

SIMERA SENSE

HyperScape100

Interface Control Document

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Author(s): E. Grobbelaar, J. Vos
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Table of Contents

1. Introduction.....	8
1.1 Identification.....	8
1.2 Intended Use.....	8
1.3 Context and Summary.....	8
2. Referenced Documents	9
3. System Description and Context	10
3.1 Physical Description	10
3.2 Physical Properties.....	11
4. Description of System Interfaces.....	14
4.1 Interface Identification and Definition.....	14
4.2 Optical Interface.....	15
4.2.1 Interface 1: Target in View to xScape100 OFE.....	15
4.3 Mechanical Interfaces.....	15
4.3.1 Interface 2: xScape100 OFE to Satellite Components	15
4.3.2 Interface 5: HyperScape100 Control Electronics to Satellite Components.....	17
4.4 Thermal Interfaces	20
4.4.1 Interface 3: xScape100 OFE to Satellite Components	20
4.4.2 Interface 4: HyperScape100 Sensor Unit to Satellite Components.....	20
4.4.3 Interface 6: HyperScape100 Control Electronics to Satellite Components	20
4.5 Electrical Interfaces.....	21
4.5.1 Interface 7: Satellite Components to HyperScape100 Control Electronics	21
4.6 Environmental Interfaces.....	27
4.6.1 Thermal Radiation Interface	27
4.6.2 Cosmic Radiation Interfaces	27
5. Environmental Requirements	28
5.1 Transportation	28
5.1.1 Temperature.....	28
5.1.2 Humidity	28
5.1.3 Vibration	28
5.1.4 Shock.....	28

5.1.5	Cleanliness	28
5.2	Storage	28
5.2.1	Temperature	28
5.2.2	Humidity	28
5.2.3	Cleanliness	28
5.3	Assembly, Integration and Testing.....	29
5.3.1	Vibration	29
5.3.2	Shock.....	29
5.3.3	Mechanical Interface with OFE.....	29
5.4	In-Orbit.....	29
5.4.1	Survivable Temperature	29
5.4.2	Operating Temperature.....	29
5.4.3	Operating Temperature Gradients	29
5.4.4	Outgassing of Satellite Components	29

List of Figures

Figure 3-1: Typical CubeSat System Diagram	10
Figure 3-2: HyperScape100 with Axis Definition	11
Figure 3-3: Centre of Mass Position	13
Figure 4-1: Interface Identification Diagram	14
Figure 4-2: OFE Mounting Interface Dimensions	16
Figure 4-3: CE Mechanical Drawing.....	18
Figure 4-4: CE and High-Speed Connector Mounting Hole Details	19
Figure 4-5: CE Mounting Position Relative to OFE	20
Figure 4-6: CubeSat Kit Bus Compatible PC-104 Header Schematic	21
Figure 4-7: SPI Interface Timing Diagram	24
Figure 4-8: High-Speed Data Interface Timing Diagram.....	25
Figure 4-9: High-Speed Data Connector.....	25

List of Tables

Table 2-1: Referenced Documents	9
Table 3-1 System and Component Functional Description	10
Table 3-2: Physical Properties	12
Table 3-3: Natural Frequencies of the Imager from 0 – 2000 Hz	12
Table 4-1: Interface Definition	15
Table 4-2: OFE Mounting Interface Specifications	17
Table 4-3: Imager BOL Power Consumption	22
Table 4-4: High-Speed Data Interface Signal Assignment	24
Table 4-5: High-Speed Data Connector Pinout.....	26

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
FPGA	Field Programmable Gate Array
IO	Input/Output
ISO	International Organization for Standardization
LVDS	Low Voltage Differential Signalling
MSB	Most Significant Bit
NC	Not Connected
OFE	Optical Front-End
PCB	Printed Circuit Board
SPI	Serial Peripheral Interface
TML	Total Mass Loss

1. Introduction

1.1 Identification

Item Description: HyperScape100

Simera Item Number: SS100-034647

1.2 Intended Use

This document describes the interfaces and environmental conditions of the HyperScape100 Imager.

1.3 Context and Summary

The HyperScape100 is an electro-optical imaging system employing a CMOSIS CMV12000 sensor utilizing a linear variable filter. The HyperScape100 is produced by Simera Sense and is intended for earth observation applications. It is primarily designed to be implemented as part of an optical payload in a CubeSat. Its compact form factor allows for direct implementation into a 3U CubeSat structure; however, the HyperScape100 can also be used as part of larger satellite systems.

This Interface Control Document identifies, defines and describes the interfaces between the HyperScape100 and the surrounding satellite components, as well as between the HyperScape100 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]

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 HyperScape100 captures electromagnetic radiation, focuses the radiation on a sensor and converts the focused electromagnetic radiation into electrical signals. The HyperScape100 typically forms part of the payload of a satellite and is shown in the context of a typical CubeSat diagram in Figure 3-1 below.

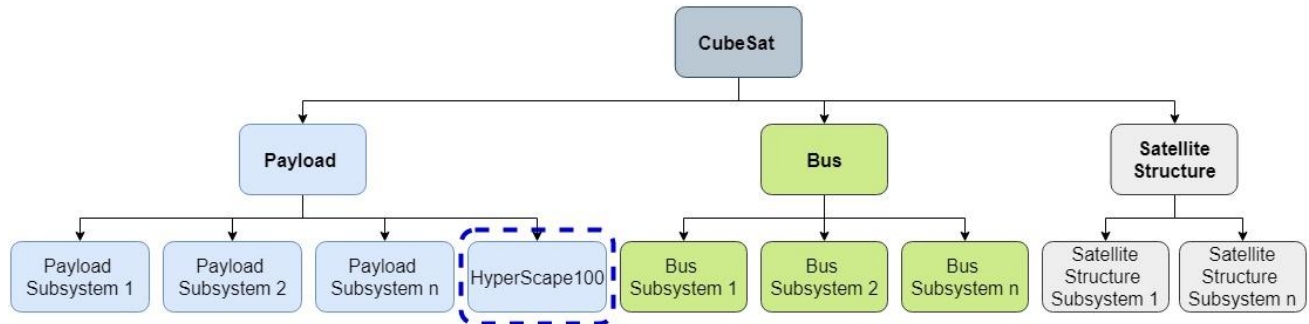


Figure 3-1: Typical CubeSat System Diagram

3.1 Physical Description

The HyperScape100, hereafter referred to as the “Imager”, consists of several subassemblies which comprises of the xScape100 Optical Front-End (OFE), the HyperScape100 Sensor Unit and the HyperScape100 Control Electronics. Table 3-1 provides a functional description of the Imager and its components

Table 3-1 System and Component Functional Description

ID	Imager/Component	Primary Function
1	HyperScape100	Collects electromagnetic radiation and converts it into electrical signals
1.1	xScape100 OFE	Focuses the collected electromagnetic radiation onto an imaging sensor
1.2	HyperScape100 Sensor Unit	Positions the sensor on the focal plane and converts the focused electromagnetic radiation into electrical signals
1.3	HyperScape100 Control Electronics	Powers and drives the sensor unit, as well as provides storage space for the captured images

Figure 3-2 illustrates the physical system subassemblies and provides the axis definition.

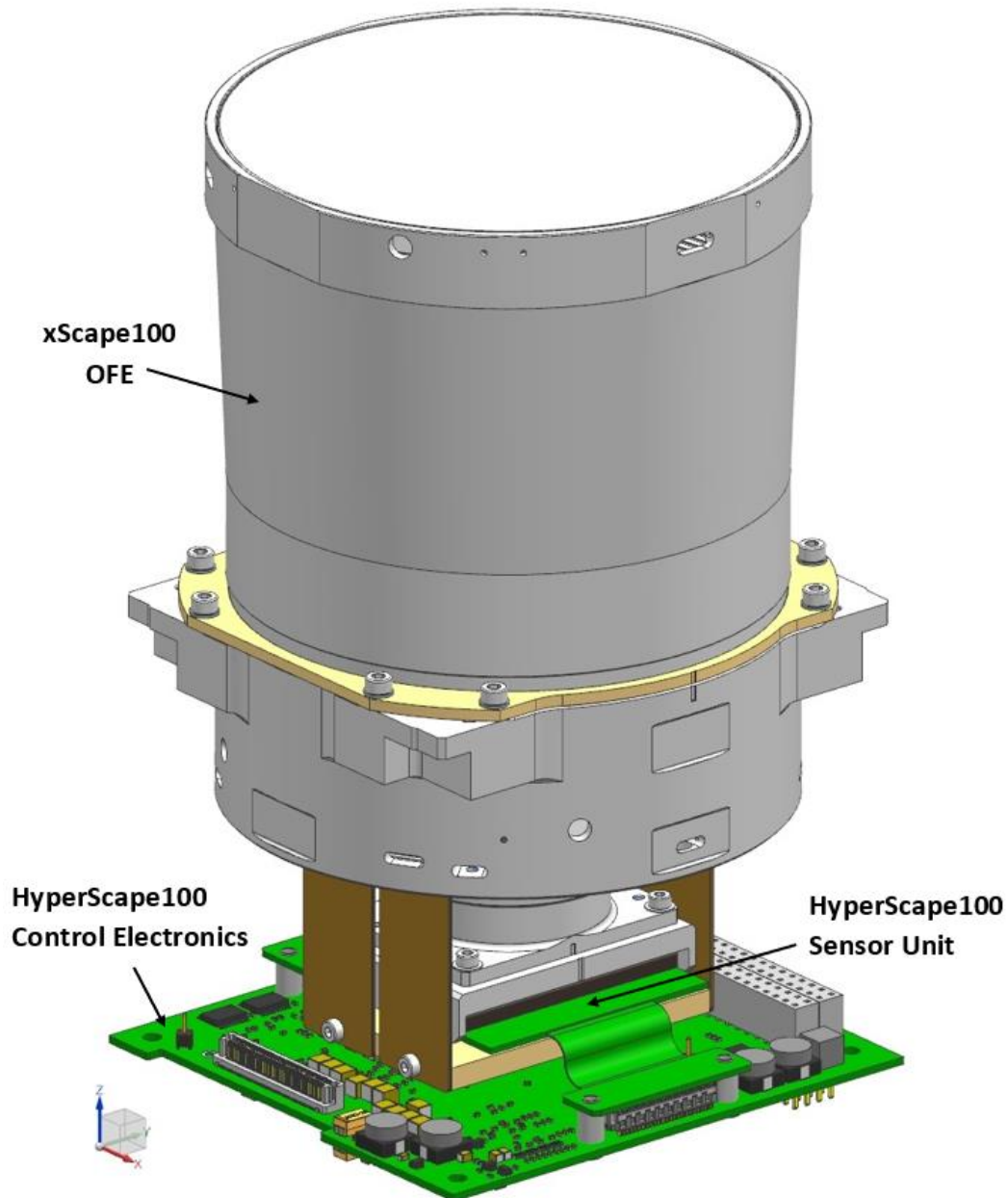


Figure 3-2: HyperScape100 with Axis Definition

3.2 Physical Properties

The physical properties of the Imager are presented in Table 3-2. 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 is shown in Figure 4-2.

Table 3-2: Physical Properties

Property	Unit	Value
Mass	kg	1.14 (± 5%)
Moments of Inertia		
I_{xx}	kg.m ²	3.70E-03 (± 5%)
I_{yy}	kg.m ²	3.65E-03 (± 5%)
I_{zz}	kg.m ²	1.55E-03 (± 5%)
Centre of Mass		
x	mm	< 0.5 (± 0.5) See Figure 3-3
y	mm	< 0.5 (± 0.5) See Figure 3-3
z	mm	7 (± 1) See Figure 3-3

Table 3-3 provides the natural frequencies of the Imager (from 0 - 2000 Hz) when it is rigidly constrained at its four mounting points which is shown in Figure 4-2.

Table 3-3: Natural Frequencies of the Imager from 0 – 2000 Hz

Mode Number	Frequency [Hz]
1	684
2	705
3	800
4	854
5	891
6	996
7	1020
8	1072
9	1157
10	1587
11	1691
12	1718
13	1820
14	1839
15	1855
16	1933
17	1947
18	1997

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

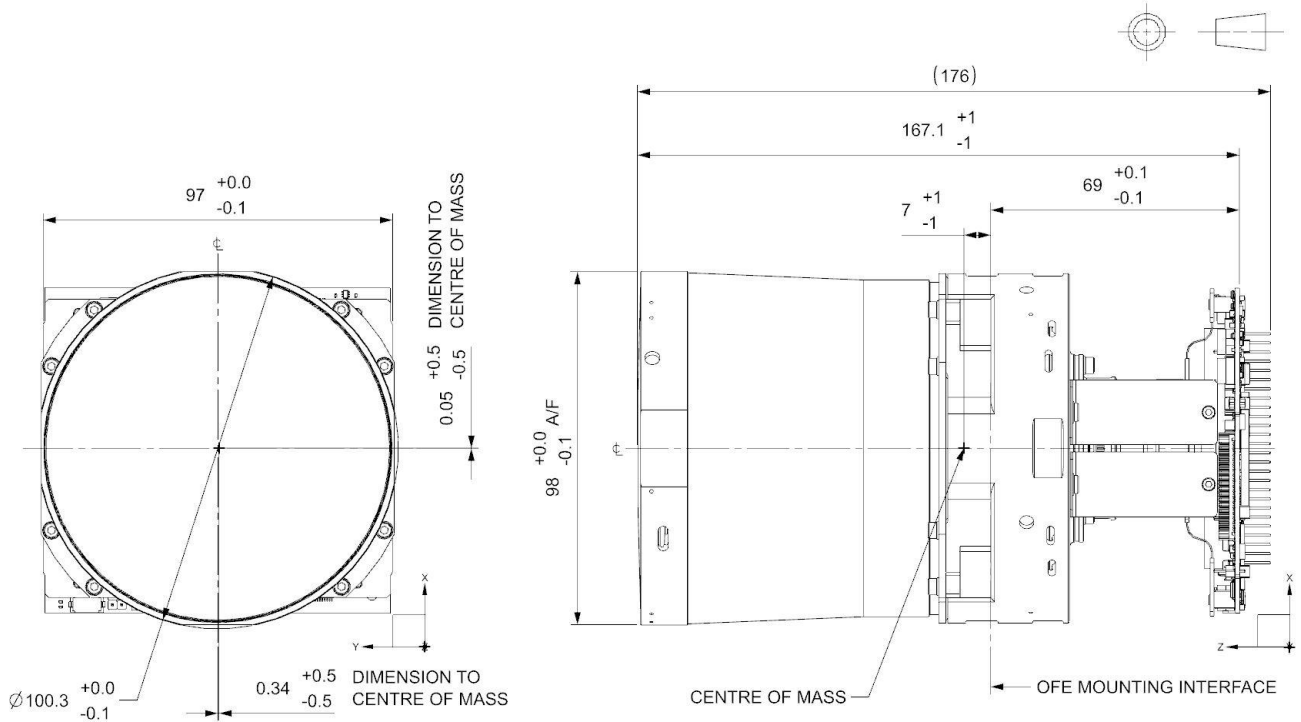


Figure 3-3: Centre of Mass Position

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 includes the satellite structure.

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

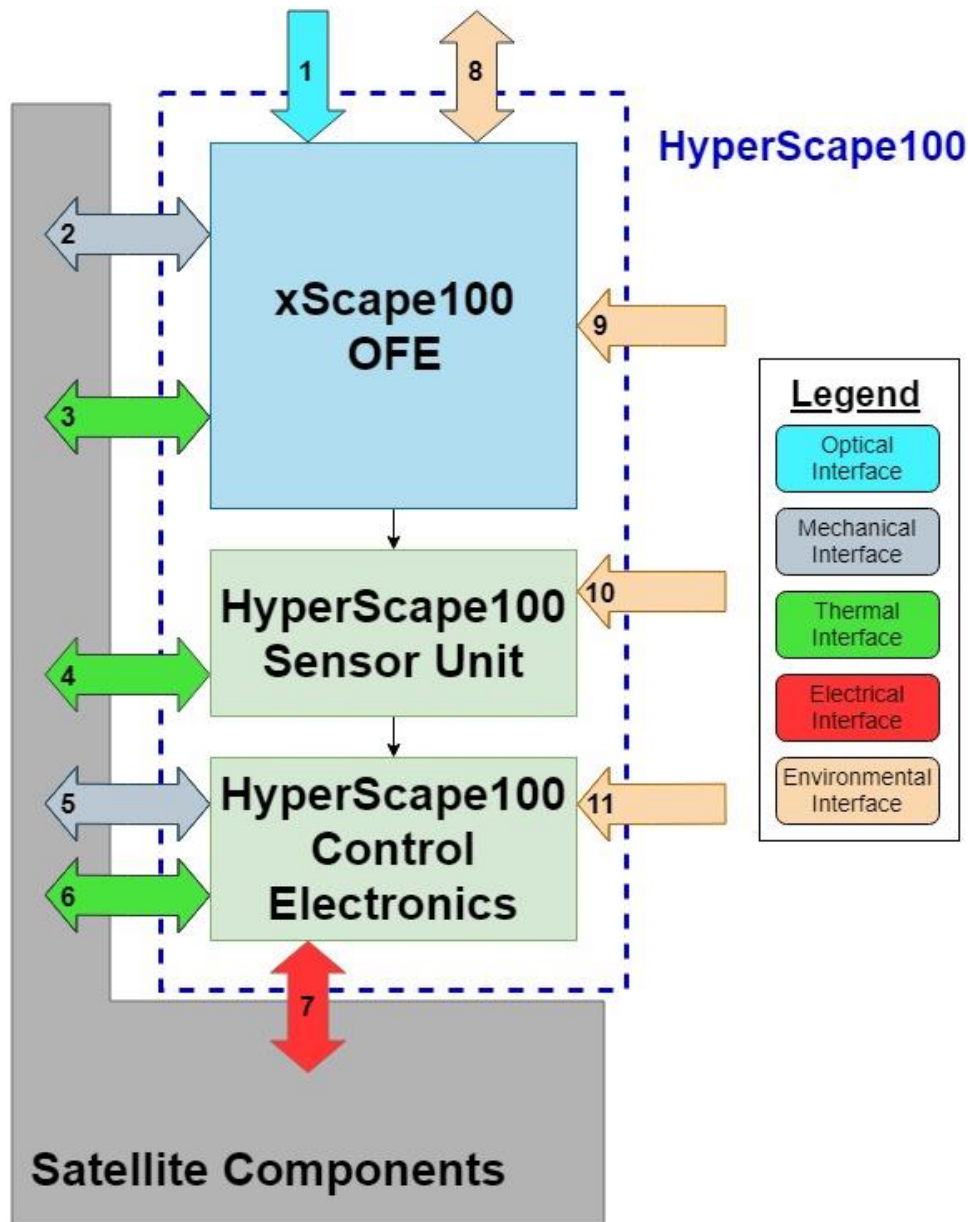


Figure 4-1: Interface Identification Diagram

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

Table 4-1: Interface Definition

Interface Number	Interface Type	Interface From	Interface To
1	Optical	Target in View	xScape100 OFE
2	Mechanical	xScape100 OFE	Satellite Components
3	Thermal	xScape100 OFE	Satellite Components
4	Thermal	HyperScape100 Sensor Unit	Satellite Components
5	Mechanical	HyperScape100 Control Electronics	Satellite Components
6	Thermal	HyperScape100 Control Electronics	Satellite Components
7	Electrical (Power and Control)	Satellite Components	HyperScape100 Control Electronics
8	Environmental (Thermal Radiation)	xScape100 OFE	Environment
9	Environmental (Cosmic Radiation)	Environment	xScape100 OFE
10	Environmental (Cosmic Radiation)	Environment	HyperScape100 Sensor Unit
11	Environmental (Cosmic Radiation)	Environment	HyperScape100 Control Electronics

4.2 Optical Interface

4.2.1 Interface 1: Target in View to xScape100 OFE

The xScape100 OFE has an optical interface at its front aperture with a diameter 95 mm and a full field of view of 2.96 degrees. 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.

4.3 Mechanical Interfaces

4.3.1 Interface 2: xScape100 OFE to Satellite Components

The OFE interfaces mechanically with the satellite structure via four 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.

The mating interface which is bolted to the OFE shall have four through holes with a diameter of 3.4 mm or larger. These through holes shall be spaced to match the hole spacing of the four M3 threaded holes (as shown in Figure 4-2) exactly and shall have a positional tolerance of 0.1 mm. In addition, all interfaces which mate directly to the mounting interface of the OFE shall have a flatness tolerance of 50 μm or smaller and shall have a N7 surface finish (this is equivalent to a surface finish with an average roughness of $R_a = 1.6 \mu\text{m}$).

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 the mounting surfaces of the OFE remain coplanar in the z-direction. Figure 4-2 provides the dimensions of the OFE's mounting interface.

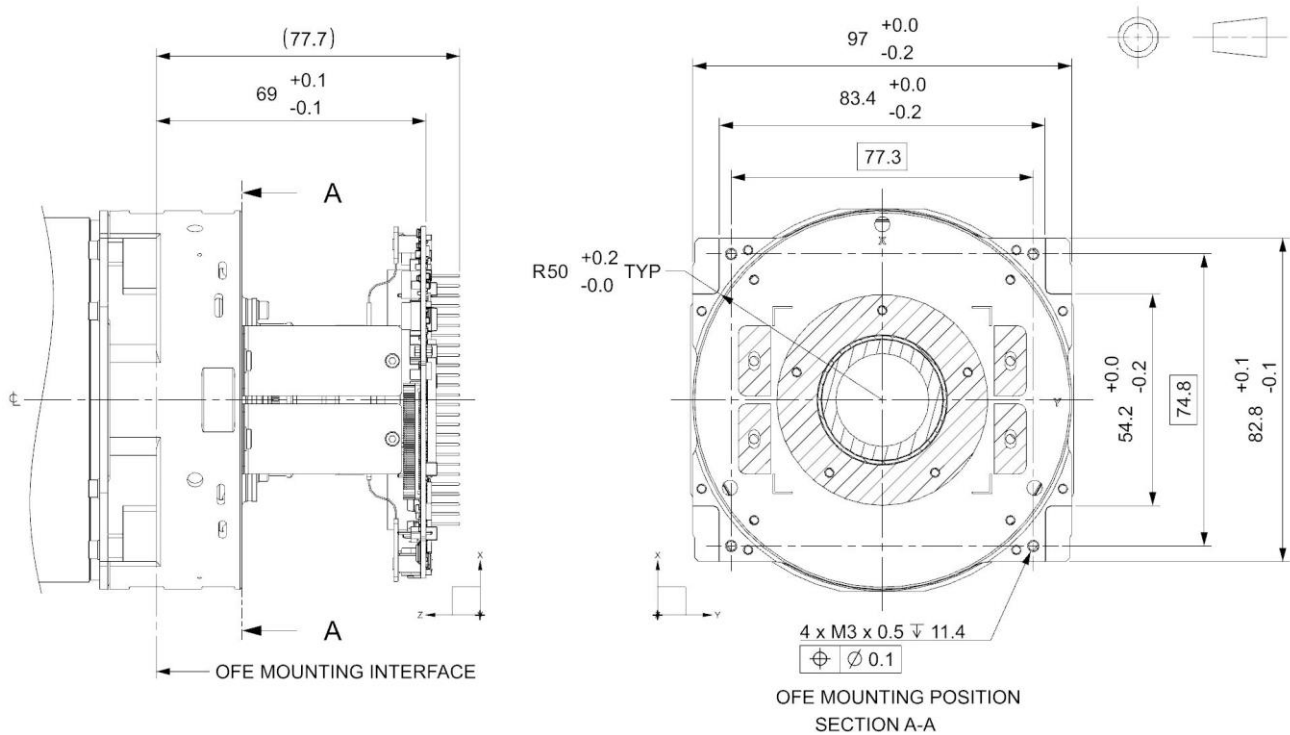


Figure 4-2: OFE Mounting Interface Dimensions

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

Table 4-2: OFE Mounting Interface Specifications

Description	Value
Interface Material	Titanium Grade 5 (Ti-6Al-4V)
Interface Surface Finish	Bare Ti-6Al-4V, N7 surface finish
Flatness	<20 μm
Number of Mounting Locations	4
Thread Specification	M3 x 0.5 (see Figure 4-2)
Depth of Thread Supplied in OFE	11.4 mm
Fastener Torque (for stainless steel A4-70 fastener material). All fasteners shall be staked using Scotch Weld EC2216 adhesive or equivalent.	1 Nm

4.3.2 Interface 5: HyperScape100 Control Electronics to Satellite Components

The HyperScape100 Control Electronics (CE) interfaces mechanically with the satellite components through the four mounting holes located on the edges of the printed circuit board (PCB). These four mounting holes are through holes in the PCB and their spacing conforms to the PC-104 standard. The function of this interface is to secure the PCB to the applicable satellite component and act as main structural support for the CE. Figure 4-3 displays the dimensions of the CE PCB, as well as the height of the components on both sides of the PCB.

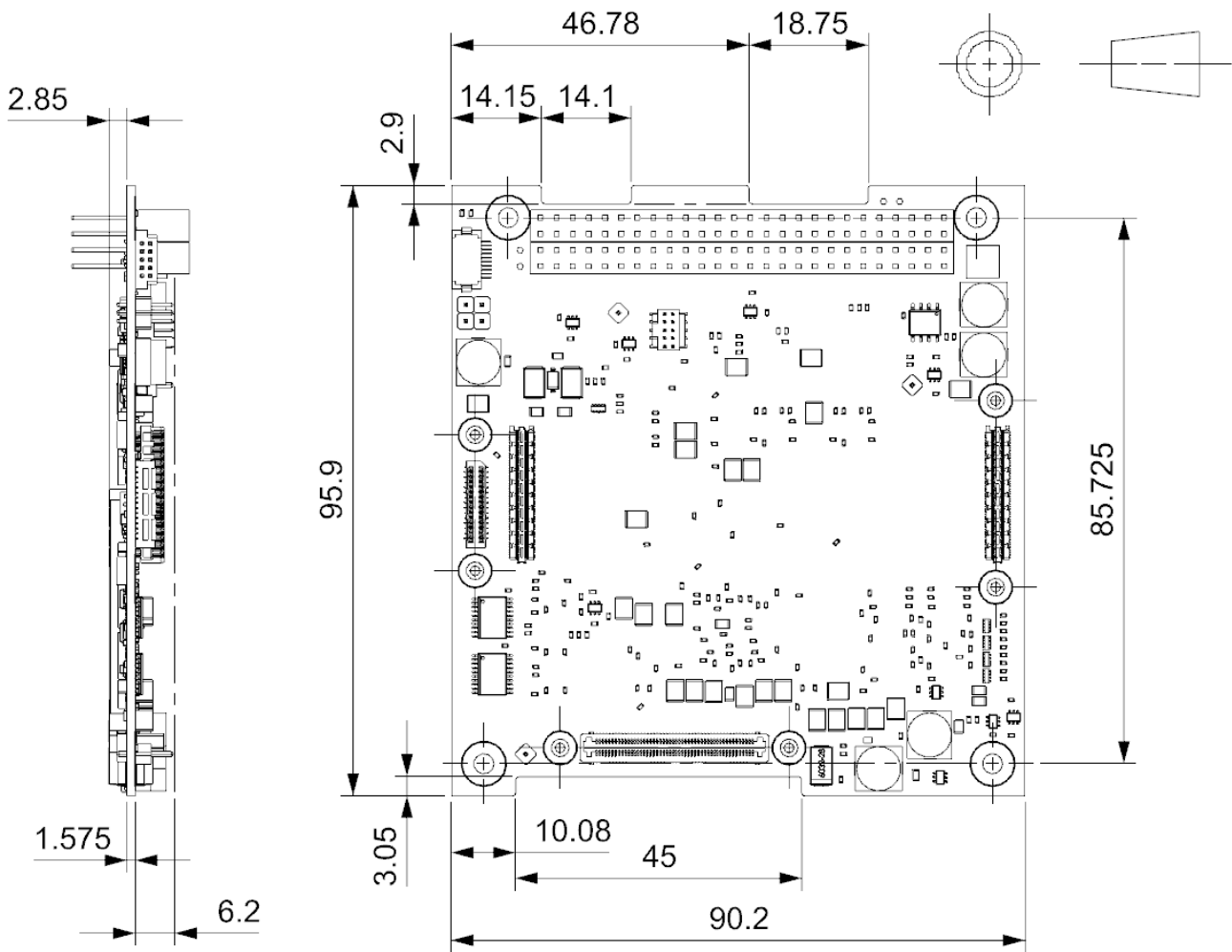


Figure 4-3: CE Mechanical Drawing

In Figure 4-4 below, the mounting details of the CE, as well as of the high-speed connector on the CE PCB are shown in more detail.

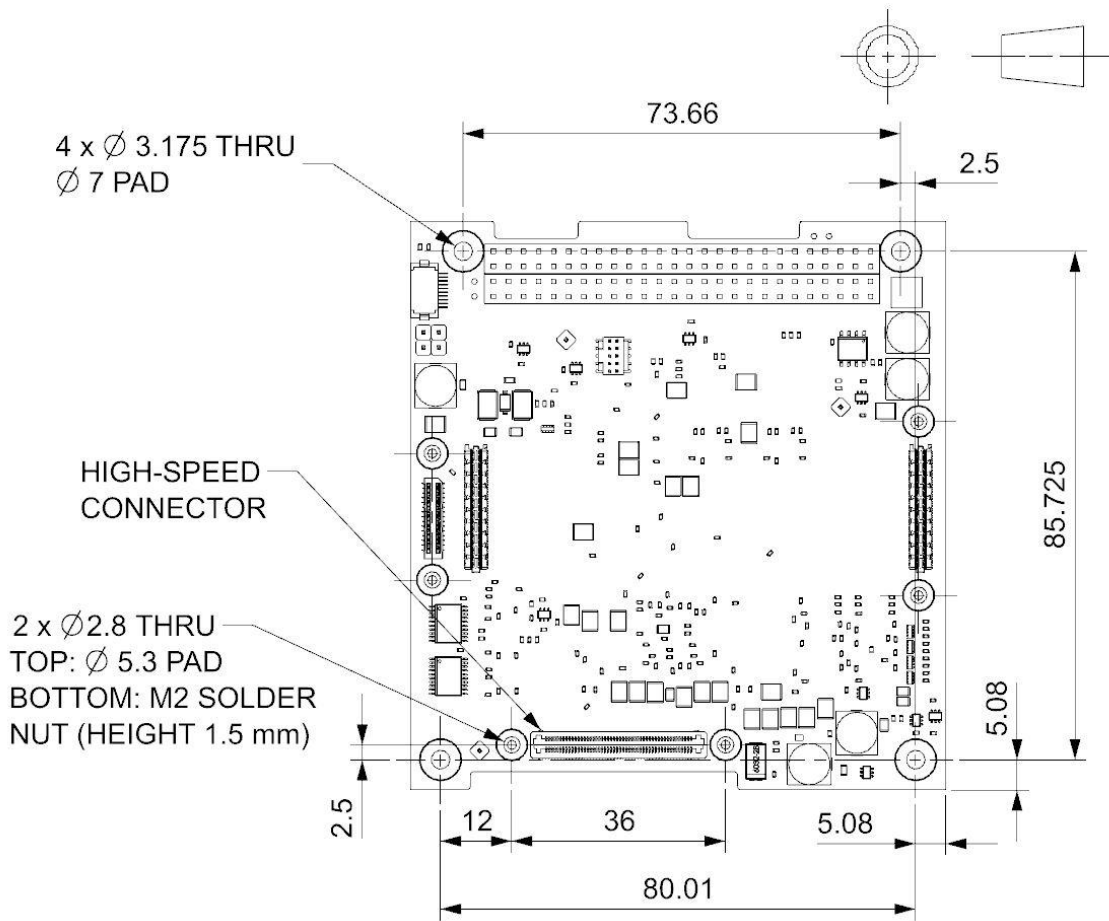


Figure 4-4: CE and High-Speed Connector Mounting Hole Details

Figure 4-5 shows the mounting position of the CE relative to the OFE.

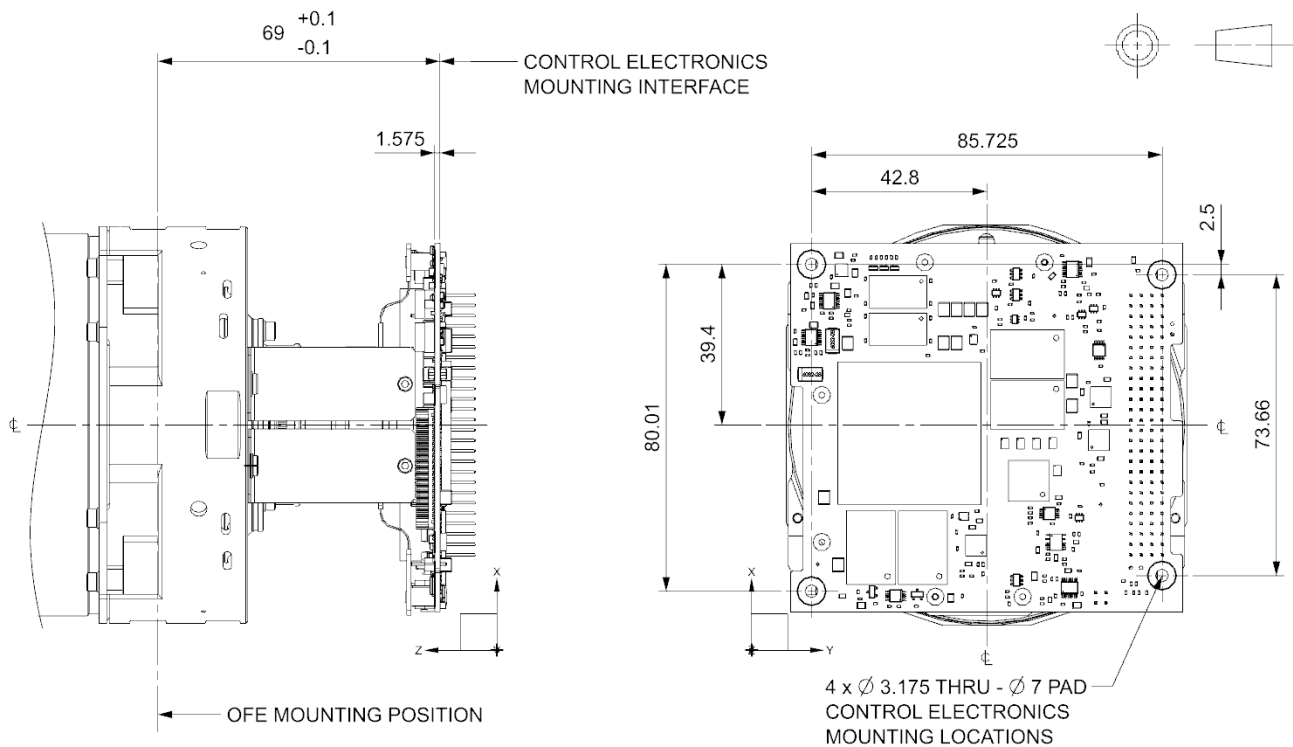


Figure 4-5: CE Mounting Position Relative to OFE

4.4 Thermal Interfaces

4.4.1 Interface 3: xScape100 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 conduction and radiation.

4.4.2 Interface 4: HyperScape100 Sensor Unit to Satellite Components

Thermal energy is exchanged by means of radiation between the HyperScape100 Sensor Unit and the surrounding satellite components. No specific requirement is placed on the amount of energy transmitted via radiation.

4.4.3 Interface 6: HyperScape100 Control Electronics to Satellite Components

The mounting points of the CE facilitates heat transfer through thermal conduction between the CE and the surrounding satellite components. In addition, thermal energy is also exchanged (by means of radiation) between the CE and the surrounding satellite components. No specific requirement is placed on the amount of energy transmitted via conduction and radiation.

4.5 Electrical Interfaces

4.5.1 Interface 7: Satellite Components to HyperScape100 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.

4.5.1.1 PC-104 Interface

The CE supports a CubeSat Kit Bus compatible PC-104 header and its pin description is given in Figure 4-6.

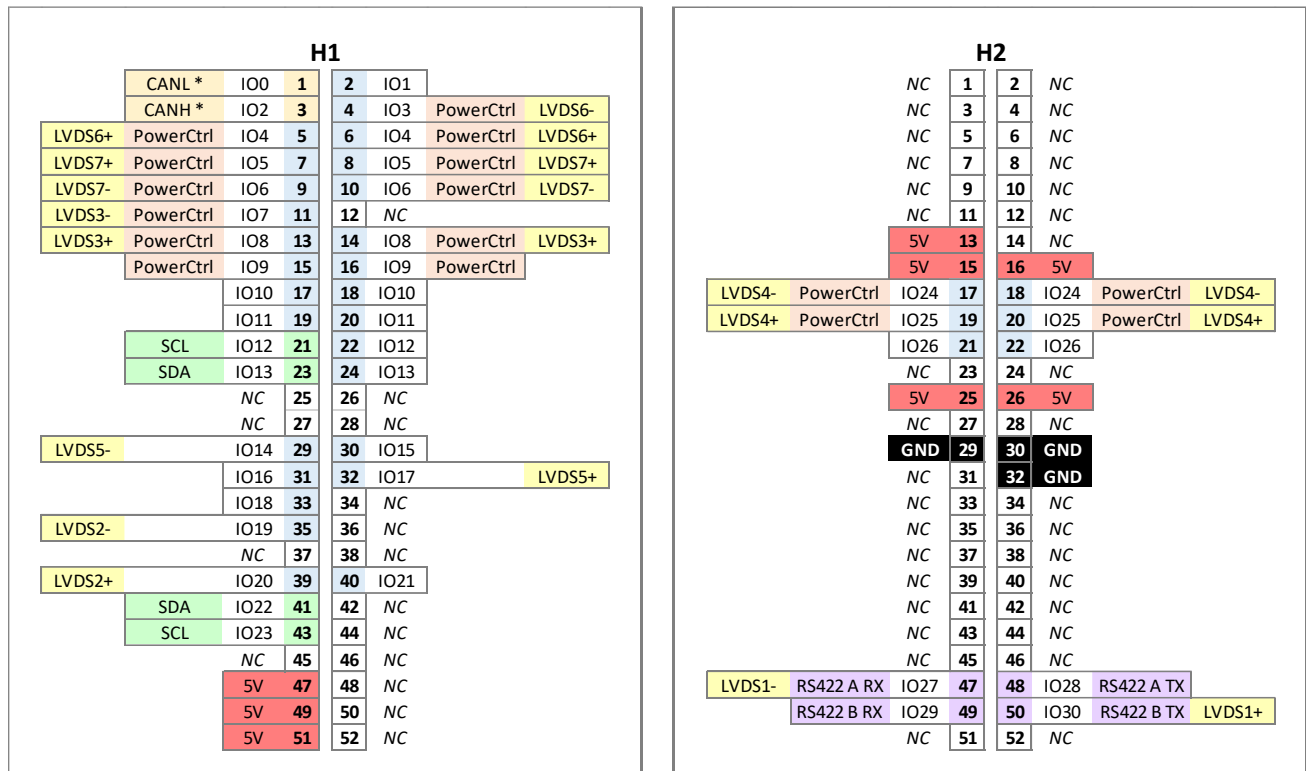


Figure 4-6: CubeSat Kit Bus Compatible PC-104 Header Schematic

The pins labelled 'NC' are not connected on the CE. The rest of the pins are not connected by default and are configured through the product configuration sheet if and how they are connected. All pins labelled 'IO_n' can be routed directly to a 3.3 V FPGA IO bank if their secondary function is not used. Those labelled 'LVDS_n±' are routed differentially and can therefore be used as LVDS pairs. The 'IO_n' pins can be used for SPI interfaces, or high speed LVDS point-to-point interfaces, or hard telecommands.

4.5.1.2 Power Interface

The CE requires a Direct Current (DC) supply regulated at 5 V \pm 10% at a current of at least 1.5 A. The nominal Beginning of Life (BOL) DC current consumption for the different modes in the operational state is given in Table 4-3.

Table 4-3: Imager BOL Power Consumption

Operational Mode	Imager Current Consumption at 5 V nominal supply voltage	Imager Power Consumption
Idle Mode	500 mA	2.5 W
Imaging Mode	1200 mA	6.0 W
Readout Mode	500 mA	2.5 W

The 5 V supply must be supplied by one, or a combination, of H1.47, H1.49, H1.51, H2.13, H2.15, H2.16, H2.25, and H2.26, depending on the selections made in the product configuration sheet. The ground connection is made by one, or a combination, of H2.29, H2.30, and H2.32.

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 is selected in the product configuration sheet, its control line “PowerCtrl” can be routed to one, or a combination, of 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, depending on the selections made in the product configuration sheet. 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 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. 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 control the CE and receive telemetry from the CE. The control interface can be I²C or SPI and provides access to 32-bit registers. As such the control interface transfers are always 4 bytes long. The paragraphs that follow provide more information on the physical interface layers.

I²C Interface

The CE implements an I²C slave interface. Refer to [2] for the I²C-bus specification. The CE supports Standard-mode and Fast-mode as defined in [2]. Depending on the selections made in the product configuration sheet, the I²C Interface can operate at either 3.3 V or 5 V voltage levels and supports 7-bit slave addressing. Each transfer always contains 4 data bytes.

The SCL signal can be routed to either H1.21 or H1.43 and the SDA signal to either H1.23 or H1.41 depending on the selections made in the product configuration sheet. The SCL and SDA signals 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 I²C slave address is taken from the product configuration sheet.

SPI Interface

The CE implements a 3.3 V logic compatible SPI slave interface which consists of four signals. These four signals can be routed to any open “ION” pin on the PC-104 Interface as defined in 4.5.1.1. 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. It has a weak ($\pm 20\text{ k}\Omega$) pullup resistor to 3.3 V.
- MOSI - Master Out Slave In signal is the data output of the master. It has a weak ($\pm 20\text{ k}\Omega$) configurable pullup/pulldown resistor to 3.3 V/GND.
- MISO – Master In Slave Out is the data output of the slave. It has a weak ($\pm 20\text{ k}\Omega$) pullup resistor to 3.3 V.
- SCK – The serial clock signal driven by the master. It has a weak ($\pm 20\text{ k}\Omega$) pulldown resistor to GND. The maximum clock rate is 10 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. Refer to Figure 4-7 for the timing diagram.

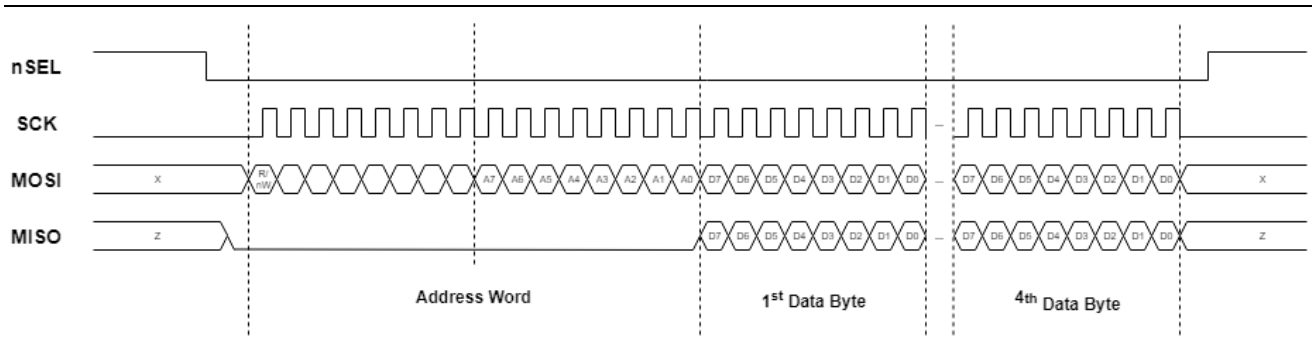


Figure 4-7: SPI Interface Timing Diagram

A transfer is initiated by the Address Word (16 bits) which specifies a read or write action as well as the register address. The CE echo’s the received action and command bits on its MISO output while the master outputs them on the MOSI line. One or more bytes of data follows the command byte during which the CE MISO output may toggle depending on the action and command.

4.5.1.3.2 Connector Details

Two Samtec SSQ/ESQ Series connectors are used, one each for H1 and H2. The PC-104 connector is optional, and its fitment and choice of connector depends on the selections made in the product configuration sheet. Instead of fitting the connectors, wires may be soldered directly into the pads instead with adjacent pads used as strain relief.

4.5.1.4 High-Speed Data Interface

The CE provides a half-duplex bi-directional high-speed data interface consisting of up to eight LVDS pairs. The LVDS pairs are all bi-directional and are organised as shown in Table 4-4.

Table 4-4: High-Speed Data Interface Signal Assignment

Pair No.	Name	Description
1	Clock	Clock to which data is synchronised
2	D0	Data Lane 0
3	D1	Data Lane 1 (optional)
4	D2	Data Lane 2 (optional)
5	D3	Data Lane 3 (optional)
6	Sync/Valid	Signals first bit in transfer. Byte invalid if not asserted.
7	Flow Control	Return line to throttle data transfer (optional)
8	Reserved	

The optional additional data lanes D1 to D3 allow faster transmission or they may be repurposed to implement full duplex communication. Data is transmitted most significant bit (MSB) first. The signal timing diagram is shown in Figure 4-8.

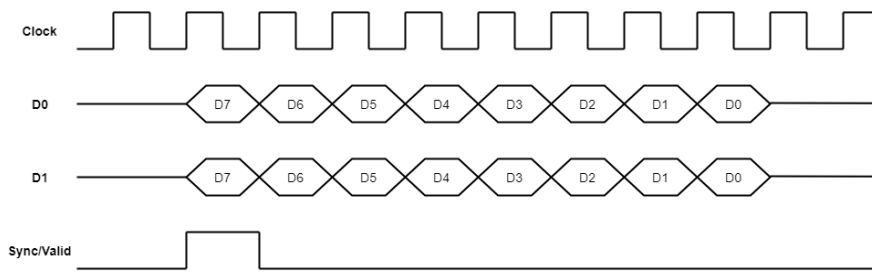


Figure 4-8: High-Speed Data Interface Timing Diagram

Transfers are always done in full bytes. The Sync/Valid signal indicates the MSB of the transfer. If it is not asserted at the beginning of the next byte, that transfer is deemed invalid and the byte transferred should be discarded. When multiple lanes are used, each lane transfers a full byte at the same time. The Sync/Valid signal is therefore applicable to all lanes.

The flow control signal is optional and can be used to throttle the data rate.

4.5.1.4.1 Connector Details

A Samtec LSHM-150-03.0-L-DV-A-N connector is used. A rendering of the connector is shown in Figure 4-9.

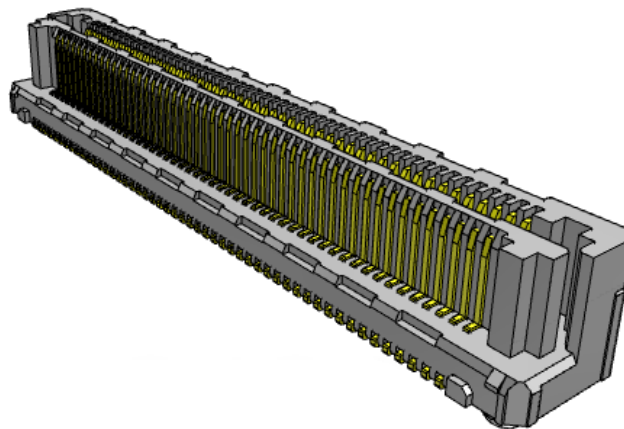


Figure 4-9: High-Speed Data Connector

The CE PCB has mounting holes either side of this connector that can be used to fasten the mating circuit to the CE. Details of the mounting holes are shown in Figure 4-4. The connector pinout is shown in Table 4-5. Do not connect to the pins labelled “Reserved”. Pin 1 is located as per the recommended PCB layout prescribed by Samtec.

Table 4-5: High-Speed Data Connector Pinout

Pin No.	Signal
1	GND
3	Reserved
5	Reserved
7	GND
9	Reserved
11	Reserved
13	GND
15	Reserved
17	Reserved
19	GND
21	Reserved
23	Reserved
25	GND
27	Reserved
29	Reserved
31	GND
33	Reserved
35	Reserved
37	GND
39	Reserved
41	Reserved
43	GND
45	Reserved
47	Reserved
49	GND
51	Reserved
53	Reserved
55	GND
57	IO
59	Reserved
61	GND
63	PairAux+
65	PairAux-
67	GND
69	Pair2+
71	Pair2-
73	GND
75	Pair4+
77	Pair4-
79	GND
81	Pair6+
83	Pair6-

Pin No.	Signal
2	GND
4	Reserved
6	Reserved
8	GND
10	Reserved
12	Reserved
14	GND
16	Reserved
18	Reserved
20	GND
22	Reserved
24	Reserved
26	GND
28	Reserved
30	Reserved
32	GND
34	Reserved
36	Reserved
38	GND
40	Reserved
42	Reserved
44	GND
46	Reserved
48	Reserved
50	GND
52	Reserved
54	Reserved
56	GND
58	Pair0+
60	Pair0-
62	GND
64	Pair1+
66	Pair1-
68	GND
70	Pair3+
72	Pair3-
74	GND
76	Pair5+
78	Pair5-
80	GND
82	Pair7+
84	Pair7-

Pin No.	Signal
85	GND
87	GND
89	GND
91	Reserved
93	GND
95	Reserved
97	GND
99	Reserved

Pin No.	Signal
86	GND
88	GND
90	GND
92	Reserved
94	GND
96	Reserved
98	GND
100	Reserved

4.5.1.5 Earth Strap

All mounting holes on the CE are connected to each other and to GND through a single 22 ohm resistor to facilitate earth strapping.

4.6 Environmental Interfaces

4.6.1 Thermal Radiation Interface

4.6.1.1 Interface 8: xScape100 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 xScape100 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 HyperScape100 Sensor Unit

There is an interface between the space environment and the HyperScape100 Sensor Unit through which cosmic radiation is transmitted to the sensor unit.

4.6.2.3 Interface 11: Environment to HyperScape100 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 degrees Celsius.

During transportation and in a non-operating condition the minimum temperature of the Imager assembly shall not be less than -10 degrees Celsius.

5.1.2 Humidity

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

5.1.3 Vibration

All handling operations shall limit static accelerations to the complete Imager assembly to less than 5 g in all directions.

5.1.4 Shock

All handling operations shall limit shock exposure to the complete Imager assembly to less than 5 g maximum.

5.1.5 Cleanliness

During transportation the Imager shall be kept in an environment with a cleanliness of at least International Organization for Standardization (ISO) level 8 as per ISO 14644-1:2015 standards.

5.2 Storage

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

5.2.1 Temperature

During prolonged storage and in a non-operating condition the maximum temperature shall not exceed 30 degrees Celsius.

During prolonged storage and in a non-operating condition the minimum temperature shall not be less than 10 degrees Celsius.

5.2.2 Humidity

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

5.2.3 Cleanliness

During prolonged storage the Imager shall be kept in an environment with a cleanliness of at least ISO level 8, as per ISO 14644-1:2015 standards, or better.

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 equivalent. In addition, during AIT the following conditions shall always be adhered to:

5.3.1 Vibration

All handling operations shall limit static accelerations to the complete Imager assembly to less than 5 g in all directions.

5.3.2 Shock

All handling operations shall limit shock exposure to the complete Imager assembly to less than 5 g maximum.

5.3.3 Mechanical Interface with OFE

During all assembly and integration procedures, all mechanical mating interfaces with the OFE shall cause zero relative displacement (in the x and y directions) between any of the OFE's four mounting points.

5.4 In-Orbit

5.4.1 Survivable Temperature

In order to ensure survival, the maximum temperature of the Imager shall not be greater than 65 degrees Celsius and the minimum temperature shall not be less than -25 degrees Celsius.

5.4.2 Operating Temperature

During operation the maximum temperature of the Imager shall not exceed 50 degrees Celsius and the minimum temperature shall not be less than -10 degrees Celsius.

5.4.3 Operating Temperature Gradients

During operation the maximum axial temperature gradient over the OFE shall not be greater than 3 degrees Celsius.

During operation the maximum transverse temperature gradient over the OFE shall not be greater than 2 degrees Celsius.

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.

Contact Us

Simera Sense (Pty) Ltd

Old Paardevlei Road
Somerset West, 7130
South Africa
sense@simera.com