Stabilization of a parametric signal-amplification system using a digital signal-processing device.

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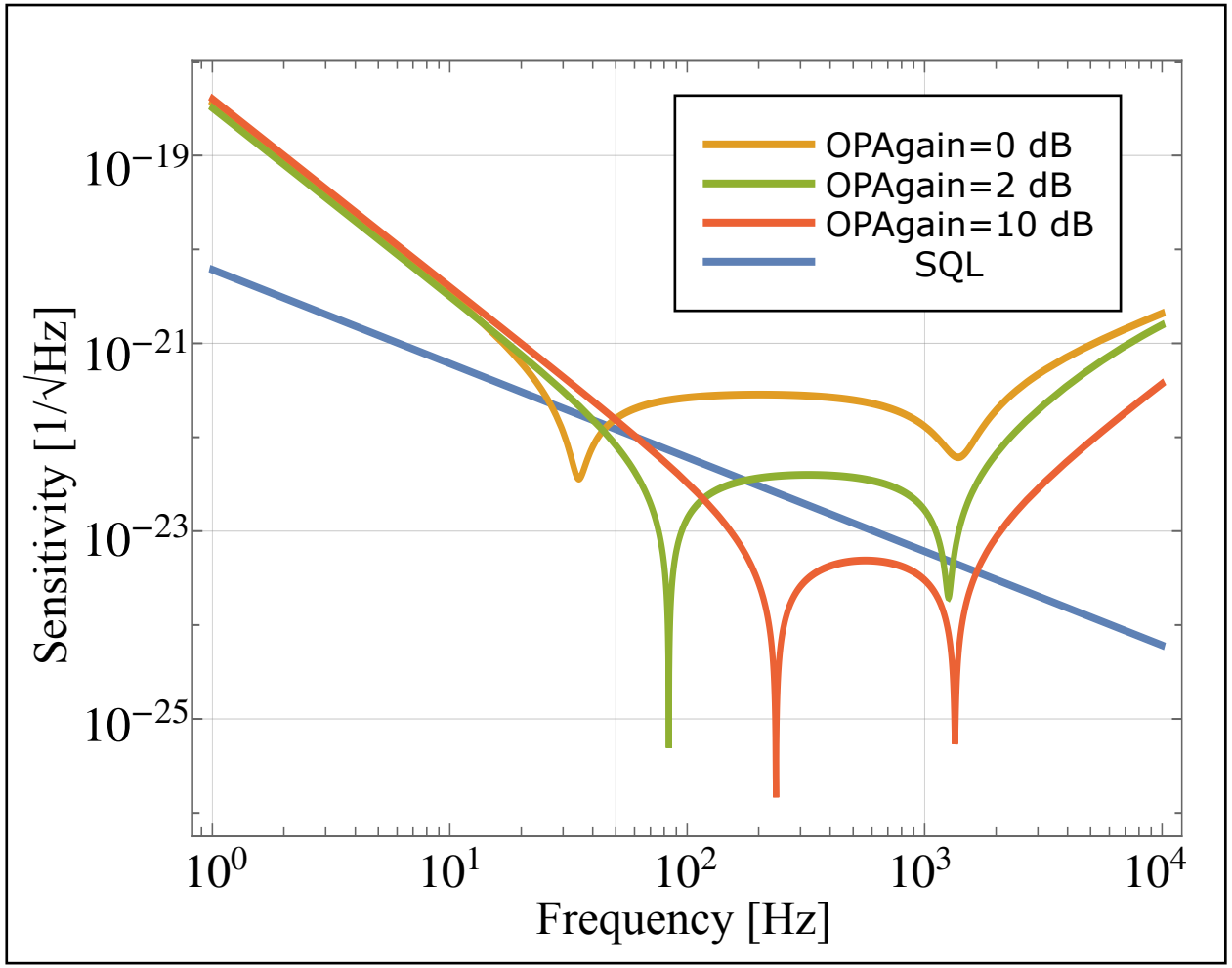
Introduction

A signal-recycling Michelson interferometer with an optical parametric amplification (OPA) has a large potential for a high-frequency gravitational-wave detection.

The OPA using a nonlinear crystal in the signal-recycling cavity amplifies the signal and makes a stiff optical spring.

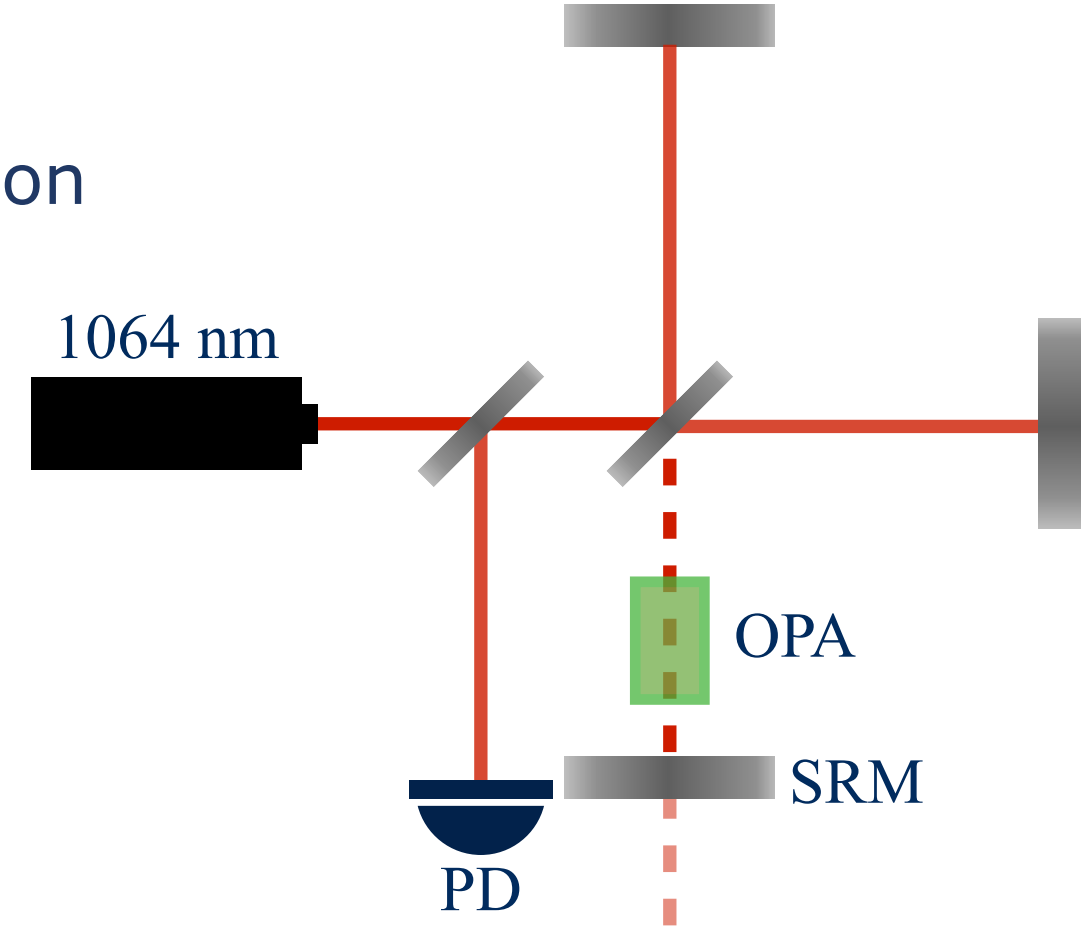


SRMI with OPA

DoFs to be controlled

- Differential length of Michelson interferometer(MICH)
- Signal recycling cavity length(SRCL)
- SHG cavity length
- Squeezing angle of OPA
- Laser power

➡We installed a real-time digital controller sBOX II.

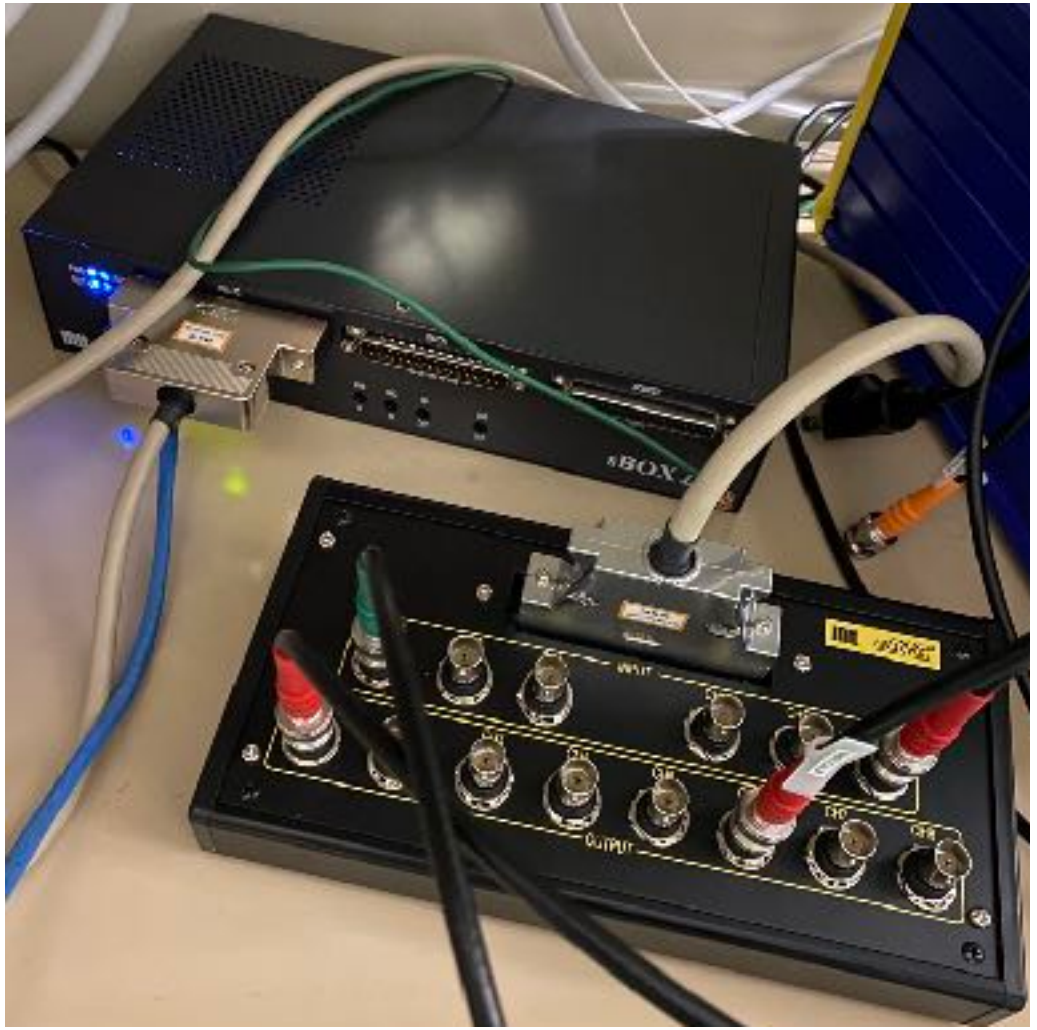


sBOX II

- sBOX II is a commercial digital signal-processing devise manufactured by MIS Corporation.
- One can compile and download a filter program written in C language.

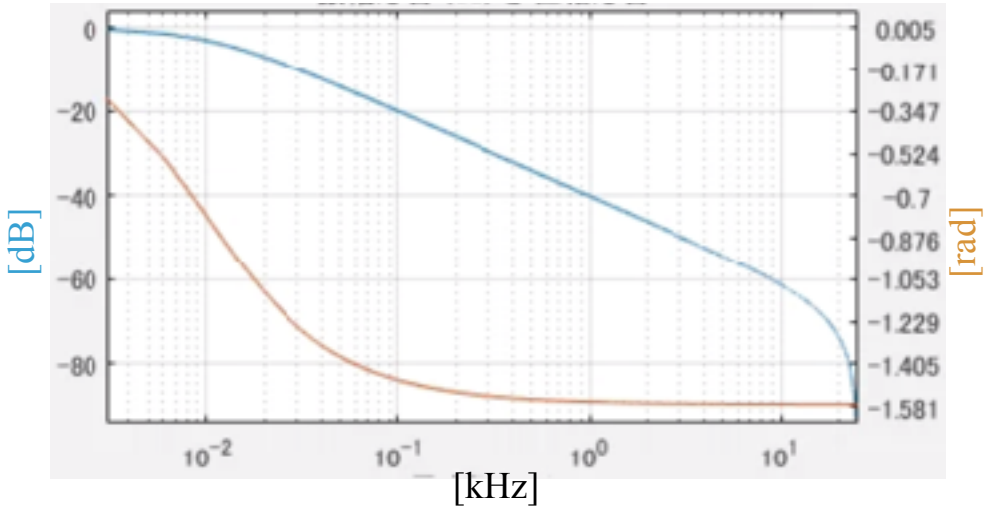
Specs of sBOX II

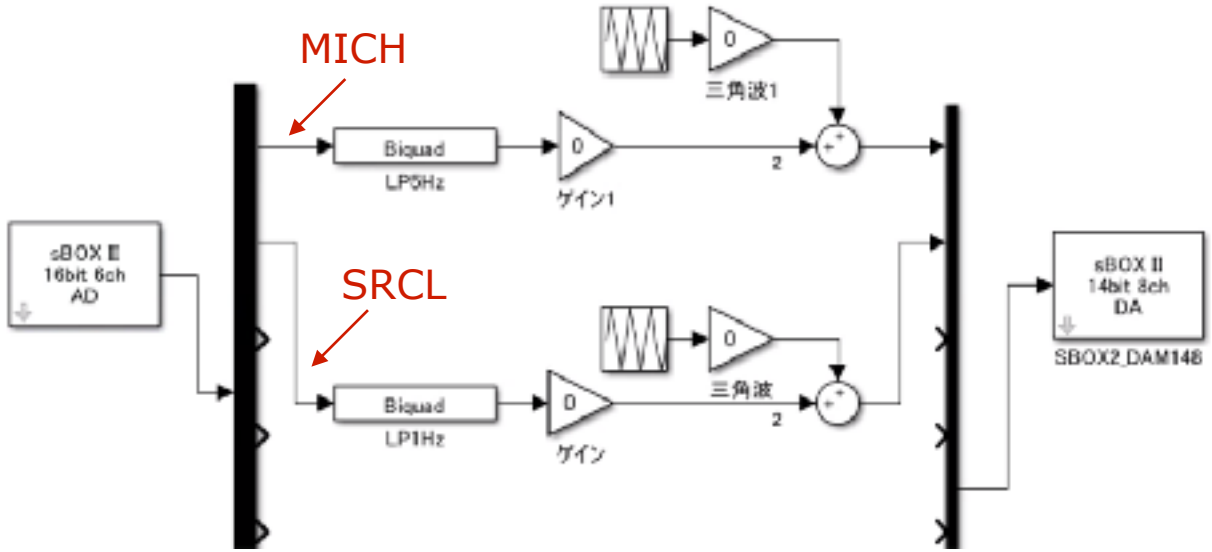
- Inputs: 6 channels, 16 bit
- Outputs: 8 channels, 14 bit
- Sampling freq: 100 kHz
  →Down-sampled to 50 kHz
- Processing delay: 50 μsec



Downloaded filters

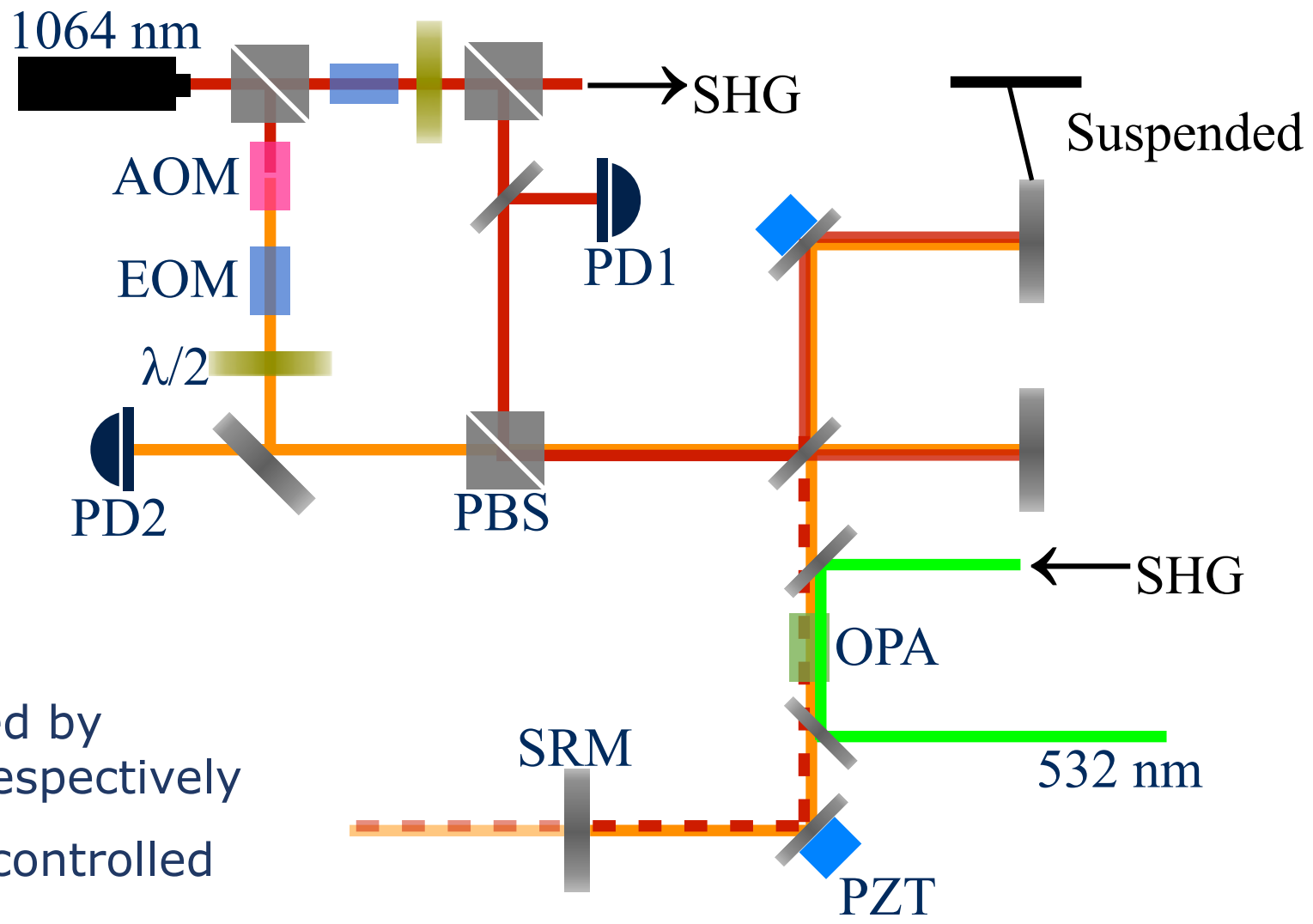
- An IIR filter designed with MathWorks filterBuilder is used to create a lowpass filter (top figure).
- The filter program was build from a block diagram written with MatheWorks Simulink (bottom figure).



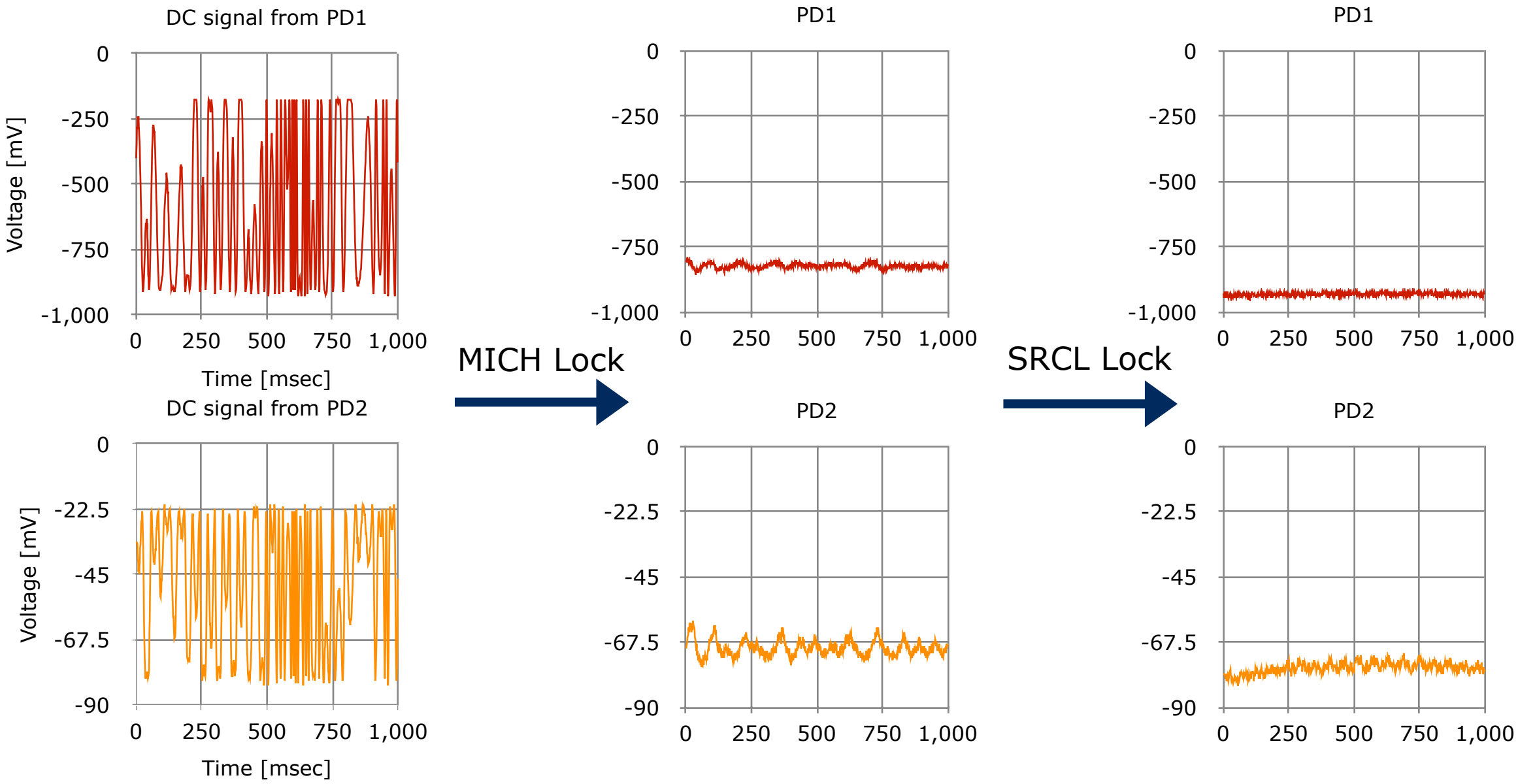


Setup

- One of the end mirrors is a small suspended mirror (200mg).
- The goal is to observe a frequency shift of the optical spring in the transfer function.
- A freq-shifted sub-carrier is used to obtain an error signal of SRCL.
- MICH and SRCL are controlled by signals from PD1 and PD2, respectively
- MICH, SRCL, SHG are to be controlled with the sBOX II



Results of MICH and SRCL control



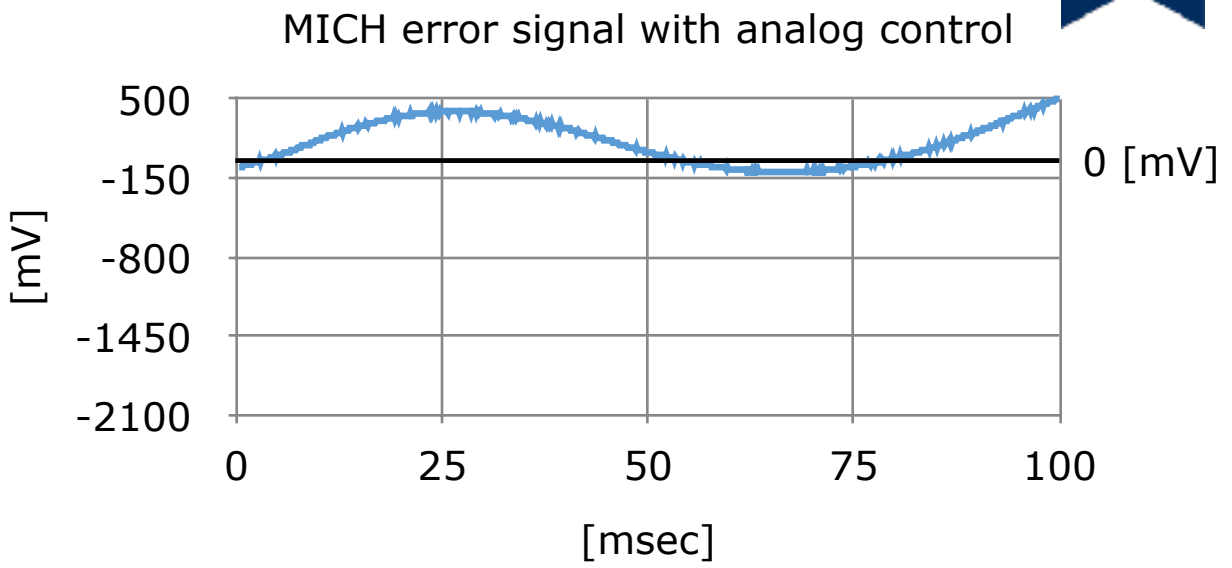
Problems

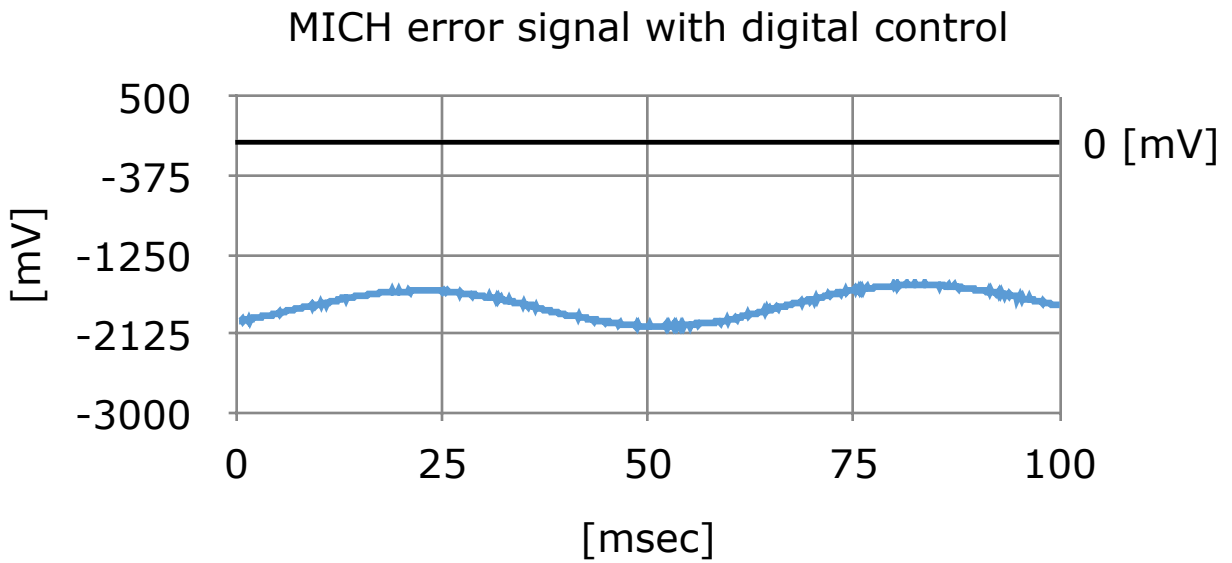
- Comparing the error signals with analog and digital controls, a large offset is introduced in the digital output.

➡ Under investigation.

- Possible aliasing noise.

  ➡ Another anti-aliasing filter is to be installed (fc=20kHz).





Conclusion

- We installed sBOX II to control the signal-recycling Michelson interferometer with an intra-cavity OPA.
- Control of the signal-recycling Michelson interferometer was realized.
- There is an issue in controlling the SHG, possibly due to the offset introduced by sBOX II.