



Design Of A Hybrid System For Automated Monitoring And Control Of Water Levels In Tanks Utilizes PIC16F877A HC-SR04 And LCSA6 Sensors

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تصميم لنظام مراقبة وتحكم آلي هجين لمستويات الماء في الخزانات باستخدام المتحكم الدقيق HC-SR04, LCSA6 وحساسات PIC16F877A

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الملخص:

تقدم هذه الورقة تصميم ومحاكاة وتقييم نظام مراقبة وتحكم آلي يستخدم وحدة التحكم الدقيقة PIC16F877A. توفر المحاكاة نظامًا لمراقبة وإدارة مستوى المياه في الخزانات العلوية والسفلية. يتم توصيل مستشعر الموجات فوق الصوتية (HC-SR04) والمجسات الموصلة (LCSA6) بالخزانات العلوية والسفلية على التوالي. وتتميز طريقة الاستشعار الهجينة هذه بالدقة والموثوقية في العديد من التطبيقات. توفر شاشة العرض البلورية السائلة (LCD) معلومات في الوقت الفعلي عن حالة الخزانين. تعرض في السطر الأول قراءات المستشعر العلوي المستمرة "مستوى المياه" في الخزان العلوي، بينما تعرض في السطر الثاني القيم المنفصلة لمستوى المياه في الخزان السفلي. تضمن آلية الضخ استمرار الخزان العلوي عند المستوى المطلوب (10% - 100%) مع مراعاة إيقاف تشغيل المضخة عن طريق تتبع توفر المياه في الخزان السفلي (مستوى المياه < 2%). يركز تصميم النظام على الكفاءة والموثوقية وحماية المضخة. يعمل المتحكم PIC16F877A كوحدة معالجة مهمة، حيث يستقبل بيانات المستشعر ومعالجتها والتحكم في مضخة المياه عبر دائرة ترانزستور-مرحل. تم تطوير البرنامج وكتابته بلغة C باستخدام MikroC Pro ، ويتم إجراء المحاكاة عبر برنامج Proteus. تظهر المحاكاة قدرة النظام على الكشف عن مستوى المياه في الخزانات والاستجابة مباشرة للتعديلات وتشغيل مضخة الماء بنجاح، وبالتالي منع الفيضان والاستنفاد. توضح هذه الورقة تقنية التصميم بالتفصيل، بما في ذلك واجهة الأجهزة والبرمجيات. توفر الورقة أيضًا توصيات لتحسين الأداء وتوسيع نطاق المشروع.

الكلمات الدالة: المتحكم الدقيق PIC16F877A، المجسات الموصلة (LCSA6)، شاشة العرض البلورية السائلة LCD، لغة C، مستشعر الموجات فوق الصوتية (HC-SR04).

Abstract

This paper presents the design, simulation, and evaluation of a monitoring and automatic control system utilizing the PIC16F877A microcontroller. The simulation is offering a system for monitoring and managing the level of

water in both the overhead and lower tanks. The ultrasonic sensor (HC-SR04) and the conductive probes (LCSA6) are attached to the overhead and lower storage tanks respectively. This hybrid sensing method affords accuracy and reliability across several applications. The liquid crystal display (LCD) provides the situation for both tanks in real-time. It displays in the first line the continuous upper sensor readings "water level" of the overhead tank and the second line demonstrates the discrete values of water level of the lower storage tank. An automated pumping mechanism ensures the overhead tank continues at the desired level (10% - 100%), with consideration stopping dry running of the pump by tracking the lower tank's water availability (water level >2%). The system's design emphasizes efficiency, reliability, and protection of pumping infrastructure. The PIC16F877A microcontroller serves as the important processing unit, managing sensor records acquisition, processing, and controlling a liquid pump via a transistor-relay circuit. The firmware is written in C language using MikroC Pro for the PIC, and the simulation is performed via Proteus software. The simulation shows the system's capacity to reveal the water level in tanks, respond directly to adjustments, and successfully alter the water pump, thereby preventing overflow and depletion. This paper details the design technique, including hardware interfacing and software. The paper additionally provides recommendations to enhance performance and expand applicability.

Keywords: HC-SR04 sensor, LCD display, LCSA6 sensor, C language, PIC16F877A .

Introduction

Water management systems are substantial for each domestic and commercial application, performing a sizeable position in conservation and operational efficiency (Anand et al., 2021). Traditional manual methods of monitoring and controlling water levels are regularly inefficient, susceptible to human errors, and can cause vast water wastage or damage to the pumping system due to dry running (Fahhiz et al., 2025). The advent of microcontrollers has revolutionized manipulation systems, allowing the improvement of sophisticated, computerized, and dependable solutions for diverse applications, consisting of water stage management (Tirones et al., 2025).

This paper specializes in the layout and implementation of an intelligent water level management system that leverages the capabilities of the PIC16F877A microcontroller. The architecture is designed to offer precise and automatic control over water transfer from a lower storage tank to an overhead tank. The aim is to retain the water level within the overhead tank inside an accepted range and ensure continuous delivery whilst concurrently protecting the water pump from damage. This is performed through the combination of effective sensing technologies: an HC-SR04 ultrasonic sensor for continuous measurement of the overhead tank's water level and an LCSA6 multi-point conductive level sensor for discrete level detection within the lower tank. Real-time information is displayed to the user through a Liquid Crystal Display (LCD), which provides the exact water level in the overhead tank (0% to 100%) and the discrete values of water level (empty, over 50%, 100%) for the lower storage tank.

The programming is performed using MikroC Pro software in order to organize the automated activation and deactivation of a water pump based totally on predefined thresholds and protection conditions. The system secures the pump operates simplest when the overhead tank requires refilling (water level at or less than 10%) and the lower storage tank has sufficient water (above 2%), stopping while the overhead tank is full (100%). This comprehensive technique aims to supply a green, dependable, and protected water management solution.

Materials:

1. PIC16F877A Microcontroller.
2. ultrasonic sensor (HC-SR04).
3. conductive probes (LCSA6)
4. BJT Transistor (2N2222).
5. Electromechanical Relay.
6. Liquid Crystal Screen (LCD).
7. Water pump.
8. Resistors, Capacitors, DC Supply, Buzzer alarm, and crystal oscillator.

The figure (1) describes the system building model of water level control. The upper sensor is installed to the inner ceiling of the tank, while the lower sensor is mounted to the storage tank at four points.

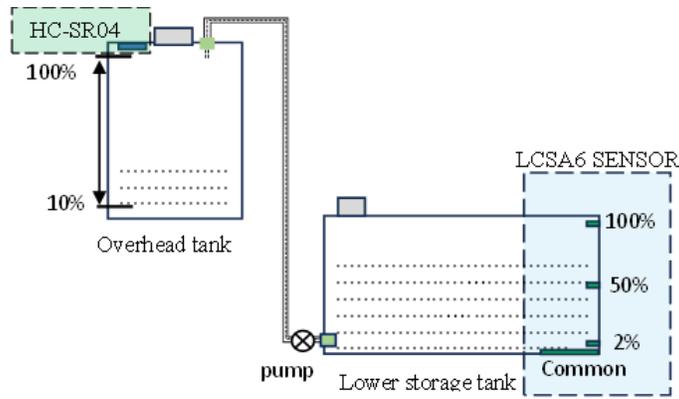


Figure 1: system building model.

The electric pump delivers water to the overhead tank according to MCU commands. These instruments are being detailed along with the other materials.

1. PIC16F877A Microcontroller MCU

The PIC16F877A microcontroller from Microchip Technology is a distinguished and value-powerful preference for embedded machine programs, characterized with the aid of its flexibility and ability to deal with an extensive range of applications. This microcontroller is selected as a consequence of its prosperous capabilities that meet the software necessities. According to (Microchip Technology Inc, 2003) the MCU features including:

- Bit Processor: Provides sufficient performance for real-time monitoring and control tasks.
- Flash Memory: With 8 KB capacity for user programs, allowing storage of control instructions and logic necessary for system operation.
- Random Access Memory (RAM): With 368 bytes capacity for temporary data storage, such as sensor readings and variables used in the program.
- EEPROM Memory: With 256 bytes capacity for storing settings that are not lost when power is disconnected, such as the target temperature.
- Digital Input/Output Ports (GPIO): Contains 33 digital ports, distributed across five ports (PORTA to PORTE), providing sufficient flexibility to connect sensors, LCD, and relay control circuit components.

2. ultrasonic sensor (HC-SR04)

The HC-SR04 ultrasonic sensor is a broadly used module for non-touch distance dimension, specifically powerful for liquid level detection (Hunter, 2023). It operates at the principle of sonar, emitting high-frequency sound waves (40 kHz) and measuring the required time for waves to reflect off a surface and return to the sensor. The distance is calculated using the formulation:

$$D = \frac{(t * V)}{2} \dots \dots \dots [1]$$

Where:

- D= The distance between the sensor and water level in metres.
- t=the required time for the sending waves to reflect and received via the sensor.
- V=speed of sound meter per second.

According to the data sheet, HC-SR04 characteristics involve: the measurement extended typically, from 2 cm to four hundred cm with an accuracy 3 millimetres. The required voltage to operate is 5V DC. Interface: Four pins: VCC (electricity), GND, Trig (trigger pules input), and Echo (echo output signal) (Mutinda, 2020).

In order to enhance accuracy in various environmental conditions, implement temperature and humidity repayment for the HC-SR04 ultrasonic sensor. This should contain integrating a temperature sensor (e.g., DHT11 or LM35) and adjusting the speed of sound calculation dynamically. Thus, the equation of sound speed is:

$$V = 331 + (0.606 * T) + (0.0124 * H) \dots \dots \dots [2]$$

Where:

- V=speed of sound meter per second.
- T= temperature in Celsius.
- H= relative humidity as a percentage.

Several studies confirm that although humidity affects the speed of sound, the effect is statistically minimal compared to temperature (about 0.37% change over the 0–100% humidity range). As a result, many high-accuracy designs prioritize temperature correction over humidity (Bartoszek et al., 2021).

According to (Kumar et al., 2023), the sound wave's speed increases to 0.607 m/s with a 1°C rise in air temperature and, conversely, it decreases with a decrease in temperature.

In this project, due to the influence within the measurement not exceeding a few centimetres, the impact of temperature on the measurement accuracy is neglected, which is suitable in consideration of the cost increase due to including additional equipment.

3. Conductive probes (LCSA6)

The LCSA6 is a multi-point conductive stage probe designed for controlling conductive liquids. Unlike ultrasonic sensors that offer non-stop measurements, conductive stage sensors commonly provide discrete values for levels detection (Comeco, 2025). They operate on the principle that conductive water completes an electrical circuit among electrodes. When the liquid touches the located probe an electrode, a small current flows, signalling the presence of liquid at that particular point.

Key functions of the LCSA6, as utilized on this gadget, include:

Multi-point detection: Capable of the usage of up to 4 electrodes (three operating and one reference) to discover a three of predefined levels. Applicability: Specifically designed for conductive liquids. Robust construction: Often features chrome steel wetted parts and PTFE insulation, making it appropriate for various industrial environments. The operation level up to 3000 milli meter.

4. BJT transistor and Relay circuit

Microcontrollers such as the PIC16F877A perform at low voltages and currents, usually 5V and a few milliamperes, consequently it is not able to directly supply the current vital to energise a relay coil, which normally requires higher cutting-edge ranges, starting from tens to hundreds of milliamperes. therefore, an NPN bipolar junction transistor (BJT) is engaged as a digital switch to interface the microcontroller with the relay in order to allow the microcontroller to safely control an excessive-strength load (Huang, 2021). The transistor's state (ON/OFF) is regulated by applying a small current to its base from the output pin of the MCU.

In this electric circuit, an electromechanical relay (EMR) will be used due to its ability to handle high currents and provide complete electrical isolation between the control circuit and the load circuit.

A "Flyback Diode" Is connecting to protect from a high inductive back electromotive force (Back EMF) that damages the transistor. The flyback diode provides a path for this inductive current to dissipate safely, thus protecting the transistor (Digilent, 2025). A resistor connected between one of the microcontroller pins and the transistor's base must be considerable to protect the MCU and BJT from damage (John Hewes, 2026).

5. Water pump

The water pump is a significant one actuator on the water level management device, accountable for transferring water from the lower to the overhead tank. The selection of the suitable pump depends on elements consisting of required flow rate and operating voltage. The AC pump is compatible with the microcontroller where the signals are sent via the transistor-relay circuit. The operation of the pump is automated controlled via the MCU based on three conditions:

- Activation: The pump is turned ON in case the water level is less than or equal to 10% of the height of the tank. The procedure leads to filling and prevents depletion for the upper tank.
- Deactivation: The pump is turned OFF in case the upper tank is filled 100% to avoid overflow and power wastage.
- Safety Interlock (Dry Run Prevention): Protection of the pump is considered via a conductive sensor attached in the lower tank. The main condition to turn the pump ON is the level of water in the lower tank must be 2% over the common rod of the sensor which is mounted at the lowest point. This condition prevents dry running and protects the pump from damage (Djalilov et al., 2023).

In addition to the protection of the pump from dry running, electrical safety is considered. A fuse rated slightly above the pump's peak operating current is located in series with the pump power line to protect against short circuits. As well as the RC snubber circuit (a resistor and capacitor in series), it should be placed across the relay contacts. This suppresses voltage spikes and "arcing" that can weld relay contacts together or damage the motor winding (Singh et al., 2023). This smart manipulate mechanism ensures efficient water managing, maintains accepted enough supply in the overhead tank, and extensively extends the life cycle of the water pump by means of stopping operation underneath destructive conditions.

6. Liquid Crystal Screen (LCD).

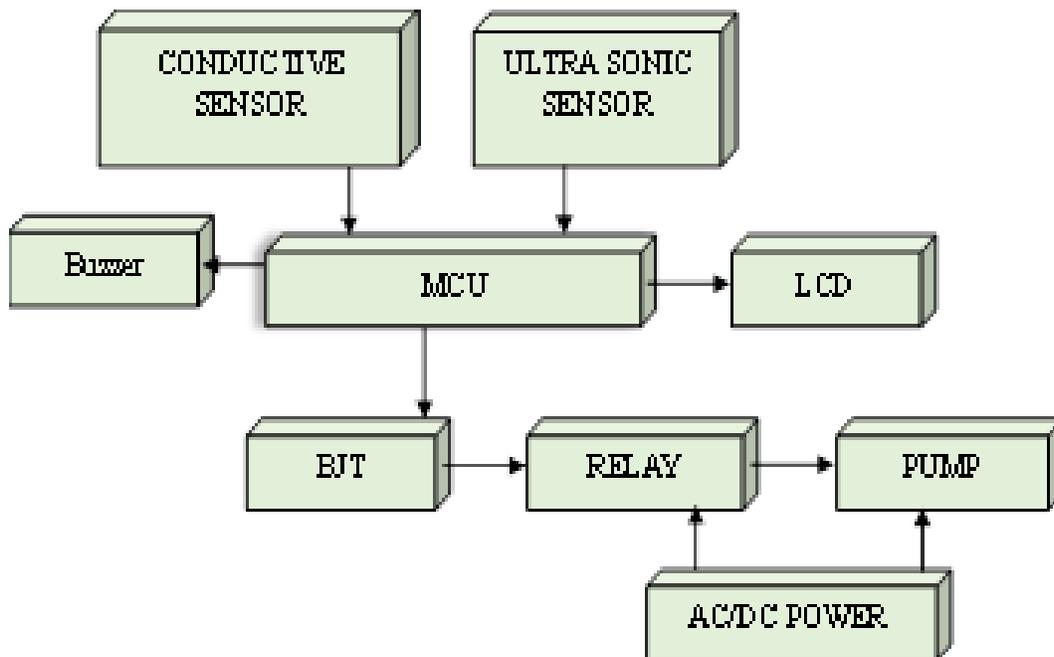
A Liquid Crystal Display (LCD) is a digital display module that is used in an extensive range of packages in diverse circuits (Mutinda, 2020). In this system, a 16x2 character LCD is employed to offer real-time visible

feedback to the user concerning the water level in each of the overhead and lower tanks, as well as the states of pump either ON or OFF. A 16x2 LCD can show 16 characters per line and has two such lines, making it appropriate for displaying the information about the situation of the system (Patil1, 2024).

Hardware Methodology

As shown in figure (2), the block diagram of the hardware system. It demonstrates the main components and their interconnection, as well as the signal direction according to the MCU. This modular design guarantees clear separation of functions and enables troubleshooting and capability improvements. The microcontroller acts as the vital hub, integrating sensor records to make clever decisions for automated water management.

- i. Power Supply: Provides the important regulated DC voltage (usually 5V) to energize the whole gadget, together with the microcontroller, sensors, and LCD. The water pump additionally requires a separate AC power supply controlled by means of a relay.
- ii. HC-SR04 Ultrasonic Sensor: Mounted at the top of the overhead tank, it constantly measures the gap to the water floor. This distance is converted into a digital percentage by the microcontroller.
- iii. LCSA6 Conductive Level Sensor: Placed in the lower storage tank with a three of electrodes at predefined ranges (2%, 50%, 100%) of tank height. It presents discrete values to the microcontroller indicating the presence or absence of water at those specific points.
- iv. PIC16F877A (MCU): The microcontroller PIC16f877A is the brain of the system. It receives records from both sensors and processes them according to its programming. Thus, it shows the situation of both tanks on the display screen and adjudicates whether to operate the pump or not according to the system requirements.
- v. LCD Display (LM016L): it is connected to the MCU in order to demonstrate the states of the pump either ON or OFF and also the level of water for both tanks. Thus, the case of the upper tank is displayed in percentage from (0 to 100%), and the lower tank is (empty, 2%, 50%, and 100%) which are according to the mounted rod.
- vi. Transistor-Relay circuit: the interface circuit essentially allows the low-power output from the microcontroller to switch the high-power water pump ON or OFF. This isolates the microcontroller from the pump's power demands.
- vii. Water pump: it is working on rang 220 AC volts. In case it is activated via transistor-relay circuit, it starts to deliver water from lower to upper tanks.
- viii. Buzzer: Connected to the Microcontroller to give an alert in case the pump is running while the water inside the lower tank has reached a level of less than 2%.



Software Methodology

The simulation was achieved via two development software programs, which are the proteus design suite for drawing the circuit and executing the simulation, and also the MikroC Pro for the PIC in order to write the program code and compile it.

The proteus design suite: is a powerful software for control systems and simulation. Evolved via Labcenter Electronics. It is a comprehensive software bundle basically used for digital design automation (EDA). It is broadly adopted for sophisticated circuit simulation, especially in the area of control and embedded systems.

The core power within the context of manipulating structures lies in its Virtual System Modelling (VSM) technology and intelligent schematic input system (ISIS). VSM permits the co-simulation of each electronic hardware and the embedded software running on microcontrollers (Gabisa et al. 2020). Whereas ISIS is the interface for the designer to draw the circuit (Apaydin et al. 2020).

The ISIS allows designing the circuit schematic, such as sensors, microcontrollers, and output devices. In addition, the real firmware code can be loaded onto the virtual microcontroller inside the simulation.

Proteus VSM then executes the code step by step while simulating the electrical components of the encompassing circuitry. This capability enables rapid prototyping and debugging, allowing the designer to observe adjustments inside the code affect the hardware reaction.

MikroC Pro for PIC: stands as a foundational and exceptionally desired integrated development environment (IDE) for embedded systems, in particular those utilizing Microchip's PIC microcontrollers.

The IDE is prominent with the aid of its intuitive user interface and effective, highly optimized C compiler that generates a compact and suited machine code. A key feature of MikroC is its huge collection of integrated libraries (MikroElektronika d.o.o., 2026).

The program for the PIC chip is written in C language, a high-level language that offers both flexibility and sturdy management. After completing writing the program, the compiler translates it into a device-readable (Hexadecimal file), that is the final executable output containing the commands the microcontroller is familiar with.

The importance of synergy between both software produces validating the code in addition to testing the design of the circuit. Several probabilities can be checked in order to achieve the effective system and investigate the errors that are associated with the prototype.

Program Logic Flowchart: The software is effective and successfully designed to continuously display on LCD the water levels in both tanks. Also control either turning ON or OFF the pump. The flowchart in Figure (3) illustrates the system's logic. It outlines the initialization process, non-stop sensor data acquisition from both the HC-SR04 and LCSA6 sensors; the MCU is processing the situation according to predefined water level thresholds. The system ensures continuous monitoring and adaptive control of the water ranges.

Starting and initializing the system, set up the equipment

1. The normal state of the system PUMP OFF.
2. Collecting data from the two sensors and displaying it on LCD screen.
3. Investigate if the upper tank's water level is equal to or greater than 100%.
 - (yes, $\Rightarrow 100\%$), the pump stays OFF which is the default case, or (is turning OFF to prevent wastage), and the system returns to monitor the water level.
4. Checking the level of water in the lower tank in case it is equal to or less than 2%.
 - (yes, $\leq 2\%$) The buzzer is activated for two seconds in order to alarm the user that the source of water is less than the pump level. Then the system turns OFF the pump and returns to monitoring.
 - (NO, $>2\%$), the program starts to investigate in the third condition.
5. Check the upper tank. The third condition to activate the pump is that the level of the water must be less than or equal to 10% of the water volume in the tank.
 - (yes, $\leq 10\%$), the pump is activated, the program demonstrates the water level in real time.
 - (NO, $>10\%$), the program loops to LCD.

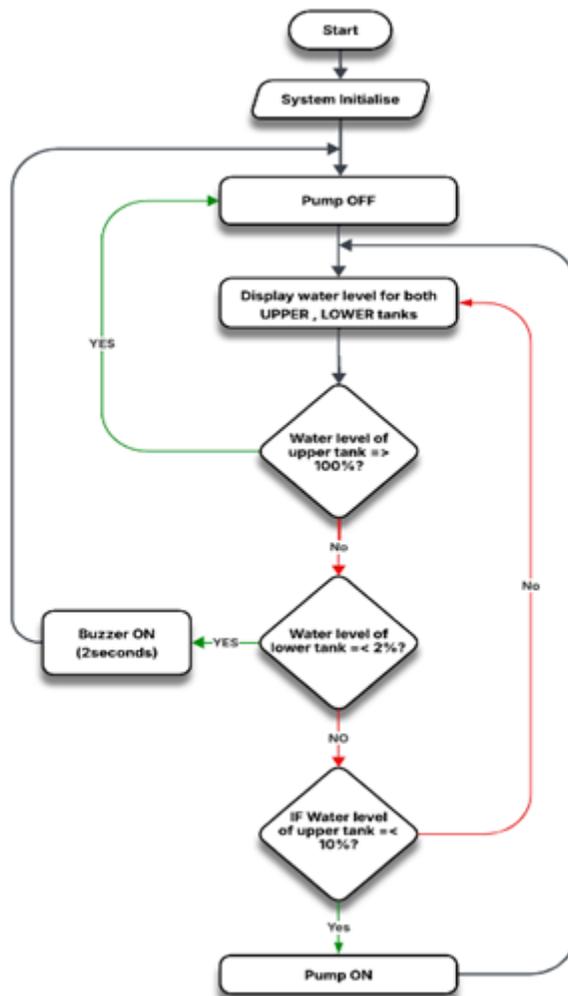


Figure 3: The program flowchart

In summary, the pump's operation is governed by way of two major conditions: it turns ON whilst the higher tank is at or underneath 10% complete along with the lower tank's water level is over 2%. And turns OFF while the upper tank's water level reaches a hundred percent. An alarm sounds if the supply tank is nearly empty to prevent the pump from dry running. In addition, a continuous real-time monitoring of water level in both the tanks is achieved.

Results

The applied intelligent water level manipulation device became tested in several situations to validate its capability and performance. The system correctly verified automated monitoring and control of water ranges in the overhead and storage lower tanks, as well as effective pump control. Key observations and consequences are summarized below

- **Water Level Monitoring**

Overhead Tank (HC-SR04): The HC-SR04 ultrasonic sensor provides non-stop and accurate real-time measurements of the water level within the overhead tank. The readings are displayed on the first line of the 16x2 LCD. The system becomes able to detect the level of water from close to-empty to full capability (0-a hundred%) within the tank's operational range.

Lower Tank (LCSA6): The LCSA6 conductive level sensor accurately detected the discrete water levels inside the lower tank. The LCD's second line efficiently indicated the situation as "Empty" (water level $\leq 2\%$), "Over 50%" ($100\% > \text{water level} \geq 50\%$), and a 100%. The transition between these states becomes instant upon the water reaching the respective electrode levels.

- **Automated Pump Control**

Overhead Tank Refill: The water pump auto-activated when the level of water decreases to 10% or less. This proactive refilling mechanism ensured a consistent water delivery.

Overhead Tank Full: The pump reliably deactivated as soon as the overhead tank reached 100% capacity, preventing overflow and conservation of energy.

Dry Run Prevention: The critical safety function for dry run prevention functioned as designed. The pump might only activate if the lower tank's water level is indicated as "Over 2%". If the water level changed to "Empty," the pump remained off, efficiently defending it from damage.

- **Response Time**

The response time from an exchange in situation (triggering a pump) to the actual pump activation/deactivation turned into discovered to be inside acceptable limits for a domestic or small-scale industrial application, normally less than 2 seconds. The LCD show is updated with minimum latency.

- **Energy Efficiency**

By exactly controlling the pump's operation based on actual requirements and preventing undesirable turning ON. The system contributed to strengthened performance. The dry run prevention mechanism further greater the efficiency by avoiding wasteful operation whilst the supply tank became depleted.

These outcomes confirm that the incorporated system correctly achieves the purpose of automatic water level monitoring and manipulation, imparting each comfort and protection for the pumping infrastructure.

Discussion

The results received from the implementation and experiment of the intelligent control system reveal its effectiveness in attaining computerized and dependable water control. The integration of the PIC16F877A microcontroller with each ultrasonic (HC-SR04) and conductive (LCSA6) sensors gives a complete answer for monitoring and controlling water tiers in a two-tank.

The computerized solution substantially reduces human intervention, minimizes water wastage due to overflow, and crucially protects the water pump from damage caused by dry running. The real-time show on the LCD enhances person awareness, permitting fast affirmation of tank statuses. The time response was discovered to be efficient, ensuring that corrective movements (pump activation/deactivation) are taken directly, which is vital for preserving constant water delivery and preventing system failure.

While the system correctly met its design objectives, several aspects warrant additional discussion. The accuracy of the HC-SR04 sensor can be stricken by environmental elements along with temperature and humidity, which affect the speed of sound. For packages requiring higher precision or running in severe environments, temperature compensation mechanisms or greater advanced ultrasonic sensors are probably considered. Similarly, the LCSA6 conductive sensor, while reliable for discrete levels, is touchy to the conductivity of the liquid. In eventualities in which water pleasant varies appreciably, this could necessitate recalibration or the use of alternative level detection techniques.

The choice of the PIC16F877A microcontroller proved adequate for the computational demands of this device, providing a stability of processing power, peripheral integration, and fee-effectiveness. The use of MikroC Pro simplified the development manner, taking into account efficient code generation and deployment. However, for greater complex structures concerning community connectivity, facts logging, or advanced predictive control algorithms, an extra effective microcontroller or a System-on-Chip (SoC) is probably extra suitable.

The dry run prevention mechanism, primarily based on the LCSA6 sensor inside the storage tank, is a critical protection characteristic that extends the lifespan of the water pump. This highlights the significance of incorporating redundant or complementary sensing technology to make certain systems robust and reliable.

Overall, the evolved effective design provides a strong and smart solution for automatic water level control, demonstrating the sensible utility of microcontrollers and sensor technology in addressing actual-global demanding situations in water management.

Conclusion

This paper efficiently presented the design, implementation, and evaluation of an intelligent system for level water control utilizing a PIC16F877A microcontroller, an HC-SR04 ultrasonic sensor for the overhead tank, and an LCSA6 conductive degree sensor for the source tank. The system correctly automates the monitoring and management of water tiers, verifying a continuous supply for the overhead tank as well as conservation the water pump from damage due to dry running. Real-time feedback through an LCD offers customers the immediate information on the capacity of each tank.

The integration of various sensor technology and a sturdy microcontroller-based manage logic proves high reliability and efficiency in maintaining desired water stages and stopping operational failure. The automatic ability to prevent pump dry running, one reason for pump damage, highlights its sensible software and economic advantages. This research contributes a well-documented and confirmed approach to computerized water management, appropriate for various domestic, agricultural, and small-scale industrial packages.

Recommendations

Environmental Compensation: for projects that necessitate high measurement accuracy, implement temperature and humidity repayment for the HC-SR04 ultrasonic sensor to enhance accuracy in various environmental conditions. This should contain integrating a temperature sensor (e.g., DHT11) and adjusting the speed of sound calculation dynamically.

Advanced Water Quality Monitoring: Incorporate extra sensors for that quality of the water parameters collectively with pH, turbidity, or conductivity in order to provide a more complete water management solution, mainly for commercial or agricultural applications.

Wireless Connectivity and Remote Monitoring: In my opinion, to achieve high effectiveness and quality, it can be done via integrated wi-fi communiqué modules to permit far-flung tracking and manipulation of the levels. This authorizes customers to get hold of indicators, view actual-time records on a smartphone software or net interface, and control pump operations.

Fault Detection and Diagnostics: Develop and integrate wise fault detection algorithms to discover and alert customers about sensor malfunctions, pump failures, or verbal exchange mistakes, thereby improving system reliability.

Predictive Maintenance: Explore the use of gadget learning algorithms to predict maintenance of the pump required based on operational facts (e.g., run time, activation frequency) to enable proactive servicing and expand gadget lifespan.

Scalability and Modularity: Design the system with more scalability, taking into account integration into larger intelligent domestic/commercial automation networks. Utilizing modular programming practices and standardized communication protocols could facilitate this.

Energy Harvesting: Investigate the opportunity of integrating renewable energy resources such as solar energy in order to create system power that is sustainable, especially for remote installations.

These recommendations intend to in addition enhance, beautify the intelligence, robustness, and person-friendliness of automated water levels management structures, addressing current obstacles and increasing their applicability.

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