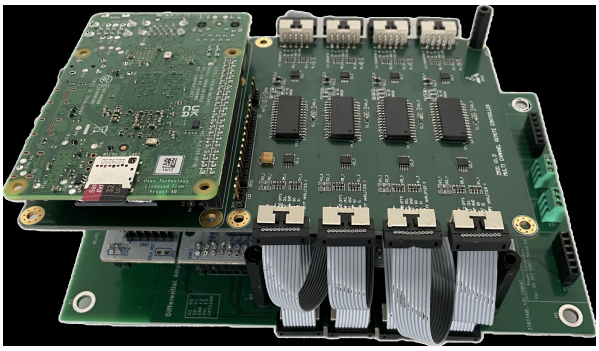
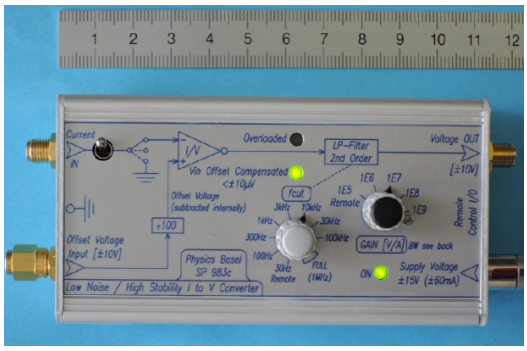
Scalable Remote-Control Platform

This project presents the design and implementation of a scalable, Raspberry Pi–based remote-control platform for Basel Precision Instruments GmbH's low-noise differential amplifiers and I/V converters. The system enables reliable multi-user configuration of up to eight devices via a web application, with automated validation through an STM32-powered testbench.



Remote control unit with external testbench



Low Noise / High Stability I to V Converter
(Source: Basel Precision Instruments GmbH (BASPI))

Background and Motivation

Low-noise differential amplifiers and I/V converters are essential for mesoscopic quantum transport experiments, where even small interference degrades results. Remote control of gain and cut-off frequency is therefore crucial for reconfiguring setups without physical access, especially in dilution refrigerators with multi-day cooldowns.

Project Objectives

This project presents a scalable control platform for up to four low-noise I/V converters and four differential amplifiers. Building on BASPI hardware, it adds digital remote control of gain and cut-off frequency to improve configurability and operational efficiency when access to instrumentation is limited.

System Design

The platform combines a Raspberry Pi control layer, a browser-based UI, and a deterministic I²C/GPIO backend driving BASPI device settings. A Django backend with a Bootstrap 5 frontend provides responsive, multi-user access; authenticated endpoints map user actions to hardware operations via a thin service layer. For production, Nginx serves the app with Gunicorn as the WSGI bridge. The Raspberry Pi communicates with MCP23017 I²C GPIO expanders to fan out control lines for up to eight devices. Signal mapping follows BASPI's binary schemes for gain and low-pass settings, with range checks before commit.

Validation and Results

Functional tests confirmed correct mapping of web-based configurations. EMC pre-compliance passed Class A limits. A microcontroller-based testbench with automated routines produced timestamped CSV reports, ensuring reproducibility and transparent documentation.

Contributions and Outlook

The system enables reliable multi-user control of up to eight devices, improving scalability and usability over the previous unit and strengthening operational efficiency in cryogenic experiments. Future work includes larger device arrays, migration to the Raspberry Pi Compute Module for improved EMC/ESD performance, and SSD storage (instead of SD) to enhance reliability.

System Overview

- Raspberry Pi–based remote-control platform
- Web UI (Django + Bootstrap 5)
- Control up to 8 devices (4 I/V + 4 diff amps)
- Multi-user access via Ethernet
- STM32 testbench for automated validation
- EMC pre-compliance (Class A) verified

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