Active Reduction of Residual Amplitude Modulation in EOMs

LIGO SURF 2019

Scott Aronson

University of Florida

8/22/2019

Motivation

What is Residual Amplitude Modulation? (RAM)

- Term used when using EOM as a phase modulator.
- Amplitude modulation of the light field at the phase modulation frequency.

What effect does RAM have on the experiment?

- EOM is used for phase modulation in a PDH cavity locking system.
- RAM induces an offset on the error signal in PDH feedback.

Proposed Solution

- It is possible to reduce the RAM induced by providing a DC offset to the modulation signal and controlling the temperature of the crystal.
- Our solution is to create an active feedback system to control this DC offset, and the temperature of the EOM.

Motivation pt.2

- This DC Bias and temperature control has been implemented in practice before and reach supression of 1×10^{-6}, but as far as I know this was only in fiber coupled EOMs. [1]
- Fiber EOMs have a V_π usually around 6-12 volts, and have less RAM in general due to better alignment.
- Free space EOMs on the other hand have a V_π on the order of hundreds of volts which makes supressing this RAM more difficult in practice.
- In lab here we use the free space variant, so high voltages must be used for the DC Bias.

Outline

1. DC Bias Control
2. Temperature Sensor Characterization
3. Future Work

Bias Tee Introduction

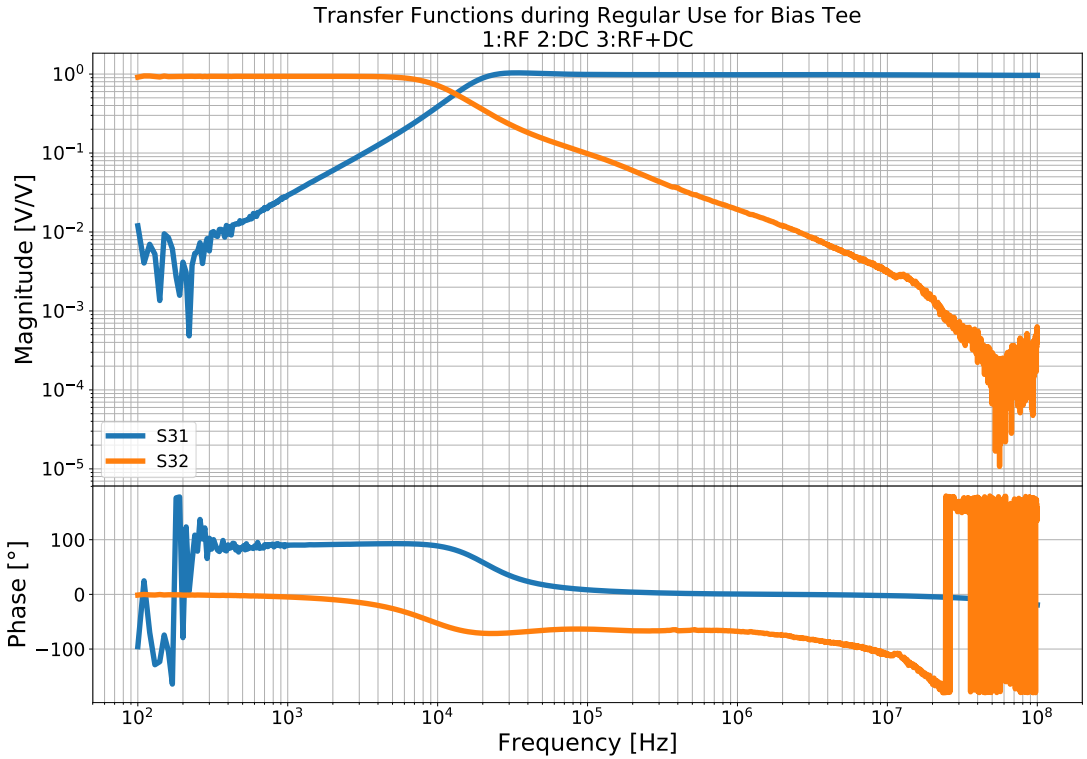


Figure: Bias Tee (Model ZFBT-4R2GW-FT) with Soldered BNC connector / Transfer Functions of Bias Tee in Regular Use

Fitting Bias Tee to Model

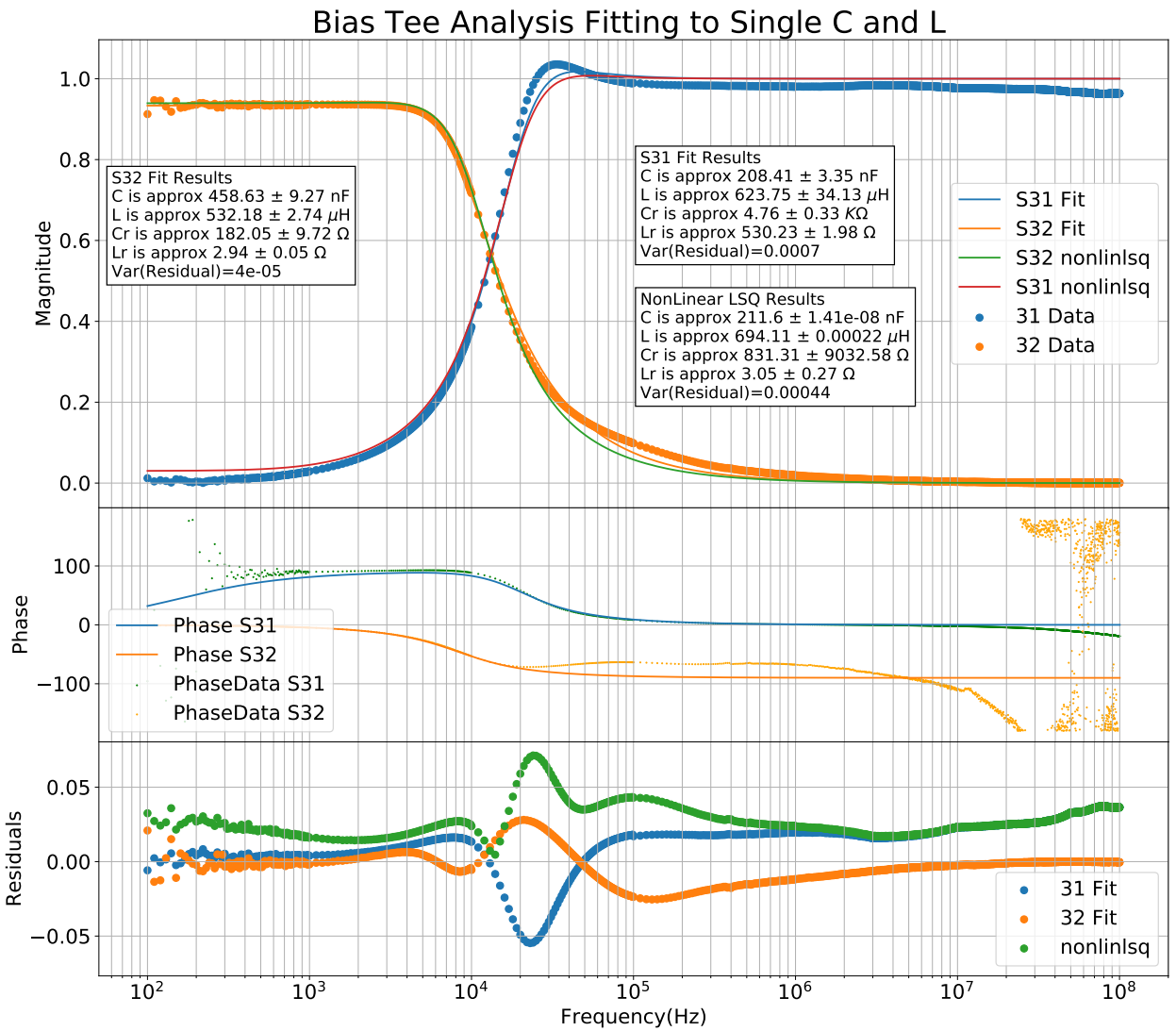
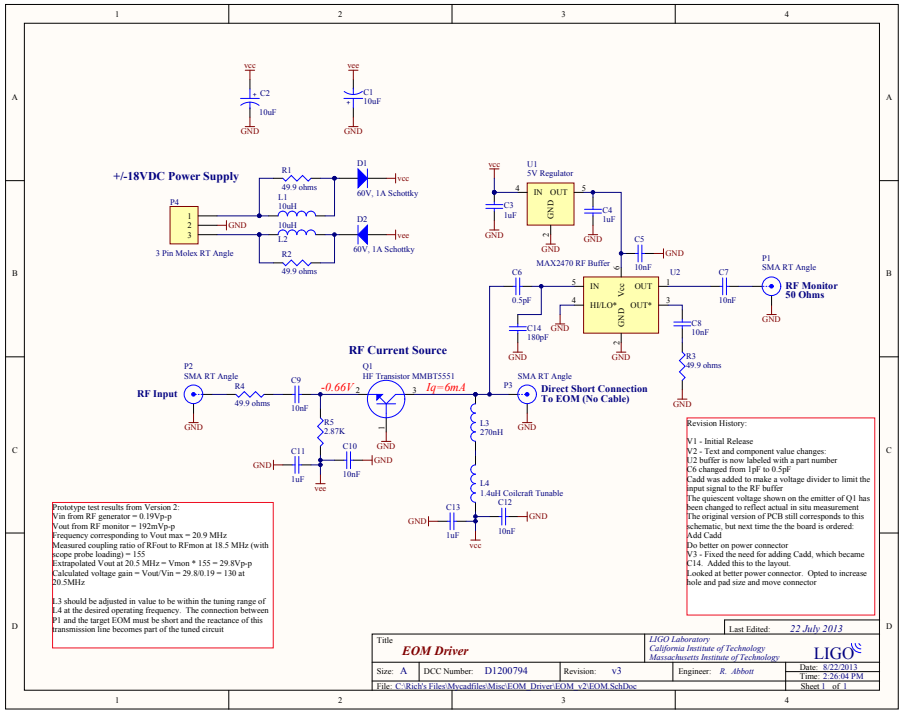


Figure: Fit of Data to Single Capacitor and Inductor

EOM Driver



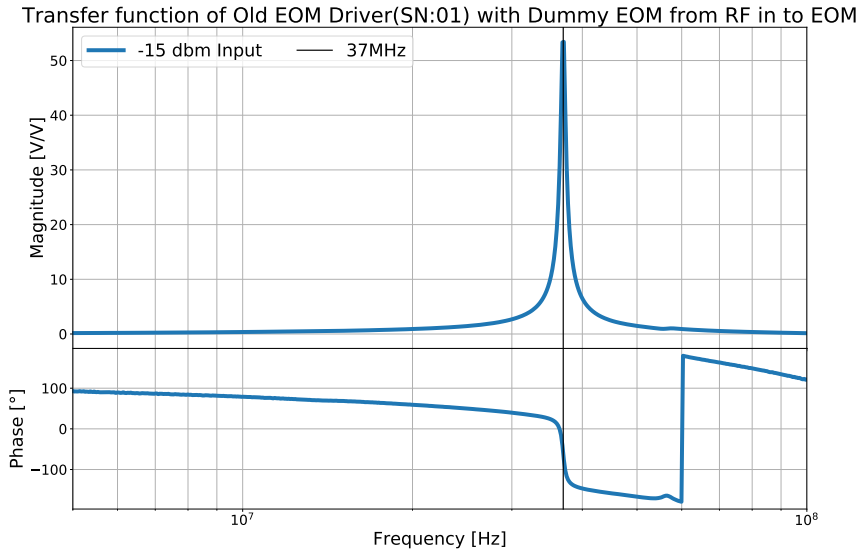


Figure: EOM Diver Schematic (DCC: D1200794-v3) and Transfer Function

Tuning the EOM driver with Bias Tee

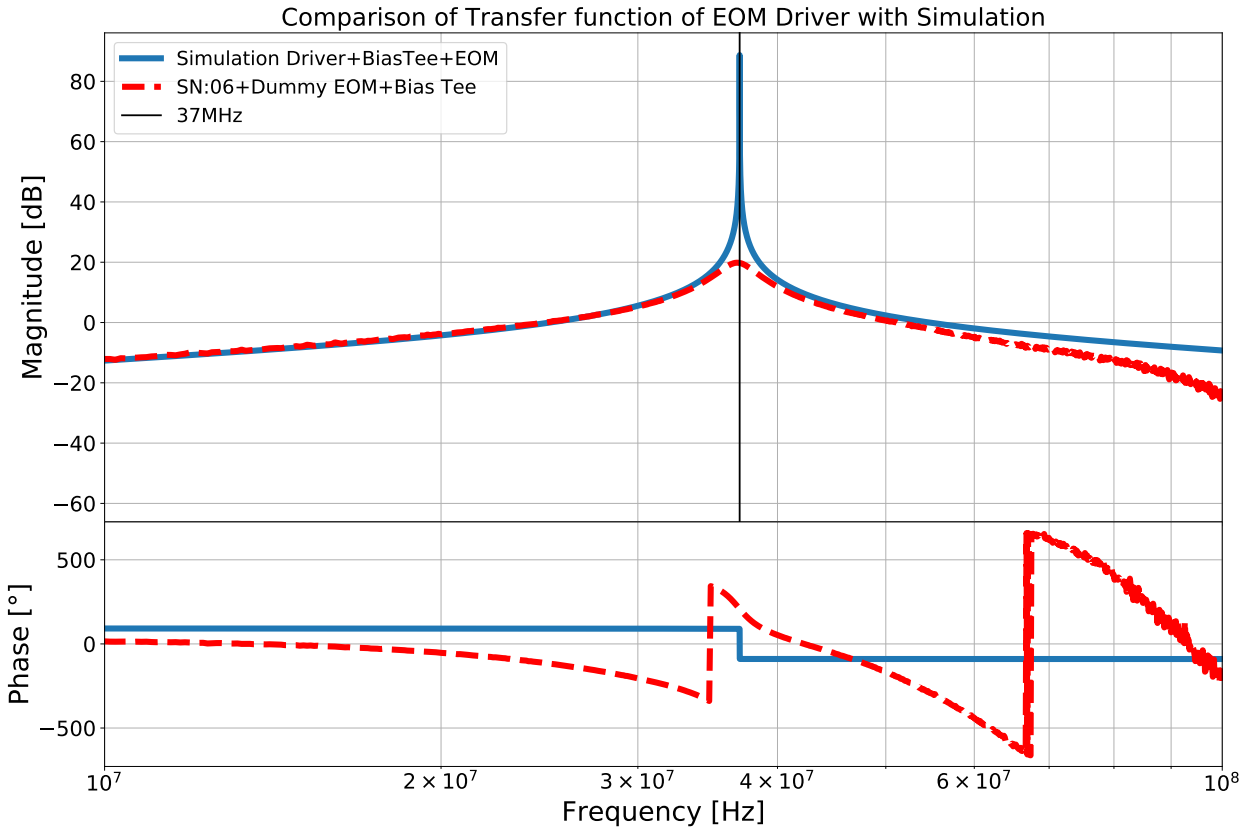


Figure: Simulated vs Measured TF of EOM driver with Bias Tee

Loss in Gain due to Bias Tee

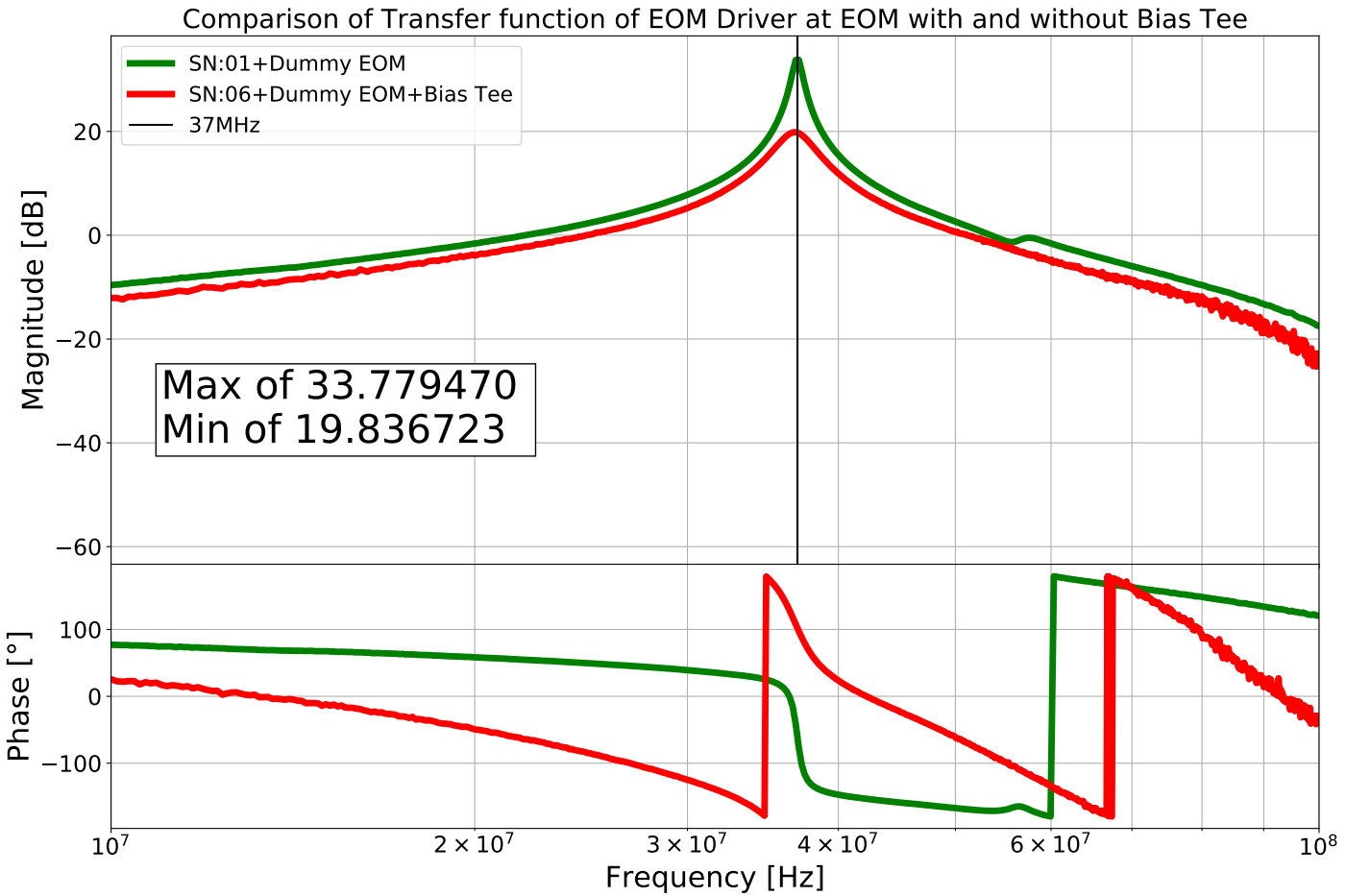


Figure: EOM Driver with Bias Tee vs without Bias Tee

Reduction of Gain with Power

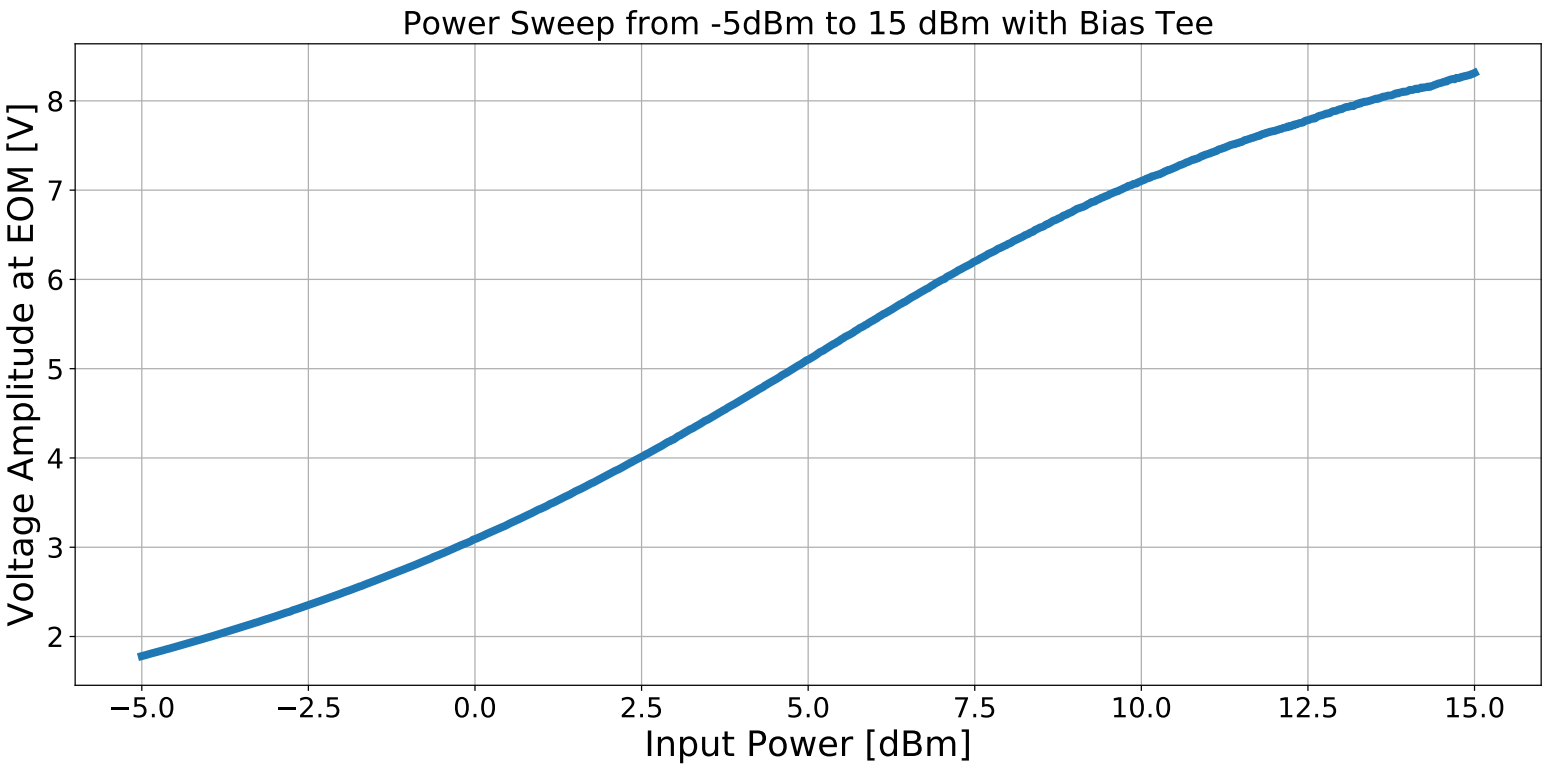
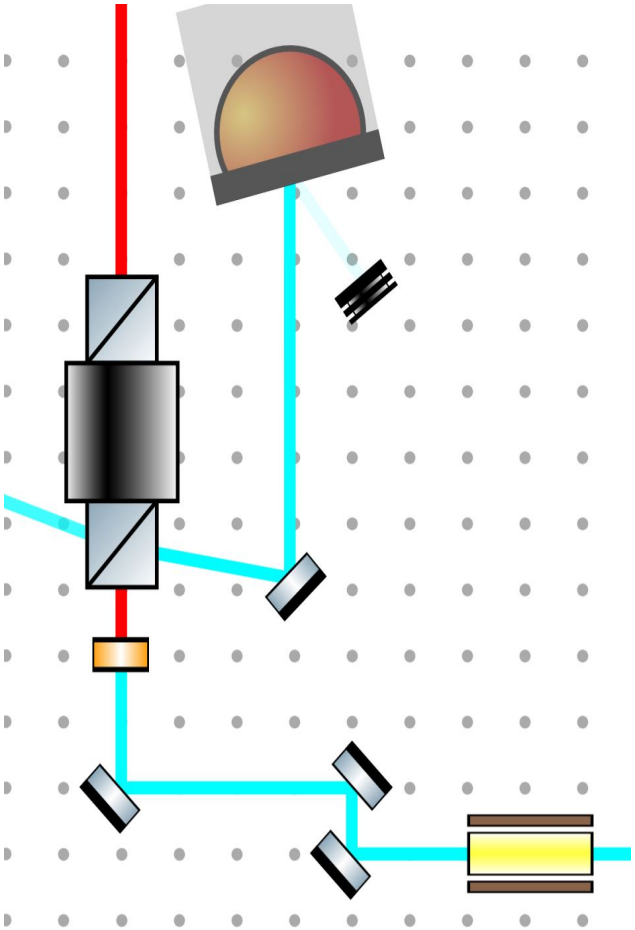


Figure: Change in Voltage at EOM with increasing input power

Setup to Measure RAM



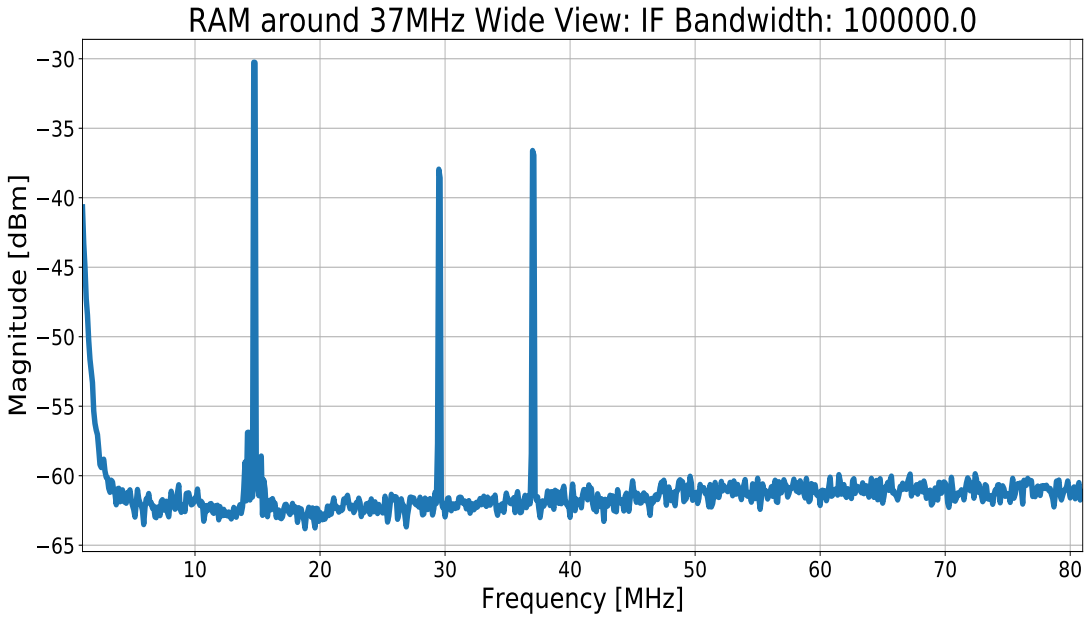


Figure: Residual Amplitude Modulation Measurement setup

Temperature Sensor Characterization

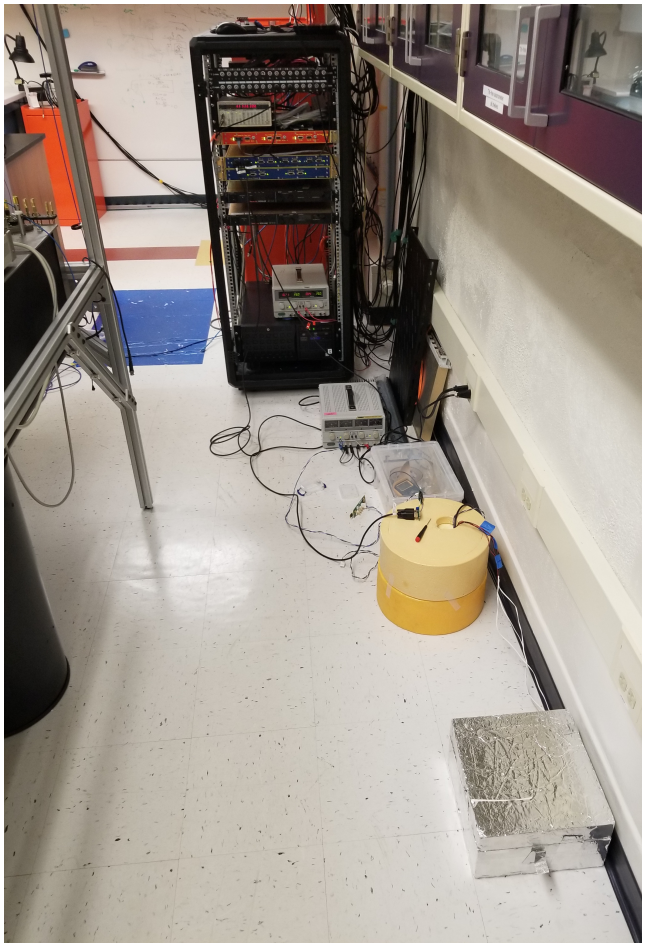


Figure: Differential Temperature Measurement Setup

Temperature Sensor Nosie Characterization

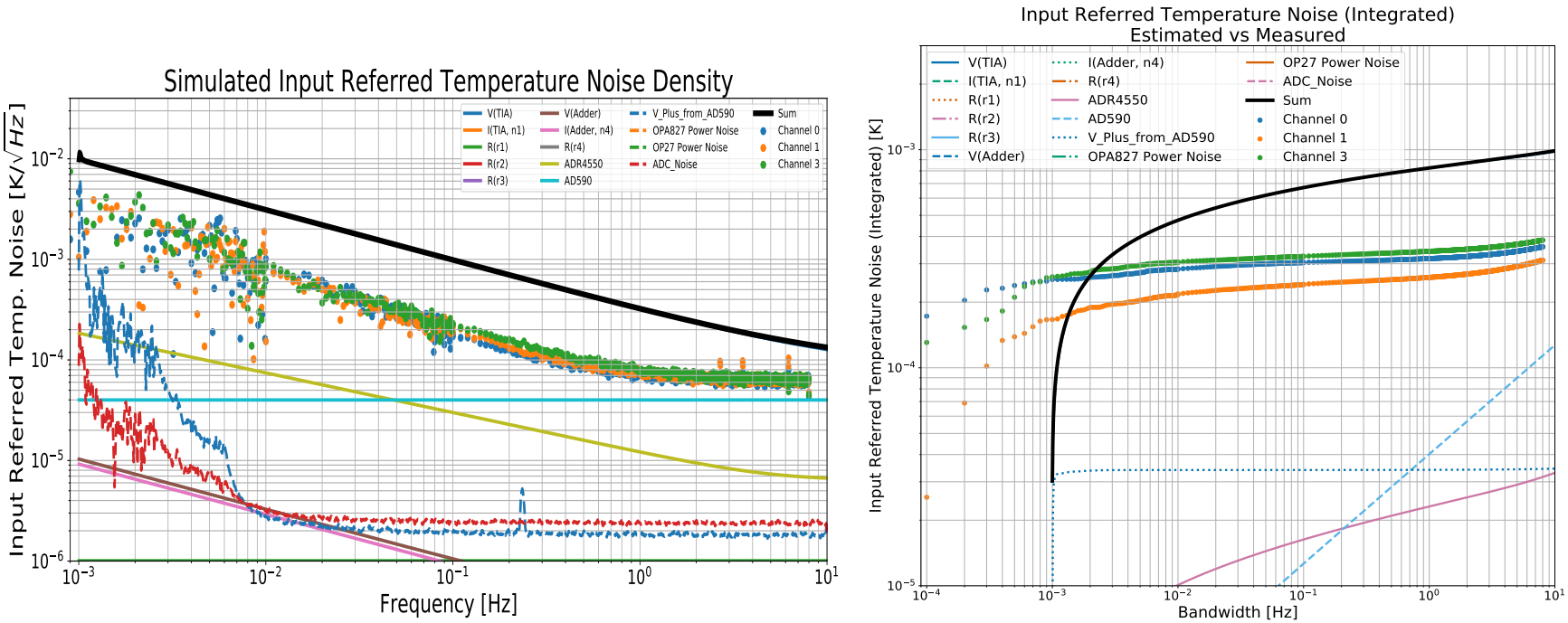
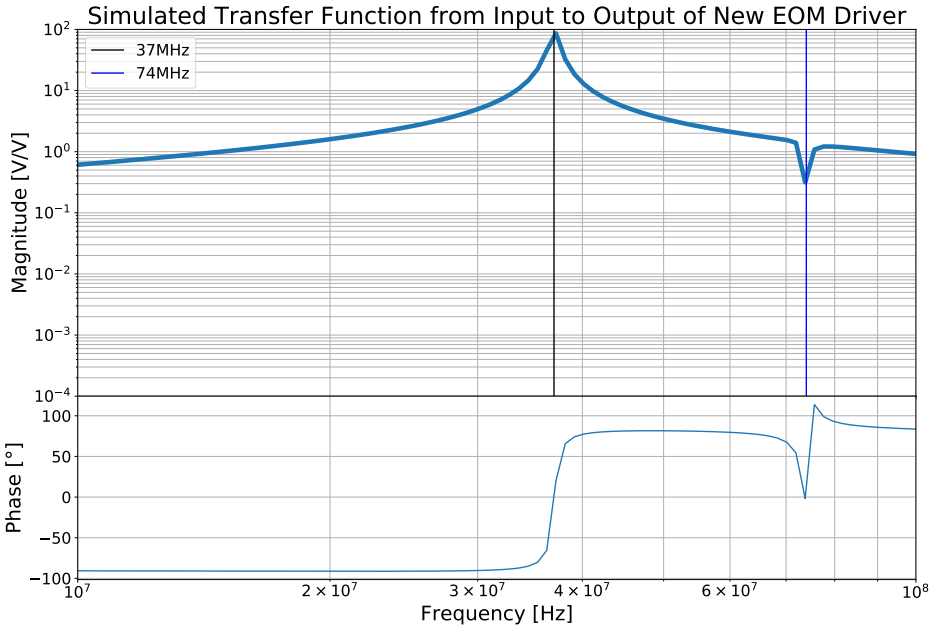


Figure: Simulated vs Real AD590 Noise Density / Integreted Noise Sum of Temperature Sensing Board (DCC:D1800304-v1)

Future Work



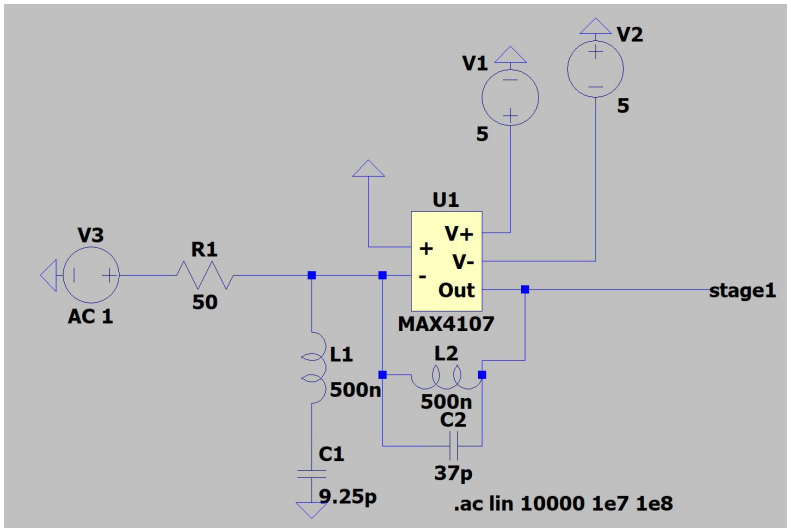


Figure: Example of possible shape for transfer function of new EOM driver

Thank you, Questions?

Acknowledgments:

- I would like to thank NSF and LIGO Lab.
- This project would have not been possible without the guidance from Anchal Gupta, Rana Adhikari, and Craig Cahillane, thank you very much.

Bibliography:


W. Zhang, M. J. Martin, C. Benko, J. L. Hall, J. Ye, C. Hagemann, T. Legero, U. Sterr, F. Riehle, G. D. Cole, and M. Aspelmeyer, "Reduction of residual amplitude modulation to 1 x 10-6 for frequency modulation and laser stabilization," Opt. Lett. 39, 1980-1983 (2014)