International Journal of Scientific Research and Engineering Development-– Volume 5 Issue 4, July-August 2022

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Design and Implementation of a Level Control System with Real Time Data Acquisition and Logging via Internet of Things

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Abstract:

Nowadays, most communication are done using the internet, but is not all, now object/device also can communicating each other wirelessly, this idea is called the Internet of Things (IoT). Things in IoT can be everything that we use in day to day activity. In this project, the "thing" is a liquid container or reservoir. Thisresearch reports on design and implementation of a level control system with real time data acquisition and logging via IoTusing microcontroller. The use of PIC16f877a microcontroller makesthe system less expensive and the use of ultrasonic transducer module HC-SR04 makes the system non-contact. The ultrasonic module transmits ultrasonic sound waves at non-audible frequency of 40 kHz, and then picks up its echo that comes from an object to the source. Time period of the output waveform is proportional to the distance between the source and the object whose distance is being measured. The microcontroller receives the output signal, performs the necessary information processing.

Keywords **—Embedded System, Water Level, Ultrasonic Sensor, Microcontroller, Data Realtime**

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I. INTRODUCTION

To obtain a desired result or product from a process plant, various variables must be measured and controlled. These include level, temperature, pressure, flow rate, etc. But in the case of this research, emphasis is on level measurement and control. Level is probably one of the most commonly measured variables in the power plant or in a process.

This study “Level Control System with Real Time Data Acquisition and logging via Internet of Things (IoT)” is designed to operate using a Microcontroller to control the level in the process. Due to extensive research and advancement in technology, new devices have been developed that can measure as well as control level. These devices are called “Microcontroller” or “Programmable Logic Controllers (PLC)”

A PLC (Programmable Logic Controller) is a digitally operating electronic device that uses a programmable memory for internal storage of instruction for implementing specific functions such as logic, sequencing, timing, counting through digital and analogue input/output modules. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analogue input and outputs extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. A microcontroller is a microprocessor (logic controller) on a single integrated circuit containing a processor core, internal input and output memory (RAM, ROM, and Ports) and programmable input/output peripherals. A microcontroller is used in instrumentation system such as in a process plant to automatically measure and control process variables such as pressure, temperature, level, and flow rate.

It is a transducer which converts one standardized instrumentation signal into another standardized instrumentation signal and compares it with a desired (programmed) value, and gives out an output so as to cause the process variable to comply with the set point.

This study employs a Microcontroller instead of a PLC since it is more cost-effective and customizable, and can still effectively perform the function the PLC would perform. It was designed to automatically control the level in a reservoir containing water from 0 to 100 Cm, by turning off the pump when the level in the reservoir exceeds the set high point value and turning on the pump when the level falls below the set low point value.

A. *Internet of Things*

Internet of Things (IoTs) is widely used as a survive technology and it makes things interconnected utilizing the internet as a backbone(Wynn &Clarkson, 2018).IoTs are used in many fields including E-Health, Smart Metering, Security and Emergencies, Logistics, Industrial Control, Retail, Agriculture, Farming, Home Automation, and Smart. Many IoTs Systems are Real-Time Systems (RTSs) which depend on Real Time Operating Systems (RTOSs). RTOS is an OS for embedded real-time systems; it's used for its essential features such as; reliability, modularity, predictability, compact, and high performance. RTOS provides multi-tasking and introduces many services; task management, memory management, and time management. For all mentioned features for the RTOS, it should be used in the IoTs Platforms. The researchers that use the RTOS formed many research directions, such as; in IoTs implementations, IoTs frameworks proposing, IoTsprotocols performance evaluation, IoTs RTOS Picking, and RTOS Adapting to work with IoTsSome of IoTs researchers are targeting a platform for the IoTs, but most of them aren't suitable for real-time systems where time is critical, and it were done for specific applications, it uses a ready-made communication protocol such as the Message Queuing Telemetry Transport(MQTT) protocol. In this work, a design and implementation for an IoTs Platform will be proposed for general applications and the critical applications; it's implemented for the real-time systems. A communication protocol is introduced for the IoTs.

B. *Objectives of the Study*

The overall aim is the design and implementation of a level control system with real time data acquisition and logging via internet of things

The specific objectives of the study are to:

a. determine and control the water level of a process control that utilizes water;
b. investigate the process of data acquisition and logging;
c. remotely measure and control level of liquid ina reservoir.

II. MATERIAL AND METHODS

This research will be carried out with the following methods:

a. The method of Wireless Water Level Indicator using Ultrasonic sensor will be used to determine the level of water in the reservoir. Ultrasonic sensor measures the distance of water level from the upper point of the reservoir. The distance is measured in centimeters and sent to receiver circuit using RF communication
b. The method of data acquisition will be achieved by ultrasonic sensor which convert water level to a digital signal while the digitized data gotten from the ultrasonic sensor will be sent to a web application and in this application the real time value of the water level will be determined.
c. From the web application the level of the water in reservoir can be determined and appropriate controlled measure can be taken from the app remotely.

III. DESIGN METHODOLOGY

The design was divided into the following units for simplicity and efficiency. Below are the following units of the project:

1. The Power Supply Unit
2. The Level Sensor Unit
3. The Controller Unit
4. The Display Unit
5. The Level Control Unit

A. *Design Specification*

- This System has the following Design Specifications:
- Input Voltage: 220/230V AC @ 50Hz.
- Level Sensor Type: Hydrostatic pressure Sensor
- Level Measurement Range: 0CM to 100CM
- Display: Supports Visual Presentation of the Level 16x4 liquid crystal display (LCD).
- Pump Type: ½ HP (500watts), Centrifugal Water Pump.
- Process Type: WATER.
- Controller Type: PIC16F877A Microcontroller from Microchip Corporation.

B. *Power Supply Unit*

This unit converts the 220V AC to 5V DC required by the circuit. It was implemented with the following components:

(a) 220V/12V Step Down Transformer
(b) Bridge Diode
(c) Capacitor
(d) Voltage regulator

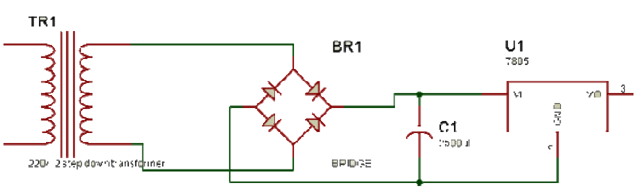

Fig.1: Power Supply Unit

C. *The Level Sensor Unit*

This unit measures the Process (Water) level in the Reservoir.
The US-100 Ultrasonic sensor operates on the principle of transmitting sound wave and receiving the reflected wave when it meets an obstacle or there is a change in density. The sensor has a Transmitter and Receiver section. The transmitter sends the 40 kHz sound wave, when the wave encounters a change in density or an obstacle, it reflects back to the receiver section. The time taken for the wave to transmit and reflect is calculated to get the distance.
The US-100 Ultrasonic modules have FOUR (4) Pins i.e. V_{CC}, Trigger, Echo and GND PIN Respectively. When the Trigger PIN is given High (5V), the module sends the 40 kHz sound wave. When the wave reflects back to the module, the Echo outputs High (5V). The Time it takes for the echo PIN to come High is total duration for the wave travel and reflection.
Below is a mathematical illustration for the ultrasonic level sensor.
This Unit is Directly Connected to the Controller Unit i.e. PIC16F877A Microcontroller through PIN 29 and PIN 30, i.e. the Trigger and Echo PIN Respectively.
The reservoir is cylindrical in shape with the following dimensions:
Diameter: 20cm; Height: 100cm
The Velocity of sound in AIR is approximately: 360m/s
Assuming the Process level in the Reservoir is 50cm
From Velocity = Distance/Time where Distance = 50cm i.e. 0.5m; Velocity = 360m/s

Time = distance/velocity = 0.5/360 = 0.001389 seconds i.e. 1.4ms
But the Time = Time of Transmission + Time of Reflection of the sound wave
Time=1.4/2 = 0.7ms.

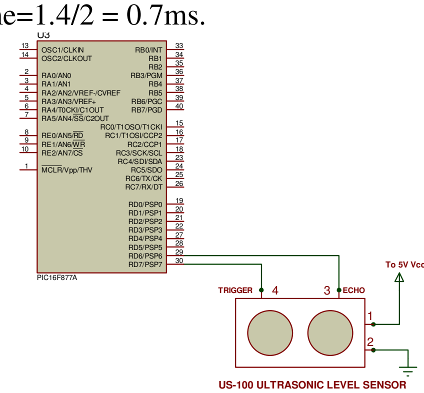

Fig.2: Level Sensor Interface with the Controller unit

D. *The Display Unit*

This Unit gives a Visual Presentation of the Water Level (in cm) inside the Reservoir. This unit, in-conjunction with the HMI unit also creates a platform that enables the user to input the SET Point.

A 16x4 (16 characters per Row, 4 Rows) liquid crystal display was selected. Below is the choice of the selection:

1. It gives a clear visual presentation of data.
2. It can to represent the Level of the Process in the Reservoir.
3. It has an easy connection interface.
4. It is cheap.
5. It is available.

The display unit gets its DATA from the Controller Unit. It is connected to The PORTD PINS of the PIC16F877A Microcontroller. Below is the circuit interface of the Display unit

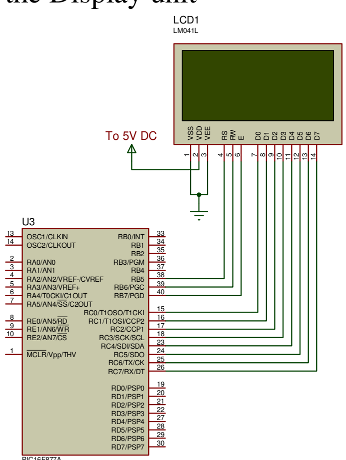

Fig 3: Display Unit Interface with the Controller unit

E. *The Pump and Pump Control Unit*

The pump control element was implemented with a 220V AC 1/2hp Water pump. The final control element (FCE) Control unit is switching circuits that assist the Controller unit to switch the Pump ON and OFF.Requirement of the Switching circuit are:

1. It should not be a complex switch circuit.
2. It should be able to Power the Pump.
3. It should be easily controlled by the controller unit i.e. easy connection interface.
4. The components involved should be available and cost effective.

The transistor switching circuit was selected. It was implemented with the Following Components:

1. 12V 30A Relay
2. BC547 NPN Transistor
3. Biasing Resistor

The transistor switching circuit was selected because it meant the above requirements. This Unit is directly controlled by the Microcontroller through PIN 15. Below is the Circuit diagram of the entire Unit.

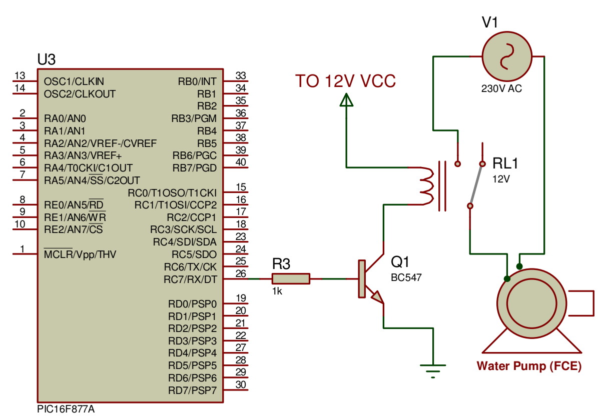

Fig.4: FCE Control Unit

Selection of the Switching Transistor

The choice of the switching transistor is based on:

1. The supply voltage
2. The maximum collector current

To determine the collector current, Collector current = relay coil current.

Relay coil current =

<u>Relay coil voltage</u>
Relay coil resistance

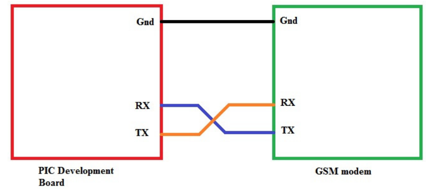

Fig.5:GSM module interfaced with the development board

Here are the features of the SIM800L breakout board are:

1. 2G quad-band @ 850/900/1800/1900 MHz
2. Receive and make calls using the speaker

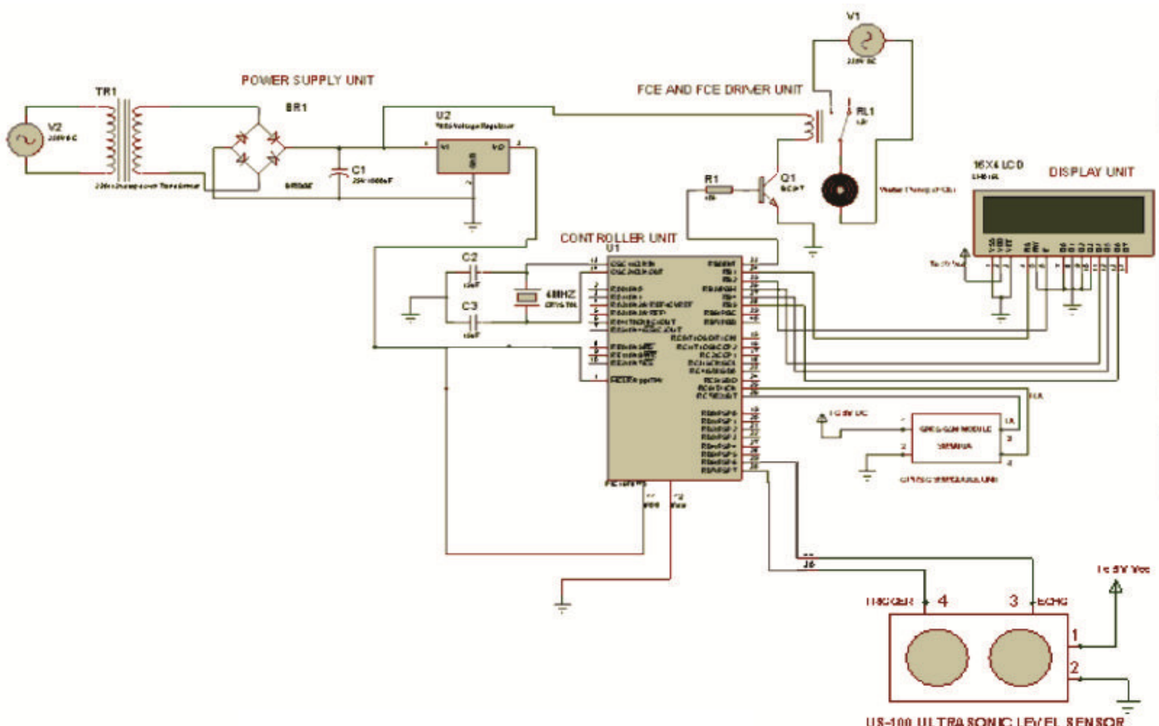

Fig.6: Circuit diagram of the system

$$= \frac{12V}{275\Omega} = 0.04A = 40mA$$

The general purpose transistor BC547 was used. The BC 547 has the following specifications:

Gain (β) = 120

$V_{BE} = 0.7V$

$I_{CC(max)} = 60mA$

F. Selection Of The GSM Module Unit

The SIM800L is a cheap and portable GSM breakout board with all the capabilities of the larger SIM900 shields.

and microphone outputs

3. Receive and send SMS
4. Connect to the Internet via GPRS
5. Listen to FM radio broadcasts
6. Accepts AT Commands

This SIM800L breakout board is ideal for projects that needs to save space.

IV. RESULTS

When the switch is turn ON, the power supply unit supplies 5V DC to the circuit, the pic16f877a (microcontroller) initializes its internal registers, configures Pin 29 to 30 as digital input pins that connects directly to the Level sensor, when done, initializes the LCD display and send the liquid level value to the displays.

The controller outputs High (5V) at PIN33 to activate the FCE, the microcontroller computes the level from ADC output, then update the LCD display. the microcontroller then compare the distance with the height of the reservoir , if it is equal, the controller deactivate the FCE.

With the help of a GPRS features in Sim800L GSM module, the level of the reservoir were predetermined and monitored remotely

V. CONCLUSIONS

A successful attempt has been made to design and construct of a level control using hydrostatic pressure rig interfaced with IOT using locally available material. The device is capable of enhancing level measurement and control in a vessel. The device has been completed and tested, it worked satisfactory.

A research approach was adopted in the implementation of this system, from whence a workable circuit was developed. The design was done using embedded system technology. This is to reduce component count, keep the system simple and cost effective.

ACKNOWLEDGMENT

We express our sincere thanks to Engr. Dr. Abdulhamidmusa, Dr. ChiomaChukwuemekaIkpo, Engr. Osundu U. and Engr. Okpo K., for their constant and valuable guidance in completing this research.

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