MultiScape200 CIS

Interface Control Document

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Document History

Revision	Date	Details
1	2020-11-05	First release of document
2	2020-11-27	Updated Figures: 3-2, 3-3, 4-3, 4-5, 4-6 and 4-7. Updated Sections: 3.2 and 5.4.1

Table of Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Description
AIT	Assembly, Integration and Testing
BOL	Beginning of Life
CE	Control Electronics
CVCM	Collected Volatile Condensable Material
DC	Direct Current
FEE	Front-End Electronics
FPGA	Field Programmable Gate Array
FWHM	Full Width at Half Maximum
GND	Ground
HPP	Half Power Point
IO	Input/Output
ISO	International Organization for Standardization
LVCMOS	Low Voltage Complementary Metal Oxide Semiconductor
LVDS	Low Voltage Differential Signalling
OFE	Optical Front-End
MSB	Most Significant Bit
NC	Not Connected
PCB	Printed Circuit Board
SPI	Serial Peripheral Interface
STP	Shielded Twisted Pair
TDI	Time Delayed Integration
TML	Total Mass Loss
VNIR	Visible and Near-Infrared

1. Introduction

1.1 Identification

Item Description: MultiScape200 CIS

Simera Item Number: 034756

1.2 Intended Use

This document describes the interfaces and environmental conditions of the MultiScape200 CIS Imager.

1.3 Context and Summary

The MultiScape200 CIS is an electro-optical push-broom imaging system employing a Gpixel GMAX3265 sensor utilizing a 7-band multispectral filter and is capable of up to 32-stage digital Time Delayed Integration (TDI) per band. The MultiScape200 CIS is produced by Simera Sense and is intended for earth observation applications. Its compact form factor allows for direct implementation into a 12U CubeSat structure; however, the MultiScape200 CIS can also be used in larger satellite systems.

This Interface Control Document identifies, defines, and describes the interfaces between the MultiScape200 CIS and the surrounding satellite components, as well as between the MultiScape200 CIS and its environment.

2. Referenced Documents

Table 2-1 lists documents that are referenced in this document. In the event of conflict between the contents of the reference documents and this document, this document shall take precedence.

Table 2-1: Referenced Documents

Ref. #	Reference
[1]	Outgassing Data for Selecting Spacecraft Materials. [Online]. Available: https://outgassing.nasa.gov/ [2018, October 24]
[2]	NXP I2C-bus specification and User Manual. [Online]. Available: https://www.nxp.com/docs/en/user-guide/UM10204.pdf [2018, October 24]
[3]	ECSS-E-ST-50-12C – SpaceWire - Links, nodes, routers and network. [Online]. Available: https://ecss.nl/standard/ecss-e-st-50-12c-spacewire-links-nodes-routers-and-networks/

For undated references, the latest released version of the reference document applies. For dated references, subsequent versions of the document do not apply. It is best practice to always refer to the latest released version. Unless otherwise stated, web links referenced above were last accessed at the release date of the current version of this document.

3. System Description and Context

The MultiScape200 CIS captures electromagnetic radiation, focuses the radiation on a sensor and converts the focused electromagnetic radiation into electrical signals. The MultiScape200 CIS typically forms part of the payload of a satellite and is shown in the context of a typical CubeSat system diagram in Figure 3-1.

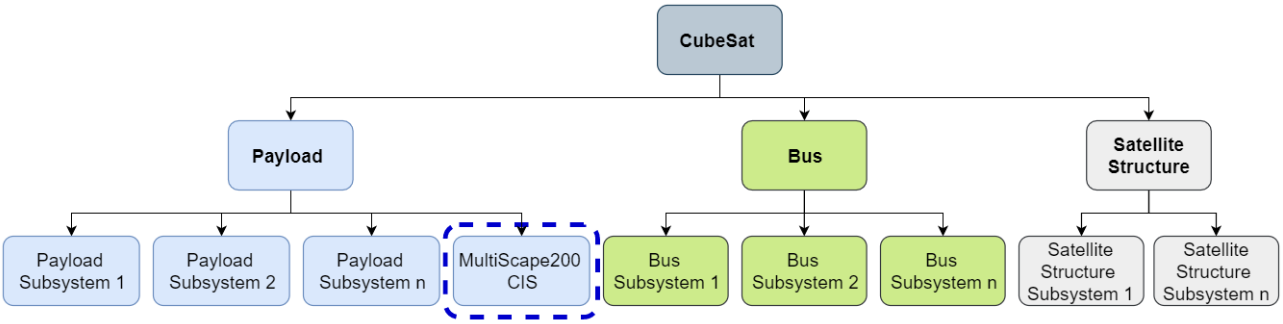

Figure 3-1: System Context Diagram

3.1 Physical Description

The MultiScape200 CIS, hereafter referred to as the "Imager", consists of several subassemblies which comprises of the xScape200 VNIR Optical Front-End (OFE), the MultiScape200 CIS Sensor Unit and the MultiScape200 CIS Control Electronics. Table 3-1 provides a functional description of the Imager and its components.

Table 3-1: System and Component Functional Description

ID	System/Component	Primary Function
1	MultiScape200 CIS	Collects electromagnetic radiation and converts it into electrical signals
1.1	xScape200 VNIR OFE	Focuses the collected electromagnetic radiation onto an imaging sensor
1.2	MultiScape200 CIS Sensor Unit	Positions the sensor on the focal plane and converts the focused electromagnetic radiation into electrical signals
1.3	MultiScape200 CIS Control Electronics	Powers and drives the sensor unit, as well as provides storage space for the captured images

Figure 3-2 shows two views of the MultiScape200 CIS and provides the axis definition. In the figure the orientation indicators on the OFE are shown which identifies the positive x-axis. Similar orientation indicators are also present on the Sensor Unit mechanics.

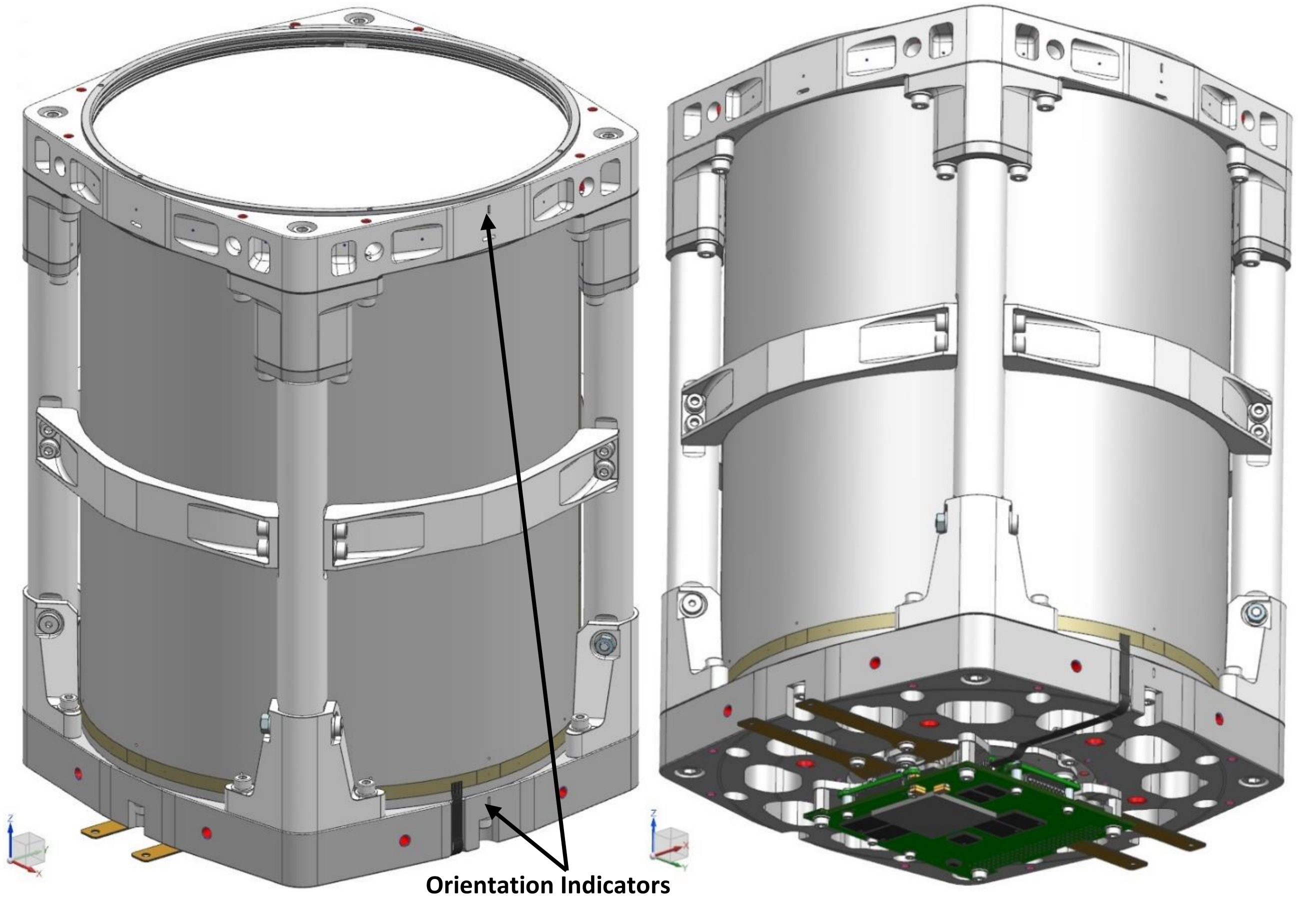

Figure 3-2: MultiScape200 CIS with Axis Definition

An exploded view of the MultiScape200 CIS showing the system subassemblies is presented in Figure 3-3. The MultiScape200 CIS Control Electronics is shown with the Bi-Lobe Breakout Adapter option included (see section 4.5.1.1 for the physical electrical interface options).

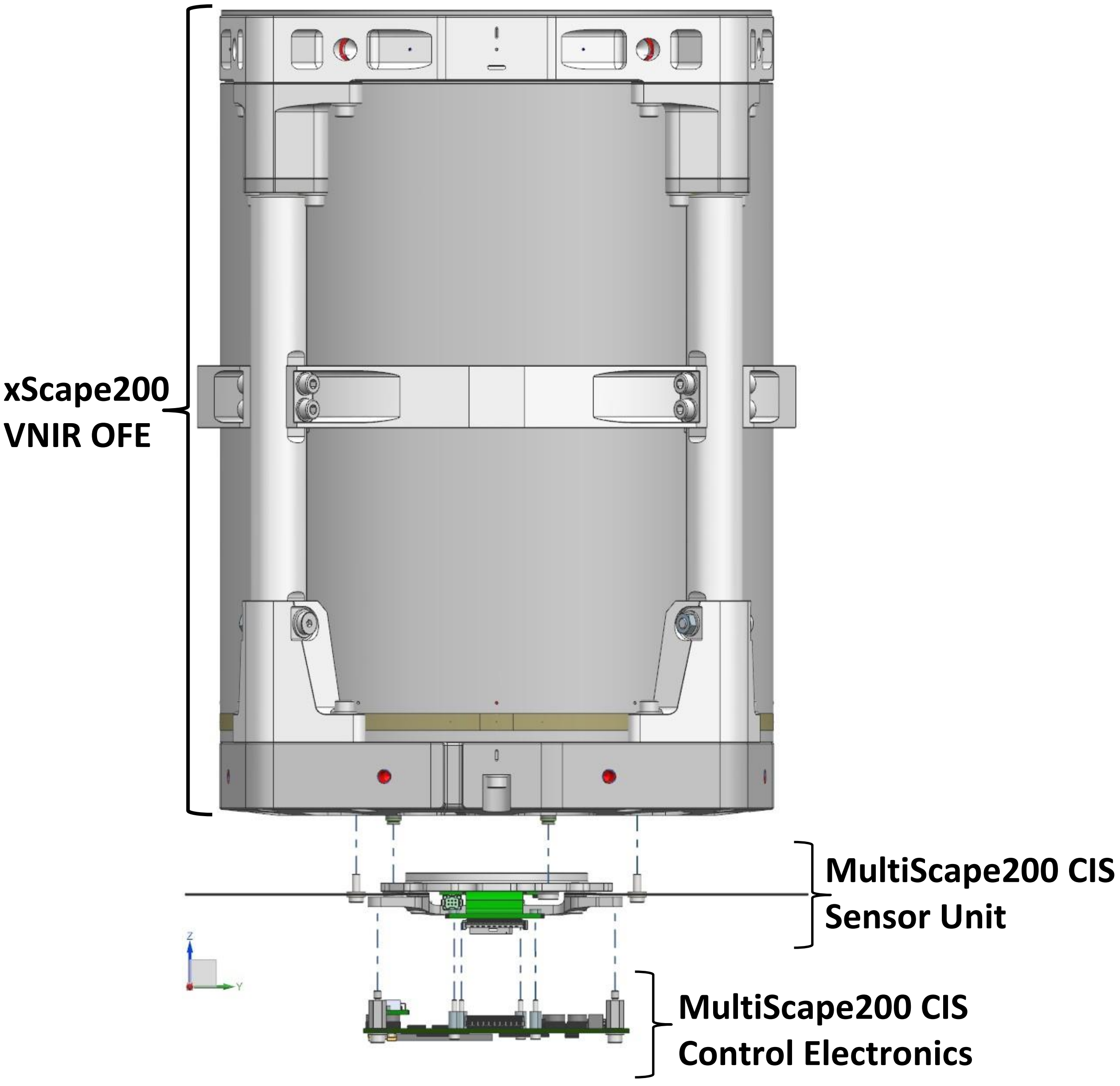

Figure 3-3: MultiScape200 CIS Exploded View

An exploded view of the MultiScape200 CIS Sensor Unit and Control Electronics is shown in Figure 3-4.

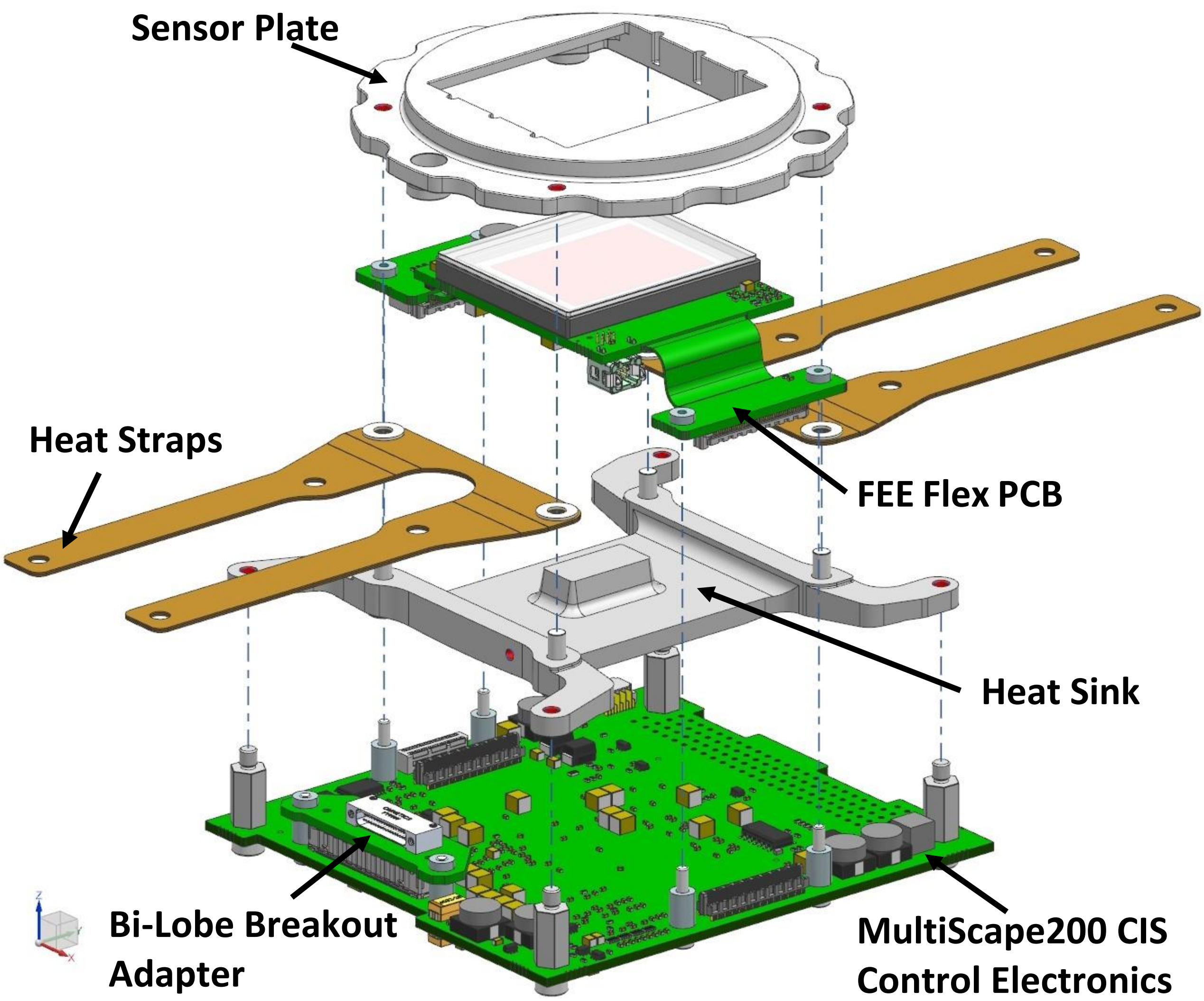

Figure 3-4: Exploded View of MultiScape200 CIS Sensor Unit and Control Electronics

Figure 3-5 shows the Imager ground projection and the position of the first pixel clocked out from the sensor active area with respect to the Imager axis system.

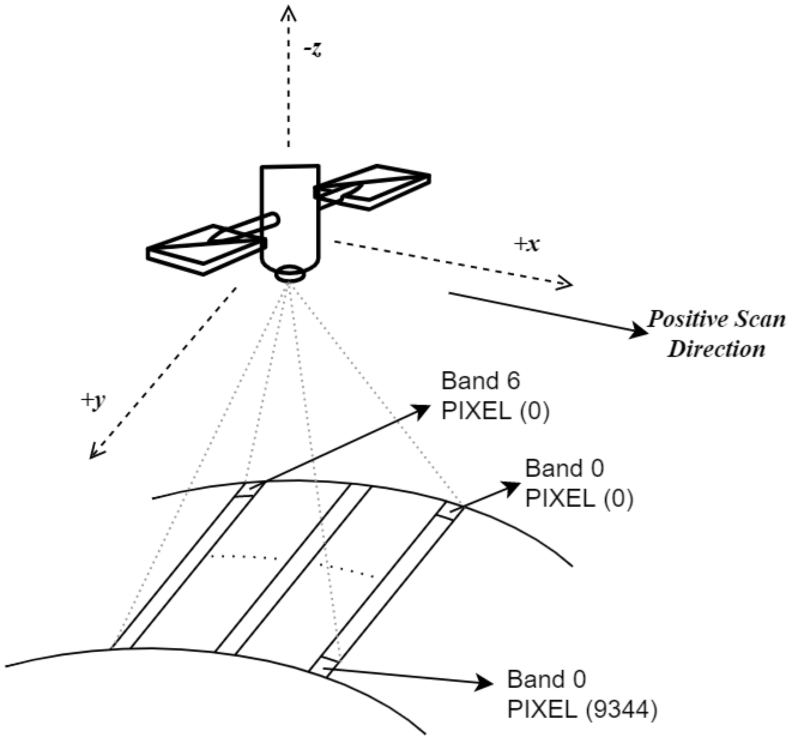

Figure 3-5: MultiScape200 CIS Ground Projection

The filter specification is provided in Table 3-2, which also shows the approximate sensor line number positioned in the middle of each of the bands.

Table 3-2: 7-Band Filter Specification

Band	Central Wavelength (nm)	FWHM Bandwidth (nm)	HPP cut-On (nm)	HPP Cut-Off (nm)	Approximate Sensor Line Number
0	490	65	457.5	522.5	2012
1	560	35	542.5	577.5	2508
2	665	30	650.0	680.0	3004
3	705	15	697.5	712.5	3500
4	740	15	732.5	747.5	3996
5	783	20	773.0	793.0	4492
6	842	115	784.5	899.5	4988

3.2 Physical Properties

The physical properties of the MultiScape200 CIS are presented in Table 3-3. The inertia tensor is given by equation 1 and the principle moments of inertia by equation 2 (units are $kg.m^2$). The reference axis system used to define the moments of inertia and centre of mass position is located at the geometric centre of the OFE's mounting points, which are shown in Figure 4-3.

Table 3-3: Imager Physical Properties

Property	Unit	Value
Mass	kg	12.1 (± 2%)
Centre of Mass		
x	mm	0.00 (± 0.5) See Figure 3-7
y	mm	-0.09 (± 0.5) See Figure 3-7
z	mm	122 (± 1) See Figure 3-7

The inertia tensor is given in equation 1 and the principle moments of inertia in equation 2 below.

$$\mathrm{I}\ [\mathrm{kg.m}^2] = \begin{bmatrix} \mathrm{I_{xx}} & \mathrm{I_{xy}} & \mathrm{I_{xz}} \\ \mathrm{I_{yx}} & \mathrm{I_{yy}} & \mathrm{I_{yz}} \\ \mathrm{I_{zx}} & \mathrm{I_{zy}} & \mathrm{I_{zz}} \end{bmatrix} = \begin{bmatrix} 349.5\mathrm{x}10^{-3} & 2.6\mathrm{x}10^{-6} & 5.0\mathrm{x}10^{-6} \\ 2.6\mathrm{x}10^{-6} & 349.3\mathrm{x}10^{-3} & 15.3\mathrm{x}10^{-6} \\ 5.0\mathrm{x}10^{-6} & 15.3\mathrm{x}10^{-6} & 98.4\mathrm{x}10^{-3} \end{bmatrix} \quad (1)$$

$$\mathrm{I}_P\ [\mathrm{kg.m}^2] = \begin{bmatrix} \mathrm{I_1} & 0 & 0 \\ 0 & \mathrm{I_2} & 0 \\ 0 & 0 & \mathrm{I_3} \end{bmatrix} = \begin{bmatrix} 170.0\mathrm{x}10^{-3} & 0 & 0 \\ 0 & 169.8\mathrm{x}10^{-3} & 0 \\ 0 & 0 & 98.4\mathrm{x}10^{-3} \end{bmatrix} \quad (2)$$

Table 3-4 provides the natural frequencies of the Imager (with a mass participation higher than 2%) when it is constrained at its six mounting points which are shown in Figure 4-3. The values presented in Table 3-4 were obtained through finite-element analysis with the Imager being mounted to the vibration jig used during the qualification environmental testing of the Imager. The vibration jig was manufactured from aluminium 6082-T6 and is shown in Figure 3-6. Note: The structural behaviour of the Imager is influenced by the mechanics of the satellite bus structure. The modes presented in Table 3-4 is therefore dependant on the mechanics to which the Imager is mounted. The modes in Table 3-4 will differ from those presented here if the satellite mounting mechanics have a different stiffness from that of the vibration jig.

Table 3-4: Natural Frequencies of the Imager

Mode Number	Frequency [Hz]
1	316
2	320
3	616
4	832
5	833
6	870
7	983
8	1052
9	1054
10	1256
11	1298
12	1386
13	1544
14	1546
15	1573
16	1670
17	1681
18	1993

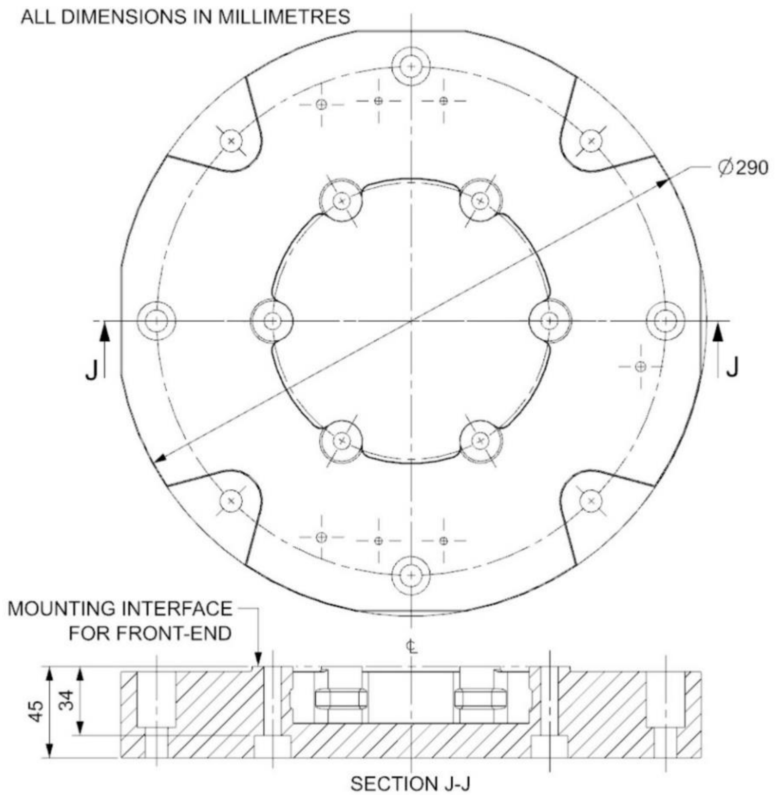

Figure 3-6: Vibration Jig

Figure 3-7 presents the envelope dimensions of the Imager and indicates the position of the centre of mass relative to the OFE's mounting points.

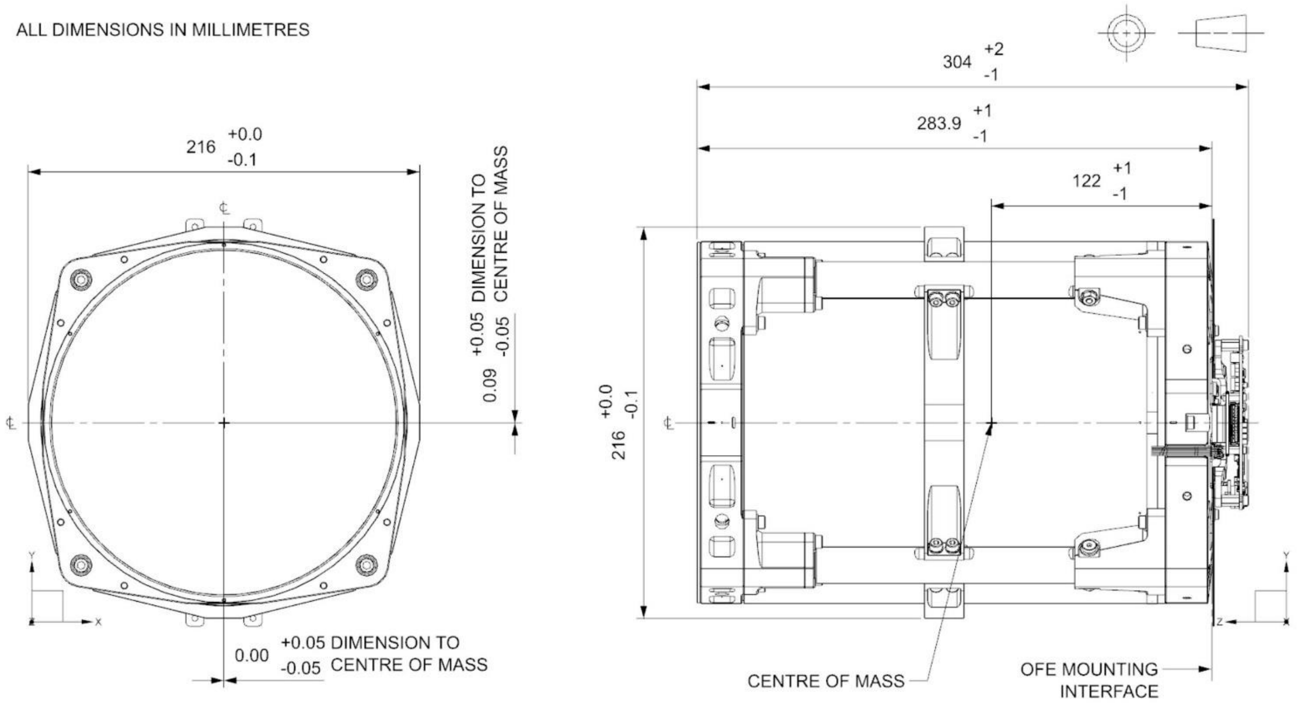

Figure 3-7: Centre of Mass Position

4. Description of System Interfaces

4.1 Interface Identification and Definition

The various interfaces between the Imager and the satellite components, as well as between the Imager and its environment, are shown graphically in Figure 4-1 below. The satellite components are herein defined as being all components which do not form part of the Imager and as such include the satellite structure.

Note: For analysis purposes it is assumed that there are no thermal interfaces via the wiring harnesses.

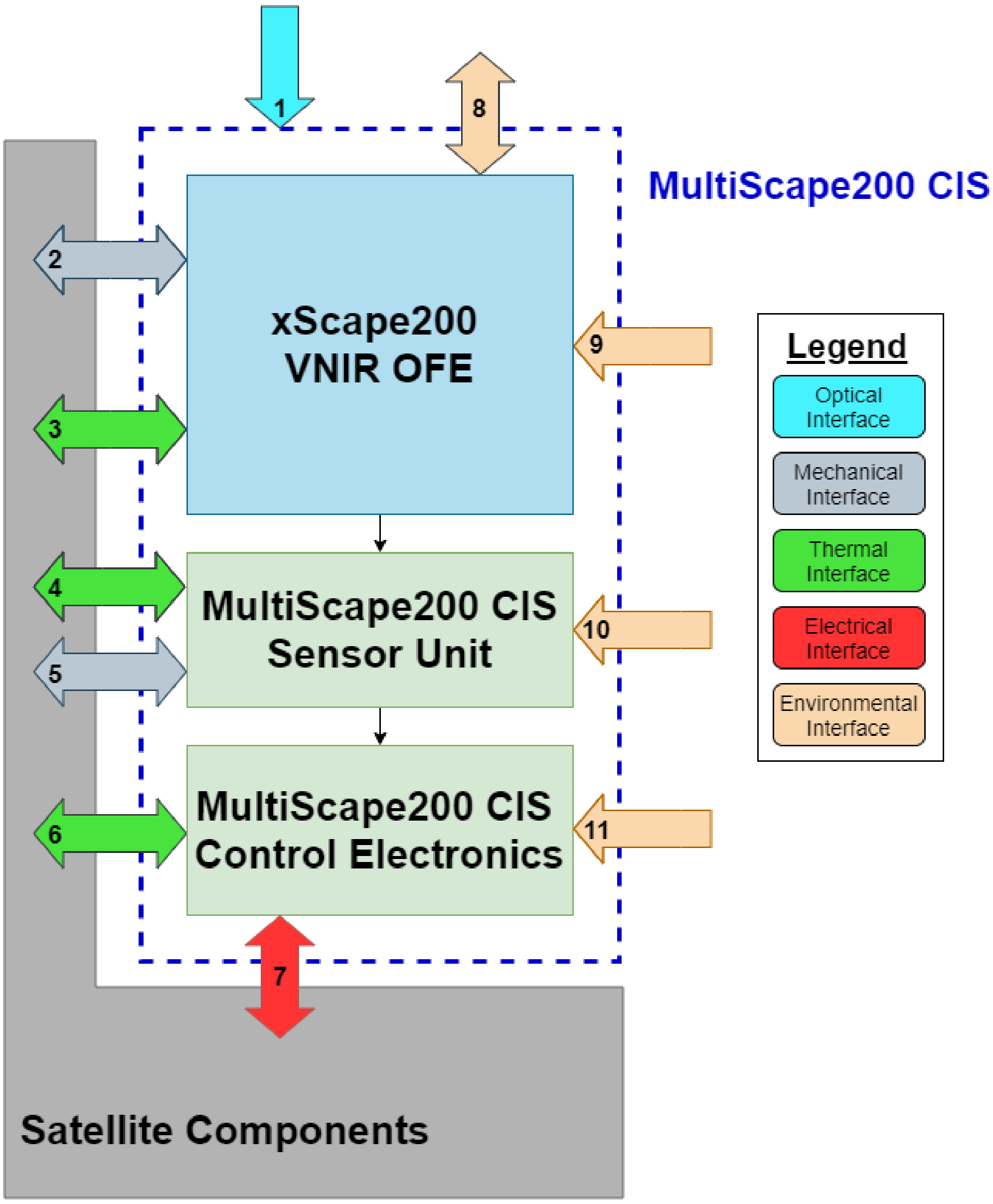

Figure 4-1: Interface Identification Diagram

The interfaces identified in Figure 4-1, are defined in Table 4-1 below. The descriptions of the interfaces are presented in the subsections that follow.

Table 4-1: Interface Definition

Interface Number	Interface Type	Interface From	Interface To
1	Optical	Target in View	MultiScape200 CIS
2	Mechanical	xScape200 VNIR OFE	Satellite Components
3	Thermal	xScape200 VNIR OFE	Satellite Components
4	Thermal	MultiScape200 CIS Sensor Unit	Satellite Components
5	Mechanical	MultiScape200 CIS Sensor Unit	Satellite Components
6	Thermal	MultiScape200 CIS Control Electronics	Satellite Components
7	Electrical (Power and Control)	Satellite Components	MultiScape200 CIS Control Electronics
8	Environmental (Thermal Radiation)	xScape200 VNIR OFE	Environment
9	Environmental (Cosmic Radiation)	Environment	xScape200 VNIR OFE
10	Environmental (Cosmic Radiation)	Environment	MultiScape200 CIS Sensor Unit
11	Environmental (Cosmic Radiation)	Environment	MultiScape200 CIS Control Electronics

4.2 Optical Interface

4.2.1 Interface 1: Target in View to MultiScape200 CIS

The MultiScape200 CIS has an optical interface at its front aperture with a diameter of 190 mm, an across-track full field of view of 1.6° and an along-track full field of view of 1.2°. The function of this interface is to enable the collection of electromagnetic radiation by the OFE. This optical interface shall remain unobscured during imaging to ensure optimal performance of the Imager.

The electromagnetic radiation collected from the target in view is filtered by the 7-band spectral filter utilized by the sensor. The target is scanned in the direction of the x-axis in push-broom imaging fashion. The scanning speed shall therefore stay constant, especially with TDI enabled, for the duration of imaging. The Imager roll and yaw shall be kept stable for the duration of imaging. Jitter shall be minimized for optimal image quality.

The maximum sun exposure time (the maximum amount of time the Imager may continuously have the sun directly within its field of view with the sensor not powered) shall be limited to 1 minute. The maximum sun exposure time is specified at 1 minute to avoid over heating of the sensor.

Figure 4-2 shows the point source transmittance of the OFE using the physical stray light baffle design of the system. Figure 4-2 reports the power on the sensor (shown on the y-axis) when observing a source of collimated light (with an output of 1 W) as it is moved from the on-axis position (0°) to 10° off-axis relative to the optical axis of the OFE. Note: the degrees indicated on the x-axis are the half-angles as measured from the optical axis of the OFE.

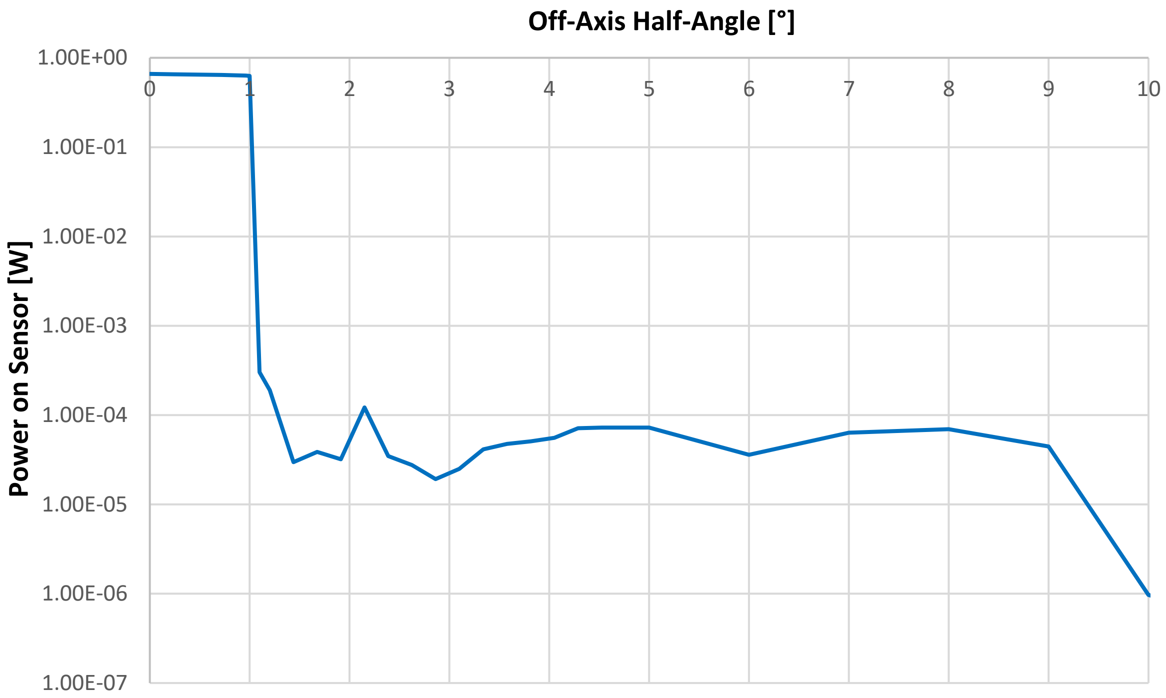

Figure 4-2: Point Source Transmittance of OFE

Based on the data presented in Figure 4-2, it is recommended that a sun exclusion half-angle of 2.2° is used to ensure satisfactory stray light suppression. A sun exclusion half-angle of 2.2° results in less than 1/10000 of the power entering the OFE from outside the field of view of the OFE reaching the sensor. For half-angles larger than 10°, the transmittance continues to decrease even further and never rises above $1x10^{-4}$ of the input power again.

4.3 Mechanical Interfaces

4.3.1 Interface 2: xScape200 VNIR OFE to Satellite Components

The OFE interfaces mechanically with the satellite structure via six threaded mounting points which are located on the OFE. The function of this interface is to secure the OFE to the applicable satellite components and act as the main structural support for the Imager. Figure 4-3 provides the dimensions of the OFE's mounting interface.

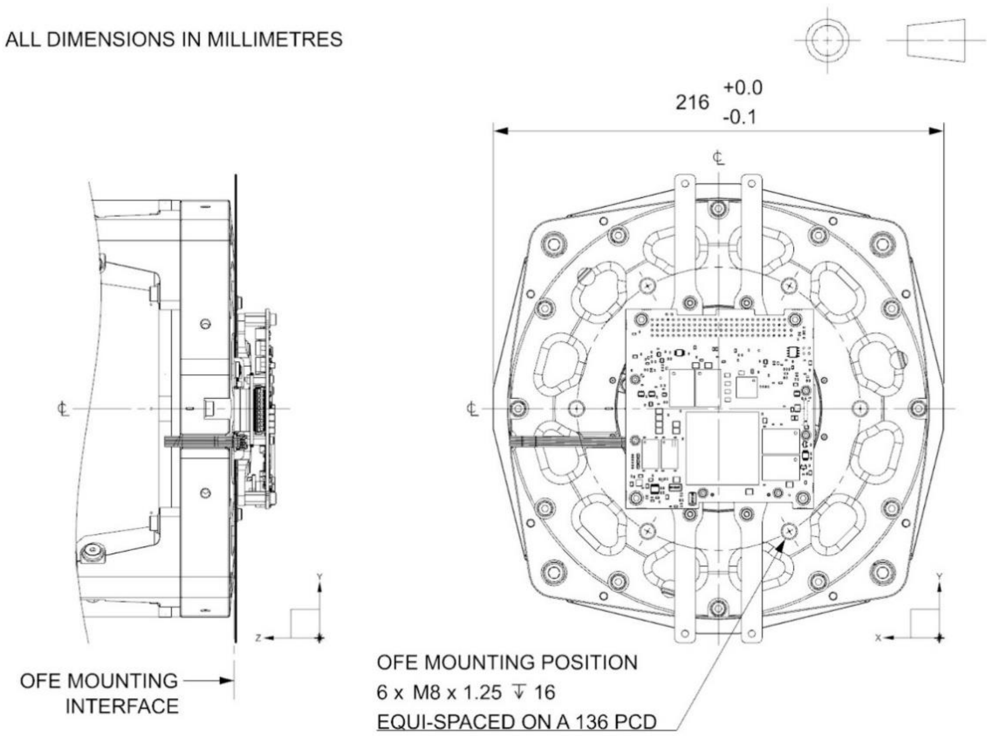

Figure 4-3: OFE Mounting Interface Dimensions

The details of the OFE's mounting interface are specified in Table 4-2 below.

Table 4-2: OFE Mounting Interface Specifications

Description	Value
Interface Material	Aluminium 6082-T6
Interface Surface Specification	N7 surface finish, Alodine Clear (MIL-DTL-5541 Type II)
Flatness	< 20 µm
Number of Mounting Locations	6
Thread Specification	M8 x 1.25 (see Figure 4-3)
Recommended Minimum Fastener Insertion Depth	12 mm
Maximum Depth of Thread Supplied in OFE	16 mm
Fastener Torque (for stainless steel A4-70 fastener material). All fasteners shall be staked using Scotch Weld EC2216 adhesive or equivalent.	18 Nm

Any mating mechanics to which the OFE will be mounted shall adhere to the following requirements. The mating mechanics to which the OFE will be mounted shall be manufactured from aluminium and have six through holes with a diameter of 8.4 mm or larger. These through holes shall be spaced to match the hole spacing of the six M8 threaded holes (as shown in Figure 4-3) and shall have a positional tolerance of 0.1 mm.

The mechanics to which the OFE will be mounted shall have six raised surfaces which will act as the mating interfaces to the OFE. These six mating interfaces shall, at each of the six fastener locations, be in contact with the OFE over an area with a diameter of at least 20 mm. All six these interfaces shall be coplanar to within 40 µm or less. A tolerance of less than 40 µm, will lead to a reduced drop in optical performance during mounting of the Imager. It is therefore recommended that the coplanarity tolerance of the six mating interfaces be reduced as much as possible. The mating interfaces shall also have a surface finish of at least N7 (this is equivalent to a surface finish with an average roughness of R_a = 1.6 µm).

For an area with a diameter of 45 mm surrounding each of the six mounting fastener locations, the thickness of the supporting mechanics shall not exceed 7 mm (this is excluding the height of the six raised surfaces which shall be 0.5 mm or less above the mounting mechanics nominal surface). This is required to prevent distortion of the OFE during fastening of the six M8 fasteners to the torque specification given in Table 4-3. The thickness of the mounting mechanics material outside this diameter of 45 mm, surrounding the OFE’s mounting fasteners, can be increased if required to accommodate the loads imposed on the structure and to prevent amplification of the loads being transmitted to the Imager.

Figure 4-4 shows a recommended preliminary design which can be used as departure point to meet the aforementioned interface requirements. The purpose of the design presented in Figure 4-4 is only to communicate the interface requirements. This design should not be regarded as adequate to meet the stiffness requirements (for the structural loads specific to the launch configuration and environment) without conducting a suitable coupled finite element analyses to verify that the loads imposed on the Imager is within acceptable margins as agreed upon between the customer and Simera Sense.

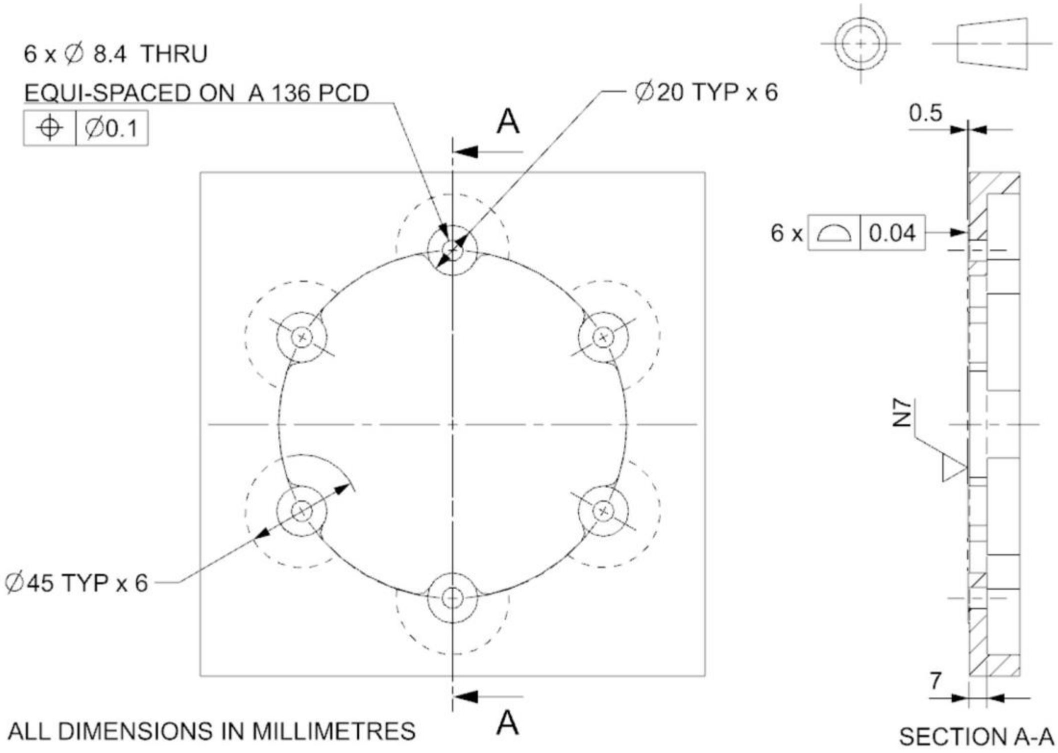

Figure 4-4: OFE Mounting Mechanics Interface Requirements

Table 4-3 summarises the requirements of the mechanical mounting interface to which the OFE will be mounted.

Table 4-3: OFE Mounting Mechanics Interface Requirements

Description	Value
Interface Material	Aluminium 6082-T6
Interface Surface Specification	N7 surface finish
Number of Mounting Locations	6
Coplanarity of Six Raised Surfaces	< 40 µm
Through Hole Dimensions	8.4 mm (see Figure 4-4)
Maximum Height of Raised Surface Relative to Rest of Mounting Interface Mechanics	0.5 mm (see Figure 4-4)
Maximum Material Thickness in 45 mm Diameter Surrounding Bolt Location.	7 mm Excluding Height of Raised Surfaces (see Figure 4-4)

NOTE: Caution shall be exercised during the assembly of any mechanics to the mounting interface of the OFE. Any mechanics which must be mounted to the OFE, shall first be secured to the OFE's mounting interface, only then shall the mechanics be joined to the rest of the satellite structure. This shall be done to ensure that there is no distortion of the OFE's mounting interface in the z-direction.

4.3.2 Interface 5: MultiScape200 CIS Sensor Unit to Satellite Components

4.3.2.1 Heat Straps Mounting Interface

The Sensor Unit interfaces with the satellite components through four heat straps which are used to dissipate heat from the sensor's heat sink to the satellite component via conduction. Each of the heat straps terminate with a 3.5 mm through hole, to be used to secure the heat strap to the applicable satellite component. Each of the heat straps consist of three layers of copper to give a total heat strap thickness of 0.75 mm. The dimensions of the heat strap mounting interfaces and their positions relative to the Imager's axis system are shown in Figure 4-5. When securing the heat straps to the applicable satellite component, it shall be ensured that there is sufficient compliance in each heat strap, so as to not induce any strain on the sensor unit when securing the heat straps to the applicable satellite component.

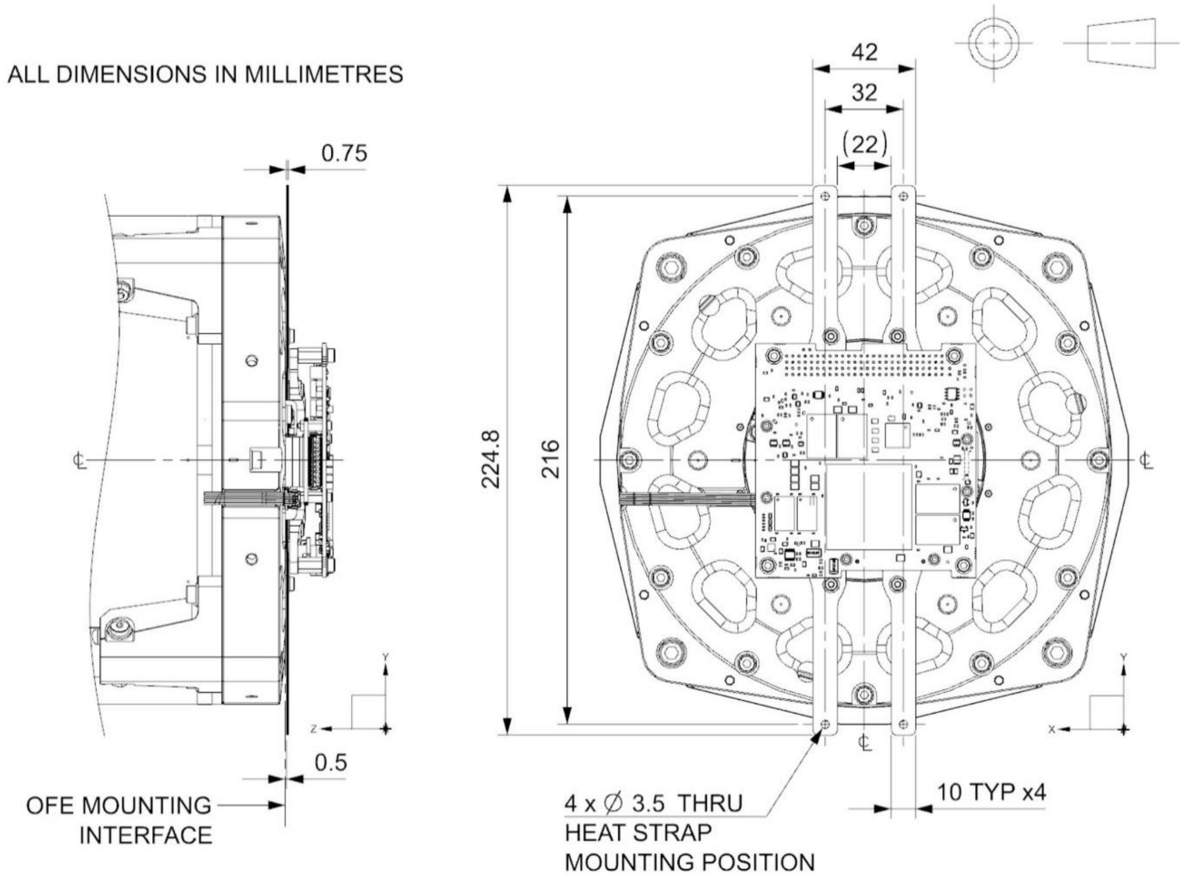

Figure 4-5: Heat Strap Mounting Details

The details of the heat strap mounting interfaces are specified in Table 4-4 below.

Table 4-4: Specifications of Heat Straps

Description	Value
Heat Strap Material	Copper C11000
Interface Surface Specification	Bare Copper, N7 surface finish
Heat Strap Thickness	0.75 mm
Number of Mounting Locations	4
Fixation Details	One 3.5 mm through hole per heat strap (see Figure 4-5)

4.3.2.2 Mounting Configurations of Sensor Unit to OFE

Three options exist for mounting of the Sensor Unit relative to the OFE. In option 1 the Sensor Unit is in its nominal position as shown in Figure 4-3 (sensor aligned with x-axis). In addition to being mounted in its nominal position, the Sensor Unit can be mounted in two additional rotational positions (rotated by 30° around the z-axis in either a clockwise or counterclockwise direction) relative to the OFE. Figure 4-6 shows option 2 where the Sensor Unit has been rotated relative to the OFE by 30° clockwise (as seen from the bottom of the Sensor Unit) around the z-axis. Option 3 is shown in Figure 4-7 where the Sensor Unit has been rotated relative to the OFE by 30° counterclockwise (as seen from the bottom of the Sensor Unit) around the z-axis. One of the three options above shall be selected by the client prior to integration of the Sensor Unit with the OFE.

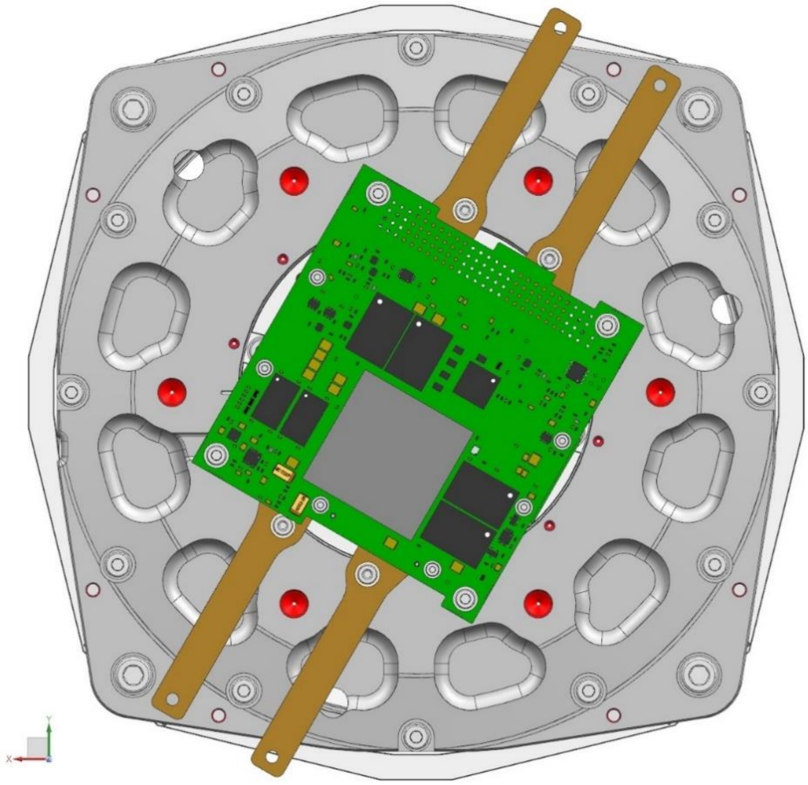

Figure 4-6: Option 2 - Sensor Unit Rotated 30° Clockwise Around Z-axis

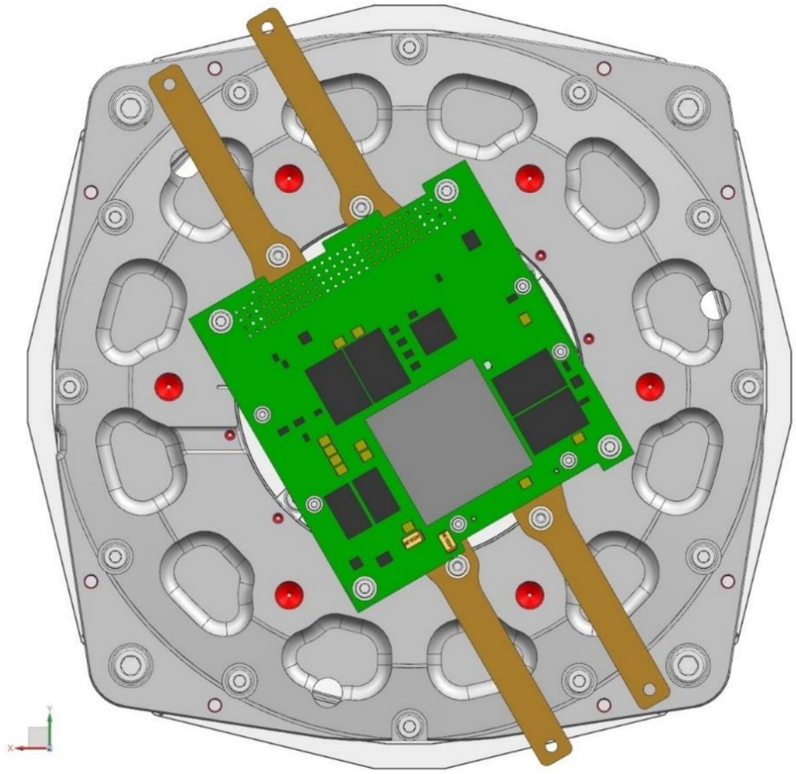

Figure 4-7: Option 3 - Sensor Unit Rotated 30° Counterclockwise Around Z-axis

4.4 Thermal Interfaces

4.4.1 Interface 3: xScape200 VNIR OFE to Satellite Components

The mounting interface between the OFE and applicable satellite components facilitates heat transfer through thermal conduction between the OFE and the satellite components. In addition, thermal energy is also exchanged (by means of radiation) between the OFE and the surrounding satellite components. No specific requirement is placed on the amount of energy transmitted via radiation. However, no thermal energy is to be dissipated into the OFE structure via conduction through its mounting interface.

4.4.2 Interface 4: MultiScape200 CIS Sensor Unit to Satellite Components

Thermal energy is exchanged by means of radiation and conduction between the MultiScape200 CIS Sensor Unit and the surrounding satellite components. No specific requirement is placed on the amount of energy transmitted via radiation.

Heat straps are provided which connects the MultiScape200 CIS Sensor Unit's heat sink directly to the applicable satellite component in order to dissipate (via conduction) the heat generated by the sensor. This will allow for increased imaging time. These heat straps shall be connected directly to the applicable satellite components using the 3.5 mm through holes provided in each of the heat straps as shown in Figure 4-5. These heat straps shall not make contact with any other part of the Imager to avoid heat dissipation into the mechanical structure of the Imager. Also, as the purpose of the heat straps is to remove heat from the sensor, no thermal energy shall be input to the sensor's heat sink via these heat straps. The thermal interface between each heat strap and the applicable satellite component to which it is mounted shall have a maximum thermal conductive resistance of less than 0.08 K/W (total allowable maximum thermal resistance for all four heat strap interfaces shall be less than 0.32 K/W).

4.4.3 Interface 6: MultiScape200 CIS Control Electronics to Satellite Components

Thermal energy is exchanged by means of radiation between the MultiScape200 CIS Control Electronics and the surrounding satellite components. No specific requirement is placed on the amount of energy transmitted via radiation.

4.5 Electrical Interfaces

4.5.1 Interface 7: Satellite Components to MultiScape200 CIS Control Electronics

This interface consists of a single or of multiple electrical connector(s) to act as interface between the CE and the applicable satellite component(s). The function of this interface is to transmit power, control and data to and from the CE. Figure 4-8 displays the dimensions of the CE PCB, as well as the height of the components on both sides of the PCB.

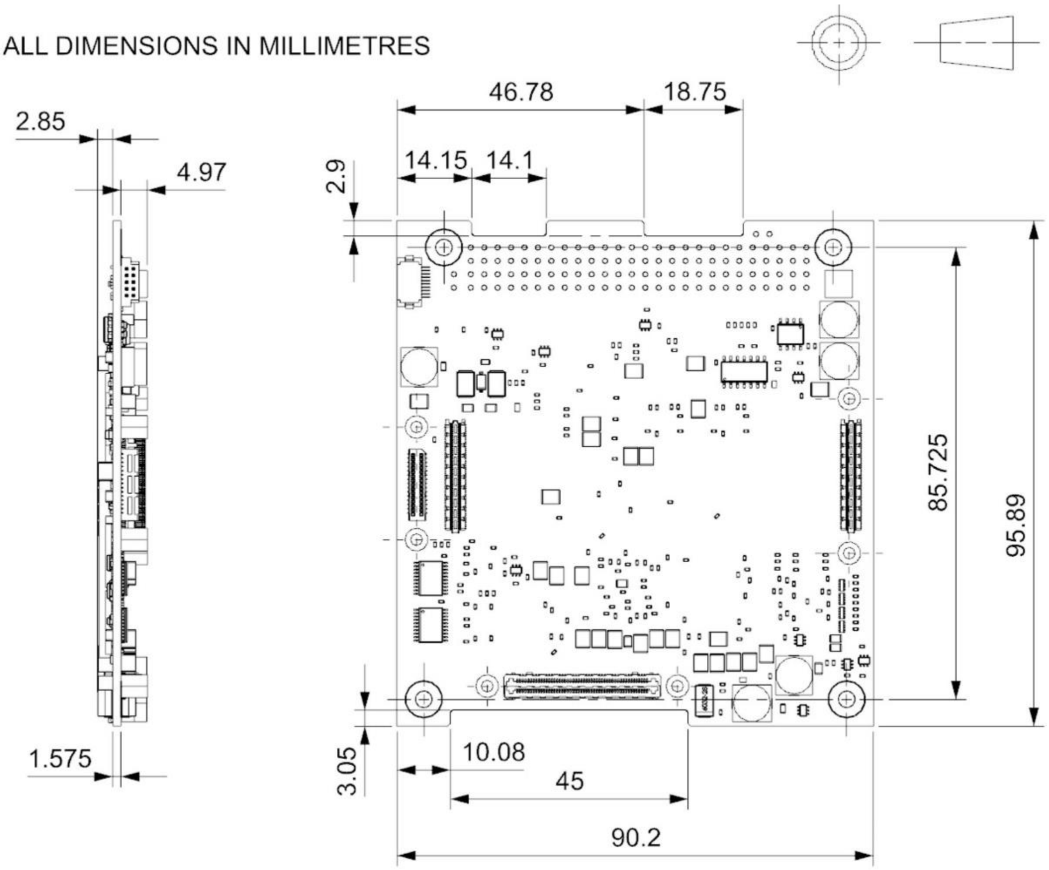

Figure 4-8: CE Mechanical Drawing

4.5.1.1 Physical Electrical Interfaces

4.5.1.1.1 PC-104 Interface (H1 and H2)

The CE supports a CubeSat Kit Bus compatible PC-104 header and its pin description is given in Table 4-5 and Table 4-6. The pins labelled ‘Not Used’ are not connected on the CE, while those labelled ‘5 V RETURN’ are always connected for the power ground return. The rest of the pins (including 5 V and I^2C signals) are not connected by default but are configured through the product configuration sheet if and where they are connected. All pins labelled ‘IO*n*’ are 3.3 V Low Voltage Complementary Metal Oxide Semiconductor (LVCMOS) compatible input/output pins. Those labelled ‘LVDS*n*±’ are routed differentially and can be used as LVDS pairs to implement SpaceWire (conforms to [3]), the standard high-speed data interface, or USART over LVDS. The PC-104 interface provides access to the power, control and data interfaces meaning it can be used as the only physical interface to the CE without requiring the high-speed interface.

Table 4-5 : CubeSat Kit Bus Compatible PC-104 Header (H1) Pinout

Pin	Signal	Pin	Signal
1	IO0	2	IO1
3	IO2	4	IO3 / PowerCtrl / LVDS6-
5	IO4 / PowerCtrl / LVDS6+	6	IO4 / PowerCtrl / LVDS6+
7	IO5 / PowerCtrl / LVDS7+	8	IO5 / PowerCtrl / LVDS7+
9	IO6 / PowerCtrl / LVDS7-	10	IO6 / PowerCtrl / LVDS7-
11	IO7 / PowerCtrl / LVDS3-	12	Not Used
13	IO8 / PowerCtrl / LVDS3+	14	IO8 / PowerCtrl / LVDS3+
15	IO9 / PowerCtrl	16	IO9 / PowerCtrl
17	IO10	18	IO10
19	IO11	20	IO11
21	IO12 / I^2C SCL	22	IO12
23	IO13 / I^2C SDA	24	IO13
25	Not Used	26	Not Used
27	Not Used	28	Not Used
29	IO14 / LVDS5-	30	IO15
31	IO16	32	IO17 / LVDS5+
33	IO18	34	Not Used
35	IO19 / LVDS2-	36	Not Used
37	Not Used	38	Not Used
39	IO20 / LVDS2+	40	IO21
41	IO22 / I^2C SDA	42	Not Used
43	IO23 / I^2C SCL	44	Not Used
45	1-Wire Vcc	46	1-Wire Data
47	5 V Optional Input	48	Not Used
49	5 V Optional Input	50	Not Used
51	5 V Optional Input	52	Not Used

Table 4-6 : CubeSat Kit Bus Compatible PC-104 Header (H2) Pinout

Pin	Signal	Pin	Signal
1	Not Used	2	Not Used
3	Not Used	4	Not Used
5	Not Used	6	Not Used
7	Not Used	8	Not Used
9	Not Used	10	Not Used
11	Not Used	12	Not Used
13	5 V Optional Input	14	Not Used
15	5 V Optional Input	16	5 V Optional Input
17	IO24 / PowerCtrl / LVDS4-	18	IO24 / PowerCtrl / LVDS4-
19	IO25 / PowerCtrl / LVDS4+	20	IO25 / PowerCtrl / LVDS4+

Pin	Signal	Pin	Signal
21	IO26	22	IO26
23	Not Used	24	Not Used
25	5 V Optional Input	26	5 V Optional Input
27	Not Used	28	Not Used
29	5 V RETURN	30	5 V RETURN
31	Not Used	32	5 V RETURN
33	Not Used	34	Not Used
35	Not Used	36	Not Used
37	Not Used	38	Not Used
39	Not Used	40	Not Used
41	Not Used	42	Not Used
43	Not Used	44	Not Used
45	Not Used	46	Not Used
47	IO27 / LVDS1-	48	IO28
49	IO29	50	IO30 / LVDS1+
51	Not Used	52	Not Used

Connector Details

The PC-104 connector is optional, and its fitment and choice of connector depends on the selections made in the product configuration sheet. The options are:

Samtec SSQ-126-21-G-D
Samtec SSQ-126-23-G-D
Samtec SSQ-126-04-G-D
Samtec ESQ-126-38-G-D
Samtec ESQ-126-39-G-D
Samtec ESQ-126-49-G-D
Samtec TSW-126-07-G-D

Two connectors are used, one each for H1 and H2. Instead of fitting the connectors, wires up to 26 AWG in thickness may be soldered directly into the connector through-hole pads with the adjacent through-hole pads used as strain relief.

4.5.1.1.2 High-Speed Interface (P5)

The CE provides a high-speed board-to-board connector supporting very high data rates. The connector pinout is shown in Table 4-7. Do not connect to the pins labelled 'Reserved'. The 'CE_on' signal can be used to determine the power status of the CE: this signal is pulled up to 3.3 V through a 10 kΩ resistor on the CE. The LVDS signals can also be configured as 3.3 V LVCMOS compatible single-ended I/O's. The PowerCtrl signal is routed directly to the power switch. See 4.5.1.2 for details. The signals 'I^2C SDA' and 'I^2C SCL' are both routed directly to the I^{2}C buffer. See 4.5.1.3.1 for details. The high-speed interface provides access to the power, control and data interfaces meaning it can be used as the one and only interface to the CE without requiring the PC104 interface. Default signal assignments are shown in the tables.

Table 4-7 : High-Speed Interface Connector (P5) Pinout

Pin	Signal	Default IO Assignment	Pin	Signal	Default IO Assignment
1	Signal GND		2	Signal GND	
3	Reserved [1]		4	Reserved [1]	
5	Reserved [1]		6	Reserved [1]	
7	Signal GND		8	Signal GND	
9	Reserved [1]		10	Reserved [1]	
11	Reserved [1]		12	Reserved [1]	
13	Signal GND		14	Signal GND	
15	Reserved [1]		16	Reserved [1]	
17	Reserved [1]		18	Reserved [1]	
19	Signal GND		20	Signal GND	
21	Reserved [1]		22	Reserved [1]	
23	Reserved [1]		24	Reserved [1]	
25	Signal GND		26	Signal GND	
27	Reserved [1]		28	Reserved [1]	
29	Reserved [1]		30	Reserved [1]	
31	Signal GND		32	Signal GND	
33	Reserved [1]		34	Reserved [1]	
35	Reserved [1]		36	Reserved [1]	
37	Signal GND		38	Signal GND	
39	Reserved [1]		40	Reserved [1]	
41	Reserved [1]		42	Reserved [1]	
43	Signal GND		44	Signal GND	
45	Reserved [1]		46	Reserved [1]	
47	Reserved [1]		48	Reserved [1]	
49	Signal GND		50	Signal GND	
51	Reserved [1]		52	Reserved [1]	
53	Reserved [1]		54	Reserved [1]	
55	Signal GND		56	Signal GND	
57	IO31	PPS	58	IO32 / LVDS8+	HS_RR+ / US_nCTS+
59	CE_on		60	IO33 / LVDS8-	HS_RR- / US_nCTS-
61	Signal GND		62	Signal GND	
63	IO34 / LVDS9+	HS_Ctrl+ / US_EOF+	64	IO36 / LVDS10+	HS_D1+
65	IO35 / LVDS9-	HS_Ctrl- / US_EOF-	66	IO37 / LVDS10-	HS_D1-
67	Signal GND		68	Signal GND	
69	IO38 / LVDS11+	HS_D0+ / US_TxData+	70	IO40 / LVDS12+	HS_Clk+ / US_Clk+
71	IO39 / LVDS11-	HS_D0- / US_TxData-	72	IO41 / LVDS12-	HS_Clk- / US_Clk-

Pin	Signal	Default IO Assignment	Pin	Signal	Default IO Assignment
73	Signal GND		74	Signal GND	
75	IO42 / LVDS13+	SpW_DIN+ / SPI_SCK	76	IO44 / LVDS14+	SpW_SIN+ / SPI_nSEL
77	IO43 / LVDS13-	SpW_DIN- / SPI_GND [1]	78	IO45 / LVDS14-	SpW_SIN- / SPI_MOSI
79	Signal GND		80	Signal GND	
81	IO46 / LVDS15+	SpW_DOUT+ / SPI_MISO	82	IO48 / LVDS16+	SpW_SOUT+ / not used [1]
83	IO47 / LVDS15-	SpW_DOUT- / SPI_GND [1]	84	IO49 / LVDS16-	SpW_SOUT- / not used [1]
85	Signal GND		86	5 V RETURN	
87	PowerCtrl		88	I^2C SDA	
89	5 V RETURN		90	5V RETURN	
91	5 V RETURN		92	I^2C SCL	
93	5 V RETURN		94	5 V RETURN	
95	5 V		96	5 V	
97	5 V		98	5 V	
99	5 V		100	5 V	

1. Do not connect

Connector Details

A Samtec LSHM-150-02.5-L-DV-A-N connector is used. A rendering of the connector is shown in Figure 4-9. Note the connector is hermaphroditic: pin 1 mates to pin 2.

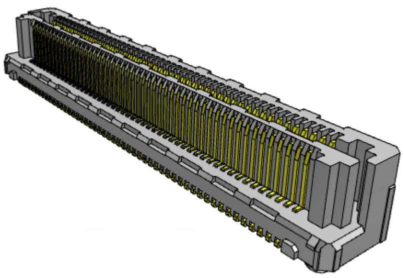

Figure 4-9: High-Speed Data Connector (P5)

The CE PCB has a mounting hole, fitted with a soldered spacer having a 2.25 mm through hole, on either side of the High-Speed Data Connector(P5). M2 fasteners can be inserted from the bottom of the CE, through the soldered spacers, to fasten the mating circuit to the CE. Details of the mounting holes are shown Figure 4-10. Pin 1 is located as per the recommended PCB layout prescribed by Samtec.

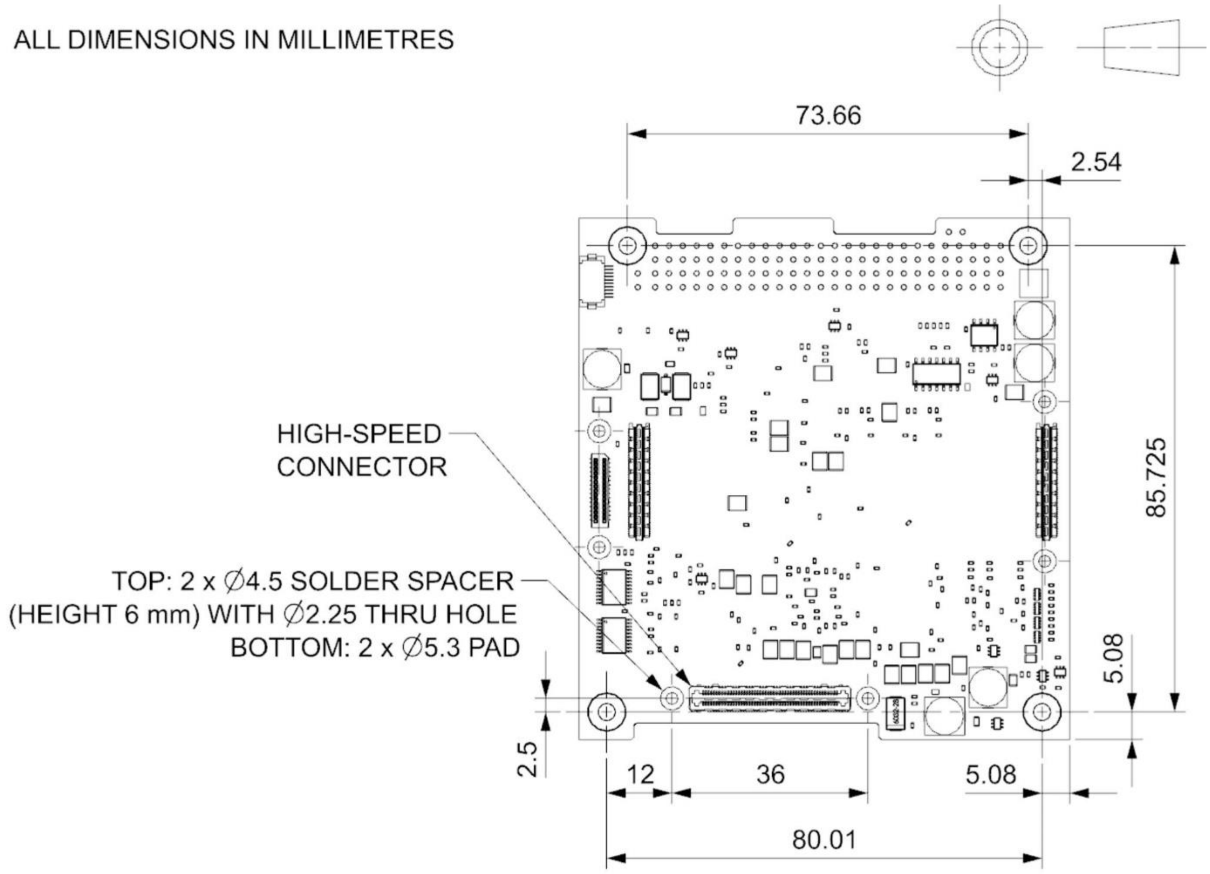

Figure 4-10: High-Speed Data Connector (P5) Position on CE

Bi-Lobe Breakout Adapter

The Imager can optionally be supplied with a breakout adapter that adapts the LSHM connector (P5) to an Omnetics MNSO-37-AA-N-ETH-M (P9). The preassembled mating connector, MNPO-37-WD/WC, with custom 18 inch long harness is also available. The pinout is provided in Table 4-8, including the default IO assignments. Wire is 30AWG throughout, with shielded twisted pair for the LVDS pairs.

Table 4-8 : High-Speed Interface Bi-Lobe Connector (P9) Pinout

Pin	Signal	Default IO Assignment	Pin	Signal	Default IO Assignment
1	5 V		20	5 V	
2	I^2C SCL		21	5 V	
3	I^2C SDA		22	5 V RETURN	
4	PowerCtrl		23	5 V RETURN	
5	IO49 / LVDS16-	SpW_SOUT- / not used [1]	24	5 V RETURN	
6	IO48 / LVDS16+	SpW_SOUT+ / not used [1]	25	IO45 / LVDS14-	SpW_SIN- / SPI_MOSI
7	Signal GND	LVDS14 Shield	26	IO44 / LVDS14+	SpW_SIN+ / SPI_nSEL
8	IO47 / LVDS15-	SpW_DOUT- / SPI_GND [1]	27	Signal GND	LVDS15 Shield

Pin	Signal	Default IO Assignment	Pin	Signal	Default IO Assignment
9	IO46 / LVDS15+	SpW_DOUT+ / SPI_MISO	28	IO41 / LVDS12-	HS_Clk- / US_Clk-
10	Signal GND	LVDS12 Shield	29	IO40 / LVDS12+	HS_Clk+ / US_Clk+
11	IO43 / LVDS13-	SpW_DIN- / SPI_GND [1]	30	Signal GND	LVDS13 Shield
12	IO42 / LVDS13+	SpW_DIN+ / SPI_SCK	31	IO37 / LVDS10-	HS_D1-
13	Signal GND	LVDS10 Shield	32	IO36 / LVDS10+	HS_D1+
14	IO39 / LVDS11-	HS_D0- / US_TxData-	33	Signal GND	LVDS11 Shield
15	IO38 / LVDS11+	HS_D0+ / US_TxData+	34	IO33 / LVDS8-	HS_RR- / US_nCTS-
16	Signal GND	LVDS8 Shield	35	IO32 / LVDS8+	HS_RR+ / US_nCTS+
17	IO35 / LVDS9-	HS_Ctrl- / US_EOF-	36	Signal GND	LVDS9 Shield
18	IO34 / LVDS9+	HS_Ctrl+ / US_EOF+	37	IO31	PPS
19	CE_on				

1. Do not connect

The position of the Bi-Lobe Breakout Adapter connector relative to the CE's mounting holes is shown in Figure 4-11.

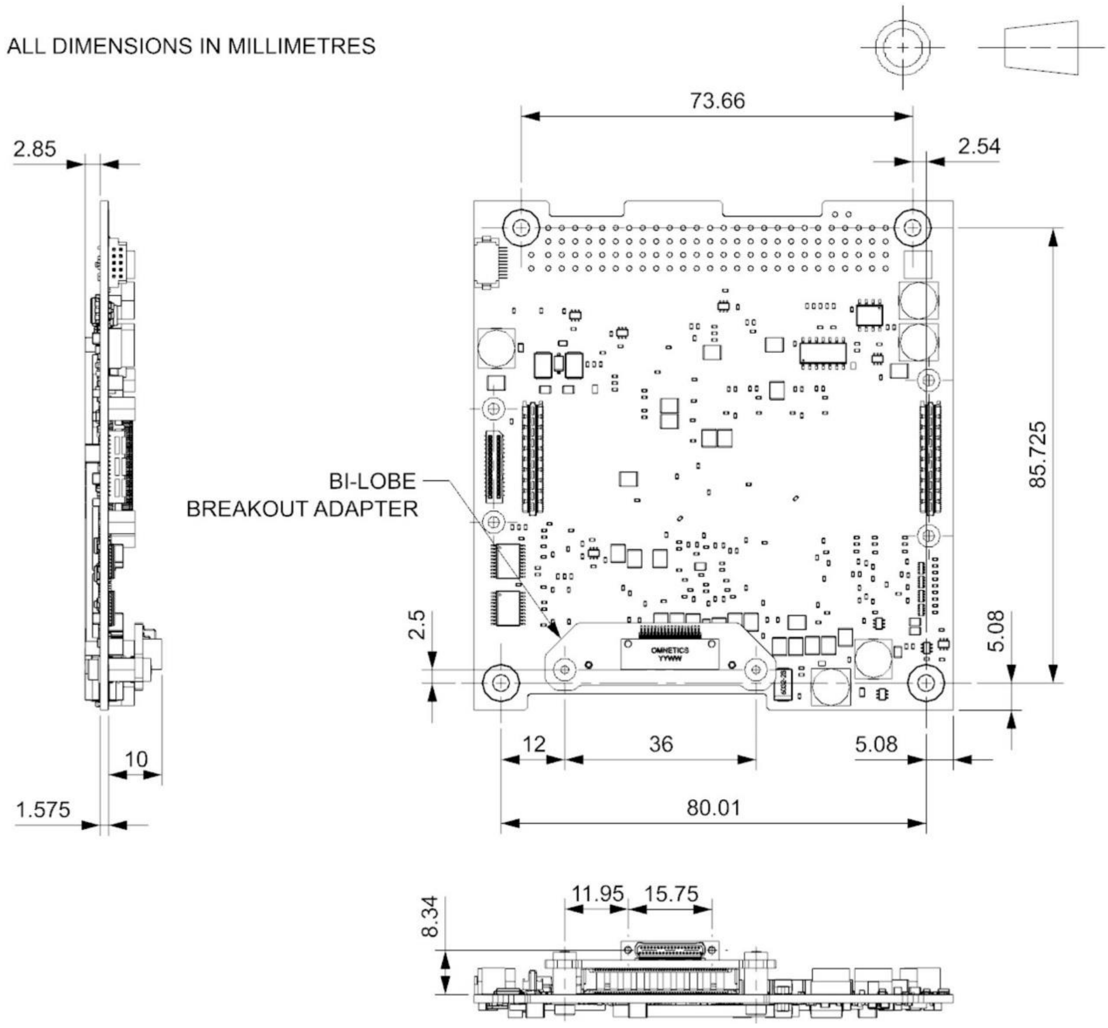

Figure 4-11: Bi-Lobe Breakout Adapter Position

Datamate Breakout Adapter

The Imager can optionally be supplied with a breakout adapter that adapts the LSHM connector (P5) to a Harwin M80-5424205 (P9). The pinout is provided in Table 4-9, including the default IO assignments.

Table 4-9 : High-Speed Interface Datamate Connector (P9) Pinout

Pin	Signal	Default IO Assignment	Pin	Signal	Default IO Assignment
1	IO31	PPS	22	CE_on	
2	IO32 / LVDS8+	HS_RR+ / US_nCTS+	23	Signal GND	LVDS8 Shield
3	IO33 / LVDS8-	HS_RR- / US_nCTS-	24	IO34 / LVDS9+	HS_Ctrl+ / US_EOF+
4	Signal GND	LVDS9 Shield	25	IO35 / LVDS9-	HS_Ctrl- / US_EOF-
5	IO36 / LVDS10+	HS_D1+	26	Signal GND	LVDS10 Shield
6	IO37 / LVDS10-	HS_D1-	27	IO38 / LVDS11+	HS_D0+ / US_TxData+
7	Signal GND	LVDS11 Shield	28	IO39 / LVDS11-	HS_D0- / US_TxData-
8	IO40 / LVDS12+	HS_Clk+ / US_Clk+	29	Signal GND	LVDS12 Shield
9	IO41 / LVDS12-	HS_Clk- / US_Clk-	30	IO42 / LVDS13+	SpW_DIN+ / SPI_SCK
10	Signal GND	LVDS13 Shield	31	IO43 / LVDS13-	SpW_DIN- / SPI_GND [1]
11	IO44 / LVDS14+	SpW_SIN+ / SPI_nSEL	32	Signal GND	LVDS14 Shield
12	IO45 / LVDS14-	SpW_SIN- / SPI_MOSI	33	IO46 / LVDS15+	SpW_DOUT+ / SPI_MISO
13	Signal GND	LVDS15 Shield	34	IO47 / LVDS15-	SpW_DOUT- / SPI_GND [1]
14	IO48 / LVDS16+	SpW_SOUT+ / not used [1]	35	Signal GND	not used
15	IO49 / LVDS16-	SpW_SOUT- / not used [1]	36	Signal GND	not used
16	PowerCtrl		37	5 V RETURN	
17	I^2C SDA		38	5 V RETURN	
18	I^2C SCL		39	5 V RETURN	
19	5 V RETURN		40	5 V RETURN	
20	5 V		41	5 V	
21	5 V		42	5 V	

The position of the Datamate Breakout Adapter connector relative to the CE's mounting holes is shown in Figure 4-12.

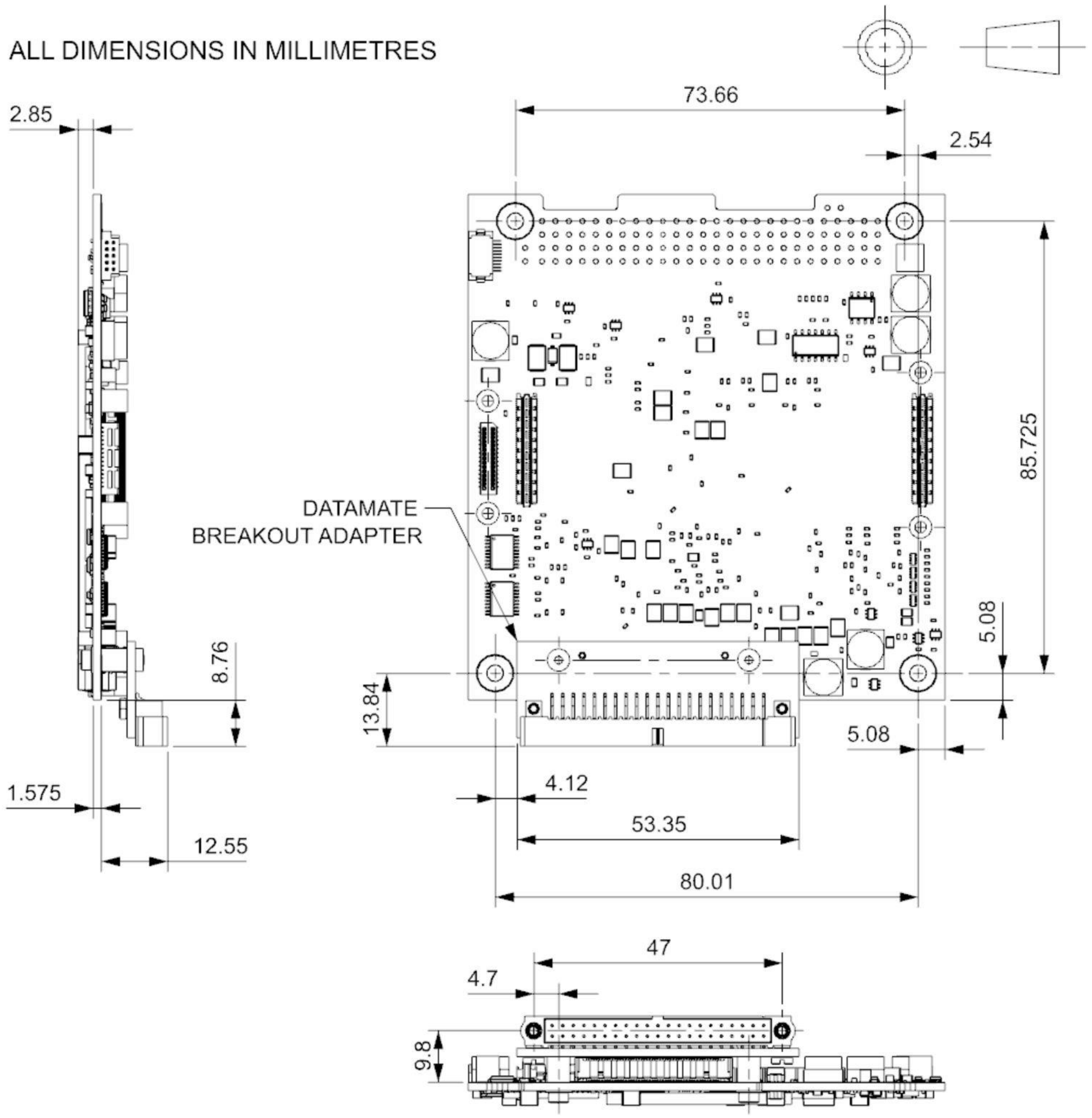

Figure 4-12: Datamate Breakout Adapter Position

4.5.1.2 Power Interface

The CE requires a regulated 5 V ± 10% Direct Current (DC) supply at a current of at least 1.5 A. This DC input power supply is filtered on the CE using a discrete Electro-Magnetic Interference (EMI) filter. The nominal DC current consumption for the different modes in the operational state is given in Table 4-10.

Table 4-10: Nominal Imager Power Consumption Values at Room Temperature

Operational Mode	Beginning of Life (BOL)	After 25 krad TID
Idle Mode (1)	470 mA	495 mA
Imaging Mode (2)	1100 mA	1160 mA
Readout Mode (3)	470 mA	495 mA

(1) CE is powered on, but the FEE is off. Control and High-Speed Data interfaces are static.
(2) CE and FEE are powered on, and an image is being captured.
(3) CE is powered on, but the FEE is off. Control and High-Speed Data interfaces are active.

The 5 V supply must be supplied by one, or a combination, of the PC104 connector pins H1.47, H1.49, H1.51, H2.13, H2.15, H2.16, H2.25, and H2.26, or the high-speed interface connector pins P5.95, P5.96, P5.97, P5.98, P5.99 and P5.100. The ground connection is made by one, or a combination, of PC104 connector pins H2.29, H2.30, and H2.32, or the high-speed interface connector pins P5.86, P5.89, P5.90, P5.91, P5.93, P5.94.

The CE has an optional power switch onboard that can be used to switch power to the Imager on. This may be used if the 5 V supplied to the CE is not switched. If this power switch option is selected in the product configuration sheet, its control line 'PowerCtrl' can be routed to one of the PC104 connector pins H1.4, H1.5, H1.6, H1.7, H1.8, H1.9, H1.10, H1.11, H1.13, H1.14, H1.15, H1.16, H2.17, H2.18, H2.19 or H2.20, or the high speed connector pin P5.87. The 'PowerCtrl' control signal is active high. To turn on the CE, the 'PowerCtrl' control signal must be driven high by applying a voltage between 2.5 V and 5.0 V for at least 100 ms.

The 'PowerCtrl' signal may optionally be used to power the CE off (as well as on). If this option is selected the Imager can be turned off by driving 'PowerCtrl' low to between 0 V and 0.5 V for at least 100 ms. This option can be enabled in the product configuration sheet. If this option is selected, the CE will power-cycle itself in the event of a radiation induced overcurrent condition.

The 'PowerCtrl' signal may optionally be latched onboard the CE. If this option is enabled, the 'PowerCtrl' signal may be deasserted after the CE has switched on (after 100 ms) which enables the CE to turn the Imager completely off in the event of a radiation induced overcurrent condition. This option can be enabled in the product configuration sheet. The 'CE_on' signal, or an unused 'IO*n*' signal, may be used as feedback and will be driven high when the imager is powered on and pulled to GND when the imager is turned off.

4.5.1.3 Control Interface

This interface is used to command the CE and receive telemetry from the CE. The Imager acts as a slave on the control interface. The standard control interface is I^2C and SPI (both run in parallel), but UART (RS-422/RS-485) and SpaceWire is also supported. The master provides a single ID byte to the Imager, which identifies the specific command or request. The master may then continue a command transaction by writing one or more parameter bytes to the Imager. In the case of request transactions, the master will read data bytes from the Imager. The ID byte is partitioned as follows:

Transaction Type	ID Byte Range
Command	0x00 – 0x7F
Request	0x80 – 0xFF

Since the ID byte is unique for each command or request, it is used to determine the length and the structure of the remaining transaction bytes (payload). Little-endian mode is used for parameters and data that span multiple bytes. The paragraphs that follow provide more information on the physical interface layers.

4.5.1.3.1 I^2C Interface

The CE implements an I^2C slave interface compliant to Standard-mode and Fast-mode as defined in [2]. Depending on the selections made in the product configuration sheet, the I^2C Interface can operate at either 3.3 V or 5 V voltage levels and supports 7-bit slave addressing.

The SCL signal can be routed from either H1.21, H1.43 or P5.92 and the SDA signal from either H1.23, H1.41 or P5.88 depending on the selections made in the product configuration sheet. The I^2C signals are buffered using an NXP PCA9517ADP and can optionally be pulled up to the bus voltage (3.3 V or 5 V as configured) if enabled in the product configuration sheet. The I^2C slave address is taken from the product configuration sheet.

Command Transactions

Command transactions are in the form of an I^2C write transfer, with a mandatory Command ID byte, followed by optional parameter bytes.

			1 byte	0 - N bytes	
S	Slave Address	W	Command ID	Parameter(s)	P

Figure 4-13: I^2C Command Transaction

Request Transactions

Request transactions are in the form of a combined write-read transfer. An I^2C write transfer of the Request ID byte is immediately followed by a I^2C read transfer of one or more data bytes.

			1 byte				0 - N bytes	
S	Slave Address	W	Request ID	Sr	Slave Address	R	Data	P

Figure 4-14: I^2C Request Transaction

4.5.1.3.2 SPI Interface

In addition to the I^2C interface, the CE also implements a 3.3 V LVCMOS compatible SPI slave interface consisting of four signals. These four signals can be routed to the 'IO*n*' pins on the physical electrical interfaces as defined in 4.5.1. The four SPI signals are:

- nSEL – Active low select signal generated by the master to select the slave interface. When not active (high) the SPI interface is not selected and placed in its reset state. All communication is initiated by the master first driving this nSEL signal low. It is kept low for the duration of the communication.
- MOSI - Master Out Slave In signal is the data output of the master.
- MISO – Master In Slave Out is the data output of the slave.
- SCK – The serial clock signal driven by the master. The maximum clock rate is 1 MHz.

The SPI interface conforms to the SPI standard "00" (clock polarity '0', clock phase '0'). As such the values on the MOSI and MISO lines are valid at the rising edge of SCK and remain valid until the next SCK shift edge.

Command Transactions

Command transactions require the SPI master to send a sequence of bytes on the MOSI line, as shown in Figure 4-15, consisting of a Command ID byte, followed by three mandatory turn-around bytes, then optional parameter bytes. The turn-around bytes may have an arbitrary value. The bytes received by the master (on the MISO line) are not used.

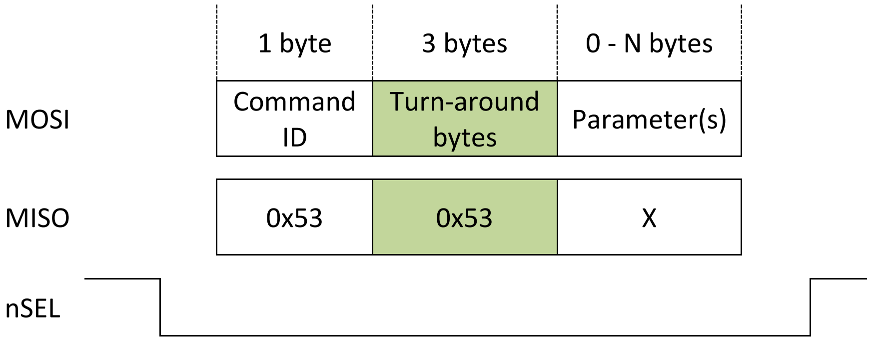

Figure 4-15: SPI Command Transaction

Request Transactions

Request transactions require the SPI master to send a sequence of bytes on the MISO line, as shown in Figure 4-16, consisting of a Request ID byte, followed by three mandatory turn-around bytes, then one or more arbitrary bytes (depending on the length of the requested data). The turn-around bytes may have arbitrary value. The bytes received by the master (on the MISO line), after the turn-around bytes have been sent, represent the return data. In other words, the first 4 bytes received on the MISO line should be ignored.

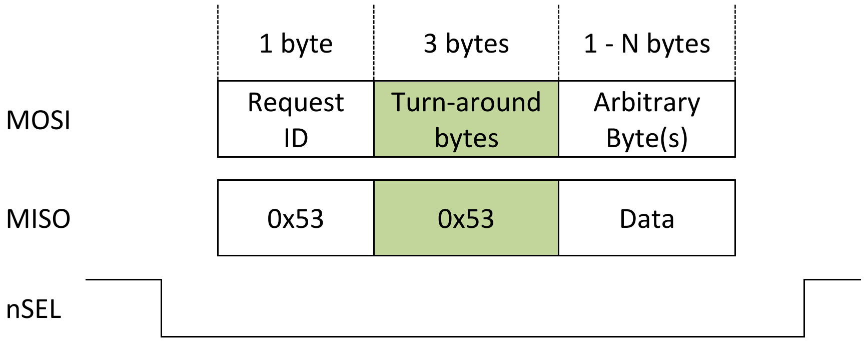

Figure 4-16: SPI Request Transaction

4.5.1.4 Data Interface

The imager provides a high-speed data interface consisting of up to seven LVDS pairs that can be routed to any 'LVDS*n*±' pin pair on the PC-104 interface (4.5.1.1.1) or the High-Speed Interface (4.5.1.1.2). The Simera Sense Standard High-Speed LVDS, USART, and SpaceWire protocols are supported.

4.5.1.4.1 Standard High-Speed LVDS Link

The standard high-speed link consists of a clock, a synchronisation channel, a receiver ready line, and 1, 2 or 4 data lanes. The clock is free running and activated as soon as the interface is enabled for data read out. The bit rate can be set from 100 to 800 Mbps (per data lane) and the clocking can be configured to be single data rate (SDR) or double data rate (DDR). 800 Mbps is only supported in DDR. Various clock alignment options are also available.

Up to seven LVDS pairs are used:

- HS_Clk – Clock to which HS_D[n] and HS_Ctrl is synchronised.
- HS_D[0-3] – The data Lanes. The standard high-speed link can be configured to use 1, 2 or 4 lanes
- HS_Ctrl – Conveys synchronisation and other out-of-band status information for the entire link
- HS_RR – Optionally returned from the data sink to provide flow control

When using the standard high-speed link, the data interface has three possible states:

- OFF – The interface is turned off and all output signals (all except HS_RR) are driven low.
- INACTIVE – HS_Clk is running. HS_Ctrl has the "SYNC" bit set ('1') properly, however, the "LA" bit is cleared ('0'), and no data is sent.
- ACTIVE – HS_Clk is running. HS_Ctrl has both "SYNC" and "LA" bits set ('1'). Valid data may be sent in this state, as indicated by the "DV" bit.
-

Data is transferred in bytes of 8 bits, most significant bit (MSB) first. The most basic one byte transfer cycle using a single data lane is shown in Figure 4-17.

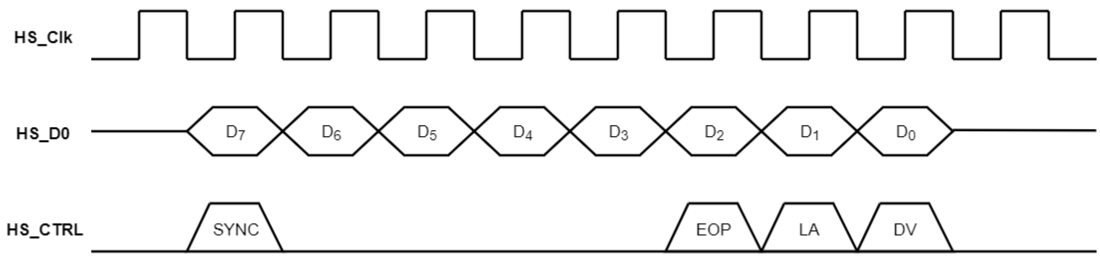

Figure 4-17: Standard High-Speed Link Byte Transfer Cycle Waveform

Single vs two data lane byte ordering is shown in Figure 4-18.

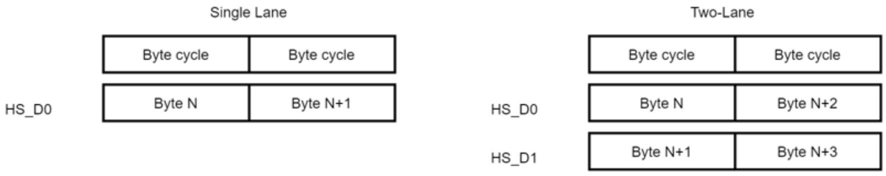

Figure 4-18: Single vs Two Data Lane Byte Ordering

The information in the HS_Ctrl channel is applicable to all data lanes. The bits are defined as follow:

- SYNC – This is the byte synchronisation bit which is used to mark the start of a new byte. It is always set ('1') when the link is in any state other than the OFF state.
- EOP – The end of packet bit is set during the transfer of the last byte of a data packet. Data is formatted into packets (see Section 4.5.1.4.3) and this bit can be used to indicate the boundary between packets. The EOP bit will only be set when the link is in ACTIVE state and a valid byte is output (DV bit is set, '1').
- LA – This bit indicates the links state. It is set when the link is in ACTIVE state.
- DV – The data byte(s) on the data lane(s) are valid only when this bit is set ('1').

HS_RR allows the data sink to throttle the flow of data. When HS_RR is asserted ('1'), the receiver is ready to accept more data. When HS_RR is deasserted ('0') the interface is requested to stop transmitting and will do so by setting the DV bit low ('0'). The interface will wait in this state indefinitely until HS_RR is asserted ('1'). The interface may transmit up to 4 bytes once the data sink sets HS_RR low ('0'). The receiver should therefore be willing to receive up to 4 more valid bytes after setting HS_RR low ('0'). This is shown in Figure 4-19.

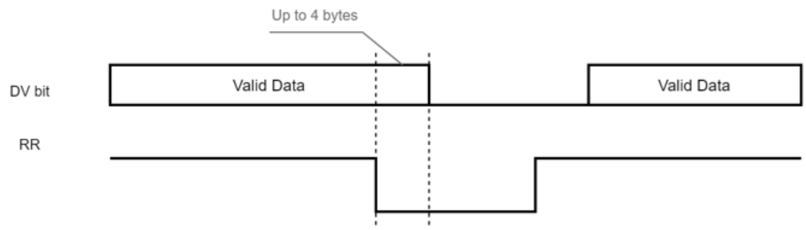

Figure 4-19: High-Speed Link HS_RR Operation

4.5.1.4.2 USART Link

The USART Link consists of a clock, data, clear-to-send, and end-of-frame signals. The clock is free running and activated as soon as the interface is enabled for data read out. Data is transmitted in 10-bit transfers (a start bit, 8 data bits, and a stop bit) similar to a UART, but synchronised to the clock. The basic transfer is shown in Figure 4-20.

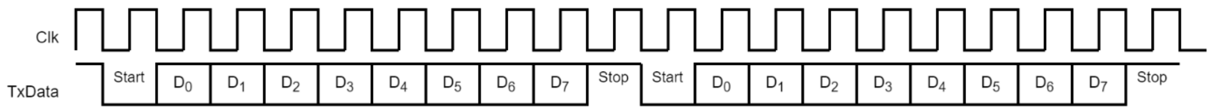

Figure 4-20: USART Data Transfer

The USART link does not make provision for multiple data lanes. The bit rate (baud rate) can be set from 400 kbps up to 25 Mbps. Four LVDS pairs are used:

- US_Clk – Clock to which US_TxData and US_EOF is synchronised.
- US_TxData – The data line. When the interface is idle, this line is driven high ('1').
- US_nCTS – Active low "clear to send" signal driven by the data sink (receiver) to perform flow control. The data interface transmits data while US_nCTS is asserted ('0') and will stop transmitting when de-asserted ('1').
- US_EOF – This is an "end of frame" signal pulsed high after the last data byte has been transmitted.

When using the USART link, the data interface has three possible states:

- OFF – The interface is turned off. US_Clk and US_EOF are driven low ('0'), while US_TxData is driven high ('1').
- INACTIVE – US_Clk is running. US_EOF is driven low ('0') and US_TxData is driven high ('1').
- ACTIVE – US_Clk is running. Valid data may be sent in this state.

The operation of US_nCTS is shown in Figure 4-21. Once US_nCTS is de-asserted ('1'), the interface will finish the current byte before returning the US_TxData line to the Idle state ('1'). The interface will wait in this state indefinitely until US_nCTS is asserted ('0').

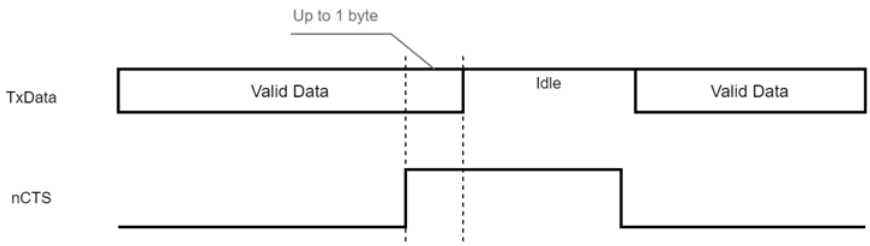

Figure 4-21: USART US_nCTS Operation

The US_EOF line is used to indicate the end of the data frame. It is always exactly 10 US_Clk cycles long and will never be asserted (‘1’) less than 40 US_Clk cycles after the last valid data byte is transmitted. It may however be asserted (‘1’) more than 40 US_Clk cycles after the last valid data byte is transmitted. The operation of US_EOF is shown in Figure 4-22.

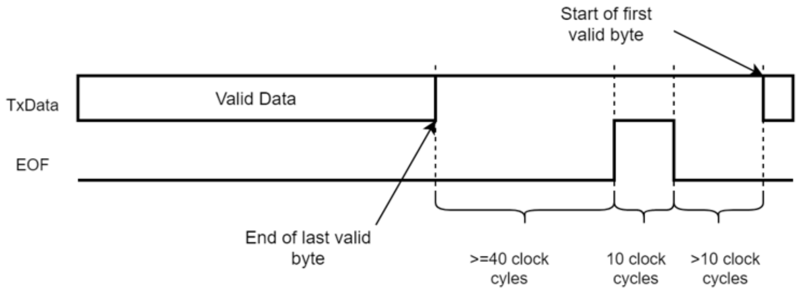

Figure 4-22: USART US_EOF Operation

4.5.1.4.3 Data Format

Image data is stored in the Flash memory in a packet-based format which may be read out via the Data Interface as a continuous stream. During an imaging session, the pixel data from each sensor line is formatted into individual packets which are time stamped. Additional packets are injected into the stream in real time, so that relevant ancillary data from the user and imager may be included. User ancillary packets are generated using data received from the satellite bus, which typically includes attitude data, ephemeris data and timing information. Imager ancillary packets allow the exact imager settings applied during the session to be stored.

Each packet includes a header, payload and footer. The header is used to identify the packet and extract the variable length payload. The payload content is uniquely defined for each identifier. The footer is in the form of a CRC-32 applied to the full packet. The packet format is shown in Figure 4-23.

64-bit	n x 32-bit	32-bit
Header	**Payload**	**Footer**

Figure 4-23: Imager Data Packet Description

A typical imaging session will generate a stream of packets as shown in Figure 4-24.

Session Start
Imager Ancillary Data
User Ancillary Data (2)
Time Sync (2)
Scene Start
Exposure Start
Line Data (Band 0, Line 0)
Exposure Start
Line Data (Band 0, Line 1)
…
Exposure Start
Line Data (Band 0, Line 8)
Thumbnail Line Data (Band 0, Line 0) (3)
Exposure Start
…
Exposure Start
Line Data (Band 0, Line 288)
Thumbnail Line Data (Band 0, Line 36)
Exposure Start
Line Data (Band 0, Line 289)
Line Data (Band 1, Line 0)
Exposure Start
Line Data (Band 0, Line 290)
Line Data (Band 1, Line 1)
…
Exposure Start
Line Data (Band 0, Line 578)
Imager Ancillary Data (1)
Line Data (Band 1, Line 289)
User Ancillary Data (2)
Line Data (Band 2, Line 0)
…
Imager Ancillary Data (1)
User Ancillary Data (2)
End Session

(1) Injected by Imager automatically
(2) Injected as user provides command via Control Interface
(3) Assumes thumbnail reduction factor of 8

Figure 4-24: Data Output Example for an Imaging Session

4.5.1.5 Grounding

All mounting holes on the CE are connected to each other and to GND through a broadband 100 nF ceramic capacitor to facilitate grounding. The FEE is grounded to the OFE through a 470 kΩ resistor.

4.6 Environmental Interfaces

4.6.1 Thermal Radiation Interface

4.6.1.1 Interface 8: xScape200 VNIR OFE to Environment

The front aperture of the OFE exchanges heat through thermal radiation with the space environment at the aperture. The function of this interface is to transmit thermal energy between the OFE and the space environment by means of radiation.

4.6.2 Cosmic Radiation Interfaces

4.6.2.1 Interface 9: Environment to xScape200 VNIR OFE

There is an interface between the space environment and the OFE through which cosmic radiation is transmitted to the OFE.

4.6.2.2 Interface 10: Environment to MultiScape200 CIS Sensor Unit

There is an interface between the space environment and the sensor unit through which cosmic radiation is transmitted to the sensor unit.

4.6.2.3 Interface 11: Environment to MultiScape200 CIS Control Electronics

There is an interface between the space environment and the CE through which cosmic radiation is transmitted to the CE.

5. Environmental Requirements

5.1 Transportation

5.1.1 Temperature

During transportation and in a non-operating condition the maximum temperature of the Imager assembly shall not exceed 50 °C and the minimum temperature of the Imager assembly shall not be less than -10 °C.

5.1.2 Humidity

The humidity during transportation shall be less than 60%, non-condensing.

5.1.3 Shock/Vibration

All handling operations shall limit the peak acceleration exposure of the Imager to less than 25 g, in any direction.

5.1.4 Cleanliness

During transportation the Imager shall be kept in an environment with a cleanliness level equal to or better than International Organization for Standardization (ISO) class 8, as per ISO 14644-1:2015 standards.

5.2 Storage

During storage it is assumed that the Imager will not be in motion, therefore vibration and shock loading conditions are not relevant. During storage the following conditions shall be adhered to:

5.2.1 Temperature

During prolonged storage and in a non-operating condition the maximum temperature of the Imager shall not exceed 30 °C and the minimum temperature of the Imager shall not be less than 10 °C.

5.2.2 Humidity

The humidity during prolonged storage shall be between 30% and 60%, non-condensing.

5.2.3 Cleanliness

The Imager shall be stored in an environment with a cleanliness level equal to or better than ISO class 8, as per ISO 14644-1:2015 standards.

5.3 Assembly, Integration and Testing

All Assembly, Integration and Testing (AIT) procedures must be performed in an ISO class 8 cleanroom, as per ISO 14644-1:2015 standards, or better. In addition, during AIT the following conditions shall always be adhered to:

5.3.1 Shock

All handling operations shall limit shock exposure of the Imager assembly to less than 30 g for 10 ms, in any direction.

5.3.2 Mechanical Interface with OFE

During all AIT procedures, all mechanical mating interfaces with the OFE shall cause zero relative displacement (in the x-y plane) between any of the OFE's mounting points.

5.4 In-Orbit

5.4.1 Survivable Temperature

In order to ensure survival, the maximum temperature of the Imager shall not exceed 60 °C and the minimum temperature of the Imager shall not be less than -20 °C.

5.4.2 Operating Temperature

During operation the maximum temperature of the OFE shall not exceed 50 °C and the minimum temperature of the OFE shall not be less than -10 °C.

5.4.3 Operating Temperature Gradients

During operation the maximum axial temperature gradient over the OFE shall not be greater than 5 °C.

During operation the maximum transverse temperature gradient over the OFE shall not be greater than 4 °C.

5.4.4 Outgassing of Satellite Components

Material used in satellite components, which are near the Imager, shall have a maximum Total Mass Loss (TML) of less than 1.0% and a maximum Collected Volatile Condensable Material (CVCM) of less than 0.10%. Refer to [1] for a list of material TML and CVCM data.

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