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Development of a Smart Liquid Level Controller

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***Abstract*—**In this paper, we present a microcontroller-based liquid level controller which identifies the various levels of a liquid, carries out certain actions and is capable of communicating with the human being and other devices through the GSM network. This project is useful in ensuring that a liquid is not wasted. It also contributes to the internet of things paradigm, which is the future of the internet. The method used in this work includes designing the circuit and simulating it. The circuit is then implemented on a solderless breadboard after which it is implemented on a strip board. A C++ computer program is developed and uploaded into the microcontroller. This program instructs the microcontroller on how to carry out its actions. In other to determine levels of the liquid, an ultrasonic wave is sent to the surface of the liquid similar to radar or the method for detecting the level of sea bed. Message is sent to the phone of the user similar to the way computers send messages to phones of GSM users. It is concluded that the routine of observing the levels of a liquid in a tank, refilling the tank when the liquid level is too low can be entirely handled by a programmable device without wastage of the liquid or bothering a human being with such tasks.

***Keywords*—**Arduino Uno, HC-SR04 ultrasonic sensor, Internet of Things, IoT, SIM900 GSM Module.

I. Introduction

THE Internet of Things (IoT) is defined as a technology in which programmable devices communicate with one another to carry out a useful action [1]. The IoT is an advancement in technology that puts together a global network of computerized devices or objects that are capable of communicating and exchanging data with one another over the Internet [2]. Alternatively, this is the paradigm of connecting any digital device, mostly programmable, to the Internet. Such devices, connected to the internet from different geographical locations, can now interact with each other. Examples of these devices are mobile phones, television sets, washing machines, refrigerators, lamps, smart wrist watches etc. The IoT devices are not limited to a complete device but also include components of machines, for example an engine of an automobile or the pump of a bore hole [3]. Quality of life will definitely improve through IoT by creating new products and services that will make homes, roads and subsequently, cities smarter [4].

This research aims at designing and developing an IoT device that is capable of communicating with other devices over the Global System of Mobile (GSM) network.

II. Materials and Method

A. Materials

In this project, we use a microcontroller board (Arduino Uno), a GSM module, an HC-SR04 ultrasonic sensor, a liquid pump, a 5 V relay, a buzzer, a 12 V step-down transformer, some 1N4007 diodes, a capacitor, a limiting resistor and a Light Emitting Diode (LED).

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B. Design

The project is divided into four units: The power supply unit consisting of the 12 V step-down transformer, the 1N4007 diodes, the capacitor, the limiting resistor and the LED; the processing unit consisting of the Arduino Uno board and the 5 V relay; the output unit consisting of the GSM module, the liquid pump and the buzzer; and the input unit consisting of the HC-SR04 ultrasonic sensor. Fig 1 shows the block diagram of the project.

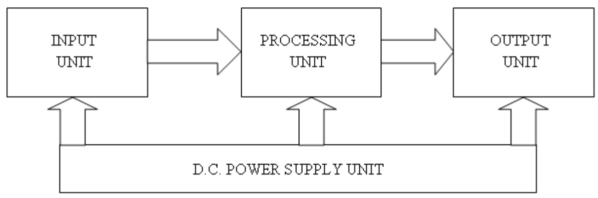

Fig. 1 Block Diagram

C. Design and Development of Direct Current (d.c.) Power Supply Unit

Electronic circuits are powered by a direct current (d.c.) source. This direct current is provided by a battery or a dedicated circuit called the power supply circuit. It is more cost-effective to use the power supply circuit as batteries are costly and require replacement from time to time. For example, in tube amplifiers, d.c. voltage is needed for plate, screen grid and control grid. Similarly, the emitter and collector bias in transistors must also be direct current [5]. These transistors are the building blocks of the microcontroller, which is the chief component of this project.

The power supply unit is developed according to the circuit diagram in Fig. 2. The components are selected based on their characteristics from manufacturers' data sheet as compared to their required functions in the circuit.

The transformer, T1 steps down the alternating current (a.c.) voltage of 230 V to a 12 V a.c. The diodes, D1, D2, D3 and D4 convert the 12 V a.c. to a pulsating d.c. The capacitor, C1 removes the pulses (ripples) in this d.c. voltage. The voltage regulator integrated circuit (IC), U1 provides a stable 9 V output to the microcontroller board. Resistor R1 limits current passing through the LED, D5. This LED serves as an indicator which lights when the switch SW1 is closed.

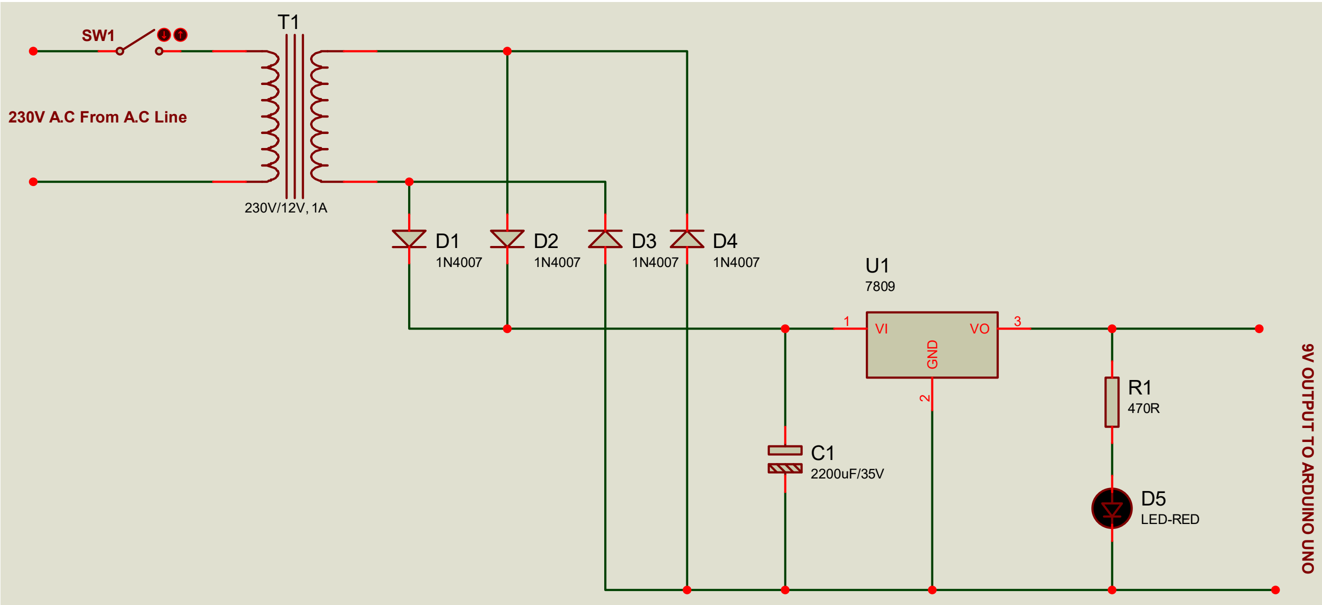

Fig. 2 The Power Supply Unit

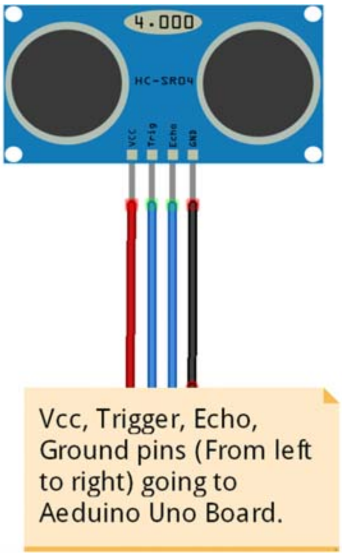

Fig. 3 The Ultrasonic Sensor

D.Design and Development of Input Unit

In many applications like vehicle control, medical applications, robotic movement control, etc.; distance measurement of an object is used. This can be done using a variety of sensors: Ultrasonic, IR, radar, laser, etc. Measurement using ultrasonic sensors is the cheapest and its reliability among several others is very high [6].

For this research work, the input unit consists of the HC-SR04 ultrasonic sensor. The HC-SR04 ultrasonic sensor behaves like radar. It sends out an ultrasonic sound pulse (high-frequency sound pulse) and then measures how long it takes for the echo of the sound to be received. The sensor has 2 openings on its front. One opening is the transmitter while the other one is the receiver. The speed of sound, which depends on nature of medium and temperature of the medium, is approximately 341 meters [7].

The ATmega328PU microcontroller receives the time taken from the sensor and uses the following mathematical equation to calculate the distance (depth) of the surface of the liquid in a tank.

$$x = \frac{vt}{2}$$

where: x is the distance (depth) of the surface of the liquid, v is the speed of sound in air, t is the time given to the microcontroller by the ultrasonic sensor.

Fig. 3 shows the ultrasonic sensor.

E. Design and Development of Processing Unit

The processing unit consists of Arduino Uno board. The main component on the board is the ATmega328PU microcontroller. Other components on this board are there to guaranty the proper functioning of the microcontroller. These components include a 16 MHz crystal oscillator, a pair of 22 pF capacitors, a 10 K pull- up resistor, a normally- open push button switch, a D.C jack for 9 V supply to the board, a LED, a series resistor to the LED and a Universal Serial Bus (USB) to serial converter for program uploading.

The Arduino Uno is a microcontroller board built around the ATmega328 microcontroller. Most Arduino Uno boards are manufactured based on the dual in-line package version of ATmega328 microcontroller. The dual in-line version has a total of 28 pins out of which 20 pins are for digital input/ output. 6 of these 20 digital input/output pins can be used as Pulse Width Modulation (PWM) outputs and 6 can be used as analog inputs. The Arduino Uno microcontroller board comes with an easy-to-use Arduino integrated development environment (IDE) which makes it very easy to upload programs to the microcontroller [8]. Fig. 4 shows the circuit diagram of the processing unit.

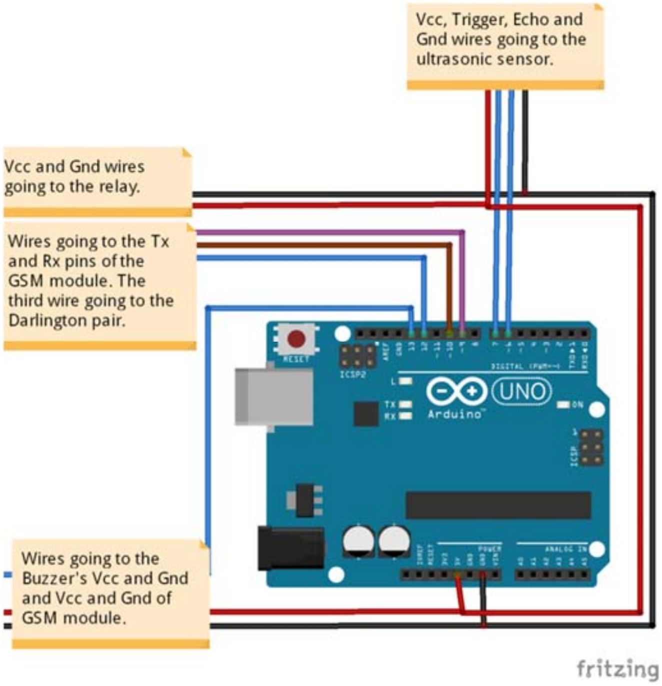

Fig. 4 The Processing Unit

F. Design and Construction of Output Unit

The output unit consists of SIM900 GSM Module – This means the module supports communication in 900 MHz band [9]. We are from Nigeria and most of the mobile network providers in this country operate in the 900 MHz band. Other components in this unit are 5 V relay, Darlington pair transistors and piezo electric buzzer. Fig. 5 shows the circuit diagram of the output unit while Fig. 6 shows the complete circuit diagram.

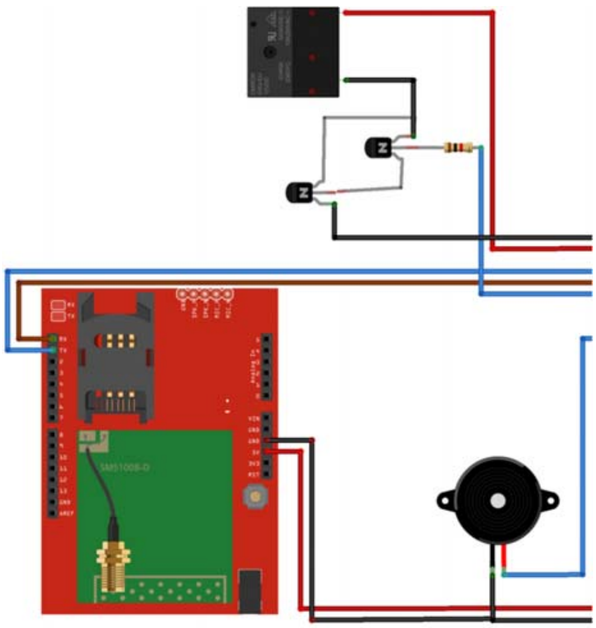

Fig. 5 The Output Unit

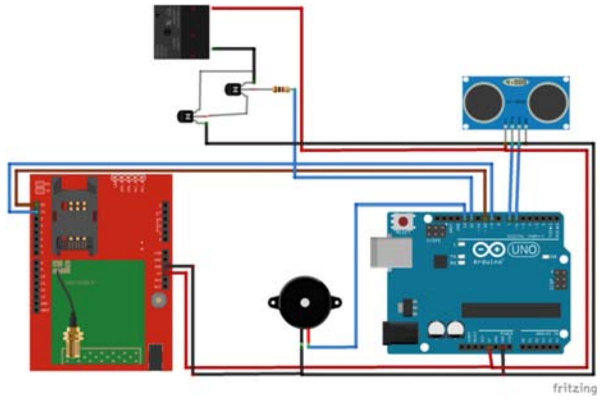

Fig. 6 The Complete Circuit diagram

III. Working Principle

This prototype project is developed using a cylindrical tank whose internal height is 50 cm. The ultrasonic sensor is placed on the cover of the tank looking downwards into the tank. When the level of liquid in the tank is low (10 cm high), the microcontroller sends a HIGH signal to the Darlington pair transistors. These transistors switch on the 5 V electromechanical relay which in turns switches on the pump. The pump then sends water to the tank. When the liquid level is 45 cm high, that is 5 cm away from the sensor, the sensor alerts the microcontroller, which in turns sends a LOW signal to the transistors and to the relay, thereby switching off the pump. If for any reason the liquid level goes below 10 cm and reaches 5 cm, the microcontroller sends a signal to the GSM module which in turns sends a message to the user's phone. Simultaneously, the microcontroller sends a signal to the buzzer which continuously sounds the buzzer.

IV. Result

The responses of the different parts of this project depend on the behavior of the HC-SR04 ultrasonic sensor. The project is tested for all the various conditions and it works fine. Table I summarizes the test results.

TABLE I
Test Result

Depth of Liquid Surface as Measured using a Standard Tape (cm).	Response obtained from the device.
5.2	Message is sent to the user's phone. Buzzer sounds continuously.
10.4	Pump starts.
45.5	Pump stops.

V. Conclusion and Recommendation

A. Conclusion

An Arduino-based Smart Liquid Level Controller was designed and developed. The hardware part was developed partly in Usmanu Danfodiyo University, Sokoto, Sokoto state, Nigeria while the remaining part of the hardware was developed in University of Maiduguri, Maiduguri, Borno state, Nigeria. The software work was done through collaboration among the authors over the internet. This project was tested and it works fine. It is applicable in creating smart homes and industries.

B. Recommendation

A lot more advancement can be done to this design. It can be a part of smart home where all appliances are connected together. A robot can be part of this smart home and intervene when the liquid level goes to extra low level. Other smart appliances that can be included in such smart home are a refrigerator that sends a message to a user that opens its door without closing it properly and a gate that opens or closes when the users are approaching, a car that alerts the user if the fuel in its tank has gone below a particular minimum level, a stereo system that that can be operated from a different location to wake a kid in his/her room etc.

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REFERENCES

[1] Pallavi Sethi and Smruti R. Sarangi (2017). Internet of Things: Architectures, Protocols, and Applications. Journal of Electrical and Computer Engineering. Volume 2017. Article ID 9324035.

[2] Internet of Things (IoT) for Automated and Smart Applications By Yasser Ismail https://www.intechopen.com/books/internet-of-things-iot-for-automated-and-smart-applications/introductory-chapter-internet-of-things-iot-importance-and-its-applications Accessed 3 September 2020

[3] A Simple Explanation Of 'The Internet Of Things' By Jacob Morgan https://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/#58afce3a1d09 Accessed 17 March 2020

[4] Priya Matta and Bhasker Pant (2019). Internet of Things: Genesis, Challenges and Applications. Journal of Engineering Science and Technology. Volume 14. No. 3 (2019) 1717-1750

[5] Principles of Electronics by V. K. Mehta & Rohit Mehta, Multicolour Revised Edition, S. Chand & Company. Pages 442 – 467.

[6] Prof. D. S. Vidhya, Miss Cecilia Jane D'Silva, Miss Delicia Perlin Rebelo, Mr. Linford William Fernandes and Miss Clarissa Joella Costa (2016). Obstacle Detection using Ultrasonic Sensors. International Journal for Innovative Research in Science & Technology. Volume 2, Issue 11, ISSN (online): 2349-6010.

[7] Distance Measurement Using Ultrasonic Sensor And Displaying On LCD https://maker.pro/arduino/projects/distance-measurement-using-ultrasonic-sensor-and-displaying-on-lcd Accessed 17 March 2020

[8] Arduino Uno R3 https://www.pololu.com/product/2191 Accessed 17 March 2020

[9] How to Interface GSM Module to Arduino-Send and Receive SMS http://www.circuitstoday.com/interface-gsm-module-with-arduino Accessed 25 December 2019