LIGO in your hands

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Introduction

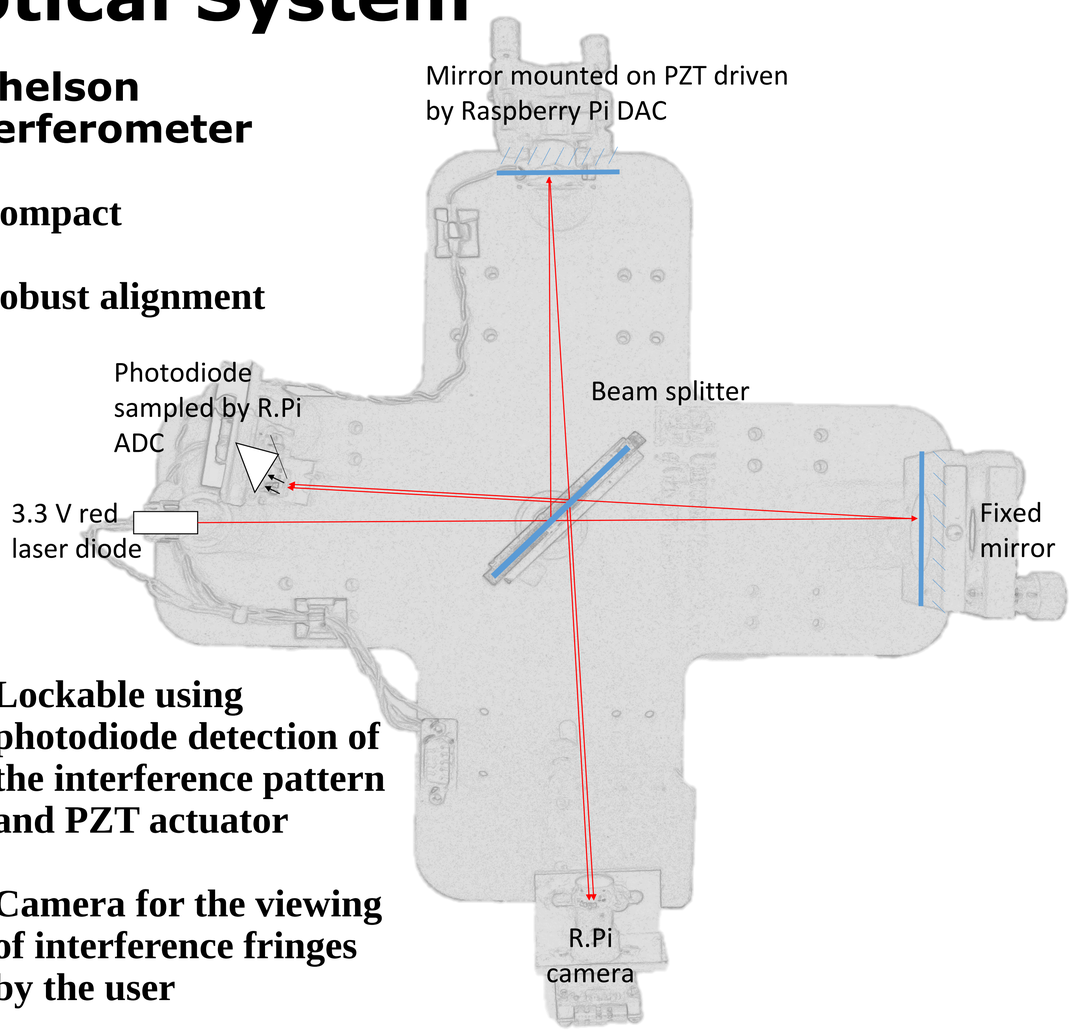
The aim of this multidisciplinary project was to design and build a highly portable Michelson interferometer, locked and stabilised by a Raspberry Pi, suitable for public outreach events.

This required the design and construction of optical and electronic systems as well as the programming of a multithreaded Python GUI and proportional control algorithm.

Optical System

Michelson Interferometer

- Compact
- Robust alignment



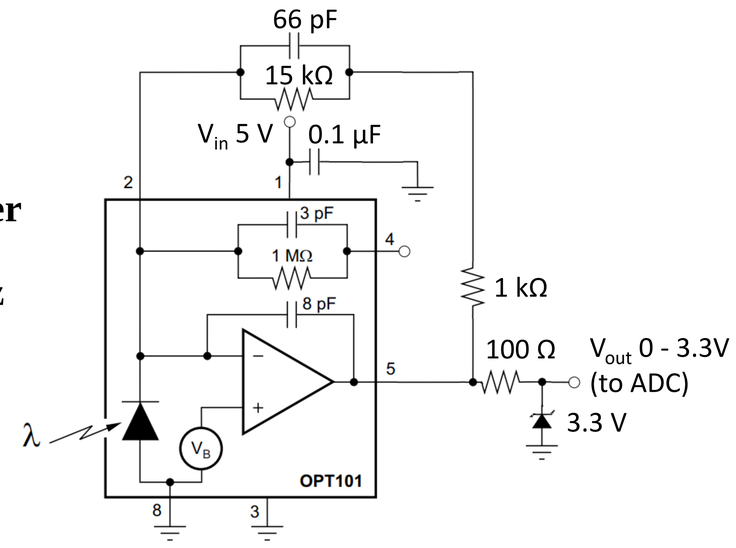
- Lockable using photodiode detection of the interference pattern and PZT actuator
- Camera for the viewing of interference fringes by the user

Electronic Systems

Raspberry Pi Model 3, camera, 7” touchscreen, laser, photodiode circuit, PZT driver circuit, DC-DC converters and fans all designed to be powered by a single 2 A 5 V transformer or power bank.

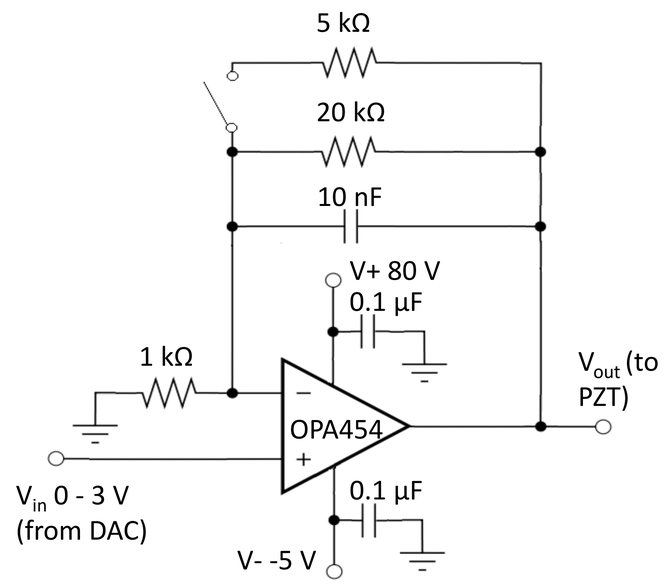
Photodiode circuit

- OPT101 combined photodiode and amplifier
- Sampling rate of 12 kHz under Python
- Zener diode used to protect ADC



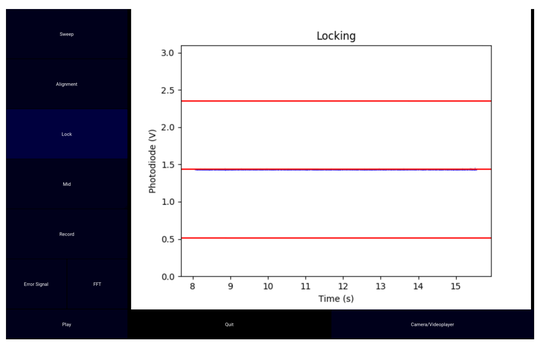
PZT driver circuit

- OPA454 high voltage op-amp
- Asymmetric power supply (V- -5V, V+ 80V) from DC-DC converters
- Two resistor paths giving gains of 5 and 21 for driving 2.5 to 10.5 fringes

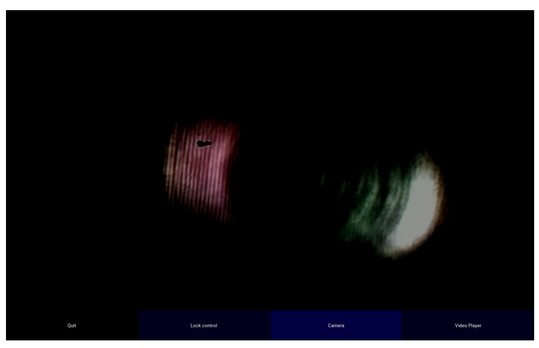


User Interface

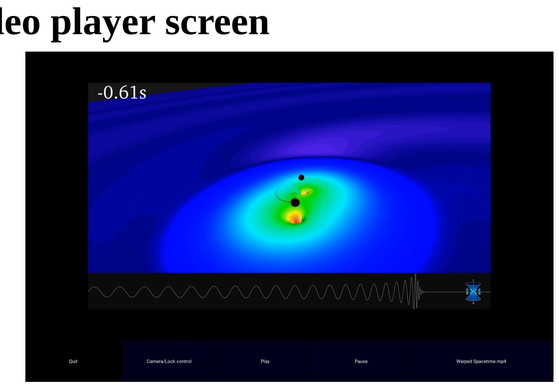
- Touchscreen compatible
- Lock control, system alignment mode and recording screen with error value plotting



- Live camera feed screen

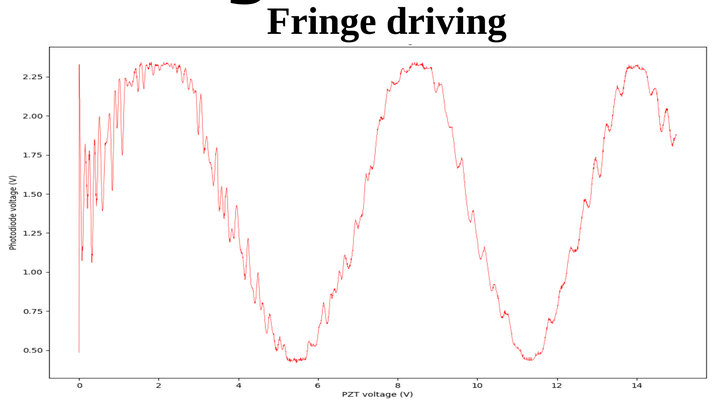


- Video player screen

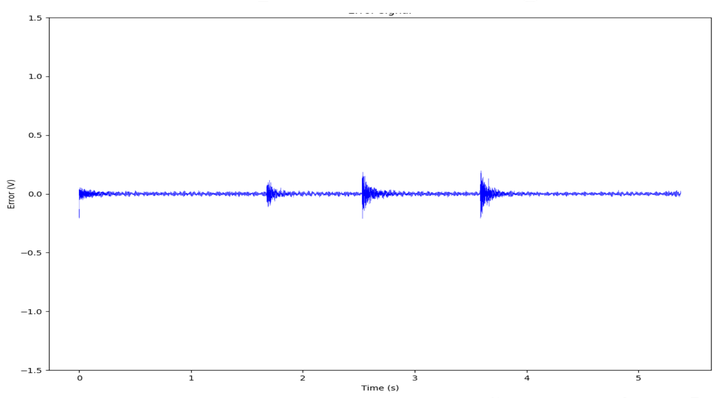


Locking and Sound Recording

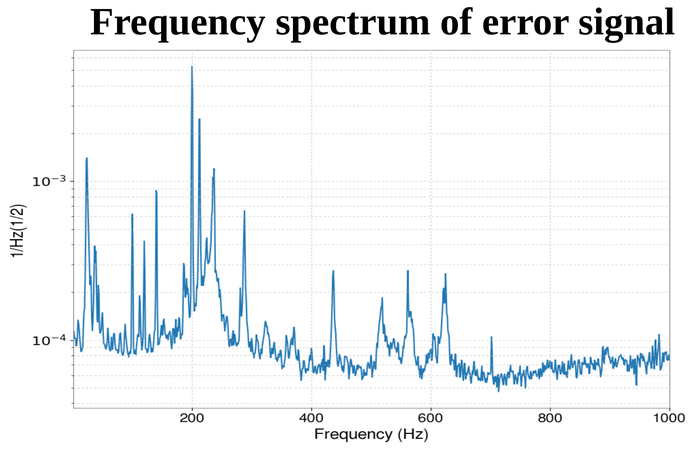
Fringe driving



Proportional locking



Frequency spectrum of error signal



- Proportional control at 8000 Hz
- Selectable locking point
- Fast Fourier Transform frequency analysis
- Alignment mode fringe driving
- Error signal recording and sound playback

Final product

- Excellent for outreach events and undergraduate labs
- Highly portable
- Highly interactive
- Low power requirements
- Economical
- Expandable