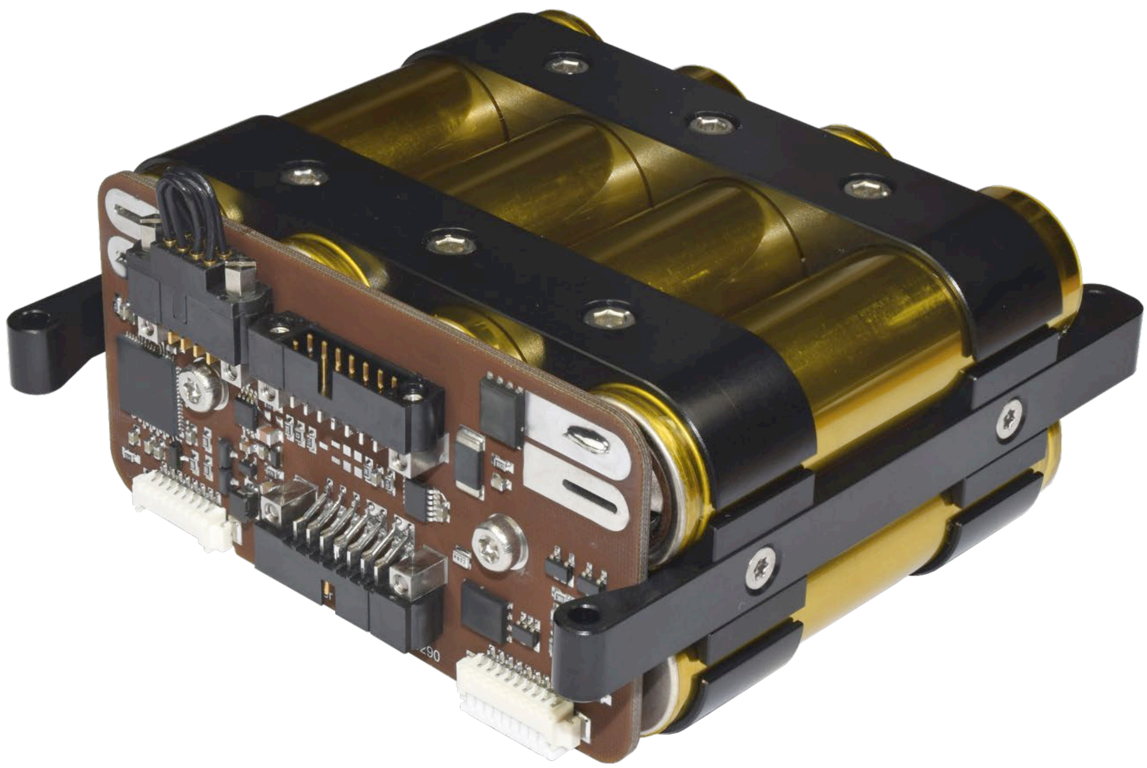

NanoPower BPX

Datasheet

High-capacity battery pack for nano-satellites

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1 Table of Contents

2 Overview

The NanoPower BPX (BPX) is a high-capacity lithium ion battery pack with a heater for nano-satellites. Several BPX battery packs can be coupled in parallel if greater capacity packs are needed.

2.1 Highlighted Features

- Lithium ion battery back for space applications
- Utilizes 18650 lithium ion cells, 2600 mAh cell (Nominal)
- Can be configured for nominal voltages ranging up to 29.6 V
- Provides telemetry over I^2C
    - Voltage
    - Current
    - Temperature
- Autonomous heater system
- Fits standard PC104
- Weight: 500 g
- PCB material: Glass/Polyimide IPC 6012C cl. 3/A
- IPC-A-610 Class 3 assembly

2.2 Customization Options

As GomSpace realizes that different applications place different requirements to a power system, the NanoPower products present a variety of options for customization. Options are to be agreed upon time of order placement.

Below are the standard configurations. It is possible with option 2, to connect several BPX in parallel using PBAT2 connector to get higher total capacity.

To find the nominal voltage of the chosen battery pack use the following equation (Vnom(cell) is found in the battery datasheet):

*Vnom(pack) = Vnom(cell) * Number of series cells*

To find the current capacity of the battery pack use the following equation:

*Icap(pack) = Icap(cell) * Number of parallel cells*

To find the nominal capacity (Wh) of the battery pack use the following equation:

*Pcap(pack) = Vnom(pack) * Icap(pack)*

Configuration	Number of cells	Capacity [Wh]	V_{range} [V]	$V_{nominel}$ [V]	Capacity [Ah]
2S-4P	8	75	6 - 8.4	7.2 V	10.4
4S-2P	8	75	12 - 16.8	14.4 V	5.2
8S-1P	8	75	24 - 33.6	28.8 V	2.6

2.3 Measurements

The NanoPower BPX provides a number of measurement points that enables monitoring of the condition of the system. These measurements are available as digital readings retrievable through the I^2C interface. Measurements include:

- Current into and out of batteries (not available with option 2)
- Battery voltage
- Four temperature measurements
- Heater current measurement

2.4 Short Circuit Protection

The protection level depends on the configuration and subject to activation through the enable pin. The battery output on connector PBAT1 have two operating modes, depending on option selected (se chapter 2.7) if option 1 or 3 is selected the PBAT1 is short-circuit protected, if option 2 is selected the PBAT1 has raw battery, and no short-circuit protection.

Configuration	Short-circuit protected current level
2S-4P	10 A
4S-2P	10 A
8S-1P	3 A

2.5 Enable Pin

Depending on option, the raw unprotected battery power is accessible through the PBAT2 all other function of the BPX is powered off.

The enable pin on PBAT1 and PBAT2 (default: active high) is used to activate the battery packs onboard functions: housekeeping, heater control, and toggles the over current protected battery power switch to on. See the block diagram in the following chapter.

2.6 ISS Acceptance Test

GomSpace offers an option to perform an ISS acceptance test to meet NASA and NanoRacks safety requirements for ISS launch. This includes: vibration test, vacuum test, battery testing and a test report.

2.7 Block Diagram

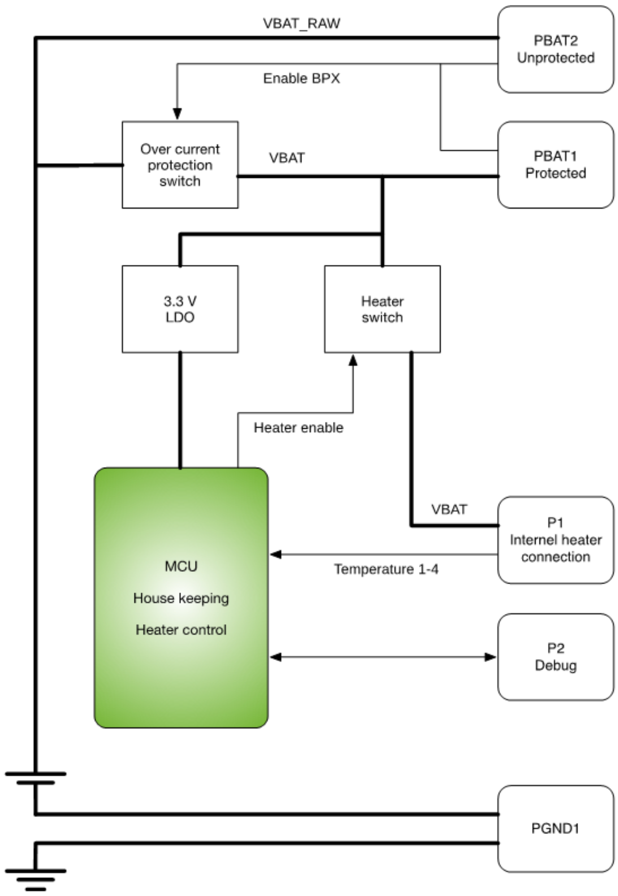


Figure 1 BPX Block diagram option 1 and 2

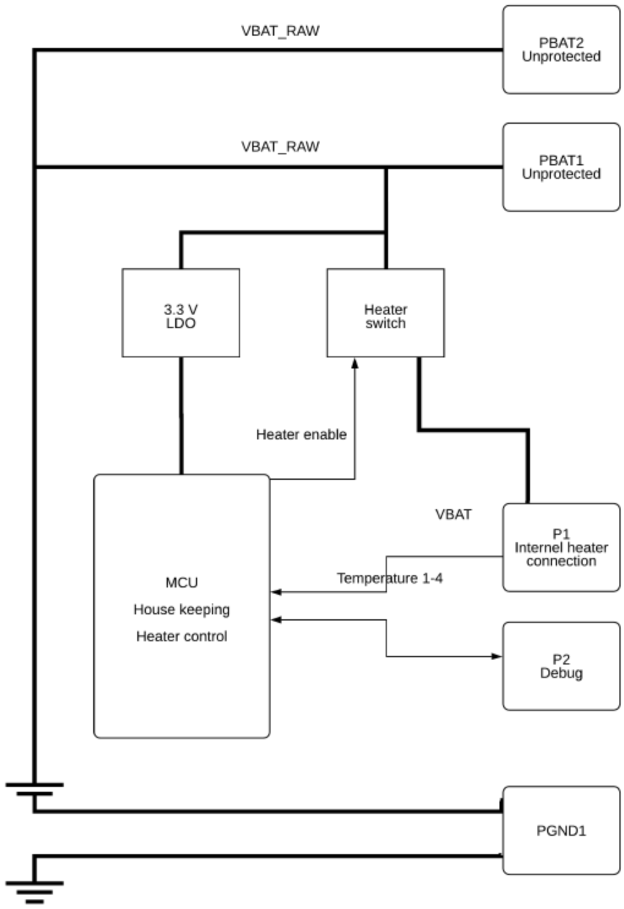
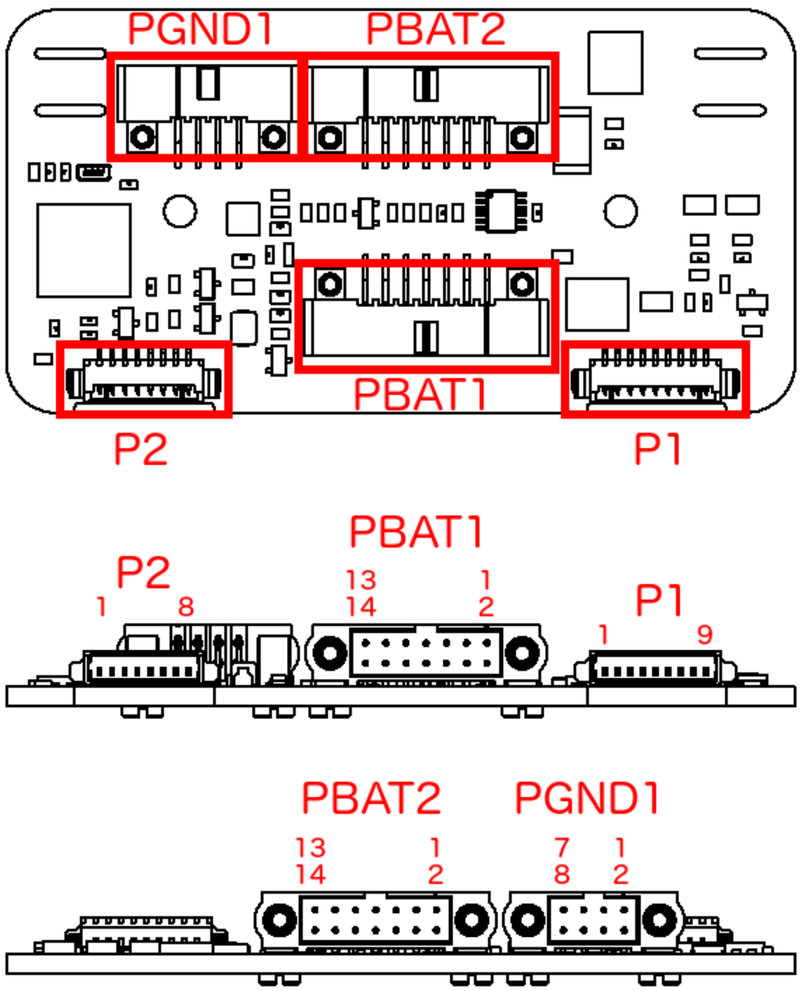


Figure 2.1 BPX Block diagram option 2

3 Hardware Layout



3.1 P1 - Heater Connector

Picoblade Molex 0532610971

Pin	Description
1	Heater Supply
2	Heater Supply
3	GND
4	GND
5	3.3 V to temperature sensor heater
6	Vtemp 1
7	Vtemp 2
8	Vtemp 3
9	Vtemp 4

3.2 P2 - Debug

Picoblade Molex 0532610871

Used by GomSpace for MCU programming.

Pin	Description
1	GND
2	VCC 3.3 V
3	UART RX
4	UART TX
5	Reset
6	ISP SCK
7	ISP MOSI
8	ISP MISO

3.3 PBAT1 - Battery Connector

Harwin M80-5421442.The connector type is limited to 3 A per pin.

The only difference between PBAT1 and PBAT2 is the VBAT protected and VBAT raw pins depending on option. The I^2C, the Enable BPX and Kill switch pins are the same net on the PCB.

Pin	Description	Pin	Description
1	GND	2	GND
3	GND	4	GND
5	VBAT (Protected, se chapter 2.4)	6	VBAT (Protected, se chapter 2.4)
7	VBAT (Protected, se chapter 2.4)	8	VBAT (Protected, se chapter 2.4)
9	I^2C SCK	10	Enable BPX*
11	I^2C Data	12	GND
13	NC	14	Kill switch*

* Se option sheet for enabling BPX

3.4 PBAT2 - Battery Connector

Harwin M80-5421442. The connector type is limited to 3 A per pin.

The only difference between PBAT1 and PBAT2 is the VBAT protected and VBAT raw pins depending on option. The I^2C, the Enable BPX and Kill switch pins are the same net on the PCB.

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*
11	I^2C Data	12	GND
13	NC	14	Kill switch*

*Se option sheet for enabling BPX

3.5 PGND1 - Ground Breaker

Harwin M80-5430805

Pin	Description	Pin	Description
1	Battery GND	2	Battery GND
3	Battery GND	4	Battery GND
5	System GND	6	System GND
7	System GND	8	System GND

4 Data Interface

The NanoPower BPX uses the CubeSat Space Protocol (CSP) to transfer data to and from CSP nodes on-board the main system bus. CSP is a routed network protocol that can be used to transmit data packets between individual subsystems on the satellite bus and between the satellite and ground station. For more information about CSP please read the documentation on http://www.libcsp.org

4.1 I^2C

The standard method to communicate with the BPX is over multi-master I^2C. Please note that since the CSP router sends out an I^2C message automatically when data is ready for a subsystem residing on the I^2C bus, the bus needs to be operated in I^2C multi-master mode.

The BPX uses the same I^2C address as the CSP network address per default. The BPX's own I^2C address is 0x07 per default.

4.2 I^2C Slave Mode

Slave mode operation disables the use of the CSP stack, and uses a slave-mode only protocol instead. A limited set of the CSP commands is available in this mode.

5 Debug Interface

The debug interface is a USART that uses the GomSpace Shell (GOSH) to present a console-like interface to the user. GOSH is a general feature present on all GomSpace products. Supported baud rate is 38400 8 bit, no parity and one stop-bit (8N1).

The console can be used during checkout of the BPX to send commands and set parameter. During integration into the satellite, the debug interface can be used to evaluate and see incoming and outgoing traffic through the BPX. Telemetry and housekeeping parameters can also be monitored. Here is a short list of features of the debug interface:

- Inspect CSP traffic (incoming and outgoing)
- Inspect I^2C driver (useful during early driver development)
- Inspect runtime performance
- Run tests (ping, etc.)
- Modify routing table
- Modify, save and restore default parameters

6 Heater and Temperature Sensor

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

The heater PCB contains four heating elements each placed between two batteries. Each element has its own temperature sensor. Below are two pictures of the PCB with the elements and sensors:

Figure 2 Heater top

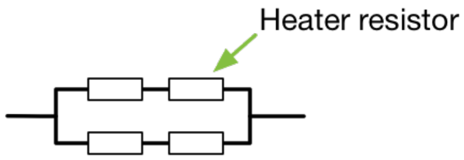
Figure 3 Heater bottom

Red marks = heater
Green marks = Temperature sensor

Heater characteristics:

Parameter	Condition	Min.	Typ.	Max.	Unit
Heater Element					
Heater resistance	8 V 2S-4P		10		Ω
	16 V 4S-2P		40		Ω
	32 V 8S-1P		150		Ω
Heater power	8 V 2S-4P		6		W
	16 V 4S-2P		6		W
	32 V 8S-1P		6		W

Heater resistor circuit setup is shown to the right.



Two temperature sensors with an analog interface are mounted just under each battery-set to provide battery temperatures for housekeeping purposes. A complete thermal control system can be implemented using the two optional heater elements.

For SPI communication details please see the datasheet for the Texas Instruments LM60CIM3.

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

7 Absolute Maximum Ratings for the PCB

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the BPX. Exposure to absolute maximum rating conditions for extended periods may affect the reliability.

Symbol	Description	Min.	Max.	Unit
V	Supply Voltage	0	35	V
T_{op}	Electronic Operational Temperature	-40	+85	°C
T_{bat}	Battery Operational Temperature	See battery cell datasheet		

8 Electrical Characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
Heater output power	Software enable heater		6		W
Enable • **Input low** • **Input high**	Default active high Onboard 300kΩ pull down	 0 2		 0.4 VBAT	 V V
Battery Voltage	Depends on battery configuration, see chapter 2.2	6		33.6	V
Discharge/charge		See battery cell datasheet			
Power Consumption	VBAT = 16 V Enable active BPX booted and idle		4		mA
Off current	Enable not active, BPX switched off.		15		μA

9 Physical Characteristics

Description	Value	Unit
Mass	500	g
Size	Fits in a PC104 stack 93 x 86 x 41	 mm

10 Physical Layout

10.1 PCB Description

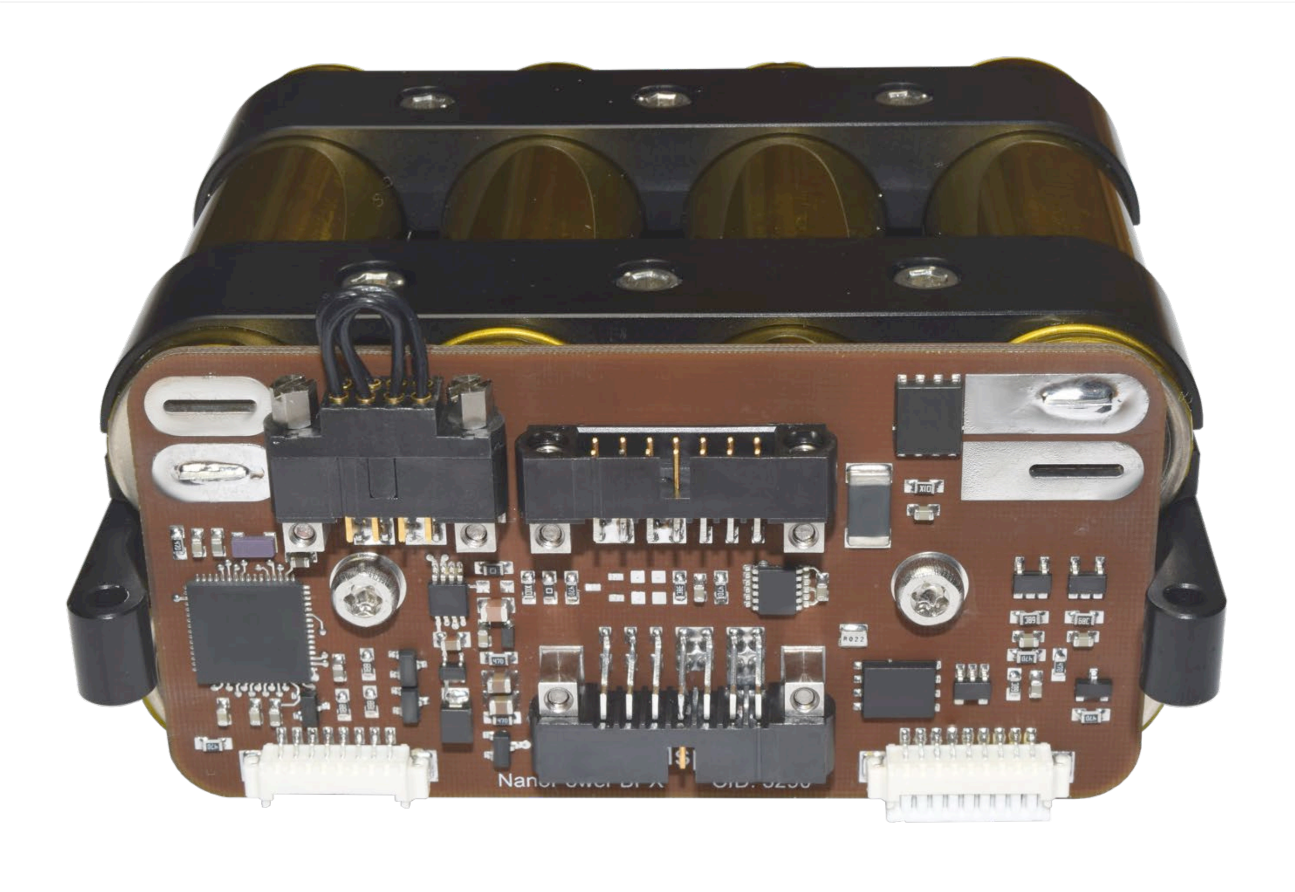


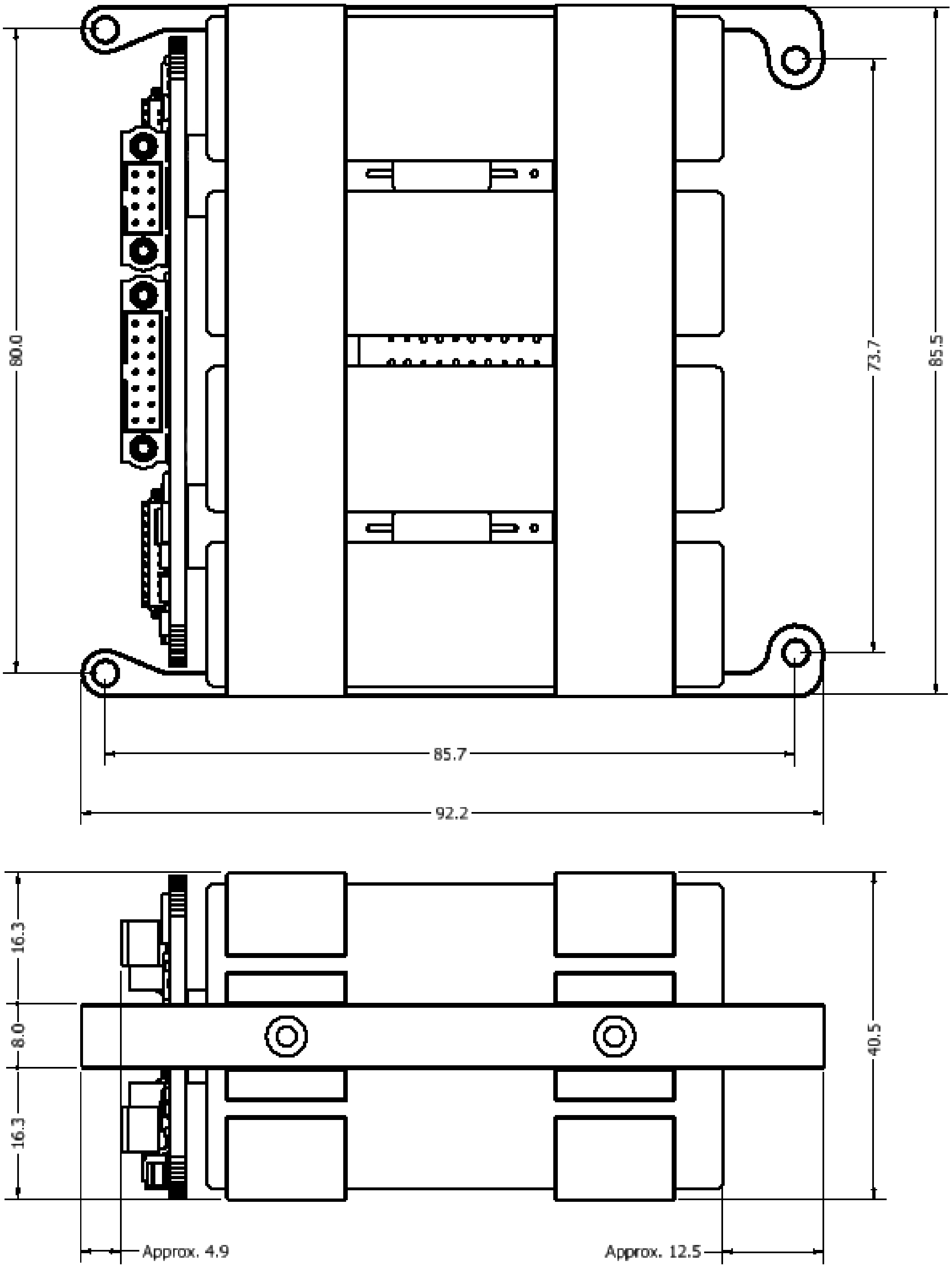
Figure 4 PCB front

All connectors are placed along the upper and lower edge of the PCB. Top left and right corners are the tab connectors from the batteries.

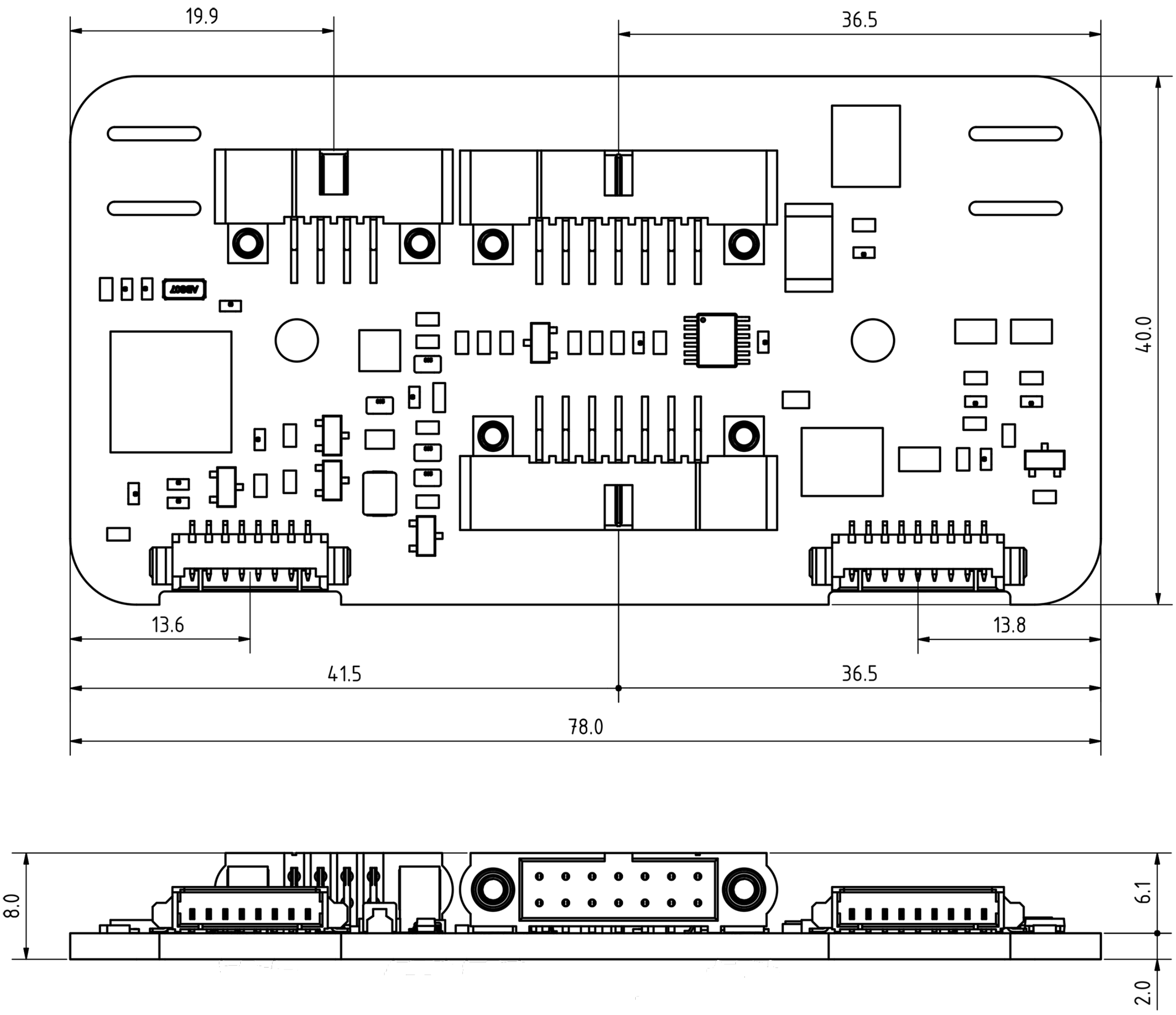
The IC on the middle left is the MCU. To the right of that is the 3.3 V LDO. In the top right corner next to the battery tabs is the VBAT switch and just mid right is the VBAT controller. Lower right is the heater switch.

11 Mechanical Drawing

All dimensions in mm.



PCB front.



12 Changelog

Date	Revision	Author	Description
12-11-2015	1.0	KLK/TIM	First release
5-4-2016	1.1	KLK	Updated Block diagram, corrections
16-9-2016	1.2	KLK	Added chapter 3.5, small changes to block diagram
3-10-2016	1.3	KLK	More info in chapter 4.3 and 4.4
28-3-2017	1.4	KLK	Added chapter 3.6
25-10-2017	1.5	PNN/KLK	Added in (now) chapter 5, supported baud rate. New Layout. Moved changelog to the back.
28-11-2017	1.6	KLK	Added Temperature Sensor to chapter 6. Added chapter 9.
24-4-2018	1.7	KLK	Change to chapter 6 Heater and Temp. Sensor
8-5-2018	1.8	KLK	Text corrections to chapter 3.2. Added NanoPower to header.
05-11-2021	2.0	PNN	Over current protection removed from P60 option, to support parallel connection of BPX's.