README: FDQ Data Files

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1 Introduction

The two data files FDQ_SDF and FDQ_ENG that were generated from the Firas Data Quality step in the FIRAS data pipeline were binary files that had a specific structure unique to the FIRAS experiment. The HDF5 format is a way to provide these data to the public without requiring them to write their own code to read the original data.

The main differences between these data and the original output of FDQ is (1) it is, as mentioned, in HDF5 format, (2) all the data are together in a single file instead of separate files being generated over time to minimize the size of each binary file, and (3) the floating point values in the original files were stored in a VAX floating point format, and these were converted to the current IEEE standard.

Each file contains multiple groups of data. In the sections, I will go over each group and try to describe each separate value in the group.

In addition to the names, I will list their size. I will list "i" or "u" for integer or unsigned integer and "f" for float. The number after it specifies the size in bytes of the number. "i2" is a 2 byte signed integer. The number in "[]" means that it is an array of the specified size.

The original data also had an ADT data type which was just an array of 2 4 byte integers as the computer may not have had the ability to use 8 byte integers. We just now store the data as an 8 byte integer.

At the end of each section, there is usually a "spare" entry. These were added in case more information needed to be stored in each section later on. If something needed to be added, it could be taken from the spare bytes and every other data value would still be located at the same position in the binary data as strict offsets were probably used to find certain data values.

2 Engineering Data: FDQ_ENG

2.1 CT_HEAD

Entries in CT_HEAD

- GMT - String (14 chars) - GMT of start collect

- TIME - i8 - Binary time. Number of 100ns intervals since 1858-11-17.
- SPACE_TIME - i1[6] - Spacecraft time
- MJR_FRM_NO - i4 - Major frame number
- ORBIT - i4 - Orbit number
- HSKP1_TLM_FMT - i1 - Telemetry format for major frame 1
- HSKP2_TLM_FMT - i1 - Telemetry format for major frame 2
- INGEST_SPARES - i1[18] - extra bytes in case more data needed to be added
- DATASET_ID - i2 - CT dataset id
- INSTR_SPARES - i1[6] - extra bytes in case more data needed to be added

2.2 EN_HEAD

Entries in EN_HEAD

- LIMITS - String (23 chars) - Limits file name
- CONVERT - String (23 chars) - Conversion file name
- A_SPARE - i4 - Unknown
- KEY_ID - i2 - Type of engineering data: 0 = non-statistics, 1 = average, 2 = sigma, 3 = minimum, 4 = maximum
- NUMBER_OF_RECORDS - i4 - Number of engineering records used in forming statistics
- ENGHEAD_SPARES - i1[8] - extra bytes in case more data needed to be added
- SCI_TIME - SCI_TIME_DT[4] - binary time for each channels IFG
- FIRST_ENG_TIME - i8 - Time tag of first engineering record used in forming engineering trends
- LAST_ENG_TIME - i8 - Time tag of last engineering record used in forming engineering trends
- DQ_SUMMARY_FLAG - i1[4] - Data quality summary flags for the four FIRAS channels
- IFG_NO - i4[4] - IFG number within segment
- ATT_SUMMARY_FLAG - i1[4] - Attitude data quality summary flags for the four FIRAS channels
- ENGHEAD_SPARES2 - i1[34] - extra bytes in case more data needed to be added

2.2.1 SCI_TIME_DT

Entries in SCI_TIME_DT. This is the custom sci time datatype. Has a single entry that contains an ADT.

BIN_TIME - i8 - time for the specific channel

2.3 EN_STAT

Entries for EN_STAT

- STAT_WORD_1 - u2 - UNKNOWN
- INT_REF_TEMP_A - u2 - Internal reference source side A status
- REF_HRN_TEMP_A - u2 - Reference horn side A status
- STAT_WORD_4 - u2
- STAT_WORD_5 - u2
- SKY_HRN_TEMP_A - u2 - Sky horn side A status
- EXT_CAL_TEMP_A - u2 - External calibrator side A status
- STAT_WORD_8 - u2
- STAT_WORD_9 - u2
- INT_REF_TEMP_B - u2 - Internal reference source side B status
- REF_HRN_TEMP_B - u2 - Reference horn side B status
- STAT_WORD_12 - u2
- STAT_WORD_13 - u2
- SKY_HRN_TEMP_B - u2 - Sky horn side B status
- EXT_CAL_TEMP_B - u2 - External calibrator side B status
- STAT_WORD_16 - u2
- GRT_ADDR - i1[2] - Dwell address A, B
- MICRO_STAT_BUS - i1[4] - Micro status bus readout
- BOL_CMD_BIAS - i1[4] - commanded bolometer bias.
- DWELL_STAT - i1[2] - Dwell status A, B
- LVDT_STAT - i1[2] - LVDT status A, B
- HOT_SPOT_CMD - i1[2] - Commanded hot spot value for A, B side

- ENGSTAT_SPARES - i1[10] - Spares
- POWER_A_STATUS - i1[2] - Status for power to FIRAS A
- POWER_B_STATUS - i1[2] - Status for power to FIRAS B
- ENGSTAT_SPARES2 - i1[6] - Spares

In addition, there is GROUP1, size u2[16] and GROUP2, size u2[14], which was setup to access multiple variables simultaneously that might/could not be replicated in the HDF5 data.

2.4 EN_ANALOG

Entries in EN_ANALOG. Everything here is GRTs.

- A_LO_XCAL_TIP - float - A-side Low current thermometer on the tip of the external calibrator
- A_LO_SKYHORN - float - A-side low current thermometer on the skyhorn
- A_LO_REFHORN - float - A-side low current thermometer on the reference horn
- A_LO_ICAL - float - A-side low current thermometer on the internal calibrator
- A_LO_DIHEDRAL - float - A-side low current thermometer on the dihedral
- A_LO_BOL_ASSEM - float[4] - A-side low current thermometer on the bolometer assembly
- A_LO_MIRROR - float - A-side low current thermometer on the mirror assembly
- A_LO_CAL_RESISTORS - float[4] - A-side low current thermometer on the cal resistors
- A_LO_XCAL_CONE - float - A-side low current thermometer on the cone of the external calibrator
- A_LO_COLLIMATOR - float - A-side low current thermometer on the collimator
- A_HI_XCAL_TIP - float - A-side high current thermometer on the tip of the external calibrator
- A_HI_SKYHORN - float - A-side high current thermometer on the skyhorn
- A_HI_REFHORN - float - A-side high current thermometer on the reference horn

- A_HI_ICAL - float - A-side high current thermometer on the internal calibrator
- A_Hi_DIHEDRAL - float - A-side high current thermometer on the dihedral
- A_Hi_BOL_ASSEM - float[4] - A-side high current thermometer on the bolometer assembly
- A_HI_MIRROR - float - A-side high current thermometer on the mirror assembly
- A_HI_CAL_RESISTORS - float[4] - A-side high current thermometer on the cal resistors
- A_HI_XCAL_CONE - float - A-side high current thermometer on the cone of the external calibrator
- A_HI_COLLIMATOR - float - A-side high current thermometer on the collimator
- B_LO_XCAL_TIP - float - B-side Low current thermometer on the tip of the external calibrator
- B_LO_SKYHORN - float - B-side low current thermometer on the skyhorn
- B_LO_REFHORN - float - B-side low current thermometer on the reference horn
- B_LO_ICAL - float - B-side low current thermometer on the internal calibrator
- B_LO_DIHEDRAL - float - B-side low current thermometer on the dihedral
- B_LO_BOL_ASSEM - float[4] - B-side low current thermometer on the bolometer assembly
- B_LO_MIRROR - float - B-side low current thermometer on the mirror assembly
- B_LO_CAL_RESISTORS - float[4] - B-side low current thermometer on the cal resistors
- B_LO_XCAL_CONE - float - B-side low current thermometer on the cone of the external calibrator
- B_LO_COLLIMATOR - float - B-side low current thermometer on the collimator
- B_HI_XCAL_TIP - float - B-side high current thermometer on the tip of the external calibrator

- B_HI_SKYHORN - float - B-side high current thermometer on the skyhorn
- B_HI_REFHORN - float - B-side high current thermometer on the reference horn
- B_HI_ICAL - float - B-side high current thermometer on the internal calibrator
- B_Hi_DIHEDRAL - float - B-side high current thermometer on the dihedral
- B_Hi_BOL_ASSEM - float[4] - B-side high current thermometer on the bolometer assembly
- B_HI_MIRROR - float - B-side high current thermometer on the mirror assmbly
- B_HI_CAL_RESISTORS - float[4] - B-side high current thermometer on the cal resistors
- B_HI_XCAL_CONE - float - B-side high current thermometer on the cone of the external calibrator
- B_HI_COLLIMATOR - float - B-side high current thermometer on the collimator
- TEMP_CTL - float[8] - temperature controllers
- IPDU_TEMP - float[2] - IPDU temps A, B
- CNA_TEMP - float[4] - Channel temps
- DBX_TEMP - float[2] - Drivebox temps
- STAT_MON_TEMP - float[2] - Status monitor temps
- PAMP_CHAN - float - Channel preamp
- PAMP_OP - float - Optical preamp
- HOT_SPOT - float[2] - Hot spot heater A, B
- MTM_CAL_MTR - float[2] - MTM/Cal motos
- MTM_POS - float[2] - MTM position
- BOL_VOLT - float[4] - Bolometer voltages
- IPDU_VOLT - float[20] - IPDU voltages
- IPDU_AMP - float[12] - IPDU currents

In the original code, there were multiple ways to access the fields. You could access each variable separately through the names. Or you could access all the temperature data through GRT which would be a length 64 float array. You could also access each A/B-high/lo GRT separately through length 16 float arrays. All the data after the A/B thermometers could be accessed in a single length 62 float array.

2.5 EN_XCAL

Entries in EN_XCAL

- POS - i2[2] - XCAL position - 0 = error, 1 = in sky horn, 2 = stowed (out of sky horn), 3 = transit (between in and out)
- XCAL_SPARES - i1[50] - Spares

2.6 CHAN

Entries in CHAN

- UP_SCI_MODE - i1 - uP science mode.
- FAKEIT - i1 - whether fakeit data
- UP_ADDS_PER_GROUP - i1 - number of samples averaged onboard before being sent to the ground
- UP_SWPS_PER_IFG - i1 - number of sweeps per interferogram
- XMIT_MTM_SPEED - i1 - MTM speed at transmit (fast or slow)
- XMIT_MTM_LEN - i1 - MTM length at transmit (short or long)
- SCI_GAIN - i2 - scientific gain
- DITHER - i1 - dither bit
- SETUP_SPARES - i1[15] - Spare bytes

2.7 EN_TEMPDIFF

Entries in EN_TEMPDIFF. Stores temperature differences between the bracketing housekeeping major frames from which this engineering record was derived. These values are used for consistency checking in the FIRAS pipeline software FES4_APP_H.TXT to eliminate data whose housekeeping values vary too much between major frames

- XCAL - i2 - external calibrator temperature diff
- ICAL - i2 - internal calibrator temperature diff

- SKYHORN - i2 - skyhorn temperature diff
- REFHORN - i2 - refhorn temperature diff
- DIHEDRAL - i2 - dihedral temperature diff
- COLLIMATOR_MIRROR - i2 - collimator and mirror temperature diff
- BOL_ASSEM - i2[4] - bolometer assembly temeprature diff

2.8 EN_TAIL

Entries in EN_TAIL

- ENGTAIL_SPARES - i1[8] - spares
- HSKP_FLAG - i1 - housekeeping flag: 0 = housekeeping present, 1 = no housekeeping data for time of engineering record
- LMAC_ANALOG_TEMP - f4 - LMAC temperature for analog converter. Spacecraft sides 1 and 2. Read FIRAS side A only.
- LMAC_DIGITAL_TEMP - f4 - LMAC temperature for digital converter. Spacecraft sides 1 and 2. Read FIRAS side A only.
- TLM_QUAL_MAJ_FRM - i1[2] - Overall telemetry quality for MJF
- ENG_SPARES - i1[9] - spares

3 Science Data: FDQ_SDF

3.1 CT_HEAD

See same entry in previous section.

3.2 SCI_HEAD

Entries in SCI_HEAD. Science data channel header written by FIRAS stripper and FIRAS preprocessor

- CHAN_ID - i2 - channel ID
- GAIN - i2 - gain
- MTM_SPEED - i2 - mtm speed (fast or slow)
- MTM_LENGTH - i2 - mtm length (long or short)
- DATA_QUAL - i1[60] - data quality flags
- DATA_READY - i2[8] - data ready flags

- SC_HEAD0 - i2 - data block synchronization
- SC_HEAD1A - i1 - block type (sci mode)
- SC_HEAD1B - i1 - block ID
- SC_HEAD2 - i2 - SW version number
- SC_HEAD3 - i2 - Status bits
- SC_HEAD4 - i2 - Transmit time LSW
- SC_HEAD5 - i2 - Transmit time MSW
- SC_HEAD6 - i2 - Data check
- SC_HEAD7 - i2 - No a/d samples for collect cycle
- SC_HEAD8 - i2 - points process for collect cycle
- SC_HEAD9 - i2 - adds per group (1, 2, 3, 8, or 12)
- SC_HEAD10 - i2 - data points per mirror sweep
- SC_HEAD11 - i2 - number of mirror sweeps
- SC_HEAD12 - i2 - LSW frame counter
- SC_HEAD13 - i2 - MSW frame counter
- SC_HEAD14 - i2 - Deglitcher threshold factor
- SC_HEAD15 - i2 - Noise level
- SC_HEAD16 - i2 - S/L counter constants
- SC_HEAD17 - i2 - Deglitcher seed sample
- SC_HEAD18 - i2 - command counter
- SC_HEAD19 - i2 - program checksum
- SC_HEAD20 - i2 - saturated sample count
- SC_HEAD21 - i2 - glitch total
- SC_HEAD22 - i2 - deglitcher overflow address
- SC_HEAD23 - i2 - Division of IFG performed (FCI RMS files only)
- SC_HEAD24 - i2 - FCI raw science intermediate dump data type
- SC_HEAD25 - String (2 chars) - HI/LO channel indicator

3.3 IFG_DATA

Entries in IFG_DATA. Raw science data

- IFG - i2[512] - Interferogram in counts
- GLTCH - u2[32] - on board glitch map

3.4 DQ_DATA

Entries in DQ_DATA. Fields written by data qualify

- FAKE - i2 - fakeit pulse status
- XCAL_POS - i2 - position of xcal 0
- IREF_TEMP - f4 - internal reference source temperature. No longer being calculated by FDQ
- ENG_TIME - i8 - time of associate engineering record
- ENG_REC - i4 - engineering record number
- DATA_QUALITY - i1[110] - data quality flags
- IFG_NO - i4 - interferogram number within segment
- DQ_SPARES - i1[24] - spares

3.5 COLLECT_TIME

Entries in COLLECT_TIME

- MIDPOINT_TIME - i8 - midpoint of collect time for science IFG
- BADTIME_FLAG - i1 - flag for invalid computed midpoint of collect time
- FPP_SPARE - i1 - spare

3.6 ATTITUDE

Entries in ATTITUDE. These recorded pointing information. All quantities are in Epoch 2000.0 coordinates

- PIXEL_NO - i4 - FIRAS pixel number, high resolution (res=6)
- EQUATORIAL - f4[3] - FIRAS pointing in celestial equatorial coordinates
- RA - i2 - Right ascension of FIRAS pointing. Units in 10^{-4} radians. Runs from $-\pi$ to π

- DEC - i2 - Declination of FIRAS pointing. Units in 10^{-4} radians. Runs from $-\pi/2$ to $\pi/2$
- TERR_PIXEL_NO - i4 - Terrestrial coordinates based pixel number, high resolution (res=6)
- TERR_LATITUDE - i2 - Terrestrial latitude of COBE. Units in 10^{-4} radians. Runs from $-\pi/2$ to $\pi/2$
- TERR_LONGITUDE - i2 - Terrestrial longitude of COBE. Units in 10^{-4} radians. Runs from $-\pi$ to π
- EARTH_LIMB - i2 - Angle of earth limb from FIRAS skyhorn line-of-sight. Units in 10^{-4} radians. Runs from 0 to π
- EARTH_LIMB_AZIMUTH - i2 - Azimuth angle of Earth limb about FIRAS LOS in SC frame. Units in 10^{-4} radians. Runs from $-\pi$ to π
- SUN_ANGLE - i2 - Angle of sun in FIRAS skyhorn LOS. Units in 10^{-4} radians. Runs from 0 to π
- MOON_ANGLE - i2 - Angle of moon in FIRAS skyhorn LOS (phi). Units in 10^{-4} radians. Runs from 0 to π
- MOON_AZ_ANGLE - i2 - Azimuth angle of moon about FIRAS LOS in SC frame (theta). Units in 10^{-4} radians. Runs from $-\pi$ to π
- MOON_PHASE - i2 - Phase of moon. Units in 10^{-4} radians. Runs from $-\pi$ to π
- SUN_MOON_DIST - f4 - the sun/moon distance. Units in km.
- COBE_MOON_DIST - f4 - the COBE/moon distance. Units in km.
- ALTITUDE - i2 - COBE altitude. Units in 0.1km.
- PROJECTED_BARYCENTRIC_VELOCITY - i2 - Solar system barycentric velocity of COBE projected along LOS. Units in 0.01km/s
- MCILWAIN_L_PARAM - i2 - McIlwain L parameter. Units in Earth radii.
- GALACTIC_LONGITUDE - i2 - Galactic longitude. Units in 10^{-4} radians. Runs from $-\pi$ to π
- GALACTIC_LATITUDE - i2 - Galactic latitude. Units in 10^{-4} radians. Runs from $-\pi/2$ to $\pi/2$
- ECLIPTIC_LONGITUDE - i2 - Ecliptic longitude. Units in 10^{-4} radians. Runs from $-\pi$ to π
- ECLIPTIC_LATITUDE - i2 - Ecliptic latitude. Units in 10^{-4} radians. Runs from $-\pi/2$ to $\pi/2$

- ORBITAL_PHASE - i2 - Geocentric angle from the orbital ascending node to COBE position. Units in 10^{-4} radians. Runs from $-\pi$ to π
- PROJECTED_GEOCENTRIC_VELOCITY - i2 - Geocentric velocity of COBE projected along LOS. Units = m/s
- SCAN_ANGLE - i2 - Azimuth angle, about the sun direction, of FIRAS LOS, positive in the ascending sense from the ecliptic. Units in 10^{-4} radians. Runs from $-\pi$ to π
- SC_ROTATION_ANGLE - i2 - Spacecraft rotation angle. Units in 10^{-4} radians. Runs from $-\pi$ to π
- SOLUTION - i1 - Source of attitude solution: 0 = None, 1 = Simulated, 2 = Predicted, 3 = Coarse, 4 = Fine without DIRBE, 5 = Fine with DIRBE, 6 = Definitive
- PIXEL_DEFINITION - i1 - Type of pixelization: 'q' = Standard quad-cube, 'O' = orbit average, 'S' = scan angle, 'E' = geocentric quad-cube
- SKYMAP_INDEX - i2 - Information supporting pixel definitiion: 'q' = standard quad-cube skymap index, 'O' = orbit origin (units = 0.1d), 'S' = scan angle (units = 0.1d), 'E' = skymap index
- EXC_GALACTIC_LAT - i2 - Exclude data with $\pm$ of galactic latitude. Units in 10^{-4} radians. Runs from 0 to $\pi/2$
- TERR_RAD_BYTE - i1 - Terrestial radiation region location flag. Information only. Region determined from mission planning files. Byte 0 = OK, Byte 1 = North Van Allen Belt, Byte 2 = South Van Allen Belt, Byte 3 = South Atlantic Anomaly. Independent of attitude quality flags
- OUTSIDE_GALAXY_CUT - i1 - Flag indicating whether FDS destriper included this record in its stripe. Calculation based on whether its pixel center is outside the galactic latitude cut in the FDS driver. The flag is set by FAD. 0 = Not Set Yet (pre-FAD data), 1 = record included (outside ¿ galactic cut), 2 = record excluded (within ¡= galactic cut)
- ATT_SPARES - i1[2] - extra bytes in case extra data was needed