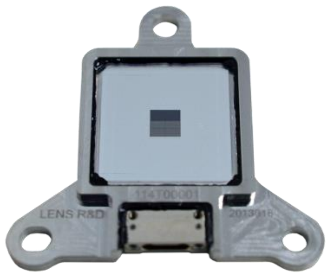

MAUS SUN SENSOR

PRODUCT SPECIFICATION DOCUMENT

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DOCUMENT CHANGE RECORD

Issue	Date	Total pages	Pages affected	Brief description of change
1	17-08-2020	15	All	New document
1a	04-12-2020	15	7	Clarification update of equations
1b	11-01-2020	15	10	Requirement on resistance sapphire to housing deleted
1c	12-04-2021	14	5, 15	Suggestion for acceptance testing added Updated Applicable Document version number

Contents

List of figures

List of tables

List of equations

Abbreviations

AD	Applicable Document
ADC	Analogue to Digital Converter
BOL	Begin of Life
COTS	Commercial Off The Shelf
CTE	Coefficient of Thermal Expansion
EMC	Electro Magnetic Compatibility
EOL	End of Life
FOV	Field of View
ICD	Interface Control Document
LOS	Line Of Sight
MAIT	Manufacturing Assembly Integration and Test
NTC	Negative Temperature Coefficient resistor (thermistor)
PIND	Particle Induced Noise Detection
PSD	Power Spectral Density
RD	Reference Document
Req	Requirement

Applicable documents

AD	Document name	Document number	Issue
[AD-01]	MAUS interface control document	20-LRD-ICD-0003	2
[AD-02]	MAUS interface control drawing	114T701	02
[AD-03]	Precision fastener	500M085	01
[AD-04]	Washer vented	500M086	01
[AD-05]	Delivery, Packing, Storage, Handling, and Transportation procedure.	19-LRD-PR-0052	1d

Reference documents

RD	Document name	Document number	Issue

1 Introduction

The MAUS Sun sensor, see Figure 1 is a high reliability CubeSat Sun sensor with a nominal field of view of 64 degrees in diagonal which is specifically designed for highly demanding satellite applications.

This document specifies the performance of the sensor and shall be read in conjunction with the interface control document [AD-01] and the interface control drawing [AD-02].

Figure 1 MAUS Sun sensor

2 Solar direction angles

Apart from the quadrant definition as given in [AD-02] it is necessary to define the reference frame of the Sun sensors in order to avoid sign errors in the attitude control subsystem. All MAUS Sun sensors use the reference definition given below.

These diagrams provide the definition of the angles α and β to be calculated by means of the formulas given in Equation 1. It can be deducted that a negative α means that the sun is to the top of the Sun sensor and that a negative β means that the sun is to the right of the Sun sensor (both when viewed from the top side).

The illumination given in Figure 2 is for positive α and positive β of the MAUS Sun sensor.

All MAUS Sun sensors use the reference definition given in Equation 1. The definition is applicable for the non-compensated utilization. In order to improve the accuracy further the sensor can be implemented with standard calibration tables or using a simplified compensation formula, see Equation 2.

$$S_a = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\alpha)}{\tan(\alpha_{max})}$$

$$S_b = \frac{Q_1 + Q_2 - Q_3 - Q_4}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\beta)}{\tan(\beta_{max})}$$

Equation 1 BiSon64-ET α and β formulas

$$S_{a\_compensated} = S_a - C_a = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} - C_a = \frac{\tan(\alpha)}{\tan(\alpha_{max})}$$

$$S_{b\_compensated} = S_b - C_b = \frac{Q_1 + Q_2 - Q_3 - Q_4}{Q_1 + Q_2 + Q_3 + Q_4} - C_b = \frac{\tan(\beta)}{\tan(\beta_{max})}$$

Equation 2 α and β formulas with correction in radian

C_a is the offset correction parameter used to compensate zenith offset in the α direction.
C_b is the offset correction parameter used to compensate zenith offset in the β direction.

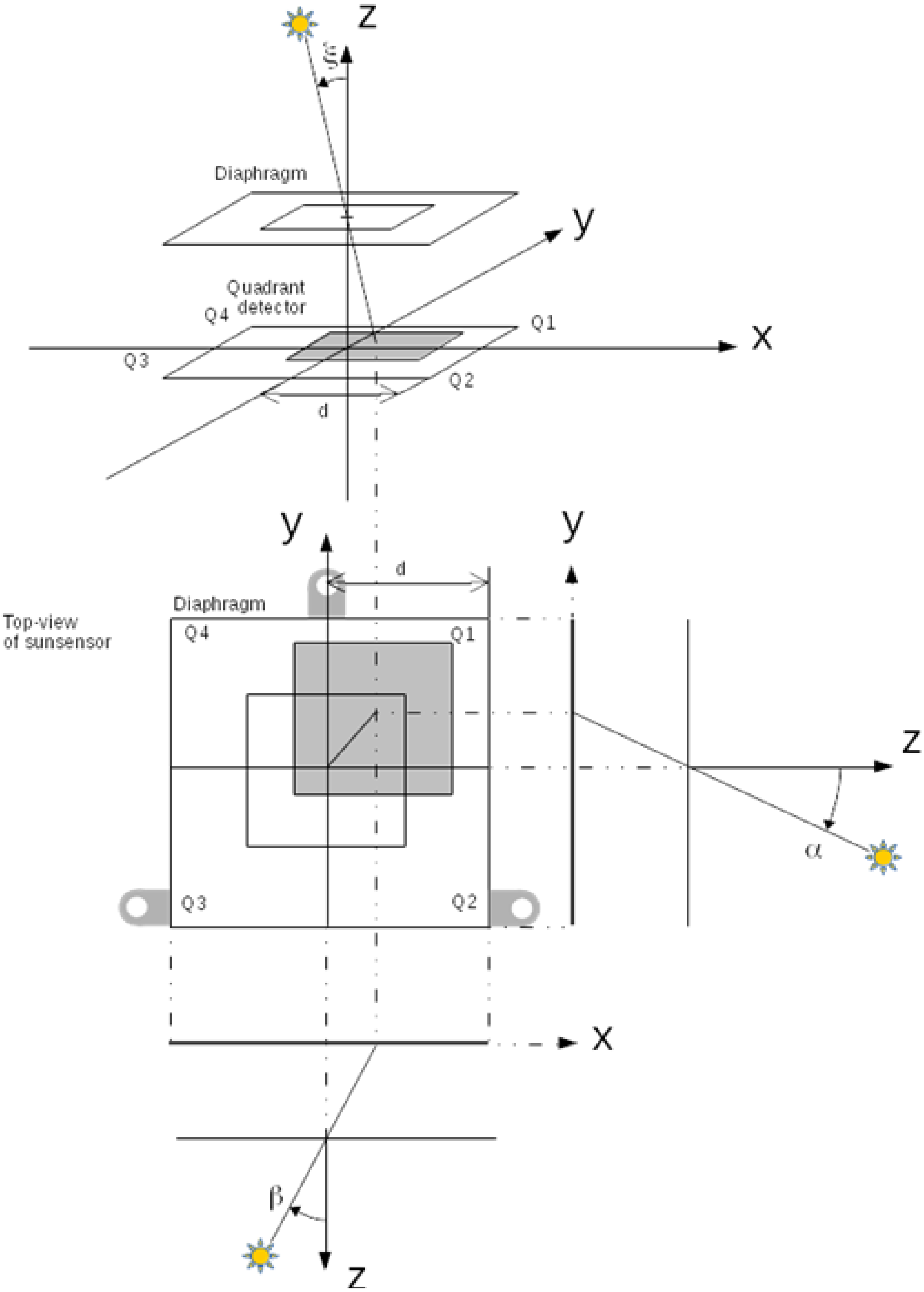

Figure 2 α and β reference frame and angle visualization

3 Mechanical interfaces

The dimensions of the mechanical interfaces are given in interface control drawing [AD-02]. The counterpart on which the Sun sensor will be mounted shall have at least the same accuracies as the sensor as defined in the IC-drawing.
The X axis of the right-hand Cartesian reference system is defined by the line through the center of the lower right and lower left mounting points. The Z axis is fixed by means of the plane running through the three mounting feet.

3.1 Repeatability of mounting

Req. 3.1 The repeatability of mounting shall be better than 0.06 degrees, when using the prescribed mounting hardware (special fasteners with washers, [AD-03] and [AD-04]). The dimensions and accuracies of the counterpart on which the Sun sensor will be mounted shall be in line with the Sun sensor specifications as stated on the IC-drw [AD-02] and assembly is according to the prescribed procedure as given in paragraph 6.3 of [AD-05].

3.2 Fastening torque

The special fasteners defined in [AD-03] shall be fastened with a torque of 1Nm ± 10%.

3.3 Mass

Req. 3.3 The mass of the unit is ≤16 grams but more accurately given on sheet 1 of [AD-02].

3.4 Centre of gravity

The center of gravity is given on sheet 1 of [AD-02]. But there are no requirements on the CoG.

4 Optical interfaces

The optical interfaces are defined on sheet 2 of [AD-02] in combination with the reference frame definition as given in par 2.

Req. 4-1 The field of view of the sensors shall be >62° in both diagonals.

The actual angles and associated limits are given on sheet 2 of [AD-02].

5 Electrical interfaces

The electrical connections are as given on sheet 3 of [AD-02].

The sensor will generate 4 analogue currents.

Req. 5-1 The currents generated shall be -1.45mA ±20% at normal incidence at 20°C ±5°C.
Req. 5-2 The currents generated shall be -1.45mA ±60% at normal incidence over the full temperature range.

These values are at 1 Am(0) sun illumination and 0 bias (measured with a transimpedance amplifier) over the full temperature range.

Req. 5-3 The internal thermistor shall have a nominal value of 10kΩ ±10% @ 25°C.

5.1 Grounding and isolation

Req. 5.1-1 The resistance from the common ground to case shall be 1MΩ<R<10MΩ.
Req. 5.1-2 The capacitance between the sensor and ground shall be <100pF.
Req. 5.1-3 Deleted

5.2 Specified accuracy

Req. 5.2-1 The specified accuracy for the sensors is better than 3.5 degrees if no calibration table is used.

Req. 5.2-2 The specified accuracy for the sensors is better than 2 degree if a sensor specific offset and gain correction is implemented.

Req. 5.2-3 The specified accuracy for the sensors is better than 0.5 degree 3σ if calibration tables are used.

6 Environmental specifications

6.1 Storage conditions

Req. 6.1 The sensor should be stored in a dust free, dry and temperature-controlled environment with a temperature range of 0°C to +30 °C and a relative humidity of 40% to 60% storage lifetime under these conditions is longer than 5 years when kept in the original packaging.

6.2 Operating temperature range

Req. 6.2 The sensors shall perform within specifications when operated in the range of -40°C to +80°C.

6.3 Non-operating temperature range

Req. 6.3 The sensors shall survive a non-operating temperature range of -45°C to +85°C.

6.4 Temperature cycling

The sensors shall meet the temperature cycling requirements specified in Table 1.

Req.	Conditions	Temperature range	Number of cycles
6.4	Thermal vacuum cycling (qualification)	-40°C….+80°C	1000

Table 1 Thermal cycling specification

6.5 Vibration specifications

Vibration specifications of the sensor are given below. It should be noted that these are qualification levels. Any safety margins required for the mission shall therefore be subtracted from the given level to see if the sensors meet mission requirements. The sine and random qualifications have been performed using the in [AD-03] and [AD-04] defined hardware and torqued to the level specified in chapter 3.2.

6.5.1 Eigenfrequency

Req. 6.5.1 The first eigenfrequency shall be >200Hz.

6.5.2 Sine vibration

Req. 6.5.2 The sensors shall be able to function within specifications after being subject to vibration test levels specified in Table 2 in all three axes.

Sine vibrations	
Frequency Hz	**Level**
5...44.6	10mm peak to peak 5mm zero to peak
44.6...100	20g
1 octave/minute 1 sweep up/1 sweep down	

Table 2 Sine vibrations

6.5.3 Random vibrations qualification

Req. 6.5.3 The sensor shall be able to function within specifications after being subjected to vibration test levels specified in Table 3 and Figure 3 in all three axes.

Random vibrations						
Frequency (Hz)	**ASD (G^2/Hz)**	**dB**	**OCT**	**dB/OCT**	**Area**	**Grms**
20.00	0.01	*	*	*	*	*
100.00	0.75	18.75	2.32	8.08	20.31	4.51
175.00	0.75	0.00	0.81	0.00	76.56	8.75
500.00	0.50	-1.76	1.51	-1.16	270.04	16.43
2000.00	0.01	-16.99	2.00	-8.49	396.28	19.91
Total RMS level: 19.91g						
Duration: 180 seconds						

Table 3 Random vibrations

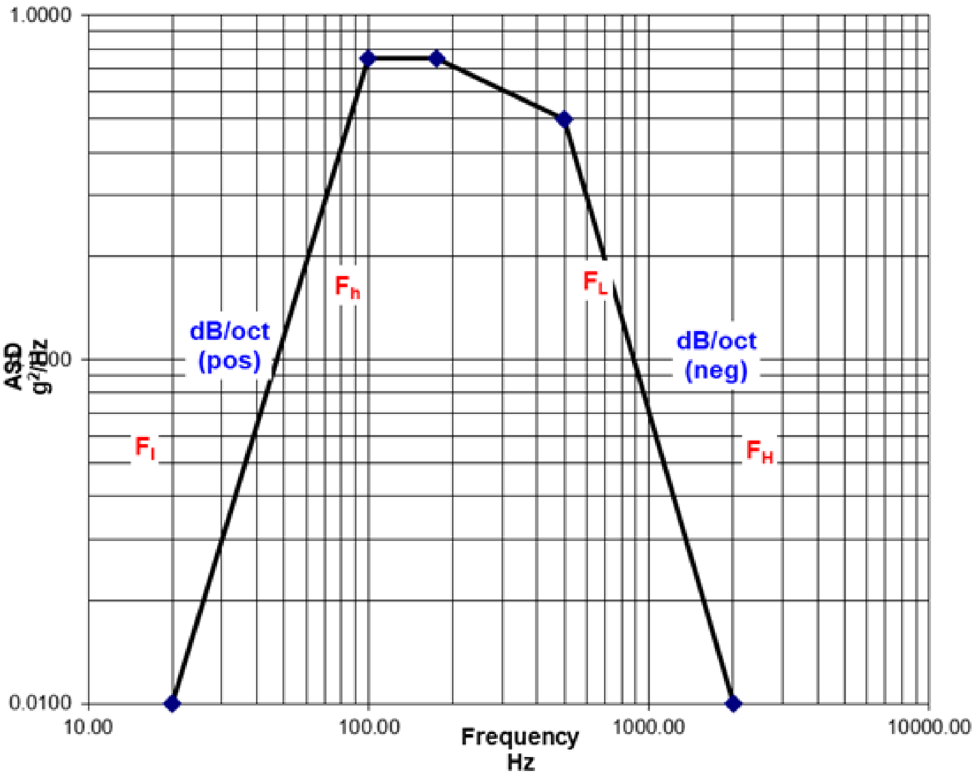

Figure 3 Random vibration profile

6.5.4 Shock specification

Req. 6.5.4 The sensor shall be able to function within specifications after being subject to vibration test levels specified in Table 4 and Figure 4 in all three axes.

Pyro shock	
Frequency Hz	**Level g**
100	20
1000	1000
2000	1500
10000	1500
3 shocks in any direction	

Table 4 Pyro shock specifications

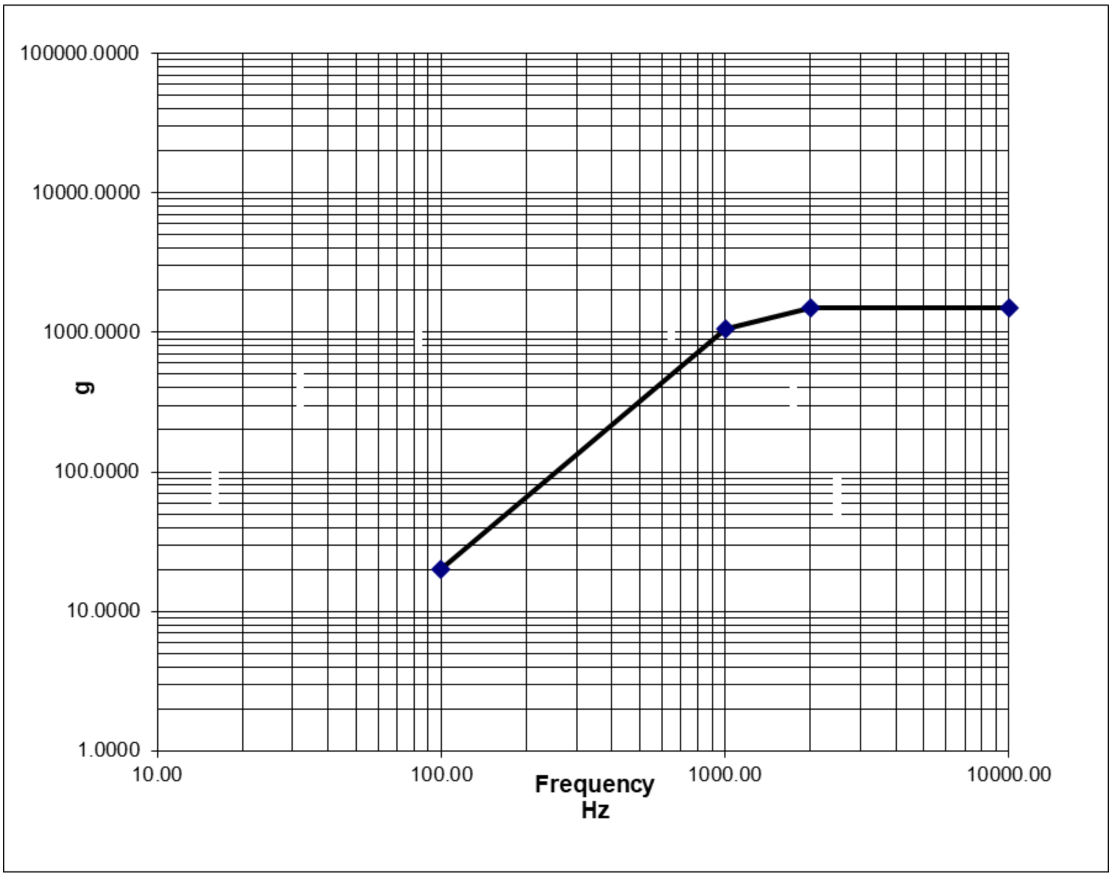

Figure 4 Pyro shock profile

6.6 Cosmic radiation resistance

Req. 6.6 Bare diodes shall sustain 4E14 1MeV electron testing without failure at a fluence of 1E11 electrons per second. Tolerance on radiation test parameters shall be ±5%.

6.7 Standard acceptance testing activity

Req. 6.7 The sensors will be calibrated before delivery.

6.8 Optional test

Vibration testing and Thermal cycling are optional test, and must be agreed upon with Lens R&D.

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