Robert C. Byrd Green Bank Telescope
NRAO Green Bank

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Caltech Continuum Backend FITS Specification

HTML version Available[1]

Contents

Abstract

This document describes the format and contents of the GBT Caltech Continuum Backend FITS files.

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[1]http://www.gb.nrao.edu/GBT/MC/doc/dataproc/gbtCCBFits/gbtCCBFits/gbtCCBFits.html

1 Overview

The Caltech Continuum Backend (CCB) YGOR manager produces a single data file in FITS format per YGOR scan, as is the current practice for backends at the GBT. This FITS file complies with standards and practices laid out in GBT/SPN/004 "Device and Log FITS Files for the GBT", with additions and modifications dictated by the CCB itself.

The CCB FITS file comprises:

- A primary header data unit (PHDU) with no data (NDIM=0 or NAXIS1=0). The PHDU contains general information about the observation such as scan number, scan type, date, and time. It also contains keywords whose values describe the configuration of the backend.

- A binary table extension (the PORT table) describing the inputs to the backend.

- A binary table extension (the CCBSTATE table) describing the beamswitched phases of data found in the data table (see below). The CCBState table is a modified form of standard GBT State tables.

- A binary table extension called the Data table with integration data, consistent with current GBT practice and intent.

All of these tables are standard to GBT FITS files described in SPN/004, or variations upon them.

2 Primary Header

The primary header contains all required GBT FITS keywords, for example:

```
SIMPLE  =                     T / file does conform to FITS standard
BITPIX  =                     8 / number of bits per data pixel
NAXIS   =                     0 / number of data axes
EXTEND  =                     T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A\&A...376..359H
ORIGIN  = 'NRAO Green Bank'    /
INSTRUME= 'CCB'                 / device or program of origin
GBTMCVER= '4.6     '           / telescope control software release
FITSVER = '1.2     '           / FITS definition version for this device
DATEBLD = 'Mon Sep 20 20:58:25 UTC 2004' / time program was linked
SIMULATE=                     0 / Is the instrument in simulate mode?
DATE-OBS= '2004-10-09T07:50:01' / Manager parameter startTime
TIMESYS = 'UTC     '           / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT'           / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT  = '2230+114'           / Manager parameter source
PROJID  = 'AGBT04C_018_04'     / Manager parameter projectId
OBSID   = 'lineFSW '           / Manager parameter scanId
SCAN    =                   305 / Manager parameter scanNumber
END
```

In addition to the above standard keyword/value pairs, the following intrument-specific keyword/value pairs are recorded:

Keyword	Values	Related CCB Library Call	Units
ACTPSW	A,B,Both,None	ccb_set_phase_switch_cnf.active_switches	
	NOTES: Designate active phase switches		
INPSWSTA	0,1	".closed_switches	
	NOTES:Important if one switch is held constant so you know what it was		
INPSWSTB	0,1	".closed_switches	
	NOTES:Important if one switch is held constant so you know what it was		
SMPPERST	integer	".samp_per_state	100 ns
	NOTES: number of ADC samples per phase switch state		
CALCYCLN	integer	ccb_set_cal_diode_cnf.ncal	
	NOTES: number of integrations in the calibration cycle		
CALOFFIG	integer	".diode_times	
	NOTES:duration of the cal off step, integrations		
LCALONIG	integer	".diode_times	
	NOTES:duration of the left cal on step, integrations		
BCALONIG	integer	".diode_times	
	NOTES:duration of the both cal on step, integrations		
RCALONIG	integer	".diode_times	
	NOTES:duration of the right cal on step, integrations		
INTGPD	integer	ccb_set_timing_cnf.integ_period	
	NOTES: number of phase switch cycles which go into one integration		
PSWDT	integer	ccb_set_timing_cnf.phase_switch_dt	100 ns
	NOTES:phase switch transition blanking interval		
CRISEDT	integer	".diode_rise_dt	100 ns
	NOTES:Cal diode settling time after being switched on (determines # blanked integs)		
CFALLDT	integer	".diode_fall_dt	100 ns
	NOTES:Cal diode settling time after being switched off determines # blanked integs)		
RNDTRPDT	integer	".roundtrip_dt	100 ns
	NOTES:Internal hardware round trip delay		
HOLDOFF	integer	".holdoff_dt	100 ns
	NOTES:minimum interval between hardware interrupts		
INTEGRAT	integer	ccb_integration_time()	100 ns
	NOTES: integration time per phase after blanking		
FAKESMP	logical		
	NOTES: T indicates that data were generated from the CCB's fixed pseudorandom sequence.		

3   PORT Table

A standard (SPN/004) PORT binary table extension is recorded in order to allow the CCB inputs to be cross-indexed with the physical descriptions provided in the IF manager IF table. There are two columns: BANK (a character), and PORT (a non-zero integer). A given value of PORT uniquely identifies a physical input to the CCB, and may be used to index physical descriptions (frequency, feed, polarization ,etc) in the IF manager IF table. It also uniquely defines a row in the PORT table. The BANK column is retained for compliance with the GBT FITS standard and are set to a fiducial value of 'A'.

Additionally there is a SLAVE column indicating which daughter card a given input port is associated with. Data are unsigned 8-bit integers with valid values 0,1,2,3.

The order of the rows of the PORT table correspond to the ordering of PORT columns in the DATA table. The number of rows NPORTS of the PORT table is equal to the number of ports input ports selected as active in the manager for the given scan.

4   CCBSTATE Table

A binary table extension called CCBSTATE records the physical definitions of the phases of the data. There are a number of rows equal to the number of phases NPHASES returned for each CCB input port for each integration.

Columns PHIA and PHIB records the values of the phase switches A & B at each phase state. Valid values are 0 or 1. Data type of each entry in the column is an unsigned byte.

The ordering of rows in the CCBSTATE table corresponds to ordering of the phase columns in the DATA table. The number of rows in the CCBSTATE table is equal to the number of phases in the phase switch cycle (which is in turn equal to 2 to the power of the number of active phase switches– hence 1,2, or 4). The number of phases in the phase switch cycle is referred to as NPHASES elsewhere in this docuemt.

Comments

- NPHASES is equal to $2^{NACTPSW}$ where NACTPSW is the number of active phase switches. Since NACTPSW has valid values of 0, 1, and 2, NPHASES can be 1, 2, or 4.

- This table is analagous to GBT Backends' STATE tables but differs due to the different implementations of CALs (individual integrations are Cal On or Cal off, rather than having sub-integrations or "phases" be Cal On or Cal Off as for other GBT backends) and SIGREF (next bullet point) for this backend.

- The REF state corresponds to "PHIA XOR PHIB". A SIG state is "NOT(PHIA XOR PHIB)". With two phase switches active there will be two physically distinct rows of the CCBSTATE table that correspond to SIG and two that correspond to REF.

5   DATA Table

The DATA binary table extension contains raw accumulated total power integrations for each phase of each CCB input port that was used for a given scan.

The first (DMJD) column of the data array contains the MJD of the integration start.

The DATA column is a multidimensional column with dimensions (NPORTS,NPHASES). Each datum is recorded as a 32 bit two's complement integer; subsequent transformation to unsigned values is facilitated by recording a TZERO keyword with a value of 2^{31}. The order of the PORT and PHASE sub-columns should correspond to the order of the rows in the PORT and CCBSTATE tables respectively. The number of phases NPHASES is determined by the number of active switches and is 1, 2, or 4. The number of ports NPORTS is equal to the number of ports selected in the manager as active for the given scan.

A second multi-dimensional OVRFLOW column, of the same dimensions as the DATA column, comprises LOG-ICAL data with "T" indicating integrations that overflowed and "F" indicating integrations that did not. The value at subcolumn M row N in the OVRFLOW column denotes the overflow status of the integration datum at subcolumn M row N of the DATA column.

One multi-dimensional LOGICAL column contains the four SLAVEOK flags. Two LOGICAL columns contain CAL A and CAL B ON flags indicating whether, for a given integration, a given call was on or not; the "integration usable" flag is a separate SHORT-INT column, indicating whether each integration is usable based on the cal diode rise and fall time flags applied by the CCB.

Comments

- Integration data are returned by the CCB as unsigned 32 bit integers. Conversion from signed 32 bit two's complements values, to unsigned 32 bit values, may require use of double precision on the data processing end.

- The "integration usable columns" is short int not logical in order to more closely line up the columns with machine byte boundaries, for better performance.

- The SLAVEOK flags can be associated with individual columns of data (ie input ports) using the information in the SLAVE column of the PORT table.

- The cabling-dependent mapping of the CCB's "Cal A" and "Cal B" to a physical Cal diode (nominally Left and Right, or perhaps, tags in the calibration FITS file database) is presently unspecified.

A   Appendix: Example FITS Table Headers

A.1   PHDU

```
SIMPLE  =                     T / file does conform to FITS standard
BITPIX  =                     8 / number of bits per data pixel
NAXIS   =                     0 / number of data axes
EXTEND  =                     T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
ORIGIN  = 'NRAO Green Bank'    /
INSTRUME= 'CCB     '           / device or program of origin
GBTMCVER= 'integration'        / telescope control software release
FITSVER = '2.0     '           / FITS definition version for this device
DATEBLD = '2005-06-13T18:26:23' / time program was linked
SIMULATE=                     0 / Is the instrument in simulate mode?
DATE-OBS= '2005-06-23T20:27:12' / Manager parameter startTime
TIMESYS = 'UTC     '           / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT_SIMULATOR' / Simulation of the Robert C. Byrd 100m
OBJECT  = 'ou812   '           / Manager parameter source
PROJID  = 'TCCB    '           / Manager parameter projectId
OBSID   = 'blah    '           / Manager parameter scanId
SCAN    =                     1 / Manager parameter scanNumber
ACTPSW  = 'Both    '           / active phase switches
INPSWSTA=                     T / closed phase switch A
INPSWSTB=                     T / closed phase switch B
ADCSAMPT=               1.0E-07 / ADC sample time in seconds
SMPPERST=                   250 / number of 100 ns samples per switch state
CALCYCLN=                    10 / number of integrations per calibration cycle
CALOFFIG=                     8 / number of integrations per cals off phase
LCALONIG=                     2 / number of integrations per left cal on phase
RCALONIG=                     0 / number of integrations per right cal on phase
BCALONIG=                     0 / number of integrations per both cals on phase
INTGPD  =                   500 / number of switch cycles per integration
PSWDT   =                     1 / number of blanked samples after switch change
CRISEDT =                     1 / number of blanked samples after calibration on
CFALLDT =                     1 / number of blanked samples after calibration off
RNDTRPDT=                     5 / number of 100 ns samples per propagation delay
HOLDOFF =                     7 / minimum number of samples between interrupts
INTEGRAT= 2.490000000000000E-05 / integration time per integ. per phase bin (s)
FAKESMP =                     0 / flags generation of fake pseudo-random samples
COMMENT A phase-switch bin represents one switch setting for an integration
END
```

A.2 PORT Table

```
SIMPLE  =                      T / file does conform to FITS standard
BITPIX  =                      8 / number of bits per data pixel
NAXIS   =                      0 / number of data axes
EXTEND  =                      T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
ORIGIN  = 'NRAO Green Bank'    /
INSTRUME= 'CCB     '             / device or program of origin
GBTMCVER= 'integration'          / telescope control software release
FITSVER = '2.0     '             / FITS definition version for this device
DATEBLD = '2005-06-13T18:26:23' / time program was linked
SIMULATE=                      0 / Is the instrument in simulate mode?
DATE-OBS= '2005-06-23T20:27:12' / Manager parameter startTime
TIMESYS = 'UTC     '             / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT_SIMULATOR' / Simulation of the Robert C. Byrd 100m
OBJECT  = 'ou812   '             / Manager parameter source
PROJID  = 'TCCB    '             / Manager parameter projectId
OBSID   = 'blah    '             / Manager parameter scanId
SCAN    =                      1 / Manager parameter scanNumber
ACTPSW  = 'Both    '             / active phase switches
INPSWSTA=                      T / closed phase switch A
INPSWSTB=                      T / closed phase switch B
ADCSAMPT=                1.0E-07 / ADC sample time in seconds
SMPPERST=                    250 / number of 100 ns samples per switch state
CALCYCLN=                     10 / number of integrations per calibration cycle
CALOFFIG=                      8 / number of integrations per cals off phase
LCALONIG=                      2 / number of integrations per left cal on phase
RCALONIG=                      0 / number of integrations per right cal on phase
BCALONIG=                      0 / number of integrations per both cals on phase
INTGPD  =                    500 / number of switch cycles per integration
PSWDT   =                      1 / number of blanked samples after switch change
CRISEDT =                      1 / number of blanked samples after calibration on
CFALLDT =                      1 / number of blanked samples after calibration off
RNDTRPDT=                      5 / number of 100 ns samples per propagation delay
HOLDOFF =                      7 / minimum number of samples between interrupts
INTEGRAT= 2.490000000000000E-05 / integration time per integ. per phase bin (s)
FAKESMP =                      0 / flags generation of fake pseudo-random samples
COMMENT A phase-switch bin represents one switch setting for an integration
END
```

A.3   CCBSTATE Table

```
XTENSION= 'BINTABLE'            / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                    8 / width of table in bytes
NAXIS2  =                    4 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'PHIA    '            / label for field   1
TFORM1  = '1J      '            / data format of field: 4-byte INTEGER
TUNIT1  = 'state   '            / physical unit of field
TTYPE2  = 'PHIB    '            / label for field   2
TFORM2  = '1J      '            / data format of field: 4-byte INTEGER
TUNIT2  = 'state   '            / physical unit of field
EXTNAME = 'CCBSTATE'            / name of this binary table extension
NPHASES =                    4 / number of phases per phase switching cycle
END
```

A.4   DATA Table

```
XTENSION= 'BINTABLE'            / binary table extension
BITPIX  =               8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   96 / width of table in bytes
NAXIS2  =                  200 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    7 / number of fields in each row
TTYPE1  = 'DMJD    '            / label for field   1
TFORM1  = '1D      '            / data format of field: 8-byte DOUBLE
TUNIT1  = 'd       ' / physical unit of field
TTYPE2  = 'SLAVEOK '            / label for field   2
TFORM2  = '4L  '            / data format of field: 1-byte LOGICAL
TUNIT2  = 'bool    '            / physical unit of field
TTYPE3  = 'USABLE  '            / label for field   3
TFORM3  = 'I       '            / data format of field: 2-byte INTEGER
TUNIT3  = 'status  '            / physical unit of field
TTYPE4  = 'CALA    '            / label for field   4
TFORM4  = 'L       '            / data format of field: 1-byte LOGICAL
TUNIT4  = 'state   '            / physical unit of field
TTYPE5  = 'CALB    '            / label for field   5
TFORM5  = 'L       '            / data format of field: 1-byte LOGICAL
TUNIT5  = 'state   '            / physical unit of field
TTYPE6  = 'OVRFLOW'            / label for field   6
TFORM6  = '16L     '            / data format of field: 1-byte LOGICAL
TUNIT6  = 'bool    '            / physical unit of field
TTYPE7  = 'DATA    '            / label for field   7
TFORM7  = '16J     '            / data format of field: 4-byte INTEGER
TZERO7  =           2147483648 / offset for unsigned integers
TSCAL7  =                    1 / data are not scaled
TUNIT7  = 'ulong   '            / physical unitof field
```

```
EXTNAME = 'DATA    '               / name of this binary table extension
TDIM6   = '(4,4)   '               / size of the multidimensional array
TDESC6  = 'PORT,CCBSTATE'          / definition of axes
TDIM7   = '(4,4)   '               / size of the multidimensional array
TDESC7  = 'PORT,CCBSTATE'          / definition of axes
END
```