LIGO

Intensity Stabilization in Advanced LIGO

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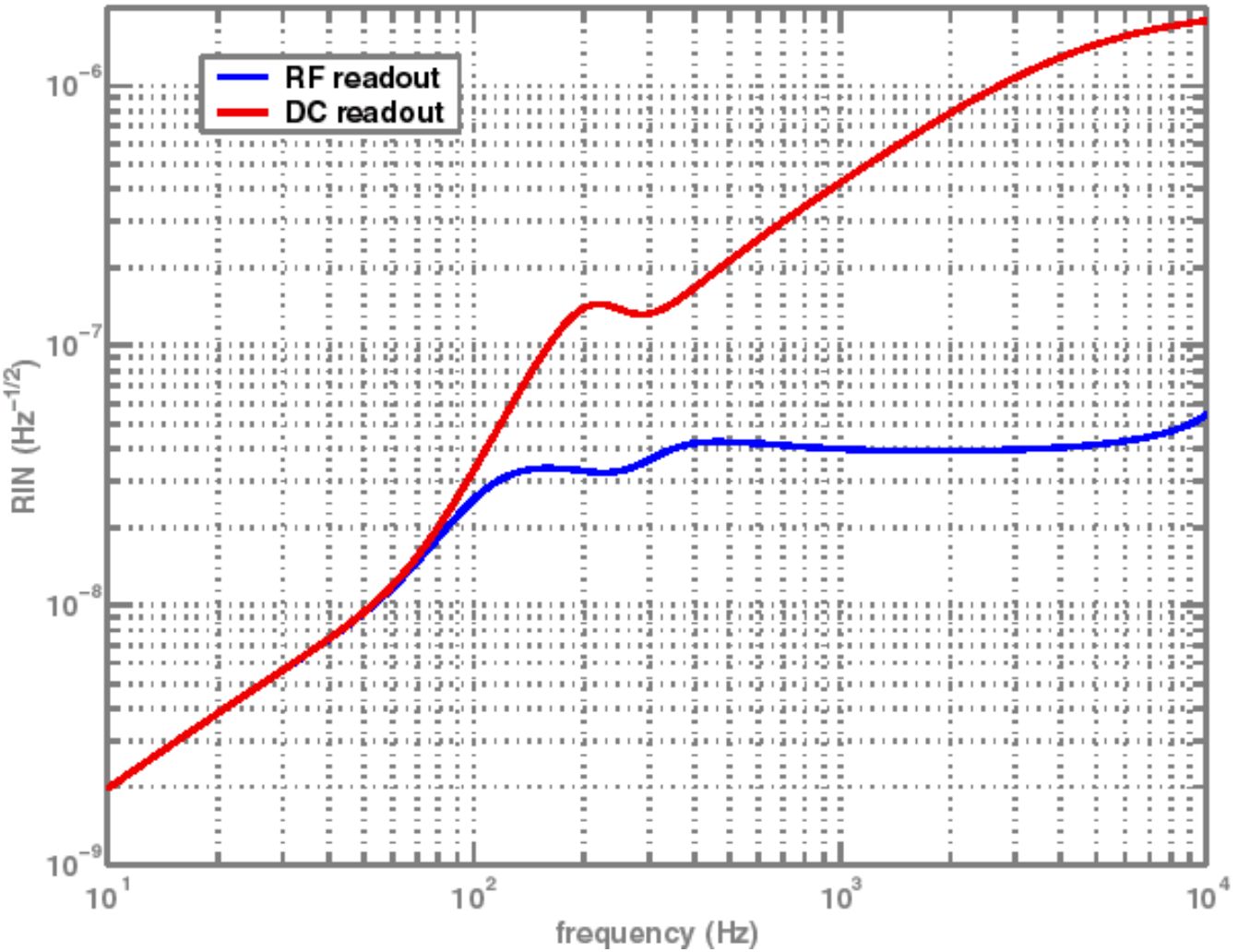
Outline

- Intensity Noise in Advanced LIGO
- The Pre-stabilized laser
- PSL Current Actuators
- Low-noise, High-power Photodiode
- Intensity Stabilization Servo
- Results

Advanced LIGO Intensity Noise Requirement

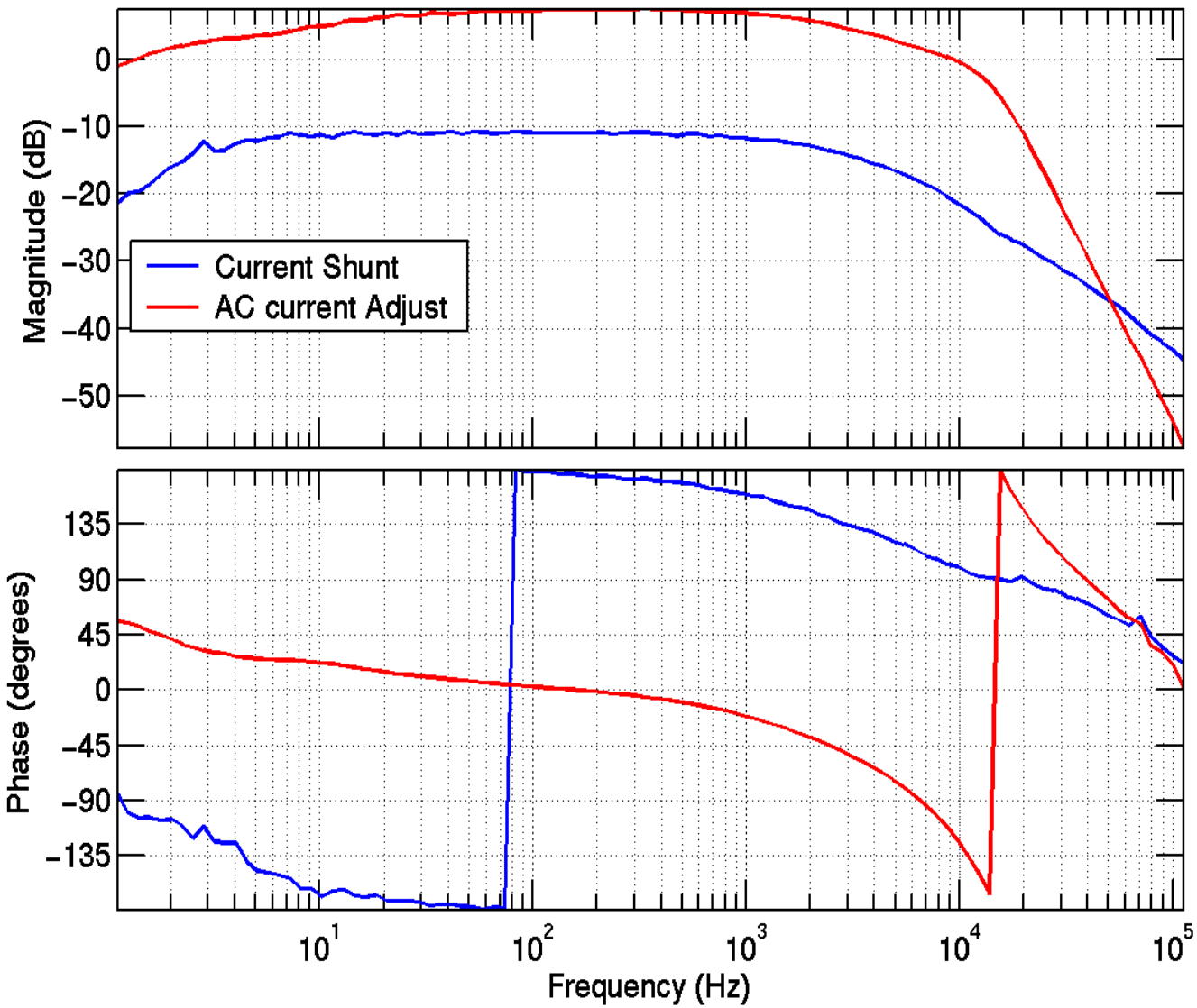


- Radiation pressure on test masses with 1% arm power mismatch
- RIN: 2x10^{-9}**/rtHz @ 10Hz**
- Requirement based in part on readout scheme at high frequency

The Pre-stabilised Laser

- For experiments, used LIGO-1 10 Watt MOPA
- Pre-modecleaner
  - Spatial filter for modes higher than TEM:00
  - Filter for very high-frequency intensity noise
    - pole at cavity half-width/half-max (25MHz)
  - Reduces beam jitter
- Frequency stabilized

PSL Current Actuators

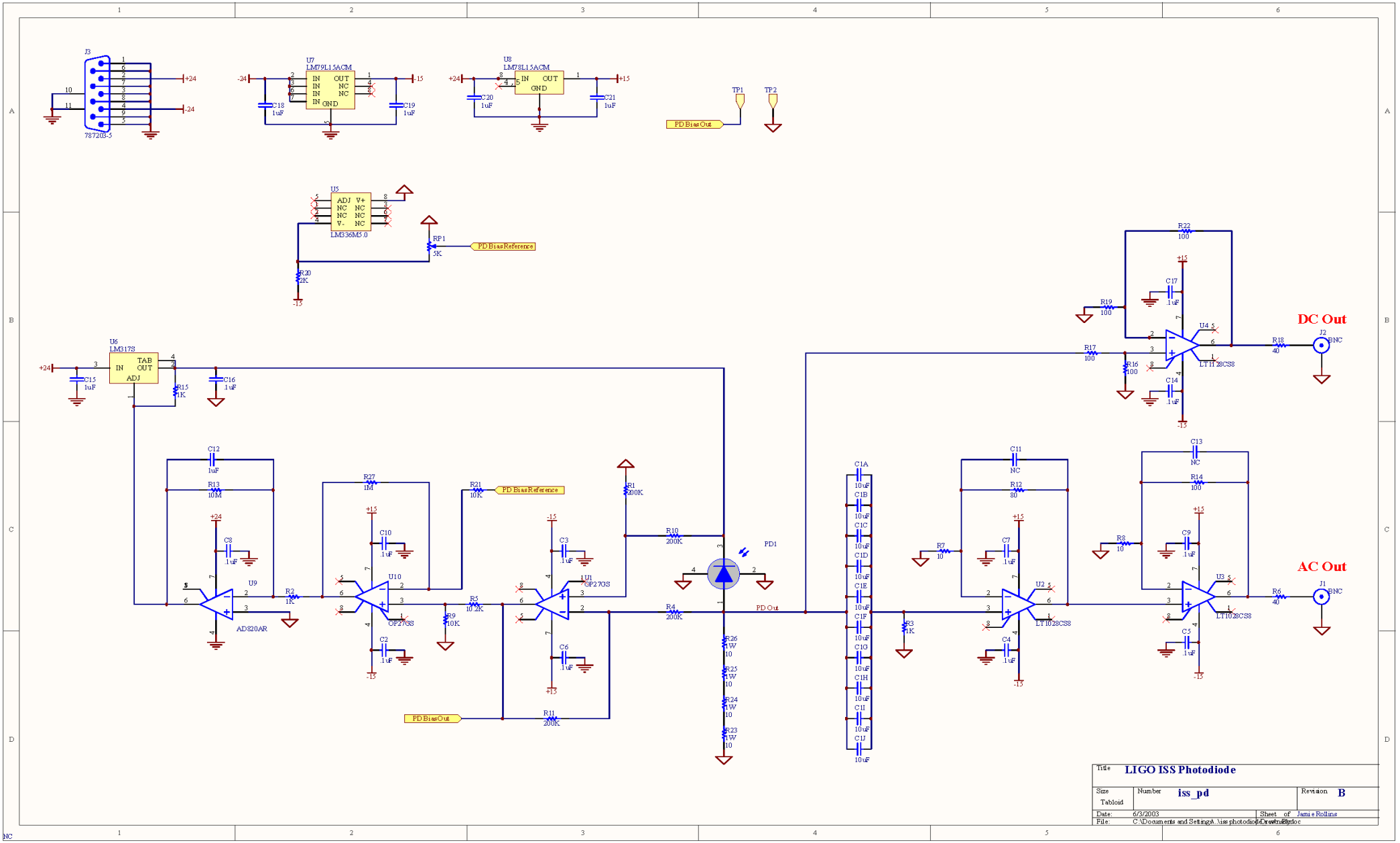


- AC current adjust
  - ± 2.5 Amps/Volt
  - poles:
    - 4 @ 10kHz
- Current shunt
  - ± 250 mAmps/Volt
  - Poles:
    - 1 @ 3kHz
    - more > 200kHz

Low-noise, High-power Photodiode

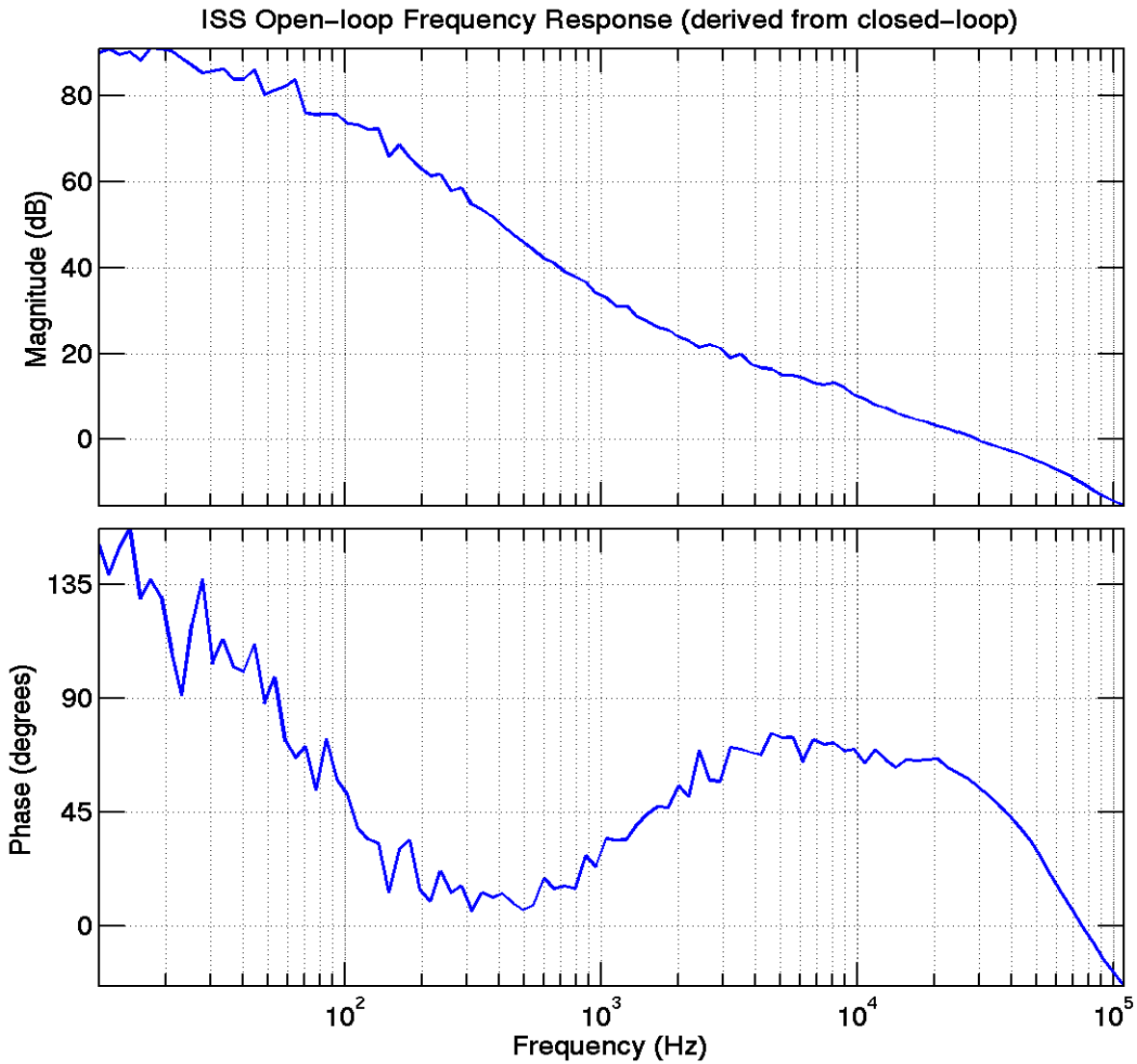
- Design considerations:
  - Very Low noise
    - First stage input voltage noise < 7 *nVrms/√Hz @ 10Hz,* < *3 nVrms/√Hz* @ 100Hz
  - High-power
    - Photocurrents ~300 mA
    - Heat dissipation a problem --> lots of heat sinking
    - Use low bias voltages (< 5V) --> ***Bias feedback control circuit***
  - AC coupled
    - Elliminates need for high-current, low-noise trans-impedence stage
    - Elliminates need for stable DC reference
    - Requires high capacitance, => 10 surface mount capacitors
- Hamamatsu G5832-02 2mm photodiodes (~.93 QE)

Low-noise, High-power Photodiode

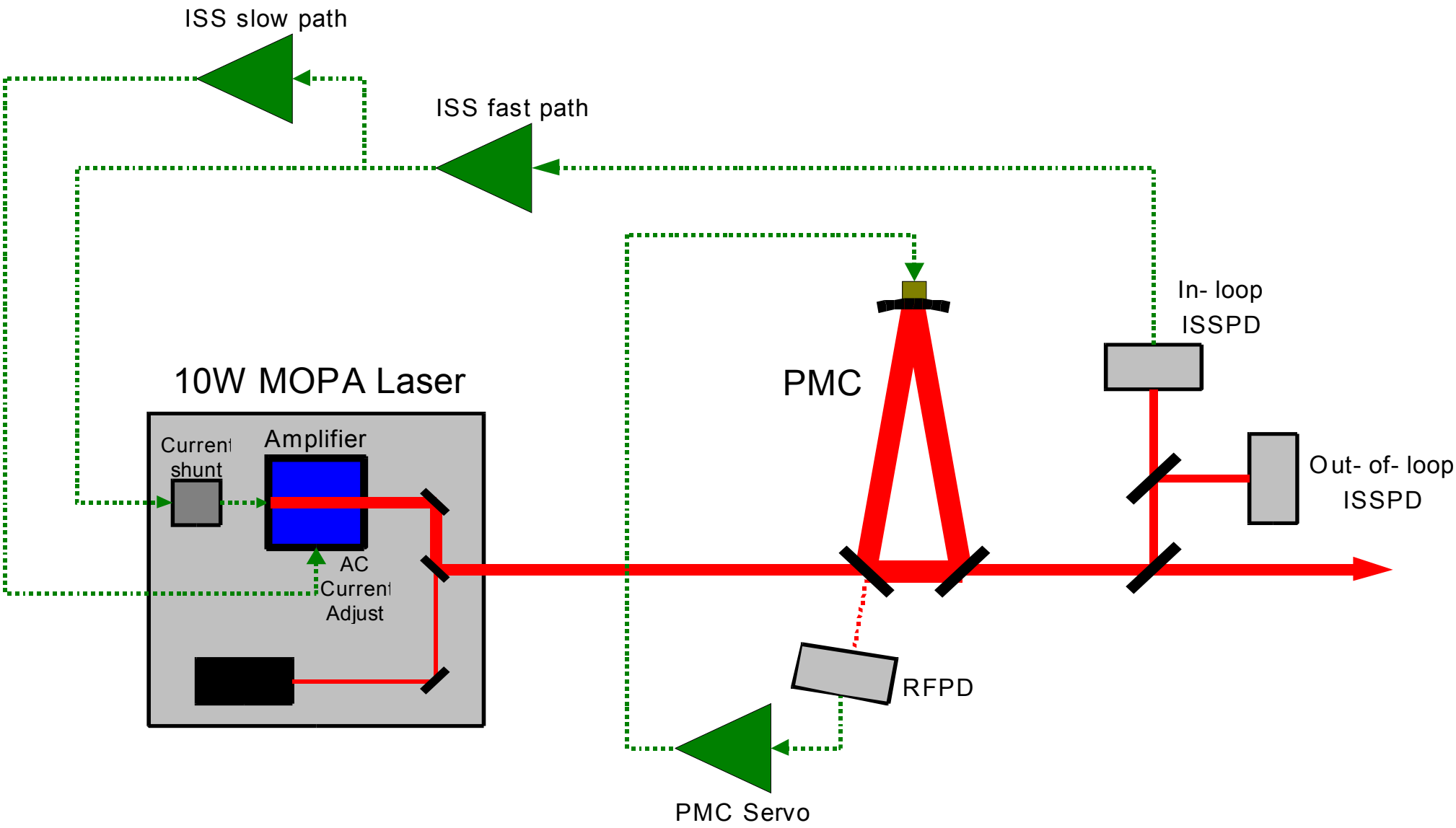


Intensity Stabilization Servo

- Requirements:
  - 80dB of gain @ 10Hz
  - 10kHz unity gain
  - AC coupled
- 2-loop topology:
  - Current shunt alone did not have enough dynamic range.
  - Used high-dynamic range AC current adjust at low frequency.



Intensity Stabilization Servo



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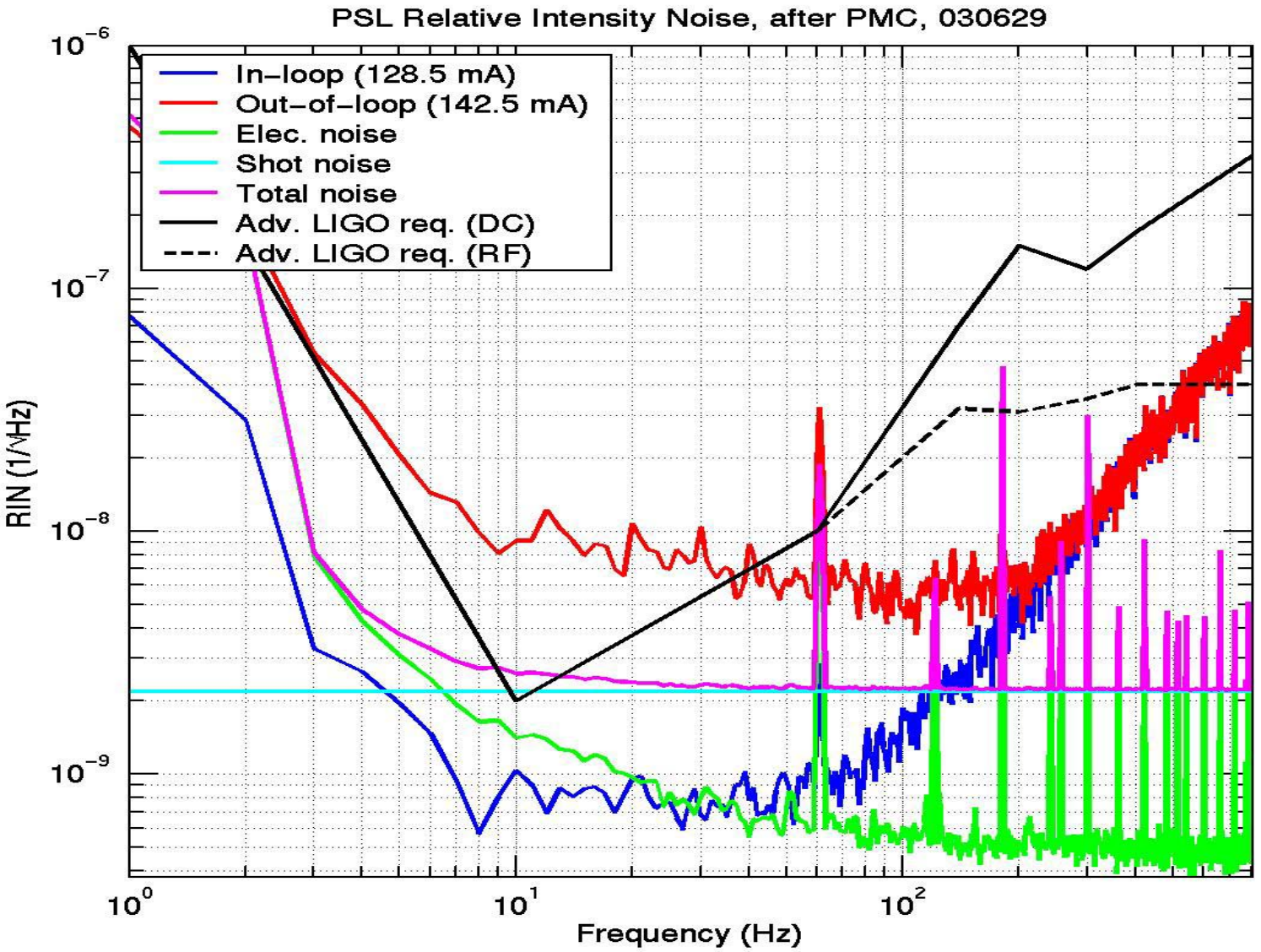
Results



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What we have tried

- Ruled out:
  - Scatter (ND filters in front of pd's)
  - Electronics noise (in photodiode and servo)
  - High-frequency noise hitting slew-rate limits
  - Photodiode bias noise (tried fixed bias voltage)
  - Capacitive sparking
  - PMC (frequency->intensity conversion)
  - Beam Jitter
  - Polarization jitter
- Need to investigate further:
  - Another out-of-loop PD to verify that limit is actually on light (need third low-noise photodiode)
  - Beam splitter coatings
  - Try using simple reflections
  - Vacuum Compatible PDs