Status of Detector Commissioning

LSC Meeting, August 2000

LIGO-G000195-00-D

Livingston overview: what's new

- PSL installed, characterized
  - Frequency servo upgrades identified
  - New optical mounts designed, installed
- Mode cleaner installed, tested
  - More optimal servo operating state identified
- Small optics suspensions
  - Interaction of permanent magnets identified
- Installation of remaining in-vacuum components + realignment of core optics – ongoing

Hanford overview: what's new

- Arm cavity tests – completed 04/10/00
  - 24 hour engineering run
  - Common-mode servo
- Suspensions characterization
  - Diagonalization of sensors/actuation
  - Mirror internal resonances
- Installation of remaining in-vacuum components + realignment of core optics – 04/10 to 05/26/00
  - Optics rehung
  - Beam reducing telescopes, baffles installed
- PSL and IO improvements
  - Reduction of acousto-mechanical coupling
  - Overall reduction of PSL frequency noise
- Power-recycled interferometer locking – on going
  - Digital loops for length control
  - Arm cavity or power-recycled Michelson locked

Arm cavity tests: Control systems

- "Lock acquisition" servo
  - Analog servo, feedback to ITM only: designed for high bandwidth to acquire State 4 of ifo
  - In fact, we found that system locks better with low bw (< 100 Hz); turn up gain after acquiring
  - Ultimate high-performance servo: ugf ~ 300 Hz; PM ~
- Test mass resonances
  - Had to notch out lowest order axisymmetric modes at 9.5 and 14.5 kHz (expected)
  - And also non-axisymmetric modes at 6.5 kHz (surprised, can be improved with beam centering on optic)
- This servo used during 24 hr E1 run

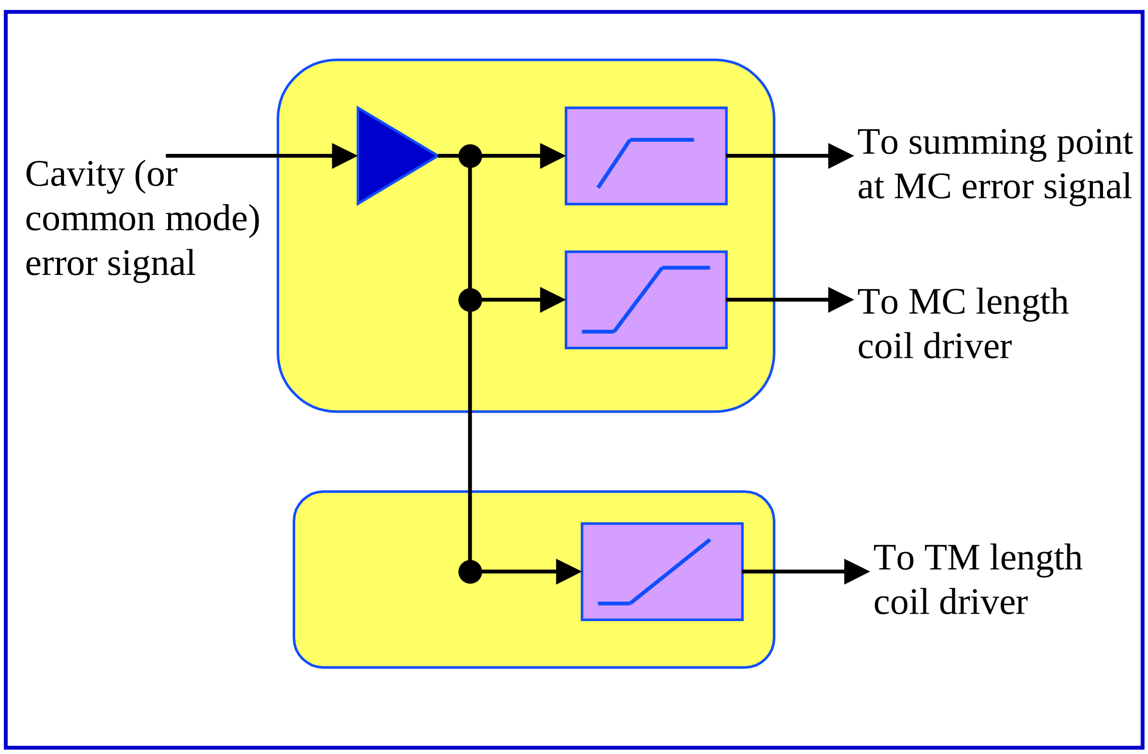
Arm cavity tests: Control systems

- "Common mode" servo
  - Provides final level of frequency stabilization
  - Arm cavity common-mode error signal is fed back to

    TMs at low freqs.

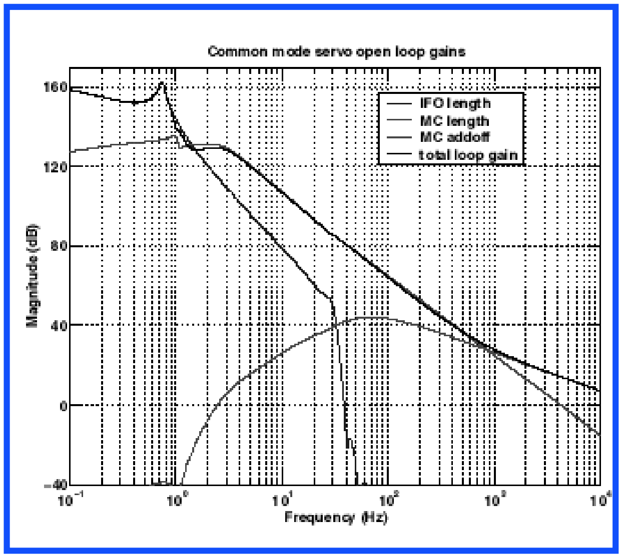
    Mode cleaner length

    Mode cleaner error point offset



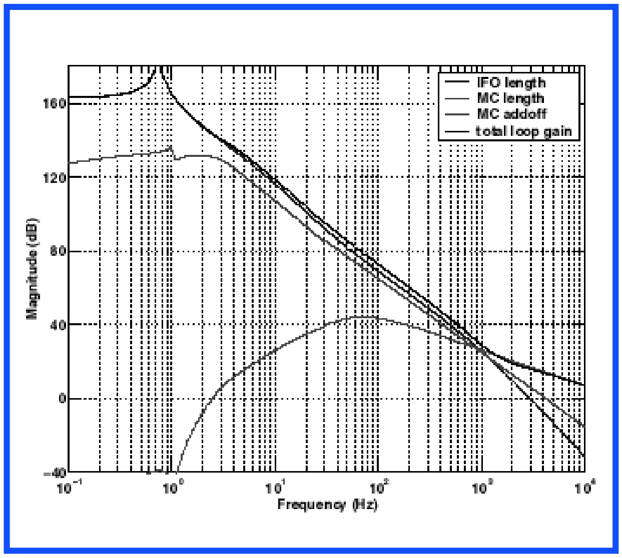
Common mode servo

- Servo design



- Low freq gain in ITM path prevents lock
    - Length-alignment coupling (?)

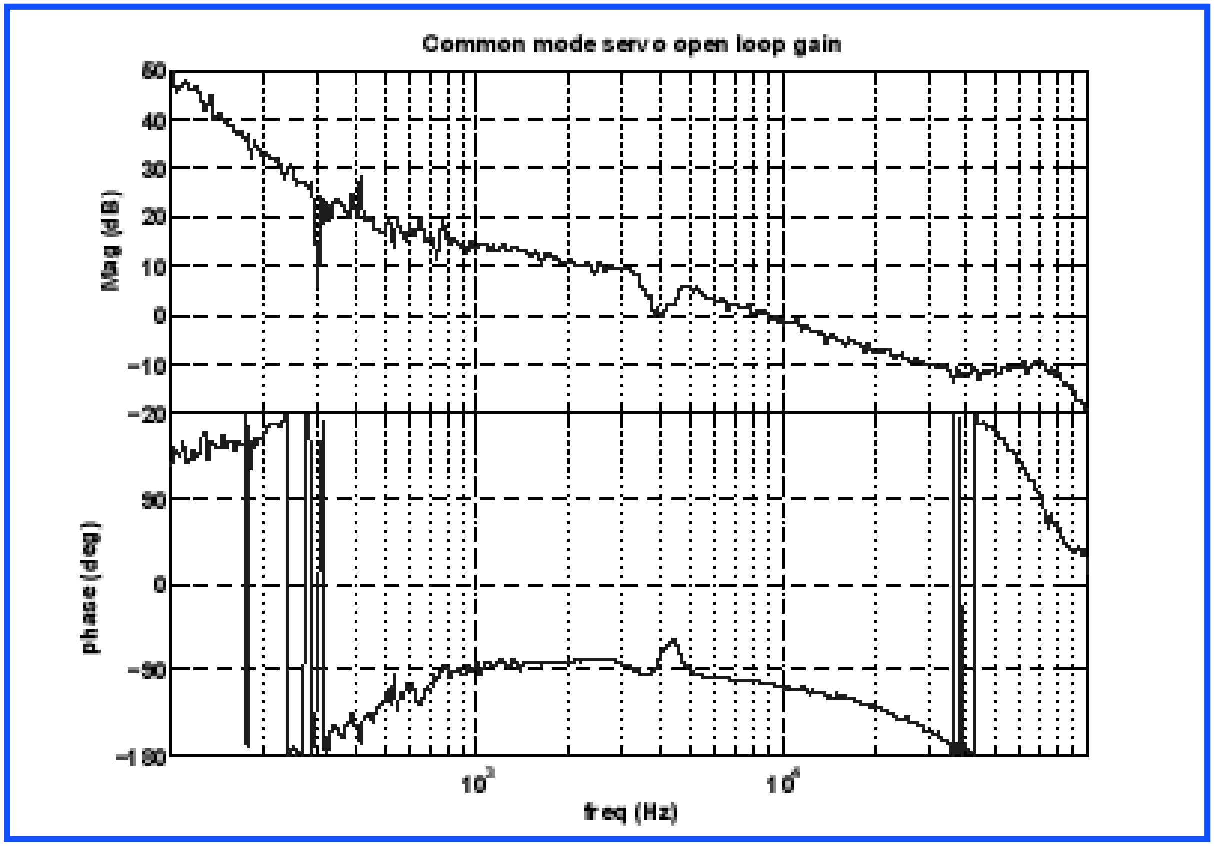
- Servo realization



- MC length path doesn't dominate at any freq.
- Fix: increase ITM gain after acquiring

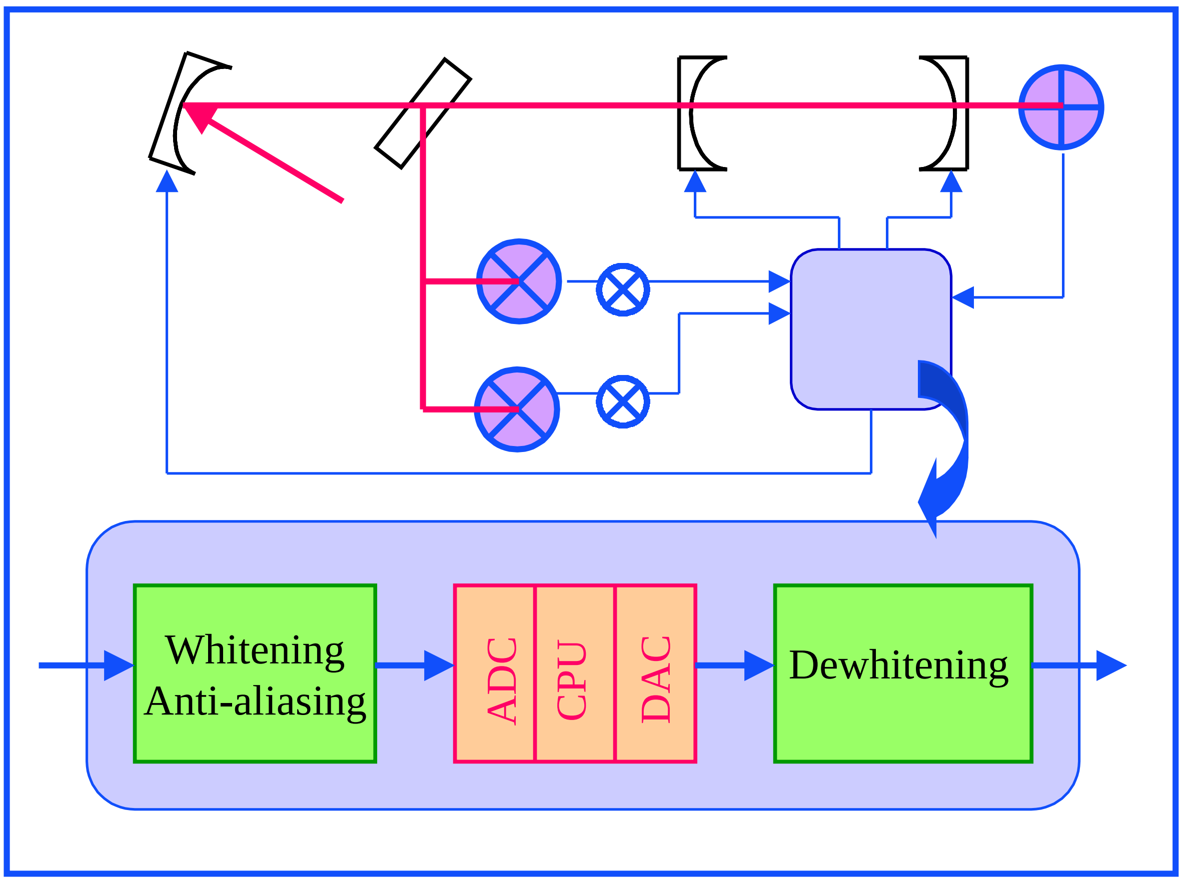
Common mode servo test

- Loop gain (calculated from closed loop gain)
  - Unity gain frequency = 20 kHz achieved



Alignment controls

- Closed loop testing of 40% of ASC system – 4 mirror orientation angles and two input beam pointing d.o.f.
- Low bw (few Hz) digital control system

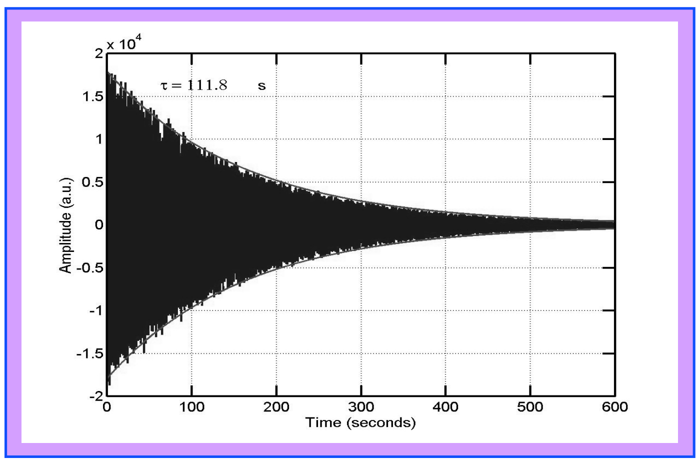


Arm cavity tests: Cavity characterization

- Resonant reflectivity
  - Best results (X arm): visibility = 0.02 (➔ 70 ppm average loss per mirror)
  - Expect visibility = 0.01 (➔ 30 ppm per mirror)
  - Measurement limited by beam clipping
- Cavity storage time = 466.6 μsec
  - ➔ Finesse = 220
  - ➔ T_{ITM} + Loss = 0.0281 (nominal design = 0.03)
- Cavity macroscopic length = 2009.11 m (surveying ➔ 2009.12 m)
- Mode matching ~ 0.96
  - Determined by measuring Gaussian mode with and without the resonant cavity
- Michelson contrast (carrier power)
  - $1 - C = P_{dark}/(P_{dark} + P_{bright}) = 0.0032$

Suspensions

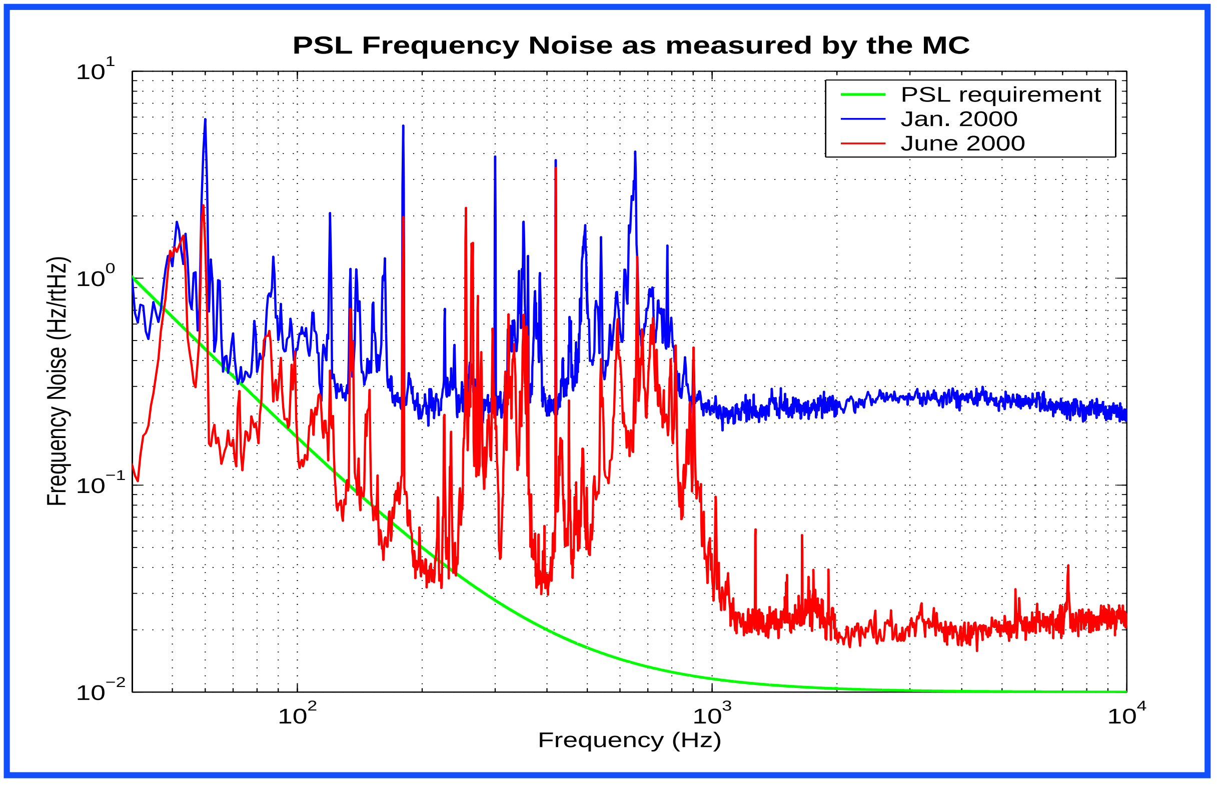
- Diagonalization
  - Four sensors ➔ primary degrees of freedom (translation, pitch, yaw)
  - Four em actuators ➔ independent motion of primary dofs
- Test mass internal mode eigenfrequencies and Q factors
  - TM internal thermal noise
  - Stability of length control loops
  - Measure decay time ➔ Q
  - Q ~ $10^4 - 10^7$



- Coupling of 1.064 µm light to sensors
  - Modulated LED ➔ coherent detection
  - New sensors ➔ relatively insensitive to 1.064 µm due to optical filtering and geometry

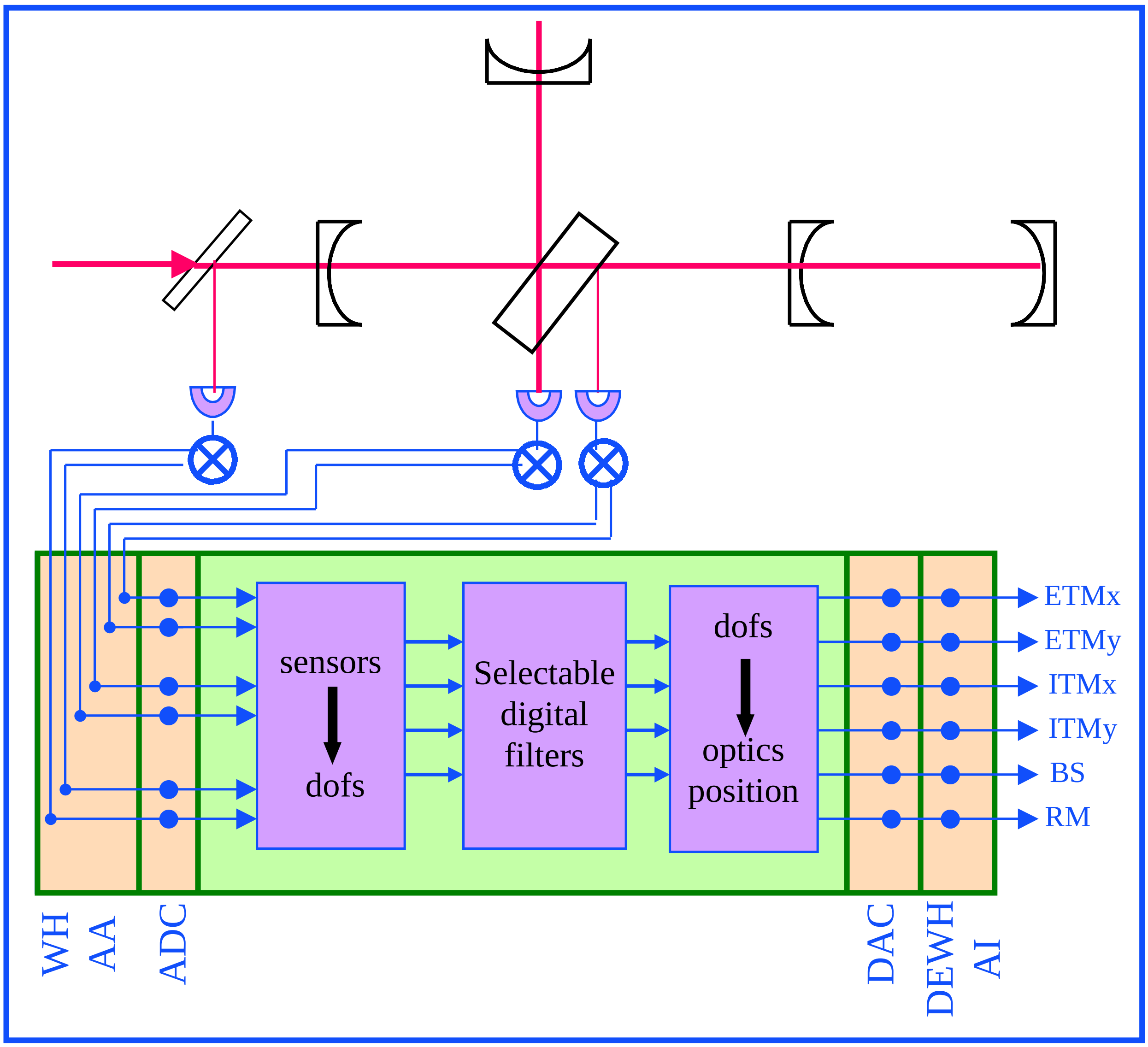
Frequency noise from PSL

- Acoustic and mechanical noise
  - changed optical mounts
  - isolated parasitic paths
- Broad background
  - carrier resonance in reference cavity
  - saturation in rf photodetection



Interferometer locking

- Digital LSC system



Interferometer locking: present to near (?) future

- Power recycled Michelson locks
  - Carrier or sideband resonance
- Arm cavity locks
  - Feedback to ITM or ETM
- …get both locking at same time…
- …add second arm cavity…
- …full ifo!