LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Electrostatic Actuator Drive Electronics Interface Control Document

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This is an internal working note
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1 Introduction

The purpose of this document is to capture the interface definition for the advanced LIGO system. The nature of all Interface Control Documents (ICD) is to describe the design implementation of the requirements in the specifications (requirements and design descriptions) as they relate to interfaces. During the design phases of the program the ICD is a 'living' document; It must be actively maintained and controlled. Once the ICD has achieved a reasonable level of completion (at least for sections related to a few subsystems), it will be released with a Document Change Notice (DCN) which is signed by the leaders/managers for all subsystems involved. This places the ICD under configuration control. For each subsequent revision, a DCN is required. This DCN is initiated by the systems engineering group and signed by all the leaders/managers of the effected subsystems. The DCN lists the changes and the reasons for the changes. The DCN also indicates if the changes effects cost, schedule or performance. It is the responsibility of the systems engineering group to arrange for appropriate review or approval by a Material Review Board (MRB), Technical Review Board (TRB) or the Configuration Control Board (CCB) as required in the process of reviewing the DCN.

The advanced LIGO system is divided into subsystems as listed in Table 1. Of all the possible pair wise interactions, less than half have interface definition, as indicated in Table 1.

Table 1: Subsystem interface matrix

LIGO.4.						SUS					AOS								
WBS	Subsystems			FAC	SEI	UK	US	PSL	IO	COC	PhDr	ATC	COS	ISC	DAQ	SUP	LDAS	INS	SYS
1	Facilities		FAC		✓	✓	✓	✓		✓					✓		✓		
2	Seismic Isolation		SEI			✓	✓					✓	✓	✓	✓	✓		✓	✓
3A	Suspensions (SUS)	UK Scope	UK				✓			✓	✓	✓	✓	✓	✓	✓		✓	✓
3B		US Scope	US						✓	✓			✓	✓	✓	✓		✓	✓
4	Pre-Stabilizaed Laser		PSL						✓					✓	✓				
5	Input Optics		IO										✓	✓	✓				✓
6	Core Optics Components		COC																✓
7A	Auxiliary Optics (AOS)	Photon Drive	PhDr											✓	✓				✓
7B		Active Thermal Compensation	ATC											✓	✓				✓
7C		Core Optics Support	COS											✓					✓
8	Interferometer Sensing & Control		ISC												✓				
9	Data Acquisition		DAQ														✓		
10	Support Equipment		SUP																
12	LIGO Data Analysis System		LDAS																✓
13	Installation		INS																
14.5	Systems Engineering		SYS																

Note: The cells in Table 1 should eventually cite the section in which the interface is defined.

The Suspension subsystem is further divided into the United Kingdom (UK) team's scope and the United States (US) team's scope. In this way the interfaces between elements common to the overall assemblies produced by both teams are effectively captured in this ICD.

The Auxiliary Optics Subsystem (AOS) is also divided into its principal subsystem elements, due to the considerably different nature of these various elements, and the likelihood that different groups will address the design of each element.

1.1 Applicability of the System Interface Matrix to the Electrostatic Actuator Drive Electronics

The Electrostatic Actuator Drive Electronics represents a constituent part of the Interferometer Sensing and Control (ISC) subsystem, and as such will interface to a subset of the subsystems (as detailed in table 1) to which the ISC interfaces. This subset is listed below, and is used as the basis for this document.

i) Interferometer Sensing and Control (ISC)

ii) Seismic Isolation (SEI)

iii) Suspensions (SUS)

iv) Support Equipment (SUP)

2 Applicable Documents

Ref No	Document Title	ID Number
	Electrostatic Actuator Drive Electronics documentation	
1	Electrostatic drive amplifier for controls prototype tests	E040109-00-K
2	Electrostatic Drive Evaporation Mask	D040146-00-K
	LIGO Design Guidelines	
3	LIGO Laboratory Electronics EMC Requirements	E020986-01-D
4	LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures	E960022-B-E
5	LIGO Vacuum Compatible Materials List	E960050-B-E
	AdvLIGO Documents	
6	Satellite Amplifier	D961289-B1-C
7	AdvLIGO Electrostatic Actuator Drive Electronics Test Specification	Exxxxxx
8	AdvLIGO Electrostatic Actuator Drive Electronics Manufacturing and Assy Details	Exxxxxx
9	AdvLIGO Electrostatic Actuator Drive Electronics Subrack Manufacturing and Assy Details	Exxxxxx
10	AdvLIGO Electrostatic Actuator Drive Electronics Subrack Test Specification	Exxxxxx
	AdvLIGO Drawings	
11	AdvLIGO Electrostatic Actuator Drive Electronics PCB Schematic	Dxxxxxx
12	AdvLIGO Electrostatic Actuator Drive Electronics PCB BOM	Dxxxxxx
13	AdvLIGO Electrostatic Actuator Drive Electronics PCB Fabrication Drawing	Dxxxxxx
14	AdvLIGO Electrostatic Actuator Drive Electronics Wiring Details	Dxxxxxx
15	AdvLIGO Subrack Backplane Schematic	Dxxxxxx
16	AdvLIGO Subrack Backplane BOM	Dxxxxxx
17	AdvLIGO Subrack Backplane Fabrication Drawing	Dxxxxxx
18	AdvLIGO Subrack (Complete) Assy	Dxxxxxx
19	AdvLIGO Subrack (Complete) BOM	Dxxxxxx

Table 2-1

Note: ICD INFORMATION: The drawings listed in table 2-1 contain interface information. Revisions must be coordinated with a revision to E03xxxx and with LIGO systems engineering

3 Electrostatic Actuator Drive Electronics to Interferometer Sensing and Control (ISC) Interfaces

3.1 Electrical Interface

3.1.1 Electrostatic Actuator Drive Electronics Connector Details and Pin Allocation

The Electrical Connection to the Electrostatic Actuator Drive Electronics Module is via a Male Normal Density 15 way D type connector TBC mounted on the front face of the rack-mounted unit. The pin allocations are as shown below:-

Pin Number	Signal Name	Description
1	Signal Ground Return	
8	DLR0+	Ch0 Differential Line Receiver, + (i/p)
15	DLR0-	Ch0 Differential Line Receiver, - (i/p)
7	DLR1+	Ch1 Differential Line Receiver, + (i/p)
14	DLR1-	Ch1 Differential Line Receiver, - (i/p)
6	DLR2+	Ch2 Differential Line Receiver, + (i/p)
13	DLR2-	Ch2 Differential Line Receiver, - (i/p)
5	DLR3+	Ch3 Differential Line Receiver, + (i/p)
12	DLR3-	Ch3 Differential Line Receiver, - (i/p)
4	DLR4+	Ch4 Differential Line Receiver, + (i/p)
11	DLR4-	Ch4 Differential Line Receiver, - (i/p)

Table 3.1.1-1

In addition the outer screen braid is to be terminated to the connector backshell (TBC).

3.2 Electrical Properties

The Electrostatic Actuator Drive Electronics is to handle 5 channels of actuator electronics per board (i.e. 4 quadrants and a bias channel).

The input/output common mode range shall be ±10 Volts TBC

3.2.1 Cabling Requirements

The control input to the electronics will be via Screened Multiple Twisted Pair Cable.

3.2.2 Electronics Bandwidth Requirements

The Electronics Module bandwidth shall be as follows:-

Actuator Electronics Bandwidth 5KHz TBC

3.2.3 Noise Performance

The Electronics Module Noise and Electrostatic Actuator combined noise performance shall be as follows:-

Actuator Current Noise TBD

(Equivalent to TBD N/√Hz)

3.3 Physical Interfaces

The Electrostatic Actuator Drive Electronics PCBs will be designed to allow mounting in TBD style Subrack suitable for mounting in a 19'' Rack system.

The Electrostatic Actuator Drive Electronics PCBs required for a complete suspension will be supplied mounted in a TBD Subrack Assembly, comprising backplane with inlet connector for connection of low & high voltage supplies.

Each Subrack may be installed in a Satellite or 'main instrumentation' location.

3.4 Subrack Power Interface

The low voltage power inlet connector for the Subrack will be of type TBC and pinout as follows. The Connector is located on the Subrack backplane PCB:-

Pin Number	Signal Name	Description
TBC		

Table 3.4.-1

The high voltage power inlet connector for the Subrack will be of type TBC and pinout as follows. The Connector is located on the Subrack backplane PCB:-

Pin Number	Signal Name	Description
TBC		

Table 3.4-2

3.5 Power Interface Electrical Properties

The Electrostatic Actuator drive electronics low voltage supply shall comply with the following specifications:

Positive Supply:-	TBD ± TBD Vdc
Positive Supply Current:-	TBD A (Max)
Negative Supply:-	TBD ± TBD Vdc
Negative Supply Current:-	TBD A (Max)
Regulation:-	TBD
Noise:-	TBD mV rms

Specifications for the supply requirements for the high voltage symmetrical supplies follow:

Positive Supply:-	100 (TBC) ± TBD Vdc
Positive Supply Current:-	TBD A (Max)
Negative Supply:-	100 (TBC) ± TBD Vdc
Negative Supply Current:-	TBD A (Max)
Regulation:-	TBD
Noise:-	TBD mV rms

n.b. The high voltage output is nominally 20V less than its respective supply rail. (TBC)

3.6 Thermal Considerations

The Maximum dissipation from the Electrostatic Actuator Drive Electronics shall be as follows-

Item	Maximum Dissipated Power	Notes
Amp?	TBD	TBD

Table 3.6-1

The thermal environment may require active management. Alternatively a convectional cooling solution may prove to be sufficient (i.e. allow for adequate air flow around the unit). TBD

4 Electrostatic Actuator Drive Electronics to Seismic Isolation (SEI) Interfaces

4.1 Electrical Interfaces

4.1.1 Electrostatic Actuator Drive Electronics Connector Details and Pin Allocation

Electrical Connection to the Electrostatic Actuator Drive Electronics is via SHV female connectors (Part Number TBD) mounted on the front of the rack mounted unit (TBC). The pin allocations are as shown below (TBC):-

Pin Number	Signal Name	Description
TBD	TBD	TBD

Table 4.1.1-1

4.1.2 Electrostatic Actuator Drive Electronics Cable Harness

Cable Harnessing shall comply with the requirements of Applicable Document [3]

The cable harness shall have the following properties:-

Connector Mating to ESD Drive Electronics:	SHV Male
	Part Number TBD
Cable type:	TBD

4.2 Electrical Precautions

Due to the high voltage supply rails and the likely HV output of the actuator drive electronics it may be necessary to incorporate a HV safety interlock that would disable the supply under the following conditions:- (TBC)

- Loss of board supply (TBC)
- Connector becomes unplugged (TBC)

For additional safety, a fixed current limit of 1mA shall be utilized (TBC)

5 Electrostatic Actuator Drive Electronics to Suspensions (SUS) Interfaces

5.1 Electrical Interfaces

5.1.1 Electrostatic Actuator Mask Connection Details and Pad Allocation

Electrical connection to the Electrostatic Actuator mask (attached to reaction mass surface) is direct using UHV compatible solder joint connections to the mask terminal pads.

The maximum allowable soldering temperature is:- (TBC)

The mask solder pad allocations are as shown below:- (TBC)

Pad Number	Signal Name	Description
1	BIAS1	Ch 0 Bias Pad 1
2	BIAS2	Ch 0 Bias Pad 2
3	BIAS3	Ch 0 Bias Pad 3
4	BIAS4	Ch 0 Bias Pad 4
5	QUAD1	Ch 1 Quadrant 1
6	QUAD2	Ch 2 Quadrant 2
7	QUAD3	Ch 3 Quadrant 3
8	QUAD4	Ch 4 Quadrant 4

Table 5.1.1-1

5.1.2 Electrostatic Actuator Drive Electronics Cable Harness

Cable Harnessing shall comply with the requirements of Applicable Document [3] where appropriate

The cable harness shall have the following properties:-

Connector Mating Pigtail to SEI Bridge:	TBD
	Part Number TBD
Backshell:	Requirement TBD Part Number TBC
Cable type:	TBD
Cable resistance:	< 10 Ohms (TBC)

6 Pigtail Cabling Materials

The following table lists all materials used in the Electrostatic Actuator Drive Electronics manufacture, including connectors, electronic components and cable harness (pigtail). This list excludes materials external to the vacuum chamber.

Item	Material	Where Used	Vacuum Review Board Approval Status
1	Teflon insulated wire TBC	Actuator Pigtail	Approved (Initial LIGO)
2	Standard tin/lead solder (e.g. Sn 63)	Mask Pad Connections	TBD
TBD			

Table 6-1

7 Cable Manufacture and Cleaning

Parts will be manufactured in accordance with AdvLIGO Electrostatic Actuator Drive Electronics Wiring Details, Dxxxxxx TBC. Part cleaning shall comply with the requirements of Applicable Document [4].

7.1 Finished Item Packaging for Storage and Shipping

Packaging for storage and shipping shall comply with the requirements of Applicable Document [5] that are relevant to the state of cleanliness.

7.2 Handling

Finished parts should only be handled in a Clean, static safe working environment, using standard static safe handling precautions and clean item handling procedures.

8 Electrostatic Drive Electronics Manufacturing

8.1 Finished Item Packaging for Storage and Shipping

Sub Rack units will be packaged for storage and shipping by enclosing in anti-static wrap, and secured in packing crates. Shipping crate format TBC.

8.2 Handling

Finished parts should only be handled in a static safe working environment, using standard static safe handling precautions.

9 Electrostatic Actuator Drive Electronics to Support Equipment (SUP) Interfaces

Level of testing required TBC

10 Quality Assurance

10.1 Requirements Verification Matrix

A Verification Matrix will be added once the format and content of the document are agreed