A power recycled, Fabry-Perot arm cavity Michelson interferometer with resonant sideband extraction.

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We present our simplified control system design as well as implementation details and recent experimental results.

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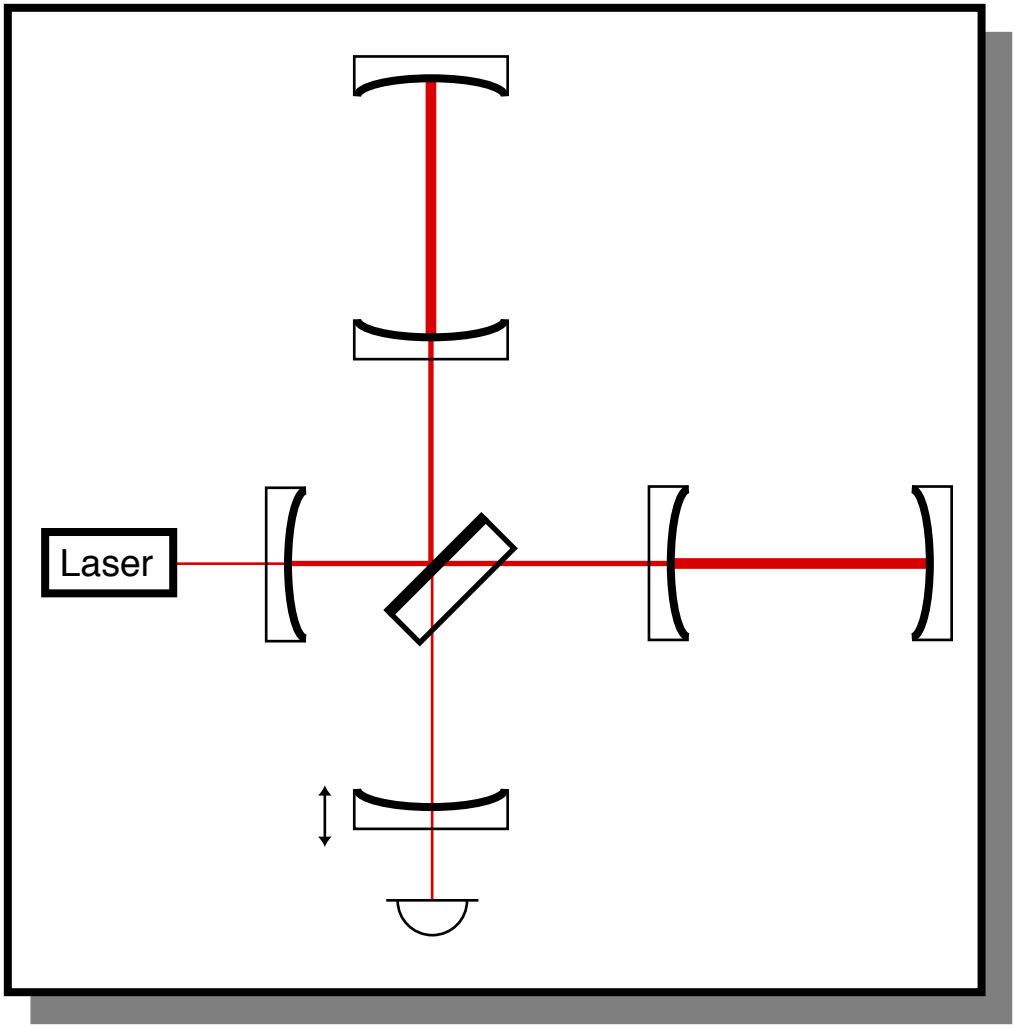
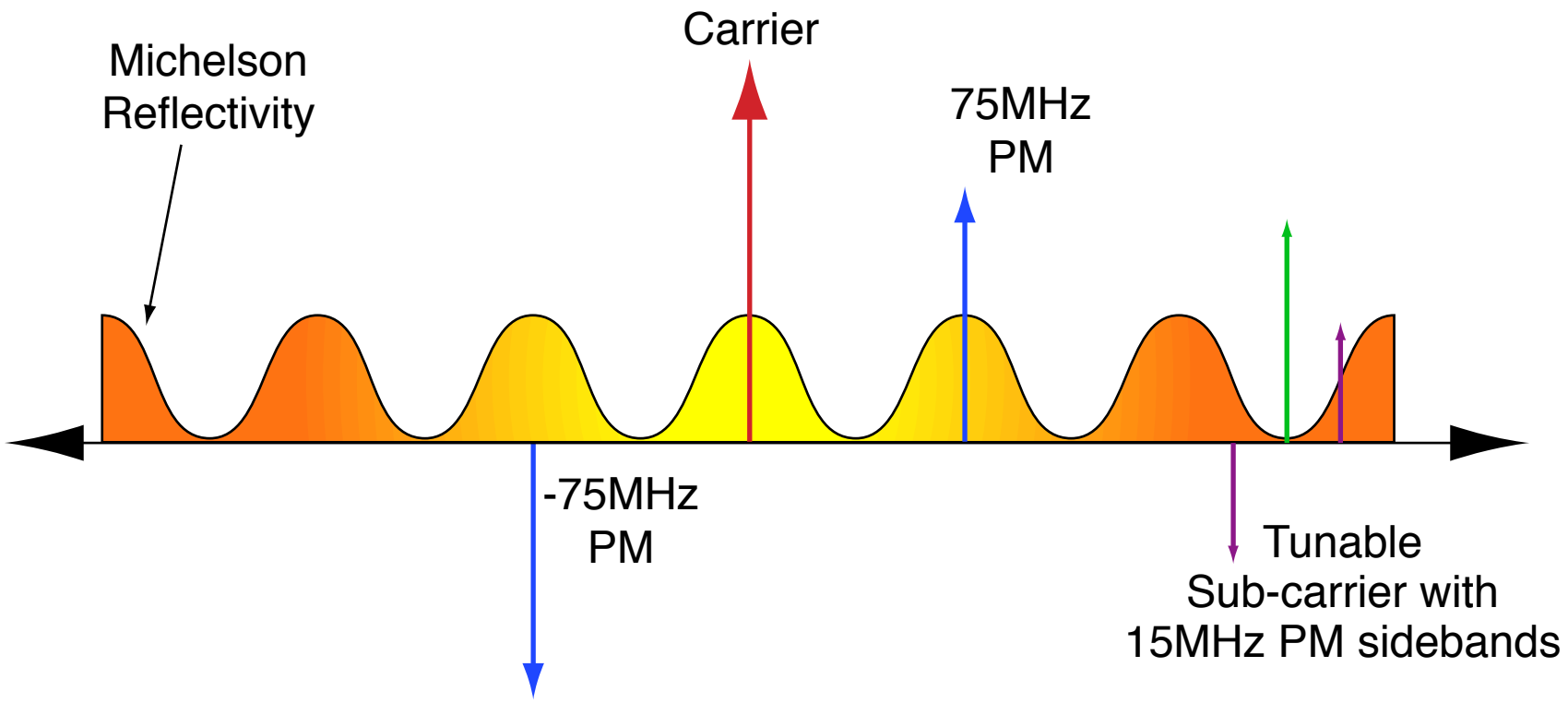
Interferometer Degrees of Freedom



Arm cavity common mode
Arm cavity differential mode
Power cavity
Michelson
Signal Cavity

The first four degrees of freedom must be locked to a fixed point with the signal cavity tuned to an arbitrary position.

Input Beam Modulation Components

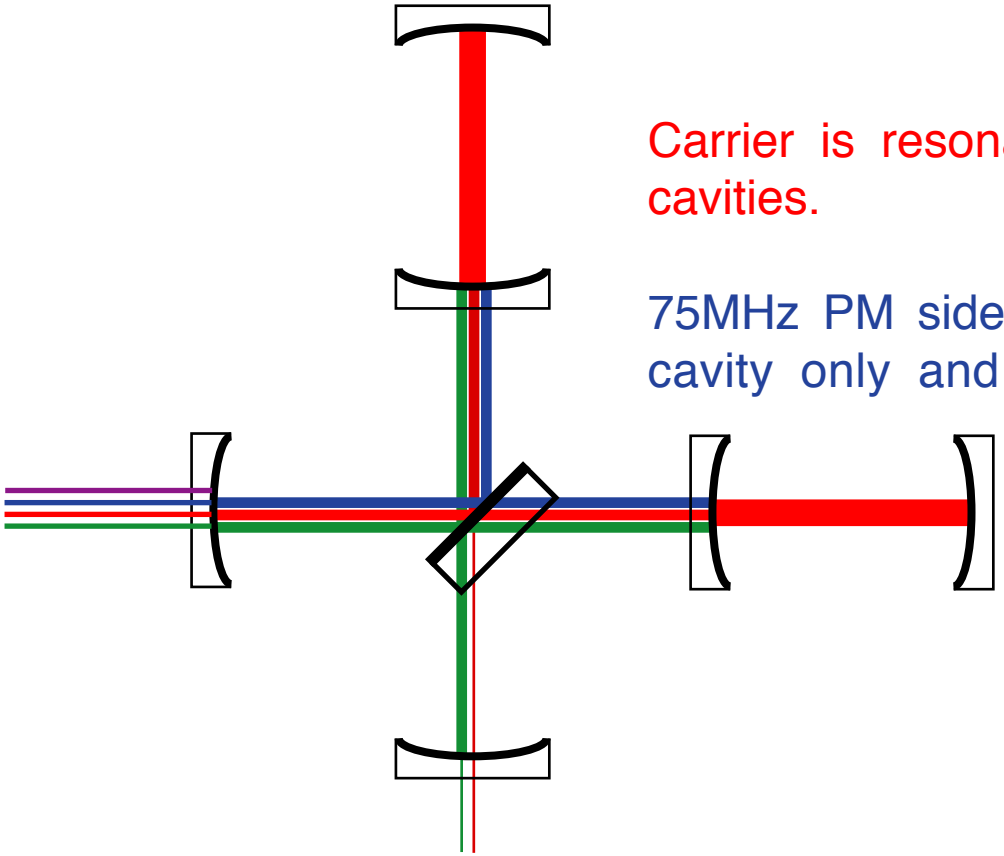


The input beam consists of:

PM@75MHz

Variable offset phase locked subcarrier with PM@15MHz

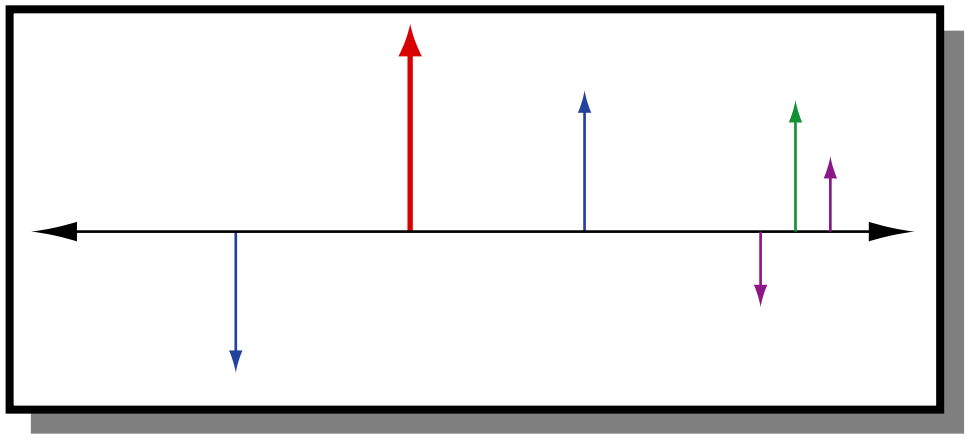
Modulation Frequency Resonance Conditions



Carrier is resonant in power cavity and arm cavities.

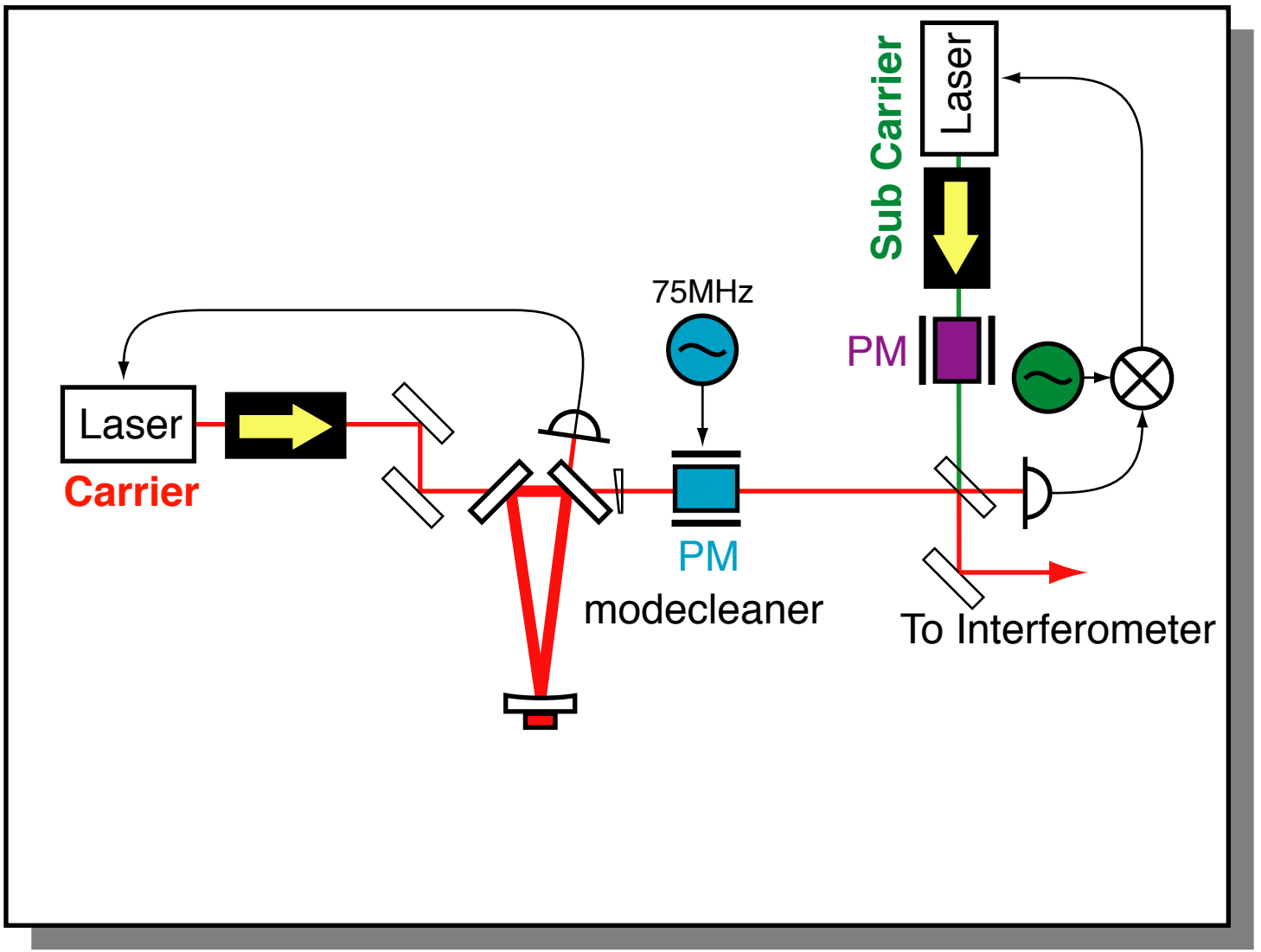
75MHz PM sidebands are resonant in power cavity only and completely reflected by the Michelson.

Subcarrier is resonant in power-signal cavity and is mostly transmitted by the Michelson.

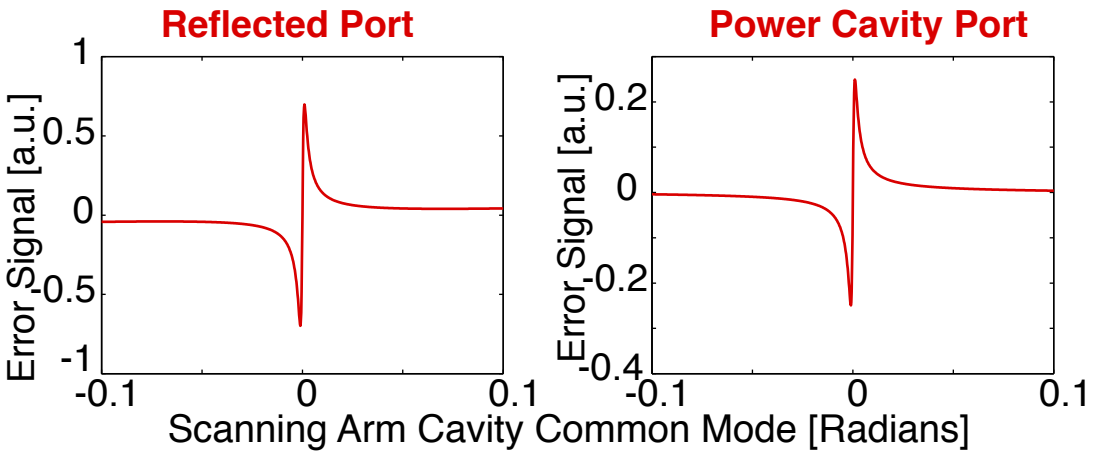


15MHz subcarrier PM sidebands are non-resonant everywhere.

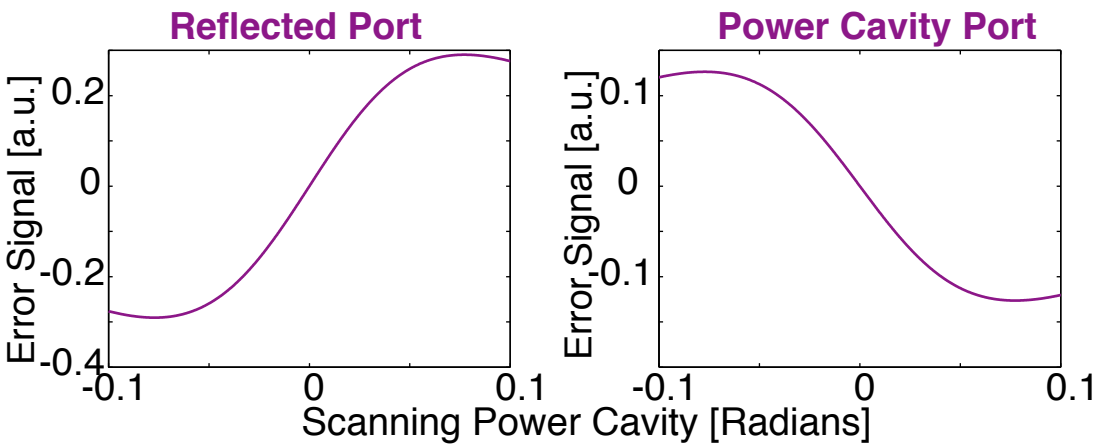
Input Field Generation



Arm Cavity Common Mode Error Signal



Power Cavity Error Signal



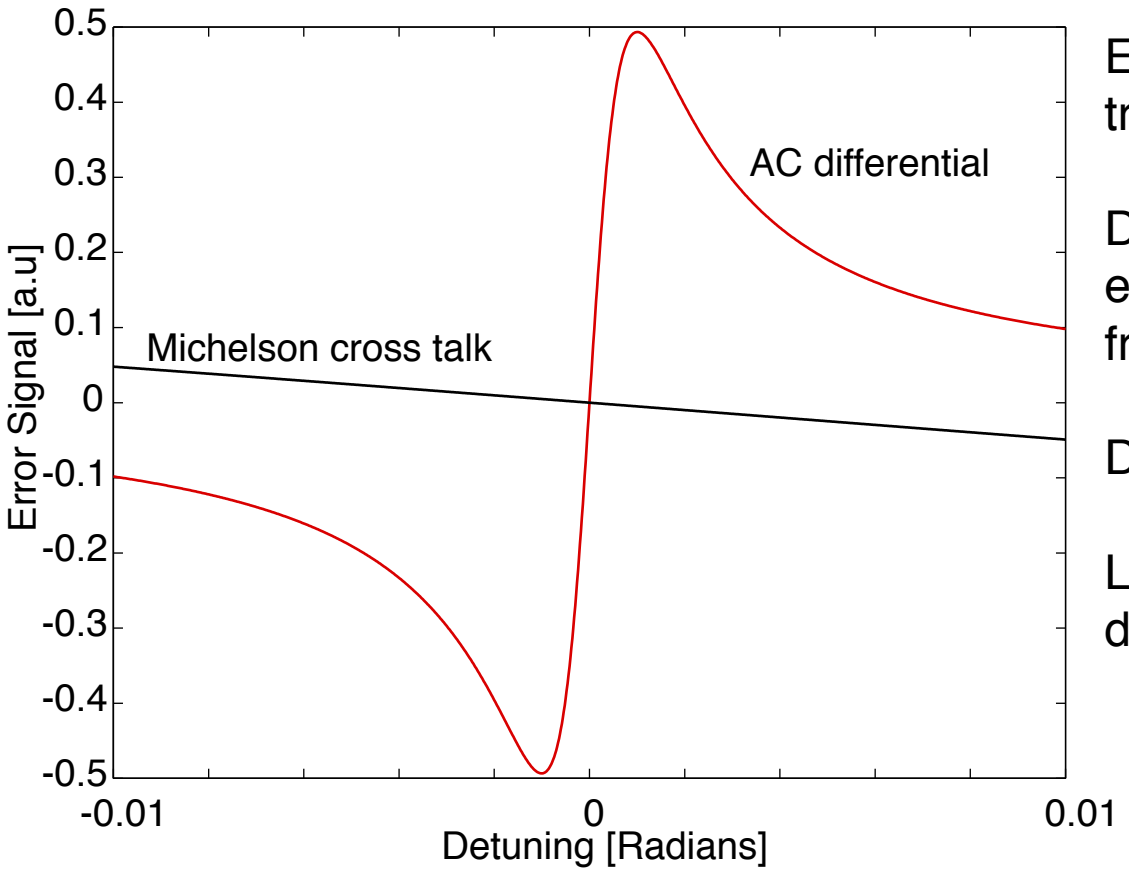
Error signals are obtained from a combination of reflected field and the circulating power cavity field demodulated at 75MHz.

The two error signals are linearly independent due to the sign change of the power cavity error signal slope at the two ports.

All other error signals are insignificant at these two outputs.

Both these error signals are completely isolated from signal cavity tuning (when Michelson is locked).

Arm Cavity Differential Mode Error Signal



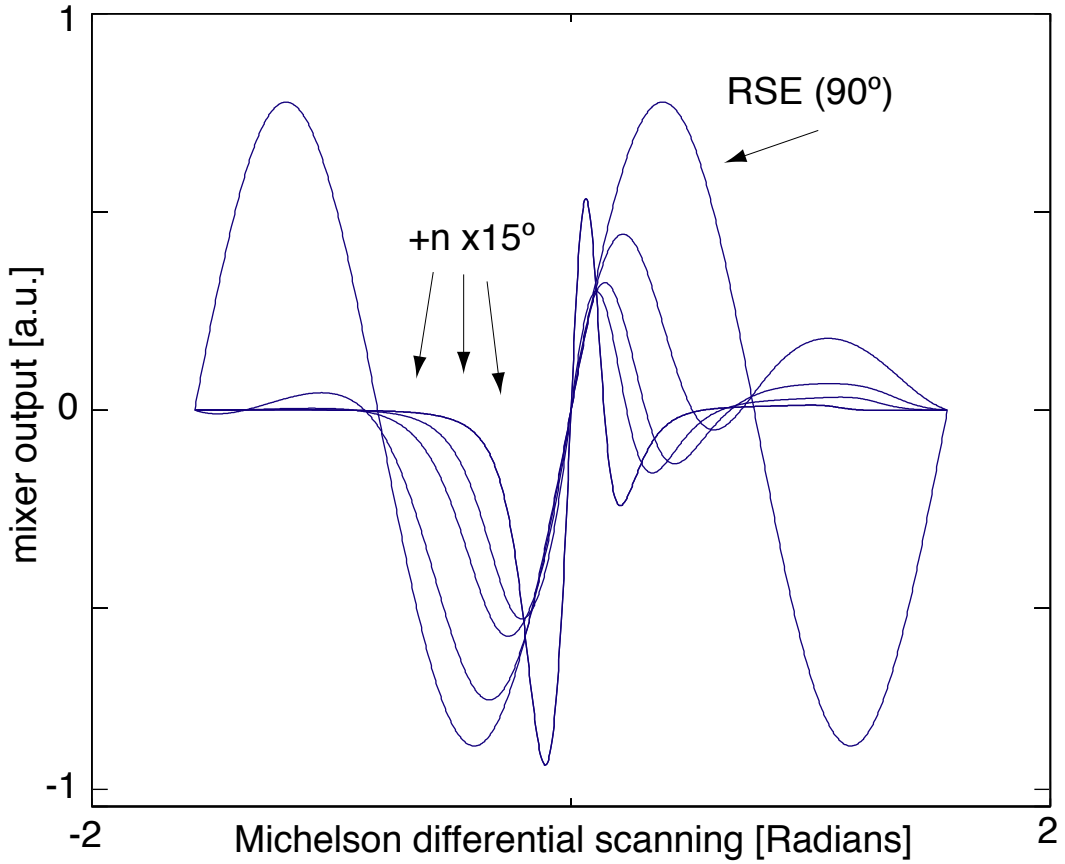
Error signal obtained from transmission output.

Demodulation frequency equal to subcarrier offset frequency.

DC gain change = 14dB

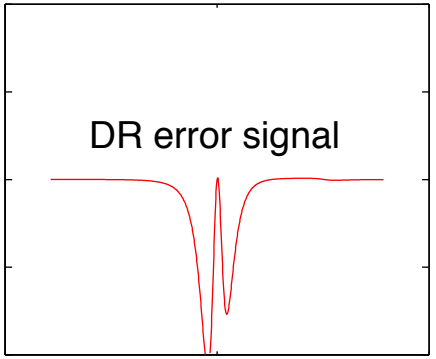
Largest cross talk term is due to Michelson

Michelson Error Signals for Different Signal Cavity Detunings

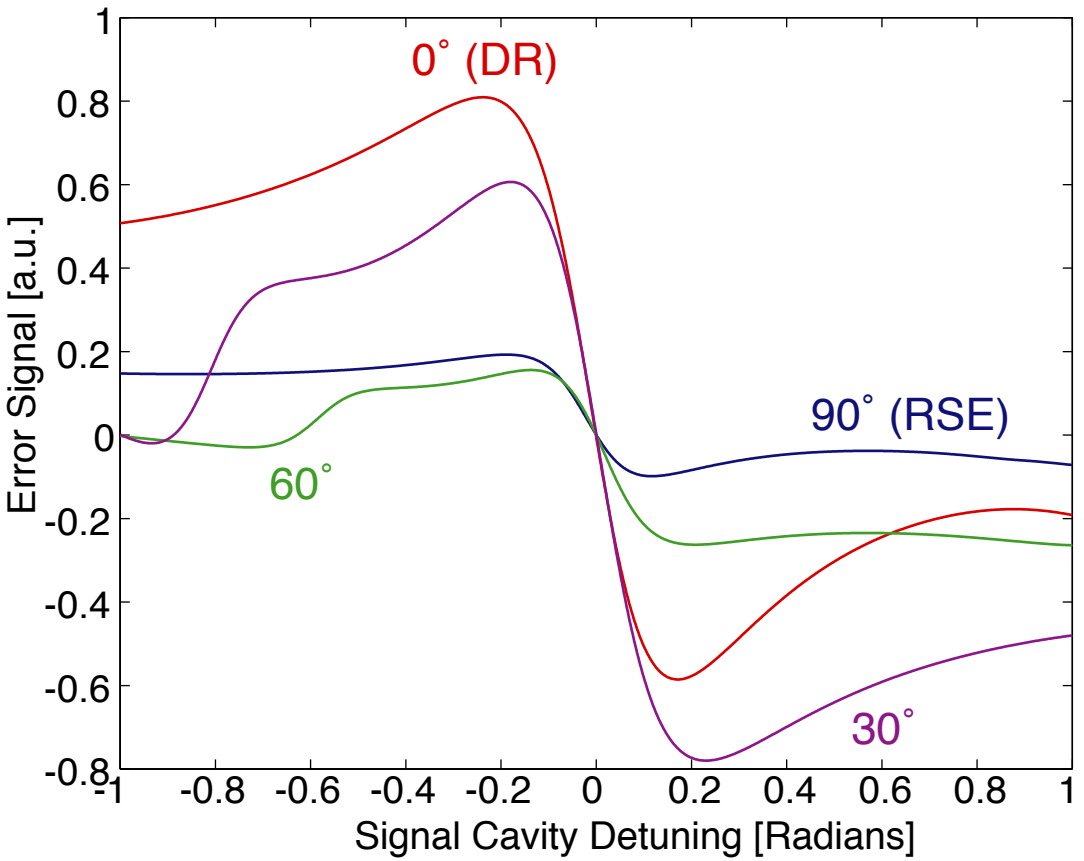


Michelson error signal obtained from beat between subcarrier and carrier PM sidebands. Requires a demodulation at the subcarrier frequency and at the PM sideband frequency.

Can provide an error signal for all detuned points except for exactly at dual recycling where the error signal is not zero crossing.



Signal Cavity Error Signals

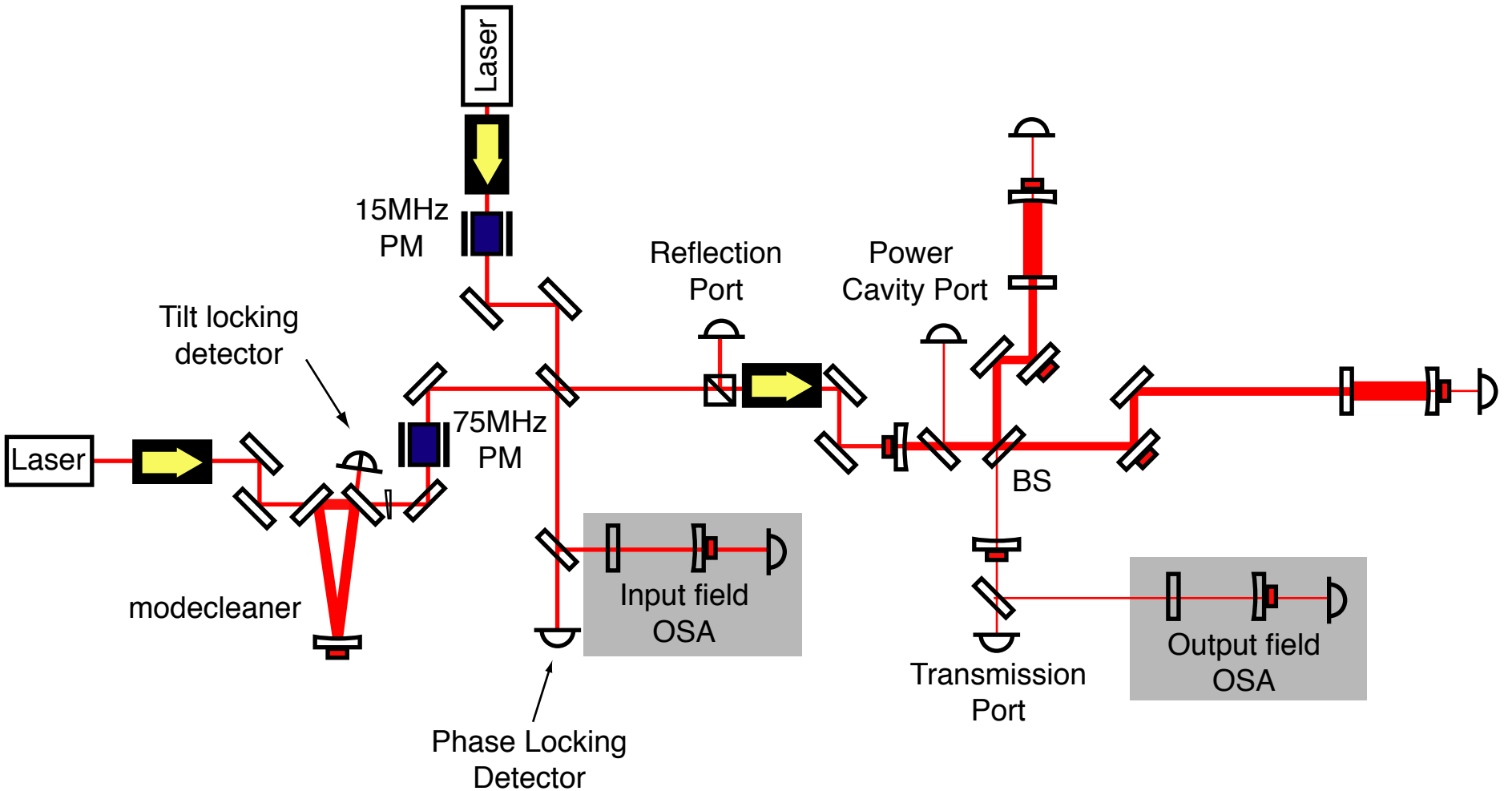


Error signal obtained from reflected port demodulated at 15MHz.

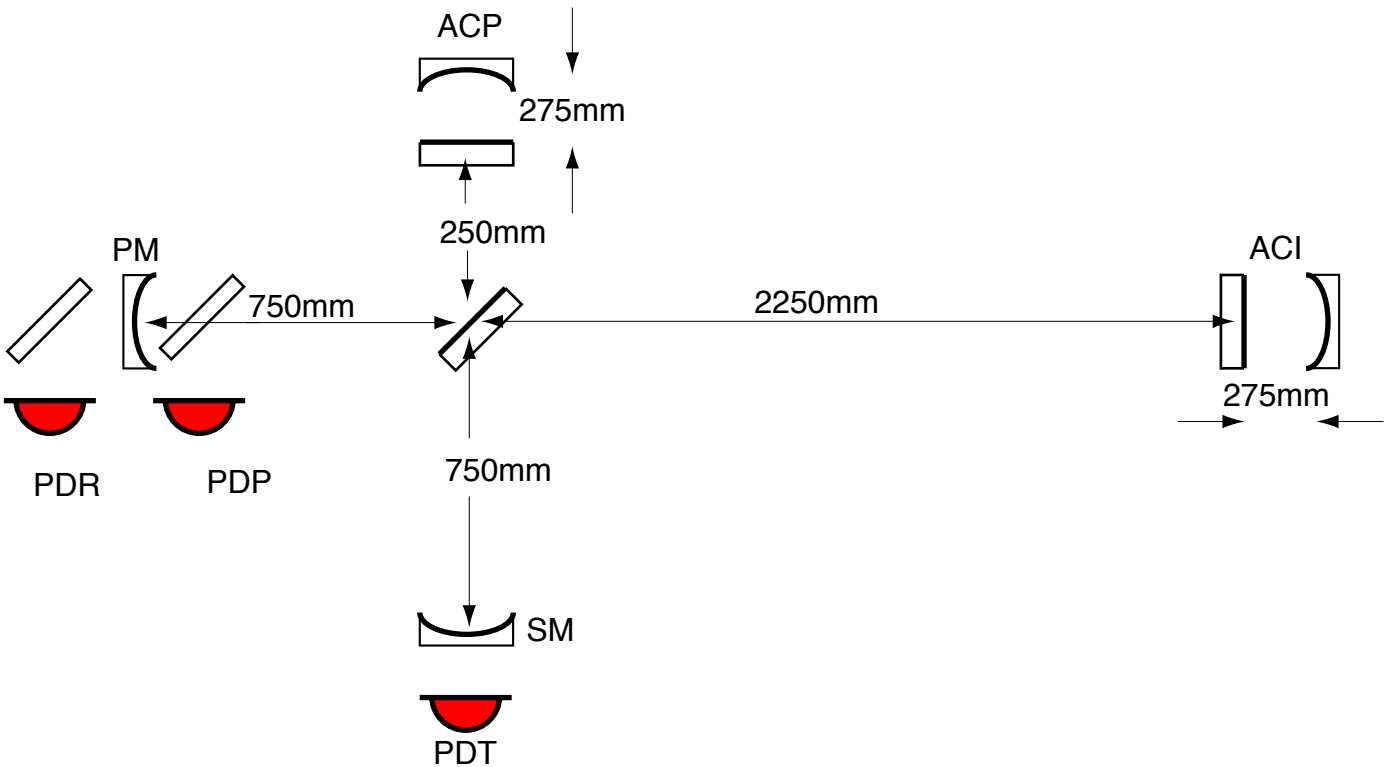
Change in gain=19dB caused in part by change in subcarrier transmission to dark fringe

Poor signal cavity locking will neccesitate an alternative signal extraction system (due to coupling into arm cavity differential error signal).

RSE Michelson Optical Layout

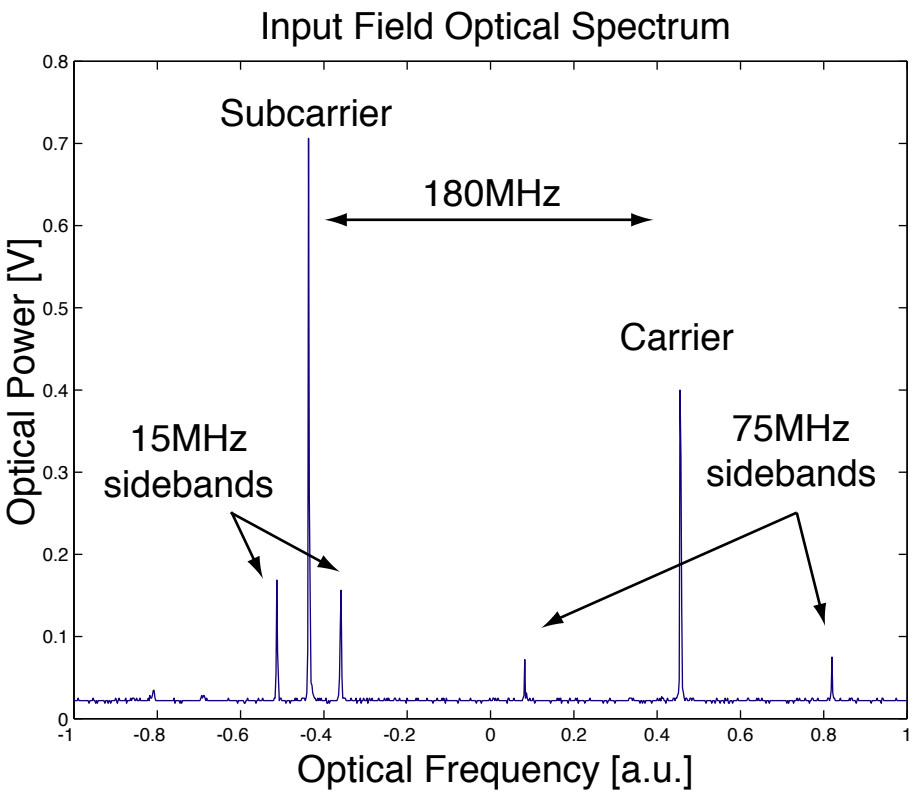


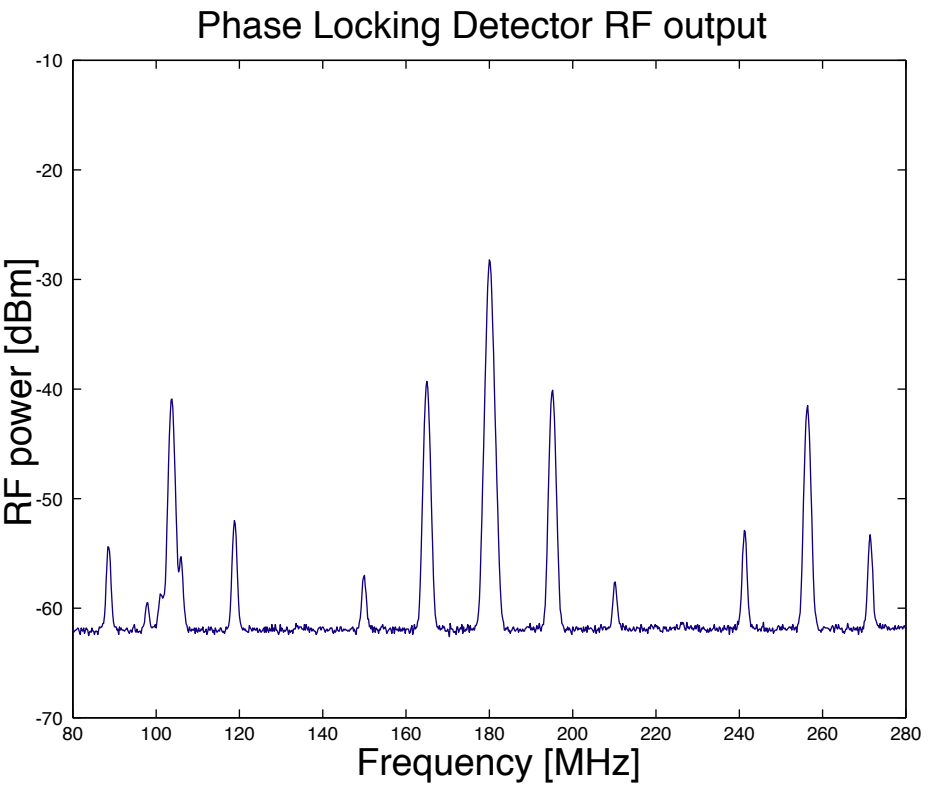
Interferometer dimensions for 75MHz phase modulation



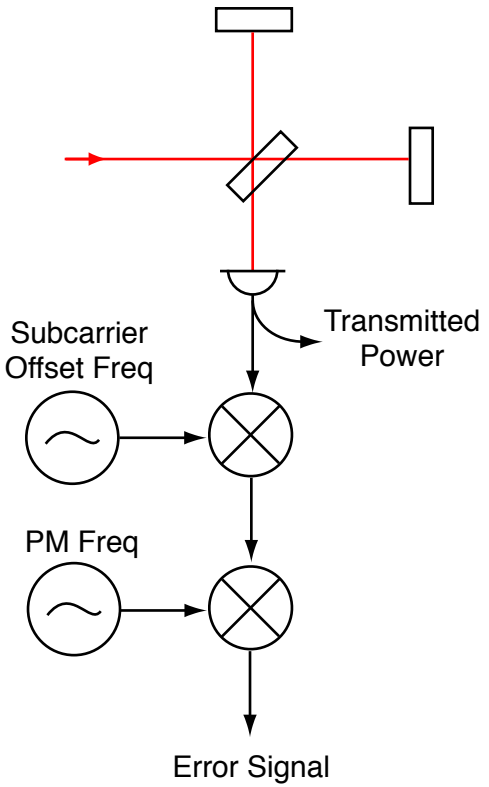
Power cavity FSR 150MHz and 50MHz
Michelson completely reflective at 75MHz
Arm cavity length is a free parameter

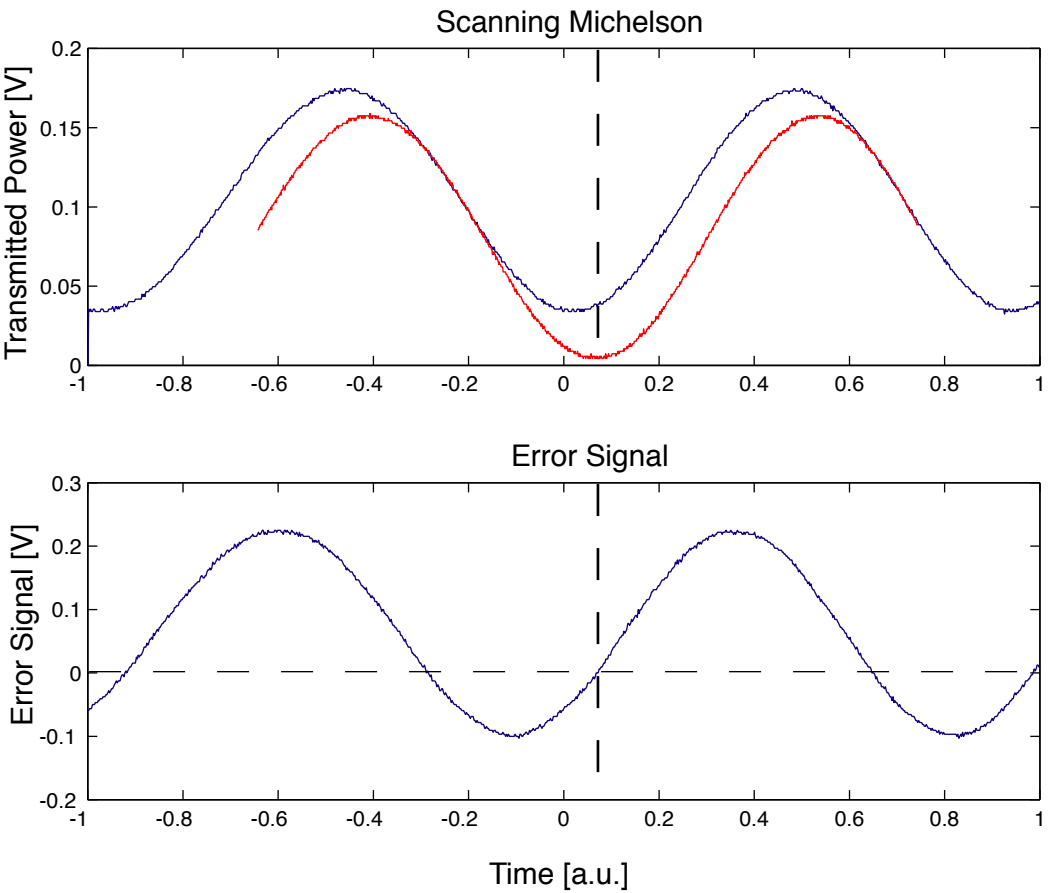
Input Field Measurements



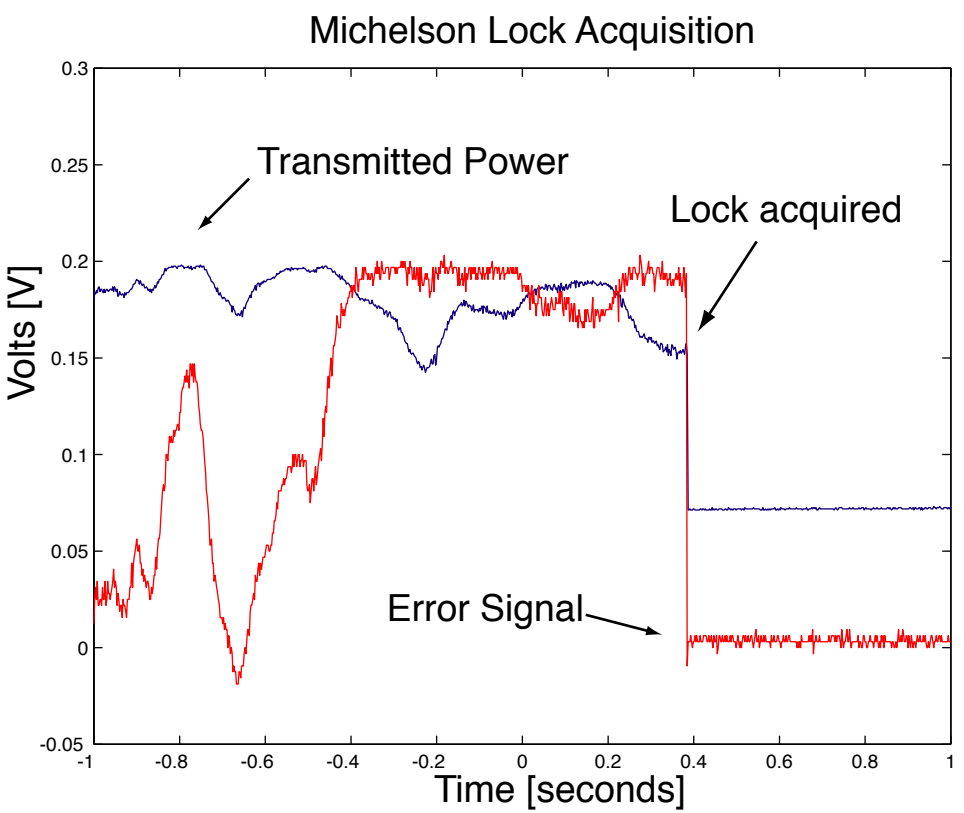


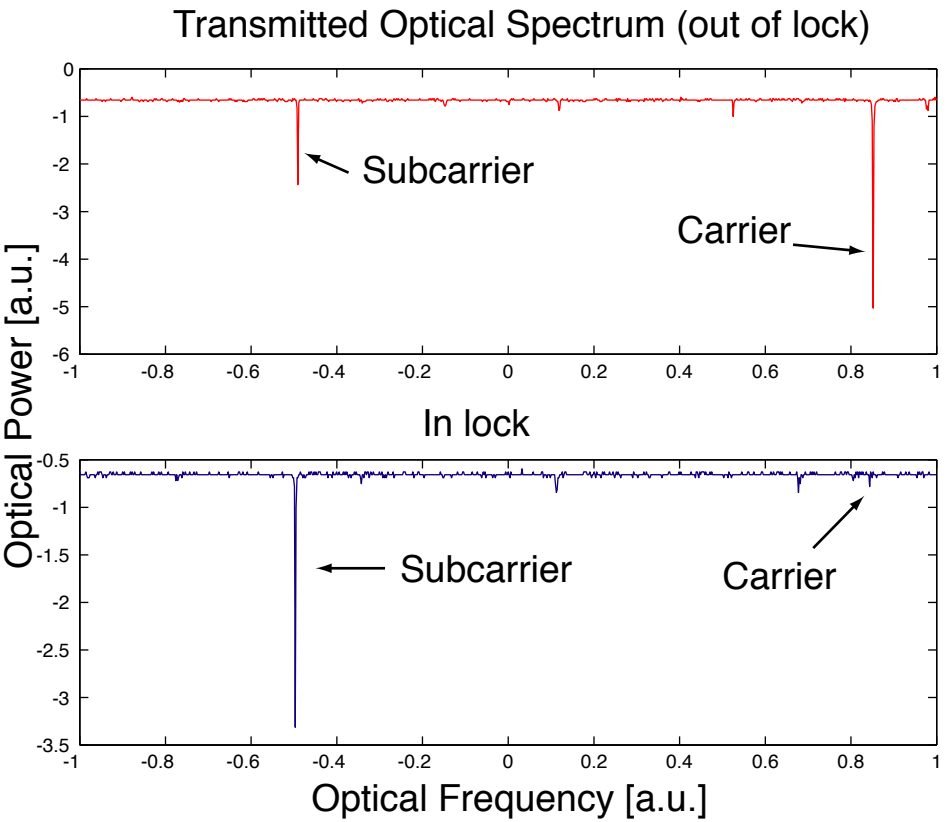
Michelson Error Signal



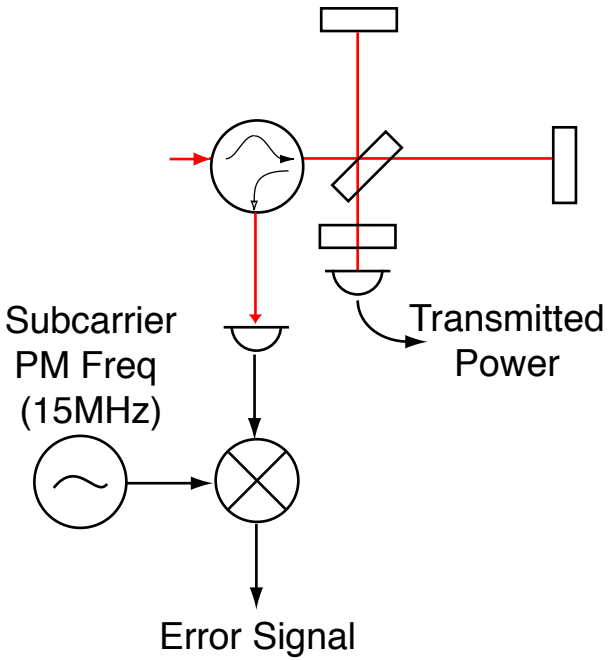


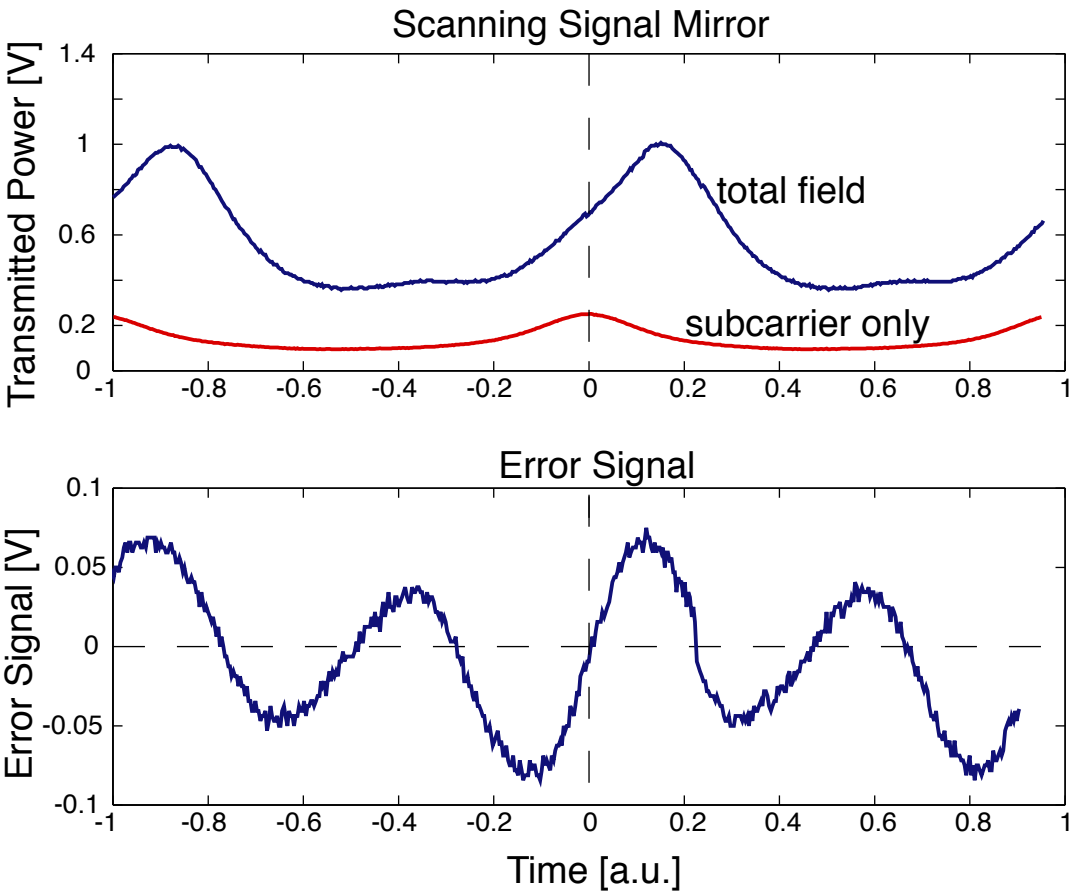
Michelson Locking Performance





Signal Recycled Michelson Error Signal





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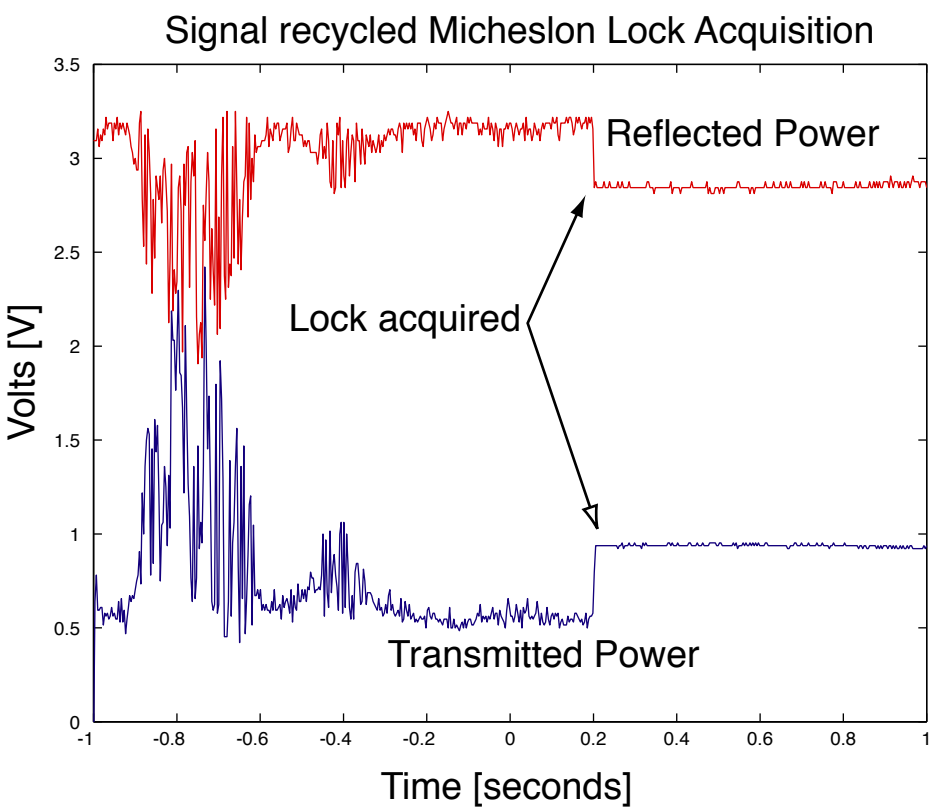
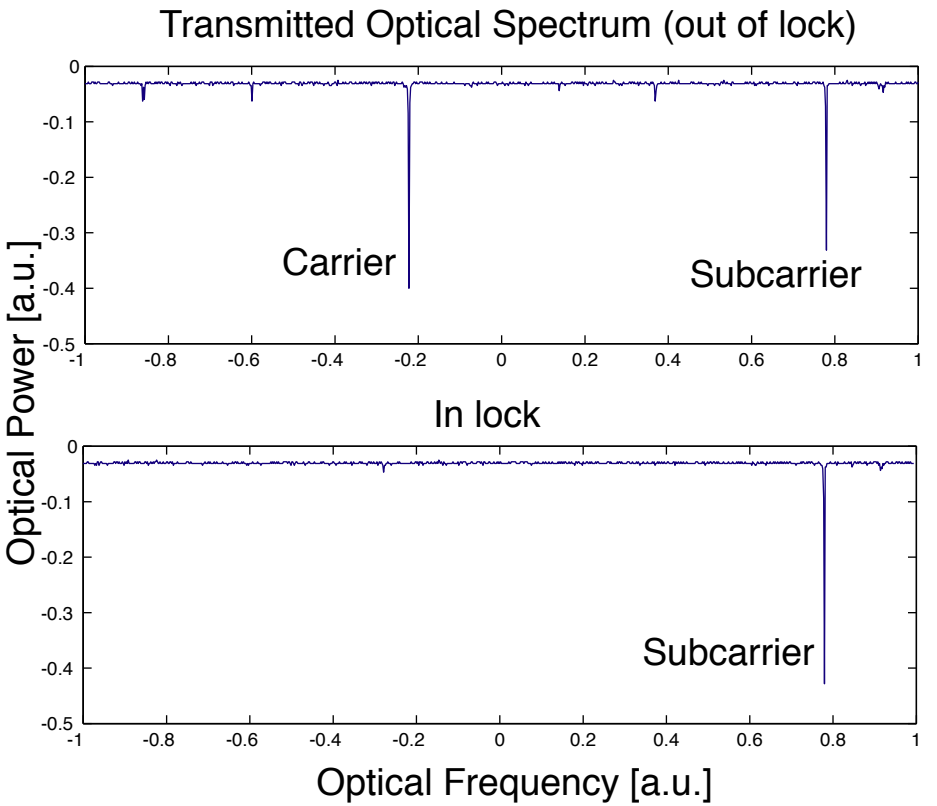
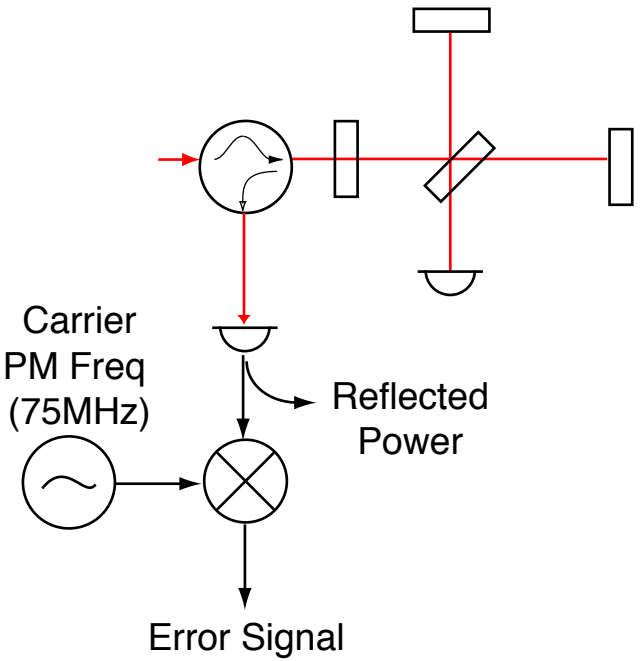
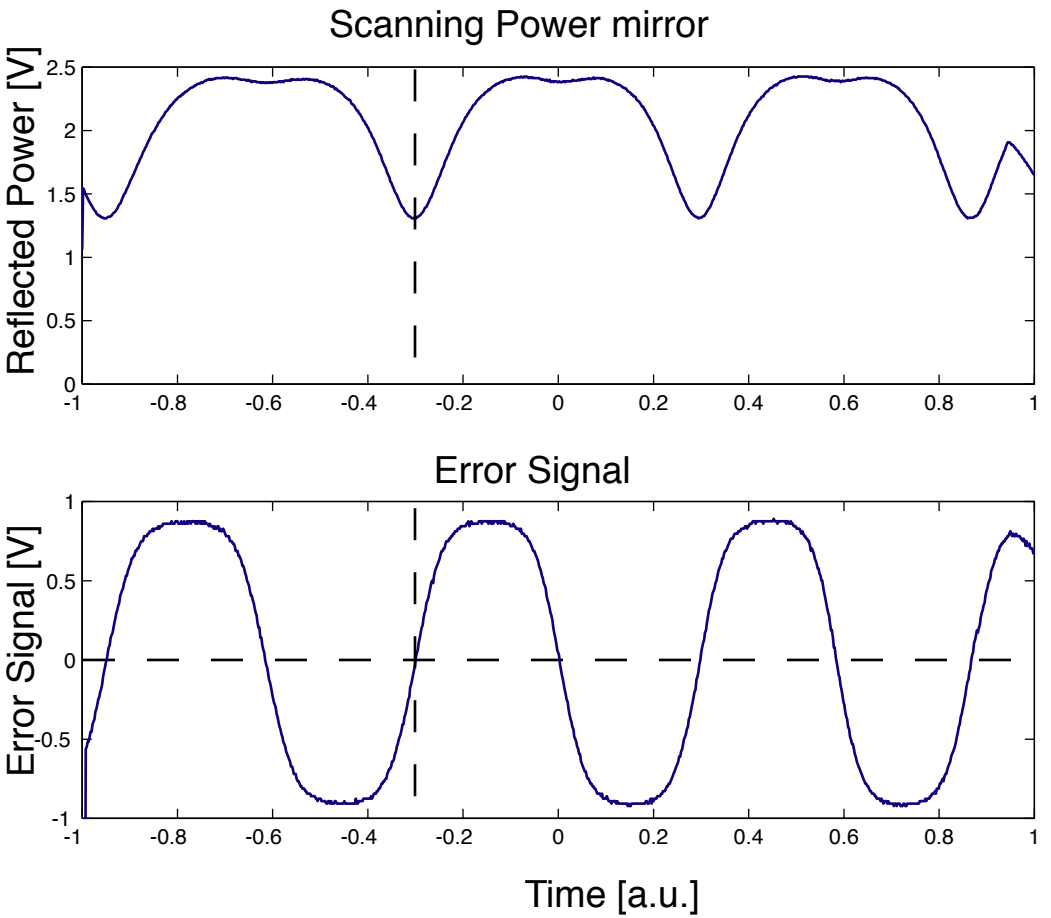


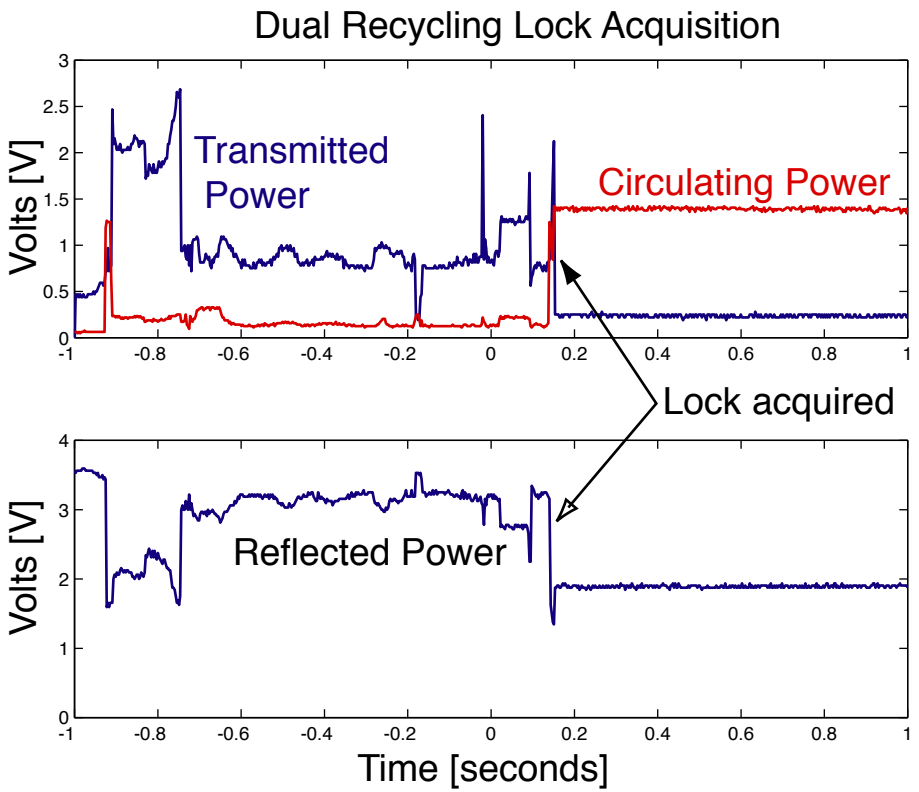


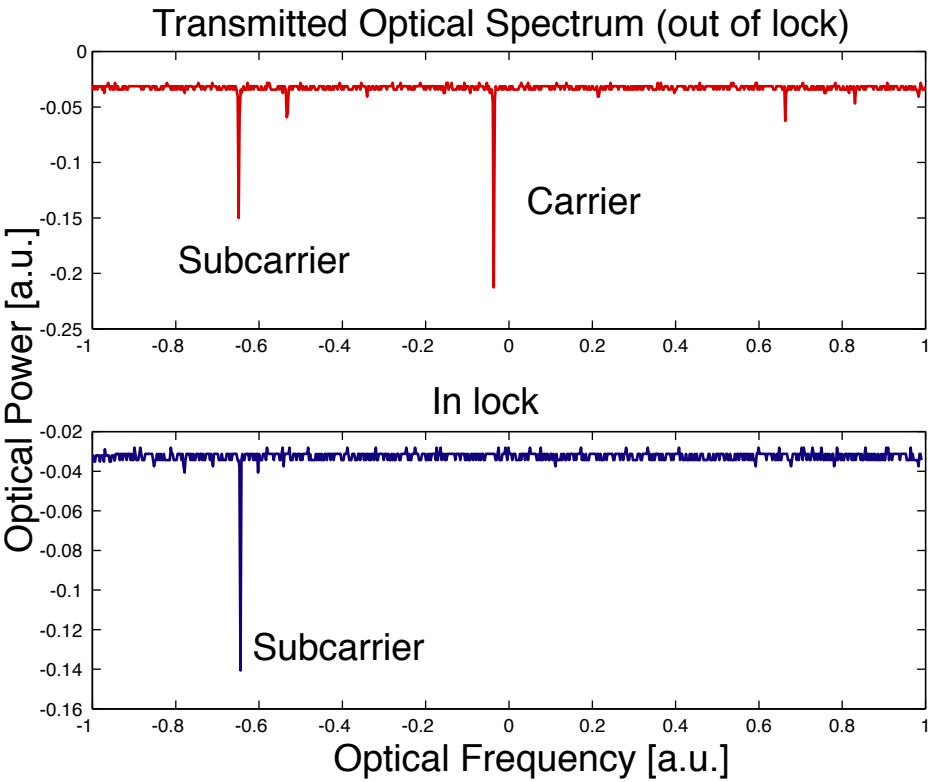
Dual Recycled Michelson Error Signal



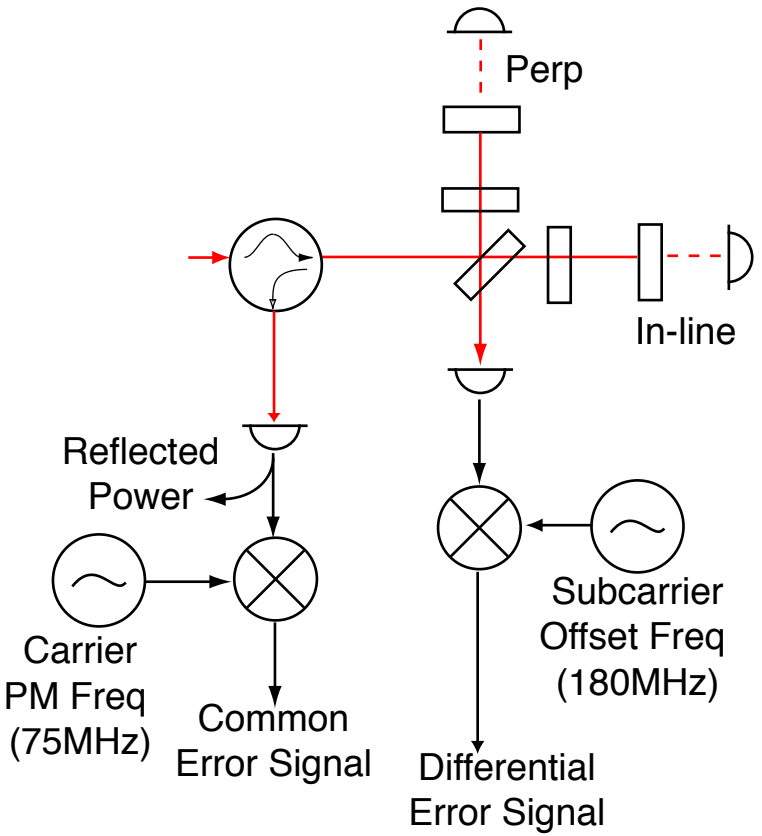


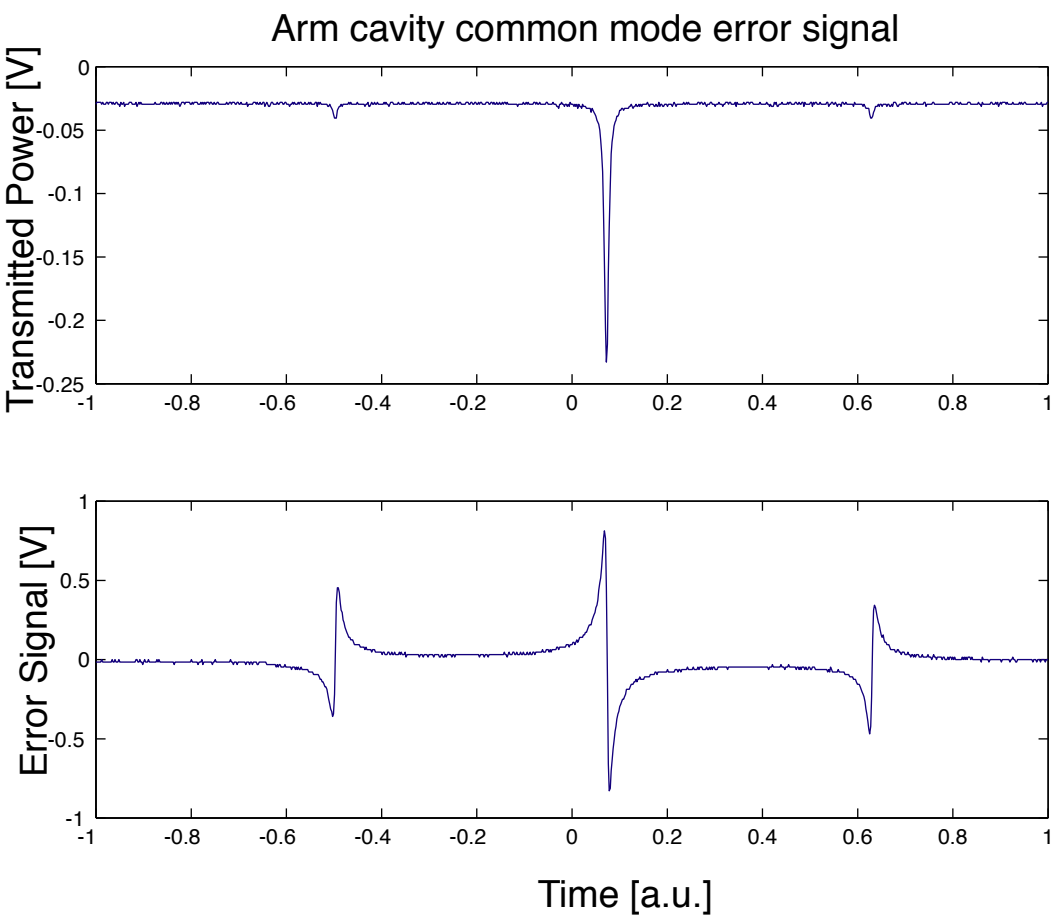
Dual Recycled Michelson Locking Performance



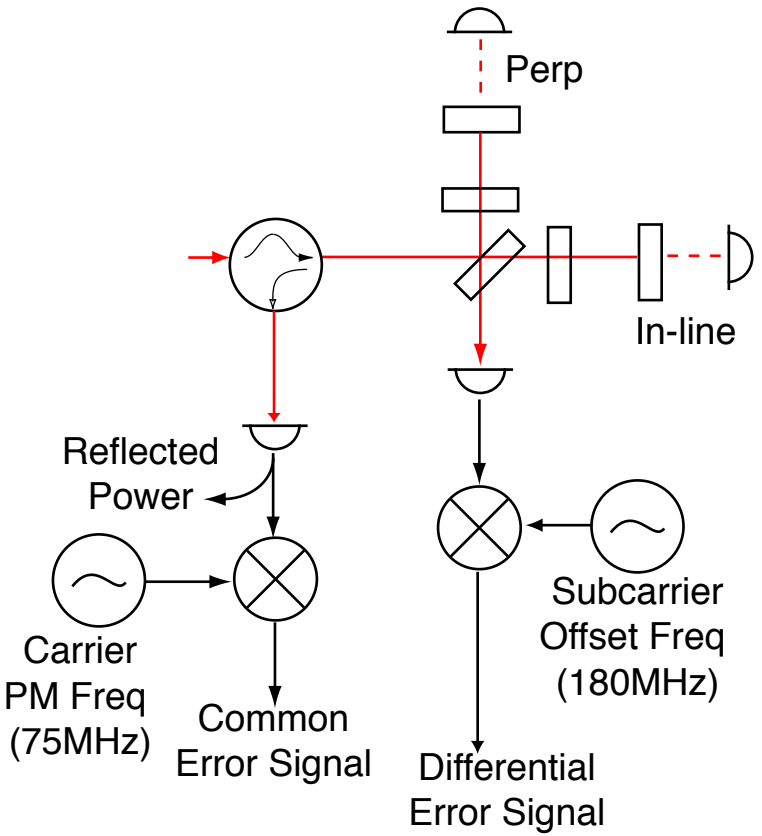


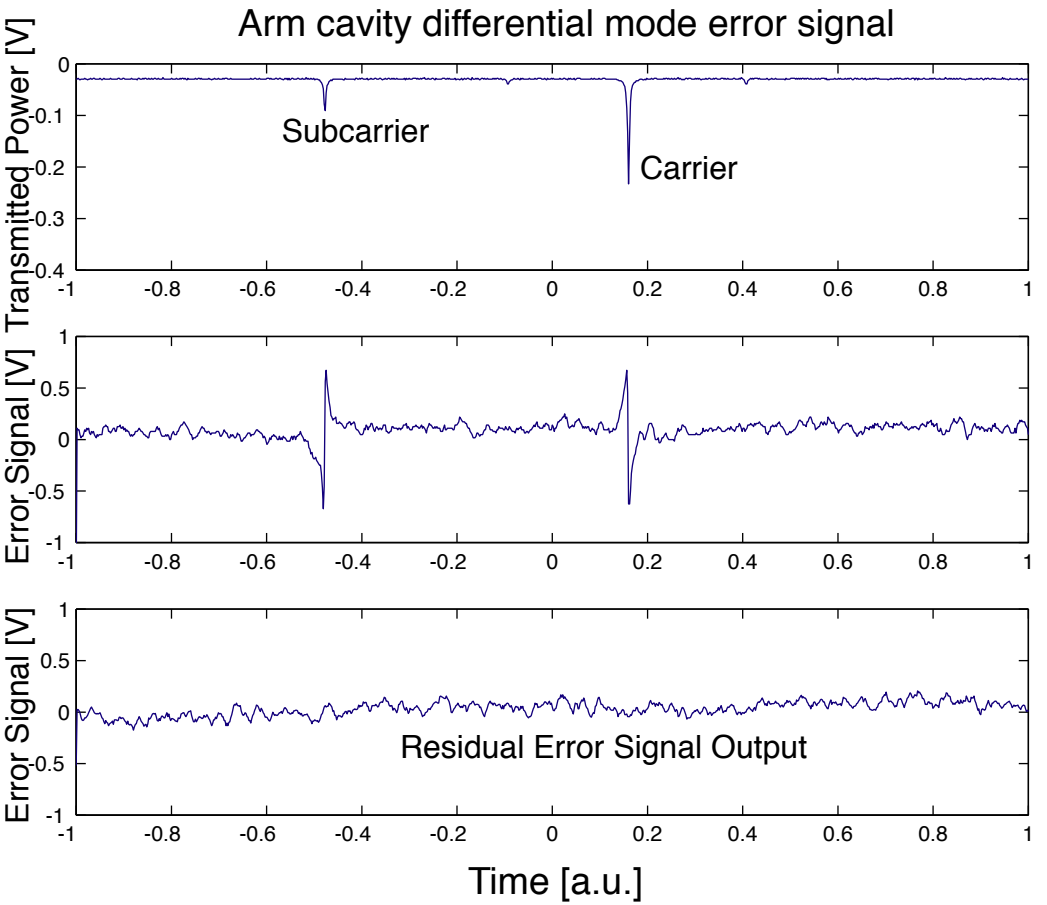
Arm Cavity Michelson Error Signals



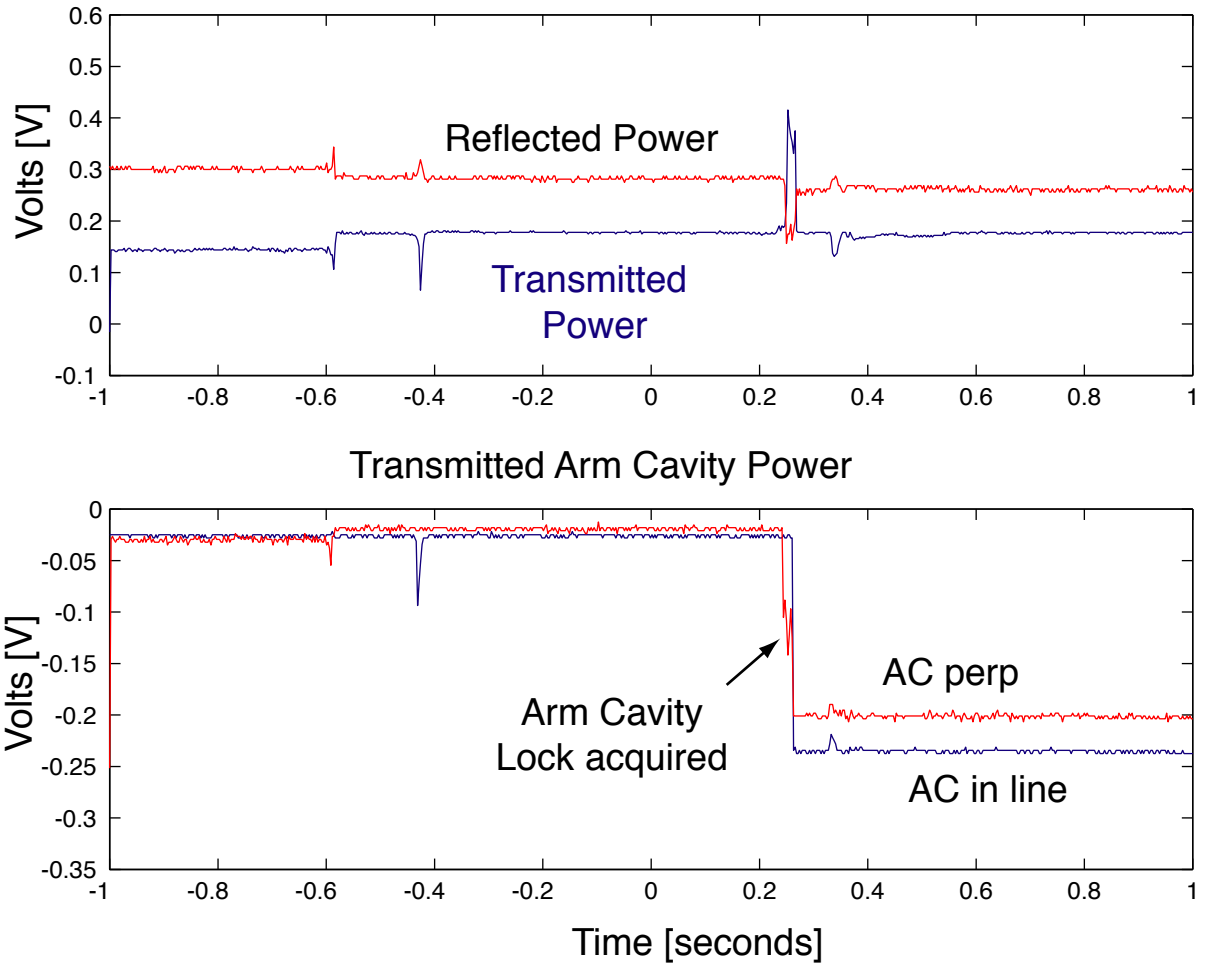


Arm Cavity Michelson Error Signals

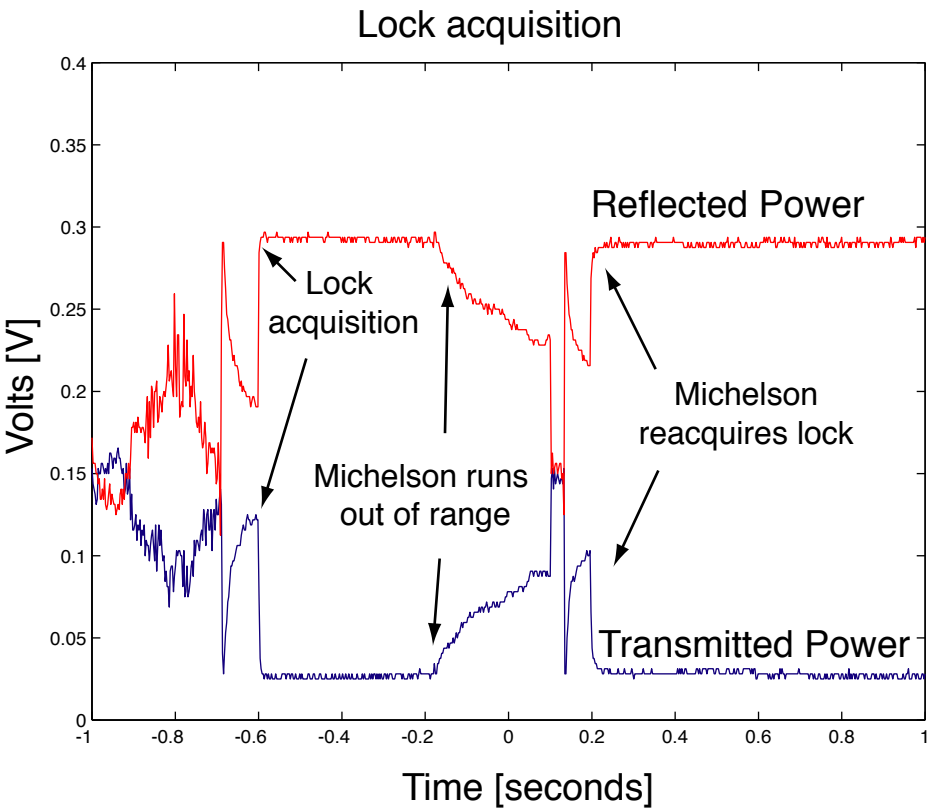


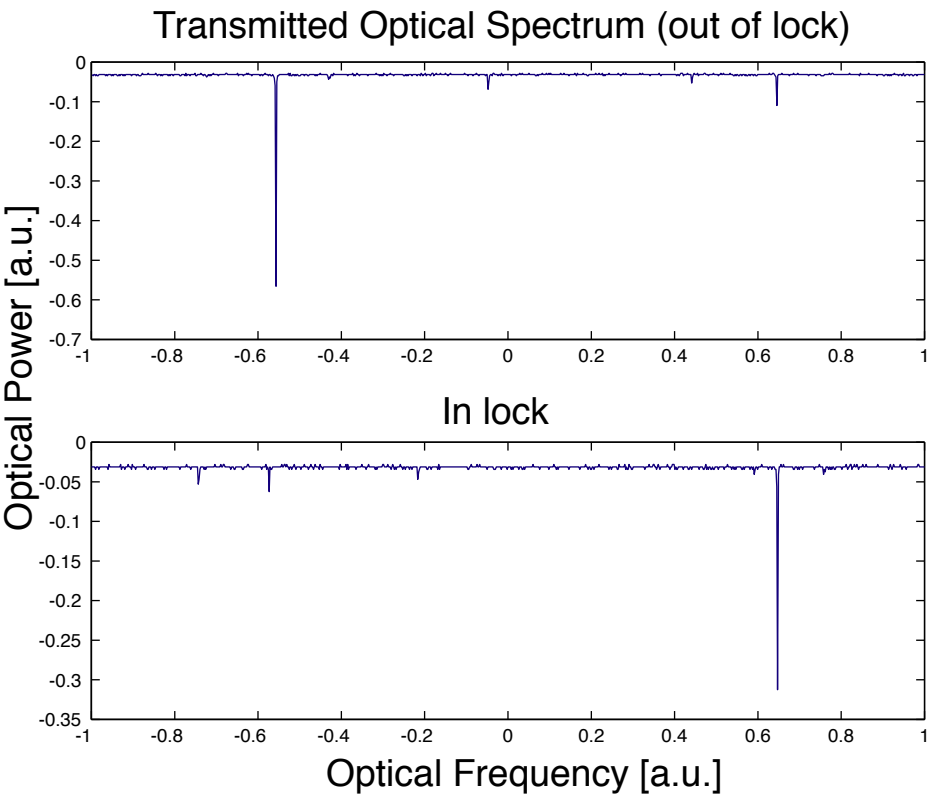


Arm Cavity Michelson Locking Performance



Resonant Sideband Extraction Locking Performance





Arm cavities locked independently using tilt locking

Conclusions

Strengths

AC common mode locking insensitive to signal cavity detuning.
Good error signal for signal cavity.
Good error signal for Michelson as signal cavity is detuned.

Weaknesses

Power cavity locking depends on carrier loss in arm cavities.
Arm cavity differential locking.

(i) linearly dependent on demodulation phase
(ii) limited by residual error of phase locking and signal cavity locking.

Note 1, Linda Turner, 05/09/00 02:00:46 PM
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