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Automatic Water Level Control With Dry Run Protection of Pump

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***Abstract*—** Water Level Measurement & Control forms an important part of any process in the industries as well as domestic purposes. It is generally observed that the measurement and control of liquid level is done either with the help of various continuous control strategies employing Proportional-Integral(PI)/Proportional-Integral-Derivative(PID) Controller in many plants where as in many other applications discrete control of pump starting and stopping is done for both for industrial & domestic purposes. Here in this particular work we propose a automatic liquid level monitoring & modified control strategy in the control algorithm which helps the pump not to operate when there is no water in the underground tank thus preventing the dry run of the pump helping in conservation of energy, preventing water wastage as well as protecting the pump from operating under dry run condition by switching the pump off. The system designed uses Arduino UNO as the Microcontroller board actuating the control action via a relay circuit to turn on or off a operating Dc pump as a prototype model.

***Keywords*—** Water level Measurement & Control,Pump, Discrete control, Arduino UNO

I. INTRODUCTION

Water is one of the most importnt natural resoursce useful to the mankind in many of the possible ways in domestic, agricultural, as well as industrial applications. Hence wastage of water is one of the major concern that mankind needs to look at under every circumstances.Its usage in all sphere of life from domestic to industrial applications highlights the need of effective water management scheme in every area.

We use pumps everywhere from our houses to industries. Major purpose of a pump is to pull liquid from one place to another place. Generally in our homes, we pull water from an underground reservoir tank to a terrace mounted overhead water tank.In this process it is kind of a hassle to keep the records of when the overhead tank is empty, when to turn on the pump, when the overhead tank is full, when to turn off the pump, weather if the underground reservoir tank has water or not and many more things. This full process of keeping an eye on all the things and timely turning on or off the pump is somewhat time consuming, irritating and a big hassle.

The devlopment of electronics industry & the computing power in the last few decades have made researchers to develop low cost applications making human life much more comfortable handling various critical and time consuming applications with much more ease. Therefore, computer based control system employing microcontroller alongside elctronics components are becoming more common in recent development of control system [8].

In this work we focusses on devloping a dicrete water level control system which serves for namely three purposes firstly saving water at large by preventing the overflow, energy conservation by switching off the pump in certain appropiate conditions & last but not least the objective is to also prevent the dry run of the pump enhancing the longevity of the operating pump. The automatic water pump controller also finds its application in agricultural farms, industries, offices, households and all places where discrete monitoring & control of liquid level is performed.

The next sections of the article is organized as follows, Section II describes about the Related Works in the Level control Field, Section III describes the Proposed methodology, Section IV shows the real time implementation of the prototype of the above system with the results Section V focuses on the performance evaluation and Section VI concludes research work with future directions.

II. RELATED WORK

Control systems are also classified as sequential, continuous or discrete.Hence various conventional & adavanced schemes has been proposed for the control of level of the liquid in domestic and indusrial apllications for continuous level monitoring & control [1,2&3] where various advanced techniques like fuzzy , IMC as well as Fractional based

Proportional-integral-derivative control schemes are applied on Level control loops for effective control of the liquid level in industrial applications. On the otherhand discrete control are widely applied acroos in domestic & industrial areas for sequential as well as discrete control of water or liquid [4,5,6&7]. Researchers have also monitored the level of liquid over the network for efficient Liquid or water level management[9].

III. PROPOSED METHODOLOGY FOR DESIGNING THE SYSTEM

A. Working Principle:

There are several methods for water level monitoring and control presented in various works but mostly designed so far concentrated on the pump switching based on water level content of the the overhead tank. This work presents a scheme to monitor the the overhead tank water level as well as the underground tank water level simultaneously and then determine the decision of switching the pump on or off.Thus the level of water in both tank together decides in operating the pump helping the entire system to conserve energy, water & also ensure protection of the pump from dry run.The concept can be applied successfully in domestic water level control system with indication of water level along with the prevention of wastage of the most important natural resources ensuring the device protection.

The designed control system for the water level is shown in Figure 1. below:

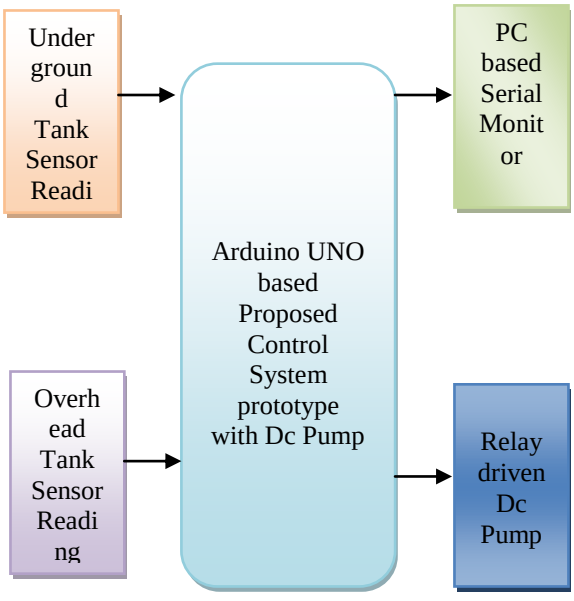

Figure 1. Block Diagram of the Water level control system with dry run protection

The designed control system, is a closed loop control device as shown in the block diagram in Figure 1. makes use of measuring Water level as input to control power supply to a Water pump. Thus the resulting output signal is a discrete variable (on/off signal) actuated using an electronic circuit. The major advantage of the system derives from the fact that it is not limited to the size and nature of the liquid tank.

A lower limit level of the water will be pre-set in the program code for the underground tank below which the pump is not allowed to turn on thus preventing the dry run. The controller will check the reading of that supersonic sensors mounted in the underground tank as well as the level of liquid in the overhead tank and then decide the on the operating status of the pump. If the level of water is below the pre-set limit in the underground tank, the pump won't be allowed to turn on and the buzzer will be triggered for notifying the user indicting the level of liquid in the underground tank. If water is present in the underground tank, the controller will sense the reading of the ultrasonic sensor mounted on the overhead tank. There will be two preset values for lower and upper level for consideration of the overhead tank empty & filled up status.If the reading of the overhead tank is found to be below the lower preset value and the underground tank has water above the lower limit of preset value, the pump is allowed to turn on via the relay module and it will continue to fill up water untill the level of water reaches the upper or overflow preset value.

After the tank gets filled up to the high upper level preset value the system will not trigger the pump untill & unless the level of water in the overhead tank reaches the lower level preset value again.

B. System Overview:

As described & depicted in the previous section the following components have been used for designing the above system:

i. ArduinoUNO board: This forms the brain of the designed system. It houses the ATmega 328 microcontroller. The logic for designing the scheme is implemented via coding in to the Arduino board.

ii. Ultrasonic Sensor (HC-SR04): It is basically a distance sensor and is used for detecting the distance using SONAR method. The transmitter emits a high frequency ultrasonic sound wave which is reflected back from any obstacle (in our case the liquid level) and receiver receives it as an echo. The echo is then processed by the control circuit to calculate the time between the transmission & reception of the signal (t). This time can subsequently be used to measure the measure the distance (d) between the sensor and the reflecting object thus giving an indication of the level of water in both the tank in a similar manner. The time calculated by the

processing circuit is converted to distance by the following calculation as shown below:

d=distance measured
t= time of high pulse
distance = $\frac{343\ x\ t}{2}$
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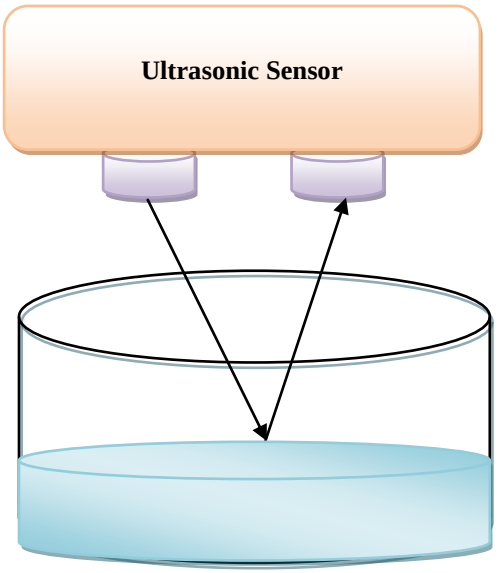

Figure 2. Ultrasonic sensor measuring principle

iii. Relay & Pump: The relay is used as isolation between the Arduino board and the pump load connected to the proposed system. The control output from the Arduino board is used to drive the pump via the relay driver circuit.

iv. Power Supply: The power supply forms one of the most inherent part of the entire system providing energy for the Arduino board, Sensors as well as the DC motor based pump for their efficient working.

v.Arduino Software (IDE) as the Programming platform: The platform helps us in coding the logic for the proposed system using some functions in C/C++ language. The serial monitor window serves as an indication for the level display and corresponding control action for the proposed system.
Flowchart of the Code:

The basic logic of the code is shown in the flowchart described below:

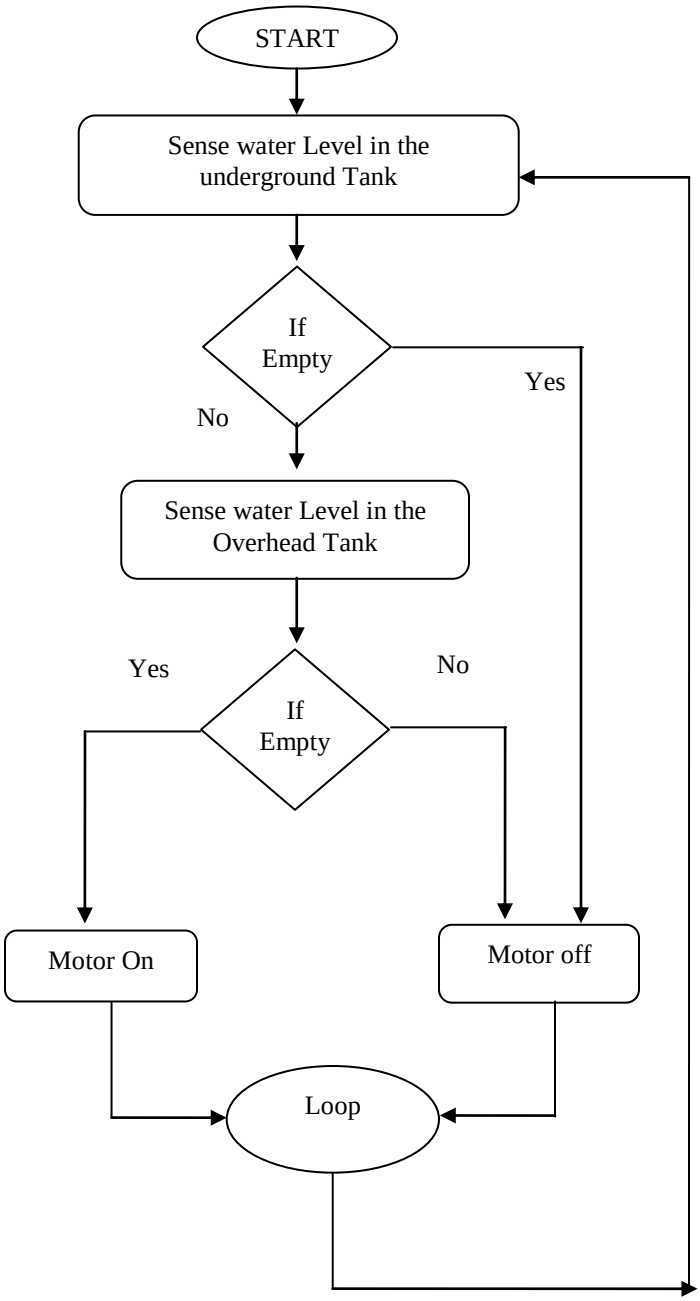

Figure 3.Flowchart of the proposed control system

IV. REAL-TIME IMPLEMENTATION OF THE AUTOMATIC LEVEL CONTROL SYSTEM WITH PUMP DRY RUN PROTECTION

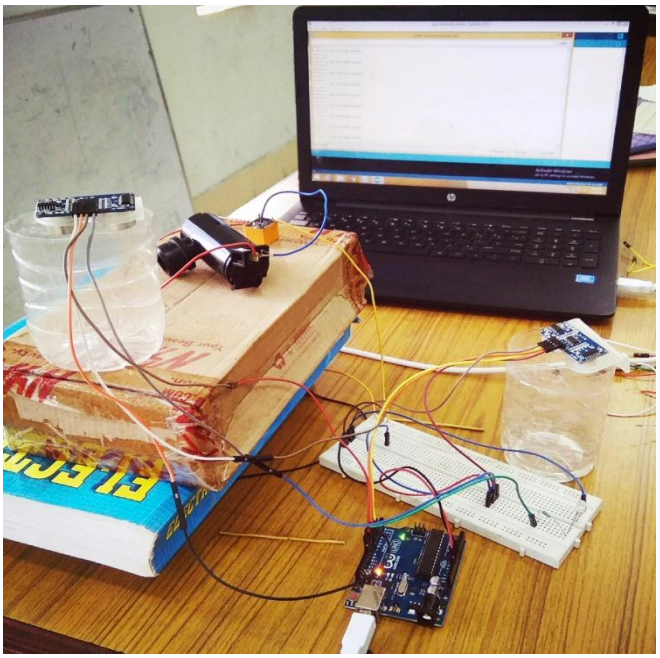

Figure 4. Hardware implementation of Automatic Level Control System with dry run protection with the DC motor based pump

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Level in Underground Tank:19
Level in Overhead Tank:5
Gnd tank has water  pump on
Level in Underground Tank:19
Level in Overhead Tank:5
Gnd tank has water  pump on
Level in Underground Tank:19
Level in Overhead Tank:5
Gnd tank has water  pump on
Level in Underground Tank:19
Level in Overhead Tank:4
Gnd tank has water  pump on
Level in Underground Tank:19
Level in Overhead Tank:4
Gnd tank has water  pump on
Level in Underground Tank:4
Level in Overhead Tank:13
overhead tank has water pump off
Level in Underground Tank:4
Level in Overhead Tank:12
overhead tank has water pump off
Level in Underground Tank:4
Level in Overhead Tank:12
overhead tank has water pump off
Level in Underground Tank:4
Level in Overhead Tank:13
overhead tank has water pump off
```

Figure 5. Real-time Results for verification for the proposed system

V. PERFORMANCE EVALUATION OF THE PROPOSED SYSTEM

Case 1: If the overhaead tank is filled & underground tank is filled then the pump is off

As there is water in the overhead tank no need of pumping the water is required hence conservation of energy and prevention of wastage of water.

Case 2: If the overhaead tank is empty & underground tank is filled then the Pump is on

As there is no water in the tank as well as underground tank has water hence pumping of water is required which is achieved by switching the pump on.

Case 3: If the overhaead tank is empty & underground tank is empty then the pump is off

Though there is no water in the overhead pump so starting the pump on is a necessity but absence of water in the underground tank as indicated by the sensor helps the system tyo switch off the pumpPump Dry Run Protection & Conservation of electrical energy

Case 4: If the overhaead tank is Filled & underground tank is empty then the pump is off

Since there is no requirement of water in trhe overhaed tank the pump is off.

TABLE 1 : OBSERVATION TABLE FOR LIQUID LEVEL OF BOTH UNDERGROUND & OVERHEAD TANK ALONG WITH CORRESPONDING PUMP STATUS

No of Observation	Underground Level sensor reading (cm)	Overhead level Sensor reading (cm)	Pump status
1.	4	20	Off
2.	19	5	On
3	3	4	Off
4	5	13	Off

IV. CONCLUSION AND FUTURE SCOPE

The designed prototype system has been successfully tested & verified & the results obtained ensured that the control system designed is capable of obtaining threee distinct advantages:

1. Efficient utilisation of electrical energy
2. Device /Pump Protection by preventing the dry Run
3. Non wastage of water.

This whole prototype system will be made out of inexpensive components and will be cheap to make. Low powered components in this system will use a very minimal amount of power to run and save electricity. The automation system will reduce the everyday hassle of the user. The entire system is designed for a DC motor based pump. It can be designed for an ac motor based pump with proper driver circuit.

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