INTERFACE CONTROL DOCUMENT

This document defines the external electrical, mechanical, thermal and command interfaces for integrating the High-Power TCU. It covers 48 heater outputs, 100 PT1000 and 12 PT100 inputs, and Ethernet, RS422 and RS232 command and telemetry.

The product is rated 5 kW only at 50 V with the high-current mating option. Total intake shall never exceed 100 A, or 50 A with the default mating cables. Reducing input voltage does not increase the permitted current: 25 V and 200 A is prohibited. At 25 V the input power ceiling is 2.5 kW with high-current mates, or 1.25 kW with default mates. Electronics and distribution losses are included within these ceilings.



High Power TCU assembly.

Product configuration	Definition
Heater outputs	Four banks of 12; 7 A per output, 50 A per bank
Temperature inputs	Channels 1-100 PT1000; channels 101-112 PT100
Operating input	12-50 V DC
Mass and envelope	Approximately 1.8 kg; 240 x 160 x 47 mm
Companion documents	Product Datasheet and User Guide, Issue 04

Use the numbered connector contact tables for harness manufacture. Connector drawings marked functional allocation are not mating-face views. Verify marked contact numbers and polarity before applying power.

1 Document Scope & Configuration

The High-Power TCU combines a temperature and command Controller with a modular heater Driver comprising four banks of 12 outputs. This ICD defines what the installation must provide and the constraints that apply at the external connectors.

Item	Issue 04 definition
Sensor allocation	100 PT1000 and 12 PT100; passive two-wire inputs
Calibration band	-100 to +150 deg C
Power entry	Two parallel feeds from one common source
Heater contact allocation	Outputs 1-12; pin 13 NC; pins 14-25 GND return
Digital I/O	3.3 V logic level
Acquisition range	16-bit conversion on +/-10 V input span
Mechanical interface	240 x 160 x 47 mm; approximately 1.8 kg
Documentation scope	External connections, operating limits and integration procedures

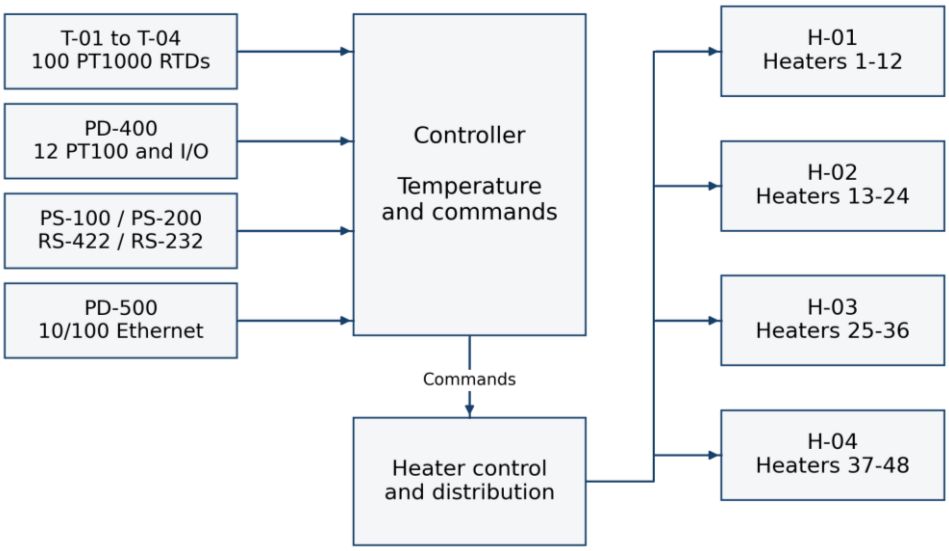
Operating limits apply to the complete input, each feed, every heater bank and every output simultaneously. Nominal calculated calibration points and power projections are not recorded unit acceptance results. Installation-specific qualification and calibration records remain part of product assurance.

2 Terms Units and Conventions

VCCIN	Positive of the common 12-50 V external input
Heater output	Switched positive supplied to a resistive load
Heater return	Dedicated load return, separate from sensor reference
PT1000 / PT100	Platinum RTD of 1000 / 100 ohms at 0 deg C
On-state current	Current while a PWM pulse is on
Average current	Time average over the stated interval
RMS current	Current used for conductor and contact heating
Idle	All heaters off; acquisition and communications idle
Heater ready	All heaters off; unit prepared to accept heating commands
FET	Field effect transistor
Design limit	Maximum permitted integration or commanded operating value

Voltages refer to the associated return. Temperature is in deg C, resistance in ohms and current in amperes. Interface directions are from the TCU perspective. Differential + and - suffixes identify pair polarity, not power polarity.

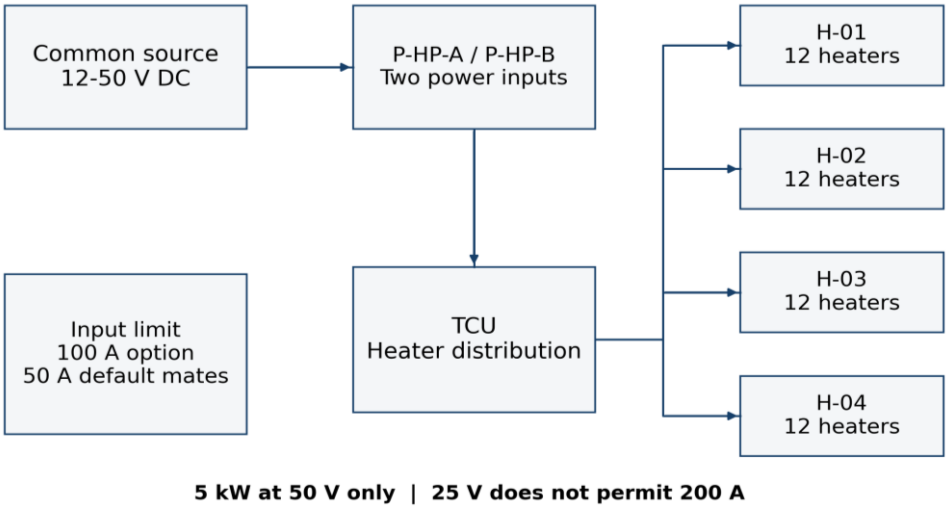
3 System Architecture



Functional interfaces with orthogonal signal connections.

Temperature measurements and external commands determine the permitted heater demand. Each heater bank remains subject to its own limit and the whole-unit input ceiling. Sensor numbering does not imply a one-to-one heater assignment.

4 Power Connection Overview



Both power connectors feed the same source bus.

The product is rated 5 kW only at 50 V with the high-current mating option. Total intake shall never exceed 100 A, or 50 A with the default mating cables. Reducing input voltage does not increase the permitted current: 25 V and 200 A is prohibited. At 25 V the input power ceiling is 2.5 kW with high-current mates, or 1.25 kW with default mates. Electronics and distribution losses are included within these ceilings.

The power inputs are parallel feeds, not independently isolated source inputs. One remaining feed cannot sustain the original two-feed demand. The external source and harness shall provide fault isolation appropriate to the mission.

5 Operating State Definitions

State	Heaters	Measurement and communication
Unpowered	No intentional output	Unavailable
Startup	Inhibited	Initialization before control
Idle	All off	Acquisition stopped; links and memory idle
Heater ready	All off	Prepared for heating; activity on request
Monitoring	Off or approved schedule	Defined sensor scan and traffic
Heating	Scheduled within all limits	Temperature and fault supervision
Fault	Affected demand inhibited	Report faults and valid remaining telemetry

Before entering Idle, disable automatic heater demand and command every output off. On leaving Idle, confirm valid monitoring and off-state readback before restoring heater demand. Keep independent source inhibition available during commissioning and recovery.

6 Main Input Electrical Parameters

Parameter	Definition
Operating range	12-50 V DC at the unit input
Rated high-power point	5 kW at 50 V only
Nominal overvoltage supervision	55 V; operation above 50 V is not rated
High-current mate limit	100 A total; 50 A per feed
Default mate limit	50 A total; 25 A per feed
Bank operational limit	50 A per bank
Heater on-state limit	7 A per output
Input source	Single common source for both feeds
Reverse polarity	Not permitted

The product is rated 5 kW only at 50 V with the high-current mating option. Total intake shall never exceed 100 A, or 50 A with the default mating cables. Reducing input voltage does not increase the permitted current: 25 V and 200 A is prohibited. At 25 V the input power ceiling is 2.5 kW with high-current mates, or 1.25 kW with default mates. Electronics and distribution losses are included within these ceilings.

The source limit includes electronics, heater current and all distribution losses. Qualify startup and low-voltage operation with the intended harness, source impedance and load schedule.

7 Power Input Connector A

Field	Definition
Reference	P-HP-A
Unit connector	280-056P1-2P2MEGPA
Default mate	280-047S1-2W2MEL
Removable crimp socket	850-057-0812
Default cable rating	25 A per power pin
High-current option	50 A per power pin; factory non-removable contacts

Cavity	Signal	Function
A1	GND	Main input return
A2	VCCIN	12-50 V input positive

For 50 A per power pin, contact Glenair directly and specify factory non-removable contacts and the approved cable termination. There is no separate ordering code specified here. The default mating cable is rated 25 A per power pin.

Use AWG #8 positive and return main conductors. Obtain supplier-approved termination for the selected mate; the specified conductor must not be forced into an incompatible removable crimp socket. Mark both ends of the harness and verify cavity numbers, rather than inferring polarity from connector gender.

Both inputs are on the same bus. The connector shell is not a substitute for the A1 return. Reduce demand to the surviving feed limit before operating with one feed disconnected.

8 Power Input Connector B

Field	Definition
Reference	P-HP-B
Unit connector	280-056P1-2P2MEGPA
Default mate	280-047S1-2W2MEL
Removable crimp socket	850-057-0812
Default cable rating	25 A per power pin
High-current option	50 A per power pin; factory non-removable contacts

Cavity	Signal	Function
A1	GND	Main input return
A2	VCCIN	12-50 V input positive

For 50 A per power pin, contact Glenair directly and specify factory non-removable contacts and the approved cable termination. There is no separate ordering code specified here. The default mating cable is rated 25 A per power pin.

Use AWG #8 positive and return main conductors. Obtain supplier-approved termination for the selected mate; the specified conductor must not be forced into an incompatible removable crimp socket. Mark both ends of the harness and verify cavity numbers, rather than inferring polarity from connector gender.

Both inputs are on the same bus. The connector shell is not a substitute for the A1 return. Reduce demand to the surviving feed limit before operating with one feed disconnected.

9 Power Mating Selection and Current Sharing

For the 50 A-per-pin power mating option, the client shall contact Glenair directly and specify factory non-removable power contacts and the required cable termination. The default mating cable specification is 25 A per power pin.

Configuration	Feed A limit	Feed B limit	Total ceiling
Default mating cables	25 A	25 A	50 A
Factory high-current mates	50 A	50 A	100 A
One default feed only	25 A	Disconnected	25 A
One high-current feed only	50 A	Disconnected	50 A

For parallel branch resistances RA and RB, IA = Itotal x RB/(RA+RB) and IB = Itotal x RA/(RA+RB). If RB is 20% above RA, the lower-resistance feed carries 54.55% of the intake. Its 50 A ceiling then limits the total to 91.67 A; the equivalent default-mate ceiling is 45.83 A.

A 1 mOhm added resistance at 50 A causes 50 mV drop and 2.5 W local heating; at 25 A it causes 25 mV and 0.625 W. Include both the positive and return terminations in the measured loop resistance. Supplier contact rating, cable temperature and installation derating govern the actual harness acceptance.

10 Source Budget Versus Input Voltage

Input	100 A ceiling	Default 50 A ceiling	Minimum R for 7 A
12 V	1200 W	600 W	1.714 ohm
25 V	2500 W	1250 W	3.571 ohm
28 V	2800 W	1400 W	4.000 ohm
40 V	4000 W	2000 W	5.714 ohm
50 V	5000 W	2500 W	7.143 ohm

The product is rated 5 kW only at 50 V with the high-current mating option. Total intake shall never exceed 100 A, or 50 A with the default mating cables. Reducing input voltage does not increase the permitted current: 25 V and 200 A is prohibited. At 25 V the input power ceiling is 2.5 kW with high-current mates, or 1.25 kW with default mates. Electronics and distribution losses are included within these ceilings.

These are total input power ceilings, not guaranteed delivered heater power. For each heater use its minimum cold resistance: Ion = Vheater / Rcold. Average heater power is duty x Vheater squared / Rheater. Duty reduces average power but not on-state current.

25 ohm load	28 V	50 V
On-state current	1.12 A	2.00 A
On-state power	31.36 W	100.00 W
Power at 25% duty	7.84 W	25.00 W
48 channels at 25% duty	376.32 W	1200.00 W
48 channels on together	53.76 A	96.00 A

The simultaneous current row excludes electronics and exceeds the default 50 A intake limit at both voltages.

11 Heater Output Electrical Parameters

Each heater output is limited to 7 A on-state. Each 12-channel bank is limited to 50 A, and the complete unit remains subject to the selected 100 A or 50 A intake limit. Low duty cycle does not permit an on-state current above these limits.

Parameter	Definition
Outputs	48; four banks of 12
Load type	Resistive heaters
Switching	High-side positive switching with dedicated return
On-state current	7 A maximum per channel
Bank intake	50 A operational limit
Output voltage	Input bus less distribution and harness drops
PWM reference	10 kHz; up to 99% duty subject to pulse verification
Off state	No commanded conduction; not galvanic isolation
Connector pins	1-12 outputs; 13 NC; 14-25 GND return

Seven simultaneous 7 A loads draw 49 A in one bank before overhead; eight draw 56 A and are prohibited. Inductive loads require separate approval.

12 Heater Channel Current Supervision

The unit supervises heater current and reports channel faults. The 7 A figure is the maximum permitted normal on-state current; it is not a precision current clamp or a claim that every fault trips exactly at 7 A.

Condition	Integration action
Normal operation	Keep current at or below 7 A per output
Unexpected current	Remove demand and inspect the load and harness
Repeated trip	Keep the affected output inhibited; do not retry a persistent fault
Recovery	Use controlled low-energy re-enable after the fault is cleared

Validate supervision and response using the delivered unit and source energy limits. Fault current can briefly exceed operating current; source and harness protection shall account for the prospective short-circuit current.

13 Heater Fault Response and Recovery

On a heater fault, remove demand from the affected channel and prevent its automatic region from repeatedly restoring an unsafe load. If an entire bank is affected, inhibit all twelve outputs in that bank.

Condition	Required response
Persistent short	Keep affected demand off and isolate source energy as required
Repeated faults	Stop retries and retain diagnostic telemetry
Lost communications	Apply the agreed mission safe-state policy
Status reset	Clears records only; not a heater-off command
Recovery	Inspect load and harness, verify off state, then test at limited energy

A command acknowledgement or zero average current is not proof of electrical isolation. Isolate and verify discharged voltage before servicing or unmating.

14 Heater Bank Current Limits

Each 12-channel bank has a 50 A operational limit. The sum of the four bank demands must also respect the 100 A total intake ceiling, or 50 A with default mates. Four simultaneous 50 A bank demands are not permitted.

Demand	Consequence
Twelve outputs at 7 A	84 A; above the bank operational limit
Seven outputs at 7 A	49 A before local overhead
Four banks at 25 A	100 A before whole-unit electronics
Default mating installation	50 A total; 25 A per source feed

Allocate margin for electronics, current uncertainty, transients and unequal feed sharing. Verify that delivered protection settings and the approved scheduler support the selected operating envelope before full-load release.

15 Load Current and Dissipation

Output and input losses heat the TCU and harness, not the remote heater. Use RMS current for resistive losses: Ploss = Irms squared x Rloop. For a channel with on-state current Ion and fractional duty D, Irms = Ion x square root of D.

7 A on-state channel	Duty	RMS current
Continuous on	100%	7.000 A
Half duty	50%	4.950 A
Quarter duty	25%	3.500 A

FET, conductor and contact resistance increase with temperature. Use the hot installation resistance and feasible simultaneous schedule in the thermal budget. A low average current can still produce large instantaneous source demand.

Do not add external heater power to enclosure dissipation. Include electronics, switching, conductor and connector losses separately.

16 PWM Scheduling and Aggregate Limits

Demand	One bank	Four banks
12 x 7 A all on	84 A; prohibited	336 A; prohibited
7 x 7 A on	49 A before overhead	196 A; prohibited
4 x 7 A on	28 A	112 A; prohibited
3 x 7 A on	21 A	84 A before overhead
12 x 2 A on	24 A	96 A before overhead

Phase scheduling can reduce coincident current but does not relax the channel, bank or feed limit. With 48 x 7 A at 25% duty, average heater current is 84 A, while aligned pulses would reach 336 A. Such aligned operation is prohibited.

The PWM reference is 10 kHz. Verify permitted pulse widths and duty settings through the approved command interface. Reserve margin below each input and bank limit.

The product is rated 5 kW only at 50 V with the high-current mating option. Total intake shall never exceed 100 A, or 50 A with the default mating cables. Reducing input voltage does not increase the permitted current: 25 V and 200 A is prohibited. At 25 V the input power ceiling is 2.5 kW with high-current mates, or 1.25 kW with default mates. Electronics and distribution losses are included within these ceilings.

17 Fuse Coordination and Start-up

Coordinate fuses with normal current, input charging, harness limits and source short-circuit energy. A fuse is not a precision 7 A channel limiter. Select DC interruption capability for the prospective source fault current.

Charging pulse illustration	I squared t
9 A for 100 us	0.0081 A squared s
1 A for 100 us	0.0001 A squared s

These rectangular pulses illustrate the calculation only; they are not acceptance waveforms for this product. Integrate the recorded startup i(t) squared and compare with the fuse minimum pre-arcing I squared t, including temperature, repetition and ageing margins.

Coordinate each default feed against its 25 A mating cable rating, or 50 A per feed with the approved high-current option. The fuse rating also depends on harness derating, source fault current and duty history.

18 RTD Allocation and Design Range

Channel group	Sensor	Connection
1-25	PT1000	T-01
26-50	PT1000	T-02
51-75	PT1000	T-03
76-100	PT1000	T-04
101-112	PT100	PD-400

Parameter	PT1000	PT100
Channels	1-100	101-112
Calibration band	-100 to +150 deg C	-100 to +150 deg C
Resistance at -100 deg C	602.5584 ohm	60.25584 ohm
Resistance at 0 deg C	1000 ohm	100 ohm
Resistance at +150 deg C	1573.2513 ohm	157.32513 ohm
Wiring	Two-wire signal and return	Two-wire signal and return
Acquisition span	+/-10 V, 16 bit	+/-10 V, 16 bit

Use nominal platinum coefficients with alpha approximately 0.00385. Calibrate the electronics and the installed lead resistance. The physical RTD element class and thermal mounting determine the additional installed sensor error.

19 Platinum Resistance Conversion

For T at or above 0 deg C, R(T) = R0 x (1 + A x T + B x T squared). Below 0 deg C, add C x (T - 100) x T cubed inside the bracket. Use the negative-temperature branch when solving below zero.

Coefficient	Nominal value
R0	1000 ohm for PT1000; 100 ohm for PT100
A	3.9083 x 10^-3 per deg C
B	-5.775 x 10^-7 per deg C squared
C	-4.183 x 10^-12 per deg C fourth power
Positive inversion	Quadratic solution continuous at 0 deg C
Negative inversion	Numerical root of the negative-temperature expression

Apply the calibrated channel transfer to obtain resistance, then invert the platinum law using the correct PT1000 or PT100 nominal resistance. Use the negative-temperature branch below zero. Do not reuse thermistor beta conversion on these channels.

Resistance injection checks electronics and lead compensation, not the thermal calibration of the installed RTD element.

20 PT1000 Calibration Design Points

Temperature deg C	Resistance ohm	Nominal raw code
-100	602.5584	1046
-75	703.3202	1214
-50	803.0628	1379
-25	901.9234	1541
0	1000.0000	1700
25	1097.3466	1857
50	1193.9713	2010
75	1289.8741	2161
100	1385.0550	2310
125	1479.5141	2456
150	1573.2513	2600

Resistance is the required calibration input. Raw code is a rounded nominal design prediction for signed 16-bit conversion on the +/-10 V span, not an acceptance value or measured residual. Use each channel calibration record for the actual conversion.

Record programmed and verified resistance, raw average, dispersion, temperature and harness identity. Check intermediate points not used to fit the calibration.

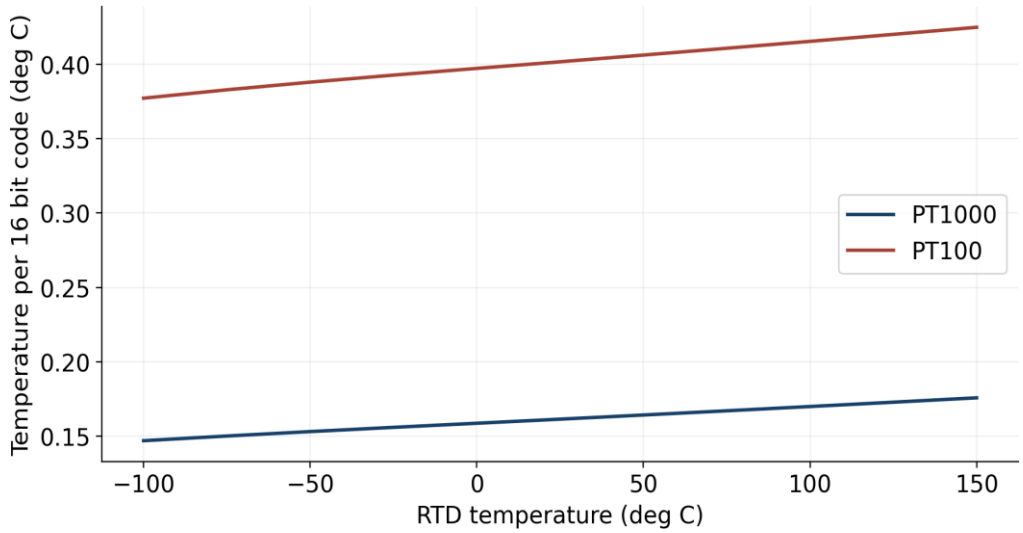
21 PT100 Calibration Design Points

Temperature deg C	Resistance ohm	Nominal raw code
-100	60.2558	399
-75	70.3320	464
-50	80.3063	529
-25	90.1923	593
0	100.0000	657
25	109.7347	719
50	119.3971	781
75	128.9874	842
100	138.5055	903
125	147.9514	962
150	157.3251	1022

Resistance is the required calibration input. Raw code is a rounded nominal design prediction for signed 16-bit conversion on the +/-10 V span, not an acceptance value or measured residual. Use each channel calibration record for the actual conversion.

Record programmed and verified resistance, raw average, dispersion, temperature and harness identity. Check intermediate points not used to fit the calibration.

2 RTD Code Resolution and Averaging



Nominal change represented by one raw ADC code on the +/-10 V span.

Parameter	Value
Full input span	20 V: -10 V to +10 V
Output width	16 bits
Raw code step	305.1758 uV
Maximum nominal PT1000 step	Approximately 0.176 deg C per raw code
Maximum nominal PT100 step	Approximately 0.425 deg C per raw code

These are raw quantization steps, not calibrated absolute temperature accuracy. Averaging and oversampling may reduce noise and support finer averaged estimates, but they do not change the 16-bit raw code step. Validate settling, scan rate and averaging in the intended workload.

23 RTD Lead Resistance and Error Sensitivity

Temperature	PT1000 deg C/ohm	PT100 deg C/ohm	Two-wire implication
-100 deg C	0.2467	2.4673	Sum both conductors
0 deg C	0.2559	2.5587	Sum both conductors
150 deg C	0.2677	2.6773	Sum both conductors

At 0 deg C, one ohm of total uncompensated lead resistance gives approximately +0.256 deg C on PT1000 and +2.559 deg C on PT100. Two-wire lead resistance is included in the sensed resistance. The analog-return contact and common-return voltage error also contribute.

Two-wire lead and contact resistance add to the sensed resistance. Calibrate through the actual harness or measure and compensate its loop resistance. Review compensation when cable length, contact termination or temperature changes.

Keep RTD references separate from heater return currents. PT100 inputs are ten times more sensitive to uncompensated lead resistance than PT1000 inputs at the same temperature.

24 WireFlow Calibration Instrument

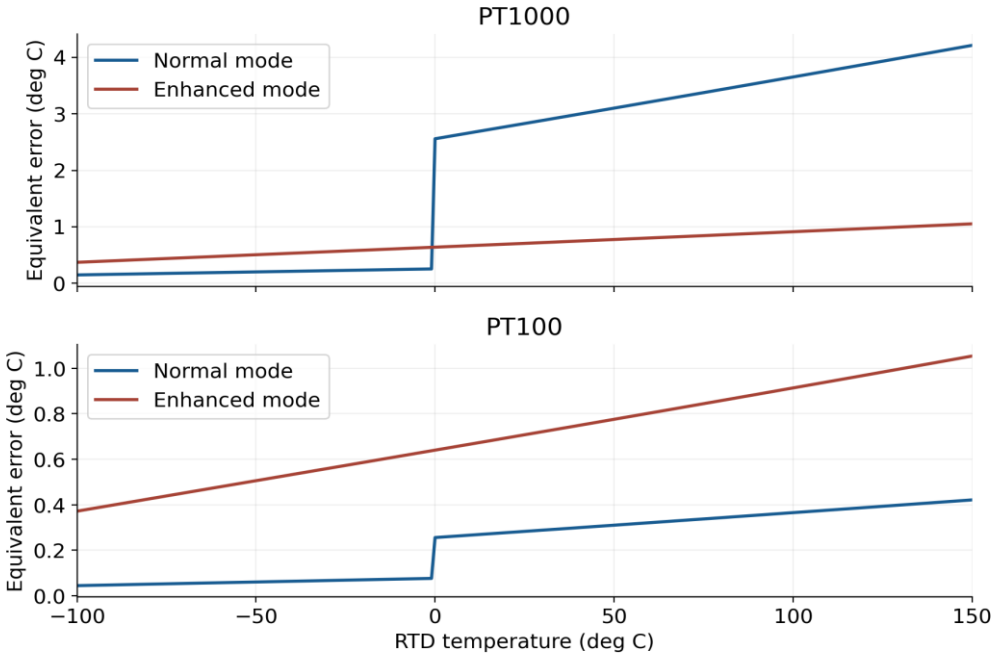
The RTD electronics have been calibrated using the WireFlow WF 2144 USB programmable resistor module, as confirmed by CAVU. The design tables define the required injected resistances; actual residuals shall come from the recorded calibration data.

Parameter	Instrument specification relevant to this test
Normal outputs	Four isolated resistor channels
Resistance span	16 ohms to 160 kOhms
Per-channel maximum dissipation	100 mW
Normal accuracy below 100 ohms	0.03% maximum resistance error
Normal accuracy below 1 kOhm	0.1% maximum resistance error
Normal accuracy below 10 kOhm	1% maximum resistance error
Enhanced mode	Series paired channels; 0.25% maximum resistance error
Enhanced available outputs	Two effective outputs per four-channel module
Initial output	Open circuit until programmed

Both RTD resistance bands fit the module range. Enhanced mode combines channels 0/1 or 2/3 externally in series. Keep each simulated RTD return isolated from USB/PC earth except through the intended TCU harness. The programmed or reported value is not an independent metrology measurement.

WF 2144 calibration reference

25 Calibration Instrument Temperature Contribution



Equivalent temperature error from the resistor module resistance-error bounds.

Type and point	Resistance ohm	Normal bound deg C	Enhanced bound deg C
PT1000 / -100	602.558	0.149	0.372
PT1000 / 0	1000.000	2.559	0.640
PT1000 / 150	1573.251	4.212	1.053
PT100 / -100	60.256	0.045	0.372
PT100 / 0	100.000	0.256	0.640
PT100 / 150	157.325	0.421	1.053

Equivalent error is resistance error divided by the local dR/dT. PT100 normal mode is preferable to enhanced mode across this band. For PT1000 above 1000 ohms, enhanced mode improves the published bound, but it can still exceed 1 deg C near the top of the band.

Do not claim sub-degree absolute electronics calibration from resistance-module resolution alone. Use independently verified injected resistance where a tighter absolute error is required. The plots show calibrator contribution only, not the full sensor or TCU uncertainty.

26 RTD Calibration Procedure

Step	Action
1	Inhibit heaters; stabilize the unit; record input voltage and ambient temperature.
2	Confirm PT1000 channels 1-100, PT100 channels 101-112 and +/-10 V acquisition span.
3	Connect an isolated resistor output between the assigned signal and sensor return.
4	Program each resistance in the design-point table; allow readings to settle.
5	Record verified resistance, raw average, dispersion and channel identity.
6	Apply the approved per-channel calibration and platinum conversion.
7	Check independent intermediate points, monotonicity and open/short recognition.
8	Retain correction, residuals, instrument and harness identification with the unit.

The nominal code step is not an accuracy claim. Calibration acceptance is based on measured residuals and traceable injected resistance.

27 Temperature Telemetry and Range Representation

Function	Definition
Converted temperature request	0xE4; selector 0 all, 1-112 individual
All-channel ordering	112 consecutive temperatures in ascending channel order
Legacy temperature field	Signed 16-bit Q8.8, big-endian
Legacy numerical range	-128.000 to +127.996 deg C
Example +25.5 deg C	Hexadecimal 19 80
Example -10 deg C	Hexadecimal F6 00
Full +150 deg C band	Requires a wider temperature representation or resistance/raw telemetry
Raw temperature acquisition	0xE0 reference command; use the command-specific response definition

The electrical design band reaches +150 deg C; a Q8.8 converted temperature cannot encode that upper value. Do not clip a +150 deg C calibration result into a plausible lower temperature. Use the agreed full-range representation for the mission interface.

For a host-side calibration using the complete band, read raw resistance/ADC data and apply the documented conversion, or use the agreed wider field in the command definition. Invalid, stale, overrange and open/short status shall be retained independently of the numerical temperature.

28 Communication Electrical Summary

Parameter	RS-422	RS-232	Ethernet
Active ports	Primary and redundant	One	One
Physical signaling	Full-duplex differential	Single-ended TX/RX	10BASE-T / 100BASE-TX
Startup reference	921600 bit/s, 8-N-1	115200 bit/s, 8-N-1	Auto-negotiation
Pairs/conductors	Separate TX and RX pairs	TX, RX, reference	100-ohm TX/RX pairs
Connector	PS-100 / PS-200	PS-200	PD-500
Reference	Signal ground	Signal ground	Magnetics & chassis scheme
Application	Hive Talk serial frames	Hive Talk serial frames	Binary Execute service

Active operational interfaces are Ethernet 10/100, primary and redundant RS422, and RS232. Retained CAN and RS485 contacts are inactive and shall be left unconnected.

Physical line compatibility does not establish complete-unit EMC qualification or command authority. Validate each link under the intended heater switching schedule.

29 RS422 Electrical Interface

Parameter	Definition
Interface	Full-duplex differential TX and RX pairs
Startup reference	921600 bit/s; 8 data bits, no parity, one stop bit
Driven differential level	At least 2 V into the specified 100-ohm load
Receive common-mode range	-7 to +12 V
Receiver recognition margin	Use +/-200 mV integration margin
Receiver termination	100 ohms at the receiving end
TX polarity	Y positive, Z negative
RX polarity	A positive, B negative

Connect TCU Y to host RX+, Z to host RX-, host TX+ to TCU A and host TX- to TCU B. Use separate twisted pairs and the assigned signal reference. Confirm baud rate against the unit configuration.

30 RS422 Primary and Redundant Harnesses

Function	TCU signal	PS-100 primary	PS-200 redundant
Host TX+ to TCU RX+	A	6	6
Host TX- to TCU RX-	B	7	7
TCU TX- to host RX-	Z	8	8
TCU TX+ to host RX+	Y	9	9
Signal reference	SIGNAL_GND	3	3

The two links are separate electrical ports but share the Controller and its power. They are not redundant independent processing units. Use one command master at a time and avoid conflicting writes on different interfaces.

Terminate each point-to-point receiver once. Multiple parallel terminations lower load impedance and increase driver current. Verify polarity, termination resistance and idle common-mode voltage before sending configuration commands.

Keep heater current out of serial signal ground. Cable shield termination is a chassis/EMC decision and must not be improvised as a power return. Run a ping/readback test on each link independently before relying on automatic failover.

31 RS232 Electrical Interface

Parameter	Definition
Connector	PS-200
Receive / transmit	Contact 4 RX; contact 5 TX
Reference	Contact 3 signal ground
Start-up reference	115200 bit/s; 8-N-1
Flow control	None
Receive signalling	True bipolar RS232; below -3 V or above +3 V
Transmit signalling	At least +/-5 V under the specified load

Cross host TX to TCU RX and host RX to TCU TX. Do not connect a TTL serial adapter directly to this interface. Include signal reference and check Ping/readback before permitting heater demand.

32 Ethernet Physical Interface

Parameter	Definition
External line	10BASE-T / 100BASE-TX
Connector	PD-500; 15 contacts
Duplex	Negotiated or configured for the installation
Pair impedance	100 ohms differential
Receive pair	10 RX-; 11 RX+
Transmit pair	13 TX-; 14 TX+
Signal reference	8 GND
Auxiliary output	1 +5 V; approved load only; do not back-power
Unused contacts	2-7, 9, 12 and 15; leave open

Use the approved Ethernet mating harness with controlled pair routing. Ethernet pairs are line signals, not 3.3 V GPIO. Do not apply PoE or a DC supply to these contacts.

Check link speed, duplex and packet integrity with the intended heater switching load.

33 Ethernet Network and Execute Service

Parameter	Examined reference interface
Service transport	gRPC over cleartext HTTP/2
TCP port	50051
Service / method	sf2cmd.Device / Execute
Schema	Delivered sf2cmd.proto, proto2
Request fields	seq uint32; cmd_id uint32; optional payload bytes
Response fields	seq uint32; status int32; optional payload bytes
Payload	Binary command bytes, not the complete serial ASCII frame
Address allocation	DHCP reference; static allocation may be configured
Security	No TLS or command authorization established by the reference client

Use the controlled integration network and the agreed IP allocation. The sequence field associates responses with requests; the status field and command-specific payload determine acceptance. A connected TCP channel alone is not a successful heater command.

An Ethernet timeout may follow successful execution if only the response was lost. Read resulting state before repeating a non-idempotent write. Retain command authority arbitration when serial and Ethernet are both connected.

TCU software documentation

34 Digital IO and Service Electrical Interfaces

Interface	Electrical definition	Restriction
PD-400 digital inputs	3.3 V logic level	Do not apply 5 V
PD-400 digital outputs	3.3 V logic level	Signal loads only; not heater power
PJ-300 programming	3.3 V signals	Approved service harness only
PJ-300 reference	Contact 8, +3.3 V output	Do not back-power the unit
CAN and RS485	Inactive retained contacts	Leave unconnected

PD-400 contact 11 is DIGITAL_OUTPUT8. Use the connector table and approved software assignment.

Confirm signal-load compatibility before connecting an external device. Service connections shall not carry heater current.

35 Connector Inventory and Mating Parts

Interface	Unit connector	Mate
T-01 to T-04	A99089-513; socket	A98100-513
H-01 to H-04	280-029S3S25MEPA; socket	280-018P3S25MEGL
P-HP-A / P-HP-B	280-056P1-2P2MEGPA; pin	280-047S1-2W2MEL
Power removable contact	Unit interface above	850-057-0812
PS-100 / PS-200	A98100-009; pin	A99100-009
PD-400	A98014-025 detailed interface	Confirm mating shell against supplied unit
PD-500	A98014-015; pin	A99015-015
PJ-300	A98100-009; pin	A99100-009

For 50 A per power pin, contact Glenair directly and specify factory non-removable contacts and the approved cable termination. There is no separate ordering code specified here. The default mating cable is rated 25 A per power pin.

Use the supplied mating harness or verify the exact shell and contact arrangement against the populated unit before purchasing replacements. Connector ordering identity does not replace the numbered contact map.

36 Contact Table Conventions and Electrical Classes

Contact class	Interpretation
RTD signal	Passive resistance input; do not inject voltage
RTD return	Sensor reference only
Heater output	Switched positive, 7 A maximum on-state
Heater GND return	Dedicated power return; pins 14-25
Digital I/O	3.3 V logic
RS422	Differential TX or RX pair
RS232	Bipolar TX or RX signal
Ethernet	Differential Ethernet line pair
Power input	12-50 V positive and return
NC / inactive	Leave externally unconnected

All contacts are listed, including unused ones. Directions are from the TCU viewpoint. Drawing views shall distinguish mating face from termination side, which are mirrored. For manufacture, use marked cavity numbers and the supplier connector drawing.

37 Sensor Connector T01 Contacts Part 1

T-01: PT1000 channels 1-25. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
1	SENSOR1	PT1000 input
2	AGND	Sensor return
3	SENSOR3	PT1000 input
4	AGND	Sensor return
5	SENSOR6	PT1000 input
6	AGND	Sensor return
7	SENSOR9	PT1000 input
8	AGND	Sensor return
9	SENSOR12	PT1000 input
10	AGND	Sensor return
11	SENSOR15	PT1000 input
12	AGND	Sensor return
13	SENSOR18	PT1000 input
14	AGND	Sensor return
15	SENSOR21	PT1000 input
16	AGND	Sensor return
17	SENSOR24	PT1000 input
18	AGND	Sensor return
19	SENSOR2	PT1000 input
20	AGND	Sensor return
21	SENSOR5	PT1000 input
22	AGND	Sensor return
23	SENSOR8	PT1000 input
24	AGND	Sensor return
25	SENSOR11	PT1000 input
26	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

38 Sensor Connector T01 Contacts Part 2

T-01: PT1000 channels 1-25. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
27	SENSOR14	PT1000 input
28	AGND	Sensor return
29	SENSOR17	PT1000 input
30	AGND	Sensor return
31	SENSOR20	PT1000 input
32	AGND	Sensor return
33	SENSOR23	PT1000 input
34	AGND	Sensor return
35	SENSOR25	PT1000 input
36	AGND	Sensor return
37	SENSOR4	PT1000 input
38	AGND	Sensor return
39	SENSOR7	PT1000 input
40	AGND	Sensor return
41	SENSOR10	PT1000 input
42	AGND	Sensor return
43	SENSOR13	PT1000 input
44	AGND	Sensor return
45	SENSOR16	PT1000 input
46	AGND	Sensor return
47	SENSOR19	PT1000 input
48	AGND	Sensor return
49	SENSOR22	PT1000 input
50	AGND	Sensor return
51	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

39 Sensor Connector T02 Contacts Part 1

T-02: PT1000 channels 26-50. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
1	SENSOR26	PT1000 input
2	AGND	Sensor return
3	SENSOR29	PT1000 input
4	AGND	Sensor return
5	SENSOR31	PT1000 input
6	AGND	Sensor return
7	SENSOR34	PT1000 input
8	AGND	Sensor return
9	SENSOR37	PT1000 input
10	AGND	Sensor return
11	SENSOR40	PT1000 input
12	AGND	Sensor return
13	SENSOR43	PT1000 input
14	AGND	Sensor return
15	SENSOR46	PT1000 input
16	AGND	Sensor return
17	SENSOR49	PT1000 input
18	AGND	Sensor return
19	SENSOR27	PT1000 input
20	AGND	Sensor return
21	SENSOR30	PT1000 input
22	AGND	Sensor return
23	SENSOR33	PT1000 input
24	AGND	Sensor return
25	SENSOR36	PT1000 input
26	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

40 Sensor Connector T02 Contacts Part 2

T-02: PT1000 channels 26-50. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
27	SENSOR39	PT1000 input
28	AGND	Sensor return
29	SENSOR42	PT1000 input
30	AGND	Sensor return
31	SENSOR45	PT1000 input
32	AGND	Sensor return
33	SENSOR48	PT1000 input
34	AGND	Sensor return
35	SENSOR50	PT1000 input
36	AGND	Sensor return
37	SENSOR28	PT1000 input
38	AGND	Sensor return
39	SENSOR32	PT1000 input
40	AGND	Sensor return
41	SENSOR35	PT1000 input
42	AGND	Sensor return
43	SENSOR38	PT1000 input
44	AGND	Sensor return
45	SENSOR41	PT1000 input
46	AGND	Sensor return
47	SENSOR44	PT1000 input
48	AGND	Sensor return
49	SENSOR47	PT1000 input
50	AGND	Sensor return
51	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

41 Sensor Connector T03 Contacts Part 1

T-03: PT1000 channels 51-75. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
1	SENSOR51	PT1000 input
2	AGND	Sensor return
3	SENSOR53	PT1000 input
4	AGND	Sensor return
5	SENSOR56	PT1000 input
6	AGND	Sensor return
7	SENSOR59	PT1000 input
8	AGND	Sensor return
9	SENSOR62	PT1000 input
10	AGND	Sensor return
11	SENSOR65	PT1000 input
12	AGND	Sensor return
13	SENSOR68	PT1000 input
14	AGND	Sensor return
15	SENSOR71	PT1000 input
16	AGND	Sensor return
17	SENSOR74	PT1000 input
18	AGND	Sensor return
19	SENSOR52	PT1000 input
20	AGND	Sensor return
21	SENSOR55	PT1000 input
22	AGND	Sensor return
23	SENSOR58	PT1000 input
24	AGND	Sensor return
25	SENSOR61	PT1000 input
26	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

42 Sensor Connector T03 Contacts Part 2

T-03: PT1000 channels 51-75. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
27	SENSOR64	PT1000 input
28	AGND	Sensor return
29	SENSOR67	PT1000 input
30	AGND	Sensor return
31	SENSOR70	PT1000 input
32	AGND	Sensor return
33	SENSOR73	PT1000 input
34	AGND	Sensor return
35	SENSOR75	PT1000 input
36	AGND	Sensor return
37	SENSOR54	PT1000 input
38	AGND	Sensor return
39	SENSOR57	PT1000 input
40	AGND	Sensor return
41	SENSOR60	PT1000 input
42	AGND	Sensor return
43	SENSOR63	PT1000 input
44	AGND	Sensor return
45	SENSOR66	PT1000 input
46	AGND	Sensor return
47	SENSOR69	PT1000 input
48	AGND	Sensor return
49	SENSOR72	PT1000 input
50	AGND	Sensor return
51	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

43 Sensor Connector T04 Contacts Part 1

T-04: PT1000 channels 76-100. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
1	SENSOR76	PT1000 input
2	AGND	Sensor return
3	SENSOR78	PT1000 input
4	AGND	Sensor return
5	SENSOR81	PT1000 input
6	AGND	Sensor return
7	SENSOR84	PT1000 input
8	AGND	Sensor return
9	SENSOR87	PT1000 input
10	AGND	Sensor return
11	SENSOR90	PT1000 input
12	AGND	Sensor return
13	SENSOR93	PT1000 input
14	AGND	Sensor return
15	SENSOR96	PT1000 input
16	AGND	Sensor return
17	SENSOR99	PT1000 input
18	AGND	Sensor return
19	SENSOR77	PT1000 input
20	AGND	Sensor return
21	SENSOR80	PT1000 input
22	AGND	Sensor return
23	SENSOR83	PT1000 input
24	AGND	Sensor return
25	SENSOR86	PT1000 input
26	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

44 Sensor Connector T04 Contacts Part 2

T-04: PT1000 channels 76-100. Passive RTD signals and analog returns; supplied signal leads AWG #24 to #28.

Contact	Signal	Function
27	SENSOR89	PT1000 input
28	AGND	Sensor return
29	SENSOR92	PT1000 input
30	AGND	Sensor return
31	SENSOR95	PT1000 input
32	AGND	Sensor return
33	SENSOR98	PT1000 input
34	AGND	Sensor return
35	SENSOR100	PT1000 input
36	AGND	Sensor return
37	SENSOR79	PT1000 input
38	AGND	Sensor return
39	SENSOR82	PT1000 input
40	AGND	Sensor return
41	SENSOR85	PT1000 input
42	AGND	Sensor return
43	SENSOR88	PT1000 input
44	AGND	Sensor return
45	SENSOR91	PT1000 input
46	AGND	Sensor return
47	SENSOR94	PT1000 input
48	AGND	Sensor return
49	SENSOR97	PT1000 input
50	AGND	Sensor return
51	AGND	Sensor return

Use the channel reverse lookup to identify the nonsequential signal allocation. Do not use a sensor return for heater or other power current.

45 Additional PT100 Connector PD400 Contacts

PD-400 provides PT100 channels 101-112 and 3.3 V digital I/O. All twelve PT100 channels use contact 13 as the sensor reference. Signal mating leads are AWG #24 to #28.

Contact	Signal	Function
01	SENSOR102	PT100 input
02	SENSOR104	PT100 input
03	SENSOR106	PT100 input
04	SENSOR108	PT100 input
05	SENSOR110	PT100 input
06	SENSOR112	PT100 input
07	DIGITAL_OUTPUT1	3.3 V digital output
08	DIGITAL_OUTPUT2	3.3 V digital output
09	DIGITAL_OUTPUT3	3.3 V digital output
10	DIGITAL_OUTPUT4	3.3 V digital output
11	DIGITAL_OUTPUT8	3.3 V digital output
12	DIGITAL_OUTPUT6	3.3 V digital output
13	SIGNAL_GND	Sensor / signal reference
14	SENSOR101	PT100 input
15	SENSOR103	PT100 input
16	SENSOR105	PT100 input
17	SENSOR107	PT100 input
18	SENSOR109	PT100 input
19	SENSOR111	PT100 input
20	DIGITAL_INPUT1	3.3 V digital input
21	DIGITAL_INPUT2	3.3 V digital input
22	DIGITAL_INPUT3	3.3 V digital input
23	DIGITAL_INPUT4	3.3 V digital input
24	DIGITAL_INPUT5	3.3 V digital input
25	DIGITAL_INPUT6	3.3 V digital input

Contact 11 is DIGITAL_OUTPUT8. Preserve the assigned label. Do not inject voltage into PT100 contacts or use contact 13 as a heater return.

46 Heater Connector H01 Contacts

H-01: heater channels 1-12. Unit connector 280-029S3S25MEPA; mate 280-018P3S25MEGL. Use AWG #20 feed and return conductors.

Pin	Signal	Function
1	HEATER1	Heater output; 7 A max
2	HEATER2	Heater output; 7 A max
3	HEATER3	Heater output; 7 A max
4	HEATER4	Heater output; 7 A max
5	HEATER5	Heater output; 7 A max
6	HEATER6	Heater output; 7 A max
7	HEATER7	Heater output; 7 A max
8	HEATER8	Heater output; 7 A max
9	HEATER9	Heater output; 7 A max
10	HEATER10	Heater output; 7 A max
11	HEATER11	Heater output; 7 A max
12	HEATER12	Heater output; 7 A max
13	NC	Leave open
14	GND_RETURN	Dedicated heater return
15	GND_RETURN	Dedicated heater return
16	GND_RETURN	Dedicated heater return
17	GND_RETURN	Dedicated heater return
18	GND_RETURN	Dedicated heater return
19	GND_RETURN	Dedicated heater return
20	GND_RETURN	Dedicated heater return
21	GND_RETURN	Dedicated heater return
22	GND_RETURN	Dedicated heater return
23	GND_RETURN	Dedicated heater return
24	GND_RETURN	Dedicated heater return
25	GND_RETURN	Dedicated heater return

Pins 1-12 are outputs in order. Pin 13 is NC. Pins 14-25 are GND return. Use all assigned returns and verify bank return capacity. The bank operational limit is 50 A.

47 Heater Connector H02 Contacts

H-02: heater channels 13-24. Unit connector 280-029S3S25MEPA; mate 280-018P3S25MEGL. Use AWG #20 feed and return conductors.

Pin	Signal	Function
1	HEATER13	Heater output; 7 A max
2	HEATER14	Heater output; 7 A max
3	HEATER15	Heater output; 7 A max
4	HEATER16	Heater output; 7 A max
5	HEATER17	Heater output; 7 A max
6	HEATER18	Heater output; 7 A max
7	HEATER19	Heater output; 7 A max
8	HEATER20	Heater output; 7 A max
9	HEATER21	Heater output; 7 A max
10	HEATER22	Heater output; 7 A max
11	HEATER23	Heater output; 7 A max
12	HEATER24	Heater output; 7 A max
13	NC	Leave open
14	GND_RETURN	Dedicated heater return
15	GND_RETURN	Dedicated heater return
16	GND_RETURN	Dedicated heater return
17	GND_RETURN	Dedicated heater return
18	GND_RETURN	Dedicated heater return
19	GND_RETURN	Dedicated heater return
20	GND_RETURN	Dedicated heater return
21	GND_RETURN	Dedicated heater return
22	GND_RETURN	Dedicated heater return
23	GND_RETURN	Dedicated heater return
24	GND_RETURN	Dedicated heater return
25	GND_RETURN	Dedicated heater return

Pins 1-12 are outputs in order. Pin 13 is NC. Pins 14-25 are GND return. Use all assigned returns and verify bank return capacity. The bank operational limit is 50 A.

48 Heater Connector H03 Contacts

H-03: heater channels 25-36. Unit connector 280-029S3S25MEPA; mate 280-018P3S25MEGL. Use AWG #20 feed and return conductors.

Pin	Signal	Function
1	HEATER25	Heater output; 7 A max
2	HEATER26	Heater output; 7 A max
3	HEATER27	Heater output; 7 A max
4	HEATER28	Heater output; 7 A max
5	HEATER29	Heater output; 7 A max
6	HEATER30	Heater output; 7 A max
7	HEATER31	Heater output; 7 A max
8	HEATER32	Heater output; 7 A max
9	HEATER33	Heater output; 7 A max
10	HEATER34	Heater output; 7 A max
11	HEATER35	Heater output; 7 A max
12	HEATER36	Heater output; 7 A max
13	NC	Leave open
14	GND_RETURN	Dedicated heater return
15	GND_RETURN	Dedicated heater return
16	GND_RETURN	Dedicated heater return
17	GND_RETURN	Dedicated heater return
18	GND_RETURN	Dedicated heater return
19	GND_RETURN	Dedicated heater return
20	GND_RETURN	Dedicated heater return
21	GND_RETURN	Dedicated heater return
22	GND_RETURN	Dedicated heater return
23	GND_RETURN	Dedicated heater return
24	GND_RETURN	Dedicated heater return
25	GND_RETURN	Dedicated heater return

Pins 1-12 are outputs in order. Pin 13 is NC. Pins 14-25 are GND return. Use all assigned returns and verify bank return capacity. The bank operational limit is 50 A.

49 Heater Connector H04 Contacts

H-04: heater channels 37-48. Unit connector 280-029S3S25MEPA; mate 280-018P3S25MEGL. Use AWG #20 feed and return conductors.

Pin	Signal	Function
1	HEATER37	Heater output; 7 A max
2	HEATER38	Heater output; 7 A max
3	HEATER39	Heater output; 7 A max
4	HEATER40	Heater output; 7 A max
5	HEATER41	Heater output; 7 A max
6	HEATER42	Heater output; 7 A max
7	HEATER43	Heater output; 7 A max
8	HEATER44	Heater output; 7 A max
9	HEATER45	Heater output; 7 A max
10	HEATER46	Heater output; 7 A max
11	HEATER47	Heater output; 7 A max
12	HEATER48	Heater output; 7 A max
13	NC	Leave open
14	GND_RETURN	Dedicated heater return
15	GND_RETURN	Dedicated heater return
16	GND_RETURN	Dedicated heater return
17	GND_RETURN	Dedicated heater return
18	GND_RETURN	Dedicated heater return
19	GND_RETURN	Dedicated heater return
20	GND_RETURN	Dedicated heater return
21	GND_RETURN	Dedicated heater return
22	GND_RETURN	Dedicated heater return
23	GND_RETURN	Dedicated heater return
24	GND_RETURN	Dedicated heater return
25	GND_RETURN	Dedicated heater return

Pins 1-12 are outputs in order. Pin 13 is NC. Pins 14-25 are GND return. Use all assigned returns and verify bank return capacity. The bank operational limit is 50 A.

50 Serial Connector PS100 Contacts

Contact	Signal	Direction	Function
01	CAN1_H	Inactive	Leave unconnected
02	CAN1_L	Inactive	Leave unconnected
03	SIGNAL_GND	Reference	Signal reference
04	RS485_A	Inactive	Leave unconnected
05	RS485_B	Inactive	Leave unconnected
06	RS422_1A	Input	RS422 RX+
07	RS422_1B	Input	RS422 RX-
08	RS422_1Z	Output	RS422 TX-
09	RS422_1Y	Output	RS422 TX+

Use supplied mating leads, normally AWG #24 to #28. Preserve pair polarity and signal reference; unused contacts remain open.

51 Serial Connector PS200 Contacts

Contact	Signal	Direction	Function
01	CAN2_H	Inactive	Leave unconnected
02	CAN2_L	Inactive	Leave unconnected
03	SIGNAL_GND	Reference	Signal reference
04	RS232_RX	Input	RS232 receive
05	RS232_TX	Output	RS232 transmit
06	RS422_2A	Input	RS422 RX+
07	RS422_2B	Input	RS422 RX-
08	RS422_2Z	Output	RS422 TX-
09	RS422_2Y	Output	RS422 TX+

Use supplied mating leads, normally AWG #24 to #28. Preserve pair polarity and signal reference; unused contacts remain open.

52 Ethernet Connector PD500 Contacts

Contact	Signal	Direction	Function
01	+5V	Output	Auxiliary 5 V; approved load only
02	N.C.	None	Leave open
03	N.C.	None	Leave open
04	N.C.	None	Leave open
05	N.C.	None	Leave open
06	N.C.	None	Leave open
07	N.C.	None	Leave open
08	GND	Reference	Signal reference
09	N.C.	None	Leave open
10	RX-	Input	Ethernet receive pair
11	RX+	Input	Ethernet receive pair
12	N.C.	None	Leave open
13	TX-	Output	Ethernet transmit pair
14	TX+	Output	Ethernet transmit pair
15	N.C.	None	Leave open

Use supplied mating leads, normally AWG #24 to #28. Preserve pair polarity and signal reference; unused contacts remain open.

53 Programming Connector PJ300 Contacts

Contact	Signal	Direction	Function
01	JTAG_TMS	Input	Approved 3.3 V programming harness
02	JTAG_SELECT	Input	Approved 3.3 V programming harness
03	JTAG_TDO	Output	Programming data output
04	SIGNAL_GND	Reference	Signal reference
05	JTAG_TCK	Input	Approved 3.3 V programming harness
06	JTAG_TDI	Input	Approved 3.3 V programming harness
07	JTAG_TRST	Input	Approved 3.3 V programming harness
08	+3.3V(OUT)	Output	3.3 V reference; do not back-power
09	JTAG_NRST	Input	Approved 3.3 V programming harness

Use only the approved 3.3 V ground-service programming harness. Keep heating inhibited and do not back-power through the reference output.

54 Sensor Channel to Contact Lookup

Bank index	T-01 ch : pin	T-02 ch : pin	T-03 ch : pin	T-04 ch : pin
1	1 : 1	26 : 1	51 : 1	76 : 1
2	2 : 19	27 : 19	52 : 19	77 : 19
3	3 : 3	28 : 37	53 : 3	78 : 3
4	4 : 37	29 : 3	54 : 37	79 : 37
5	5 : 21	30 : 21	55 : 21	80 : 21
6	6 : 5	31 : 5	56 : 5	81 : 5
7	7 : 39	32 : 39	57 : 39	82 : 39
8	8 : 23	33 : 23	58 : 23	83 : 23
9	9 : 7	34 : 7	59 : 7	84 : 7
10	10 : 41	35 : 41	60 : 41	85 : 41
11	11 : 25	36 : 25	61 : 25	86 : 25
12	12 : 9	37 : 9	62 : 9	87 : 9
13	13 : 43	38 : 43	63 : 43	88 : 43
14	14 : 27	39 : 27	64 : 27	89 : 27
15	15 : 11	40 : 11	65 : 11	90 : 11
16	16 : 45	41 : 45	66 : 45	91 : 45
17	17 : 29	42 : 29	67 : 29	92 : 29
18	18 : 13	43 : 13	68 : 13	93 : 13
19	19 : 47	44 : 47	69 : 47	94 : 47
20	20 : 31	45 : 31	70 : 31	95 : 31
21	21 : 15	46 : 15	71 : 15	96 : 15
22	22 : 49	47 : 49	72 : 49	97 : 49
23	23 : 33	48 : 33	73 : 33	98 : 33
24	24 : 17	49 : 17	74 : 17	99 : 17
25	25 : 35	50 : 35	75 : 35	100 : 35

Each cell gives acquisition channel number followed by its signal contact. Its return is the next even contact. Channel assignment is not sequential by contact number: for example T-01 channel 3 is on contact 3, but channel 4 is on contact 37.

This reverse lookup is derived from every individual standard contact assignment, not a sequential pin formula. Contact 51 is the additional analog reference. Sensor channel numbers must not be confused with heater-output numbers.

55 PT100 and Heater Reverse Lookup

PT100 channel	PD-400 signal	Return	Nominal type
101	14	13	PT100
102	1	13	PT100
103	15	13	PT100
104	2	13	PT100
105	16	13	PT100
106	3	13	PT100
107	17	13	PT100
108	4	13	PT100
109	18	13	PT100
110	5	13	PT100
111	19	13	PT100
112	6	13	PT100

Bank	Heaters	Output pins	Return pins
H-01	1-12	1-12	14-25
H-02	13-24	1-12	14-25
H-03	25-36	1-12	14-25
H-04	37-48	1-12	14-25

For heater n: bank = floor((n-1)/12)+1 and output pin = 1 + ((n-1) modulo 12). Pin 13 is NC on every heater connector. Verify load labels by unpowered continuity and a low-energy one-channel test.

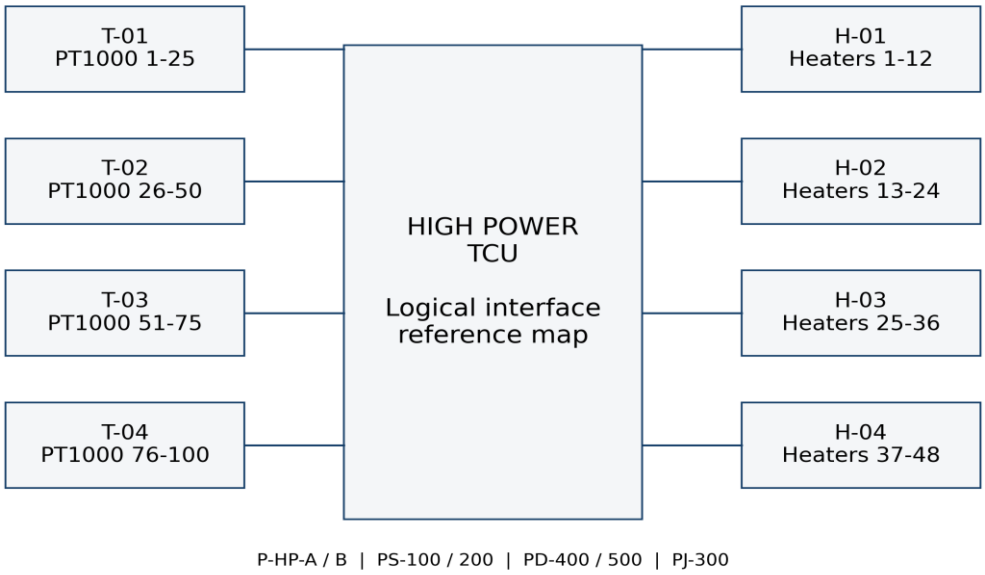
56 Harness Grounding and Shielding

Keep input power, heater returns, sensor references and communication references in their assigned paths. Do not use a sensor contact, communication reference or enclosure fastener as a heater return.

Harness	Wire and routing requirement
Power input positive / return	AWG #8; matched loops and supplier-approved terminations
Heater feed / return	AWG #20; use all assigned return contacts
RTD and discrete signals	Supplied mate leads, AWG #24 to #28
RS422	Twisted TX and RX pairs plus defined reference
RS232	TX, RX and controlled signal reference
Ethernet	100 ohm differential pairs; supplied Ethernet harness
Shields and shells	Bond according to system EMC scheme; not load returns

Separate heater switching loops from RTD pairs. Control common-return impedance and include the installed sensor lead resistance in calibration.

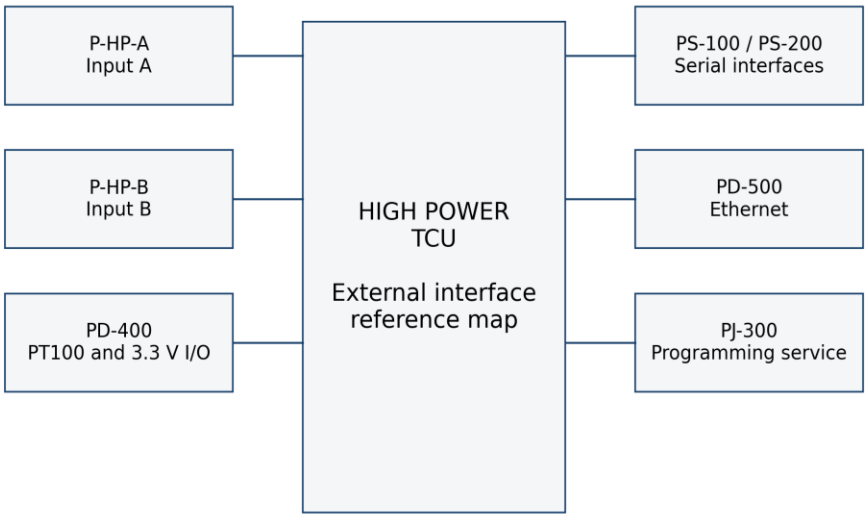
57 External Connector Reference Drawing



Logical sensor and heater connector references; not physical connector placement.

T-01 to T-04 contain the 100 PT1000 inputs. H-01 to H-04 contain the 48 heater outputs. The contact tables define every connection; the diagram is not a mating-face pin layout.

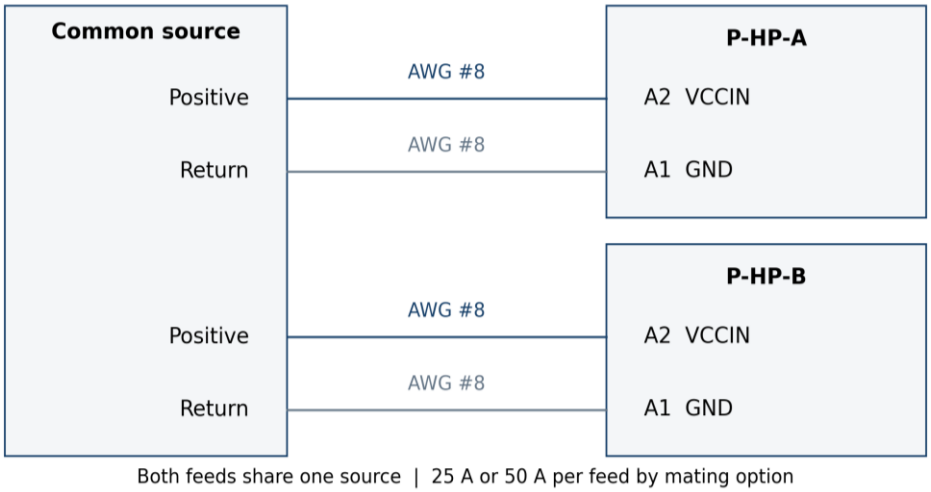
58 Power Communication and Service References



Connector identifiers correspond to the numbered contact tables.

Use these references on harness labels, continuity records and integration drawings. Preserve connector identity at both ends of each cable.

59 Power Harness Connection Drawing

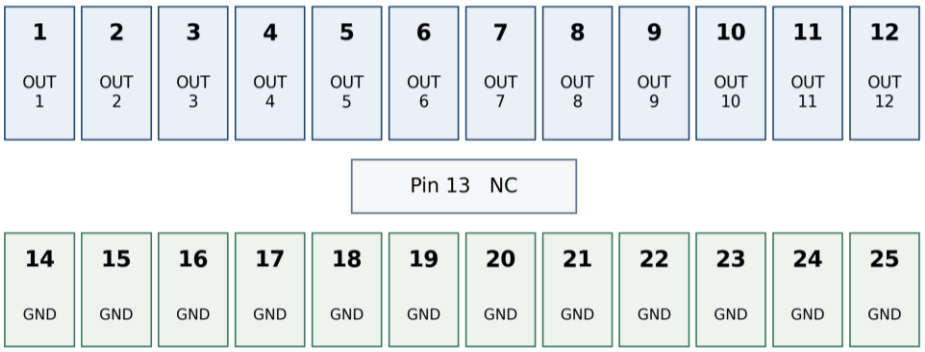


Positive and return connections for both parallel input feeds.

For 50 A per power pin, contact Glenair directly and specify factory non-removable contacts and the approved cable termination. There is no separate ordering code specified here. The default mating cable is rated 25 A per power pin.

Input positive and return conductors are AWG #8. Use supplier-approved termination for the actual mate. Do not cut strands or force this conductor into a smaller removable contact barrel.

60 Heater Connector Allocation Drawing



Pin allocation for all four heater output connectors.

Outputs are on pins 1-12, pin 13 is NC, and pins 14-25 are GND return. This functional allocation is not a contact-face geometrical drawing; use the supplier mating-face drawing to locate the marked cavities.

61 Heater Harness Connection Drawing



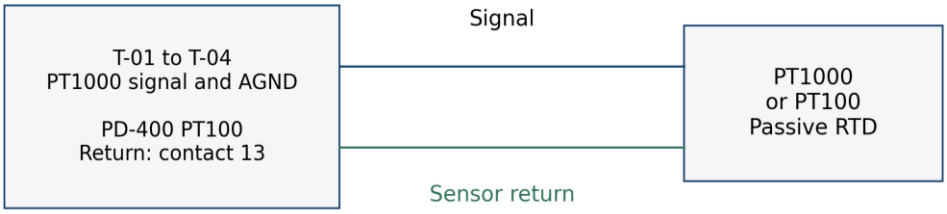
Use all assigned return contacts | 7 A maximum on-state per channel

50 A per card and 100 A / 50 A total intake limits still apply

Each heater uses a switched positive and dedicated power return.

Use AWG #20 heater feed and return conductors. Distribute the bank return across all twelve return contacts; do not concentrate the whole bank current in one return. The 50 A bank limit still applies.

62 RTD Harness Connection Drawing



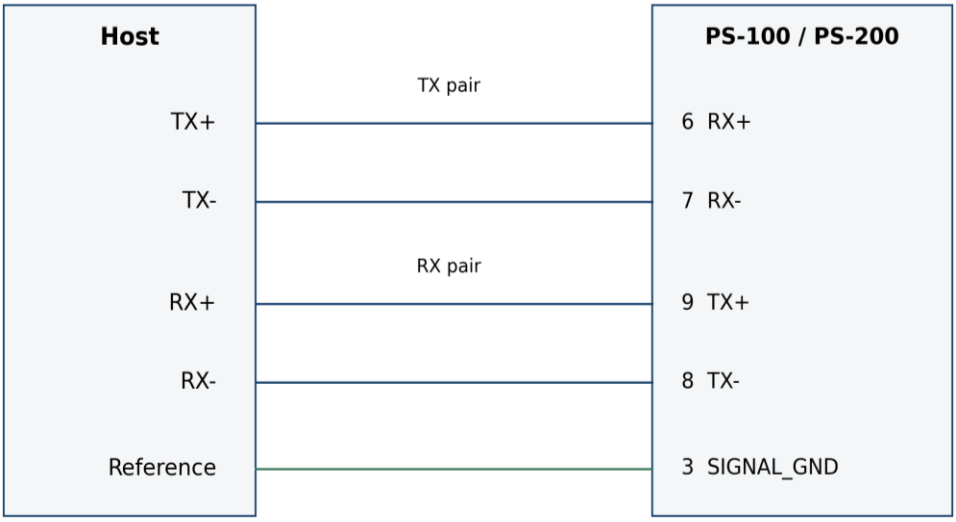
Signal harness: supplied mating leads, AWG #24 to #28

Use the channel-to-contact table; sensor pins are not sequential

Passive RTD wiring to the assigned signal and sensor reference.

The supplied signal mates may use AWG #24 to #28. Include both conductor and contact resistance in two-wire calibration. Contact 13 is the common PT100 reference on PD-400.

63 RS422 Harness Connection Drawing

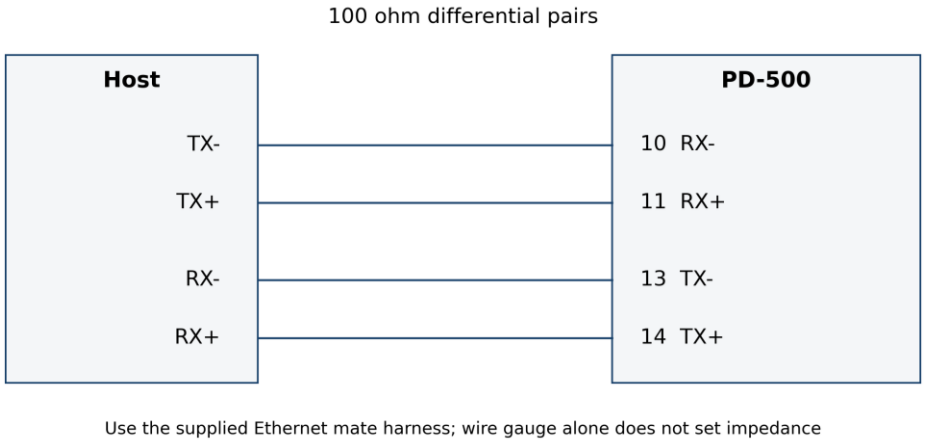


Twisted differential pairs | Supplied leads AWG #24 to #28

Host transmit connects to TCU receive; TCU transmit connects to host receive.

The allocation is the same on PS-100 and PS-200 for the respective RS422 port. Use twisted pairs and contact 3 for the defined signal reference. Unused CAN and RS485 contacts remain open.

64 Ethernet Harness Connection Drawing



PD-500 pair identities for a host-to-TCU link.

Use the approved mating cable and network interface. Preserve 100 ohm differential routing and pair polarity; conductor gauge alone does not guarantee Ethernet performance.

65 Harness Wire Sizes and Termination

Harness group	Conductor	Requirement
Input positive and return	AWG #8	Both power feeds; matched loop resistance
Heater positive and return	AWG #20	Use all return contacts; 7 A max per output
Sensor and discrete signals	AWG #24-28	As supplied with the mating connector
Serial signals	AWG #24-28	Twisted differential pairs where applicable
Ethernet	Supplied mate harness	Controlled differential impedance

AWG #8 is the main conductor requirement, not an instruction to crimp it into an incompatible socket. The supplier shall provide a suitable factory termination or an approved transition for the selected power mating assembly.

Gauge does not alone establish ampacity. Accept the complete harness for insulation temperature, vacuum or air environment, bundling, duty cycle, return sharing, contacts and mission derating. AWG #20 is not an unconditional 7 A continuous vacuum-bundle guarantee.

66 Harness Voltage Drop and Heating

Circuit at 20 deg C	Loop resistance	Current	Drop / loss
AWG #8, 1 m one-way	4.122 mOhm	25 A	0.103 V / 2.576 W
AWG #8, 1 m one-way	4.122 mOhm	50 A	0.206 V / 10.305 W
AWG #20, 1 m one-way	66.617 mOhm	7 A on	0.466 V / 3.264 W
Same heater at 25% duty	66.617 mOhm	3.5 A RMS	0.466 V on / 0.816 W avg

Examples include one outgoing and one equal-length return conductor of nominal copper, but not connector or splice resistance. Actual parallel returns change the return contribution. Resistance rises by approximately 23.6% from 20 to 80 deg C.

Two balanced AWG #8 feed loops at 50 A each dissipate about 20.61 W total per 1 m one-way run; at 25 A each, about 5.15 W. Allocate these losses to the harness, not to remote heater power.

Use actual cable resistance and temperature for final acceptance. Copper calculation: rho at 20 deg C = 1.7241 x 10^-8 ohm m; resistance temperature coefficient 0.00393 per deg C.

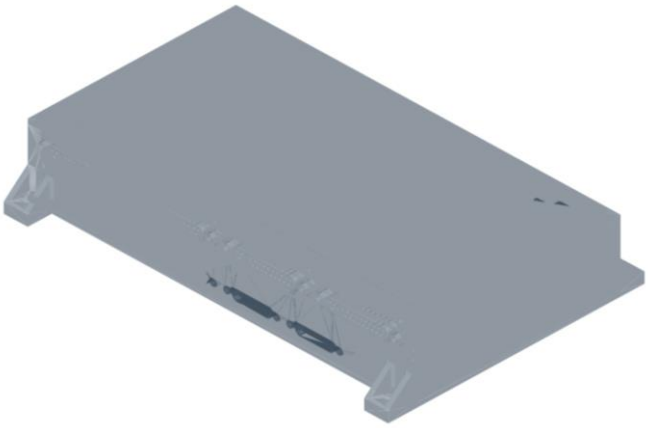
67 Signal Harness Lead Compensation

1 m one-way copper at 20 deg C	Loop R	PT1000 error at 0 deg C	PT100 error at 0 deg C
AWG #24	0.1684 ohm	+0.043 deg C	+0.431 deg C
AWG #28	0.4258 ohm	+0.109 deg C	+1.090 deg C

These are nominal uncompensated two-wire errors, excluding contacts and sensor tolerance. Double one-way length doubles conductor resistance and its approximate error. Lead resistance also varies with harness temperature.

Calibrate using the actual sensor harness where practical. For replaced cables, repeat loop-resistance characterization and update the affected channel correction. Keep signal return and heater return routing separate.

68 Mechanical Envelope and Assembly View

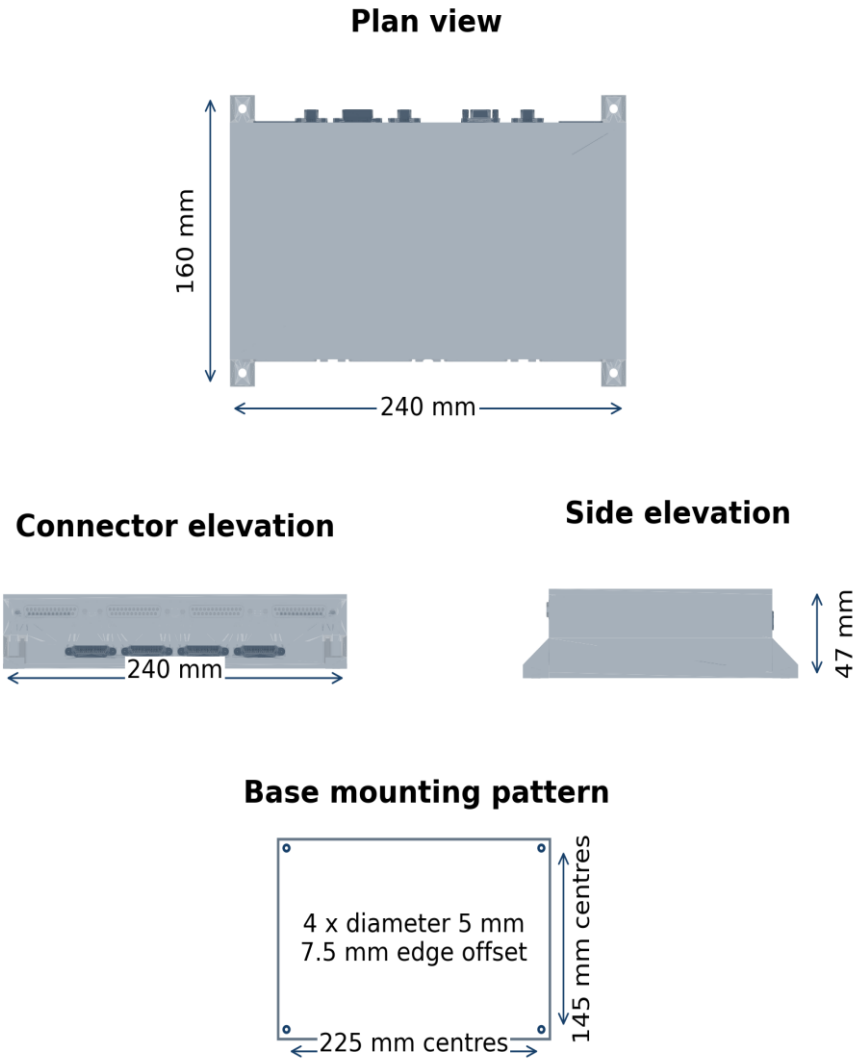


High Power TCU assembly. Mating cable clearance is additional.

Parameter	Nominal value
Envelope	240 x 160 x 47 mm
Mass	Approximately 1.8 kg
Mounting	Four diameter 5 mm base holes
Hole centre spacing	225 x 145 mm
Hole edge offset	7.5 mm
Excluded from envelope	Mating plugs, backshells, bends and service clearance

Use the high-power interface dimensions rather than standard-unit dimensions. Reserve clearance for the selected power harness termination and cable bend radius.

69 High Power Mechanical Drawing



Dimensions in millimetres.

70 Mounting Coordinates and Integration Tolerances

Hole	X mm	Y mm	Z mm
M1	7.5	7.5	0
M2	232.5	7.5	0
M3	7.5	152.5	0
M4	232.5	152.5	0

Feature	Nominal dimension	ISO 2768 medium example
Base length	240 mm	+/-0.5 mm
Base width	160 mm	+/-0.5 mm
Height	47 mm	+/-0.3 mm
Hole diameter	5 mm	+/-0.1 mm
X hole span	225 mm	+/-0.5 mm
Y hole span	145 mm	+/-0.5 mm
Edge offset	7.5 mm	+/-0.2 mm

These are proposed general integration tolerances calculated from the ISO 2768-1 medium dimension intervals, not tolerance metadata extracted from the STEP file. Location, flatness and perpendicularity need explicit drawing requirements; independent linear tolerances do not establish a complete positional-tolerance scheme.

General tolerance standard

71 Mass Properties and Structural Planning

Planning quantity	Calculated value or definition
Unit mass	Approximately 1.8 kg
Envelope geometric centre	X 120 mm; Y 80 mm; Z 23.5 mm
Uniform-envelope Ixx	0.00417135 kg m squared
Uniform-envelope Iyy	0.00897135 kg m squared
Uniform-envelope Izz	0.01248000 kg m squared
Illustrative 30 g inertia force	529.74 N total
Equal four-fastener share	132.435 N per fastener
30 g lateral moment at 23.5 mm	12.449 N m

The geometric centre and uniform-box inertias are planning calculations, not measured centre of gravity or mass properties of the assembled electronics. STEP geometry lacks the full material/population data needed for those real quantities.

The 30 g example is a load case for preliminary integration, not a declared launch qualification level. Actual interface loads require mission spectra, centre of gravity, dynamic amplification, joint stiffness and preload. Do not copy standard-unit inertias into the high-power flight model.

72 Fasteners and Thermal Mounting

The four nominal 5 mm holes permit a preliminary M4 clearance-fastener installation, subject to the actual mounting stack and customer hardware. Use washers and an approved locking method without transferring connector mating torque to the base mounting fasteners.

Calculated M4 example	Value
Assumed fastener class	A2-70; 450 MPa proof stress
Tensile stress area	8.78 mm squared
Example target preload	60% proof = 2370.6 N per fastener
Assumed torque coefficient	K = 0.18
Calculated torque	T = K x F x d = 1.707 N m
Approval status	Assembly example; not final flight torque

A final torque cannot be inferred from hole diameter alone. Friction, lubrication, surface coating, thread engagement and baseplate material determine preload. NASA-STD-5020 provides a bolted-joint verification framework; it does not make this example a qualified joint.

The standard baseplate reference is Al7075-T6 with Ra 3.2 um. Do not reuse the old 22740 mm squared contact area for this geometry. The new full rectangular footprint is 38400 mm squared, but only actual mating lands transfer heat.

Fastener design and verification reference

73 Thermal Dissipation and Conduction

The enclosure rejects electronics, FET, conductor and contact losses. External heater energy is dissipated at the remote heater and is not enclosure heat. The defined monitoring profile projects approximately 9.91 W electronics input at 50 V before heater-dependent losses.

Illustrative enclosure heat	Allowed rise	Required thermal resistance
10 W	20 deg C	2.00 K/W
20 W	20 deg C	1.00 K/W
30 W	20 deg C	0.67 K/W

Required thermal resistance is temperature rise divided by dissipation. These are planning examples, not measured unit thermal performance. Verify mounting interface, hot-case loading, contact resistance and the real RMS current schedule.

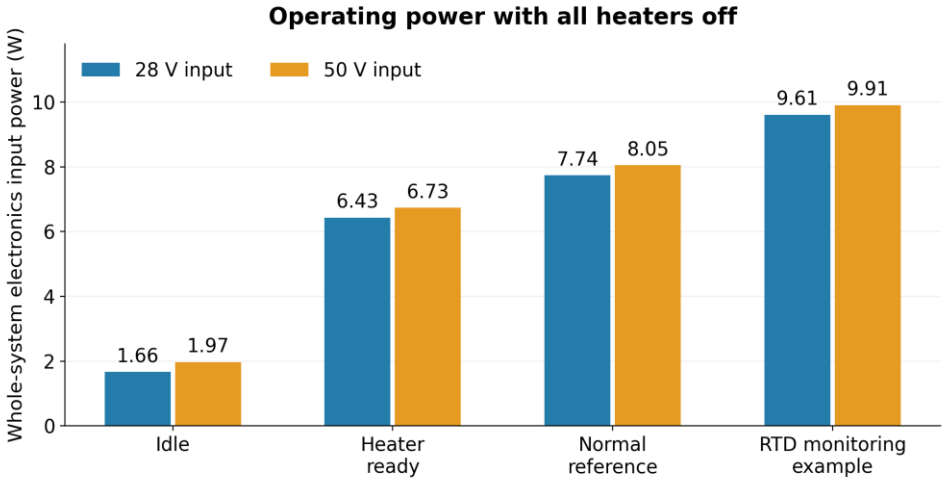
74 Environmental and Assurance Interfaces

Parameter	Integration envelope	Status
Unit operational target	-40 to +85 deg C	Design target; load derating applies
Standard survival reference	-50 to +90 deg C	Not transferred as high-power qualification
Ground storage reference	+5 to +30 deg C	Standard documentation reference
Sensor calibration band	-100 to +150 deg C	Remote RTD range, not unit ambient range
Connector temperature capability	Supplier component rating	Not full-unit qualification
EMC	RE / RS / CE / CS campaign	Configuration-specific evidence
Shock and vibration	Mission interface loads	Not inferred from connector catalog
Radiation	Mission assurance assessment	Existing Controller architecture

The sensor elements may be at temperatures different from the TCU enclosure. RTD calibration range and TCU ambient operating temperature are different requirements. Preserve that distinction in thermal tests and user displays.

Standards specify methods and classification; they do not supply missing qualification results. The final high-power build and harness should be represented in the product-assurance campaign rather than substituting standard-unit measurements.

75 Whole System Electronics Power Charts



Reconciled whole-system electronics projections with heater elements disconnected.

Operating state	28 V input	50 V input
Idle	1.66 W / 59.4 mA	1.97 W / 39.3 mA
Heater ready	6.43 W / 229.7 mA	6.73 W / 134.7 mA
Normal reference	7.74 W / 276.4 mA	8.05 W / 160.9 mA
RTD monitoring example	9.61 W / 343.1 mA	9.91 W / 198.1 mA

Electronics values are whole-system engineering projections from the reconciled measurement and circuit model, with heater elements disconnected. They are not measured high-power-unit acceptance limits. Heater energy, load-dependent conduction and harness losses are additional.

Idle keeps all heaters off with acquisition, communication and memory activity stopped. Heater ready prepares all four banks for heating while their outputs remain off. The monitoring workload is defined in the next section.

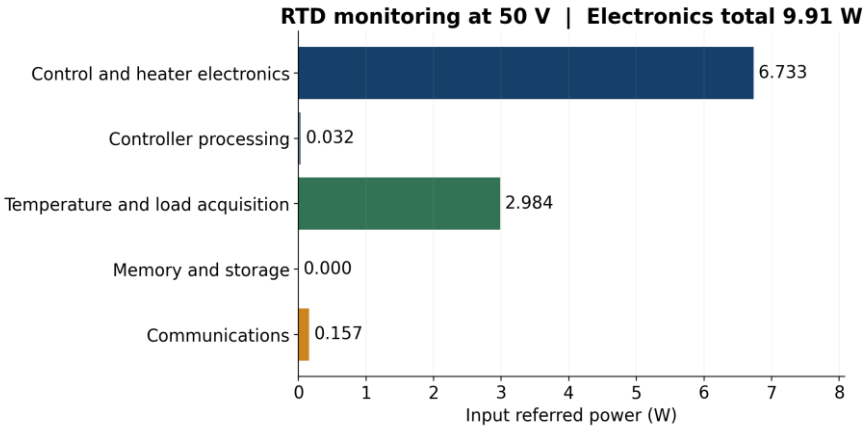
76 Workload Definition for Power Budgeting

State	Conditions
Idle	All heaters off; acquisition, traffic and memory idle
Heater ready	All outputs off; all four banks prepared for heating
Normal reference	Heaters off; reference processing and communication workload
RTD monitoring	100 PT1000 and 12 PT100 at 25 deg C; full acquisition activity; 25% processing utilization; 100BASE-TX link; one RS422 at 10% traffic; memory idle

These profiles describe whole-system electronics consumption with external heater elements disconnected. They are projections for power planning, not measured acceptance limits for a delivered high-power unit.

Add remote heater energy and load-dependent distribution and harness losses to the selected electronics profile. Record the actual voltage, scan rate, traffic and heating schedule for verification.

77 Electronics Power Breakdown



Defined 50 V monitoring profile by functional activity.

Section	Heater ready	RTD monitoring
Control and heater electronics	6.733 W	6.733 W
Controller processing increment	0.000 W	0.032 W
Temperature and load acquisition	0.000 W	2.984 W
Memory and storage increment	0.000 W	0.000 W
Communications increment	0.000 W	0.157 W

Zero activity increment means idle consumption is already included in the electronics baseline; it does not mean that the section has zero total power. The sum is whole-system electronics power, before external heater loads.

78 Heater Load and Mission Energy Examples

48 x 25 ohm load	Bus	Duty	Heater energy per hour
Reference mission load	28 V	25%	376.32 Wh
Reference mission load	50 V	25%	1200.00 Wh
Half the channels	50 V	25%	600.00 Wh
All channels	50 V	50%	2400.00 Wh

Average source energy adds electronics and distribution losses to the external heater energy. For 48 x 25 ohm heaters at 50 V and 25% duty, average heater intake is 24 A, but aligned on pulses reach 96 A. That pulse is not allowed with the default 50 A total mates.

Phase distribution can make the same average workload compatible with a lower instantaneous intake, provided the card and source scheduler enforce their limits. At 50 V a nominal 100 A source leaves about 4.99 kW for heaters before conduction losses in the defined monitoring state.

Orbit energy equals the sum of Pstate x duration for each state and heater segment. Include eclipse survival duty, contingency heating and conversion/harness margins; do not multiply the 5 kW class by an entire orbit unless full-power heating is actually commanded.

79 Command Frame and CRC Definition

Serial frame format is $SSDDCCLLLL[PAYLOAD]:RR followed by line feed. Fields are hexadecimal ASCII. SS and DD are source/destination addresses, CC is command, LLLL is the binary payload length and RR is the CRC.

Field	Definition
SS / DD	Two hex characters each; default host 00 to TCU 01
CC	Two hex characters; command identifier
LLLL	Four hex characters; binary payload byte count
Payload	Two hex characters per binary byte
Delimiter	Colon before the CRC
CRC	Polynomial 0xEB; initial 0; MSB-first; no final XOR
CRC coverage	ASCII bytes from SS through colon; exclude $, CRC and line feed
Outstanding requests	One at a time
Response transport	The requesting interface

For each covered byte, XOR it into the CRC accumulator. Repeat eight times: shift left one bit and XOR 0xEB when the old bit 7 was set. Keep the accumulator to eight bits. Transmit the result as two uppercase hexadecimal characters.

The frame length on the wire is 15 + 2 x payload bytes including the final line feed. A one-byte payload therefore uses 17 bytes; a zero-payload ping uses 15 bytes.

80 Command Examples and Response Validation

Transaction	ASCII frame before line feed
Ping request	$0001010000:17
Ping acknowledgement	$0100FF000100:38
Read temperature channel 1	$0001E4000101:A0
Read all temperatures	$0001E4000100:90

Check start marker, address, declared binary length, payload length, colon, CRC and returned status before consuming a response. A positive transport delivery does not by itself establish application acceptance.

The all-temperature response lists channels in order. Label channels 1-100 as PT1000 and 101-112 as PT100. Use the complete temperature representation discussed earlier; Q8.8 cannot carry the upper +150 deg C endpoint.

On a timeout, read resulting state before repeating a state-changing request. Command retries shall not create additional automatic-control region actions or bypass source current scheduling. A status-history reset is not a heater-off operation.

81 Application Command Reference

Function	Reference ID	Payload or interpretation
Ping	0x01	No payload; acknowledgement
Node address	0x85	Read configured address
Temperature	0xE4	Selector 0 all, 1-112 individual
Raw sensor data	0xE0	Command-specific raw ADC response
Raw heater monitoring	0xE1	Command-specific current response
Heater power	0xE8	Selector 0 all, 1-48 individual
Set / get heater state	0x70 / 0x71	Heater selector and state; verify readback
Automatic control	0x28	Region selector and mode
Set / get region	0x30 / 0x31	Region configuration
Region status	0x34	Field-specific status record
Region history	0x38	Read history
Status reset	0x3C	Reset status data; not a load inhibit
Heater parameters	0x36 / 0x37	Read/write approved load parameters
Housekeeping	0x49	Field-specific engineering quantities

These reference command identifiers follow the software guidance. Use the command-specific payload definitions and endianness. Raw duty IDs are not assumed available merely because an archived guide mentions them.

82 Telemetry Encoding and Validity

Quantity	Reference representation	Interpretation
Temperature	Signed 16-bit Q8.8, big-endian	signed16 / 256 deg C; range constraint applies
Heater power	Unsigned 16-bit integer, big-endian	Integer watts
Region float fields	32-bit IEEE-754, little-endian	Field-specific units
Housekeeping floats	32-bit IEEE-754, big-endian	Field-specific units
Raw acquisition	ADC/current command definition	Not already deg C or watts
State and fault	Command-specific status fields	Distinct from current averages

Do not apply one byte order globally. For example 19 80 encodes +25.5 deg C in Q8.8, while a 32-bit region float is serialized differently. Preserve all-channel ordering and response selectors.

Validate data freshness, overrange, configuration and channel/card fault flags before using temperatures in a control loop. A plausible number can be stale or obtained from the wrong RTD scaling. The software numerical temperature range must cover the intended mission control band.

83 Region Control and Manual Heater Authority

An automatic region associates selected sensor channels with selected heaters and a temperature policy. Disable the affected automatic region before a controlled manual heater test; otherwise the control loop can overwrite a manual state command.

Configuration item	Required consistency
Sensor membership	Correct PT1000/PT100 channel allocation and calibrated valid data
Heater membership	Physical load labels and bank mapping verified
Thresholds	Inside the intended sensor/telemetry band
Control mode	Read back automatic/manual state
Load parameters	Cold resistance, bus voltage, current and power interpretation
Aggregate scheduler	50 A per card and 100 A / 50 A system intake
Fault response	Inhibit affected output and prevent repeated unsafe retries
Persistence	Read configuration after restart before restoring heating

Region zero is not used in the reference set/get workflow. State writes shall be followed by reads. A configuration write accepted by the transport is not proof that a load is connected or that the source can carry its simultaneous PWM current.

84 Start-up and Commissioning Sequence

Step	Action
1	Isolate the source; verify connector polarity, mate rating and harness continuity.
2	Maintain independent heater inhibition and connect the command interface.
3	Apply a current-limited source with no heater demand.
4	Read identity and validate temperatures, faults and interface operation.
5	Read back region and heater configuration and confirm the selected source budget.
6	Select Heater ready; verify every heater is still off and monitoring is valid.
7	Exercise one low-energy load at a time to confirm physical mapping.
8	Increase load while measuring each feed, each bank and total input current.

Complete-system readiness includes hardware startup, software initialization and valid telemetry. Use the observed ready state; no fixed software-ready delay is inferred from a circuit timing calculation.

85 Idle Entry Wake and Shutdown

Transition	Required ordering
Enter Idle	Disable automatic demand; command all outputs off; verify state
Remain in Idle	Keep the defined safe state and command supervision
Wake	Select Heater ready; allow readings to settle; verify outputs off
Resume heating	Revalidate source, bank and channel budgets before demand
Normal shutdown	Command off, inhibit automatic loops, verify current, isolate source
Emergency shutdown	Use the independent source inhibit required by the fault plan

Idle reduces electronics consumption but is not electrical isolation of the heater connectors. A floating or lost control state is not equivalent to a commanded off state. Verify reset and brownout behaviour during acceptance.

Isolate both feeds and verify discharged voltage before connector removal.

86 Electrical Integration Test Matrix

Test	Stimulus and observation	Acceptance basis
Input polarity	Unpowered continuity for A1/A2 on both feeds	Matches power contact tables
Current sharing	Incremental resistive load; measure both feeds	Each feed below selected mate/cable limit
RTD scan	Inject design resistance grid by channel	Correct type, monotonic conversion and valid status
Temperature faults	Open and short each representative path	No plausible valid temperature on a fault
Heater mapping	One low-energy load per output	Correct physical channel and return
Channel trip	Controlled overcurrent/current-step test	Matches final calibrated threshold and timing
Card trip	Controlled load with both path currents recorded	Approved bank limit and delivered fault response
Sleep/wake	Commanded Idle with all heaters off	All heaters remain off; orderly recovery
Communications	Each active transport; CRC/status/readback	Correct framing and no conflicting authority
High-bus OV	Current-limited controlled threshold test	Nominal 55 V supervision & agreed heater inhibition

This matrix defines acceptance actions, not completed test results. Use hardware energy limits and independent isolation during fault tests. Record waveform bandwidth, current probe zero, source impedance and sample rate for transient results.

87 Calibration Verification and Records

Record field	Content
Unit identity	Hardware assembly and channel population
Instrument	WF 2144 identification, calibration status and mode
Injected resistance	Requested and actual/independently verified values
Test environment	Ambient and unit temperature; bus voltage
Harness	Cable identity, lead resistance and return routing
Acquisition	ADC span, oversampling and averaging conditions
Correction	Per-channel coefficients or excitation/transfer correction
Residuals	Verification points and maximum error by channel
Fault checks	Open, short, overrange and stale-data recognition
Result	Pass/fail against the agreed accuracy requirement

Calibration with the WF 2144 is part of the unit calibration record. Acceptance uses the actual sweep data, residual maxima and instrument certificate. The nominal injection points supplied in this ICD define the test inputs; they are not recorded unit residuals.

If a required absolute tolerance is tighter than the module published bound, use independently verified resistance or a more accurate standard. A physical RTD thermal calibration remains distinct from this electronics injection procedure.