Construction of Automatic Water Dispenser for Corona Virus Prevention

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Abstract

The main goal of this research is to construct an automatic water dispenser for corona virus prevention. This research is one of the applications of ultrasonic sensor. The whole system is constructed using HC-SR04 ultrasonic sensor, ATMEGA328P microcontroller, relay and water dispenser. The ultrasonic sensor is used to sense the presence of hands below the outlet of the water dispenser. ATMEGA328P microcontroller is used as the main control and processing device of the whole system. The relay is used for switching the power of the water dispenser. The water pump is used to pump-out the water to the outlet of the water dispenser. In this work, an AC 220 V water pump is used as the water dispenser The ATMEGA328P microcontroller always monitor the output ofHC-SR04 ultrasonic sensorand produce the switching signal to the relay based on the presence of hands. The CircuitMaker 2000 software is used to draw the required circuit connection diagram.The control program for ATMEGA328P microcontroller is written with C programming language and compiled using Arduino 1.8.12 software. When the hand is below the outlet of dispenser, the water will automatically flow out. Therefore it is not required to operate the tap with our dirty hands, and corona virus can also be prevented.

1. Introduction

Corona Virus (Covid19) is wreaking havoc in the world. Almost every country is suffering from the Corona Virus. WHO has already announced it a Pandemic disease and many cities are under lockdown situation, people can't step out of their homes, and thousands have lost their lives, as in [1]. To save our life, the corona virus disease must be protected in various types of ways. Among them, one of the important fact is that regularly and thoroughly clean our hands with an alcohol-based hand rub or wash them with soap and water. Washing your hands with soap and water or using alcohol-based hand rub kills viruses that may be on our hands, as in [2].

Therefore an automatic water dispenser is designed and developed in this research. The various types of technologies are improved day by day, and among them the microcontroller is the brain of the embedded system. The microcontroller is suitable for the automation systems, control process and it can give the accurate results. By using ultrasonic sensor, the system does not require to contact with the target. In this research, the interfacing between HC-SR04 ultrasonic sensor and ATMEGA328P microcontroller are performed to automatically pump–out the water from the dispenser.

2. General Description of the System

In this section, the general description of the whole system is described. Firstly, the brief explanation of the system is discussed using block diagram. Then, the general descriptions of the electronic components used in this research are also described.

2.1. Brief Explanation of the System

The automatic water dispenser contains five main units and they are ultrasonic sensor, main control unit, dispenser driver unit, water dispenser and power supply unit. The ultrasonic sensor transmits and receives ultrasonic pulses that relay back information of the obstacle. It also produces echo output for main control unit to start system operation. The main control unit receives the echo output of ultrasonic sensor, processes distance measurement and makes decision to start dispenser driver unit. The dispenser driver unit switches-on or switches-off the water dispenser based on the presence of the hand. The water dispenser performs to flow out the water using water pump. The power supply unit provides regulated +5 V for the whole system. The block diagram of automatic water dispenser is shown in Figure 1.

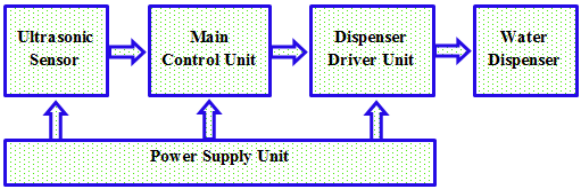

Figure 1. Block diagram of the automatic water dispenser

2.2. Ultrasonic Sensor

In this research, HC-SR04 ultrasonic sensor is used to detect the presence of the hand at the below the outlet of dispenser. The HC-SR04 ultrasonic sensor is a popular and low cost solution for non-contact distance measurement function. It is able to measure distances from 2 cm to 400 cm with an accuracy of about 3 mm, as in [3]. This module includes ultrasonic transmitter, ultrasonic receiver and its control circuit. HC-SR04 sensor consists of four connection pins namely: Vcc (+5 V), Trig (Trigger input of sensor), Echo (Echo output of sensor) and Gnd (Ground) pins. Trig and Echo pins are used for interfacing between the HC-SR04 ultrasonic sensor and ATMEGA328P microcontroller. The photograph of HC-SR04 ultrasonic sensor is shown in Figure 2.

Figure 2. Photograph of HC-SR04 ultrasonic sensor

2.3.ATMEGA328P Microcontroller

The Atmel Pico Power ATMEGA328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATMEGA328P achieves throughputs close to 1MIPS per MHz. This empowers system designed to optimize the device for power consumption versus processing speed.

ATMEGA328P is a high performance, low power 8-bit microcontroller family. It is also advanced RISC architecture including:131 powerful instructions, most single clock cycle execution, 32 x 8 general purpose working registers, fully static operation, up to 20 MIPS throughput at 20 MHz and on-chip 2-cycle multiplier. ATMEGA328P has high endurance non-volatile memory segments such as 32 kilo bytes of in-system self-programmable flash program memory, 1 kilo byte EEPROM, 2 kilo bytes internal SRAM, Write/Erase cycles: of 10,000 Flash/100,000 EEPROM, and data retention of 20 years at 85°C/100 years at 25°C.

All AVR ports have true Read-Modify-Write functionality when used as general digital I/O ports. Each output buffer has symmetrical drive characteristics with both high sink and source capability. The pin driver is strong enough to drive LED displays directly. All port pins have individually selectable pull-up resistors with a supply voltage invariant resistance, as in [4]. The device operates between 1.8 V to 5.5 V.The pin diagram and the photograph of ATMEGA328P microcontroller are shown in Figure 3 and Figure 4 respectively.

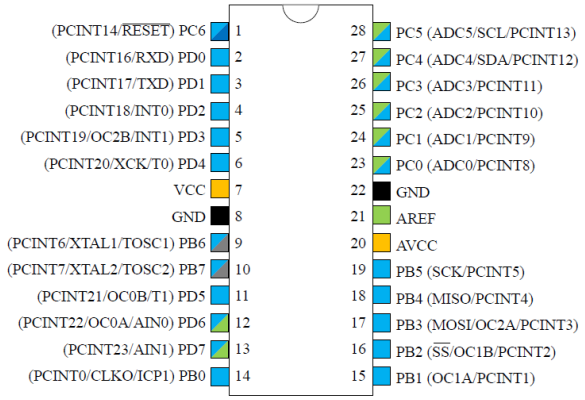

Figure 3. Pin diagram of ATMEGA328P microcontroller

Figure 4. Photograph of ATMEGA328P microcontroller

2.4. Electromagnetic Relay

A relay is an electromagnetic switch. In other words it is activated when a current is applied to it. Relays are used where it is necessary to control a circuit by a low-power signal with complete electrical isolation between control and controlled circuits. The main part of a relay is the coil at the centre. A small current flowing through the coil in the relay creates a magnetic field that pulls one switch contact against or away from another. Usually relays are used to turn on a second circuit. The first circuit activates the relay which then turns on the second circuit. Transistors and ICs must be protected from the brief high voltage produced when a relay coil is switched off. Current flowing through a relay coil creates a magnetic field

which collapses suddenly when the current is switched off, as in [5]. In this research, a protection diode (1N4001) is connected backwards across the relay coil to provide this protection. There are different types of relays and they operate at different voltages. In this research, a 5 V relay is used to switch the water pump. The internal circuit and photograph of relay are shown in Figure 5.

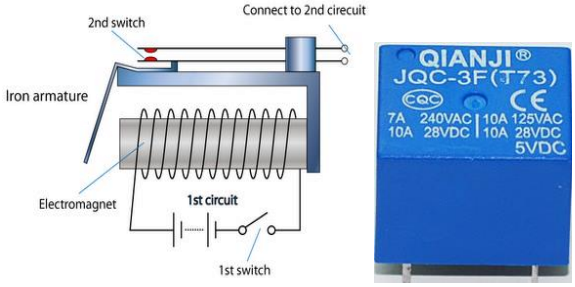

Figure 5. Internal circuit and photograph of relay

3. Hardware Connection of the Whole System

In the hardware connection, the whole system is developed by using HC-SR04 ultrasonic sensor, ATMEGA328P microcontroller, a 5 V electromagnetic relay, and WP-300D water pump.

Firstly, the regulated power supply circuit is constructed by using step-down transformer, full wave bridge rectifier, capacitors and L7805 positive voltage regulator. In circuit connection, AC 220 V main line is stepped-down to AC 12 V by using step-down transformer. The output of transformer AC 12 V is converted to the corresponding DC voltage by full wave bridge rectifier. Then, the rectified voltage is by filtered by using 1000 µF capacitor. The filtered voltage is regulated by L7805 voltage regulator. The output of L7805 regulator produces regulated +5 V and it is also filtered with 0.1 µF capacitor in order to remove noises.

In the pin configuration of microcontroller, PB1 ofATMEGA328P microcontroller is used as digital output to provide the trigger signal for HC-SR04 ultrasonic sensor. PB2 of microcontroller is used as digital input to receive the echo signal output of ultrasonic sensor. PB4 of microcontroller is used as digital output to control water dispenser with the help of relay. PB5 of microcontroller is also used as digital output to control light emitting diode (LED) for indicating the status of system operation.

In circuit connection, reset pin of ATMEGA328P microcontroller is connected to the +5 V power supply by inserting 10 kΩ resistor. VCC pin of microcontroller is applied +5 V and the two GND pins are connected to the ground line of power supply. In this hardware design, a 16 MHz crystal oscillator and two 22 pF capacitor are used as the oscillator circuit for microcontroller. These components are fitted at the OSC1 and OSC2 pins of microcontroller. It is required to produce the stable 16 MHz clock frequency for performing microcontroller operation. PB1 ofATMEGA328P microcontroller is fed to the Trig pin of HC-SR04 ultrasonic sensor to provide the trigger signal. This trigger signal is required to start the ultrasonic wave transmission from the ultrasonic transmitter. The Echo output pin of HC-SR04 ultrasonic sensor is also connected to PB2 of microcontroller. PB4 of microcontroller is connected to the base of C9013 NPN transistor via 1 kΩ resistor and the emitter is connected to the ground. The collector of C9013 transistor is connected to one of power supply pin of relay. Another power supply pin of relay is applied +5 V. The output AC 220 V main power is controlled by relay used for switching water dispenser. The photograph of water dispenser is shown in Figure 6. PB5 of microcontroller is wired to the anode of LED by inserting 1 kΩ current limiting resistor.

Figure 6. Photograph of water dispenser

In circuit operation, the echo output of the ultrasonic sensor is initially in the digital LOW state. When the hand is placed below of the ultrasonic sensor, the sensor produces the echo signal which is digital HIGH state. The echo signal is received by PB2 of microcontroller. At the same time, PB4 of microcontroller sends the activation signal to the base of C9013 transistor. The transistor saturates for activating relay and the water pump also switches-on. When the hand is removed below the ultrasonic sensor, the water pump switches-off. The schematic diagram

of the automatic water dispenser is shown in Figure 7. The photograph of main control system is shown in Figure 8.

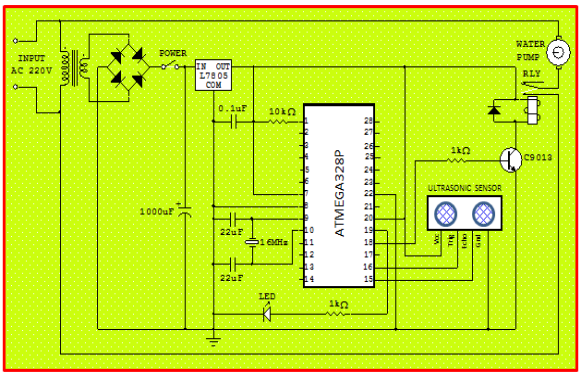

Figure 7. Schematic diagram of the automatic water dispenser

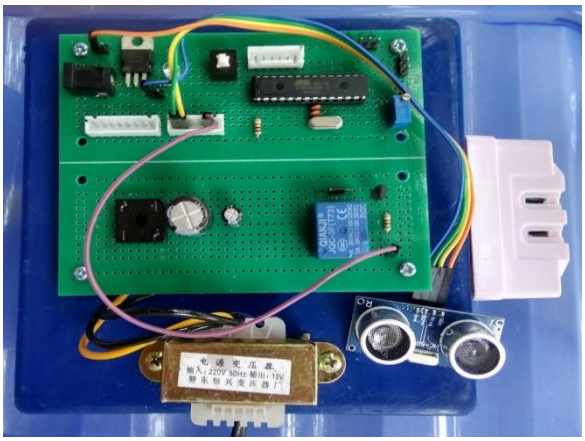

Figure 8. Photograph of main control system

3.1. Software Development and Machine Code Writing into ATMEGA328P Microcontroller

In this research, the source code (Water_Dispenser) for ATMEGA328P microcontroller is written with C programming language. Firstly, the digital input/output pins of microcontroller are configured for trigger, echo, LED and water pump. The Trig pin is declared as an output, the Echo pin as an input, and start serial communications.Firstly the Trig pin is set to digital low state for 2 microseconds. Then, it is set to digital high for 10 microseconds, which sends out an 8 cycle sonic burst from the transmitter, which then bounces of an object and hits the receiver. When the sound waves hit the receiver, it turns the Echo pin high for however long the waves were traveling for. The speed of sound is approximately 340 m/s or 340 cm/10000 µs, therefore the distance between the ultrasonic sensor and the hand can be calculated, as in (1).

$$Distance = time*340/20000 \quad (1)$$

The source code is composed of two main functions namely: “setup()” function and “loop()” function. The setup part is where the code is written so that the program runs. The loop part is where the code is written so that the program runs with repetition until the power off. The source code is responsible for ultrasonic sensor to measure the distance of the hand in front of it. In this work, the distance between the sensor and the hand is set as 15 cm. When the distance is less than 15 cm, the developed system switches-on the water dispenser and else the system switches-off the water dispenser. After completing the source code, it is compiled by using Arduino 1.8.12 software. And then the machine code is uploaded into ATMEGA328P microcontroller. The snapshot of Arduino 1.8.12 software screen is also shown in Figure 9.

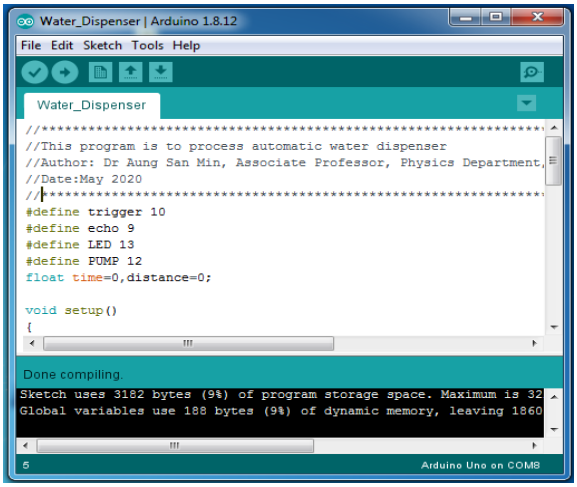

Figure 9. Snapshot of Arduino 1.8.12 software screen

4. Discussion

The constructed system is aimed for automatic water dispenser and constructed by using HC-SR04 ultrasonic sensor, ATMEGA328P microcontroller, relay, AC 220 V water pump, and other electronic components. ATMEGA328P microcontroller contains 14 digital input/output pins and 6 analog input pins. In this research, only four digital input/output pins are used and the analog pins are not used. Among them, one digital input pin of microcontroller is used for receiving the echo signal of the ultrasonic sensor. Three digital output pins are used in which one is to produce the trigger signal for ultrasonic sensor, the next one is used to send the activation signal for water dispenser, and the last one is used to control LED.The oscillating frequency of the microcontroller is 16 MHz.

The operating voltage of the whole system is DC +5 V which is obtained from the AC 220 V main line. The maximum AC output power of relay used in this research is 1.68 kW. The ultrasonic sensor is used to check the presence of hands below the outlet of water dispenser.The microcontroller continuously calculates the distance between the ultrasonic sensor and the hand and controls the water dispenser to switch-on or switch-off the water pump. To start water dispenser operation, the distance between the HC-SR04 ultrasonic sensor and the hand is set to 15 cm. That setting distance value can be changed in the source code.The range of measurable distance of HC-SR04 ultrasonic sensor is from 2 cm to 400 cm.The frequency range of an ultrasonic wave from the transmitter is 40 kHz.

In the whole system operation, when the system power is switched-on, the developed water dispenser is ready to use and the system waits your hands to flow out the water.When the hand is below the outlet of dispenser, the dispenser will switch-on and automatically flow out the water on your hands. When the hands are removed from the system, the dispenser will switch-off again. The photograph of the developedautomatic water dispenser is shown in Figure 10.

Figure 10. Photograph of the developed automatic water dispenser

5. Conclusion

In this research work, an automatic water dispenser for corona virus prevention is designed, developed, and tested successfully. The performance of the developed system is reliable.The system switches-on and switches-off on its own automatically and therefore it can save the water. Moreover, the developed system does not have to operate the water tap with the dirty hands, it can also obtain a healthier lifestyle and the corona virus can also be prevented.

By using this research framework, other improved researches such as automatic hand dryer, automatic liquid level controller, non-contact range measuring system, and intruder security alert can also be developed. It is also needed to modify the controlling part to sustain the water level of tank.It can be performed by fitting another ultrasonic sensor or float sensor in the tank. If the water level is below the specified point, the water from the water source will be filled into the tank.We will try more improved researches for upcoming research papers. Therefore, we hope that the developed system is practically helpful to study how to interface ultrasonic sensor and ATMEGA328P microcontroller, how to control AC 220 V water pump with relay, and how to apply basic electronics for university students.

Acknowledgments

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