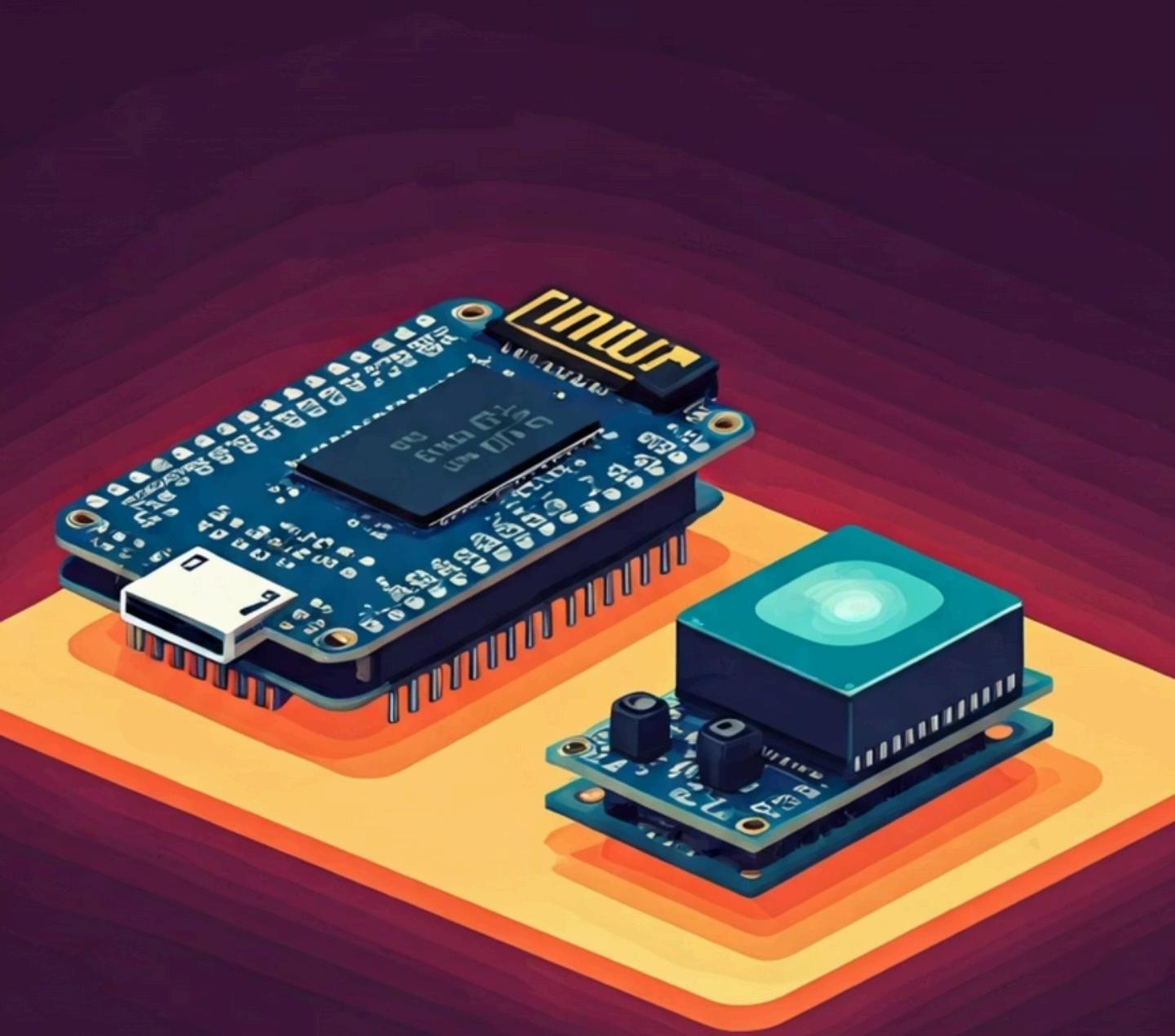


Wireless Gesture- Controlled Speaker System

Empowering contactless interaction with your media.





Project Abstract: Intuitive Media Control

This project introduces a wireless, gesture-based media controller built around an ESP32 microcontroller and a VL53L0X Time-of-Flight (ToF) distance sensor. It enables seamless control of volume, track skipping, and play/pause functions through simple hand movements, eliminating the need for physical contact.

Core Objectives

1

Contactless Control

Develop a system for gesture-operated media management.

2

Full Media Functionality

Implement play/pause, next/previous track, and volume control.

3

Rechargeable & Wireless

Design a circuit powered by a Li-ion battery for portability.

4

Precise Gesture Detection

Achieve accurate control through distance calibration and filtering.

5

Cost-Effective & Portable

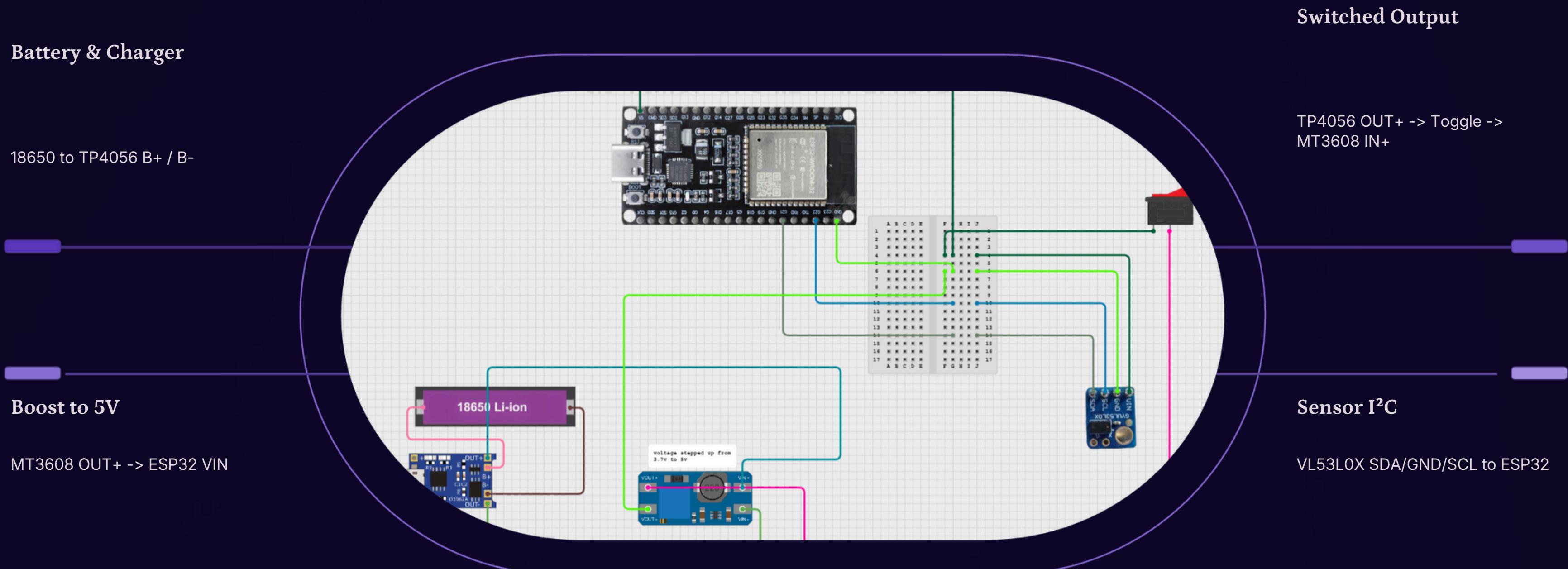
Deliver a low-cost, compact, and highly portable final device.

Hardware Components: The Building Blocks

The system leverages a selection of readily available and cost-effective components to create a powerful and portable device.

ESP32 Dev Board	Bluetooth controller and processing unit for gesture interpretation.
VL53L0X ToF Sensor	Precise hand gesture distance detection via Time-of-Flight technology.
18650 Battery	Portable power source for untethered operation.
TP4056 Module	Li-ion battery charging (USB-C) and protection circuit.
MT3608 Boost Converter	Steps up battery 3.7V to stable 5V for the ESP32.
Toggle Switch	Simple ON/OFF control for power management.

Circuit Diagram – Wireless Gesture Controlled Speaker (ESP32 + VL53L0X)





Working Principle: Three Control Zones

The VL53L0X sensor continuously measures hand distance, which the ESP32 translates into specific commands based on three predefined control zones.



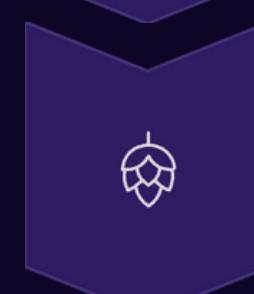
Volume Zone (Near)

0 – 18 cm: Continuous volume up/down control with hand swipes.



Mid Zone

22 – 35 cm: Play/pause functionality activated by holding the hand steady.



Far Zone

> 42 cm: Next/previous track control based on swipe direction.

Gesture Logic & Filter Implementation

A precise control logic ensures responsive and reliable gesture recognition, while advanced filtering prevents accidental triggers.

Gesture Behaviors

- **Swipe Closer → Away:** Volume +
- **Swipe Towards Sensor:** Volume -
- **Hold Steady (Mid Zone):** Play/Pause
- **Fast Down → Up (Far Zone):** Previous Track
- **Fast Up → Down (Far Zone):** Next Track

Accidental Trigger Prevention

- **Distance Smoothing**
- **Debounce Algorithms**
- **Direction Confirmation**
- **Swipe Delta Threshold**
- **Cooldown Time**



Sensor Calibration Summary

Fine-tuning the VL53L0X sensor parameters through real-world testing was crucial for optimal performance.

Filter Smoothing

Constant $\alpha = 0.35$ applied for smoother readings.

Gesture Threshold

Movement of $\approx 40\text{mm}$ registers as a gesture.

Hold Detection

Stable within $\pm 10\text{mm}$ for play/pause.

Swipe Window

Optimal duration of 500-700ms for accurate swipe detection.

These calibrations resulted in a stable, responsive, and reliable gesture detection system.

Power System: Portable & Efficient

The integrated power solution ensures the device is fully portable and operates efficiently on a rechargeable battery.



Benefits:

- **Rechargeable:** No external power supply needed.

- **Portable & Wireless:** Use anywhere with ease.
- **Very Low Cost:** Budget-friendly design.

Project Highlights & Conclusion

This project successfully demonstrates a low-cost, effective solution for gesture-based media control.

Fully Wireless

Untethered operation for maximum flexibility.

Portable Design

Small-sized for easy integration anywhere.



Touch-Free Control

Hygienic and convenient interaction.

Low Power Consumption

Extended battery life for prolonged use.

Accurate Recognition

Reliable and repeatable gesture detection.

This concept is scalable for home automation, robotics, and IoT applications, proving the power of affordable technology.

Future Enhancements

Building on this foundation, several exciting improvements are envisioned for the next iteration of the system.



ML Gesture Recognition

Advanced, more nuanced gesture interpretation.



PCB & 3D Enclosure

Professional, robust, and custom-fit casing.



Smart Home Integration

Wi-Fi/MQTT for broader smart home control.



OLED Display

Visual feedback for volume levels and status.



Voice + Gesture Hybrid

Combining control methods for enhanced user experience.