

RadTC Payload Packet Structure

**Radiation Tolerant Computer payload (RadTC)**

Doc #: ####-#-#### Rev 1.0

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Prepared By: Matthew Handley

SSEL

Date: 05/27/2015

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CERTIFICATION LOG

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**REVISION LOG**

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| Rev. | Area(s) Affected | Date | Approval |
| 1.0 | Initial Release | xx/yy/zzzz | K. Mashburn |
| 1.1 | Revised both packets to match current telemetry of RTCS (Connor Julien) | 06/22/2016 |  |
| 1.2 | Revised tile packet for RadSat and corrected errors in the offset column. (Connor Julien) | 01/28/2018 |  |
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# Scope

This document describes the command and telemetry interface between the RadTC Payload (“the payload”) and the RadSat Spacecraft Bus (“the bus”).

# Communications Methodology

Upon power up the payload shall begin normal operations autonomously. The payload shall transmit telemetry packets only after requested by command from the bus. Payload telemetry packet transmission will be complete within 2.0 seconds (TBR) of request from the bus. When gracefully powering down the payload, the bus will issue a POWER\_DOWN command to the payload 5 seconds (TBR) prior to removing power from the payload, so that the payload may safe itself. The payload shall survive non-graceful power downs, when the bus is unable to alert the payload that power is about to be removed.

The payload and bus shall communicate at 9600bps over full duplex asynchronous 3.3V LVDS.

All commands and telemetry packets shall begin with a 0xC0 sync byte and end with a two-byte CRC followed by another 0xC0 sync byte. The packet CRC (Cyclic Redundancy Check) is computed across all bytes in the packet from beginning to end, excluding the SYNC and CRC bytes. All CRCs are computed using the CCITT-16-CRC standard. Example C source code for this CRC calculation can be found in .

To prevent the sync byte from appearing in the data or CRC, the Serial Line Internet Protocol (SLIP) as documented in RFC1055[[1]](#footnote-1) shall be used to byte stuff any sync or escape characters. The following table defines the END, ESC, ESC\_END, and ESC\_ESC character to be used.

|  |  |  |
| --- | --- | --- |
| **Hex value** | **Abbreviation** | **Description** |
| 0xC0 | END | Frame End |
| 0xDB | ESC | Frame Escape |
| 0xDC | ESC\_END | Transposed Frame End |
| 0xDD | ESC\_ESC | Transposed Frame Escape |

# Telemetry Packet Structure

The telemetry packets contain all of the information about the payload’s operation for the past day. This includes information about the computation FPGA (counter values, active tiles, faulted tiles, temperature), information about the power supplies (min/max/avg current & voltage), and general information (1Hz system counter, scrubber, and watchdog counter). The information for the day is accumulated by the Spartan-6 FPGA. This information is broken into two distinct telemetry packets.

## TLM\_TILE Telemetry Packet Structure

This telemetry packet contains information about the many-tile system. This includes the Artix-7 FPGA counter values, the Spartan-6 system counter, the active/faulted tile status, the watchdog timer status, and any faults detected during readback scrubbing. The total size of this packet is 52 bytes.

| **Mnemonic** | **Size** | **Offset** | **Type** | **Units** | **Description** |
| --- | --- | --- | --- | --- | --- |
| SYNC | 1 | 0 | INT8U | none | 0xC0 Sync byte |
| PKT\_TYPE | 1 | 1 | INT8U | none | 0x88 TLM\_TILE packet type identifier |
| S6\_COUNT | 4 | 2 | INT32U | Counts | Count value |
| ACT\_TILES | 2 | 6 | INT16U | none | Active processors |
| FAULTED\_TILES | 2 | 8 | INT16U | none | Faulted processors |
| FAULT\_COUNT\_TILE0 | 2 | 10 | INT16U | Counts | Tile0 fault counter |
| FAULT\_COUNT\_TILE1 | 2 | 12 | INT16U | Counts | Tile1 fault counter |
| FAULT\_COUNT\_TILE2 | 2 | 14 | INT16U | Counts | Tile2 fault counter |
| FAULT\_COUNT\_TILE3 | 2 | 16 | INT16U | Counts | Tile3 fault counter |
| FAULT\_COUNT\_TILE4 | 2 | 18 | INT16U | Counts | Tile4 fault counter |
| FAULT\_COUNT\_TILE5 | 2 | 20 | INT16U | Counts | Tile5 fault counter |
| FAULT\_COUNT\_TILE6 | 2 | 22 | INT16U | Counts | Tile6 fault counter |
| FAULT\_COUNT\_TILE7 | 2 | 24 | INT16U | Counts | Tile7 fault counter |
| FAULT\_COUNT\_TILE8 | 2 | 26 | INT16U | Counts | Tile8 fault counter |
| FAULTS\_INJECTED | 2 | 28 | INT16U | Counts | Number of faults injected |
| TOTAL\_FAULTS | 2 | 30 | INT16U | Counts | Number of total faults |
| MOVE\_TILE\_COUNT | 2 | 32 | INT16U | Counts | Number of tiles moved |
| NEXT\_SPARE | 1 | 34 | INT8U | None | Next spare that will be activated |
| READBACK\_FAULTS | 2 | 35 | INT16U | none | Number of read back faults that have occurred |
| WATCHDOG | 1 | 37 | INT8U | none | How many watchdog repairs have occurred |
| ACT\_PROC1 | 1 | 38 | INT8U | none | First active tile with processor |
| ACT\_PROC2 | 1 | 39 | INT8U | none | Second active tile with processor |
| ACT\_PROC3 | 1 | 40 | INT8U | none | Third active with processor |
| ACT\_PROC1\_CNT | 2 | 41 | INT16U | Counts | First active processor counter |
| ACT\_PROC2\_CNT | 2 | 43 | INT16U | Counts | Second active processor counter |
| ACT\_PROC3\_CNT | 2 | 45 | INT16U | Counts | Third active processor counter |
| VOTER\_CNTS | 2 | 47 | INT16U | none | Voter value |
| CRC | 2 | 49 | INT16U | None | CRC |
| SYNC | 1 | 51 | INT8U | none | 0xC0 Sync byte |

## TLM\_HEALTH Telemetry Packet Structure

The power supply information includes the minimum, maximum, and average levels for the past day in addition to the value at the time of the state-of-health file writing. This telemetry packet also contains the temperature of the Virtex-6 and the two TI microcontrollers.

All analog telemetry (voltages, currents, and temperatures) are represented as signed integers in units volts, amps, and Celsius. The total size of this packet is 123 bytes.

| **Mnemonic** | **Size** | **Offset** | **Type** | **Units** | **Description** |
| --- | --- | --- | --- | --- | --- |
| SYNC | 1 | 0 | INT8U | none | 0xC0 Sync byte |
| PKT\_TYPE | 1 | 1 | INT8U | none | **0x33** TLM\_HEALTH packet type identifier |
| VOLTAGE\_INS\_IN | 2 | 2 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_IN | 2 | 4 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_IN | 2 | 6 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_IN | 2 | 8 | INT16S | V | Analog Tlm |
| VOLTAGE\_INS\_3V3D | 2 | 10 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_3V3D | 2 | 12 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_3V3D | 2 | 14 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_3V3D | 2 | 16 | INT16S | V | Analog Tlm |
| VOLTAGE\_INS\_2V5D | 2 | 18 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_2V5D | 2 | 20 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_2V5D | 2 | 22 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_2V5D | 2 | 24 | INT16S | V | Analog Tlm |
| VOLTAGE\_INS\_1V8D | 2 | 26 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_1V8D | 2 | 28 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_1V8D | 2 | 30 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_1V8D | 2 | 32 | INT16S | V | Analog Tlm |
| VOLTAGE\_INS\_1V0SD | 2 | 34 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_1V0SD | 2 | 36 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_1V0SD | 2 | 38 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_1V0SD | 2 | 40 | INT16S | V | Analog Tlm |
| VOLTAGE\_INS\_0V95AD | 2 | 42 | INT16S | V | Analog Tlm |
| VOLTAGE\_AVE\_0V95A D | 2 | 44 | INT16S | V | Analog Tlm |
| VOLTAGE\_MAX\_0V95A D | 2 | 46 | INT16S | V | Analog Tlm |
| VOLTAGE\_MIN\_0V95A D | 2 | 48 | INT16S | V | Analog Tlm |
| CURRENT\_INS\_IN | 2 | 50 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_IN | 2 | 52 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_IN | 2 | 54 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_IN | 2 | 56 | INT16S | A | Analog Tlm |
| CURRENT\_INS\_3V3D | 2 | 58 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_3V3D | 2 | 60 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_3V3D | 2 | 62 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_3V3D | 2 | 64 | INT16S | A | Analog Tlm |
| CURRENT\_INS\_2V5D | 2 | 66 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_2V5D | 2 | 68 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_2V5D | 2 | 70 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_2V5D | 2 | 72 | INT16S | A | Analog Tlm |
| CURRENT\_INS\_1V8D | 2 | 74 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_1V8D | 2 | 76 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_1V8D | 2 | 78 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_1V8D | 2 | 80 | INT16S | A | Analog Tlm |
| CURRENT\_INS\_1V0SD | 2 | 82 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_1V0SD | 2 | 84 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_1V0SD | 2 | 86 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_1V0SD | 2 | 88 | INT16S | A | Analog Tlm |
| CURRENT\_INS\_0V95AD | 2 | 90 | INT16S | A | Analog Tlm |
| CURRENT\_AVE\_0V95AD | 2 | 92 | INT16S | A | Analog Tlm |
| CURRENT\_MAX\_0V95AD | 2 | 94 | INT16S | A | Analog Tlm |
| CURRENT\_MIN\_0V95AD | 2 | 96 | INT16S | A | Analog Tlm |
| A7\_TEMPERATURE | 2 | 98 | INT16S | ° C | Virtex-6 junction temperature |
| PC1\_TEMPERATURE | 2 | 100 | INT16S | °C | Power controller #1 internal temp sensor |
| PC2\_TEMPERATURE | 2 | 102 | INT16S | °C | Power controller #2 internal temp sensor measurement |
| SYSTEM\_RUNTIME\_DAYS | 4 | 104 | INT32U | days | System runtime - days |
| SYSTEM\_RUNTIME\_HRS | 4 | 108 | INT32U | Hours | System runtime – hours |
| SYSTEM\_RUNTIME\_MINS | 4 | 112 | INT32U | Mins | System runtime – minutes |
| SYSTEM\_RUNTIME\_SECS | 4 | 116 | INT32U | Secs | System runtime - seconds |
| CRC | 2 | 120 | INT16U | None | CRC |
| SYNC | 1 | 122 | INT8U | none | 0xC0 Sync byte |

# Command Packet Structure

The command packets are sent to the payload to request telemetry and inform the payload of impending power down. Command packets shall conform to the FIREBIRD packet structure, as outlined in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mnemonic** | **Size** | **Offset** | **Normal Value** |
| **SYNC** | **1** | **0** | **0xC0** |
| **SCID\_SOURCE** | **1** | **1** | **Varies** |
| **SOURCE\_ID** | **1** | **2** | **0x09** |
| **SCID\_DESTINATION** | **1** | **3** | **Varies** |
| **DESTINATION \_ID** | **1** | **4** | **0x09** |
| **CMDTLM** | **1** | **5** | **0x01** |
| **CMD\_ID** | **1** | **6** | **Varies, see table below** |
| **SEQ\_NUM** | **1** | **7** | **0x00** |
| **SEQ\_IDX** | **1** | **8** | **0x00** |
| **PKT\_NUM** | **1** | **9** | **Varies** |
| **DATA\_LEN** | **1** | **10** | **0x00** |
| **CRC** | **2** | **11** | **Varies** |
| **SYNC** | **1** | **13** | **0xC0** |

**The following table defines the various valid CMD\_ID values.**

|  |  |
| --- | --- |
| **Command Name** | **CMD\_ID Value** |
| **GET\_TILE** | **0x88** |
| **GET\_HEALTH** | **0x33** |
| **SOFT\_POWER\_DOWN** | **0xF0** |

# ****Appendix A: CCITT-16-CRC Source Code****

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\*

\* Space Science and Engineering Laboratory

\* Montana State University

\*

\* Flight Software

\*

\* Filename : crc\_driver.c

\* Header File(s):

\* Description :

\* Authors(s) : Matthew Handley

\* Date Created : 06/21/2012

\* Date Modified : 05/27/2015

\* Modifier(s) :

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

/\* PROTOTYPE \*/

INT16U SWCalcCRC ( INT8U \*, INT16U );

/\* CONSTANTS \*/

const static INT16U CCITT\_CRC16\_Coeff[] =

{

0x0000, 0x1021, 0x2042, 0x3063, 0x4084, 0x50a5, 0x60c6, 0x70e7,

0x8108, 0x9129, 0xa14a, 0xb16b, 0xc18c, 0xd1ad, 0xe1ce, 0xf1ef,

0x1231, 0x0210, 0x3273, 0x2252, 0x52b5, 0x4294, 0x72f7, 0x62d6,

0x9339, 0x8318, 0xb37b, 0xa35a, 0xd3bd, 0xc39c, 0xf3ff, 0xe3de,

0x2462, 0x3443, 0x0420, 0x1401, 0x64e6, 0x74c7, 0x44a4, 0x5485,

0xa56a, 0xb54b, 0x8528, 0x9509, 0xe5ee, 0xf5cf, 0xc5ac, 0xd58d,

0x3653, 0x2672, 0x1611, 0x0630, 0x76d7, 0x66f6, 0x5695, 0x46b4,

0xb75b, 0xa77a, 0x9719, 0x8738, 0xf7df, 0xe7fe, 0xd79d, 0xc7bc,

0x48c4, 0x58e5, 0x6886, 0x78a7, 0x0840, 0x1861, 0x2802, 0x3823,

0xc9cc, 0xd9ed, 0xe98e, 0xf9af, 0x8948, 0x9969, 0xa90a, 0xb92b,

0x5af5, 0x4ad4, 0x7ab7, 0x6a96, 0x1a71, 0x0a50, 0x3a33, 0x2a12,

0xdbfd, 0xcbdc, 0xfbbf, 0xeb9e, 0x9b79, 0x8b58, 0xbb3b, 0xab1a,

0x6ca6, 0x7c87, 0x4ce4, 0x5cc5, 0x2c22, 0x3c03, 0x0c60, 0x1c41,

0xedae, 0xfd8f, 0xcdec, 0xddcd, 0xad2a, 0xbd0b, 0x8d68, 0x9d49,

0x7e97, 0x6eb6, 0x5ed5, 0x4ef4, 0x3e13, 0x2e32, 0x1e51, 0x0e70,

0xff9f, 0xefbe, 0xdfdd, 0xcffc, 0xbf1b, 0xaf3a, 0x9f59, 0x8f78,

0x9188, 0x81a9, 0xb1ca, 0xa1eb, 0xd10c, 0xc12d, 0xf14e, 0xe16f,

0x1080, 0x00a1, 0x30c2, 0x20e3, 0x5004, 0x4025, 0x7046, 0x6067,

0x83b9, 0x9398, 0xa3fb, 0xb3da, 0xc33d, 0xd31c, 0xe37f, 0xf35e,

0x02b1, 0x1290, 0x22f3, 0x32d2, 0x4235, 0x5214, 0x6277, 0x7256,

0xb5ea, 0xa5cb, 0x95a8, 0x8589, 0xf56e, 0xe54f, 0xd52c, 0xc50d,

0x34e2, 0x24c3, 0x14a0, 0x0481, 0x7466, 0x6447, 0x5424, 0x4405,

0xa7db, 0xb7fa, 0x8799, 0x97b8, 0xe75f, 0xf77e, 0xc71d, 0xd73c,

0x26d3, 0x36f2, 0x0691, 0x16b0, 0x6657, 0x7676, 0x4615, 0x5634,

0xd94c, 0xc96d, 0xf90e, 0xe92f, 0x99c8, 0x89e9, 0xb98a, 0xa9ab,

0x5844, 0x4865, 0x7806, 0x6827, 0x18c0, 0x08e1, 0x3882, 0x28a3,

0xcb7d, 0xdb5c, 0xeb3f, 0xfb1e, 0x8bf9, 0x9bd8, 0xabbb, 0xbb9a,

0x4a75, 0x5a54, 0x6a37, 0x7a16, 0x0af1, 0x1ad0, 0x2ab3, 0x3a92,

0xfd2e, 0xed0f, 0xdd6c, 0xcd4d, 0xbdaa, 0xad8b, 0x9de8, 0x8dc9,

0x7c26, 0x6c07, 0x5c64, 0x4c45, 0x3ca2, 0x2c83, 0x1ce0, 0x0cc1,

0xef1f, 0xff3e, 0xcf5d, 0xdf7c, 0xaf9b, 0xbfba, 0x8fd9, 0x9ff8,

0x6e17, 0x7e36, 0x4e55, 0x5e74, 0x2e93, 0x3eb2, 0x0ed1, 0x1ef0

};

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* Function : INT16U SWCalcCRC ( INT8U \*, INT16U )

\* Description : Calculates the CCITT CRC for the generator polynomial:

\* x^16 + x^12 + x^5 + 1.

\* Arguments : INT8U \* buffer - buffer to calculate the crc

\* : INT16U bufferSize - lengh of the buffer

\* Returns : returns 16bit crc

\* Remarks :

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

INT16U SWCalcCRC ( INT8U \* buffer, INT16U bufferSize )

{

INT16U CRC;

INT8U C;

INT16U i;

CRC = 0xffff; //seed the CRC

for ( i = 0 ; i < bufferSize; i++ )

{

C = buffer[i];

CRC = (CRC << 8) ^ CCITT\_CRC16\_Coeff[((CRC >> 8) ^ C) & 0x00ff];

}

return CRC;

}

1. RFC1055: A NONSTANDARD FOR TRANSMISSION OF IP DATAGRAMS OVER SERIAL LINES: SLIP <https://tools.ietf.org/html/rfc1055> [↑](#footnote-ref-1)