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LabVIEW based Level Monitoring using IoT

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Abstract

This paper presents a novel approach to level monitoring using Internet of Things (IoT) technology, specifically focusing on the application of LabVIEW software. The proposed system leverages the power of logical controllers like PID, Fuzzy logic and IMC..., thereby replacing traditional physical instruments with virtual counterparts. The system inputs, namely the liquid level and outflow rate, are obtained via the MyRIO from the tank level sensor DPT and flow rate sensor respectively. These inputs are analyzed on LabVIEW, and the resulting decisions are transferred to the MyRIO, which manipulates the actuator. The system demonstrates promising performance in simulations, and hardware experimentation validates the feasibility of controlling a MyRIO, using LabVIEW. This research contributes to the growing field of IoT-based monitoring systems, offering a reliable and efficient solution for level monitoring.

Keywords: LabVIEW, MyRio, Level Monitoring, PID controller, IoT, MATLAB.

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1. Introduction

In recent years, the fusion of Internet of Things (IoT) technologies with a multitude of applications has transformed the methodologies for system monitoring and control. One such application is the surveillance and regulation of levels in industrial operations, where precise and real-time data is vital for sustaining operational productivity and guaranteeing safety. This paper introduces a LabVIEW-based level monitoring system utilizing IoT, amalgamating the capabilities of LabVIEW for data procurement and analysis with the connectivity and remote access features of IoT.

The proposed system exploits LabVIEW, a robust graphical programming environment extensively employed for measurement and automation applications, to devise a comprehensive solution for level monitoring. LabVIEW furnishes an intuitive and user-friendly interface for the design and implementation of monitoring systems, making it an optimal platform for this project.

By incorporating LabVIEW with IoT technologies, the system facilitates remote monitoring, data logging, and real-time alerts for level measurements, thereby augmenting the efficiency and convenience of level monitoring procedures. The IoT component of the system enables uninterrupted connectivity between the level monitoring devices and the central monitoring station. Utilizing IoT protocols and communication standards, the level data gathered from sensors can be securely and efficiently transmitted to a cloud-based platform or a local server. This facilitates centralized data management, remote access, and real-time visualization of level measurements, providing operators and stakeholders with invaluable insights and enabling immediate actions based on the monitored data.

The LabVIEW-based level monitoring system using IoT holds significant potential for various industries, including manufacturing, chemical processing, water treatment, and more. By implementing this system, operators can benefit from real-time level data, proactive monitoring, and enhanced decision-making capabilities. The IoT connectivity ensures that critical level information is accessible from anywhere, enabling remote monitoring and control, reducing downtime, and optimizing resource allocation. In conclusion, this paper introduces a LabVIEW-based level monitoring system using IoT, merging the versatility of LabVIEW with the connectivity and remote access features of IoT.

The integration of LabVIEW and IoT technologies provides a comprehensive solution for level monitoring, allowing for real-time data acquisition, centralized data management, and remote access to level measurements. The proposed system has the potential to significantly enhance efficiency, safety, and decision-making in various industrial processes that rely on accurate and timely level monitoring..

2. Existing System

2.1. Controller

For effective regulation of a level process, a level transmitter or sensor necessitates significant user intervention. A level control system incorporates a controller that receives information from the level transmitter for this purpose. The controller generates an output to a control valve after juxtaposing the set point, also referred to as the intended control level, with the actual level.

When selecting a controller, it is essential to consider factors such as the type and level range of the input sensor (level transmitter). The utilization of proportional, on/off, or PID control algorithms is necessary. Once the model has been established, control methods are indispensable to maintain the process in a steady state.

2.2. Drawback of this system

Instrumentation engineers bear the responsibility of overseeing and managing numerous operations within the existing system. The intricacies of text-based programming in contemporary technology pose challenges in exhibiting real-time simulation and identifying and rectifying issues. The LabVIEW software emerges as a solution to these challenges, accelerating and simplifying processes. Level control measures typically involve a progressive cooling process, implying that the power of the Control valve must be diminished or completely turned off when the water level decreases.

3. Methodology

Water level control is the process of measuring or detecting changes in water level as well as altering the amount of energy entering or leaving the water to obtain the desired level in the process tank. The PID algorithm is used to control the level in the process. It consists of water supply tank (sump), pumps, level transmitter, transparent level tank, rotameter, pneumatic control valve, I/P converter and interfacing unit. It also senses the current signal and sends it to the display box. The current to pressure converter converts the current signal (4-20mA) to pressure signal (3-15psi). The control valve is used to adjust the flow. The purpose of Level Transmitter is to sense the level and produce an output current. One component of this strategy is the use of LabVIEW software, which has improved features that allow ongoing process monitoring even after the process variable reaches the set point. When the process variable varies, the parameters automatically adapt to the new conditions, resulting in the desired result. The IOT module will be connected to the microcontroller for the real time monitoring purpose.

3.1. Need for this work

In today's market, real-time monitoring, simple control over multiple variables, and prompt defect detection and correction are essential. The cooling process takes time, so the system needs to be sped up.

3.2. Design of PID Controller

A PID controller is majorly used in industry where heating and cooling processes are controlled like fluid level monitoring and control, flow control etc. Defining Set point and Process variable is considered to be the primary parameter for control. A process variable is the one which needs to be controlled and set point is the desired value for the parameter, you are controlling. A PID controller is an instrument used in industrial control applications to regulate temperature, flow, pressure, speed and other process variables. PID (proportional-integral-derivative) controllers use a control loop feedback mechanism to control the process variables and it is the most accurate and controller show in fig 1. PID controllers have three modes of control:

1. Proportional (P) Control
2. Integral (1) Control
3. Derivative (D) Control

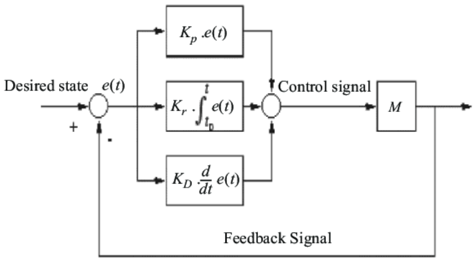


Figure.1. Block Diagram of PID Controller

3.3. PID controller Tuning

A PID controller is considered to be a traditional one it is used in many of the process industries. The representation or the implementation of the process may vary, but the performance of it is still continuing by providing its efficiency. PID control is used at the lowest level; the multivariable controller gives the set points to the controllers at the lower level. The PID controller can thus be said to be the "bread and butter" of control engineering. It is an important component in every control engineer's tool box. For PID controller, there are thousands of tuning methods available and for this process model Ziegler Nichol's, Tyreus Luyben, Internal Model Control and Genetic Algorithm are done.

3.3.1. By Ziegler Nichol’s Method

It is introduced in 1940's which made a big impact among the control engineers regarding the control of a process using PID technology. Ziegler Nichol's is a kind of technique which provides the improved performance, ease of use, low cost. Even though, it is widely used due to the stability concern engineers used it reluctantly. It is a heuristic tuning rule which attempts to provide the efficient values for the process containing PID controller. Using ZN method, PID loops are used for practical applications to improvise performance. This method requires Ku (ultimate gain) and Pu (ultimate time period). To find the values bode and root locus are needed, which can be found by coding in an M-File. It provides a table to find K_p, K_i and K_d values by substituting the determined Ku and Pu values form the table 1

Table.1. Formulae for Ziegler Nichol

Control Modes	K_P	T_I	T_D
P	1/K (τ/α)	-	-
PI	0.91/K (τ/α)	3.33α	-
PID	1.2/K (τ/α)	2.0	0.5

4. Mathematical Model of the Process Tank

Liquid or fluid is supplied from a supply tank or main tank via a pump, with the flow rate being modulated by an actuator or control valve. The supply tank or main tank liquid level is gauged through a pressure transmitter, which conveys the differential pressure signal (4-20mA) to the controller. The system's mathematical model is encapsulated by a first-order system.

(In general): Ratio of accumulation of mass in system = Ratio of mass entering system – Ratio of mass leaving system

$$\frac{d(\rho Ah)}{dt} = \rho \mathrm{Qin} - pQout$$

For first order transfer function for the process control system is defined as:

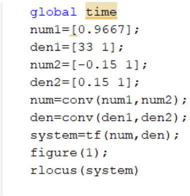
(In general): $\frac{H(s)}{Q(s)} = \frac{R}{[\tau s + 1]}$

(For Level process): $\frac{H(s)}{Q(s)} = \frac{1.86}{[52s+1]} * \frac{-2.5s+1}{2.5s+1}$

Where:

1. R: Resistance of flow
2. τ_s: Time constant
3. e^{-dt}: Death time

4.1. MATLAB Coding



```
global time
num1=[0.9667];
den1=[33 1];
num2=[-0.15 1];
den2=[0.15 1];
num=conv(num1,num2);
den=conv(den1,den2);
system=tf(num,den);
figure(1);
rlocus(system)
```

Figure.2. MATLAB Coding

The figures 2 shows the coding used to get $K_{u\ value}$ and Frequency(ω) from the Root locus.

4.2. PID Values from ZN Method

By using the transfer function, obtain Ku values in using MATLAB software and using of formula from the table 1 to calculate the optimal values of PID controller using of ZN method. The values are inserted in the table 2.

Table.2. Formulae for Ziegler Nichol

Control Modes	K_P	T_I	T_D
P	23.97	-	-
PI	21.97	1.63	-
PID	28.76	3.59	57.53

$P_u = 2\Pi/\omega$. And $P_u = 14.17$.

4.3. Internet of Things

The term "Internet of Things" (IoT) describes a network of actual physical objects, including cars, appliances, and other items, that have sensors, software, and network connectivity built into them. These systems continuously monitor temperature levels by utilizing real-time sensors that are integrated inside the surroundings. Cloud computing is used to transmit the data that these sensors have gathered to a centralized monitoring platform.

IoT level Control System Components: The Thing Speak web portal is utilized in the process of monitoring level. To obtain the data, the MyRio and IOT module are connected. How It Operates: To maintain a constant temperature range, establish a level setpoint and hysteresis. Make a LABVIEW VI and add parts to read Thing Speak palette data. Configure the Thing

Speak connection by entering the channel ID and API key. Connect the output Data from the IOT device to the input of the VI. Run the VI and the data to be monitor will be sent to the application.

5. Hardware Implementation

Hardware implementation consists of having close loop-controlled system like fig 3 show. The main component of level process control is, Level tank with measurements, Controller or MyRIO, Control valve and converters for signal converting process.

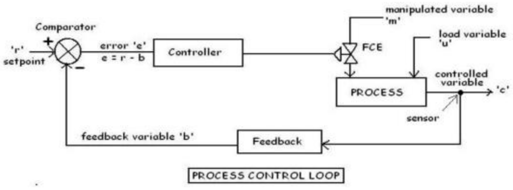


Figure.3. Block Diagram of Level Process Control

By using of fig 3, the level transmitter as using of differential pressure transmitter which using of differential pressure in tank pressure and atmosphere pressure, MyRIO kit act like controller which hold controller algorithm and data acquiring from sensors and transducer and Final control elements as control valve which an actuator to control the inflow and outflow of the level process control.

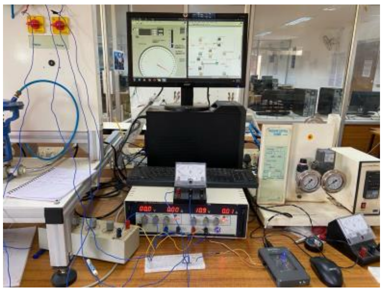


Figure.4. Real-Time Implementation of Level Process.

The fig 4 show the implementation and hardware setup of the process station and which is directly connected to PC for digital processing of real time data.

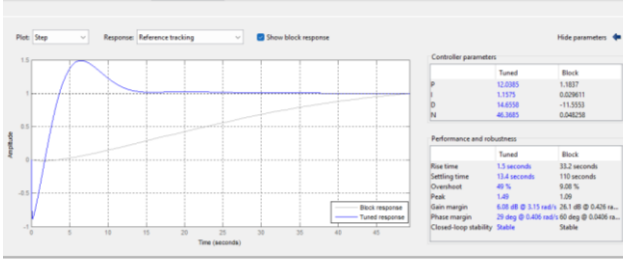
6. Results

The outcomes of the IoT-integrated, LabVIEW-based level monitoring system are detailed herein. The system was deployed and assessed in an authentic industrial setting to gauge its efficacy and performance in level monitoring. Real-time Level Monitoring: The LabVIEW-based system proficiently accomplished real-time tracking of level measurements from an array of sensors. The system exhibited precise and current data on the level status, enabling operators to supervise the levels in real-time. Data Visualization: The potent visualization tools of LabVIEW were harnessed to construct graphical interfaces and dashboards for visualizing level data.

The system offered lucid and informative displays of level measurements, facilitating easy interpretation of information by operators. Remote Access and Control: The incorporation of IoT technologies facilitated remote access to the level monitoring system.

Authorized personnel could monitor and regulate the level measurements from any location using web-based interfaces or mobile applications. The system guaranteed secure access and permitted remote adjustments or receipt of notifications/alerts based on specific level thresholds. System Integration and Scalability: The LabVIEW-based level monitoring system was successfully amalgamated with pre-existing industrial control systems, thereby augmenting the overall monitoring capabilities.

The system exhibited scalability by accommodating the addition of more sensors and the expansion to monitor multiple locations or processes. Performance Evaluation: The performance of the LabVIEW-based level monitoring system was appraised based on several metrics, including the accuracy of level measurements, response time, system reliability, and the user-friendliness of the interface. The system met the desired performance criteria and provided reliable and accurate level monitoring result are show in fig show in 5 and 6.



Plot: Step

Response: Reference tracking

☑ Show block response

Controller parameters

	Tuned	Block
P	12.0385	1.1837
I	1.1575	0.029611
D	14.6558	-11.5553
N	46.3685	0.048258

Performance and robustness

	Tuned	Block
Rise time	1.5 seconds	33.2 seconds
Settling time	13.4 seconds	110 seconds
Overshoot	49 %	9.08 %
Peak	1.49	1.09
Gain margin	6.08 dB @ 3.15 rad/s	26.1 dB @ 0.426 ra...
Phase margin	29 deg @ 0.406 rad/s	60 deg @ 0.0406 ra...
Closed-loop stability	Stable	Stable

Figure.5. Output Response of the PID Controller

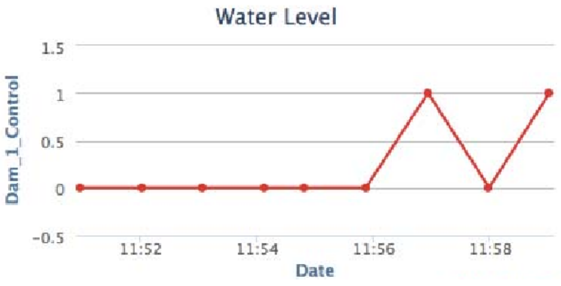


Figure.6. Command Center to Cloud

7. Conclusion

The deployment of the IoT-integrated, LabVIEW-based level monitoring system in an industrial environment has demonstrated its substantial efficacy and robust performance. The system’s capability for real-time level monitoring has proven to be precise, providing operators with up-to-date information essential for effective supervision. The utilization of LabVIEW’s advanced visualization tools has resulted in the creation of intuitive graphical interfaces, significantly enhancing data interpretation and decision-making processes. Moreover, the integration of IoT technologies has revolutionized the accessibility of the monitoring system, enabling remote oversight and control. This feature not only adds convenience but also ensures operational continuity by allowing prompt responses to threshold-based alerts. The system’s seamless integration with existing industrial control systems and its inherent scalability underscore its adaptability and potential for broader application across various monitoring scenarios. The comprehensive performance evaluation of the system underscores its reliability and accuracy in level measurements, coupled with a user-friendly interface that facilitates ease of use. Overall, the LabVIEW-based level monitoring system stands as a testament to the advancements in industrial monitoring solutions, offering a scalable, accurate, and remotely accessible option that aligns with the evolving needs of modern industries.

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