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RPW Instrument -Time Domain Sampler (TDS)

RPW/TDS CALBA software requirements specification

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Issue	Rev.	Date	Authors	Modifications
1	0	20/12/2017	J. Soucek, D. Pisa	Initial version. Applies to CALBA version 0.8

Acronym List

Acronym	Definition	Acronym	Definition
ADC	Analogue-to-Digital Converter	SEU	Single Event Upset
AIT	Assembly Integration and Test	SFP	Single Point Failure
AIV	Assembly Integration and Validation	SGSE	Software Ground Support Equipment
DAC	Digital-to-Analogue Converter	SpW	SpaceWire
DPU	Data Processing Unit	STM	Structural Thermal Model
EEE	Electronic Electrical Electromechanical	S/W	Software
EGSE	Electric Ground Support Equipment	TBC	To Be Confirmed
EID-A	Experiment Interface Document part A	TBD	To Be Defined
EID-B	Experiment Interface Document part B	TBW	To Be Written
EM	Engineering Model	TC	TeleCommand
EMC	ElectroMagnetic Compatibility	TCS	Thermal Control System
DMAF	Direct Memory Accessing Filter component	TDS	Time Domain Sampler
FM	Flight Model	TDS SW	TDS Software (flight software)
CDF	Common Data Format	TID	Total Ionizing Dose
HF	High Frequency	TM	TeleMetry
HK	Housekeeping	TNR-HFR	Thermal Noise /High Frequency Receiver
HW	Hardware	TRR	Test Readiness Review
I/F	Interface	Ksps	Kilo-samples per seconds
LF	Low Frequency	SPS	Samples per second
LFR	Low Frequency Receiver	FFT	Fast Fourier transform
LVPS	Low-Voltages Power Supply	UTP	Unit Test Plan
MEB	Main Electronics Box	ITP	Integration Test Plan
MOS	Margin Of Security	RSWF	Regular Snapshot Waveform (TDS product)
N/A	Not Applicable	TSWF	Triggered Snapshot WF (TDS product)
QPL	Qualified Part List	WF	waveform
PCB	Printed Circuit Board	CWF	Continuous WaveForm (TDS product)
PDU	Power Distribution Unit	ROC	RPW Operations Center
RPW	Radio and Plasma Waves (experiment)	L1	Level 1 (defined in AD2)
S/C	SpaceCraft	L2	Level 2 (defined in AD2)

Table of Contents

1. INTRODUCTION

This document provides a specification of the ground calibration software for RPW TDS data (CALBA). This version of the document applies to CALBA version 0.8.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

This document responds to the requirements of the documents listed in the following table:

Mark	Reference	Title of the document	Authors	Version/Date
AD1	ROC-TST-GSE-ICD-00023-LES	ROC-SGSE Calibration Software ICD	X. Bonin	Iss. 02, Rev. 02 06/06/2016
AD2	ROC-TST-GSE-NTT-00017-LES	Data format and metadata definition for the ROC-SGSE data	X. Bonin	Iss. 02, Rev. 01 14/10/2016
AD3	ROC-GEN-SYS-NTT-00019-LES	ROC Engineering Guidelines For External Users	X. Bonin	Iss. 02, Rev. 00 12/10/2017

2.2 Reference documents

The present document refers to the documents listed in the following table:

Mark	Reference	Title of the document	Authors	Version/Date
RD1	ROC-PRO-SFT-SUM-000XX-LES	RPW Calibration Software User Manual for TDS-CALBA	D. Pisa	Iss. 01, Rev. 00 20/12/2017
RD2				
RD3				
RD4				

3. TDS MODES AND DATA PRODUCTS

3.1 Modes of operation

TDS software implements the following modes of operation described in this section. TDS can operate in one of nominal modes where the HF inputs are being used and the LF input section is powered off or in LFM backup mode, where low frequency inputs are sampled. TDS support the following nominal modes:

Normal mode: Basic mode of operation. In this mode TDS performs on-board processing of waveform data and transmits to DPU periodically regular waveform and statistical data products (as listed in Section **Error! Reference source not found.**). It collects the best identified event in an internal queue and this queue is dumped to the DPU when requested by TC.

Burst mode: A higher datarate mode of the RPW instrument. TDS operates in the same way as in the NORMAL mode, but a different configuration for RSWF and MAMP data products can be applied.

Detection mode SBM1: This special mode is targeted at obtaining high resolution measurements of interplanetary shock crossings and is defined on RPW level in AD2. In this mode, TDS transmits to DPU, in addition to all normal mode data products, regularly spaced high resolution waveform snapshots at a high cadence (several per minute). These should be stored in DPU circular buffer and only used when an IP shock crossing is detected.

Detection mode SBM2: This special mode is targeted at obtaining high resolution in-situ measurements of the type III emission generating region and is defined on RPW level in AD2. In this mode, TDS performs the same operations as in normal mode and provides the same data products. In addition to that, TDS keeps a secondary queue of automatically detected snapshots which is flushed to DPU at a higher rate, providing significantly better data coverage for Langmuir waves.

The **LFR redundancy mode** is a backup mode, where TDS acts as a replacement for LFR. In this mode, the LF inputs are being used and the HF input section is powered off. TDS provides data products similar to LFR: waveform snapshots, continuous waveform and spectral products.

The mode determines what science TM is generated as defined in the table below.

Mode	Description	Data products
NORMAL	Normal mode (SURVEY_NORMAL)	RPW-TDS-SURV-RSWF RPW-TDS-SURV-TSWF RPW-TDS-SURV-MAMP RPW-TDS-SURV-STAT RPW-TDS-SURV-HIST1D RPW-TDS-SURV-HIST2D
BURST	Burst mode (SURVEY_NORMAL)	Same as NORMAL
SBM1	Selection burst mode 1 (IP shock focused) SBM1_DUMP	Same as NORMAL + RPW-TDS-SBM1-RSWF
SBM2	Selective burst mode 2 (Type III focused)	Same as NORMAL + RPW-TDS-SBM2-TSWF

	SBM2_ACQ	
LFM	Low frequency mode SURVEY_BACKUP	RPW-TDS-LFM-RSWF RPW-TDS-LFM-CSWF RPW-TDS-LFM-PSD RPW-TDS-LFM-SM

4. CALBA SOFTWARE AND CALIBRATION APPROACH

CALBA is a small software utility designed to convert TDS Level 1 CDF files to higher level products (L1R or L2).

4.1 Waveform snapshot products

The following waveform snapshot products are produced by TDS and processed by CALBA:

- RPW-TDS-SURV-RSWF
- RPW-TDS-SURV-TSWF
- RPW-TDS-SBM1-RSWF
- RPW-TDS-SBM2-TSWF
- RPW-TDS-LFM-RSWF

The CALBA software coverts the snapshot L1 files in to L1R, where the field data is left in integer units, but metadata (such as data artefacts and input configuration) are decommutated and converted in a form equivalent to L2 product. The L1R file indicates unambiguously the transfer function that shall be used by the next level software to generate L2 data. For Each L1 product, two L1R files are generated – one for electric and one for magnetic components.

4.2 LFM continuous waveform

In LFM mode, TDS provides decimated waveform RPW-TDS-LFM-CWF at a sampling frequency up to 128 Hz and for up to 6 components. This waveform is calibrated by CALBA to physical units (Volts and nT) using a constant factor.

4.3 LFM spectral products

LFM spectral products, only produced in LFM mode, are provided by TDS in two distinct packets, also translated into L1 files:

RPW-TDS-LFM-PSD (containing the auto spectrum)

RPW-TDS-LFM-SM (containing the cross-spectral part of the spectral matrix).

The two datasets are merged by CALBA into a single L2 dataset L2_RPW-TDS-LFM-PSDSM, containing full calibrated spectral matrices. The spectral matrices are calibrated in physical units (Volts for electric inputs and nT for magnetic signals) by CALBA using spectral transfer functions provided by SCM and BIAS teams.

4.4 Statistical products

The statistical data products

- RPW-TDS-SURV-STAT
- RPW-TDS-SURV-MAMP
- RPW-TDS-SURV-HIST1D/2D

are converted by CALBA directly into L2 files. Calibration of amplitudes (to Volts) is performed via frequency independent constant factors (which however depend on TDS input configuration). A transfer function is applied to obtain values of estimated peak frequency in kHz (SURV-STAT). Histograms do not require calibration, but CALBA adds histogram axis vectors in physical units in the L2 files.

5. CALBA REQUIREMENTS

In this section are outlined the requirements on the functionality of CALBA software.

5.1 General requirements

CRS-001: Basic function

CALBA software shall allow processing of any properly formatted TDS L1 CDF file (described in AD2) and convert it into corresponding L1R or L2 files. Any anomalies in the source file shall be reported.

CRS-0101: Programming language

CALBA shall be written in IDL language with the aid of bash scripts and shall run on a standard Linux system (e.g. Debian 8).

CRS-0110: **Version control**

The version control is maintained in the IAP git software repository.

CRS-0120: Version tagging

The sources must be tagged with the version number on the IAP repository before being uploaded to the ROC repository.

CRS-0130: Master CDF

For each data product, CALBA shall use a dedicated master CDF as the initial output file. The master files are generated from skeletons and maintained in the ROC git repository.

CRS-140: Global attributes

Global attributes following the specification in *AD2* shall be included in the generated L1R and L2 files. These can be copied from the master CDF, from the source L1 file or calculated based on data and configuration.

CRS-150: Software Interface

The interface of the software (command line parameters, environment variables and configuration file) shall be compliant with AD1 and described in RD1.

5.2 HF mode calibration requirements

CRS-0201: Waveform calibration

CALBA shall process waveform snapshot data products

L1_RPW-TDS-SURV-RSWF

L1_RPW-TDS-SURV-TSWF

L1_RPW-TDS-SBM1-RSWF

L1_RPW-TDS-SBM2-TSWF

into L1R files, where the waveform data in variable WAVEFORM_DATA is provided in uncalibrated integer units.

CRS-0202: Waveform calibration E/B

Electric and magnetic components shall be processed into separate L1R files, for example

- L1_RPW-TDS-SURV-RSWF-E
- L1_RPW-TDS-SURV-RSWF-B.

Each file shall only contain the waveform components and metadata associated with electric resp. magnetic part of the waveform.

CRS-0210: Transfer function index

An index uniquely identifying a calibration function to be used for each snapshot shall be specified in the L1R file in the CALIBRATION_TABLE_INDEX.

CRS-0220: Input channel configuration

CALBA shall parse the configuration of TDS input channels stored in L1 files in variable INPUT_CONFIG and convert it into explicit channel configurations in CHANNEL_CONFIG variable. Gain information shall be propagated in the choice of calibration table.

CRS-0230: Artefacts

CALBA shall parse artefacts from L1 HF_DATA_ARTEFACTS variable and use it to fill in CHANNEL_OVERFLOW and BUFFER_OVERLOW variables.

CRS-0240: Other metadata

CALBA shall copy other metadata variables, such as RPW_STATUS_INFO, BIA_STATUS_INFO, SNAPSHOT_SEQ_NR, FILTER_COEFS, …, verbatim into L1R files.

CRS-0250: MAMP data product

L1_RPW-TDS-SURV-MAMP data product shall be calibrated using constant factors derived based on input channel configuration directly into L2 files.

CRS-0260: STAT data product

L1_RPW-TDS-SURV-STAT data product shall be calibrated using constant factors derived based on input channel configuration directly into L2 files.

CRS-0270: HIST1D and HIST2D data product

L1_RPW-TDS-SURV-HIST1D and L1_RPW-TDS-SURV-HIST1D data product shall be calibrated directly into L2 files. The data themselves are histograms, therefore shall be left uncalibrated. CALBA should however add correct histogram axes in physical units.

5.3 LFM mode calibration requirements

CRS-0301: LFM Waveform calibration

CALBA shall process waveform data product L1_RPW-TDS-LFM-RSWF into L1R files, where the waveform data is provided in uncalibrated integer units.

CRS-0302: LFM waveform calibration E/B

Separate L1R files shall be provided for electric (L1R_RPW-TDS-LFM-RSWF-E) and magnetic (L1R_RPW-TDS-LFM-RSWF B) components of the waveform. Each file shall only contain the waveform components and metadata associated with electric resp. magnetic part of the waveform.

CRS-0310: LFM CWF Waveform calibration

CALBA shall process waveform data product L1_RPW-TDS-LFM-CWF into L2 files, where the waveform data is calibrated using a constant factor derived from ground calibration.

CRS-0320: LFM spectral products

CALBA shall process waveform data product L1_RPW-TDS-LFM-PSD and L1_RPW-TDS-LFM-SM into a combined L2 product L2_RPW-TDS-LFM-PSDSM, where:

- Auto and cross spectra are combined into 5 x 5 complex matrices
- When cross spectral elements are not present, fill values are used
- The spectral matrices are calibrated into physical units (Volts for electric inputs and nT for magnetic signals) using frequency dependent spectral transfer functions (SCM and BIAS).
- Frequency axis in Hz is included in the CDF file.