beyond gravity



FLEX PCDU

Flexible Power Conditioning and Distribution Unit

FLEX is Beyond Gravity's next-generation modular Power Conditioning and Distribution Unit, designed for flexible spacecraft power architectures. Supporting MPPT and S3R solar array regulation, battery currents up to 160 A and configurable power distribution functions, FLEX delivers a scalable solution from small satellites to high-power platforms.

Key features

- FLEX is a modular Power Conditioning and Distribution Unit (PCDU) providing centralised electrical power management at the core of the spacecraft Electrical Power Subsystem (EPS).
- Supports common mid-size satellite EPS architectures:
  - Unregulated main bus: 28V, 50V, 70V or 100V
  - Regulated distribution: 28V primary and up to 28V secondary
  - Solar array regulation: MPPT or S3R
- In-orbit software configuration of battery charge control, power distribution and LCL parameters
- Radiation-tolerant design for mission lifetimes exceeding 10 years in LEO, MEO and GEO
- Low-profile design supports stacked launch configurations and dispenser integration, complemented by umbilical battery charging and monitoring.
- FLEX's scalable architecture supports PCDU, PCU and PDU configurations built from common, pre-developed modules, reducing cost and risk.
- Supported unit configurations range from min. 4 modules and approximately 1 kW to max. 24 modules and approximately 15 kW.
- Reliable performance at competitive cost. Rigorous component selection, up-screening and testing build on Beyond Gravity's decades of space-equipment heritage.

Standard Modules

- CTR - Control
- SAR - Solar Array Regulator with S3R or MPPT control
- BAT - Battery Interface
- LCL – Latching Current Limiter
- HST - Heater Switch
- DEP - Deployment Drive
- REG - Regulated Supply
- SEC - Secondary Supply
- Custom I/O modules on request

Radiation Tolerance

- Suitable for LEO, MEO and GEO, with additional shielding available for demanding radiation environments
- Single-event latch-up immunity: LET threshold ≥53 MeV·cm²/mg
- Components TID tolerance: >50 krad (Si)

Physical / Environment

- Operating temperature: −20° C to +65° C, qualified
- Random vibration: 25 g RMS
- Mechanical shock: 2000 g SRS at 2000 Hz
- Unit envelope dimensions:
  - Height: 150 mm (5.9 in)
  - Length: 330 mm (13.0 in)
  - Width: varies by configuration

Example Applications

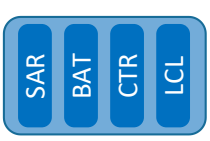
FLEX PCDU MPPT 3 kW

- 13 modules
- Unregulated main bus up to 50 V
- 3 kW MPPT Solar Array Regulator
- Primary distribution with up to 28+28* LCLs
- Heater supply through up to 72+72* outputs
- Actuator drive for 14+14* Pyro, NEA or TK



FLEX PCDU MPPT 1 kW

- Minimum configuration, 4 modules
- Unregulated main bus up to 50 V
- 1 kW MPPT Solar Array Regulator
- Primary distribution with up to 7+7* LCLs



FLEX PCDU S3R 15 kW

- 22 modules
- Unregulated main bus up to 100 V
- Regulated 28 V primary bus
- 15 kW S3R Solar Array Regulator
- Primary distribution 100 V through up to 56+56 LCLs, 28 V through up to 14+14* LCLs
- Heater supply through up to 108+108 outputs
- Actuator drive for 14+14* pyro, NEA or thermal-knife channels



Units can be configurated to meet mission requirements.

* Channel quantities are stated as nominal + redundant.

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Example Applications

FLEX PDU 3 kW

- 12 modules
- Main bus input up to 100 V
- Primary distribution through up to 28+28* LCLs
- Heater supply through up to 72+72* outputs
- Actuator drive for 14+14* Pyro/NEA/TK
- Secondary distribution 28V/5V through up to 16 LCLs



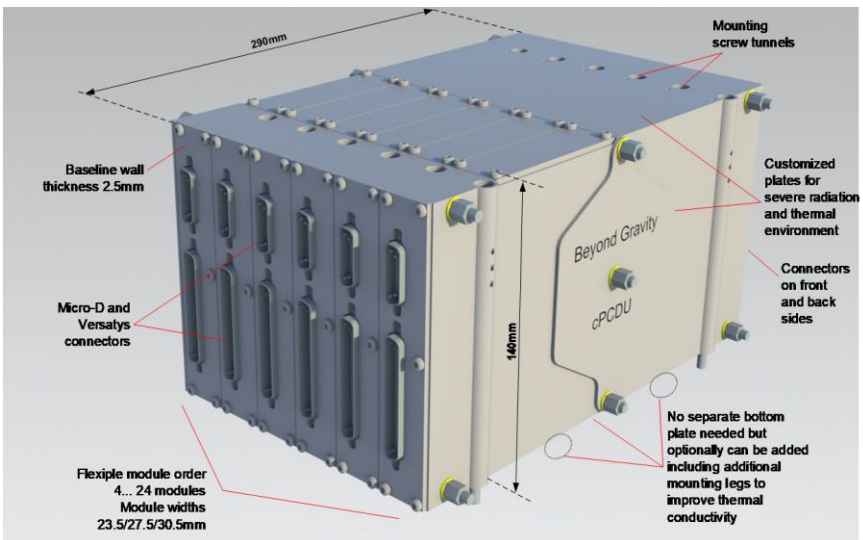
FLEX PDU 1 kW

- 5 modules
- Main bus input up to 100 V
- Primary distribution through up to 14+14* LCLs
- Secondary distribution 28 V / 5 V through up to 16 LCLs



Units can be configurated to meet mission requirements.

* Channel quantities are stated as nominal + redundant.



FLEX Module	Functions/Features
CTR **Control Module**	• Redundant TM/TC interfaces via CAN and discrete signals • Internal PCDU control • Redundant auxiliary power supply generation • Non-volatile MRAM for in-flight configuration
SAR (with MPPT) **Solar Array Regulator Module**	• 3 x 335 W synchronous GaN FET buck DC/DC converters with MPPT control • Total output power: up to 1 kW • Efficiency: >98%; maximum solar-array (SA) input voltage: 100 V
S3R **Solar Array Regulator Module**	• Sequential Switching Shunt Regulator (S3R); 6 independent shunt stages + 1 common-reference stage; max. 10 A per SA section; main bus up to 100 V • Solar array passivation by high-reliability latching relays
BAT **Battery IF Module**	• Battery interface with isolation switch rated up to 160 A • Majority-voted Main Error Amplifier (MEA) • Umbilical power interface and integrated capacitor bank
SEC **Secondary Supply Module**	• Secondary power conversion • Isolated DC/DC converter with two adjustable output-voltage rails • Up to 8 configurable, LCL-protected secondary outputs
LCL **Latching Current Limiter Module**	• Protected primary-bus power distribution • Up to 14 independently controlled outputs • Current limits and trip-off times configurable on the ground and in flight
HS **Heater Switch Module**	• Primary-bus heater power distribution • Up to 36 individually controlled outputs in six protected groups
DEP **Deployment Module**	• Voltage- or current –controlled deployment-actuator interfaces • 14 configurable outputs for pyrotechnic devices, NEAs and thermal knives • Inhibit-strap interface and 3-stage ARM-SELECT-FIRE activation

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FLEX Module Details

CTR – Control Module

Key Features

- Dual-redundant control architecture with independent A and B control sides
- Fully cross-coupled CAN command and telemetry interfaces
- Redundant auxiliary DC/DC converters for internal power supplies
- Individually protected auxiliary supplies with dedicated Latching Current Limiters (LCLs)
- External on/off control and status monitoring for each auxiliary supply
- Disconnect Non-Essential Loads (DNEL) control via CAN or discrete commands

Physical

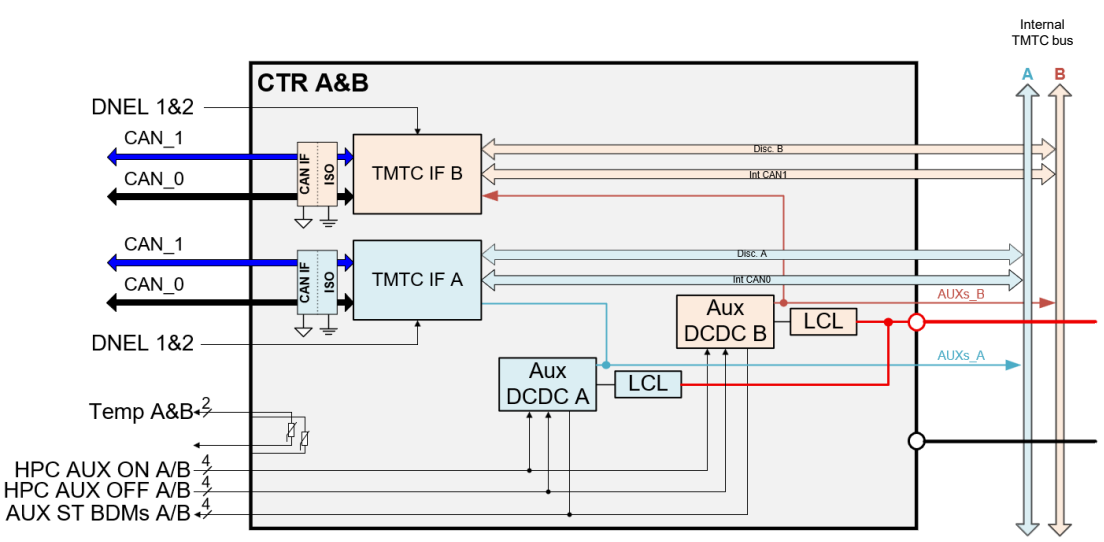
- Module mass: 0.8 kg (1.8 lb)
- Module dimensions:
  150 x 330 x 23,5 mm
  (5.9 × 13.0 × 0.93 in)

Performance

- **Maximum power consumption:** 20 W
- **CAN data rate:** up to 1 Mbit/s
- **Non-volatile memory:** 1 Mbit for configuration parameters
- **DNEL implementation options:**
  - CAN-based software control
  - Discrete command with software-controlled load distribution
  - Discrete command with hardware-controlled load distribution

External Interfaces

- **2 x CAN buses:** CAN_0 and CAN_1, each connected to control sides A and B
- **2 x AUX-supply on/off** High-Power Command (HPC) inputs for sides A and B
- **2 x AUX-supply status outputs** via Bi-level Discrete Monitor (BDM) interfaces: sides A and B
- **2 x Discrete temperature telemetry (TM) outputs** for sides A and B
- **2 x Discrete DNEL telecommand (TC) inputs** accessible to both control sides A and B



Functional Block Diagram of the
Control Module - CTR

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FLEX Module Details

S3R – Sequential Switching Shunt Regulator Module

Key Features

- Six independently controlled solar-array (SA) shunt stages
- One additional shunt stage with a common voltage reference shared across S3R modules
- Up to 10 A current capability per solar-array section
- Support for unregulated main buses up to 100 V
- End-of-life passivation by short-circuiting the solar-array sections

Physical

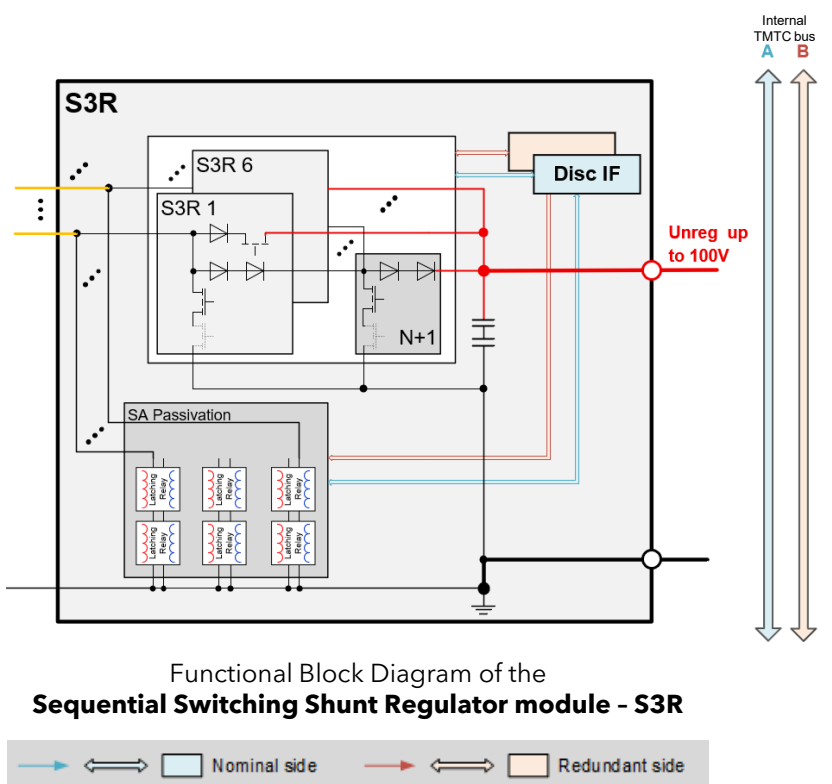
- Module mass: 1.1 kg (2.4 lb)
- Module dimensions:
  150 x 330 x 30,5 mm
  (5.9 × 13.0 × 1.20 in)

Performance

- **Regulator efficiency:** up to 98.5%
- **Shunt stages:** six independently controlled stages plus one common-reference stage
- **Solar-array current:** up to 10 A per section
- **Bus-voltage regulation:** fault-tolerant Main Error Amplifier (MEA)
- **End-of-life passivation:** radiation-hardened latching relays short-circuit the solar-array sections; reversible while the bus is battery-powered

External Interfaces

- 6 x solar-array (SA) section interfaces
- Assembly, integration and test (AIT) interface



Functional Block Diagram of the
Sequential Switching Shunt Regulator module – S3R

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FLEX Module Details

SAR (MPPT) – **Maximum Power Point Regulator Module**

Key Features

- Solar array (SA) interface with 3 individually controlled maximum power point tracking (MPPT) regulators
- Supported for unregulated main bus voltages up to 50 V
- End-of-life (EOL) passivation by short-circuiting SA sections
- Up to 3 modules can operate in parallel
- Flexible redundancy scheme, e.g. 8+1 redundancy

Physical

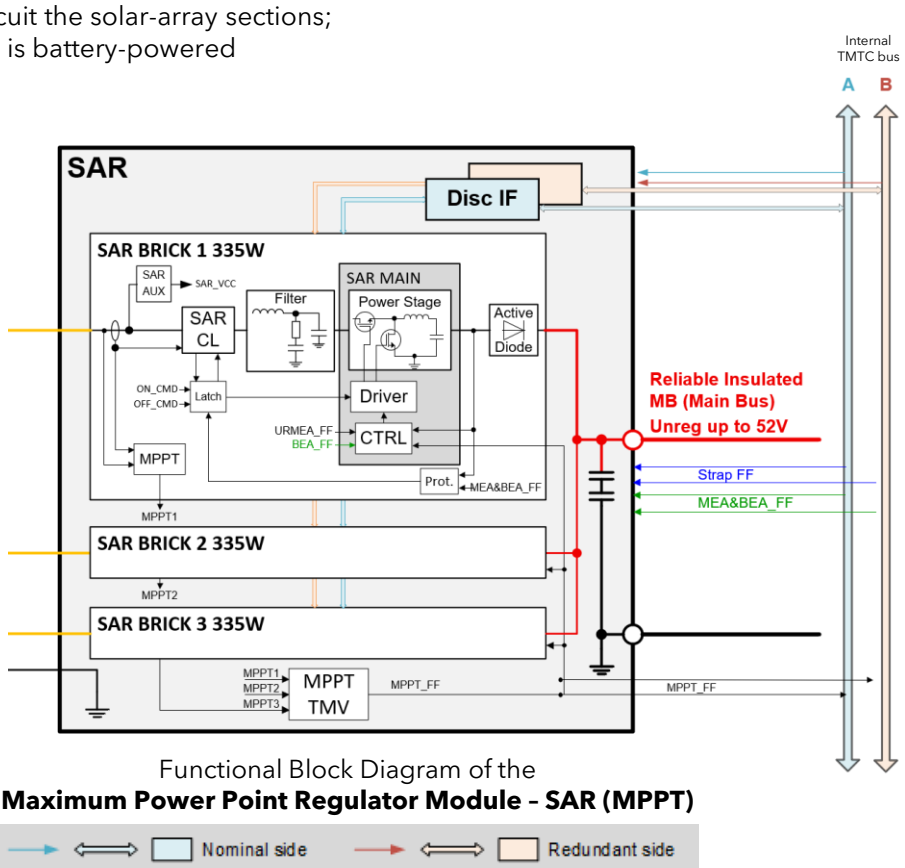
- Module mass: 1.1 kg (2.4 lb)
- Module dimensions:
  150 x 330 x 27,5 mm
  (5.9 × 13.0 × 1.08 in)

Performance

- **Rated power**: 3 × 335 W
- **Converter efficiency:** up to 98%
- **Input/output voltage ranges:**
  - 26 to 64 V input / 22 to 38 V output
  - 40 to 100 V input / 32 to 52 V output
- **Redundancy:** MPPT regulators can be connected in parallel within one module or across multiple modules
- **Bus-voltage regulation:** fault-tolerant Main Error Amplifier (MEA)
- **End-of-life passivation:** radiation-hardened latching relays short-circuit the solar-array sections; reversible while the bus is battery-powered

External Interfaces

- 3 x independently controlled solar-array section interfaces



Functional Block Diagram of the
Maximum Power Point Regulator Module – SAR (MPPT)

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FLEX Module Details

BAT – Battery Interface Module

Key Features

- Battery interface with high-current isolation switch
- Battery current capability up to 160 A
- Programmable end-of-charge voltage and charging current
- Support for unregulated main buses up to 100 V
- End-of-life battery passivation function
- Integrated bus-capacitor bank

Physical

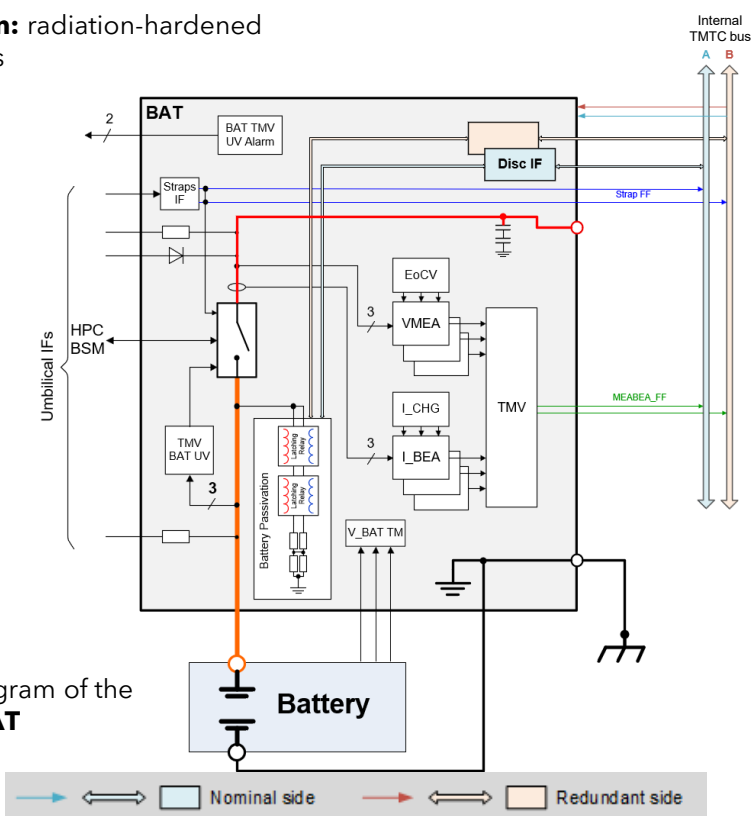
- Module mass: 0.7 kg (1.5 lb)
- Module dimensions:
  150 x 330 x 21,5 mm
  (5.9 × 13.0 × 0.85 in)

Performance

- **Main bus options:** 28 V, 50 V or 100 V, unregulated
- **Battery current:** up to 160 A
- **Battery isolation:** latching switch with inrush-current control
- **On-state resistance:** $R_{DS(on)}$ <1 mΩ
- **Bus-voltage regulation:** fault-tolerant Main Error Amplifier (MEA)
- **Charging control:** eight programmable settings for end-of-charge voltage and battery current
- **Battery telemetry:** three cell-voltage and three temperature measurements
- **End-of-life passivation:** radiation-hardened latching isolation relays

External Interfaces

- Battery power interface
- High-power command (HPC) input for the battery isolation switch
- Battery isolation-switch status output
- Umbilical interface for battery charging and monitoring
- Three separation-strap interfaces
- Battery-cell voltage sensing



Functional Block Diagram of the **Battery Module - BAT**

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FLEX Module Details

LCL – Latching Current Limiter Module

Key Features

- Primary-bus distribution with up to 40 A continuous output current
- 14 independently controlled, LCL-protected outputs
- Two outputs configurable as Retriggerable Latching Current Limiters (RLCLs)
- Hardware-configurable current limits and trip-off times
- Four command-selectable protection settings available in flight
- Parallel output configuration for loads up to 20 A
- Cross-strapped control for redundant output allocation
- Compatible with regulated and unregulated power buses

Physical

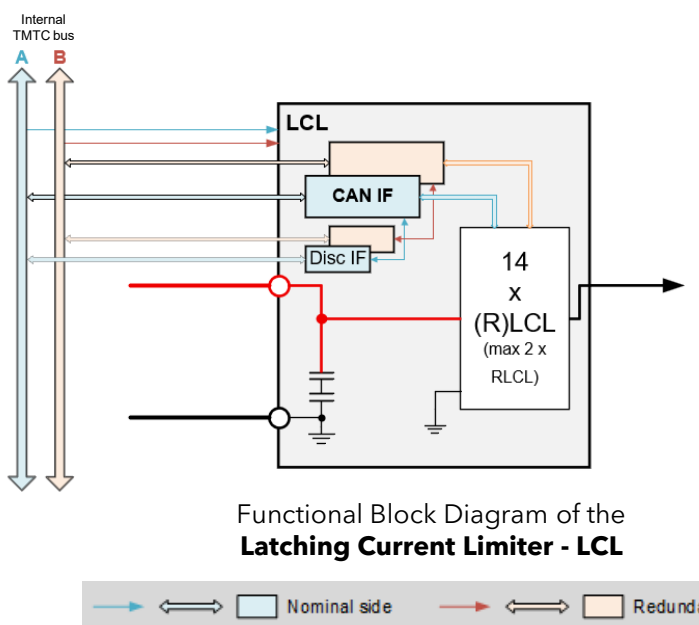
- Module mass: 0.7 kg (1.5 lb)
- Module dimensions:
  150 x 330 x 21,5 mm
  (5.9 × 13.0 × 0.85 in)

Performance

- **Continuous output current:** up to 40 A total
- **Nominal output ratings:** 6 × 1 A, 4 × 3 A, 2 × 5 A and 2 × 10 A
- **RLCL capability:** two 1 A outputs configurable as RLCLs
- **Fault tolerance:** loss limited to one output after a single failure
- **Failure protection:** no single failure results in permanent output activation
- **Monitoring:** output voltage, current and switch-fault telemetry
- **Optional isolation:** series switch available for each output

External Interfaces

- 14 LCL-protected power outputs



Functional Block Diagram of the
Latching Current Limiter - LCL

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FLEX Module Details

HS – Heater Switch Module

Key Features

- Primary-bus heater power distribution with up to 40 A total output current
- Up to 36 individually controlled heater outputs arranged in 6 groups
- Each heater group protected by a 5 A Heater Latching Current Limiter (HLCL)
- Cross-strapped control for allocation of redundant outputs within one module
- Compatible with regulated and unregulated power buses
- Optional closed-loop thermal control for 8 nom. +8 red. channels

Physical

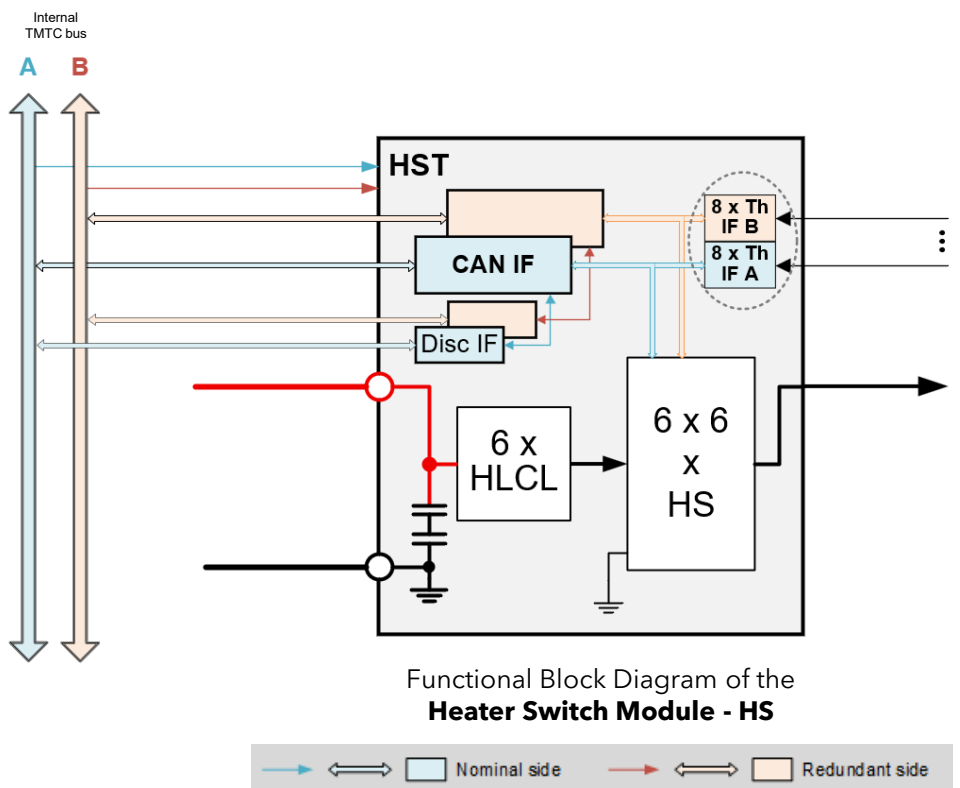
- Module mass: 0.7 kg (1.5 lb)
- Module dimensions:
  150 x 330 x 21,5 mm
  (5.9 × 13.0 × 0.85 in)

Performance

- **Continuous output current:** up to 40 A total
- **Heater-group protection:** 5 A HLCL per group
- **Fault tolerance:** loss limited to one heater group after a single failure
- **Failure protection:** no single failure results in permanent output activation
- **LCL operation:** heater outputs can be configured as LCLs, without capacitive-load restrictions

External Interfaces

- 36 x individually controlled heater outputs
- 6 x independently protected heater groups



Functional Block Diagram of the
Heater Switch Module - HS

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FLEX Module Details

DEP – Deployment Actuator Drive Module

Key Features

- Up to 14 configurable actuator drive channels
- Voltage- or current-controlled operation
- Configurable drive current, voltage and pulse duration
- Three-stage ARM–SELECT–FIRE activation sequence
- Optional ARM switch: latching relay
- Support for pyrotechnic and non-explosive actuators

Physical

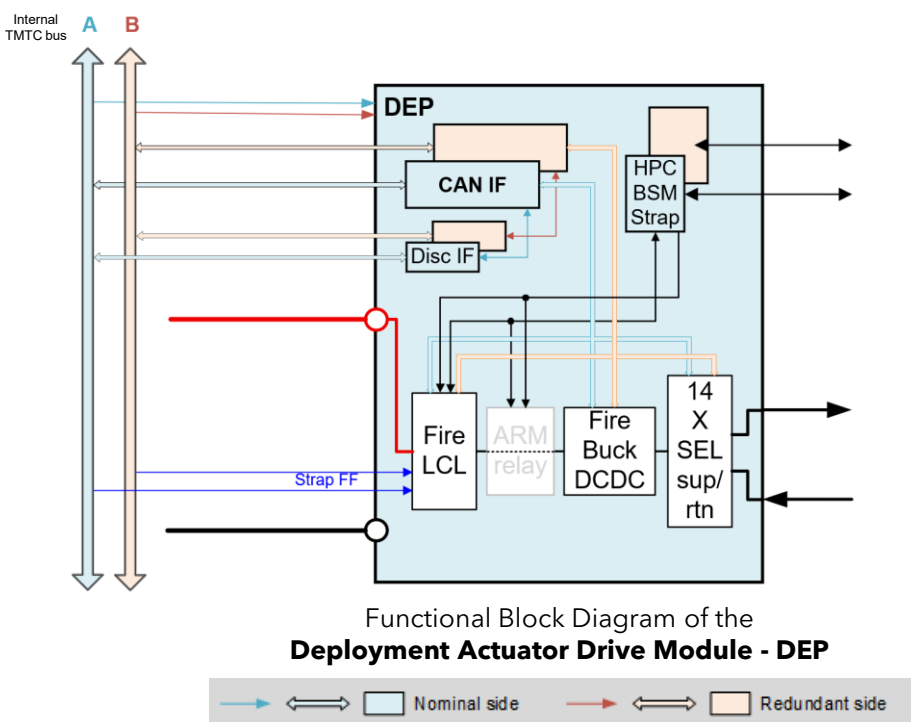
- Module mass: 0.8 kg (1.8 lb)
- Module dimensions:
  150 x 330 x 21,5 mm
  (5.9 × 13.0 × 0.85 in)

Performance

- **NASA Standard Initiator (NSI):** 1 A; 1 W, 5-minute no-fire rating
- **Thermal knife:** 20.5 V ±0.5 V;
  1.4 A nominal; 2.8 A peak for <1 s
  - Inrush-current threshold: >4.5 A
  - Activation time: up to 65 s
- **Non-Explosive Actuator (NEA):** 24.5 V ±0.5 V; 1.5 A
  - Activation time: 10 to 640 s,
    configurable in 10 s increments
  - Output-current protection: 3.0 A ±25%
- **Pyrotechnic actuator:** 4 to 6 A; 10 to 100 ms pulse;
  load resistance <1 Ω
- **Hold-Down and Release Mechanism (HDRM):**
  customised actuator interface available on request

External Interfaces

- 14 actuator drive outputs
- Inhibit/ARM interface
- High-Power Command (HPC) input
- Barrier Status Monitoring (BSM) output



Functional Block Diagram of the
Deployment Actuator Drive Module - DEP

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FLEX Module Details

SEC – Secondary Supply Module

Key Features

- Isolated, regulated secondary power distribution up to 300 W
- Isolated DC/DC converter with two point-of-load converters
- Configurable secondary high-voltage (SEC-H) and secondary low-voltage (SEC-L) supply rails
- Eight LCL-protected outputs, each selectable as SEC-H or SEC-L
- Optional output cross-coupling

Physical

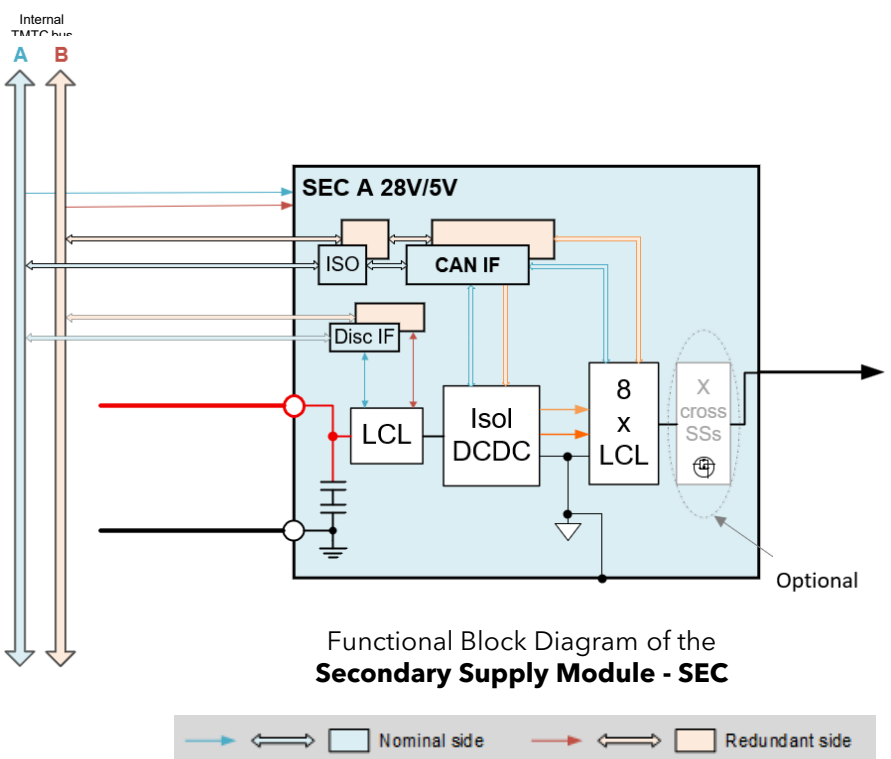
- Module mass: 1.1 kg (2.4 lb)
- Module dimensions:
  150 x 330 x 27,5 mm
  (5.9 × 13.0 × 1.08 in)

Performance

- **Converter efficiency:** up to 96%
- **SEC-H output voltage:**
  configurable from 20 V to 29 V
- **SEC-L output voltage:**
  configurable from 5 V to 16 V

External Interfaces

- 8 x LCL-protected power outputs
- Optional MOSFET switch on each output for external cross-coupling



Functional Block Diagram of the
Secondary Supply Module - SEC

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FLEX Module Details

REG – Regulated 28 V Supply Module

Key Features

- Down-converted, regulated 28 V power supply with up to 900 W output capacity
- Three parallel 300 W DC/DC converters with balanced current sharing
- Parallel operation of multiple REG modules for increased output power
- External power distribution and protection via LCL modules

Physical

- Module mass: 1.1 kg (2.4 lb)
- Module dimensions: 150 x 330 x 21,5 mm (5.9 × 13.0 × 0.85 in)

Performance

- **Rated output power:** 3 × 300 W, 900 W total
- **LCL-Protection:** overvoltage and overcurrent protection
- **Nominal output voltage:** 28 V ±1%
- **Converter efficiency:** up to 98%
- **Voltage regulation:** triple-modular-redundant Main Error Amplifier (TMR MEA)

External Interfaces

- No direct load interfaces; distribution is provided by LCL modules

Product availability: Please contact our sales team

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