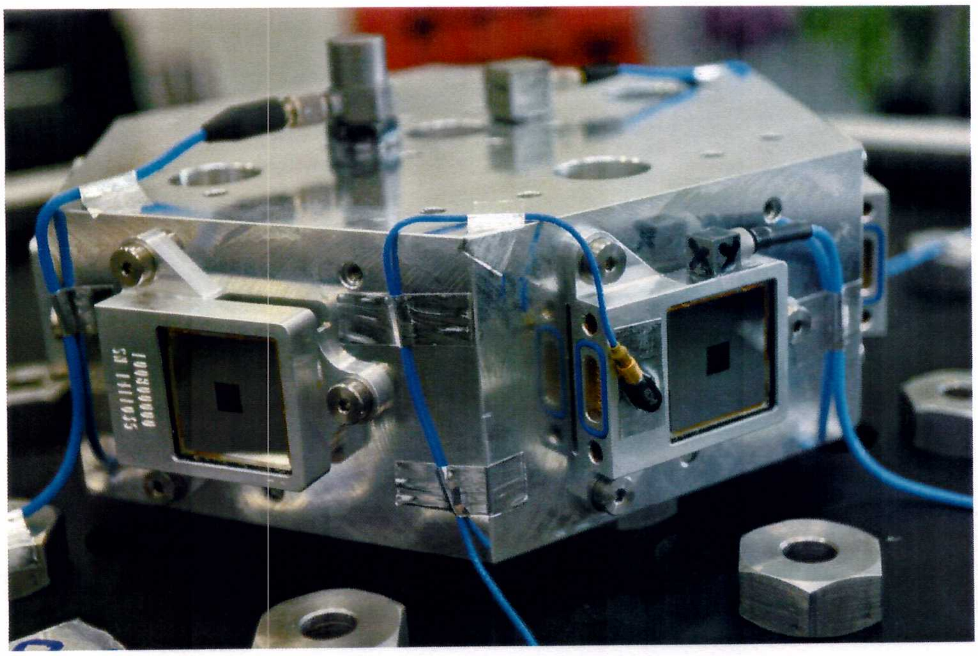

BiSon64 SUNSENSOR

PRODUCT SPECIFICATION DOCUMENT

	Name	Signature
Prepared by:	J.A.P. Leijtens (Lens Research & Development)	
Checked by:	J.M.M. Uittenhout (Lens Research & Development)	
Approved by:	N/A	

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Applicable and reference documents

Nr	Document number	Document name	Issue
[AD1]	100B502	BiSon64 interface control drawing	01
[AD2]	500M010	Precision fastener	00
[AD3]	500M011	Washer	00

Abbreviations

AD	Applicable Document
ADC	Analogue to Digital Converter
COTS	Commercial Off The Shelf
CTE	Coefficient of Thermal Expansion
DNL	Differential Non Linearity
EMC	Electro Magnetic Compatibility
FOV	Field of View
ICD	Interface Control Document
LISN	Line Impedance Stabilization Network
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
RMS	Root Mean Square
TBV	To be validated (tests still need to be performed)

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1 Introduction

The BiSon64 sunsensor is a high reliability sunsensor with a nominal field of view of 64 degrees in diagonal which is specifically designed for demanding satellite applications. This document shall be read in conjunction with the interface control drawing [AD1].

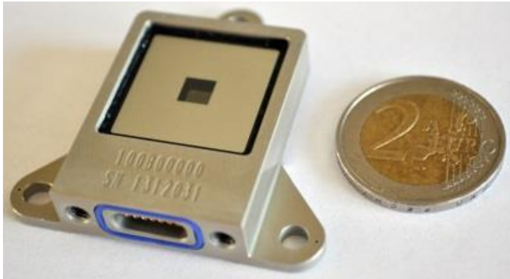

Photo 1 BiSon64 Sunsensor

2 Reference frame

Apart from the quadrant definition as given in [AD1] it is necessary to define the reference frame of the sunsensors in order to avoid sign errors in the attitude control subsystem. The BiSon64 sunsensors use the reference definition given below.

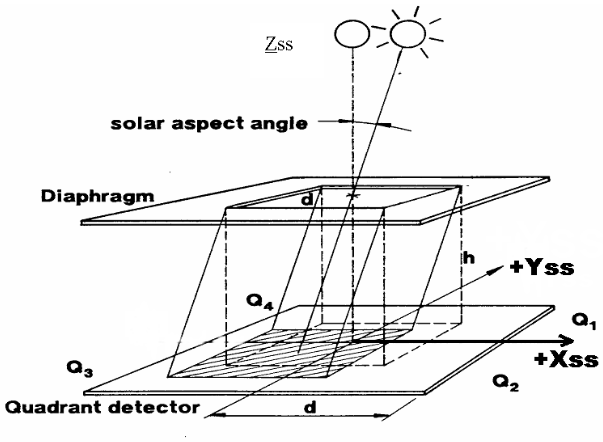

Figure 1 Axis definition BiSon64

For this definition of the quadrants, the following formulas can be used to calculate the angles:

$$S_A = \frac{Q_3 + Q_4 - Q_1 - Q_2}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\alpha)}{\tan(\alpha_{MAX})} \quad \text{and} \quad S_B = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\beta)}{\tan(\beta_{MAX})}$$

Figure 2 α and β formulas

The definition of the angles α and β however are not given in above diagram. Based on the formulas given however, it can be deducted that a positive α means the sun is to the right of the sensor and (contra intuitive) a positive β means the sun is below the sensor (both when viewed from the top side). (The illumination given in Figure 1 is for positive α and negative β.)

3 Mechanical interfaces

The dimensions of the mechanical interfaces are given in [AD1] the actual reference of the sensor is formed by the line through the center of the two lower mounting holes. The actual reference hole is the right lower hole which has a H7 fit and defines the position of the sensor sensitive surface. The left lower hole is a slotted hole (see detail Z) which defines the rotation around the reference hole. The third hole is merely for ensuring the sensor is mounted flat on the surface.

3.1 Repeatability of mounting

When the flatness of the mounting interface is better than 0.02mm and the in [AD3 and AD4] prescribed mounting hardware is used for the two reference holes, the repeatability of mounting is better than 0.15 degrees. In case special dedicated special fasteners are used (with a tolerance of 0..-10µm on the shaft the repeatability is better than 0.05 degrees.

3.2 Fastening torque

The special fasteners defined in [AD2] shall be fastened with a torque of 1 Nm ± 10%.
The M4 fastener used for the oversized hole shall be fastened with a torque between 0.63Nm and 1.5Nm (consequently 1 Nm ± 10%) can be used for all three bolds.

3.3 Mass

The mass of the unit is <25 grams but more accurately given on page 1 of [AD1]

3.4 Centre of gravity

The center of gravity is given on page 1 of [AD1]

4 Optical interfaces

The optical interfaces are defined on page 2 of [AD1] in combination with the reference frame definition as given in par 2.

It should be noted that for both on axis and diagonal fields of view two fields of view are given. In each case the smaller field of view given is the nominal end of the measurement field of view (sun leaves one or two sensor quadrants) and the larger field of is the sun exclusion field of view (direct sunlight will not generate any signal anymore on the sensor). The given fields of view are nominal fields of view which are dependent on manufacturing tolerances, but under no circumstances shall the measurement field of view be smaller than 61 degrees in either diagonal to ensure the ability to get full spherical coverage with 6 sensors only. (This is, taking mounting tolerances of the sensors in account.)

5 Electrical interfaces

The electrical connections are as given on page 3 of [AD1].

The sensor will generate 4 analogue currents which will be:

1,95 mA nominal for each quadrant at normal incidence and 2.5mA max per quadrant.

These values are ± 15% at 20 °C, 1 Am(0) sun illumination and 0 bias (measured with a transimpedance amplifier).

For monitoring purposes a thermistor is added which is fully floating.

5.1 Grounding and isolation

In order to avoid any charge build-up on the detector a 1.2 MOhm ±20% discharge resistor is integrated in the sensor (>1Mohm) the capacitance of the sensor to ground < 100 pF.

5.2 Conductivity of external surfaces

In order to avoid build-up of electrical charge, the electrical conductivity of the external surfaces (including the sapphire window) is better than 10 kOhm.

5.3 Specified accuracy

The specified accuracy for the sensors is:

- 2.5 degrees 3σ if no calibration table is used.
- 0.5 degrees 3σ if a calibration table is used.

For this accuracy to be reached the readout electronics shall have:

- An offset of < 1mV per channel at a full scale of 10V.
- 12 bit accuracy.
- Inter channel gain equality of better than 0.1%.

Alternatively calibration with the readout electronics actually used can be performed (on a cost reimbursement basis).
The units will be calibrated over a field of 45*45 degrees from zenith (63 degrees in diagonal) the calibration table format is TBD.

6 Environmental specifications

6.1 Storage conditions

Sensors 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 20% to 80% storage lifetime under these conditions is longer than 5 years when kept in the original packaging.

6.2 Operating temperature range

The sensors are specified for operation in the range of -40°C to +80 °C.

6.3 Non-operating temperature range

The sensors are specified for applications in the range of -45°C to +85 °C in the non-operating condition.

6.4 Temperature cycling

The sensors are designed to meet the following specifications:

Conditions	Temperature range	Number of cycles
Burn in	-45°C..+85°C	10 (performed on each sensor)
Full range high rate thermal cycle	-40°C..+80°C@ >8°C/min	1000
Double sine thermal cycle	-20°C..+60°C base cycle with 20°C modulation.	30000 (TBV)

Table 1 Thermal cycling specification

As part of the acceptance test procedure a 10 cycle burn in test is performed according to MIL-STD-883 M method 1010 B before final electrical measurements and visual inspection. For these cycles the temperature range shall be limited to -45°C to +85°C

6.5 Vibration specifications

Vibration specifications of the sensors are given below. It should be noted that these are qualification levels and sensors are actually tested to these 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 [AD2] and [AD3] defined hardware and torqued to 1Nm ± 10%

6.5.1 Eigenfrequency

The eigenfrequency has been verified by test to be above 2000Hz (tested up to 2000Hz but no start of resonance detected).

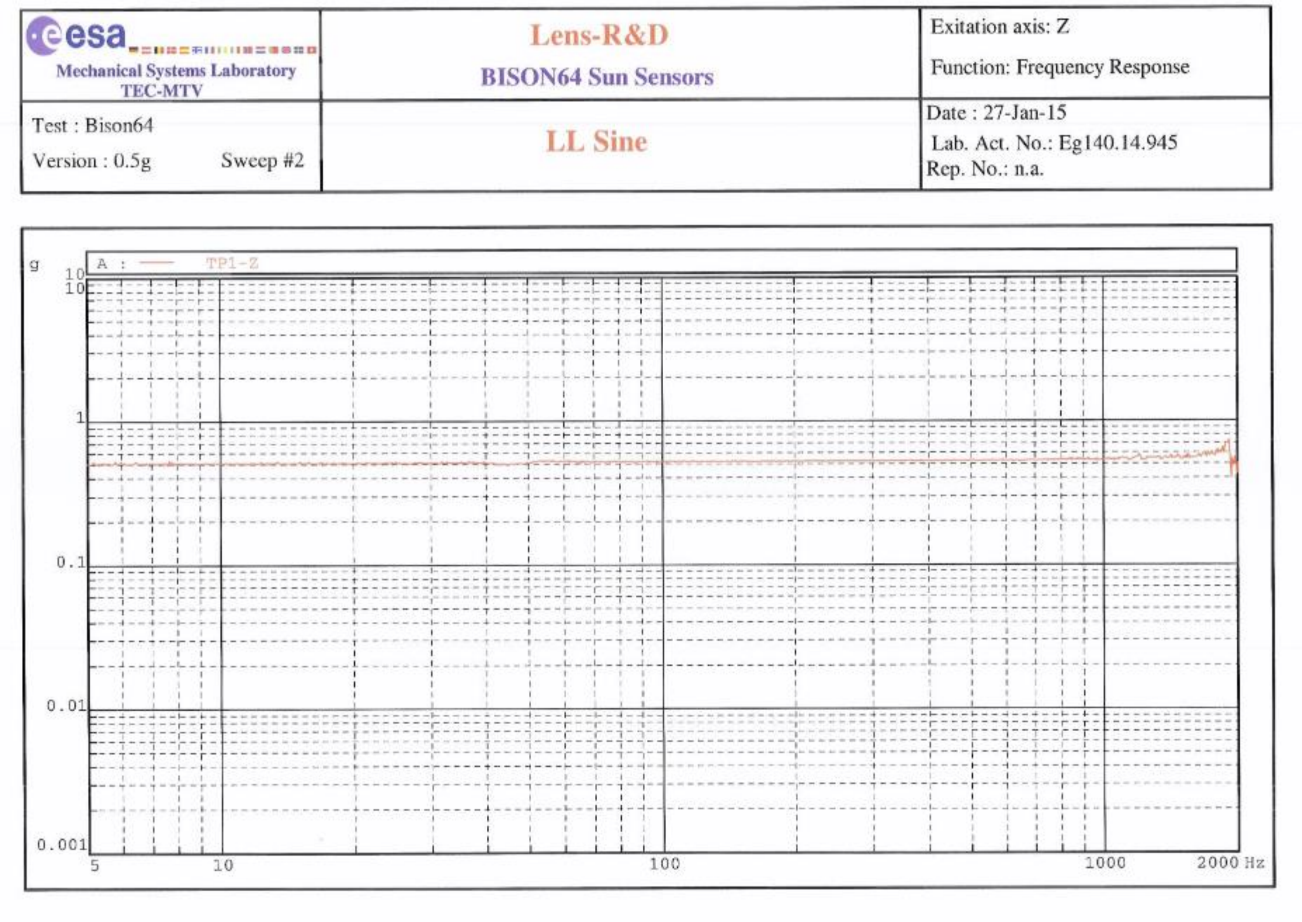

Figure 3 Resonance search results 4

NOTE: the small resonance seen at 1900Hz is inherent to the shaker

6.5.2 Sine vibration

Specified levels have been applied both in all three axis separately. The given levels are the applied qualification levels.

Sine vibrations	
Frequency (Hz)	Level
5..27.3	20mm peak to peak
27.3..100	30g
1 octave/minute 1 sweep up/1 sweep down	

Table 2 Sine vibrations

An example of the applied sine vibration level is given below:

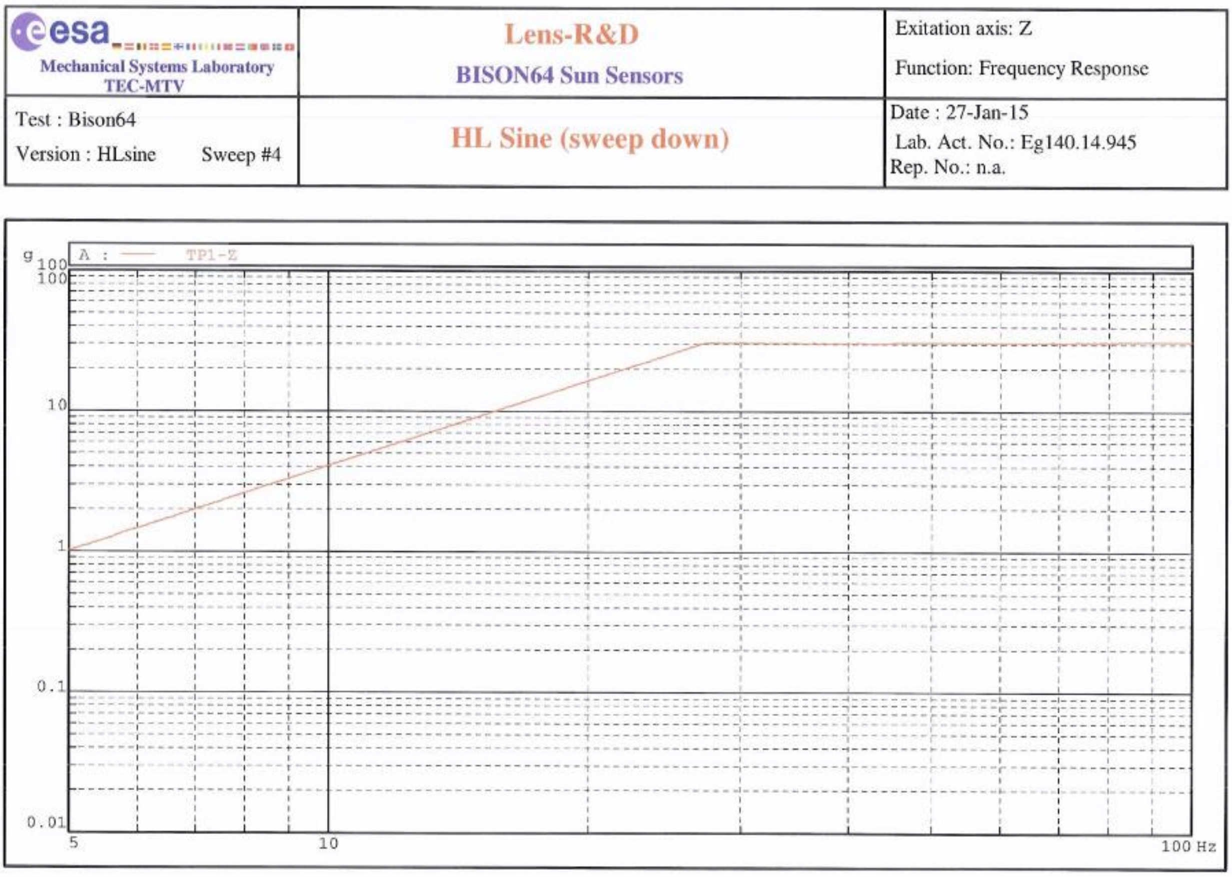

Figure 4 Example of sine level applied

6.5.3 Random vibrations

The qualification level random vibration levels applied to the BiSon64 sensor are given below. These levels have been applied to all three axes. Additional random vibration testing will be done on every individual sensor as part of the acceptance procedure (see par 6.5.5) in frame of the PIND test.

Random vibrations	
Frequency	PSD
Hz	g²/√Hz
20..100	6dB/oct
100..1000	1
1000..2000	-6dB/oct
RMS level 37.68 g	
Duration 180 seconds	

Table 3 Random vibrations

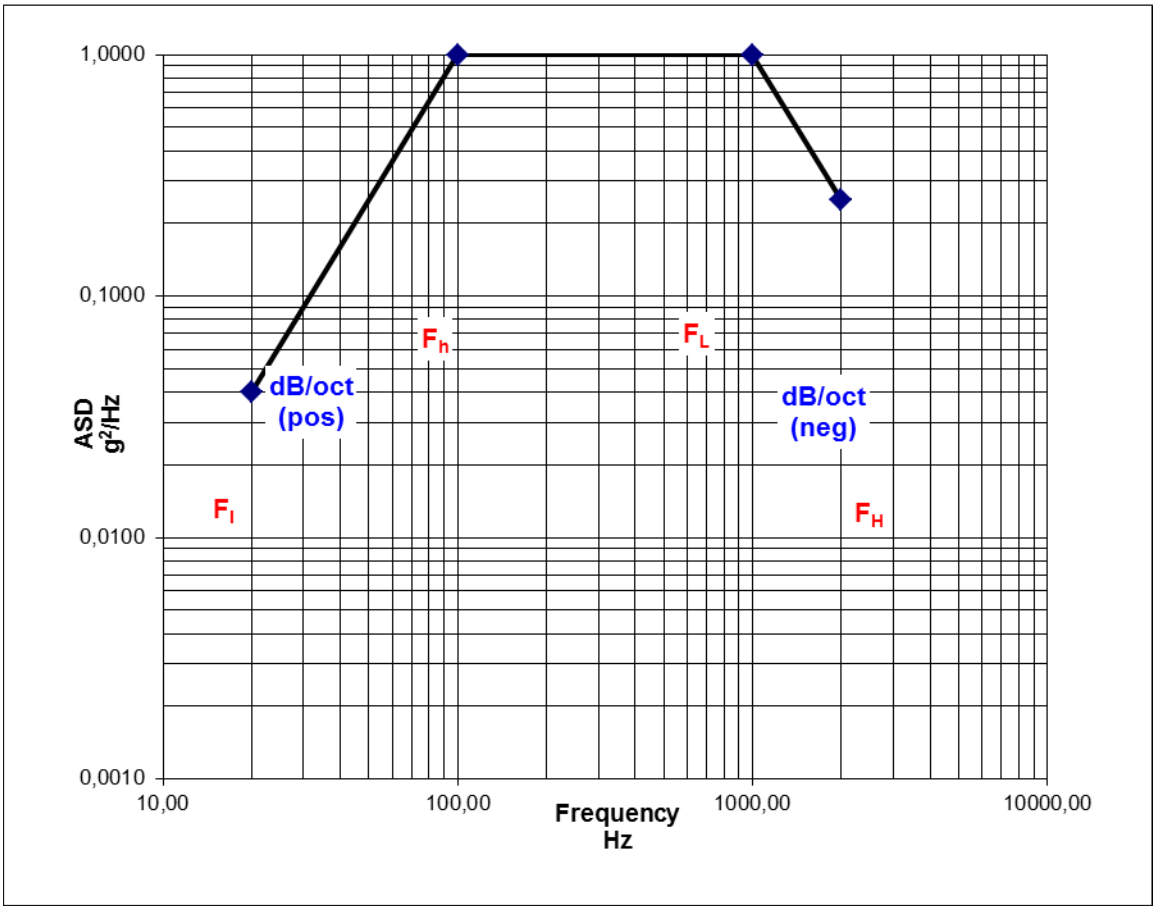

Figure 5 Random vibration profile

An example of the random vibration levels applied is given below.

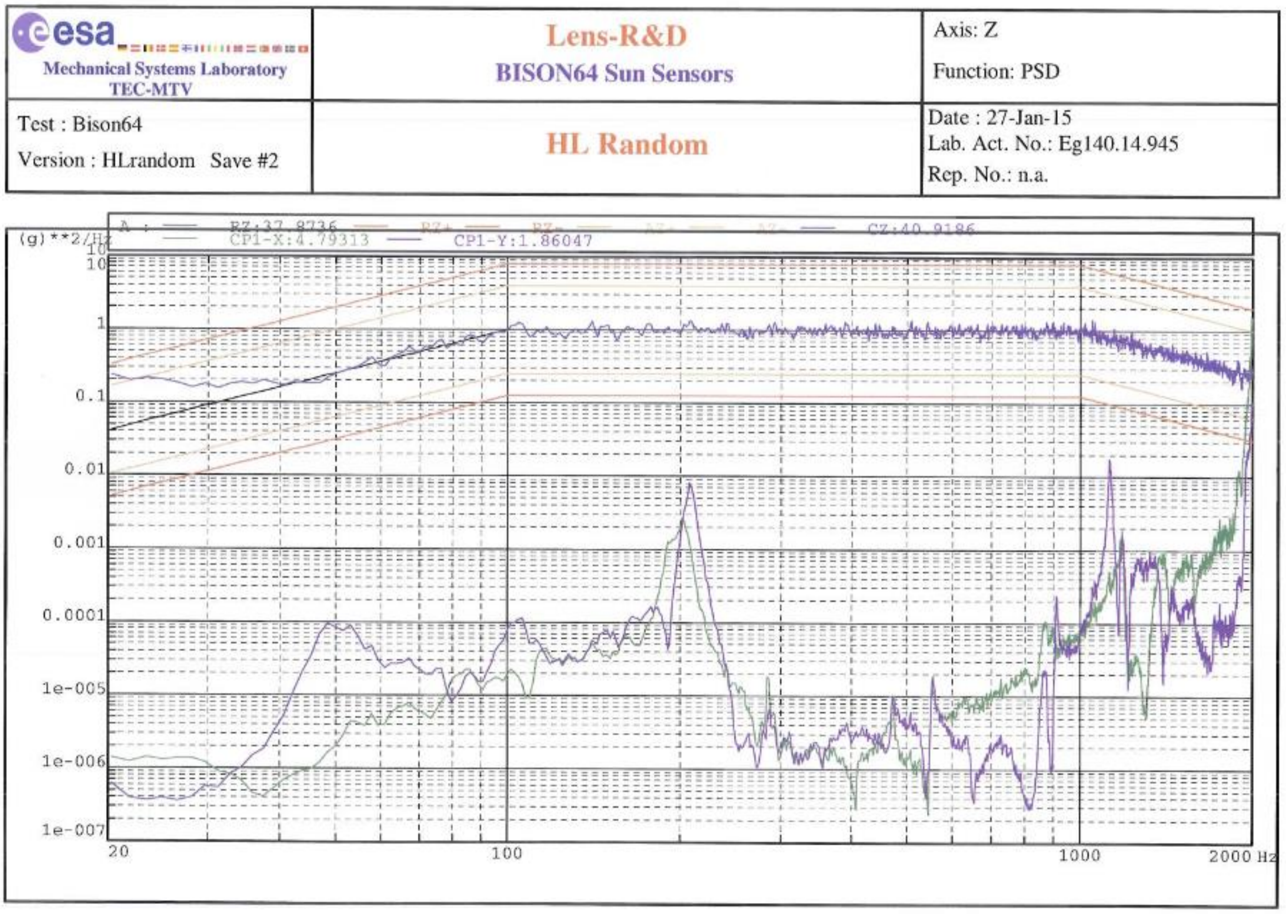

Figure 6 Example of random vibration applied

6.5.4 Shock specification

The sensors have been tested to the below given pyro shock specifications:

Pyro shock	
Frequency	Level
Hz	g
100	40
1000	2100
2000	3000
10000	3000
3 shocks in any direction	

Table 4 Pyro shock specifications

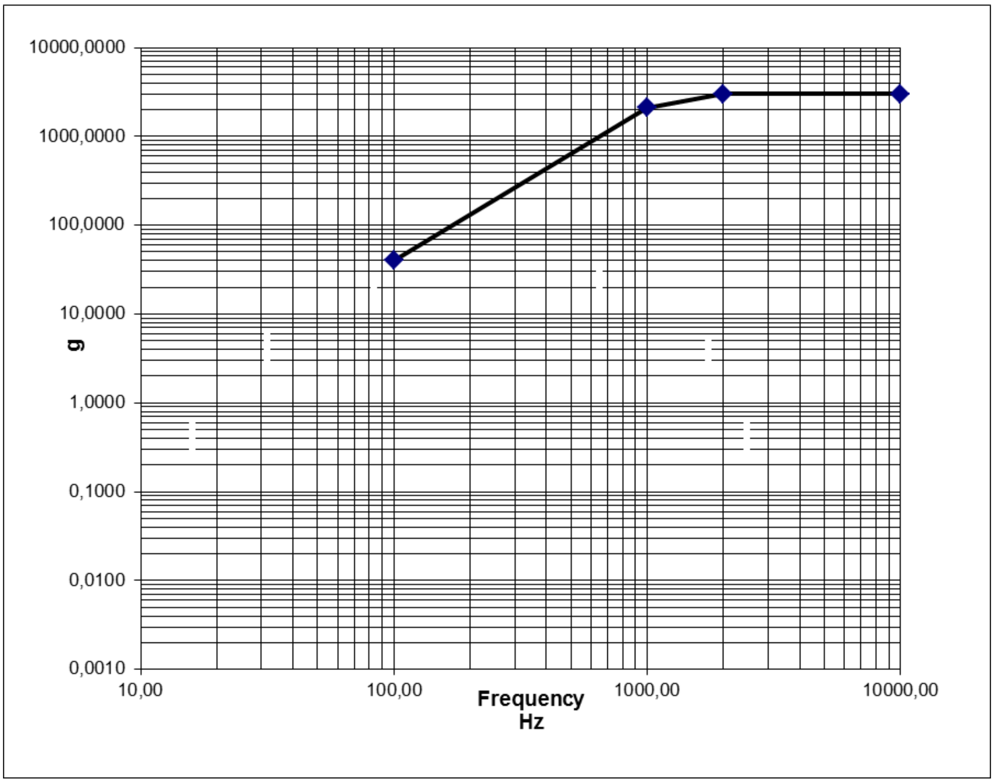

Figure 7 Pyro shock spectrum specified

The actual test levels applied have been well above the specified levels as demonstrated in the below given SRS spectrum.

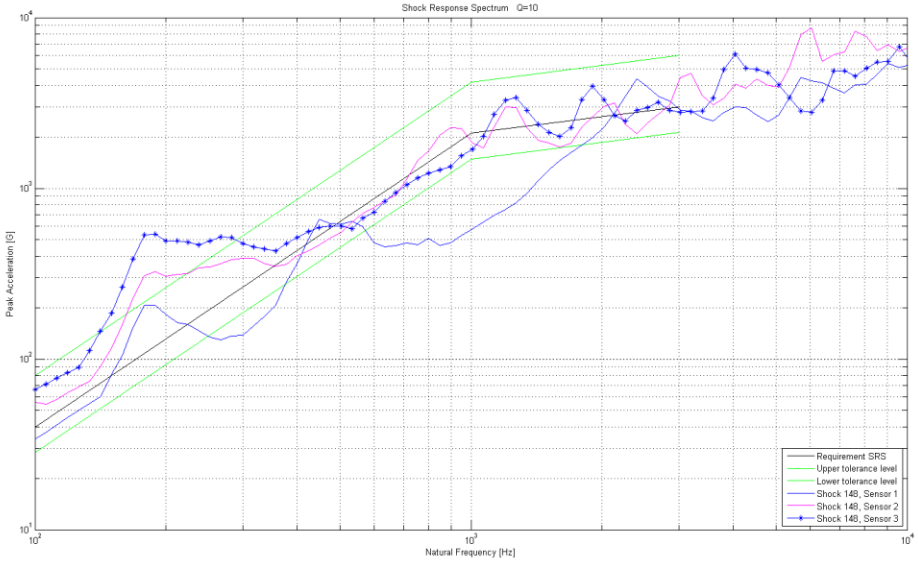

Figure 8 SRS spectrum applied in Z direction during pyro-shock testing

NOTE: the blue solid line is the acceleration out of plane

6.5.5 PIND testing

As part of the acceptance procedure a PIND (Particle Induced Noise Detection) test is performed on each of the devices according to MIL-STD-883 Method 2020 A.

These tests consist of a number of 1000g 0,1ms shocks and a number of 20g random vibration periods as given in the sequence below.

a. 3 times a 1000g pre-test shocks.
b. 20g random Vibration for 3 ±1 seconds.
c. 3 times a 1000g pre-test shocks.
d. 20g random Vibration for 3 ±1 seconds. 3 co-test shocks.
e. 3 times a 1000g pre-test shocks.
f. 20g random Vibration for 3 ±1 seconds.
g. 3 times a 1000g pre-test shocks.
h. 20g random Vibration for 3 ±1 seconds.

As a consequence of the acceptance procedure, every flight unit is shock tested 12 times albeit not at the pyro shock levels specified in par 6.5.4.

6.6 Radiation testing

There are only a limited number of components in the BiSon64 non off these components are sensitive to radiation with exception of the four quadrant photodiodes. In order to verify the radiation sensitivity of the components several radiation tests have been performed.

6.6.1 1MeV electrons

The most elaborate tests performed to date are the 1MeV electron tests. These tests were performed in three stages.

1. 1.10^{15} electron exposure
2. 2.10^{15} electron exposure
3. 7.10^{15} electron exposure

This sequence is preceded by quantum efficiency measurements and followed by quantum efficiency measurements. The measurement results show clearly that the photodiodes have a very high tolerance to 1MeV electrons and should be considered qualified to be used on long duration missions.

The measurement results are given in Figure 9.

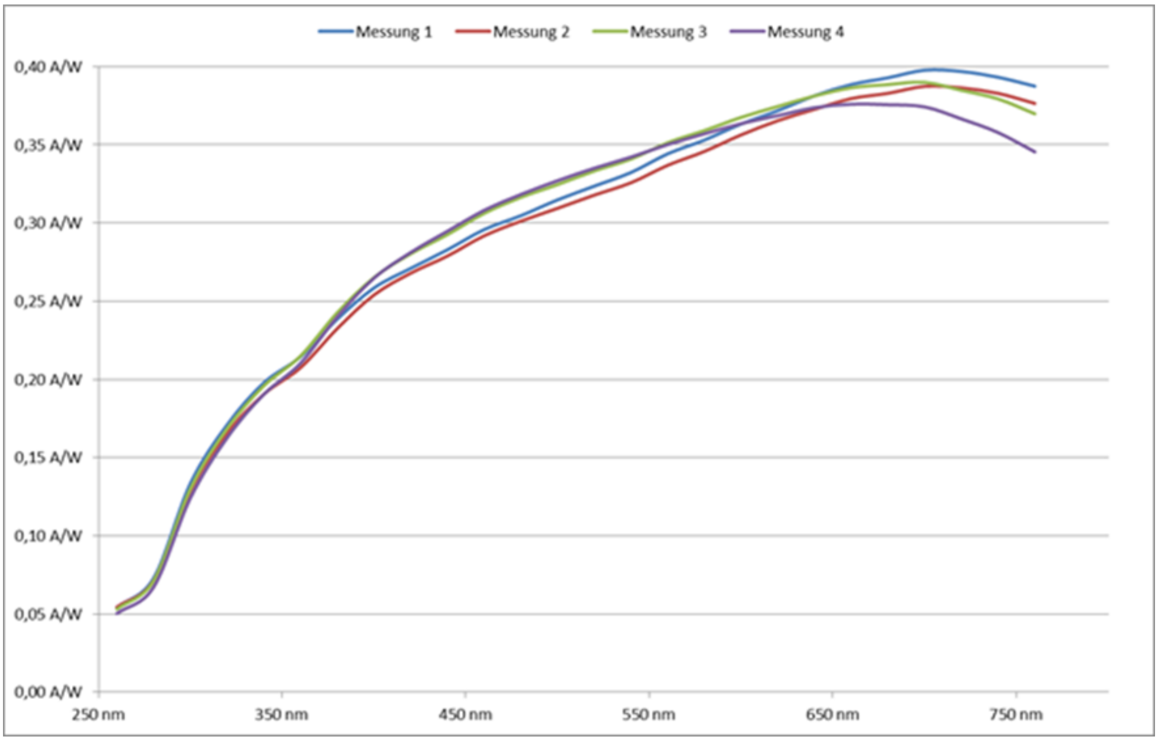

Figure 9 Quantum efficiency as a function of 1MeV electron dose

6.6.2 Co-60 total dose

The most commonly known radiation test are gamma tests done with a Co-60 source. Tests up to 1Mrad(si) have been completed and show a very high radiation tolerance of the used devices. Up till 193krad these tests were performed at 360 rad/hour and after this at a doserate of 2.4krad/hour. These tests were successfully passed without any measurable degradation in quantum efficiency and only a marginal increase in dark current as shown in Figure 10.

It should be noted that dark current is not an important parameter for sunsensor applications.

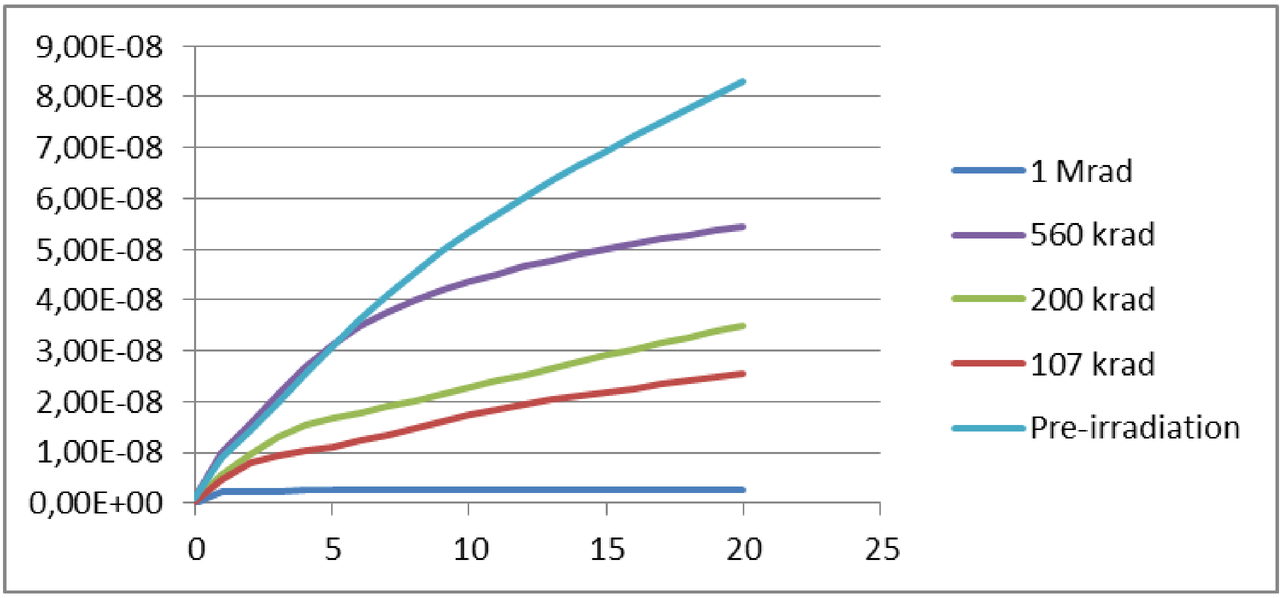

Figure 10 Dark-current increase measured on QP100-H

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