A Step Towards A Monolithic Interferometer for Measuring Creep in Fused Silica

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Background: How does stress affect fused silica bonds used in gravitational wave detectors?

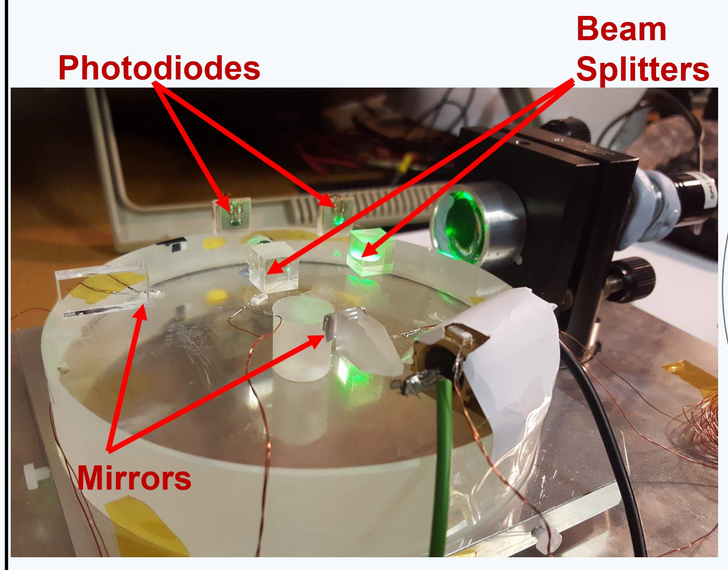
Objective: Measure creep deformation in bonds of a fused silica Michelson interferometer.

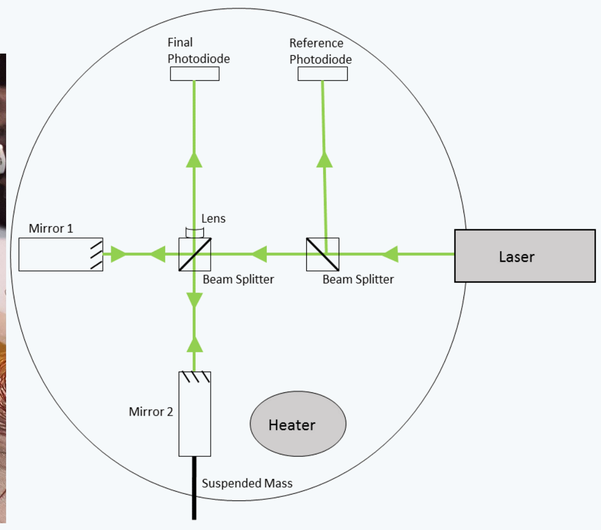
Result: **Noise reduction and signal amplification**

Method

Interferometer:

A monolithic fused silica interferometer using a green laser.



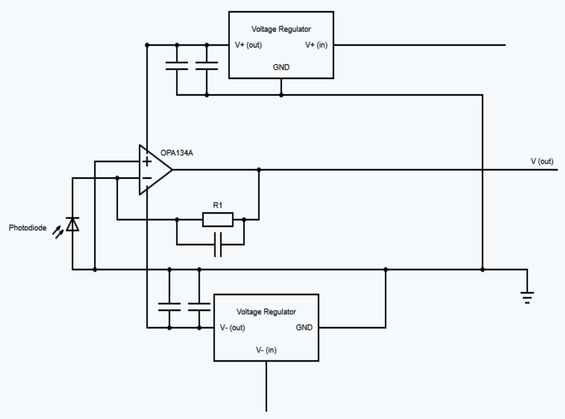


Electronics:

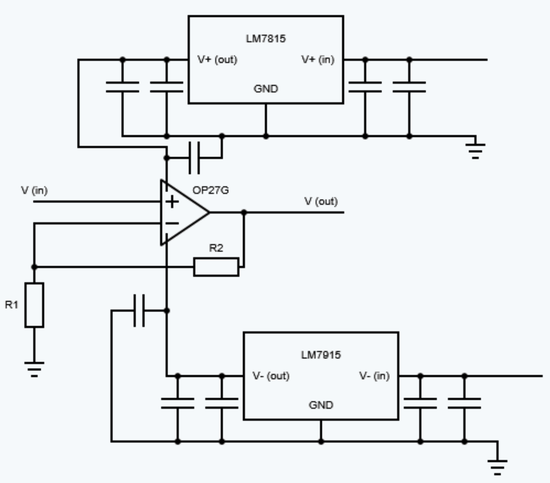
Three operational amplifier circuits that:

1. Convert photodiode current to voltage.
2. Amplify the first photodiode voltage.
3. Amplify the second photodiode signal.

Signal Amplifier Circuit [2 and 3]

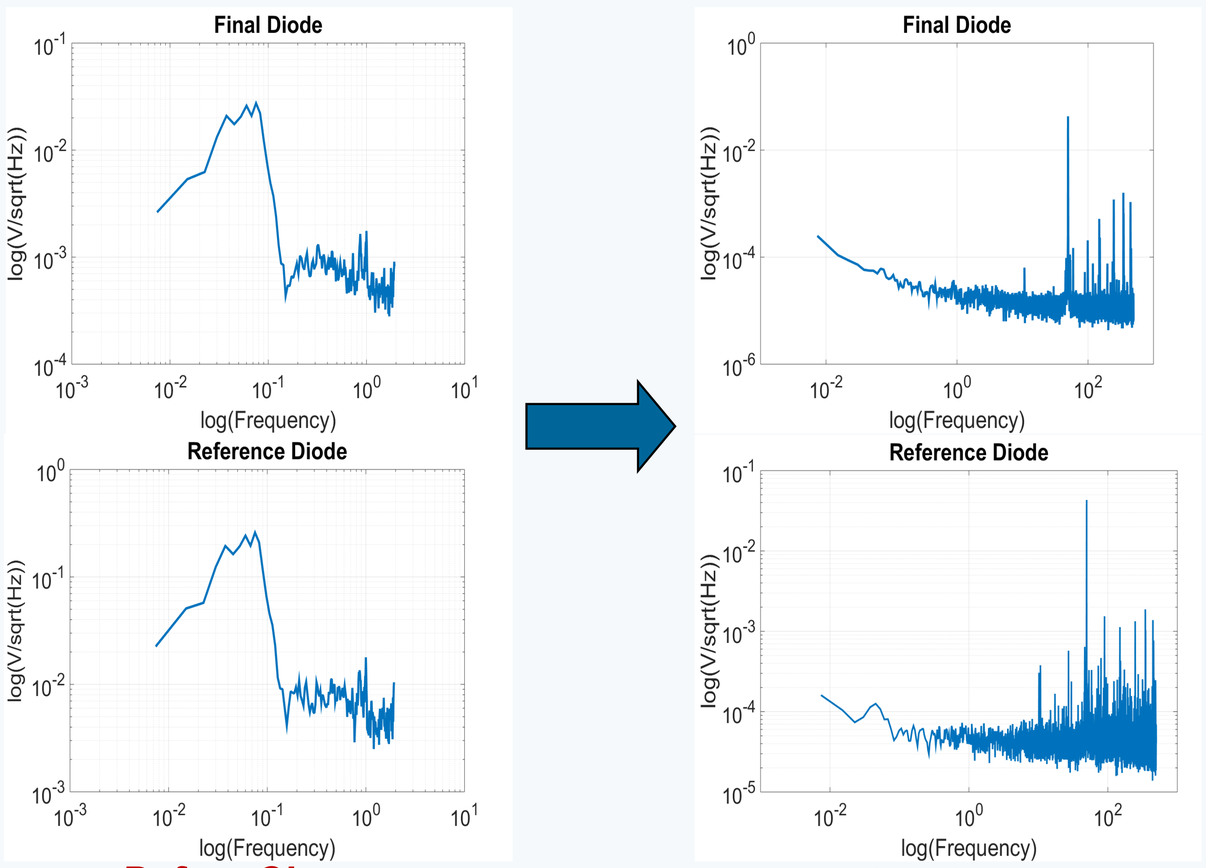


Photodiode Circuit [1]



Results

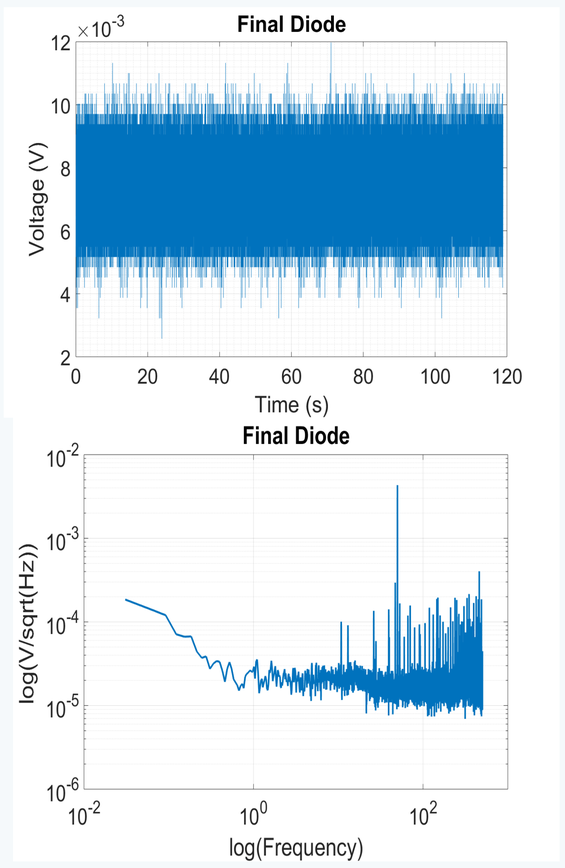
Noise Power Spectral Densities



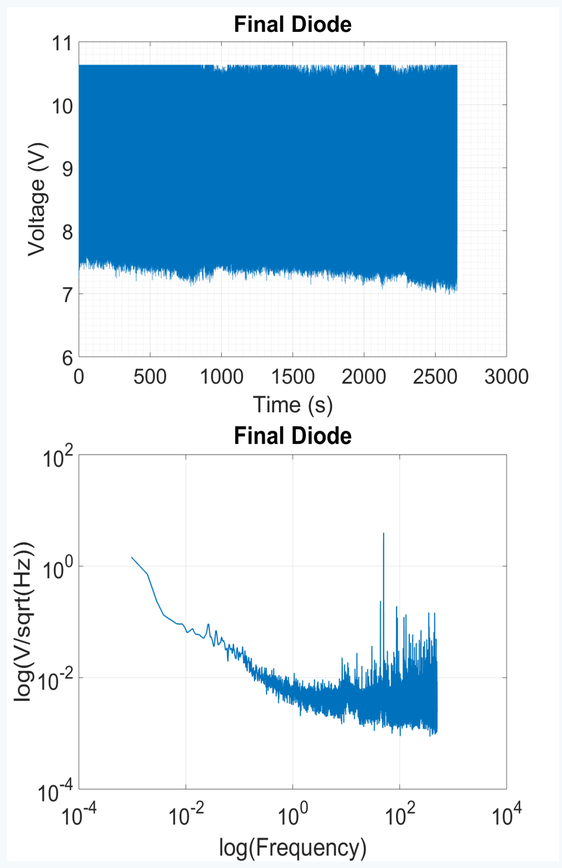
Before Changes

After Changes

Signal Amplification



X 1000



Photodiode data, with no lights, before and after changes:

1. Replaced OPA134A op-amp [8nV/sqrt(Hz)] with lower noise AD8674 op-amp [2.8nV/sqrt(Hz)].
2. Wire wrap put on bare wires.
3. Used higher sampling rate with a higher frequency [30 samples to 100] to smoothen plot.

Need noise level to be less than 2×10^{-5} V, required by estimated change in path length [approx. 1pm].

Digitisation step size from 16 bit DAQ is larger than this [15×10^{-5} V].

Photodiode data, with green laser on, before and after amplification.

Signal is successfully amplified up to max voltage that DAQ can receive [10.6V].

The noise has not been amplified disproportionally however there is greater noise. Op-amp circuit providing extra noise.

Conclusion

Total noise reduced from 10^{-3} V to approx. 10^{-5} V but is still larger than required due to digitisation and interference.

Final interference signal has been amplified to required voltage but amplifier circuit is providing more noise.

Future

1. Amplify both photodiode signals.
2. Use a Faraday cage to block 50Hz mains noise.
3. Use a DAQ with higher bit resolution to reduce digitisation noise.