LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note	**LIGO-T1500012-v1**	2015/01/14

L1 OMC Controls

A. Mullavey, V. Frolov

California Institute of Technology
LIGO Project, MS 18-34
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project, Room NW22-295
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
Route 10, Mile Marker 2
Richland, WA 99352
Phone (509) 372-8106
Fax (509) 372-8137
E-mail: info@ligo.caltech.edu

LIGO Livingston Observatory
19100 LIGO Lane
Livingston, LA 70754
Phone (225) 686-3100
Fax (225) 686-7189
E-mail: info@ligo.caltech.edu

http://www.ligo.caltech.edu/

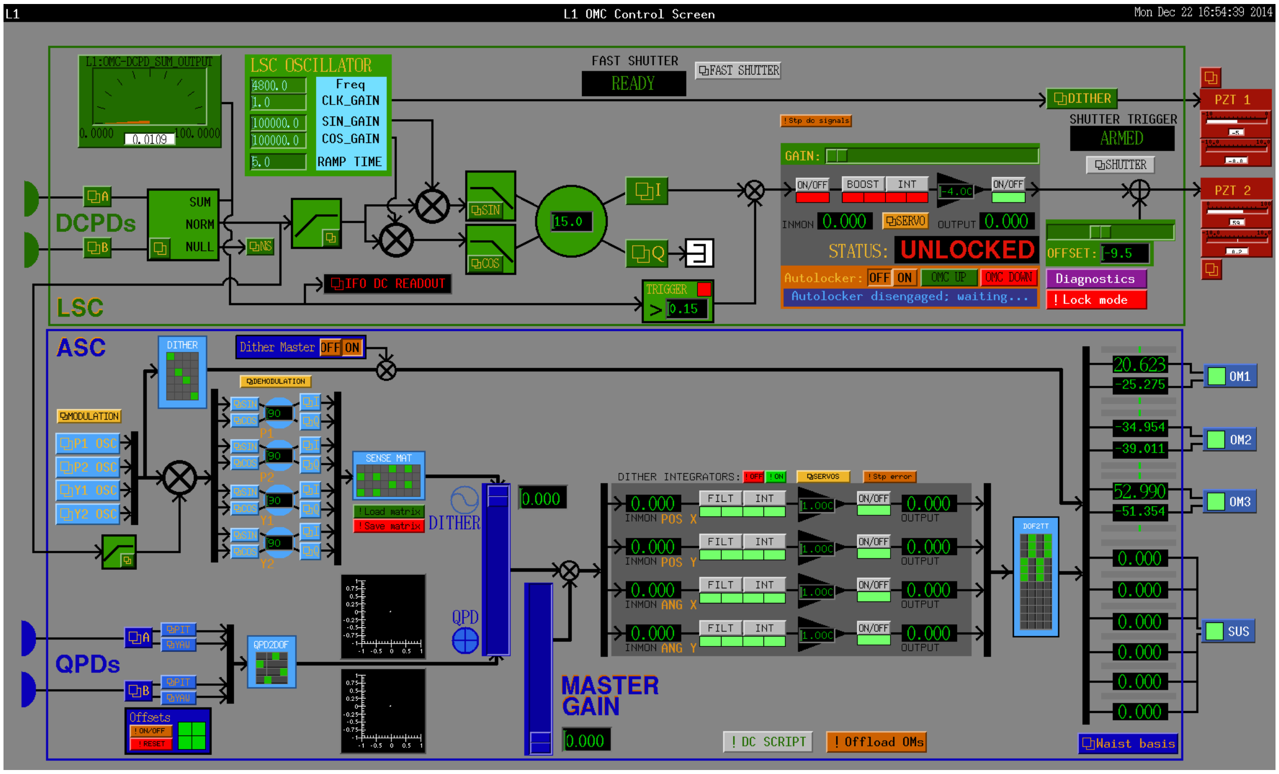

Figure 1: The OMC control MEDM screen.

1 Introduction

In this document we provide details about the length and angular control scheme of the Advanced LIGO Output Mode Cleaner (OMC) as it was during the 50 Mpc lock. Here we only provide a brief description of the OMC layout, for more details on the design of the OMC, see T1000276 [?]. Figure ?? shows the medm overview screen for the OMC length and angular controls.

2 Length Sensing and Control

The OMC is a four-mirror bow-tie cavity, used to filter out the DC carrier light from the RF fields and higher order spatial modes. For cavity length actuation two of these mirrors are mounted on PZT actuators. Each PZT has enough range to travel multiple FSRs of the cavity. After the output coupler, the transmitted beam is split 50/50 and sent to two DCPDs.

The OMC is locked to the interferometer beam using a dither locking scheme. In this scheme the length of the cavity is modulated by dithering one of the PZT mirrors. In our case this is PZT1. The length oscillator settings are shown below in Table ??.

Table 1: LSC Oscillator

Channel	Frequency [Hz]	Clock Gain [cts]	Sine Gain [cts]	Cos Gain [cts]
P1	4800	1	100000	100000

The cavity length error signal is then obtained by demodulating the normalized transmitted power (from the sum of the two DCPDs) at the modulation frequency. The error signal is fed back to the PZT2 to hold the cavity on resonance. The unity gain frequency of the loop is approximately 30 Hz.

Before locking the OMC, the cavity needs to be tuned onto resonance. The offset has been calibrated in volts. There's approximately 40V between carrier fringes and approximately 7V between the carrier and the 45MHz sideband.

3 Alignment Sensing and Control

The interferometer beam is steered into the OMC using 3 tip-tilt mirrors (OM1, OM2 and OM3) which are located on the HAM6 table before the OMC. There are four angular degrees of freedom of the OMC that need to be controlled, i.e. pitch and yaw for angle and translation. The tip-tilt mirrors provide six degrees, however two of these degrees of freedom are used to center the AS wave front sensor, that is on the transmission side of OM3. As such each 3x3 sensing matrix, one for pitch and one for yaw, need to be measured and inverted, to decouple these degrees of freedom.

There are two types of angular sensing schemes for the OMC. The first scheme is for rough initial alignment, and uses a pair of quadrant photo-diodes (QPDs) that are located on the same bread-board as the OMC. Here some of the input light is tapped off, split 50/50, and sent to one near-field QPD and one far-field QPD. The second sensing scheme is a dither scheme similar to the length sensing scheme. Here, the pitch and yaw of two of the TT mirrors (OM1 and OM3) are dithered at frequencies near 600 Hz. The oscillator settings are shown below in Table ??. Note that channel 1 goes to OM1 and channel 2 goes to OM3. Also in the dither matrix, each oscillator signal is divided by a factor of 10 before being sent to the OMs.

Table 2: ASC Oscillators

Channel	Frequency [Hz]	Clock Gain [cts]	Sine Gain [cts]	Cos Gain [cts]
P1	575.1	1000	1000	1000
P2	600.1	1000	1000	1000
Y1	625.1	1000	1000	1000
Y2	650.1	1000	1000	1000

The transmitted PD power is demodulated at each dither frequency, to obtain four error signals. The dither alignment scheme requires the cavity to be locked, hence why the QPD sensing scheme is required for initial alignment.

The DOF2TT matrix was set, by exciting each tip-tilt in pitch and yaw and measuring the response of each OMC QPD and the AS WFS. The measured sensing matrix was then inverted and installed into the DOF2TT matrix (shown in Table ??). It should be noted that the QPD to DOF matrix was made to be a simple identity matrix. The QPD loops were closed with a UGF of approximately 100 mHz.

The DITHER2DOF matrix was set by sending an excitation into the error point of each QPD loop, and measuring the response to the angular dither error signals. This matrix was then inverted and installed into the DITHER2DOF matrix (shown in Table ??).

Table 3: DOF2TT matrices

Pitch:	POS	ANG
OM1	3.4587	-2.1487
OM2	-1.0502	0.6524
OM3	-0.274	2.1742

Yaw:	POS	ANG
OM1	-3.7058	-2.4204
OM2	-1.0085	-0.6587
OM3	0.3853	2.0967

Table 4: DITHER2DOF matrices

	PIT1	PIT2
POS	-0.8316	-0.9234
ANG	-0.5693	-1.0994

	YAW1	YAW2
POS	0.9759	0.90890
ANG	-0.6630	-1.1380