International Standard

ISO 17981

Space systems — Cube satellite (CubeSat) interface

Systèmes spatiaux — Interface de satellite cubique (CubeSat)

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides requirements for internal and external interfaces of CubeSat. There is increasing demand of CubeSat development and utilization worldwide. CubeSats are often built with emphasis on low cost and fast delivery. Low cost can be achieved by extensive use of non-space-qualified commercial-off-the-shelf parts and units. Fast delivery is, however, often difficult to achieve when the interface of different units, such as printed circuit board (PCB), do not match each other. The incompatibility can cause significant delay in the satellite project, leading to the loss of business opportunity or academic/technology competition.

There is also increasing trend that a CubeSat platform that contains all the satellite bus functionalities by a single vendor is combined with a mission payload. A common standard on the interface between the CubeSat platform and the mission payload broadens the choice for the those who want to do a space mission but do not want to build a satellite to select the platform depending on their needs. This document makes it easier for CubeSat vendors to enter the market of CubeSat platforms.

This document aims to shorten the time required to design, develop, assemble, integrate and test CubeSat by clarifying the interface from the beginning of the satellite project. The document also aims to promote international trade of CubeSat units/platforms and international collaboration.

Space systems — Cube satellite (CubeSat) interface

1   Scope

This document describes internal and external interfaces of CubeSat. The internal interface includes the interface between components and the interface between a CubeSat platform and a mission payload. The external interface is limited to the umbilical connectors, i.e. access port. The document also describes the items to be included in the datasheet of the CubeSat components and platforms. The datasheet requirements apply to catalogued commercial products ready for sale.

This document does not cover the interface between CubeSat and its deployer, i.e. POD.

This document is applicable to CubeSats of all sizes.

2   Normative references

There are no normative references in this document.

3   Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
CubeSat
picosatellite measuring 100 mm cubic and weighting 1,33 kg or less

[SOURCE: ISO 17770:2017, 3.1, modified — Note 1 to entry has been removed.]

3.2
CubeSat form factor
volume unit measuring 100 mm × 100 mm × 100 mm expressed by "U" to describe the volume of each *CubeSat* (3.1)

3.3
1U CubeSat
single Cubesat
satellite measuring 100 mm × 100 mm × 113,5 mm and weighing 1,33 kg or less

Note 1 to entry: For the exact external dimension, see ISO 17770.

3.4
3U CubeSat
triple Cubesat
satellite measuring 100 mm × 100 mm × 340,5 mm and weighing 4,00 kg or less

Note 1 to entry: For the exact external dimension, see ISO 17770.

3.5
PC-104 style
CubeSat (3.1) architecture made of stackable printed circuit boards each of which has a 104-pin connector

Note 1 to entry: PC-104 is originally a specification of embedded computer to define both *CubeSat form factors* (3.2) and computer buses. PC-104 board used in CubeSat inherits an approximate size of 90 mm × 90 mm, a stackable 104-pin connector and four mounting holes at the corners from the original PC-104 specification.

3.6
backplane style
CubeSat (3.1) architecture made of one interface PCB at the bottom that is called backplane and other printed circuit boards vertically inserted to the backplane

3.7
CubeSat platform
combination of *CubeSat* (3.1) units to provide all the necessary satellite bus functionality, such as power, command and data handling, communication, attitude control

3.8
deployer
box that encloses *CubeSats* (3.1) within a confined volume with a lid at one side that closes the ejection port during the launch phase

EXAMPLE   POD (picosatellite orbital deployer).

[SOURCE: ISO 17770:2017, 3.2, modified — Note 1 to entry has been removed; EXAMPLE has been added.]

4   Abbreviated terms

ADCS   attitude determination control system

AGND   analogue ground

BPB   backplane board

CAD   computer aided design

CAN   controller area network

COTS   Commercial off the shelf

DGND   digital ground

ECSS   European Cooperation for Space Standardization

EIA   Electronic Industries Alliance

EMC   electromagnetic compatibility

GND   ground

I2C   inter-integrated circuit

ISS   international space station

I/O   input and output

LVDS   low voltage differential signalling

PCB   printed circuit board

POD   picosatellite orbital deployer

SCL   serial clock

SDA   serial data

SPI   serial peripheral interface

TIA   Telecommunications Industry Association

TRL   technology readiness level

UART   universal asynchronous receiver/transmitter

USB   Universal Serial Bus

5   Internal interface requirements

5.1   Unit to unit interface

5.1.1   General

The envelope shall have enough clearance or notches between the external panel and the unit so that harness can go through it. A unit shall not rely on the other units to mechanically fix itself. It shall be fixed by poles fixed to the satellite structure though the mounting holes or attached directly to the satellite structure. Connection via harness should be avoided as much as possible. Mating connectors should be available widely in the market. A tool to safely remove the mating connectors shall be available. Ground lines and pins, or grounding point shall be clearly marked and shall have the minimum resistance. In-rush current associated with activation shall be minimized. There should be two or more types of digital communication interfaces and one or more general purpose digital I/O and one or more analogue I/O. Spacing to the neighbouring components shall be enough to avoid collision during vibration.

5.1.2   PC-104 style

5.1.2.1   General

An example of PC-104 style is given in Annex B.

5.1.2.2   Envelope and mounting holes

Unit shall conform to the maximum envelope of 95,89 mm × 90,17 mm shown in Figure 1. Some part of the four sides should be notched to provide harness routing. Each unit shall be equipped with four mounting holes whose diameter is 3,2 mm or larger. The location of the mounting holes shall be as shown in Figure 1. No parts shall be mounted within 6,4 mm diameter from the centres of the mounting holes. The height of 104-pin female connectors, such as ESQ-126-38-G-D or compatibles, is 11,05 mm as shown in Figure 2. The parts height mounted on the top side (the side with the female connector) should not exceed 11 mm. Some units with tall parts such as ADCS can be necessary to be placed at the top of the stack. If the parts are mounted at the bottom side, the distance B in Figure 2 shall be extended by using a connector with long male connector pins, such as ESQ-126-39-G-D or compatibles, and adjusting the spacer length.

Dimensions in millimetres

5,08 80,01

95,89 85,73

2,54

2,54 13,97

5,08 7,62

12,70

5,08

7,62 73 ,66

90,17
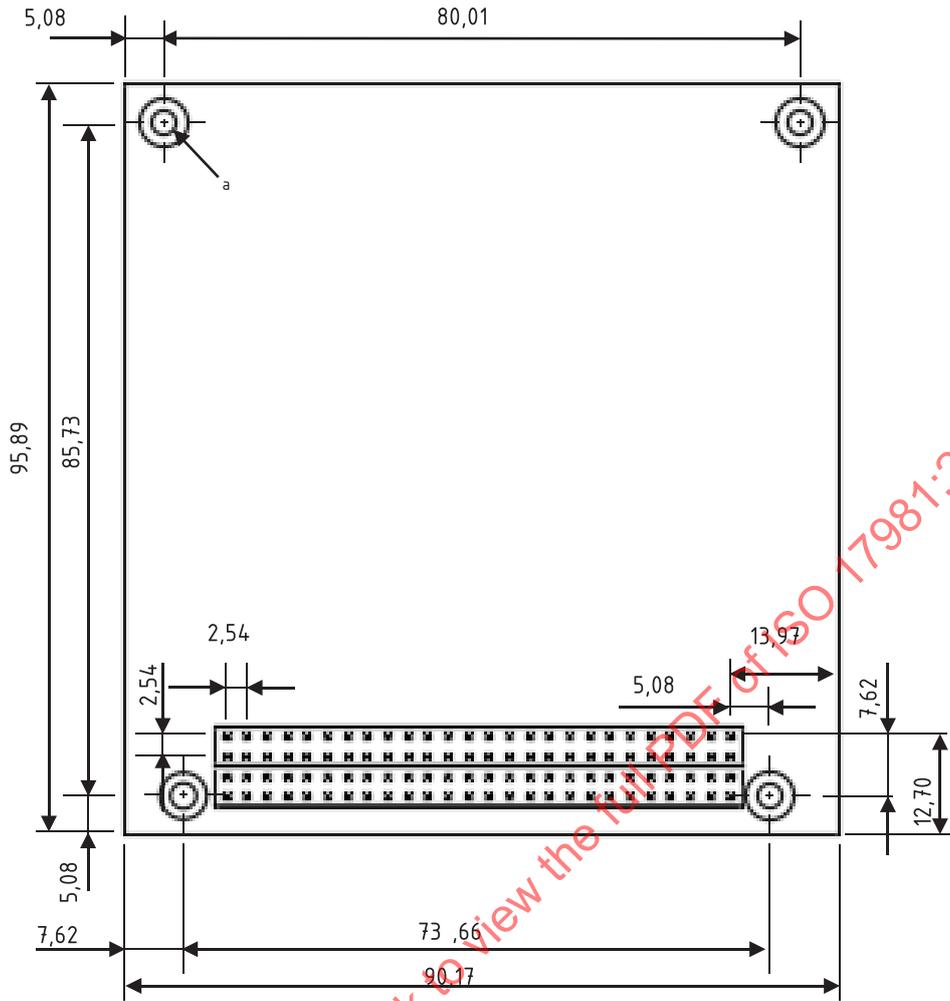
a   4-DIA3.2 THRU.

Figure 1 — PC-104 style UNIT

B

1 A
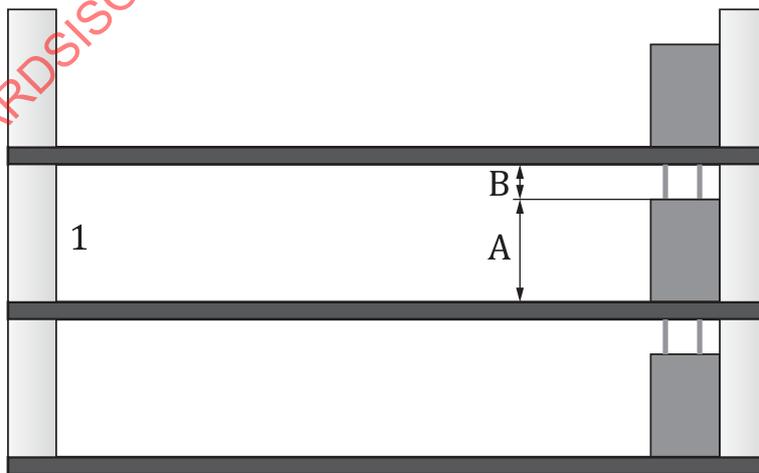
Key

1   spacer

Figure 2 — PC-104 style stacking condition

5.1.2.3 Connector

Unit shall have a 104-pin connector. The connector is made of two double 26 pin connectors such as ESQ-126-38-G-D or compatibles. The exact location with respect to the mounting holes shall be as shown in Figure 1.

5.1.2.4 Ground lines

The pin numbers H2-29, H2-30, H2-31, H2-32 shall be allocated to the ground as shown in Figure 3.

5.1.2.5 Power lines

The pin numbers H2-25 and H2-26 shall be allocated to the regulated power of 5 V. The pin numbers H2-27 and H-28 shall be allocated to the regulated power of 3,3 V, as shown in Figure 3. Other pins may be assigned to deliver the power if necessary.

5.1.2.6 Analogue lines

Several pins shall be allocated for analogue data lines for sensing and other purposes.

5.1.2.7 Digital lines

The pin number H1-41 shall be allocated to the I^{2}C-SDA. The pin number H1-43 shall be allocated to I^{2}C-SCL, as shown in Figure 3. There is a variety of digital communication protocols used in CubeSat. Some are given in Annex A.
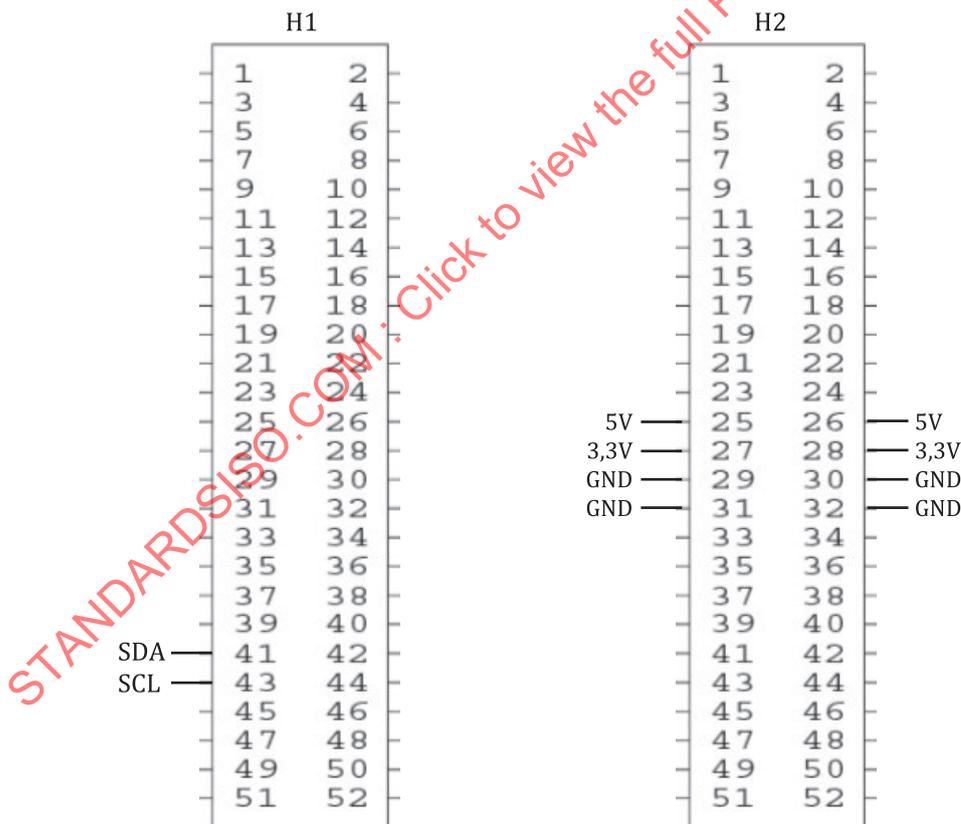
Figure 3 — PC-104 style pin assignment

5.1.2.8 Others

A proper tool, such as a PC/104 extractor tool, should be used to extract the PC-104 connector to avoid damaging the connector.

5.1.3   Backplane style

Backplane routing shall be reconfigurable either via redesigning the hardware routing or via software change. The backplane shall be firmly attached to the satellite body preferably via bolts. Each unit attached to the backplane shall not use its connector for mechanical fixation. Care should be taken when data lines are near the regulated power lines on the backplane to avoid any noise coupling.

The direction of the connectors on the backplane shall be marked clearly so that no mistake occurs when a unit board is inserted to the backplane.

The connection to the external solar panels should be made via connectors to avoid harness. If harness is used, soldering the cables directly into PCB shall be avoided.

Examples of backplane style are given in Annex C.

5.2   Mission payload to platform interface

5.2.1   Mechanical connection

The mission payload shall be attached firmly to the CubeSat structure via through-holes or other methods. The connector should not be used to mechanically fix the payload to the satellite structure.

5.2.2   Connection methods

The payload and the platform are connected by:

— direct connection via connectors;

— indirect connection through a back-plane or an interface board; or

— harness.

5.2.3   Ground lines

Adequate ground lines shall be provided between the platform and the mission payload unless there is a specific need from the payload to have separate grounding.

5.2.4   Power

The platform shall provide stable power to the payload. In-rush current associated with activation of the mission payload shall not cause any harm to the platform operation.

5.2.5   Analogue data interface

At least one analogue connection between the platform and the mission payload shall be provided for analogue data transfer in both directions. If the interface is not bidirectional, at least one connection for each direction shall be provided.

5.2.6   Digital data interface

Two or more types of digital data communication shall be provided between the platform and the mission payload. Typical digital data communication protocols are listed in Annex A. At least one general purpose I/O between the platform and the mission payload shall be provided in both directions. If the interface is not bidirectional, at least one connection for each direction shall be provided.

5.2.7   Debugging

The CubeSat platform shall provide pins or connectors accessible from outside the satellite for monitoring and debugging of the mission payload software.

5.2.8 EMC

The CubeSat platform and the mission payload shall not cause any harm to each other via electromagnetic noise radiated or conducted.

5.2.9 Fault isolation and recovery

The CubeSat platform and the mission payload shall be designed so that anomaly or failure at one side does not affect the other side. The CubeSat platform shall be able to protect itself from over-current to the mission payload. If the CubeSat platform hosts multiple mission payloads, the platform shall protect each mission payload from the fault of other mission payloads. The CubeSat platform shall be able to power cycle and/or reset the mission payload automatically and/or by receiving a command from the ground.

5.2.10 Harmlessness to other payloads, platform and missions

The mission payload shall not cause any harm to other payloads, the CubeSat platform or the missions to be carried out. Examples are electromagnetic interference, excessive heat dissipation and blocking views of other payloads by the deployable.

5.2.11 Safety requirements

The CubeSat platform shall meet the safety requirements given by launch providers. If the mission payload poses a unique hazard, either the mission payload or the CubeSat platform shall be able to control the hazard.

5.2.12 Radiation

Since COTS electronic components are often used in construction, care shall be taken to ensure that the CubeSat platform has resistance to radiation effects in space, especially in the case of semiconductors. Single event effects shall also be considered. De-rating principles should also be applied.

6 Datasheet requirements for CubeSat units

6.1 General

The information given in 6.2 to 6.7 shall be provided in the datasheet.

6.2 General requirements

The items listed in Table 1 shall be provided in the public domain datasheet or upon request by the customer. In addition to the items listed in Table 1, information related to procurement, such as price, delivery time and export control issues, shall be provided by the unit vendor to the customer upon request for quotation.

Table 1 — Items to be provided in public domain datasheet

	Note
Document information	
Document number and issue date	
Revision number	
Revision dates	
Summary of revision contents	
Mechanical	
Mass	Unit: kg
Size	Unit: mm
a They can be combined into the pin assignment table.	

Table 1 *(continued)*

Physical configuration	Indicate the physical configuration and the outline dimension in drawing
Mounting hole location	Indicate the mounting hole location and quantity in drawing
Fastener information	Describe the type of fastener and the fastener torque with tolerance in unit of Nm
Centre of mass location	Indicate the location of centre of mass in drawing
Three-dimensional CAD model	In a standard format electronic file such as STEP
Allowable mechanical environment	Vibration (random, sinusoidal if any), shock and quasi-static load (if any) levels
Thermal	
Heat dissipation	Unit: W Describe in each operational mode with tolerance considering input voltage, current and RF output (if any)
Allowable temperature range	Describe allowable temperature range in non-operational, operational, and start up
Temperature sensor type	Describe type of temperature sensor, data type (digital or analogue) and data format.
Temperature reference position	Describe where the temperature reference position is located
Thermal path	Describe heat reduction strategy by conduction and/or radiation if any
Electrical	
Grounding/bonding point	Indicate location of the grounding or bonding point where continuity check will be made
Input voltage	Unit: V
Input condition	Describe the condition to turn on the unit, such as specification of the power supply, switches etc.
Power consumption (in-rush, peak, nominal)	Unit: W Show the waveforms of the in-rush current and the voltage measured by an oscilloscope
Fault detection and recovery	Describe how to detect faults such as latch-up and recover from them
Fault isolation	Describe fault isolation mechanism not to cause any harm to other units when the unit power is shut-off
Pin assignment	
Connector specifications	Describe the connector type and its commercial product name for each connector ID
Pin assignment table	Describe the connector pin assignment in a table format for each connector. Each connector shall have connector ID.
Full name of signal [a]	Describe full name of signal
Acronym for signal [a]	Describe abbreviated name of each signal
Type of signal [a]	Describe the type of signal of each pin (e.g. analogue, digital, pulse)
Wire gauge	Describe wire gauge (AWG) if harness is connected to the pin inside the unit
Current [a]	Describe the max and the nominal current of pin with an analogue signal (including power) assigned
Voltage [a]	Describe the max and the nominal voltage of each pin
Input or output [a]	Describe whether each pin is input, output or bi-directional.
Frequency or bit rate	Describe frequency or bit rate of the signal, if applicable
[a] They can be combined into the pin assignment table.	

Table 1 *(continued)*

Hot/Return pairing information	Describe pairing hot or return pin number, if applicable
Onboard housekeeping data availability	Describe the housekeeping data (e.g. temperature) available and their pin assignment. A table to convert the signal output to the real physical value shall be provided.
Data interface specification	Describe the digital data interface (e.g. SPI, UART, etc.) available and their pin assignment.
Analogue ground or digital ground	It should be noted that analogue ground (AGND) and digital ground (DGND) are not exactly the same. Analogue ground is typically grounded to one point of the metallic structure. Digital ground is the ground of electronics circuit. If the unit differentiate AGND and DGND, the impedance between the two shall be listed.
Software	
Development kit availability	If available, describe the specification of the development kit, e.g. computer platform, programming language, software libraries, etc.
Sample code availability	If available, describe the specification of the sample code, e.g. computer platform, programming language, etc.
Others	
Test results	See ISO 19683 for the items listed
Flight heritage or TRL	See ISO 16290 for TRL definition If flight heritage exists, information about orbit, duration and launchers
Radiation hardness	If available, describe the tolerance level of total ionization dose (flight or test data), mitigation methods against single event effects
List of materials	If any material of outgas concern is used
List of parts	If any parts with concerns, such as the ones listed in Ref,[4] is used

a   They can be combined into the pin assignment table.

6.3 Electrical power system unit

The following items shall be provided in the datasheet in public domain:

— maximum, nominal and minimum available power;

— number of power output channels;

— output voltages;

— power consumption;

— output current limit of each channel;

— over-current protection;

— ISS launch compliance;

— inhibit logics to assure cold launch;

— battery specification including capacity and protection mechanisms;

— ripples in the power lines;

— block diagram showing inhibits to be used for end of life electrical passivation;

— block diagram showing inhibits to be used for safety review (an example is shown in Figure 4).

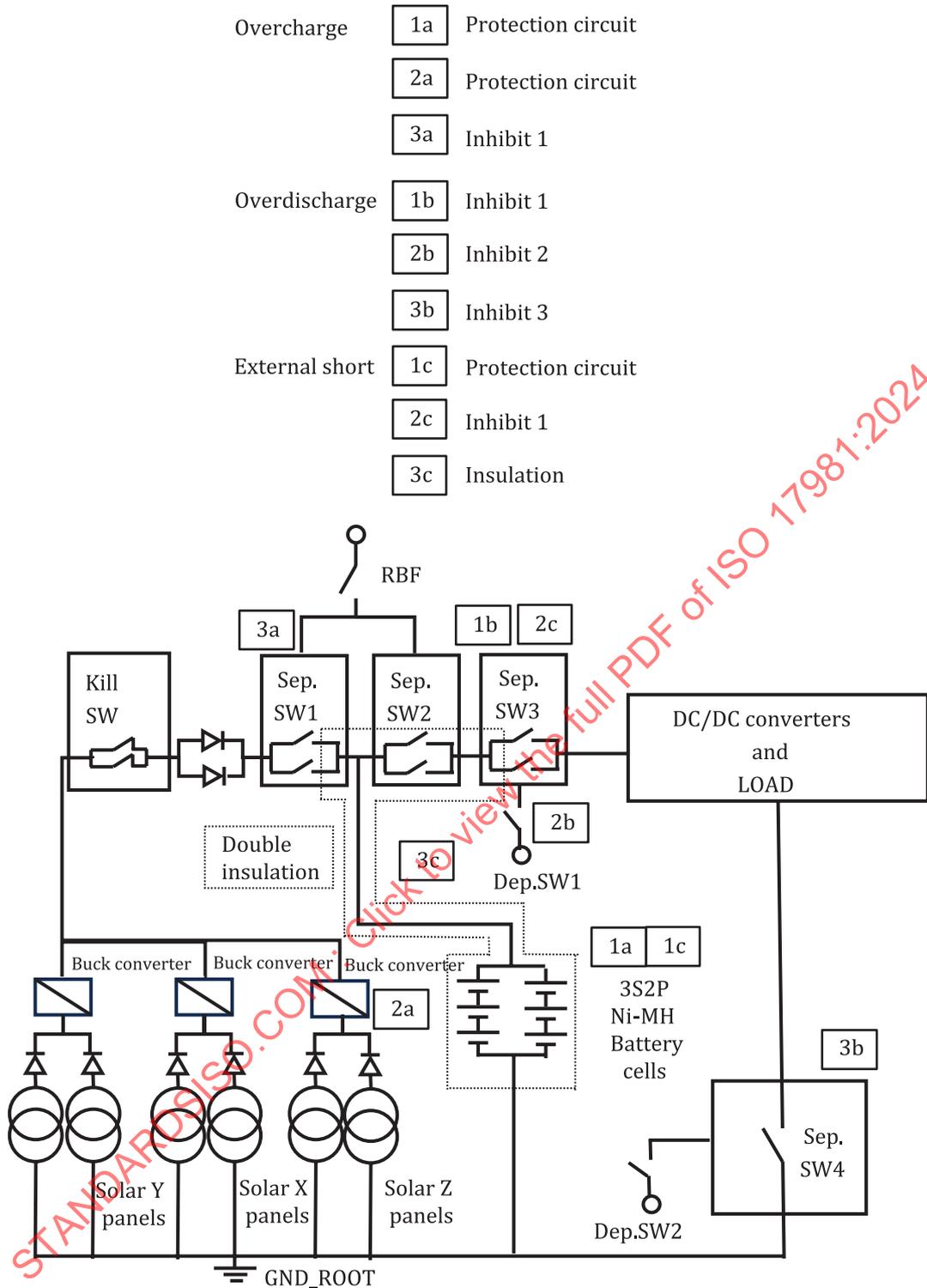**Figure 4 — Example of EPS block diagram to be used for safety review**

6.4 Communication unit

The following items shall be provided in the datasheet in public domain:

— frequency including bandwidth;

— data rates;

— receiver sensitivity;

— transmitter output power;

— data protocol;

— modulation options;

— RF cable interface specification.

6.5   Command and data handling unit

The following items shall be provided in the datasheet in public domain:

— processor specification;

— volatile memory specification;

— non-volatile memory specification;

— code storage specification;

— critical data storage;

— power output specification (if any);

— OS (if any).

6.6   Attitude determination and control unit

The following items shall be provided in the datasheet in public domain:

— control mode;

— estimation mode;

— control loop rate;

— pointing accuracy for ADCS units including pointing actuators;

— maximum torque, rotation speed, and momentum storage for reaction wheel;

— maximum torque and diploe moment for magnetic torquer;

— measurement accuracy, range and resolution for sensors;

— exclusive angle, update rate and slew rate for star tracker;

— field of view and update rate for sun sensor;

— field of view for Earth sensor;

— orthogonality, update rate, noise density for magnetometer;

6.7   Antenna unit

The following items shall be provided in the datasheet in public domain.

— maximum number of deployment test allowable;

— non-preferred positions to mount on the satellite body, if any, for the case of a patch antenna due to EMC issues.

7 Datasheet requirements for CubeSat platforms

7.1 General

The information given in 7.2 to 7.8 shall be provided in the datasheet either in public domain except the ones in 7.8. Information related to procurement, such as price, delivery time and export control issues, shall be provided by the platform vendor to the customer upon request for quotation.

7.2 Mechanical interface

The following items shall be provided in the datasheet.

— 3D CAD file in a standard format, such as STEP;

— available payload volume and mass;

— volume and mass of the platform;

— physical configuration and outline dimension in drawing;

— payload mounting method.

7.3 Electrical interface

The following items shall be provided in the datasheet:

— umbilical connector specification;

— connector specification;

— connector assignment;

— data transfer speed from the mission payload to the platform.

7.4 Software information

The following items shall be provided in the datasheet:

— software development environment;

— availability of source codes; if available, description of source code programming language;

— availability of ground station operation source code; if available, description of source code programming language.

7.5 Operation-related Information

The following items shall be provided in the datasheet:

— maximum, nominal and minimum available power to the payload;

— power consumption by platform during each operation mode (e.g. data downlink, sun-tracking, nadir pointing);

— nominal supply voltage to the payload;

— maximum supply current to the payload;

— over-current protection threshold;

— battery capacity;

— thermal dissipation method from the payload to the platform;

— thermal control methods of the platform itself;

— data storage capacity allocated for the mission data;

— ADCS sensing and pointing accuracy and control modes;

— ADCS stability;

— software in-orbit reconfigurability;

— satellite position and time stamp;

— housekeeping data;

— uplink specification including frequency, bandwidth, modulation, speed, data format;

— downlink specification including frequency, bandwidth, modulation, speed, data format;

— antenna specification including the antenna pattern and the maximum gain;

— ground station specification including antenna and radio equipment;

— fault detection isolation and recovery mechanisms.

7.6 Safety information

The following items shall be provided in the datasheet:

— initial sequences after deployment from a CubeSat deployer;

— inhibit logics to assure cold launch;

— battery specification including capacity and protection mechanisms;

— block diagram showing inhibits to be used for end of life electrical passivation;

— block diagram showing passivation circuits of pressured vessel if any;

— EPS block diagram for safety review as shown in Figure 3.

7.7 Reliability information

The following items shall be provided in the datasheet:

— table of TRLs (see ISO 16290) for all subsystems;

— flight heritage including orbit, duration, launchers;

— uplink command validation;

— single event effects protection mechanism;

— satellite reset;

— test results (see ISO 19683).

7.8 Assembly, integration and testing Information

The following items shall be provided as documents:

— satellite assembly procedure;

— functional test procedure;

— deployment test procedure if the platform has any deployable, such as antenna or solar panel;

— mechanical test procedure;

— thermal test procedure;

— end-to-end mission simulation test procedure (see ISO 19683:2017, 8.30);

— battery charging procedure.

8 External electrical interface (umbilical)

The following items shall be included in the umbilical connector, i.e. access port:

— flight pins;

— software debug and programming; the debugging includes communication (monitoring, commanding, etc.) with the flight computer;

— battery charging; the battery's positive and negative pins should be separated at least by one pin, which is either removed or connected to the ground via a high resistance;

— battery status monitor;

— inhibit check.

Annex A
(informative)

Typical digital data communication for CubeSats

A.1 General

This annex gives a brief overview of typical digital communication used for CubeSats. The technical detail of each serial communication should be found in various textbooks and handbooks[5].

A.2 I2C

I2C is used typically for communication between a micro-controller and peripheral devices. Most of micro-controllers and peripherals for embedded system already has built-in I2C ports. The communication is based on leader/follower arrangement. The leader device controls the communication. There can be multiple followers (such as sensors) to one leader (such as a micro-controller). The communication uses two lines (SCL and SDA). The speed is from 100 kbps to 3,4 Mbps.

A.3 SPI

SPI is used typically for communication between a micro-controller and peripheral devices. Most of micro-controllers and peripherals for embedded system already has built-in SPI ports. The communication is based on leader/follower arrangement. The leader device controls the communication. There can be multiple followers (such as sensors) to one leader (such as a micro-controller). The communication uses four lines (SCLK, MOSI, MISO, CS). The speed is up to several Mbps.

A.4 UART

UART is used typically for communication between a micro-controller and a micro-controller. Most of micro-controllers for embedded system already has built-in UART ports. The communication is one-to-one with a pair of Tx and Rx ports. The communication uses two lines for full duplex communication. The speed is up to 115 kbps. As USB to UART or RS-232 to UART converters are widely available, the micro-controller programming/debug can be made through UART channel from the external PC.

A.5 CAN

CAN is used typically for communication among multiple micro-controllers and peripheral devices. Many micro-controllers and peripherals for embedded system already have built-in CAN controllers, especially the ones for automobile application. CAN provides multi-leader priority-based bus access. All nodes are connected by two differential wires terminated with 120 Ohm impedance, giving the network noise immunity. All nodes are transceivers. The speed is up to 1 Mbps. CAN is defined by ISO 11898-1,[6] ISO 11519[7] and other standards.

A.6 USB

USB is used typically for communication between PC and peripheral devices. The host device can also provide power to the peripherals. The USB standard is maintained by USB Implementers Forum. Although USB started as a serial interface for PC, USB devices for embedded systems are now widely available in the market. USB makes a serial multi-level start topology with the maximum 127 nodes, where one leader host controller and one follower communicate each other. For versions 1.0 and 2.0, four (Data+, Data-, +DC power, GND) wires are used. For version 3.0, 10 wires are used.

A.7 SpaceWire

SpaceWire is the physical interconnection media and data communication protocols to enable the reliable sending of data at high-speed (between 2 Mb/s and 400 Mb/s) from one unit to another[8]. SpaceWire originated from IEEE 1355-1995.[9] SpaceWire is specific to communication among devices onboard spacecraft. SpaceWire is defined by ECSS-E-ST-50-12C. See Reference [10].

A.8 Ethernet

Ethernet has been widely used for Local Area Networks. It is defined by IEEE 802.3 working group. It can have multiple speed levels from 10 Mbps to 100 Gbps. Most PCs have an Ethernet port. Data is transferred via unshielded twisted pair (UTP) cable with RJ-45 connectors if not using an optical fiber cable. Ethernet also defines OSI layers 2. In the layer 2, Ethernet protocol frame includes 6-byte destination address (MAC address) and 6-byte source address (MAC address).

A.9 LVDS

LVDS is defined as TIA/EIA-644 and TIA/EIS0-899. It is physical layer interface for high-speed digital communication (1 Gbps to 3 Gbps). It utilizes differential communication. It is typically used for point-to-point or multi-drop (M-LVDS) up to 32 receivers high speed communication.

A.10 SpaceFibre

SpaceFibre operates high-speed serial full duplex data links. The SpaceFibre interface expands and complements the capabilities of the SpaceWire interface, providing data links of higher speed – (up to 20 Gb per second and higher), as well as protocols for high-performance methods of service quality assurance – Quality of service (QoS) and Fault detection, isolation, and recovery (FDIR) which are built in the SpaceFibre interface protocol. See Reference [11] for further details.

Annex B
(informative)

PC-104 style example

PC-104 is originally a specification of embedded computer to define both CubeSat form factors and computer buses. PC-104 board used in CubeSat inherits an approximate size of 90 mm × 90 mm, a stackable 104-pin connector and four mounting holes at the corners from the original PC-104 specification.

According to the Internet, a commercial kit of CubeSat existed already in 2003. It was introduced into the market in September 2003, while the first launch of CubeSat was only three months earlier June 2003. PC-104 style was adopted by CubeSat Kit (see Reference [12].). Since then, many commercial vendors selling CubeSat units used PC-104 style. According to survey done in Reference [13], among 104 CubeSats that had been launched or were under development by January 2015, 59 % of CubeSats chose PC-104 style.

PC-104 style is made by stacking units. Each unit has 104 pins as shown in Figure 1. An example of satellite configuration that uses PC-104 style is shown in Figure B.1. The pin assignment of the 104-pin connector differs depending on the unit vendor. Only the pins specified in Figure 3 are common for most of the vendors.
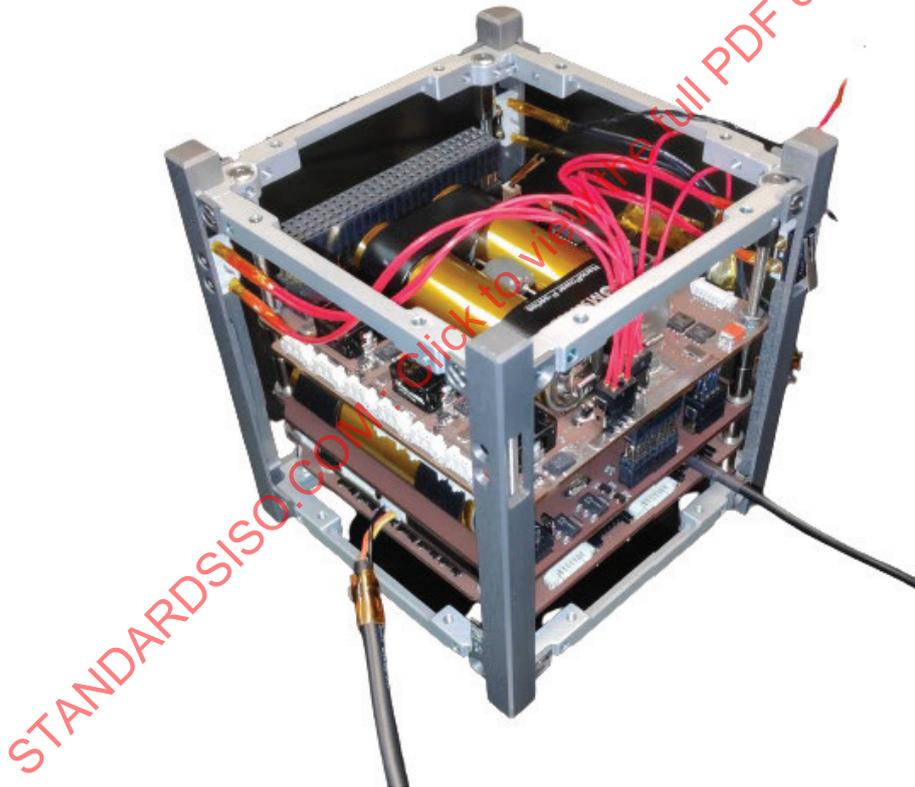

Figure B.1 — Example of PC-104 style 1U CubeSat

Since the functions of the PC-104 pins differ so much with different implementations, the end result is that most of the pins are unused and a lot of the advantage of using the stack is lost. Even though there are 104 pins, an implementation such that on GreenCube, shown in Figure B.2, only about 20 are used. Therefore, even though there are several lines that can be used to transfer signals and power between boards, the developers sometimes must rely on cabling to interconnect the boards. In this case, the manufacturers of CubeSats board will limit the use of the PC104 stack to the bare minimum – some communication lines and power delivery, and resort to placing many connectors on the edges of the boards that the end-user will connect to different bus boards or payload. Additionally, a particular connector may be used to service more than one

payload, resulting in the need of a split cable or of a routing board. A split cable is a cable with one connector on one side and two or more connectors at the other side, used to distribute the lines of the first connector to more than one device. A routing board on the other hand can be used to receive the lines with a straight cable and routing it to separate connectors – this implementation simplifies design and assembly but is more cumbersome and adds failure points. An additional solution that can be implemented by the user is to use the routing board to direct the connectors signals to the PC104 stack, but it still requires the use of cables.
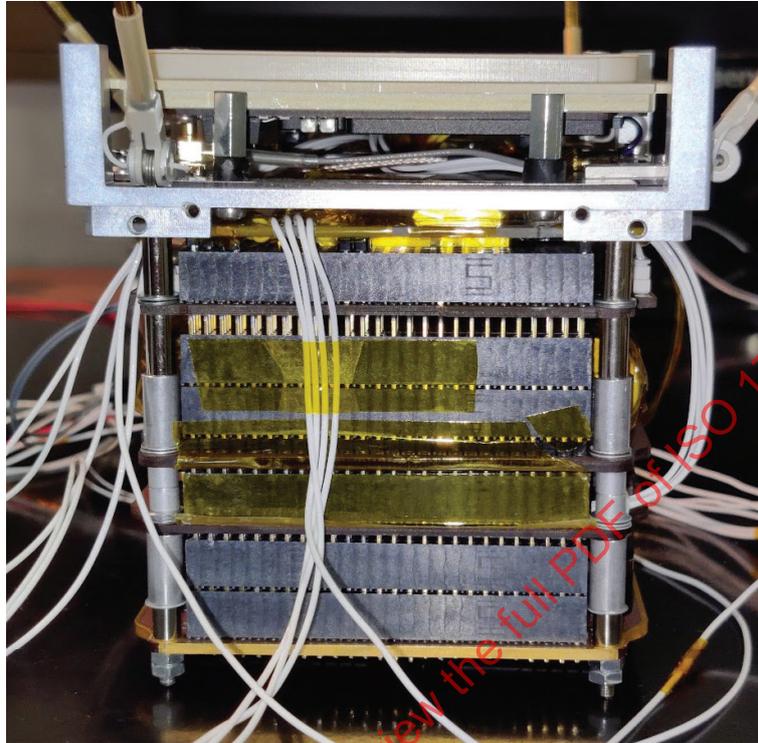

Figure B.2 — Example of PC-104 stack on a CubeSat

A disadvantage of using the PC-104 stack is the fact that if a pin carries a particular signal, that signal is carried by the same pin to all boards connected to the stack, with no possibility of routing. The only available routing option is to interrupt the line by cutting the pin to prevent the signal to propagate to the next board, but it is not a recommended operation for the integrity of the connector. This means that if two boards utilize the same pin for different functions, the two cannot be connected together. This might be the reason why most boards manufacturers will not use the majority of the pins, as the more pins are used the more likely that there will be conflict between boards across manufacturers.

Even though the PC-104 stack connector is sold in a variety of configurations, regarding length, material and shape of the pins, the design also imposes a fixed distances between the boards which might add for the need of an "extension" to be able to reach the pins of the next board, or impose a distance between the two boards which is greater than necessary, to accommodate the female part of the connector. This can result in wasted empty space between the PC-104 boards.

The high number of pins dictates that the insertion force to mate two PC-104 connects is high, between 50 N and 100 N, with the extraction force on the other hand roughly 70 % of the insertion[14]. The high insertion force can induce stress on the PCB during mating, as the user must be careful while applying pressure to avoid any unwanted stress on the boards themselves. The high extraction force helps the mechanical connection between the two boards and significantly contributes to the stiffness of the assembly. At the same time, separating the two boards is not simple. During manual extraction, it is likely that one side of the connector disconnects before the other, resulting in a jerking motion that can bend the pins at the other end of the connector. Bent pins can break easily and render the insertion more difficult. To avoid this issue there are extractor tools that can be used, which aligns to the edges of the connectors and push the boards apart, but they cannot be used on all board shapes.

Figure B.3 shows an example of the pin assignment on the GreenCube 3U CubeSat, launched in 2022. In this case, only 20 of the 104 pins are used. This pinout is compatible with many products from one of the CubeSat board vendors in the European region, but some features were requested and set during configuration of the product, before shipping, as is the case for the H1-47 to H1-52 pins. According to the vendor, these are six independent switchable lines of either 5 V or 3,3 V, that can be assigned in any configuration on the six pins when configuring the EPS (electrical power system) during purchase. This means that a payload board with a PC-104 stack connector powered by one of those lines is only compatible with an EPS which uses the same configuration of pins as the particular vendor.

Figure B.3 — Example of a pinout for the PC-104 stack

Annex C
(informative)

Backplane style example

This annex shows an example of CubeSat buses that use a backplane style. Figure C.1 shows the internal structure of the BIRDS platform. The BIRDS platform is an educational 1U CubeSat platform. The platform uses a backplane interface.
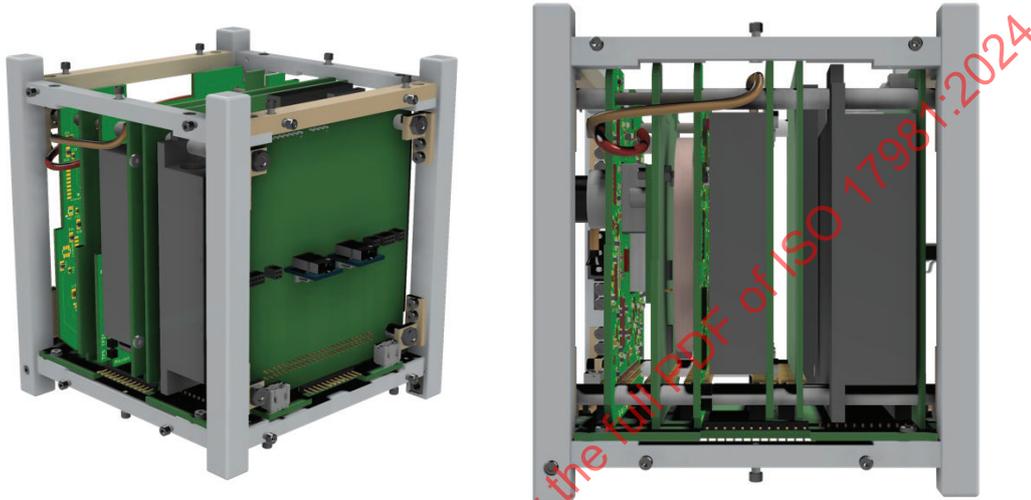

Figure C.1 — Example of backplane style 1U CubeSat

Each board that carries satellite bus functions or satellite mission payloads is inserted into the backplane board. Figure C.2 shows the payload size requirements of each unit PCB inserted to the backplane. The size of each PCB is 90 mm × 86 mm and uses a 50-pin male connector (NRPN252PARN-RC, LPC-50M2LG, or equivalent) for connection with the backplane board (BPB). It is the same architecture adapted by UNISEC-Europe CubeSat Interface Standard[15], although the pin-assignment is different. In addition, the platform secures each board with four long bolts as shown in Figure C.1. Therefore, 3,8 mm diameter holes are provided at the four corners of the board for passing the long bolts. Structurally the boards are fixed to the CubeSat structural frames through the bolts at the four corners of each board.
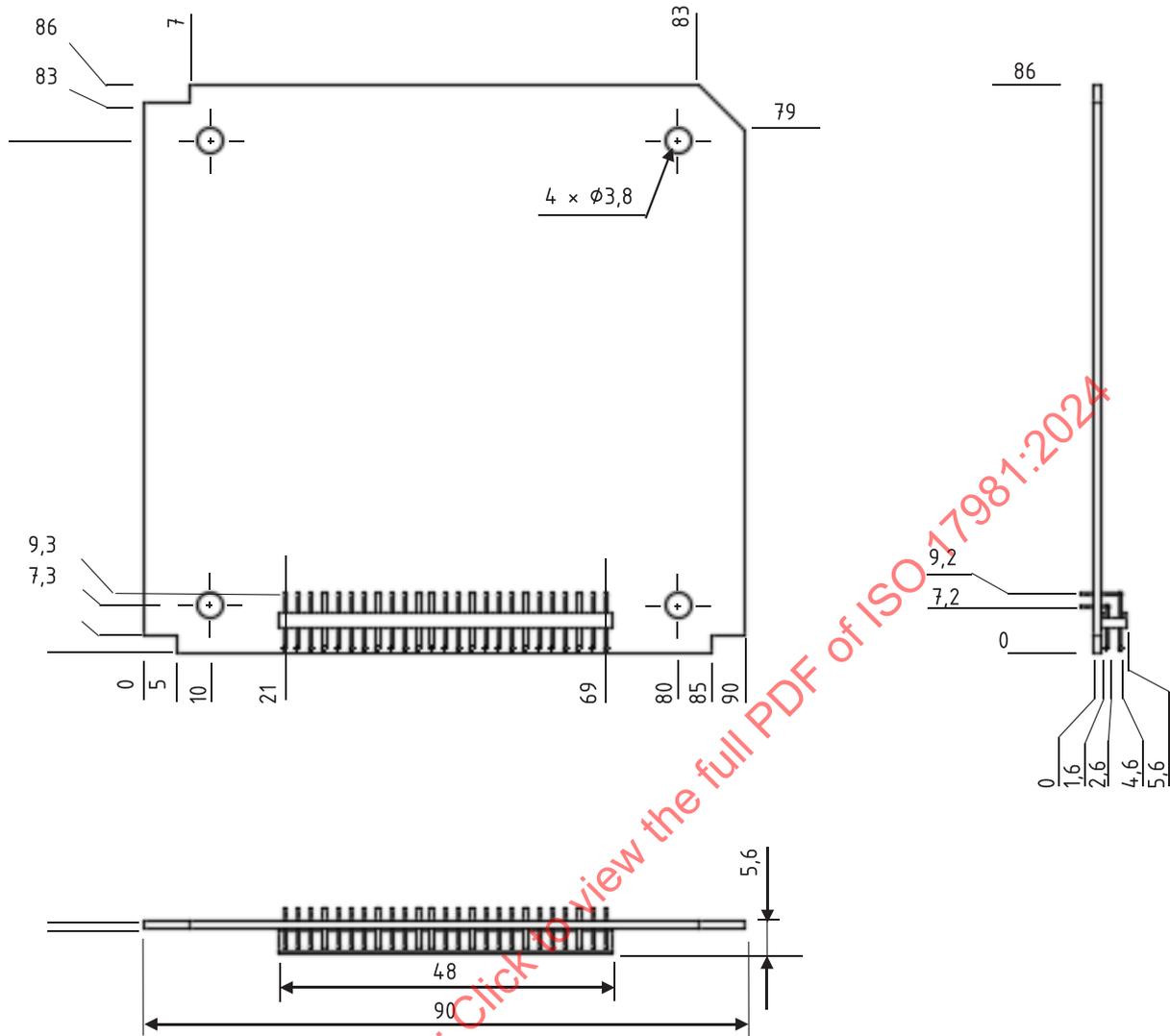
Dimensions in millimetres

Figure C.2 — Example of PCB size requirement for backplane style

Figures C.3 and C.4 show the position of the connectors on BPB. Table C.1 lists the specification of each connectors. The pin assignment for the connectors used in BIRDS platform is shown in Table C.2 to Table C.14. The backplane board is equipped with complex programmable logic device (CPLD) from Lattice Semiconductor (ispMACH4000ZE) to add flexibility in connection between components. CPLD is shown in the right of Figure C.3. The CPLD can adapt the change of pin-assignment in the mission boards so there is no need to remake the backplane when routing changes is needed. The detail of CPLD device can be found in Reference [16]. The solar panels are attached to BPB via connectors (SP1, SP2, SP3, SP4, SP5). In this example, harness-free is achieved except the RF cables for UHF and VHF.

Figure C.3 — Example of connectors on BPB

Dimensions in millimetres

Figure C.4 — Example of connector requirements on BPB

Table C.1 — Connector specification

No.	Connector name	Number of pins	Connector description	Manufacturer	Model No.	Current rating [A]	Voltage rating [V]	Operating temperature [°C]
1	C101	50	FAB	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
2	C102	50	EPS/OBC	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
3	C103	50	COM	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
4	C104	50	Mission1	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
5	C105	50	Mission2	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
6	C106	50	RAB/Ant	Hirose	A3C-50DA-2DSA (71)	1	200	-55 to +85
7	SW1	2	Dep.SW	Molex	0554600272	1,5	125	-40 to +105
8	SW2	2	Dep.SW	Molex	0554600272	1,5	125	-40 to +105
9	SW3	2	Dep.SW	Molex	0554600272	1,5	125	-40 to +105
10	SW4	2	Dep.SW	Molex	0554600272	1,5	125	-40 to +105
11	SP1	12	+X Solar Panel	Hirosugi	PSR-210154-12	1	500	-40 to +105
12	SP2	12	-X Solar Panel	Hirosugi	PSR-210154-12	1	500	-40 to +105
13	SP3	12	+Y Solar Panel	Hirosugi	PSR-210154-12	1	500	-40 to +105
14	SP4	12	-Y Solar Panel	Hirosugi	PSR-210154-12	1	500	-40 to +105
15	SP5	12	-Z Solar Panel	Hirosugi	PSS-210204-12	1	500	-40 to +105
16	JTAG	6	Programmer connector	Würth Elektronik	61300411121	3	250	-40 to +105

NOTE This table provides examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

Table C.2 — C101 connector pin assignment

C101 (FAB)		
Signal name	Pin number	Signal name
Prog_GIO_1	1 | 2	**Prog_GIO_2**
Prog_GIO_3	3 | 4	**Prog_GIO_4**
Prog_GIO_5	5 | 6	**Prog_GIO_6**
FAB_to_RAB_GIO_1	7 | 8	**FAB_to_RAB_GIO_2**
FAB_to_RAB_GIO_3	9 | 10	**FAB_to_RAB_GIO_4**
FAB_to_RAB_GIO_5	11 | 12	**FAB_to_RAB_GIO_6**
GND-SYS	13 | 14	*GND-SYS*
SUP_5V0	15 | 16	*SUP_5V0*
FAB_to_OBC_GIO_1	17 | 18	**FAB_to_OBC_GIO_2**
FAB_to_OBC_GIO_3	19 | 20	**FAB_to_OBC_GIO_4**
POWERSC_-Y	21 | 22	TEMP_2 -Y

Key

Digital connection (fixed)

Digital connection (configurable by user through CPLD)

Power connection

<u>Analog connection</u>

Table C.2 *(continued)*

C101 (FAB)			
Signal name	Pin number		Signal name
SUP_UNREG_1	23	24	SUP_UNREG_1
SUP_3V3_2	25	26	SUP_3V3_2
POWERSC_+Y	27	28	TEMP_1 +Y
RAW_POWER	29	30	RAW_POWER
POWERSC_-Y	31	32	TEMP_5 -Y
POWERSC_-Z	33	34	TEMP_3 -Z
SUP_UNREG_2	35	36	SUP_UNREG_2
POWERSC_-X	37	38	TEMP_4 -X
Kill_SW	39	40	DEP_SW_1
DEP_SW_2	41	42	CPLD1/ DEP_SW_3
CPLD2/ DEP_SW_4	43	44	CPLD3/ TEMP_6
CPLD4	45	46	CPLD5
CPLD6	47	48	GND_BAT
SUP_3V3_1	49	50	SUP_3V3_1

Key

Digital connection (fixed)

Digital connection (configurable by user through CPLD)

Power connection

Analog connection

Table C.3 — C102 connector pin assignment

C102 (OBC/EPS)			
Signal name	Pin number		Signal name
Prog_GIO_1	1	2	Prog_GIO_2
Prog_GIO_3	3	4	Prog_GIO_4
Prog_GIO_5	5	6	Prog_GIO_6
OBC-COM_1	7	8	OBC-COM_2
FAB_to_RAB_GIO_3	9	10	FAB_to_RAB_GIO_4
FAB_to_RAB_GIO_5	11	12	FAB_to_RAB_GIO_6
GND-SYS	13	14	GND-SYS
SUP_5V0	15	16	SUP_5V0
FAB_to_OBC_GIO_1	17	18	FAB_to_OBC_GIO_2
FAB_to_OBC_GIO_3	19	20	FAB_to_OBC_GIO_4
CPLD8	21	22	CPLD9
SUP_UNREG_1	23	24	SUP_UNREG_1
SUP_3V3_2	25	26	SUP_3V3_2
CPLD10	27	28	CPLD11
RAW_POWER	29	30	RAW_POWER

Key

Digital connection (fixed)

Digital connection (configurable by user through CPLD)

Power connection

Analog connection

Table C.3 *(continued)*

C102 (OBC/EPS)			
Signal name	Pin number		Signal name
CPLD12	31	32	*CPLD13*
CPLD14	33	34	*CPLD15*
SUP_UNREG_2	35	36	*SUP_UNREG_2*
CPLD16	37	38	*CPLD17*
Kill_SW	39	40	**DEP_SW_1**
DEP_SW_2	41	42	*CPLD18*
OBC-COM_3	43	44	**OBC-COM_4**
OBC-COM_5	45	46	**OBC-COM_6**
OBC-COM_7	47	48	OBC-COM_8
SUP_3V3_1	49	50	*SUP_3V3_1*
Key			
Digital connection (fixed)			
Digital connection (configurable by user through CPLD)			
Power connection			
Analog connection			

Table C.4 — C103 connector pin assignment

C103 (COM)			
Signal name	Pin number		Signal name
COM_to_RAB_GIO_1	1	2	**COM_to_RAB_GIO_2**
COM_to_RAB_GIO_3	3	4	**COM_to_RAB_GIO_4**
COM_to_RAB_GIO_5	5	6	**COM_to_RAB_GIO_6**
OBC-COM_1	7	8	**OBC-COM_2**
FAB_to_RAB_GIO_3	9	10	**FAB_to_RAB_GIO_4**
FAB_to_RAB_GIO_5	11	12	**FAB_to_RAB_GIO_6**
GND-SYS	13	14	*GND-SYS*
SUP_5V0	15	16	*SUP_5V0*
CPLD19	17	18	*CPLD20*
CPLD21	19	20	*CPLD22*
CPLD23	21	22	*CPLD24*
SUP_UNREG_1	23	24	*SUP_UNREG_1*
SUP_3V3_2	25	26	*SUP_3V3_2*
CPLD25	27	28	*CPLD26*
CPLD27	29	30	*CPLD28*
CPLD29	31	32	*CPLD30*
CPLD31	33	34	*CPLD32*
SUP_UNREG_2	35	36	*SUP_UNREG_2*
CPLD33	37	38	*CPLD34*
Key			
Digital connection (fixed)			
Digital connection (configurable by user through CPLD)			
Power connection			
Analog connection			

Table C.5 *(continued)*

C104 (MSN-1)			
Signal name	Pin number		Signal name
CPLD61	45	46	*CPLD62*
CPLD63	47	48	*CPLD64*
SUP_3V3_1	49	50	*SUP_3V3_1*
Key			
Digital connection (fixed)			
Digital connection (configurable by user through CPLD)			
Power connection			

Table C.6 — C105 connector pin assignment

C105 (MSN-2)			
Signal name	Pin number		Signal name
COM_to_RAB_GIO_1	1	2	**COM_to_RAB_GIO_2**
COM_to_RAB_GIO_3	3	4	**COM_to_RAB_GIO_4**
COM_to_RAB_GIO_5	5	6	**COM_to_RAB_GIO_6**
FAB_to_RAB_GIO_1	7	8	**FAB_to_RAB_GIO_2**
FAB_to_RAB_GIO_3	9	10	**FAB_to_RAB_GIO_4**
FAB_to_RAB_GIO_5	11	12	**FAB_to_RAB_GIO_6**
GND-SYS	13	14	*GND-SYS*
SUP_5V0	15	16	*SUP_5V0*
CPLD39	17	18	*CPLD40*
CPLD41	19	20	*CPLD42*
CPLD43	21	22	*CPLD44*
SUP_UNREG_1	23	24	*SUP_UNREG_1*
SUP_3V3_2	25	26	*SUP_3V3_2*
CPLD45	27	28	*CPLD46*
CPLD47	29	30	*CPLD48*
CPLD49	31	32	*CPLD50*
CPLD51	33	34	*CPLD52*
SUP_UNREG_2	35	36	*SUP_UNREG_2*
CPLD53	37	38	*CPLD54*
CPLD55	39	40	*CPLD56*
CPLD57	41	42	*CPLD58*
CPLD59	43	44	*CPLD60*
CPLD61	45	46	*CPLD62*
CPLD63	47	48	*CPLD64*
SUP_3V3_1	49	50	*SUP_3V3_1*
Key			
Digital connection (fixed)			
Digital connection (configurable by user through CPLD)			
Power connection			