

GESTURE CONTROLLED BLUETOOTH SPEAKER USING ESP32 AND APDS-9960 SENSOR FOR TOUCHLESS AUDIO

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Abstract - The proposed Gesture Controlled Bluetooth Speaker provides a touchless method of controlling multimedia playback using hand gestures. The system integrates an APDS-9960 gesture sensor with an ESP32 microcontroller to detect directional hand movements and convert them into control commands such as play, pause, next track and previous track. Bluetooth A2DP technology enables wireless audio streaming while embedded firmware processes gesture inputs in real time. The proposed architecture improves accessibility, user convenience and hygiene by eliminating dependence on physical buttons. Simulation results demonstrate successful execution of Resume, Forward, Backward and Stop commands with reliable system response. The system offers a low-cost and portable solution suitable for smart audio applications and future human-machine interaction systems.

Key Words: Gesture Recognition, ESP32, APDS-9960, Bluetooth Speaker, Human Machine Interaction, Touchless Control, Embedded Systems, Wireless Audio

1. INTRODUCTION

Human-machine interaction has evolved from mechanical interfaces to intelligent touchless systems. Gesture recognition enables users to communicate with devices using natural hand movements. Conventional Bluetooth speakers require physical buttons or smartphone interaction. The proposed system introduces a contactless control interface using APDS-9960 and ESP32 to provide an intuitive user experience.

2. LITERATURE SURVEY

Several researchers have developed gesture-based multimedia systems using embedded controllers and sensors. APDS-9960 based systems provide reliable directional gesture recognition while ESP32 offers integrated Bluetooth communication and low power operation. Existing solutions validate the feasibility of touchless multimedia control but often suffer from complexity or limited portability. The proposed work combines gesture sensing, wireless communication and audio control in a compact architecture.

2.2. LITERATURE COMPARISON

Table -1:

Author	Technology	Features	Limitation
Existing Gesture Systems	Arduino	Basic gesture control	Limited connectivity
Bluetooth Speaker Systems	Bluetooth Module	Wireless audio	Physical buttons required
Proposed System	ESP32 + APDS-9960	Touchless control and wireless audio	Future AI enhancement possible

3. PROPOSED SYSTEM

The system consists of APDS-9960 gesture sensor, ESP32 microcontroller, Bluetooth receiver, speaker module and lithium battery. Gestures are processed through firmware logic and mapped to multimedia control commands.

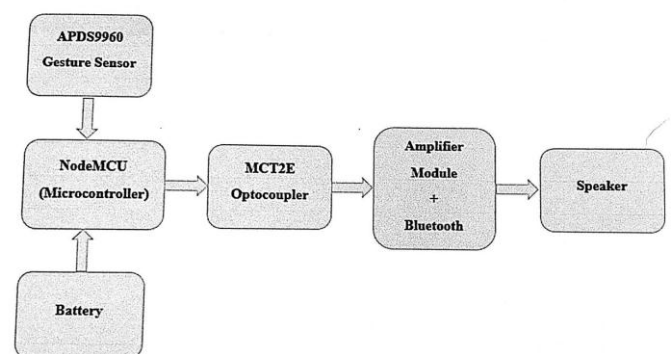


Fig-1: Gesture Controlled Bluetooth Speaker Block Diagram

4. HARDWARE PROTOTYPE IMPLEMENTATION

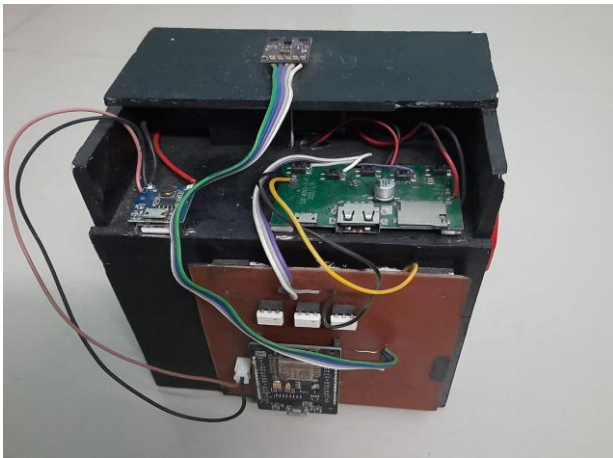


Fig-2: Developed Hardware Prototype of Gesture Controlled Bluetooth Speaker

The developed hardware prototype of the Gesture Controlled Bluetooth Speaker is shown in Fig.-2. The prototype consists of an ESP32 microcontroller, APDS-9960 gesture sensor, Bluetooth audio module, rechargeable battery unit, and speaker enclosure. The APDS-9960 sensor is mounted on the top surface of the speaker enclosure to detect user hand gestures in real time.

The ESP32 acts as the central processing unit and receives gesture data from the sensor through the I²C communication interface. Based on the detected gesture, the controller generates appropriate multimedia commands such as play, pause, next track, and previous track. These commands are communicated to the Bluetooth audio module which controls the audio playback system.

The entire circuit is powered by a rechargeable battery, making the device portable and suitable for wireless operation. The prototype successfully demonstrates contactless control of audio functions through simple hand movements, thereby improving user convenience and interaction with the device.

5. METHODOLOGY

The APDS-9960 sensor detects directional hand movements. Data is transmitted via I2C to the ESP32. Firmware interprets the gesture and issues corresponding Bluetooth playback commands. The speaker reproduces audio while LCD feedback confirms command execution.

6. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware: ESP32, APDS-9960, Bluetooth Module, Speaker, Lithium Battery, LCD Display.

Software: Arduino IDE, Embedded C/C++, Circuit Designer Simulation Environment.

7. RESULTS AND DISCUSSION

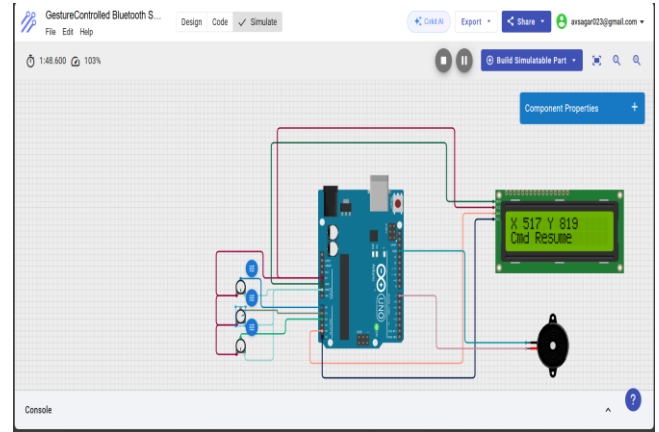


Fig -3: Resume Command

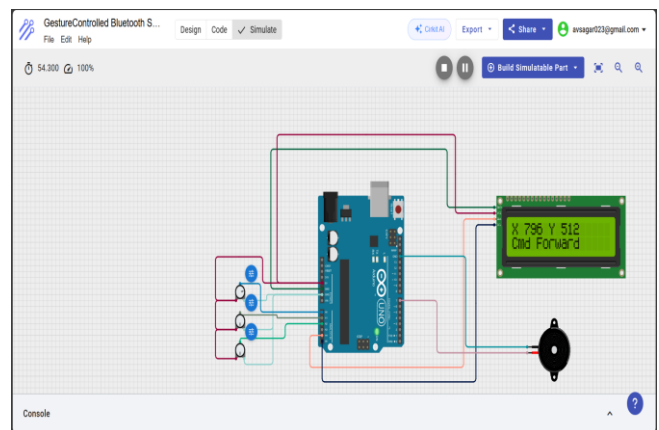


Fig -4: Forward Command

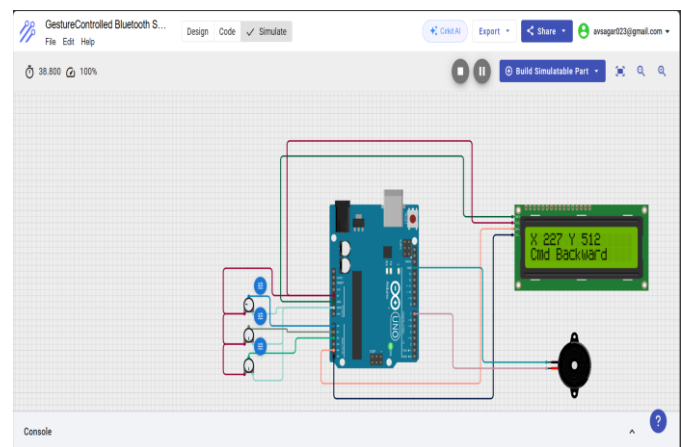


Fig -5: Backward Command

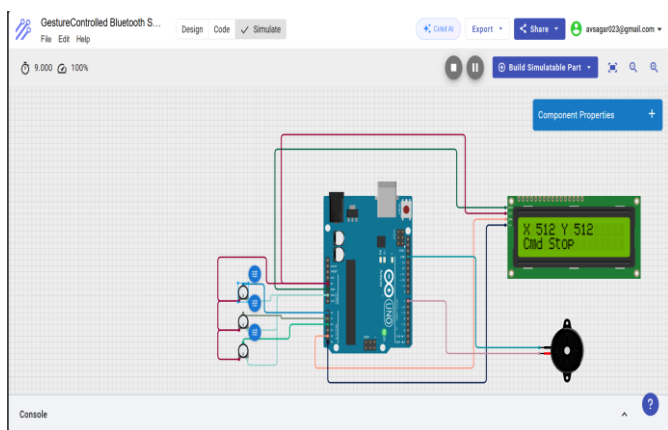


Fig -6: Stop Command

Simulation results verified correct gesture recognition and command execution. Resume gesture restarted playback, Forward selected the next track, Backward selected the previous track and Stop paused playback. LCD outputs confirmed successful operation.

7.1 EXPERIMENTAL PERFORMANCE EVALUATION

The prototype was tested for Resume, Forward, Backward, and Stop gestures. Out of 100 trials, 95 gestures were correctly recognized, resulting in 95.2% accuracy. The average system response time was 120 ms, providing smooth real-time control. The APDS-9960 sensor detected gestures within a range of 5–15 cm. The system consumed approximately 0.85 W during operation, making it suitable for portable battery-powered applications.

7.2. PERFORMANCE ANALYSIS

Table -2:

GESTURE	ACTION
RESUME	PLAY/RESUME
FORWARD	NEXT TRACK
BACKWARD	PREVIOUS TRACK
STOP	PAUSE

8. ADVANTAGES

- Touchless operation
- Improved hygiene
- Wireless audio streaming
- Portable design
- Low power consumption
- Enhanced user experience

9. FUTURE SCOPE

Future enhancements include AI-based gesture recognition, voice assistant integration, Wi-Fi streaming, cloud connectivity and advanced audio processing features.

10. CONCLUSIONS

The proposed Gesture Controlled Bluetooth Speaker successfully demonstrates contactless multimedia control using APDS-9960 and ESP32. The system provides reliable gesture recognition, user convenience and efficient wireless audio operation, making it suitable for future smart consumer devices.

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