Bradley Davis

The communication between the ground and satellite is separated into packets. This document specifies the form and function of these packets.

Packet Protocol

Detailed Description of Communication Packets

Revision: 1.0.2



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# 1 Packet Header

The function of the packet header is to convey the recipient and sender of each packet. It also indicates whether the packet is part of a larger packet (multipacket or file transfer). Throughout this document, multipacket represents a set of two or more packets primarily used to transfer files.

The header is two bytes long. The first byte contains the recipient, sender, and multipacket flag, see bit allocation in table 1. The second byte is the length of the body in number of dwords (32b). The choice of dwords allows future expandability of packet lengths up to , the current RCS limits packets to a length of 253B. A packet might require padding at the end of the body to increase the body length to a multiple of single dwords.

Table 1: Packet Header First Byte

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Bit index | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Function | Sender  0x0: Ground  0x1: ADCS  0x2: IFJR  0x3: IHU  0x4: PMIC  0x5: RCS | | | Recipient  0x0: Ground  0x1: ADCS  0x2: IFJR  0x3: IHU  0x4: PMIC  0x5: RCS | | | | Multipacket Flag |

## 1.1 Multipacket Additional Header

For a multipacket, there are an additional two bytes appended to the packet header. These represent a 16b long serial number for the packet. By analyzing the serial numbers of all packets received for a multipacket, the recipient can figure which packets were lost and request those specific packets from the sender.

# 2 Packet Body

The body of a packet is unique to every system and command. The details of every command are explained below.

## 2.1 Multipacket

The function of a multipacket is to transfer data that is longer than a single packet can support. The primary uses of a multipacket are images and processor binaries.

Every packet, except the last packet, will be completely full. There is a low chance that the last packet is also completely full. From the file size given in the first packet and the knowledge on the length of packets, the recipient can immediately figure the number of packets it is going to receive and how full the last packet is going to be.

### 2.1.1 First Packet

The first packet provides details on the file being transferred, including length and file name. The first 4 bytes represents the file length as an unsigned integer, file sizes are limited to . The next several bytes, until a null character is reached, represents the filename as a string. Immediately following the null character is the start of the file.

### 2.1.2 Second to (n – 1)th Packet

The second and onward packet, to one before the last, just contains the data of the file.

### 2.1.2 nth Packet

The last packet also contains just the data of the file; however, there is a likely possibility that this packet will not be completely full. If so, the same padding rules apply as normal packets: add padding until the body is an even multiple of dwords. Once this packet is received, or communication times out, the recipient will identify which packets were lost in transmission and request them again using their serial numbers

### 2.1.3 Lost Packet Request

If a packet is lost, the recipient will send a request for retransmission of that specific packet. The body of this message will be a byte to indicate lost packets (0xFF) and the serial numbers of lost packets sequentially appended. If number of lost packets exceeds the number that fit in a single packet, change the lost packet byte to (0xFE) and send additional requests. Once all packets are accounted for, send a multipacket transfer success message and began assembling packets.

### 2.1.4 Multipacket Transfer Success

Upon successful completion of a multipacket transfer, send a message to the sender to inform of the success so it can resume normal operation, or possibly begin another multipacket. The body of this message is (0x00 0x01 0xF6 0x80), which is the Unicode character for 🚀.

## 2.2 ADCS Commands

Each command has an uplink and downlink form. Uplink is the ground to the ADCS. Downlink is the ADCS to the ground. The commands are used to get health data, get diagnostic data, get raw attitude sensor values, and request a maneuver.

### 2.2.1 Diagnostic Report

A full diagnostic report is requested from the ADCS with the command ID 0x00, see table 2. The ADCS replies with command ID 0x80, current position, attitude, coil driver PWM count, and coil currents as listed in table 3. The coil PWM count in the raw value at which the PWM output is set low.

Table 2: ADCS Diagnostic Report Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 3: ADCS Diagnostic Report Downlink

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 |
| Function | 0x80 | Lat (int32, (10-4) min/LSB) | | | | Long (int32, (10-4) min/LSB) | | | |
|  |  |  | | | |  | | | |
| Index | 0x09 | 0x0A | 0x0B | 0x0C | 0x0D | 0x0E | 0x0F | 0x10 | 0x11 |
| Function | Roll (uint24, 224 = 2π) | | | Pitch (uint24, 224 = 2π) | | | Yaw (uint24, 224 = 2π) | | |
|  |  | | |  | | |  | | |
| Index | 0x12 | 0x13 | 0x14 | 0x15 | 0x16 | 0x17 | 0x18 | 0x19 | 0x1A |
| Function | X Count (int16) | | Y Count (int16) | | Z Count (int16) | | X Current (int24, 1nA/LSB) | | |
|  |  | |  | |  | |  | | |
| Index | 0x1B | 0x1C | 0x1D | 0x1E | 0x1F | 0x20 |  | | |
| Function | Y Current (int24, 1nA/LSB) | | | Z Current (int24, 1nA/LSB) | | |  | | |

### 2.2.2 IMU Sensor

The IMU sensor data is requested from the ADCS with the command ID 0x01 and sensor ID, see table 4. The ADCS replies with command ID 0x81, and raw sensor values as listed in table 5.

Table 4: ADCS IMU Sensor Uplink

|  |  |  |
| --- | --- | --- |
| Index | 0x00 | 0x01 |
| Function | 0x01 | Sensor ID  0x0: IMU 0  0x1: IMU 1  0x2: IMU 2  0x3: IMU 3 |

Table 5: ADCS IMU Sensor Downlink

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 |
| Function | 0x81 | X Mag (raw) | | | Y Mag (raw) | | Z Mag (raw) | | X Gyro (raw) | |
|  |  |  | | | | |  |  |  |  |
| Index | 0x09 | 0x0A | 0x0B | | 0x0C | 0x0D | 0x0E | 0x0F | 0x10 |  |
| Function | Y Gyro (raw) | | Z Gyro (raw) | | | X Accel (raw) | | Y Accel (raw) | |  |
|  |  | | |  | |  | |  | |  |
| Index | 0x11 | 0x12 | |  | |  | |  | |  |
| Function | Z Accel (raw) | | |  | |  | |  | |  |

### 2.2.3 Maneuver to a Point

A maneuver to a point is requested from the ADCS with the command ID 0x02, reference frame, and position see table 6. The ADCS attempts to point the satellite at the fixed point. The ADCS replies with command ID 0x82, and estimated time of completion as listed in table 7. If multiple maneuvers are requested, the most recently received will be performed.

Table 6: ADCS Maneuver to a Point Uplink

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 | 0x08 | 0x09 |
| Function | 0x02 | Reference Frame  0x0: Earth  0x1: Space | Latitude (int32, (10-4) min/LSB) | | | | Longitude (int32, (10-4) min/LSB) | | | |

Table 7: ADCS Maneuver to a Point Downlink

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 |
| Function | 0x82 | ETC (uint32, Unix Time) | | | |

### 2.2.4 Maneuver to an Attitude

A maneuver to an attitude is requested from the ADCS with the command ID 0x03, reference frame, and position see table 8. The ADCS attempts to point the satellite at the fixed attitude. The ADCS replies with command ID 0x83, and estimated time of completion as listed in table 9. If multiple maneuvers are requested, the most recently received will be performed.

Table 8: ADCS Maneuver to an Attitude Uplink

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 |
| Function | 0x03 | Roll (uint24, 224 = 2π) | | | Pitch (uint24, 224 = 2π) | | |
|  |  |  |  |  |
| Index | 0x08 | 0x09 | 0x0A |
| Function | Yaw (uint24, 224 = 2π) | | |

Table 9: ADCS Maneuver to an Attitude Downlink

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 |
| Function | 0x83 | ETC (uint32, Unix Time) | | | |

## 2.3 IFJR Commands

Each command has an uplink and downlink form. Uplink is the ground to the IFJR. Downlink is the IFJR to the ground. The commands are used to get health data, get diagnostic data, and request a reprogram.

### 2.3.1 Status Report

A simple status report is requested from the IFJR with the command ID 0x00, see table 10. The IFJR replies with command ID 0x80, current code version numbers, and SD card used size as listed in table 11.

Table 10: IFJR Status Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 11: IFJR Status Downlink

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 |
| Function | 0x80 | ADCS | IHU | PMIC | RCS |
|  |  |  |  |  |  |
| Index | 0x05 | 0x06 | 0x07 | 0x08 | 0x09 |
| Function | SD Card Used Size (uint40, 1B/LSB) | | | | |

### 2.3.2 Diagnostic Report

A full diagnostic report is requested from the IFJR with the command ID 0x01 and device ID, see table 12. The IFJR replies with command ID 0x81, and current code version numbers as listed in table 13.

Table 12: IFJR Diagnostic Report Uplink

|  |  |  |
| --- | --- | --- |
| Index | 0x00 | 0x01 |
| Function | 0x01 | Device ID  0x0: ADCS  0x1: IFJR  0x2: IHU  0x3: PMIC  0x4: RCS |

Table 13: IFJR Diagnostic Report Downlink

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 |
| Function | 0x81 | Version | Last Program (uint32, Unix Time) | | | |

### 2.3.3 Reprogram Device

A device reprogram is requested from the IFJR with the command ID 0x02 and device ID, see table 14. The IFJR replies with command ID 0x82, and programming duration as listed in table 15.

Table 14: IFJR Reprogram Device Uplink

|  |  |  |
| --- | --- | --- |
| Index | 0x00 | 0x01 |
| Function | 0x02 | Device ID  0x0: ADCS  0x1: IFJR  0x2: IHU  0x3: PMIC  0x4: RCS |

Table 15: IFJR Reprogram Device Downlink

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 |
| Function | 0x82 | Time (uint24, 1ms/LSB) | | |

## 2.4 IHU Commands

Each command has an uplink and downlink form. Uplink is the ground to the IHU. Downlink is the IHU to the ground. The commands are used to get health data, get diagnostic data, and standard telemetry. The standard telemetry is usually not needed to be requested as it is sent out at a regular interval.

### 2.4.1 Diagnostic Report

A full diagnostic report is requested from the IHU with the command ID 0x00, see table 16. The IHU replies with command ID 0x80 and current operation mode, current time, reset count, and SD card used size as listed in table 17.

Table 16: IHU Diagnostic Report Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 17: IHU Diagnostic Report Downlink

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | | 0x01 | | 0x02 | | 0x03 | | 0x04 | 0x05 | | | 0x06 | | |
| Function | 0x80 | | Mode | | Current Time (uint32, Unix Time) | | | | | | | | Reset Count | | |
|  |  |  | |  | |  | |  | |  |  | | |
| Index | 0x07 | | 0x08 | | 0x09 | | 0x0A | | 0x0B |  | |  | | |
| Function | SD Card Used Size (uint40, 1B/LSB) | | | | | | | | |  |  | | |

### 2.4.2 Standard Telemetry

A standard telemetry packet is requested from the IHU with the command ID 0x01, see table 18. The IHU replies with command ID 0x81, current operation mode, and telemetry from each subsystem as listed in table 19. A standard telemetry packet is sent at regular intervals during the event ihuPeriodic. Normally, a request for a standard telemetry packet does not need to be requested. Temperature readings are signed 8b integers with 1°C/LSB. Voltages and currents are each unsigned 12b integers, forming 3 bytes together. Voltages are 2mV/LSB and currents are 1mA/LSB. Powers (including heater output) are unsigned 8b integers with 50mW/LSB.

Table 18: IHU Standard Telemetry Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x01 |

Table 19: IHU Standard Telemetry Downlink

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 |
| Function | 0x81 | Mode | Current Time (uint32, Unix Time) | | | | Reset Count | IHU Temp |
|  |  |  |  |  |  |  |  |  |
| Index | 0x08 | 0x09 | 0x0A | 0x0B | 0x0C | 0x0D | 0x0E | 0x0F |
| Function | IHU SD Card Used Size (uint40, 1B/LSB) | | | | | Error Status | ADCS Temp | ADCS Status |
|  |  |  |  |  |  |  |  |  |
| Index | 0x10 | 0x11 | 0x12 | 0x13 | 0x14 | 0x15 | 0x16 | 0x17 |
| Function | Lat (int32, (10-4) min/LSB) | | | | Long (int32, (10-4) min/LSB) | | | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x18 | 0x19 | 0x1A | 0x1B | 0x1C | 0x1D | 0x1E | 0x1F |
| Function | Roll (uint24, 224 = 2π) | | | Pitch (uint24, 224 = 2π) | | | Yaw (uint24, 224 = 2π) | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x20 | 0x21 | 0x22 | 0x23 | 0x24 | 0x25 | 0x26 | 0x27 |
| Function | Yaw | IFJR Temp | PMIC Temp | Battery 0 Voltage & Current | | | Battery 1 V & I | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x28 | 0x29 | 0x2A | 0x2B | 0x2C | 0x2D | 0x2E | 0x2F |
| Function | Batt 1 V & I | Batt 0 Temp | Batt 1 Temp | Batt 0 Heat | Batt 1 Heat | Solar Panel 0 Voltage & Current | | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x30 | 0x31 | 0x32 | 0x33 | 0x34 | 0x35 | 0x36 | 0x37 |
| Function | Solar Panel 1 Voltage & Current | | | Solar Panel 2 Voltage & Current | | | Solar Panel 3 V & I | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x38 | 0x39 | 0x3A | 0x3B | 0x3C | 0x3D | 0x3E | 0x3F |
| Function | PV 3 V & I | Pin (uint16) (1mW/LSB) | | Pout (uint16) (1mW/LSB) | | 3.3V Rail Voltage & Current | | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x40 | 0x41 | 0x42 | 0x43 | 0x44 | 0x45 | 0x46 | 0x47 |
| Function | 5.0V Rail Voltage & Current | | | PMIC Channels’ State | | RCS Temp | RCS Status | TX Power |
|  |  |  |  |  |  |  |  |  |
| Index | 0x48 | 0x49 | 0x4A | 0x4B |  |  |  |  |
| Function | RX Power | RX SNR | Payload Frames in TX Queue | |  |  |  |  |

## 2.5 EPS Commands

Each command has an uplink and downlink form. Uplink is the ground to the EPS. Downlink is the EPS to ground. The commands are used to get diagnostic data from the EPS.

### 2.5.1 Diagnostic Report

A full diagnostic report is requested from the EPS with the command ID 0x00, see table 20. The EPS replies with command ID 0x80, state of primary and secondary PMIC, battery voltages, currents, and temperatures, solar panel voltages, currents, and temperatures, voltage rail voltages and currents, regulator temperatures, power channel currents and switch status, and net energy for the day as listed in table 21. The net energy is reset at 0:00:00 UTC every day.

Voltages are unsigned 16b integers with 100µV/LSB. Currents are unsigned 16b 100µA/LSB, unless otherwise defined. Temperatures are signed 8b integers with 1°C/LSB. Power channel switch status is a unsigned 16b integer, each bit corresponds to a single channel: [15..10] 3V-0..5, [9..8] 5V-0..1, [7..2] U-0..5, [1..0] Heater P..S. “P” and “S” are used to indicate reference to the primary or secondary PMIC, hardware defined as their software roles might switch.

Table 20: EPS Diagnostic Report Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 21: EPS Diagnostic Report Downlink

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 |
| Function | 0x80 | 1st/2nd Role | Battery P Voltage | | Battery P Current (int16) | | Battery S Voltage | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x08 | 0x09 | 0x0A | 0x0B | 0x0C | 0x0D | 0x0E | 0x0F |
| Function | Battery S Current | | Batt P Temp | Batt S Temp | Solar Panel 0 Voltage | | Solar Panel 0 Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x10 | 0x11 | 0x12 | 0x13 | 0x14 | 0x15 | 0x16 | 0x17 |
| Function | Solar Panel 1 Voltage | | Solar Panel 1 Current | | Solar Panel 2 Voltage | | Solar Panel 2 Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x18 | 0x19 | 0x1A | 0x1B | 0x1C | 0x1D | 0x1E | 0x1F |
| Function | Solar Panel 3 Voltage | | Solar Panel 3 Current | | PV 0 Temp 0 | PV 0 Temp 1 | PV 0 Temp 2 | PV 1 Temp 0 |
|  |  |  |  |  |  |  |  |  |
| Index | 0x20 | 0x21 | 0x22 | 0x23 | 0x24 | 0x25 | 0x26 | 0x27 |
| Function | PV 1 Temp 1 | PV 1 Temp 2 | PV 2 Temp 0 | PV 2 Temp 1 | PV 2 Temp 2 | PV 3 Temp 0 | PV 3 Temp 1 | PV Temp 2 |
|  |  |  |  |  |  |  |  |  |
| Index | 0x28 | 0x29 | 0x2A | 0x2B | 0x2C | 0x2D | 0x2E | 0x2F |
| Function | 3V Rail P Voltage | | 3V Rail P Current | | 3V Rail S Voltage | | 3V Rail S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x30 | 0x31 | 0x32 | 0x33 | 0x34 | 0x35 | 0x36 | 0x37 |
| Function | 5V Rail P Voltage | | 5V Rail P Current | | 5V Rail S Voltage | | 5V Rail S Current | |
| Index | 0x38 | 0x39 | 0x3A | 0x3B | 0x3C | 0x3D | 0x3E | 0x3F |
| Function | 3V Reg P Temp | 3V Reg S Temp | 5V Reg P Temp | 5V Reg S Temp | MPPT 0 P Temp | MPPT 0 S Temp | MPPT 1 P Temp | MPPT 1 S Temp |
|  |  |  |  |  |  |  |  |  |
| Index | 0x40 | 0x41 | 0x42 | 0x43 | 0x44 | 0x45 | 0x46 | 0x47 |
| Function | 3V-0 P Current | | 3V-0 S Current | | 3V-1 P Current | | 3V-1 S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x48 | 0x49 | 0x4A | 0x4B | 0x4C | 0x4D | 0x4E | 0x4F |
| Function | 3V-2 P Current | | 3V-2 S Current | | 3V-3 P Current | | 3V-3 S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x50 | 0x51 | 0x52 | 0x53 | 0x54 | 0x55 | 0x56 | 0x57 |
| Function | 3V-4 P Current | | 3V-4 S Current | | 3V-5 P Current | | 3V-5 S Current | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x58 | 0x59 | 0x5A | 0x5B | 0x5C | 0x5D | 0x5E | 0x5F |
| Function | 5V-0 P Current | | 5V-0 S Current | | 5V-1 P Current | | 5V-1 S Current | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x60 | 0x61 | 0x62 | 0x63 | 0x64 | 0x65 | 0x66 | 0x67 |
| Function | U-0 P Current | | U-0 S Current | | U-1 P Current | | U-1 S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x68 | 0x69 | 0x6A | 0x6B | 0x6C | 0x6D | 0x6E | 0x6F |
| Function | U-2 P Current | | U-2 S Current | | U-3 P Current | | U-3 S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x70 | 0x71 | 0x72 | 0x73 | 0x74 | 0x75 | 0x76 | 0x77 |
| Function | U-4 P Current | | U-4 S Current | | U-5 P Current | | U-5 S Current | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x78 | 0x79 | 0x7A | 0x7B | 0x7C | 0x7D | 0x7E | 0x7F |
| Function | Battery Heater P Current | | Battery Heater S Current | | Channel Switch Status | | Energy (int16) (10J/LSB) | |

## 2.6 Payload Commands

Each command has an uplink and downlink form. Uplink is the ground to the payload. Downlink is the payload to the ground. The commands are used to get diagnostic data, take and download photos, and download experimental data. To change parameters of the experiment, such as measurement interval, send a file up that the experiment will understand.

### 2.6.1 Diagnostic Report

A full diagnostic report is requested from the payload with the command ID 0x00, see table 22. The payload replies with command ID 0x80 as listed in table 23.

Table 22: Payload Diagnostic Report Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 23: Payload Diagnostic Report Downlink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x80 |

### 2.6.2 Take Photo

A take photo event is requested from the payload with the command ID 0x01, desired time to expose, and camera ID, see table 24. The payload replies with command ID 0x81, status, and photo ID as listed in table 25. Multiple request can be stacked, and they will all be taken. To retrieve a photo, use the [download photo](#_2.6.3_Download_Photo) command.

Table 24: Payload Take Photo Uplink

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 |
| Function | 0x01 | Time to Expose (uint32, Unix Time) | | | | Camera ID  0x0: Ground Wide  0x1: Germination |

Table 25: Payload Take Photo Downlink

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 |
| Function | 0x81 | Status | Photo ID | |

### 2.6.3 Download Photo

A photo download is requested from the payload with the command ID 0x02 and photo ID, see table 26. The payload replies with a multipacket file transfer, see [2.1](#_2.1_Multipacket). If a photo ID of is requested, the next photo not yet transferred will be sent. The specifics of the file being transferred is explained in the Image Format document.

Table 26: Payload Download Photo Uplink

|  |  |  |  |
| --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 |
| Function | 0x02 | Photo ID | |

### 2.6.4 Experiment Report

An experiment report is requested from the payload with the command ID 0x03 and photo ID, see table 27. The payload replies with a multipacket file transfer, see [2.1](#_2.1_Multipacket). If an experiment ID of is requested, the next experiment report not yet transferred will be sent. The specifics of the file being transferred is explained in each experiment’s documentation.

Table 27: Payload Experiment Report Uplink

|  |  |  |
| --- | --- | --- |
| Index | 0x00 | 0x01 |
| Function | 0x03 | Experiment ID  0x0: Radiation  0x1: Temperature  0x2: Germination |

## 2.7 RCS Commands

Each command has an uplink and downlink form. Uplink is ground to the RCS. Downlink is RCS to ground. The commands are used to get diagnostic data and change parameters of the radios.

### 2.7.1 Diagnostic Report

A full diagnostic report is requested from the RCS with the command ID 0x00, see table 28. The RCS replies with command ID 0x80, transmitting radio power, receiving radio power, radio center frequencies, daily bad packet count, and receiver signal to noise ratio as listed in table 29. The daily bad packet count resets at 0:00:00 UTC every day. The bad packet count includes partial packets received, and packets with wrong cyclic redundancy check. Power data are unsigned 16b integers with 1mW/LSB. SNR is an unsigned 8b integer with 0.1dB/LSB

Table 28: RCS Diagnostic Report Uplink

|  |  |
| --- | --- |
| Index | 0x00 |
| Function | 0x00 |

Table 29: RCS Diagnostic Report Downlink

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 |
| Function | 0x80 | TX Power | | RX Power | | TX Center Frequency (uint24, 100Hz/LSB) | | |
|  |  |  |  |  |  |  |  |  |
| Index | 0x08 | 0x09 | 0x0A | 0x0B | 0x0C | 0x0D |  |  |
| Function | RX Center Frequency (uint24, 100Hz/LSB) | | | Bad Packet Count (uint16) | | RX SNR |  |  |

### 2.7.2 Change Radio

A change to a radio is requested from the RCS with the command ID 0x01, radio ID, max transmit power, and center frequency, see table 30. The RCS replies with command ID 0x81 and status as listed in table 31.

Table 30: RCS Change Radio Uplink

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Index | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 |
| Function | 0x01 | ID | Power (uint16) (1mW/LSB) | | Center Frequency (uint24, 100Hz/LSB) | | |

Table 31: RCS Change Radio Downlink

|  |  |  |
| --- | --- | --- |
| Index | 0x00 | 0x01 |
| Function | 0x81 | Status |