Length Control Modeling

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LIGO-G950036

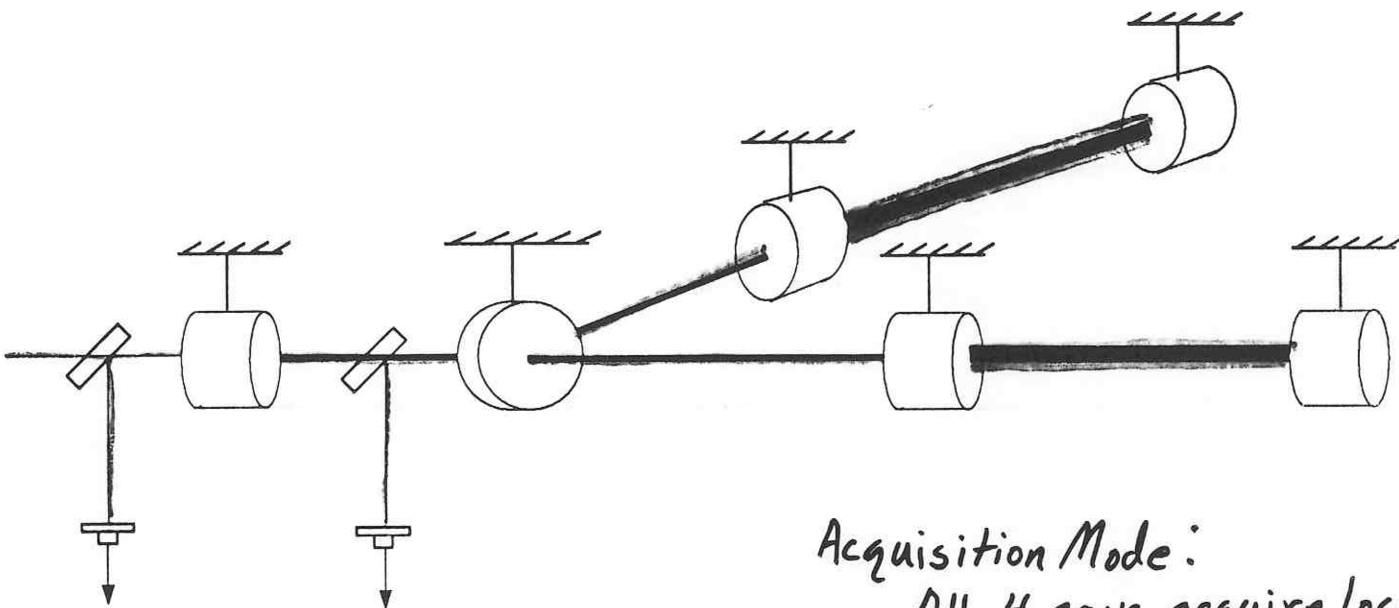
Length Control Modeling

Lisa Sievers 5/25/95

- What is It?
- What are we doing ("big picture" and "right now")?
- What are the main technical issues?

Length Control System Modeling

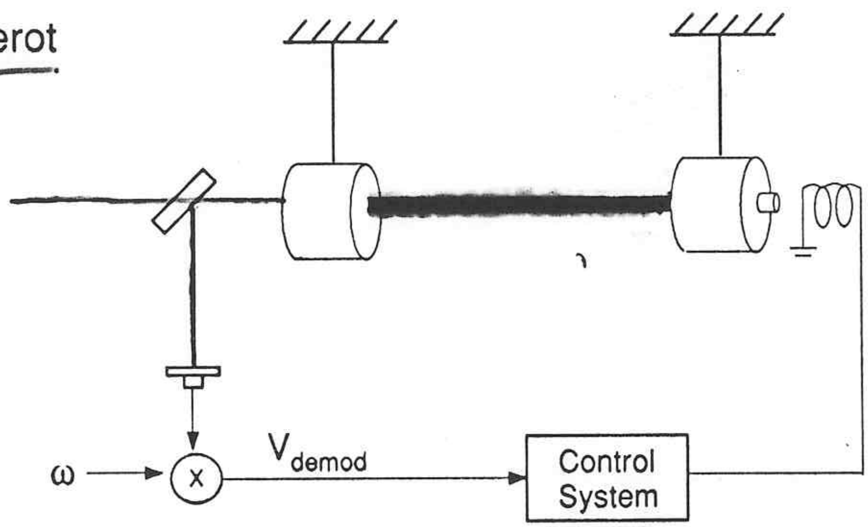
LIGO Recycled/Recombined Interferometer



Acquisition Mode:
All 4 cavs acquire lock

Operation Mode:
Keep cavs in lock, low noise

Single Fabry Perot



'Big Picture'

What Are We Doing?

OPERATIONS MODE MODELING (Mature State)

- Optical Modeling (MR,RW)

  Model validation ongoing (HY)
- Control System Modeling (LS)

  Work planned for late fall

ACQUISITION MODE MODELING (Infancy)

- SINGLE CAVITY

  Work complete (JC, DR, MR, LS)
- COUPLED CAVITY

  Optics Modeling work complete (DR solved technical challenges in writing modeling code with "fast" execution time). Control System model in progress (LS).
- RECOMBINED IFO

  Optics Modeling work complete (DR). Control System model to be done.
- RECOMBINED/RECYCLED IFO

  To be done (DR believes it will go quickly)

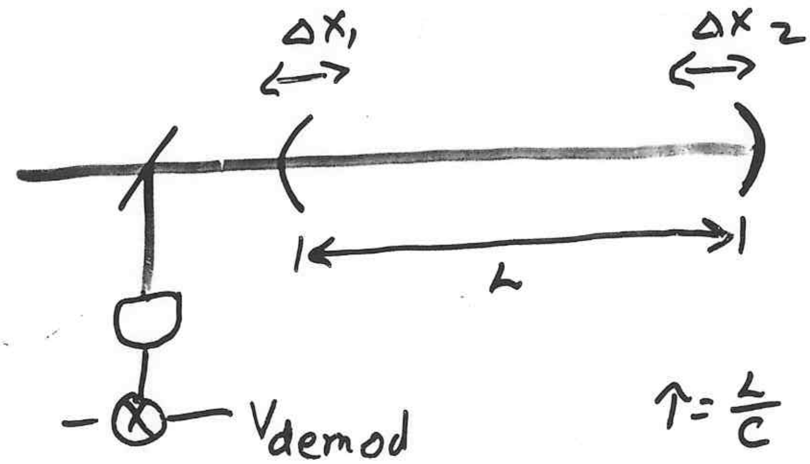
Recent Results From Operations Mode Modeling

- ALL Single Fabry Perot transfer function models (including those derived from acquisition model) match out to frequencies well above the free spectral range (HY, DR, LS)

- Analytic Single Fabry Perot transfer functions derived that are valid well beyond FSR (Can apply same method to get analytic transfer function expressions for coupled cavity)

$$\frac{V_{demod}}{\Delta x_1} \propto \frac{1}{1 - r_1 r_2 e^{-2\tau s}}$$

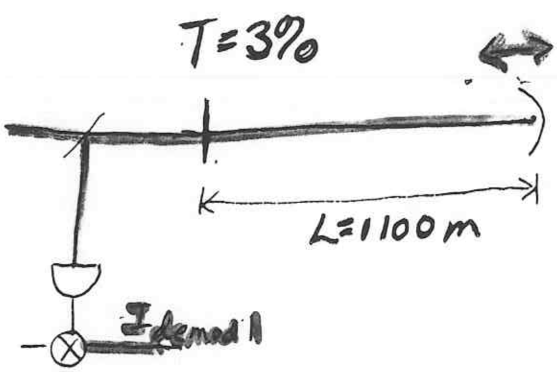
$$\frac{V_{demod}}{\Delta x_2} \propto \frac{e^{-\tau s}}{1 - r_1 r_2 e^{-2\tau s}}$$



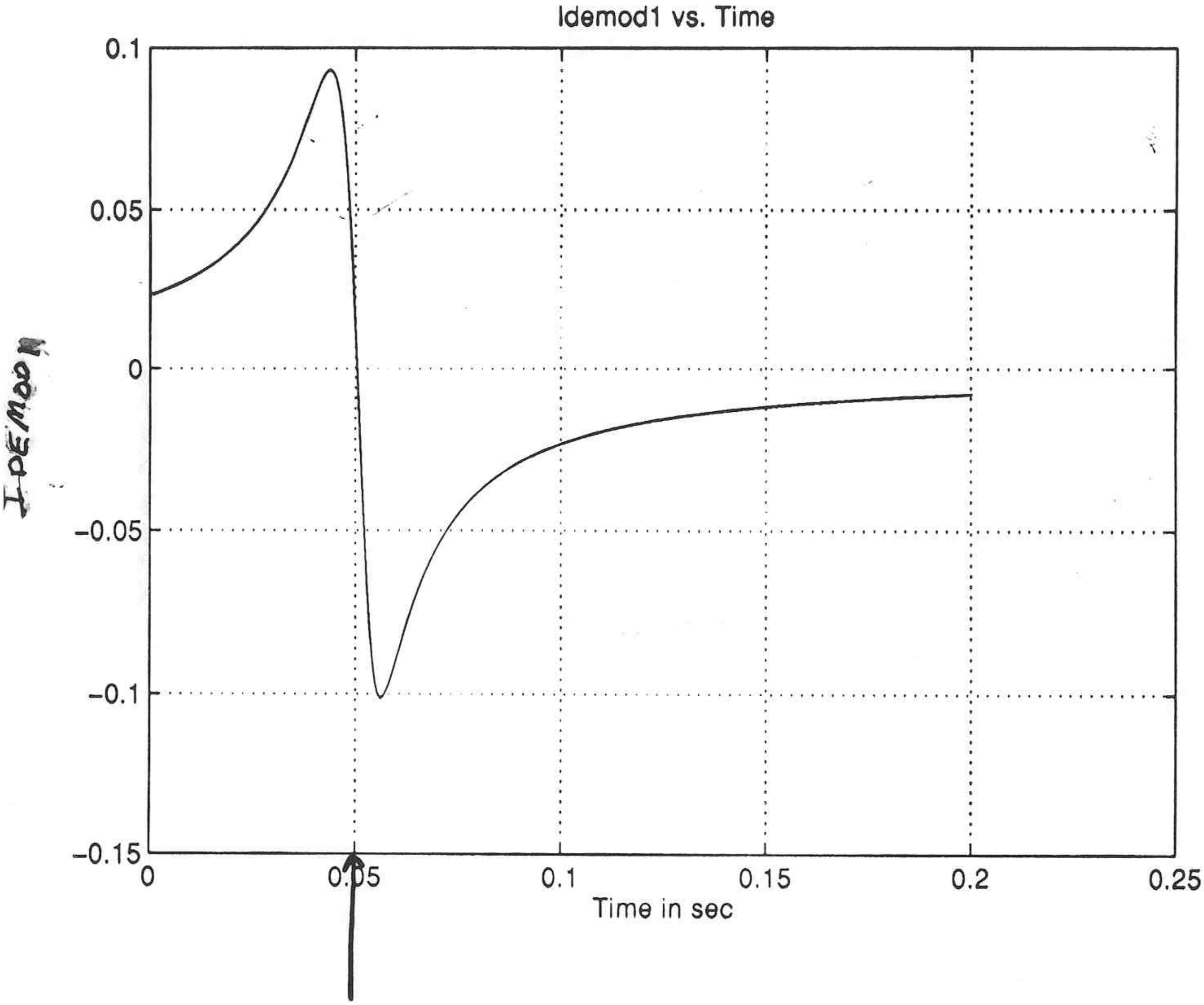
Recent Results from Acquisition Mode Modeling (Thoughts on Control Design for Coup Cavs)

- Before design servo, need to know properties of signal to be controlled
- Plotted 'fringes' (i.e. demodulator output as cavities move through resonance)
- Insights, Insights, Insights ....

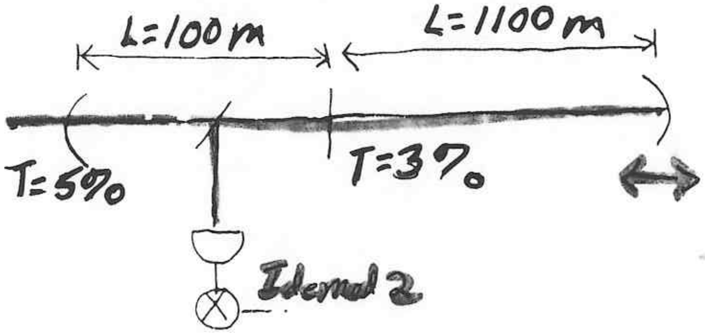
  (Too early to draw conclusions, though)



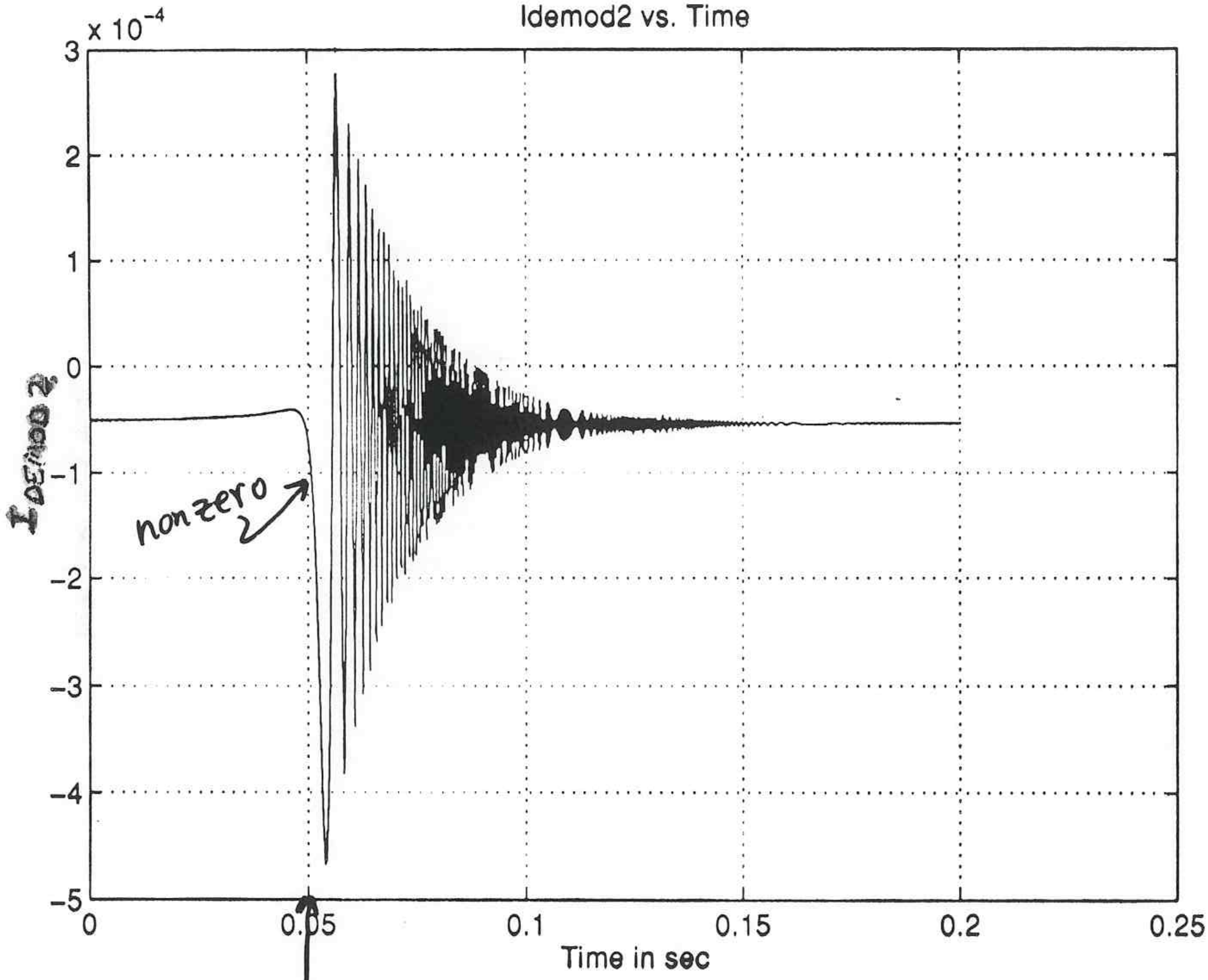
Finesse = 200
FSR = 136 KHz
cavity pole = 333 Hz
velocity = .1 um/sec



Cavity goes through resonance



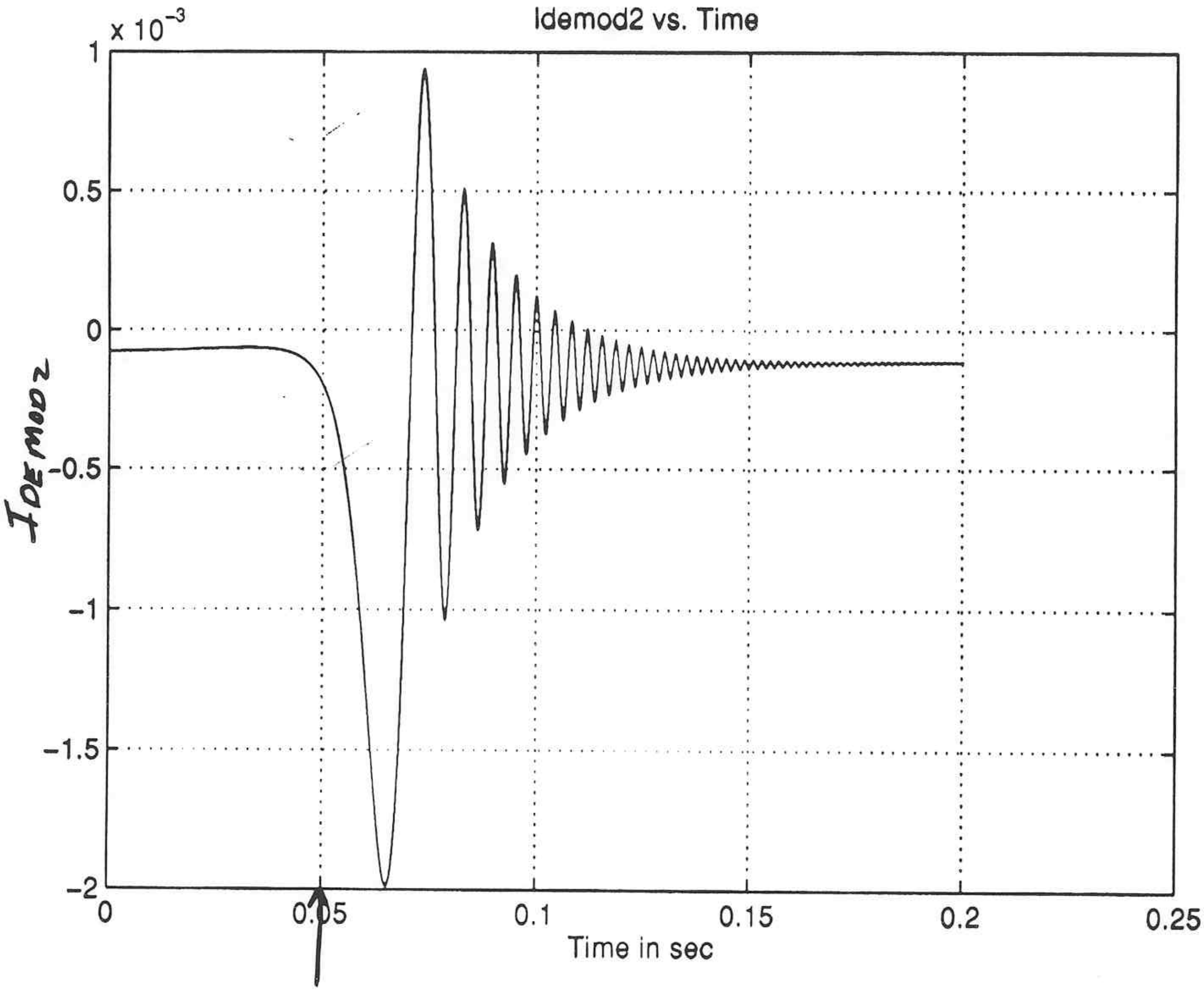
Back Cavity.
Finesse = 200
cavity pole = 333Hz
$V_{BACK\ MIRROR}$ = .1mm/sec
Front Cavity:
Fixed Distance off Resonance



Back cavity
goes through resonance

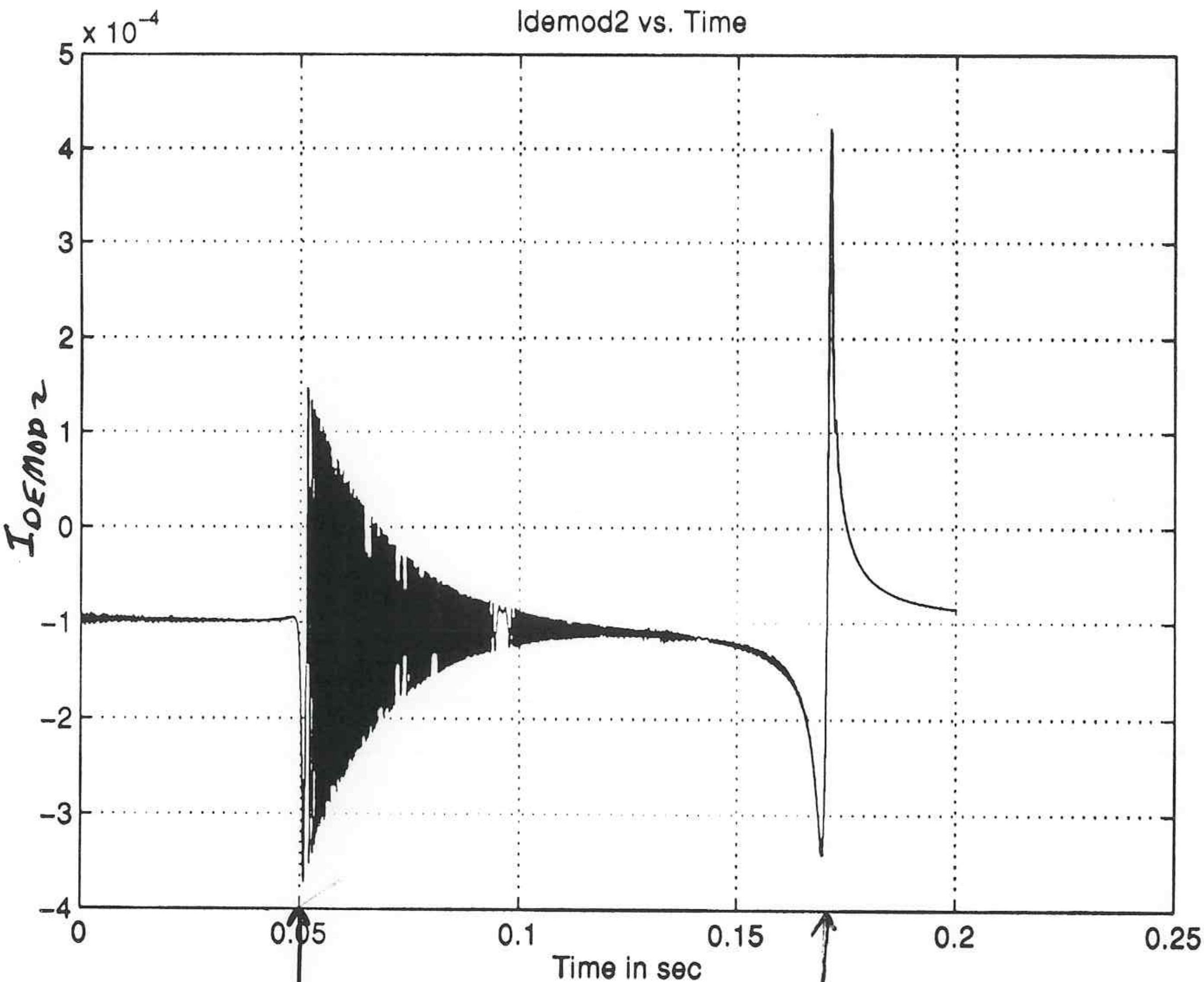
BACK Cavity:

$V_{BACKMIRROR} = .01 \mu m/sec$



Back Cavity:

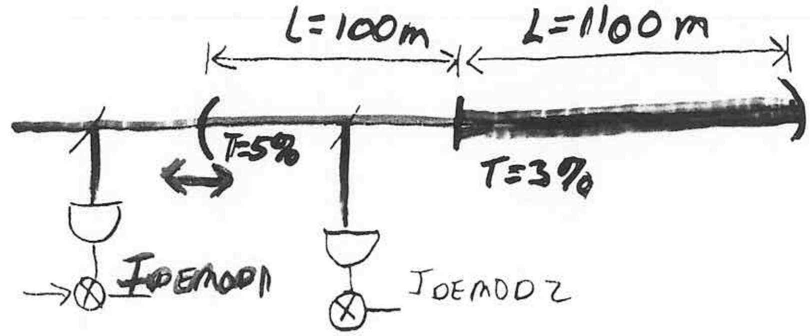
$V_{BACK\ MIRROR}$ = 1 um/sec

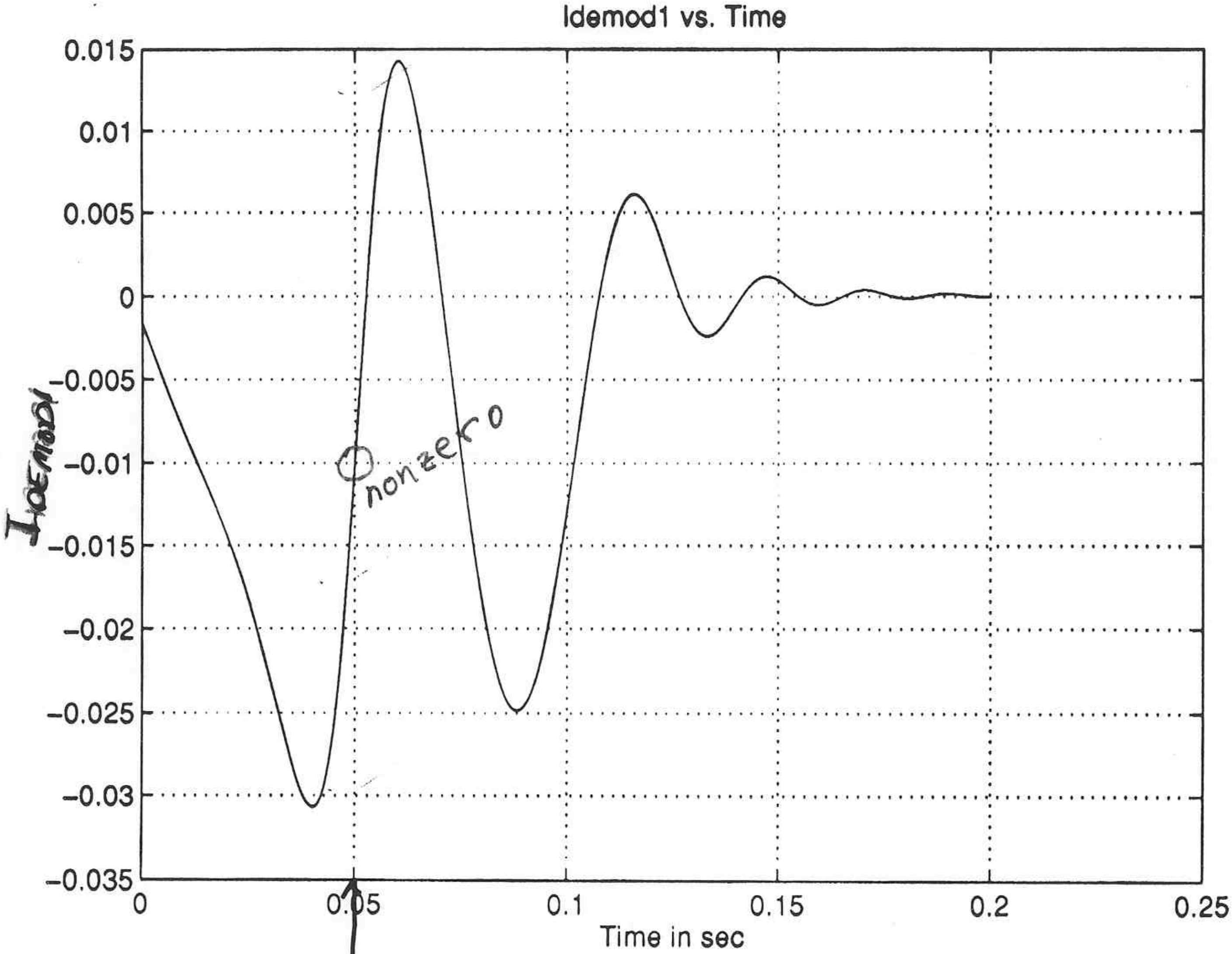


Carrier Resonant IN BACK CAVITY

SIDEBAND RESONANT IN BACK CAVITY (Interesting Control Issues)

Back Cavity:
Finesse = 200
Cavity pole = 333Hz
ON RESONANCE





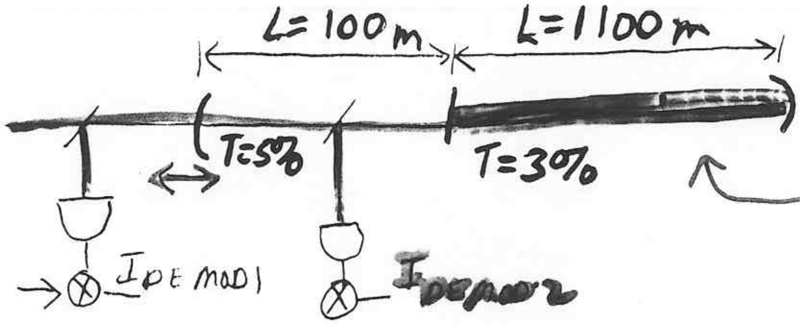
Front Cavity Goes Through Resonance

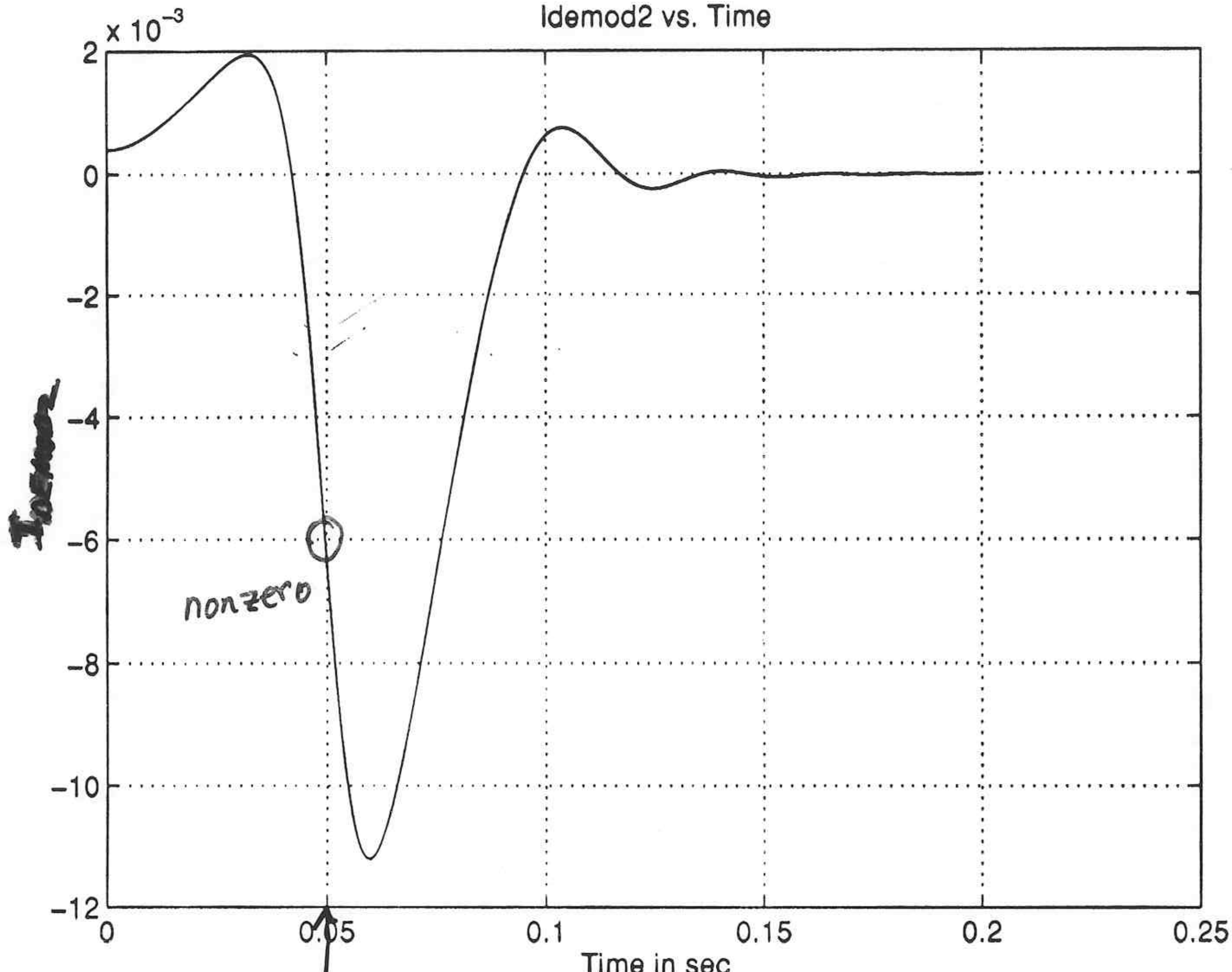
Back Cavity:

Finesse = 200

Cavity pole = 333Hz

ON RESONANCE





Front Cavity Goes Through Resonance

What Are the Main Technical Issues?

- Model Validation
- Computational Speed of Modeling Code
- Control Design?