

Abstract

This project presents a real-time control system in which an ESP32-CAM acts as the master controller of eight Arduino Pro Minis using the I²C protocol. Each Arduino drives two CD74HC4067 demultiplexers, resulting in a total of 16 demux modules. The system provides 16 nodes of type A and 16 nodes of type B that can be flexibly interconnected by the user through a web-based dashboard (hosted on Firebase). This enables remote configuration and monitoring of wiring experiments with minimal latency.

The platform is initially oriented toward **academic laboratories**, where it can serve as a valuable tool in the **Microcontroller Laboratory** for remote configuration and testing, in the **Electronics Laboratory** for signal routing without manual rewiring, in the **Mechatronics Laboratory** when paired with relays, and in the **Chemistry Laboratory** when extended with pumps or valves, etc.

However, its applicability is not confined to academic settings. Thanks to its modular and scalable design, the system can also be employed in industrial prototyping, automated testing facilities, research environments, and many other contexts where dynamic, remotely configurable wiring is required. In this sense, the project demonstrates a flexible foundation that can be expanded far beyond laboratory use — limited only by the creativity and needs of its users.

The system targets low-latency multiplexed device control across 16×16 connection points, emphasizing reliability, observability, and simple deployment. We detail the hardware design (level shifting, power, and signal integrity), firmware (I²C protocol, retry and timeout logic), and the web client (RTDB schema, state reconciliation, and UI). Benchmarks show an end-to-end command latency of < 300 ms under typical Wi-Fi conditions, demonstrating the feasibility of using this platform as a remote wiring system for academic laboratories and beyond.