GOMSPACE

User Manual

NanoPower BPX 100 Wh

User manual for the NanoPower BPX 100 Wh battery pack

MAN 1076873
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GOMSPACE

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Contents

List of Abbreviations

CSP Cubesat Space Protocol.

ESD Electrostatic Discharge.

GOSH GomSpace Shell.

I^2C Inter-Integrated Circuit.

1 Introduction

The NanoPower BPX 100 Wh (BPX) is a high-capacity lithium-ion battery pack for nanosatellites with an integrated heating system and telemetry sampling. This manual describes how to handle, prepare and utilize the features of the NanoPower BPX 100 Wh.
Please refer to the NanoPower BPX 100 Wh datasheet[1] regarding electrical and mechanical characteristics.

1.1 Overview

1.1.1 BPX 100 Wh components

The NanoPower BPX 100 Wh (see Figure 1.1) arrives with three additional items, the BPX ground breaker and an Electrostatic Discharge (ESD) cable, see Figure 1.2. These components are necessary for handling and installing the NanoPower BPX 100 Wh, see Section 1.2.

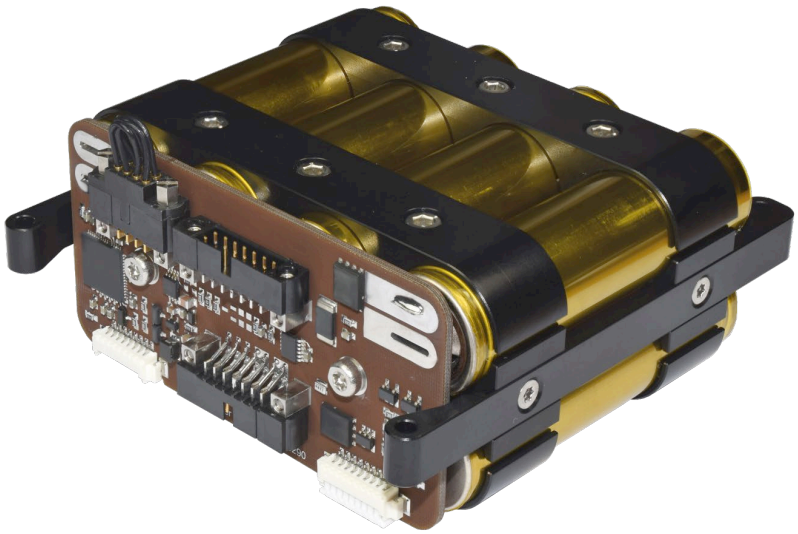


Figure 1.1: The NanoPower BPX 100 Wh with BPX ground breaker mounted (upper left)

(a) ESD cable

Figure 1.2: The NanoPower BPX accessories

1.1.2 Connector placement

The NanoPower BPX 100 Wh has a total of five connectors; PBAT1, PBAT2, PGND1, P1 and P2, see Figure 1.3 for the placement of the connectors and Table 1.1 for a description of each. Please refer to the NanoPower BPX datasheet [1] for the pinout of each connector.

Designator	Description
PBAT1	Main Power connector
PBAT2	Secondary Power connector
PGND1	Ground breaker connector
P1	Heater connector
P2	Debug connector

Table 1.1: Overview of connectors

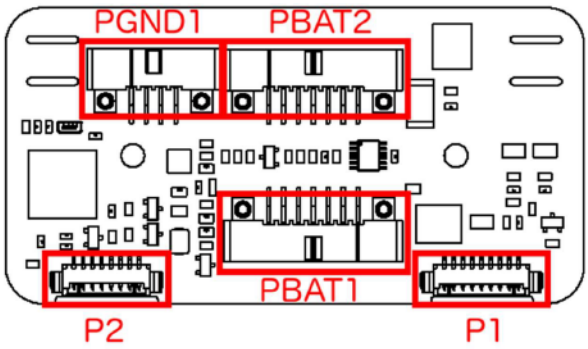


Figure 1.3: Placement of connector PBAT1, PBAT2, PGND1, P1 and P2

1.2 Unpacking and handling precautions

Warnings:

This high-performance battery contains batteries capable of delivering very high currents. Be very careful to avoid shorts.

Balance out charge between NanoPower BPX battery packs when connecting them in parallel.

Please use an ESD mat and a wrist strap as a minimum. Wear gloves to avoid fingerprints on the product. If any cleaning of the parts are required prior to flight, use only ESD safe cleaning methods and a neutral, non-reactive, isopropyl alcohol (IPA) solvent.

Do not touch or handle the product without proper grounding!

1.2.1 Handling, Grounding

The NanoPower BPX 100 Wh system employs components based on Field Effect Transistors (FETs) and requires anti-static handling precautions. It is crucial that the NanoPower BPX 100 Wh has the same ground potential as the system it connects to, before other connections are made. This can be achieved using the ESD cable supplied with the BPX through P2, see Figure 1.2b and Figure 1.4. The ESD cable can be removed only when the BPX has connection to the system ground through either PBAT1 or PBAT2.

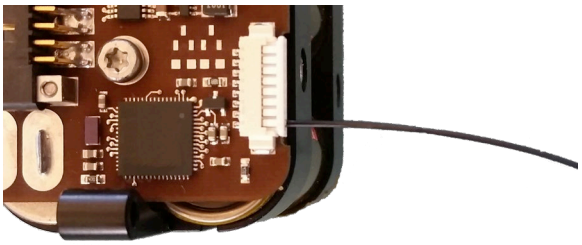


Figure 1.4: ESD cable inserted into BPX connector P2

⚠ **CAUTION:** Do not touch or handle the product without proper ESD grounding!

1.2.2 Electrical integration

The NanoPower BPX 100 Wh contains battery cells capable of delivering very high currents. Caution must therefore be taken to avoid short circuits when integrating the BPX. To limit the chance of faults when connecting the NanoPower BPX to an electrical system the following conditions must be met:

- The ground breaker at PGND1 is disconnected
- The battery pack must be charged according to Section 1.2.3.
- The first pack in a string must be connected through PBAT1 to the system.

⚠ **CAUTION:** Do not insert the ground breaker before the NanoPower BPX 100 Wh is connected through PBAT1.

1.2.3 Charging

Before using the NanoPower BPX 100 Wh, it is important to charge the device. Charging is done through connector PBAT1 or PBAT2, please refer to the datasheet for pinouts [1]. The BPX 100 Wh should be charged according to the specifications in Table 1.2. (Vop can be found in ds under chapter 2.2)

Step	Method	Specification
Step 1	Constant current (CC)	charge at <= 3.4A until Vop
Step 2	Constant voltage (CV)	charge to Vop until 50mA is reached per BPX

Table 1.2: Recommended charging cycle

NOTE: Before connecting multiple BPX 100Wh in parallel, a power supply or the P60 can be used to charge them individually; connecting one BPX 100 Wh at the time and charging according to Table 1.2.

1.2.4 Storage conditions

The NanoPower BPX 100 Wh will always have a small amount of self-discharge, and it is therefore important that actions are taken to prolong the battery life before storing it for a longer period. To prolong the BPX's battery life, the storage conditions given in Table 1.3 are recommended.

Parameter	Condition	Note
Temperature	between 0°C and 20°C	Optimal 0°C and 10°C
Charge level	between 30% and 60%	Voltage of 28.7V–30.6V (8S1P) Voltage of 14.4V–15.3V (4S2P)

Table 1.3: Recommended storage conditions

When the recommended storage conditions in Table 1.3 are respected, the battery pack can be stored according to Table 1.4.

Type	Time	Condition
Shelf storage	12 months	Ground breaker disconnected

Table 1.4: Total storage time before reconditioning of the BPX is needed

NOTE: The performance of the battery cells will degrade over time, even when stored in optimal conditions. Further details on current consumption and cell self-discharge can be found in the NanoPower BPX 100Wh datasheet [1].

2 Communication

2.1 Terminal (GOSH)

As an extension of the BPX interface, there is a command line utility available. This command system works by interpreting commands given on the serial port of the BPX and calling the BPX C-library functions. This means that they are available directly on the serial port by typing commands. This is great for debugging, configuring and getting started with the BPX.

The GomSpace Shell (GOSH) currently runs on almost all GomSpace products and on the ground-station PC in a small application called CSP-term that is freely available. This means the BPX commands can be executed from several different sources, depending on where you have access to a GOSH shell. When issuing a command from the Ground-station, TNC or OBC, the underlying CSP-protocol will ensure to route the commands correctly to the BPX and back again.

NOTE: When the BPX is off, it is advised to remove the serial cable. Leak current on the Rx line can in some case keep powering the electronics.

2.2 Command and Data Interface

The NanoPower BPX 100 Wh is an independent network node designed for the CSP protocol and I^2C bus communication. The CSP protocol is implemented in all GomSpace products and provides a highly capable and integrated networking architecture that can be utilized across multiple physical link implementations to cover both the space and ground segment.

2.2.1 How to send a command

If you have a NanoMind OBC in your satellite, drivers for the all NanoPower systems are already included. If you do not, there is also the option of writing a custom driver, based on the CSP interface specification.

1. **Using client library (C-interface)** All the functions and commands in GOSH are using the C-interface in <bpx/io.h> header file. These functions are also available to be called from any part of your own C-code. In order to get BPX housekeeping data just issue a C-call to the function bpx_hk_get(). The C-interface will take care of generating the correct request and sending the request over the CSP network to the BPX, wait for the reply, decode the data and represent it nicely in a C data structure called ‘bpx_hk_t’. This makes it very easy to write a housekeeping collector or send commands to power subsystems on and off from anywhere on the satellite.
2. **Write your own driver** If you do not have a GomSpace OBC, or a GomSpace ground station with the C client library or GOSH, GomSpace is happy to share with you the source-code for the CSP network protocol and the C-library. This way you can port the nanopower drivers to your own CPU and architecture. Please contact GomSpace for more information about this option.

Information like uptime, identification etc. can be accessed through the standard CSP interface, please see http://www.libcsp.org for more information.

2.2.2 CSP Network Interface

Applies to latest version of BPX - Your system may have other commands or may not support some of these commands. If you are in doubt, please contact GomSpace for further help

Mnemonic	Port	Request/Reply Data	Bytes	Description
GET_HK	9	empty	0	Send empty packet to request housekeeping struct.
		struct bpx_hk_t;	struct	Reply: Data-structure (see below)
RESET_COUNTERS	15	uint8 magic=0x42;	1	Send this command to reset boot counter magic = 0x42
		none	x	
CONFIG_CMD	17	uint8 cmd;	1	Use this command to control the config system. cmd=1: Restore default config
		none	x	
CONFIG_GET	18	none	x	Use this command to request the BPX config.
		struct eps_config_t	struct	Reply: Data-structure (see below)
CONFIG_SET	19	struct eps_config_t	struct	Use this command to send a config to the BPX and save it.
		none	x	
MAN_HEAT_ON	20	uint16_t heat_time	2	Use this command to start heating manually for a specific period of time (s). This works with any configurations.
		uint8 reply	1	reply = 0x01 means manual heat on OK
MAN_HEAT_OFF	21	none	x	Use this command to interrupt and stop manual heating.
		uint8 reply	1	reply = 0x01 means manual heat off OK

Information like uptime, identification etc. can be accessed through the standard CSP interface, please see libcsp.org for more information.

2.2.3 Housekeeping Format:

The housekeeping data is a structure as specified below:

```
typedef struct {
    uint16_t cur_charge;        //! Not Available
    uint16_t cur_discharge;     //! Not Available
    uint16_t cur_heater;        //! Heater current in mA
    uint16_t vbatt;             //! Battery voltage in mV
    int16_t bat_temp1;          //! Battery temperature 1 in ddegC
    int16_t bat_temp2;          //! Battery temperature 2 in ddegC
    int16_t bat_temp3;          //! Battery temperature 3 in ddegC
    int16_t bat_temp4;          //! Battery temperature 4 in ddegC
    uint32_t counter_boot;      //! Number of reboots
    uint8_t bootcause;          //! Cause of last reset
} bpx_hk_t;
```

Reset cause can be 0=Power On Reset, 1=External Reset, 2=Brown Out Reset, 4=WDT reset, 8=JTAG reset

2.2.4 I²C Bus Specification

The I²C interface is used for commanding the NanoPower and for receiving housekeeping and status messages. NanoPower operates on the I²C bus as multi-master node, which is either as slave receiver or as master transmitter. NanoPower transmits at 400 kbit and can receive at anything from up to 400 kbit. The CSP network stack takes care of the I²C bus addressing and framing format. The CSP/ I²C frame looks like this:

<start><write><csp-header><data><stop>

Where the CSP header is 4 bytes big endian (For more information on this, see libcsp.org and read the specification for the csp_if_i2c interface), and the data field contains the request/reply as specified in the command and data handling section of this datasheet.

Paramter	Condition	Min	Typical	Max	Unit
I²C speed transmit			400		kbit
I²C speed receive		0		400	kbit
I²C / CSP address	Default (can be changed through GOSH)		7		

2.2.5 I²C Slave Mode

For users, which do not wish to support the CSP protocol, or the multi-master I²C, interface. The BPX comes with a separate slave-mode I²C interface. Setting the 'board i2cslave' to 1 can enable this interface.

NOTE: When the BPX is set to slave mode, the CSP commands like "bpx hk", "cmp ident", etc in GOSH does not work. Furthermore, the slave interfaces, ie. "bpxslave" commands do not work either as the unit cannot be both slave and master at the same time.

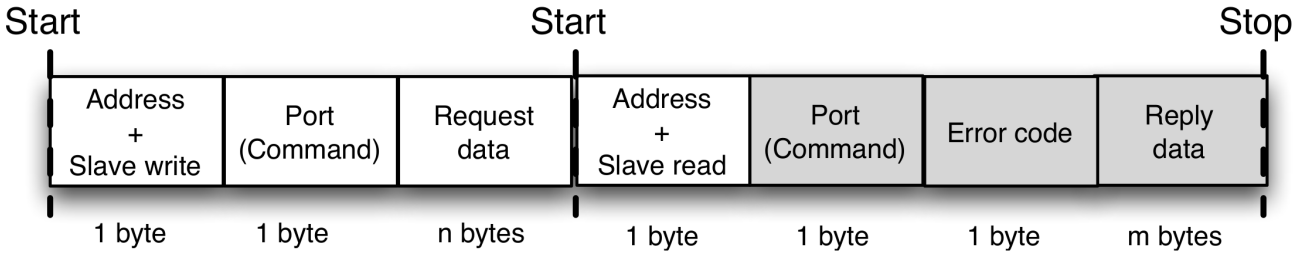
NOTE: Commands "RESET_COUNTERS", "CONFIG_CMD" and "CONFIG_SET" are writing to the eeprom, which can't finish within an I²C transaction. Expect these commands to be finished within 500 ms after execution.

The I²C slave mode of 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. An I²C master wishing to communicate with the BPX device, should send a single byte specifying the command number, followed by any command arguments. The command number should match the CSP port number from multi-master mode.

The BPX returns the same 1-byte command number, followed by an error code.

- A successful command will return an error code of 0.
- Errors are marked by returning a non-zero error code. If a command is marked erroneous, the remaining bytes of the reply will be undefined and should be discarded.

The following figure shows the command sequence on the I²C bus. White boxes are data sent from the I²C master, while grey boxes marks data read from the BPX system:



As in CSP mode, all values of more than 1 byte must be transmitted in big endian byte order.

Additional Slave Mode Commands

Since the CSP stack is not used, the command set has been extended with a ping and reboot command. The CSP service handler normally handles these commands

Mnemonic	Port	Request / Reply Data	Bytes	Description
PING	1	`uint8_t value`	1	One byte ping value. Any value can be used.
		`uint8_t value`	1	The BPX replies with the same value as in the ping request.
REBOOT	4	`uint8_t magic[4]`	4	Magic sequence must be: 0x80, 0x07, 0x80, 0x07
		`none`		The BPX is rebooted, so no reply is generated. A stop condition should be sent after the request, instead of the repeated START.

3 Configuration

The BPX allows the user to setup a number of configurations like auto-heater parameters. This is done in two different config structs through the standard command system through the 'bpx conf' commands:

```
bpx # bpx conf
  get                   Conf get
  set                   Conf set
  edit                  Edit local config
  print                 Print local config
  restore               Restore config from default
```

Furthermore, there are dedicated GOSH commands to handle the default configs:

```
bpx # conf
  restore               Configuration restore
  store_default         Store configuration as default
  batt_critical_level   Set/get the voltage where heater stops
```

To view the current config of the BPX type 'bpx conf get' in GOSH and to edit the config type 'bpx conf edit'. To send and save the configuration on BPX type 'bpx conf set'.

On the BPX, a configuration has two instances: a working config and a default config:

The working config is the one currently used by BPX and it can be edited through the 'conf get', 'conf edit' and 'conf set' commands.

The default config can be seen as a backup config which can only be set before launch through GOSH by 'conf store_default'. There are three ways of restoring the default config:

- By typing 'conf restore' in BPX GOSH
- By using the restore command over I^2C ('bpx conf restore' in GOSH)
- If a checksum error is found in the working config, the default config is restored

The config struct is defined as

```
typedef struct __attribute__((packed)) {
  uint8_t battheater_mode; //! Mode for battheater [0=OFF,1=Auto]
  int8_t battheater_low;   //! Turn heater on at [degC]
..int8_t battheater_high;  //! Turn heater off at [degC]
} bpx_config_t;
```

The BPX will turn on the heater if the mode is set to auto (1) and the average temperature of the temperature sensors is below the 'battheater_low' value.

It will turn off the heater when the average temperature is above the 'battheater_high' value or if mode is set to off (0).

It will also stop if the filtered battery voltage is under the 'batt_critical_level'.

It will turn on again when the filtered battery voltage is 10 % over ‘batt_critical_level’. The ‘batt_critical_level’ is configurable only through GOSH.

4 References

[1] **GomSpace**
Datasheet 1076870
NanoPower BPX 100 Wh

5 Change Log

Version	Change Description
1.0.0	Initial version