

Interface Control Document (ICD)

Thermal Control Unit

28/Aug/2024



Interface Control Document (ICD)– Thermal Control Unit

CAVU-TCU-ICD-v2025.4

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CHANGE RECORD

ISSUE	DATE	CHANGE RECORD	AUTHOR
01	28/08/2024	First Issue	SYS-CAVU
02	12/10/2024	Pin Map Update	HW-CAVU
03	14/02/2025	Drawing Update	MCH-CAVU
04	17/09/2025	Voltage Update	HW-CAVU

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LIST OF ABBREVIATIONS AND ACRONYMS

AOCS	Attitude and Orbit Control Subsystem
AOS	Acquisition of Signal
API	Application Program Interface
AR	Acceptance Review
BB	Base Band
BGS	Base Ground Station
BOF	Spacecraft Body Fixed Reference Frame
CAM	Camera
CONOPS	Concept of Operations
COSMOS	Command and Control of Embedded Systems (Ball Aerospace)
COTS	Commercial Off-The-Shelf
DCMC	Data Collection Mission Center
DCPS	Data Collection Planning System
DCS	Data Collection System
DSS	Dynamic Satellite Simulator
ECI	EARTH CENTERED INERTIAL FRAME
EPS	Electrical Power Subsystem
FDIR	Fault Detection Identification and Recovery
FDS	Flight Dynamics System
FM	File Manager
FT	FDIR Tests
FTP	File Transfer Protocol
GED	Geodetic Reference Frame
GSR	Ground Segment Revision
GPS	Global Positioning System Sensor
GRD	Ground
HW	Hardware
ICRS	International Celestial Reference System

IMC	Image Mission Center
IMPS	Imaging Mission Planning System
IOT	In-Orbit Test
IP	Internet Protocol
ITRS	International Terrestrial Reference System
KSAT	Kongsberg Satellite Services AS
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
LOS	Loss of Signal
MCC	Mission Control Center
MEC	Mechanical Reference Frame
MTF	Modulation Transfer Function
OBC	On Board Computer
OBDH	On-board Data Handling
OPS	Routine Operation Phase
PCD	Plataforma de Coleta de Dados
PLP	Primary Level Product
REL	Earth Target Relative Frame
RIPS	Raw Image Processing System
RTS	Real Time System
SATCON	Satellite Controller
SBCD	Sistema Brasileiro de Coleta de Dados
S/C	Spacecraft
SCC	Satellite Control Center
SDR	Software Defined Radio
SLA	Service Level Agreement
SMS	Short Message Service
SOE	Sequence Of Events
SOH	Satellite Operation Handbook

SSO	Sun-synchronous orbit
STR	Star Tracker Frame
SW	Software
TC	Telecommand
TCS	Thermal Control Subsystem
TER	Terrestrial Reference Frame
TLE	Two-Line Elements
TM	Telemetry
TMTC	Telemetry and Telecommand Subsystem
TT&C	Telemetry, Tracking and Command
UHF	Ultra-High Frequency
VAL	Validation Phase Tests
VPN	Virtual Private Network
WGS	World Geodetic System
YST	Yaw Steering Reference Frame

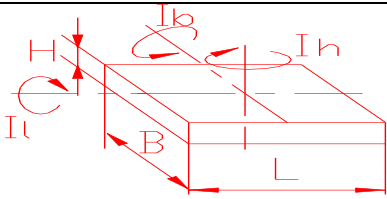
1 MECHANICAL CHARACTERISTICS

Table 1 - Mass Properties

Unit mass (kg) : 1.180			Tolerance (kg) ^{1*} : ±0.010			
Dimensions (mm) without screw base	L: 130.0	± 0.1	B: 170.0	± 0.1	H: 38.0	± 0.1
Dimensions (mm) with screw base	L: 160.0	± 0.1	B: 170.0	± 0.1	H: 38.0	± 0.1
Screw center dimensions (mm)	L: 145.0	± 0.1	B: 155.0	± 0.1	H: -	-
CG Locations (mm)	Y _{CG} : -1.9	±:0.1	X _{CG} : 0.23	±:0.1	Z _{CG} : 16.05	±:0.1
Inertia CG (g.m ²)	I _{yy} : 3626762.1	±:0.1	I _{xx} : 2654368.9	±:0.1	I _{zz} : 5330470.5	±:0.1

^{1*} General tolerance: ISO 2768 Medium

Table 2 - Base Plate

Material Description (symbol):	Al7075-T6
Contact area (mm ²):	22740
Roughness (µm):	3.2
Assembly Directions (if applicable): Z axis direct to geocentre, and X axis direct to the flight direction.	
Remarks: The baffle shall be made of non-metallic material and it shall be made of fiberglass.	
 Figure 1 - Unit Reference	Note: l, b and h are related to the unit reference hole.

1.1 ISOMETRIC VIEW



Figure 2 – TCU isometric view

1.2 TOP VIEW

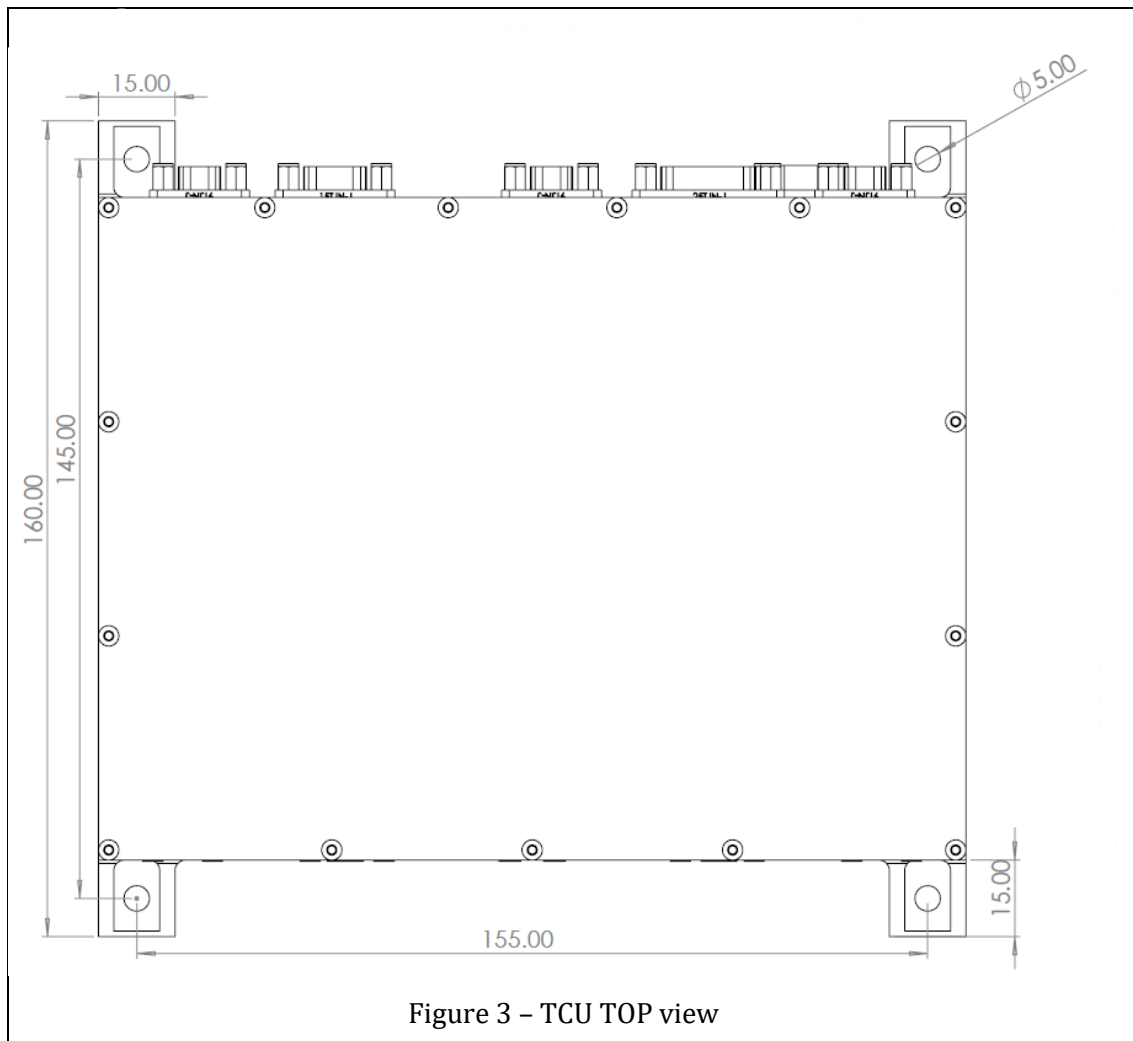
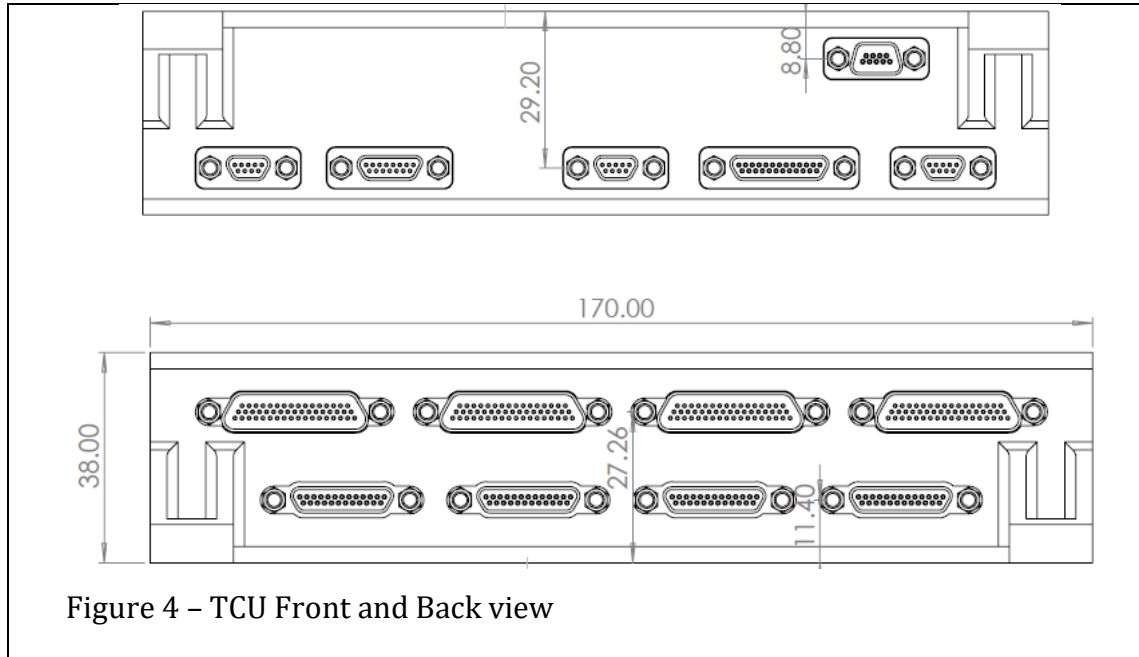
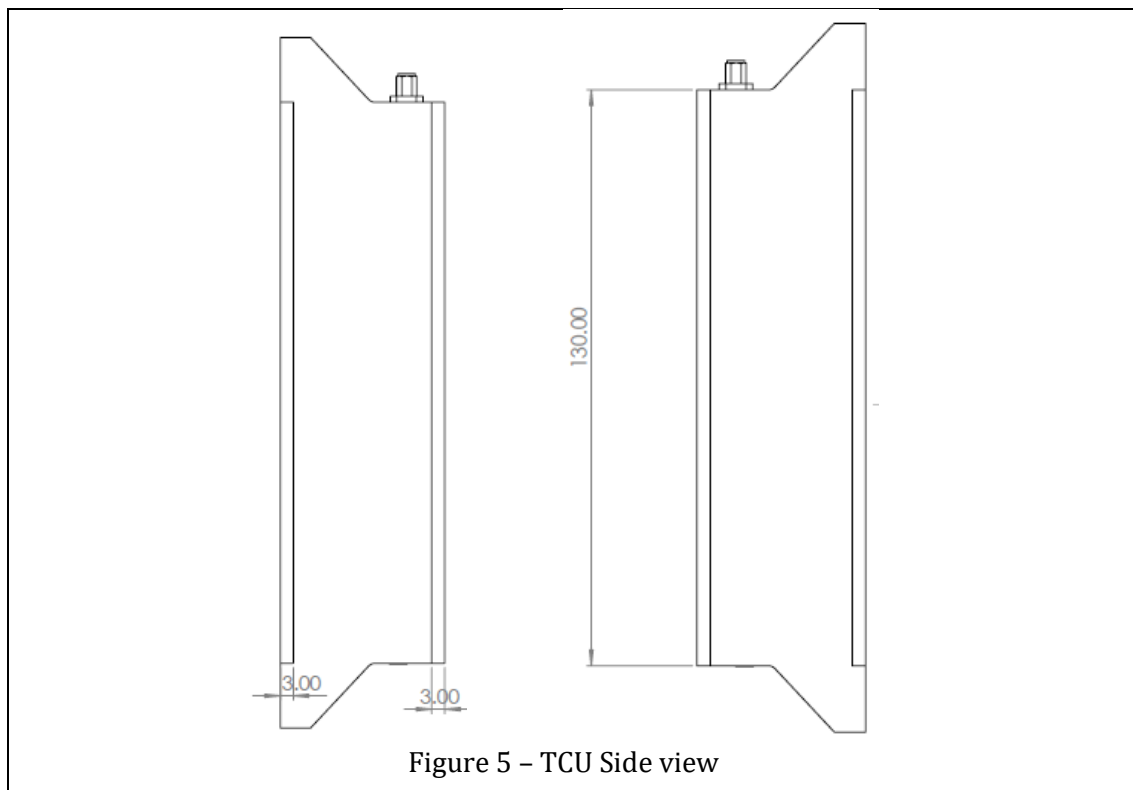


Figure 3 - TCU TOP view

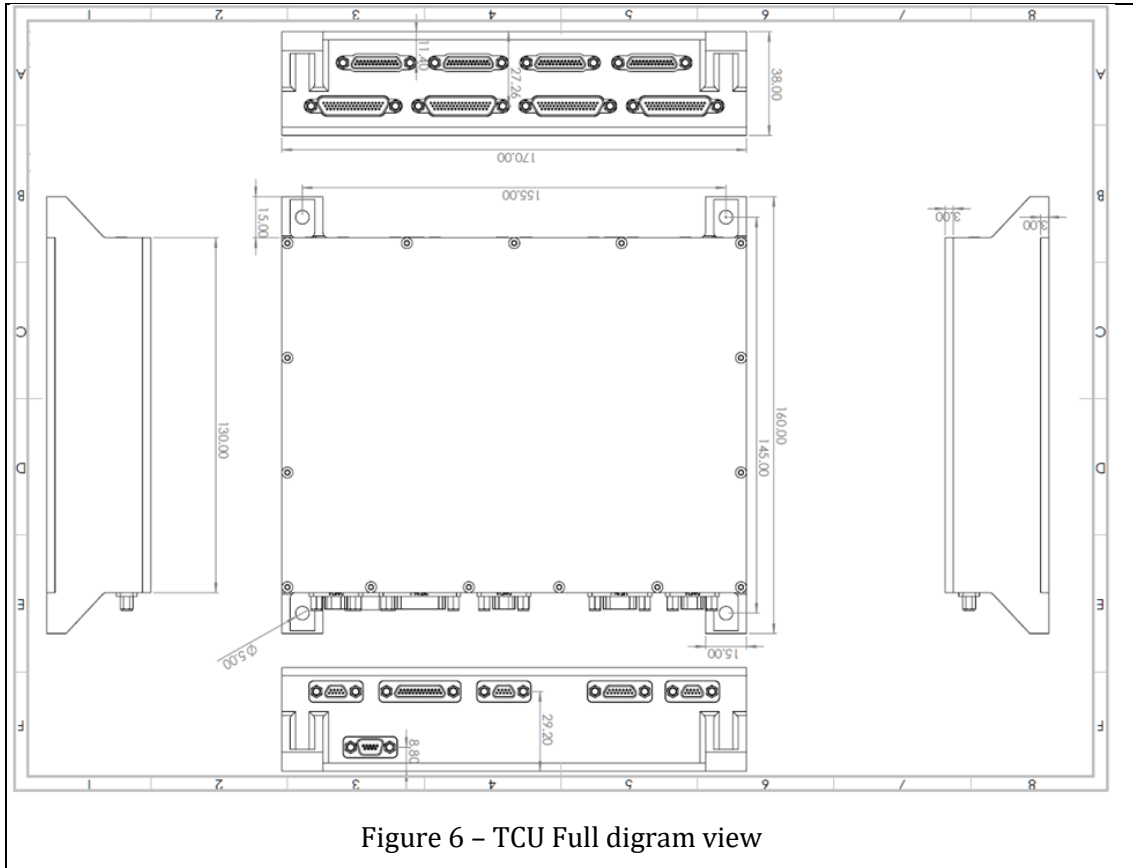
1.3 FRONT AND BACK VIEW



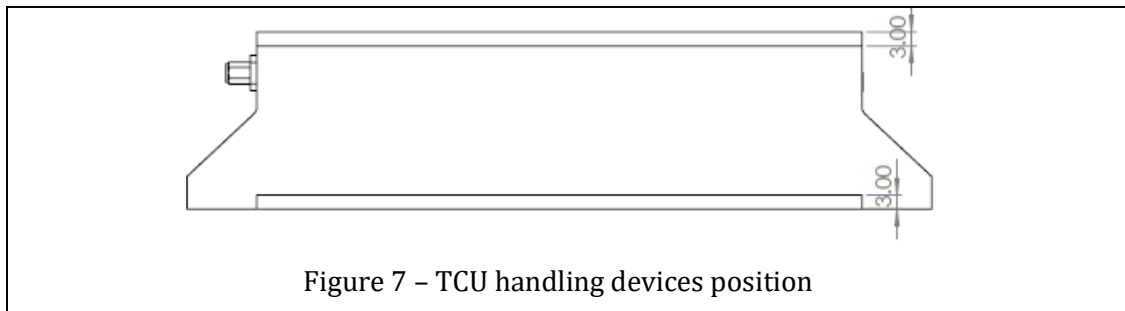
1.4 TWO SIDE VIEW



1.5 FULL DRAWING VIEW



1.6 HANDLING DEVICES POSITION



1.7 GROUNDING POINTS POSITION

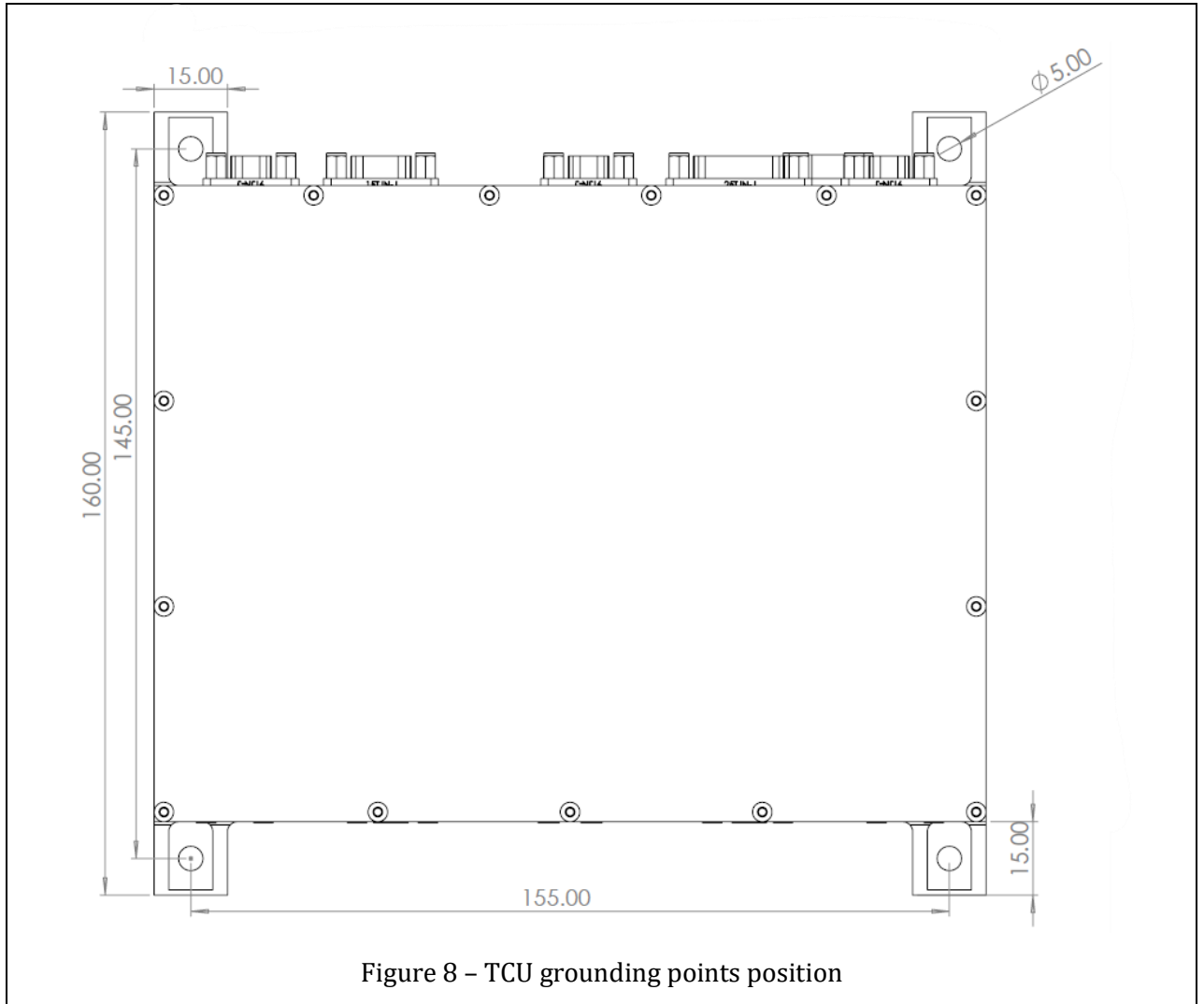


Figure 8 – TCU grounding points position

1.8 CONNECTOR IDENTIFICATION AND LOCALIZATION

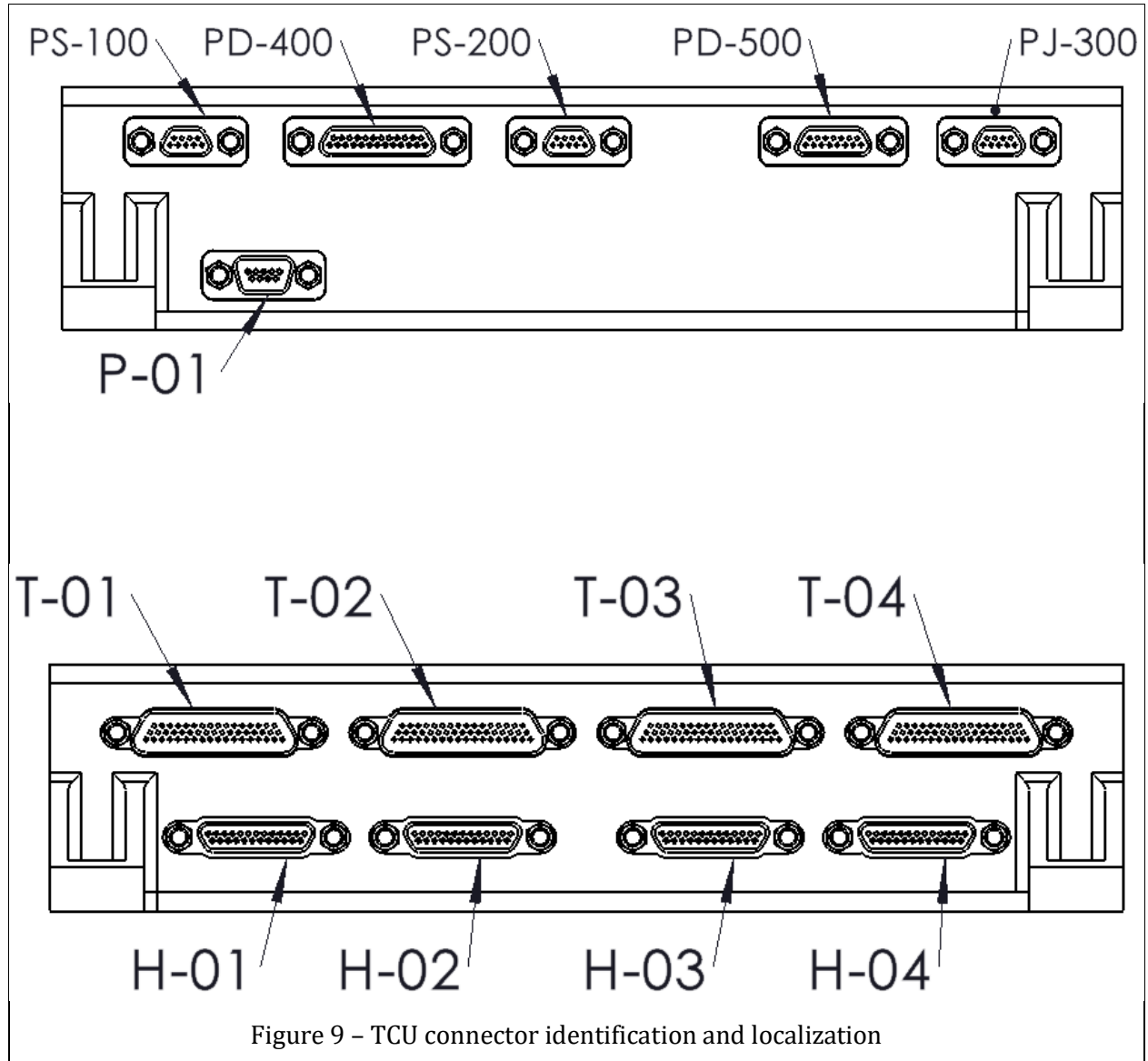


Figure 9 – TCU connector identification and localization

2 THERMAL CHARACTERISTICS

Table 3 - Temperature Range (°C)

Description	Min. [°C]	Max. [°C]
In Orbit Operation		
Operational temperature	-40	+80
In Orbit No Operation		
Survival temperature (SVHR-TCS DRIVER- 0180)	-50	+90
Ground Storage	+5	+30

Table 4 - Heat Dissipation (W)

ON	10 W
Stand-by	3.5 W

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3 ELECTRICAL POWER

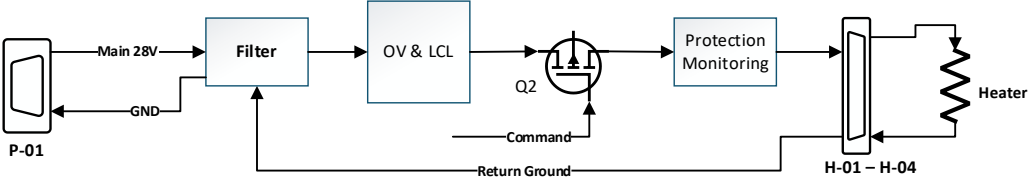
Table 5 – Electrical Power Input Characteristics

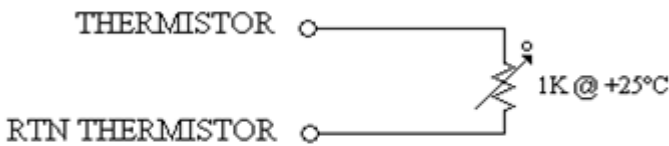
Parameter	28 V Variant	50 V Variant	Notes
Nominal input voltage	28 V DC	50 V DC	Un-Regulated
Operating voltage range	20 V – 36 V	36 V – 70 V	Continuous operation range
Over-voltage protection threshold	36 V $\pm$ 0.5 V	70 V $\pm$ 0.5 V	Hardware shutdown above this limit
Under-voltage cutoff	19 V $\pm$ 0.5 V	35 V $\pm$ 0.5 V	Automatic power-off below this limit
Maximum input current	15 A (default)	8 A (default)	Configurable at order
Peak current (short-duration)	Up to 25 A for < 5 s	Up to 12 A for < 5 s	Requires SW and HW limit change
Input power capacity	420 W continuous	420 W continuous	At default current limit
Peak power (transient)	700 W for $\leq$ 5 s	700 W for $\leq$ 5 s	Requires HW and SW update
Input connector	Micro-D	Micro-D	Refer to Connector Map
Polarity protection	Implemented via reverse-blocking stage	Implemented via reverse-blocking stage	Reverse connection protected
Inrush current limiting	Active soft-start circuitry	Active soft-start circuitry	Limits surge during power-up
Filtering	Pi-filter and LC network	Pi-filter and LC network	Conducted EMI suppression per ECSS-E-ST-20

Table 6 – Power Distribution and Channel Protection

Parameter	Value	Notes
Number of controlled heater channels	48 channels	Individually current-limited
Per-channel max current	3 A	Hardware Cap
Per-channel nominal power (28 V bus)	~80 W (peak)	At 3 A per channel
Total continuous power	420 W (28 V $\times$ 15 A)	Shared across all channels
Power control method	PWM 5–100 % duty cycle, 10 kHz	Closed-loop thermal control
Channel protection	Current-sense feedback with cutoff	Automatic latch-off on over-current
Bus protection	e-fuse	resettable
Short-circuit protection	Analog over-current trip and digital monitoring	Hardware cutoff within < 10 μ s
Surge protection	Transient suppressor (TVS) array	Meets MIL-STD-704/ESA power bus transients
Over-voltage protection	Hardware cutoff above limit	See power input table
Housekeeping monitoring	Input V, I; each board V, I; heater currents	Reported via telemetry interface

4 HEATER AND SENSOR INTERFACE CHARACTERISTICS

Signal Name	HEATERS LINES
Signal Characteristic	RESISTIVE LOAD
Interface Circuit Drawing	
	
Remarks: Maximum 3A per each Heater Line	

Signal Name	THERMISTORS LINES AND THERMAL TELEMETRIES LINES
Signal Characteristic	RESISTIVE LOAD
Interface Circuit Drawing	
	
Remarks: Default 30K NTC for all 112 Channels	

5 DATA INTERAFCE

Table 7 – Data Interface Electrical Characteristics Summary

Parameter	RS-422-1 / RS-422-2	RS-232	CAN-1 / CAN- 2	Notes
Interface standard	TIA/EIA-422 differential	TIA/EIA-232 single-ended	ISO 11898-2 high-speed	—
Signal type	Differential TX± / RX±	TXD / RXD	CANH / CANL	—
Data rate range	1.2 kbps – 16 Mbps	1.2 kbps – 921.6 kbps	1 Mbps	Configurable in software
Default baud rate	115 200 bps	115 200 bps	1 Mbps	Can be reprogrammed via command
Isolation	Selectable (Isolated / Non-Isolated)	Non-isolated	Non-isolated	RS-422 isolation chosen at order
Termination	100 Ω selectable	—	120 Ω selectable	Factory default: enabled on receiver side
Common-mode range	–7 V to +7 V	±15 V (RS-232 compliant)	–2 V to +7 V	—
ESD protection	Integrated on all I/O lines	Integrated	Integrated	IEC 61000-4-2 compliant protection
Default protocol layer	Transparent serial	Transparent serial	CAN 2.0B frames	-
Ground reference	Signal GND	Signal GND	Signal GND	bonding at harness
Connector	Micro-D	Micro-D	Micro-D	Refer to “Connector Map”

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Table 8 – RS-422 (X2) - Signal Interface Characteristics

Field	RS-422-1	RS-422-2	Notes
Interface type	Differential, full-duplex (TX±, RX±)	Differential, full-duplex (TX±, RX±)	Per TIA/EIA-422
Galvanic isolation	Configurable (Yes/No at order)	Configurable (Yes/No at order)	Isolation option selectable during procurement
Data rate	1.2 kbps to 16 Mbps (configurable)	1.2 kbps to 16 Mbps (configurable)	Default 115 200 bps unless specified
Word format	8-N-1 (default);	Same	Software-configurable
Receiver input sensitivity	≥ ±200 mV differential	≥ ±200 mV differential	Standard RS-422 threshold
Differential output (driver)	≥ 2.0 V (no load), compliant with RS-422	≥ 2.0 V (no load), compliant with RS-422	Into 100–120 Ω load
Input impedance	≥ 12 kΩ (per line)	≥ 12 kΩ (per line)	Typical RS-422 receiver
Common-mode range	–7 V to +7 V	–7 V to +7 V	Relative to signal ground
Failsafe bias	Present (idle = logic high)	Present (idle = logic high)	Biasing internal to TCU
Termination	100 Ω selectable (enable/disable)	100 Ω selectable (enable/disable)	Factory default: enabled on TCU receiver
ESD protection	System-level ESD protection on I/O	System-level ESD protection on I/O	Meets typical IEC/ESD practices
Frame/protocol	Transparent serial link	Transparent serial link	Higher-layer protocol per mission ICD
Ground reference	Signal GND	Signal GND	Single-point bonding per harness design
Connector	Micro-D; pinout per Connector Map	Micro-D; pinout per Connector Map	See ICD “Connector Map” section

Table 9 – RS-232 (X1) - Signal Interface Characteristics

Field	Value	Notes
Interface type	Single-ended, TXD/RXD	EIA/TIA-232-F compatible
Data rate	1.2 kbps to 921.6 kbps (configurable)	Default 115 200 bps unless specified
Word format	8-N-1 (default)	Software-configurable
Output voltage (mark/space)	±5 V to ±9 V typical	Within RS-232 compliance
Input threshold	Recognizes RS-232 compliant ±3 V min	Noise-immune thresholds
Flow control	None	-
ESD protection	System-level ESD protection on I/O	Meets typical IEC/ESD practices
Frame/protocol	Transparent serial link	Higher-layer protocol on App
Ground reference	Signal GND	Single-point bonding per harness design
Connector	Micro-D; pinout per Connector Map	See ICD “Connector Map” section

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Table 10 – CAN 2.0B (X2) - Signal Interface Characteristics

Field	CAN-1	CAN-2	Notes
Interface type	ISO 11898-2 (High-Speed CAN)	ISO 11898-2 (High-Speed CAN)	2.0A/2.0B frames supported
Data rate	Up to 1 Mbps (configurable)	Up to 1 Mbps (configurable)	Default 1 Mbps unless specified
Bit timing	Programmable (prop/phase segments)	Programmable (prop/phase segments)	Set during integration
Bus levels	Recessive ≈ 2.5 V; Dominant differential ≈ 1.5 – 2.0 V	Same	Per ISO 11898-2
Common-mode range	-2 V to $+7$ V (typical)	-2 V to $+7$ V (typical)	Relative to GND
Input impedance	High-Z receiver per ISO 11898-2	High-Z receiver per ISO 11898-2	—
Termination	$120\ \Omega$ selectable (enable/disable)	$120\ \Omega$ selectable (enable/disable)	Bus requires exactly two $120\ \Omega$ ends
Transceiver modes	Normal, Standby, Listen-Only (Silent)	Normal, Standby, Listen-Only (Silent)	For commissioning/EMC
Error handling	Error active/passive, bus-off per ISO	Same	Status exposed via HK/telemetry
ESD protection	System-level ESD protection on CANH/CANL	System-level ESD protection on CANH/CANL	Meets typical IEC/ESD practices
Ground reference	Signal GND	Signal GND	Bonding per harness design
Connector	Micro-D; pinout per Connector Map	Micro-D; pinout per Connector Map	See ICD “Connector Map” section

6 LIST OF CONNECTORS

Table 11 - List of Connectors

Connector Code	Connector Name	Male Female	Connector Type	Connection With
T -01	TCS Sensor batch 01	M	51 pin contacts P/N: A99089-513	A98100-513
T -02	TCS Sensor batch 02	M	51 pin contacts P/N: A99089-513	A98100-513
T -03	TCS Sensor batch 03	M	51 pin contacts P/N: A99089-513	A98100-513
T -04	TCS Sensor batch 04	M	51 pin contacts P/N: A99089-513	A98100-513
H -01	TCS Heater batch 01	F	25 pin contacts P/N: A98055-025	A99100-025
H -02	TCS Heater batch 02	F	25 pin contacts P/N: A98055-025	A99100-025
H -03	TCS Heater batch 03	F	25 pin contacts P/N: A98055-025	A99100-025
H -04	TCS Heater batch 04	F	25 pin contacts P/N: A98055-025	A99100-025
P -01	TCU Power Input	M	9 pin contacts P/N: A99089-009	A98100-009
PS-100	OBC/Serial Connection1	F	9 pin contacts P/N: A98055-009	A99100-009
PD-400	Digital I/O and Spare Sensor Inputs	F	25 pin contacts P/N: A98055-025	A99100-025
PS-200	OBC/Serial Connection2	F	9 pin contacts P/N: A98055-009	A99100-009
PD-500	Factory Hardware Debug	F	15 pin contacts P/N: A98055-015	A99015-015
PJ-300	JTAG Interface	F	9 pin contacts P/N: A98055-009	A99100-009

7 PIN ASSIGNMENT

Table 12 - TCS Sensor batch 01 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
T -01	TCS Sensor batch 01	M	51 pin contacts P/N: A99089-513		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
1	SENSOR1	12	175μ	+	N
2	AGND	0	1	-	N
3	SENSOR3	12	175μ	+	N
4	AGND	0	1	-	N
5	SENSOR6	12	175μ	+	N
6	AGND	0	1	-	N
7	SENSOR9	12	175μ	+	N
8	AGND	0	1	-	N
9	SENSOR12	12	175μ	+	N
10	AGND	0	1	-	N
11	SENSOR15	12	175μ	+	N
12	AGND	0	1	-	N
13	SENSOR18	12	175μ	+	N
14	AGND	0	1	-	N
15	SENSOR21	12	175μ	+	N
16	AGND	0	1	-	N
17	SENSOR24	12	175μ	+	N
18	AGND	0	1	-	N
19	SENSOR2	12	175μ	+	N
20	AGND	0	1	-	N
21	SENSOR5	12	175μ	+	N
22	AGND	0	1	-	N
23	SENSOR8	12	175μ	+	N
24	AGND	0	1	-	N
25	SENSOR11	12	175μ	+	N
26	AGND	0	1	-	N
27	SENSOR14	12	175μ	+	N
28	AGND	0	1	-	N
29	SENSOR17	12	175μ	+	N

30	AGND	0	1	-	N
31	SENSOR20	12	175μ	+	N
32	AGND	0	1	-	N
33	SENSOR23	12	175μ	+	N
34	AGND	0	1	-	N
35	SENSOR25	12	175μ	+	N
36	AGND	0	1	-	N
37	SENSOR4	12	175μ	+	N
38	AGND	0	1	-	N
39	SENSOR7	12	175μ	+	N
40	AGND	0	1	-	N
41	SENSOR10	12	175μ	+	N
42	AGND	0	1	-	N
43	SENSOR13	12	175μ	+	N
44	AGND	0	1	-	N
45	SENSOR16	12	175μ	+	N
46	AGND	0	1	-	N
47	SENSOR19	12	175μ	+	N
48	AGND	0	1	-	N
49	SENSOR22	12	175μ	+	N
50	AGND	0	1	-	N
51	AGND	0	1	-	N

Table 13 - TCS Sensor batch 02 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
T -02	TCS Sensor batch 02	M	51 pin contacts P/N: A99089-513		
Contact Number	Signal Name	Max Voltage (V)	Curr (mA)	Pol (+/-)	Shd Y/N
1	SENSOR26	12	175μ	+	N
2	AGND	0	1	-	N
3	SENSOR29	12	175μ	+	N
4	AGND	0	1	-	N
5	SENSOR31	12	175μ	+	N
6	AGND	0	1	-	N
7	SENSOR34	12	175μ	+	N
8	AGND	0	1	-	N
9	SENSOR37	12	175μ	+	N
10	AGND	0	1	-	N
11	SENSOR40	12	175μ	+	N
12	AGND	0	1	-	N
13	SENSOR43	12	175μ	+	N
14	AGND	0	1	-	N
15	SENSOR46	12	175μ	+	N
16	AGND	0	1	-	N
17	SENSOR49	12	175μ	+	N
18	AGND	0	1	-	N
19	SENSOR27	12	175μ	+	N
20	AGND	0	1	-	N
21	SENSOR30	12	175μ	+	N
22	AGND	0	1	-	N
23	SENSOR33	12	175μ	+	N
24	AGND	0	1	-	N
25	SENSOR36	12	175μ	+	N
26	AGND	0	1	-	N
27	SENSOR39	12	175μ	+	N
28	AGND	0	1	-	N
29	SENSOR42	12	175μ	+	N
30	AGND	0	1	-	N
31	SENSOR45	12	175μ	+	N

32	AGND	0	1	-	N
33	SENSOR48	12	175μ	+	N
34	AGND	0	1	-	N
35	SENSOR50	12	175μ	+	N
36	AGND	0	1	-	N
37	SENSOR28	12	175μ	+	N
38	AGND	0	1	-	N
39	SENSOR32	12	175μ	+	N
40	AGND	0	1	-	N
41	SENSOR35	12	175μ	+	N
42	AGND	0	1	-	N
43	SENSOR38	12	175μ	+	N
44	AGND	0	1	-	N
45	SENSOR41	12	175μ	+	N
46	AGND	0	1	-	N
47	SENSOR44	12	175μ	+	N
48	AGND	0	1	-	N
49	SENSOR47	12	175μ	+	N
50	AGND	0	1	-	N
51	AGND	0	1	-	N

Table 14 - TCS Sensor batch 03 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
T -03	TCS Sensor batch 03	M	51 pin contacts P/N: A99089-513		
Contact Number	Signal Name	Max Voltage (V)	Curr (mA)	Pol (+/-)	Shd Y/N
1	SENSOR51	12	175μ	+	N
2	AGND	0	1	-	N
3	SENSOR53	12	175μ	+	N
4	AGND	0	1	-	N
5	SENSOR56	12	175μ	+	N
6	AGND	0	1	-	N
7	SENSOR59	12	175μ	+	N
8	AGND	0	1	-	N
9	SENSOR62	12	175μ	+	N
10	AGND	0	1	-	N
11	SENSOR65	12	175μ	+	N
12	AGND	0	1	-	N
13	SENSOR68	12	175μ	+	N
14	AGND	0	1	-	N
15	SENSOR71	12	175μ	+	N
16	AGND	0	1	-	N
17	SENSOR74	12	175μ	+	N
18	AGND	0	1	-	N
19	SENSOR52	12	175μ	+	N
20	AGND	0	1	-	N
21	SENSOR55	12	175μ	+	N
22	AGND	0	1	-	N
23	SENSOR58	12	175μ	+	N
24	AGND	0	1	-	N
25	SENSOR61	12	175μ	+	N
26	AGND	0	1	-	N
27	SENSOR64	12	175μ	+	N
28	AGND	0	1	-	N
29	SENSOR67	12	175μ	+	N
30	AGND	0	1	-	N
31	SENSOR70	12	175μ	+	N

32	AGND	0	1	-	N
33	SENSOR73	12	175μ	+	N
34	AGND	0	1	-	N
35	SENSOR75	12	175μ	+	N
36	AGND	0	1	-	N
37	SENSOR54	12	175μ	+	N
38	AGND	0	1	-	N
39	SENSOR57	12	175μ	+	N
40	AGND	0	1	-	N
41	SENSOR60	12	175μ	+	N
42	AGND	0	1	-	N
43	SENSOR63	12	175μ	+	N
44	AGND	0	1	-	N
45	SENSOR66	12	175μ	+	N
46	AGND	0	1	-	N
47	SENSOR69	12	175μ	+	N
48	AGND	0	1	-	N
49	SENSOR72	12	175μ	+	N
50	AGND	0	1	-	N
51	AGND	0	1	-	N

Table 15 - TCS Sensor batch 04 Pin assignment

Connector	Connector Name	M/F	Connector Type		
T -04	TCS Sensor batch 04	M	51 pin contacts P/N: A99089-513		
Contact Number	Signal Name	Max Voltage (V)	Curr (mA)	Pol (+/-)	Shd Y/N
1	SENSOR76	12	175μ	+	N
2	AGND	0	1	-	N
3	SENSOR78	12	175μ	+	N
4	AGND	0	1	-	N
5	SENSOR81	12	175μ	+	N
6	AGND	0	1	-	N
7	SENSOR84	12	175μ	+	N
8	AGND	0	1	-	N
9	SENSOR87	12	175μ	+	N
10	AGND	0	1	-	N
11	SENSOR90	12	175μ	+	N
12	AGND	0	1	-	N
13	SENSOR93	12	175μ	+	N
14	AGND	0	1	-	N
15	SENSOR96	12	175μ	+	N
16	AGND	0	1	-	N
17	SENSOR99	12	175μ	+	N
18	AGND	0	1	-	N
19	SENSOR77	12	175μ	+	N
20	AGND	0	1	-	N
21	SENSOR80	12	175μ	+	N
22	AGND	0	1	-	N
23	SENSOR83	12	175μ	+	N
24	AGND	0	1	-	N
25	SENSOR86	12	175μ	+	N
26	AGND	0	1	-	N
27	SENSOR89	12	175μ	+	N
28	AGND	0	1	-	N
29	SENSOR92	12	175μ	+	N
30	AGND	0	1	-	N
31	SENSOR95	12	175μ	+	N
32	AGND	0	1	-	N

33	SENSOR98	12	175μ	+	N
34	AGND	0	1	-	N
35	SENSOR100	12	175μ	+	N
36	AGND	0	1	-	N
37	SENSOR79	12	175μ	+	N
38	AGND	0	1	-	N
39	SENSOR82	12	175μ	+	N
40	AGND	0	1	-	N
41	SENSOR85	12	175μ	+	N
42	AGND	0	1	-	N
43	SENSOR88	12	175μ	+	N
44	AGND	0	1	-	N
45	SENSOR91	12	175μ	+	N
46	AGND	0	1	-	N
47	SENSOR94	12	175μ	+	N
48	AGND	0	1	-	N
49	SENSOR97	12	175μ	+	N
50	AGND	0	1	-	N
51	AGND	0	1	-	N

Table 16 - TCS Heater batch 01 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
H -01	TCS Heater batch 01	F	25 pin contacts P/N: A98055-025		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
1	HEATER_GND	0	3	-	N
2	HEATER_GND	0	3	-	N
3	HEATER_GND	0	3	-	N
4	HEATER_GND	0	3	-	N
5	HEATER_GND	0	3	-	N
6	HEATER_GND	0	3	-	N
7	HEATER_GND	0	3	-	N
8	HEATER_GND	0	3	-	N
9	HEATER_GND	0	3	-	N
10	HEATER_GND	0	3	-	N
11	HEATER_GND	0	3	-	N
12	HEATER_GND	0	3	-	N
13	HEATER_GND	0	3	-	N
14	HEATER_1	36/70	3	+	N
15	HEATER_2	36/70	3	+	N
16	HEATER_3	36/70	3	+	N
17	HEATER_4	36/70	3	+	N
18	HEATER_5	36/70	3	+	N
19	HEATER_6	36/70	3	+	N
20	HEATER_7	36/70	3	+	N
21	HEATER_8	36/70	3	+	N
22	HEATER_9	36/70	3	+	N
23	HEATER_10	36/70	3	+	N
24	HEATER_11	36/70	3	+	N
25	HEATER_12	36/70	3	+	N

Table 17 - TCS Heater batch 02 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
H -02	TCS Heater batch 02	F	25 pin contacts P/N: A98055-025		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
1	HEATER_GND	0	3	-	N
2	HEATER_GND	0	3	-	N
3	HEATER_GND	0	3	-	N
4	HEATER_GND	0	3	-	N
5	HEATER_GND	0	3	-	N
6	HEATER_GND	0	3	-	N
7	HEATER_GND	0	3	-	N
8	HEATER_GND	0	3	-	N
9	HEATER_GND	0	3	-	N
10	HEATER_GND	0	3	-	N
11	HEATER_GND	0	3	-	N
12	HEATER_GND	0	3	-	N
13	HEATER_GND	0	3	-	N
14	HEATER_13	36/70	3	+	N
15	HEATER_14	36/70	3	+	N
16	HEATER_15	36/70	3	+	N
17	HEATER_16	36/70	3	+	N
18	HEATER_17	36/70	3	+	N
19	HEATER_18	36/70	3	+	N
20	HEATER_19	36/70	3	+	N
21	HEATER_20	36/70	3	+	N
22	HEATER_21	36/70	3	+	N
23	HEATER_22	36/70	3	+	N
24	HEATER_23	36/70	3	+	N
25	HEATER_24	36/70	3	+	N

Table 18 - TCS Heater batch 03 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
H -03	TCS Heater batch 03	F	25 pin contacts P/N: A98055-025		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
1	HEATER_GND	0	3	-	N
2	HEATER_GND	0	3	-	N
3	HEATER_GND	0	3	-	N
4	HEATER_GND	0	3	-	N
5	HEATER_GND	0	3	-	N
6	HEATER_GND	0	3	-	N
7	HEATER_GND	0	3	-	N
8	HEATER_GND	0	3	-	N
9	HEATER_GND	0	3	-	N
10	HEATER_GND	0	3	-	N
11	HEATER_GND	0	3	-	N
12	HEATER_GND	0	3	-	N
13	HEATER_GND	0	3	-	N
14	HEATER_25	36/70	3	+	N
15	HEATER_26	36/70	3	+	N
16	HEATER_27	36/70	3	+	N
17	HEATER_28	36/70	3	+	N
18	HEATER_29	36/70	3	+	N
19	HEATER_30	36/70	3	+	N
20	HEATER_31	36/70	3	+	N
21	HEATER_32	36/70	3	+	N
22	HEATER_33	36/70	3	+	N
23	HEATER_34	36/70	3	+	N
24	HEATER_35	36/70	3	+	N
25	HEATER_36	36/70	3	+	N

Table 19 - TCS Heater batch 04 Pin assignment

Connector Code	Connector Name	Male Female	Connector Type		
H -04	TCS Heater batch 04	F	25 pin contacts P/N: A98055-025		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
1	HEATER_GND	0	3	-	N
2	HEATER_GND	0	3	-	N
3	HEATER_GND	0	3	-	N
4	HEATER_GND	0	3	-	N
5	HEATER_GND	0	3	-	N
6	HEATER_GND	0	3	-	N
7	HEATER_GND	0	3	-	N
8	HEATER_GND	0	3	-	N
9	HEATER_GND	0	3	-	N
10	HEATER_GND	0	3	-	N
11	HEATER_GND	0	3	-	N
12	HEATER_GND	0	3	-	N
13	HEATER_GND	0	3	-	N
14	HEATER_37	36/70	3	+	N
15	HEATER_38	36/70	3	+	N
16	HEATER_39	36/70	3	+	N
17	HEATER_40	36/70	3	+	N
18	HEATER_41	36/70	3	+	N
19	HEATER_42	36/70	3	+	N
20	HEATER_43	36/70	3	+	N
21	HEATER_44	36/70	3	+	N
22	HEATER_45	36/70	3	+	N
23	HEATER_46	36/70	3	+	N
24	HEATER_47	36/70	3	+	N
25	HEATER_48	36/70	3	+	N

Table 20 - TCU Power Input Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
P -01	TCU Power Input	M	9 pin contacts P/N: A99089-009		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
01	POWER_GND	0	5	-	N
02	POWER_GND	0	5	-	N
03	POWER_GND	0	5	-	N
04	POWER_GND	0	5	-	N
05	POWER_GND	0	5	-	N
06	VCC	36/70	5	+	N
07	VCC	36/70	5	+	N
08	VCC	36/70	5	+	N
09	VCC	36/70	5	+	N

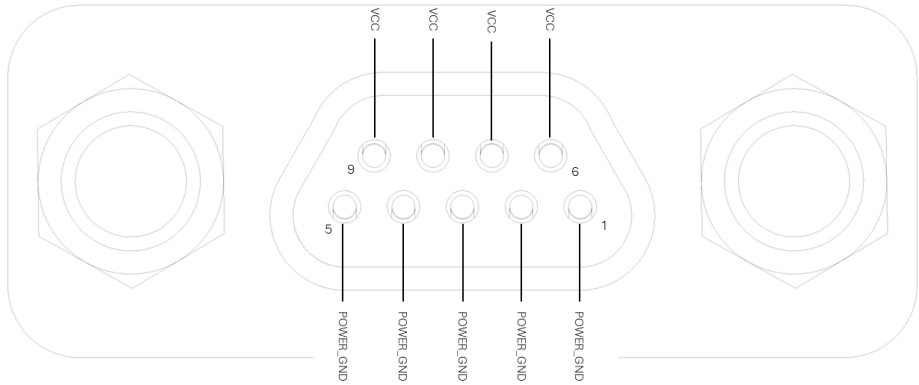


Table 21 - OBC/Serial Connection1 Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
PS-100	OBC/Serial Connection1	F	9 pin contacts P/N: A98055-009		
Contact Number	Signal Name	Max Voltage (V)	Max Current (mA)	Pol (+/-)	Shd Y/N
01	CAN1_H	-7/+12	10	P	N
02	CAN1_L	-7/+12	10	N	N
03	SIGNAL_GND	0	1000	-	N
04	RS485_A	-7/+12	10	P	N
05	RS485_B	-7/+12	10	N	N
06	RS422_1A	-7/+12	10	P	N
07	RS422_1B	-7/+12	10	N	N
08	RS422_1Z	-7/+12	10	N	N
09	RS422_1Y	-7/+12	10	P	N

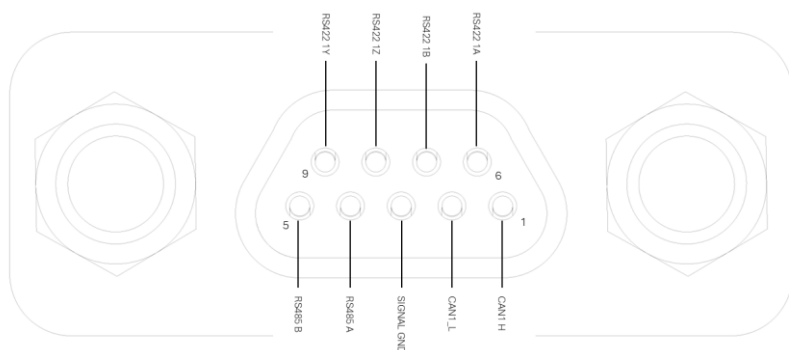


Table 22 - Digital I/O and Spare Sensor Inputs Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
PD-400	Digital I/O	F	25 pin contacts P/N: A98055-025		
Contact Number	Signal Name	Max Voltage (V)	Max Current (A)	Pol (+/-)	Shd Y/N
01	SENSOR102	12	175μ	+	N
02	SENSOR104	12	175μ	+	N
03	SENSOR106	12	175μ	+	N
04	SENSOR108	12	175μ	+	N
05	SENSOR110	12	175μ	+	N
06	SENSOR112	12	175μ	+	N
07	DIGITAL_OUTPUT1	5	10m	+	N
08	DIGITAL_OUTPUT2	5	10m	+	N
09	DIGITAL_OUTPUT3	5	10m	+	N
10	DIGITAL_OUTPUT4	5	10m	+	N
11	DIGITAL_OUTPUT8	5	10m	+	N
12	DIGITAL_OUTPUT6	5	10m	+	N
13	SIGNAL_GND	0	1	-	N
14	SENSOR101	12	175μ	+	N
15	SENSOR103	12	175μ	+	N
16	SENSOR105	12	175μ	+	N
17	SENSOR107	12	175μ	+	N
18	SENSOR109	12	175μ	+	N
19	SENSOR111	12	175μ	+	N
20	DIGITAL_INPUT1	5	10m	+	N
21	DIGITAL_INPUT2	5	10m	+	N
22	DIGITAL_INPUT3	5	10m	+	N
23	DIGITAL_INPUT4	5	10m	+	N
24	DIGITAL_INPUT5	5	10m	+	N
25	DIGITAL_INPUT6	5	10m	+	N

Table 23 - OBC/Serial Connection2 Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
PS-200	OBC/Serial Connection2	F	9 pin contacts P/N: A98055-009		
Contact Number	Signal Name	Max Voltage (V)	Max Current (mA)	Pol (P/N)	Shd Y/N
01	CAN2_H	-7/+12	10	P	N
02	CAN2_L	-7/+12	10	N	N
03	SIGNAL_GND	0	1000	N.A.	N
04	RS232_RX	12	10	N.A.	N
05	RS232_TX	12	10	N.A.	N
06	RS422_2A	-7/+12	10	P	N
07	RS422_2B	-7/+12	10	N	N
08	RS422_2Z	-7/+12	10	N	N
09	RS422_2Y	-7/+12	10	P	N

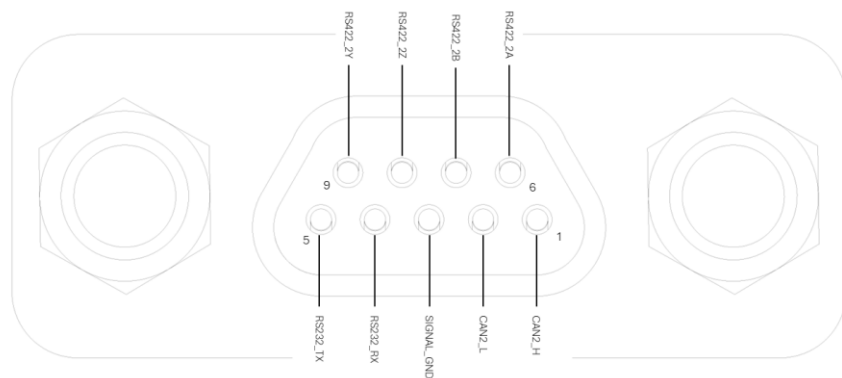


Table 24 - Factory Hardware Debug Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
PD-500	Factory Hardware Debug	F	15 pin contacts P/N: A98055-015		
Contact Number	Signal Name	Max Voltage (V)	Max Current (mA)	Pol (+/-)	Shd Y/N
01	PG1.2: 1.2V_POWER_GOOD	5	5	+	N
02	PG331: 3.3V_1_POWER_GOOD	5	5	+	N
03	PG332: 3.3V_2_POWER_GOOD	5	5	+	N
04	PG5: 5V_POWER_GOOD	5	5	+	N
05	PG12: 12V_POWER_GOOD	5	5	+	N
06	N.C.	-	-	X	N
07	SYSTEM_RESET	3.3	N.A.	+	N
08	SIGNAL_GND	0	1000	-	N
09	L2: LED2	2.5	10	+	N
10	L3: LED3	2.5	10	+	N
11	L4: LED4	2.5	10	+	N
12	L5: LED5	2.5	10	+	N
13	L6: LED6	2.5	10	+	N
14	L7: LED7	2.5	10	+	N
15	N.C.	-	-	X	N

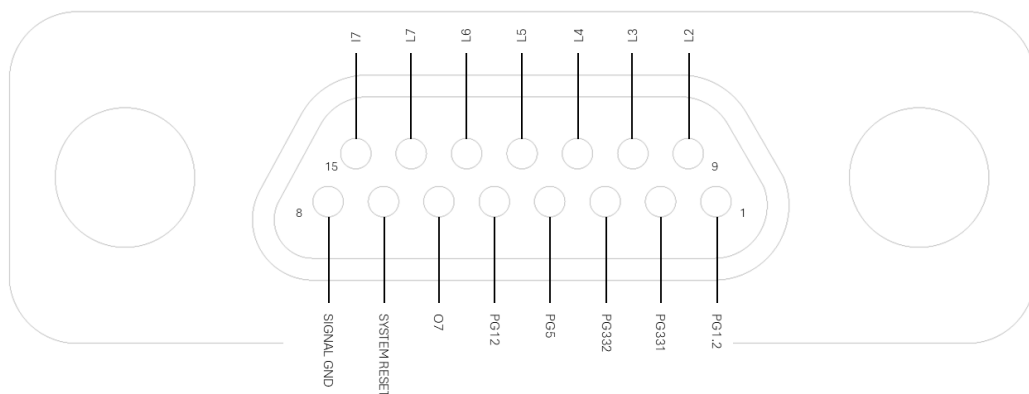


Table 25 - JTAG Interface Pin Assignment

Connector Code	Connector Name	Male Female	Connector Type		
PJ-300	JTAG Interface	F	9 pin contacts P/N: A98055-009		
Contact Number	Signal Name	Max Voltage (V)	Max Current (mA)	Pol (+/-)	Shd Y/N
01	JTAG_TMS	+3.3	10	N.A.	N
02	JTAG_SELECT	+3.3	10	N.A.	N
03	JTAG_TDO	+3.3	10	N.A.	N
04	SIGNAL_GND	0	1000	-	N
05	JTAG_TCK	+3.3	10	N.A.	N
06	JTAG_TDI	+3.3	10	N.A.	N
07	JTAG_TRST	+3.3	10	N.A.	N
08	+3.3V(OUT)	+3.3	500	N.A.	N
09	JTAG_NIRST	+3.3	10	N.A.	N

