openEPS Electrical Power Supply Datasheet

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Acknowledgements

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System Description

The openEPS Electrical Power Supply (EPS) is intended for mission critical power management on CubeSats. The system includes four independent maximum power point tracking converters, each with two solar panel connectors. Up to four parallel sets of two-cell series strings (up to eight cells in total) of lithium-ion batteries can be connected to the battery module interface. Each of 18 independantly controlled output channels can be connected to any of the regulated bus voltages, or to the unregulated battery voltage. Current, voltage and temperature sensors provide comprehensive system monitoring and threshold limit control. The system was developed as an open source initiative at the University of Alberta in hopes that it will be useful to other groups developing small, low-cost satellites.

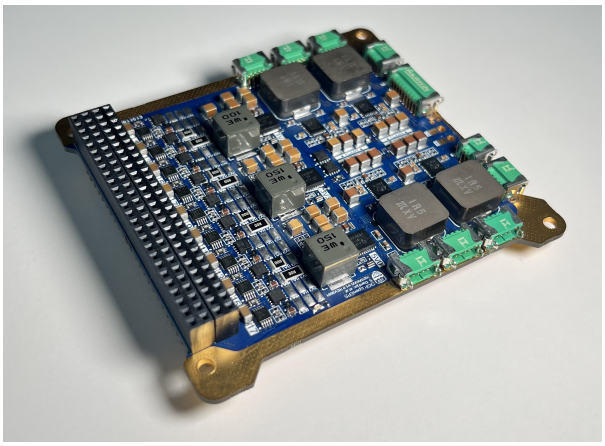

Figure 1: Photograph showing a fully implemented prototype of the openEPS for CubeSats

Highlighted Features

- Four parallel MPPT converters, each with a maximum input power capacity of 24 W, and a maximum input current of 3 A
- Three regulated bus voltages (1.2V, 3.3V, and 5.0V) with independent voltage and current monitoring and protection
- 18 independently controlled power output channels with voltage and current monitoring and both hardware and software controlled over current protection thresholds
- Independently monitored and protected 3.3V power output channel to solar panel interfaces for solar panel mounted sensors or deployment actuation
- Controlled with CANbus, UART, or SPI interface using the CubeSat Space Protocol (CSP) network protocol
- Configurable ground station watchdog timer to recover from failure to connect with a ground station

Open Source Links

https://github.com/sdamkjar/openEPS

Contents

1 Electrical Specifications

1.1 Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings (Table 1) may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated throughout the rest of this document is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability and lifetime.

Table 1: Absolute maximum ratings

Parameter	Min	Max	Units
Solar Panel Connectors (P1 to P8)			
Solar panel input V+	−0.3	19.0	V
Solar panel I2C pins	−0.5	7.0	V
3.3V supply to solar panels	−0.3	19.0	V
Inhibit Switch Connector (P9)			
Any inhibit switch connector pin	−0.6	10	V
Flight Preparation Panel (FPP) Connector (P10)			
JTAG inputs: TCK, TMS, TDI, nTRST	−0.5	6.5	V
JTAG outputs: TDO	−0.3	4.6	V
Debug UART (RX, TX)	−0.5	6.5	V
RBF ground charge enable	−12	12	V
RBF always on, always off	−0.6	10	V
RBF deploy disable	−0.3	4.6	V
Battery Module Connector (P11)			
Battery V+	−0.3	19.0	V
Battery module I2C pins	−0.5	7.0	V
3.3V supply to battery module	−0.3	19.0	V
Stack Connector (H1 and H2)			
Stack connector SPI or UART (MISO, MOSI, CLK, nCS, RX, TX)	−0.3	4.6	V
CANbus terminals (CANH, CANL)	−14	14	V
Any power output channel	−0.3	19.0	V

Table 2: Operating environment ratings

Parameter	Test Conditions	Min	Max	Units
Pin Current Ratings				
P1 to P10 current rating per pin			2.0	A
H1,H2 current rating per pin			6.2	A
Temperature Ratings [1]				
Operating temperature	Free-air	−40	105	°C
	Vacuum	−40	TBD	°C
Junction temperature [2]		−40	130	°C
Storage temperature		−40	150	°C

[1] Ratings for EPS module only! (NOT including battery module or solar panels)

[2] Thermal shutdown protection is intended to protect the device during momentary overload conditions. The maximum rated junction temperature will be exceeded when this protection is active. Continuous operation above the specified absolute maximum operating junction temperature may impair device reliability or permanently damage the device.

1.2 MPPT Converters

Electrical specifications of the MPPT converters is given in Table 3. The MPPT converters are designed using the LTC3119 buck-boost converter controller. All specifications are at 25 °C unless otherwise specified.

Table 3: MPPT Converter and solar panel interface electrical specifications

Parameter	Test Conditions	Min	Typ	Max	Units
Input voltage (V_{PVIN})		3.0		18.0	V
Input current per converter	$V_{PVIN} = 3.0\,V$			6.0	A
	$V_{PVIN} = 18.0\,V$			1.3	A
Input power per converter (P_{PVIN})	$V_{PVIN} > 8.0\,V$			24	W
Solar panel connector V+ current in				6.0	A
Solar panel connector 3.3V current out				2.0	A
Output ripple voltage	**See Fig. 3**				
Switching frequency			400		kHz
Output soft-start rise-time			6		ms
Input under-voltage lock-out	Falling (ON to OFF)	2.44	2.50	2.56	V
	Rising (OFF to ON)	2.60	2.70	2.80	V
Output voltage limit		7.92	8.00	8.08	V
Thermal shutdown threshold			165		°C
Converter efficiency	**See Fig. 2**				

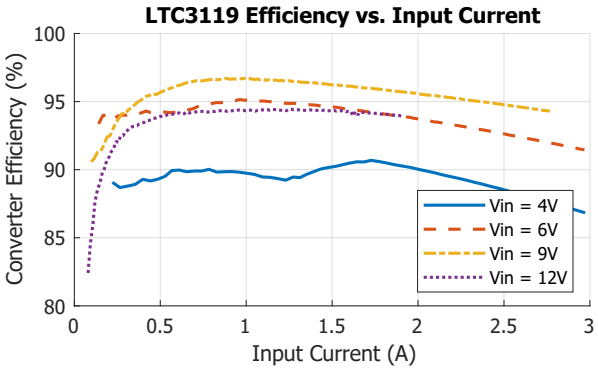

Figure 2: MPPT converter efficiency

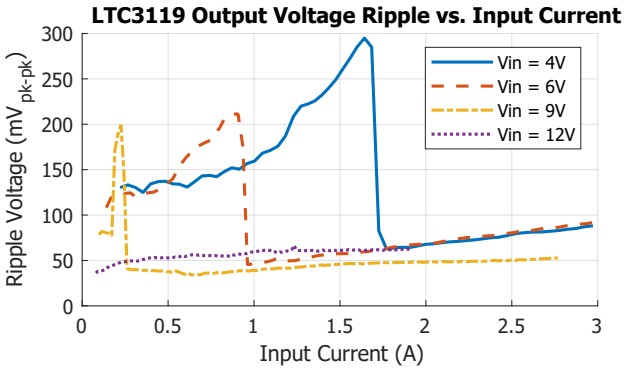

Figure 3: MPPT converter ripple voltage.

1.3 Bus Regulators

Electrical specifications of the bus regulators is given in Table 4. The bus regulators are designed using the TPS53319 buck converter controller. All specifications are at 25 °C unless otherwise specified.

Table 4: 1.2 V Bus regulator electrical specifications

Parameter	Test Conditions	Min	Typ	Max	Units
Output current				8	A
Output voltage		1.15	1.20	1.21	V
Output ripple voltage	**See Fig.** TBD				
Switching frequency		250	300	350	kHz
Output soft-start rise-time			0.7		ms
Input under-voltage lock-out	Falling (ON to OFF)	4.25	4.45	4.58	V
	Rising (OFF to ON)	4.00	4.20	4.33	V
Output under-voltage protection		0.78	0.84	0.9	V
Output under-voltage protection delay		0.8	1.0	1.2	ms
Output over-voltage protection		1.38	1.44	1.5	V
Output over-voltage protection delay			1		μs
Thermal shutdown threshold			145		°C
Converter efficiency	**See Fig.** TBD				

Table 5: 3.3 V Bus regulator electrical specifications

Parameter	Test Conditions	Min	Typ	Max	Units
Output current				6	A
Output voltage		3.22	3.30	3.33	V
Output ripple voltage	**See Fig.** TBD				
Switching frequency		250	300	350	kHz
Output soft-start rise-time			0.7		ms
Input under-voltage lock-out	Falling (ON to OFF)	4.25	4.45	4.58	V
	Rising (OFF to ON)	4.00	4.20	4.33	V
Output under-voltage protection		2.15	2.31	2.48	V
Output under-voltage protection delay			0.7		ms
Output over-voltage protection		3.80	3.96	4.13	V
Output over-voltage protection delay			1		μs
Thermal shutdown threshold			145		°C
Converter efficiency	**See Fig.** TBD				

Table 6: 5.0 V Bus regulator electrical specifications

Parameter	Test Conditions	Min	Typ	Max	Units
Output current				4	A
Output voltage		4.90	5.00	5.05	V
Output ripple voltage	**See Fig.** TBD				
Switching frequency		250	300	350	kHz
Output soft-start rise-time			0.7		ms
Input under-voltage lock-out	Falling (ON to OFF)	4.25	4.45	4.58	V
	Rising (OFF to ON)	4.00	4.20	4.33	V
Output under-voltage protection		3.25	3.50	3.75	V
Output under-voltage protection delay			0.7		ms
Output over-voltage protection		5.75	6.00	6.25	V
Output over-voltage protection delay			1		μs
Thermal shutdown threshold			145		°C
Converter efficiency	**See Fig.** TBD				

2 Mechanical Specifications

Table 7: Mechanical Specifications

Parameter	Test Conditions	Min	Typ	Max	Units
Overall Dimensions		$93.3 \times 87.6 \times 15.3$			mm
Mass	No battery		93.00		g