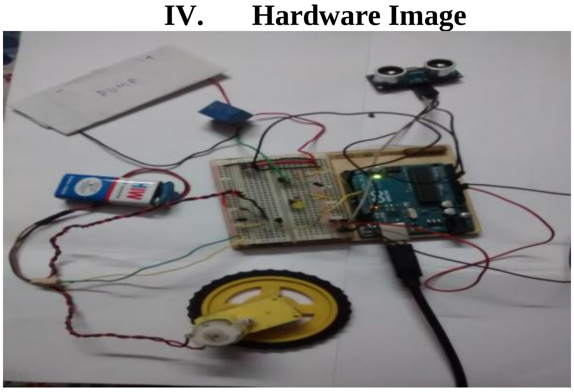
a) The pump will start if the water level is below the LSP and will stop when the level reaches the USP. It will again start only when the tank is empty.

b) The pump will start if the tank is empty and will stop if and only if the level reaches the USP, else if the water level stays in between the USP and LSP, the pump will run (On off Control [5]). This approach is efficient if the water usage rate is high such as in industrial application.

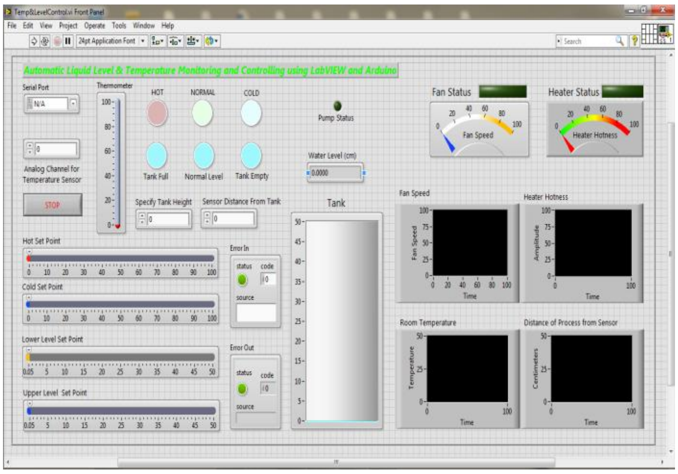
III. Flow Chart



IV. Hardware Image



V. Front Panel



VI. Result

In this paper results of three different conditions are shown. In figure 1 all the process variable that is temperature and level are at normal condition thus all the final control elements that is heater, cooling fan and pump are in off state, thus the system is in stable condition.

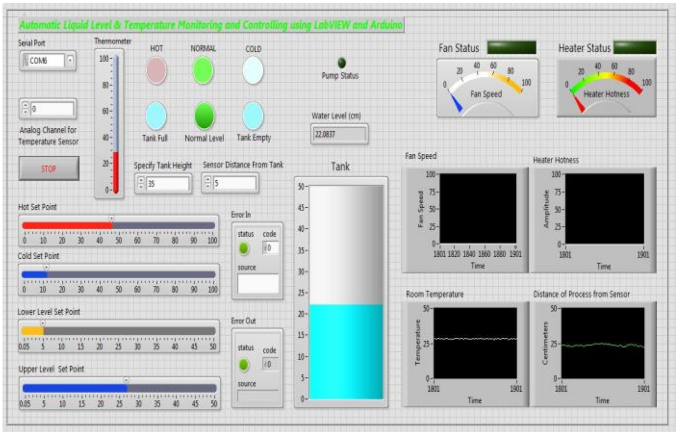


Figure 1: Normal Condition

In figure 2 the temperature is above the upper set point thus system is hot which is indicated by the hot led. This turns the cooling fan on and adjust its speed according to the error. And also the process level is less than lower set point thus making the pump turn on.

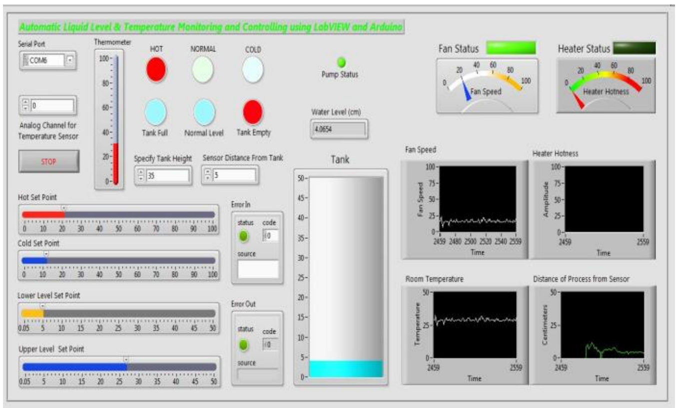


Figure 2: High Temperature and Tank Empty

In the third condition the temperature is below the lower set point thus system is cold which is indicated by cold led. This condition turns the heater on and adjust its hotness according to the error. Also the process level is greater than upper set point which makes pump turn off.

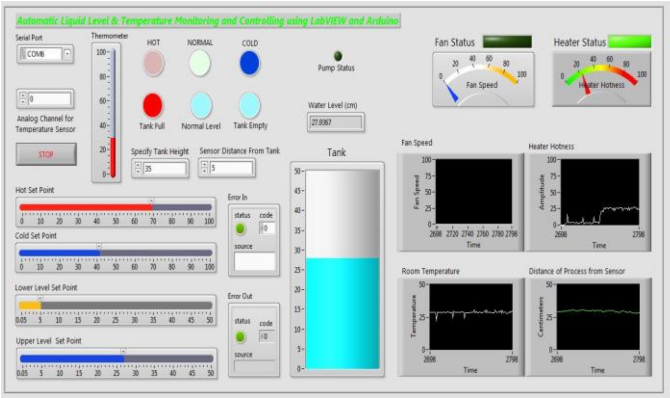


Figure 3: Low Temperature and Tank Full

VII. Advantages

- The best part of this project is its simplicity and easy programming.
- The interfacing of LabVIEW with Arduino opens a new door of interactive and easy GUI programming and a better controlling.
- The P Control action makes the system easy and simple.
- All the data can also be stored in an easy to access database for the further reference use and system analysis.
- The temperature sensor (TMP36) and the ultrasonic sensor (HCSR04) for this project are carefully chosen in a cost effective manner with a high degree of precision. The hardware's used in this project are also cost effective and easy to use.

VIII. Applications

This Interactive Automated Temperature and level Controller can be used in any plant or industry where the précised and stable temperature and/or level control is highly required. It can be used in Room temperature control as well as household applications also. As the data can be logged for further analysis or reference, this system can be used in the field of Artificial Intelligence [6].

IX. Future Scopes

The prototype is developed for the initial testing purpose only using P control for simplicity and fast response. As such, many improvements can be made upon this initial design. To improve the accuracy and reduce the response time, the system can be implemented using PID control [7]. The design can be again modified to adaptive controller [8] for the modification of the temperature range according to the need, thus making it completely autonomous.

Using the Virtual Instrumentation can completely replace the traditional controllers with virtual instruments. It turns out to be that using technologically advanced virtual instrument technology to replace traditional measuring and testing technology is not only feasible, but also better and more systemically stable.
Again, this system can be fuzzified [9] to make it more efficient and increase controllability and can be used in the field of Artificial Intelligence.

X. Conclusion

With virtual instrument being the platform and the shortcomings of traditional temperature control system, this paper combines graphical programming language LabVIEW [10] and the basic principles of P controller to conduct liquid level and temperature control of a system. The virtual instrument technology inherits the advantages of traditional instrument and avoids the shortcomings. Users can change and redefine the functions of the instrument based on their own needs.

In this paper, the liquid level and temperature control system is designed in LabVIEW with Proportional (P) controller. With the controller, the system controlled the liquid level and temperature successfully. In this case, the P controller showed accurate in a system control as the result.

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