FLORIS Calibration Unit

Calibration Unit EICD

Doc :	FLX-ICD-ALM-CU-0002
Issue:	5:0
Date :	01.01.2019
DRD Code :	IF-02/DM-03

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Internal reference: ALM-PRO-3362

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Change Record

Modification	**Page**	**Iss.**	**Rev.**	**Date**
First Issue	all	1	0	18.12.2017
Functional logic and description added	§7/8	2	0	29.01.2018
AI-5 of FLX-MN-ALM-CU-0002: safe loop updated: hall sensor #4 is removed, switch #1 added is included. Change of 1 instead of 10 steps for the diffuser only.	21			
AI-6 of FLX-MN-ALM-CU-0002, CU control algorithm included in the EICD	21			
Switch Ground connected to cable shielding Correction of pin numbering for table 2/3	§5.1, table 1/2			
Connector definition pin out & electrical details updated Electrical scheme updated following CU-URR-RID-070 ICU/CU high level functionality removed (figure 2 of Issue 2) Update CU logic half step positioning removed Update sensors mvt step number changes marked by right border Grounding	§5 §5.1&5.2 §6 §7 §7 §8 all §8 all §9	3	0	13.07.2018

Modification	Page	Iss.	Rev.	Date
Pin-out tables and electrical details corrected to be in line with figure 1 Update mvt durations Nominal voltage for hall sensor and nominal voltage for baumer added	§5 §8 §5.2	3	1	02.08.2018
PDR-CU-AI #011: Current profiles for the motor are provided.	§9	4	0	01.01.2019
PDR-CU-AI #018: step 3 of “go to safe position from unknown position” corrected by “if not, go to step 4”.	§8.7			
PDR-CU-AI#077: Baumer GND wires removed	Table 2 / 3 / 6 / 7			
PDR-CU-AI#083: connector name correct in §5 are corrected	§5			
“thermistor Motor X” updated in “thermistor X Motor”, X being the number	table 2 / 3 / 6 / 7			
Step number 8’500 replaced by 8’499 in table 12 to be consistent	Table 12			
Hall sensor OMH3131S replaced by OMH090S	Appendix A			
PDR-CU-AI#076: Electrical drawings for motor and hall sensors and electrical data updated	§5.3 Appendix F			

Modification	**Page**	**Iss.**	**Rev.**	**Date**
Number of steps defined as "nominal" in §8	§8	4	0	20.11.2018
Pin out updated for power lines update : Phase A, Phase A return, Phase B, Phase B return	table 4,5,8,9			
Update §4 abbreviation	§4			
Connector reference added	§5.1			
EICD Drawing updated	Appendix D	5	0	01.02.2019
The connector references table is removed. DCL document mentioned as listing the connectors references.	§5.1			
Motor winding resistance updated to 54 Ohm instead of the 50 ohm	table 6/10/11			
Motor power updated to 10.951 W instead of the 9W.	table 10/11			
Section 10 added for harness description PDR-CU-AI#076: Signal category / EMC class /grouping	§11			

Contents

1 Introduction

1.1 Project Overview

The Earth Explorer - Fluorescence Explorer (FLEX) mission will map vegetation fluorescence to quantify photosynthetic activity.

The conversion of atmospheric carbon dioxide and sunlight into energy-rich carbohydrates through photosynthesis is one of the most fundamental processes on Earth – and one on which we all depend.

Information from FLEX will improve our understanding of the way carbon moves between plants and the atmosphere and how photosynthesis affects the carbon and water cycles.

In addition, information from FLEX will lead to better insight into plant health and stress. This is of particular relevance since the growing global population is placing increasing demands on the production of food and animal feed. At the moment, photosynthetic activity cannot be measured from space, but FLEX's novel sensor will observe this faint glow.

The FLEX satellite will orbit in tandem with one of the Copernicus Sentinel-3 satellites, taking advantage of its optical and thermal sensors to provide an integrated package of measurements.

Mission objectives can therefore summarized as follows:

- To assess the quality of fluorescence-derived photosynthesis data against classical optically-based methods (i.e. from fraction of absorbed photosynthetically active radiation times Light Use Efficiency).
- To address in more detail temporal and spatial scaling issues (from towers to satellite footprints).
- To identify and characterize the effects of different types of stress on fluorescence and photosynthesis (especially drought and freezing air temperatures).
- To indicate potential applications of the novel fluorescence observations.

Mission orbit:

- Orbit: Sun-synchronous
- Measurement altitude: 815 km

The FLEX Space Segment consists of a single satellite carrying the FLuORescence Imaging Spectrometer (FLORIS) push-broom instrument. This high-resolution imaging spectrometer will acquire data in the 500– 780 nm spectral range, with a sampling of 0.1 nm in the oxygen bands (759–769 nm and 686–697 nm) and 0.5–2.0 nm in the red edge, chlorophyll absorption and Photochemical Reflectance Index bands.

The monthly global maps will have an on-ground spatial resolution of 300 × 300 m2 with a swath width of 150 km.

1.2 Scope of the Document

The document defines the CU electrical interfaces, to ensure compatibility among involved interface ends by documenting form, fit, and function.

In addition, in order to provide to LDO with a self-standing document, the movement activation logic and the associated parameters are also reported in this document.

2 Responsibility

LDO is responsible for the connector definition of the Floris Calibration Unit electrical interfaces.

Almatech is responsible for defining the pin layout and the specification of the signal of each line used.

Almatech is responsible to deliver the electrical line and connector of the Floris Calibration Unit.

Almatech is responsible of providing the activation logic behind each type of movement. LDO is responsible of its implementation at ICU level.

LDO is responsible of the definition of the length of the external lines.

LDO is the approval authority.

3 Applicable and Reference Documents

3.1 Applicable Documents

Ref.	Title	Reference	Iss.
AD 105	Cover Letter	FLX-LET-FNM-INS-0003	3
AD 106	Special Condition of Tender	FLX-OF-FNM-INS-0001	4
AD 100	Contract for FLEX Unit/sub-system	Draft Contract	
AD 101	Generic Statement of Work for FLEX Unit/sub-system	FLX-SOW-FNM-INS-0001	2
AD 102	Specific Statement of Work	FLX-SOW-FNM-INS-0005	2
AD 103	Floris Calibration Unit User Requirement Specification	FLX-RS-FNM-INS-0006	5
AD 201	FLORIS Radiation Environment RS	FLX-RS-FNM-INS-0016	4
AD 202	FLEX FEMM Requirements Specification	FLX-RS-FNM-INS-0023	1
AD 203	FLEX GMM &TMM Requirements Specification	FLX-RS-FNM-INS-0024	1
AD 204	FLEX CAD Model Requirements Specification	FLX-RS-FNM-INS-0025	1
AD 205	FLEX Cleanliness Requirements for Sub-contractors	FLX-RS-FNM-INS-0028	3
AD 206	FLEX Instrument General Design Interface Requirements	FLX-RS-FNM-INS-0029	3
AD 208	FLEX PA Requirements for Subcontractors	FLX-RS-FNM-INS-0021	2
AD 209	FLEX PA SW Requirements for Subcontractors	FLX-RS-FNM-INS-0022	1
AD 210	FLEX Configuration Control and Documentation Management Plan	FLX-PL-FNM-INS-0001	3
AD 211	FLEX List of Acronyms and Abbreviations	FLX-LI-FNM-INS-0003	2

3.2 Reference Documents

Ref.	Title	Reference	Iss.	Date
[RD01]	FLORIS Calibration Unit Almatech Proposal	17-10S-225	1.0	15.06.2017
[RD02]	Leonardo Clarification Letter	FLX-LET-FNM-INS-0009	--	18.10.2017
[RD03]	Floris CU Negotiation Meeting #1 between Leonardo and Almatech	FLX-MIN-FNM-INS-0041		15.11.2017
[RD04]	FLORIS Calibration Unit – EICD	FLX-ICD-ALM-CU-0002	C	28.01.2019
[RD05]	FLORIS Calibration Unit, Functional Analysis Report	FLX-RP-ALM-CU-0002	2.0	31.08.2018
[RD06]	Phytron document, Project: Almatech Flex, Technical description	-	1.0	13.06.2018
[RD07]	Floris Calibration Unit, Declared Component List	FLX-LI-ALM-CU-0013	2.0	17.01.2019
[RD08]	Floris Calibration Unit, Motor Power Consumption	FLX-RFD-ALM-CU-0017	1.0	01.02.2019

4 Acronyms and Abbreviations

The abbreviations and acronyms used in this document are in accordance with [AD 211].

Abbrev.	Description	Abbrev.	Description
BS	Baumer Switch	MN1	Motor Nominal 1- Phase A
BS1N	Baumer Switch #1 Nominal	MN2	Motor Nominal 2 – Phase A return
		MN3	Motor Nominal 3 – Phase B
		MN4	Motor Nominal 4 – Phase B return
BS2R	Baumer Switch #2 Redundant	MR1	Motor Redundant 1- Phase A
		MR2	Motor Redundant 2 – Phase A return
BS3N	Baumer Switch #3 Nominal	MR3	Motor Redundant 3 – Phase B
		MR4	Motor Redundant 4 – Phase B return
BS4R	Baumer Switch #4 Redundant	TM3N	Thermistor #3 Motor Nominal
HS	Hall Sensor	TM4R	Thermistor #4 Motor Redundant
HS1N	Hall Sensor #1 Nominal	TI1N	Thermistor Interface #1 Nominal
HS1R	Hall Sensor #1 Redundant	TI2R	Thermistor Interface #2 Redundant
HS2N	Hall Sensor #2 Nominal		
HS2R	Hall Sensor #2 Redundant		
HS4N	Hall Sensor #4 Nominal		
HS4R	Hall Sensor #4 Redundant		

5 Interface Definition

The Calibration unit is provided with end wires and 4 connectors and a bonding stud:

- DBM44S main signal line (connector J33)
- DBM44S redundant signal line (connector J133)
- DAM15P main power line (connector J34)
- DAM15P redundant power line (connector J134)
- Bonding Stud M4 (ALM-DES-225-0117)

Table 1: Connector Definition

Connector Ref	Type	Number of Contacts	Type of contact
DBM44S	DBM	44	Socket (female)
DAM15P	DAM	15	Pin (male)

5.1 Connectors References

The connector references for the Flight model are described in the Declared Component List document, see [RD07].

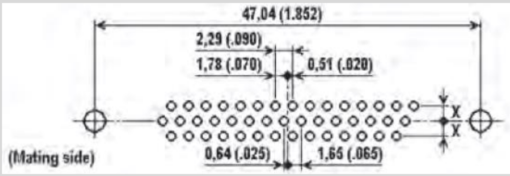
5.2 Connectors Pin Out

The connectors pin list is reported in Table 2 to Table 5.

Refer to §4 for abbreviations used for the signal and power lines of CU.

Table 2: Main signal line connector IF to ICU

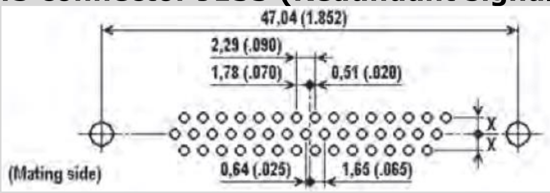
DBM44S connector J33 (Nominal signal lines)



Pin n°	Pin duty	Pin n°	Pin duty	Pin n°	Pin duty
1	Hall sensor 1 (HS1N) Ground	16	Hall sensor 1 (HS1N) VCC	31	Hall sensor 1 (HS1N) Output
2	-	17	-	32	-
3	Hall sensor 2 (HS2N) Ground	18	Hall sensor 2 (HS2N) VCC	33	Hall sensor 2 (HS2N) Output
4	-	19	-	34	-
5	Hall sensor 4 (HS4N) Ground	20	Hall sensor 4 (HS4N) VCC	35	Hall sensor 4 (HS4N) Output
6	-	21	-	36	-
7	-	22	Baumer Switch 1 (BS1N) VCC	37	Baumer Switch 1 (BS1N) Output
8	-	23	-	38	-
9	-	24	-	39	-
10	-	25	-	40	-
11	-	26	Baumer Switch 3 (BS3N) VCC	41	Baumer Switch 3 (BS3N) Output
12	-	27	-	42	-
13	-	28	-	43	-
14	-	29	Thermistor 3 Motor (TM3N)	44	Thermistor 3 Motor (TM3N)
15	Thermistor Interface 1 (TI1N)	30	Thermistor interface 1 (TI1N)		

Table 3: Redundant signal line connector IF to ICU

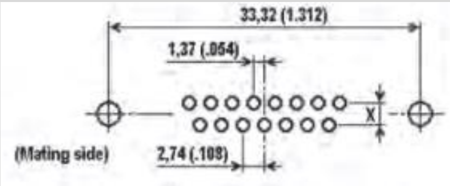
DBM44S connector J133 (Redundant signal lines)



Pin n°	Pin duty	Pin n°	Pin duty	Pin n°	Pin duty
1	Hall sensor 1 (HS1R) Ground	16	Hall sensor 1 (HS1R) VCC	31	Hall sensor 1 (HS1R) Output
2	-	17	-	32	-
3	Hall sensor 2 (HS2R) Ground	18	Hall sensor 2 (HS2R) VCC	33	Hall sensor 2 (HS2R) Output
4	-	19	-	34	-
5	Hall sensor 4 (HS4R) Ground	20	Hall sensor 4 (HS4R) VCC	35	Hall sensor 4 (HS4R) Output
6	-	21	-	36	-
7	-	22	-	37	-
8	-	23	-	38	-
9	-	24	Baumer Switch 2 (BS2R) VCC	39	Baumer Switch 2 (BS2R) Output
10	-	25	-	40	-
11	-	26	-	41	-
12	-	27	-	42	-
13	-	28	Baumer Switch 4 (BS4R) VCC	43	Baumer Switch 4 (BS4R) Output
14	-	29	Thermistor 4 Motor (TM4R)	44	Thermistor 4 Motor (TM4R)
15	Thermistor Interface 2 (TI2R)	30	Thermistor interface 2 (TI2R)	-	-

Table 4: Main power line connector IF from ICU

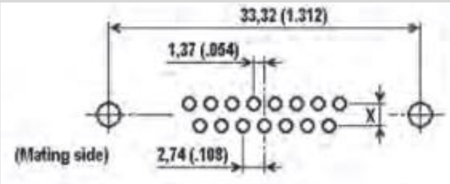
DAM15P connector J34 (Main power lines)



Pin n°	Pin duty	Pin n°	Pin duty
1	Motor Nominal 1 (MN1) Phase A	9	
2	Motor Nominal 2 (MN2) Phase A return	10	
3	Motor Nominal 3 (MN3) Phase B	11	
4	Motor Nominal 4 (MN4) Phase B return	12	
5		13	
6		14	
7		15	
8			

Table 5: Redundant power line connector IF from ICU

DAM15P connector J134 (Redundant power lines)



Pin n°	Pin duty	Pin n°	Pin duty
1	Motor Redundant 1 (MR1) Phase A	9	
2	Motor Redundant 2 (MR2) Phase A return	10	
3	Motor Redundant 3 (MR3) Phase B	11	
4	Motor Redundant 4 (MR4) Phase B return	12	
5		13	
6		14	
7		15	
8			

5.3 Electrical details

A general electrical drawing is available in Appendix F.

The winding drawings for the motor is detailed in Figure 1 and the motor phase properties are detailed in Table 6.

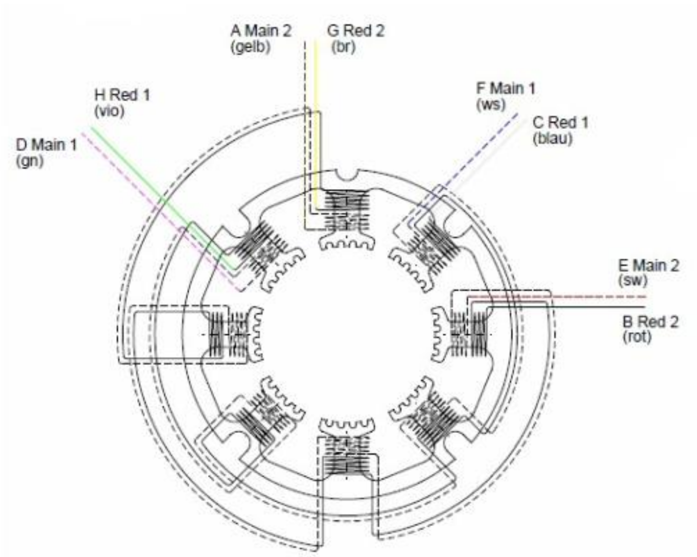


Figure 1: Motor main and redundant windings – Winding Schema [RD06]

Table 6: Motor Phases Properties [RD06]

Motor Phase properties	Value	Tolerances
Resistance per phase	54 Ohm	+/- 10%
Inductance per phase	50 mH	+/- 20%

Table 7: connector J33 DBM44S electrical data details

connector J33 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
1	Hall sensor 1 (HS1N) Ground				C2=20 pF between Ground & Output	max:0.25
2						
3	Hall sensor 2 (HS2N) Ground				C2=20 pF between Ground & Output	max: 0.25
4						
5	Hall sensor 4 (HS4N) Ground				C2=20 pF between Ground & Output	max: 0.25
6						
7						
8						
9						
10						
11						
12						
13						
14						
15	Thermistor Interface 1 (TI1N)			1000 at 0°C		

connector J33 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
16	Hall sensor 1 (HS1N) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Ground	max: 0.25
17						
18	Hall sensor 2 (HS2N) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Ground	max: 0.25
19						
20	Hall sensor 4 (HS4N) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Ground	max: 0.25
21						
22	Baumer Switch 1 (BS1N) VCC	max 15VDC nom: 3.3 VDC	0.5 mA nominal, 33mA peak for maximum of 1 micro-second			
23						
24						
25						
26	Baumer Switch 3 (BS3N) VCC	max 15VDC nom: 3.3 VDC	0.5 mA nominal, 33mA peak for maximum of 1 micro-second			
27						

connector J33 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
28						
29	Thermistor 3 Motor (TM3N)			1000 at 0°C		
30	Thermistor Interface 1 (TI1N)			1000 at 0°C		
31	Hall sensor 1 (HS1N) Output	l				max: 0.25
32						
33	Hall sensor 2 (HS2N) Output					max: 0.25
34						
35	Hall sensor4 (HS4N) Output					max: 0.25
36						
37	Baumer Switch1 (BS1N) Output	15VDC max	Switch current: 2 DC max			
38						
39						
40						
41	Baumer Switch 3 (BS3N)Output	15VDC max	Switch current: 2 DC max			
42						

connector J33 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
43						
44	Thermistor 3 Motor (TM3N)			1000 at 0°C		

Table 8: connector J133 DBM44S electrical data details

connector J133 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
1	Hall sensor 1 (HS1R) Ground				C2=20 pF between Ground & Output	max:0.25
2						
3	Hall sensor 2 (HS2R) Ground				C2=20 pF between Ground & Output	max: 0.25
4						
5	Hall sensor 4 (HS4R) Ground				C2=20 pF between Ground & Output	max: 0.25
6						
7						
8						
9						
10						
11						
12						
13						
14						
15	Thermistor Interface 2 (TI2R)			1000 at 0°C		

connector J133 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
16	Hall sensor 1 (HS1R) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Ground	max: 0.25
17						
18	Hall sensor 2 (HS2R) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Ground	max: 0.25
19						
20	Hall sensor 4 (HS4R) VCC	min: 4.5 Max: 24 nom: 5	typ: 5 max: 5	R1=820 Ohm between VCC & output	C1=0.1µF between VCC & Groundl	max: 0.25
21						
22						
23						
24	Baumer Switch 2 (BS2R) VCC	max: 15VDC nom: 3.3 VDC	0.5 mA nominal, 33mA peak for maximum of 1 micro-second			
25						
26						
27						

connector J133 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
28	Baumer Switch 4 (BS4R) VCC	max: 15VDC nom: 3.3 VDC	0.5 mA nominal, 33mA peak for maximum of 1 micro-second			
29	Thermistor 4 Motor (TM4R)			1000 at 0°C		
30	Thermistor Interface 2 (TI2R)			1000 at 0°C		
31	Hall sensor 1 (HS1R) Output					max: 0.25
32						
33	Hall sensor 2 (HS2R) Output					max: 0.25
34						
35	Hall sensor4 (HS4R) Output					max: 0.25
36						
37						
38						
39	Baumer Switch2 (BS2R) Output	15VDC max	Switch current: 2 DC max			
40						
41						

connector J133 DBM44S						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**resistance [Ohm]**	**capacitance [F]**	**Power Dissipation [W]**
42						
43	Baumer Switch 4 (BS4R)Output	15VDC max	Switch current: 2 DC max			
44	Thermistor 4 Motor (TM4R)			1000 at 0°C		

Table 9: connector J34 DAM15P electrical data detail

connector J34 DAM15P						
Pin N°	**Pin duty**	**Voltage [V]**	**Current [mA]**	**Resistance [Ohm]**	**Inductance [mH]**	**Power Dissipation [W]**
1	Motor Nominal 1 (MN1) - Phase A	max: 27.5	max: 300	54 Ω (per phase) +/- 10%	50 mH (per phase) +/- 20%	10.951 W (two phase on), [RD08]
2	Motor Nominal 2 (MN2) – Phase A return					
3	Motor Nominal 3 (MN3) - Phase B					
4	Motor Nominal 4 (MN4) - Phase B return					
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Table 10: connector J134 DAM15P electrical data detail

<table>
<tr><th colspan="7">connector J134 DAM15P</th></tr>
<tr><th>Pin N°</th><th>Pin duty</th><th>Voltage
[V]</th><th>Current
[mA]</th><th>Resistance
[Ohm]</th><th>Inductance
[mH]</th><th>Power Dissipation
[W]</th></tr>
<tr><td>1</td><td>Motor Red 1 (MR1) – Phase A</td><td rowspan="4">max: 27.5</td><td rowspan="4">max: 300</td><td rowspan="4">54 Ω (per phase) +/- 10%</td><td rowspan="4">50 mH (per phase) +/- 20%</td><td rowspan="4">10.951 W (Two phase on), [RD08]</td></tr>
<tr><td>2</td><td>Motor Red 2 (MR2) - Phase A return</td></tr>
<tr><td>3</td><td>Motor Red 3 (MR3) – Phase B</td></tr>
<tr><td>4</td><td>Motor Red 4 (MR4) –Phase B return</td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>15</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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6 Electrical Scheme

In Figure 2 is presented the electrical scheme, in accordance with the tables above.

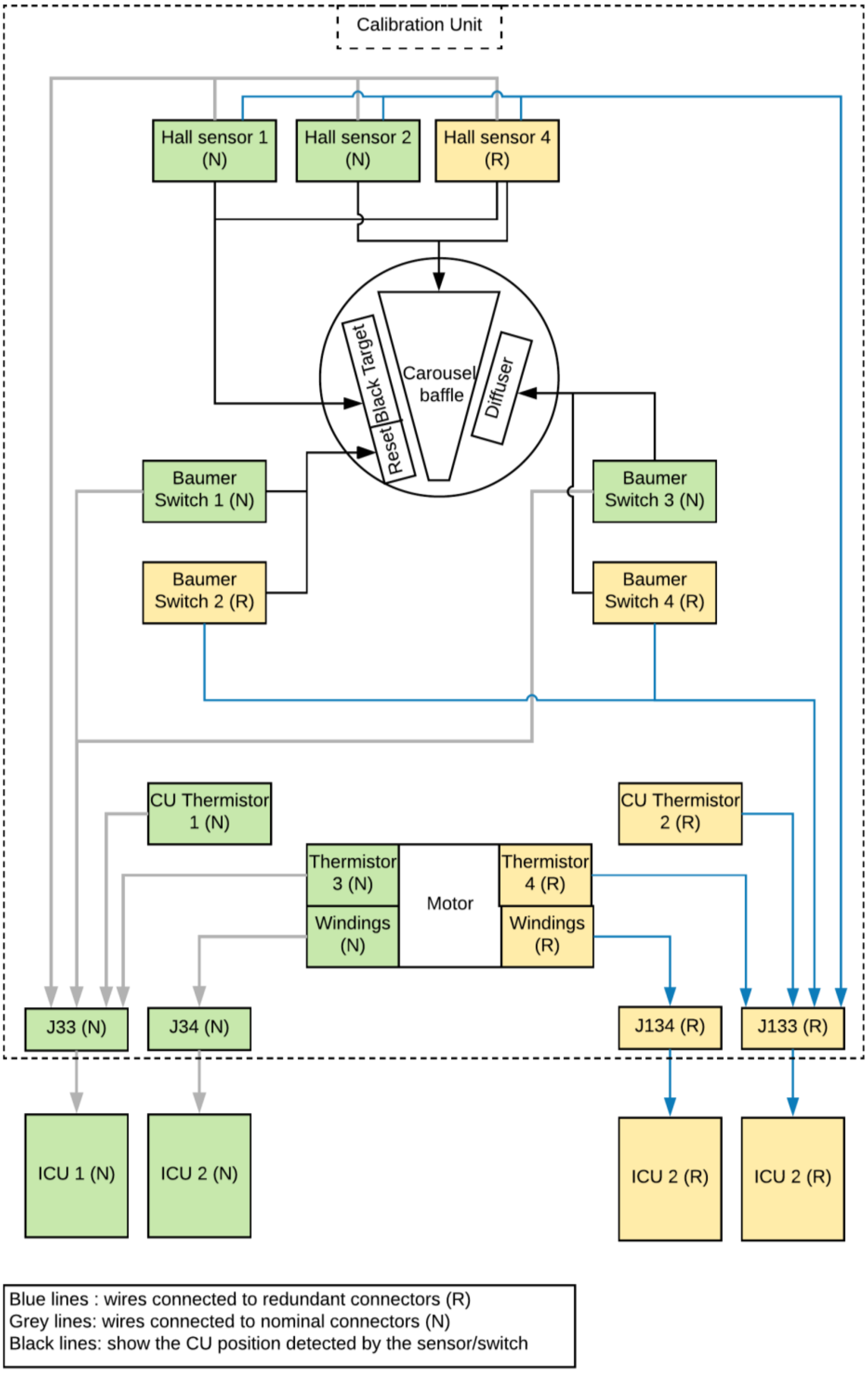


Figure 2: CU electrical scheme

7 Description of Functional Logic

In Figure 3, the event handling and function control of the CU is shown in form of a flowchart. The functions reported in Figure 3 are detailed in the functional tree (see §8).

Note also that the function "Go to position" includes the functionalities reported in §8.3 §8.4 and §8.5.

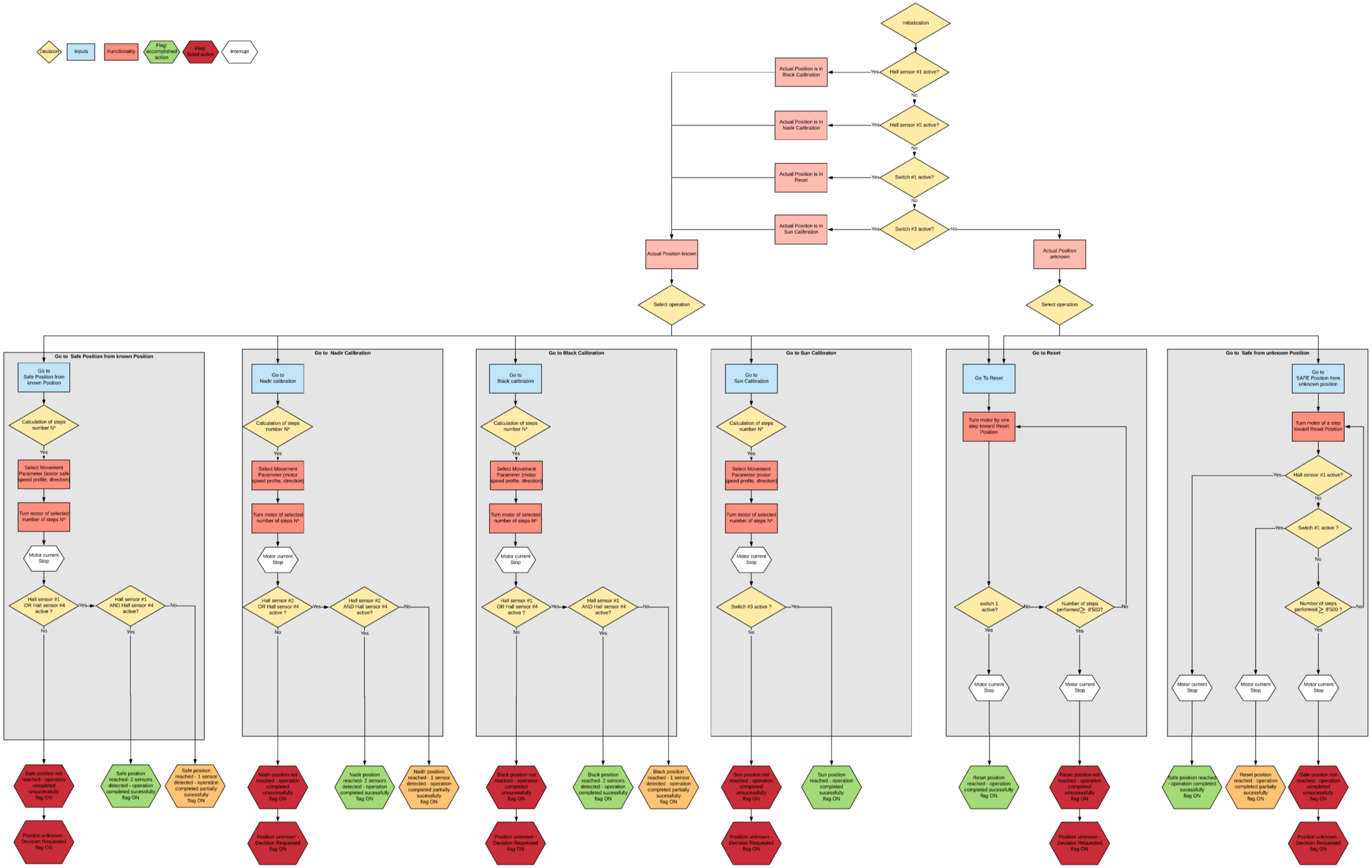


Figure 3: CU functional logic

8 Functional Tree

The Calibration Unit provides means to perform the following list of base functions:

- Carousel Current Position Identification
- Go to Black Calibration Position
- Go to Sun Calibration Position
- Go to Nadir position
- Go to Reset position
- Go to SAFE position from known position
- Go to SAFE position from unknown position

Each of the above functions are detailed in the section to follow. Depending on the instrument activity the above reported functions can be opportunely combined to achieve all the macro-movement defined in FLO-CU-URD-REQ-0960.

8.1 Carousel Current Position Identification

At any given time the current position knowledge is ensured by hall and Baumer switch sensors accordingly to Table 11.

Table 11: Carousel current position identification

Carousel Position	Logical status						
	Hall Sensor 1	**Hall Sensor 2**	**Hall Sensor 4**	**Baumer Switch 1**	**Baumer Switch 2**	**Baumer Switch 3**	**Baumer Switch 4**
Sun Calibration	0	0	0	0	0	1	1
Nadir position	0	1	1	0	0	0	0
Black Calibration = Launch position = SAFE position	1	0	1	0	0	0	0
Reset Position	0	0	0	1	1	0	0
Unknown position	0	0	0	0	0	0	0

8.2 Position and Movement Definition

The Nadir position is defined as the reference position at 0 degree (FLO-CU-URD-REQ-0180) and the other positions are expressed with respect to this reference position, see Figure 4.

The positive movement is defined as positive when going toward the Sun Calibration Position as shown in Figure 4.

The Black Calibration position is also the Safe and launch positions. The Reset position can also be considered as a safe position because this position ensures that no direct light enters inside the instrument.

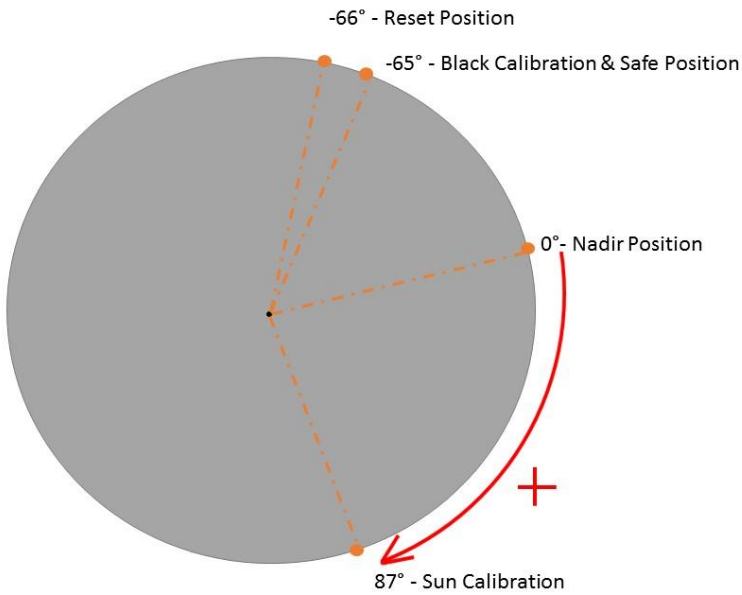


Figure 4: Position and Movement Definition

8.3 Go to Black Calibration Position

Depending on the results of the §7, the movement parameters are selected according to Table 12.

Table 12: Movement Parameters to perform function "Go to Black calibration position"

Carousel current position	Nominal Step number [-]	Micro- stepping [-]	Movement total time [sec]
Black calibration position	0	No	0
Sun calibration position	-8'444	No	~53.5
Nadir position	-3'611	No	~23.5
Reset position	+55	No	~0.5
Unknown	Go to Reset		

8.4 Go to Sun Calibration Position

Depending on the results of the §7, movement parameters are selected according to Table 13.

Table 13: Movement Parameters to perform function "Go to Sun calibration position"

Carousel current position	Nominal Step number [-]	Micro- stepping [-]	Movement total time [sec]
Black calibration position	+8’444	No	~53.5
Sun calibration position	0	No	0
Nadir position	+4’833	No	30
Reset position	+8’499	No	~54
Unknown		Go to Reset	

8.5 Go to Nadir Position

Depending on the results of the §7, movement parameters are selected according to Table 14.

Table 14: Movement Parameters to perform function “Go to Observation position”

Carousel current position	Nominal Step number [-]	Micro- stepping [-]	Movement total time [sec]
Black calibration position	+3’611	No	~23.5
Sun calibration position	-4’833	No	30
Nadir position	0	No	0
Reset position	+3’666	No	~24
Unknown		Go to Reset	

8.6 Go to Safe Position from known Position

Depending on the results of the §7, movement parameters are selected according to Table 15.

Table 15: Movement Parameters to perform function "Go to Safe position from known position"

Carousel current position	Step number [-]	Micro- stepping [-]	Movement total time [sec]
Black calibration position	0	No	0
Sun calibration position	-8'444	No	15
Nadir position	-3'611	No	~7
Reset position	+55	No	~0.5

8.7 Go to SAFE Position from Unknown Position

The following steps are performed following Figure 3.

1. The motor is activated to impose one step toward reset position.
2. Check the Hall Sensor #1 status.
    - If triggered, go to step 5
    - If not, go to step 3
3. Check the Baumer Switch #1 Status.
    - If triggered go to step 6
    - If not go to step 4
4. Check that the number of steps performed is equal or higher than 8'500 steps.
    - If yes, go to step 9
    - If not repeat step 1 and 2.
5. Hall Sensor #1 activation, cut the motor current. Go to step 7
6. Baumer Switch #1 activation, cut the motor current. Go to step 8.
7. Raise flag "Safe position reached – Operation completed successfully"
8. Raise flag " Reset position reached – Operation completed partially successfully"
9. Baumer Switch #1 not detected, cut the Motor current and raise flag " Safe position not reached – operation completed unsuccessfully" and flag "Position unknown – Decision Requested"

8.8 Go to Reset Position

The following steps are performed:

1. The motor is activated to impose one step toward Reset position.
2. Check Baumer switch #1 status.
    - If triggered go to step 4.
    - If not go to step 3.
3. Check that the number of steps performed is equal or higher to 8’500 steps.
    - If yes go to step 5
    - If not repeat steps 1 and 2.
4. Baumer switch #1 activation cut the motor current. Go to step 6
5. Cut the motor current and raise flag “Reset position not reached – operation completed unsuccessfully” and flag “Position unknown – Decision Requested”.
6. Raise flag “Reset Position Reached – operation completed successfully”

9 Current Profiles Proposal

The current profiles are defined in function of the kinematic movements defined in [RD05] which are discretized to perform a motor angle of 1.8° per full step. The "two phases ON" is applied following the direction rotation as defined in Table 16.

Table 16: "Two Phase on" sequence for clockwise and counter clockwise rotation (TBC by motor supplier)

Clockwise	Phase A	Phase B	Counter clockwise
	+	+	
	-	+	
	-	-	
	+	-	

The definition of the clockwise rotation is given with respect to the motor shaft with respect to the CU positions, see Figure 5 (TBC by motor supplier).

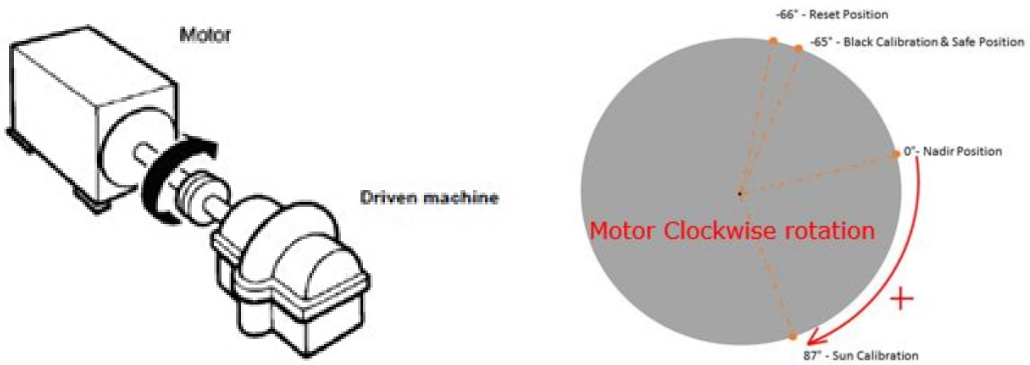


Figure 5: Clockwise motor rotation definition (TBC by motor supplier)

The current profiles are established to start and end each movement with the single phase on "A-" ensuring a stable static position (rotor alignment with the permanent dipole of the motor). It means that each movement start and end within a half step which is requested when switching from "single phase on" positions to "two phase on" positions and inversely, see Figure 7. In order to guarantee that the final positions are still within the tolerances and to integrate the additional half steps, the final number of steps are slightly different from the nominal number of steps determined in §8.

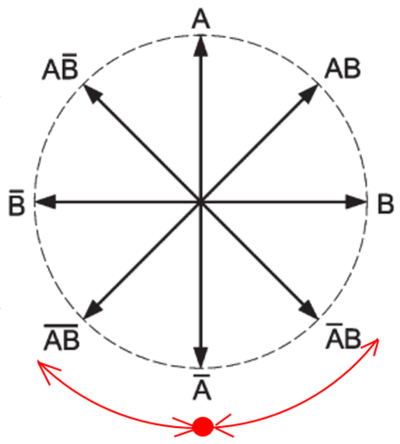


Figure 6: Half steps needed at the end/start of the movement in order to switch from "two phases on" positions to "single phase on" position (CW and CCW rotation)

The current profiles are available in the excel file "FLEX-ICD-ALM-0002-Current_Profiles_Proposal-Iss_4_0.xlsx" attached in this document and Table 17 and Table 18 lists the provided current profiles.

Remarks:

- These current profiles are TBC and will be updated with the tests results performed with EGSE.
- The Safe movement from Reset position to safe (black calibration) is not needed, because the reset position is already identified as a safe position.
- The movement from reset position to black position (mvt_6) does not use the movement kinetic equation due to the very short distance and time. Instead, a current profile with a constant speed is used.
- The current profiles starting from an unknown position start by activating the single phase on "A-" and this means that the motor can skip at worst 4x half steps at low speed in CW or CCW direction in the case where the motor was in a non-stable static position defined by "two phase on" (TBC by tests).
- The movements from unknown position have their current profiles only defined until to reach the constant speed phase. The constant speed phase is hold until one sensor is activated cutting the motor current.
    - When the motor is stopped after reset detection ("go to Reset from unknown position"), the rotor could be in a non-stable static position defined by "two phases on" or in a stable static position defined by a "single phase on" (TBC by tests). To stop the movement with the correct single phase on "A-", additional half steps after the detection might be necessary to be in line with next movement starting phase "A-". A maximum 7 half electrical steps in CCW direction (toward reset switch) shall be performed, see Figure 7. These steps will try to force the end-stop but will not result in a movement of the rotor.

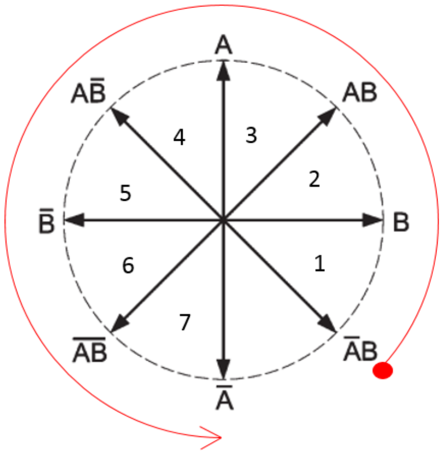


Figure 7: Additional electrical half steps in CCW direction needed after the Reset detection ("go to reset from unknown position) to start the next movement with phase "A-"

- When the safe position is detected during a movement "go to safe from unknown", the motor is cut whatever the motor phases active. After a safe movement it is advised to apply a movement "go to reset from unknown position" to reset the position and to be in line with the starting phase of the next movement.

- In order to perform a reverse movement from known position, the current profiles tables listed in Table 17 shall be performed in reverse order.

Table 17: Provided Current Profiles List (TBC) – Optimized to start/end with a "single phase on"

Mvt [-]	From: [-]	To: [-]	Optimized Step Number [-]
Safe_1	Sun Calibration	Safe	8'445
Safe_2	Nadir	Safe	3'613
Mvt_1	Nadir	Black	3'613
Mvt_2	Nadir	Sun Calibration	4'833
Mvt_3	Nadir	Reset	3'669
Mvt_4	Sun Calibration	Black Calibration	8'445
Mvt_5	Sun Calibration	Reset	8'501
Mvt_6	Black Calibration	Reset	57

Table 18: Provided Current Profile for movement from unknown position (TBC)

Mvt [-]	From: [-]	To: [-]	Motor rotation [-]	Comment [-]
Safe_unknown	Unknown	Safe	CCW	Provided profiles only defined until to reach the constant speed phase
Reset_unknown	Unknown	Reset	CCW	

10 Grounding

The Grounding of CU is performed by electrically connecting all parts/assemblies with metallic contacts with or without alodine.

10.1 Grounding of Main Assemblies

Table 19: Grounding of the Main Assemblies

Assemblies	Reference
CU Stator Assy	ALM-DES-225-0100
CU Rotor Assy	ALM-DES-225-0200
<u>Grounding:</u>	
The grounding between the CU stator assembly (blue) and the CU rotor assembly (green) is made by metallic contact through the harmonic drive and the ball bearing.	

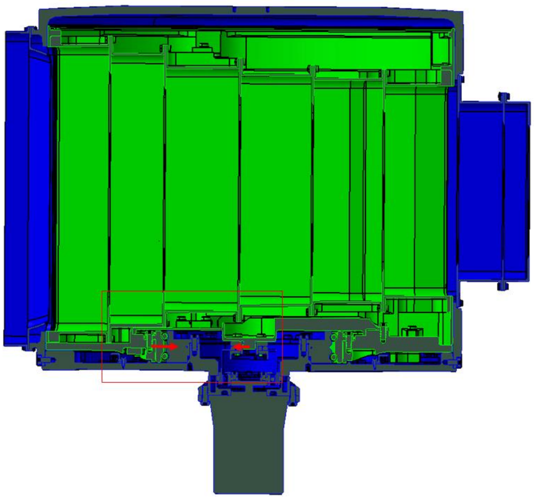


Figure 8: Grounding of Stator assembly (blue) and Rotor assembly (green)- cut view

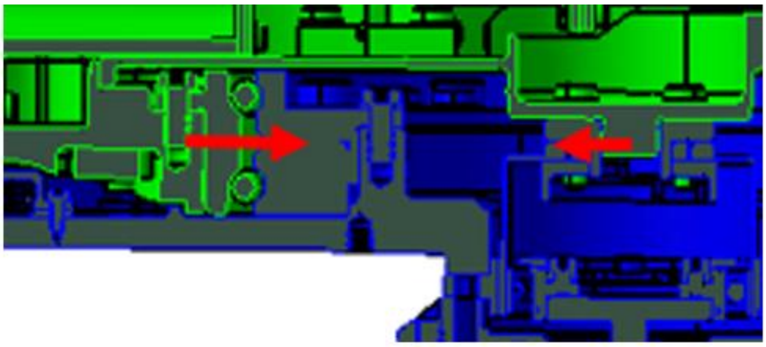


Figure 9: Zoom of grounding between Stator and Rotor assemblies

10.2 Grounding of Rotor Assembly

Table 20: Grounding between Ball Bearing Assembly and Carousel

Assemblies / Parts	Reference
Ball Bearing Assy	ALM-DES-225-0213
Carousel	ALM-DES-225-0201

Grounding:

The grounding between the Ball Bearing assembly (pink) and the Carousel (yellow) is made by metallic contact.

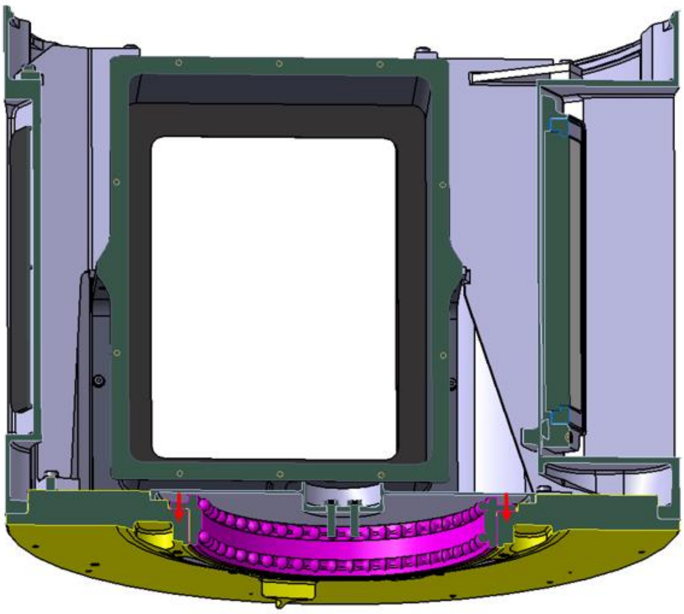


Figure 10: Grounding of Carousel (yellow) and Ball Bearing Assembly (pink)-cut view

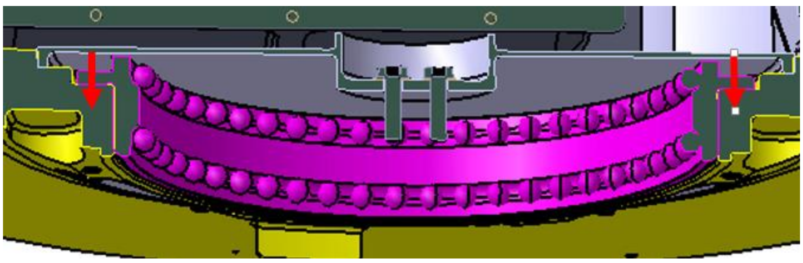


Figure 11: Zoom of grounding between Carousel and Rotor assembly

Table 21: Grounding Between Reflective Round Wall and Carousel

Assemblies / Parts	Reference
Reflective Round Wall	ALM-DES-225-0207
Carousel	ALM-DES-225-0201

Grounding:

The grounding between the Carousel (yellow) and the Reflective Wall (purple) is made by metallic contact.

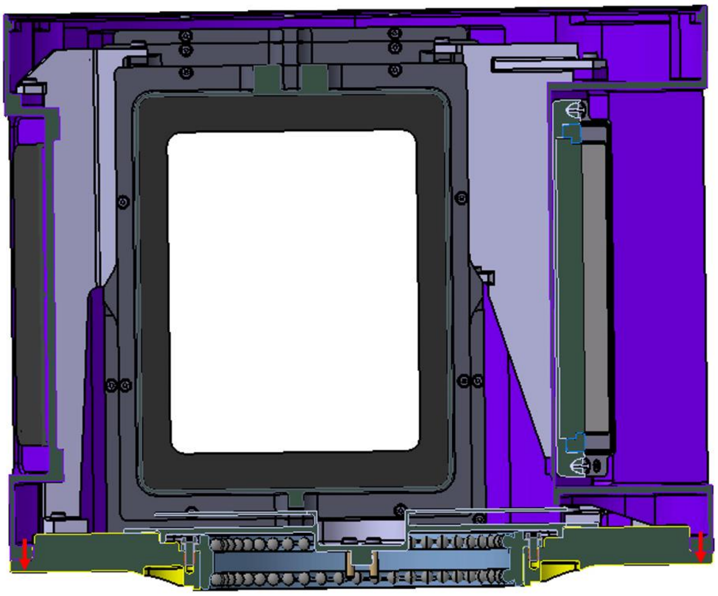


Figure 12: Grounding of Carousel (yellow) and Reflective Wall (purple) – cut view

Figure 13: Zoom of grounding between Carousel and Reflective Wall

Table 22: Grounding Between Reflective Wall, Carousel and Stiffeners and Nadir Baffle assembly

Assemblies / Parts	**Reference**
Reflective Round Wall	ALM-DES-225-0207
Carousel	ALM-DES-225-0201
Stiffener 1	ALM-DES-225-0215
Stiffener 2	ALM-DES-225-0216
Nadir Baffle Assy	ALM-DES-225-0300

Grounding:

The grounding between the Stiffeners (light blue) and the Carousel (yellow) is made by metallic contact, as well as the grounding between the Stiffeners with the Reflective Wall (purple).

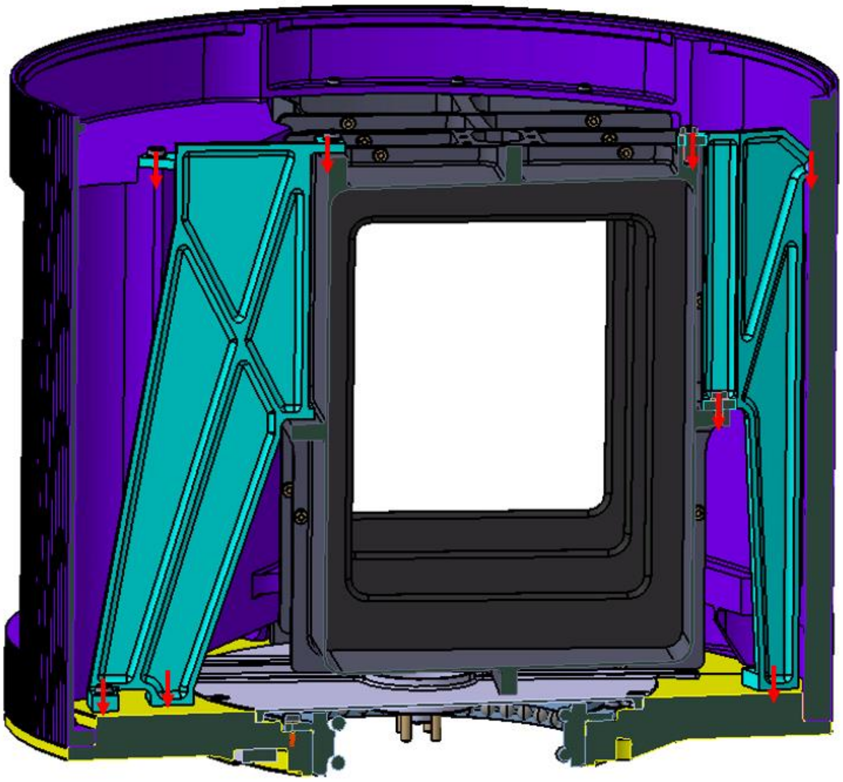


Figure 14: Grounding of stiffeners (light blue) with Carousel (yellow) and Reflective Wall (purple) and Nadir Baffle assembly (black)

Table 23: Grounding between Nadir Baffle, Reflective Wall and Carousel

Assemblies / Parts	Reference
Carousel	ALM-DES-225-0201
Nadir Baffle Assy	ALM-DES-225-0300
Reflective Round Wall	ALM-DES-225-0207
Grounding:	
The grounding between the Nadir Baffle assembly (black) and the Carousel (yellow) is made by metallic contact, as well as the grounding between the Nadir Baffle assembly with Reflective Wall (purple).	

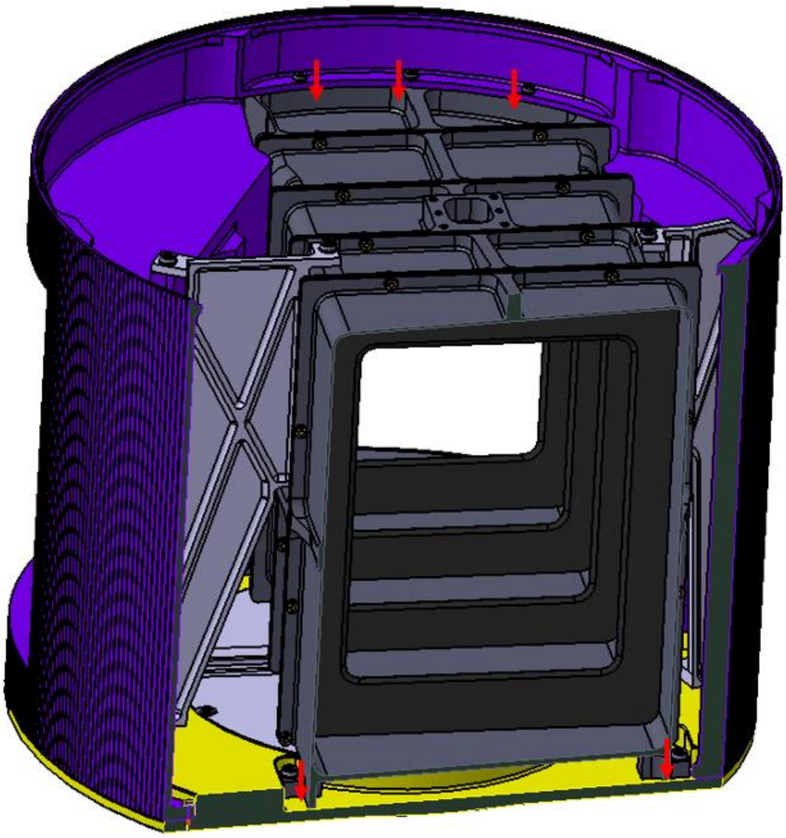


Figure 15: Grounding of Nadir Baffle assembly (black) with Carousel (yellow) and Reflective Wall (purple)

Table 24: Grounding between Bearing Cover and Carousel

Assemblies / Parts	Reference
Carousel	ALM-DES-225-0201
Bearing Cover	ALM-DES-225-0206
Grounding:	
The grounding between the Carousel (yellow) and the Bearing Cover (orange) is made by metallic contact.	

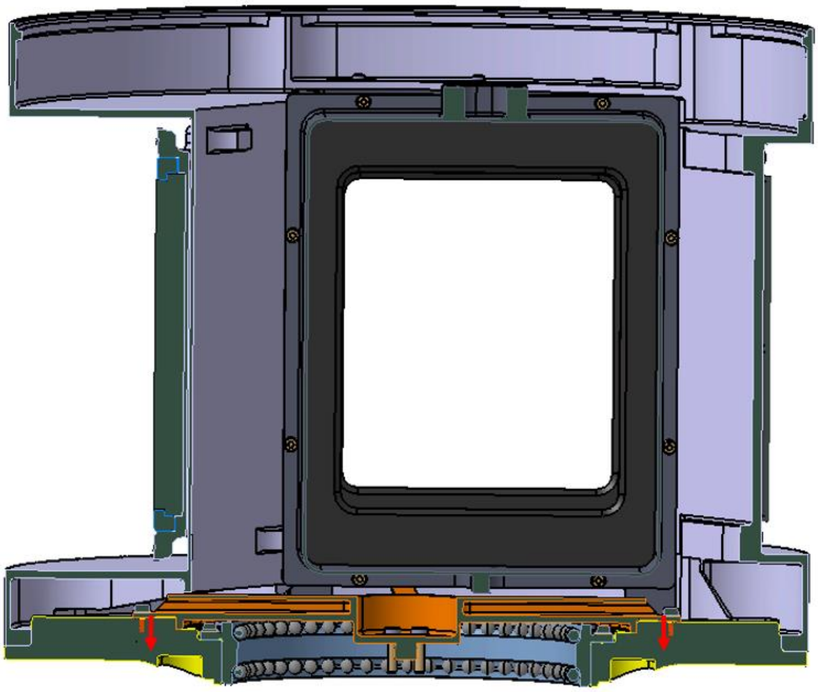


Figure 16: Grounding of Carousel (yellow) and Bearing Cover (orange) – cut view

Table 25: Grounding between Sun Diffuser and Reflective Wall

Assemblies / Parts	Reference
Reflective Round Wall	ALM-DES-225-0207
Sun Diffuser Assy	ALM-DES-225-0210

Grounding:
The grounding between the Sun Diffuser assembly (white) and Reflective Wall (purple) is made by metallic contact.

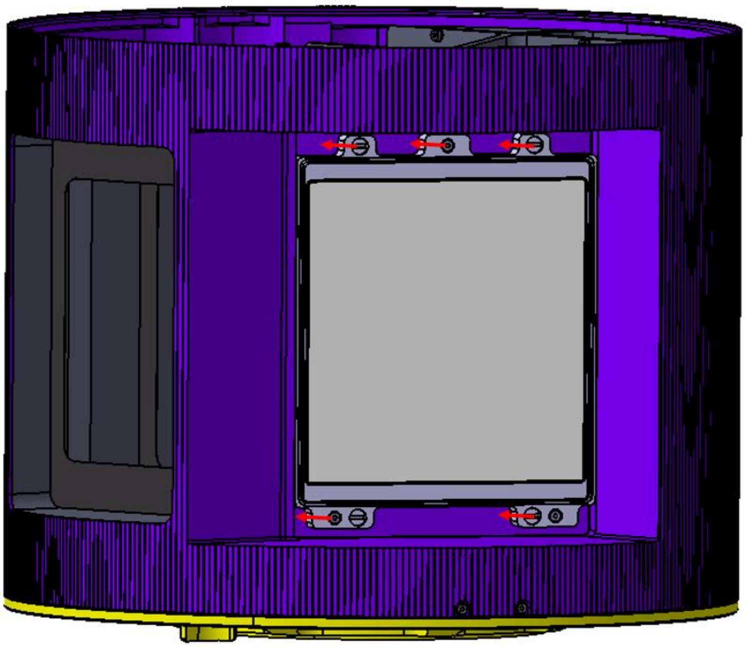


Figure 17: Grounding of Reflective Wall (purple) and Sun Diffuser assembly (white

Table 26: Grounding between Carousel and Magnetic Concentrator assembly

Assemblies / Parts	Reference
Magnetic Concentrator Assy	ALM-DES-225-0220
Carousel	ALM-DES-225-0201
Grounding: The grounding between the Magnetic Concentrator assembly (pink) and Carousel (yellow) is made by metallic contact.	

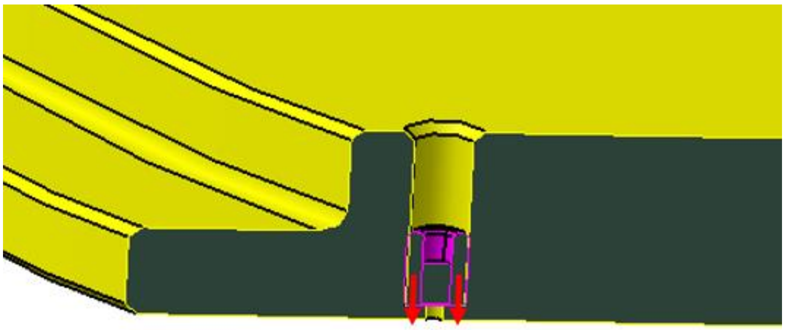


Figure 18: Grounding of Magnetic Concentrator assembly (pink) and carousel (yellow)

10.3 Grounding of Stator Assembly

Table 27: Grounding of the Harmonic Drive Assembly and the Base Support and Adapter

Assemblies / Parts	Reference
Base Support	ALM-DES-225-0101
Harmonic Drive Assy	ALM-DES-225-0129
Adapter	ALM-DES-225-0110
Grounding:	
The grounding between the Harmonic Drive assembly (blue) and the Base Support (light blue) is made by metallic contact, as well as the grounding between the Harmonic Drive assembly and the adapter (yellow)	

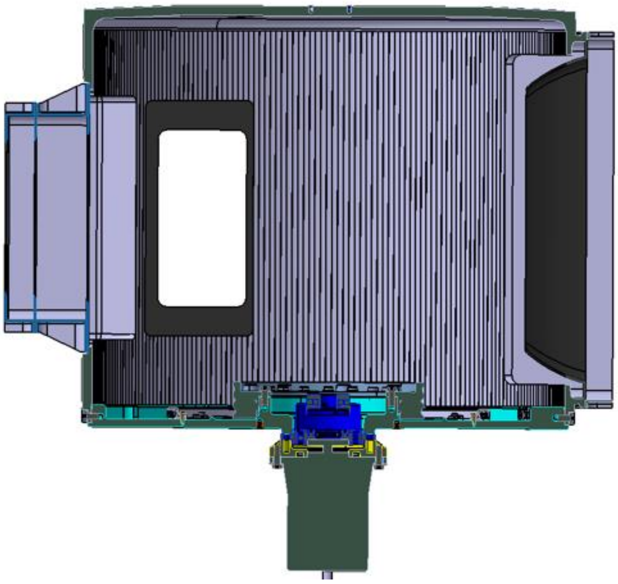


Figure 19: Grounding of Harmonic Drive assembly (blue) with Base support (light blue) and Adapter (yellow)-cut view

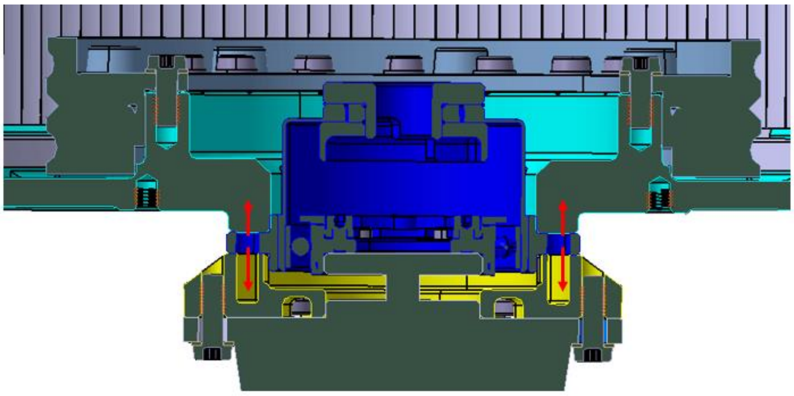


Figure 20: Zoom of grounding between the Harmonic Drive assembly with the Adapter and the Base Support

Table 28: Grounding between Motor and Adapter

Assemblies / Parts	Reference
Adapter	ALM-DES-225-0110
Motor	ALM-DES-225-0501
Grounding:	
The grounding between the Motor (red) and Adapter (yellow) is made by metallic contact	

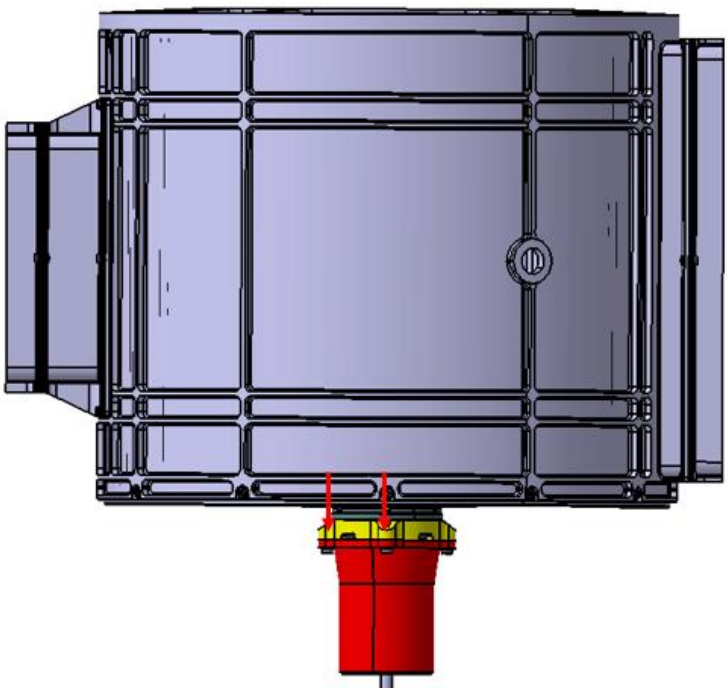


Figure 21: Grounding of Motor (red) with Adapter-cut view

Table 29: Grounding of Base Support with Housing and Ball Bearing assembly

Assemblies / Parts	Reference
Ball Bearing Assy	ALM-DES-225-0213
Base Support	ALM-DES-225-0101
Housing	ALM-DES-225-0102

Grounding:

The grounding between the Base Support (light Blue) and the Ball Bearing assembly (orange) is made by metallic contact, as well as the grounding between the Base Support and the Housing (green).

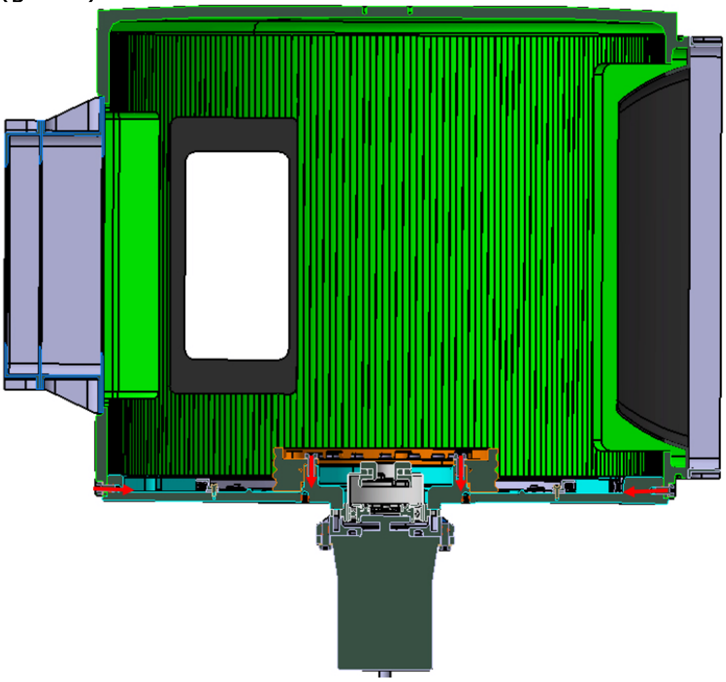


Figure 22: Grounding of Base Support (light blue) with Ball Bearing assembly (orange) and Housing (green)-cut view

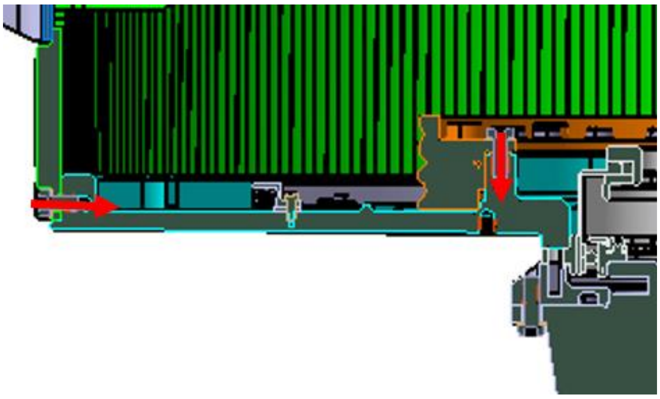


Figure 23: Zoom of Base Support grounding

Table 30: Grounding of Housing with Baffles and Apertures

Assemblies / Parts	Reference
Housing	ALM-DES-225-0102
Housing Junction Earth Aperture	ALM-DES-225-0114
Sun Baffle Assy	ALM-DES-225-0400
Stator Interbaffle	ALM-DES-225-0103
Housing Junction Instrument Aperture	ALM-DES-225-0108

Grounding:

The grounding between the Housing (green) and the Sun Baffle assembly (black) is made by metallic contact, as well as the grounding between the Housing with the Stator Interbaffle (brown) and the Housing Junction Earth Aperture (pink) and the grounding between the Interbaffle and the Housing Junction Instrument Aperture (yellow).

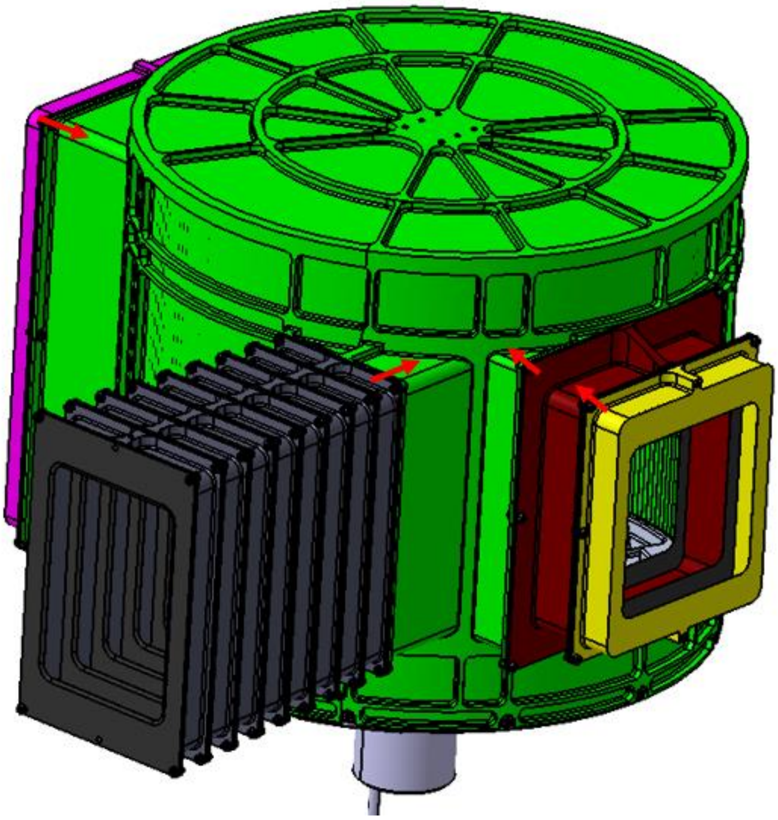


Figure 24: Grounding of Housing (green) with Sun Baffle assembly (black) and Interbaffle (brown) and Housing Junction Earth Aperture (pink) and Housing Junction Aperture (yellow)-cut view

11 Harness Description

The CU harness has to connect all electrical and electrical components to the connectors located outside the CU. Two separate harnesses are identified:

- Cables connecting electrical components located outside CU:
    - Motor cables
    - Motor thermistors cables
- Cables connection electrical component located inside CU:
    - Hall sensors cables
    - Switches cables
    - Interface thermistor cables

A global view of CU harness is showed in Figure 25. The cables are shielded when they are outside CU (in grey) and not shielded when they are inside CU (in blue).

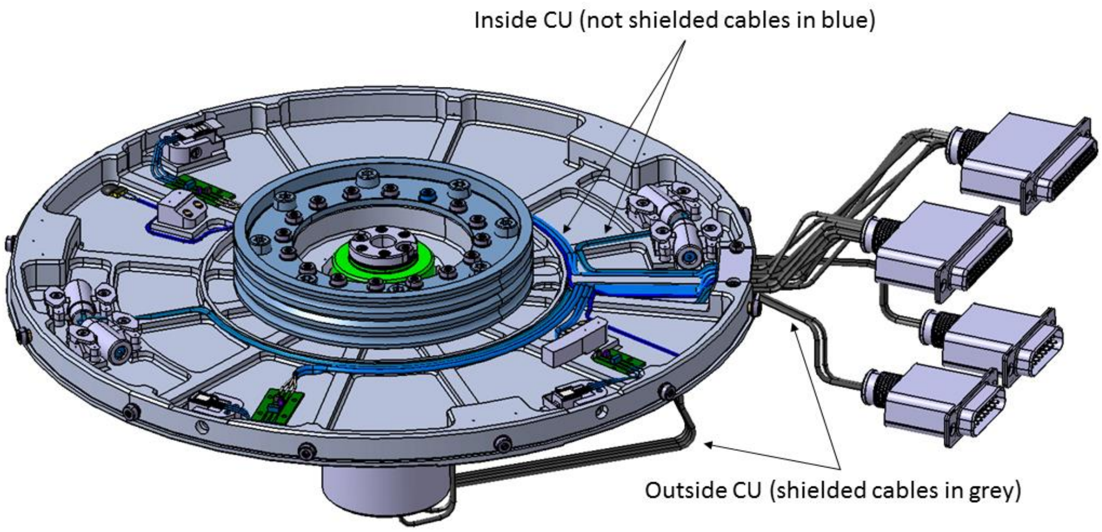


Figure 25: Harness Global view – Rotor assembly and Housing hidden

The cables are described in the following sections in terms of references, signal category, grouping and EMC classes as defined in Table 31.

Table 31: EMC Class Definition (FLO-INS-GDI-REQ-5340, [AD206])

EMC Class	Definition
1	Power (primary / secondary)
2	Digital signals, high level (non-sensitive) analogue signals (except RF)
3	Pyrotechnics
4	low level (sensitive) analogue signals
5	RF signals (via coaxial lines, waveguides, microwave transmission lines)

11.1 Cables of Components Located Outside CU

The routing of the motor cables and motor thermistors cables are showed in Figure 26. These cables are shielded all along their length, because they are always located outside CU.

These cables are briefly described in Figure 26 (refer to the EICD drawing in Appendix D and [RD07] for more details).

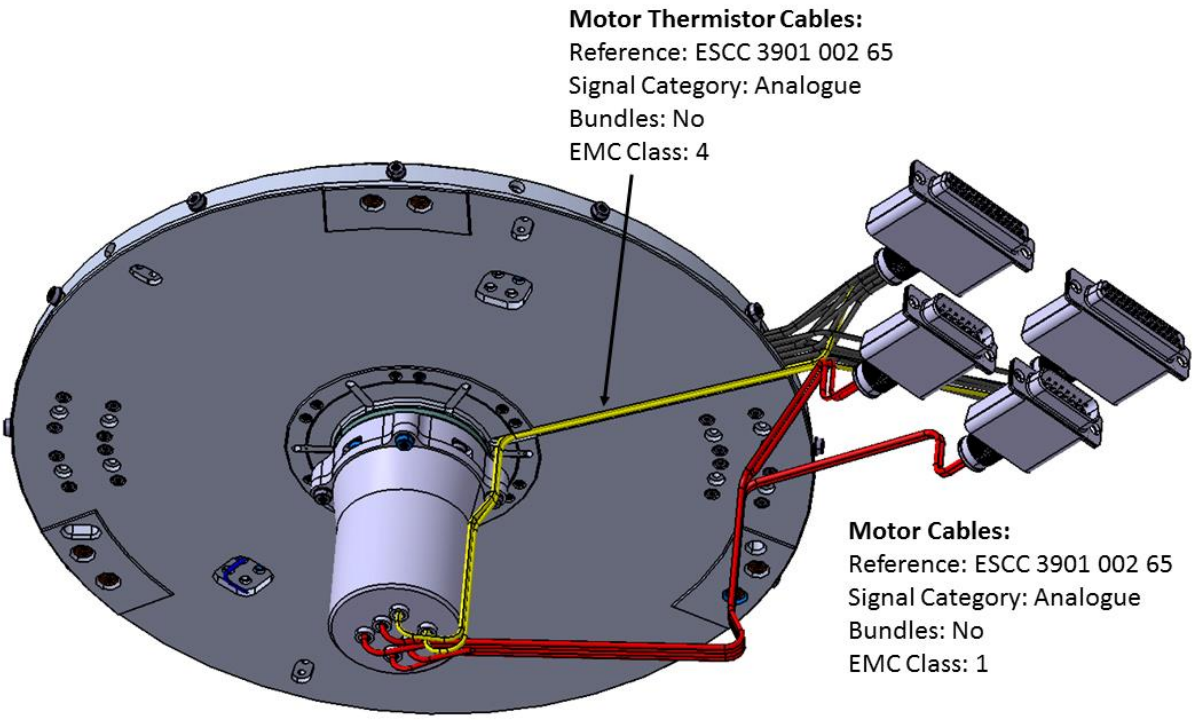


Figure 26: Motor (red) and Motor thermistor (yellow) cables routing and description

11.2 Cables of Components Located Inside CU

For the electrical/electronical components located inside CU, the cables are without shielding when inside CU, but with shielding when outside CU. In order to achieve this configuration, the shielding of a cable is removed along the necessary inside length and the remaining stays shielded until to reach the connector.

Each cable is passing through a feedthrough marking the transition from inside/outside CU as showed in Figure 27.

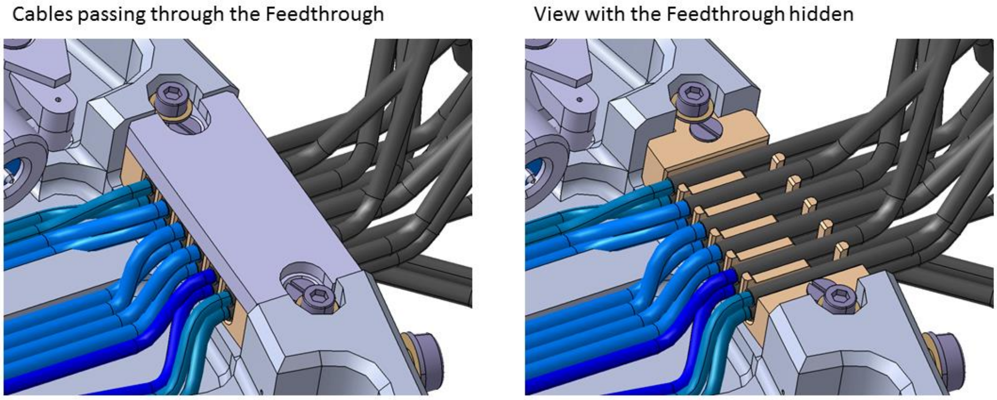


Figure 27: Feedthrough (in blue: Cables without shielding, in grey: cables with shielding)

The routing of the hall sensors cables are showed in Figure 28 and Figure 29 where they are briefly described (refer to the EICD drawing in Appendix D and [RD07] for more details).

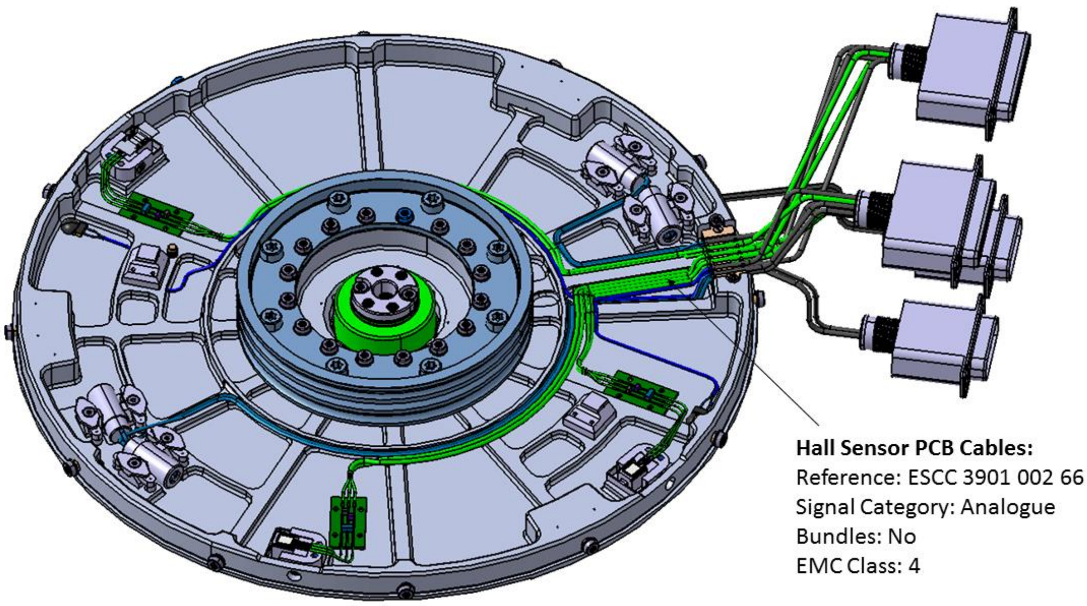


Figure 28: Hall sensor PCB to connector cables (in green) description and routing

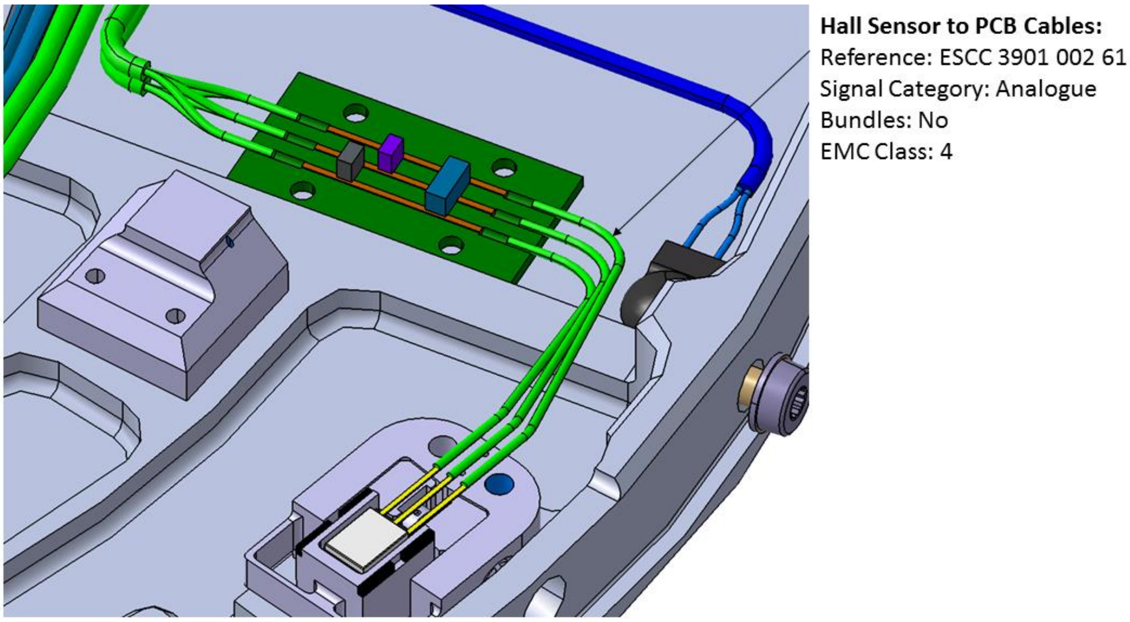


Figure 29: Hall sensor to PCB cable (in green) description and routing

The routing of the Interface Thermistor cables are showed in Figure 30 where they are briefly described (refer to the EICD drawing in Appendix D and [RD07] for more details).

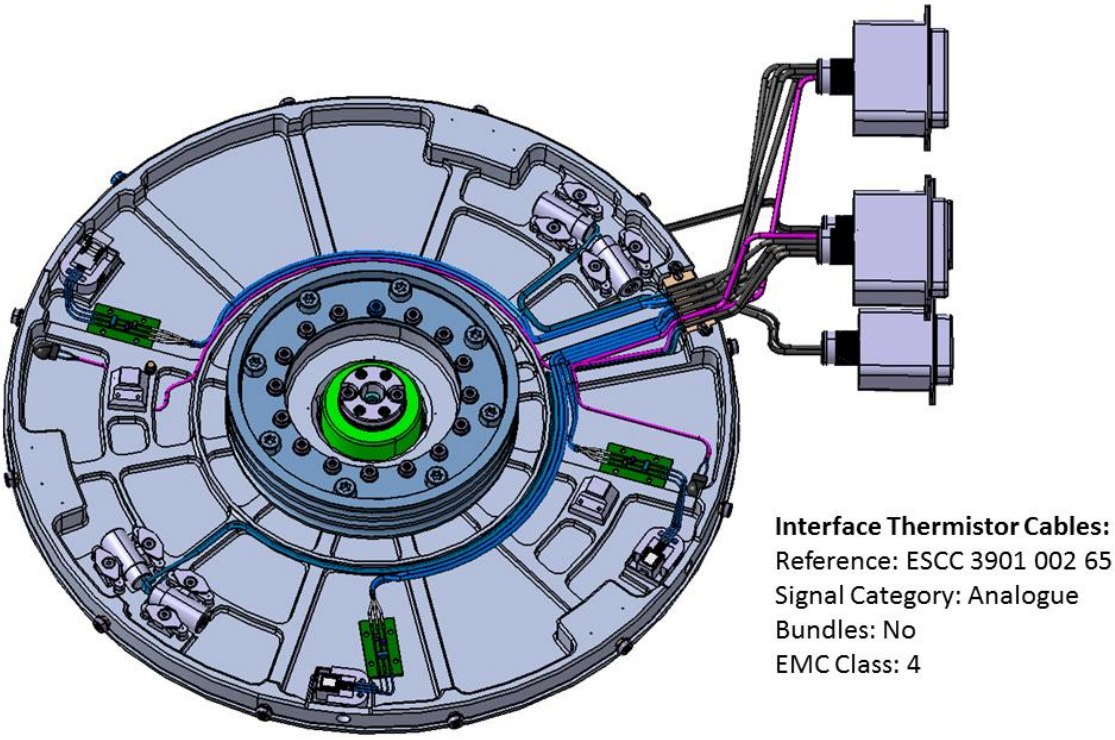


Figure 30: Interface Thermistor cable (in pink) description and routing

The routing of the Switch cables are showed in Figure 31 where they are briefly described (refer to the EICD drawing in Appendix D and [RD07] for more details).

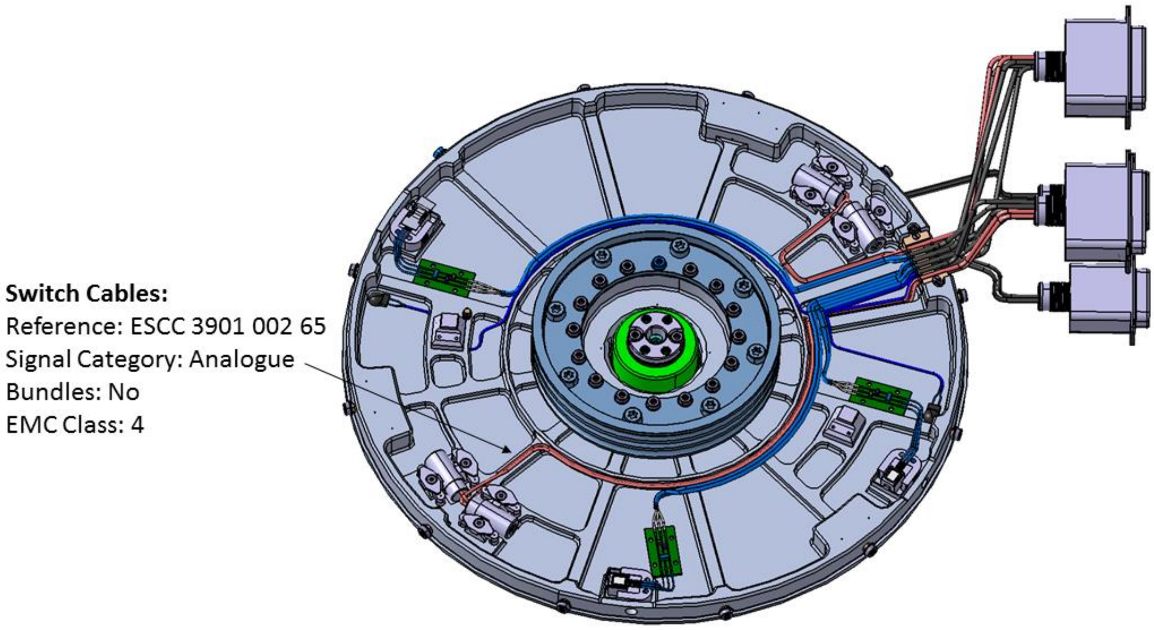


Figure 31: Switch cable (in orange) description and routing

12 Conclusion

The EICD data and functional logic are reported and described in the above reported sections. Further details are reported in the component datasheet reported in the appendixes.

Appendix A
Hall sensors datasheet

High Reliability Hallogic® Hall-Effect Sensors

OMH090, OMH3019, OMH3020, OMH3040, OMH3075, OMH3131 (B, S versions)

Ceramic Package

Features:

- Designed for non-contact switching operations
- Operates over a broad range of supply voltages
- Excellent temperature stability operates in harsh environments
- Suitable for military and space applications
- Processing patterned after class B or S of MIL-STD-883
- Through Hole 0.40" [10.16 mm] lead length minimum
- ESD Rating of Class 3B per MIL-STD-883G, M3015.7, HB model.

Description:

These Hall-effect devices contain a monolithic integrated circuit which incorporates a Hall element, a linear amplifier, a threshold amplifier, and Schmitt trigger on a single Hallogic® silicon chip. Included on-chip is a band-gap voltage regulator that allows operation with a wide range of supply voltages. These devices feature logic level output and provide up to 21 mA of sink current. This allows direct driving of more than 7 TTL loads or any standard logic family using power supplies ranging from 4.5 to 24 volts. Output amplitude is constant at switching frequencies from DC to over 200 kHz.

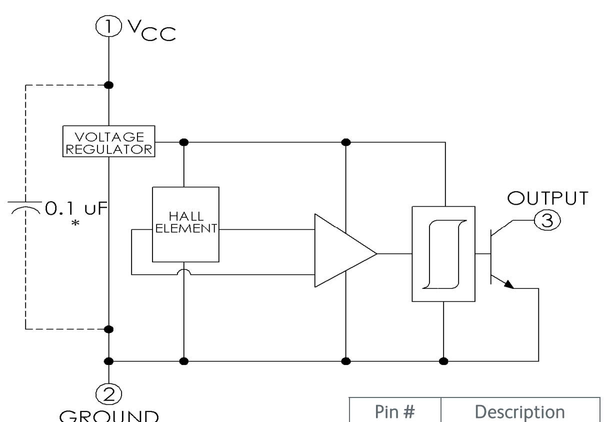
The **Uni-Polar** turns on with a (logic level "0") after a sufficient magnetic field from the south pole of a magnet approaches the symbolized face of the device (operating point) and turns off (logic level "1") after the magnetic field reaches a minimum value. The **Bi-Polar** device turns on (logic level "0") in the presence of a magnetic south pole and turns off (logic level "1") when subjected to a magnetic north pole. Both magnetic poles are necessary for operation for Bi-Polar devices. This feature makes these sensors ideal for applications in non-contact switching operations, brushless DC motors and for use with multiple pole magnets.

B and S devices are processed to OPTEK's military screening program patterned after MIL-STD-883. This product has passed Radiation Hardness testing up to 350 Krad (si) per MIL-STD-883 method 1019.6 and up to 150 Krad (si) for ELDRS.

Contact your local representative or OPTEK for more information.

Applications:

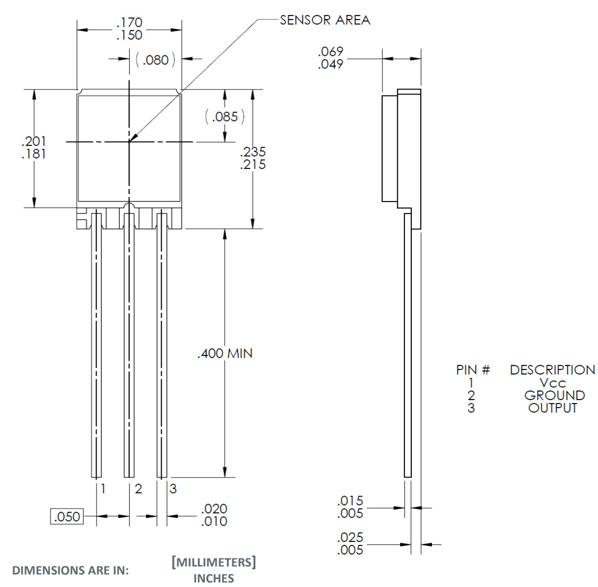
- Non-contact switching operations
- Brushless DC motors
- Multiple pole magnets
- Non-contact reflective object sensor
- Assembly line automation
- Machine automation
- Machine safety
- End of travel sensor
- Door sensor



Pin #	Description
1	V_{CC}
2	Ground
3	Output

* Add capacitor for stable operation

Lead finish = Solder Dipped (Sn 63/37)



General Note
TT Electronics reserves the right to make changes in product specification without notice or liability. All information is subject to TT Electronics' own data and is considered accurate at time of going to print.

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High Reliability Hallogic® Hall-Effect Sensors

OMH090, OMH3019, OMH3020, OMH3040, OMH3075, OMH3131 (B, S versions)

Absolute Maximum Ratings (T_A = 25° C unless otherwise noted)

Supply Voltage, V_{CC}	25 V
Storage Temperature Range, T_S	-65°C to +150°C
Operating Temperature Range, T_A	-55°C to +125°C
Lead Soldering Temperature (1/8 in. (3.2 mm) from case for 5 seconds with soldering iron)	260°C[1]
Output ON Current, I_{SINK}	25 mA
Output OFF Voltage, V_{OUT}	25 V
Magnetic Flux Density, B	Unlimited

Notes:
(1) Heat sink leads during hand soldering.

Part Number	Hi-Reliability Hallogic® Sensor	Operate Point Gauss Min / Typ / Max	Release Point Gauss Min / Typ / Max	Hysteresis Gauss Min / Typ / Max	V_{CC} (Volts) Min / Max	Package
OMH090B		50/90/180	30 / 65 / 160	10 / 30 / 60		
OMH090S						
OMH3019B	Uni-Polar Non-Latching	175 / 300 / 500	125 / 235 / 420	30 / 100 / 155	4.5 / 24.0	Through Hole
OMH3019S						
OMH3020B		70 / 220 / 350	50 / 180 / 330	15 / 55 / 200		
OMH3020S						
OMH3040B		70 / 150 / 200	50 / 115 / 180	10 / 35 / 60		
OMH3040S						
OMH3131B		20 / 60 / 95	10 / 45 / 85	5 / 15 / 40		
OMH3131S						
OMH3075B	Bi-Polar Latching	50 / 150 / 250	-250 / -150 / -50	100 / 250 / 500		
OMH3075S						

Electrical Characteristics (V_{CC} = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH090, OMH090B, OMH090S Uni-Polar

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point(1)	45 50 20	- 90 -	210 180 180	Gauss	-55°C +25°C +125°C
B_{RP}	Magnetic Release Point	25 30 25	- 65 -	150 160 140	Gauss	-55°C +25°C +125°C
B_H	Magnetic Hysteresis	5 10	- 30	95 60	Gauss	-55°C +25°C & +125°C
I_{CC}	Supply Current	- - -	- 5 -	9 11 5	mA	-55°C,V_{CC} = 24 V, Output On, B≥250 Gauss +25° +125°C
V_{OL}	Output Saturation Voltage	- -	- 125	300 400	mV	-55°C,V_{CC} = 4.5 V, I_{OL} = 30 mA,B≥250 Gauss +25°C & +125°C
I_{OH}	Output Leakage Current	- - -	- 0.50 -	10 11 12	µA	-55°C,V_{CC} = 24 V, V_{OUT} =24 V, B≤250 Gauss +25° +125°C
t_r	Output Rise Time	-	0.13	1.00	µs	R_L = 820 Ω, C_L = 20 pF, V_{CC} = 14 V (guaranteed not tested)
t_f	Output Fall Time	-	0.14	1.00	µs	

Electrical Characteristics (Vcc = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH3019, OMH3019B, OMH3019S Uni-Polar

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point(1)	175 -	300 -	500 575	Gauss	+25°C -55°C & +125°C
B_{RP}	Magnetic Release Point	125 100	235 -	420 -	Gauss	+25°C -55°C & +125°C
B_H	Magnetic Hysteresis	30 20	100 -	155 -	Gauss	+25°C -55°C to +125°C
I_{CC}	Supply Current	-	5	9	mA	V_{CC} = 24 V, Output On, B ≤ 50 Gauss
V_{OL}	Output Saturation Voltage	-	125	300	mV	V_{CC} = 4.5 V, I_{OL} = 15 mA, B ≥ 500 Gauss
I_{OH}	Output Leakage Current	-	0.10	1.0	µA	V_{CC} = 24 V, V_{OUT} = 24 V, B < 50 Gauss
t_r	Output Rise Time	-	0.13	1	µs	R_L = 460 Ω, C_L = 20 pF, V_{CC} = 12 V (guaranteed not tested)
t_f	Output Fall Time	-	0.14	1	µs	

Notes:
(1) South pole facing symbolized surface.

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Electrical Characteristics (V_{CC} = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH3020, OMH3020B, OMH3020S Uni-Polar

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point[(1)]	70 -	220 -	350 425	Gauss	+25°C -55°C & +125°C
B_{RP}	Magnetic Release Point	50 25	180 -	330 -	Gauss	+25°C -55°C & +125°C
B_H	Magnetic Hysteresis	15 10	55 -	200 -	Gauss	+25°C -55°C & +125°C
Icc	Supply Current	-	4	7	mA	V_{CC} = 24 V, Output On, B ≤ 50 Gauss
V_{OL}	Output Saturation Voltage	-	100	400	mV	V_{CC} = 4.5 V, I_{OL} = 15 mA, B ≥ 350 Gauss
I_{OH}	Output Leakage Current	-	0.10	10	µA	V_{CC} = 24 V, V_{OUT} = 24 V, B ≤ 50 Gauss
t_r	Output Rise Time	-	0.21	1	µs	R_L = 820 Ω, C_L = 20 pF, V_{CC} = 12 V (guaranteed not tested)
t_f	Output Fall Time	-	0.10	1	µs	

Electrical Characteristics (V_{CC} = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH3040, OMH3040B, OMH3040S Uni-Polar

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point[(1)]	70 75	150 -	200 270	Gauss	+25°C -55°C & +125°C
B_{RP}	Magnetic Release Point	50 25	115 -	180 210	Gauss	+25°C -55°C & +125°C
B_H	Magnetic Hysteresis	10 20	35 -	60 -	Gauss	+25°C -55°C & +125°C
Icc	Supply Current	- -	4 -	8 8 10	mA	+25°C, V_{CC} = 24 V, Output On, B ≥ 300 Gauss +125°C -55°C
V_{OL}	Output Saturation Voltage	-	100	400	mV	V_{CC} = 4.5 V, I_{OL} = 20 mA, B ≥ 250 Gauss
I_{OH}	Output Leakage Current	- - -	- 0.10 -	11 10 12	µA	-55°C, V_{CC} = 24V, V_{OUT} = 24V, B ≤ 75 Gauss +25°C, V_{CC} = 24V, V_{OUT} = 24V, B ≤ 100 Gauss +125°C, V_{CC} = 24V, V_{OUT} = 24V, B ≤ 75 G
t_r	Output Rise Time	-	0.21	1	µs	R_L = 820 Ω, C_L = 20 pF, V_{CC} = 12 V (guaranteed not tested)
t_f	Output Fall Time	-	0.10	1	µs	

Notes:
(1) South pole facing symbolized surface.

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Electrical Characteristics (V_{CC} = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH3075, OMH3075B, OMH3075S Bi-Polar Latching

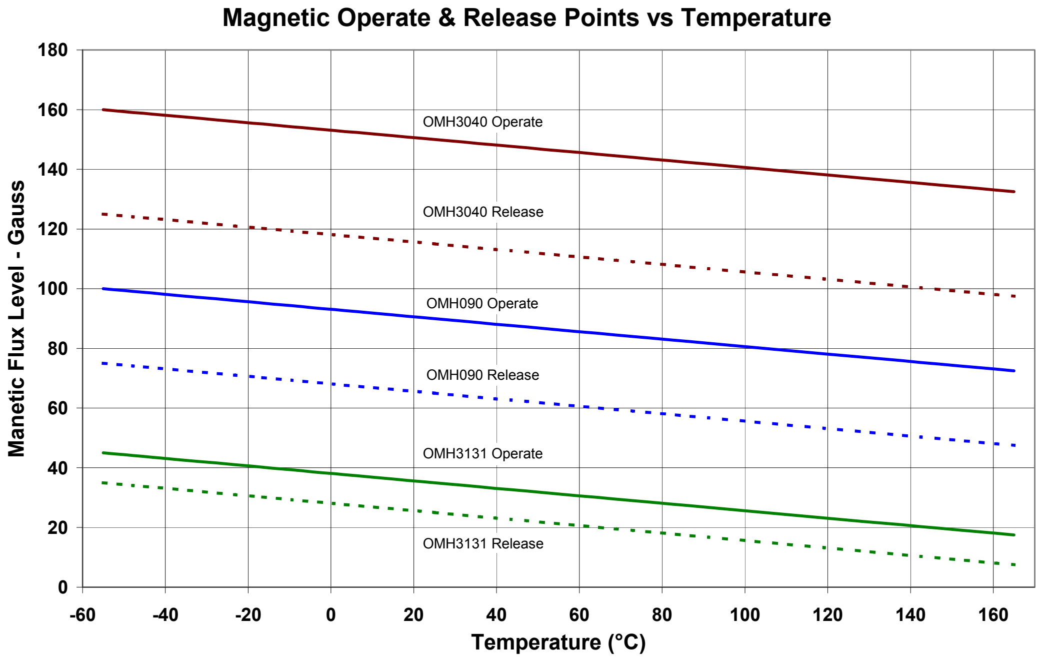
SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point[(1)]	50 25	150 -	250 275	Gauss	+25°C -55°C & +125°C
B_{RP}	Magnetic Release Point	-250 -275	-150 -	-50 -25	Gauss	+25°C -55°C & +125°C
B_H	Magnetic Hysteresis	100 50	250 -	500 -	Gauss	+25°C -55°C & +125°C
I_{CC}	Supply Current	- -	4 -	8 8 10	mA	+25°C, V_{CC} = 24 V, (Output On), B ≥ -250 Gauss +125°C -55°C
V_{OL}	Output Saturation Voltage	- - -	- 100 -	500 400 400	mV	-55°C +25°C, V_{CC} = 4.5 V, I_{OL} = 20 mA, B ≥ 250 Gauss +125°C
I_{OH}	Output Leakage Current	-	0.10	1.0	µA	V_{CC}= 24 V, V_{OUT} = 24 V, B ≤ -250 Gauss
t_r	Output Rise Time	-	0.21	1	µs	R_L = 820 Ω, C_L = 20 pF, V_{cc} = 12 V (guaranteed not tested)
t_f	Output Fall Time	-	0.10	1	µs	

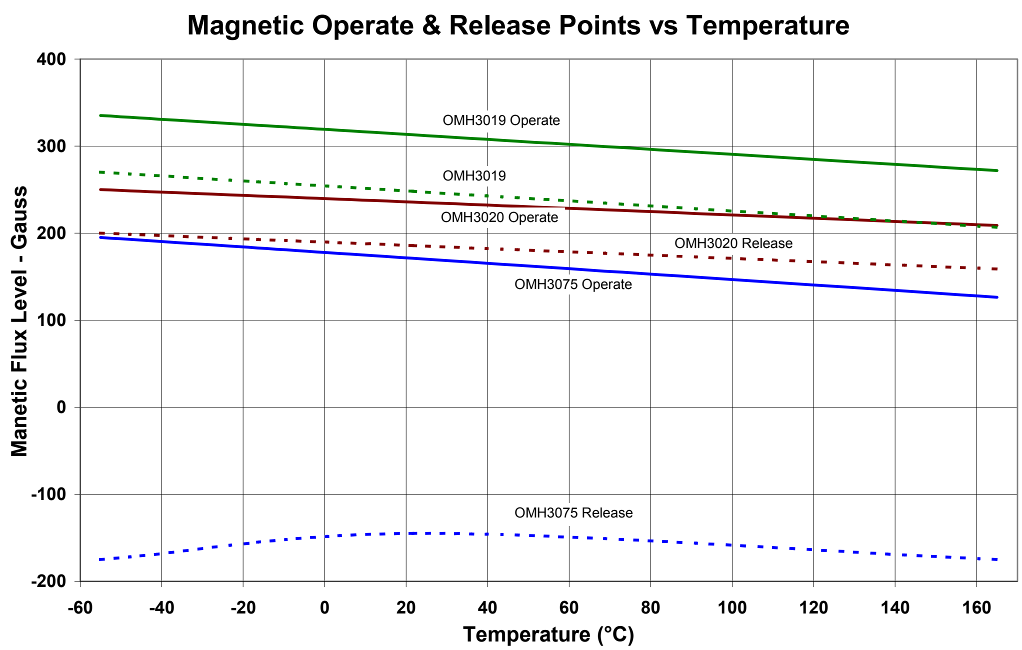
Electrical Characteristics (V_{CC} = 4.5 V to 24 V, T_A = 25° C unless otherwise noted)
OMH3131, OMH3131B & OMH3131S Uni-Polar

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
B_{OP}	Magnetic Operate Point[(1)]	20 10	60 -	95 150	Gauss	+25°C -55°C to +125°C
B_{RP}	Magnetic Release Point	10 5	45 -	85 145	Gauss	+25°C -55°C to +125°C
B_H	Magnetic Hysteresis	5 5	15 -	40 145	Gauss	+25°C -55°C to +125°C
I_{CC}	Supply Current	-	4	7	mA	V_{CC} = 24 V, Output On, B > 250 Gauss
V_{OL}	Output Saturation Voltage	-	100	400	mV	V_{CC} = 4.5 V, I_{OL} = 15 mA, B ≥ 250 Gauss
I_{OH}	Output Leakage Current	-	0.10	10	µA	V_{CC} = 24 V, V_{OUT} = 24 V, B ≤ 0 Gauss
t_r	Output Rise Time	-	0.21	1	µs	R_L = 820 Ω, C_L = 20 pF, V_{cc} = 12 V (guaranteed not tested)
t_f	Output Fall Time	-	0.10	1	µs	

Notes:
(1) South pole facing symbolized surface.

OMH090, OMH3019, OMH3020, OMH3040, OMH3075, OMH3131 (B, S)





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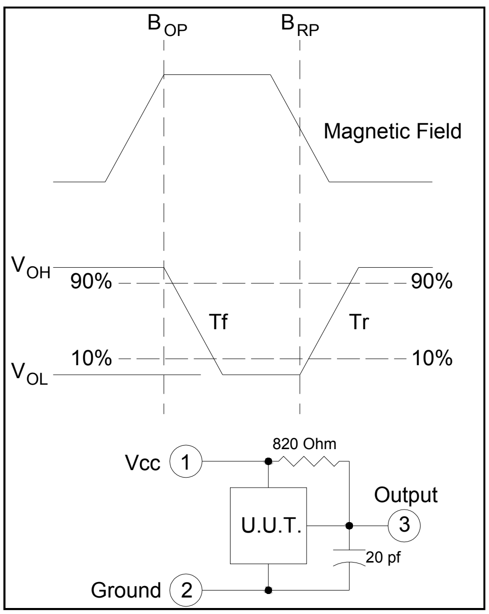
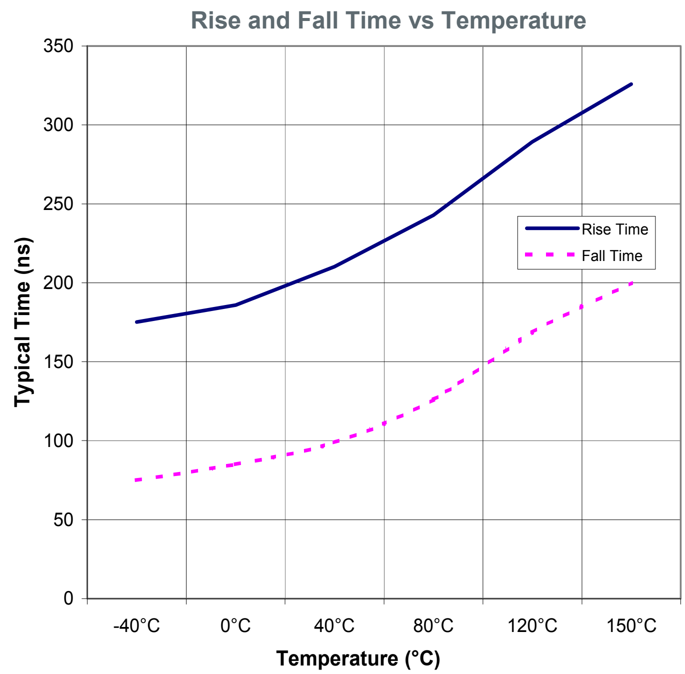
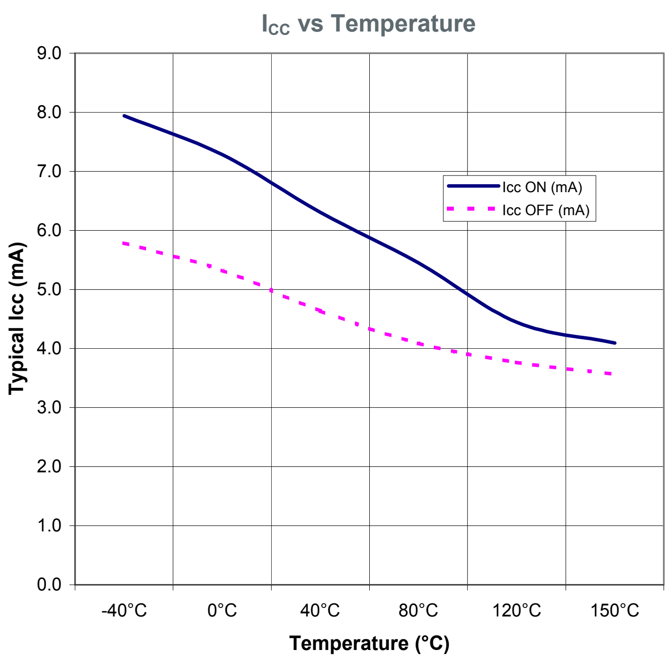
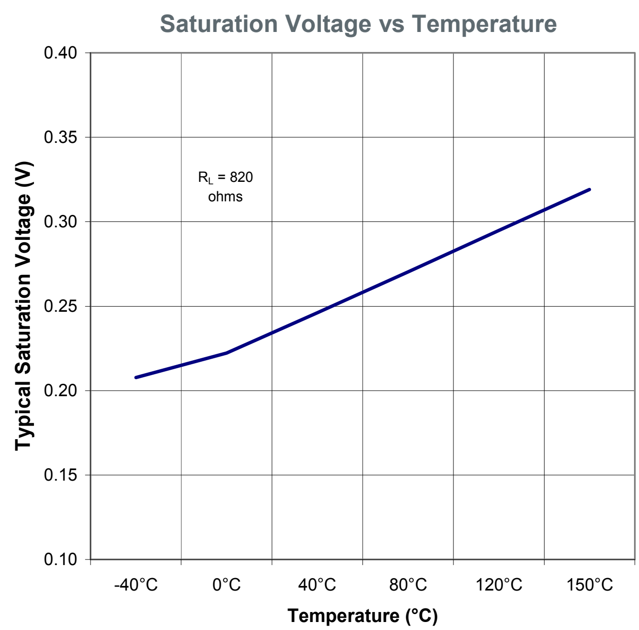
OMH090, OMH3019, OMH3020, OMH3040, OMH3075, OMH3131 (B, S)









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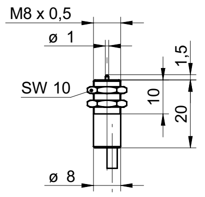
Appendix B
Baumer Switch datasheet

My-Com precision switches

MY-COM B75/80

dimension drawing



general data	
repeat accuracy	< 0,001 mm
activating force	75 cN
mech. pre-run / overrun	- / 1,5 mm approx.
measurement type	contact with medium
direction of approach	frontal

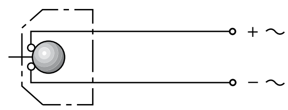
electrical data	
DC voltage max.	15 VDC
switch. current DC max.	2 mA
AC voltage max.	24 VAC
switch. current AC max.	50 mA
output circuit	break function (NC) mechanical

mechanical data	
activating pin	zirconium oxide ZrO_2
housing material	brass nickel plated
dimension	8 mm
type	cylindrical threaded
housing length	20 mm
connection types	cable, 80 cm

ambient conditions	
operating temperature	-20 ... +75 °C
protection class	IP 50

photo

connection diagram



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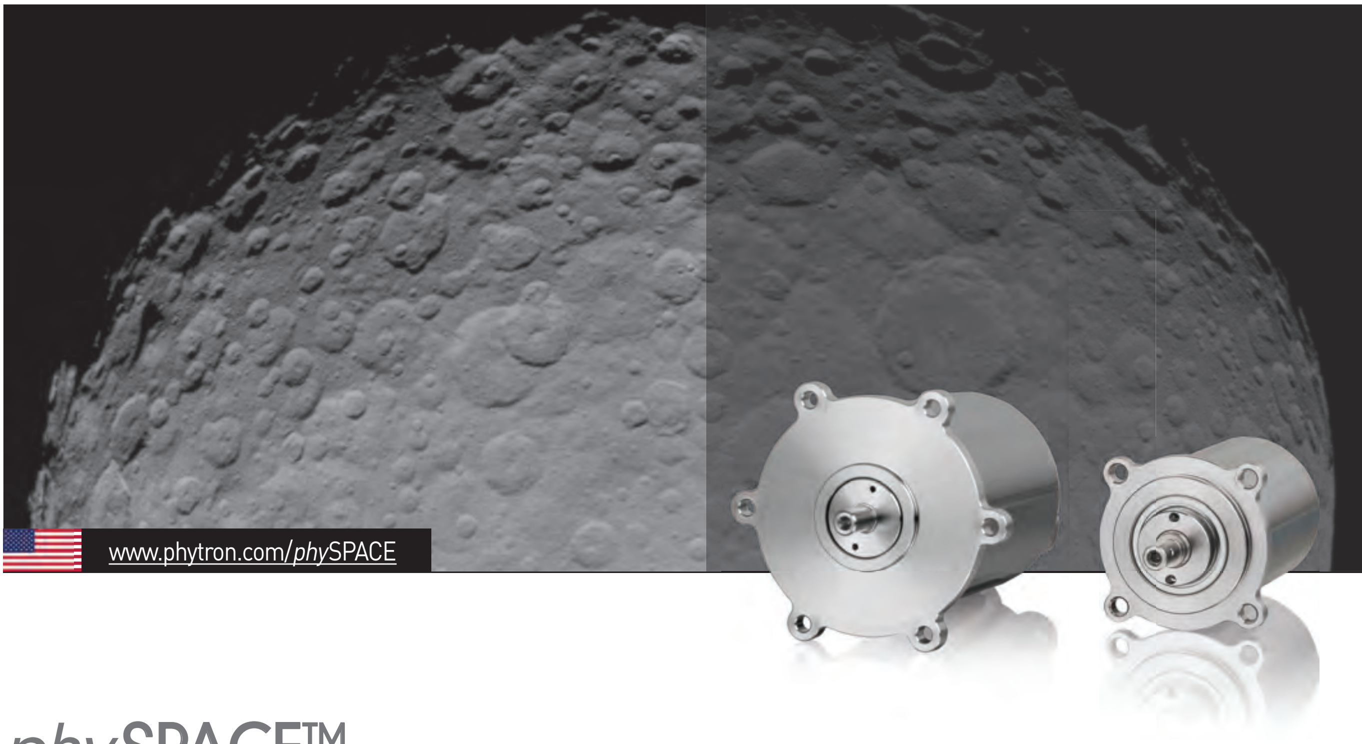
Appendix C
Phytron motor datasheet

SPACE



*phy*SPACE™

Stepper Motor Series for SPACE applications, Standard and Customised solutions

With 25 years of space heritage and over 300 motors in space we know how to optimise weight, power consumption, thermal dissipation and stray magnetic flux without sacrificing precision or reliability.

*phy*SPACE™ represents a standard stepper motor series for SPACE applications. This series comes with features essential to usage in extreme environments. Beyond that it is also the basis for customised projects - to optimise motor-load coupling.

Our *phy*SPACE™ stepper motors are cost-efficient, clean and reliable even within extreme environments. The *phy*SPACE™ series is developed and built to resist vacuum, vibrations, low/high temperature and radiation while maintaining high performance, precise positioning, long life.

Highlights

Performance & Lifetime

phytron *phy*SPACE™ motors are based on a technology that can also be found in the most challenging projects of our time. From a variety of satellites up to the Mars rover Curiosity: phytron motors drive applications in distant worlds - highly accurate, reliable and durable. Driven within their specification range, high-quality components and a proven design make sure: These motors won't let you down!

Cleanliness

phytron motors for use in space contain only materials that also meet the requirements of the ECCS (European Cooperation for Space Standardisation). Thus, each material has a maximum TML (Total Mass Loss) value of 1% and a maximum CVCM (Collected Volatile Condensable Materials) value of 0.1 %. You will receive your space motor, double-wrapped and vacuum-sealed.

In Focus

Vacuum

Radiation Resistance

Standard

- 2-phase stepper motors
- holding torques from 3.1 to 420 mNm without gearing
- diameters from 20 to 57 mm
- 200 steps (1.8° per full step)
- designed for high shock and vibration loads
- 4 leads parallel
- preconditioned, protection IP 20
- embedded K-type thermocouple
- Ambient temp. -40 °C... +120 °C
- up to +200 °C (winding)
- radiation up to 10^6 J/kg
- bake-out temperature up to 200 °C (24 h)
- outgassing TML <1 %, CVCM <0.1% (at <125 °C)

Options

- "light weight" upgrade (Titan)
- "space-testing" upgrade (vibration, shock, thermal cycling)
- Winding cold redundant
- for Cryo applications up to -269 °C

Customised Solutions

- special designs based on the *phy*SPACE series
- Gears

Edition 2016 August

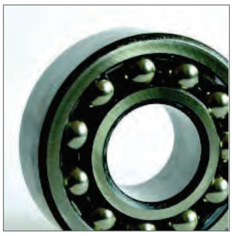
phytron
Extreme. Precision. Positioning.

Space

*phy*SPACE stepper motor

Structure design

The structure design of the *phy*SPACE™ motors presents an optimum of lightweight, stiffness and surface protection. As is commonly done in high-vacuum class all structural elements such as housing, flanges and shafts are made of stainless steel. Even the standard version in stainless steel is optimised in terms of weight: The quadratic flange is reduced to flange lugs and the flanges are hollowed to save additional weight. In order to save even more weight the *phy*SPACE™ comes with the option for a „light-weight"-material like titanium.

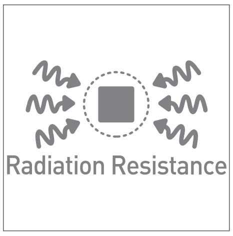


Bearings

The shock and vibration loads of a rocket launch can stress or damage the ball bearings significantly - resulting in reduced life under certain circumstances - when the motor hasn´t even been put into operation. The *phy*SPACE™ standard motor is equipped with special ABEC 7 bearings. A duplex bearing assembly in the front flange dissipates the vibration loads safely into the housing structure. Especially when in a vacuum, unlubricated ball bearings can be affected by „cold welding", and thus degrading and even binding the bearings.

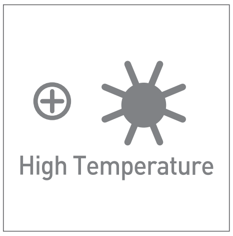
Adhesives

The adhesives used are qualified for space applications according to ECSS Q-70-02A. They represent an optimum of strength, ductility, low outgassing rates and thermal resistance. The outgassing rates (TML, CVCM) comply with the European Space Standards and American space standard.



Radiation Resistance

The *phy*SPACE™ motors are designed for radiation of up to 10^6 J/kg for use in space applications. A motor not designed for radiation will not only suffer degradation of the insulation and the adhesives - especially the grease of the ball bearing reducing the efficiency and will eventually cause the motor to fail.



Temperature Management

All materials selected for the *phy*SPACE™ motors can withstand a short-term winding temperature of up to 200° C. Due to the lack of convection in a vacuum, the motors can heat up very quickly and often work at a high temperature level - depending on the duty-cycle. In our *phy*SPACE™ motors we integrate a thermocouple to allow monitoring of the exact winding temperature. This is how you protect your motors from overheating.

Preconditioning

The selected materials and components are outgassed by a phytron process at up to 200 °C in vacuum chambers, so that outgassing materials cannot deposit in the ball bearings or inside the motor. This way we provide a minimum molecular contamination of the surrounding system so that the motors can even operate close to optical systems.

Handling and Storage

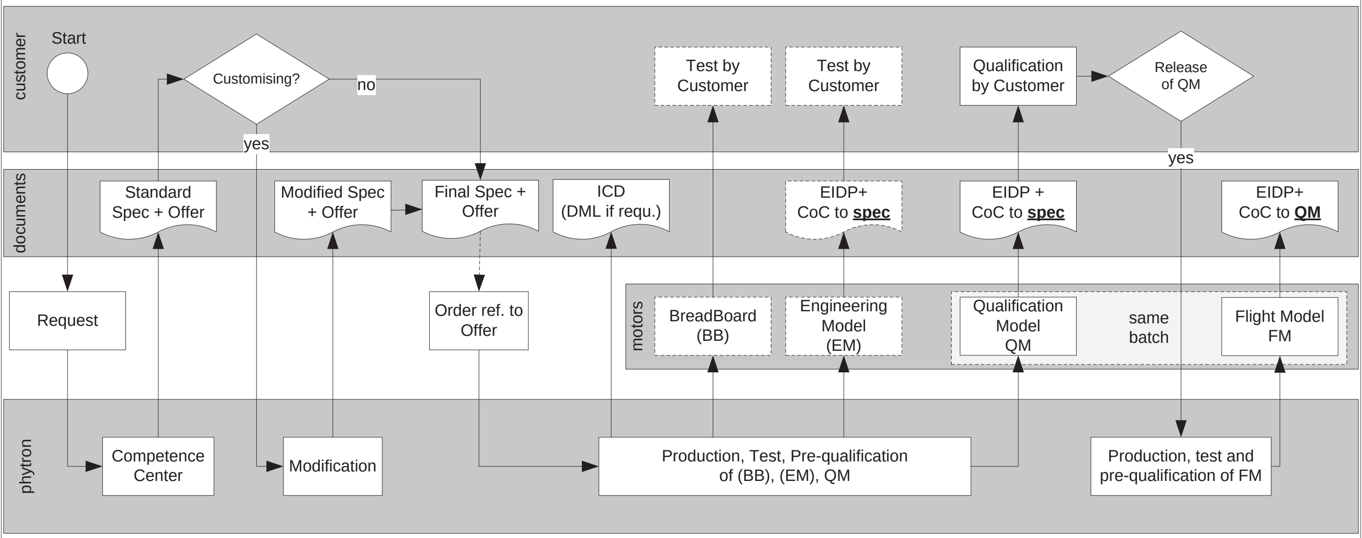
*phy*SPACE™ motors are primarily designed for use in a vacuum. For this reason the motors must always be handled under controlled conditions: On the ground at 20 °C +/-10 °C and relative humidity <=50%, in clean rooms and clean boxes. Long-term storage is permitted only in unopened original phytron packaging. After storage, or not rotating for more than 6 months, a „running-in" is highly recommended in order to distribute the grease evenly again. The motors are to be handled with suitable gloves. Since the rotor is magnetic, it must be handled in a clean environment so that no metal particles can be pulled through the opening at the at the rear of the motor into the motor. Particles in the motor lead to an impairment of operation, the lifetime, or even failure of the motor due to binding.

Service, Consulting and Customising

Of course we are happy if our standard already fulfills your application's needs! Although our *phy*SPACE™ series integrates our application experience of the last decades - sometimes the standard is just not enough. We offer to create customised solutions to make our motor a perfect fit for your application, because sometimes even small changes make the difference.

Road-Map & Milestones

phytron project partnership: receive the perfect space motor for your application.

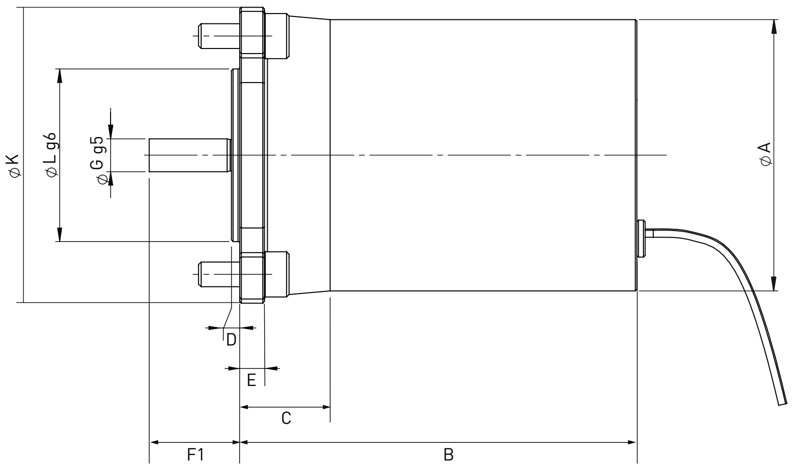


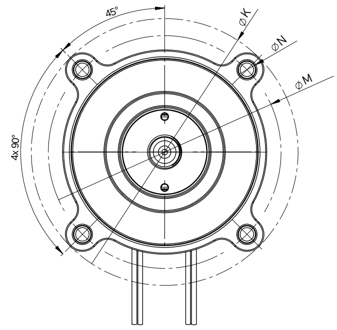
Space

Technical Characteristics

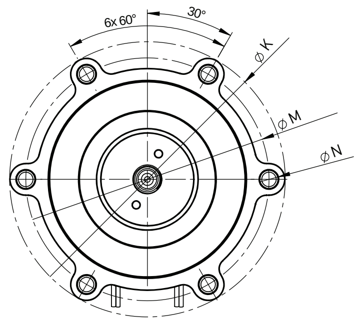
		Standard	Upgrade Options
General Characteristics	Number of steps / step angle	200 / 1.8 °	
	Physical step accuracy (non accumulating)	3 to 5 %	
	Speed (typical for continuous operation)	400 rpm	
	Preferred direction	clockwise (facing the motor shaft)	
	Bearing quality / arrangement	ABEC7 / Duplex (front)+ floating bearing (rear)	
	Lubrication	space grade compatible	non / dry
	Housing	stainless steel	„light weight" titan
	Protection class	IP 20	
	Expected lifetime (typical)	20 x 10^6 revolutions	
Electrical	Operating voltage	up to 48 V	
	Control	bipolar	
	Leads: amount / wiring / wire exit	4-leads bipolar / parallel / axial	cold redundant
	Lead insulation	Kapton	
	Temperature sensor	type K	
	Dielectric strength	>500 V_{AC} with 50 Hz	
	Insulation resistance (depending on diameter)	>100 MΩ with up to 500 V_{DC}	
Cleanliness	Pre-Conditioning	first outgassing by phytron	
	CVCM (Collected volatile condensable materials) at 125°	< 0,1 %	
	TML (Total Mass Loss) at 125°	<1 %	
	Magnetic emission	upon request	
Environemntal	Surrounding Environment	vacuum (UHV)	
		atmosphere (with restrictions)	
	Radiation resistant up to a dose of	10^6 J/kg	
	Environment temperature (operating)	-40...+120 °C	higher temperature upgrade/ Cryo temperature upgrade
	Environment temperature (non operating)	-70...+140 °C	
	Temperature max. (winding)	max. +200 °C	
	Environment (storage)	+10...+50 °C; original packing	
	Humidity (max.)	<=50 %	
	Vibration GRMS	20	
Test	Test: electric / mechanic / dynamic / climate	standard	
	Test: Vibration / Shock / Thermal Vacuum Cycling	–	„space-testing"
	EIDP (End Item Data Package)	standard	

Stepper motor space™ 19-2 to 56-2





*phy*SPACE™ 19-2 to 42-2



*phy*SPACE™ 52-2 and 56-2

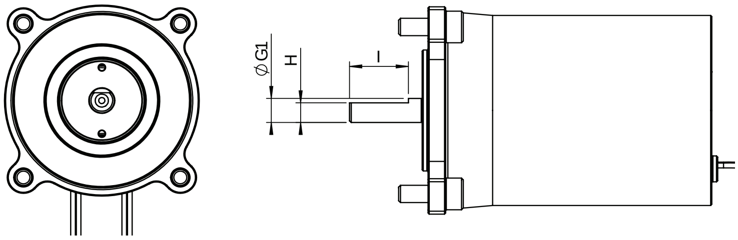
Dimensions / Electrical and Mechanical Charcteristics

*phy*SPACE™ Standard 200-step 4 lead parallel bipolar	Electrical Characteristics				Mechanical Charcteristics						Dimensions in mm										
	Current/ Phase I_N	Resistance/ Phase [4]	Max. operating voltage [5]	AWG	Holding torque [1]	Power-OFF torque	Rotor inertia	Loads [2] axial	Loads [2] radial	Mass [3]											
	A	Ω	V_{DC}		mNm	mNm	kg cm²	N	N	g	A	B	C	D	E	F1	G^{g5}	K	L^{g6}	M	N
19–2	0.6 1.2	2.1 0.63	48	28	3.8	0.9	0.0009	10	15	70	20	34	10.5	1.5	2	7.5	2.5	32	10	27	2.2
25–2	0.6 1.2	3.25 0.95		28 26	13	2	0.0025	15	25	100	26	36	10.5	2.5	2.5	9.5	3	38	14	33	2.7
32–2	0.6 1.2	4.6 1.25		26	50	3	0.01	30	45	211	33	48	11	2.5	3	11	4	47	18	42	3.2
42–2	1.2 2.5	1.7 0.34		24 22	140	5	0.045	30	50	425	43	60	16	2.5	3.5	16	5	62	22	54	4.2
52–2	1.2 2.5	2.6 0.6		24 22	450	12	0.15	65	100	900	53	75.5	17	1	5	21	6	75	38	66	5.2
56–2	1.2 2.5	3.9 0.8		24 22	500	50	0.24	50	80	970	57	70	16.5	2.5	4.5	22	6	77	38	68	5.2

[1] Holding torque in bipolar mode with parallel windings. Two phases on at rated current
[2] Axial radial loads are for mounting purposes only. A flexible coupling must be used in operation.
[3] The use of titanium parts reduces the overall weight by 20 %.
[4] differently with redundant winding
[5] max. operating voltage of the power stage (intermediate circuit voltage)
All values given above refer to room temperature and atmospheric pressure. Other sizes available upon request

Space

Option: Shaft Design



More shaft options upon request.

Dimensions

Stepper motor	Dimensions in mm		
Size	G1	H	I
*phy*SPACE 19	2.5	2	4.5
*phy*SPACE 25	3	2.5	6.5
*phy*SPACE 32	4	3.5	8
*phy*SPACE 42	5	4	13
*phy*SPACE 56	6	5	18.5

Derating - Duty-Cycle-Design for Applications in Vacuum

Motors operating in a vacuum heat up very quickly depending on their duty cycle. Driven with nominal current the maximum temperature will be reached within several minutes. Therefore it is necessary to monitor the motor's temperature (K-element) or to design a duty cycle with enough off-time to always keep the motor a safe temperature level.

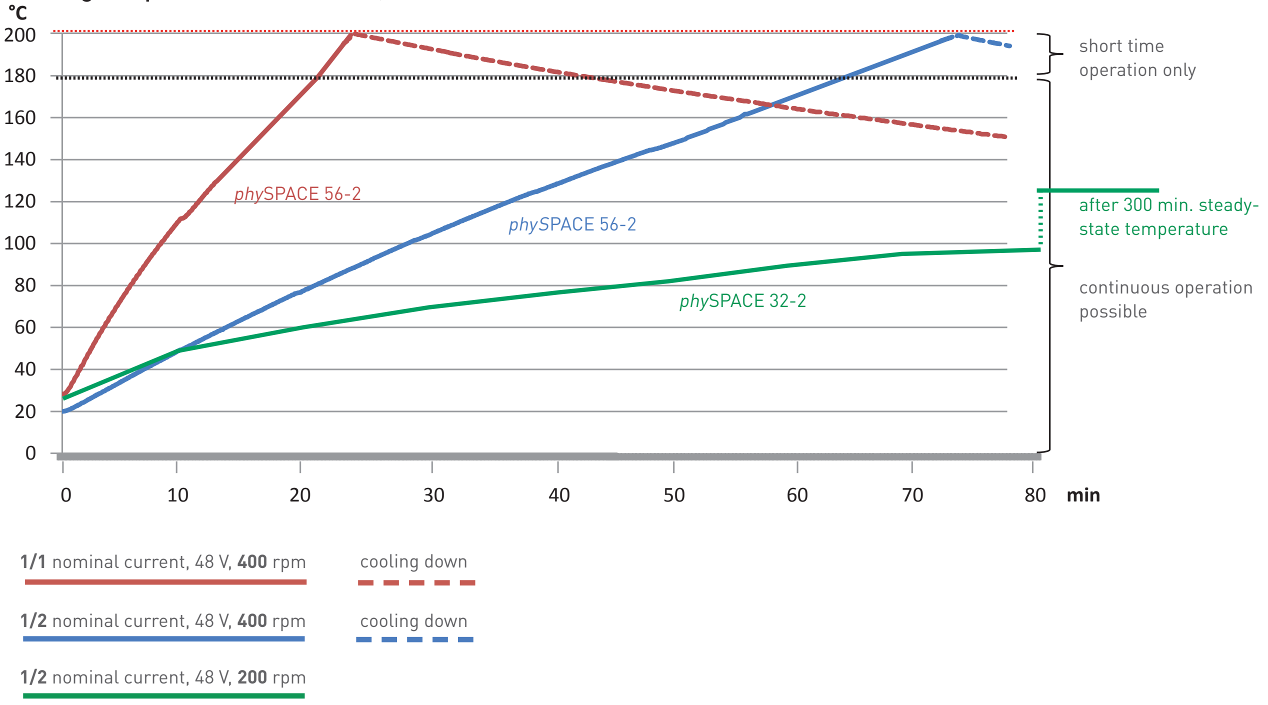
The shown curve is set at an environmental temperature of 20 °C. To give you an idea of how the chosen current influences the motor temperature we drew two curves of a motor similar to the *phy*SPACE™ 56. Driven with 400 rpm at 50 % of the nominal current, the motor takes longer to heat up due to less ohmic losses then driven with the full nominal current.

The third curve (*phy*SPACE™ 32-2) with 0.5 nominal current and 200 rmp only leads to a steady state temperature within the safe temperature limits.

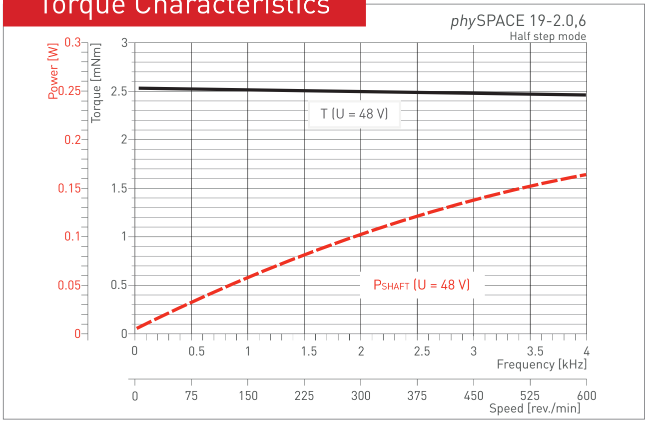
A higher rotational speed increases the magnetic losses. Therefore high speeds should be avoided as far as possible to reduce heat losses and to protect the bearings.

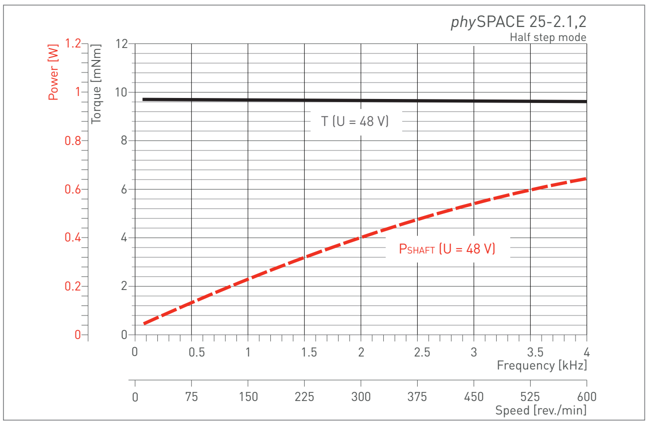
The cooling down speed during the off-time depends on the temperature delta in between the current motor temperature and the environmental temperature and the connected structure's thermal capacity.

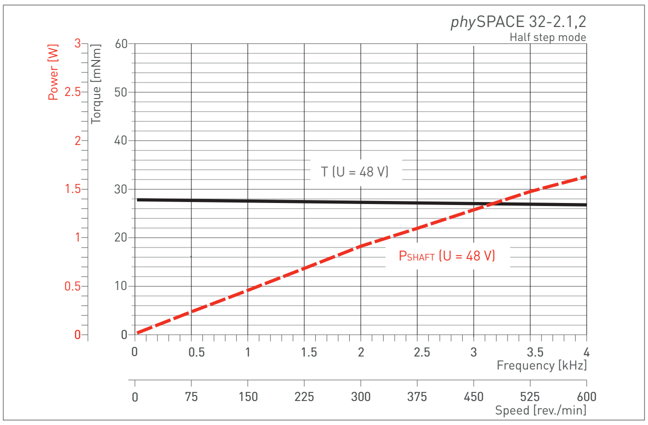
winding temperature (in vacuum), environment 20 °C

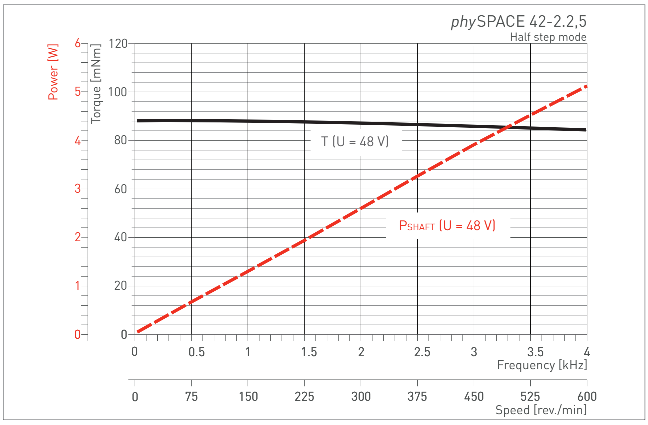


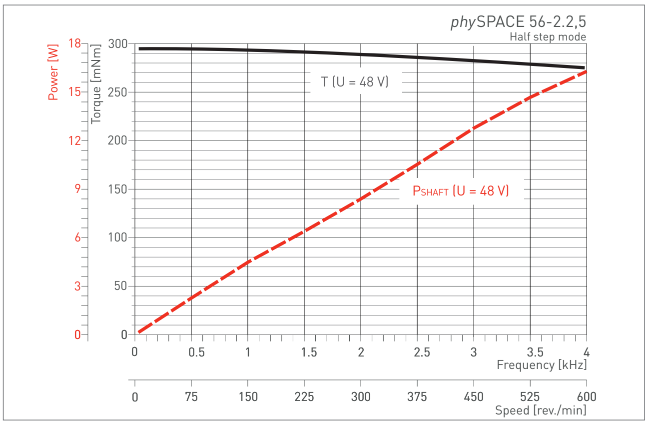
Torque Characteristics











Motor Temperature Sensors: K-type Thermocouple

The insulated temperature sensor in phytron motors is integrated in the motor windings. The response time to temperature changes of the windung is very short, compared to temperature sensors mounted outside the motor housing. The temperature is measured all the time (even if only one motor phase is powered at a time), because the sensor is always mounted between the phases.

Efficient Customising - the Perfect Fit

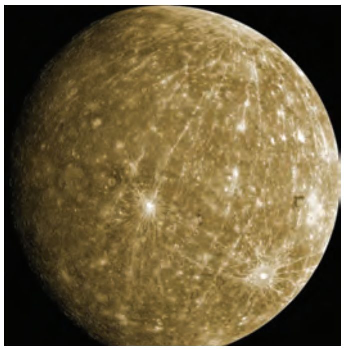
We proudly contribute to projects of:

Tailored Stepper Motors for Space Applications

BepiColombo - MERTIS (due to launch in 2015)

MErcury Radiometer and Thermal Infrared Spectrometer

- Instrument: http://www.dlr.de/os/desktopdefault.aspx/tabid-6956/
- Mission: http://www.esa.int/Our_Activities/Space_Science/BepiColombo_overview2
- for: Polish Academy of Science (PAS), DLR, ESA



Bepi Colombo image: NASA

MAVEN (2013)

Launch date: Nov. 18, 2013; mission target: mars - explore its upper atmosphere; orbit insertion date: Sept. 22, 2014

- grating flip mechanism, 90° deflecting angle moving in hard end stops
- cleanliness for optics
- motor: size 25, hybrid stepper 200 steps/rev
- gear: integrated planetary gear ratio 50:1, 90 deg travel
- structural parts titanium, hybrid bearings, lubrication
- titanium coupling: compensation of an axial length reduction during deformation without additional stress
- for LASP / NASA

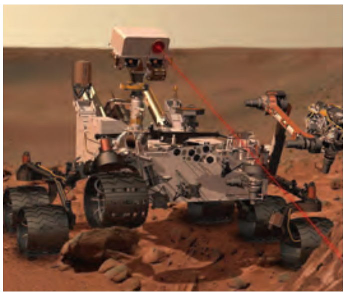
LASP MAVEN
image: NASA/Goddard Space Flight Center

Tailored Stepper Motors for Space Applications

Mars rover CURIOSITY for NASA (2011)

phytron stepper motor focuses laser and the analysis camera

- focuses the laser light and the analysis camera inside the ChemCam instrument on the sample.
- excels in reliability, durability, vacuum compatibility and minimal outgassing rates.
- optimised for mechanical friendly smooth running and is capable of precise positioning even without feedback or complex electronics



Mars rover CURIOSITY - ChemCam
image: NASA

JUNO (2011)

Mirror rotation in Ultraviolet Imaging Spectrograph

- phytron´s stepper motor : VSS 32
- Instrument: http://adsabs.harvard.edu/abs/2008AGUFMSM41B1678G
- Mission: http://www.nasa.gov/mission_pages/juno/main/index.html
- NASA / ESA

Juno
image by NASA/JPL

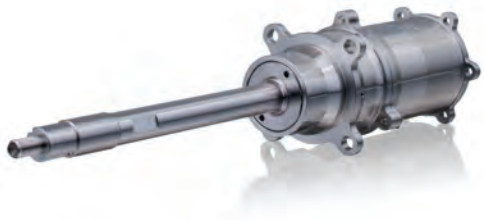
MIRIS (2010)

Multi-purpose infrared imaging system (MIRIS)

- Instrument: http://www.isas.jaxa.jp/home/rikou/kogata_eisei/symposium/2nd/koto/07.pdf
- for: Astronomy and Space Technology R&D Division, Korea Astronomy and Space Science Institute

Space

Tailored Stepper Motors for Space Applications



EnMAP mission

Shutter calibration mechanism as part of the scientific payload of the German EnMAP mission.

- customised titanium gear shaft for low weight and strength
- tailored magnet arrangement to minimise stray magnetic flux
- redundant windings cater for loss of primary coils
- Harmonic Drive gears for space conditions
- duplex bearings to better absorb shock and vibration
- central housing configuration for optimised force transmission (hybrid assembly technology)
- for: Kayser-Threde and HTS

A perfect fit for EADS Astrium.

High precision positional actuator for the
X-Band Downlink Antenna for the KOMPSAT S/C:

- customised titanium main structure for low weight and optimal strength
- integrated Harmonic Drive gear unit
- duplex bearings to withstand shock and vibration
- special lubrication system to prolong lifetime
- customised leadwire exit to meet project constraints
- motor model endurance tested in vacuum and N2 atmosphere (bearings, lubrication system, gears)

SOLACES (2003)

- stepper motor with 200 steps/revolution (1,8°)
- designed for 300 N axial force
- holding torque 70 mNm / driving torque 60 mNm
- spindle system, non-magnetic
- special grease; designed for ultra high vacuum at -50 °C to +40 °C
- for: IPM Freiburg

Tailored Stepper Motors for Space Applications

Rosetta - Cosima (2004)

Cometary Secondary Ion Mass Analyser

- motor: stepper motors VSS19
- Instrument: http://www.mps.mpg.de/de/projekte/rosetta/cosima/#instrument
- Mission: http://www.esa.int/Our_Activities/Space_Science/Rosetta
- for: Max-Max-Planck-Institut, Extraterrestrische Physik München

STEREO (2006)

The sun in 3D

- Mission: http://www.nasa.gov/mission_pages/stereo/main/index.html
- for: NASA + The Johns Hopkins University

XMM-Newton - EPIC (2000)

European Photon Imaging Camera (EPIC)

- Instrument: http://sci.esa.int/xmm-newton/31281-instruments/?fbodylongid=774
- Mission: http://xmm.esac.esa.int/
- for: Max-Max-Planck-Institut, Extraterrestrische Physik München, ESA

Cassini-Huygens (1997)

Exploring Saturn

- Mission: ESA: http://www.esa.int/Our_Activities/Space_Science/Cassini-Huygens
- Mission: NASA: http://www.nasa.gov/mission_pages/cassini/main/
- for: Max-Planck-Institut, Heidelberg, ESA, NASA

MOS-IRS-P2 (1996)

Indian Remote Sensing Satellite-P2

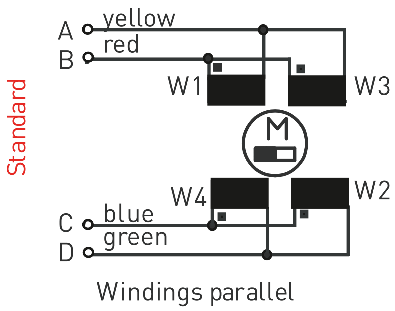
- Mission: https://earth.esa.int/web/guest/missions/3rd-party-missions/historical-missions/irs-p3
- für: DLR

Space

Electrical Connection

4-lead

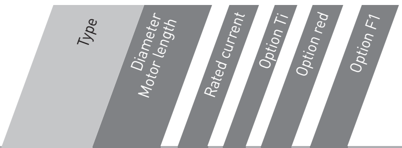
bipolar control



All illustrations, descriptions and technical specifications are subject to modifications; no responsibility is accepted for the accuracy of this information.

Ordering Code

The variable elements of the product are displayed in colour.



Ordering code: *phy*Space 43 - 2 - 2,5 - Ti - red - F1

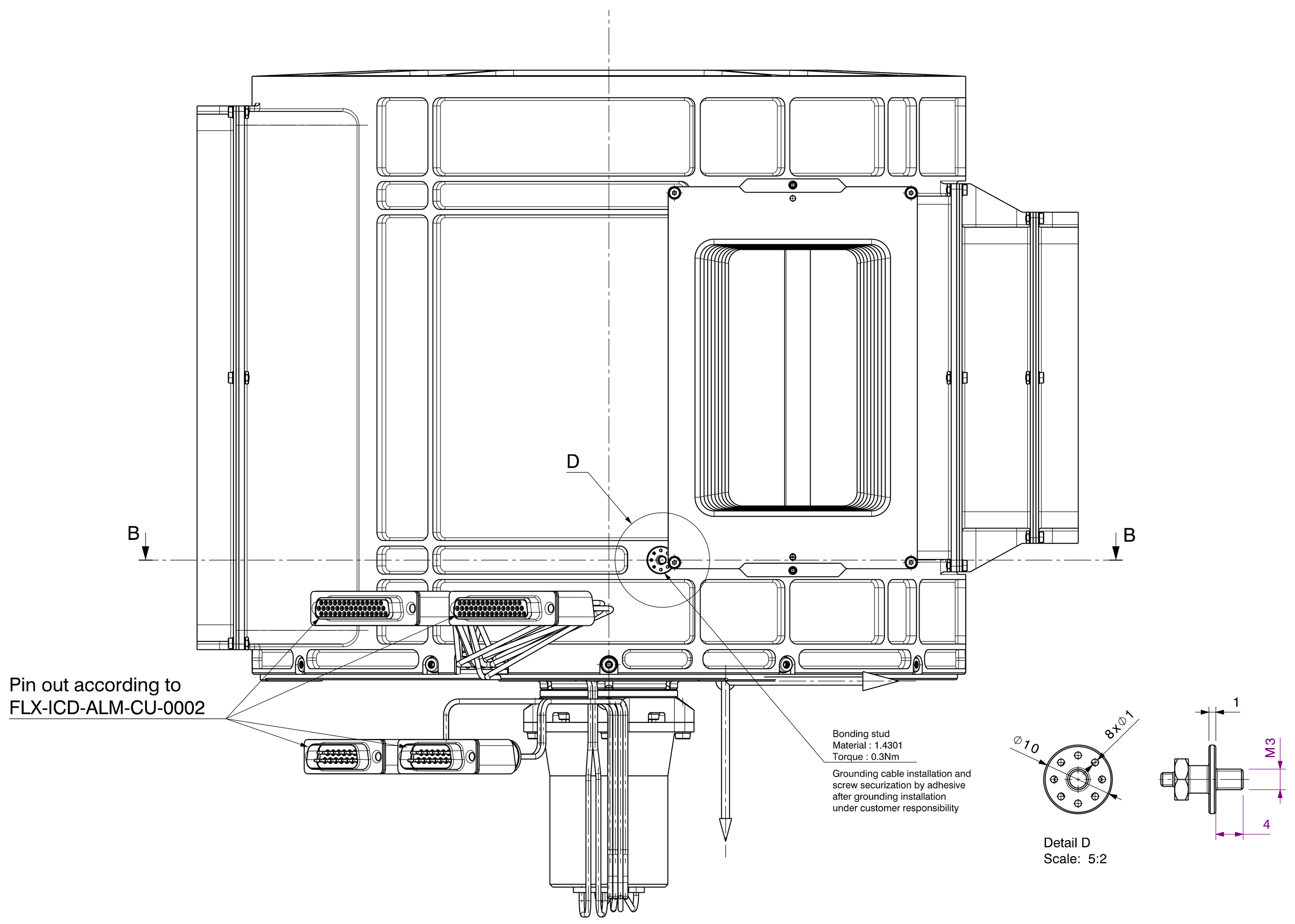
Options

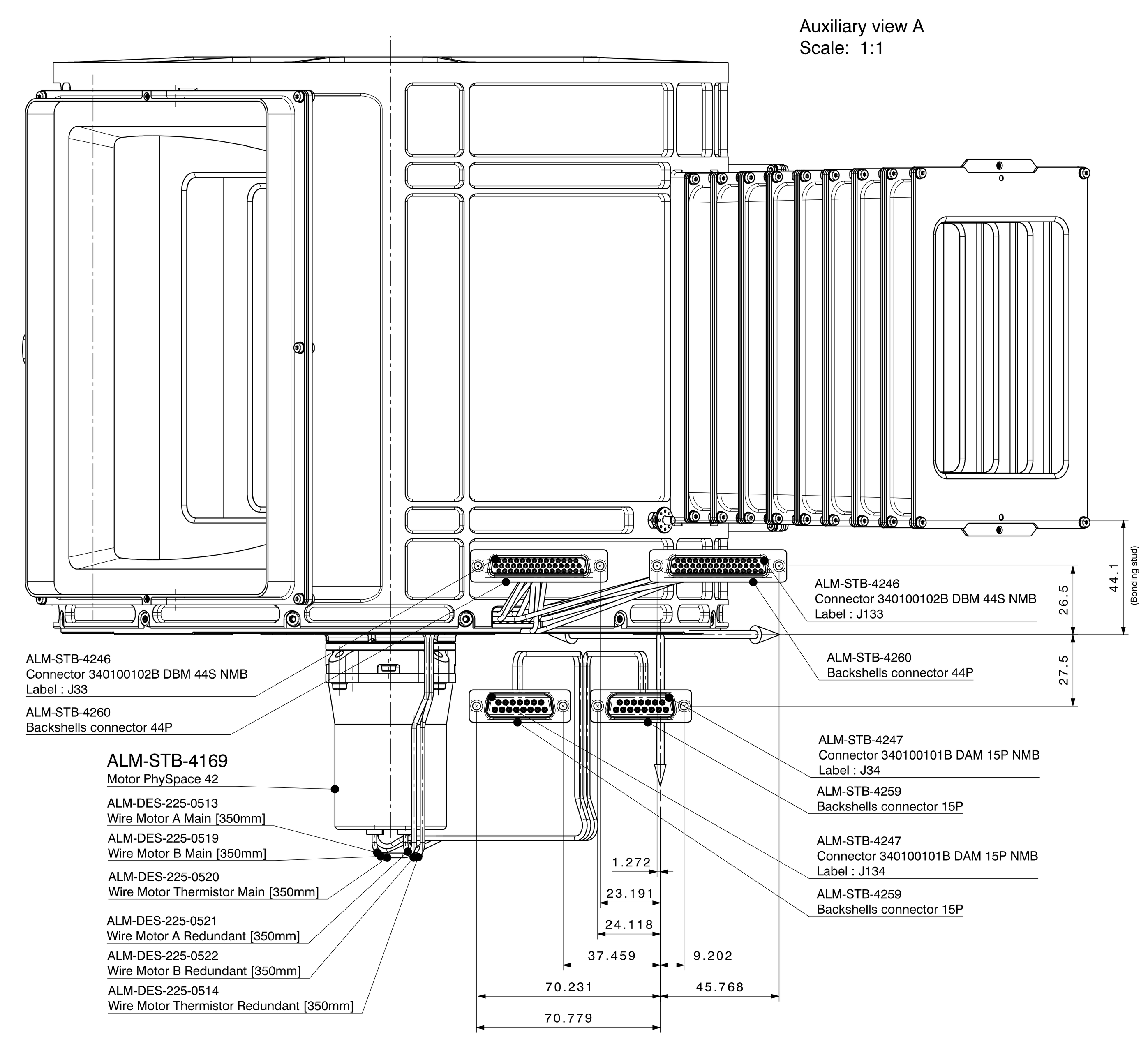
Diameter - Motor size	19 - 2 25 - 2 32 - 2 42 - 2 52 - 2 56 - 2	
Rated current (A/Phase)	0,6 1,2 2,5	for *phy*SPACE 19 to 32 for *phy*SPACE 19 to 56 for *phy*SPACE 42 to 56
Option	Ti	Titanium housing
Option	red	Winding cold redundant
Option	F1	Shaft design flat (front)

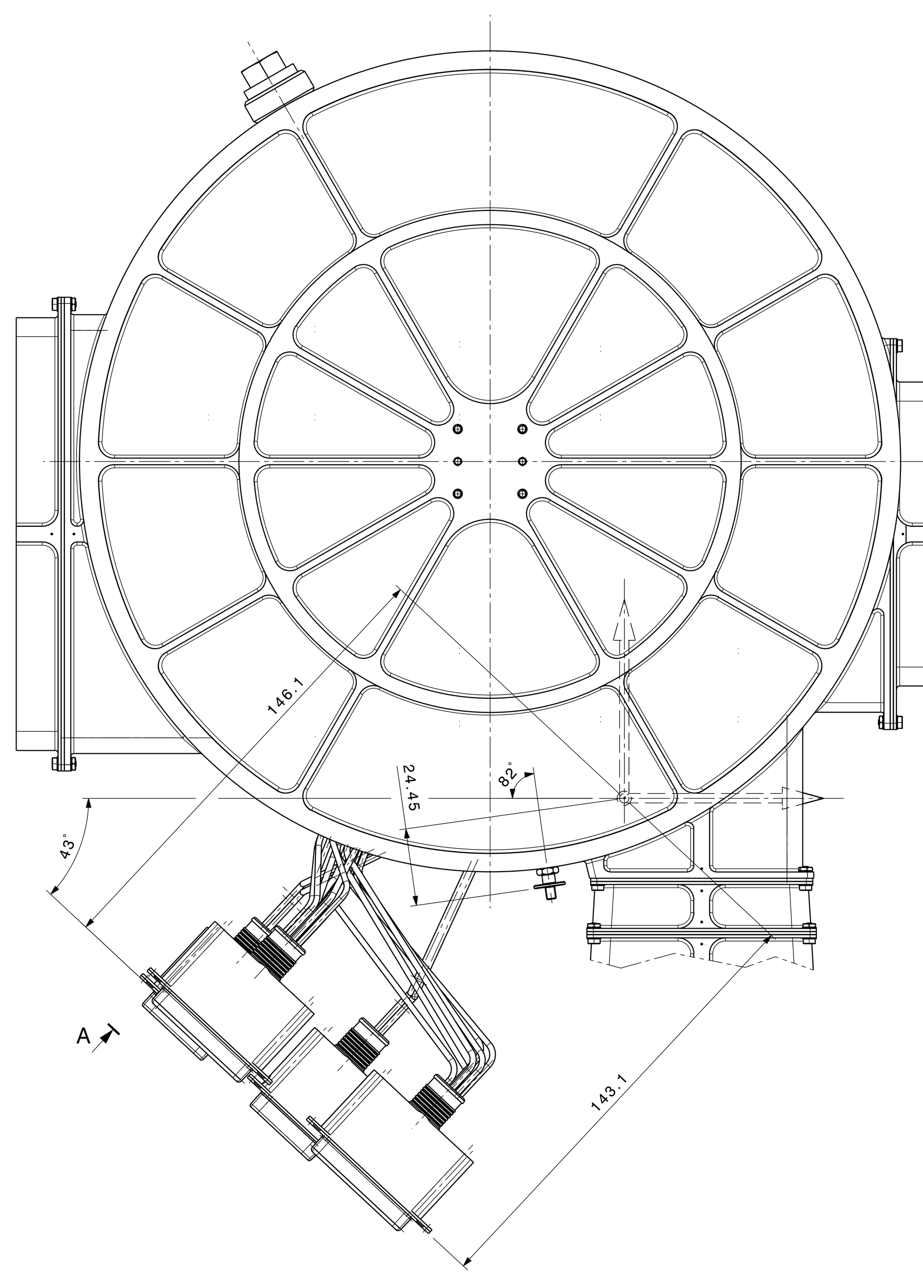
Phytron, Inc.
Mr. Wahid Lahmadi
600 Blair Park Road Suite 220
Williston, VT 05495
USA
T +1-802-872-1600 F +1-802-872-0311

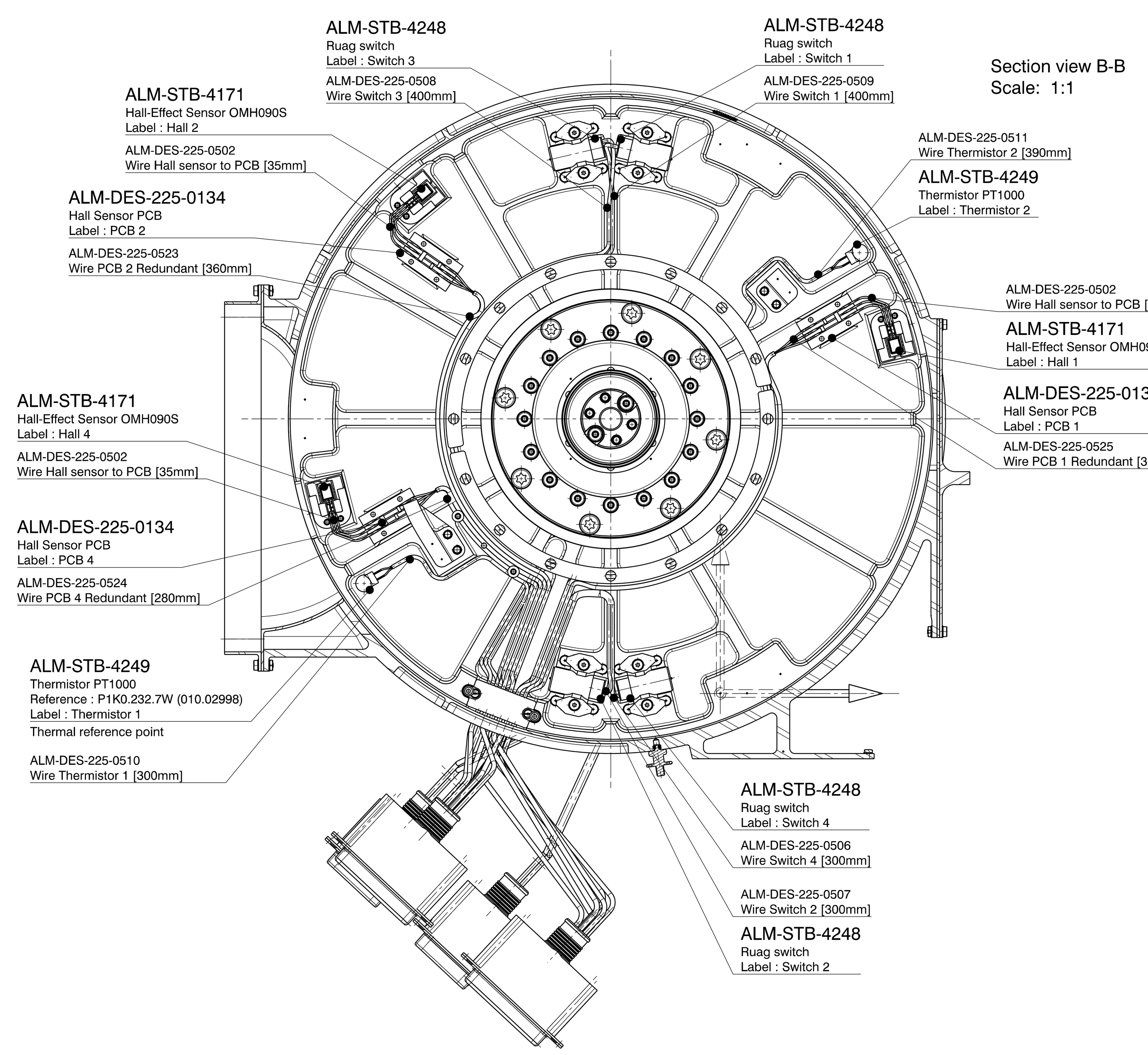
Appendix D
EICD Drawing

A	24.01.2018 JJ	First issue
B	20.07.2018 JJ	Global update of design and add wires lenght
C	28.01.2019 JJ	Global Update for MRR









Wire lenght description

Wire #	Wire part number	Wire fonction	Component	Wire type [AWG] Inside CU	Wire lenght [mm] Inside CU	Wire type [AWG] Outside CU	Wire lenght [mm] Outside CU
1	ALM-DES-225-0513	Motor A Main	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
2	ALM-DES-225-0519	Motor B Main	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
3	ALM-DES-225-0521	Motor A Redundant	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
4	ALM-DES-225-0522	Motor B Redundant	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
5	ALM-DES-225-0520	Wire Motor Thermistor Main	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
6	ALM-DES-225-0514	Wire Motor Thermistor Redundant	Motor	-	-	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	350
7	ALM-DES-225-0509	Wire Switch 1	Baumer switch 1	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	310	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	90
8	ALM-DES-225-0507	Wire Switch 2	Baumer switch 2	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	160	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	140
9	ALM-DES-225-0508	Wire Switch 3	Baumer switch 3	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	310	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	90
10	ALM-DES-225-0506	Wire Switch 4	Baumer switch 4	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	160	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	140
11	ALM-DES-225-0505	Wire PCB 1 Main	PCB 1	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	230	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	90
12	ALM-DES-225-0525	Wire PCB 1 Redundant	PCB 1	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	180	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	140
13	ALM-DES-225-0504	Wire PCB 2 Main	PCB 2	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	270	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	90
14	ALM-DES-225-0523	Wire PCB 2 Redundant	PCB 2	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	220	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	140
15	ALM-DES-225-0503	Wire PCB 4 Main	PCB 4	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	190	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	90
16	ALM-DES-225-0524	Wire PCB 4 Redundant	PCB 4	3x AWG 28 twisted-unshielded Axon : ESCC 3901 002 66	140	3x AWG 28 twisted-shielded Axon : ESCC 3901 002 66	140
17	ALM-DES-225-0510	Wire Thermistor 1	Thermistor 1	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	210	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	90
18	ALM-DES-225-0511	Wire Thermistor 2	Thermistor 2	2x AWG 28 twisted-unshielded Axon : ESCC 3901 002 65	250	2x AWG 28 twisted-shielded Axon : ESCC 3901 002 65	140
19	ALM-DES-225-0502	Wire Hall sensor to PCB	PCB 1 - Hall sensor 1 PCB 2 - Hall sensor 2 PCB 3 - Hall sensor 4	AWG 28 (3x) Axon : ESCC 3901 002 61	35	-	-

Connectors pins according to : FLX-ICD-ALM-CU-0002
Power consumption according to : FLX-ICD-ALM-CU-0002
Electrical components according to : FLX-ICD-ALM-CU-0002

General tolerances / Tolérances générales (ISO 2768-f)

Linear dimesions (in mm)									Angular dimensions			
Nominal dimension	≥ 0.5 ...3	> 3 ...6	> 6 ...30	> 30 ...120	> 120 ...400	> 400 ...1000	> 1000 ...2000	> 2000 ...4000	...10	> 10 ...50	> 50 ...120	> 120 ...400
Tolerance	± 0.05	± 0.05	± 0.1	± 0.15	± 0.2	± 0.3	± 0.5	-	± 1°	± 30'	± 20'	± 10'

N-Class roughness / Classe de rugosité N (Ra in μm)

N10	12.5	N6	0.8
N9	6.3	N5	0.4
N8	3.2	N4	0.2
N7	1.6	N3	0.1

Project	17-10P-225	Drawn	28.01.2019	Joel Junod
Seperate RPL Nb	---	Checked		Digitally signed by Marco Lai (Qualified Signature) Date: 2019.01.30 18:57:39 +01'00'
Internal Drawing Nb	ALM-DES-225-0003	Release		

Scale: 1:1

almatech Parc scientifique EPFL CH-1015 Lausanne

Tot. Mass: --- | Sheet N°/Nb: 1/1 | Format: 2A0

Title: FLORIS Calibration Unit - EICD

Drawing Number: FLX-ICD-ALM-CU-0002

Revision: C

Appendix E
PT1000 (CU interface Thermistor)

RESISTANCE TEMPERATURE DETECTOR
THIN FILM PLATINUM SENSOR, PTC
RANGE 100 TO 2000 OHMS AT 0°C, WITH
A TEMPERATURE RANGE OF -200°C TO +200°C

ESCC Detail Specification No. 4006/015

Issue 1	February 2018

Document Custodian: European Space Agency – see https://escies.org

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DOCUMENTATION CHANGE NOTICE

(Refer to https://escies.org for ESCC DCR content)

DCR No.	CHANGE DESCRIPTION

TABLE OF CONTENTS

1 GENERAL

1.1 SCOPE

This specification details the ratings, physical and electrical characteristics and test and inspection data for the component type variants and/or the range of components specified below. It supplements the requirements of, and shall be read in conjunction with, the ESCC Generic Specification listed under Applicable Documents.

1.2 APPLICABLE DOCUMENTS

The following documents form part of this specification and shall be read in conjunction with it:

(a) ESCC Generic Specification No. 4006, Thermistors (Thermally Sensitive Resistors).

1.3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

For the purpose of this specification, the terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply.

1.4 THE ESCC COMPONENT NUMBER AND COMPONENT TYPE VARIANTS

1.4.1 The ESCC Component Number

The ESCC Component Number shall be constituted and marked as follows:

Example: 400601501

- Detail Specification Reference: 4006015
- Component Type Variant Number: 01 (as required)

1.4.2 Component Type Variants and Range of Components

Variant Number	Based on Type (Article Number)	Nominal R_Z (Ω) (at 0°C)	Operating Temperature Range T_{op} (°C)	Maximum Operating Current I_{OP} (mA) (Notes 1, 2)	Maximum Rated Current I_{MAX} (mA)
01	P0K1.232.7W (010.02991)	100	-50 to +150	1	4
02	P0K1.232.7W (010.02992)	100	-200 to +200	1	4
03	P0K2.232.7W (010.02993)	200	-50 to +150	0.7	2.8
04	P0K2.232.7W (010.02994)	200	-200 to +200	0.7	2.8
05	P0K5.232.7W (010.02995)	500	-50 to +150	0.45	1.3
06	P0K5.232.7W (010.02996)	500	-200 to +200	0.45	1.3
07	P1K0.232.7W (010.02997)	1000	-50 to +150	0.3	1.3
08	P1K0.232.7W (010.02998)	1000	-200 to +200	0.3	1.3
09	P2K0.232.7W (010.02998)	2000	-50 to +150	0.2	0.9
10	P2K0.232.7W (010.03000)	2000	-200 to +200	0.2	0.9

RESISTANCE vs. TEMPERATURE LIMITS

Variant Number		R_Z (Ω) Over T_{op} (Note 2)							
		-200°C	-100°C	-50°C	0°C	+50°C	+100°C	+150°C	+200°C
01	Min	-	-	80.087	99.882	119.185	138.202	156.932	-
	Max	-	-	80.524	100.117	119.608	138.808	157.717	-
02	Min	17.957	59.931	80.087	99.882	119.185	138.202	156.932	175.377
	Max	19.081	60.58	80.524	100.117	119.608	138.808	157.717	176.333
03	Min	-	-	160.174	199.764	238.37	276.404	313.864	-
	Max	-	-	161.048	200.234	239.216	277.616	315.434	-
04	Min	35	119.86	160.174	199.764	238.37	276.404	313.864	350.754
	Max	38.162	121.168	161.048	200.234	239.216	277.616	315.434	352.666
05	Min	-	-	400.435	499.41	595.925	691.01	784.66	-
	Max	-	-	402.62	500.585	598.04	694.04	788.585	-
06	Min	89.785	299.655	400.435	499.41	595.925	691.01	784.66	876.885
	Max	95.405	302.93	402.62	500.585	598.04	694.04	788.585	881.665
07	Min	-	-	800.87	998.82	1191.85	1382.02	1569.32	-
	Max	-	-	805.24	1001.17	1196.08	1388.08	1577.17	-
08	Min	179.571	599.315	800.87	998.82	1191.85	1382.02	1569.32	1753.77
	Max	190.811	605.86	805.24	1001.17	1196.08	1388.08	1577.17	1763.33
09	Min	-	-	1601.74	1997.64	2383.7	2764.04	3138.64	-
	Max	-	-	1610.48	2002.34	2392.16	2776.16	3154.34	-
10	Min	359.143	1198.62	1601.74	1997.64	2383.7	2764.04	3138.64	3507.54
	Max	381.623	1211.61	1610.48	2002.34	2392.16	2776.16	3154.34	3526.66

NOTES:

1. Operating current is limited by self-heating. Mounting details have a major influence on self-heating.
2. For test purposes, when zero power is dissipated (i.e. ≤ I_{OP}) and the ambient temperature is held as specified and measured with tolerance ±0.01°C, the value is referred to as R_Z (Zero Power Resistance).

1.5 MAXIMUM RATINGS

The maximum ratings shall not be exceeded at any time during use or storage.

Maximum ratings shall only be exceeded during testing to the extent specified in this specification and when stipulated in Test Methods and Procedures of the ESCC Generic Specification.

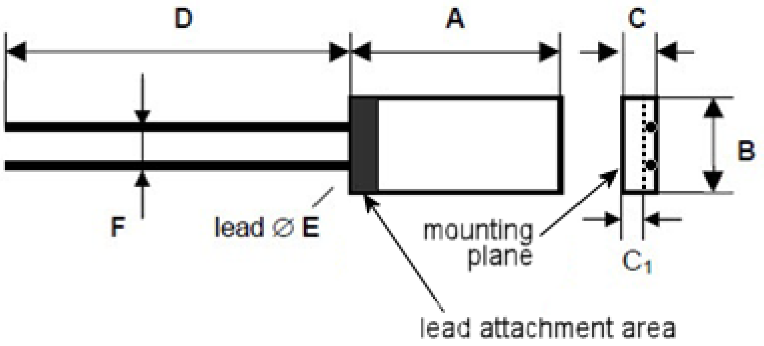
Characteristics	Symbols	Maximum Ratings	Units	Remarks
Maximum Rated Current	I_{MAX}	See Para. 1.4.2	mA	
Power Dissipation	P_D	20	mW	
Operating Temperature Range	T_{op}	See Para. 1.4.2	ºC	
Storage Temperature Range	T_{stg}	-200 to +200	ºC	

1.6 HANDLING PRECAUTIONS

These components are susceptible to damage by electrostatic discharge. Therefore, suitable precautions shall be employed for protection during all phases of manufacture, testing, shipment and any handling.

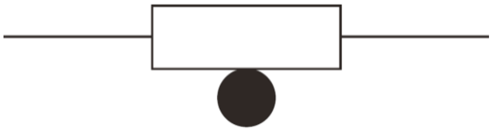
These components are categorised as Class 2 per ESCC Basic Specification No. 23800 with a Minimum Critical Path Failure Voltage of 2000 Volts.

1.7 PHYSICAL DIMENSIONS



Symbol	Dimensions (mm)		Remarks
	Min	Max	
A	2.1	2.4	
B	1.8	2.2	
C	0.9	1.3	total thickness of the lead attachment area
C_1	0.55	0.85	substrate thickness excluding the lead attachment area
D	9	10.7	
ØE	0.18	0.22	lead diameter
F	0.75	1.25	

1.8 FUNCTIONAL DIAGRAM



1.9 MATERIALS AND FINISHES

1.9.1 Body
Thin film Platinum printed on an Al_2O_3 substrate, covered with a transparent, glass passivation layer. The area of lead attachment on the substrate is also covered with a transparent, glass passivation layer.

1.9.2 Lead Material and Finish
Platinum wire.

1.10 WEIGHT
350mg maximum.

2 REQUIREMENTS

2.1 GENERAL
The complete requirements for procurement of the components specified herein are as stated in this specification and the ESCC Generic Specification. Permitted deviations from the Generic Specification, applicable to this specification only, are listed below.

Permitted deviations from the Generic Specification and this Detail Specification, formally agreed with specific Manufacturers on the basis that the alternative requirements are equivalent to the ESCC requirement and do not affect the component's reliability, are listed in the appendices attached to this specification.

2.1.1 Deviations from the Generic Specification

2.1.1.1 Deviations from Special In-Process Controls – Chart F2
(a) Pre-Encapsulation (internal Visual) Inspection: shall not be performed.

2.1.1.2 Deviations from Screening Tests – Chart F3
(a) Radiographic Inspection: shall not be performed.

2.1.1.3 Deviations from Qualification and Periodic Tests - Chart F4
(a) Shock (Specified Pulse): shall not be performed.
(b) Vibration: shall not be performed.
(c) Resistance to Soldering Heat: not applicable.
(d) Dissipation Constant: shall not be performed.
(e) Thermal Time Constant: shall not be performed.
(f) Solderability: not applicable.
(g) Short Time Load: E_{TH} and I_{TH} shall be as specified in Para. 2.7 in the Detail Specification. Zero Power Resistance shall be measured before and after the test and Change in Zero Power Resistance shall be calculated; the limits specified in Para. 2.7 in the Detail Specification shall apply.

2.2 MARKING

The marking shall be in accordance with the requirements of ESCC Basic Specification No. 21700 and as follows.

The information to be marked on the component or the primary package shall be:

(a) The ESCC Qualified Component Symbol (for ESCC qualified components only).
(b) The ESCC Component Number (see Para. 1.4.1).
(c) Traceability information.
(d) Sensitivity to Electrostatic Discharge Symbol.

2.3 THERMAL SHOCK

Thermal Shock shall be performed as specified in the ESCC Generic Specification. The Test Condition shall be C with an exposure time of 10 minutes at each temperature extreme.

2.4 TERMINAL STRENGTH

The test conditions for Terminal Strength, tested as specified in the ESCC Generic Specification, shall be as follows:

- Test Condition: A
- Method of Holding: The component body shall be glued to the test fixture.
- Applied Force: 2 (+0.5 -0)N. The force shall be applied gradually to both terminals together and then maintained for a period of 5 seconds minimum.

2.5 ELECTRICAL MEASUREMENTS AT ROOM, HIGH AND LOW TEMPERATURES

Electrical measurements shall be performed at room, high and low temperatures.

2.5.1 Room Temperature Electrical Measurements

Unless otherwise specified, the measurements shall be performed at T_{amb} = +22 ±3°C.

Characteristics	Symbols	Test Method and Conditions	Limits		Units
			Min	Max	
Zero Power Resistance at 0°C	R_Z	ESCC No. 4006, Note 1	Note 2		
Insulation Resistance	R_I	ESCC No. 4006, Note 3	100	-	MΩ

NOTES:

1. Zero Power Resistance shall be measured at T_{amb} = +25 ±0.01°C and +85 ±0.01°C with I_{OP} test conditions as specified in Para. 1.4.2. The resistance value at 0°C shall be calculated using the measured values and the following equation:

   $$R_0 = R_T \div (1 + AT + BT^2)$$

   Where:
   - R_0 : calculated Zero Power Resistance at 0°C
   - R_T : measured Zero Power Resistance at T_{amb} = T (in °C)
   - A = 3.9156 $\times 10^{-3}$
   - B = -6.4413 $\times 10^{-7}$

   All measurements and calculations shall be recorded against serial number.
2. See Para. 1.4.2 for R_Z limits.
3. The measurements shall be performed on a sample of 5 components with 0 failures permitted. In the event of any failure a 100% inspection may be performed.

2.5.2 High and Low Temperatures Electrical Measurements

Characteristics	Symbols	Test Method and Conditions	Limits		Units
			Min	Max	
Zero Power Resistance over T_{op}	R_Z	ESCC No. 4006, Note 1	Note 2		

NOTES:

1. Zero Power Resistance shall be measured at the following temperatures, each with an accuracy of ±0.01°C, and with I_{OP} test conditions as specified in Para. 1.4.2:
   - For Variants 01, 03, 05, 07, 09, T_{amb} = (in °C):
     0, +10, +20, +30, +40, +50, +60, +70, +80, +90, +100
   - For Variants 02, 04, 06, 08, 10, T_{amb} = (in °C):
     -196, 0, +10, +20, +30, +40, +50, +60, +70, +80, +90, +100

   The resistance value at each temperature specified in Para. 1.4.2 shall be calculated using the measured values and the equation given in Para. 2.5.1 Note 1. All measurements and calculations shall be recorded against serial number.
2. See Para. 1.4.2 for R_Z limits at each specified temperature.

2.6 PARAMETER DRIFT VALUES

The test methods and test conditions shall be as per the corresponding test defined in Para. 2.5.1 Room Temperature Electrical Measurements.

The drift values (Δ) shall not be exceeded for each characteristic. The corresponding absolute limit values for each characteristic shall not be exceeded.

Characteristics	Symbols	Limits			Units
		Drift Value (Δ)	Absolute		
			Min	Max	
Zero Power Resistance at 0°C	R_Z	±0.1%	See Para. 2.5.1		

2.7 INTERMEDIATE AND END-POINT ELECTRICAL MEASUREMENTS

The test methods and test conditions shall be as per the corresponding test defined in Para. 2.5.1 Room Temperature Electrical Measurements.

Test Reference per ESCC No. 4006	Characteristics	Symbols	Limits		Units
			Min	Max	
Moisture Resistance					
Initial Measurements	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Final Measurements	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
	Insulation Resistance	R_I	100	-	MΩ
Terminal Strength					
Initial Measurements (Note 1)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Final Measurements	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
Short Time Load (P_D = Note 2)					
Initial Measurements (Note 1)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Final Measurements	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
Low Temperature Storage					
Initial Measurements (Note 3)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Final Measurements	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
Operating Life					
Initial Measurements (Note 3)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Intermediate Measurements (1000 hours)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
	Insulation Resistance	R_I	100	-	MΩ
Final Measurements (2000 hours)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
	Insulation Resistance	R_I	100	-	MΩ

Test Reference per ESCC No. 4006	Characteristics	Symbols	Limits		Units
			Min	Max	
High Temperature Storage					
Initial Measurements (Note 3)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
Intermediate Measurements (1000 hours)	Zero Power Resistance at 0°C	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%
Final Measurements (2000 hours)	Zero Power Resistance	R_Z	See Para. 2.5.1		
	Change in Zero Power Resistance at 0°C	$\Delta R_Z/R_Z$	-	±0.1	%

NOTES:
1. Zero Power Resistance values recorded during Room Temperature Electrical Measurements during Chart F3 may be used as initial measurements.
2. E_{TH} and I_{TH} shall be adjusted to provide Maximum Rated Current as specified in Para. 1.5.
3. Zero Power Resistance values recorded during the final measurements of the previous test may be used as initial measurements.

2.8 BURN-IN CONDITIONS

Characteristics	Symbols	Test Conditions	Units
Ambient Temperature	T_{amb}	+150 ±10	°C
Test Current	I_{TEST}	2 x I_{OP} (Note 1)	mW

NOTES:
1. See Para. 1.4.2 for I_{OP} values.

2.9 OPERATING LIFE CONDITIONS

The conditions shall be as specified for Burn-in.

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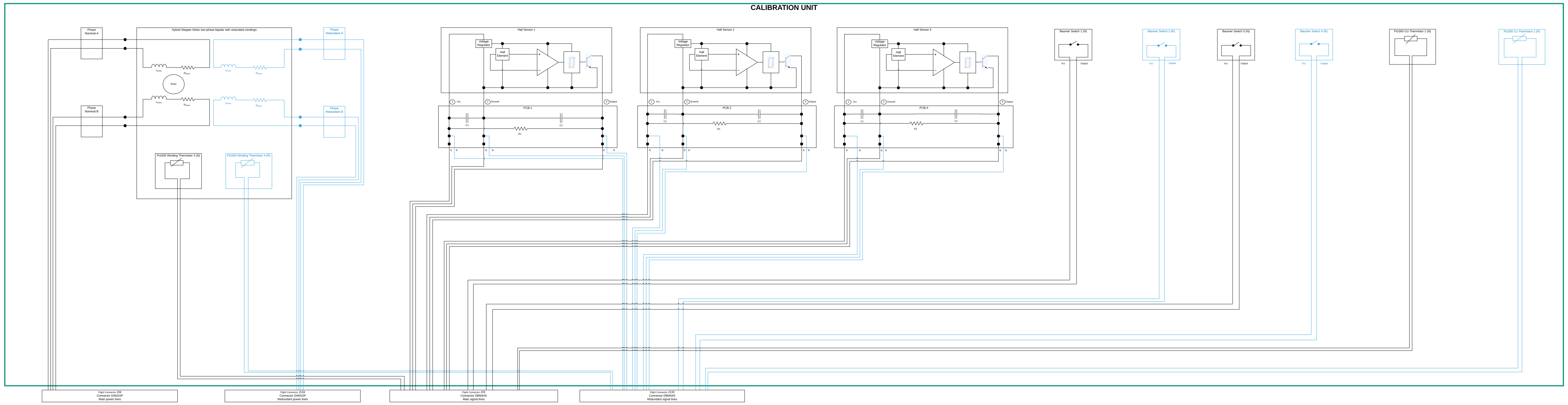
APPENDIX 'A'

AGREED DEVIATIONS FOR INNOVATIVE SENSOR TECHNOLOGY IST AG (CH)

Items Affected	Description of Deviations
Para. 2.1.1, Deviations from the Generic Specification	Paras. 9.1.3(b), 9.1.4, 9.2(e), 9.6, Data Documentation: The relevant delivered data documentation for the components of the delivery lot, shall not be traceable to component serial number.
Para. 2.1.1.1, Deviations from Special In-Process Controls – Chart F2 Para. 2.1.1.2, Deviations from Screening Tests – Chart F3 Para. 2.1.1.3, Deviations from Qualification and Periodic Tests – Chart F4	Para. 8.5, External Visual Inspection: shall be performed in accordance with ESCC No. 2054000, and the Manufacturer's visual inspection procedure as specified in the PID.
Para. 2.1.1.3, Deviations from Qualification and Periodic Tests – Chart F4	Para. 8.19, Permanence of Marking: shall not be performed.
Para. 2.2, Marking	The serial numbers of the components of the delivery lot shall not be marked on the components nor on the packaging.

Appendix F
Electrical Drawing


CALIBRATION UNIT
Phase Nominal A
Hybrid Stepper Motor two-phase bipolar with redundant windings
Phase Redundant A
Lphase
Rphase
Rotor
Lphase
Rphase
Phase Nominal B
Phase Redundant B
Pt1000 Winding Thermistor 3 (N)
Pt1000 Winding Thermistor 4 (R)
Hall Sensor 1
Voltage Regulator
Hall Element
1 Vcc
2 Ground
3 Output
PCB-1
C1
C2
R1
N R
Hall Sensor 2
Voltage Regulator
Hall Element
1 Vcc
2 Ground
3 Output
PCB-2
C1
C2
R1
N R
Hall Sensor 4
Voltage Regulator
Hall Element
1 Vcc
2 Ground
3 Output
PCB-4
C1
C2
R1
N R
Baumer Switch 1 (N)
Vcc Output
Baumer Switch 2 (R)
Vcc Output
Baumer Switch 3 (N)
Vcc Output
Baumer Switch 4 (R)
Vcc Output
Pt1000 CU Thermistor 1 (N)
Pt1000 Cu Thermistor 2 (R)
Flight Connector J34
Connector DAM15P
Main power lines
Flight Connector J134
Connector DAM15P
Redundant power lines
Flight Connector J33
Connector DBM44S
Main signal lines
Flight Connector J133
Connector DBM44S
Redundant signal lines