Home Automation System of AC appliances with IR Remote Control by Raspberry Pi Zero W

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Abstract

Automation system is famous for all over the world. Nowadays, people have been trying to control everything automatically without any physical efforts. In the proposed work, home automation system has been introduced to control the home AC appliances without any muscle power. The task of the system is to turn ON or OFF for different home AC appliances. Lighting, fan, window curtain, door pane of the smart home system have been controlled by using IR remote controlled module, relay driver and Raspberry Pi Zero W.

Keywords: *IR remote controlled module, home automation, photodiode, GPIO, Wi-Fi*

1. Introduction

For saving electricity and physical strength, people need the help of technology. The lack of awareness of human beings is a major problem for loss of electricity. So people want to control the things they use automatically. There are several types of home automation system. The first and the most common used home automation system is the wired home automation system, controlled by switches. After that the wireless home automation system has been introduced. Remote controlled home automation system is very famous and the most utilized home automation system **[12]**.

The first wireless home automation system is the remote controlled automation system and is regarded as a user friendly automation system all over the world. In this system, a remote control module, such as mobile phone and keypad, can control all sorts of home appliances according to the user's choice.

To save energy and ensure adequate safety, most of the houses in the cities of developed countries have used remote control, mobile or touch screen based home automation system. In this paper, the attempt to reduce the electricity consumption and physical strength has been made by using the wireless IR remote controlled automation system.

In IR remote controlled module, keypad transmitter and photodiode have been used to transmit and receive the signal. Raspberry Pi reads the output signal from receiver photodiode, and then these signals control the ON/OFF of electrical appliances **[8, 11].**

2. Related Works

Shewak, S.D. & S.N. Gaikwad presented An IoT based Real-Time Weather Monitoring System Using Raspberry Pi**[11]**. Both analog and digital sensors were used for environmental parameter measuring. The system used for Temperature and humidity sensor (DHT11), Light intensity sensor (LDR) Rain water level measuring sensor (ULN 2803) and pressure and altitude sensor (BMP 180). The data from the sensor is read by server that is Raspberry Pi and stored in CSV as well as text files.

Nisarg et al proposed IoT based Home Automation System using Raspberry Pi-3**[10]**. In this project, there are components like PIR sensor, Web camera, Raspberry Pi-3, Smart phone for android app, and then three electrical appliances such as light, fan and lock. When PIR sensor is sensed via a person then Web camera captures the image and sends it to android app via raspberry pi. If the image displayed on the application is authenticated by the user having app in smart phone. Once the image is authenticated by the user having app in smart phone then he can send that person inside the door by using smart phone. After the door is opened the user having the app sends the signal to start the light and fan using smart phone operated mobile app.

3. Proposed Approach

In this proposed work, remote controlled module (transmitter & receiver), Raspberry Pi Zero W

and relay driver have been used to construct the IR remote controlled home automation system. The signal from the transmitter (e.g.0xFF6897) is transmitted and received by the receiver (photodiode). And then the data received by Raspberry Pi card control the ON/OFF condition for AC power appliances of smart home system. The proposed system can minimize the power consumption and make the adequate safety. **[9, 10]**

4. Hardware Description

(i) IR remote controlled module
  (a) Transmitter (key-pad)
  (b) Receiver (photodiode)
(ii) Raspberry Pi Zero W
(iii) Relay drivers

4.1. Raspberry Pi Zero W

Raspberry Pi Zero is a single board computer. This system requires a micro SD card with a Raspbian OS as shown in Figure (4.2). It has 16GB memory. Figure (4.1) shows Raspberry Pi Zero W and GPIO pin layout. (*) means special purpose GPIO. There are (i) miniHDMI, (ii) microUSB connector to display the information on TV or to use with keyboard and mouse, and (iii) microUSB power input for power supply. And then USB hub can be used for more than one USB device. **[1-7]**

GPIO pin layout			
3V3	1	2	5V
*GPIO2	3	4	5V
*GPIO3	5	6	GND
*GPIO4	7	8	GPIO14*
GND	9	10	GPIO15*
*GPIO17	11	12	GPIO18*
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3V3	17	18	GPIO24
*GPIO10	19	20	GND
*GPIO9	21	22	GPIO25
*GPIO11	23	24	GPIO8*
GND	25	26	GPIO7*
*ID-SD	27	28	ID-SC*
*GPIO5	29	30	GND
*GPIO6	31	32	GPIO12*
*GPIO13	33	34	GND
*GPIO19	35	36	GPIO16*
GPIO26	37	38	GPIO20*
GND	39	40	GPIO21*

Figure (4.1) Raspberry Pi Zero W & GPIO pin

Figure (4.2) Micro SD card

Raspberry Pi Zero W has a 40 pin GPIO (general purpose input/output) connector on the board to allow the attachment of electronic hardware to Raspberry Pi and built in Wi-Fi and Bluetooth. Voltage supply to the power USB should be in the range of 5-5.25 V. And then it has an on-board camera connector for cameramodule.

4.2. IR Remote Controlled Module

As shown in Figure (4.3), there are two components: (i) IR receiver and (ii) IR transmitter. IR receiver is a photodiode sensor with amplifier circuit and IR transmitter transmits the effective signal, and then IR receiver receives these signals as shown in Figure (4.4). The typical transmitted code waveform of the remote controlled system is shown in figure (4.5).

Figure (4.3) IR Remote Controlled Module

There will be blind area due to the interference object in Figure (4.4). After receiving the signal, IR remote control R_x provides the output for remote control device.

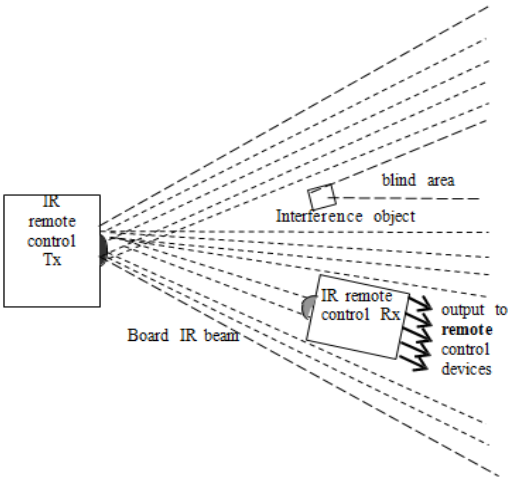

Figure (4.4) Basic IR remote controlled

In Figure (4.5), the first bit provides frame synchronization for the decoder with duration time of 1 ms and the next six bits give an ON/OFF form of control. The transmitted signal takes 8 ms and is 33 kHz modulation. The waveform can be tested by high resolution oscilloscope.

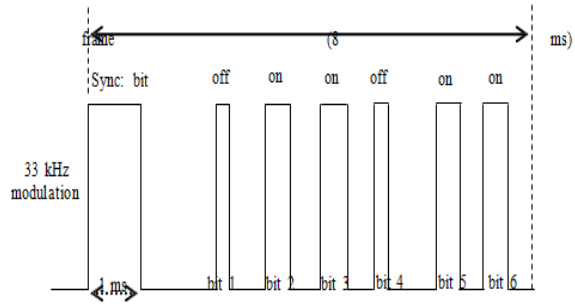

Figure (4.5) typical transmitter waveform of Remote controlled system

In program, the button with respective hex code is defined first and then it is applied for respective case. For example, button 1 with 0XFF6897 is used for lighting (ON) case.

Table (1) shows the relationship between button of transmitter, respective code and proposed work condition. Red buttons and blue buttons do not used in this work.

Table (1) Proposed work condition with Button of transmitter & Respective Code

Button	Code	Proposed Work Condition
1	0XFF6897	Lighting **(ON)**
2	0XFF9867	Fan **(ON)**
3	0XFFB04F	Window Curtain **(ON)**
4	0XFF30CF	Door Pane **(ON)**
5	0XFF18E7	Lighting **(OFF)**
6	0XFF7A85	Fan **(OFF)**
7	0XFF10FF	Window Curtain **(OFF)**
8	0XFF5AA5	Door Pane **(OFF)**
9	0XFF38C7	All **(OFF)**
0	0XFF4A5B	All **(ON)**

4.3. Relay Module

Relay module is an electrically operated switch. Many relays use an electromagnet to operate a switch ON/OFF. Relays can be used to control a circuit by a low-power signal or to control several circuits by one signal. The relay module, shown in Figure (4.6), has V_{cc}, GND and signal. It can act as a switch if the circuit and the load circuit have different supply voltages.

Figure (4.6) Electromagnetic Relay

Electromagnetic relay is a switch worked by electromagnet. There are large numbers of turns on the coil of relay. So the small amount of current flowing through the coil can produce magnetic field strong enough to attract the armature. If a current flows through the coil, the soft iron core is magnetized and attracts the soft- iron armature. The movement of the armature can make open or closed of the switch. Relay driver circuit driven by transistor is shown in figure (4.7). This circuit is essential for ON/OFF condition of AC appliances.

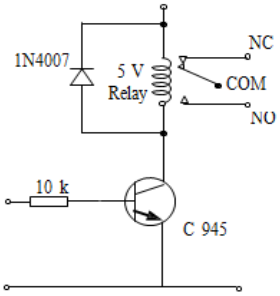

Figure (4.7) Relay driver circuit with transistor

Four 5V relay contacts, four C 945 transistors, four IN4004 diodes and four 10 k resistors have been used to construct the relay module as shown in Figure (4.8).

Figure (4.8) Relay Module

4.4 Output Display

Figure (4.9) shows the output display for the proposed system. It consists of output LEDs, relay module and AC appliance connectors.

Figure (4.9) Output Display

4.5 Programming Languages

There are considerable numbers of programming languages which have been adapted for Raspberry Pi. Python programming language is recommended by the Raspberry Pi foundation especially for the beginners. But the users are not restricted to use only Python. C, C^{++}, Java, Scratch and Ruby programming languages can be used with Raspberry Pi.

5. Experimental Setup

Hardware block diagram of smart home automation with IR remote control is shown in Figure (5.1). Raspberry Pi card controls the appliances according to the transmitted signal. As shown in Figure (5.2), the receiver reads the output signal of transmitter and sends it to Pi card by GPIO27. After that Pi card provides the output from GPIO23 for Lighting, GPIO24 for Fan, 25 for Window Curtain and 26 for Door-pane.

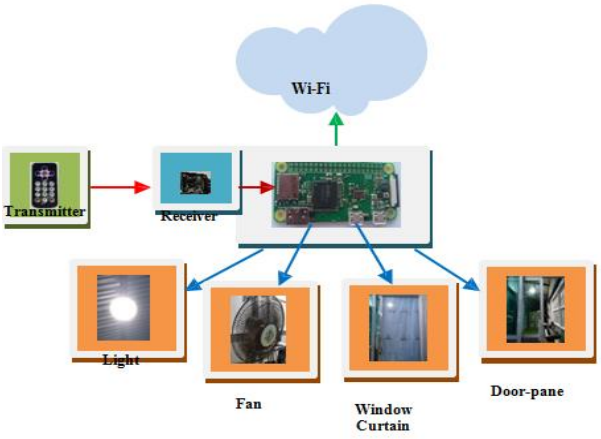

Figure (5.1) Hardware block diagram

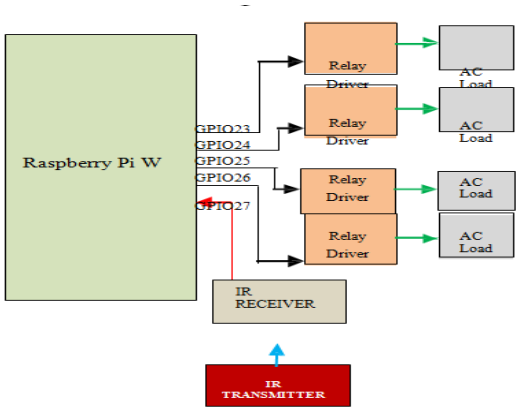

Figure (5.2) Schematic diagram of the whole System

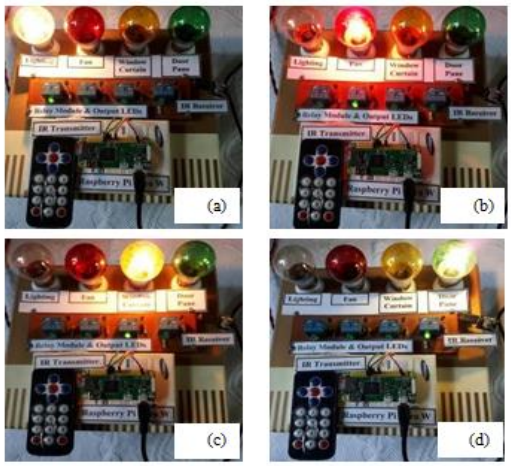

Figure (5.3) One-environmental condition

As shown in Figure (5.3) (a), button 1 of transmitter provides the high output of Lighting when the day light condition becomes dam. Button 2 switches on for Fan system in accordance with the current environmental temperature in Figure (5.3) (b). In the morning of fine weather condition, Window Curtain is opened by button 3 in Figure (5.3) (c) and also do for Door-pane by button 4, shown in Figure (5.3) (d).

Figure (5.4) Two-environment condition

Table (2) shows the two-environmental condition and transmitter button being used for Figure (5.4). The condition for whether day or night, hot or cold and visit or not, can be emphasized. The first condition is that the weather is so hot at night. So button 1 and 2 of key-pad are used for Lighting and Fan. In the last condition, the visitor has arrived in warm day time. Button 3 is used for window curtain to get ventilation and door-pane is opened by button 4.

Table (2) Two-environmental condition

Environment Condition	Figure	Button being used
Hotter at night	(5.4)(a)	Button 1 & 2
Hot at night	(5.4)(b)	Button 1 & 3
Visit at night	(5.4)(c)	Button 1 & 4
So Hot in day time	(5.4)(d)	Button 2 & 3
Visit & Hot in day time	(5.4)(e)	Button 2 & 4
Visit & Warm in day time	(5.4)(f)	Button 3 & 4

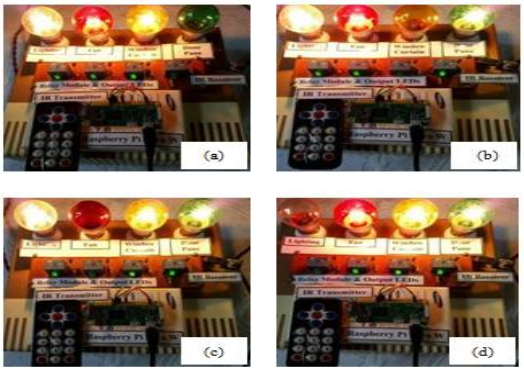

Figure (5.5) Three-environmental condition

The three-environmental condition which we emphasize is shown in Table (3). If the weather is so hot at night in the first, Lighting, Fan and Window Curtain should be switched on. The last condition is that the visitor has arrived in the so-hot day time. Button 2 for Fan, 3 for Window Curtain and 4 for Door-pane have been used.

Table (3) Three-environmental condition

Environment Condition	Figure	Button being used
So Hot at night	(10)(a)	Button 1, 2 & 3
Visit at Hot night	(10)(b)	Button 1, 2 & 4
Visit at Warm night	(10)(c)	Button 1, 3 & 4
Visit in So Hot day time	(10)(d)	Button 2, 3 & 4

Figure (5.6) Four-environmental condition

When the visitor has arrived at so hot night, all AC appliances should be switched on by using button 1, 2, 3 and 4. If not, all appliances switch off as shown in Figure (5.6).

6. Results and Discussion

IR transmitter key-pad gives the control pulse during 8 ms. First synchronized bit and six bits of pulse-code information are produced by transmitter according to the key-pad button. This signal is detected and decoded in the IR receiver and it provides the output to activate the external devices via broad IR beam. But there is a problem to activate the relay driver for the output of multi-AC appliance. The photograph of the failure of relay driver is shown in Figure (6.1). In this circuit, four AC appliances are switched on. But the relay driver (4) is in OFF condition as shown in Figure (6.1)(a), and driver (1), (2) and (4) switch off in Figure (6.1)(b).

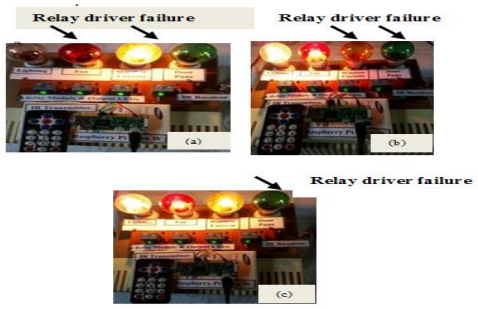

Figure (6.1) Failure of relay driver

7. Conclusion

To control AC appliances automatically without any physical efforts, to save energy and ensure adequate safety, the smart home automation of AC appliances with IR remote control by using Raspberry Pi Zero W has been constructed and tested successfully. The system is cost-effective, and is very accurate in its operation. The system can be used to control real AC appliances ON/OFF condition such as lights, fan or air-conditioner, window-pane, door-pane, window curtain and all other AC appliances. But the application for two or more AC appliances can cause the failure of relay module. On the other hand, there are un-activate relay driver (4) in Figure (6.1)(a) and drivers (1), (2) and (4) when four AC appliances of the system are used simultaneously. This is due to the power supply of relay module. So the relay module supply should be used separately.

The proposed system is easy to install and gives the user satisfaction.

Although all control switches are ON, some of the outputs are still OFF in the remote controls of the products. This is because that the power supply of the system cannot be able to work for all switches. In this propose work, high power supply can be replaced for all control switched running.

The environmental conditions sometimes cannot be predicted precisely, especially in some particular case. For example strong wind during winter would make the actual feel temperature much lower than what it is. In this conditions manual control system is essential than automatic control system with sensor.

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