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Input Optics CDS Preliminary Design

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1 INTRODUCTION

1.1. Document Organization

The document is organized as follows:

- Section 2 Suspension Systems describes the suspension systems that will be used for each of the suspended optics in the input optics system.
- Section 3 Alignment Control Systems describes the controls that will be used to provide alignment control of the mode cleaner.
- Section 4 Length Control Systems describes the controls that will be used to provide mode cleaner length control.
- Section 6 Optical Lever Systems describes the optical lever electronics that will be used to provide an independent read back of MMT 3 orientation.
- Section 7 Cameras describes the camera systems that will be used to provide for operator viewing of optical beams and chamber interiors.
- Section 8 Mode Matching Controls and Monitoring describes the electronics that will be used to monitor the Bull's Eye detectors.
- Section 9 Analyzer Cavity Controls and Monitoring describes the control and monitoring of the commercial analyzer cavities.
- Section 10 RF Photodetector Monitoring describes the electronics used for control and monitoring of the RFAM photodetector and the MC noise monitoring photodetector
- Section 11 System Layout/Design describes the rack layout, operator screens, alarms, back up and restore functions for the system.
- Section 12 DAQ and GDS Interfaces is a list of the signals and test points that will be provided to the DAQ and GDS systems.

1.2. System Overview

A block diagram of the IOO CDS system is included in Appendix 1 IOO CDS Block Diagram. Not shown in the figure are the suspension controls. Suspension controls are described in section 2.

It is the function of the CDS to provide all electronics hardware and software required to meet the design requirements outlined in LIGO document number T980039, "Input Optics CDS Design Requirements". The suspension, vacuum cabling and feedthroughs, mode cleaner alignment, optical lever and camera systems in the input optics are identical to their equivalent systems in the interferometer and will be implemented in the same manner. This will provide an opportunity for "prototype testing" and the ability to gain operational experience with these detector systems.

In addition, the interface to the DAQ and GDS systems is the same as for other detector systems. This will allow these systems to be tested using a fully operational detector subsystem. Following installation and commissioning of the WA 2K input optics any lessons learned could be incorporated into the final designs of these systems.

1.3. Acronyms

- ASC- Alignment Sensing and Control
- CDS- Control and Data System
- DAQ- Data Acquisition Subsystem
- FM- Folding Mirror
- GDS- Global Diagnostics Subsystem
- GW- Gravity Wave
- IFO- Interferometer
- IOO- Input Optics Subsystem
- LED- Light Emitting Diode
- LIGO- Laser Interferometer Gravitational-wave Observatory
- LOS- Large Optics Suspension
- LSC- Length Sensing and Control
- MC- Mode Cleaner
- MMT- Mode-Matching Telescope
- N/A- Not Applicable
- PD- Photodiode/detector
- PIT- Pitch of optic being controlled
- PSL- Pre-Stabilized Laser Subsystem
- RFAM- Radio Frequency Amplitude Modulation
- RFPD- Radio Frequency Photodiode/detector
- SOS- Small Optics Suspension
- SUS- Suspension Subsystem
- TBD- To Be Determined
- WFS- Wavefront Sensor
- YAW- Yaw of optic being controlled

1.4. Applicable Documents

- *Input Optics Final Design*- LIGO T980009
- *Mode Cleaner Length/Frequency Control Design*- LIGO T970218
- *ASC CDS Conceptual Design*- LIGO T970062
- *LIGO DAQ Final Design*- LIGO T980026
- *Global Diagnostics Preliminary Design*- LIGO T970172
- *Global Diagnostics Reflective Memory Organization*- LIGO T980020
- *Input Optics CDS Design Requirements Document*- LIGO T980039

2 SUSPENSION SYSTEMS

2.1. Suspension Electronics

Table 1 is a list of the suspension controllers and the respective dynamic range and requirements for the input optics.

Table 1: IOO Suspension Controller Noise and Dynamic Range Requirements

Optic	*Dynamic Range Length and Angle*	*Noise*
MMT1, MMT2	500 um p-p >5 mrad p-p	$5x10^{-16}\left(\frac{f}{40}\right)^{-2}(m/(\sqrt{Hz}))$ f > 40 Hz
MC1, MC2, MC3	27 um p-p 1.5 mrad p-p	$3.8x10^{-18}\left(\frac{f}{40}\right)^{-2}(m/(\sqrt{Hz}))$ f > 40 Hz
FM1, FM2 (2Km IFO only)	500 um p-p > 5 mrad p-p	$5x10^{-16}\left(\frac{f}{40}\right)^{-2}(m/(\sqrt{Hz}))$ f > 40 Hz
MMT3	40 um p-p 1 mrad p-p	$5x10^{-16}\left(\frac{f}{40}\right)^{-2}(m/(\sqrt{Hz}))$ f > 40 Hz

The suspension electronics to be used for the input optics are described in detail in LIGO document T970113. The dynamic range and noise requirements allow a coil driver circuit to be used that has a flat response for 0<freq.<10KHz. This flat response will be achieved by using a resistance in series with each sensor actuator coil. In addition, the dynamic range and noise requirements for MMT3 will allow a small optic suspension controller to be used even though it is a large optic. This will save rack space and eliminate the need for additional high voltage power supplies.Table 2 shows the resistance, maximum drive current and predicted noise for each suspension controller. These values will meet the range requirements shown in Table 1.

Table 2: Coil Driver Series Resistance vs. Controller

Controller	*Series Resistance*	*Max. Drive Current*	*Predicted Noise*
MMT1, MMT2, FM1, FM2	430 ohms	58 mAp-p	$1.6x10^{-17}\left(\frac{f}{40}\right)^{-2}\ (m/(\sqrt{Hz}))$ f > 40Hz
MC1, MC2, MC3	7.82K ohms	3.20 mAp-p	$3.8x10^{-18}\left(\frac{f}{40}\right)^{-2}\ (m/(\sqrt{Hz}))$ f > 40 Hz
MMT3	227 ohms	110 mAp-p	$5.2x10^{-19}\left(\frac{f}{40}\right)^{-2}\ (m/(\sqrt{Hz}))$ f > 40 Hz

2.2. Vacuum Cabling and Feedthroughs

The vacuum cabling used for the input optics suspension systems will MDC model KAP-R25-300 cable with MDC model D25-PCC 25 pin D connectors on each end. The vacuum feedthroughs will be MDC model 633002-1000. Port assignments are as detailed in section 11.2. of this document.

3 ALIGNMENT CONTROL SYSTEMS

The following is a block diagram of the mode cleaner alignment control system.

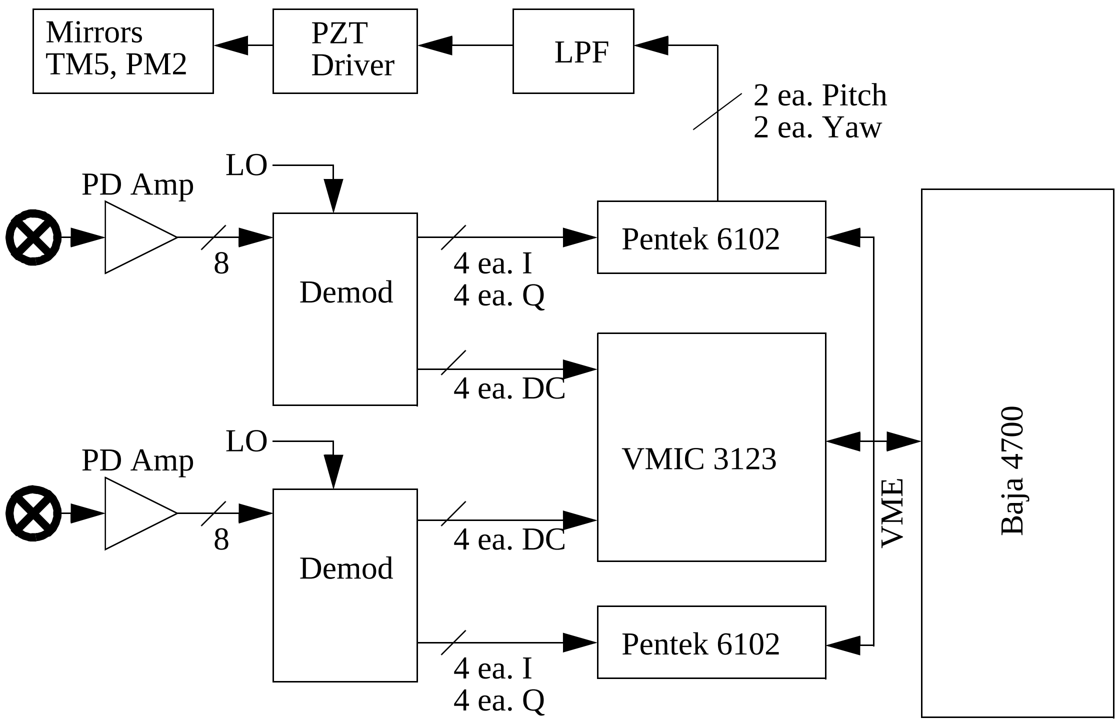


Figure 1: Mode Cleaner Alignment Controls

The complexity of the mode cleaner alignment system does not require a digital servo implementation as shown in the figure above, but it has been decided that mode cleaner alignment controls should use the same components/technology as the IFO ASC systems. This will allow an early prototype of the IFO ASC system to be developed and tested. If it were decided that the mode cleaner alignment controls were not to be used as a prototype for the IFO ASC system and the IOO system should use the most simple/risk free approach possible, the Pentek 6102s and Baja4700 shown in the figure above could be replaced by a single analog module with inputs for each of the I phases, pitch and yaw calculation circuitry, low pass filter function, adjustable gain and an adjustable 2x2 transformation matrix. In this configuration, slow ADCs (VMIC3123) and DACs (VMIC4116) would be used to monitor and control the analog hardware as is done in other systems such as suspension. I and Q phases, PZT outputs, etc. would be passed straight to the DAQ/GDS system via independent monitors and analog input connections would be provided for GDS to inject test signals.

3.1. Mode Cleaner ASC Electronics

The photodiode pre-amplifiers and WFS demodulator are identical to those used for the IFO WFS system described in LIGO document T970062, ASC CDS Conceptual Design. The Pentek model 6102 ADC/DAC module will be used for the analog to digital and digital to analog conversion of the signals. The CPU will be a Heurikon Baja4700 processor. The ADC and DAC sampling frequencies will be 2048 and 8192 samples per second, respectively and will be derived from the GPS clocks (4.19MHz=2^{22}) used by the DAQ system. Anti-alias filters have been incorporated into the output of the demodulator boards. These clock rates will ensure a highly oversampled system which will reduce input referred noise and phase delay through the controller, but at the same time not be so high that they require special effort to ensure that the processor can complete the required tasks on a sample by sample basis.

A VMIC 3123 ADC module will be used to monitor the DC photodiode current for WFS segment. These modules are 16 bit ADCs and the sample frequency will be set to 1 Hz. VMIC 4116 DAC modules and Xycom 220 binary output modules (not shown in Figure 1: Mode Cleaner Alignment Controls) will be used to provide operator control of such things as local oscillator phase and photodetector gains.

The bias voltage for each photodiode segment will be greater than 100 VDC.

3.2. Mode Cleaner ASC Software

The figure below is a block diagram of the mode cleaner alignment software.

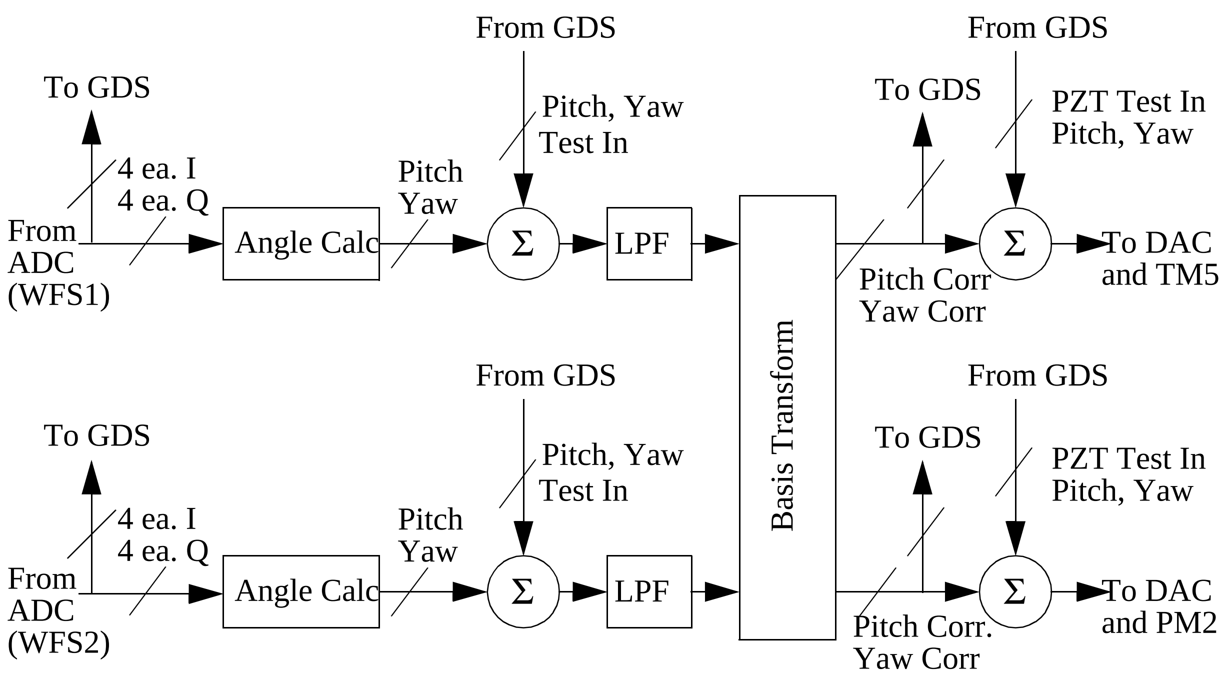


Figure 2: Mode Cleaner Alignment Software

The angle calculation shown in the figure will use the I phase signals to calculate the error signal for each sensor (pitch and yaw). The operator will be able to monitor the Q phase signals and adjust the local oscillator phase to minimize this signal, i.e. maximize the I phase signal.

Modeling of the system by the detector ISC group has shown that the servo filter function (LPF block in Figure 2: Mode Cleaner Alignment Software) can be a single pole at 0.1Hz. The basis transformation will be described by the following equations:

$$TM5_{yaw} = A_{TM5yaw} \times WFS1_{yaw} + B_{TM5yaw} \times WFS2_{yaw}$$

$$TM5_{pitch} = A_{TM5pitch} \times WFS1_{pitch} + B_{TM5pitch} \times WFS2_{pitch}$$

$$PM2_{yaw} = A_{PM2yaw} \times WFS1_{yaw} - B_{PM2yaw} \times WFS2_{yaw}$$

$$PM2_{pitch} = A_{PM2pitch} \times WFS1_{pitch} - B_{PM2pitch} \times WFS2_{pitch}$$

where:

$$1 \cong A_{xx} \cong B_{xx}$$

The interface to the GDS system will be via reflective memory as described in LIGO document T9700172 and T980026.

Operator interfaces and software will be developed that will allow the operator to view PD outputs, demodulator outputs, PZT outputs, adjust servo gains, adjust local oscillator phase, enable the servo loops, monitor and adjust transformation matrix coefficients and monitor the status of the test inputs from GDS, i.e. which test inputs are active.

4 LENGTH CONTROL SYSTEMS

The function of the mode cleaner length/frequency servo is to keep the mode cleaner resonant with the input light and to suppress the frequency fluctuations of the input light to the required level. The servo must have sufficient gain that the mode cleaner length deviates from the perfectly resonant length by no more than 10^{-13} m_{rms}. The requirements for the mode cleaner are given in LIGO T970218.

Figure 3 is a block diagram of the MC length control subsystem. Because of the high bandwidth of the controller feedback path an analog implementation is used. However, gain settings, Detection Mode Bypass and diagnostic control signals will be digitally controlled through VME. The controller consists of a photodetector and two EUROCARD modules. The photodetector (PD) is the same type used for the LSC, the only difference being the resonant frequency. The first controller module contains the demodulator, LSC Additive Offset input, pre-amplifier, filter and Detection Mode Bypass. In the second module the feedback path splits into the MC actuator path and laser frequency control path. The signals from these two paths are converted to frequencies by the SOS controller and the PSL wideband actuator. The feedback to the mode cleaner actuator crosses over with laser feedback path at about 1.7Hz. At frequencies below this crossover the feedback is mainly to the mode cleaner length actuator. Above this frequency feedback is mainly to the wideband input to the PSL. This cross over frequency is adjusted remotely via the MCA_GAIN control signal. The filter section of the first module has two parallel paths. In Acquisition Mode a low gain 1/*f* signal path is used. In Detection Mode a high gain bypass stage is switched in which includes some aggressive filtering to achieve frequency noise suppression at 7KHz of 1.6×10^{-5} Hz/rtHz. This bypass is switched in via a programmable attenuator and therefore may be “ramped” in as required.

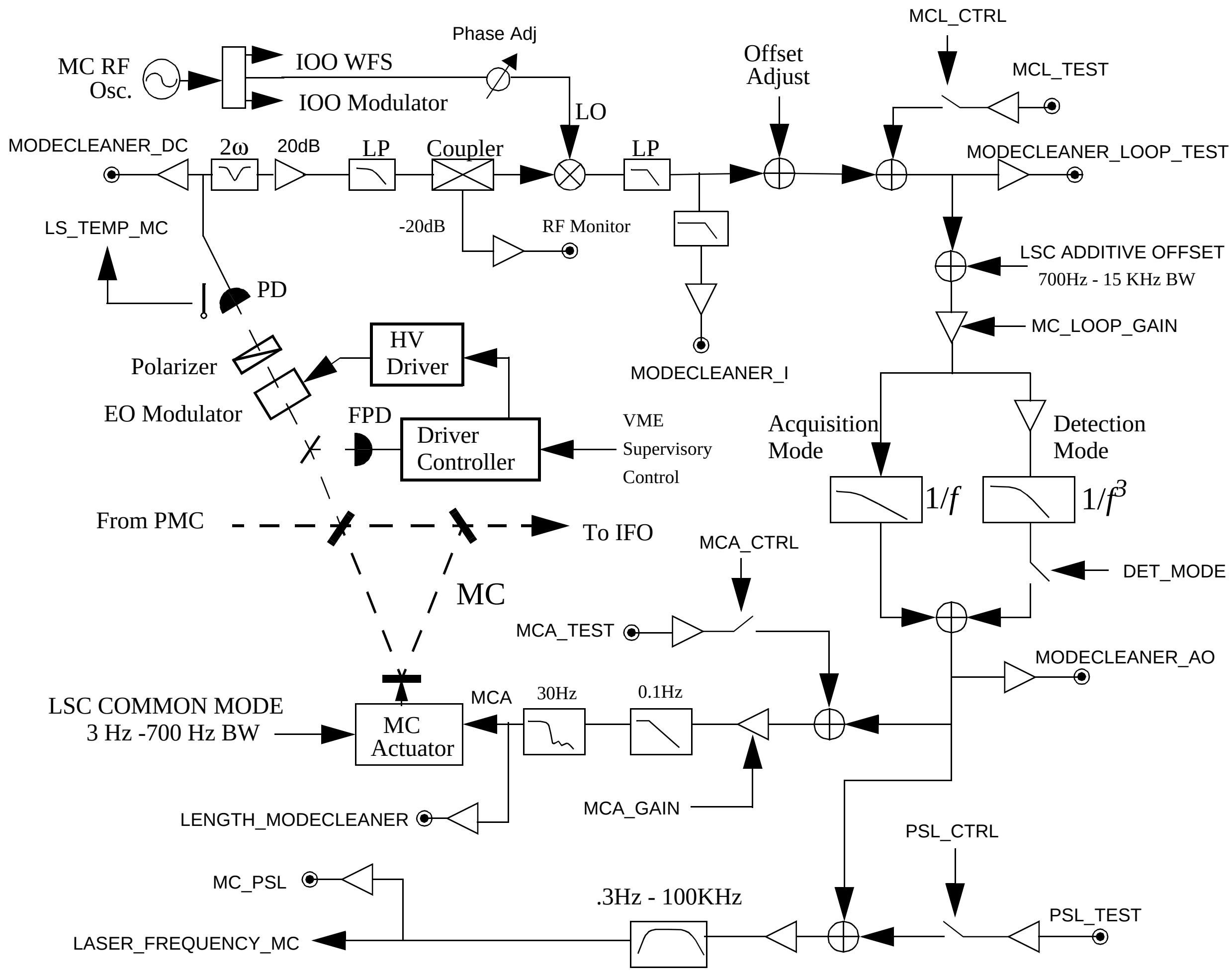


Figure 3: Mode Cleaner Servo Electronics Block Diagram

4.1. Control Signals

The following is a list of control signals for controlling the switching of test input signals, gain adjust controls, etc. within the Mode Cleaner frequency control servo loop. See Mode Cleaner Servo Electronics Block Diagram for location of each control signal.

Table 3: Mode Cleaner Control Signals

Name	*Description*	*Signal Type*	*Range*	*Bits*
OFFSET	Offset Adjust following mixer	Potenti-ometer	± 100mV	
MCL_CTRL	Test input switch following mixer	Digital	On / Off	1
MC_LOOP_GAIN	MC Loop Gain Control	Digital	± 15 dB	12
DET_MODE	Detection Mode Switch	Digital	Attenua-tor	12
MCA_CTRL	MC Actuator Test Input Switch	Digital	On / Off	1
PSL_CTRL	Laser Frequency Test Input Switch	Digital	On / Off	1
MCA_GAIN	MC Actuator path Gain	Digital	± 15 dB	12
LO_PHASE	MC LO Phase adjust	Trim Cap		

4.2. Test and Monitor Points

Test Input Signals shows the Test input specifications for the Mode Cleaner Servo.

Table 4: Test Input Signals

Name	*Description*	*Range*	*Coupling*
MCL_TEST	MC I-phase stimulus after mixer	± 5 Volt	DC
MCA_TEST	MC Actuator Stimulus	± 5 Volt	DC
PSL_TEST	Laser Frequency Stimulus from MC	± 5 Volt	DC

Mode Cleaner Monitoring Points lists the monitoring points in the mode cleaner servo.

Table 5: Mode Cleaner Monitoring Points

Name	*Description*	*Range*	*Load*
MODECLEANER_I	MC Length Sensor I_phase	± 15 Volts	Hi Z
LENGTH_MODECLEANER	MC Length Sensor Control Signal	± 15 Volts	Hi Z
LASER_FREQUENCY_MC	Laser Frequency Control Signal	± 15 Volts	Hi Z
MODECLEANER_DC	MC Length Sensor photodiode DC out	± 15 Volts	HI Z
LS_TEMP_MC	MC Photodiode Temperature	± 15Volts	Hi Z
MODECLEANER_LOOP_TEST	MC Length Sensor following Test in	± 15 Volts	Hi Z
RF_ MONITOR	Directional Coupler Output from PD	± 3.5 Volts	50 Ohms
MODECLEANER_AO	MC Length Sensor after Additive Offset	± 15 Volts	HI Z

4.3. IO / LSC Interface

The LSC subsystem outputs a signal to the Additive Offset input (LSC_AO) of the Mode Cleaner Length-Frequency Servo (See Mode Cleaner Servo Electronics Block Diagram).This is the LSC common mode length which is derived from the I-phase of the Recycling Port, $S_{RI,}$ in Detection Mode and the I-phase of the Pickoff Port, $S_{PI,}$ in Acquisition Mode. A second signal from the Pickoff Port is input directly into the Mode Cleaner Actuator.

Table 6: IO / LSC Interface Signals

Signal Name	*Description*	*Bandwidth*	*Note*
S_{RI}	LSC Additive input to MC Servo, Detection Mode	700Hz - 15KHz	± 1V limit
S_{PI}	LSC Additive input to MC Servo, Acquisition Mode	700Hz - 15KHz	± 1V limit
S_{RI}	LSC Input to MC Actuator	3Hz - 700Hz	Input direct to SUS

4.4. RF Photodiode

The RF photodiode for the Mode Cleaner length control is located on IOT7 and outputs an RF signal to the Mode Cleaner demodulator located in a Eurocard crate in rack 2X8 for the 2Km and rack 1X2 for the 4Km.

The photodetector will consist of a single photodiode module of the same type developed for the LSC system. This design will be documented separately once it is complete. Listed below are the main features of the module:

- The load for the photocurrent is the impedance of a parallel resonant circuit tuned to the Mode Cleaner resonant sideband frequency f_{mc}.
- A trap at $2f_{mc}$ is included in front of the pre-amp to keep this frequency component from saturating the pre-amp.
- The pre-amp is a low-noise wideband opamp operating from ±5V supplies. The voltage gain is nominally set at 10.
- A DC output is provided for monitoring the diode current.
- A negative-resistance bias circuit provides a constant voltage across the diode over the full range of photocurrent. It also provides thermal shutdown should the bias circuit overheat, a status bit to indicate shutdown status, an enable pin that allows the bias supply to be shutdown remotely and a built in current limit.

Table 7 gives the main specifications of the photodiode circuits.

Table 7: Photodiode specifications

Parameter	*2 Km*	*4 Km*
Modulation Frequency	26.7 MHz	33.3 MHz
Photodiode capacitance	85 pF	85 pF
Photodiode series resistance	9 Ohms	9 Ohms
Photodiode pole frequency	3.4 MHz	5.4 MHz
Resonant load	550 Ohms	350 Ohms
Preamp gain	10	10
Photodetector transimpedance (resonant load x gain x 0.5 for back termination)	2750 Ohms	1750 Ohms

Table 8 describes the interface between the photodetector and the demodulator board. All of the connections from the photodetector are brought back to the demodulator including power and ground. There are no other connections to the photodetector. The photodetector will be electrically isolated from the optical table to prevent ground currents from flowing between the photodetector and the demodulator board.

Table 8: Photodiode to Demodulator Board Interface

Signal Name	*Description*	*BW*	*Connector*	*Load*
PD_RF	Photodiode signal in	200 MHz	TNC	50 Ohms
PD_DC	PD DC Current in	100 KHz	TNC	1 KOhm
BIAS_ENABLE	PD Bias enable out	Logic Level	DB-9/6	Hi Z
BIAS_STATUS	PD Bias Status in	Logic Level	DB-9/7	Hi Z
PD_TEMP1	PD Temperature 1 in	DC	DB-9/4	Bias circuit
PD_TEMP2	PD Temperature 2 in	DC	DB-9/5	Bias circuit
+ 15 Volts	+ 15 volts out	DC	DB-9/1	300 mA
-15 Volts	- 15 volts out	DC	DB-9/3	300 mA
Ground	Ground return	DC	DB-9/8,9	Ground

4.5. Electro-Optic Shutter Control

A fast Electro-optic shutter is used to control the amount of light incident on the photodiode as described in LIGO T970218. Figure 4 is a block diagram of the shutter and controller. Figure 5 is a flow diagram of the operation of the shutter. A fast photodiode (PD) sampling a fraction of light incident on the EO Modulator provides a trigger/reference level. When the MC is

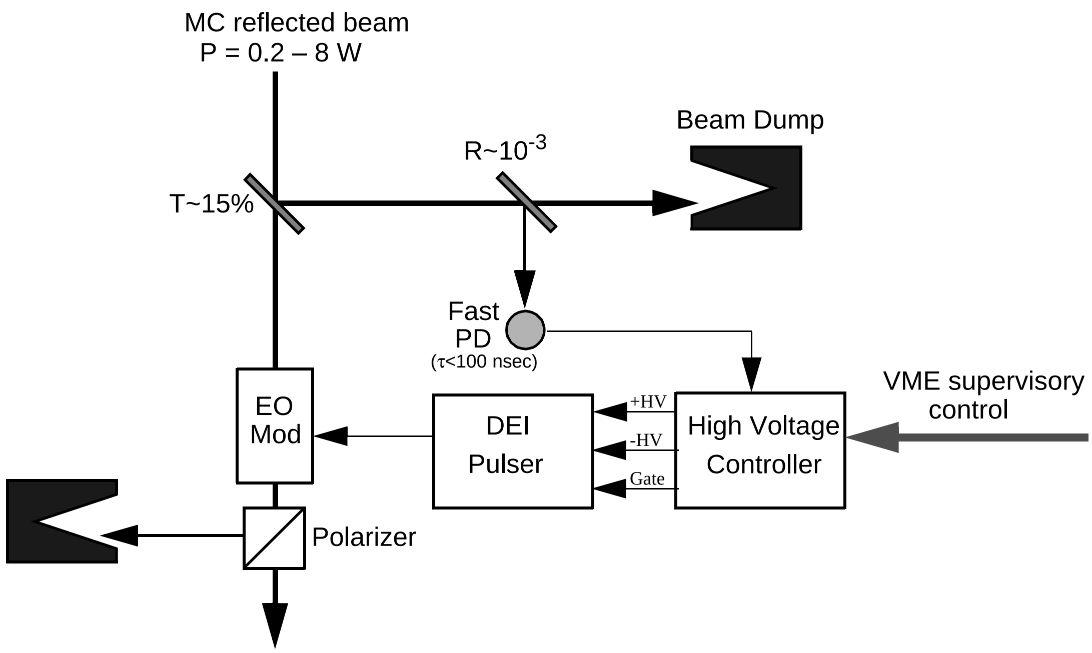


Figure 4: Electro-optic shutter control block diagram.

unlocked, a high level on the photodiode keeps the attenuation factor high (10-100X) so that power incident on the length sensor is below ~100mW, but is still large enough to allow locking of the MC.

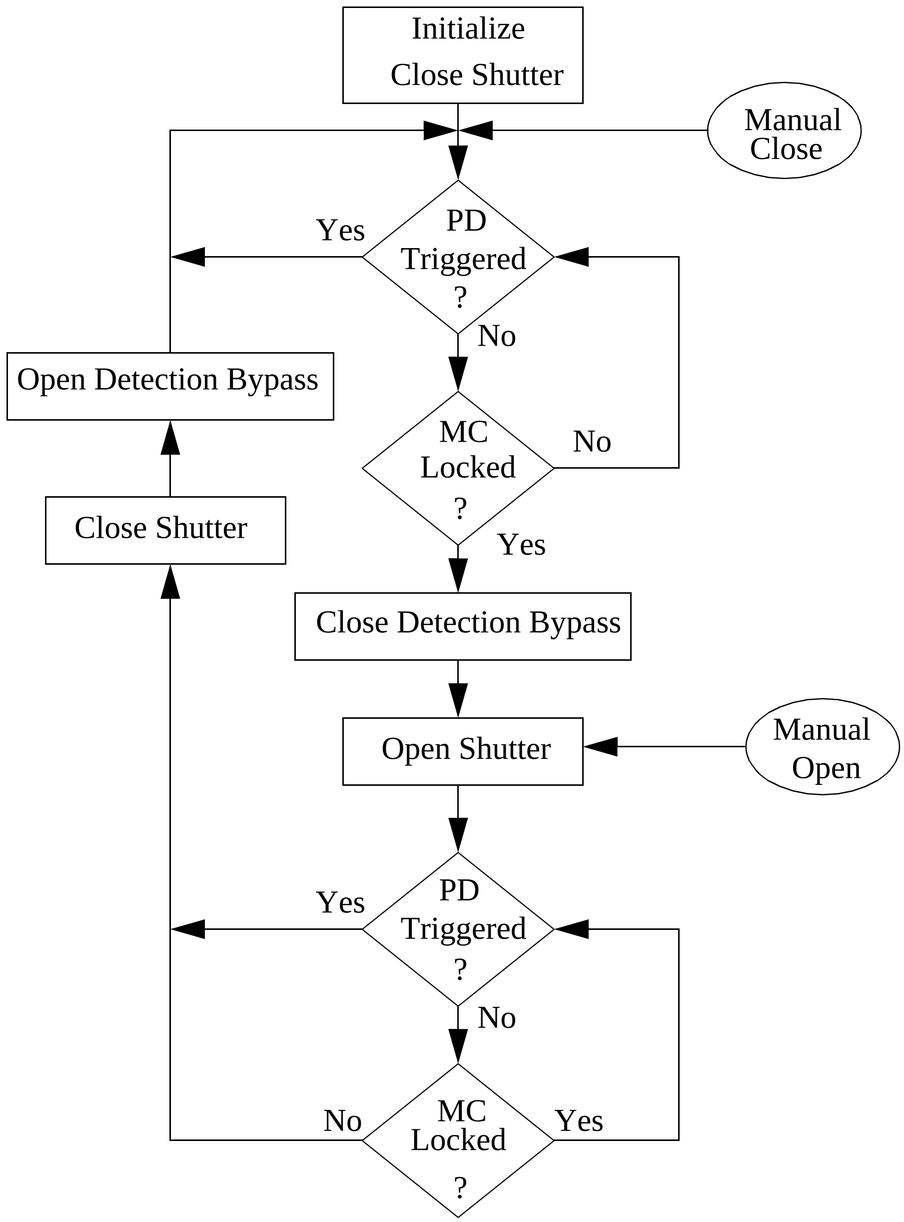


Figure 5: Flow Diagram for the Electro-optic shutter

5 MIRROR AND LENS FINE ACTUATOR CONTROLS

Motorized mirrors will be controlled via pico motors and the RS232 port of the mode cleaner control CPU (Motorola MVME162-333). At this time there is no provision for an external or separate monitoring of the mirror position/angle.

6 OPTICAL LEVER SYSTEMS

The optical lever used for MMT3 will be identical to the optical levers described in LIGO document T970062, ASC CDS Conceptual Design. The current signal from each photodetector segment will be amplified by a current to voltage amplifier with a transimpedance of 1 Kohm. Following initial system setup and testing this value may be adjusted to optimize the signal matching into the ADC front end. The bias voltage for the photodetector segments will be 15 VDC.

All angle calculations, etc. will be performed in software as described in LIGO document T970062, ASC CDS Conceptual Design. The sample frequency will be greater than 3 Hz.

Motorized mirrors will be controlled via pico motors and the RS232 port of the mode cleaner control CPU (Motorola MVME162-333). At this time there is no provision for an external or separate monitoring of the mirror position/angle.

7 CAMERAS

Commercial video to ATM converters will be used to transmit video images from each of the cameras in the input optics system to operator consoles in the control room. The control system will not provide any image processing. Operators in the control room will be able to view live video on the operator consoles or on video monitors. The snap shot functions built into the operator consoles can be used to grab and store individual images. A more detailed description of the system can be found in LIGO document T970062, ASC CDS Conceptual Design.

8 MODE MATCHING CONTROLS AND MONITORING

A block diagram of the mode matching Bull’s Eye detector system is shown in the figure below.

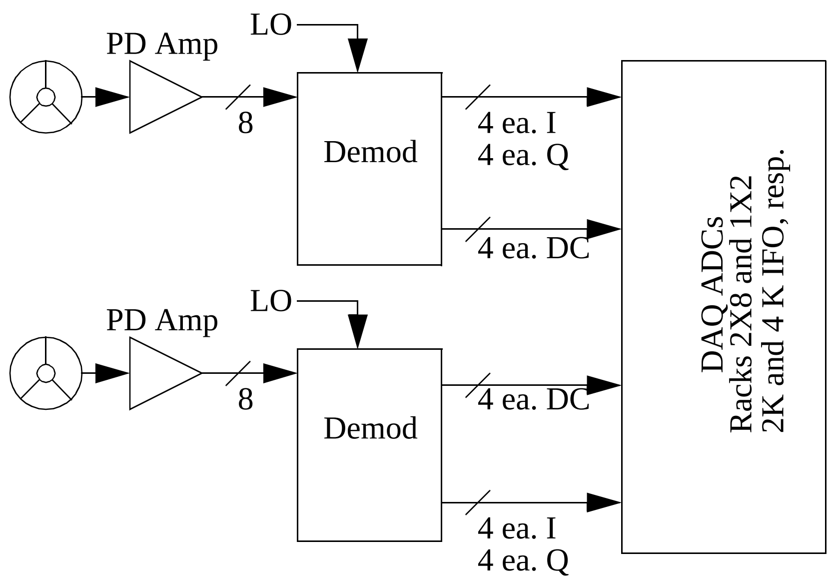


Figure 6: Mode Matching Control and Monitoring

As can be seen from the figure, the Bull’s Eye detector system will use photodetector amplifiers, and demodulator boards that are identical to those used by the MC alignment controls. The sample rate for the I&Q signals will be 256 samples per second and the DC signals will be sampled at 16 samples per second. The algorithm for calculating the mode from the demodulated outputs is TBD and will be performed by the GDS.

The bias voltage for the photodiode segments will be < 30 VDC and most likely be 15 or 24 VDC as these voltages are readily available in the rack.

9 ANALYZER CAVITY CONTROLS AND MONITORING

The analyzer cavity that has been selected for use in the IOO is a Coherent model 216. This analyzer will be ordered with a Coherent model 251 Spectrum Analyzer Controller. All controls for the cavity are via front panel knobs and switches. The controller will need to be modified to incorporate a sweep voltage monitor and remote on/off capability.

Operator displays and software will be developed that will allow the operator to view detector output versus sweep voltage and turn the analyzer on and off remotely. At this time, no other functions will be incorporated into the control and monitoring of the analyzer cavities on the PSL table and IOT7.

10 RF PHOTODETECTOR MONITORING

10.1. RFAM Photodetector

An RF photodetector will be located on the PSL table of each interferometer. These photodetectors will have front end electronics that are tuned to the IFO resonant sideband frequency (29.486 MHz and 24.493 MHz for 2K and 4K IFOs, respectively) followed by a simple diode detection scheme. The output of the detector will be passed to an ADC input provided by the DAQ system and sampled at 1 Hz. The detector will be designed such that the fractional sensitivity is better than 1 ppm at the resonant frequency, i.e.:

$$\frac{RFmon(sensitivity)}{DCmon} = 1ppm$$

A block diagram of the electronics is shown in Figure 7: RF AM Electronics Block Diagram below.

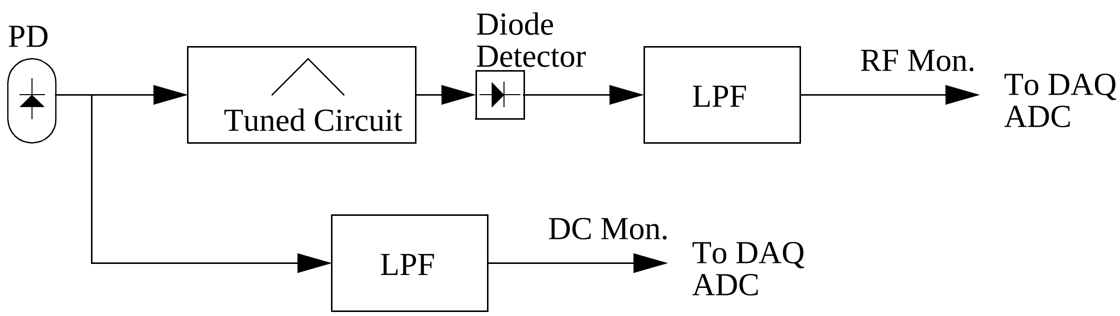


Figure 7: RF AM Electronics Block Diagram

10.2. MC Noise Monitoring Photodetector

A block diagram of the mode cleaner noise monitoring photodetector system is shown in the figure below.

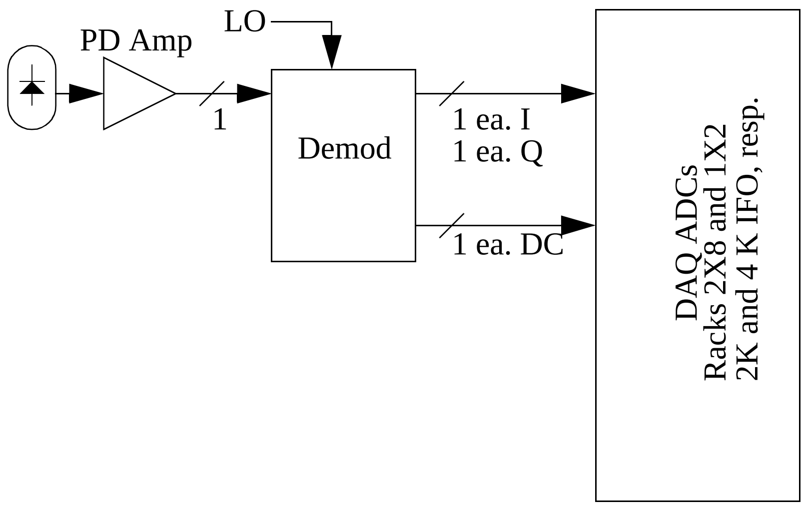


Figure 8: Noise Monitoring Photodetector System

The mode cleaner noise monitor photodetector amplifier will be identical to the photodetector amplifiers and demodulators used for the mode cleaner length control system, with the exception that they will be tuned to operate at the IFO resonant sideband frequency(29.486 MHz and 24.493 MHz for 2K and 4K IFOs, respectively). Signals from the detector will be passed directly to the DAQ/GDS systems to be digitized.

11 SYSTEM LAYOUT/DESIGN

11.1. Rack Design/Layout

LIGO drawing D980211 shows the layout for the WA 2K IOO suspension rack (W2X4). The WA 4K and LA 4K racks (W1X6 and L1X6, respectively) will be identical to W2X4, with the exception that the controller for FM2 will be removed in the 4K IFOs.

LIGO drawing D980232 shows the layout for the WA 2K IOO controls rack (W2X7). The WA 4K and LA 4K racks (W1X3 and L1X3, respectively) will be identical.

11.2. Vacuum Port Assignments

Table 9 details the vacuum port assignments for the IOO suspension cabling and feedthroughs.

Table 9: IOO Vacuum Port Assignments

IOO CDS Component	*Other System or Subsystem*	*Port*
WA 2 Km MC mirror 1 cabling	Vacuum Chamber	Port WH7D4
WA 2 Km MC mirror 2 cabling	Vacuum Chamber	Port WH8D1
WA 2 Km MC mirror 3 cabling	Vacuum Chamber	Port WH7D4
WA 2 Km MMT1 cabling	Vacuum Chamber	Port WH7D1
WA 2 Km MMT2 cabling	Vacuum Chamber	Port WH8D1
WA 2 Km MMT3 cabling	Vacuum Chamber	Port WH7D6
WA 2 Km SM1 cabling	Vacuum Chamber	Port WH7D6/
WA 2 Km SM2 cabling	Vacuum Chamber	Port WH7D1
WA/LA 4 Km MC mirror 1 cabling	Vacuum Chamber	Port WH1D4/ LH1D4
WA/LA 4 Km MC mirror 2 cabling	Vacuum Chamber	Port WH2D1/ LH2D1
WA/LA 4 Km MC mirror 3 cabling	Vacuum Chamber	Port WH1D4/ LH1D4
WA/LA 4 Km MMT1 cabling	Vacuum Chamber	Port WH1D1/ LH1D1
WA/LA 4 Km MMT2 cabling	Vacuum Chamber	Port WH2D1/ LH2D1
WA/LA 4 Km MMT3 cabling	Vacuum Chamber	Port WH1D6/ LH1D6

All mechanical interfaces to the vacuum chamber shall be 25 pin D connectors mounted in pairs to 4.5” conflat flanges. These 4.5” conflat flanges are then mounted in groups of three to the 12” conflat flanges on each vacuum chamber port. The 4.5” conflat flanges with 2 each 25 pin D connectors are MDC part number 63002-1000.

12 DAQ AND GDS INTERFACES

The interface to the DAQ and GDS systems will be via analog signals and reflective memory as described in LIGO documents T980020 and T980026. The signals passed to and from the systems will be as shown in Table 10 below.

Table 10: DAQ and GDS Signals

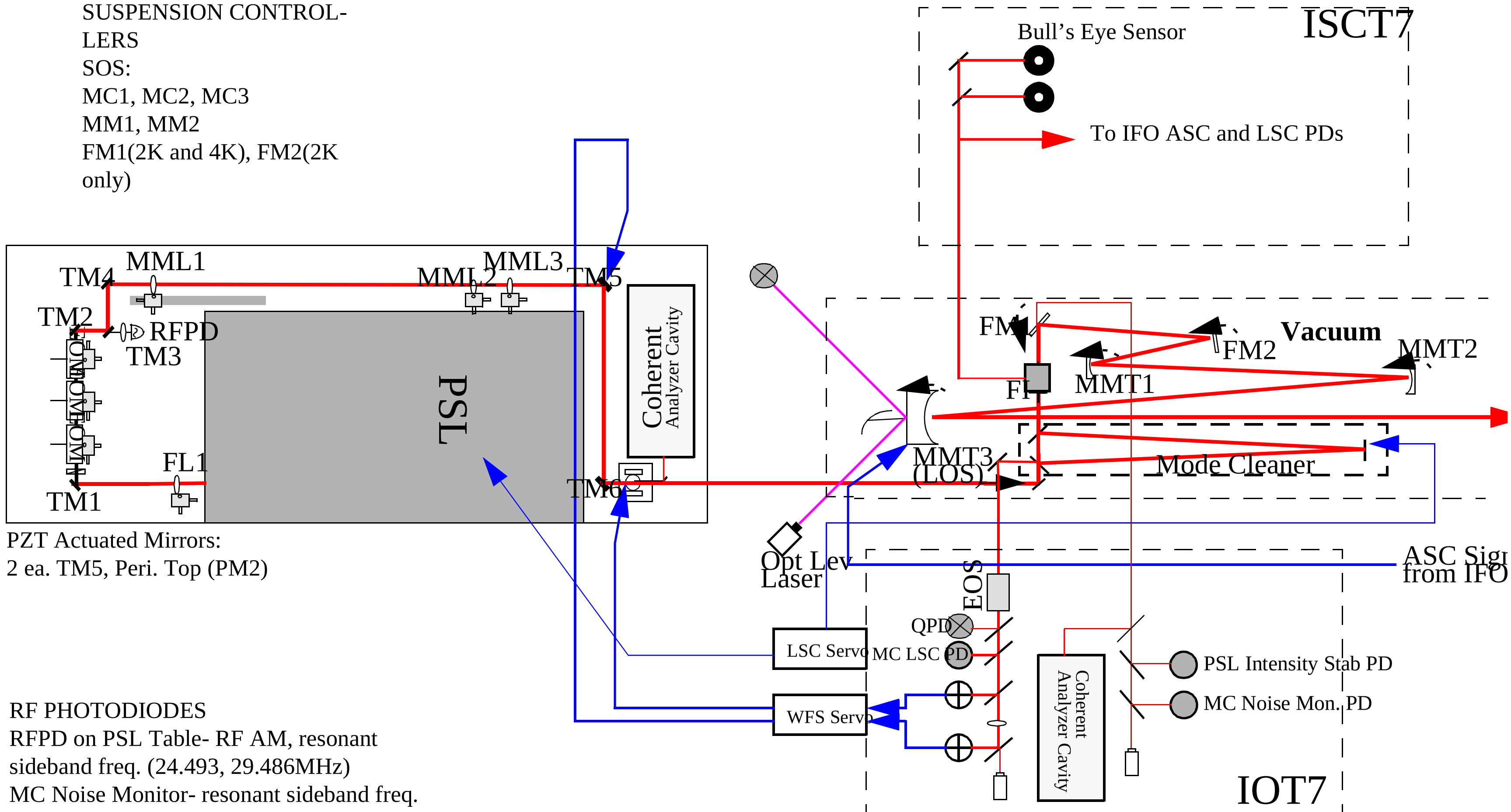
Signal	*Type*	*Sample Rate*	*Analog/Digital*
All Suspension Local PD read backs	Output to DAQ	2048	Analog
All SUS coil currents	Output DAQ	2048	Analog
Sum Coil currents	Output to DAQ	16384	Analog
All MC ASC demodulated PD signals I & Q	Output to DAQ	IOO ASC sample freq.	Digital
All MC ASC output signals	Output to DAQ	IOO ASC sample freq	Digital
All MC ASC PD DC outputs	Output to DAQ	1	Digital
All MC LSC demodulated PD signals I & Q	Output to DAQ	16384	Analog
MC LSC output signal (MC length)	Output to DAQ	256	Analog
MC LSC output signal (PSL freq)	Output to DAQ	16384	Analog
MC LSC PD DC output	Output to DAQ	1	Analog
MC LSC PD Temp.	Output to DAQ	1	Analog
Bull’s Eye Sensor demodulated PD signals	Output to DAQ	256	Analog
RFAM PD	Output to DAQ	1	Analog
Noise Monitor RFPD demodulated signals I & Q	Output to DAQ	16384	Analog

Table 10: DAQ and GDS Signals

Signal	*Type*	*Sample Rate*	*Analog/Digital*
MC Misalign/shift test input	Input from GDS	IOO ASC sample freq	Analog
MC ASC PD Test Inputs	Input from GDS	IOO ASC sample freq	Analog
MC LSC Test input at error summing junction	Input from GDS	16384	Analog
MC LSC Test input before feedback split MC/laser	Input from GDS	16384	Analog

APPENDIX 1 IOO CDS BLOCK DIAGRAM

SUSPENSION CONTROLLERS
SOS:
MC1, MC2, MC3
MM1, MM2
FM1(2K and 4K), FM2(2K only)



PZT Actuated Mirrors:
2 ea. TM5, Peri. Top (PM2)

RF PHOTODIODES
RFPD on PSL Table- RF AM, resonant sideband freq. (24.493, 29.486MHz)
MC Noise Monitor- resonant sideband freq. (24.493, 29.486MHz)

APPENDIX 2 SCHEMATIC LIST

Table 11: IOO Schematic List

System	*Title*	*Number*
SUS	SOS Controller Schematic	D980181
SUS	WA 2K IOO Suspension System Wiring	D980213
SUS	WA 2K SUS Controls Rack Drawing	D980211
IOO/ ASC	Wavefront Demodulator Board	D980233
IOO/ ASC	WFS Sensor Head Schematics	D980012
IOO/ ASC	WA 2K IOO Controls Rack Drawing	D980232
IOO/ ASC	WA 2K Mode Cleaner Alignment Control System Wiring	D9800TBD
IOO/ ASC	WFS to VME Cross Connect Chassis Wiring	D9800TBD
IOO/ LSC		