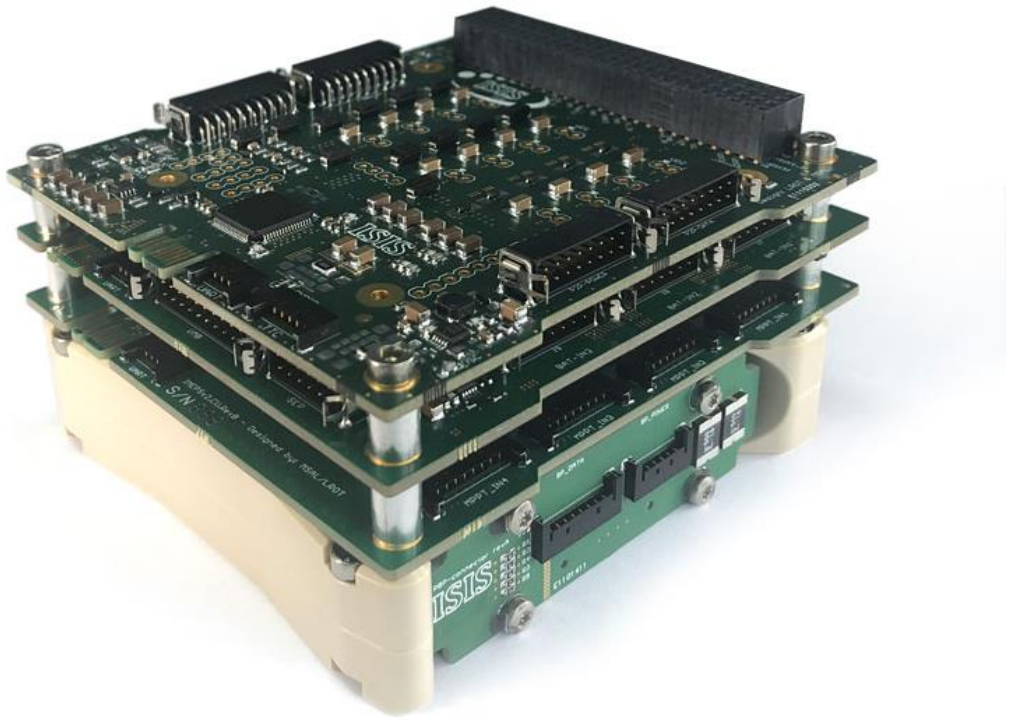


Modular EPS Datasheet

ISIS.MEPS.DS. 001, version 1.0

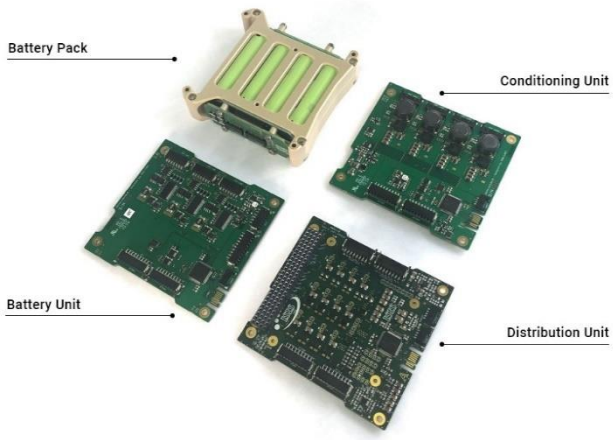
Modular and highly configurable power system suitable for CubeSat missions from 3U upwards.

General Description

The modular Electrical Power Subsystem (EPS) is a second-generation EPS designed and manufactured by ISISpace. The system leverages wide bandgap semiconductor technologies, implementing GaN-FETs to improve solar power conversion efficiency and performance, while minimizing EMI. The modular architecture allows the EPS to be tailored to the needs of the platform without requiring customization.

The modular design in turn yields benefits in mass and volume expenditure, reliability and eases development schedules when platforms evolve. The distributed design philosophy allows unprecedented flexibility in output bus count and voltage, and enables tailorable redundancy for selectable parts of the platform, depending on the needs of the mission.

This modular EPS based on PC104 form factor and designed as an adaptable solution targeting larger nanosatellites from 3U upwards and microsatellites.



Product Features

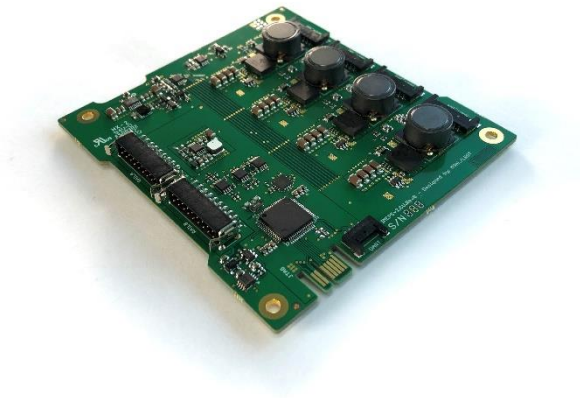
- Communication over two independent I^2C or UART interfaces, SPI optional
- FRAM-based MCUs for improved radiation tolerance
- Hardware over-current protection and hardware-based maximum power point tracking
- Hardware Supervisor including Watchdog
- Solar Panel interface utilizes GaN-FETs
- Output load channels:
  - Buck regulated power channels
  - Over-current and reverse-current protection in hardware
  - Over-voltage protection through TVS diodes
  - Turn on voltage ramp control (soft start)
  - Software configurable auto enable and latch-off retry enable timings
  - Accurate voltage, current and power sensing on each channel
- Rich housekeeping telemetry available
- Very low idle consumption when no enabled output channels

Optional Features

Battery Units

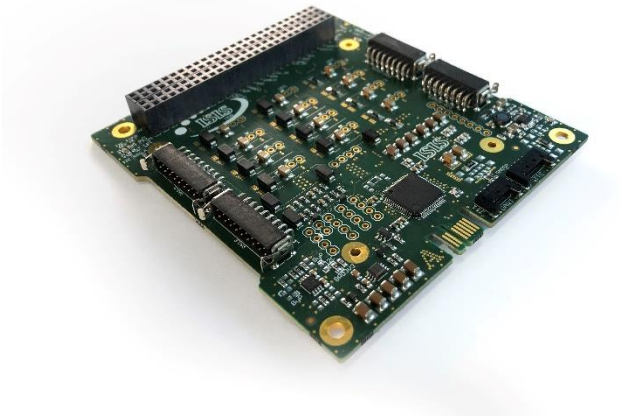
- Up to three Battery Packs (IPBP) per Battery Unit board (IPBU)
- Available in configurations which supply from 45 Wh, 90 Wh, 135Wh and more. Multiple IPBP's and IPBU's can be placed in parallel for redundancy

Conditioning Unit



- Each additional Conditioning Unit (IPCU) allows for further 4x 39W MPPT channels
- Multiple IPCU's can be placed in parallel for redundancy

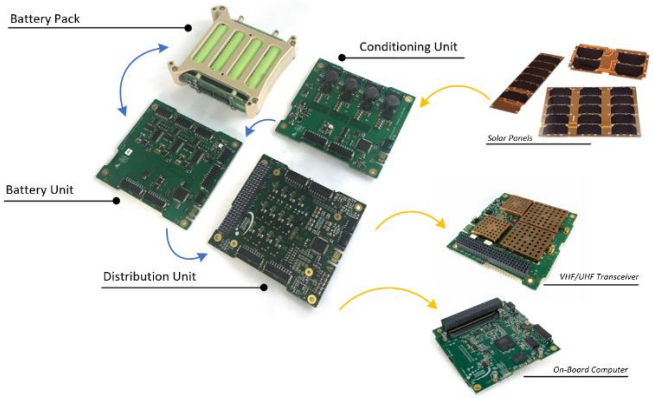
Distribution Unit



- Each additional Distribution Unit (IPDU) allows for a further
  - 4x switchable output channel at Vbat (12.8V – 16V)
  - 2x user defined voltages (up to 12V)
  - Each user defined voltage has 4x switchable output channel.
  - User definable 'permanent' channels, and fully configurable auto-enable output bus time delays.
- Multiple IPDU's can be placed in parallel for redundancy
- Multiple IPDU's can have their output channels electrically orded for supply redundancy
- Multiple IPDU's can be placed in series to create master-slave power chains

Compatibility

- Interoperable with ISISpace Solar Panels, On-Board Computer, Structures and Radios
- Compliant to CubeSat standard



Flight Heritage & Quality Assurance

- Design based on heritage from PEASSS Cubesat flown in 2016.
- First generation Modular EPS successfully flown in 2018.
- Qualification Test Level:
  - Thermal: -40 to +80 ºC.
  - Static loads: +10.8 [g], three axes.
  - Sine & random vibration: ASAP5 levels.
- Flight units thermally acceptance tested for workmanship.
- IPC-A-610 Class 3 PCB and assembly, flight units thermally acceptance tested.

Ordering Information

Please contact sales@isispace.nl for ordering information.

Specification

Parameter	Value	Unit
Environmental Characteristics		
Operational temperature	-40 to +70(a)	°C
Storage temperature	-40 to +85(a)	°C
Storage lifetime	12	months
Common Power Rail		
Rail Voltage	12.8 – 16.0	V
Rail Maximum Current	~12	A
Harness Interconnect	multicore wire, Harwin M80 L-Tek	-
Board Interconnect Topology	Daisy Chain, Point to Point	-
Power Distribution Unit (IPDU)		
Height	11	mm
Weight	51.6 g (incl. top mount full CSKB) 57.4 g (incl. bottom mount full CSKB)	g
Idle consumption	66 (4.1mA @ 16V) (regulation of VD1 at 5V and VD2 at 3.3V, no external load)	mW
Input maximum current	8	A
Output Regulator Topology	Buck only. Buck or boost regulator or customization possible on daughterboard style “SonBoard”.	-
Output Regulator Modes	Fixed frequency (loads >= 1A) Burst mode (loads < 1A) Design adapted for low EMI as verified by test.	-
Output voltage domains	VD0: fixed (= rail voltage) VD1: user selectable (only below rail voltage) VD2: user selectable (only below rail voltage) VD1 and VD2 default configuration is 5V and 3V3 respectively	-
Output channels	VD0: x 4 VD1: x 4 VD2: x 4 Option using Sonboard mounted regulator: VDx: x 4	-
Output maximum current	max 3A per channel (limited by OC protection) max total for VD1: 4A (continuous), 6A(peak) max total for VD2: 4A (continuous), 6A(peak)	-
Electrical Protection	- overcurrent/thermal limit on Unit input - overvoltage protection on all domains on each output bus channel: - overcurrent/thermal protection - voltage ramp slew rate control - reverse current protection	-

Parameter		Value	Unit
Functional Protection		- Safety Mode (when VD0 low) - Emergency Low Power Mode (when VD0 low) - Hardware Supervisor including Watchdog -TT&C Watchdog (stack reset on EPS comms timeout)	-
Monitoring		- MCU/PCB temperature voltage, current and power measurements on: - total unit input - total output for VD0 - total output for VD1 regulator - total output for VD2 regulator - each output bus channel voltage on: - local board power supply	-
Communication bus		I2C, UART, SPI optional. Single wire command only interface. Each Unit provides an isolated I2C bus segment to its stack, separated from the other Units.	-
Power Battery Pack (IPBP)			
Height		21	mm
Weight		252	g
Configuration		4 series	-
Voltage	Nominal	14.4	V
	Min/max	10 min, 16.8 absolute maximum	V
	Operating	12.8-16.0	V
Capacity	Nominal	3200	mAh
Input current	Max	1.6	A
Battery Cell			
Chemistry		Lithium-Ion	-
Voltage	nominal	3.6	V
	Min/max	2.5 min, 4.2 abs max	V
Capacity		3200	mAh
Output current	max	6.4	A
Battery heater	resistance	100	Ohm
	current	160 (16V @ ~2.5W)	mA
Power Battery Unit (IPBU)			
Height		10	mm
Weight		48.7	g
Idle consumption		63 (3.9mA @ 16V)	mW
Battery Channels/Packs per BU		Minimum packs:1 Maximum packs: 3 Individual parallel battery channels available: 3	-
Battery Channel max output current		4 (Note: Connecting single battery pack to multiple parallel BU channels possible. Provides current sharing and/or redundancy)	A
BU max input power (per battery channel/pack)		19.2W @ 12V / 25.6W @16V	W
BU max output power (per battery channel/pack)		48W @ 12V / 64W @16V	W

Parameter	Value	Unit
Functional Protection	- Emergency Low Power Mode (when string voltage low) - TT&C Watchdog (unit reset on comms failure, does not interrupt power provision)	-
Monitoring	Per cell voltage Total input/output current, voltage and power 2 x temperature sensors per pack	-
Battery balancing	Yes, per pack closed loop controlled in orbit configurable: enable/disable, voltage thresholds	-
Battery heating	Yes, per pack closed loop controlled in orbit configurable: enable/disable, voltage thresholds	-
Power Conditioning Unit (IPCU)		
Height	12	mm
Weight	58	g
Idle consumption	MPPT: 33.1mA @ 10V, 0.331 W MCU: 3.9 mA @ 16 V, 0.066 W note: MPPT circuitry power taken from attached solar panels (sunlight only). MCU circuitry power taken from internal EPS power rail (sunlight and eclipse).	-
Output Regulator Topology	Boost only	-
Harvesting Mechanism	Maximum Power Point Tracking	-
PV input min/max voltage	2V min, 13V max (with battery voltage >14V)	V
Maximum input current	3	A
Output voltage	16	V
CU max input power (per channel)	39 (5 series, 6 parallel solar cells strings)	W
Channels per CU	4	-
Electrical Protection	- overvoltage protection - reverse current protection	-
Functional Protection	- TT&C Watchdog	-
Monitoring	- MCU/PCB temperature voltage and current on: - channel input voltage, current and power on: - channel output	-
Battery dependency	None, Unit can produce power with or without a battery on the output, allowing sunlight-only platform configurations.	-

Electrical Description

The modular EPS consists of four types of elements:

- ISISpace Power Conditioning Unit (IPCU) – Solar panel input to common power rail
- ISISpace Power Battery Unit (IPBU) – Secondary power storage and retrieval control
- ISISpace Power Battery Pack (IPBP) – Battery holder with integrated fuse
- ISISpace Power Distribution Unit (IPDU) – Power regulation to attached subsystem loads

One or more of each of these units can be combined to form the platform EPS. An example of the setup is shown in Figure 1 and a detailed schematic in Figure 1.

Each unit is designed to be fully independent, with a design focus on reliability. Reliability can be further increased by doubling up units, providing redundancy. The inter-unit interfaces are minimized and standardized to minimize risk of fault propagation. The standard bus organization for the common power rail consists of a daisy-chain to minimize required harness length and ease harness routing. Point to point transfer of the power is still possible when this is desired.

The daisy chain harness includes provisions for the platform I^2C bus, allowing a distribution unit to supply a stack not only with power but also with the primary platform communications channel. This removes the need for dedicated stack-to-stack interconnect boards for power and platform bus. The distribution unit additionally provides point-to-point connectors for breaking out the most commonly used data signals from the local CSKB, allowing inter-stack CSKB connections to be routed without the need for additional break-out boards.

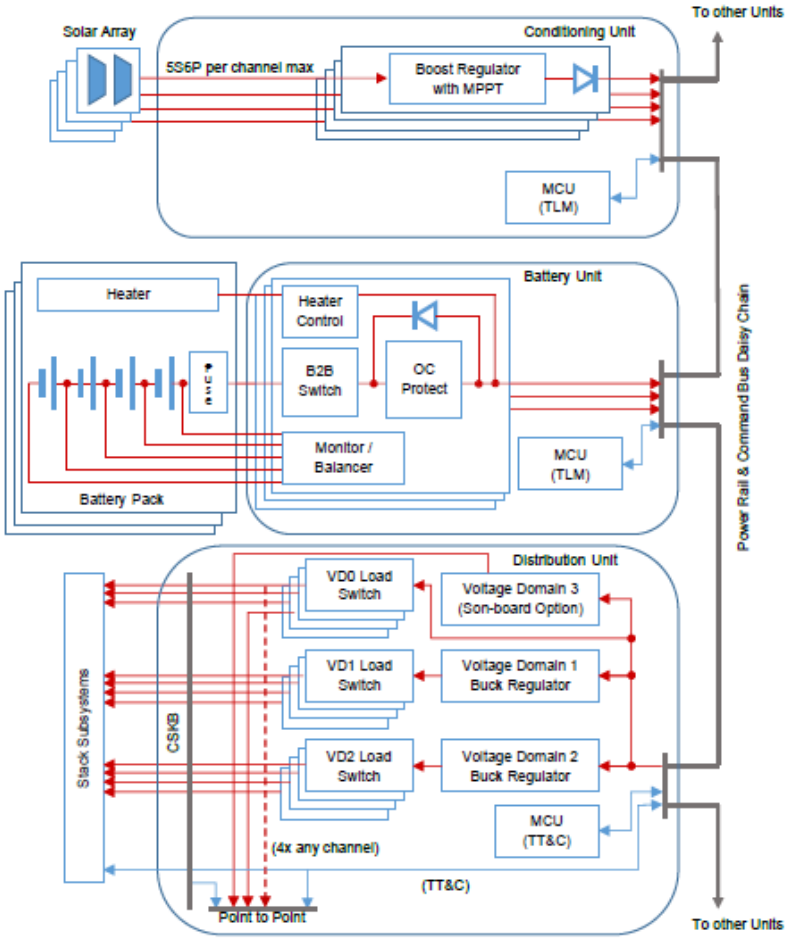


Figure 1 Modular EPS Schematic

Grounding Scheme

Each of the EPS boards allows placement of resistors and/or filtering capacitor arrangements between the board ground and the chassis mounting holes.

By default the EPS PCB's are not connected to chassis anywhere, with two exceptions:

1. A high ohmic bleed resistor is located on (each) Battery Unit allowing any chassis developed potential to bleed off into the system ground at the battery.
2. A pair of capacitors connects the power and ground to chassis at the Conditioning Unit input as part of a pi-filter providing common mode and differential mode filtering.

To control EM noise from returning over the solar panel input harness to the outside of the satellite, forming a circuit with the chassis, a pi-filter setup is used. The common mode and differential mode bypass capacitors are placed on the Conditioning Unit, while the inductor bead is either added in the harness or mounted on the solar panel side.

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