GOMSPACE

NanoPower
P31u / P31us

Datasheet

Electric Power System for mission critical space applications with limited resources

GomSpace ApS • Alfred Nobels Vej 21C • DK-9220 Aalborg East • Denmark
www.gomspace.com • info@gomspace.com • +45 96356111

1 Table of contents

2 Changelog

Date	Doc Rev.	Product Rev.	Author	Description	Valid for firmware version
05/05-2014	1	9	MB	First version of datasheet for NanoPower P31u v9 Updated information on: serial port, heater, connections.	2.11
11/06-2014	2	9	MB	Rearranged sections in datasheet. Fixed spelling errors. Updated block diagram.	2.11
05/08-2014	3	9	MB	Added section on operating without battery Added option for I^2C wdt to perform hard reset Updated 'board' command information Updated photo of BP4	2.12
17/10-2014	4	9	MB	Updated information on charging. Fixed battery mode error in housekeeping	2.12
12/02-2015	5	9	MB	Updated for firmware 2.16. Updated Dedicated WDT description.	2.16
18/03-2015	6	9	MB	Added s-version power consumption to table.	2.16
19/08-2015	7	9	MB	Fixed textual problem on page 9	2.16
27/08-2015	8	9	MB	Updated config and config2 operation as per firmware 2.17.	2.17
01/03-2016	9	9	KLK	Applied new GomSpace layout and split into datasheet and manual	2.17
07/04-2016	10	9	KBA	Updated for firmware 2.18	2.18
25/04-2016	11	9	KBA	Updated for firmware 2.19	2.19
06/06-2016	12	10	MB	Updated product revision to 10 due to changed battery overcurrent protection value (6A -> 4A) Fixed error in power-consumption	2.19
19/08-2016	13	10	KLK	Fixed textual problem on page 15. Reapplied temperature sens	2.19

Firmware Revision	Changes
2.11	Update to P31u-9 board Added new onboard heater channel Fixed issue with GND wdt not resetting when set to 1 hour
2.12	Fixed issue where I^2C wdt could do reset when disabled. Added option for choosing I^2C timeout action to hard reset.
2.16	Fixed issue on firmware 2.12 where EPS would do random resets when communication in slave I^2C mode. Updated GND WDT functionality. It will now timeout on reboots as well. See updated description.
2.17	Operation of config and config2 are changed to both function in the same manner. 'eps conf set' sets new config to RAM and 'eps conf confirm' saves to RAM. If new confirm command is send within 30 seconds the original RAM config is restored. MPPT algorithm now resets to the user set vboost value.
2.18	Improved robustness of I^2C driver, including graceful I^2C bus error handling.
2.19	Fixed error check in I2C driver. Fixed memory issue in GOSH command history.
2.20	Fix wrong text in error printout.

3 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 P31 (P31) is designed as a reliable and flight proven system with digital interface and advanced features like maximum power point tracking and latchup-protection.

3.1 Highlighted Features

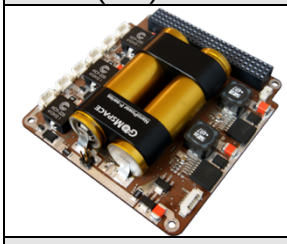
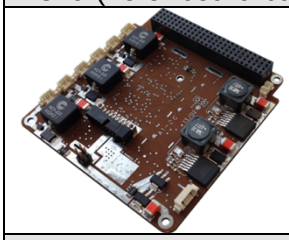
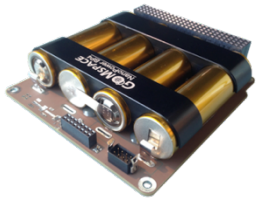
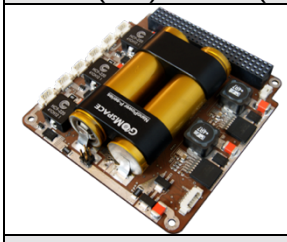
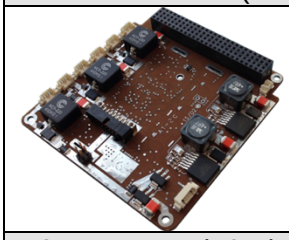
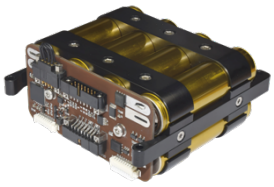
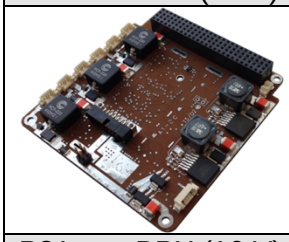
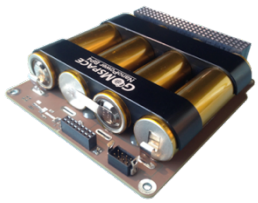
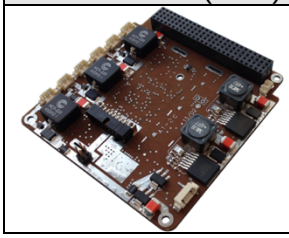
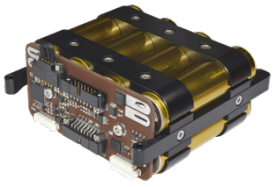
- 3 input channels with independent power-point setting giving an input power capacity of 30 W.
- The standard series are optimized for panels with up to 2 solar cells in series. The s-series is optimized for up to 7 solar cells in series.
- Maximum power point tracking.
- Battery under-voltage and over-voltage 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
- Remove-Before-Flight-pin interface
- Onboard lithium ion battery pack (*s series has no batteries but requires an external battery pack*)
- Battery heater
- Interface to battery board NanoPower BP4 or NanoPower BPX
- Can operate after end of battery lifetime
- I^2C interface
- Operational temperature: -40 °C to +85 °C
- Fits standard PC104
- Dimensions: 96 mm x 90 mm x (16 to 26) mm
- PCB: glass/polyamide from ESA approved producer
- IPC-A-610 Class 3 assembly

3.2 General Description

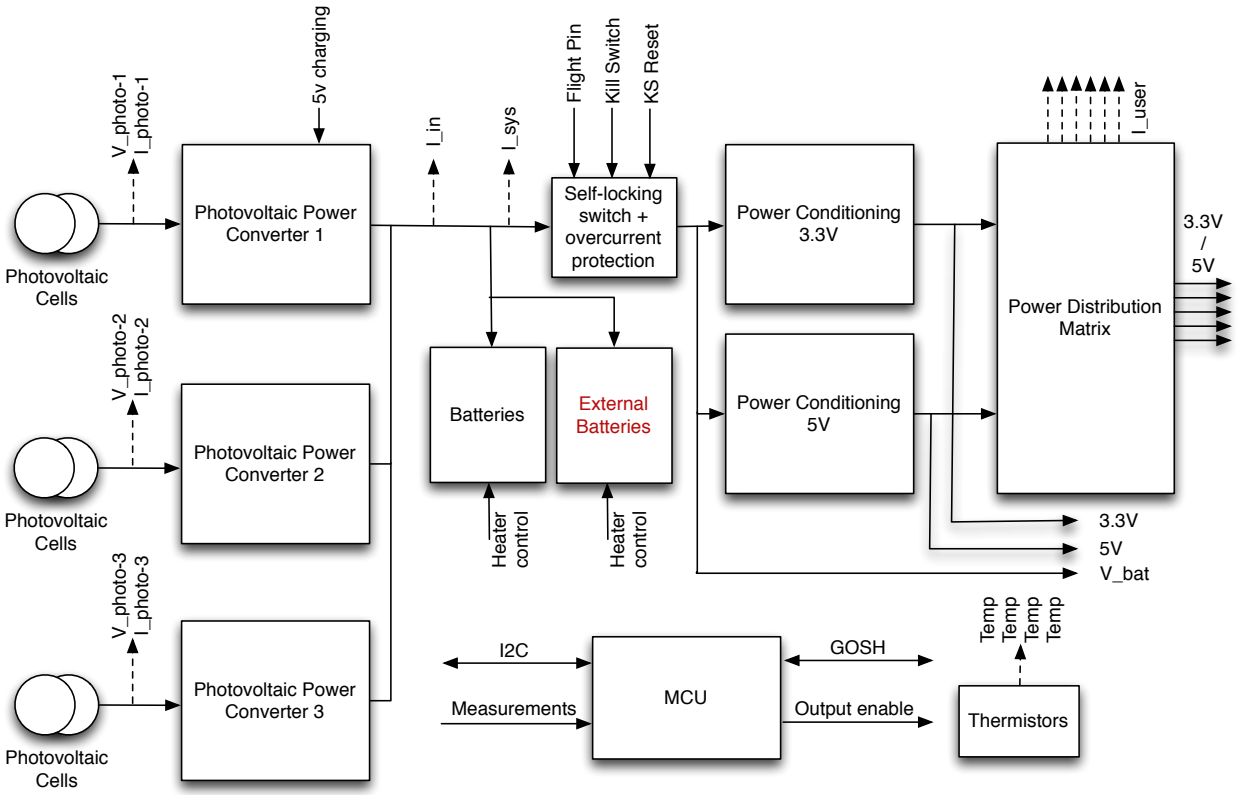
The P31 power supplies are designed for small, low-cost satellites with power demands from 1-30 W. Employing a strictly KISS design philosophy, the P31 interfaces to triple junction photo-voltaic cells and uses a highly efficient boost-converter to condition their output power in order to charge the 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.

3.3 Configurations

NanoPower P31 is available in two different configurations, the normal version P31u and the high voltage version P31us. Each can seamlessly be connected to the GomSpace batteries BP4 or BPX. Below is a table with all the combinations. Note that the batteries are ordered separately.

Power Modules	Battery Modules
P31u (8 V)	
	
P31u (no onboard battery) + BP4 (8 V)	
	
P31u (8 V) + BP4 (8 V)	
	
P31u 8 V + BPX (8 V)	
	
P31us + BP4 (16 V)	
	
P31us + BPX (16 V)	
	

3.4 Block Diagram



3.5 Microcontroller

The P31 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 I^2C 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.

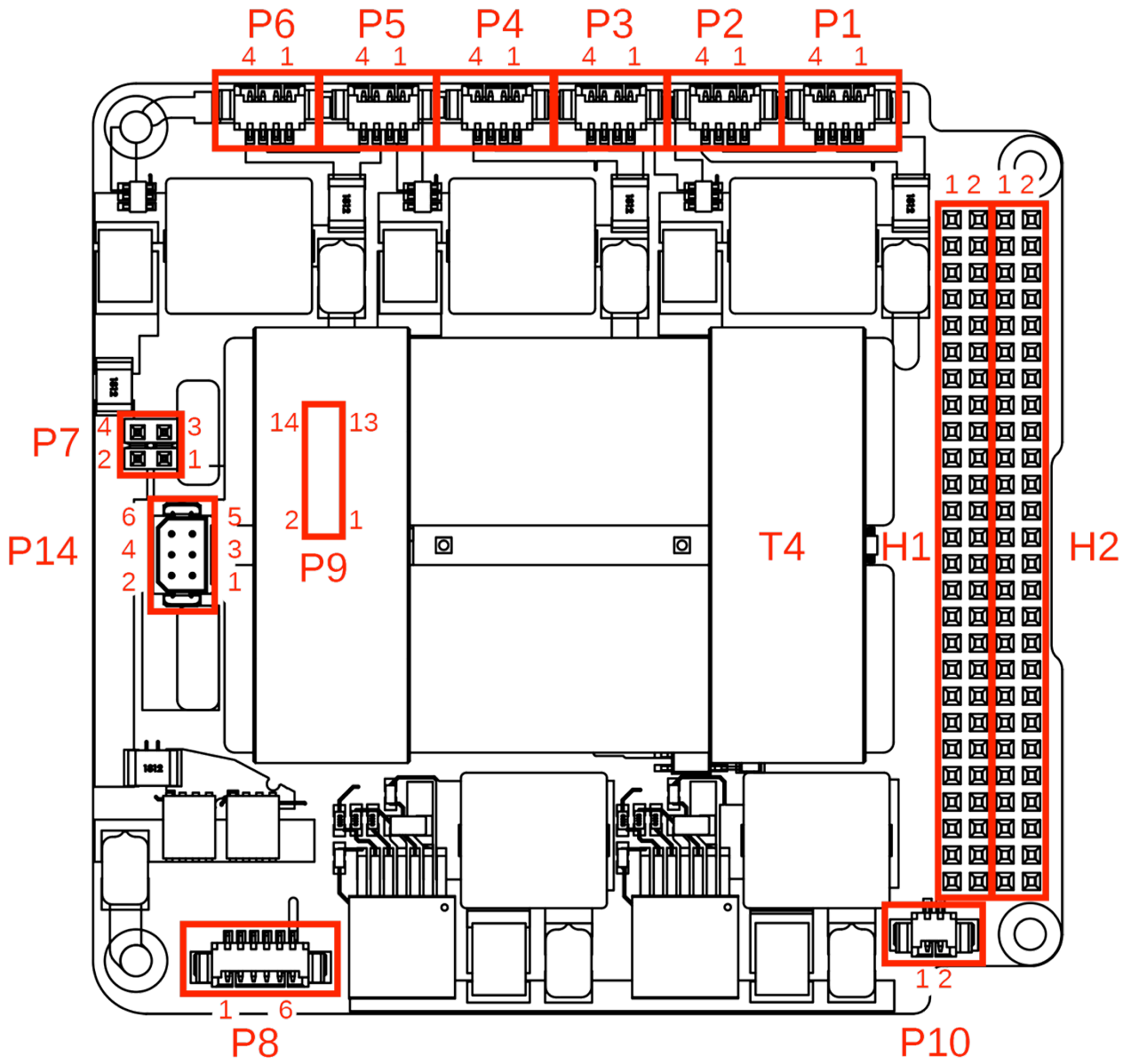
3.6 Multiple Photo-Voltaic Inputs

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. The inputs are designed for two triple junction cells in series and a number of such in parallel. Each series string must have a protection diode in series in order to avoid non-illuminated cells from drawing current from illuminated ones.

4 Connector Pinout

4.1 P31u Top



T1-T4 is four temperature sensors (see bottom as well, chapter 4.2).

4.1.1 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
H2-36	EPS RX	I	Serial port Rx (optional)
H2-38	EPX TX	O	Serial port Tx (optional)
H2-45	V_BAT	O	Battery voltage
H2-46	V_BAT	O	Battery voltage

4.1.2 P1 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.3 P2 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.4 P3 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.5 P4 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.6 P5 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.7 P6 – Solar Input

Picoblade 4 pin. Solar panel input connectors.

Pin	Usage
1	GND
2	GND
3	Vsc
4	Vsc

4.1.8 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

Note that for ISS-launch version of the NanoPower P31u, P7 is exchanged with a 6 pin Harwin M80-8280642.

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

4.1.9 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 P31).*
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 a two pin connector that must be shorted to switch on P31, alternatively KS+ can be shorted to any ground common with P31.*
6	CHARGE	

4.1.10 P9 – to NanoPower BPX

(Harwin M80-5421442) Battery board extension connector to a BPX. It cannot co-exist with onboard batteries.

The connector type is limited to 3 A per pin.

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

4.1.11 P10 – Kill Switch

(Picoblade 2 pin) Kill switch connectors

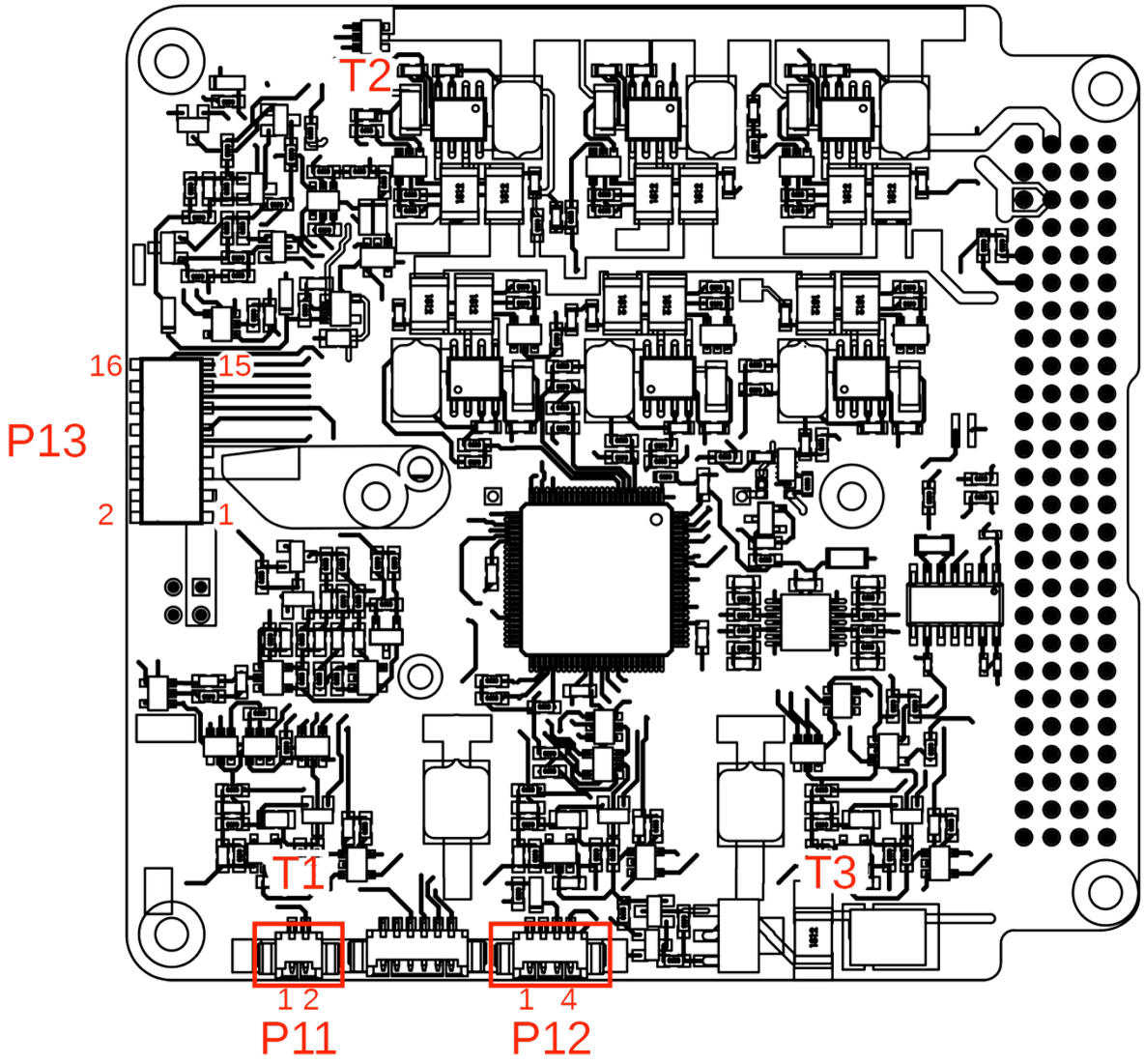
Pin	Usage	Description
1	KS- (GND)	*KS on P10 and P11 is a two pin connector that must be shorted to switch on P31, alternatively KS+ can be shorted to any ground common with P31.*
2	KS+	*KS on P10 and P11 is a two pin connector that must be shorted to switch on P31, alternatively KS+ can be shorted to any ground common with P31.*

4.1.12 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)

4.2 P31u Bottom



T1-T4 is four temperature sensors (see top as well, chapter 4.1).

4.2.1 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 P31, alternatively KS+ can be shorted to any ground common with P31.*
2	KS+	*KS on P10 and P11 is a two pin connector that must be shorted to switch on P31, alternatively KS+ can be shorted to any ground common with P31.*

4.2.2 P12 – GOSH Interface

(Picoblade 4 pin) Serial connector for GOSH interface.

Pin	Usage
1	GND
2	Not Connected
3	RxD
4	TxD

4.2.3 P13 – to NanoPower BP4

Battery board extension connector for BP4.

Pin	Name	Description	Pin	Name	Description
1	Vbat	Battery voltage connection	**2**	Vbat	Battery voltage connection
3	Vbat	Battery voltage connection	**4**	Vbat	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)

4.3 Solar panel input converters

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

5 Electrical Characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
Battery					
- Voltage	Battery connection	6.0 (*12.0)	7.40 (*14.9)	8.40 (*16.80)	V V
- Current, charge	(Depends on battery configuration)				A
- Current, discharge	Overcurrent protection threshold ***		4***	6.00	A
PV inputs	Photo-voltaic inputs				
- Voltage	(Customer selectable)	0 (*0)	4.2 (*8.4)	8.5 (*17)	V V
- Current, charge		0.00		2.00	A
5V_in	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	3.0	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	Raw battery voltage				
- Voltage	(Depends on battery configuration)	6.0 (*12.15)		8.40 (*16.80)	V
- Current out			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 P31us
** A completely unloaded 5 V channel may show oscillations.
*** For higher threshold, please enquire at info@GomSpace.com.

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 P31 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.

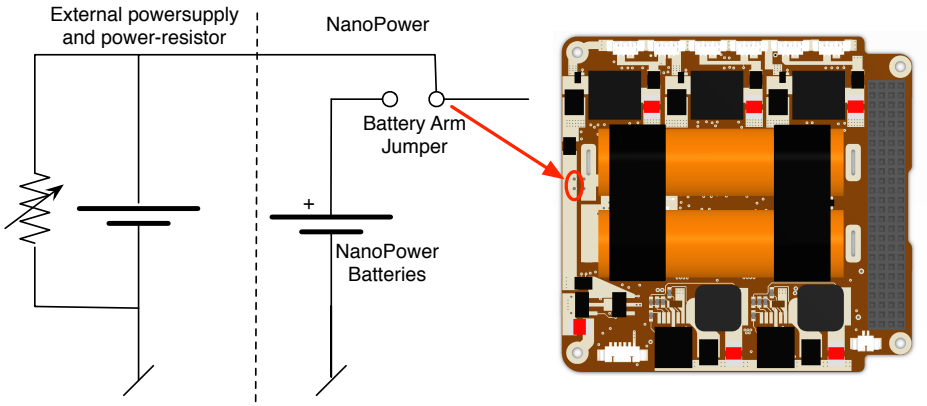
For flight configuration in is recommended to solder the header connection securely together.

Warning: *When using BP4 together with a P31u unit with onboard batteries it is important to ensure that batteries on P31u and BP4 have exactly the same charge before connecting them together. This can be done by connecting them with a sliding resistor and an ampere-meter to let them equal out their charge state at a controlled pace. Start with a high resistance and gradually lower it as the two battery sets equalize their charge (voltage difference must be smaller than <100 mV before direct connection). Do not let the current go above 1 A.*
As standard batteries are shipped from GomSpace with same charge, but it is important to verify the voltage of both battery packs before connecting them.

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.



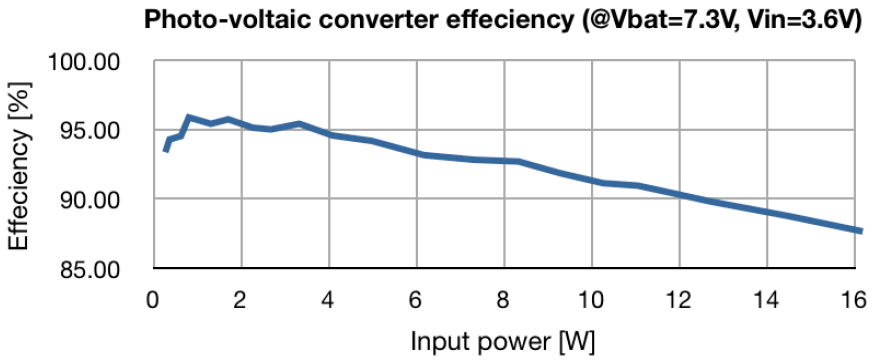
Warning: *P31u power supplies are capable of operation with batteries that have lost all capacity or even completely without batteries. However, operating without batteries should only be considered as a failure backup mode. If you consider using the P31u entirely without batteries, please consult GomSpace first.*

7 Performance

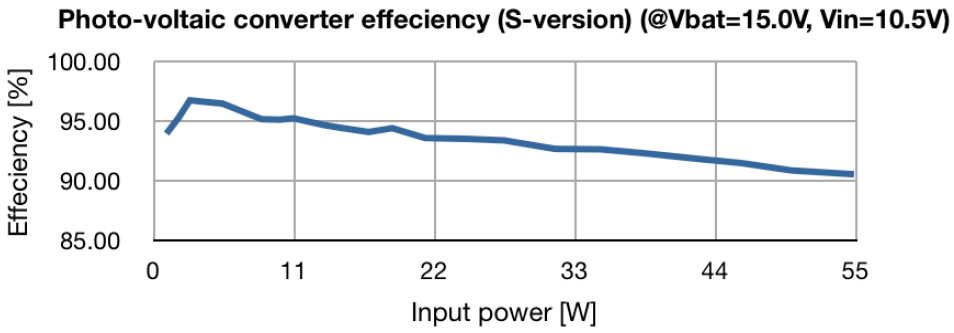
The P31 is designed with efficiency and reliability in mind. One of the most critical current paths in a satellite system is the Photo-Voltaic (PV) input that supplies energy for the batteries. On the P31 the PV input path consists of a boost-converter that converts the approximately 4.2 V *(8.4 V for P31us)* from two series connected triple-junction cells up to 8.4 V *(16.8 V for P31us)* on the batteries. The component-count in this path is kept to a minimum and are all power- and current-derated by 70%. Also, the component-count in the controller circuitry for the photovoltaic and power conditioning converters is kept extremely low and employs only analogue components.

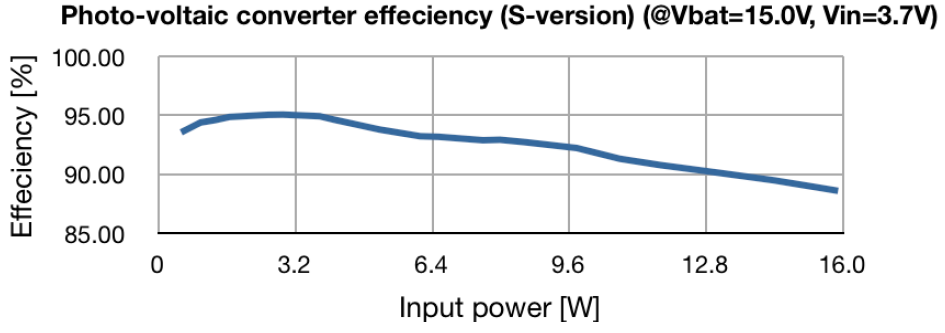
7.1 Converters efficiency

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



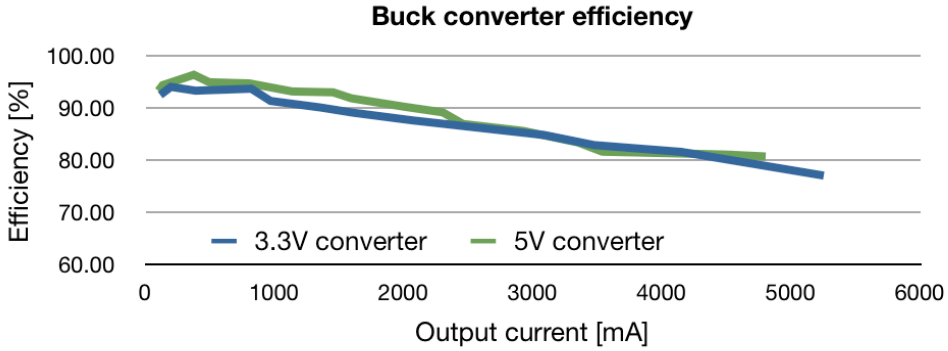
Efficiency of a single S-version photovoltaic input converter is show below for input powers up to 55 W with an input voltage of 10.5 V and up to 16 W for an input voltage of 3.7 V.





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.*

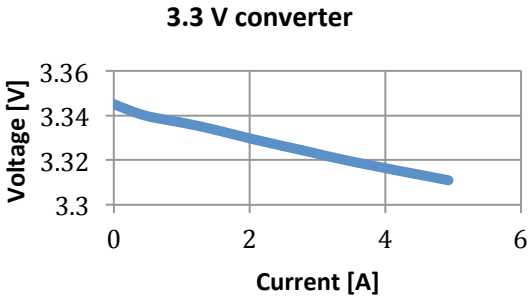
Efficiency of the power-conditioning converter, measured from battery to user outputs, can be seen on the figure below:

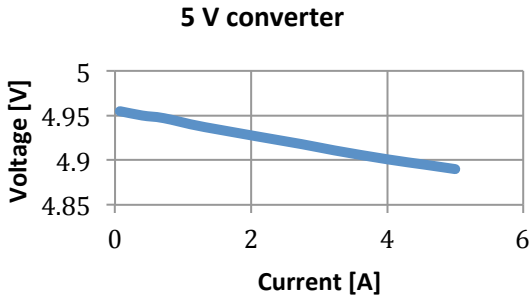


7.2 Line loss / Voltage drop

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).





8 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.

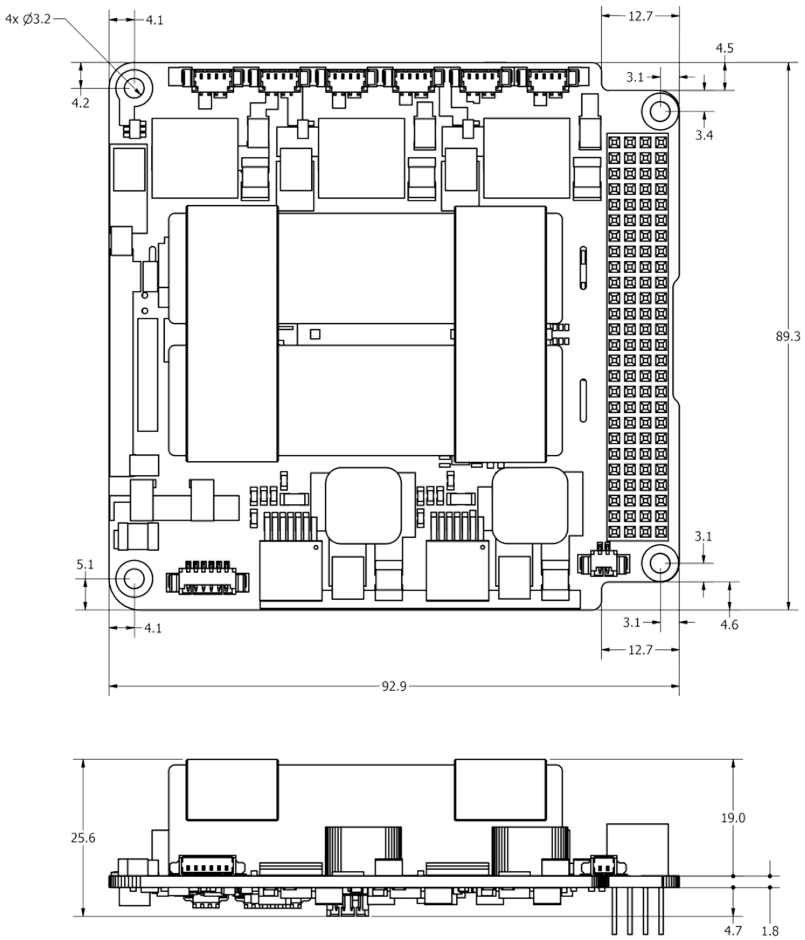
9 Physical Dimensions

Masses will vary depending on customer choices.

Model	Mass
NanoPower P31u without batteries. With low stack connector	100 g
NanoPower P31u. With 2600 mAh batteries. With high stack connector	200 g
NanoPower P31us	370 g

Dimensions are given in mm.

P31u



P31us