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Technical Specifications of the SCM Waveforms Calibration Software

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Date	**15/12/2017**	
Reference	**SO-SP-RPW-SC-0181-LPC2E**	

Document under configuration control	Yes	No	from	
		x		

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MODIFICATIONS

File: SO-SP-RPW-SC-0181-LPC2E_Iss01_Rev01.docx

Edition	Revision	Date	Commentaries
1	0	22/07/2016	First version
1	1	15/12/2017	- Update of the list of the applicable documents - L2R are replaced by L1R - Fig. 5 is corrected - add of REQ-RCS-SCM-10-060 and REQ-RCS-SCM-10-070 concerning the delivery requirements - §6 : Add of L2 datasets requirements - Add explanations on how to use matrix transfer to calibrate multi-components waveforms

LIST OF TBC AND TBD

LIST OF TBC (AC in french)

Chapter	Description	Dependency
6	Sampling frequencies for TDS	

LIST OF TBD (AD in french)

Chapter	Description	Dependency
6	Sampling frequencies for TDS and LFM modes	

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1 PURPOSE

This document provides the technical specifications of the calibration software (RCS) for the waveforms magnetic data coming from the Search Coil Magnetometer (SCM) unit. SCM measurements go through two analyzers, LFR and TDS. Several parameters are computed by TDS and LFR, but the software described here is only dedicated to waveforms data.
The software described here is dedicated to compute calibrated science data at sensor level (L2 and L2S) from science data at receiver level (L1R), with the levels defined by the ROC in [AD3].

2 DOCUMENTATION

2.1 Applicable documents

[AD1] RPW Calibration Software ICD Documentation, ROC-TST-GSE-ICD-00023-LES, Iss.02, Rev.02, May 13, 2016
[AD2] RPW Operation Centre – RPW Calibration Software Interface Control Document, ROC-PRO-PIP-ICD-00037-LES, Iss.01, Rev.01, 12/10/2017
[AD3] RPW Ground Segment - Data format and metadata definition for the ROC-SGSE data, ROC-TST-GSE-NTT-00017-LES, Iss.02, Rev.01, 14/10/2016
[AD4] RPW Operation Centre – RPW Data Products, ROC-PRO-DAT-NTT-00006-LES, Iss.01, Rev.01, 17/11/2017
[AD5] RPW Operating Centre - ROC Engineering Guidelines For External Users, ROC-GEN-SYS-NTT-00019-LES, Iss.02, Rev.00, 17/11/2017

2.2 Reference documents

[RD1] Product Assurance - Common Coding Rules For Programming Languages, RNC-CNES-Q-HB-80-501, Version 4, 17/09/2009
[RD2] Assurance Produit - Règles Pour l'Utilisation du langage IDL (Interactive Data Language), RNC-CNES-Q-HB-80-534, Version 3, 02/06/2008
[RD3] RPW Instrument - LFR Low Frequency Receiver, RPW-MEB-LFR-00003, Iss.1, Rev.11, Oct 23, 2015
[RD4] RPW Instrument - Time Domain Sampler (TDS) - Software User Manual, RPW-SYS-MEB-TDS-SUM-00155-IAP, Iss.1, Rev.0, 29/11/2015

2.3 Glossary

ASM	Averaged Spectral Matrix
BP	Basic Parameter
CDF	Common Data Format
CLI	Command Line interface
DC	Direct Current
ELF	Extremely Low Frequency
HF	High Frequency
IDL	Interactive Data Language
L2	RPW Level 2 calibrated science data at sensor leveRPW Level 2 calibrated
L2S	science data at sensor level during ground tests
LF	Low Frequency
LFM	Low Frequency Mode
LFR	Low Frequency Receiver
MF	Medium Frequency
RCS	RPW Calibration Software
RCT	RPW Calibration Table
RGTS	ROC-SGSE pipeline
RPW	Radio Plasma Waves instrument
ROC	RPW Operation Center

RODP	ROC Operations and Data Pipeline
RSWF	Regular Waveform Snapshot
SCM	Search Coil Magnetometer
TF	Transfer Functions
TDS	Time Domain Sampler
TSWF	Triggered Waveform Snapshot
VLF	Very Low Frequency
WF	Waveform

3 SEARCH COIL MAGNETOMETERS AND RECEIVERS

3.1 SCM sensor

SCM is a magnetic sensor dedicated to the measurement of the fluctuating magnetic fields for 3 components in the ELF-VLF frequency range (Bx-LF, By-LF, Bz-LF) and for 1 component in the VLF-MF frequency range (Bx-MF).
SCM is composed of 3 orthogonal antennas assembled orthogonally (Figure 1).
The 3 antennas are:

- 2 LF magnetic antennas (mono band) built of a ferrite core wound by a couple of coils (primary and secondary) adapted for LF measurements (length 104mm, diameter 20mm).
- 1 LF-MF magnetic antenna (bi band) consisting in a LF magnetic antenna which is wound by an additional couple of coils (primary and secondary) to allow measurements in both LF and MF frequency ranges.

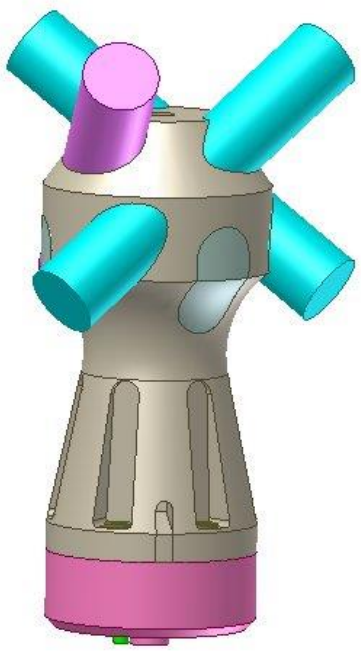

Figure 1

The signals measured by the search coils are amplified separately with:

- 3 LF amplification channels
- 1 MF amplification channel

The correspondence between the amplification channel number and the component is given in Table 1.

Amplification channel number	Component
1	By-LF
2	Bz-LF
3	Bx-LF
4	Bx-MF

Table 1

The outputs of the 4 amplification channels are analog data.

Each signal, crossing its dedicated amplifier is amplified and delayed. The amplifying factors and the delays depend on the frequencies. Figure 2 shows the response of the channel 1. Those curves are known as transfer functions (TF). Similar transfer functions have been measured for every channel.

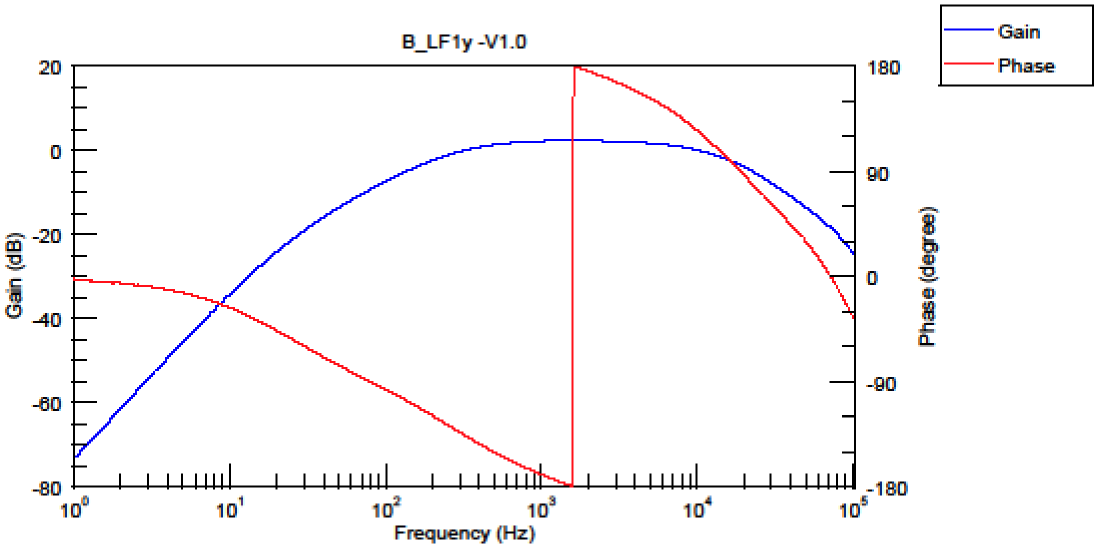

Figure 2

The blue curve represents the gain applied to the input signal B_{in} in dB. The input signal B_{in} is in nT and output signal V_{out} in V.

$$gain\ (dB) = 20.Log_{10}\left(\frac{V_{out}}{B_{in}}\right)$$

The gain depends on the frequencies.

The phase is the expression of a time delay due to electronic components but is expressed as an angle.
The output signal at time *t* comes from the input signal acquired at time *t – delay*. In general, this delay depends on the frequency. For a sinusoidal input signal at frequency f we have:

$$\begin{aligned} Vout_f(t) &= gain_f.Bin_f(t - delay_f) \\ &= gain_f.A_f.cos\left(2.\pi.f.(t - delay_f)\right) \\ &= gain_f.A_f.cos(2.\pi.f.t - 2.\pi.f.delay_f) \\ &= gain_f.A_f.cos\left(2.\pi.f.t + d\varphi_f\right) \\ &with\ d\varphi_f = -2.\pi.f.delay_f \end{aligned}$$

3.2 LFR analyser

The LFR instrument is designed to produce and transmit waveforms (WF), averaged spectral matrices (ASM) and basic parameters (BP) from LF electromagnetic measurements (quasi DC-10kHz).

The LFR analyzer is the nominal receiver for the SCM low frequency data.

The LFR block diagram (Figure 3) shows the 3 LF components as input. On each channel, an anti-aliasing filter is applied before converting the analog data to device data and then, down-sampling and decimating the data to produce waveforms at 4 different sampling frequencies:

- f0 = 24576 Hz
- f1 = 4096 Hz
- f2 = 256 Hz
- f3 = 16 Hz

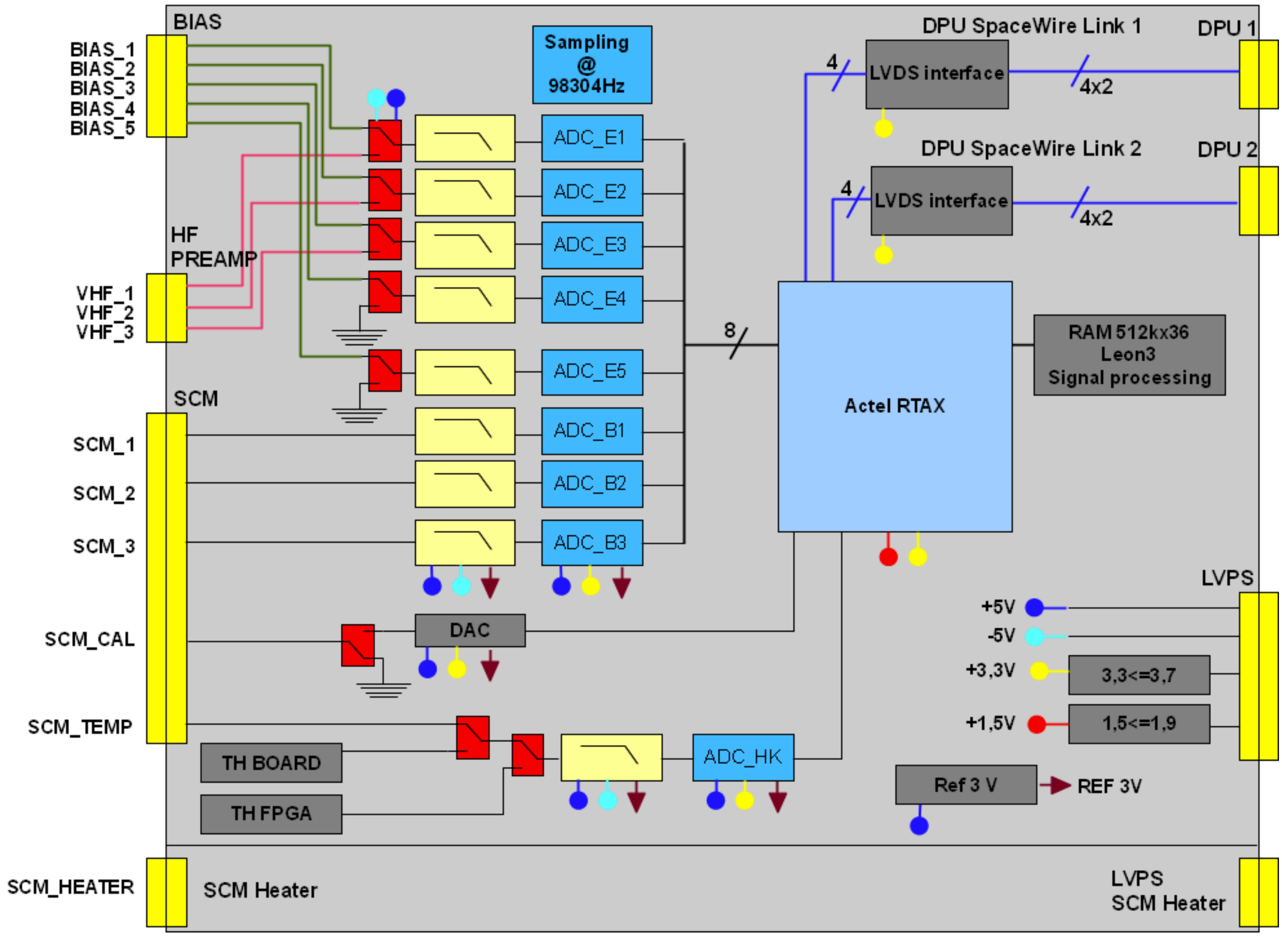

Figure 3: LFR block diagram

LFR can run in four modes:

- NORMAL: low cadence mode basically run all the time along the orbit
- BURST: high cadence mode.
- SBM1: high cadence mode for the interplanetary shocks measurements.
- SBM2: high cadence mode for in-situ type III measurements.

NORMAL and BURST modes are exclusive, but SBM1 runs in parallel with NORMAL mode and SBM2 also runs in parallel with NORMAL mode.
See RD3 more details.

3.3 TDS analyser

The TDS is a medium frequency (MF) wave analyser module of RPW. It allows digitizing and processing analogic signals from electric and magnetic antennas at a sampling rate up to 512 kHz. The primary function of TDS is to provide on-board selected multi-component waveform snapshots at high sampling rate. Additionally, TDS allows to sample low frequency electric and magnetic field inputs and serve as a backup in the case of LFR failure. TDS produces waveforms, power spectra, averaged cross spectral matrices and statistical data.
In nominal (high frequency) mode, TDS process the MF component of SCM and the 3 electric HF components.
TDS supports a LFR redundancy mode; in this mode TDS process 6 multiplexed low frequency analog channels: 2 differential electric signals, 3 LF magnetic signals and the spacecraft potential.
Figure 4 shows the block diagram of TDS.

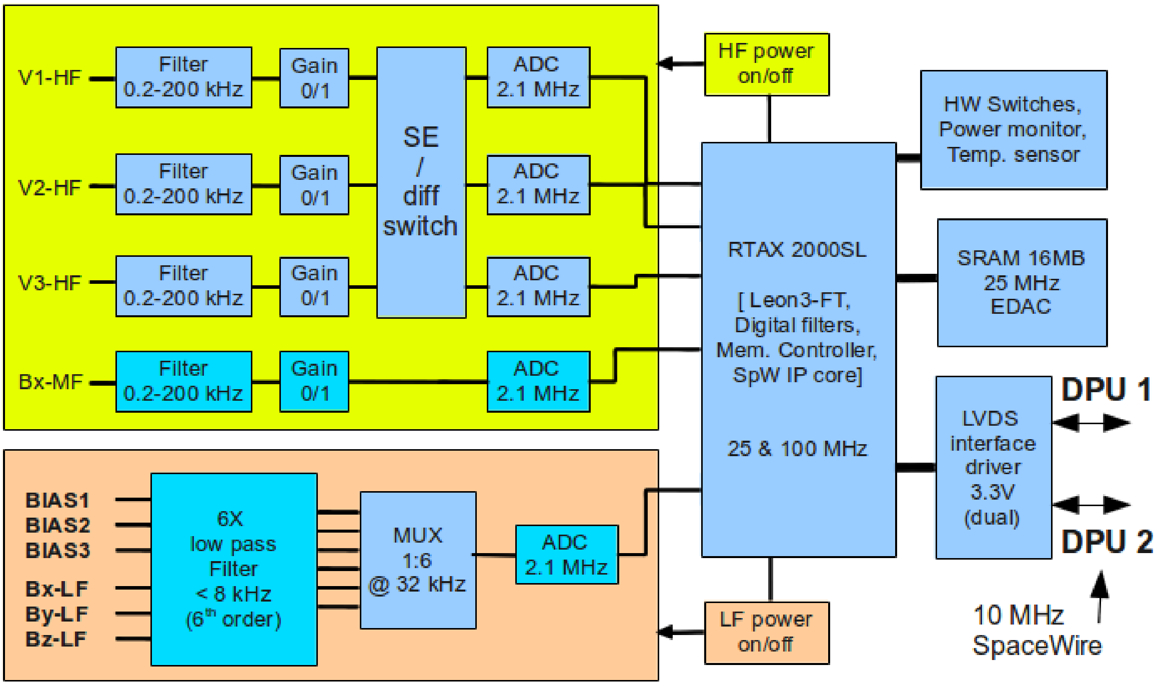

Figure 4: TDS block diagram

4 RPW MODES

In nominal mode, RPW can be configured in 3 following modes:

- SURVEY_NORMAL: it is a low cadence mode that will basically run all the time along the orbit, except during the short periods of time during which the SURVEY_BURST high cadence mode will be operated.
- SURVEY_BURST: short periods of time where the analyzers acquire data at high cadence. Those periods are programmed.
- DETECTION: In addition to the data flow from SURVEY_NORMAL mode, the analyzers produce selected data. The selection depending upon sub-mode SBM1 or SBM2.

5 DATA PROCESSING LEVELS

The processing levels are defined in DA2. Table 2 shows the levels dedicated to science data.

Level	Data Type
L0	RPW TM/TC data unpacketed and uncompressed
L1	RPW level 1 uncalibrated science data, engineering unit. Time-tagged.
L1R	RPW level 1 uncalibrated science data, engineering unit with the name and the index of the calibration table to use at the receiver level. Time-tagged.
L2	RPW level 2 calibrated science data at sensor level. Time-tagged.
L2S	RPW level 2 calibrated science data at sensor level during the ground tests (same as L2). Time-tagged.

Table 2

Calibrating the data consists in computing the L2S data product from lower levels: L1 is computed from L0, then L1R from L1 and last, L2 (or L2S) from L1R. This document specifies the process to

compute L2 (or L2S) waveforms magnetic data from L1R waveforms magnetic data. Figure 5 illustrates this conversion.
Note that L2S science data formats are the same as L2 science data formats and the computing algorithms are the same. The differences are about the metadata, the file names and the calibration tables (RCT) used to compute these data may differ.

At the receiver (LFR or TDS) output, waveform data is expressed in telemetry (TM) unit.
At the receiver (LFR or TDS) entry, waveform data is expressed in V or mV.
At the sensor (SCM) entry, waveform is expressed in nT.

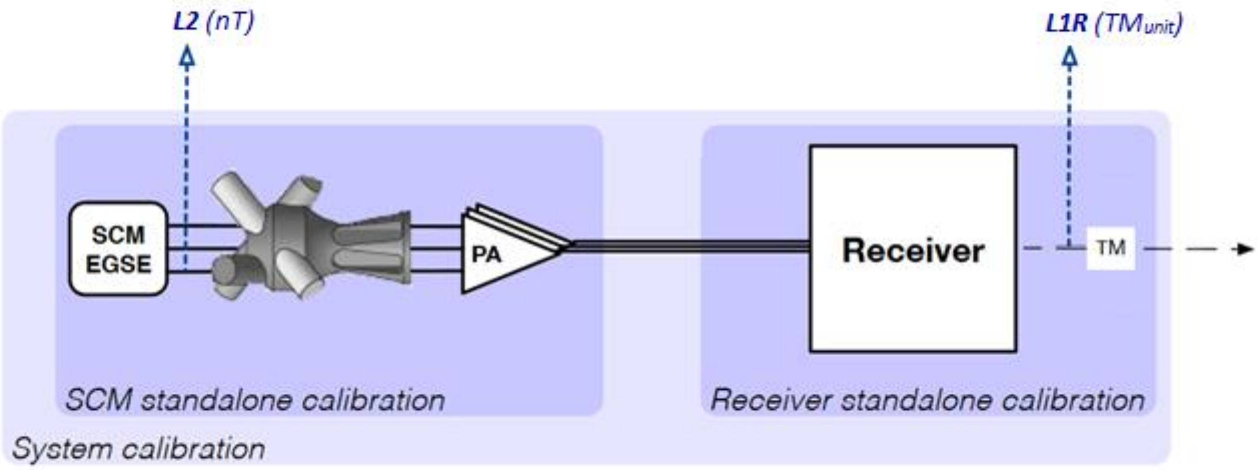

Figure 5: magnetic waveform data level

6 DATASETS

REQ-RCS-SCM-6-010: Computation of the LFR L2 data product
The calibration software must be able to compute in the RODP pipeline, all the magnetic waveforms produced by LFR; they are listed in column #1 of Table 3 and are computed from datasets in column #2.

Dataset name	From	Content
SOLO_L2_RPW-LFR-SURV-CWF-B	SOLO_L1R_RPW-LFR-SURV-CWF	3 continuous comp. B_LF at 16 Hz Or 3 continuous comp. B_LF at 256 Hz
SOLO_L2_RPW-LFR-SURV-SWF-B	SOLO_L1R_RPW-LFR-SURV-SWF	snapshots of 3 comp. B_LF at 24576 Hz, 4096 Hz and 256 Hz
SOLO_L2_RPW-LFR-SBM1-CWF-B	SOLO_L1R_RPW-LFR-SBM1-CWF	3 continuous comp. B_LF at 4096 Hz
SOLO_L2_RPW-LFR-SBM2-CWF-B	SOLO_L1R_RPW-LFR-SBM2-CWF	3 continuous comp. B_LF at 256 Hz

Table 3: magnetic waveform products by LFR

REQ-RCS-SCM-6-015: Computation of the LFR L2S data product
The calibration software must be able to compute in the RGTS pipeline, all the magnetic waveforms produced by LFR; they are listed in column #1 of Table 4 and are computed from datasets in column #2.

Dataset name	From	Content
ROC-SGSE_L2S_RPW-LFR-SURV-CWF-B	ROC-SGSE_L1R_RPW-LFR-SURV-CWF	3 continuous comp. B_LF at 16 Hz Or 3 continuous comp. B_LF at 256 Hz
ROC-SGSE_L2S_RPW-LFR-SURV-SWF-B	ROC-SGSE_L1R_RPW-LFR-SURV-SWF	snapshots of 3 comp. B_LF at 24576 Hz, 4096 Hz and 256 Hz
ROC-SGSE_L2S_RPW-LFR-SBM1-CWF-B	ROC-SGSE_L1R_RPW-LFR-SBM1-CWF	3 continuous comp. B_LF at 4096 Hz
ROC-SGSE_L2S_RPW-LFR-SBM2-CWF-B	ROC-SGSE_L1R_RPW-LFR-SBM2-CWF	3 continuous comp. B_LF at 256 Hz

Table 4: magnetic waveform test products by LFR

REQ-RCS-SCM-6-020: Computation of the TDS L2 data product
The calibration software must be able to compute in the RODP pipeline, all the magnetic waveforms produced by TDS; they are listed in column #1 of Table 5 and are computed from datasets in column #2. The sampling frequencies for TDS datasets are TBC.

Dataset name	From	Content
SOLO_L2_RPW-TDS-SURV-RSWF-B	SOLO_L1R_RPW-TDS-SURV-RSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
SOLO_L2_RPW-TDS-SURV-TSWF-B	SOLO_L1R_RPW-TDS-SURV-TSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
SOLO_L2_RPW-TDS-SBM1-RSWF-B	SOLO_L1R_RPW-TDS-SBM1-RSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
SOLO_L2_RPW-TDS-SBM2-TSWF-B	SOLO_L1R_RPW-TDS-SBM2-TSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
SOLO_L2_RPW-TDS-LFM-RSWF-B	SOLO_L1R_RPW-TDS-LFM-RSWF	1 snapshots of 3 comp. B_MF at TBD Hz
SOLO_L2_RPW-TDS-LFM-CWF-B	SOLO_L1R_RPW-TDS-LFM-CWF	3 continuous comp. B_LF at TBD Hz

Table 5: TDS magnetic waveform data products

REQ-RCS-SCM-6-025: Computation of the TDS L2S data product
The calibration software must be able to compute in the RGTS pipeline, all the magnetic waveforms produced by TDS; they are listed in column #1 of Table 6 and are computed from datasets in column #2. The sampling frequencies for TDS datasets are TBC.

Dataset name	From	Content
ROC-SGSE_L2S_RPW-TDS-SURV-RSWF-B	ROC-SGSE_L1R_RPW-TDS-SURV-RSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
ROC-SGSE_L2S_RPW-TDS-SURV-TSWF-B	ROC-SGSE_L1R_RPW-TDS-SURV-TSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
ROC-SGSE_L2S_RPW-TDS-SBM1-RSWF-B	ROC-SGSE_L1R_RPW-TDS-SBM1-RSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
ROC-SGSE_L2S_RPW-TDS-SBM2-TSWF-B	ROC-SGSE_L1R_RPW-TDS-SBM2-TSWF	1 snapshots of 1 comp. B_MF at 65534.4 Hz or 131069 Hz or 262138 Hz or 524275 Hz
ROC-SGSE_L2S_RPW-TDS-LFM-RSWF-B	ROC-SGSE_L1R_RPW-TDS-LFM-RSWF	1 snapshots of 3 comp. B_MF at TBD Hz
ROC-SGSE_L2S_RPW-TDS-LFM-CWF-B	ROC-SGSE_L1R_RPW-TDS-LFM-CWF	3 continuous comp. B_LF at TBD Hz

Table 6: TDS magnetic waveform data products

7 CALIBRATION METHOD

7.1 Using transfer function

This section describes the method used to calibrate a waveform composed of *n* samples regularly acquired every *dt* seconds, i.e. the signal is sampled at $f_s = 1 / dt$.

As the electronic components have amplified the amplitude of the signal by a factor and have added a phase to the input signal, calibrating a waveform consists in subtracting the phase and dividing the amplitude by the factor. As we see, the response depends on the frequencies, so if the output signal is decomposed into the sum of sinusoid waveforms

$$V_{out} = \sum_k A_k.\cos(2.\pi.f_k.t + \varphi_k)$$

, and if we know the gain factors $\{g\}_k$ and the phases added $\{d\varphi\}_k$ at frequencies $\{f\}_k$,we can easily compute the input signal as

$$B_{in} = \sum_k A_k/g_k.\cos(2.\pi.f_k.t + \varphi_k - d\varphi_k)$$

We first need to interpolate the original gains vector and phases vector at the frequencies $\{f\}_k$ to obtain $\{g\}_k$ and $\{d\varphi\}_k$.

We can then use a Fourier transform to decompose V_{out} using $\{f\}_k$ = { 0, df, 2.df, 3.df, …, n/2.df} where df = f_s / n.

$$V_{out} = \sum_{k=0}^{k=n/2} A_k.\cos(2.\pi.k.df.t + \varphi_k)$$

The general algorithm to calibrate a waveform V_{out} is:

- compute $X(k) = FFT(V_{out})(k)$
- express $X(k) = A_k.e^{i\varphi_k}$
- compute $A'_k = A_k/g_k$
- compute $\varphi'_k = \varphi_k - d\varphi_k$
- compute $X'(k) = A'_k.e^{i\varphi'_k}$
- compute $B_{in} = FFT^{-1}(X')$

If we call this algorithm “Calibrate_wave”, we can write B_{in} = Calibrate_wave(V_{out}, $\{1/g\}_k$, $\{-d\varphi\}_k$).

Other calibration algorithms can be used to reduce artefacts in the output data, but at first we will use this basic one.

7.2 Using transfer matrix

Let’s call B_1, B_2, B_3 the components of the magnetic vector measured by SCM and J_1, J_2, J_3 the output components of SCM as shown on Figure 6.

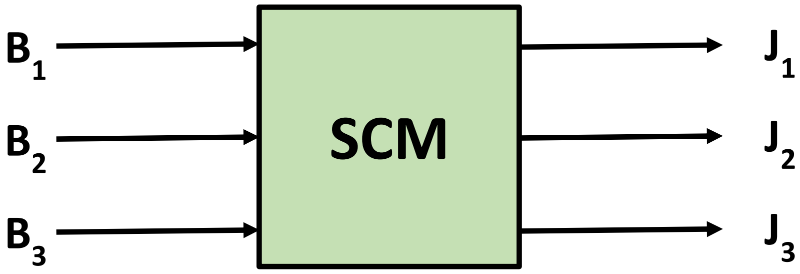

Figure 6 : SCM entries and outputs

The output signals J_1, J_2 and J_3 are coupled and can't be calibrated separately.
As the dependences are linear, the general expression of (J_1, J_2, J_3) at ω pulsation is given by Equation 1.

$$\begin{pmatrix} J_1(\omega) \\ J_2(\omega) \\ J_3(\omega) \end{pmatrix} = \begin{pmatrix} a_{11}(\omega) & a_{12}(\omega) & a_{13}(\omega) \\ a_{21}(\omega) & a_{22}(\omega) & a_{23}(\omega) \\ a_{31}(\omega) & a_{32}(\omega) & a_{33}(\omega) \end{pmatrix} . \begin{pmatrix} B_1(\omega) \\ B_2(\omega) \\ B_3(\omega) \end{pmatrix}$$

Equation 1

Calibrating data consists in computing *B* when *J* is given. We can invert the matrix to obtain Equation 2.

$$\begin{pmatrix} B_1(\omega) \\ B_2(\omega) \\ B_3(\omega) \end{pmatrix} = \begin{pmatrix} b_{11}(\omega) & b_{12}(\omega) & b_{13}(\omega) \\ b_{21}(\omega) & b_{22}(\omega) & b_{23}(\omega) \\ b_{31}(\omega) & b_{32}(\omega) & b_{33}(\omega) \end{pmatrix} . \begin{pmatrix} J_1(\omega) \\ J_2(\omega) \\ J_3(\omega) \end{pmatrix}$$

Equation 2

To minimize the computation effort, the $b_{ij}(\omega)$ have been stored in the RCT of SCM in the form of transfer functions and will be used to compute the contribution of each J_j channel (j = 1, 2 or 3) to B_i signal (I = 1, 2 or 3).These functions are called "rBij-LF-gains" and "rBij-LF-phases".

To retrieve the waveform B_i (i = 1, 2 or 3), we need to calibrate J_1, J_2 and J_3 and sum the 3 resulting waveforms. This can be written as:

B_i = Calibrate_wave(J_1 , rBi1-LF-gains, rBi1-LF-phases) +
Calibrate_wave(J_2 , rBi2-LF-gains, rBi2-LF-phases) +
Calibrate_wave(J_3 , rBi3-LF-gains, rBi3-LF-phases)

8 GENERAL ALGORITHM

REQ-RCS-SCM-8-010: modes
The software has one mode per output dataset. The mode is a parameter of the CLI as described in AD1.

REQ-RCS-SCM-8-020: using master CDF
For each mode, the calibration software needs to copy the dedicated master CDF as the initial output file. A master CDF defines the structure of the output file (variables and attributes) and gives values of constant attributes and constant variables.

REQ-RCS-SCM-8-030: Global attributes reported

Some of the global attributes must be copied from the input file to the output file. This concerns the global attributes in the list below:
PARENTS, PARENT_VERSION, PROVIDER, TEST_CREATION_DATE, TEST_DESCRIPTION, TEST_DESCRIPTION, TEST_ID, TEST_LAUNCHED_DATE, TEST_LOG_FILE, TEST_LOG_FILE, TEST_NAME, TEST_REQUEST_ID, TEST_TEMP_DEGREES, TEST_TERMINATED_DATE, TEST_UUID, …
This list is not exhaustive and may depend on the dataset to produce. The meaning of the attributes is given in AD3.

REQ-RCS-SCM-8-040: Global attributes computed
Some of the global attributes must be computed from data. This concerns the global attributes in the list below:
DATA_VERSION, CALIBRATION_VERSION, GENERATION_DATE, LOGICAL_FILE_ID, SOFTWARE_NAME, SOFTWARE_VERSION, SPECTRAL_RANGE_MAX, SPECTRAL_RANGE_MIN, TIME_MAX, TIME_MIN, …
This list is not exhaustive and may depend on the dataset to produce. The meaning of the attributes is given in AD3.

REQ-RCS-SCM-8-050: Magnetic data selection
The L1R input datasets contain only magnetic data. First of all, the calibration software needs to identify the magnetic components.

- For LFR, the *B* variable contains magnetic waveforms. For the snapshot data, B has the dimension [3, n]; the first dimension represents the 3 channels for B_1, B_2 and B_3 where B_i is the voltage coming from the pre-amplifier number i of SCM at the entry of LFR and n represents the number of samples of the snapshot. For continuous data, the B variable has dimension [3] and contains the values of B_1, B_2 and B_3.
- For TDS in nominal mode (not LFM), the waveforms are stored in the variable *WAVEFORM_DATA* and have dimension [n], where n is the number of sample of the snapshot. It contains the waveform of the B_MF4x component. However, the sign of the signal must be determined. To do so, the calibration software needs to explore the *CHANNEL_CONFIG* variable with dimension [1, 2]. Let Sig_id_1 *= CHANNEL_CONFIG[1, 1]* and Sig_id_2 *= CHANNEL_CONFIG[1, 2] ;* that means that *WAVEFORM_DATA* contains $Signal_{Sig\_id1} - Signal_{Sig\_id2}$. Table 7 gives the correspondence between the Sig_ids and the Signals. The valid combinations for magnetic data are *CHANNEL_CONFIG = [4, 0]* and *CHANNEL_CONFIG = [0, 4]*. In the first case, *WAVEFORM_DATA* contains B_4 which is the voltage of the pre-amplifier number 4 of SCM at the entry of TDS or *CHANNEL_CONFIG = [0, 4]* and, in the second case, *WAVEFORM_DATA* contains $-B_4$.

Sig_id	Signal
0	Ground (= 0)
1	V_1
2	V_2
3	V_3
4	B_4

Table 7: Sig_id and Signal correspondences

For TDS in LFM mode, *WAVEFORM_DATA* has dimension [3, n] for snapshots or [3] for continuous waveforms. The first dimension represents 3 magnetic channels B_1, B_2 and B_3.

REQ-RCS-SCM-8-060: Snapshots calibration
For a dataset containing waveform snapshots, each record of the input L1R CDF file contains several components of size N. It is not sure that the waveforms are exactly of size N. It may happen that only n samples are stored and the rest from n+1 to N are FILLVALUES. The software will extract the starting part with real data and calibrate it using the algorithm described in section 7. In the output variable, the values from n+1 to N need to be set with FILLVALUE.

REQ-RCS-SCM-8-070: Continuous waveform calibration
For a dataset containing continuous waveforms, each record contains one sample or k samples (one for every k channels). Using the *Epoch* and *SAMPLING_RATE* variables of consecutive records, the software needs to compute the longest continuous part of the waveform, starting at record i = 1. “continuous” means that we consider all successive records j such that $Epoch_{j+1} - Epoch_j$ is about (1. / $SAMPLING\_RATE_{j+1}$); when this condition becomes false, the records from i to j form the longest continuous part.
Each magnetic waveform of each channel, extracted from records i to j, will be calibrated as a waveform of j – i + 1 samples and f_s = $SAMPLING\_RATE_j$ using the algorithm described in section 7.

REQ-RCS-SCM-8-080: Computation of variable attributes
Variables have attributes, some are constant and their values are fixed in the master CDF. Some others have to be computed because they depend on the data. This concerns the attributes `SCALMIN, SCALEMAX,` … of the variables representing the output magnetic waveform and the sampling frequency.
This list is not exhaustive.

REQ-RCS-SCM-8-090: Support data variable
The L2 data product contains additional data that needs to be copied without modification from the L1R data. Some are not relevant and have been discarded from the master CDF.

9 INTERFACES

REQ-RCS-SCM-9-010: Respect of Interfaces
The calibration software have to respect the interfaces defined in AD2. Special attention must be taken about the file descriptor when a new mode is added or versions are updated.

10 REQUIEREMENTS ABOUT CONCEPTION AND DEVELOPPEMENT

10.1 Language and operating system

REQ-RCS-SCM-10-010: Language
The calibration software is written in IDL language. The version used is 8.5.

REQ-RCS-SCM-10-020: Operating System
The calibration software needs to run on linux debian 8.5 distribution (Jessie)

10.2 Software quality and product insurance

REQ-RCS-SCM-10-030: Writing rules
The calibration software must be written in accordance with the RNC documents RD1, RD2.

REQ-RCS-SCM-10-040: Versioning
The sources are versioned on the LPC2E software repository.

REQ-RCS-SCM-10-050: Tagging version at LPC2E
The sources must be tagged with the version number on the LPC2E repository before being deposited to the ROC repository.

REQ-RCS-SCM-10-060: Delivery
The sources and the executable are deposited at https://gitlab.obspm.fr/ROC/RCS/SCMCAL as described in AD5.

REQ-RCS-SCM-10-070: Tagging version delivered at the ROC
Every deposited version at the ROC must be tagged as described in AD5.