NanoPower
P31u

Datasheet
Electric Power System for mission critical space applications
with limited resources

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2 Overview

The power supply is the heart of a satellite. It is therefore very important not to compromise on quality and reliability of it. The NanoPower P31u is designed as a reliable and flight proven system with digital interface and advanced features like maximum power point tracking and latchup-protection.

2.1 Highlighted Features

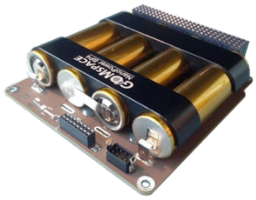
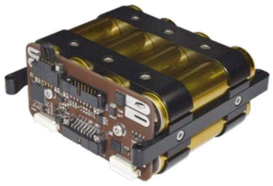
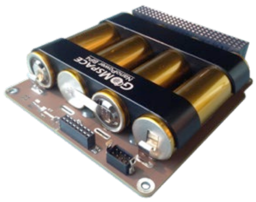
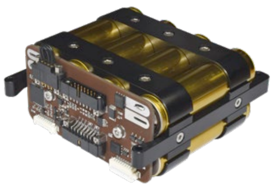
- 3 step-up input channels with independent power-point setting giving an input power capacity of 30 W.
- Maximum power point tracking.
- Battery under-voltage and over-voltage protection
- Two regulated power buses: 3.3 V @ 5 A and 5 V @ 4 A (user selectable)
- 6 configurable and controlled output switches with latching current limiter
- Extensive Watchdog timers
- Discrete control of output switches
- Onboard housekeeping measurements
- Separation-switch interface with latching mechanism (option dependent)
- Remove-Before-Flight-pin interface
- Interface to battery board NanoPower BP4 or NanoPower BPX (option dependent)
- I^2C interface
- Operational temperature: -40 °C to +85 °C
- Fits standard PC104
- IPC-A-610 Class 3 PCB and assembly

2.2 General Description

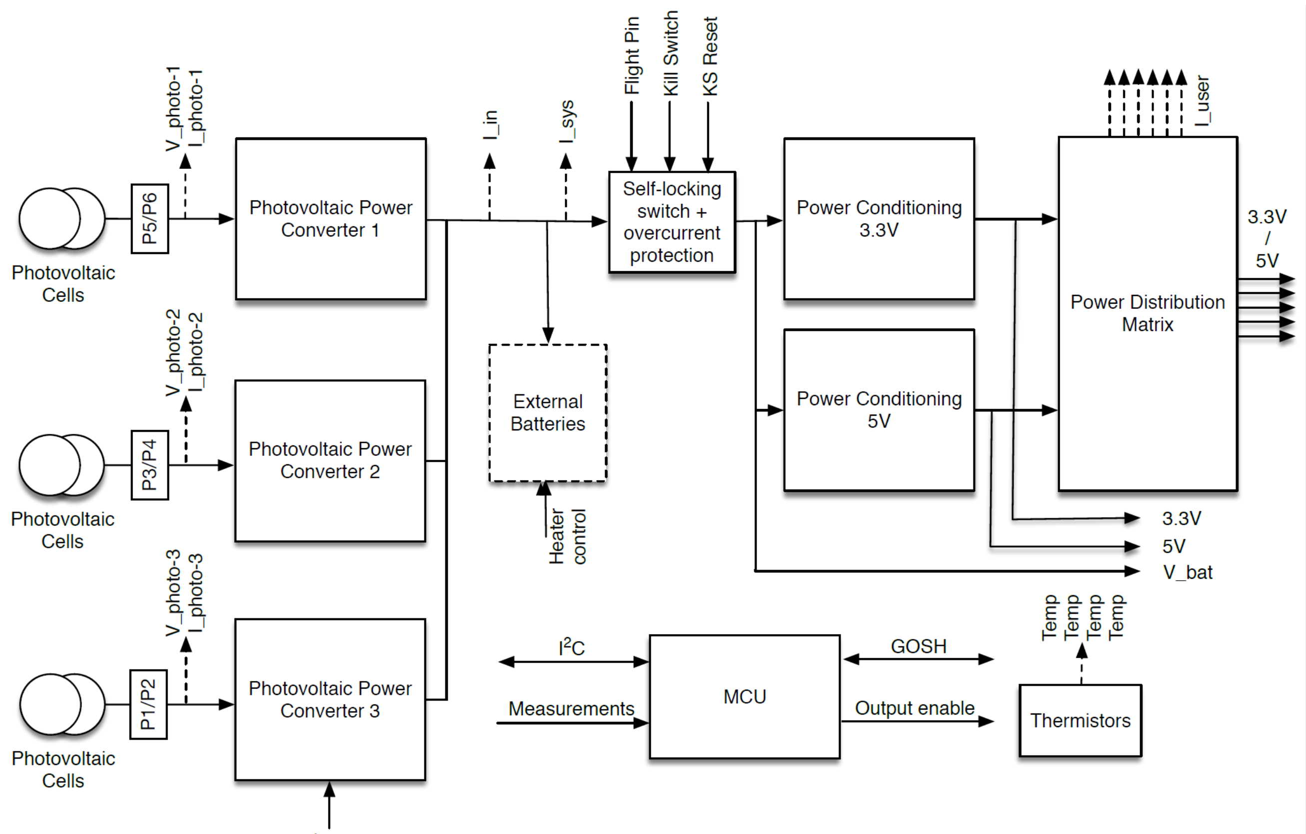
The P31u power supplies are designed for small, low-cost satellites with power demands from 1-30 W. Employing a strictly KISS design philosophy, the P31u interfaces to triple junction photo-voltaic cells and uses a highly efficient boost-converter to condition their output power to charge the provided lithium-ion battery. The incoming power along with the energy stored in the batteries is used to feed two buck-converters supplying a 3.3 V @ 5 A and a 5 V @ 4 A (configurable) output bus. Six individually controllable output switches with over-current shut-down and latch-up protection, each separately configurable to either 3.3 V or 5.0 V output.

2.3 Configurations

The P31u can seamlessly be connected to the GomSpace batteries BP4 or BPX. Below is a table with all the combinations. Note that the battery modules are ordered separately.

Power Modules	Battery Modules
P31u (no onboard battery) + BP4 (8 V)	
	
P31u (no onboard battery) + BPX (8 V)	
	
P31u (no onboard battery) + BP4 (16 V)	
	
P31u (no onboard battery) + BPX (16 V)	
	

2.4 Block Diagram



2.5 Microcontroller

The P31u features a microcontroller that provides maximum power-point tracking (MPPT) capability, measures and logs voltages, currents and temperatures of the system, enables user control etc. Using an I²C interface, it is possible to read out measurements, control the on/off-state of 3.3 V and 5 V busses, switch on/off the MPPT and to set/read various parameters.

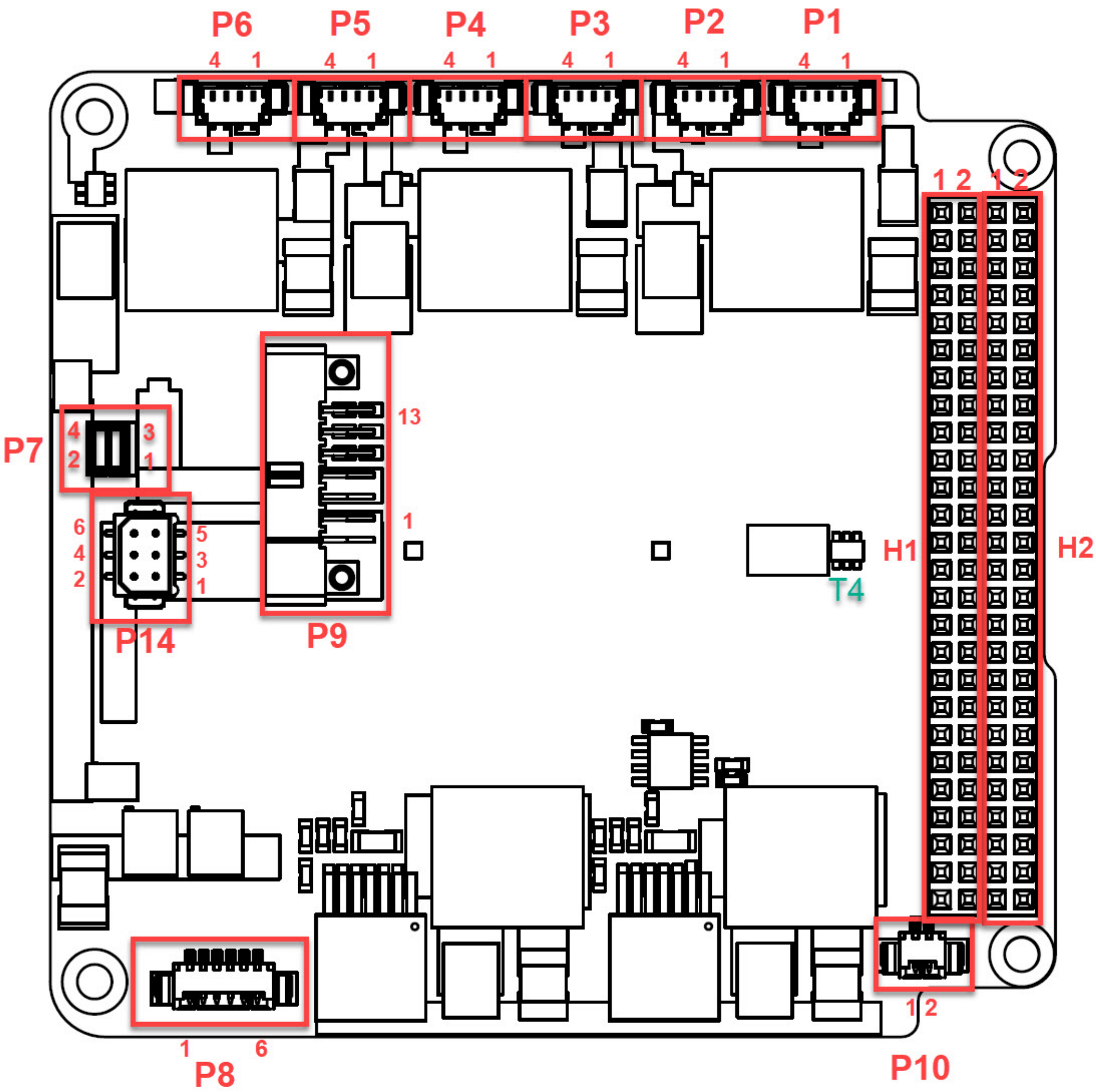
2.6 Multiple Photo-Voltaic Inputs

The P31u have three individual photo-voltaic input channels each having its own power-point setting. On satellites with up to three solar panels in the sunlight, this enables the voltage to be set independently on all panels thus capturing the exact maximum power-point at all illuminated cells when MPPT is employed. If used on a "box" satellite such as a CubeSat, simply connecting pairs of opposite mounted solar panels in parallel to each of the three inputs will allow individual conversion of the power from all cells in sunlight.

The photo-voltaic input converter is designed to handle up to 2 A input current. Each series string must have a protection diode in series in order to avoid non-illuminated cells from drawing current from illuminated ones.

3 Connector Pinout

3.1 P31u Top



Temperature sensors – T4

3.1.1 H1/H2 Stack Connectors

Pin	Mnemonic	Dir	Description
H1-32	5 V_in	I	5 V battery charge input (Same as P8 pin 6)
H1-41	I2C-SDA	I/O	I^2C serial data
H1-43	I2C-SCL	I/O	I^2C serial clock
H1-47	OUT-1	O	Latch-up protected output
H1-49	OUT-2	O	Latch-up protected output
H1-51	OUT-3	O	Latch-up protected output
H1-48	OUT-4	O	Latch-up protected output
H1-50	OUT-5	O	Latch-up protected output
H1-52	OUT-6	O	Latch-up protected output

Pin	Mnemonic	Dir	Description
H2-25	+5 V	O	Permanent 5 V output
H2-26	+5 V	O	Permanent 5 V output
H2-27	+3.3 V	O	Permanent 3.3 V output
H2-28	+3.3 V	O	Permanent 3.3 V output
H2-29	GND	O	Power ground
H2-30	GND	O	Power ground
H2-31	AGND	O	Analogue ground
H2-32	GND	O	Power ground
H2-45	V_BAT	O	Battery voltage
H2-46	V_BAT	O	Battery voltage

3.1.2 P1 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.3 P2 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.4 P3 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.5 P4 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.6 P5 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.7 P6 – Solar Input
Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

3.1.8 P7 - ARM Connector

(2x2 2.54 mm male-header) Battery ARM connector: This connects the batteries to the P31u circuitry.

Pin	Usage
1	Vbat cell terminal
2	Vbat system
3	Vbat cell terminal
4	Vbat system

3.1.9 P8 - Flight Preparation Panel

P8: (Picoblade 6 pin) Flight preparation panel connector

Pin	Usage	Description
1	GND	
2	RBF	*RBF pin on P8 must be shorted to ground to engage*
3	KS	*KS on P8 must be shorted to ground to override kill switch (switch on P31u).*
4	KS_RESET	*KS_RESET on P8 must be shorted to ground to engage reset.*
5	Vbat (through 100k Ω)	*KS on P10 and P11 Is used for measuring the battery voltage, is useful when the batteries should be charged*
6	CHARGE	5 V Charging interface on photovoltaic power converter no.3

3.1.10 P9 – to NanoPower BPX

(Harwin M80-5421442) Battery board extension connector to a BPX.

The connector type is limited to 3 A per pin.

Pin	Description	Pin	Description
1	GND	**2**	GND
3	GND	**4**	GND
5	BAT_RAW Battery Voltage	**6**	BAT_RAW Battery Voltage
7	BAT_RAW Battery Voltage	**8**	BAT_RAW Battery Voltage
9	I^2C SCK	**10**	Enable BPX (VCC 3.3V)
11	I^2C Data	**12**	GND
13	NC	**14**	NC

3.1.11 P10 – Kill Switch

(Picoblade 2 pin) Kill switch connectors

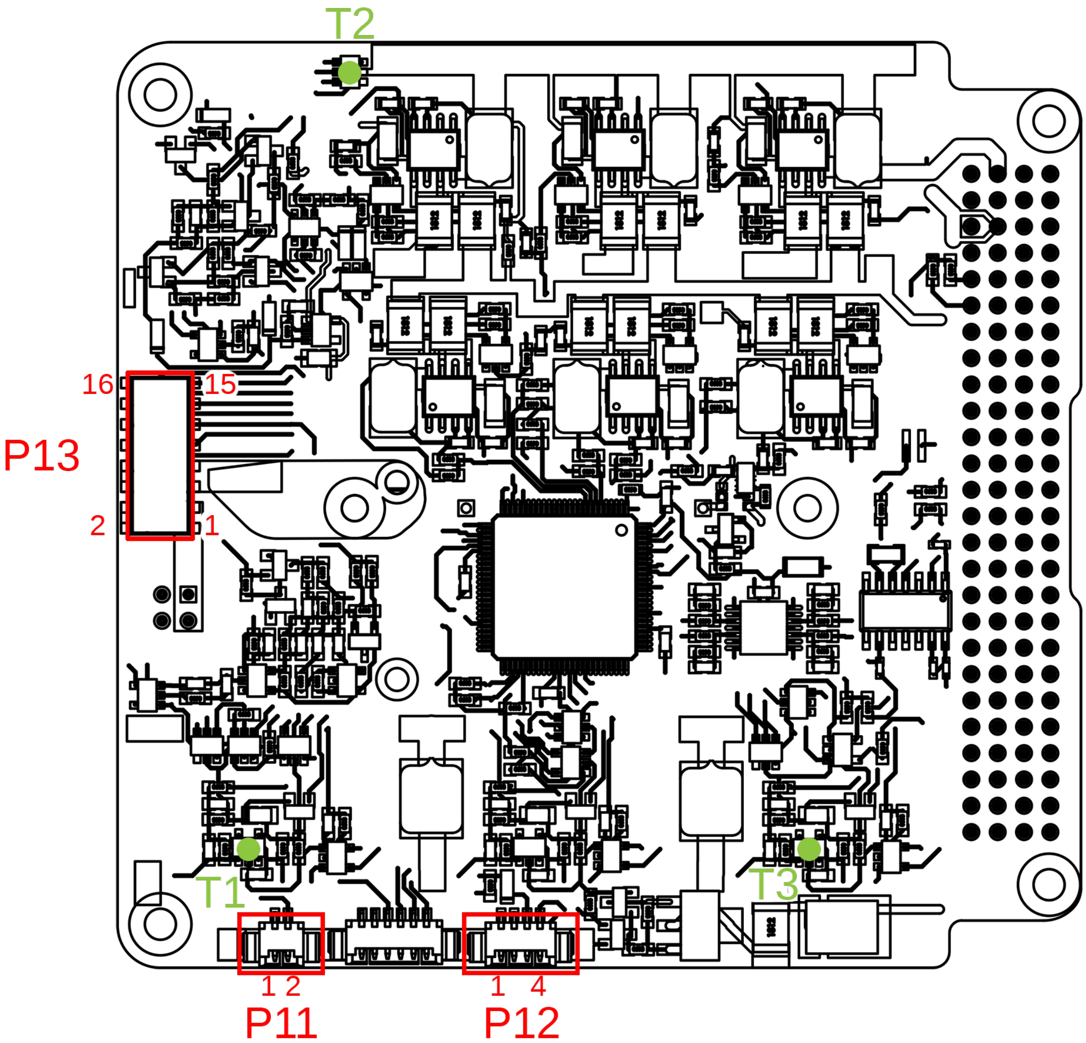
Pin	Usage	Description
1	KS- (GND)	*KS on P10 and P11 is a two-pin connector that must be shorted to switch on P31u, alternatively KS+ can be shorted to any ground common with P31u.*
2	KS+	*KS on P10 and P11 is a two-pin connector that must be shorted to switch on P31u, alternatively KS+ can be shorted to any ground common with P31u.*

3.1.12 P14 – Optional Battery Ground Break Connector

(Harwin M80-8280642) Optional battery ground break connector

Pin	Usage
1	GND
2	Battery minus (BAT GND)
3	GND
4	Battery minus (BAT GND)
5	GND
6	Battery minus (BAT GND)

3.2 P31u Bottom



Temperature sensors – T1, T2, T3

3.2.1 P11 – Kill Switch

(Picoblade 2 pin) Kill switch connectors

Pin	Usage	Description
1	KS- (GND)	*KS on P10 and P11 is a two-pin connector that must be shorted to switch on P31u, alternatively KS+ can be shorted to any ground common with P31u.*
2	KS+	*KS on P10 and P11 is a two-pin connector that must be shorted to switch on P31u, alternatively KS+ can be shorted to any ground common with P31u.*

3.2.2 P12 – GOSH Interface

(Picoblade 4 pin) Serial connector for GOSH interface.

Pin	Usage
1	GND
2	Not Connected
3	RxD
4	TxD

3.2.3 P13 – to NanoPower BP4

Battery board extension connector for BP4.

Pin	Name	Description	Pin	Name	Description
1	VBat_RAW	Battery voltage connection	**2**	VBat_RAW	Battery voltage connection
3	VBat_RAW	Battery voltage connection	**4**	VBat_RAW	Battery voltage connection
5	GND	Ground	**6**	GND	Ground
7	GND	Ground	**8**	GND	Ground
9	MOSI	SPI MOSI	**10**	MISO	SPI MISO
11	SCK	SPI SCK	**12**	VCC	Supply voltage for temperature sensors
13	SC2	Chip select for temperature sensor 2	**14**	CS1	Chip select for temperature sensor 1
15	HS	Active high heater control	**16**	PS	Active high power switch control (optional)

3.3 Solar Panel Input Converters

Converter 1: P6 and P5
Converter 2: P4 and P3
Converter 3: P2 and P1

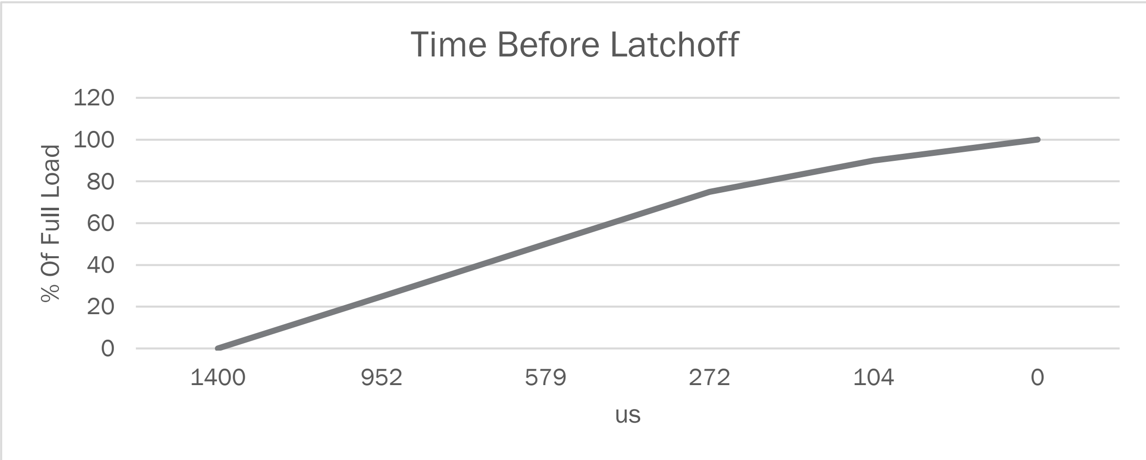
4 Electrical Characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
Battery					
- Voltage	Battery connection 2 cells in series	6.0	7.20	8.40	V
	Battery connection 4 cells in series	(*12.0)	(*14.4)	(*16.80)	V
- UVD	Under voltage detection		1600		us
- Current, charge	(Depends on battery configuration)				A
- Current, discharge	Overcurrent protection threshold		4	6.00	A
- OCD (I_Sys)	Over current detection	1	580***	1400	us
PV inputs	Photo-voltaic inputs				
- Voltage	(Customer selectable)	0	4.2	8.5	V
		(*0)	(*8.4)	(*17)	V
- Current, charge		0.00		2.00	A
Charge Pin	Battery charge input				
-Voltage	5 V => 0.9 A charge, 4 V => 0 A	4.10	5.00	5.00	V
-Current, cont	@5 V		0.9	1.1	A
OUT-1,2,3,4,5,6	Latch-up protected outputs				
- Voltage	Configurable		3.3/4.98		V
- Current limit	Current cut-off limit (Cust. select)	0.5	Select	2.5	A
+5 V	5 V regulated output (always on)				
- Voltage		4.89	4.98	5.05	V
- Current, cont. **	Total current including output channels	0.005		4.00	A
+3.3 V	3.3 V regulated output (always on)				
- Voltage		3.29	3.34	3.39	V
- Current, cont.	Total current including output channels	0		5.00	A
V_BAT	Battery voltage				
- Voltage	Over Voltage protected	6.0		8.40	V
	See Block Diagram	(*12.15)		(*16.80)	
- Current out	(Depends on battery configuration)		4		A
Power consumption	Power consumed by P31u		160 (*260)		mW
Off current	Current consumed with separation switch OFF		35	60	µA
Shell-life	Period until batteries are fully discharged when separation switch is OFF. (Depends on battery configuration)	700	1400		Days

* Only on P31u 16 V version
** A completely unloaded 5 V channel may show oscillations.
*** See Chapter 6

4.1 Over Current Detector (OCD)

The overcurrent detector for the system has a time before latch-off depending on the normal current that is used by the entire system, if the system is loaded by 50% of the total output power I_sys (see 3.4) and there occurs a short circuit then the time before latch-off is 580 µs see table below.



4.2 The Power Distribution Switches

The output switch shut off all power to the load when an OCD occurs, just as a circuit breaker would do. A fault condition is deemed to be anytime the output current exceeds the current limit for more than 28 ms. Once the output shuts off, it remains off until either the fault load is removed from VOUT or until the p31u cycles automatically after 500 ms. If the fault is still present after cycled it will again shut off all power to the load after 28 ms.

5 Heater and Temperature Sensor

Lithium-ion batteries cannot charge in low temperatures (see battery datasheet). Using a heater on BP4 to maintain temperature above charging threshold is a software option. Software default mode is set to manual.

Parameter	Condition	Min.	Typ.	Max.	Unit
Heater Elements on BP4					
Heater resistance	8 V		2x22		Ω
	16 V		2x82		Ω
Heater power	8V		6		W
	16V		6		W

Temp sensor Texas Instruments TMP121

Parameter	Min.	Typ.	Max.	Unit
Temperature Sensors				
- Range	-40		125	°C
- Accuracy	-2	1.5	2	°C

6 Batteries

For information on battery specifications, please see the GomSpace battery datasheet (gs-ds-battery).

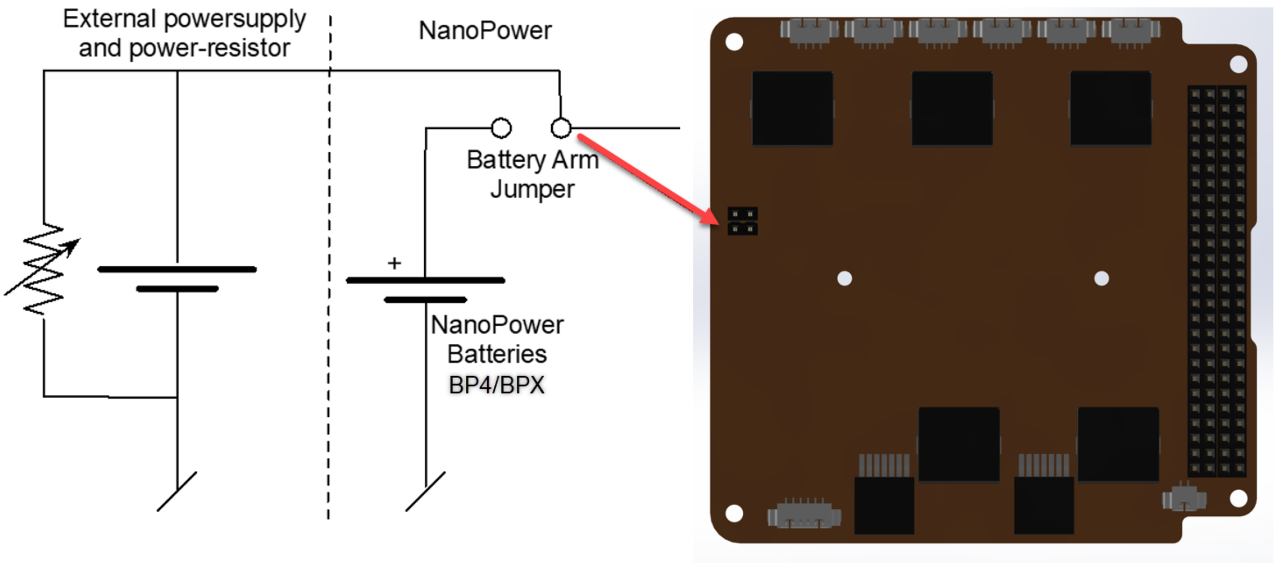
6.1 Connecting the Batteries

To connect the batteries to the rest of the circuit, connect jumpers to the battery ARM connector (P7).

Battery voltage is on the two pins towards the batteries (pin 1 and 3) and P31u circuit is on the two pins towards the edge (pin 2 and 4). The two jumper connections are redundant in the way that it is enough to short one to connect the batteries to the circuit.

6.2 Operating Without Batteries

During testing, it can sometimes be beneficial to operate without batteries connected. Instead, a bench power supply and a power resistor can be used to simulate the batteries. The power supply must be set to a voltage that corresponds to the battery voltage range of P31u, e.g. 7.4 V. The power resistor is used to sink current coming in from battery charging and must be sized accordingly both in terms of resistance value and in terms of power rating.



Example: With a voltage of 7.4 V and a 5 Ω resistor the simulated battery can sink 7.4 V/5 Ω = 1.48 A of current and the resistor must be able to dissipate 7.4 V * 1.48 A = 10.9 W.

Warning: *P31u power supplies are capable of operation with batteries that have lost all capacity or even completely without batteries. However, operating without batteries should only be considered as a failure backup mode.*

7 Physical Characteristics

P31u

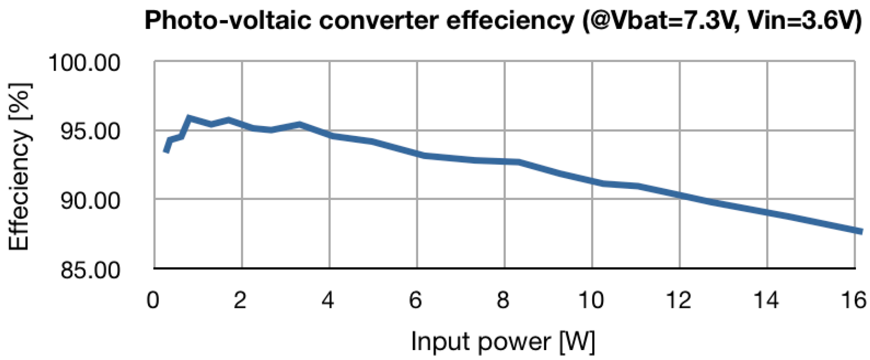
Description	Value	Unit
Mass (With low stack connector)	100	g
Size	89.3 x 92.9 x 15.3	mm

8 Performance

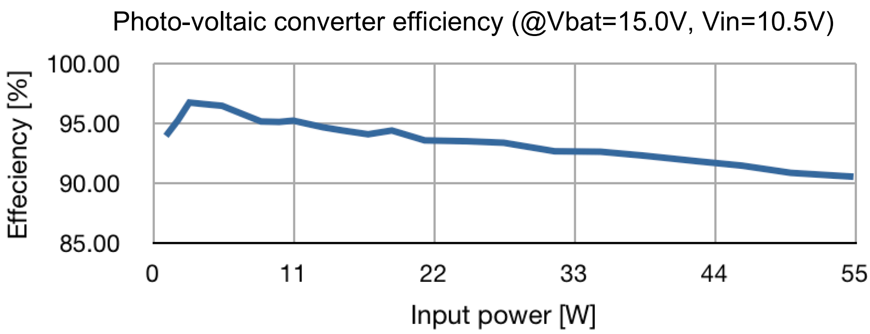
The P31u is designed with efficiency and reliability in mind. One of the most critical current paths in a satellite system is the Photo-Voltaic (PV) input that supplies energy for the batteries.

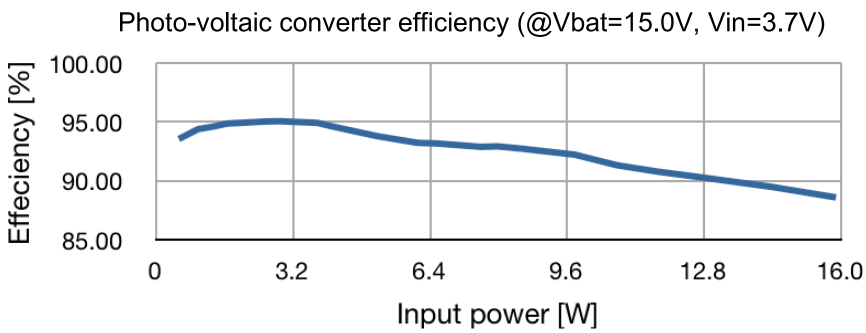
8.1 Converters efficiency

Efficiency of a single normal version photovoltaic converter is shown in the graph below for up to 16 W.



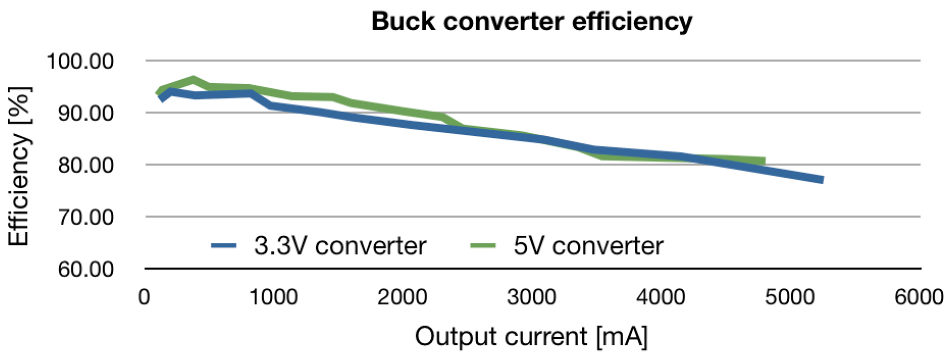
Efficiency of a P31u 16 V photovoltaic input converter is show below for input powers up to 55 W with an input voltage of 10.5 V and up to 16 W for an input voltage of 3.7 V.





NOTE: *Efficiency of input converters depends very much on the actual current through the converter. Therefore, in general if input voltage is higher, then efficiency is higher at the same power input.*

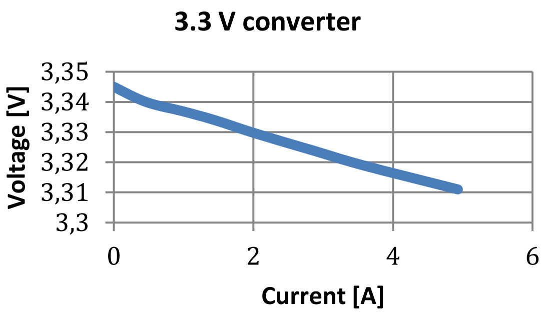
Efficiency of the power-conditioning converter, measured from battery to user outputs, can be seen on the figure below:

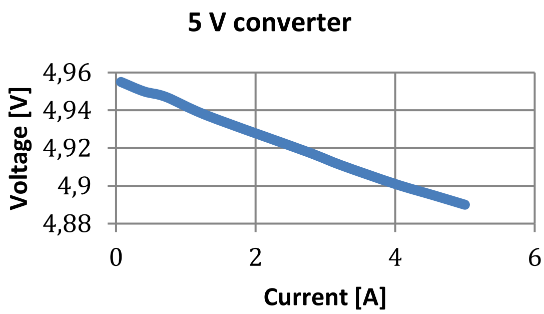


8.2 Line loss / Voltage drop

From output converters to the users there is a certain resistance that will result in loss. The output switch, the PCB tracks and the stack connector all have resistance. A total resistance from power converters to users is typically <50 mΩ.

A measurement of the voltage drop on the 3.3 V and 5 V bus is show below. The current is drawn from a single pin in the stack connector (H2-26 and H2-27 respectively).





9 Environment Testing

To simulate the harsh conditions of launch and space, the P31u has been exposed to a number of environment tests. For detailed information about the tests please contact GomSpace.
The P31u has flown successfully on several satellites and performed perfectly.

10 Mechanical Drawing

Dimensions are given in mm.