40m DC readout review, report and recommendations

LIGO-T050168-00-R

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References are given in the text.

Remit

To establish technical readiness to proceed with a new element of the 40m R&D program: tests of DC readout and an associated Output Modecleaner. To evaluate whether the planned work is likely to deliver on the main goal of preparing these techniques for implementation on Advanced LIGO.

Summary of the review telecon

A telecon review was held on Tuesday July 19th 2005.

Attending:-
Caltech: Bob Taylor, Ben Abbott, Rob Ward, Jay Heefner, Mohana Mageswaran, Hiro Yamamoto, Mike Smith, Steve Vass, Seiji Kawamura, Ryan Kinney, Dan Busby, Osamu Miyakawa, Rana Adhikari, David Blair, Ju Li, Alan Weinstein, Dennis Coyne, Carol Wilkinson
LHO: Fred Raab, Dick Gustafson, Daniel Sigg
MIT: Peter Fritschel, Dave Ottoway, Nergis Mavalvala
Florida: Guido Mueller, Dave Tanner Germany: Kentaro Somiya
Glasgow: Ken Strain (chair).

The main subject of the review was a presentation LIGO-G050324-00-R, based on the longer technical document LIGO-T050086-00-R. Thanks to Alan and the 40m team for a clear and comprehensive presentation

Most of the meeting was spent working through a presentation covering recent progress on the 40\,m as well as the proposals for DC readout including the output modecleaner. The majority of questions arising were requests for minor clarification of detail, and these are not recorded here.

The following points, possibly requiring some attention, arose during the presentation:-

It would be helpful to obtain a better knowledge of the loss difference between the two arms (by measurement) to give a better idea of the expected DC 00 mode light at the output. (Slide 6.)

Some concern was raised about the relative motion of output optics and the (isolated) interferometer optics. Are low-scatter mirrors required? (Slide 11.). This could have minor cost and significant timescale implications depending on the availability of the required mirrors.

Some issues arose relating to the best photodiode to use for the DC readout, and how to use it. The layout should provide a clear view of the beam position on the diode. Some work is still required to select the type of diode. (Slide 15.)

Some noise-coupling calculations were carried out using RSENOISE, there is some concern as this code is relatively untested.

These points are probably no surprise to the team.

Recommendations.

The design work has reached a stage where we are able to approve the general plan as sound and very likely to benefit the process of designing Advanced LIGO. We, therefore, fully support the plan as stated. The general approach was felt to be very good, and there are only a few minor points to emphasise.

- It would be prudent to select output optics for low-scatter, although the cost and delivery schedule for low-scatter optics may be require the initial use of lower quality mirrors.

- As more information becomes available on the operation of the interferometer with RF readout, this should be applied to the model for DC readout (e.g. loss unbalance) to ensure the model is as realistic as practical.

- Some additional noise analysis using (where possible) independent methods may help to reduce the chance of any of the noise couplings (frequency noise etc.) being larger than expected.

The additional resources required for this work are modest in comparison with its probable significance to Advanced LIGO.

Annex

Guido Mueller provided some reflections on some of the more technical points discussed at the review telecon, and these form the basis of the following notes.

- OMC 3 or 4 mirrors? Alan emphasized the 4 mirror OMC but several of the attendees at the review questioned whether it was necessary to go to a 4-mirror design. We neither see the motivation for going away from our standard 3 mirror MC's nor do we see strong objections against a 4 mirror OMC (in the context of the 40m tests and Advanced LIGO). We note that the 3-mirror option gives better defined polarization rejection.

- High finesse vs. low finesse OMC? The choice depends on the static and dynamic amount of higher order modes at the dark port. It is hard to pinpoint without more experimental data. For reason of simplicity of operation, we agree with the selection of moderate Finesse (~300) cavity to start with but the situation should be monitored.

- Homodyne phase angle. We would like to see a study on the 40m (with DC readout operating) where they try to measure the displacement sensitivity for

both homodyne phases and then optimize the homodyne phase. Perhaps we should be prepared to tune to a higher peak frequency if possible (~25kHz), to reduce less technical noise.

- We think overall it is a good plan. The primary goal is to study lock acquisition, followed by investigation of the effect of tuning the homodyne phase, and a comprehensive study of technical noise couplings, unforeseen pitfalls, etc. The team should also keep in mind how their results and experience can be applied to develop debugging strategies for Advanced LIGO, bearing in mind the limitations arising because the two systems are very different.