CYGNSS Raw IF Data File Format

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# Introduction

This document contains a description of the format of raw IF (intermediate frequency) data files created by the CYGNSS Science Operations Center (SOC). These files are delivered to the science team for analysis.

# Overview

The SOC delivers two files for each raw IF data collection: one Raw IF Metadata file and one Raw IF Data file.

# Byte Ordering and Data Types

All multi-byte values are stored in big endian order. The DDMI uses the ANSI/IEEE 754 standard for binary floating-point arithmetic. The “FLOAT” floating point number is stored using four bytes (32 bits: 1 sign bit, 8 bit exponent and 23 bit fraction). The first byte consists of the sign bit followed by the 7 most significant bits of the biased exponent. The second byte contains the least significant bit of the biased exponent and the 7 most significant bits of the fraction. The remaining 2 bytes complete the fraction.

In the double precision format, “DOUBLE”, more bits are used in the mantissa (for increased precision) and the exponent (for increased range). The first byte contains the sign bit of the mantissa and 7 most significant bits of the biased exponent. The second byte holds the 4 least significant bits of the biased exponent followed by the 4 most significant bits of the fraction. The remaining 6 bytes hold the remaining bits of the fraction.

# Raw IF Metadata File Contents

The Raw IF Metadata file contains the ID of the spacecraft, a single Data Recorder Track 0 (DRT0) packet and one or more Pulse per Second (PPS) tables.

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| **Table 1 – Raw IF Metadata File Contents** | | |
| **Bytes** | **Description** | **Notes** |
| 0 | Spacecraft SCID from SwRI document 17790-ObsID, Observatory Unique Identifier Specification | 0xF7: CYGNSS 1  0xF9: CYGNSS 2  0x2B: CYGNSS 3  0x2C: CYGNSS 4  0x2F: CYGNSS 5  0x36: CYGNSS 6  0x37: CYGNSS 7  0x49: CYGNSS 8  0x00: end to end simulator  0x0E: engineering model  0x0D: default |
| 1-35 | DRT0 packet. See Table 2 below. |  |
| 36-83 | First PPS table. See Table 3 below. |  |
| 84-N | Additional PPS tables. See Table 3 below. |  |

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| **Table 2 – Data Recorder Track 0 (DRT0) Packet** | | |
| **Bytes** | **Description** | **Notes** |
| 0-3 | Packet Type ASCII “DRT0” | Four ASCII chars |
| 4-5 | GPS weeks at start | Weeks since Jan 6 1980, unsigned integer |
| 6-9 | GPS seconds at start | Second of week, unsigned integer |
| 10 | Data format – Using format identifier see Table 4 |  |
| 11-14 | Sample Rate | unsigned integer, Hz |
| 15 | Channel 0: Frontend selection, See Table 5 |  |
| 16-19 | Channel 0: LO Frequency | unsigned integer, Hz |
| 20 | Channel 1: Frontend selection, See Table 5 |  |
| 21-24 | Channel 1: Carrier Frequency | unsigned integer, Hz |
| 25 | Channel 2: Frontend selection, See Table 5 |  |
| 26-29 | Channel 2: LO Frequency | unsigned integer, Hz |
| 30 | Channel 3: Frontend selection, See Table 5 |  |
| 31-34 | Channel 3: LO Frequency | unsigned integer, Hz |

The PPS table provides the sample index of the data recorder latched on each measurement tick. Since the nominal measurement tick rate is 10Hz this packet contains 10 sample index values. The intention is that this information can be used when post-processing the raw data recorded from the receiver in order to align the post-processing calculations with the correct samples used by the receiver in the real time processing. This would allow comparison of post-processed data with the real-time navigation solution etc. Tick 0 is the PPS tick on which the measurements used for the DDMI’s navigation solution are latched.

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| **Table 3 – Pulse Per Second (PPS) Table** | | |
| **Bytes** | **Description** | **Notes** |
| 0-7 | GPS seconds of last PPS | GPS seconds of week, DOUBLE |
| 8-11 | Tick 0 Sample Index (PPS Tick) | Unsigned integer |
| 12-15 | Tick 1 Sample Index | “ |
| 16-19 | Tick 2 Sample Index | “ |
| 20-23 | Tick 3 Sample Index | “ |
| 24-27 | Tick 4 Sample Index | “ |
| 28-31 | Tick 5 Sample Index | “ |
| 32-35 | Tick 6 Sample Index | “ |
| 36-39 | Tick 7 Sample Index | “ |
| 40-43 | Tick 8 Sample Index | “ |
| 44-47 | Tick 9 Sample Index | “ |

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| **Table 4 – Data Format** | | | |
| **Value** | **Data Format** | **Description** | **ADC Precision** |
| 0 | Channel 1, I Only | Records data from source into data recorder channel 0, sampling I only | 2 bit (Sign-Mag) |
| 1 | Channels 1, 2 - I Only | Records data from source into data recorder channel 0 and 1, sampling I only | 2 bit (Sign-Mag) |
| 2 | Channels 1, 2, 3 - I Only | Records data from source into data recorder channel 0, 1 and 2, sampling I only | 2 bit (Sign-Mag) |
| 3 | Channels 1, 2, 3, 4 - I Only | Records data from source into all four data recorder channels, sampling I only | 2 bit (Sign-Mag) |
| 4 | Channel 1 - I and Q | Records data from source into data recorder channel 0, sampling I and Q | 2 bit (Sign-Mag) |

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| **Table 5 – Front End Selection** | |
| **Value** | **Description** |
| 1 | RF 1 - MAX2769 (zenith antenna) |
| 2 | RF 2 – MAX2769 (starboard antenna) |
| 3 | RF 3 – MAX2769 (port antenna) |
| 4 | RF 4 – MAX2769 (unimplemented) |

# Raw IF Data File Contents

Raw IF data files contain only binary raw IF data, no metadata. The source of the binary raw IF data is Byte 9 through Byte N of the File Transfer Packet Data (FD00) packets emitted by the DDMI. The complete contents of the FD00 packet is listed in Table 6 below.

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| **Table 6 – FD00 Packet** | | |
| **Bytes** | **Description** | **Notes** |
| 0 | SpW Target Logical Address | Unsigned integer |
| 1 | SpW Protocol ID | “ |
| 2-5 | Packet Type ASCII “FD00” | “ |
| 6-7 | Packet Length – Length of data excluding all header bytes | “ |
| 8 | Sequence Byte | “ |
| 9 | Data byte 0, binary raw IF data |  |
| 10 | Data byte 1 |  |
| 11 | Data byte 2 |  |
| … | … |  |
| N | Last data byte |  |

The raw IF file contains Bytes 9-N of multiple contiguous FD00 packets. The FD00 packets are expected to contain consecutive Sequence Byte numbers. If a missing FD00 packet is detected, 2048 zero bytes are inserted in the raw IF file in place of the missing data.

Note that the first packet FD00 packet in the stream carries a DRT0 header block (see Table 2) at the beginning of the data bytes. The rest of this first packet and all subsequent packets contain the binary raw IF sample data. See Appendix A for the format.

# Appendix A - Raw Data Formats

A number of data formats are used internally by the DDMI to allow for different numbers of collection channels. These are bit-packed for optimum storage size. The following tables specify the mapping of front-end samples to the raw data file.













