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SMART CONTROL OVER HOME APPLIANCES WITH HAND GESTURES /GESTICULATE USING FLEX SENSORS

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Abstract: In this technology driven world, the home automation system became easy to people. Especially this automation is very useful for housebound people as well as for crippled persons. Though there exist new technology/ avant-garde with voice control/virtual assistances, many are still facing problems to use them conveniently and effectively. We came up with proposed system of flex sensor-based home automation such that the people who does not understand the new technology can operate or control the appliance very easily. This system's aim to help housebound people or crippled people to operate home appliances very easily with their hands signs even if they were not educated. This system increases quality and efficiency of working devices. In this system we have integrate voice assistance control of Alexa, which makes easier to handle for people. Based on requirement, the designed prototype can be switched into different modes (gesture control and voice control) for controlling home appliances. In this work, the prototype of the proposed system has been designed, tested, and validated with some use cases which are discussed in the results and discussions.

Index Terms - ESP32, Flex sensors, RF module, Relay module.

I. INTRODUCTION

In this modern world, many new technologies that are currently emerging and advancing. As technology continues to evolve, it will undoubtedly transform the way we live, work, and interact with the world around us. Home automation system made people to control their household appliances in smarter way such that they can operate remotely from anywhere. It became comfort, cost-efficient, easy to use. Many are still having difficulty using them properly and easily. So, to resolve some difficulty we can use flex sensor-based home automation. In this flex sensor-based home automation system we can use some of the hand gestures to control over it. This system is favourable for old people as well as crippled peoples. It is also useful and easy to operate for uneducated/ untutored people and hospitalized bedridden people. It can be used without getting out of bed or chair and useful for the anguished people. We can also integrate voice assistance to make it easier to operate.

II. LITERATURE REVIEW

In [1], the proposed system is to recreate a word based on gesture. The authors had used smart phone to convert word-to-speech. The flex sensors are used to recognise gestures. The gestures are converted into speech using smart phone [2]. The authors in [3] developed a sign translation tool, which is used to translate user gestures into speech. It is constructed as for dumb people will be able to communicate with a hearing person. The gestures are converted into speech which is hearable by listening persons. The system proposed in [4] is used to control the household appliances by recognising the user's movements using a camera. Based on movements or gestures recognised by camera, the appliances are turned ON/OFF automatically. The authors in [5] designed Bluetooth-based system wherein a collection of capacitive sensors is used to identify hand movements and send information to the computer through the Bluetooth to control home appliances. Bluetooth communication uses less power than other communication methods. The authors in [6] have developed the original Hand Talk glove in 2001.The Sign Language Translator is made up of two distinct parts: a leather golf glove with ten flexible sensors embedded in it that tracks the location of the fingers by detecting the electrical resistance when the fingers are bent. The change in electrical current is transformed into digital signals by a tiny microcontroller on the back of the hand and wirelessly sent to a computer. After reading the numerical numbers, the computer transforms them into the letters that show up on the screen. The authors in [7]

have discussed about the design of gloves to position the flex sensors. To find the fingers motion we attached flex sensors to finger-like structures of glove with a medical tape to prevent displacement. Depending on the lengths of the user's fingers, the overlapping of flex sensors on glove is depended. The gloves cloth is made from three layers of polyamide/Lycra fabric, and it is helpful to separate sensors from contacting.

III. METHODOLOGY, MATERIALS, AND IMPLEMENTATION

3.1. METHODOLOGY

This project is divided into two parts and they are transmitter module and receiver module.

3.1.1. Transmitter Module:

The transmitter module consists of power supply unit, four flex sensors, RF transmitter interfaced with ESP32 microcontroller board. The power supply unit consists of power adapter which converts AC supply to 12V DC voltage and then voltage regulator (7805) to produce 5V DC required for ESP32. The flex sensor works on the principle of variable resistance being produced when the flex senor bends, thus converting flex bends into electrical voltage. The electrical voltage is then converted into a digital data using an Adafruit ADS 1x15. The digitised data will be given to the esp32 microcontroller board. The RF transmitter (R433) is used to wirelessly transmit data from the flex sensors to the receiver module.

3.1.2. Receiver Module:

The receiver module consists of power supply unit, RF receiver and four channel relays which are used to control the electrical appliances. The power supply unit is used to power up the circuitry at the receiver module. The signal received by the RF receiver is connected to relays. Relays, which function as switches for household appliances, receive signals from the receiver. The flex sensors in the hand gloves are programmed to determine whether the relays are to be turned ON or OFF so that the corresponding home appliances can be controlled.

The block diagram of the proposed design is shown in Fig.1.

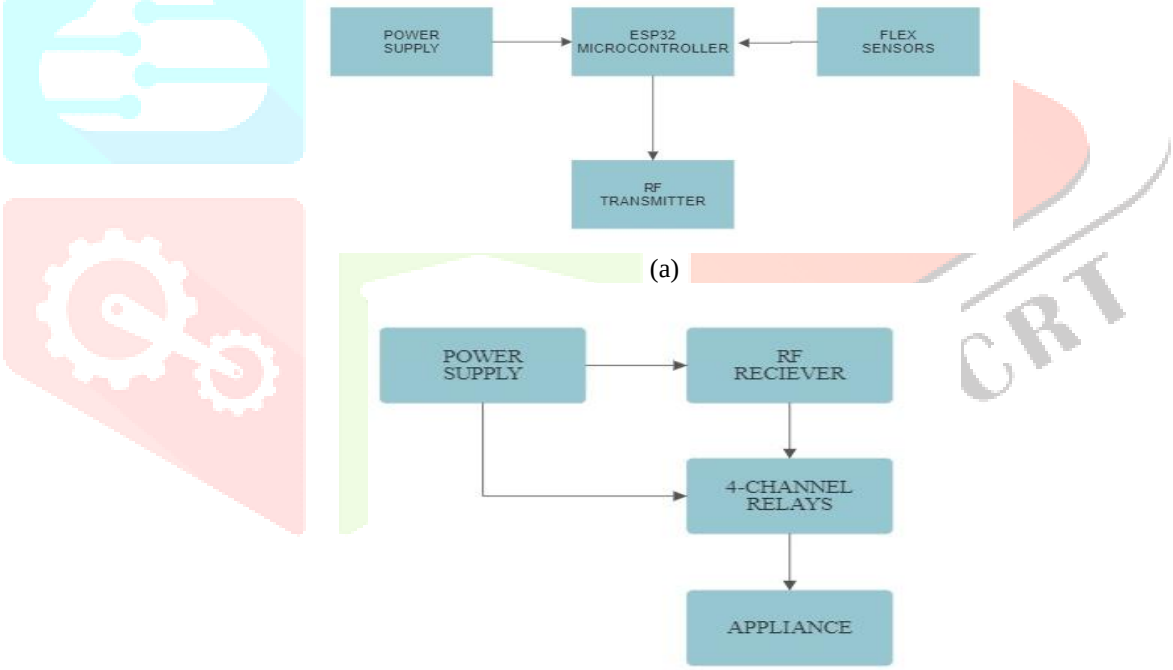


Fig.1. Block diagram (a) transmitter module (hand gloves) and (b) receiver module

Additionally, the ESP32 will be interfaced with the newest AI based voice control assistant, called Alexa. Users' voices will be recognised by Alexa and the decoded signal is given as an input signal for the ESP32. The signal is sent via an RF module to relays, which switch ON or OFF the household appliances in accordance with the signal.

3.2 MATERIALS

To implement the project, we have used the following components: Four Flex sensors, ESP32, Adafruit ADS 1x15, 4 channel relay module, Arduino IDE compiler, RF module, Connecting wires.

3.2.1. Flex Sensors:

Flex sensor is also called a "bend sensor" as its resistance varies with the amount of bend in the surface. Carbon resistive elements on a flexible substrate are present inside the flex sensor. The value of resistance is inversely proportional to the amount of carbon. When the flex sensor is bent, it changes the resistance, which may cause errors in the output voltage. To reduce errors caused by the source impedance of the flex sensor, we used an operational amplifier as an impedance buffer. A buffer is

used to isolate the sensor and provide a low-impedance output that is not affected by the changing resistance of the sensor. The circuit's impedance buffer is a single-sided operational amplifier because its name suggests that the input signal is likely to be a single-ended signal rather than a differential signal. Overall, to reduce source impedance on the circuit and also to improve accuracy and quality, an impedance buffer is used with the flex sensor.

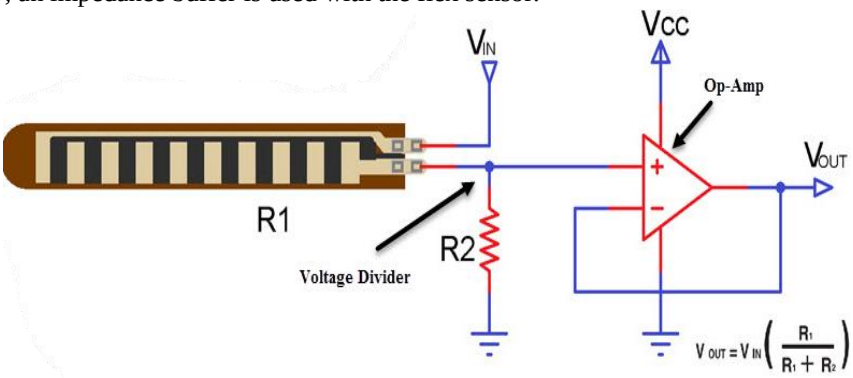


Fig.2. Circuit to measure electric voltage at the flex sensor

3.2.2. ESP 32:

ESP32 device is a standalone system. It can be connected by other devices like mobiles, PCs, etc. through Wi-Fi and Bluetooth technologies by using its SPI/SDIO or I2C/UART interfaces. It is like a slave device to a Node MCU, which reduces the burden on the primary CPU caused by communication stack. Its pin diagram is shown in Fig.3.

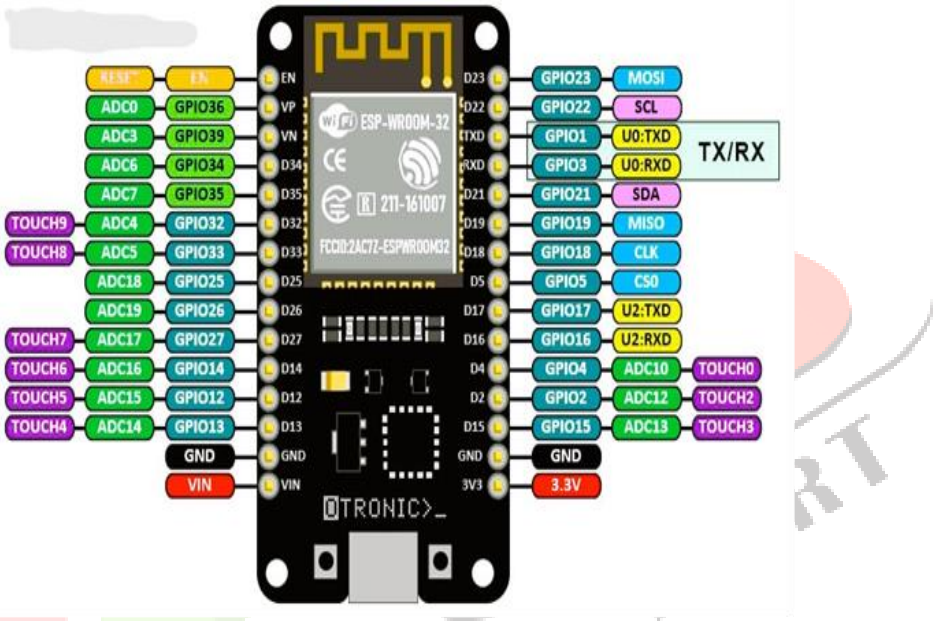


Fig.3. ESP32 pin diagram

3.2.3. Adafruit ADS 1x15:

Adafruit ADS 1x15 series, as depicted in fig.4. have two versions and they are Adafruit ADS 1015 which is having 12-bit ADC with 4 channels and Adafruit ADS 1115 with 16-bit ADC with 4 channels. The gain range of Adafruit ADS 1x15 versions are within 2/3x to 16x. It allows us to amplify weak signals with more accuracy.

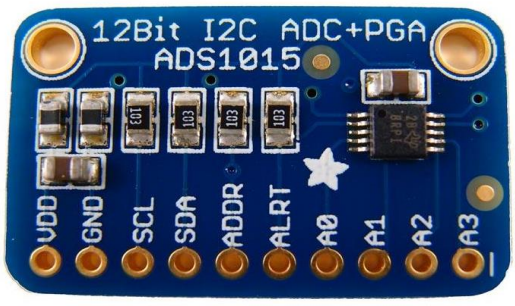


Fig.4. Adafruit ADS 1x15

3.2.4. 4 Channel Relay Module:

The 4-channel relay module operates as 4 different electric circuits using control signal or microcontroller. Relay acts as a switch which can be used to turn ON/OFF the appliances connected to it. It's like a circuit which is open and closes to perform operations. It enables and disables the flow of current via the linked circuit. Lots of appliances including lights, fans, motors, and others can be operated by using relay modules.

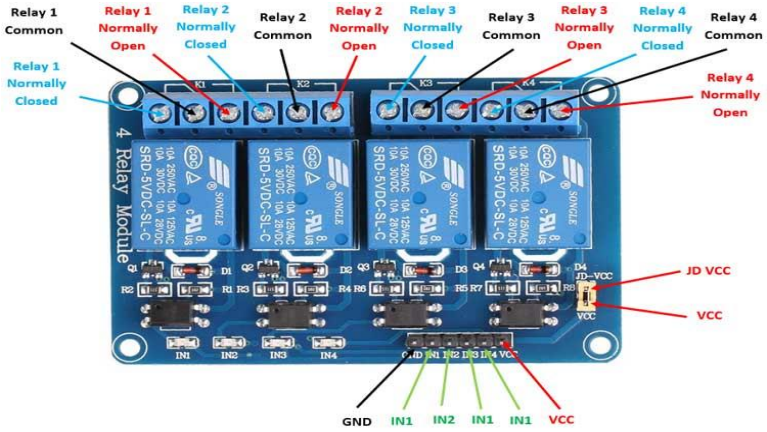


Fig.5. 4 Channel relay module

3.2.5. Arduino IDE Compiler:

Arduino IDE is used to programme the ESP32 board. It is an open-source software application it can be used to write code and compile. This IDE supports the programming languages C and C++, as well as providing a cluster of libraries and a sample of code for beginners.

3.2.6. RF module:

3.2.6.1. RF Transmitter:

A radio frequency transmitter is used in so many numbers of applications. It is used for wireless communication. It converts electrical signals into radio signals. It transmits the radio signals through air or other mediums within specified region. These RF transmitters are used in applications like radio, television, broadcasting, wireless communication systems, remote control devices and military communications. A typical commercially available RF transmitter is shown in Fig.6.a.

3.2.6.2. RF Receiver:

The RF receiver converts the modulated radio signals into electrical signals. It receives radio signals through the antenna within specified region. These RF receivers are used in applications like radio, television, broadcasting, wireless communication systems, remote control devices and military communications. It is depicted in Fig.6.b.

Fig.6.a. RF transmitter and Fig.6.b. RF receiver

3.3 IMPLEMENTATION

The prototype has been designed under two phases: Transmitter module and Receiver module. A hand glove with four flex sensors has been designed as a transmitter, which is depicted in Fig.7.

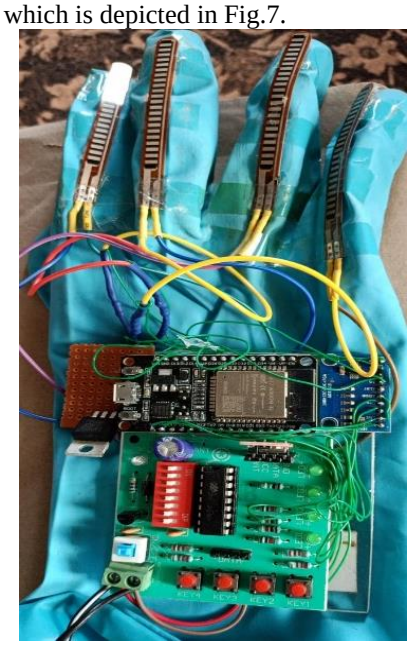


Fig.7. Transmitter module

The data from the flex sensors are transmitted wirelessly through the RF transmitter. The 4 relay modules attached with the receiver module are connected to the switches of an electrical switch board containing 4 power plugs, as shown in Fig.8. The appliances connected through this switch board can be controlled remotely through the flex sensors.

Fig.8. Receiver module

An Arduino IOT Cloud Remote App has been used to develop a user interface (application dashboard) to monitor and to control the appliances. Moreover, the sensor data will be automatically stored in the Arduino IoT Cloud which can later be used for analysis and billing purpose.

To have a voice control, an Alexa has also been integrated in the design. The Alexa works on the principle of speech recognition. Hence, appliances are controlled through some speech instructions given to Alexa. Finally, the prototype is tested and validated with the required outputs, which are discussed in Section 4.

IV. RESULTS AND DISCUSSION

The prototype has been designed to operate in the following modes:

4.1. ON-MODE

Fist Gesture (bending all the fingers and bringing them into the palm to form a fist) can be used to activate turning ON the appliances. After this, an appliance will be turned ON by bending the flex senor of the respective finger. Table.1. (S. No 1-5) demonstrates the functionality of this mode.

4.2. OFF-MODE

Pointing Gesture (extending the index finger while keeping other fingers bent) can be used to activate turning OFF the appliances. After forming the pointing gesture, individual appliances can be turned OFF by bending the flex senor of respective finger. Table.1. (S. No 6-10) demonstrates the functionality of this mode.

4.3. Voice command mode

In this mode, Alexa (voice assistant for home automation) integrated with ESP32 is used to control the various home appliances. The test cases for verifying the functionality of this mode are illustrated here under.

1. "Alexa switch on appliance 1"

Fig.9.a. Appliance 1 is ON

2. "Alexa switch on appliance 2"

Fig.9.b. Appliance 2 is ON

3. "Alexa switch on appliance 3"

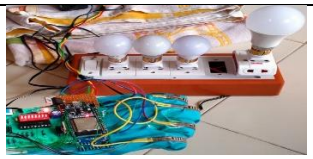
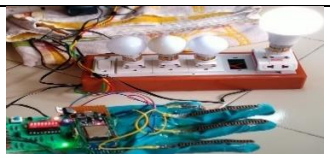
Fig.9.c. Appliance 3 is ON

4. "Alexa switch on appliance 4"

Fig.9.d. Appliance 4 is ON

Table.1. Test cases to demonstrate the functionality of the prototype (1 refers to flex sensor is bent and 0 refers to flex sensor is not bent)

V. CONCLUSION

no.	Flex1	Flex2	Flex3	Flex4	Name of Mode	Appliance No. & State	
1	1	1	1	1	Switched to On mode	-	
2	1	0	0	0	ON mode	Appliance 1- ON	
3	0	1	0	0	ON mode	Appliance 2- ON	
4	0	0	1	0	ON mode	Appliance 3- ON	
5	0	0	0	1	ON mode	Appliance 4- ON	
6	0	1	1	1	Switched to OFF mode	-	
7	1	0	0	0	OFF mode	Appliance1- OFF	
8	0	1	0	0	OFF mode	Appliance 2- OFF	
9	0	0	1	0	OFF mode	Appliance 3- OFF	
10	0	0	0	1	OFF mode	Appliance 4- OFF	

In this paper, the design of a prototype home automation system with flex sensors has been presented. ESP32, RF module and flex sensors are used to develop a prototype home automation system which provides an easy access of the home appliances to the housebound people as well as for crippled and aged persons. As an additional feature, an Alexa (voice assistant) has been integrated so that these appliances can be controlled through voice commands also.

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