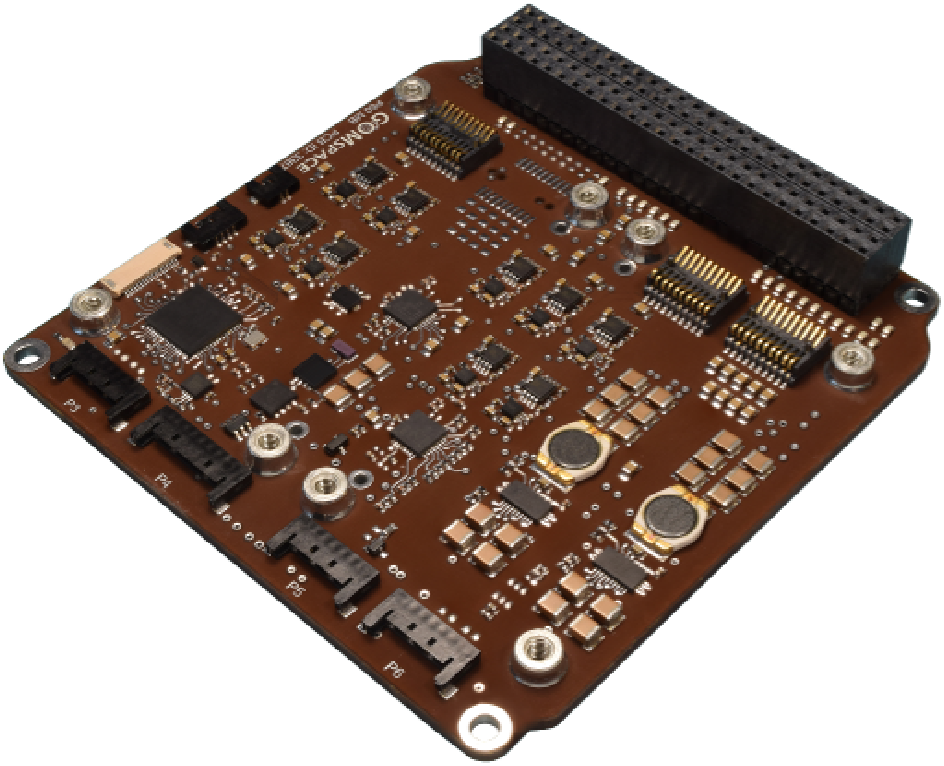

NanoPower

P60 Dock

Manual

Software Documentation

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1. Change Log

Date	Revision	Author	Description
14-06-2016	1.0	KBA	Initial version 1.0

2. Introduction

The GomSpace NanoPower P60 EPS is a flexible and modular system to rapidly implement power supply systems based on customer requirements. The P60 Dock is part of the NanoPower P60 EPS modular power supply system.

This manual describes the P60 Dock firmware version 2.1:

- Command Interface
- CSP Client API
- Parameter Tables

2.1 Unpacking and Handling Precautions

⚠	**Warning** The P60 Dock is an ESD sensitive device. Proper precautions must be observed during the handling of the device.

Please use an ESD mat and a wrist strap as a minimum. Please wear gloves to avoid fingerprints on the anodized aluminum parts, as these are particularly difficult to rinse off. If any cleaning of the parts are required prior to flight, use only ESD safe cleaning methods and a neutral, non-reactive, IPA solvent.

3. Overview

The P60 Dock can be operated through the Cubesat Space Protocol (CSP) over CAN, I^{2}C or serial port. This integrates well with other GomSpace products, and GomSpace provides a client library for commanding the P60 Dock from other systems running CSP. Refer to the Client API page for documentation of the client library API.

For integration and testing purposes, a command line interface is also available as explained in Command Interface. The command line interface uses the client API internally, so command names generally reflects the API function names.

The block diagram below shows the different P60 Dock modules.

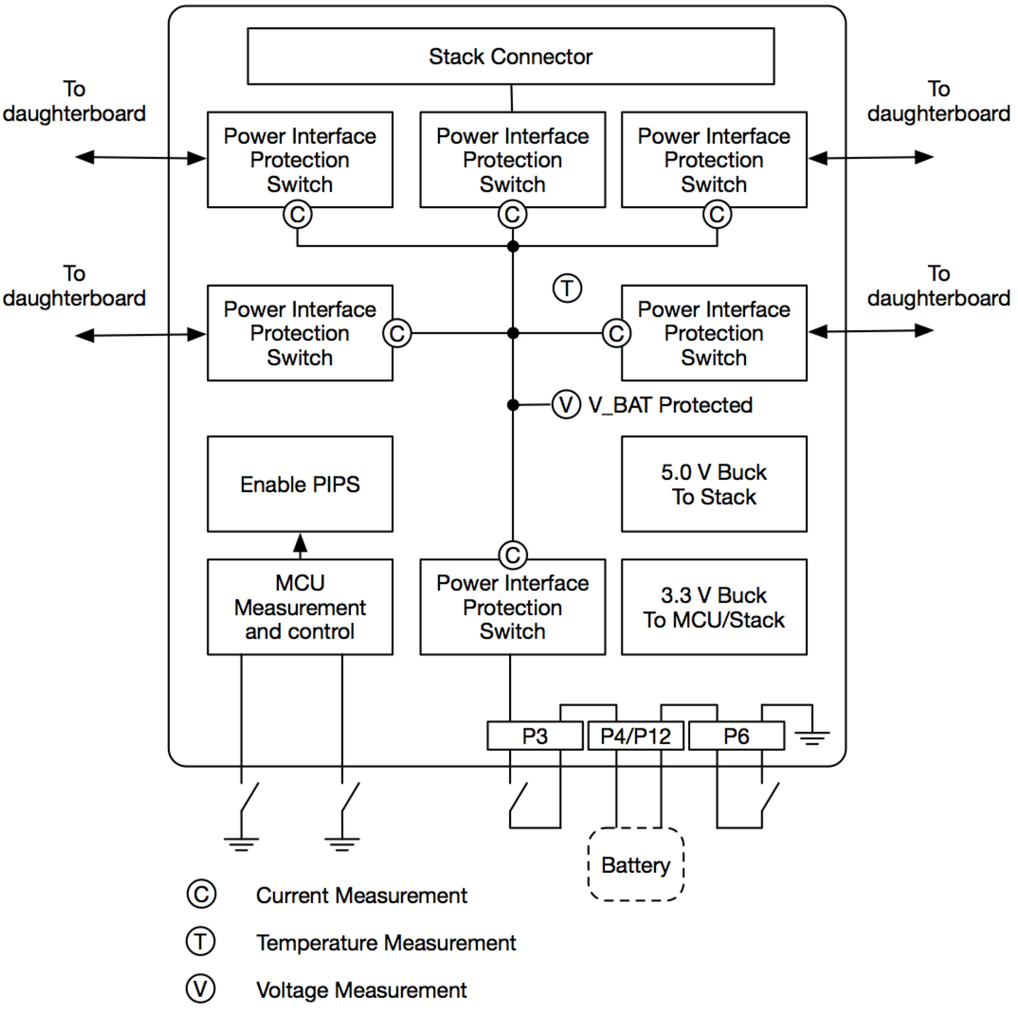

Stack Connector
To daughterboard
To daughterboard
Power Interface Protection Switch
Power Interface Protection Switch
Power Interface Protection Switch
To daughterboard
To daughterboard
Power Interface Protection Switch
Power Interface Protection Switch
C
T
V
V_BAT Protected
Enable PIPS
5.0 V Buck To Stack
MCU Measurement and control
Power Interface Protection Switch
3.3 V Buck To MCU/Stack
P3
P4/P12
P6
Battery
C Current Measurement
T Temperature Measurement
V Voltage Measurement

Fig. 3.1: P60 Dock Block Diagram

4. Command Interface

For testing and debugging purposes, the P60 Dock can be operated using the GomSpace Shell (GOSH) interface. The console interface is available in the PJ and P2 connector. The serial connection is 8 databits, 1 stopbit, no parity at 500000 baud. On Linux, the serial connection can be opened using the minicom or tio tools (tio was formerly known as gotty).

You can now execute commands in the GOSH command interpreter. An example command is `cmp ident` which lists identification info of the current subsystem:

```
p60-dock # cmp ident
Hostname: p60-dock
Model:    NanoPower P60 Dock
Revision: v0.1
Date:     Nov  3 2015
Time:     09:53:08
```

A list of available commands can be shown by running the `help` command in GOSH. Pressing the *tab* key automatically completes commands and subcommands, and shows a usage string. Commands specific to the P60 Dock are assembled under the `p60dock` command group. These commands are also available in `csp-term` for operating the P60 Dock via CSP:

```
p60-dock # p60dock
  node                Set node
  timeout             Set timeout in milliseconds
  hk                  Get HK
  gndwdt_clear        Clear GND WDT
```

Note: All of the `p60dock` commands run over loopback CSP using GOSH command wrappers around the Client API

4.1 Global Settings

The P60 Dock command line interface is written such that there are a few global variables that can be set first. The default values of the variables are:

- The P60 Dock CSP address is set to 4.
- Timeout is set to 5000 ms.

These values can be set using the `p60dock node <node>` and `p60dock timeout <timeout>`. To show the current setting, run each command without an argument.

5. Operation

The P60 Dock has three configuration parameter tables:

- Board parameters (table 0)
- Configuration parameters (table 1)
- Calibration parameters (table 2)

P60 Dock telemetry parameters are available in parameter table 4.

See Parameter Tables for details on the individual parameter tables.

5.1 Board Parameters

The Board parameters will normally be configured from factory.

If the P60 Dock has been ordered with RS422 interface, it will be enabled. This is done via parameter rs422_mode set to 1. The default baud rate for RS422 USART is set at 115200. Supported baud rates are 38400, 115200 and 500000. Baud rate is controlled by parameter rs422_speed. The RS422 USART uses 8 bit, no parity and one stop-bit (8N1).

CSP address is controlled by parameter is csp_addr. The default CSP address is 4 for the P60 Dock.

5.2 Configuration Parameters

The P60 Dock has a total of 13 channels that all can be turned on and off. Each channel can be configured with a name. Default names are listed in table below. Seven characters are available for channel names. Channel names are set by parameter out_name[].

Table 5.1: P60 Dock Output channels

Channel	Description	Default name
0	X1 VCC	x1_vcc
1	X2 VCC	x2_vcc
2	X3 VCC	x3_vcc
3	X4 VCC	x4_vcc
4	X1 VBAT	x1_vbat
5	X2 VBAT	x2_vbat
6	X3 VBAT	x3_vbat
7	X4 VBAT	x4_vbat
8	STACK VBAT	st_vbat
9	STACK 3.3V	st_3v3
10	STACK 5V	st_5v
11	GSSB 3.3V	gs_3v3
12	GSSB 5V	gs_5v

5.2.1 Channel Control

The 13 channels can all be turned on and off manually and/or automatically. From factory the P60 Dock will be configured to turn on all mounted daughterboard modules in the following way:

1. VCC and VBAT for X1 - X4 are turned on automatically when the P60 Dock has completed boot sequence
2. All other channels are not turned on automatically

To turn a channel on or off manually, set the appropriate `out_en[]` parameter.

To turn a channel on manually with a delay, set the appropriate `out_on_cnt[]` parameter to turn the channel on after X seconds. X must be larger than zero.

To turn a channel off manually with a delay, set the appropriate `out_off_cnt[]` parameter to turn the channel off after X seconds. X must be larger than zero.

5.2.2 Battery Mode Dependant Output Control

The P60 Dock output channels can be turned on and off automatically depending on the battery mode (see *Battery Voltage Level*).

Battery mode FULL

In battery mode FULL, all output channels are left unchanged.

Battery mode NORMAL

To turn a channel on automatically without delay when battery mode is NORMAL, set the appropriate `init_out_norm[]` parameter to 1.

To turn a channel on automatically with a delay when battery mode is NORMAL, set the appropriate `init_on_dly[]` parameter to turn the channel on after X seconds. X must be larger than zero. In this case the `init_out_norm[]` parameter should be 0, otherwise the channel will turn on immediately when battery mode is NORMAL.

To turn a channel off automatically with a delay when battery mode is NORMAL, set the appropriate `init_off_dly[]` parameter to turn the channel off after X seconds. X must be larger than zero. In this case the `init_out_norm[]` parameter should be 1 or the `init_on_dly[]` parameter should have a value smaller than the `init_off_dly[]` parameter.

Battery mode SAFE

To keep a channel turned on if battery mode is SAFE mode, set the appropriate `init_out_safe[]` parameter to 1 to keep the channel on when battery mode is SAFE. Otherwise the channel will be turned off when entering SAFE mode.

The parameters `init_on_dly[]` and `init_off_dly[]` are not used in battery mode SAFE.

Battery mode CRITICAL

In battery mode CRITICAL, all output channels will turned off automatically without any delay.

5.2.3 Current Limitation

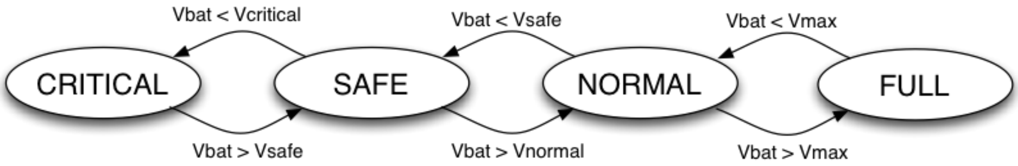
All channels have two current limitation parameters, `cur_lu_lim[]` and `cur_lim[]`.

The parameter `cur_lu_lim[]` is a hard limit, and if the channel consumes more than this limit it will be turned off immediately. It will be turned on again automatically after 5 seconds.

The parameter `cur_lim[]` is a soft limit, meaning that if the channel over a period of time on average consumes more than this limit it will be turned off. The average is calculated over time as an Exponential Moving Average (EMA). The channel will be turned on again automatically after 5 seconds.

5.2.4 Battery Voltage Level

The P60 Dock has a software low voltage protection and will automatically turn channels on and off depending on battery voltage level and a set of battery level configuration parameters (`batt_max`, `batt_norm`, `batt_safe` and batt_crit). The software low voltage protection is a four state system with a CRITICAL, a SAFE, a NORMAL and a FULL mode.



In normal mode everything is nominal but should the battery voltage drop below batt_safe, the P60 Dock will change its output switch configuration to a safe mode configuration. This allows the P60 Dock to switch off of all non-essential systems and leave a simple low power mode running.

Should the battery voltage continue to drop below batt_crit, the P60 Dock will switch off all channels.

The four battery voltage level parameters (batt_max, batt_norm, batt_safe and batt_crit) are each configurable and must be set to match the battery and the channel control (see section *Channel Control*) must be set accordingly to ensure that daughter boards are turned on/off as required by mission.

The following table shows the default settings for battery voltage levels.

Table 5.2: Recommended settings for battery voltage levels

Battery Pack Voltage	8 V	16 V	32 V
batt_max	8300 mV	16600 mV	32000 mV
batt_norm	7000 mV	14000 mV	28000 mV
batt_safe	6700 mV	13400 mV	26800 mV
batt_crit	6500 mV	13000 mV	26000 mV

5.2.5 Battery Pack

The P60 Dock must be configured with the battery pack type. The parameter batt_pack must be set with the appropriate value for the batttery pack. The following table shows possible configuration values:

Table 5.3: P60 Dock Battery pack values

Battery pack value	Description
0	None
1	Reserved
2	BP4 Battery Pack
3	BPX Battery Pack

5.2.6 Battery Heater

For the BP4 battery pack, it is possible to enable heater control. The heater mode bp_heat_mode parameter controls how the battery heater is turned on and off. The following table shows possible configuration values:

Table 5.4: P60 Dock Battery heater control modes

Battery heater mode value	Description
0	Heater always off
1	Heater on/off controlled by temperature thresholds
2	Heater always on

The heater on/off can be controlled by temperature thresholds by setting the bp_heat_high and bp_heat_low parameters. The bp_heat_low parameter determines when to turn the heater on, i.e. when the battery pack temperature goes below the bp_heat_low value, the battery heater turns on. Similar, the bp_heat_high parameter determines when to turn the heater off, i.e. when the battery pack temperature goes above the bp_heat_high value, the battery heater turns off.

Note: The bp_heat_high and bp_heat_low are set in 0.1 ℃. E.g. a value of 50 means 5.0 ℃.

5.3 Calibration Parameters

The P60 Dock has a set of calibration parameters for voltage and current measurements.

The calibration parameters are configured from factory and normally don't need to be changed.

For voltages, there is a gain parameter. The gain is a floating-point number.

For currents, there is a gain and an offset parameter. The gain is a floating-point number. The offset is a signed 16-bit integer that controls the offset in mA.

The following table lists the default values for each calibration parameter:

Table 5.5: P60 Dock Calibration values

Name	Voltage gain	Current gain	Current offset
X1 VCC	n/a	1.0	0
X2 VCC	n/a	1.0	0
X3 VCC	n/a	1.0	0
X4 VCC	n/a	1.0	0
X1 VBAT	25.0	1.0	0
X2 VBAT	25.0	1.0	0
X3 VBAT	25.0	1.0	0
X4 VBAT	25.0	1.0	0
STACK VBAT	25.0	1.0	0
STACK 3.3V	n/a	1.0	0
STACK 5V	n/a	1.0	0
GSSB 3.3V	n/a	1.0	0
GSSB 5V	n/a	1.0	0
VBAT	25.0	n/a	n/a
VCC	n/a	1.0	0
BATTERY	20.0	1.0	0

If the calibration value is n/a, it means that this value is not measured by the P60 Dock.

5.4 Telemetry Parameters

The P60 Dock will provide the measured voltage and current for each output channel in parameter v_out[] and c_out[]. In case of over-current (see section *Current Limitation*) on an output channel, the latchup[] parameter will increase by 1 each time an over-current is detected and the output channel is turned off by the current monitoring function.

The state of each output channel is provided in the out_en[] parameter.

The battery voltage measured by the P60 Dock is provided in the parameter batt_v. The battery voltage is monitored and the battery state is provided in the parameter batt_mode. The batt_mode can have one of four values:

Table 5.6: P60 Dock Battery mode values

Battery Mode value	Battery Mode description
1	CRITICAL
2	SAFE
3	NORMAL
4	FULL

The battery current is also measured and is provided in the parameter `batt_c`.

Temperature of the P60 Dock is measured in two locations on the module and is available in parameter `temp[]`.

5.5 Configuration

The P60 Dock module has two sets of configuration, the running configuration and the default configuration. The default configuration is a fallback configuration that will be restored automatically if the ground watchdog is triggered (see *Ground Watchdog*)

The P60 Dock has a set of commands to manage the configuration:

```
p60-pdu # config
  status              Show FRAM Lock status
  lock                Lock FRAM upper tables 0x1000 to 0x1800
  unlock              Unlock FRAM upper tables 0x1000 to 0x1800
  gnd_wdt             Get or set gnd wdt timeout value
  update_default      Update default factory settings in FRAM
  verify_default      Verify default factory settings in FRAM
```

5.6 Ground Watchdog

The P60 Dock module has a ground watchdog that needs to be reset at least every 48 hours if enabled. The purpose of the ground watchdog is to enable the P60 Dock to revert to the default configuration if for some reason the running configuration prevents the P60 Dock from operating.

If the ground watchdog is triggered, the P60 Dock will restore to the default configuration and then do a reset of the P60 Dock.

To enable the ground watchdog and set the timeout value, run the following command form the GOSH terminal:

```
config gnd_wdt <timeout in seconds>
```

The minimum value is 172800 seconds (48 hours). The maximum value 31536000 seconds (365 days). To disable the ground watchdog, set the timeout to 0 seconds.

Note: The P60 Dock will restore to the default configuration and then do a reset of the P60 Dock and all mounted daughter baords if the ground watchdog is triggered.

5.6.1 Propagating the Ground Watchdog Reset

The P60 Dock has an optional feature that allows to propagate the ground watchdog reset message to all P60 daughter boards.

The is achieved by setting the `p60acu_addr[]` and `p60pdu_addr[]` parameters to the CSP addresses of the P60 daughter boards. E.g if the P60 Dock has a P60 ACU-200 and tow P60 PDU-200 daughter boards with CSP addresses 2, 3 and 6 respectively, the `p60acu_addr[]` and `p60pdu_addr[]` should be set to [2 0] and the `p60pdu_addr[]` should be set to [3 6 0 0]. When the ground wtachdog is reset on the P60 Dock, the

P60 Dock will forard the ground watchdog reset message to P60 ACU-200 on CSP address 2 and the two P60 PDU-200 on CSP address 3 and 6.

Using the ground watchdog reset propagation, it is only necessary to sen d the gorund watchdog reset message to the P60 Dock.

5.7 Bus Watchdogs

The P60 Dock module has two satellite bus watchdogs, one for I^{2}C and one for CAN, which allows the P60 Dock to monitor if the satellite bus is operational. Both satellite bus watchdogs can be enabled or disabled and has individual timeout values, `wdt_i2c` and `wdt_can` respectively. The P60 Dock can be configured to reboot if the satellite bus watchdog is triggered, this is controlled by the `wdt_i2c_rst` and `wdt_can_rst`, respectively.

When configured and enabled (`wdt_i2c_rst`/`wdt_can_rst` is 1 and `wdt_i2c`/`wdt_can` > 0), the P60 Dock will reboot if no traffic is observed on the satellite bus for `wdt_i2c`/`wdt_can` seconds.

Note: The satellite bus watchdogs does not run when the battery mode is CRITICAL.

5.8 CSP Watchdogs

The P60 Dock module has two CSP watchdogs that allows to actively monitor two different nodes on the CSP satellite bus.

If a CSP address is configured for `wdt_csp_addr[]`, the P60 Dock will actively monitor the connectivity to each of these systems with a ping packet each `wdt_csp[]` seconds. If `wdt_csp_ping[]` consecutive pings are lost (maximum allowed response time is 30 ms), the corresponding power channel `wdt_csp_chan[]` is power cycled with a 5 second off time.

The CSP watchdogs will only run if the configured output channel `wdt_csp_chan[]` is on.

5.9 Antenna Deployment

The P60 Dock module has support for NanoCom ANT6 and NanoCom AR6 deployment.

To enable deployment, it is required to set the GSSB I^{2}C addresses of the ANT6 and/or the AR6 modules and the deployment delay in parameter table 1. This is done by specifying the ANT6 I^{2}C addresses in the parameter `ant6_addr` and the AR6 I^{2}C in the parameter `ar6_addr`.

It is also required to specify a delay after boot of the deployment. This is done by specifying the deployment delay in seconds in the parameter `depl_delay`.

The status and result of the deployment is reflected in the `ant6_depl` and `ar6_depl` parameters in table 4 (Parameter Tables for details on the individual parameter tables).

6. Client API

The client API consists of a set of wrapper functions that simplify the CSP interface to the P60 Dock. These functions are implemented in the `p60dock_client.c` file and can be integrated in custom code by including the `p60dock.h` header file. The file `p60dock_cmd.c` implements the GOSH commands for the P60 Dock and can be used as an additional reference for the use of the client API.

All the client functions specify a `timeout` argument that is used to specify the maximum number of milliseconds to wait for a reply. The client interface automatically performs endian conversion to network byte order on all arguments.

6.1 CSP Port numbers

The P60 Dock listens on the following CSP port numbers

Table 6.1: P60 Dock CSP port numbers

Port	Name	Description
0	CSP_CMP	Control Port
1	CSP_PING	Returns a copy of the packet received
2	CSP_PS	Returns process list
3	CSP_MEMFREE	Returns memory free
4	CSP_REBOOT	Reboots subsystem
5	CSP_BUF_FREE	Returns number of free buffers
6	CSP_UPTIME	Returns subsystem uptime
7	P60_PORT_RPARAM	Controls P60 Dock with parameter system (see *Get and Set Configuration Parameters*)
9	P60_PORT_GNDWDT_RESET	Used for ground watchdog reset (see *Reset Ground Watchdog Timer*)
10	P60_PORT_CMDCONTROL	Reserved for future use

For a description on how to use the CSP ports, please see libcsp manual. For a description on the parameter system, please see libparam manual.

6.2 Get and Set Configuration Parameters

Getting and setting configuration parameters is done by using the remote parameter system API provided by libparam.

Get a single configuration parameter from P60 Dock:

```
#include <p60dock.h>

/* Get enable status for X1 VCC */
uint8_t vcc_enable;
int res = rparam_get_single(&vcc_enable,            /* Pointer to variable */
                            P60DOCK_OUT_EN(0),      /* Logical address of parameter */
                            PARAM_UINT8,            /* Parameter type */
                            1,                      /* Parameter size */
                            P60DOCK_PARAM,          /* Parameter table id */
                            p60dock_node,           /* P60 Dock csp node address */
                            P60_PORT_RPARAM,        /* CSP port number */
                            1000);                  /* Timeout in milliseconds */
```

```
if (res > 0) {
    printf("Get VCC enable: %u\n", vcc_enable);
}
```

Set a single configuration parameter on P60 Dock:

```
#include <p60dock.h>

/* Enable X1 VCC */
uint8_t vcc_enable = 1;
int res = rparam_set_single(&vcc_enable,           /* Pointer to variable */
                            P60DOCK_OUT_EN(0),     /* Logical address of parameter */
                            PARAM_UINT8,           /* Parameter type */
                            1,                     /* Parameter size */
                            P60DOCK_PARAM,         /* Parameter table id */
                            p60dock_node,          /* P60 Dock csp node address */
                            P60_PORT_RPARAM,       /* CSP port number */
                            1000);                 /* Timeout in milliseconds */
if (res > 0) {
    printf("Set vcc enable: %u\n", vcc_enable);
}
```

6.3 Retriving Housekeeping Parameters

Retrieving Housekeeping Parameters from the P60 Dock is provided by the `p60dock_get_hk` function.

```
int p60dock_get_hk(param_index_t * mem, uint8_t node, uint32_t timeout);
```

This function is used to retrieve housekeeping parameters from the P60 Dock. The housekeeping parameters are retrieved over CSP using the remote parameter system API provided by libparam. The function `p60dock_get_hk` is basically a wrapper around the remote parameter system API. The input parameter `mem` must be provided with a pointer to memory to hold the housekeeping parameters. The input parameter `node` must provide the CSP node address of the P60 Dock and the `timeout` must provide the timeout in milliseconds. An example is shown below.

```
#include <p60dock.h>

uint8_t p60dock_node = 4;
uint8_t hk_mem[P60DOCK_HK_SIZE];
param_index_t p60dock_hk = {0};
p60dock_hk.physaddr = hk_mem;
if (!p60dock_get_hk(&p60dock_hk, p60dock_node, 1000)) {
    printf("Error getting p60dock hk\n");
} else {
    param_list(&p60dock_hk, 1);
}
```

Housekeeping parameters can also be retrieved directly from P60 Dock using the remote parameter system API provided by libparam:

```
#include <p60dock.h>

uint8_t p60dock_node = 4;
uint8_t out_en;
int res = rparam_get_single(&out_en,               /* Pointer to variable */
                            P60DOCK_HK_OUT_EN(0),  /* Logical address of parameter */
                            PARAM_UINT8,           /* Parameter type */
                            1,                     /* Parameter size */
                            P60DOCK_HK,            /* Parameter table id */
                            p60dock_node,          /* P60 Dock csp node address */
                            P60_PORT_RPARAM,       /* CSP port number */
                            1000);                 /* Timeout in milliseconds */
if (res > 0) {
    printf("Get out_en[0]: %u\n", out_en);
}
```

The above example retrieves a single parameter. It is possible to retrieve all Housekeeping parameters by retrieving the entire table:

```
#include <p60dock.h>

uint8_t hk_mem[P60DOCK_HK_SIZE];
param_index_t node_hk = {0};
uint8_t p60dock_node = 4;

node_hk.physaddr = hk_mem;
node_hk.table = p60dock_hk;
node_hk.mem_id = P60DOCK_HK;
node_hk.count = P60DOCK_HK_COUNT;
node_hk.size = P60DOCK_HK_SIZE;
int result = rparam_get_full_table(&node_hk,
                                   p60dock_node,
                                   P60_PORT_RPARAM,
                                   node_hk.mem_id,
                                   1000);
if (result != 0) {
   printf("Error retrieving P60 Dock housekeeping\n");
} else {
   printf("Retrieved P60 Dock housekeeping\n");
   /* List all out_en[] values, using parameter name */
   const param_table_t * param = param_find_name(node_hk.table,
                                                 node_hk.count,
                                                 "out_en");

   if (param != NULL) {
      for (uint8_t index = 0; index < 13; index++) {
         /* Read parameter using name */
         uint8_t *out_en = param_read_addr(param->addr + param->size * index,
                                           &node_hk,
                                           param->size);
         printf("out_en[%d]: %u\n", index, *out_en);
      }
   }
   /* List all c_out[] values, using parameter address */
   param = param_find_addr(node_hk.table, node_hk.count, 0x0000);
   if (param != NULL) {
      for (uint8_t index = 0; index < 13; index++) {
         /* Read parameter using address */
         int16_t *c_out = param_read_addr(param->addr + param->size * index,
                                          &node_hk,
                                          param->size);
         printf("c_out[%d]: %d mA\n", index, *c_out);
      }
   }
}
```

6.4 Reset Ground Watchdog Timer

The Ground Watchdog Timer is reset by a dedicated command to the P60 Dock. This can for example be used as a ground communication watch dog, i.e. this command is issued to P60 Dock on each connection with the ground station. If no communication has been received for a period of 48 hours P60 Dock will switch off and do a reset back to default configuration.

The Ground Watchdog Timer on the P60 Dock is reset by sending a single byte with the value 0x78 to CSP port P60_PORT_GNDWDT_RESET.

The P60 Dock is also capable of propagating the reset of the Ground Watchdog Timer to NanoPower P60 Input and Output Modules by configuring the CSP addresses of the NanoPower P60 ACU and PDU modules in the P60 Dock. See the Parameter Tables section for detail on this.

The following code will reset the Ground Watchdog Timer on the P60 Dock:

```c
#include <p60dock.h>

int p60dock_gndwdt_clear(uint8_t node, uint32_t timeout) {
   uint8_t magic = 0x78;
   return csp_transaction(CSP_PRIO_HIGH,
                          node,
                          P60_PORT_GNDWDT_RESET,
                          timeout,
                          &magic,
                          1,
                          NULL,
                          0);
}
```

7. Parameter Tables

A number of parameters on the P60 Dock can be adjusted through the GomSpace parameter system. The parameters are divided across four tables depending on the parameter types.

Table 0 is used for system level parameters that are expected to stay fixed for the entire mission. Table 1 is used for adjusting the operation and performance parameters. Table 2 is used for system level calibrartion parameters that are expected to stay fixed for the entire mission. Table 4 is used to store telemetry data.

Table 7.1: P60 Dock Parameter tables

Table	File	Default	Description
0	0	4	Board Configuration
1	1	5	Module Configuration
2	2	6	Calibration parameters
4	-	-	Telemetry Data

Through GOSH it is possible to list all parameters in a table by running the `param list <table>` command. Here it shows the default configuration parameters:

```
p60-dock # param list 1
Parameter list 1:
  0x0000 out_name          STR "x1_vcc" "x2_vcc" "x3_vcc" "x4_vcc"
                               "x1_vbat" "x2_vbat" "x3_vbat" "x4_vbat"
                               "st_vbat" "st_3v3" "st_5v" "gs_3v3" "gs_5v"
  0x0068 out_en            U8  1 1 1 1 1 1 1 1 0 0 0 0 0
  0x0076 out_on_cnt        U16 0 0 0 0 0 0 0 0 0 0 0 0 0
  0x0090 out_off_cnt       U16 0 0 0 0 0 0 0 0 0 0 0 0 0
  0x00AA init_out_norm     U8  1 1 1 1 1 1 1 1 0 0 0 0 0
  0x00B7 init_out_safe     U8  1 1 1 1 1 1 1 1 0 0 0 0 0
  0x00C4 init_on_dly       U16 0 0 0 0 0 0 0 0 0 0 0 0 0
  0x00DE init_off_dly      U16 0 0 0 0 0 0 0 0 0 0 0 0 0
  0x00F8 cur_lu_lim        U16 2500 2500 2500 2500 2500 2500 2500 2500 2500 2500 2500
                               2500 2500
  0x0112 cur_lim           U16 2500 2500 2500 2500 2500 2500 2500 2500 2500 2500 2500
                               2500 2500
  0x012C cur_ema           U16 100 112 122 131 140 152 161 170 0 0 0 0 0
  0x0148 cur_ema_gain      FLT 0.500000
  0x0150 vcc_vbat_link     U8  0 0 0 0
  0x014C vcc_link          U8  0 0 0 0
  0x0154 batt_pack         U8  0
  0x0156 batt_hwmax        U16 16000
  0x0158 batt_max          U16 9000
  0x015A batt_norm         U16 8000
  0x015C batt_safe         U16 7000
  0x015E batt_crit         U16 6000
  0x0160 bp_heat_mode      U8  0
  0x0162 bp_heat_low       I16 0
  0x0164 bp_heat_high      I16 0
  0x0168 wdt_i2c           U32 0
  0x0166 wdt_i2c_rst       U8  0
  0x016C wdt_can           U32 0
  0x0167 wdt_can_rst       U8  0
  0x0170 wdt_csp           U32 60 60
  0x0178 wdt_csp_ping      U8  5 5
  0x017A wdt_csp_chan      U8  0 0
  0x017C wdt_csp_addr      U8  0 0
  0x017E p60acu_chan       U8  0 0
  0x0180 p60acu_addr       U8  0 0
  0x0182 p60pdu_chan        U8   0 0 0 0
  0x0186 p60pdu_addr        U8   0 0 0 0
  0x018A conv_5v_en         U8   0
  0x0190 ant6_add           U8   0 0
  0x0194 ar6_addr           U8   0 0 0 0
  0x0198 depl_delay         U32  0
```

A parameter is modified by first switching to its table with `param mem <table>` and then running `param set <parameter> <value>`. E.g., to adjust the set the `out_en` value for channel 0 to 1, run the commands:

```
p60-dock # param mem 1
p60-dock # param set out_en[0] 1
p60-dock # param get out_en[0]
  GET out_en[0] = 1
```

The updated parameter values are only valid until next reboot. To store a parameter permanently, the parameter table must be stored to its matching file number (listed in the table above). To make our change to the `vcc_en` value permanent, we then need to run `param save <table> <file>`:

```
p60-dock # param save 1 1
Table CRC 12813
Data CRC 57665
```

The parameter system protects the stored table with two checksums: one to protect the data itself against corruption and one to ensure that the stored data matches the table structure.

System parameters in tables 0, 1 and 2 are saved in FRAM file numbers 0, 1 and 2 respectively.

The P60 Dock also has a default factory setting version of table 0, 1 and 2. The default factory settings are stored in locked FRAM sectors and must be unlocked prior to saving the parameter table. This is done using the `config unlock` command. After e.g. the `param save 0 4` command has been executed, the FRAM sectors can be relocked by calling `config lock` or by rebooting the system.

Note: As a safety measure, the `config` commands are only available through the GOSH interface and can not be executed via CSP. It is therefore not possible to unlock and modify the table 0 parameters remotely. This prevents accidental modification of e.g. the CSP address in orbit.

Telemetry data in table 4 is not saved to permanent storage and thus not backed by a file number or a default factory setting.

7.1 Table 0: Board Parameters

Table 0 holds system level configuration. Modification of these parameters require a reboot of the system, before they take effect.

Table 7.2: P60 Dock Parameter table 0: Board parameters

Name	Address	Type	Index	Default Value	Unit	Comment
uid	0x0000	STR (16)		0123456789ABCD		Board UID
type	0x0010	U8		1		Board type
rev	0x0011	U8		0		Board revision
csp_addr	0x0012	U8		2		CSP address
i2c_addr	0x0013	U8		2		I^{2}C address
i2c_speed	0x0014	U16		400	kbps	I^{2}C bitrate in kbps
can_speed	0x0016	U16		1000	kbps	CAN bitrate in kbps
kiss_en	0x0018	U8		0		Enable KISS
rs422_mode	0x0019	U8		0		RS422 mode
rs422_speed	0x001C	U32		115200	kbps	RS422 bitrate in kbps
csp_rtable	0x0020	STR (96)		*Empty*		CSP routing table

7.2 Table 1: Configuration Parameters

Table 1 contains P60 Dock runtime configuration parameters.

Table 7.3: P60 Dock Parameter table 1: Configuration parameters (part 1/2)

Name	Address	Type	Index	Default Value	Unit	Comment
out_name	0x0000	STR	[0..12]	See below		Output channel name (see below)
out_en	0x0068	U8	[0..12]	0 .. 0		Output channel enable (on/off)
out_on_cnt	0x0076	U16	[0..12]	0 .. 0	sec	Output channel on delay in seconds
out_off_cnt	0x0090	U16	[0..12]	0 .. 0	sec	Output channel off delay in seconds
init_out_norm	0x00AA	U8	[0..12]	0 .. 0		Output channel on/off in battery normal mode
init_out_safe	0x00B7	U8	[0..12]	0 .. 0		Output channel on/off in battery safe mode
init_on_dly	0x00C4	U16	[0..12]	0 .. 0	sec	Output channel on initial delay
init_off_dly	0x00DE	U16	[0..12]	0 .. 0	sec	Output channel off initial delay
cur_lu_lim	0x00F8	U16		2500 .. 2500	mA	Output channel instant latchup current limit (mA)
cur_lim	0x0112	U16		2500 .. 2500	mA	Output channel ema latchup current limit (mA)
cur_ema	0x012C	U16		0 .. 0	mA	Output channel latest current ema value (mA)
cur_ema_gain	0x0148	FLT		0.5		Output current ema gain
vcc_vbat_link	0x0150	U8	[0..3]	0 0 0 0		Output channel link VCC and corresponding VBAT (0 or 1)
vcc_link	0x014C	U8	[0..3]	0 0 0 0		Output channel linked VCC channel [0..3]
batt_pack	0x0154	U8		0		Battery Pack type (0=None, 2=BP4, 3=BPX)
batt_hwmax	0x0156	U16		16000	mV	Battery HW max value (mV)
batt_max	0x0158	U16		9000	mV	Battery full mode threshold value (mV)
batt_norm	0x015A	U16		8000	mV	Battery normal mode threshold value (mV)
batt_safe	0x015C	U16		7000	mV	Battery safe mode threshold value (mV)
batt_crit	0x015E	U16		6000	mV	Battery critical mode threshold value (mV)
bp_heat_mode	0x0160	U8		0		Battery heater mode (0=heater off, 1=on when temperature below threshold, 2=heater always on)
bp_heat_low	0x0162	I16		0	0.1 ℃	Battery heater low threshold
bp_heat_high	0x0164	I16		0	0.1 ℃	Battery heater high threshold

Table 7.4: P60 Dock Parameter table 1: Configuration parameters (part 2/2)

Name	Address	Type	Index	Default Value	Unit	Comment
wdt_i2c	0x0168	U32		0	sec	I^{2}C WDT timeout value in seconds
wdt_i2c_rst	0x0166	U8		0		Reboot if I^{2}C WDT expires (0/1)
wdt_can	0x016C	U32		0	sec	CAN WDT timeout value in seconds
wdt_can_rst	0x0167	U8		0		Reboot if CAN WDT expires (0/1)
wdt_csp	0x0170	U32	[0..1]	60 60	sec	CSP watchdog ping interval in seconds
wdt_csp_ping	0x0178	U8	[0..1]	5 5		CSP watchdog failed ping limit
wdt_csp_chan	0x017A	U8	[0..1]	0 0		Output channel to monitor via CSP
wdt_csp_addr	0x017C	U8	[0..1]	0 0		CSP address to ping when monitoring output channel via CSP
p60acu_chan	0x017E	U8	[0..1]	0 0		P60 ACU module channels (for future use)
p60acu_addr	0x0180	U8	[0..1]	0 0		P60 ACU module addresses
p60pdu_chan	0x0182	U8	[0..3]	0 0 0 0		P60 PDU module channels (for future use)
p60pdu_addr	0x0186	U8	[0..3]	0 0 0 0		P60 PDU module addresses
conv_5v_en	0x018A	U8		0		Enable 5 V converter manually (for test)
ant6_addr	0x0190	U8	[0..1]	0 0		ANT6 GSSB I^{2}C addresses
ar6_addr	0x0194	U8	[0..3]	0 0 0 0		AR6 GSSB I^{2}C addresses
depl_delay	0x0198	U32		0	sec	Deployment delay after boot

The following table shows the output channel names for each Output channel index:

Table 7.5: P60 Dock Parameter table 1: Configuration parameters

Index	Output channel name	Description
0 .. 3	x1_vcc x2_vcc x3_vcc x4_vcc	VCC for X1, X2, X3 and X4
4 .. 7	x1_vbat x2_vbat x3_vbat x4_vbat	VBAT for X1, X2, X3 and X4
8	st_vbat	Stack VBAT
9	st_3v3	Stack 3.3 V
10	st_5v	Stack 5 V
11	gs_3v3	GSSB 3.3 V
12	gs_5v	GSSB 5 V

7.3 Table 2: Calibration Parameters

Table 2 contains P60 Dock calibration parameters.

Table 7.6: P60 Dock Parameter table 2: Calibration parameters

Name	Address	Type	Index	Default Value	Unit	Comment
gain_v_out	0x0000	FLT	[0..12]	25.0 .. 25.0		Gain for output voltage measurement
gain_c_out	0x0034	FLT	[0..12]	1.0 .. 1.0		Gain for output current measurement
offs_c_out	0x0068	I16	[0..12]	0 .. 0	mA	Offset for output current measurement
vref	0x0082	U16		2500	mV	Reference voltage (mV)
gain_vbat_v	0x0084	FLT		25.0		Gain for VBAT dock current measurement
gain_vcc_c	0x0088	FLT		1.0		Gain for VCC dock current measurement
offs_vcc_c	0x008C	I16		0	mA	Offset for VCC dock current measurement
gain_aux1	0x0090	FLT		1.0		Gain for AUX1 current measurement
gain_aux2	0x0094	FLT		1.0		Gain for AUX2 current measurement
offs_aux1	0x0098	I16		0	mA	Offset for AUX1 current measurement
offs_aux2	0x009A	I16		0	mA	Offset for AUX2 current measurement
gain_batt_v	0x009C	FLT		20.0		Gain for battery voltage measurement
gain_batt_c	0x00A0	FLT		1.0		Gain for battery current measurement
offs_batt_c	0x00A4	I16		0	mA	Offset for battery current measurement

7.4 Table 4: Telemetry

This table contains P60 Dock telemetry data. The values are automatically updated once per second by the housekeeping task. The `bootcnt`, `resetcause`, `wdt_cnt_gnd`, `wdt_cnt_i2c`, `wdt_cnt_can` and `wdt_cntcsp` parameters are stored to persistent memory.

Table 7.7: P60 Dock Parameter table 4: Telemetry parameters

Name	Address	Type	Index	Default Value	Unit	Comment
c_out	0x0000	I16	[0..12]	0 .. 0	mA	Measured output current (mA)
v_out	0x001A	U16	[0..12]	0 .. 0	mV	Measured output voltage (mV)
out_en	0x0034	U8	[0..12]	0 .. 0		Output channel enable status
temp	0x0044	I16	[0..1]	0 0	0.1 °C	Measured temperature (0.1 °C)
bootcause	0x0048	U32		0		Boot cause
bootcnt	0x004C	U32		0		Boot count
uptime	0x0050	U32		0	sec	Uptime in seconds
resetcause	0x0054	U16		0		Reset cause
batt_mode	0x0056	U8		0		Battery mode (1=Critical, 2=Safe, 3=Normal, 4=Full)
heater_on	0x0057	U8		0		Heater enabled status
conv_5v_en	0x0058	U8		0		5 V Converter enabled status
latchup	0x005A	U16	[0..12]	0 .. 0		Latchup count for output channel
vbat_v	0x0074	U16		0	mV	Dock VBAT voltage
vcc_c	0x0076	I16		0	mA	Dock VCC current
batt_c	0x0078	I16		0	mA	Battery current, diff between batt_chrg and battery_discharge
batt_v	0x007A	U16		0	mV	Battery voltage
batt_temp	0x007C	I16	[0..1]	0 0	0.1 °C	Battery pack temperature
device_type	0x0080	U8	[0..7]	0 .. 0		Device type (see below)
device_status	0x0088	U8	[0..7]	0 .. 0		Device status (0=None, 1=OK, 2=Error, 3=Not found)
dearm_status	0x0090	U8		0		Status for de-arm pin
wdt_cnt_gnd	0x0094	U32		0		Ground WDT reboots
wdt_cnt_i2c	0x0098	U32		0		I^{2}C WDT reboots
wdt_cnt_can	0x009C	U32		0		CAN WDT reboots
wdt_cnt_csp	0x00A0	U32	[0..1]	0 0		CSP WDT reboots
wdt_gnd_left	0x00A8	U32		172800	sec	Ground WDT value (remaining seconds before reboot)
wdt_i2c_left	0x00AC	U32		0	sec	I^{2}C WDT value (remaining seconds before reboot)
wdt_can_left	0x00B0	U32		0	sec	CAN WDT value (remaining seconds before reboot)
wdt_csp_left	0x00B4	U8	[0..1]	5 5		CSP WDT value (remaining pings before power cycle)
batt_chrg	0x00B6	I16		0	mA	Battery charge current
batt_dischrg	0x00B8	I16		0	mA	Battery discharge current
ant6_depl	0x00BA	I8		0		ANT6 deployment status (see table below)
ar6_depl	0x00BB	I8		0		AR6 deployment status (see table below)

The following table shows the device types for the P60 Dock:

Table 7.8: P60 Dock Device type overview

Index	Type	Description
0	7	FRAM
1	2	ADC
2	2	ADC
3	1	ADC
4	4	Temperature sensor
5	6	RTC
6	5	Temperature sensor (battery pack)
7	5	Temperature sensor (battery pack)

The following table shows the deployment status values for the P60 Dock:

Table 7.9: P60 Dock Deployment status overview

Status	Description
0	Waiting for deployment
1	Deployed successfully
-1	Deployment failed or partially failed
-2	Deployment failed due to GSSB I^2C error
2	Deployment not activated (GSSB I^2C address not set for ANT6/AR6)
3	Deployment not activated (deployment delay not set)