

Advanced LIGO Engineering Change Request (ECR)

ECR Title: ECR: Topology Changes to SUS models as a result of ISC Informed Interaction

DCC No: E1300578-v1

Date: 7/2/2013

Requester: Jeff Kissel

Impacted Subsystem(s): SUS

Description of Proposed Change(s):

(1) Drive Decoupling

The DRIVEALIGN matrix, a frequency-dependent 6x6 or 3x3 matrix that is current just after all Euler Basis control signals are summed

- LOCK [Global Interferometric Control],
- OPTICALIGN [Static Alignment of Optic; only at the TOP stage],
- TEST [For out-of-loop excitations]
- DAMP [For local damping; only at the TOP stage]

was initially conceived to provide a sanctioned location for any, potentially frequency-dependent decoupling of Euler Basis control signal that causes unwanted displacement in auxiliary degrees of freedom.

The first few attempts at using this matrix for L-Force-to-P-Displacement drive decoupling, both with

the L1IMC <<https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=4823>> and H1HIFO-Y <<https://alog.ligo-wa.caltech.edu/aLOG/index.php?callRep=6742>>

have separately come to the same conclusion: we should move the DRIVEALIGN matrix *before* the sum of the Euler control signals, such that it only affects the ISC paths

- It is not necessary to decouple local damping loop control signals (and, in fact, they often *rely* on the MIMO nature of the plant), nor is it necessary to decouple the TEST or OPTICALIGN signals

- With the DRIVEALIGN containing signals both the ISC and DAMP, one must use the undamped open loop plant for the design decoupling filters -- i.e. one requires filters with very, if not impossibly, sharp Qs. If the DRIVEALIGN is pulled out of the DAMP loops, we only need to compensate the residual damped plant cross-coupling, and compensation filters become much more reasonable to implement.

(2) Alignment Control Distribution:

Because it is as yet unclear which topology we prefer, there is a switch in the suspensions that controls whether ISC signals are hierarchically distributed, either

- Offloaded (where ISC signals are injected at the lowest stage, and subsequent, filtered, control signals are fed to the input of the above stage), or

- Distributed (where ISC signals are fed directly to each stage, band-passed, and filtered accordingly).

Though mathematically equivalent, an offloaded design is more simple to implement when it comes to single-DOF decoupled cavity systems. However, once multi-DOF, coupled cavities are up and running (for example, in the DRMI), we envision using the distributed architecture to create a "fixed plant" super actuator such that to the ISC loops, the multi-stage suspensions look like a "simple" pendulum. See, e.g. <<https://dcc.ligo.org/LIGO-G1200692-v3>>.

Thus far, for Length control, commissioners have moved forward using the offloaded topology and done so successfully (and would like to continue doing so). However, for alignment control, only very-low-frequency drift control -- fed only to the top stage -- has been needed. With the current topology

Advanced LIGO Engineering Change Request (ECR)

options, having both an offloaded LSC signal and ASC distributed only to the top, requires using the offload topology and turning off lower stage ASC signals in non-obvious places.

This portion of the proposal serves to ask for a new ON/OFF switch *after* where the offload pick-off is fed to higher stages, such that a signal can be offloaded to an upper stage, and obviously blocked to other stages.

Less important things to remove in order to reduce model complication / frame size if the TRB is interested in a "do all your changes at once scenario:"

- (1) Remove the OFFLOAD path
- Originally implemented as an option for globally controlled optics
 - Would require top-level changes so many models would be affected, and implementation would be site-specific and tough (though it would be to *remove* some of these top-level dependencies)
 - Each suspension (even if not a globally controlled suspension) has the full path (a 6x6 matrix, and set of 6 filter banks), only to be terminated at the top level if not used. LOTS of "unused" EPICs channels, and as a down-sampling filter in each bank.
- (2) Remove the lower-stage damping path from the QUAD models
- Implemented early in the H2OAT test to reduce 0.4-0.5 Hz RMS motion before ISIs were functioning up to aLIGO specifications
 - No longer used / needed
 - If implemented, would complicate loop design and modeling
 - 3 filter banks, a 3x3 matrix

Reason for Change(s):

As we begin to really start using the global, interferometric feedback paths with the IMC, HIFO-Y, and DRMI, we have discovered the need for two improvements to how the control signals are distributed throughout the various stages of the suspension.

Estimated Cost: no hardware cost; no additional labor time/cost

Schedule Impact Estimate: none

Nature of Change (check all that apply):

- Safety
- Correct Hardware
- Correct Documentation

- Improve Hardware/SOFTWARE
- Improve/Clarify Documentation
- Change Interface
- Change Requirement

Importance:

- Desirable for ease of use, maintenance, safety
- Desirable for improved performance, reliability
- Essential for performance, reliability
- Essential for function
- Essential for safety

Urgency:

- No urgency
- Desirable by date/event: soon
- Essential by date/event: _____
- Immediately (ASAP)

Advanced LIGO Engineering Change Request (ECR)

Impacted Hardware/SOFTWARE (select all that apply):

Repair/Modify. List part & SNs: _____

Scrap & Replace. List part & SNs: _____

Installed units? List IFO, part & SNs:

____ ALL _____

Future units to be built

Impacted Documentation (list all dwgs, design reports, test reports, specifications, etc.):

None – software changes only

Disposition of the proposed change(s):

The disposition of this proposed engineering change request is to be completed by Systems Engineering and indicated in the “Notes and Changes” metadata field in the DCC entry for this ECR. The typical dispositions are as follows:

- **Additional Information Required**: in which case the additional information requested is defined. The ECR requester then re-submits the ECR with the new information using the same DCC number for the ECR but with the next version number.
- **Rejected**: in which case the reason(s) for the rejection are to be given
- **Approved**
- **Approved with Caveat(s)**: in which case the caveat(s) are listed
- **TRB**: the ECR is referred to an ad-hoc Technical Review Board for further evaluation and recommendation. It is the System Engineer’s (or designee’s) responsibility to organize the TRB. The System Engineer (or designee) then makes a technical decision based on the TRB’s recommendation. Links to the TRB’s documentation (charge, memos, final report, etc.) are to be added to the “Related Documents” field for this ECR.
- **CCB**: a change request for approval of additional funds or schedule impact is to be submitted to the Configuration Control Board. Links to the CCB’s documentation (CR, etc.) are to be added to the “Related Documents” field for this ECR.

Concurrence by Project Management:

Acknowledgement/acceptance/approval of the disposition is to be indicated by the electronic “signature” feature in the DCC entry for this ECR, by one of the following personnel:

- Systems Scientist
- Systems Engineer
- Deputy Systems Engineer