Interface Control Document (ICD): Suspension, UK Scope (SUS/UK) – Suspension, US Scope (SUS/US)

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LIGO-E050160-01

1.1 SUS/UK – SUS/US

This is a chapter of the master Advanced LIGO Detector, Interface Control Document (ICD), E030647.

The SUS/UK scope includes the BSC chamber suspensions; the Input Test Mass (ITM), End Test Mass (ETM), Beam Splitter (BS) and Fold Mirror (FM) suspensions. The SUS Work Breakdown Structure (WBS), M030120-00, defines the scope of the SUS efforts and differentiates the US and UK components. In addition, M030162-03 is a detailed statement of the SUS/UK scope.

The SUS/US scope includes the HAM chamber suspension assemblies; the Input and Output Mode Cleaners (IMC and OMC), Power and Signal Recycling Mirrors (PRM and SRM), Input and Output Mode Matching Telescopes (IMMT and OMMT), and Steering Mirrors (SM). The SUS Work Breakdown Structure (WBS), M030120-00, defines the scope of the SUS efforts and differentiates the US and UK components. In addition, M030162-03 is a detailed statement of the SUS/UK scope.

A block diagram of the SUS ITM and ETM suspensions is shown in Figure 1. Block diagrams for the BS and FM suspensions would be similar. Block diagram(s) of the SUS/US system is (are) pending. There are three subassemblies of the SEI/UK work scope which have interfaces to the SUS/US work scope:

- Optical Sensor and Electro-Magnetic actuator (OSEM) and Flag: Some of the SUS/UK produced OSEMs will be used in SUS/US suspensions. The Flag is a physically separate subassembly that works with the OSEM.
- OSEM Electronics: All physical and electronic/electrical interfaces to the OSEM electronics box are provided by SUS/US. In addition SUS/US will likely use the same OSEM electronics for interfacing to the OSEM in the SUS/US suspensions.
- Electro-Static Drive (ESD) Electronics: All physical and electronic/electrical interfaces to the OSEM electronics box are provided by SUS/US.

The following ICD requirement sections are organized by these three sub-assemblies. There are no anticipated differences in interfaces that depend upon the specific suspension from either SUS/UK or SUS/US.

N.B.: This ICD is in large part a union of the ICD elements of E040373-01 (OSEM), E040374-01 (OSEM Interface Electronics) and E040379-01 (Electro-Static Drive Electronics). Each of these documents have some design information unrelated to interfaces and will be re-titled "specification".

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Figure 1: Suspension Block Diagram for the BSC (Quad) ETM & ITM

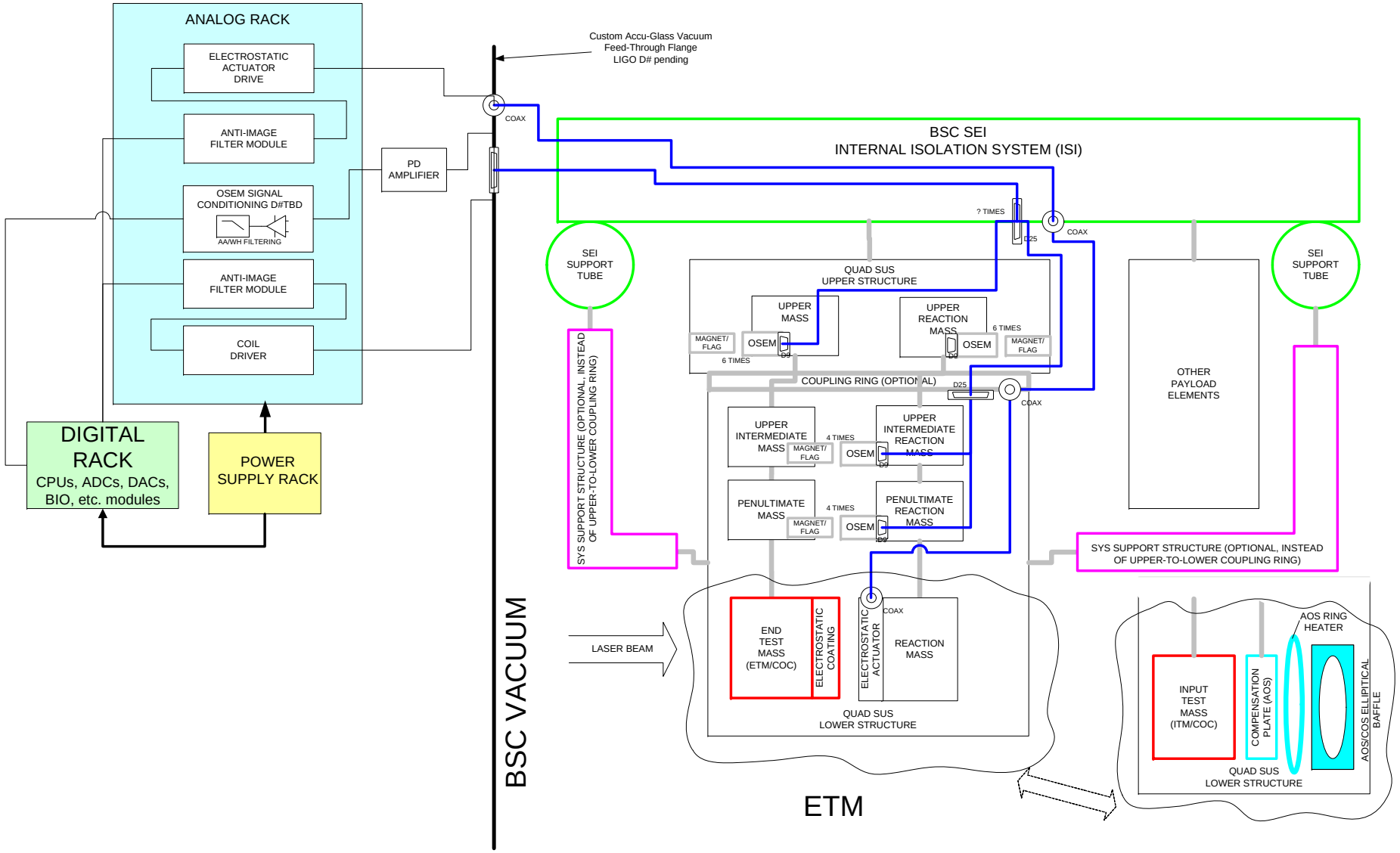
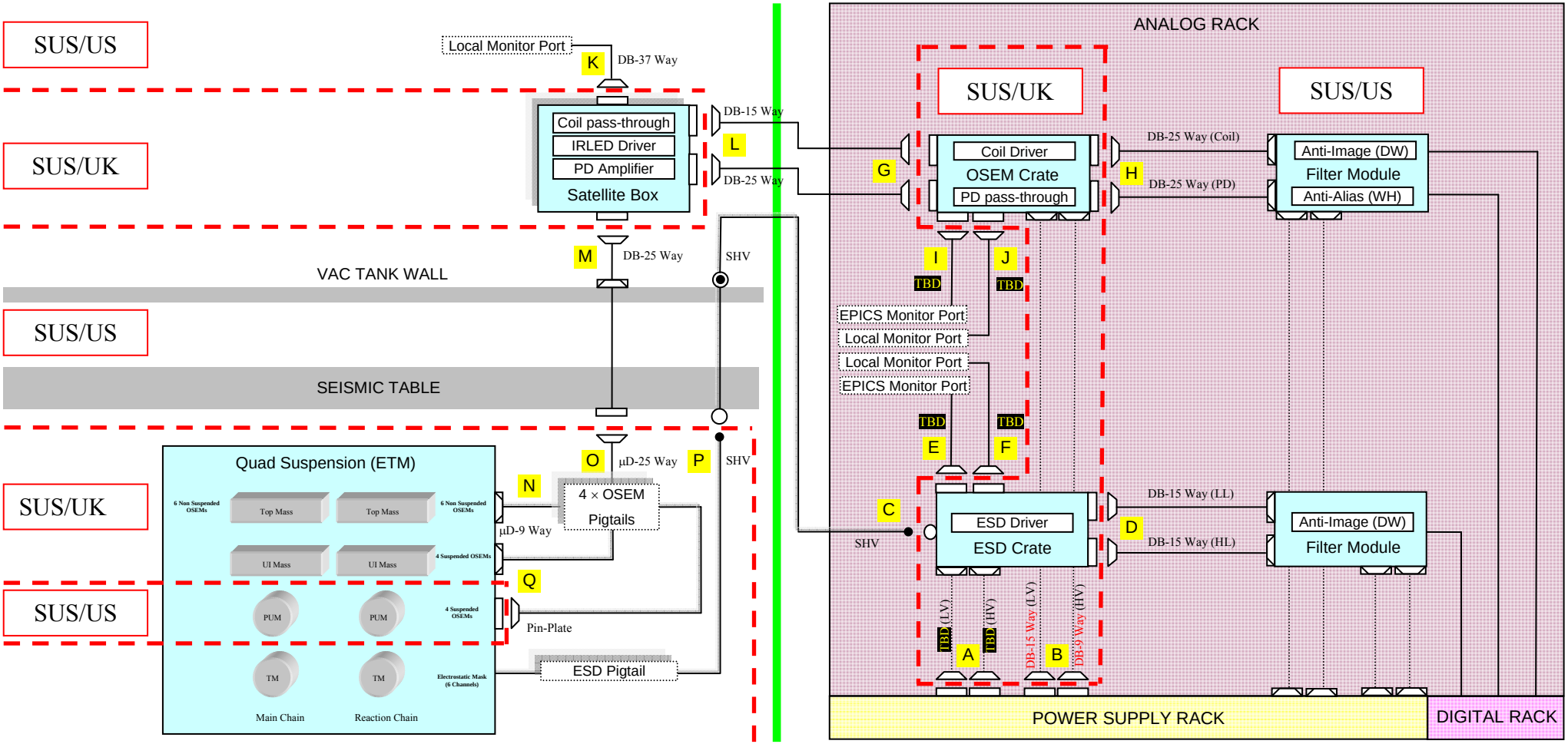


Figure 2: Electronics Block Diagram



1.1.1 Hybrid OSEM and Magnet/Flag Assembly

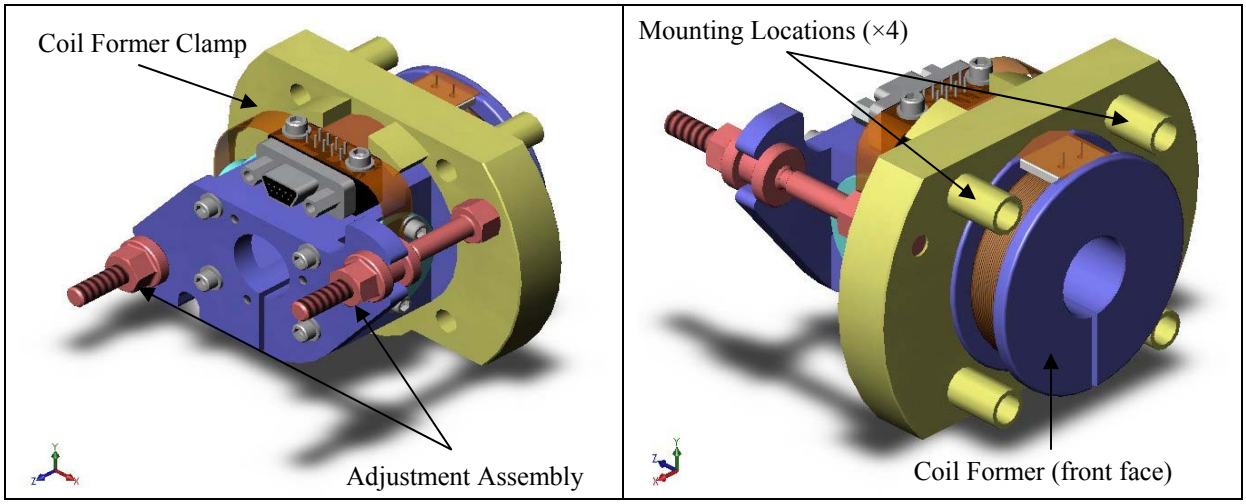
The SUS/UK Noise Prototype version of the OSEM will be used by SUS/US in its suspensions at some locations. The coil actuator and sensor characteristics would remain the same in the different applications. However the magnetic moment of the magnet/flag assembly may be different for each suspension, i.e. this is not a common part. Since the SUS/US will use the same OSEM electronics as the SUS/UK, the electrical characteristics of the OSEM head and associated electronics could be considered as an integrated subsystem. However, it is possible that alternative interfacing electronics may be developed for the different suspension applications. Consequently the characteristics of the OSEM head (actuator and sensor) and the interfacing SUS/UK electronics are specified separately.

1.1.1.1 Physical Interfaces

Integral to the function of the OSEM are the sensor assembly and actuator coil. To interface these parts with the suspension or structure the OSEM incorporates a mounting clamp and adjustment assembly. The complete OSEM assembly is shown in Figure 3.

For reference, a local co-ordinate system has been generated for the OSEM which has the sensing taking place along the z-axis. The origin is taken to be at the center of the front face of the coil former (see Figure 3).

Figure 3: OSEM Assembly Model (flag not shown)



Rear Isometric View Front Isometric View

1.1.1.1.1 Mass Properties

Requirement:

The mass of the OSEM shall be 170 grams ± 1 gram. TBC

The center of mass (CM) is located near the central z-axis at the following co-ordinates:-

x-axis = −0.01 inch (0.3 mm). TBC

y-axis = −0.03 inch (0.8 mm). TBC
z-axis = +0.76 inch ± 0.06 inch (19.3 mm ± 1.5 mm). TBC

Note that, the figure given for the CM on the z-axis incorporates the full adjustment range of the OSEM along this axis.

Explanation/description/references:
The mass budgets and balance of the suspensions requires knowledge of the mass of the OSEM.

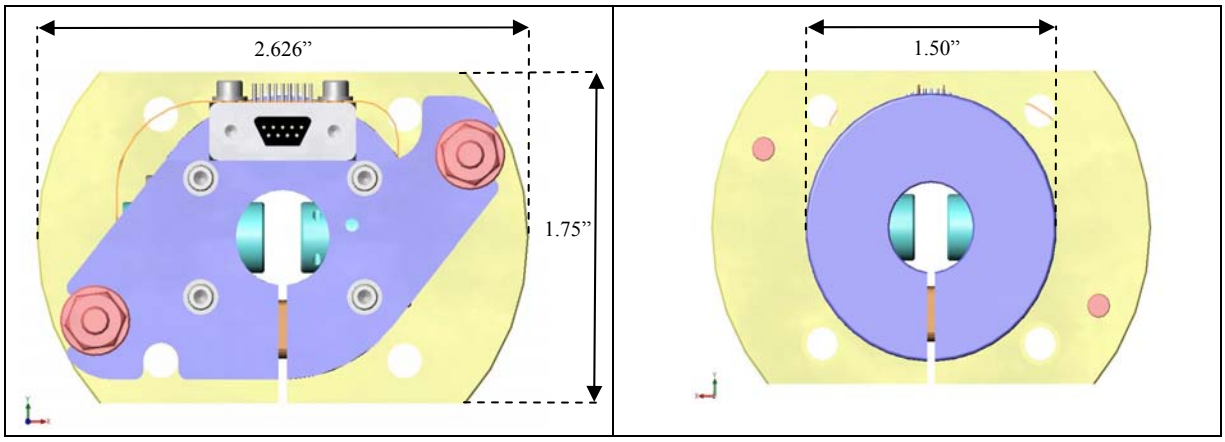
Historical Notes:
None

1.1.1.1.2 Envelope

Requirement:
The OSEM head envelope has an outer diameter of 2.626 inch (66.7 mm) with a flat-to-flat dimension of 1.750 inch (44.5 mm), which can be seen in Figure 4. The overall length of the OSEM assembly is 2.421 inch (61.5 mm). The minimum clearance-hole diameter required for the projected coil former is 1.501 inch (38.13 mm). TBC

The OSEM has an axial (z-axis) adjustment range of ± 0.22 inch (± 5.6 mm). At the midpoint of the adjustment range the front face of the coil former is 0.16 inch (4 mm) short of the mounting plane. At one extreme of the adjustment range the front face of the coil former is coincident with the front face of the coil former clamp.

Figure 4: OSEM Envelope Dimensions

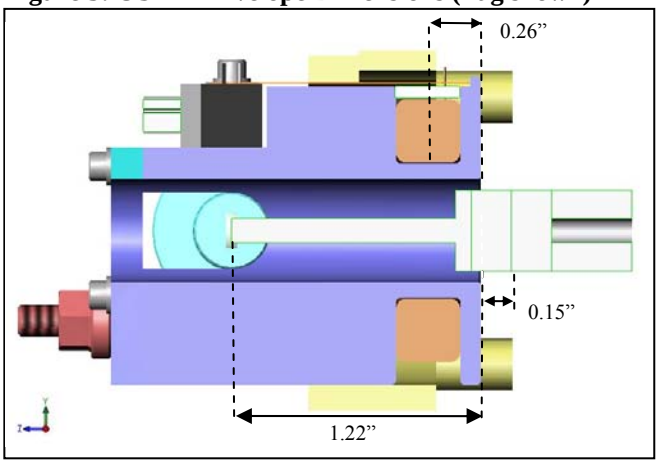


Rear Normal View Front Normal View

The minimum clearance within the internal aperture of the coil former is 0.197 inch (5.00 mm). The diameter of the flag is 0.118 inch (3.0 mm). The flag must project into the OSEM head along the z-axis a distance of 1.22 inch (30.99 mm) past the front face of the OSEM coil former. TBC

The center of the coil winding is 0.18 inch (4.57 mm) from the front face of the coil former. Nominally, the center of the magnet (∅10 mm × 10 mm) extends past the front face of the coil former by 0.15 inch (3.81 mm). See Figure 5.

Figure 5: OSEM Envelope Dimensions (flag shown)



Section through OSEM and Flag Assemblies

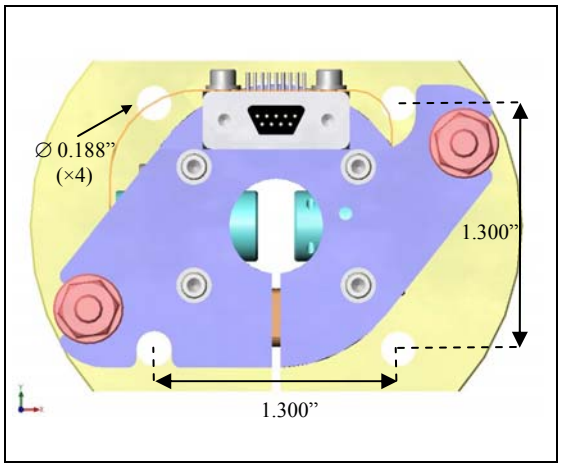
Explanation/description/references:
None

Historical Notes:
None

1.1.1.1.3 Attachment

Requirement:
The OSEM head is attached by 4 screws on 1.300 x 1.300 inch (33.0 x 33.0 mm) centers using #8 – 32 UNC screws. The clearance holes trough the mounting pillars allow for ±0.012 inch (±0.3 mm) adjustment in the x and y axes, to locate the OSEM.

Figure 6: OSEM Mounting Holes



Rear Normal View

Explanation/description/references:
None

Historical Notes:
None

1.1.1.2 Electronic/Electrical Interfaces

1.1.1.2.1 Actuator Characteristics

The OSEM electro-magnetic actuator has the following characteristics controlled by this ICD:

- Maximum continuous coil current of 200 mA
- Peak coil current 400 mA (Penultimate Mass OSEMs)
- Force constant of 0.5 N/(A^2 m^2) (Top Mass and Upper Intermediate)
- Coil winding clockwise when viewing the back face of the OSEM
- Winding inductance = 13 ± 0.1 mH measured at 100 Hz
- Winding resistance = 35 ± 2 Ohm
- Actuator coil is isolated from the OSEM body (> 100 MOhm)

1.1.1.2.2 Optical Sensor Characteristics

Requirement:
The OSEM optical sensor has the following characteristics controlled by this ICD:

- Target sensing range of 0.0276 inch (0.7 mm) p-p TBC
- The emitter is an Optek OP232 device with a forward current of 35 mA nominal (max. 100 mA)
- The photodiode is a Centronic BPX65 with a nominal 0 V bias (max. 50 V)
- Sensor temperature coefficient is 1.5 %/C
- Current transfer ratio > 0.05% TBR with flag fully retracted from the field of view

Explanation/description/references:
The hybrid sensor measured range is reported in T040110-01.
The electrical characteristics of the OSEM sensor is reported in E040373-01.

1.1.1.2.3 Interface Cabling/Connectors

Requirement:
The OSEM head has a male D9 connector (Glenair Micro-D Part No. MR7590-9P-1BSN-MC225) with strain relief on the female side.

The mating cable should be twisted pair with an overall shielded. The shield should not be terminated at the OSEM head or anywhere along the path; the shield is to be terminated only at the OSEM Interface Electronics module.

Explanation/description/references:
Per E040373-01.

1.1.1.2.4 Data Signals

Requirement:
The Data Signal assignments to the micro-D 9 way connector at the OSEM head are indicated in the following Table. Pairing is 1-6, 2-7 and 4-9

Table 1: OSEM Connector Pin-Outs (Fig. 2 N)

Pin #	Signal Name	Description
1	PD-K	Photodiode Cathode
6	PD-A	Photodiode Anode
2	LED-A	IR Emitter Anode
7	LED-K	IR Emitter Cathode
3		Not Connected (on the OSEM head side)
8		Not Connected (on the OSEM head side)
4	FN	End of coil winding
9	ST	Start of Coil winding
5	Shield	Not Connected (on the OSEM head side)

Explanation/description/references:
Per E040373-01.

1.1.1.3 Environmental

1.1.1.3.1 Thermal

Requirement:
The OSEM shall be capable of working at a steady-state temperature of TBD C at the coil and TBD C at the case of the Emitter and Photodiode while meeting all LIGO requirements (reliability, vacuum compatibility, etc.)

Explanation/description/references:
Due to differences in the conduction path and differences in the coil drive current (force) requirements, the thermal environments will be different for the SUS/UK and SUS/US

applications. This requirement is intended to insure that design changes (e.g. a material substitution) does not alter the thermal capability of the OSEM head.

Historical Notes:
None

1.1.1.4 ICD Verification Matrix

TBD

1.1.2 OSEM Electronics

1.1.2.1 Physical Interfaces

1.1.2.1.1 Location

Requirement:
The OSEM Electronics Rack Modules will be located in the LVEA (TBR), at floor level, near the BSC vacuum chamber with the associated OSEMs. All of the Rack Modules required for a suspension shall be collocated, but with remote Satellite Boxes located in close proximity to vacuum electrical feed-throughs. The specific locations for each chamber and the associated cable lengths are indicated in Drawing TBD.

Explanation/description/references:
The OSEM signals, particularly the sensor signal, are low noise sensitive signals. The OSEM Electronics may need to be in close proximity to the vacuum electrical feed-throughs to keep the cable lengths short and the EMI minimized. TBR
The specific location of the OSEM Electronics is needed to permit the SUS/US group to cable up to the modules and to arrange for, or provide, any needed infrastructure such as electrical power. We currently do not anticipate mounting the OSEM Electronics at the elevation of the electrical feed-throughs (117.5 inch (2.98 m) above the floor).

Historical Notes:
None

1.1.2.1.2 Envelope & Attachment

Requirement:
The EMC compliant OSEM Electronics Rack Module enclosure(s) shall fit standard 19 inch wide rack mounting with a height of 6U and a width of 7HP inches (TBD mm). The rack structure, and any sub-rack units (if required), used to mount the OSEM Electronics Rack Modules associated with a quad suspension shall be provided by SUS/UK. The overall dimensions of the Rack are TBD.

Explanation/description/references:
Virtually all LIGO electronics fit standard 19 inch racks, so seems natural to use this standard here as well; also consistent with E040374-01.
Individual OSEM Electronics Rack Module dimensions as well as the overall Rack dimensions are needed since SUS/US will likely use the same OSEM Electronics Rack Module but perhaps with a different packaging.

Historical Notes:
None

1.1.2.2 Electronic/Electrical Interfaces

All of the OSEM Electronics units handle 4 OSEM heads (sensor and actuator) channels. The OSEM sensor electronics is located in Satellite Boxes and the Coil Drivers are located in Rack Modules. The coil driver actuator signals pass through the Satellite Box.

1.1.2.2.1 Power Interface

Power is provided to the OSEM Electronics Rack by SUS/US.

1.1.2.2.1.1 Rack Power Interface Connection

Requirement:

The power supply connector for the OSEM electronics rack comprising 10, 14, 16 or 20 OSEM electronics channels will be a normal density 15 way male D connector and 9 way normal density male D connector with pin-outs as follows. The connectors are located on the rear of the sub-rack.

Table 2: LV Rack Power Interface Pin-Outs (Fig. 2 B)

Pin #	Signal Name	Description
1	+18V	LV Analogue positive supply
9	0V	
2	+18V	
10	0V	
3	+18V	
11	0V	
4	-18V	LV Analogue negative supply
12	0V	
5	-18V	
13	0V	
6	-18V	
14	0V	
7		
15		
8	Shield	

Table 3: HV Rack Power Interface Pin-Outs (Fig. 2 B)

Pin #	Signal Name	Description
1	+78V TBC	HV Analogue positive supply
6	0V	
2	+78V TBC	
7	0V	
3	-78V TBC	HV Analogue negative supply
8	0V	
4	-78V TBC	
9	0V	
5	Shield	

Explanation/description/references:
From E040374-01

1.1.2.2.1.2 Rack Power Requirements

Requirement:
The OSEM drive electronics module low voltage supply shall comply with the following specifications:

All supplies shall be regulated, and shall have appropriately set current limit and over voltage protection. The supply voltages specified are those seen at the Electronics inlet connector.

LV Analogue Positive Supply:	+17V < V < 19V dc
LV Analogue Positive Supply Current:	6A TBC (Max)
LV Analogue Negative Supply:	-19V < V < -17V dc
LV Analogue Negative Supply Current	6A TBC (Max)
HV Analogue Positive Supply:	+78V < V< 80V dc
HV Analogue Positive Supply Current:	1.5A (Max)
HV Analogue Negative Supply:	-80V < V < -78V dc
HV Analogue Negative Supply Current	1.5A (Max)
Noise (all rails):-	TBD mV rms at 10Hz

Since the power supplies will be located at some distance from the rack, local regulation will be provided at board level for the LV analogue supplies. Regulation will also be provided on the HV rails if required *(This requires some investigation to confirm.)*

Explanation/description/references:
From E040374-01

1.1.2.2.2 Command Input and Data Output

1.1.2.2.2.1 Command Input and Data Output Interface Cabling/Connectors

Requirement:

The electrical connection to the OSEM Electronics Rack Module is via a male normal density 25 way D type connector mounted on the front of the sub-rack unit. The pin allocations are as shown below. Each Connector will carry signals for 4 OSEM channels:

Table 4: OSEM Electronics Rack Module I/O Pin-Outs (Fig. 2 H)

Pin #	Signal Name	Description
13	Signal Ground Return	
9,22,10,23,11 24,12,25	TBC	
1	DLD A+	Ch A Differential Line Driver, + (o/p)
14	DLD A-	Ch A Differential Line Driver, - (o/p)
2	DLD B+	Ch B Differential Line Driver, + (o/p)
15	DLD B-	Ch B Differential Line Driver, - (o/p)
3	DLD C+	Ch C Differential Line Driver, + (o/p)
16	DLD C-	Ch C Differential Line Driver, - (o/p)
4	DLD D+	Ch D Differential Line Driver, + (o/p)
17	DLD D-	Ch D Differential Line Driver, - (o/p)
5	DLR A+	Ch A Differential Line Receiver, + (i/p)
18	DLR A-	Ch A Differential Line Receiver, - (i/p)
6	DLR B+	Ch B Differential Line Receiver, + (i/p)
19	DLR B-	Ch B Differential Line Receiver, - (i/p)
7	DLR C+	Ch C Differential Line Receiver, + (i/p)
20	DLR C -	Ch C Differential Line Receiver, - (i/p)
8	DLR D+	Ch D Differential Line Receiver, + (i/p)
21	DLR D-	Ch D Differential Line Receiver, - (i/p)

Explanation/description/references:
None

1.1.2.2.2.2 Sensor Data Signals

Requirement:
The nominal Detector output when the OSEM detector is fully obscured by the flag shall be:

DLDn+ = 0V DLDn- =+10V ie (DLDn+)-(DLDn-) = -10V

The nominal Detector output when the OSEM flag is fully retracted shall be:

DLDn+ = +10V DLDn- = 0V ie (DLDn+)-(DLDn-) = +10V

Hence, the nominal differential output range is +/-10V (or 20Vpk-pk)

Explanation/description/references:
From E040374-01

1.1.2.2.2.3 Actuator Drive Input Signals

Requirement:
The input signal required to produce a full-scale positive coil current is
(DLRn+)-(DLRn-) = +10V
The input signal required to produce a full-scale negative coil current is
(DLRn+)-(DLRn-) = -10V

The Input range for DLRn+ and DLRn- is –11V to +11V.

Explanation/description/references:
From E040374-01

Requirement:

The noise content of the input signal (for all OSEM coils) should meat the requirements set out in T060067-00-C (AdL Quad Suspension UK Coil Driver Design Requirements).

Explanation/description/references:

Coil current noise requirements are described in T060067-00-C.
Driver noise is detailed in the preliminary design document T050112-00-K.

1.1.2.2.2.4 Interface Cabling Requirements

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

Each signal output from the flag sensor electronics (located within the Satellite Box) to the SUS/US Anti-Aliasing & Whitening (AA/WH) Module and each coil driver output signal from the electronics (located within the Electronics Rack) to the OSEM shall be capable of driving a cable with the following properties:-

Maximum Cable Capacitance Each Wire to Ground:	10000 pF
Maximum Cable Capacitance Twisted Wire Pair:	10000 pF
Maximum Driven Cable Length:	100 m (Note 1)

Note 1: Assumes cable of capacitance 100pF/m

Explanation/description/references:
From E040374-01

1.1.2.2.3 OSEM Head Interface Cabling/Connector

Requirement:
Electrical output connection from the Satellite Box is via a normal density 25 way D type female connector mounted on the front of the Satellite Box. Note that the coil driver signals are relayed through the Satellite Box. This cable is routed through the vacuum tank wall and to the Seismic Table where it terminates with a female micro-D 25 way connector. The pin allocations are as shown below. Pairing is 2-14, 3-15, 4-16, etc.

Table 5: Satellite Box Output Connector to the vacuum tank Pin-Outs (Fig. 2 M & O)

Pin #	Signal Name	Description
1	Coil D ST	Coil D Start
2	LED D K	LED D Cathode
3	PD D A	Photodiode D Anode
4	Coil C ST	Coil C Start
5	LED C K	LED C Cathode
6	PD C A	Photodiode C Anode
7	Coil B ST	Coil B Start
8	LED B K	LED B Cathode
9	PD B A	Photodiode B Anode
10	Coil A ST	Coil A Start
11	LED A K	LED A Cathode
12	PD A A	Photodiode A Anode
13	Shield	
14	Coil D FN	Coil D Winding Finish
15	LED D A	LED D Anode
16	PD D k	Photodiode D Cathode
17	Coil C FN	Coil C Winding Finish
18	LED C A	LED C Anode
19	PD C K	Photodiode C Cathode
20	Coil B FN	Coil B Winding Finish
21	LED B A	LED B Anode
22	PD B K	Photodiode B Cathode
23	Coil A FN	Coil A Winding Finish
24	LED A A	LED A Anode
25	PD A K	Photodiode A Cathode

Explanation/Description/References:
None

1.1.2.2.4 Satellite Box to Rack Interface (Power and Photodiode Cabling Connectors)

Requirement:

The electrical connection between the OSEM Electronics Rack Module and the Satellite Box is via two connectors.

The first one, a 25 way male D type connector carries the Power and Photodiode signals, and is mounted on the front of the Satellite Box. It is connected to a 25 way Female connector on the Front panel of the OSEM Electronics Rack Module. The pin allocations are as shown below in table 6.

The second one, a 15 way male D type connector mounted on the satellite box, carries the Coil Drive signals. It is connected to a 15 way female connector mounted on the OSEM Electronics Rack Module. The pin allocation is shown in table 7.

Table 6: OSEM Electronics Rack Module Power and Photodiode interface with Satellite Box Pin-Outs (Fig. 2 L & G)

Pin #	Signal Name	Description
1	DLD A+	Differential Line Diver Ch A, (+ Sensor o/p)
2	DLD B+	Differential Line Diver Ch B, (+ Sensor o/p)
3	DLD C+	Differential Line Diver Ch C, (+ Sensor o/p)
4	DLD D+	Differential Line Diver Ch D, (+ Sensor o/p)
5	I mon A	LED Current monitor
6	I mon B	LED Current monitor
7	I mon C	LED Current monitor
8	I mon D	LED Current monitor
9	+17v	
10	+17v	
11	-17v	
12	-17v	
13	Shield	
14	DLD A-	Differential Line Diver Ch A, (- Sensor o/p)
15	DLD B-	Differential Line Diver Ch B, (- Sensor o/p)
16	DLD C-	Differential Line Diver Ch C, (- Sensor o/p)
17	DLD D-	Differential Line Diver Ch D, (- Sensor o/p)
18	Ref gnd A	LED Current monitor 0v ref
19	Ref gnd B	LED Current monitor 0v ref
20	Ref gnd C	LED Current monitor 0v ref
21	Ref gnd D	LED Current monitor 0v ref
22	0v	
23	0v	
24	0v	
25	0v	

Table 7: OSEM Electronics Rack Module interface with Satellite Box Pin-Outs: Coil connections (Fig. 2 L & G)

Pin #	Signal Name	Description
1	ST A	Coil Winding A Start
2		
3	ST B	Coil Winding B Start
4		
5	ST C	Coil Winding C Start
6		
7	ST D	Coil Winding D Start
8	Shield	
9	FN A	Coil Winding A Finish
10		
11	FN B	Coil Winding B Finish
12		
13	FN C	Coil Winding C Finish
14		
15	FN D	Coil Winding D Finish

Explanation/Description/References:
None

1.1.2.2.5 Noise Performance

The overall noise performance of the SUS/UK suspensions are defined in the Cavity Optics Suspension Design Requirements Document, T010007-03. To achieve this performance an allowable noise budget is allocated between the SUS/UK front end interface and drive electronics and the SUS/US signal conditioning and digitization electronics.

1.1.2.2.6 OSEM plus OSEM Interface Electronics

Requirement:
The combined noise performance for the OSEM Head and the OSEM Interface Electronics shall be as follows:-

- Actuator Current Noise (non penultimate masses):- see T060067-00-C
- Actuator Current Noise (penultimate masses only):- see T060067-00-C
- Sensor Differential Output Noise:- 8µV/√Hz TBC at 10Hz
  (Equivalent to 3 x 10^{-10} m/√Hz with 20V pk-pk output)

The output impedance of the coil drivers shall be as follows:-

- Top Mass Driver 100Ω TBC
- Upper Intermediate Driver 10KΩ TBC
- Penultimate Driver (science mode) 2KΩ TBC
- Penultimate Driver (acquisition mode) TBC

Explanation/description/references:
From E040374-01

1.1.2.2.6.1 Anti-Aliasing, Whitening and ADC

Requirement:
TBD

Explanation/description/references:
TBD

1.1.2.2.6.2 DAC, Anti-Imaging and De-Whitening

Requirement:

The coil drive electronics shall de-emphasize the coil driver signals as follows:-

- Top Mass and Upper Intermediate Mass coil drivers shall be de-emphasized by 2 poles nominally co-located at 1Hz and 2 zeros at 10Hz. TBC
- Penultimate Mass coil driver (science mode) shall be de-emphasized by 2 poles nominally co-located at 1Hz and 2 zeros at 10Hz. TBC
- Penultimate Mass coil driver (acquisition mode) shall be de-emphasized by TBC

Explanation/description/references:
The requirement for pole and zero locations is discussed in TBC

1.1.2.3 Environmental

1.1.2.3.1 Thermal

Requirement:
If located in the LVEA (as indicated above) then no fans are permitted and the total dissipation for the rack is < 2 kW with an ambient temperature of 22 ± 2 C.

If located in the CDS Rack Room, then the thermal environment is typical of modules in a VME rack with forced air cooling.

Explanation/description/references:
None.

1.1.2.3.2 OSEM Satellite Box Local Diagnostics

Requirement:

It is required to include the provision for enabling testing and diagnostics of the OSEM Satellite Box signals local to the equipment. Single-ended measurements of key quantities should be possible using standard multi-meter kit.

The electrical connection to the Satellite Box local diagnostics port is via a male normal density 37 way D type connector mounted on the front of the sub-rack unit. The pin allocations are as shown below.

Table 8: OSEM Satellite Electronics Module Local Monitor Port Pin-Outs (Fig. 2 K)

Pin #	Signal Name	Description
1	I mon A	LED Current Monitor A
2	V mon A	LED Voltage Monitor A
3	PD A+	Photodiode Amp A Output
4	I mon B	LED Current Monitor B
5	V mon B	LED Voltage Monitor B
6	PD B+	Photodiode Amp B Output
7	I mon C	LED Current Monitor C
8	V mon C	LED Voltage Monitor C
9	PD C+	Photodiode Amp C Output
10	I mon D	LED Current Monitor D
11	V mon D	LED Voltage Monitor D
12	PD D+ D	Photodiode Amp D Output
13	Coil A + Mon	
14	Coil B + Mon	
15	Coil C + Mon	
16	Coil D + Mon	
17	-14v	- 14v monitor (-7v)
18	+5V MON	+ 14v monitor (5v)
19	Shield	
20	Ref GND A	V & I mon A gnd
21		
22	PD A gnd	PD A gnd
23	Ref GND B	V & I mon B gnd
24		
25	PD B gnd	PD B gnd
26	Ref GND C	V & I mon C gnd
27		
28	PD C gnd	PD C gnd
29	Ref GND D	V & I mon D gnd

30	PD D gnd	PD D gnd
31	Coil A - Mon	
32	Coil B - Mon	
33	Coil C - Mon	
34	Coil D - Mon	
35	+14v	+ 14v monitor (7v)
36	0vA	
37	0vd	

1.1.2.3.3 OSEM Electronics Rack Local Diagnostics

Requirement:

It is required to include the provision for enabling testing and diagnostics of the OSEM Electronics Rack Modules local to the equipment. Single-ended measurements of key quantities should be possible using standard multi-meter kit.

The electrical connection to the OSEM Electronics Rack Module local diagnostics port is via a male normal density 25 way D type connector TBC mounted on the front of the sub-rack unit. TBC The pin allocations are as shown below.

Table 9: OSEM Electronics Rack Module Remote Monitor Port Pin-Outs (Fig. 2 J)

Pin #	Signal Name	Description
TBD	TBD	TBD
TBD	TBD	TBD
TBD	TBD	TBD
TBD	TBD	TBD

1.1.2.3.4 OSEM Electronics Rack Remote Diagnostics

Requirement:

It is required to include the provision for enabling testing and diagnostics of the OSEM Electronics Rack Modules remotely from the equipment. Differential measurements of key quantities should be possible interfacing to the EPICS system.

The electrical connection to the OSEM Electronics Rack Module remote diagnostics port is via a male normal density 25 way D type connector TBC mounted on the front of the sub-rack unit. TBC The pin allocations are as shown below.

Table 10: OSEM Electronics Rack Module Local Monitor Port Pin-Outs (Fig. 2 I)

Pin #	Signal Name	Description
TBD	TBD	TBD

TBD	TBD	TBD
TBD	TBD	TBD
TBD	TBD	TBD

1.1.2.4 ICD Verification Matrix

TBD

1.1.3 ESD Electronics

1.1.3.1 Physical Interfaces

1.1.3.1.1 Location

Requirement:
The ESD Electronics will be located in the LVEA (TBR), at floor level, near the ETM BSC vacuum chamber with the associated ETM Suspension. The specific locations for each chamber and the associated cable lengths are indicated in Drawing TBD.

Explanation/description/references:
The ESD signal is low noise and sensitive. The ESD Electronics may need to be in close proximity to the vacuum electrical feed-throughs to keep the cable lengths short and the EMI minimized. TBR
The specific location of the ESD Electronics is needed to permit the SUS/US group to cable up to the modules and to arrange for, or provide, any needed infrastructure such as electrical power. We currently do not anticipate mounting the ESD Electronics at the elevation of the electrical feed-throughs (117.5 inch (2.98 m) above the floor).

Historical Notes:
None

1.1.3.1.2 Envelope & Attachment

Requirement:
The EMC compliant ESD Electronics box shall fit standard 19 inch wide rack mounting with a height of TBD U and a depth of TBD inches (TBD mm). The rack structure, and any sub-rack units (if required), used to mount the ESD Electronics module shall be provided by SUS/UK. The overall dimensions of the Rack are TBD.

Explanation/description/references:
Virtually all LIGO electronics fit standard 19 inch racks, so seems natural to use this standard here as well; also consistent with E040379-01.

Historical Notes:
None

1.1.3.2 Electronic/Electrical Interfaces

1.1.3.2.1 Power Interface

Power is provided to the ESD Electronics by SUS/US.

1.1.3.2.1.1 Rack Power Interface Connection

Requirement:

The low voltage power supply connector for the ESD Rack or sub-rack will be of type TBC and pin-out as follows. The Connector is located on the sub-rack backplane PCB. TBC

Table 11: LV ESD Electronics Rack Power Interface Pin-Outs (Fig. 2 A)

Pin #	Signal Name	Description
TBC		

The high voltage power supply connector for the ESD Rack or sub-rack will be of type TBC and pin-out as follows. The Connector is located on the sub-rack backplane PCB. TBC

Table 12: HV ESD Electronics Rack Power Interface Pin-Outs (Fig. 2 A)

Pin #	Signal Name	Description
TBC		

Explanation/description/references:

From E040379-01

1.1.3.2.1.2 Power Supply Requirements

Requirement:

The ESD Electronics module 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)

Since the power supplies will be located at some distance from the rack, local regulation will be provided at board level for the LV analogue supplies. Regulation will also be provided on the HV rails if required *(This requires some investigation to confirm.)*

Explanation/description/references:

From E040379-01

1.1.3.2.2 Command Signals

1.1.3.2.2.1 Cabling/Connector Requirements

Requirement:

The Electrical Connection to the Electrostatic Actuator Drive Electronics Module is via two female normal density 15 way D type connector mounted on the front face of the rack-mounted unit. The pin allocations are as shown below. Pairing is 5-12, 6-13, 7-14, 8-15 etc.

Table 13: ESD Electronics Rack Module High Level Command Signal Connector Pin-Outs (Fig. 2 D)

Pin #	Signal Name	Description
1	Signal Ground Return	
8	DLRH0+	Ch0 High Differential Line Receiver, + (i/p)
15	DLRH0-	Ch0 High Differential Line Receiver, - (i/p)
7	DLRH1+	Ch1 High Differential Line Receiver, + (i/p)
14	DLRH1-	Ch1 High Differential Line Receiver, - (i/p)

6	DLRH2+	Ch2 High Differential Line Receiver, + (i/p)
13	DLRH2-	Ch2 High Differential Line Receiver, - (i/p)
5	DLRH3+	Ch3 High Differential Line Receiver, + (i/p)
12	DLRH3-	Ch3 High Differential Line Receiver, - (i/p)
4	DLRH4+	Ch4 High Differential Line Receiver, + (i/p)
11	DLRH4-	Ch4 High Differential Line Receiver, - (i/p)
3	DLRH5+	Ch5 High Differential Line Receiver, + (i/p)
10	DLRH5-	Ch5 High Differential Line Receiver, - (i/p)
2	Signal Ground Return	
9	Signal Ground Return	

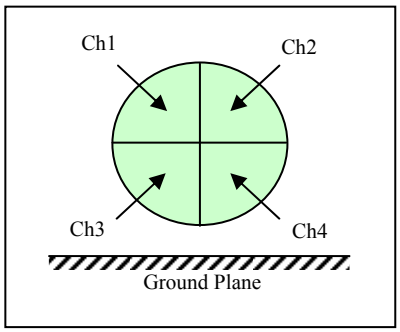
Note: ±10 V input generates ±400 V output from each channel.

Table 14: ESD Electronics Rack Module Low Level Command Signal Connector Pin-Outs (Fig. 2 D)

Pin #	Signal Name	Description
1	Signal Ground Return	
8	DLRL0+	Ch0 Low Differential Line Receiver, + (i/p)
15	DLRL0-	Ch0 Low Differential Line Receiver, - (i/p)
7	DLRL1+	Ch1 Low Differential Line Receiver, + (i/p)
14	DLRL1-	Ch1 Low Differential Line Receiver, - (i/p)
6	DLRL2+	Ch2 Low Differential Line Receiver, + (i/p)
13	DLRL2-	Ch2 Low Differential Line Receiver, - (i/p)
5	DLRL3+	Ch3 Low Differential Line Receiver, + (i/p)
12	DLRL3-	Ch3 Low Differential Line Receiver, - (i/p)
4	DLRL4+	Ch4 Low Differential Line Receiver, + (i/p)
11	DLRL4-	Ch4 Low Differential Line Receiver, - (i/p)
3	DLRL5+	Ch5 Low Differential Line Receiver, + (i/p)
10	DLRL5-	Ch5 Low Differential Line Receiver, - (i/p)
2	Signal Ground Return	
9	Signal Ground Return	

Note: ±10 V input generates ±40 V output from each channel.

Figure 7: ESD Quadrant Nomenclature



Reaction Mass Mask Normal View

Explanation/description/references:
None

1.1.3.2.2.2 Electrical Properties

Requirement:
The ESD Electronics module handles a single ETM suspension that consists of 5 channels (4 quadrants and a bias channel).

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

Explanation/description/references:
per E040379-01

1.1.3.2.3 High Voltage Drive Signals

Requirement:
Electrical connection to the ESD Electronics Rack Module 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):

Table 15: ESD Electronics Rack Module Output Pin-Outs (Fig. 2 C)

Pin #	Signal Name	Description
TBD	TBD	TBD

Explanation/description/references:
per E040379-01

1.1.3.3 Environmental

1.1.3.3.1 Thermal

Requirement:
If located in the LVEA (as indicated above) then no fans are permitted and the total dissipation for the ESD Electronics is < 2 kW with an ambient temperature of 22 ± 2 C.

If located in the CDS Rack Room, then the thermal environment is typical of modules in a VME rack with forced air cooling.

Explanation/description/references:
None.

1.1.3.3.2 ESD Electronics Rack Local Diagnostics

Requirement:

It is required to include the provision for enabling testing and diagnostics of the ESD Electronics Rack Modules local to the equipment. Single-ended measurements of key quantities should be possible using standard multi-meter kit.

The electrical connection to the ESD Electronics Rack Module local diagnostics port is via a male normal density 25 way D type connector TBC mounted on the front of the sub-rack unit. TBC The pin allocations are as shown below.

Table 16: ESD Electronics Rack Module Local Monitor Port Pin-Outs (Fig. 2 F)

Pin #	Signal Name	Description
TBD	TBD	TBD
TBD	TBD	TBD
TBD	TBD	TBD
TBD	TBD	TBD

1.1.3.3.3 ESD Electronics Rack Remote Diagnostics

Requirement:

It is required to include the provision for enabling testing and diagnostics of the ESD Electronics Rack Modules remotely from the equipment. Differential measurements of key quantities should be possible interfacing to the EPICS system.

The electrical connection to the ESD Electronics Rack Module remote diagnostics port is via a male normal density 15 way D type connector TBC mounted on the front of the sub-rack unit. TBC The pin allocations are as shown below.

Table 17: ESD Electronics Rack Module Remote Monitor Port Pin-Outs (Fig. 2 E)

Pin #	Signal Name	Description
1	Signal Ground Return	
8	TBD 0+	Ch0 Low Differential Line Driver, + (o/p)
15	TBD 0-	Ch0 Low Differential Line Driver, - (o/p)
7	TBD 1+	Ch1 Low Differential Line Driver, + (o/p)
14	TBD 1-	Ch1 Low Differential Line Driver, - (o/p)
6	TBD 2+	Ch2 Low Differential Line Driver, + (o/p)
13	TBD 2-	Ch2 Low Differential Line Driver, - (o/p)
5	TBD 3+	Ch3 Low Differential Line Driver, + (o/p)
12	TBD 3-	Ch3 Low Differential Line Driver, - (o/p)
4	TBD 4+	Ch4 Low Differential Line Driver, + (o/p)
11	TBD 4-	Ch4 Low Differential Line Driver, - (o/p)
3	TBD 5+	Ch5 Low Differential Line Driver, + (o/p)
10	TBD 5-	Ch5 Low Differential Line Driver, - (o/p)
2	Signal Ground Return	
9	Signal Ground Return	

1.1.3.4 ICD Verification Matrix

TBD