Oct 28

Active seismic isolation and sensors

59 participants

Den Martynov's presentation

Low-frequency wall needs to move down in frequency by about a factor 4-5 going from LIGO to CE. In Advanced LIGO, the low-f sensitivity is mostly limited by control noise. The goal of controls is to achieve fast lock acquisition and better duty cycle.

Suspension modes require damping. Need to suppress input noise below the observation band.

Better sensors are needed, and high noise suppression also requires a stiff platform. One needs to suppress / reduce cross couplings. Temperature variations and creep noises (might) matter.

C-6D system developed at Birmingham to sense rotations and displacements. Made out of fused silica. Silica has low thermal expansion.

Tilt-to-horizontal coupling is an important effect in active seismic isolation. C-6D can measure tilt and horizontal separately.

C-6D readout done with compact laser interferometer and digital demodulation. DFB lasers are used, which are single mode but relatively large linewidth (around 1MHz). Drawback: quite sensitive to optical feedback (small amounts of light reflected back to the laser). Fibers had to be isolated to protect from air currents / thermal effects.

C-6D system designed to stay under vacuum on GW-detector active-isolation platforms. Implementation is possible in LIGO, and probably also on the Virgo filter-0 stage.

Gold coating of silica mass can reduce emissivity (without coating, emissivity is 1).

With RMS<10nm on could even think of acquiring lock without green light.

Anamaria Effler: What could we do to reduce ground tilt? Place buildings into the ground, and other facility changes?
DM: I don't have a good answer. For sure going underground helps, but this might not be an option for all future detectors.

Matt Evans: You had the shadow sensors together with interferometric sensors. What did you use the shadow sensors for?
DM: We have both profiting from the larger linear range of shadow sensors. Once the system is stable, the interferometric sensors take over. Don't need to (re)linearize very often.
ME: For the thermal variations, inside the LIGO vacuum system the thermal environment might be very different. What do you expect the impact to be?
DM: I hope that in LIGO the temperature stability is going to be better. Already the suspension is going to help.

Brian Lantz: Would it help to have good temperature sensors in O5 to understand what's going on?
DM: Yes, certainly this would be useful information.
BL: Have you been able to observe cross-couplings in your sensor? V2T, H2T, etc
DM: Yes, we have done this quite extensively. It was possible to model the effects. At the moment, the C-6D is not suspended from a blade. Fiber bounce mode has the lowest vertical resonance.

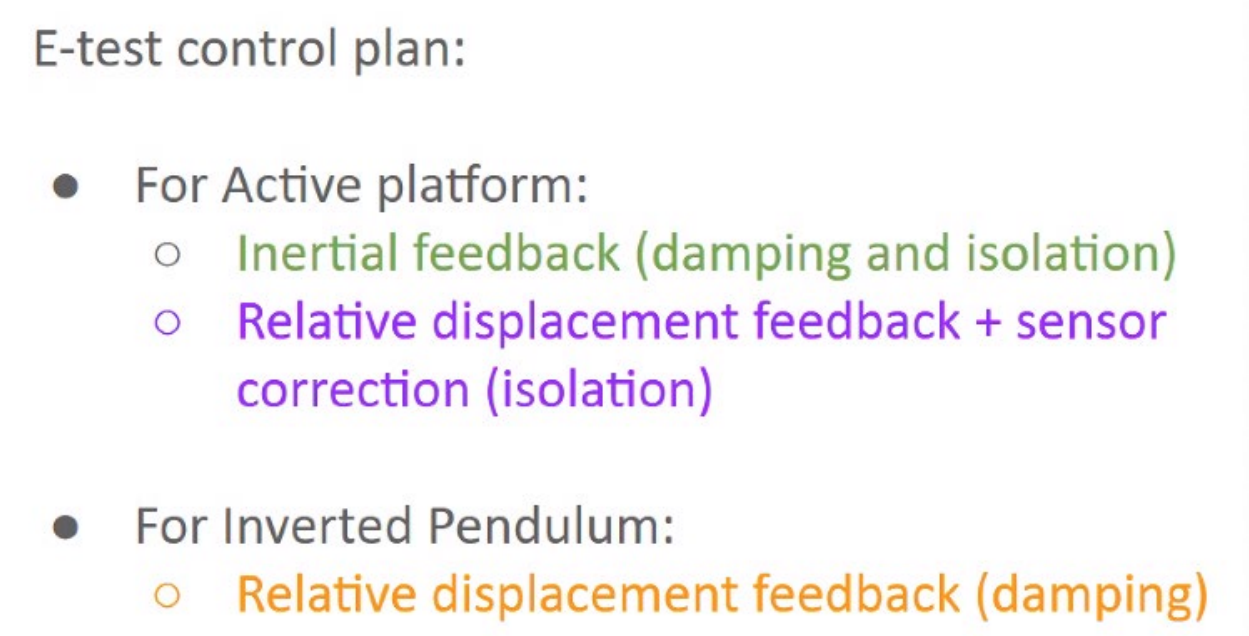
Lisa: simplification of lock acquisition – thoughts on this?
It might not work for platform far apart, but important to investigate

XGCD E-test suspensions (Haidar, Anthony)

Hybrid approach, active + passive, goal is to reduce overall length of the system

- Inverted pendulum on top of active ISI
    - Inverted pendulum enables lower resonance frequency
    - Inverted pendulum also sensitive to tilt, could it work as rotation sensor?
        - Brian: Haidar - re using the inverted pendulum as a tilt sensor. This should have the same tilt-horizontal coupling confusion as other horizontal sensors. You should calculate the response of your system to ground rotation and to ground tilt, and compare those. I expect you'll see the classic g/w^2

Page 7: control strategy



You can only isolate as well as you can sense

Active isolation requires several types of sensors – optical sensors are most promising

- Relative displacement sensors
- Inertial sensors

Another example of interferometric displacement sensor HQI

- You can use it at the top of the inverted pendulum
- 1550 nm
- Or to sense your seismometer test mass

Test on LIGO-MIT HAM ISI table

Optical accelerometer – why not tuned at higher frequency?

- 0.4-0.5 Hz resonant frequency
- Material of the block is Titanium, The thickness of the flexure is 0.08mm
- Matt: Is the coil driver noise related to the actuator design (e.g., magnetic couplings) or is it from the drive electronics (e.g., the DAC)?
    - I believe this is coil driver noise (electronics). The magnet is shielded with a qqudrupole design

Peter: can you actually buy the sensor from Exail? Custom development for now
Is it a reliable vendor? yes

Jesse for Nikhef group

Reducing the height of the SA for underground detectors (17m tower would require 33.8m large cavern,

A lot of concepts:

- Double nested inverted pendulum
- Proto IP
- Also incorporating active platform

Does an IP become unstable with an active platform?

Combine of Virgo and LIGO approaches – Nathan

Noise projections to understand performance of different designs

- Baseline ground spectra
- Also sensor performance database

Goal is to automatize controller and filter creation

Suspension modelling

- Several needs that are pushing us to write our own tool
- Cross-checked with several systems

FEMTO: matlab based

- Calculate tensions to find equilibrium
- ET concept modeled

P2400510 automated control for suspensions H2 and Hinfinity

- Matt: Some non linear noises, like bilinear Alignment noise – are these included?
    - Not yet, but they can add them
    - Conor to Everyone (Oct 28, 2024, 12:31 PM)
    - In the office next to Jesse is Riccardo Maggiore, who matched Virgo's ASC noise with a bi-linear model, so we will definitely connect residual mirror motion with those models
    -
    - Matthew J Evans to Everyone (Oct 28, 2024, 12:31 PM)
    - great… yeah, ASC -> DARM can be dominant, so good to include it early
    -
    - Conor to Everyone (Oct 28, 2024, 12:32 PM)

    - Absolutely. For ET-LF, we have the big advantage of high inertia and very low power

- Lisa: we should do another XGCD on modeling

- Ameer: are you going to build a prototype? There is one for ET pathfinder, but we would like to build an active platform, not yet planned

- Brian: below the microseism the tilt on the platform is higher than tilt on the ground
    - Do you have measurements on tilt motion on the IP vs tilt on the ground?
    - Do you have requirements on tilt on the various IP stages so the low frequency performance is not compromised?

    We plan to do modeling

Luciano: big cryostat around the mirror for ET-LF, it doesn't seem compatible with a platform below the mirror

- Several options,