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Design of water tank PID control system through lab view-based simulation

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Abstract:
A PID control algorithm is proposed to design of water tank PID control system through lab view-based simulation to control the water tank on the industrial level for many production processes. Firstly, by constructing a water tank liquid control system. Some mathematical model for water tank was deduced and built through many experiments. The simulation was carried out by LABVIEW software; through LABVIEW-based simulations, the results were analyzed, and easy to control/monitor the water level inside a water tank. The usage of LABVIEW software was mainly objective for maintaining the water level and monitoring according to the demand of industrial use. The USB-2815 data acquisition card was used for the experimental hardware and software connection. The actual results of a water level were obtained through experiments. The combination of software and hardware results showed, that the system can keep the water level in the industrial tank by set value, demand value, and peak value. Using the lab view software can quickly achieve the proper demand, which is visualized on a computer display and has many options of control to check and balance the water tank level.
Key Word: *water tank; sensors; interface; level gauge; output valve; Lab View simulation; graphic results.*

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I. Introduction

Industrial control and monitoring have become increasingly critical in this modern world and advanced technology development. Every industry has become more and more automated than before to sustain reliability and have a quality production process (1,2) in every industrial sector, such as the textile and power sectors (3). We know well that, water tanks play a preeminent role and need to keep this part in the industry very perfect and applicable. We also know that water tank construction materials are not transparent and also have a compact shape. Due to this fact, we can't see the water tank from the outside, how much water have inside, and how much needs to fill or throughout the water tank. So, by having a proper and reliable system. We can control the water level inside the tank from outside through a computer system using LABVIEW software (4). In previous studies, the water tank was owned by many methods, but all methods were not too secure and reliable—an Arduino-based water tank control system through MATLAB software(5,6). Many approaches are helpful in monitoring and controlling industrial processes, such as PLC, SCADA, wireless sensor network (WSN), and the IoT (7). Much industrial control and automation processes are controlled by the microcontroller, Arduino, ZigBee, and electronic circuits, but those are not too reliable for small industries (8,9). Very high-cost needs very complex programming and strict maintenance. In the current study, we used the sensors and then designed a lab view software program to control and monitor easily using USB-2815. Simulation helps visualize the water level and can handle from the remote site, which can be displayed on a computer screen. These sensors are connected to USB-2815 where sensors act as the input signal to the USB-2815.The method of coding is almost the same, but added a digital and advanced graphical user interface. Using this minimum coding information helps to deploy the solutions. One is the upper value and the other one is a lower valve, which shows the controlling process of water tank level and also added another stand by controlling process which helps to visualize every condition of the water tank in the form of gauge, waveform graph, and digital meter.USB-2815 interface alone is enough for this process. But to see the inner state of the water tank. The LABVIEW is very necessary to achieve the water tank level system controller design and control water flow.

II. Background

It is recently necessary to keep different kinds of tanks in industries, apartments, and high-rise buildings to use water and store it. We know well that water is pumped from the ground to a high level. It is not easy to manually check the water level and switch the ON and OFF pump to control and monitor the water level, which can be showed the upper and lower level(10,11). Sometimes it leads to the wastage of water and flow of water.

Some further drawbacks of manually controlling of water level inside the tank are given as follows:
(1) Personal mistakes.
(2) Much more chances of error.
(3) To see the water level manually and then deciding to close or open the valve wastes much more time.

So, to avoid all these disadvantages develop an automatic water control system, which can control and monitor the level of the water tank by sensors. It increased the accuracy of the system. We can generate a signal which is directed toward the controller USB-2815 interface by designing a lab view modernly programmed. This process's advantages are making the system reliable, quick to control, accurate, and available in the market at an economical cost. It is costly in some places, but its reliability and stability stand over the expenses. Figure no 1, contains a water level tank which has separated by an upper tank and a lower tank. The water tank has a pump connected with a water tank and also fixed with sensors that sense the depth of water, which is reported by the USB-2815 interface(12). The tank has been identified in two portions one is maxed level, and the other one is the minimum level. USB-2815 is interfaced with the LABVIEW. We classified the water level into three parts one is set to point, peak value, and liquid control valve. When the switch is on, water flows from lower to high value. In the simulation, we can see the different values in the form of graphs, scales, and gauges. Lab VIEW can sense data through the USB-2815 board and easily control water flow by switching on and off. The Lab VIEW is for visualization.

A. USB-2815 Controller

In the fields of Real-time Signal Processing, Digital Image Processing, and others, high-speed and high-precision data acquisition modules are demanded. ART USB2815 data acquisition module, which brings in advantages of similar products that are produced in China and other countries, is convenient for use, high cost, and stable performance. ART USB2815 is a data acquisition module based on a USB bus. It can be directly inserted into a USB interface to constitute the laboratory, product quality testing center, and systems for different areas of data acquisition, waveform analysis, and processing. It may also comprise the monitoring system for the industrial production process.

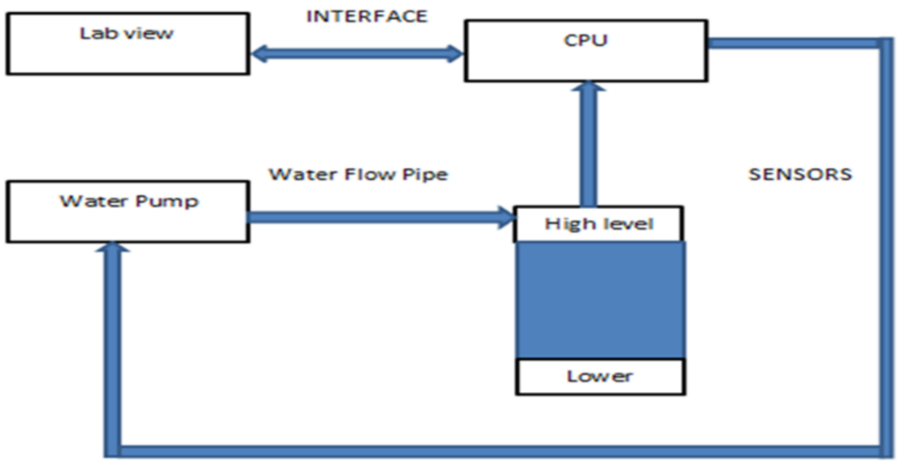

Figure no 1: A Block Diagram of Automatic Water Level Controller

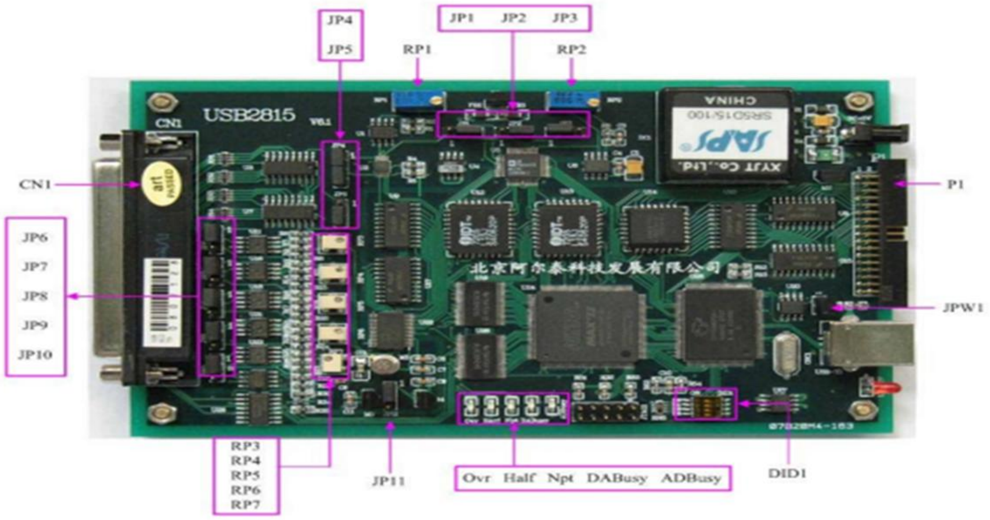

Figure no 2: Main Component Layout Diagram of USB-2815

In Figure no 2. Contain the complete layout diagram of USB-2815. All the functions of USB-2815 are given below. Signal Input and Output Connectors

CN1: analog signal input and output connector P1: digital signal input and output connector.

B. Potentiometer

RP1: Analog signal input zero-point adjustment potentiometer RP2: Analog signal input full-scale adjustment potentiometer RP3: DA0 analog signal output full-scale adjustment potentiometer RP4: DA1 analog signal output full-scale adjustment potentiometer RP5: DA2 analog signal output full-scale adjustment potentiometer RP6: DA3 analog signal output full-scale adjustment potentiometer RP7: DA analog signal output zero-point adjustment potentiometer.

Jumper: JP1, JP2, and JP3: Analog signal input range setting.

C. Jumper

JP1, JP2, and JP3: Analog signal input range setting.

D. Sensors

Figure no 3: WL705 Ultrasonic Water Level Sensor

Figure no 3, indicates the WL705 ultrasonic water level sensors, which can sense the water level in the tank. These sensors can measure the water level of about 2cm-8m. Used the latest ultrasonic distance measuring technology for accurate non-contact water level monitoring. The sensor contains a rugged transducer in a stainless-steel housing for long life. Which generates a signal, sends it to USB-2815, and finally converts it into an electrical signal in the form graph. By which we can control the water inlet valve and outlet valve.

III. Algorithm and Flow Chart

1. Interfacing Lab VIEW with USB-2815 and checking the sensor and water pump compatibility.
2. A sensor measures the water depth and measures it in centimeters to meters.
3. We divided the whole design into three parts, liquid control valve, set point, and the last one is peak value output.

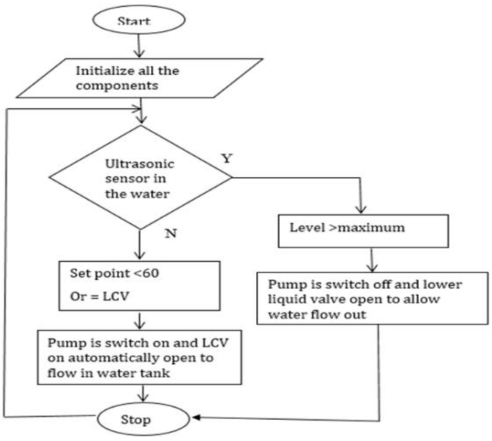

Figure no 4: A flow Diagram of the Proposal System

IV. Code Implementation in LABVIEW

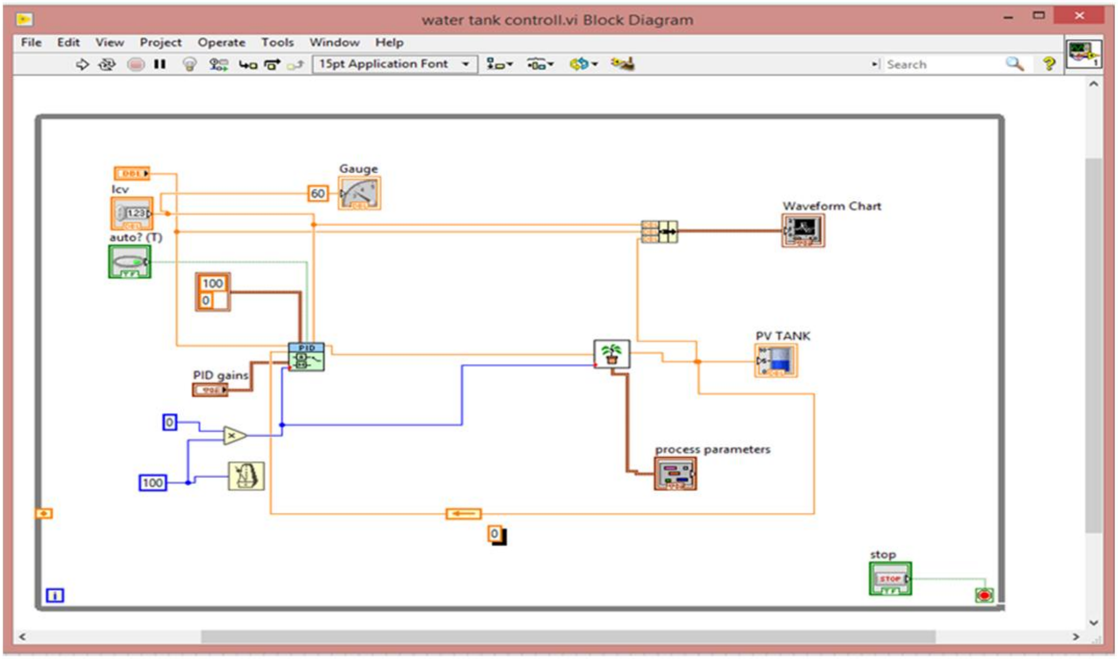

Figure no 5: A lab view Code in True Condition

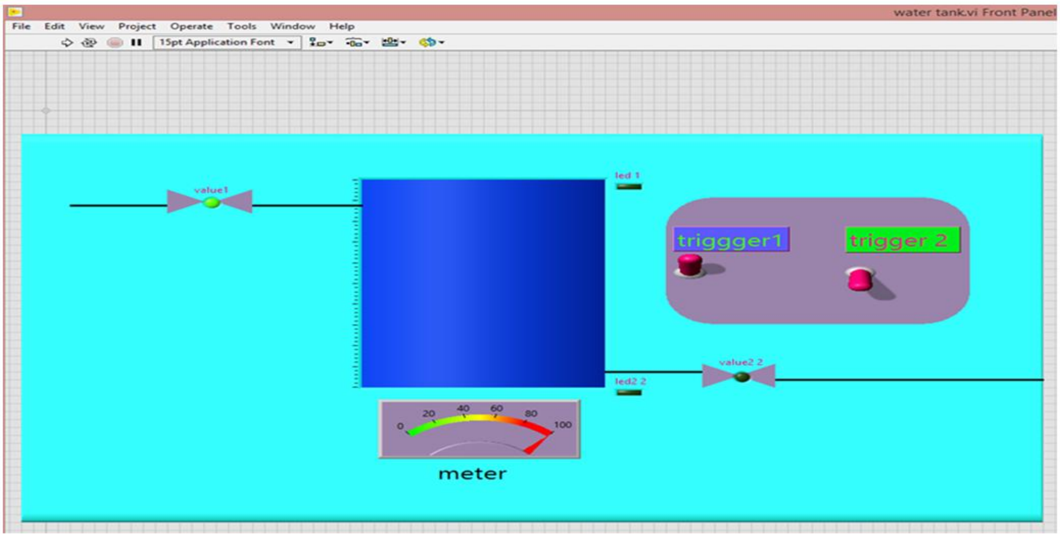

Figure no 6: Simple Lab view Diagram for Water Level

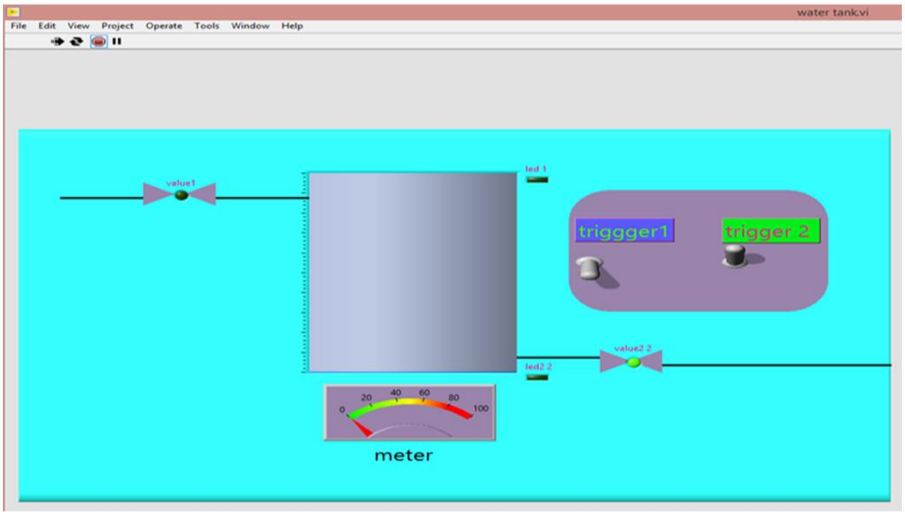

Figure no 6a: A lab view Simulation of Water Level Second Condition

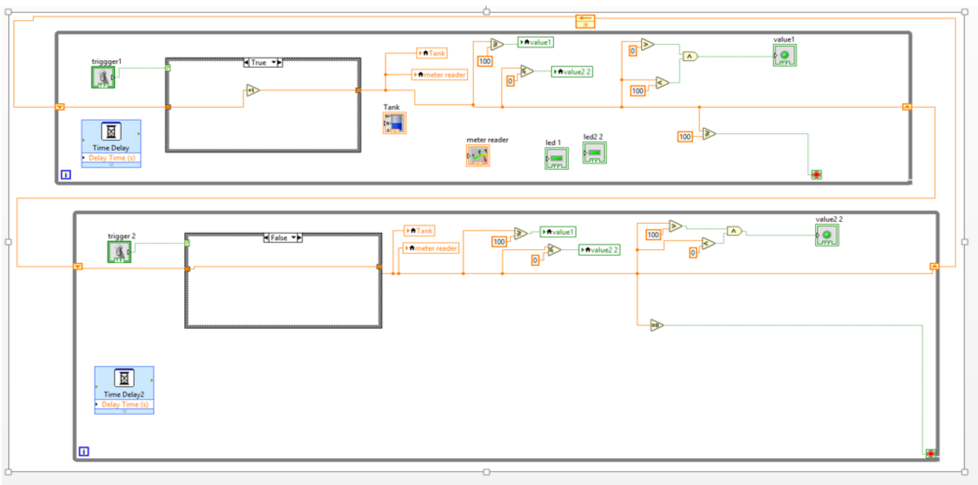

Figure 6b: A simple Lab view Code in the First Condition

Figures no 6, 6a, and 6b shows the simple results of water tank control simulations, which contain a water tank, two control valves, a gauge, and two triggers. When we want to fill the water tank, we should open the inlet valve and click the trigger. Once the water reaches its required value, trigger one closed automatically and then open trigger two to let the water outside for industrial use or another. The gauge also indicates the numerical value of water. The whole process is shown in the above programming.

V. Results

A. When the water level in the tank is the low pump is switched ON, and the LCV is also open.

The water level in the tank is divided into two portions. One is the upper portion, and the lower portion is 100cm and 30cm, respectively. The LABVIEW program is also classified into three parts: peak value, set point, and peak value output. The water level measured by the WL705 ultrasonic sensor is 25cm, which indicates the water level in the tank is below from set point value of the tank, and the pump is switched on automatically and allows to open the liquid control valve to let the water in automatically (13).

Figure no 7: Advance LABVIEW diagram for Water Level Condition

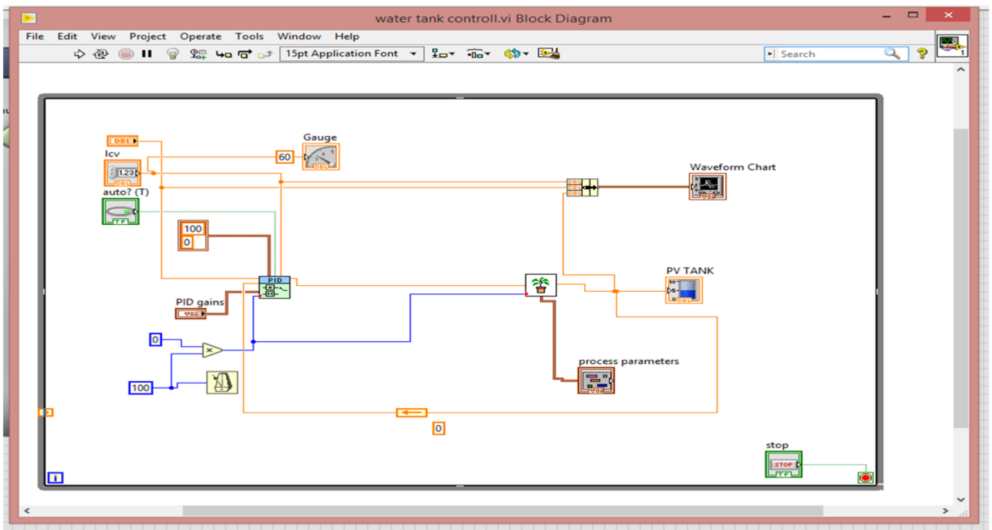

Figure no 7a: A lab view Code in actual Condition

B. Water reaches a set point value or predetermined level

In figures no 7,7a, *water reaches a set point value or predetermined level*, i.e., till the water level tank fills will be in ON condition. The water level measured by the WL705 ultrasonic sensor implies that the set point and liquid control valve are already fixed at 60cm, so the upper tank is not filled. So, the fluid control valve and pump remain in ON condition, and water still flows from the lower valve for industrial use.

Figure no 8: Advance Lab view Diagram for the Second Condition

C. when water reaches the set point value, the liquid control valve or pump switches off automatically.
In figure 8,8a water level measured by WL 705 ultrasonic sensor is 60cm implies that reaching above 60cm means the water level becomes above the demand value and near filling the whole tank, which has chosen almost 100cm. In this condition, the pump switched OFF automatically and closed the upper liquid control valve.

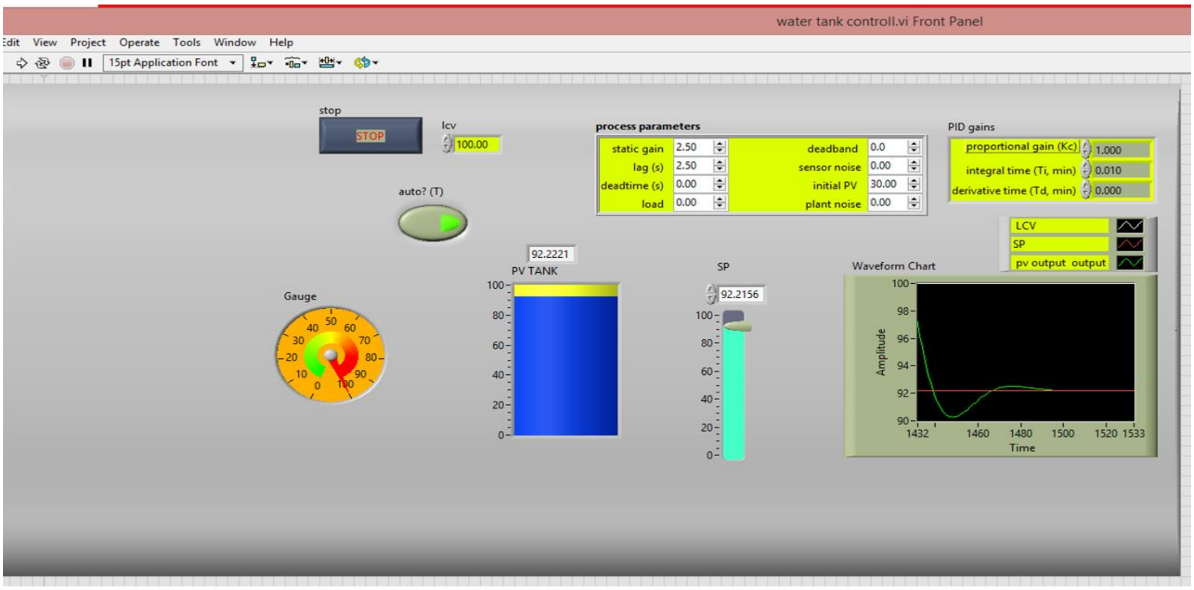

Figure no 8a: Advance lab view diagram for the third condition

VI. Major applications of using LABVIEW software

It provides a graphical or visual interface. Even users with less coding information can program and deploy test solutions. The coding process is also easy. More complex functions can easily code. Have flexibility and stability. More reliable and maintainable and can be used for a long time. It can be used in various platforms like Microsoft Windows, multiple LINUX, UNIX, and MAC OS.
Implementing LABVIEW software in this paper's leading role is to minimize the water wastage, energy consumption, and maintenance and monitor the water level automatically from the remote site.

A. Main advantages

The advantages of LABVIEW software are not limited but nowadays to an irrigation system in agriculture, industries, apartments, buildings, complexes, colleges, etc., to monitor and control the water level in the tank automatically.

VII. DISCUSSION

The simulation of the proposed design is carried out in LABVIEW. USB-2815 is used as a controller to process data. WL705 ultrasonic water level sensors detect the tank's water level intensity, which will result in a maximum out voltage of 5 volts at the USB-2815 analog pin. So the sensors sense monitoring data, the controller process it, display it on the computer screen, and take necessary control action if there is variation in water inside the water tank. Along with all these, an alert system USB-2815 is integrated, which will notify remotely available concerned in uncertain situations.

In previous studies, too much work was done on this project. Arduino was used as an interface to control the water tank level. The design of (Microcontrollers, Microprocessors) and their wide use in control systems have more significant changes in the control system. In certain industry branches, the liquid level control problem is often encountered. The nature of the liquid, the friction of the control mechanism, and other factors make the system nonlinear. Nowadays, the best-known industrial process controller is the PID controller because of its simplicity, robustness, and high reliability. It can be easily implemented on any processor, but using a PID controller is not entirely convenient when dealing with nonlinear systems.

But these systems can be successfully controlled using fuzzy logic controllers because of their independence from the mathematical model of the system. The ultrasonic sensor is connected to Arduino, where the sensor acts as an input signal to the Arduino. This Arduino reports the water level in the tank as it collects the reading from the sensor. This method also used LABVIEW software for graphical design. Many approaches are helpful in monitoring and controlling industrial processes, such as PLC, SCADA, wireless sensor network (WSN), and the IoT.

In figures no 6a, 6b, and 6c, all the results indicated the old methods of lab view interface, which could be connected with Arduino, micro controllers but also used the ultrasonic sensors(14,15), which can measure the depth and over the tank level of water inside the water tank(16,17). But some errors can appear in those methods, which affect the whole system.

In the current study LAB, VIEW software was used for the water tank control system with a new device called USB-2815, which is more reliable and can fix in large industrial plants to control the water tank level, boilers, and oil tank levels. Using the new interface device, the results are meaningful and include the latest digital visual designs, which helped in unique data collection. Due to the fast response of the USB-2815 interface, the ultrasonic sensors produce a signal and pass it to that interface to control it easily.

Figure no 7,7a, 8,8a indicated the final results through experiments. The simulations showed that all the accurate and correct data appeared on the computer screen during three experiments. It is effortless for the reader to control it quickly, avoid the whole system from any damage, and keep the system secure and advantageous.

VII. Conclusion

In the current study, a non-contact water level monitoring system is designed using LABVIEW and USB-2815, where the water level in the tank is monitored and controlled according to the pump or liquid control valve attached to the water tank closes automatically. This study overcomes the disadvantages of those sensors that can be affected very quickly by some chemicals.

The hence ultrasonic sensor provides a non-contact water level for measurement. The main objective of this study is that it can be implemented practically in any field to reduce the wastage of water and energy consumption and easily control the water level with a robust automation system.

This can be improved in the future by using an ultrasonic sensor in the tank, which is connected to a computer and USB-2815 interface. The programing software designed for this system is LABVIEW, which helps visually monitor and control water levels.

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Conflict of Interest

The authors declare that they have no competing interests.

Consist for Publication

All the authors agree to publish this paper.

Data Availability Statement
All processed data used in this study are included in the article.
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