PIC Microcontroller Based Automatic Doorbell Circuit by Using Ultrasonic Sensor and LDR

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Abstract

A kind of doorbell circuit is constructed. It is designed to be automatic and ring the bell itself. The circuit design based on an 8-bit microcontroller PIC16F877A, an ultrasonic sensor module (HCSR-04), a light dependent resistor (LDR), an alphanumeric liquid crystal display (LCD), an audio amplifier circuit, a small speaker and a 5 V regulated power supply. The whole circuit is constructed on a specially designed printed circuit board. The program code was created with PIC Basic Pro programming language. The circuit will ring the bell whenever there is someone or visitor in front of the sensor. Moreover, the door light will be automatically operated for a period if it is dark at the door. The circuit is very useful and helpful for disables and elderly persons.

Keywords: Microcontroller, ultrasonic sensor, LCD, LDR

INTRODUCTION

A doorbell is an electrical device with a button near the outside door of a house or apartment that makes a noise when pressed, to let the people inside know someone is there. But the ancient doorbells were mechanical doorbells activated by pulling a cord. Today, the doorbells are designed electrically and operated by a push button switch. In the electronic doorbells, there are only two categories, wired doorbell and wireless doorbell. The wired doorbells are hard-wired directly into the home's electrical system and typically consist of a switch located inside a button device. The switch is connected with the doorbell circuit to generate the doorbell sound. But in the type of wireless doorbell systems, they operate with the radio waves between the doorbell called switch and doorbell sound generator circuit. The next generation doorbell incorporated with intercoms and video cameras to upgrade the security level. But they are very expensive.

In this research work, it is a kind of wired doorbell and there is no doorbell switch to operate the doorbell. Moreover, there is a door light which will automatically operate. The doorbell operation is designed to become a fully automatic and intelligent. The system design consists of a PIC microcontroller (PIC16F877A), a 4MHz crystal oscillator, a light sensor (LDR, light dependent resistor), an ultrasonic ranging module (HCSR-04), door light (LED), a 3Watt audio amplifier circuit, a 3Watt speaker and an alphanumeric liquid crystal display.

The light sensor is used to operate the door light. The door light will illuminate only on the night or dark time when the someone is present in front of the door. The someone detecting sensor was an ultrasonic ranging module and it will decide the presence of someone or not. If someone is staying in front of the door, the doorbell will generate a bell sound for a few seconds. If the front door is dark at the time, the light will also switch on automatically.

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PIC Microcontroller

PIC (Peripheral Interface Controller) is a device which was developed to control the peripheral device, dispersing the function of the main CPU. PIC has the calculation function and the memory like the CPU and is controlled by the software. However, the throughput, the memory capacities are not big. It depends on the kind of PIC but the maximum operation clock frequency is about 20 MHz and the memory capacity to write the program is about 1K to 8K words. The clock frequency is related with the speed to read the program and to execute the instruction. Only at the clock frequency, the throughput cannot be judged. It changes with the architecture in the processing part. As for the same architecture, the one with the higher clock frequency is higher about the throughput.

Ultrasonic Ranging Module HC - SR04

Ultrasonic ranging module HC - SR04 provides 2cm to 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The module includes ultrasonic transmitters, receiver and control circuit. The basic principle of the circuit module is as follows;

(1) Using IO trigger for at least 10μs high level signal
(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
(3) If the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time × velocity of sound)/2.

There are four wire connection terminals which can be connected with 5V power supply pin, trigger pulse input pin, echo pulse output pin and 0V ground pin. Photo of HC SR-04 ultrasonic ranging module is shown in Figure 1.

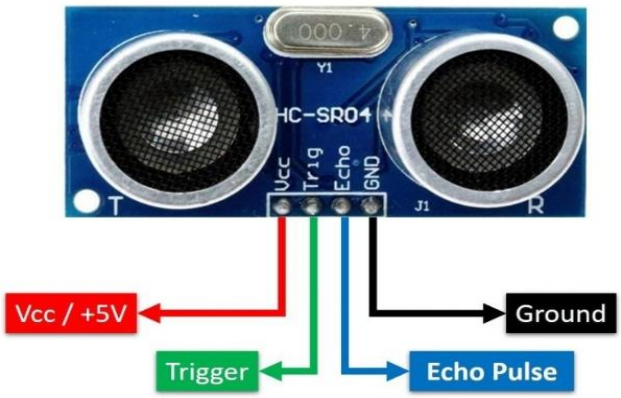

Figure 1. Photo of HC SR-04 ultrasonic ranging module

HD44780 Liquid Crystal Display

The HD44780 dot-matrix liquid crystal displays alphanumerics, Japanese katakana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8-bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver. A single HD44780 can display up to one 8-character line or two 8-character lines.

The HD44780 character generator ROM is extended to generate 208 5 × 8 dot character fonts and 32 5 × 10 dot character fonts for a total of 240 different character fonts. The low power supply (2.7V to 5.5V) of the HD44780 is suitable for any portable battery-driven product requiring low power dissipation.

Figure 2. Photograph of HD44780 LCD display

Light Dependent Resistor

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance.

Working Principle of LDR

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is that more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

PAM8403 Audio Amplifier Module

PAM8403 small digital amplifier chip is a digital high-definition sound amplifier circuit surrounding with the most reasonable configuration. The power supply filtering is upgraded to 470μf and the real amplifier board did most detailed output 3W + 3W high-fidelity sound.

Excellent noise suppression, two-channel stereo, 5V power supply can output 3W+ 3W power, can directly drive 4Ω, or 8Ω small speakers, the output power is large and full of energy. The outputs of the amplifier generate good sound quality. The unique non-LC filter Class-D digital power board can be directly operated with computer USB power supply. The left and right channel output of the "negative" and cannot be connected together, otherwise it will burn IC, and should be preceded powered speakers connected (load). Rated working voltage 2.5V ~ 5V, limit operating voltage 5.5V.

Construction of the Circuit

The components are installed and soldered on the printed circuit board. The components are installed with correct orientation on their positions. Moreover, the installations are started from shortest (dwarf) components to tall components. The soldering started by using jumpers and resistors first. Then the taller components are 40 pin IC base, 16 female terminal pins, four female pins, LDR and variable resistors which are inserted and soldered. The audio amplifier circuit and voltage regulator IC are soldered on the board. Finally, the LCD, and ultrasonic sensor module are assembled as shown in Figure 4.

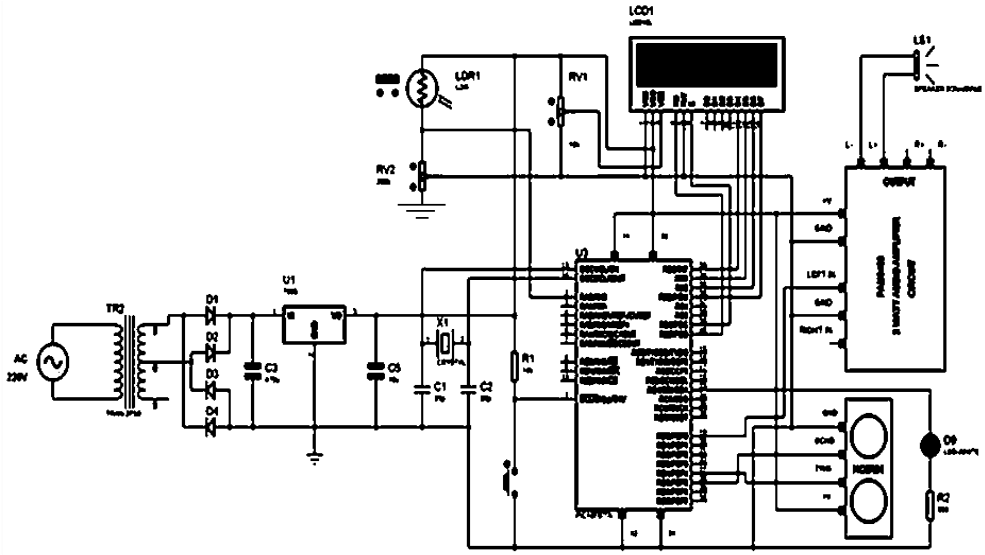

Figure 3. Schematic diagram of automatic doorbell circuit

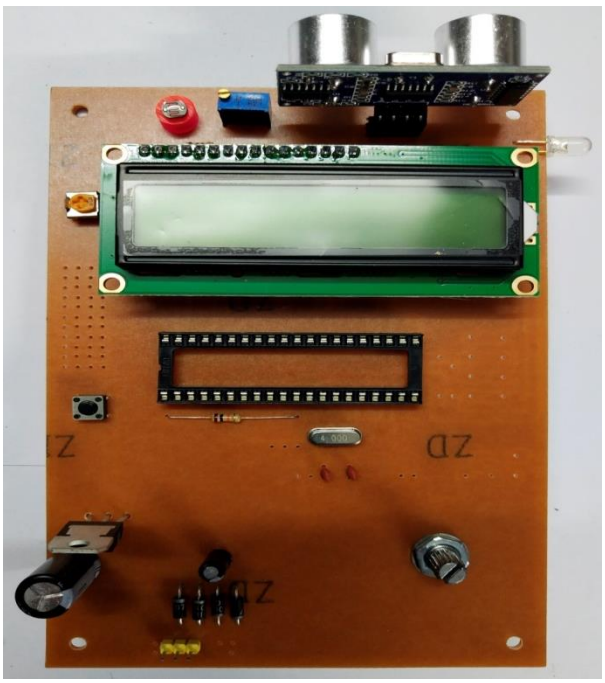

Figure 4. The installation of LCD and HCSR-04 on the circuit board

Circuit Operation

The automatic doorbell circuit board construction is illustrated with component labels in Figure 5. The transformer is on the lower side of the circuit board. The whole circuit is installed on an acrylic sheet. The ultrasonic sensor is on the top of the circuit board. The two cylinder ultrasonic transducers are facing toward someone or visitor or object. Beside the ultrasonic sensor, the LDR is located to detect the luminous level at the door. The second top side component is the LCD display. A 10 k variable resistor on the left of LCD display is used to adjust the contrast of characters on the LCD. It is used to describe the analog value of luminous, detection distance and presence of someone or visitor.

The PIC microcontroller is in the middle of the circuit board. It is a large IC and consisting of 40 pins in dual in line package. A reset input switch is on the left of IC. Pressing reset will restart the program from beginning. A 4 MHz crystal oscillator is near pin 13 and 14 of the microcontroller. On the lower right corner of the circuit board, 3 watt audio amplifier is located. The speaker is not in the photo. It is hidden under the circuit board. On the lower left side of the circuit the 5 V regulator circuit is installed. Instead of using power on/off switch, a three terminal male pins and a jumper is used in the circuit. The jumper inserted to left side is power on and opposite is power off.

Before power connection, a paper box and a ruler with cm measurement is positioned in front of the ultrasonic sensor. The paper box is located beyond the object detection. When the power supply was switched on, the LCD display illuminated as shown in Figure 6. It is the display of title and last for 5 seconds. Then the display is cleared and changes to display the distance reading in cm and detection of someone or visitor on the first line of LCD. The luminous level detection is illustrated on the second line. In this case, the luminous is 182. The measuring distance of visitor or object is at 22cm. Next, the box moved forward to sensor and LCD display changes as shown in Figure 7. The measuring distance is 19 cm and someone is detected. But the luminous is 181 and it is detection of plenty of light at the light sensor. In this case, only the doorbell sound is generated.

In Figure 8, the LDR is housed with a black cover cap. The luminous level became 11 and it is dark on the door. The visitor or object detection is 19cm and visitor or object is detected at the door. Then both the doorbell sound and door light LED are operated. After the doorbell tune is finished, the distance and light sensor value are read again for the circuit again and again. The volume of doorbell sound can be adjusted by slowly turning the knob at the amplifier circuit to clockwise.

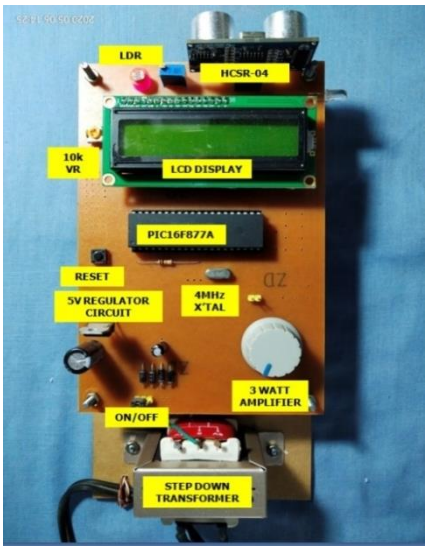

Figure 5. The automatic doorbell circuit with component labels

Figure 6. The title display illuminate on initial power up condition

Figure 7. The paper box located within detection range

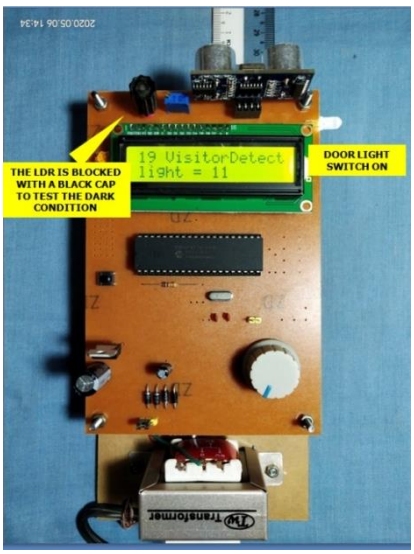

Figure 8. Someone detection at low luminous level

DISCUSSION

In this circuit design, a kind of distance ranging module is used. It is HCSR04 ultrasonic ranging module. To check someone near the door, an ultrasonic distance ranging module is used. The ranging module consists of four pins, Gnd, Echo, Trigger and +V pins. On the circuit, there are two ultrasonic transducers marking with T(transmitter) and R(receiver). The transmitter transmits eight cycles of 40 kHz (ultrasound) frequency whenever the trigger pin was connected with logic high for 10 micro seconds. When the ultrasound frequency hit to an object, the echo waves are back to the receiver transducer. Then the echo pin generates logic high pulse according to the traveled distance. But the pulse period is for the travel and return. The speed of sound is 340m/s. Therefore, the distance of object is the half of pulse period and speed of sound multiplication.

CONCLUSION

The automatic doorbell circuit is constructed and tested with a paper box blocking in front of the sensor from various distances. The operation process and results are illustrated with photos. In this circuit design, it is operating fully automatic for operating the doorbell and door light. The detection distance can be edited in the program. Although the datasheet for ultrasonic sensor describe maximum detection range for 400cm, it is only tested with 0 to 20 cm range. The door light operating level can also be adjusted to different conditions at the door. The doorbell tune can be changed to desired sound by editing program. The circuit is very useful and there are many advantages. Nowadays, touch doorbells and touch switches are replacing with automatic devices. It is helping the disables, children and visitors who are unable to reach the doorbell switch.

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References

Brian Evans., (2011). Beginning Arduino Programming: Springer Science.

I.R Sinclair., (2001). Practical Electronics Handbook.

Michael McRoberts., (2013). Beginning Arduino: Springer Science

Nick Dossis., (2002). Everyday Practical Electronics

R.M Marston., (1996). Modern CMOS Circuit Manual

T.L. Floyd., (1996). Electronic Devices

T.L. Floyd., (2007). Electronic Devices