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Automated Photodetector Frequency Response Measurement System for the Caltech 40m Interferometer

Nichin Sreekantaswamy

BITS,Pilani – Goa Campus

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Mentors: Eric Gustafson and Jameson Rollins

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Outline

- Introduction
- Photodiode Transimpedance
- Transimpedance measurement technique
- Overview of the Photodiode Frequency Response (PDFR) system
- Other factors affecting measurements (RF cable delay, demodulator boards)
- Results
- Conclusion

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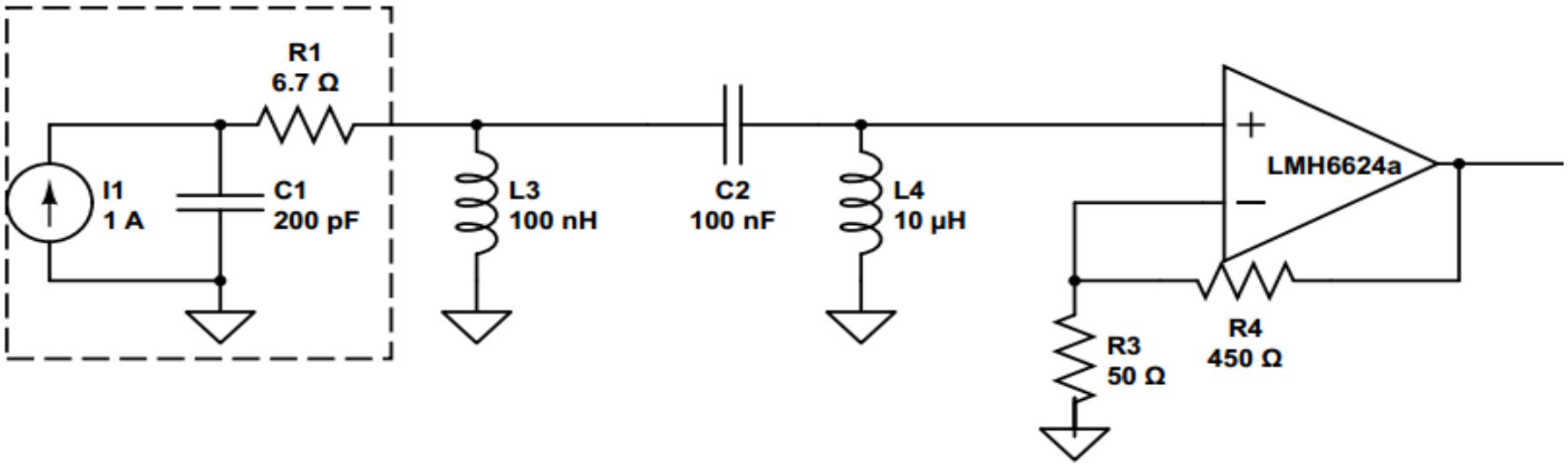
Introduction

- Several photorecievers are used to provide feedback signals to position the mirrors for correct operation of the interferometer and ensure that the optical cavity resonances are acquired and maintained (Pound-Drever-Hall technique).
- This system will enable the lab personnel to check if a photoreciever is functioning properly or not, remotely.
- GUI interface to run the frequency sweep test and then bring up its current transimpedance frequency response plots.

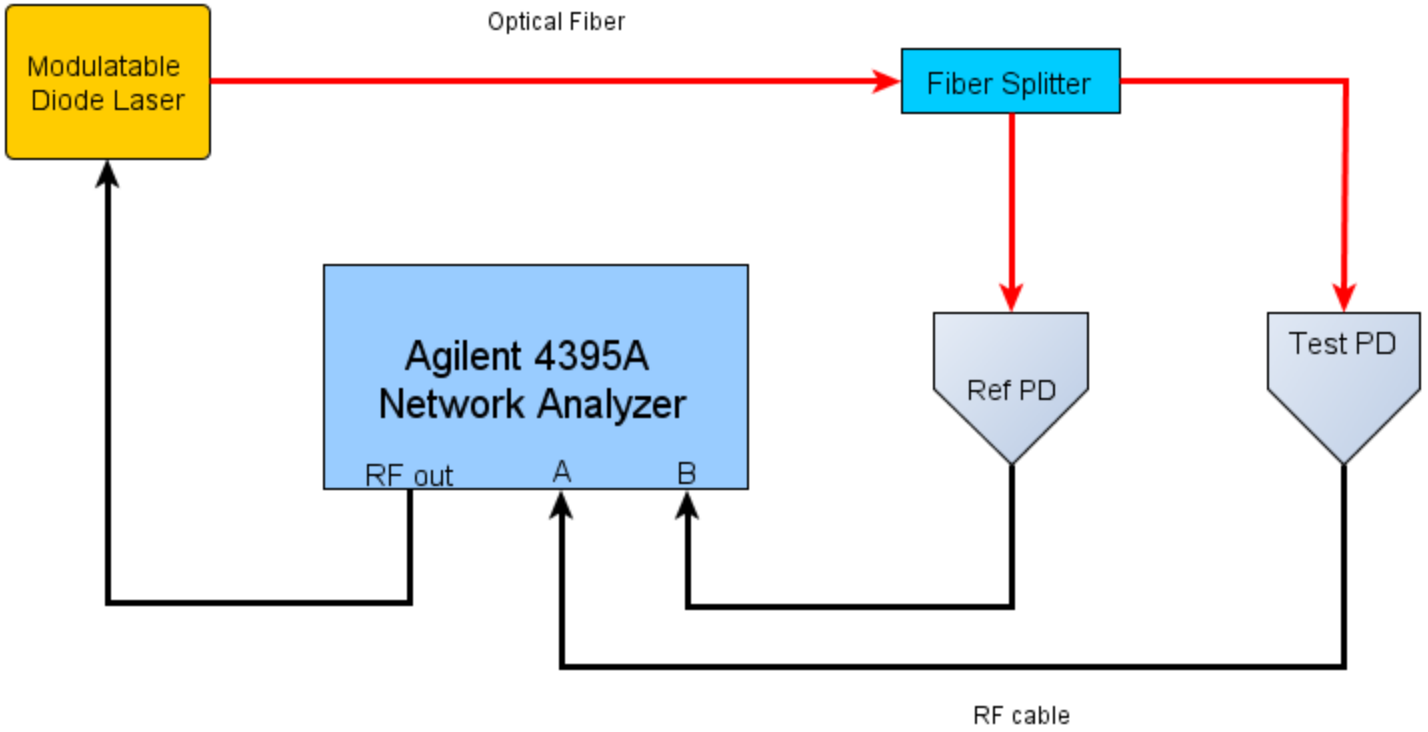
Photodetector Model

A representative model:



$$V_{\text{out}} = \frac{|Z_{LC}|}{|R + Z_{LC}|} V_{\text{in}} \qquad \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{\omega L}{\sqrt{(\omega LC)^2 + R^2(1-\omega^2 LC)^2}} \qquad \omega_0 = \frac{1}{\sqrt{LC}}$$

Single PD Transimpedance Measurement

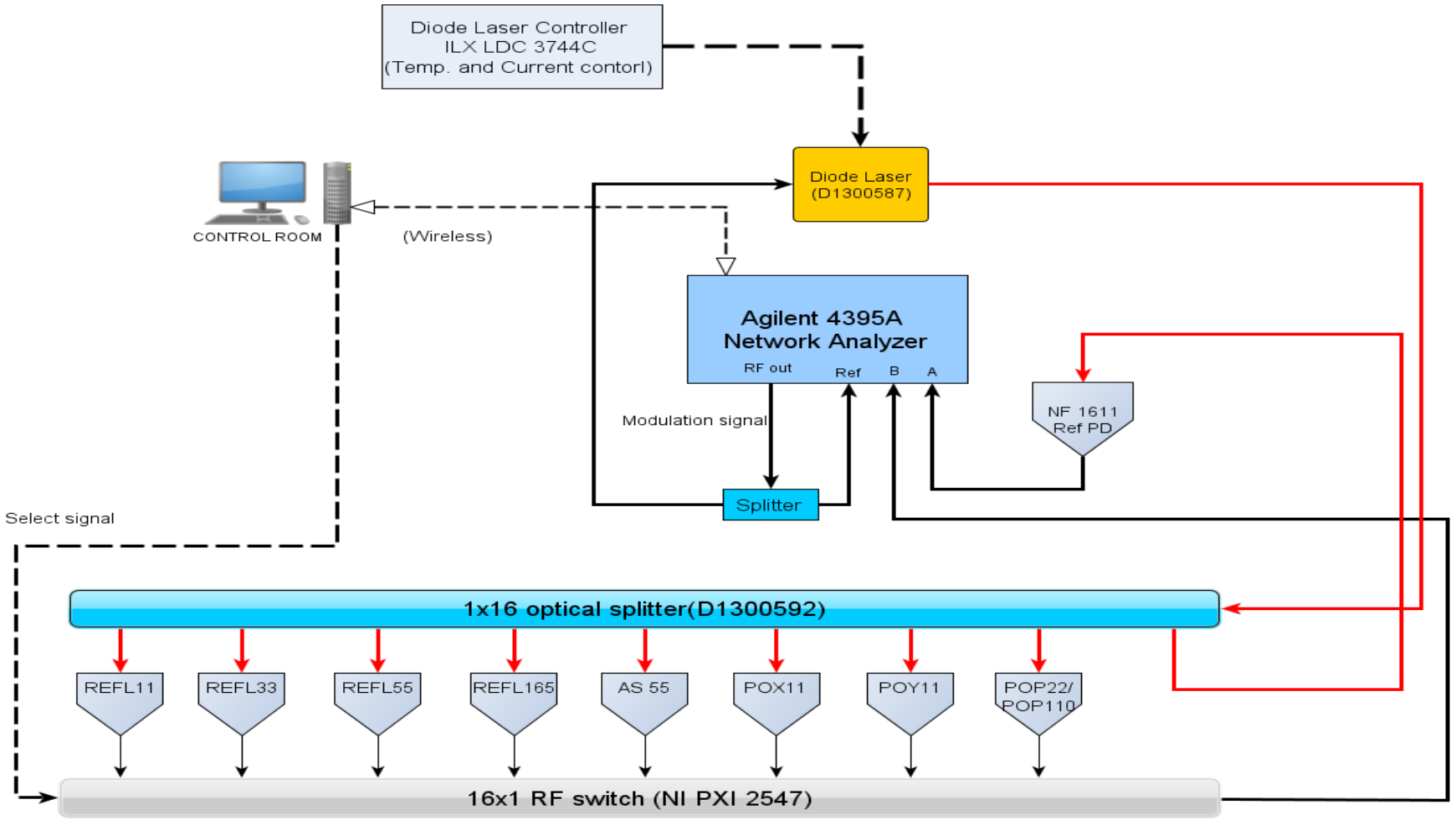


Single PD Transimpedance Measurement

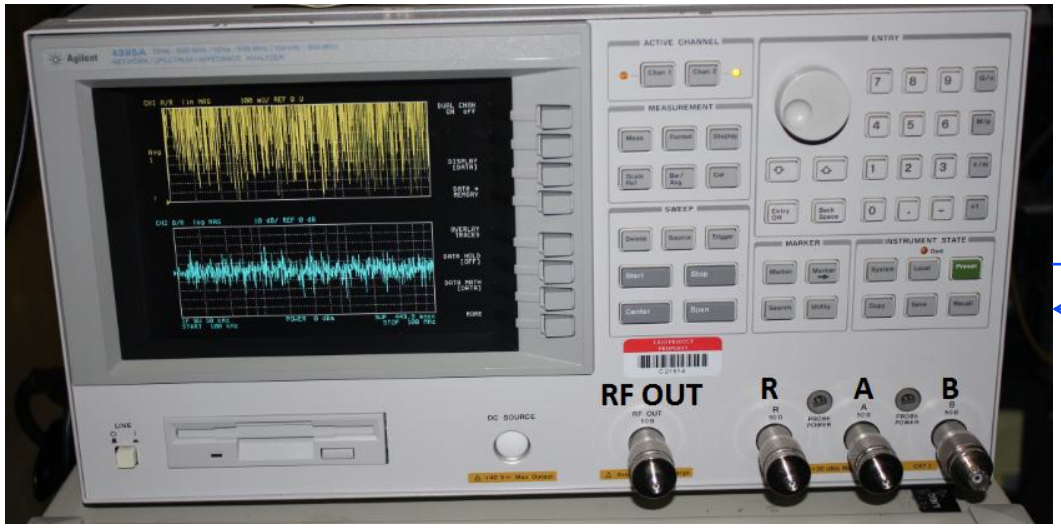
$$T_{RF,Test} = \frac{V_{RF,Test}}{V_{RF,Ref}} * \frac{V_{DC,Ref}}{V_{DC,Test}} * \frac{T_{DC,Test}}{T_{DC,Ref}} * T_{RF,Ref}$$

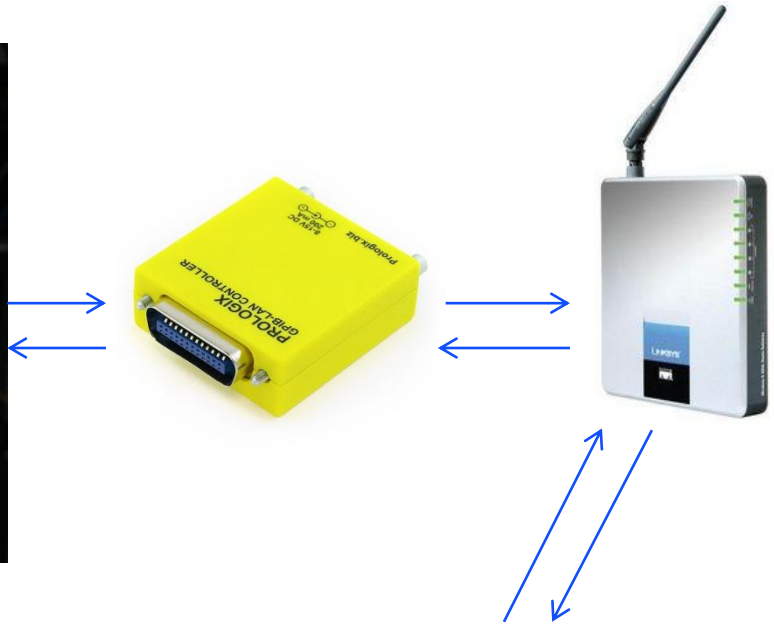
- $\frac{V_{RF,Test}}{V_{RF,Ref}}$ is measured with the network analyzer.
- $V_{DC,Ref}$ and $V_{DC,Test}$values are measured with a multimeter and stored in a database.
- The values are plugged in and the RF transimpedence for the test PD is calculated at different frequencies.

The PDFR system



Agilent Network Analyzer





- Lab's closed LAN Network
- GPIB (General Purpose Interface Bus)

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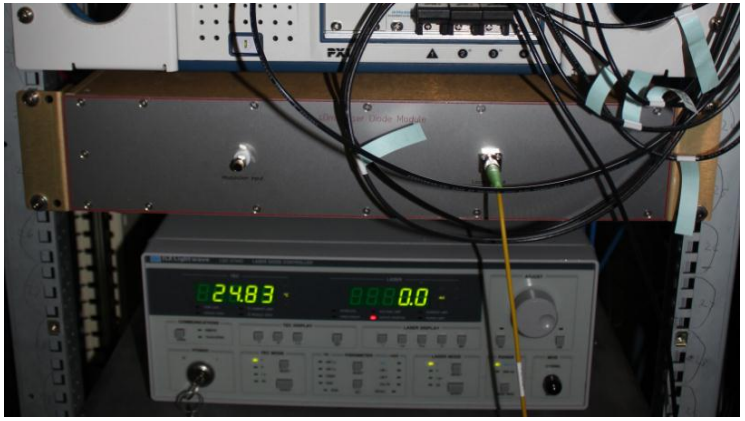
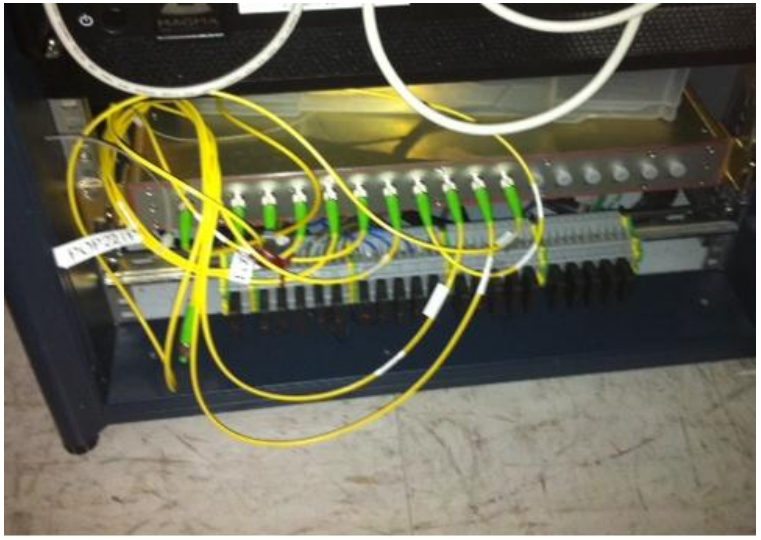
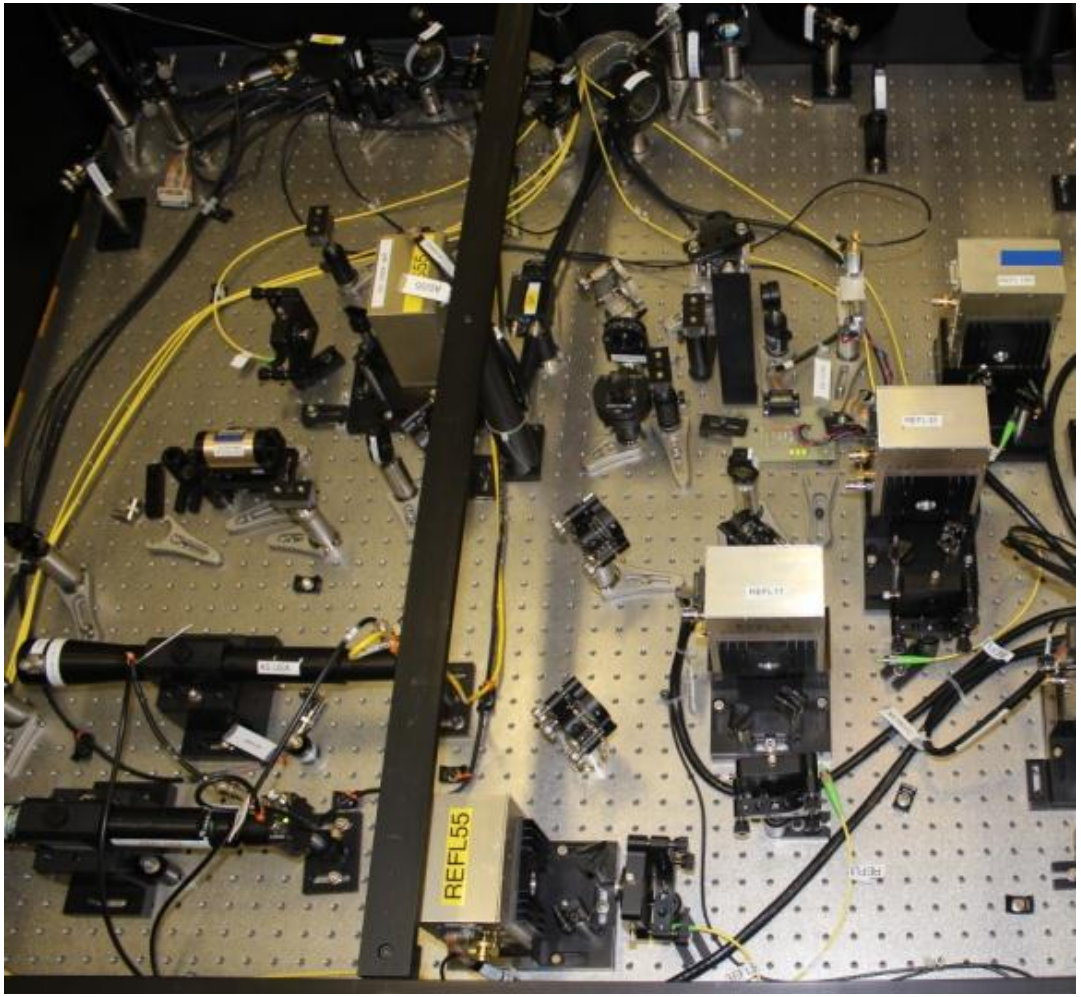
Optical Fiber Distribution

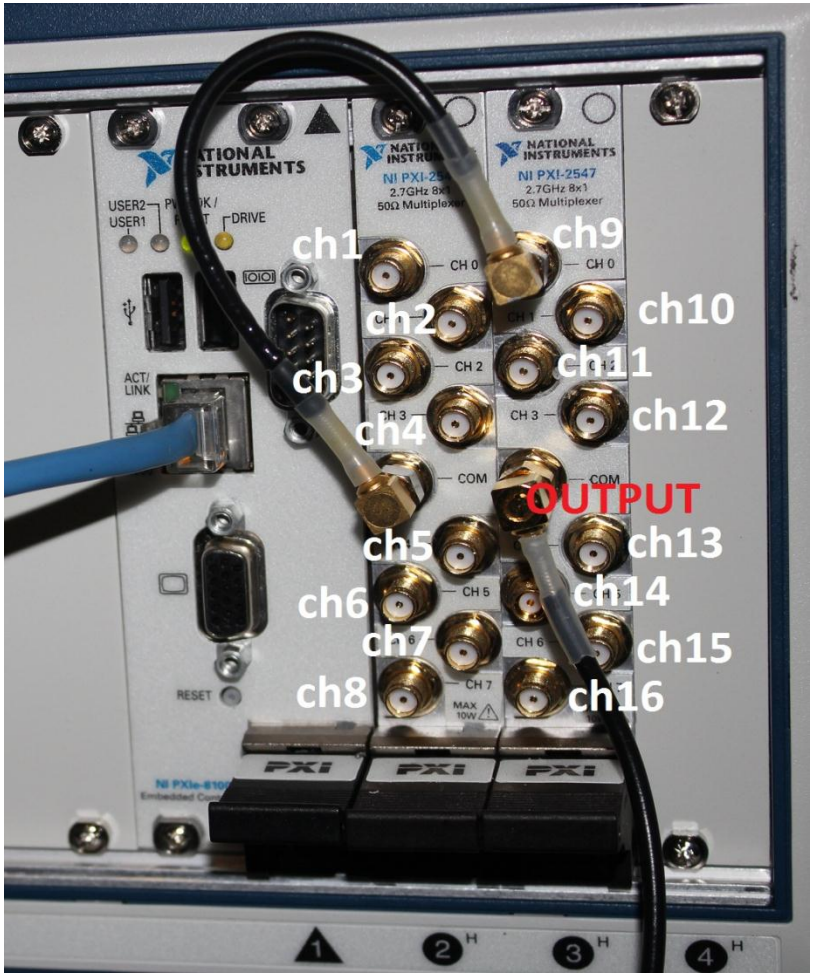






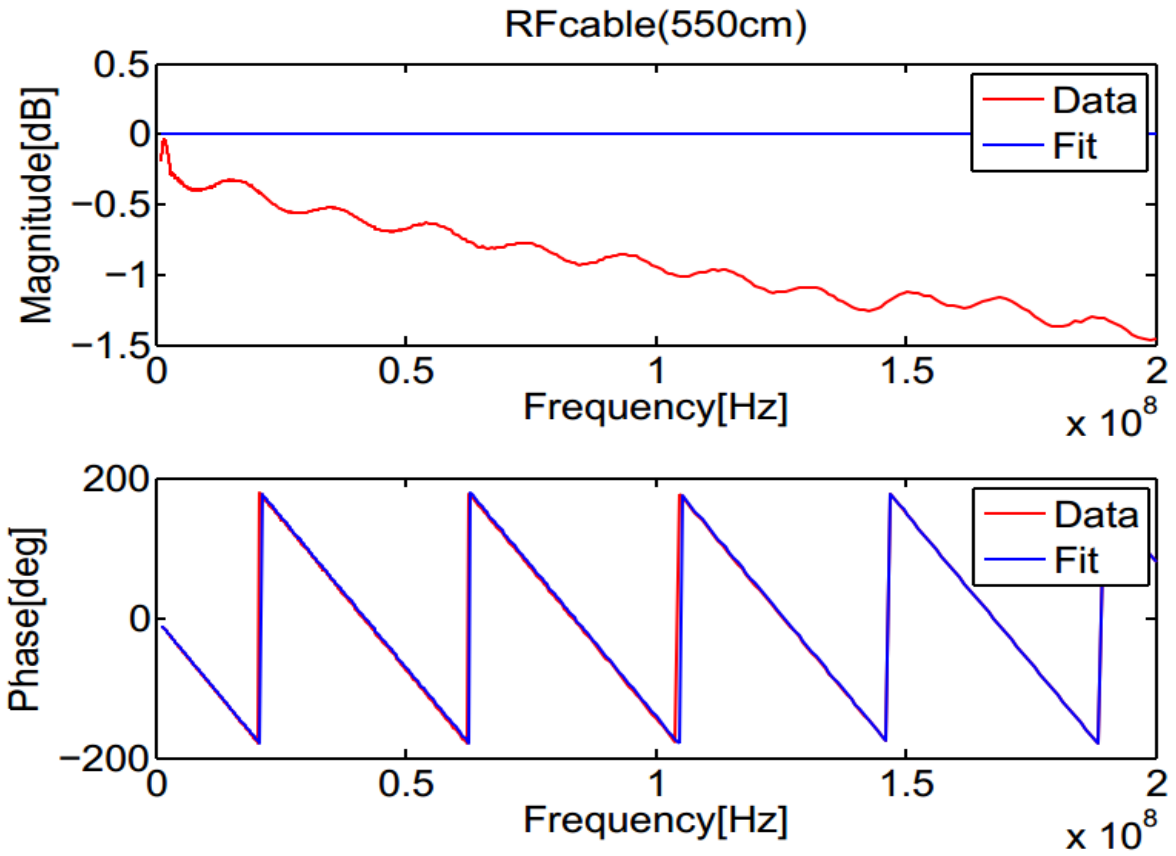
RF Multiplexer

- Channel selection using a simple TCP/IP script.
- Connected to the LAN network



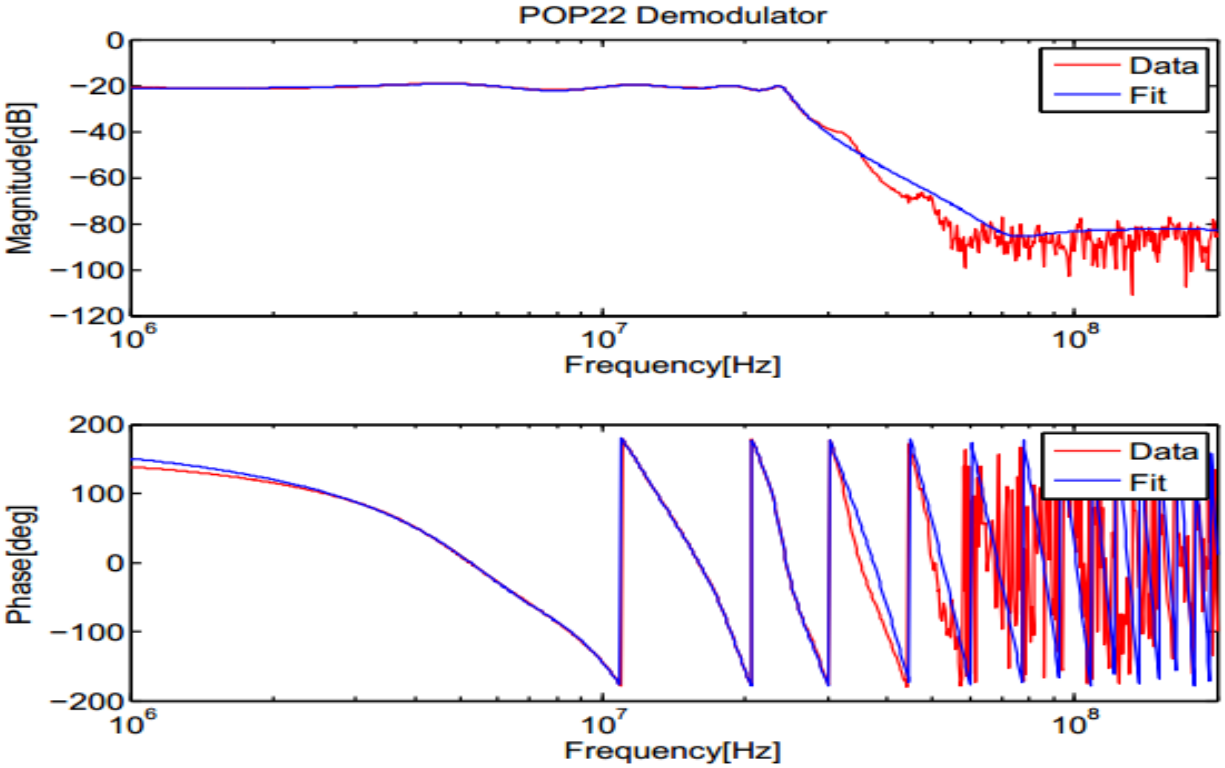
Delay in RF cables

- Transfer function for an ideal delay function : $e^{(-sT_d)}$
- The slope of the phase gives the time delay.

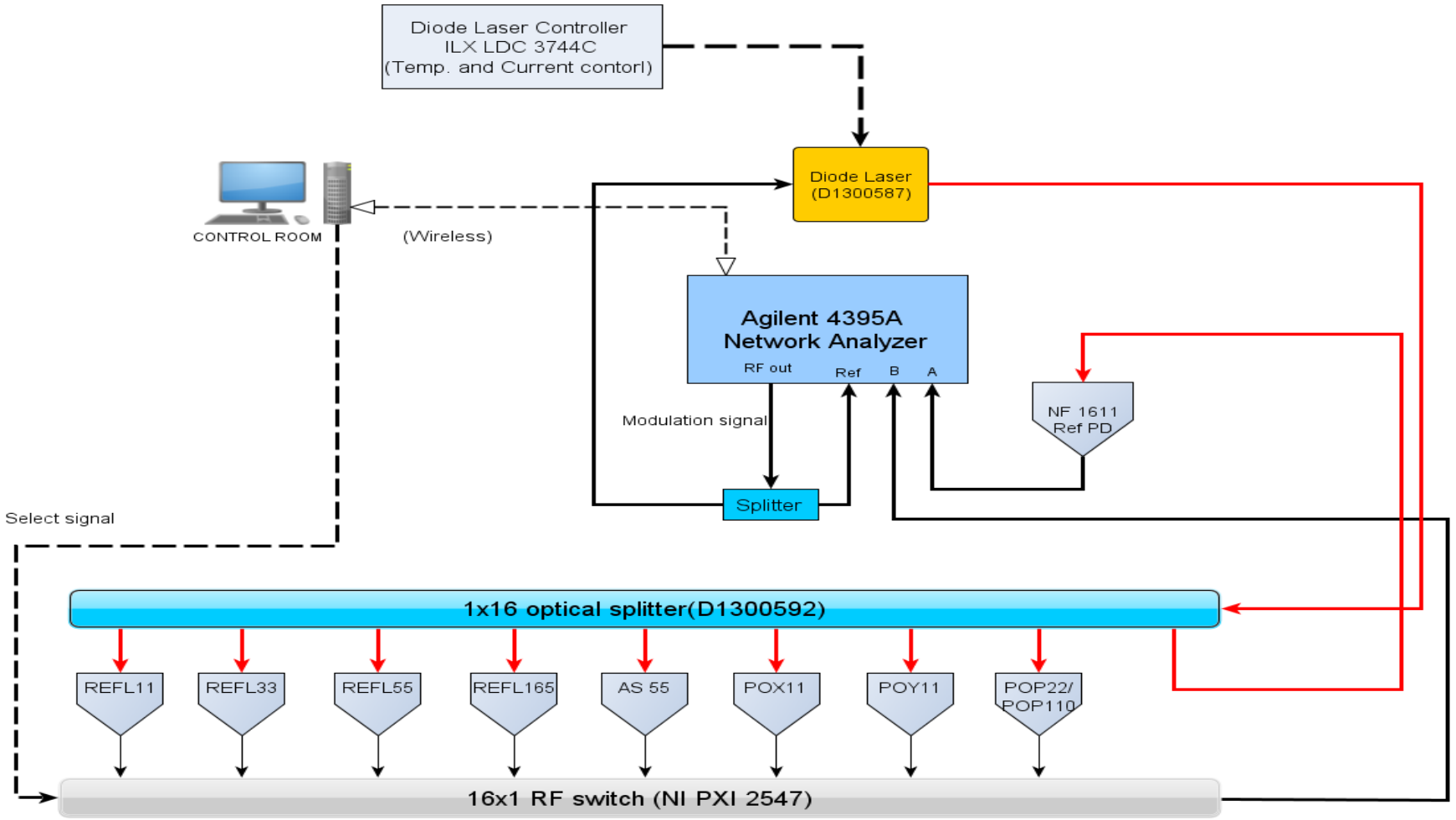


Demodulator Boards

- Demodulator board's transfer function between PD Input and PD RF MON
- Vector Fitting: Fit the frequency response into a model / transfer function or simply an equation.

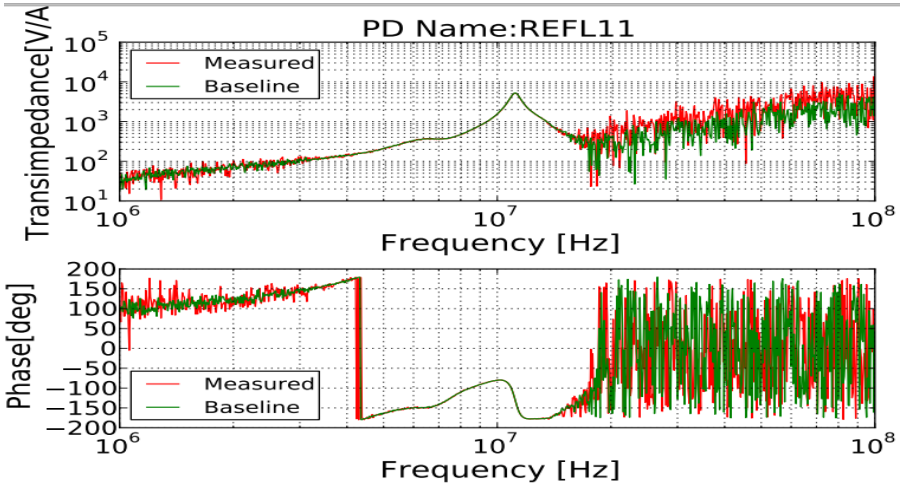


The PDFR system, Again



The PDFR GUI

- GUI window to run scripts.
- Has extra buttons for running tests on all PDs and to bring up previous measurement plots for each PD.



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Data Presentation

- Compare the transimpedance with a canonical measurement.
- Vector Fitting
  - » The transimpedance curves can be fit into a transfer function that is defined with its poles and zeros. This makes our system more robust.
  - » The PDFR system has an option to call the standard vector fitting script on Matlab and get the transfer function.

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Conclusion

- The PDFR system is very flexible and can be used to accommodate any new PD
- Vector fitting of transimpedance is being improved to be more accurate.
- Future work:
  - » More accurate curve fitting
  - » A way to detect and exclude regions of bad coherence.

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Acknowledgements

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