Project: **Sentinel-1**

Document Title: **SAR Space Packet Protocol Data Unit**

DRL-No.: **IF-6**

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Change Record

Issue	Date	Section	Description of Change
draft 1	04.04.2008	All	
1	27.05.2008	all	completely revised issue for PDR
2	07.05.2009	general	Column included for all parameters to indicate if parameter is constant or variable during the data take
		general	corrected for Typos
		1.3.1	section number introduced
		1.3.2	new section defining the parameter description scheme
		Table 3.1-2	Definition of PID and PCAT
		Table 3.2-3	“Test Mode” parameter included at octet offset 21
		Table 3.2-4 Table 3.2-5	UTC corrected to GPS time, Pointing Status Word included
		Table 3.2-6	S/C Ancillary Data Time Stamp Format included
		Table 3.2-7	Placeholder included for pointing status description
		3.2.1.1 3.2.1.2	details included
		3.2.2.1 3.2.2.2 3.2.2.6	details included
		3.2.2.3	Max. number of ECCs corrected to 48
		3.2.2.4	Description of Test Mode Configuration included
		3.2.2.5	Clarification about Rx Cannel ID and polarisation included
		3.2.3.1	section reworked
		3.2.3.2	section reworked
		3.2.5	Section and subsections updated with information available up to now (see change bars in the document): • parameter descriptions detailed • parameter resolutions added • parameter dependencies added
		3.3	Section and subsections revised (see change bars in the document) • Description of Data Output Format Types amended (Format Types A,B,C,D)
		4	Section and subsections reworked (see change bars in the document): • subsection “General” included with common information for overall section 4 • “Data Blocks” in the User Data Fields renamed into “Data Sections” to not mix up this term with “BAQ Data Block”
3	25.08.2009	all	revised and updated for SAR CDR (for changes see change bars in the document)
4	25.01.2010	Table 2.4-1	Length of Packet Secondary Header changed to 62 octets

		3.2 Table 3.2-1	Section updated with additional “Radar Sample Count” service field and changed length of Packet Secondary Header to 62 octets
		3.2.3	AI-SY-109 response for SAR CDR
		3.2.3.1	AI-OP-93 response for SAR CDR
		3.2.2.3	AI-SY-26-1 (partly) response for SAR CDR AI-OP-16 (partly) response for SAR CDR
		3.2.4.2	AI-OP-94 response for SAR CDR
		3.2.5.3	AI-IF-106 response for SAR CDR
		3.2.5.13.2.3	AI-OP-108 response for SAR CDR
		3.2.5	overall section revised, including AI-SY-23 response for SAR CDR AI-OP-110 response for SAR CDR AI-OP-16 response for SAR CDR
		3.2.5.6 3.2.5.7 3.2.5.8 3.2.5.9	sections revised
		3.2.5.14.1	section revised
		3.2.5.14.4	section revised
		3.2.6	new section introduced with service field “Radar Sample Count” including the parameter “Number of Quads” (was formerly part of the User Data Field and has been removed there)
		3.3	section revised, including AI-SY-26-1 (partly) response for SAR CDR AI-SY-113 response for CDR
		4	section completely revised and complemented with Decoding algorithms, including AI-OP-95 response for SAR CDR
		5	new section with annexes attached
5	15.09.2010	general	editorial changes and improvements
		2.3	Reference [IRD-07] changed to S1-TN-ASD-0046 “Description of Instrument Radar Database” Reference [IRD-08] for Decompression
		Table 3.2-1	PDL range of values corrected (SYS CDR AI-PL-67) Comment about Sequence Count revised
		3.2.2.3	Revision of ECC No. vs. Modes, RFC mode defined as a single mode (SAR CDR2 AI-OP-19-1) (SYS CDR AI-PL-36 #4)
		3.2.2.4	Section revised. Dependency between Test Mode and ECC No. added (SYS CDR AI-PL-108)
		3.2.3	Table 3.2-7 Definition of Pointing Status added (SYS CDR AI-PL-36 #3) Table 3.2-5 Dummy parameter removed since already defined in Table 3.2-4

		3.2.3.1	Description Field revised
		3.2.4.1	Description of Space Packet Count revised, information added for anomaly condition
		3.2.4.2	PRI Gap corrected to 13 PRIs (SYS CDR AI-PL-110)
		3.2.5.1	Dependencies clarified between BAQ Mode and Signal and Cal Types (SYS CDR AI-PL-111)
		3.2.5.4	Section revised
		3.2.5.5	Note about Calibration switches removed, since no longer used to switch power levels in SAR user data.
		3.2.5.6 3.2.5.7 3.2.5.8	Sections about Tx pulse parameters decoding revised
		3.2.5.11	SWST description revised (SYS CDR AI-PL-36 #5)
		3.2.5.12	SWL description revised
		3.2.5.13.2.4	Dependencies clarified between BAQ Mode and Signal and Cal Types
		3.2.5.13.2.5	Applicable Range corrected to 0…1023
		3.2.5.14.1	Cal Mode description revised
		3.2.5.14.2	Parameter Description field revised
		3.2.5.14.3	Dependencies clarified between BAQ Mode and Signal and Cal Types
		3.2.6	Section revised, filler octet marked as n/a (SYS CDR AI-PL-112)
		4.3, 4.4	Sections revised for: • Reconstruction laws for “Simple” and “Nominal” Reconstruction and Reconstruction Examples (SYS CDR AI-PL-36 #2) • Fig. 4-4 updated with “Simple” Reconstruction • Threshold Index part of QE channel (SYS CDR AI-PL-107)
		5	Section revised, introduction of tables for: • “Simple” Reconstruction of compressed SAR data samples • computation of number of complex samples in the Space Packet • new section for the acquisition timing of calibration signal
6	31.03.2011	3.2.5.13.1.3 3.2.5.13.2.3 3.2.5.13.2.4 3.2.5.14.2 3.2.5.14.3 Table 3.2-12 Table 3.2-13 Table 3.2-14	format of SES SSB & SAS SSB data in header corrected Position in header has changed for: • Elevation Beam Address • SAS Test Flag • Tx Pulse Number • Signal Type • Cal Type
		3.2.5.12	applicability of SWL corrected to: “SWL is applicable for all signal types”
		Table 3.2-10	Error Flag included in octet 37
		3.2.5.1	New section with description of Error Flag (section numbers for “BAQ Mode” and ”BAQ Block Length” changed to 3.2.5.2 and 3.2.5.3)
		3.2.5.2	dependencies added for “Echo” data
7	12.12.2011	3.2.3	information about reference frames added for S/C attitude quaternions

			and S/C angular rates
		3.2.5.4	filter length values corrected for filter No. 4, 5 and 8.
		Table 4.3-1	clarification of parameter N added in subtitle of table
		3.2.5.14.2	applicable range of Tx Pulse No. corrected to “0…31”
		3.2.5.13.1.2	size of code corrected to 2 bits
		3.2.4.1	*SPCT* description field updated to include action response C6-2 from S1-NC-ASU-PL-0030
		3.2.4.2	*PRICT* description field: example deleted about suppressed packets between IWS and EWS subswath transitions. Baseline approach is to generate packets for all PRIs between subswath transitions.
8	23.08.2012	3.2.2.3	ECC No. for Notch Modes added
		3.2.5.4	SAR swath Wave 1 (WV1) applicable with Filter No.1 (not Filter 3)
		3.2.5.13.2.4	Cal Type 7 modified to “EPDN Cal Iso” (Isolation Measurement)
		3.2.5.14.3	Signal Type 15 modified to “EPDN Cal Iso” (Isolation Measurement)
		3.2.5.14.4 3.2.5.14.5	typo “TCPSF” corrected to “TXPSF”
		5.3	Footnote added for clarification of Cal Window timing

Table of Contents

1 Introduction

1.1 Scope

This document gives a comprehensive description of the Sentinel-1 Space Packet on packet layer level. It describes the structure of the packets, provides the data formats and decoding algorithms for user data decoding and gives a detailed description of the annotated SAR ancillary header data.

Electrical, mechanical or transmit channel coding characteristics are not part of this document. These can be found in the electrical ICDs.

1.2 Overview

For packetized transmission of SAR data from the Instrument to the S/C platform the Space Packet Protocol Standard [SD 01] is applied.

Each Space Packet generated by the Instrument contains the complete SAR data acquired in one PRI. The standard limits the maximum packet size to (65536+6) octets but, due to decimation and BAQ compression of SAR data in nominal operation the packet size will stay well below this limit.

The format of the Space Packet is described in section 3. In each packet a SAR ancillary data field is included. The ancillary data provide the information how to interprete, decode and process the SAR radar data in the packet. In addition, they provide information about Instrument status and configuration at the moment of data acquisition (digitizing). General approach here is to provide appropriate information for ground to support SAR image decoding and processing.

In section 4 the decoding algorithms are described to retrieve the SAR radar data from the packets to finally get the usual complex radar data representation suitable to be fed into a ground image processor.

Typically, the acquired SAR data in a PRI is a radar echo received as a backscattered response of a radar pulse transmitted some few PRIs before. But also other data are generated by the Instrument like calibration, noise or test data.

1.3 Conventions and Definitions

1.3.1 Sequencing and Numbering of Parameters

The Space Packet data format is described as a sequence of octets.

The start position of a parameter or a data word within the sequence is defined by the “Octet Offset” and the “Bit Offset” within the octet. The “Octet Offset” refers to the beginning of the overall Space Packet.

The N-BIT FIELD of a parameter or data word within the sequence may not be aligned to octet boundaries and may have a size exceeding one octet.

The first bit of a N-BIT FIELD is defined to be “Bit 0” of the parameter or data word, the following bit is defined to be “Bit 1” and so on up to “Bit N-1” (see Fig. 1-1).

For the interpretation of the binary code in the N-BIT FIELD the first bit (“Bit 0”) is the most significant bit (msb), the last bit (“Bit N-1”) is the least significant bit (lsb).

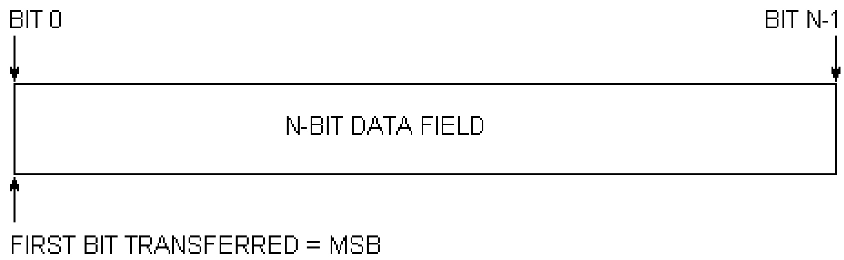


Fig. 1-1: Bit Numbering Convention

1.3.2 Parameter Field Descriptions

The packet parameters are described with the key words shown in Table 1.3-1:

Key Word	Key Word Description
Description:	This field provides a brief description of the parameter
Performance:	This field defines the performance of the parameter, i.e. whether it has a "**variable**" or "**constant**" value during the data take. If "**variable**" is indicated this means the parameter **may** be "**variable**" but does not have to be.
Short Name:	This field defines the parameter name
Code Name:	This field defines the parameter code name (identified by the subscript "code") which designates the uncalibrated parameter code.
Code Properties:	This field describes the parameter code in terms of: • Start Position • End Posiiton • Code Size • Data Type • Applicable Range of Code
Interpretation:	This field provides the interpretation of the parameter value in terms of its significance and calibration to its physical value.
Dependencies:	This field describes the dependencies of the parameter with other parameters of the packet header in order to: • show relations with other header parameters which have to be consistent • extract additional information by combining with other parameters

Table 1.3-1: Definition of Parameter Field Description

1.4 Abbreviations

ADC	Analog to Digital Converter
BAQ	Block Adaptive Quantisation
BW	Bandwidth
Cal	Calibration
DCD	Digital Compression Device
DDC	Digital Downconversion
DFD	Digital Filter Device
EC	Entropy Coding
ECC	Event Control Code
EFE	Electronical Front End
FDBAQ	Flexible Dynamic Block Adaptive Quantisation
FE	(Antenna) Frontend
HW	Hardware
ID	Identity, Identification
Int	Integer
n/a	not applicable
NPM	Normal Pointing Mode
OCM	Orbit Control Mode
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
RDB	Radar Data Base
Rx	Receive
RxM	Rx Module
S-1	Sentinel 1
SAR	Synthetic Aperture Radar
SAS	SAR Antenna Subsystem
SES	SAR Electronics Subsystem
SP	Space Packet
SSB	Setting Selector Bus
SW	Software
SWL	Sample Window Length
SWST	Sample Window Start Time
Sync	Synchronisation
TA	(Antenna) Tile Amplifier
TBC	To be confirmed
TBD	To be defined
TC	Telecommand
TCM	Timing Control Module
Temp Comp	Temperature Compensation
TRM	Transmit Receive Module
Tx	Transmit
TxM	Tx Module
VBR	Variable Bit Rate

2 Documents

2.1 Parent Documents

[PD 01]	S1-RS-TASI-CS-0001	SAR Instrument Requirements Specification

2.2 Normative Reference Documents

[NRD 01]	S1-RS-ASD-PL-0002	SES Requirements Specification
[NRD 02]	S1-IF-TASI-SC-0002	Instrument to Spacecraft I/F Requirements (IF-8)

2.3 Informative Reference Documents

[IRD 01]	S1-DD-ASD-PL-0001	SAR Instrument Technical Description
[IRD 02]	S1-IF-ASU-PL-0006	SES Interface Control Document, Annex D
[IRD 03]	S1-DD-ASU-PL-0003	SES Internal Commanding Document
[IRD 04]	S1-MA-SSE-TX-0023	TxM Users Manual
[IRD 05]	S1-DD-ASU-PL-0019	ICE TCM Design Description
[IRD 06]	S1-DD-ASU-PL-0024	ICE Receive Module Design Description
[IRD 07]	S1-TN-ASD-PL-0046	Description of the Instrument Radar Database
[IRD 08]	S1-TN-ASU-PL-0023	SAR Data Decompression for S1

2.4 Standards

[SD 01]	CCSDS 133.0-B-1	Space Packet Protocol
[SD 02]	CCSDS 301.0-B-3	Time Code Formats

3 SAR Space Packet Format

The overall Sentinel-1 SAR Space Packet format is shown in Table 2.4-1 and has a total length which is a **multiple of 4 octets.** The format is detailed in the following subsections 3.1 to 3.3 .

Space Packet								
Packet Primary Header							***Packet Data Field***	
Packet Version Number	**Packet Identification**			**Packet Sequence Control**		**Packet Data Length**	**Packet Secondary Header**	**User Data Field**
	Packet Type	Secondary Header Flag	Application Process Identifier	Sequence Flags	Packet Sequence Count			
3 bits	1 bit	1 bit	11bits	2 bits	14 bits	16 bits	62 octets	variable length
6 octets							≤ 65534 octets	
Length = Multiple of 4 Octets								

Table 2.4-1: Overall Space Packet Format

3.1 Packet Primary Header

The Packet Primary Header format is shown in Table 3.1-1 with the parameters described in Table 3.1-2.

PACKET PRIMARY HEADER						
PACKET VERSION NUMBER	PACKET IDENTIFICATION			PACKET SEQUENCE CONTROL		PACKET DATA LENGTH
	PACKET TYPE	SEC. HDR. FLAG	APPLICATION PROCESS IDENTIFIER	SEQUENCE FLAGS	PACKET SEQUENCE COUNT OR PACKET NAME	
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	
2 octets				2 octets		2 octets

Table 3.1-1: Format of Packet Primary Header

Parameter		*Length*	*Value*	*Comment*
Packet Version Number		3 bits	000_{BIN} [1]	
Packet Type		1 bit	0_{BIN}	
Secondary Header Flag		1 bit	1_{BIN}	Secondary Header is present
Application Process Identifier	PID	7 bis	100 0001_{BIN} (65_{DEC})	Process ID
	PCAT	4 bits	1100_{BIN} (12_{DEC})	Packet Category
Sequence Flags		2 bits	11_{BIN}	user data are unsegmented
Packet Sequence Count		14 bits	actual count of space packet (modulo 16384)	• starts with "0" at start of measurement • counts all packets output by the Instrument to the platform • is an ambiguous count, that wraps to "0" after "16383"
Packet Data Length		16 bits	61 to 65533	number of octets in packet data field -1

Table 3.1-2: Primary Packet Header Values

3.2 Packet Secondary Header

The Packet Secondary Header has a length of $LEN_{SH} = 62$ octets. Following the standard [SD 01] it contains a Time Code Field and an Ancillary Data Field.

The Packet Secondary Header provides the information of a number of Services as shown in Table 3.2-1. Each Service field occupies an integer number of octets.

[1] "BIN" denotes binary representation of the value

Time Code Field	Datation Service
Ancillary Data Field	Fixed Ancillary Data Service
	Sub-commutation Ancillary Data Service
	Counters Service
	Radar Configuration Support Service
	Radar Sample Count Service

Table 3.2-1: Packet Secondary Header and its Services Fields

3.2.1 Datation Service

The Datation Service provides the time stamp for the packet datation. The time stamp value is a sample of the local instrument time at a specific event within the PRI where the packet data has been acquired.

The Datation Service field consists of 6 octets as shown in Table 3.2-2.

Octet Offset	bit							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
6	Coarse Time							
7								
8								
9								
10	Fine Time							
11								

Table 3.2-2: Datation Service Field

3.2.1.1 Coarse Time

Description:	The Coarse Time represents the time stamp of the Space Packet in units of integer seconds. Nominal time base is GPS time.				
Performance:	variable value during the data take				
Short Name:	$TCOAR$				
Code Name:	$TCOAR_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 6, bit 0	Octet 9, bit 7	32 bit	unsign.integer	0 … 2^{32}-1
Interpretation:	$TCOAR = TCOAR_{code}$ [s]				
Dependencies:	only incremented on availability of platform PPS				

3.2.1.2 Fine Time

Description:	The Fine Time represents the subsecond time stamp of the Space Packet.				
Performance:	variable value during the data take				
Short Name:	$TFINE$				
Code Name:	$TFINE_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 10, bit 0	Octet 11, bit 7	16 bit	unsigned int.	0 … 2^{16}-1
Interpretation:	$TFINE = TFINE_{code} \cdot 2^{-16}$ [s]				
Dependencies:	$TFINE_{code}$ restarted from “0” on incrementation of $TCOAR_{code}$. Note, that $TFINE_{code}$ and $TCOAR_{code}$ are registered (latched) times from Hardware clocks and sampled with PRF rate. Hence, due to time sampling with PRF, the $TFINE_{code}$ transition to “0” may not be observed and observed $TFINE_{code}$ value may already be >0 if a space packet indicates a transition of $TCOAR_{code}$.				

3.2.2 Fixed Ancillary Data Field

The Fixed Auxiliary Data Service consists of 14 octets as shown in Table 3.2-3. The data in this service remains invariant for the duration of the data-take.

<table>
<tr><th>Octet Offset</th><th colspan="8">bit</th></tr>
<tr><td></td><td>bit 0</td><td>bit 1</td><td>bit 2</td><td>bit 3</td><td>bit 4</td><td>bit 5</td><td>bit 6</td><td>bit 7</td></tr>
<tr><td>12</td><td colspan="8" rowspan="4">**Sync Marker**</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td><td colspan="8" rowspan="4">**Data Take ID**</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td><td colspan="8">**ECC Number**</td></tr>
<tr><td>21</td><td>**n/a**</td><td colspan="3">**Test Mode**</td><td colspan="4">**Rx Channel ID**</td></tr>
<tr><td>22</td><td colspan="8" rowspan="4">**Instrument Configuration ID**</td></tr>
<tr><td>23</td></tr>
<tr><td>24</td></tr>
<tr><td>25</td></tr>
</table>

Table 3.2-3: Fixed Auxiliary Data Service Field

3.2.2.1 Sync Marker

Description:	The Sync Marker represents a bit pattern to support (re-)synchronisation of packet data on Space Packet layer level (e.g. in case of corruptions or disruptions in a continuous stream of Space Packets)				
Performance:	constant value during the mission				
Short Name:	*SYNC*				
Code Name:	$SYNC_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 12, bit 0	Octet 15, bit 7	32 bit	unsigned int.	one static bit pattern
Interpretation:	$SYNC = 352\mathrm{E}\,\mathrm{F}853_{\mathrm{HEX}}$				
Dependencies:	none				

3.2.2.2 Data Take ID

Description:	The Data Take ID is supposed to support ground operations to track the E2E life cycle of a data take from the planning, commanding up to the downlinking and reception of the related Space Packets of the data take. The Data Take ID will be uplinked as part of the “Perform Measurement” and “Perform Test” TC. Selection of the Data Take ID is under ground control.				
Performance:	constant value during the data take				
Short Name:	*DTID*				
Code Name:	$DTID_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 16, bit 0	Octet 19, bit 7	32 bit	unsigned int.	0 … 2^{32}-1
Interpretation:	TBD by ESA/ESOC				
Dependencies:	none				

3.2.2.3 ECC Number

Description:	The ECC Number identifies the selected Measurement, Test or RF Characterisation mode.				
Performance:	constant value during the data take				
Short Name:	ECC				
Code Name:	ECC_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 20, bit 0	Octet 20, bit 7	8 bit	enumeration	0 … 47
Interpretation:					

ECC_{code}	Measurement/Test Mode	Comment
0	*contingency*	reserved for ground testing or mode upgrading
1	Stripmap 1	
2	Stripmap 2	
3	Stripmap 3	
4	Stripmap 4	
5	Stripmap 5-N	Used for ground imaging on northern hemisphere
6	Stripmap 6	
7	Extra Wide Swath	
8	Interferometric Wide Swath	
9	Wave Mode	Leapfrog mode using alternating vignettes at different incidence angles
10	Stripmap 5-S	Used for ground imaging on southern hemisphere
11-14	*contingency*	reserved for ground testing or mode upgrading
15	RFC mode	RFcharacterisation mode based on PCC sequences (PCC 512 for EFEs and PCC 32 for TAs)
16	- Test Mode Oper - Test Mode Bypass	There are two Test Mode variants which use the same ECC program. The Test Mode variant is defined by the parameter TSTMOD in 3.2.2.4
17	Elevation Notch	Elevation Notch in centre of S3 swath
18	Azimuth Notch S1	
19	Azimuth Notch S2	
20	Azimuth Notch S3	
21	Azimuth Notch S4	
22	Azimuth Notch S5-N	Used for Az. Notch Mode on northern hemisphere
23	Azimuth Notch S5-S	Used for Az. Notch Mode on southern hemisphere
14	Azimuth Notch S6	
17-31	*contingency*	reserved for ground testing or mode upgrading
32-47	*contingency*	reserved for ground testing or mode upgrading

Dependencies:	none

3.2.2.4 Test Mode

Description:	The Test Mode parameter indicates whether the space packet is generated by a Test mode or a Measurement mode. In case of a Test mode the parameter indicates the configuration of the test performed.				
Performance:	constant value during the data take				
Short Name:	*TSTMOD*				
Code Name:	$TSTMOD_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 21, bit 1	Octet 21, bit 3	3 bit	enumeration	see “Interpretation” field
Interpretation:					

$TSTMOD_{code}$ (binary)	**Interpretation**	**Description**
000	Default	in case of any Measurement Mode (i.e. no Test Mode)
001 to 011	n/a	n/a
100	contingency used for ground testing only	Test Mode configuration: • Data via ADC • RxM digital processing (DDC, DFD, DCD) fully operational • DCD compression as per BAQ Mode
101	contingency used for ground testing only	Test Mode configuration: • Data via ADC • RxM digital processing (DDC, DFD, DCD) fully bypassed
110	Test Mode “Oper”	Test Mode configuration: • Digital Test Pattern Stimuli input to DDC • RxM digital processing (DDC, DFD, DCD) fully operational • DCD compression as per BAQ Mode [1]
111	Test Mode “Bypass”	Test Mode configuration: • Digital Test Pattern Stimuli input to DDC • RxM digital processing (DDC, DFD, DCD) fully bypassed

Dependencies:	$TSTMOD \neq 0$ indicates a Test Mode. A Test Mode is also indicated by ECC_{code} =16. In Measurement modes *TSTMOD* =0 per default.

[1] Compression may be active or bypassed in Test Mode “Oper“, i.e. it will be active in case of PRIs with “non-calibration” signal types (echo or noise) and bypassed in case of PRIs with “calibration” signal types.

3.2.2.5 RX Channel ID

Description:	The Rx Channel ID identifies the Rx channel generating the packet data. Rx polarisation is and Rx channel are in fixed relation. Therefore, the Rx Channel ID also identifies the Rx polarisation of the channel (RxV-Pol. or RxH-Pol.)				
Performance:	constant value during the data take				
Short Name:	$RXCHID$				
Code Name:	$RXCHID_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 21, bit 4	Octet 21, bit 7	4 bit	boolean	0 or 1
Interpretation:	$RXCHID = \begin{cases} \text{RxV - Pol Channel} & \text{for} \quad RXCHID_{code} = 0 \\ \text{RxH - Pol Channel} & \text{for} \quad RXCHID_{code} = 1 \end{cases}$				
Dependencies:	Combined with the information of the Tx polarisation from the “Polarisation Field” (3.2.5.13.1.1) the overall Tx/Rx polarisation of the actual packet can be identified.				

3.2.2.6 Instrument Configuration ID

Description:	The Instrument Configuration ID is intended to support ground operations. It identifies in the Space Packets the onboard configuration of the Instrument under which the Instrument has operated and generated the data take. Knowledge of the configuration is a prerequisite for ground processing of the data take raw data. The Instrument configuration ID is a patchable Instrument parameter and is under control of ground operations. It has to be patched together with an Instrument configuration change. An Instrument configuration change is mainly induced by a change of the onboard Radar Data Base (RDB), e.g. change of beam tables, ECC programs, etc...				
Performance:	constant value during the data take				
Short Name:	$ICID$				
Code Name:	$ICID_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 22, bit 0	Octet 25, bit 7	32 bit	TBD	TBD
Interpretation:	TBD by ESA/ESOC				
Dependencies:	none				

3.2.3 Sub-commutated Ancillary Data Service

This service provides Spacecraft Ancillary Data in terms of S/C PVT and S/C Attitude Data periodically received from the platform.

The S/C ancillary data are defined in Table 3.2-4 and Table 3.2-5.

The update rate of the data is up to 1Hz which is much lower than the PRF rate of Space Packet generation. Hence, it is decided to sub-commutate the data in the Space Packet Secondary Header in portions of 16bit data words. For identification of the sub-commutated data words a 16bit word index is referenced to each word which is defined in Table 3.2-4 and Table 3.2-5 .

<table>
<tr><th colspan="3">PARAMETERS</th><th>Word Index</th></tr>
<tr><td colspan="3">16 bit Dummy Data</td><td>0</td></tr>
<tr><th colspan="3">PVT ANCILLARY DATA (organised in 16 bit words)</th><th></th></tr>
<tr><td rowspan="4">X- axis position ECEF in IEEE-754 double precision format (metres)</td><td colspan="2" rowspan="4">64 bit float</td><td>1</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td rowspan="4">Y- axis position ECEF in IEEE-754 double precision format (metres)</td><td colspan="2" rowspan="4">64 bit float</td><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td rowspan="4">Z- axis position ECEF in IEEE-754 double precision format (metres)</td><td colspan="2" rowspan="4">64 bit float</td><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td rowspan="2">X- velocity ECEF in IEEE-754 single precision format (metres/sec)</td><td colspan="2" rowspan="2">32 bit float</td><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td rowspan="2">Y- velocity ECEF in IEEE-754 single precision format (metres/sec)</td><td colspan="2" rowspan="2">32 bit float</td><td>15</td></tr>
<tr><td>16</td></tr>
<tr><td rowspan="2">Z- velocity ECEF in IEEE-754 single precision format (metres/sec)</td><td colspan="2" rowspan="2">32 bit float</td><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td rowspan="4">POD Solution Data Stamp in CCSDS CUC format (64-bit) - GPS Time
(see Table 3.2-6)</td><td>1</td><td>Unsigned 16 bit integer</td><td>19</td></tr>
<tr><td>2</td><td>Unsigned 16 bit integer</td><td>20</td></tr>
<tr><td>3</td><td>Unsigned 16 bit integer</td><td>21</td></tr>
<tr><td>4</td><td>Unsigned 16 bit integer</td><td>22</td></tr>
</table>

Table 3.2-4: S/C PVT Ancillary Data Table

S/C ATTITUDE ANCILLARY DATA (organised in 16 bit words)			Word Index
Q0 Attitude Quaternion	32 bit float		23
			24
Q1 Attitude Quaternion	32 bit float		25
			26
Q2 Attitude Quaternion	32 bit float		27
			28
Q3 Attitude Quaternion	32 bit float		29
			30
S/C ωx angular rate [rad/sec]	32 bit float		31
			32
S/C ωy angular rate [rad/sec]	32 bit float		33
			34
S/C ωz angular rate [rad/sec]	32 bit float		35
			36
Data Time Stamp in CCSDS CUC format (64-bit) - GPS Time (see Table 3.2-6)	1	Unsigned 16 bit integer	37
	2	Unsigned 16 bit integer	38
	3	Unsigned 16 bit integer	39
	4	Unsigned 16 bit integer	40
Pointing Status	16 bit		41

Table 3.2-5: S/C Attitude Ancillary Data Table

The **<u>reference frames</u>** for the S/C Attitude Quaternions and the S/C angular rates as given in [NRD 02] are as follows:

- the S/C Attitude Quaternions represent the S/C attitude wrt. the Orbital Reference Frame which, in NPM/OCM, is the Zero-Doppler Reference Frame. Q0 is the real component and Q1, Q2, Q3 are the vector components of the Attitude Quaternion.
- the S/C inertial angular rate vector is measured in the Body Fixed Reference Frame.

bit→	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
word index 37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}
word index 38	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
word index 39	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}
word index 40	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}

Table 3.2-6: S/C Ancillary Data GPS Time Stamp Format (in units of seconds)

	msb															lsb
bit→	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
word index 41	AOCS OP Mode								n/a					RE	PE	YE

Table 3.2-7: Pointing Status Format

with

Parameter	Description	Value
AOCS OP Mode	AOCS Operational Mode	0: no mode 5: NPM (Normal Pointing Mode) 6: OCM (Orbit Control Mode) other values are not applicable
RE	Roll Error Status	0: roll axis is fine pointed 1: roll axis is degraded
PE	Pitch Error Status	0: pitch axis is fine pointed 1: pitch axis is degraded
YE	Yaw Error Status	0: yaw axis is fine pointed 1: yaw axis is degraded

Table 3.2-8 shows the Service field of the Sub-commutation Service providing the Data Word Index and the corresponding Data Word.

Octet Offset	bit							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
26	**Sub-commutated Ancillary Data Word Index**							
27	**Sub-commutated Ancillary Data Word**							
28								

Table 3.2-8: Sub-commutation Ancillary Data Service Field

3.2.3.1 Sub-commutated Ancillary Data Word Index

Description:	The Sub-commutated Ancillary Data Word Index is a rotating index which identifies the actual 16bit data word (see Table 3.2-4 and Table 3.2-5) in the sub-commutation frame of the Service field. A combined PVT/Attitude data set consists of 41 data words which are subcommutated in a sequence of SAR packet headers in the sequence from 1 to 41 with one word per packet header. To each word the corresponding word index (1 to 41) is assigned in the packet header which identifies the significance of the data word. ***A complete and consistent set of PVT or Attitude data is always represented by a contiguous sequence of the word indices in the relevant data set, i.e. 1 to 22 for PVT data and 23 to 41 for Attitude data (note also, that both data sets have their own time stamp).*** A word index value equal "0" will indicate invalidity of the inserted data word. A new PVT/Attitude data set is received from the platform each second. During the short time of downloading of a new data set to RxM the insertion of the old data into the header stops and the word index as well as the data word are set to value "0". This indicates that there are no PVT/Attitude data available in the header. When the download of the new data set is completed, insertion into packet headers restarts with the new PVT/Attitude data at index=1.				
Performance:	variable value during the data take				
Short Name:	$ADWIDX$				
Code Name:	$ADWIDX_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 26, bit 0	Octet 26, bit 7	8 bit	unsigned int.	0 … 41
Interpretation:	$ADWIDX = ADWIDX_{code}$ identifies the index of a 16 bit word of the combined PVT/Attitude Ancillary Data (see indices in Table 3.2-4 and Table 3.2-5). $ADWIDX_{code} = 0$ if no Ancillary Data are available in the beginning or during the data take. $ADWIDX_{code} = [1...41]$ will range from 1 to 41 if Ancillary Data are available and will be incremented by 1 for each space packet. It will wrap to 1 after 41.				
Dependencies:	Values of $ADWIDX_{code}$ and ADW_{code} are in fixed relation. ADW_{code} is not applicable for $ADWIDX_{code} = 0$ which represents the case of inactive or suspended service (no reception of Ancillary Data from platform).				

3.2.3.2 Sub-commutated Ancillary Data Word

Description:	The Sub-commutated Ancillary Data Word is a 16bit data word of the S/C Ancillary Data set (see Table 3.2-4 and Table 3.2-5) identified by $ADWIDX$.				
Performance:	variable value during the data take				
Short Name:	ADW				
Code Name:	ADW_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 27, bit 0	Octet 28, bit 7	16 bit	variable	variable
Interpretation:	The interpretation of ADW depends on the value of $ADWIDX_{code}$. The format and physical units of the ADW values can be referenced in Table 3.2-4 and Table 3.2-5 by index $ADWIDX_{code}$.				
Dependencies:	Values of $ADWIDX_{code}$ and ADW_{code} are in fixed relation.				

3.2.4 Counters Service

The Counters Service provides two counters, the Space Packet Count and the PRI Count as shown in Table 3.2-9.

Octet Offset	**bit**							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
29	**Space Packet Count**							
30								
31								
32								
33	**PRI Count**							
34								
35								
36								

Table 3.2-9: Counters Service Field

3.2.4.1 Space Packet Count

Description:	In nominal operation, the Space Packet Count represents the actual count of Space Packets output by the Instrument from the beginning of the data take. It will be a continuous count and supports simple checking for completeness of the number of Space Packets to be expected by nominal SAR Measurement Mode execution. **Exception:** In anomaly cases that result from a failure to generate a SAR Data space packet caused by • RxM FIFO overflow caused by a data rate exceeding 640 Mbps • or Packet length overflow • or both the counter will increment but not be transmitted because the output of failed Space Packets will be suppressed by the SAR Instrument during the recovery. In such an anomaly case, the Space Packet Count observed by the user in the received packets will not be continuous. In this case the number of missing counts of the Mode PRI Count (see 3.2.4.2) indicates the exact number of Space Packets lost during the anomaly condition [1]. The Instrument autonomously resumes nominal operation after the failure conditions. **Anomaly Detection:** An anomaly has occured if $SPCT$ increments >1 between adjacent packets k-1 and k. The number N of lost packets during the anomaly is: $N = PRICT_k - PRICT_{k-1} - 1$ with $PRICT_k$: the first packet after the anomaly $PRICT_{k-1}$: the last packet before the anomaly
Performance:	variable value during the data take
Short Name:	$SPCT$
Code Name:	$SPCT_{code}$

Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 29, bit 0	Octet 32, bit 7	32 bit	unsigned int.	0 … 2^{32}-1

Interpretation:	$SPCT = SPCT_{code}$ $SPCT_{code}$ is a progressive count incremented by “1” for each generated Space Packet. $SPCT_{code}$ starts with value “0” at the first Space Packet of the data take. $SPCT_{code}$ wraps to “0” after 2^{32}-1.
Dependencies:	none

[1] The number of missing counts in the Space Packet Count may be ambiguous due to the complexity of the internal recovery process. Therefore, the number of missing Mode PRI counts shall be used as a precise indicator of missing packets.

3.2.4.2 Mode PRI Count

Description:	The PRI Count represents the actual count of PRIs generated by the Instrument from the beginning of the data take (ECC execution). In the series of down-linked space packets the PRI Count may appear as a broken count between downlinked packets. Such a broken PRI Count is an indicator that space packet generation has been suppressed in the Instrument for a number of PRIs. During nominal operation suppression of space packet generation is a common means during a data take to avoid generation of useless packets which would otherwise burden data storage and downlink budgets. Examples for suppression of useless packets are e.g. during PRIs: • for warmup or stabilisation • to fade out any undesired signals from travelling Tx pulses and their echoes before performing a noise measurement Example: *SPCT* | … | s | s+1 | s+2 | s+3 | s+4 | s+5 | s+6 | … *PRICT* | … | p | p+1 | p+2 | p+16 | p+17 | p+18 | p+19 | … Between Space Packets (s+2) and (s+3) there is a gap of 13 PRIs for which no Space Packets have been recorded.
Performance:	variable value during the data take
Short Name:	*PRICT*
Code Name:	$PRICT_{code}$
Code Properties	**Start Position:** Octet 33, bit 0; **End Position:** Octet 36, bit 7; **Size of Code:** 32 bit; **Data Type:** unsigned int.; **Applicable Range of Code:** 0 … 2^{32}-1
Interpretation:	$PRICT = PRICT_{code}$ $PRICT_{code}$ is a count incremented by "1" for each PRI of the data take. It may be a broken count in the stream of recorded Space Packets. $PRICT_{code}$ wraps to "0" after 2^{32}-1. In the first generated space packet of the data take $PRICT_{code}$ starts with a value >0 since TxM gain stabilisation and optional Frontend warm-up take place in the very beginning of ECC execution for a number of PRIs with suppression of space packet generation.
Dependencies:	$PRICT_{code}$ of the first space packet of a data take (i.e. the $PRICT_{code}$ offset in first space packet) depends on ECC_{code} and on optional Frontend warm-up. Occurence of Frontend warm-up is not flagged in the space packet annotated data, so, the $PRICT_{code}$ offset value can not be predicted.

Example table:

SPCT	…	s	s+1	s+2	s+3	s+4	s+5	s+6	…
PRICT	…	p	p+1	p+2	p+16	p+17	p+18	p+19	…

Code Properties:

Start Position:	End Position:	Size of Code	Data Type	Applicable Range of Code:
Octet 33, bit 0	Octet 36, bit 7	32 bit	unsigned int.	0 … 2^{32}-1

3.2.5 Radar Configuration Support Service

The Radar Configuration Support Service provides the reporting of the radar configuration parameters that are applicable to the associated measurement data (i.e. the User Data) contained in the packet.

The Radar Configuration Support Service consists of the fields shown in Table 3.2-10.

Octet Offset	bit							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
37	**Error Flag**	**n/a**		**BAQ Mode**				
38	**BAQ Block Length**							
39	**n/a**							
40	**Range Decimation**							
41	**Rx Gain**							
42	**Tx Ramp Rate**							
43								
44	**Tx Pulse Start Frequency**							
45								
46	**Tx Pulse Length**							
47								
48								
49	**n/a**			**Rank**				
50	**PRI**							
51								
52								
53	**SWST**							
54								
55								
56	**SWL**							
57								
58								
59	**SAS SSB Message**							
60								
61								
62	**SES SSB Message**							
63								
64								

Table 3.2-10: Radar Configuration Support Service Field

3.2.5.1 Error Flag

Description:	The Error Flag indicates a parity error in the SES SSB message received by the RxM for the current packet.				
Performance:	should be always “0”. Value “1” indicates a non-nominal situation.				
Short Name:	$ERRFLG$				
Code Name:	$ERRFLG_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 37, bit 0	Octet 37, bit 0	1 bit	boolean	0,1
Interpretation:	$ERRFLG_{code} = \begin{cases} 0 & \text{for nominal condition} \\ 1 & \text{for SES-SSB message parity error} \end{cases}$ In case of $ERRFLG_{code} = 1$ the actual packet contents is inconsistent and the packet shall be discarded (not to be used for SAR image generation).				
Dependencies:	None				

3.2.5.2 BAQ Mode

Description:	The BAQ Mode indicates the mode of operation of the FDBAQ compression.				
Performance:	variable value during the data take (different values between signal types “Echo”, Noise” and “Calibration” but constant value within each signal type)				
Short Name:	$BAQMOD$				
Code Name:	$BAQMOD_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 37, bit 3	Octet 37, bit 7	5 bit	enumeration	0 … 31
Interpretation:	(see table below)				
Dependencies:	Following dependencies exist with respect to $SIGTYP_{code}$: • Calibration data ($SIGTYP_{code}$ >7, all $CALTYP_{code}$) are only with $BAQMOD_{code}$ =0 • Noise data ($SIGTYP_{code}$ =1) are only with $BAQMOD_{code}$ =0 or 3 or 4 or 5 • For Echo data ($SIGTYP_{code}$ =0) all $BAQMOD_{code}$ are allowed				

Interpretation:

$BAQMOD_{code}$	$BAQMOD$	Comment
0	BYPASS MODE	
1 to 2	-	not applicable
3	BAQ 3-BIT MODE	No EC
4	BAQ 4-BIT MODE	No EC
5	BAQ 5-BIT MODE	No EC
6 to 11	-	not applicable
12	FDBAQ Mode 0	nominal FDBAQ
13	FDBAQ Mode 1	FDBAQ with first alternative rate selection thresholds
14	FDBAQ Mode 2	FDBAQ with second alternative rate selection thresholds
15 to 31	-	not applicable

3.2.5.3 BAQ Block Length

Description:	The BAQ Block Length is the number of complex radar samples per BAQ block. The BAQ block represents a data block for which the quantisation is adapted according to the block statistics.				
Performance:	constant value during the data take				
Short Name:	$BAQBL$				
Code Name:	$BAQBL_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 38, bit 0	Octet 38, bit 7	8 bit	unsigned int.	31
Interpretation:	$BAQBL = 8 \cdot (BAQBL_{code} + 1)$ Only one operational value $BAQBL$=256 is applicable for Sentinel-1 operation.				
Dependencies:	none				

3.2.5.4 Range Decimation

Description:	The Range Decimation indicates the used LowPass filter and down-sampling ratio for decimation of the radar data in the sampling window according to the needed mode bandwidth. The resulting Sampling Frequency after decimation applies to that of the SAR user data in the Space Packet.				
Performance:	variable value during the data take (different values between swathes but constant value within each swath)				
Short Name:	$RGDEC$				
Code Name:	$RGDEC_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 40, bit 0	Octet 40, bit 7	8 bit	enumeration	0 … 11
Interpretation:	$RGDEC_{code}$ is equivalent to the selected Filter No.				

$RGDEC_{code}$ (Filter No.)	Decimation Filter Bandwidth [MHz]	Decimat. Ratio L/M	Sampling Frequency f_{dec} after Decimation [MHz]	Filter Length N_F [Samples]	SAR Swath
0	100.00	$\frac{3}{4}$	$f_{dec} = \frac{3}{4} \cdot 4 \cdot f_{ref}$	28	Full Bandwidth
1	87.71	$\frac{2}{3}$	$f_{dec} = \frac{2}{3} \cdot 4 \cdot f_{ref}$	28	S1, WV1
2	n/a	n/a	n/a	n/a	n/a
3	74.25	$\frac{5}{9}$	$f_{dec} = \frac{5}{9} \cdot 4 \cdot f_{ref}$	32	S2
4	59.44	$\frac{4}{9}$	$f_{dec} = \frac{4}{9} \cdot 4 \cdot f_{ref}$	40	S3
5	50.62	$\frac{3}{8}$	$f_{dec} = \frac{3}{8} \cdot 4 \cdot f_{ref}$	48	S4
6	44.89	$\frac{1}{3}$	$f_{dec} = \frac{1}{3} \cdot 4 \cdot f_{ref}$	52	S5
7	22.2	$\frac{1}{6}$	$f_{dec} = \frac{1}{6} \cdot 4 \cdot f_{ref}$	92	EW1
8	56.59	$\frac{3}{7}$	$f_{dec} = \frac{3}{7} \cdot 4 \cdot f_{ref}$	36	IW1
9	42.86	$\frac{5}{16}$	$f_{dec} = \frac{5}{16} \cdot 4 \cdot f_{ref}$	68	S6, IW3
10	15.1	$\frac{3}{26}$	$f_{dec} = \frac{3}{26} \cdot 4 \cdot f_{ref}$	120	EW2, EW3, EW4, EW5
11	48.35	$\frac{4}{11}$	$f_{dec} = \frac{4}{11} \cdot 4 \cdot f_{ref}$	44	IW2, WV2

with $f_{ref} = 37.53472224$ [MHz].

Note: Filter Length N_F is given for a sampling frequency of $4 \cdot f_{ref}$

Dependencies:	the selected decimation filter influences the number of complex samples after decimation (i.e. the number of complex samples in the Space Packet)

3.2.5.5 Rx Gain

Description:	The Rx Gain indicates the applied value of the commandable Rx attenuation in the receiver channel of the SES.				
Performance:	variable value during the data take (different values between swathes but constant value within each swath)				
Short Name:	RXG				
Code Name:	RXG_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 41, bit 0	Octet 41, bit 7	8 bit	unsigned int.	0 … 63
Interpretation:	$RXG = -0.5 \cdot RXG_{code}$ [dB] RXG values in the range from 0 to -31.5dB.				
Dependencies:	none				

3.2.5.6 Tx Pulse Ramp Rate

<table>
<tr><td>Description:</td><td colspan="5">The Tx Pulse Ramp Rate indicates the linear FM rate at which the frequency changes over the pulse duration.
The parameter value refers to the Tx pulse transmitted in the PRI when the SAR echo data of this Space Packet have been sampled. Hence, due to the travel time from Tx pulse transmission to its echo reception this parameter does not describe the originating Tx pulse of the SAR echo data of this packet. The number of PRIs occuring from Tx pulse transmission to echo reception is defined by parameter “Rank” (see 3.2.5.9). Hence, the Tx pulse parameter fitting to the (transmit) properties of the SAR echo data in the actual packet can be found in the packet generated “Rank” PRIs earlier (constant PRI assumed).</td></tr>
<tr><td>Performance:</td><td colspan="5">variable value during the data take (different values between swathes but constant value within each swath)</td></tr>
<tr><td>Short Name:</td><td colspan="5">$TXPRR$</td></tr>
<tr><td>Code Name:</td><td colspan="5">$TXPRR_{code}$</td></tr>
<tr><td rowspan="2">Code Properties</td><td>Start Position:</td><td>End Position:</td><td>Size of Code</td><td>Data Type</td><td>Applicable Range of Code:</td></tr>
<tr><td>Octet 42, bit 0</td><td>Octet 43, bit 7</td><td>16 bit</td><td>code</td><td>0 … 65535</td></tr>
<tr><td>Interpretation:</td><td colspan="5">$TXPRR_{code}[0]$ (bit 0 of $TXPRR_{code}$) denotes the polarity of the ramp rate $TXPRR$.
$TXPRR_{code}[1:15]$ (bit 1…15 of $TXPRR_{code}$) denotes the magnitude of the ramp rate $TXPRR$.

$TXPRR_{code}[0] = 0$ for transmitted Down-Chirp
$TXPRR_{code}[0] = 1$ for for transmitted Up-Chirp

The sign of the ramp rate can be expressed in terms of the polarity $P = TXPRR_{code}[0]$:
$S = \begin{cases} 0 & \text{for } P = 1 \\ 1 & \text{for } P = 0 \end{cases}$

The signed ramp rate $TXPRR$ is then:
$TXPRR = (-1)^S \cdot TXPRR_{code}[1:15] \cdot \frac{f_{ref}^2}{2^{21}}$ in [MHz/us]

with
$f_{ref} = 37.53472224$ [MHz]</td></tr>
<tr><td>Dependencies:</td><td colspan="5">none</td></tr>
</table>

3.2.5.7 Tx Pulse Start Frequency

<table>
<tr><td>Description:</td><td colspan="5">The Tx Pulse Start Frequency indicates the start frequency of the pulse.
The parameter value refers to the Tx pulse transmitted in the PRI when the SAR echo data of this Space Packet have been sampled. Hence, due to the travel time from Tx pulse transmission to its echo reception this parameter does not describe the originating Tx pulse of the SAR echo data of this packet. The number of PRIs occuring from Tx pulse transmission to echo reception is defined by parameter “Rank” (see 3.2.5.9). Hence, the Tx pulse parameter fitting to the (transmit) properties of the SAR echo data in the actual packet can be found in the packet generated “Rank” PRIs earlier (constant PRI assumed).</td></tr>
<tr><td>Performance:</td><td colspan="5">variable value during the data take (different values between swathes but constant value within each swath)</td></tr>
<tr><td>Short Name:</td><td colspan="5">$TXPSF$</td></tr>
<tr><td>Code Name:</td><td colspan="5">$TXPSF_{code}$</td></tr>
<tr><td rowspan="2">Code Properties</td><td>Start Position:</td><td>End Position:</td><td>Size of Code</td><td>Data Type</td><td>Applicable Range of Code:</td></tr>
<tr><td>Octet 44, bit 0</td><td>Octet 45, bit 7</td><td>16 bit</td><td>code</td><td>-22527 … +22527</td></tr>
<tr><td>Interpretation:</td><td colspan="5">$TXPSF_{code}[0]$ (bit 0 of $TXPSF_{code}$) denotes the polarity of $TXPSF$
$TXPSF_{code}[1:15]$ (bit 1…15 of $TXPSF_{code}$) denotes the magnitude of $TXPSF$

$TXPSF_{code}[0] = 0$ for negative start frequency
$TXPSF_{code}[0] = 1$ for positive frequency

The sign of the start frequency be expressed in terms of the polarity $P = TXPSF_{code}[0]$:
$$S = \begin{cases} 0 & \text{for } P = 1 \\ 1 & \text{for } P = 0 \end{cases}$$
The start frequency $TXPSF$ includes an additive term contributing from the ramp rate $TXPRR$.
With this, $TXPSF$ is defined:
$$TXPSF = \frac{TXPRR}{4 \cdot f_{ref}} + (-1)^S \cdot TXPSF_{code}[1:15] \cdot \frac{f_{ref}}{2^{14}}$$ in [MHz]
with
$f_{ref} = 37.53472224$ [MHz]</td></tr>
<tr><td>Dependencies:</td><td colspan="5">none</td></tr>
</table>

3.2.5.8 Tx Pulse Length

<table>
<tr><td>Description:</td><td colspan="5">The Tx Pulse Length indicates the transmit duration of the Tx pulse.
The parameter value refers to the Tx pulse transmitted in the PRI when the SAR echo data of this Space Packet have been sampled. Hence, due to the travel time from Tx pulse transmission to its echo reception this parameter does not describe the originating Tx pulse of the SAR echo data of this packet. The number of PRIs occuring from Tx pulse transmission to echo reception is defined by parameter “Rank” (see 3.2.5.9). Hence, the Tx pulse parameter fitting to the (transmit) properties of the SAR echo data in the actual packet can be found in the packet generated “Rank” PRIs earlier (constant PRI assumed).</td></tr>
<tr><td>Performance:</td><td colspan="5">variable value during the data take (different values between swathes but constant value within each swath)</td></tr>
<tr><td>Short Name:</td><td colspan="5">$TXPL$</td></tr>
<tr><td>Code Name:</td><td colspan="5">$TXPL_{code}$</td></tr>
<tr><td rowspan="2">Code Properties</td><td>Start Position:</td><td>End Position:</td><td>Size of Code</td><td>Data Type</td><td>Applicable Range of Code:</td></tr>
<tr><td>Octet 46, bit 0</td><td>Octet 48, bit 7</td><td>24 bit</td><td>unsigned int.</td><td>128 … 4223</td></tr>
<tr><td>Interpretation:</td><td colspan="5">$TXPL$ in units of time:
$TXPL = \frac{TXPL_{code}}{f_{ref}}$ [us] with $f_{ref} = 37.53472224$ [MHz]
Accordingly, $TXPL$ can be expressed in units of samples depending on the sampling frequency at the different stages of the digital processing in the Instrument RxM:
<table><tr><th>Stage</th><th>Applicability</th><th>Number of Tx Samples</th></tr><tr><td>1</td><td>number of real Tx Pulse samples at ADC output</td><td>$N1_{Tx} = 8 \cdot TXPL_{code}$</td></tr><tr><td>2</td><td>number of complex Tx Pulse samples (I/Q pairs) at output of DDC</td><td>$N2_{Tx} = 4 \cdot TXPL_{code}$</td></tr><tr><td>3</td><td>number of complex Tx pulse samples (I/Q pairs) after the decimation (i.e. in Space Packet)</td><td>$N3_{Tx} = ceil[TXPL \cdot f_{dec}]$
with sampling frequency f_{dec} after decimation according to 3.2.5.4</td></tr></table>Note: ceil() is rounding to next higher integer value</td></tr>
<tr><td>Dependencies:</td><td colspan="5">none</td></tr>
</table>

3.2.5.9 Rank

Description:	The Rank indicates the number of PRIs between Tx pulse transmission and the reception of the corresponding echo from the swath of interest. The parameter value refers to the PRI value of the present space packet.				
Performance:	variable value during the data take (different values between swathes but constant value within each swath)				
Short Name:	$RANK$				
Code Name:	$RANK_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 49, bit 3	Octet 49, bit 7	5 bit	unsigned int.	0 … 31
Interpretation:	$RANK = RANK_{code}$				
Dependencies:	Rank depends on PRI and on the distance to the imaged swath.				

3.2.5.10 Pulse Repetition Interval

Description:	The PRI indicates the interval between transmission of Tx pulses.				
Performance:	variable value during the data take (different values between swathes but constant value within each swath)				
Short Name:	PRI				
Code Name:	PRI_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 50, bit 0	Octet 52, bit 7	24 bit	unsigned int.	0 … 2^{24}-1
Interpretation:	$PRI = \frac{PRI_{code}}{f_{ref}}$ [us] with $f_{ref} = 37.53472224$ [MHz]				
Dependencies:	none				

3.2.5.11 Sampling Window Start Time

Descriptio-n:	The Sampling Window Start Time defines the start time of the sampling window within the PRI for non-calibration signals.
Performance:	variable value during the data take (different values between swathes and varying vaues within each swath)
Short Name:	$SWST$
Code Name:	$SWST_{code}$

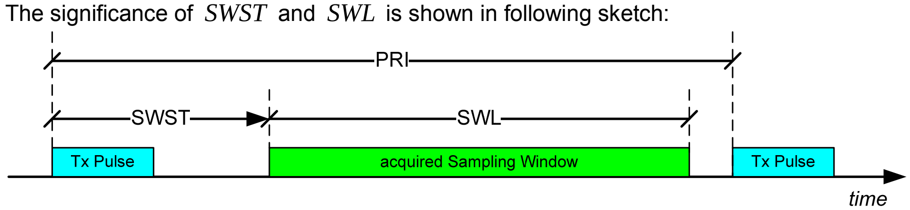
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 53, bit 0	Octet 55, bit 7	24 bit	unsigned int.	0 … 2^{24}-1

Interpretation:

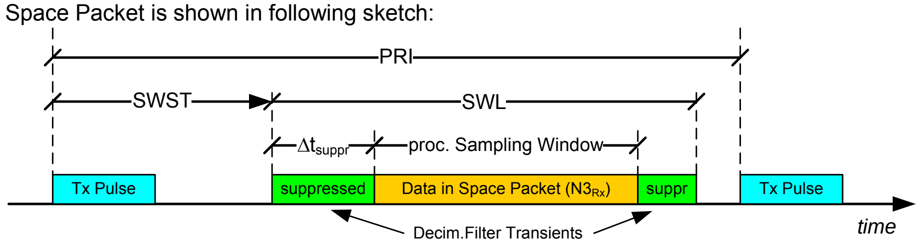
$SWST$ in units of time:

$$SWST = \frac{SWST_{code}}{f_{ref}} \text{ [us] with } f_{ref} = 37.53472224 \text{ [MHz]}$$

The significance of $SWST$ and SWL is shown in following sketch:



The part of the acquired (commanded) sampling window which is processed and captured in the Space Packet is shown in following sketch:



The Decimation Filter suppresses the FIR filter transients in the acquired sampling window. The captured data in the Space Packet correspond to the data sampled Δt_{suppr} after the start of the acquired sampling window.

$$\Delta t_{suppr} = \frac{320}{8 \cdot f_{ref}} \text{ and } N3_{Rx} \text{ as given in 3.2.5.12}$$

$SWST$ is not applicable for calibration signals ($SIGTYP_{code}$ >7).

The acquisition timing for calibration signals is shown in the Annex section 5.3.

Dependencies: none

3.2.5.12 Sampling Window Length

<table>
<tr><td>Description:</td><td colspan="5">The Sampling Window Length defines the duration of the acquired sampling window within the PRI for non-calibration signals.</td></tr>
<tr><td>Performance:</td><td colspan="5">variable value during the data take (different values between swathes and varying vaues within each swath)</td></tr>
<tr><td>Short Name:</td><td colspan="5">SWL</td></tr>
<tr><td>Code Name:</td><td colspan="5">SWL_{code}</td></tr>
<tr><td rowspan="2">Code Properties</td><td>Start Position:</td><td>End Position:</td><td>Size of Code</td><td>Data Type</td><td>Applicable Range of Code:</td></tr>
<tr><td>Octet 56, bit 0</td><td>Octet 58, bit 7</td><td>24 bit</td><td>unsigned int.</td><td>0 … 2^{24}-1</td></tr>
<tr><td>Interpretation:</td><td colspan="5">
SWL in units of time:
$SWL = \frac{SWL_{code}}{f_{ref}}$ [us] with $f_{ref} = 37.53472224$ [MHz] (see also figures in 3.2.5.11)
Accordingly, SWL can be expressed in units of samples depending on the sampling frequency at the different stages of the digital processing in the Instrument RxM:
<table>
<tr><th>Stage</th><th>Applicability</th><th>Number of Rx Samples</th></tr>
<tr><td>1</td><td>Number of real ADC samples at output of ADC</td><td>$N1_{Rx} = 8 \cdot SWL_{code}$</td></tr>
<tr><td>2</td><td>Number of complex samples (I/Q pairs) at output of DDC</td><td>$N2_{Rx} = 4 \cdot SWL_{code}$</td></tr>
<tr><td>3</td><td>Number of complex samples (I/Q pairs) after decimation (i.e. in the Space Packet).
The number of samples depends not only on SWL but also on the selected filter and its related parameters:
• $RGDEC_{code}$
• L
• M
• FilterOutputOffset</td><td>$N3_{Rx} = 2 \cdot \left(L \cdot \mathrm{int}\left[\frac{B}{M}\right] + D + 1 \right)$
with parameters L and M according to 3.2.5.4
with $B = 2 \cdot SWL_{Code} - FilterOutputOffset - 17$
with FilterOutputOffset according to Table 5.1-2
with D as a function of $C = B - M \cdot \mathrm{int}\left[\frac{B}{M}\right]$
D is to be addressed as function of C in Table 5.1-1</td></tr>
</table>
SWL is applicable for all Signal Types ($SIGTYP_{code}$).
The acquisition timing for calibration signals is shown in the Annex section 5.3.
</td></tr>
<tr><td>Dependencies:</td><td colspan="5">none</td></tr>
</table>

3.2.5.13 SAS SSB Data Field

The SAS SSB Data field indicates the actual configuration of the SAS. The content of the SAS SSB Data field will have one of two possible interpretations depending on whether the Instrument is performing an Imaging/Noise operation or a Calibration operation. This is indicated by the value of a Flag in the SAS SSB data field (see Table 3.2-11).

Octet Offset	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
59	SSBFLAG	SAS SSB Data						
60	SAS SSB Data							
61	SAS SSB Data							

Table 3.2-11: SAS SSB Data Field

Description:	The Flag in the SAS SSB message indicates both, the type of the message and the related operation (imaging/noise or calibration) commanded to the SAS.				
Performance:	variable value during the data take				
Short Name:	*SSBFLAG*				
Code Name:	$SSBFLAG_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 59, bit 0	Octet 59, bit 0	1 bit	boolean	0 or 1
Interpretation:	$SSBFLAG = \begin{cases} \text{Imaging or Noise Operation} & \text{for} \quad SSBFLAG_{code} = 0 \\ \text{Calibration Operation} & \text{for} \quad SSBFLAG_{code} = 1 \end{cases}$				
Dependencies:	none				

3.2.5.13.1 SAS SSB Data Field – Imaging/Noise

In case of the Flag="**0**" the content of the SAS SSB data field is to be interpreted for an Imaging/Noise operation as shown in Table 3.2-12.

Octet Offset	bit							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
59	**SSBFLAG = 0**	**Polarisation**			**Temp Comp**		**n/a**	
60	**Elevation Beam Address**				**n/a**		**< - - - - - - - - -**	
61	**- - - - - - - - - - - - - - Azimuth Beam Address - - - - - - - - - - - - - >**							

Table 3.2-12: SAS SSB Data (Imaging/Noise)

3.2.5.13.1.1 Polarisation

Description:	The Polarisation defines the configuration of the polarisation.				
Performance:	constant value during the data take				
Short Name:	*POL*				
Code Name:	POL_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 59, bit 1	Octet 59, bit 3	3 bit	enumeration	0 … 7

Interpretation:

POL_{code}	Polarisation		Notes
	Tx	Rx	
0	H	-	Tx Only, Horizontal
1	H	H	RxH is co-polar
2	H	V	RxV is cross-polar
3	H	V+H	RxH is co-polar, RxV is cross-polar
4	V	-	Tx Only, Vertical
5	V	H	RxH is cross-polar
6	V	V	RxV is co-polar
7	V	V+H	RxH is cross-polar, RxV is co-polar

Note:

In the Dual Polarisation case (POL_{code} =3 or POL_{code} =7) the parameter *RXCHID* (3.2.2.5) the indicates the Rx polarisation of the actual Space Packet.

Dependencies:

There are following dependencies:

POL_{code}	*RXCHID*
0	n/a
1	1
2	0
3	0 or 1
4	n/a
5	1
6	0
7	0 or 1

3.2.5.13.1.2 Temperature Compensation

Description:	The Temperature Compensation indicates the activity of temperature compensation in the SAS.				
Performance:	variable value during the data take				
Short Name:	*TCMP*				
Code Name:	$TCMP_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 59, bit 4	Octet 59, bit 5	2 bit	enumeration	0 … 3
Interpretation:	see table below				
Dependencies:	none				

$TCMP_{code}$	*TCMP* **Description**
0	Temperature Compensation Antenna FE: **OFF** Temperature Compensation Antenna TA: **OFF**
1	Temperature Compensation Antenna FE: **ON** Temperature Compensation Antenna TA: **OFF**
2	Temperature Compensation Antenna FE: **OFF** Temperature Compensation Antenna TA: **ON**
3	Temperature Compensation Antenna FE: **ON** Temperature Compensation Antenna TA: **ON**

3.2.5.13.1.3 Elevation Beam Address

Description:	The Elevation Beam Address addresses the beam excitation coefficients in elevation selected in actual PRI.				
Performance:	variable value during the data take for other modes than Stripmap				
Short Name:	*EBADR*				
Code Name:	$EBADR_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 60, bit 0	Octet 60, bit 3	4 bit	unsigned int.	0 … 15
Interpretation:	$EBADR = EBADR_{code}$ identifies one of 16 available Elevation beams that is applied in actual PRI for the SAR imaging of the actual mode swath.				
Dependencies:	none				

3.2.5.13.1.4 Azimuth Beam Address

Description:	The Azimuth Beam Address addresses the beam excitation coefficients in azimuth selected in actual PRI.				
Performance:	variable value during the data take for other modes than Stripmap and Wave				
Short Name:	*ABADR*				
Code Name:	$ABADR_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 60, bit 6	Octet 61, bit 7	10 bit	unsigned int.	0 … 1023
Interpretation:	$ABADR = ABADR_{code}$ identifies one of 1024 available Azimuth beams that is applied in actual PRI for the SAR imaging of the actual mode swath.				
Dependencies:	none				

3.2.5.13.2 SAS SSB Data - Calibration

In case of the Flag="**1**" the content of the SAS SSB data field is to be interpreted for a Calibration operation as shown in Table 3.2-13.

Octet Offset	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
59	**SSBFLAG = 1**	**Polarisation**			**Temp Comp**		**n/a**	
60	**SASTest**	**Cal Type**			**n/a**		**< - - - - - - - - -**	
61	**- - - - - - - - - - - - Calibration Beam Address - - - - - - - - - - - - - >**							

Table 3.2-13: SAS SSB Data (Calibration)

3.2.5.13.2.1 Polarisation

See section 3.2.5.13.1.1

3.2.5.13.2.2 Temperature Compensation

See section 3.2.5.13.1.2

3.2.5.13.2.3 SAS Test Mode

Description:	The SAS Test Mode parameter is a specific mode for onground testing that allows to operate the Antenna Frontend with a specific pattern of disabled TRMs. The SAS Test Mode is only applicable during calibration operation. Application of SAS Test Mode is not planned for nominal in-orbit operation (i.e. nominal $SASTM_{code}$ =1).				
Performance:	constant value during the data take				
Short Name:	$SASTM$				
Code Name:	$SASTM_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 60, bit 0	Octet 60, bit 0	1 bit	boolean	0 or 1
Interpretation:	$SASTM = \begin{cases} \text{SAS Test Mode active} & \text{for} \quad SASTM_{code} = 0 \\ \text{normal calibration mode} & \text{for} \quad SASTM_{code} = 1 \end{cases}$				
Dependencies:	(see table below)				

$SASTM_{code}$	$SSBFLAG_{code}$	$CALMOD_{code}$	$SIGTYP_{code}$	Comment
0	1	don’t care	≥8	SAS Test Mode active
1	1	all applicable	≥8	normal calibration

3.2.5.13.2.4 Cal Type

Description:	The Cal Type defines the type of applied internal calibration operation in actual PRI. There are several internal calibration operations which are characterised by the different routings of the cal signal through the RF network.				
Performance:	variable value during the data take				
Short Name:	*CALTYP*				
Code Name:	$CALTYP_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 60, bit 1	Octet 60, bit 3	3 bit	enumeration	0 … 7
Interpretation:	see table below				
Dependencies:	*CALTYP* is part of the parameter *SIGTYP* (see 3.2.5.14.3) and is identical with the values for *SIGTYP* > 7. Calibration data ($CALTYP_{code}$ >7) are only with $BAQMOD_{code}$ =0				

$CALTYP_{code}$	*CALTYP* Description	Notes
0	Tx Cal	
1	Rx Cal	
2	EPDN Cal	
3	TA Cal	
4	APDN Cal	
5 to 6	-	not applicable
7	EPDN Cal Iso	used for EPDN Cal Isolation measurement

3.2.5.13.2.5 Calibration Beam Address

Description:	The Calibration Beam Address addresses the beam excitation coefficients for a calibration operation selected in actual PRI.				
Performance:	variable value during the data take				
Short Name:	*CBADR*				
Code Name:	$CBADR_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 60, bit 6	Octet 61, bit 7	10 bit	unsigned int.	0 … 1023
Interpretation:	*CBADR* = $CBADR_{code}$ identifies one of 1024 available Calibration beams, that is applied in actual PRI for standard calibration or as part of RF characterisation by means of PCC coded calibration beam sequences.				
Dependencies:	none				

3.2.5.14 SES SSB Data Field

The SES SSB data field indicates the actual SES configuration. The SES SSB data field is shown in Table 3.2-14.

Octet Offset	Bit Offset							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
62	**Cal Mode**		**n/a**	**Tx Pulse Number**				
63	**Signal Type**				**n/a**			**Swap**
64	**Swath Number**							

Table 3.2-14: SES SSB Data Field

3.2.5.14.1 Calibration Mode

Description:	The Calibration Mode is information which is only relevant in case of a calibration operation. It indicates the type of PCC sequence applied for the actual calibration operation.				
Performance:	constant value during the data take				
Short Name:	*CALMOD*				
Code Name:	$CALMOD_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 62, bit 0	Octet 62, bit 1	2 bit	enumeration	0 … 3
Interpretation:	(see table below)				
Dependencies:	$CALMOD_{code}$ =0 and 1 applies for internal calibration within SAR measurement modes based on a PCC2 sequence $CALMOD_{code}$ = 2 and 3 applies for dedicated RFC mode (ECC_{code} =15). Don't care *CALMOD* in case of $SSBFLAG_{code}$=0 (see 3.2.5.13.1) and $SIGTYP_{code}$ <2 (see 3.2.5.14.3).				

Interpretation:

$CALMOD_{code}$	*CALMOD* Description	Comment
0	Interleaved Internal Calibration based on **PCC2** sequence	supports monitoring of Phase/Gain drift in Imaging Modes
1	Internal Calibration in Preamble/ Postamble based on **PCC2** sequence	used for Replica extraction and generation in Imaging Modes
2	Phase Coded Characterisation based on **PCC32** sequence	used for characterisation of Tile Amplifiers in RFC Mode
3	Phase Coded Characterisation based on **PCC512** sequence	used for characterisation of Tile EFE TRMs in RFC Mode

3.2.5.14.2 Tx Pulse Number

<table>
<tr><td>Description:</td><td colspan="5">The Tx Pulse Number defines the address of the Tx Pulse selected in the Chirp Generator of the SES.
The parameter value refers to the Tx pulse transmitted in the PRI when the SAR echo data of this Space Packet have been sampled. Hence, due to the travel time from Tx pulse transmission to its echo reception this parameter does not describe the originating Tx pulse of the SAR echo data of this packet. The number of PRIs occuring from Tx pulse transmission to echo reception is defined by parameter “Rank” (see 3.2.5.9). Hence, the Tx pulse parameter fitting to the (transmit) properties of the SAR echo data in the actual packet can be found in the packet generated “Rank” PRIs earlier (constant PRI assumed).</td></tr>
<tr><td>Performance:</td><td colspan="5">variable value during the data take (different values between swathes but constant value within each swath)</td></tr>
<tr><td>Short Name:</td><td colspan="5">$TXPNO$</td></tr>
<tr><td>Code Name:</td><td colspan="5">$TXPNO_{code}$</td></tr>
<tr><td rowspan="2">Code Properties</td><td>Start Position:</td><td>End Position:</td><td>Size of Code</td><td>Data Type</td><td>Applicable Range of Code:</td></tr>
<tr><td>Octet 62, bit 3</td><td>Octet 62, bit 7</td><td>5 bit</td><td>unsigned int.</td><td>0 … 31</td></tr>
<tr><td>Interpretation:</td><td colspan="5">$TXPNO = TXPNO_{code}$ identifies the Tx pulse applied in actual PRI.</td></tr>
<tr><td>Dependencies:</td><td colspan="5">The related Tx pulse parameters are given in 3.2.5.6, 3.2.5.7 and 3.2.5.8.</td></tr>
</table>

3.2.5.14.3 Signal Type

Description:	The Signal Type defines the kind of signal acquired in the actual PRI (e.g. echo, noise, calibration …).				
Performance:	variable value during the data take				
Short Name:	*SIGTYP*				
Code Name:	$SIGTYP_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 63, bit 0	Octet 63, bit 3	4 bit	enumeration	0 … 15
Interpretation:	(see table below)				
Dependencies:	*SIGTYP* for $SIGTYP_{code}$ >7 corresponds to *CALTYP* (see 3.2.5.13.2.4). Calibration data ($SIGTYP_{code}$ >7) are only with $BAQMOD_{code}$ =0 Noise data ($SIGTYP_{code}$ =1) are only with $BAQMOD_{code}$ =0 or 3 or 4 or 5				

Interpretation:

$SIGTYP_{code}$	*SIGTYP* Description	Notes
0	Echo	Radar echo signal (nominal SAR imaging)
1	Noise	Noise measurement
2 to 7	-	not applicable
8	Tx Cal	
9	Rx Cal	
10	EPDN Cal	
11	TA Cal	
12	APDN Cal	
13 to 14	-	not applicable
15	EPDN Cal Iso	used for EPDN Cal Isolation measurement

3.2.5.14.4 Swap Flag

Description:	The transiton of the Swap Flag indicates the event of potential updating of dynamic swath parameters.				
Performance:	variable value during the data take (see notes in below)				
Short Name:	$SWAP$				
Code Name:	$SWAP_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 63, bit 7	Octet 63, bit 7	1 bit	boolean	0 or 1
Interpretation:	The transition of $SWAP_{code}$ from “0” to “1” and vice versa indicates the potential updating of values of one or more of the following parameters as a result of varying flight altitude round the orbit: • $TXPNO$ • $TXPL$ • $TXPSF$ • $TXPRR$ • $RGDEC$ • SWL • $SWST$ • PRI • $RANK$ The update occurs at the PRI that indicates the transition of $SWAP$. Note 1: The $SWAP$ flag indicates updating of parameters by the implemented Instrument update mechanism, however, the updated parameter need not to change values. Note 2: The Instrument implementation allows updating of all above parameters. However, the actual measurement mode design has been optimised, so that only $SWST$ and SWL are planned to change values in a swath along the data take. Note 3: The above parameters will also change due to the transitions between subswathes in measurement modes in EW, IW and Wave . These changes are indicated by transitions of the swath number $SWATH$ (see 3.2.5.14.5).				
Dependencies:	none				

3.2.5.14.5 Swath Number

Description:	The Swath Number indicates the swath in use in the actual PRI.				
Performance:	variable value during the data take				
Short Name:	*SWATH*				
Code Name:	$SWATH_{code}$				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 64, bit 0	Octet 64, bit 7	8 bit	unsigned int.	0 … 127
Interpretation:	$SWATH = SWATH_{code}$ The swath number *SWATH* identifies an ensemble of swath specific radar parameters: • *TXPNO* • *TXPL* • *TXPSF* • *TXPRR* • *RGDEC* • *SWL* • *SWST* • *PRI* • *RANK* • *RXGAIN* • *EBADR*				
Dependencies:	none				

3.2.6 Radar Sample Count Service

Octet Offset	bit							
	bit 0	bit 1	bit 2	bit 3	bit 4	bit 5	bit 6	bit 7
65	**Number of Quads (NQ)**							
66								
67	**n/a**							

Table 3.2-15: Radar Sample Count Service Field

Description:	A Quad is defined as a quadrupel of sample values, namely: • 1 I-Part even sample value • 1 I-part odd sample value • 1 Q-Part even sample value • 1 Q-part odd sample value A complex radar sample is composed of one I-part and one Q-part sample value, respectively. Consequently, the number of overall complex radar samples in the packet can be expressed as the doubled value of the Number of Quads.				
Performance:	variable value during the data take				
Short Name:	NQ				
Code Name:	NQ_{code}				
Code Properties	**Start Position:**	**End Position:**	**Size of Code**	**Data Type**	**Applicable Range of Code:**
	Octet 65, bit 0	Octet 66, bit 7	16 bit	unsigned int.	0 … 52378 [1]
Interpretation:	$NQ = NQ_{code}$ The number $NSAMP$ of complex radar samples can be expressed as $NSAMP = 2 \cdot NQ$				
Dependencies:	none				

[1] The upper limit of the applicable range is based on a min. FDBAQ bitrate of 2.5. This leads to the max. possible number of samples $NSAMP_{\max} \cong (65534 - 62) octets \cdot 8 bit / (2 \cdot 2.5 bit) \cong 104755$ and with this $NQ_{\max} \cong 52378$

3.3 User Data Field

3.3.1 User Data Field Length

The User Data Field may have a variable length LEN_{UD} from PRI to PRI. The total length LEN_{SP} of the Space Packet is always a multiple of 4 octets.

LEN_{SP} is composed of following contributions:

$$LEN_{SP} = LEN_{PH} + LEN_{SH} + LEN_{UD}$$

with

LEN_{SP} : Total Length of Space Packet

LEN_{PH} : Length of Primary Header (6 octets)

LEN_{SH} : Length of Secondary Header (62 octets)

LEN_{UD} : Variable Length of User Data Field

With the parameter "Packet Data Length" (PDL) in the Packet Primary Header (see Table 3.1-1) LEN_{UD} can be expressed as:

$$LEN_{UD} = PDL - LEN_{SH} + 1$$

Since $LEN_{PH} + LEN_{SH} = 68\,\text{octets}$ is a multiple of 4 octets, LEN_{UD} also has to be a multiple of 4 octets to ensure that the total Space Packet length LEN_{SP} is a multiple of 4 octets.

3.3.2 User Data Format Types

The User Data Field contains one of four different format types of digitized data. The different format types are the result of applying or bypassing specific digital processing functions in the Instrument digital Rx chain.

For each format type the ADC and SAR Packetisation functions are always active. They cannot be bypassed. The term "digital processing functions" hereafter refers only to those functions that can be controlled for bypassing.

Table 3.3-1 gives an overview of the possible data format types for the different types of acquired SAR data.

Table 3.3-2 lists the criteria for identification of the data format types in the User Data Field.

The detailed data formats together with the decoding algorithms are described in section 4.

		Data Format Types				
		A	B	C	D	
		Bypass Data	Decimation Only	Decimation + BAQ	Decimation + FDBAQ (including EC)	
User Data	SAR Echo Data			**X**	**X**	Format Type D will be the nominal option
	SAR Calibration Data		**X**			Calibration Data only in Format Type B
	SAR Noise Data		**X**	**X**	**X**	For noise data different format options may be applicable
	Test Mode Data	**X**	**X**	**X**	**X**	For test mode data all format options may be applicable

Table 3.3-1: SAR Data versus Data Format Type

Data Format Type	$BAQMOD_{code}$ (3.2.5.1)	$TSTMOD_{code}$ (3.2.2.4)	Comment
A	0	5;7	only in Test Mode
B	0	0;4;6	$TSTMOD_{code}$ = 0 indicates measurement mode operation
C	3;4;5	0;4;6	$TSTMOD_{code}$ = 0 indicates measurement mode operation
D	12;13;14	0;4;6	$TSTMOD_{code}$ = 0 indicates measurement mode operation

Table 3.3-2: Data Format Type Identification

3.3.2.1 Data Format Type A "Bypass"

This format type refers to digitized data with all digital processing functions in the Rx chain bypassed (see Fig. 3-1). Typically, this format type is output in Test Mode for test and debugging purposes.

Fig. 3-1: Active Functions for Bypass applied

3.3.2.2 Data Format Type B "Decimation Only"

This format type refers to digitized data with digital downconversion and decimation function applied (see Fig. 3-2). The data are digitally downconverted to baseband, low pass filtered and down-sampled accordingly. Typically, this format type is output during the acquisiton of calibration data.

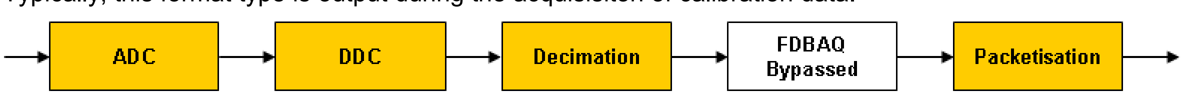


Fig. 3-2: Active Functions for "Decimation only" applied

3.3.2.3 Data Format Type C "Decimation + BAQ"

This format type refers to digitized data with all digital processing functions applied except the Entropy Coder (see Fig. 3-3). This format type is not foreseen for typical nominal operation. It offers a fix BAQ quantisation (not FDBAQ) with a fixed number of bits (according to *BAQMOD*) and without using the Entropy Coding and hence, without the impact of a VBR (variable bit rate).

Fig. 3-3: Active Functions for "Decimation + BAQ" applied

3.3.2.4 Data Format Type D "Decimation + FDBAQ"

This format type refers to digitized data with all digital processing functions active (see Fig. 3-4). The FDBAQ introduces a VBR compression. This format type is nominally used to output radar echo data.

Fig. 3-4: Active Functions for "Decimation + FDBAQ" applied

3.3.3 User Data Organisation

The user data are originating from a number of ADC samples per PRI which are digitally processed in the Instrument SES Rx chain in 4 data channels. Consequently, the user data are organised in the Space Packet User Data Field as 4 individual data sections.

The data channels/sections are defined in Table 4-1:

Channel /Section	Description	Comment
IE	I-parts of Even Samples	In-Phase Components originating from Decimation Filter even output samples 0, 2, 4, 6 ...[1]
IO	I-parts of Odd Samples	In-Phase Components originating from Decimation Filter odd output samples 1, 3, 5, 7 ...
QE	Q-parts of Even Samples	Quadrature Components originating from Decimation Filter even output samples 0, 2, 4, 6 ...
QO	Q-parts of Odd Samples	Quadrature Components originating from Decimation Filter odd output samples 1, 3, 5, 7 ...

Table 3.3-3: SAR Data Channel Definition

[1] The terminology "even" and "odd" samples originates from the Hardware counting scheme of the Decimation Filter which starts with the sample count=0 per PRI. So, e.g. the (demultiplexed) counts 0, 2,4,6,… represent the "even" samples or "even" channel and the (demultiplexed) counts 1,3,5,… the "odd" samples or "odd" channel.
In section 4, for reasons of description, the sample enumeration is always starting with sample or code number=1 for each channel.

The data sections are aligned to an integer number of 16 bit words. The sections may have different sizes in case of FDBAQ and BAQ compression applied. E.g. in these cases some sections include extra control information which are not contained in other sections. In addition, the FDBAQ compression function provides a variable bit rate in each of the 4 data channels which leads to variable data volumes.

However, the number of SAR data samples in each data section will be the same.

The number of complex samples in the packet (sampled at the output of the Decimation Filter) is recorded as a 16bit parameter value NQ (Number of Quads) which is part of the Radar Samples Count Service (section 3.2.6). The number of complex radar samples in the packets is expressed in terms of so-called “Quads” where a Quad is defined as:

1 Quad = 1 IE sample + 1 IO sample + 1 QE sample + 1 QO sample.

Consequently, the total number of complex radar samples equals **2*NQ** (see also section 3.2.6).

Table 3.3-4 shows the overview of the sequence of the packetized data sections in the User Data Field.

IE channel Data **(data section may be padded with filler bits to complete last 16 bit word)**
IO Channel Data **(data section may be padded with filler bits to complete last 16 bit word)**
QE Channel Data **(data section may be padded with filler bits to complete last 16 bit word)**
QO Channel Data **(data section may be padded with filler bits to complete last 16 bit word)**
Filler **(2 filler octets may be padded to make overall Space Packet length a multiple of 4 octets)**

Table 3.3-4: Overview of Packetisation in User Data Field

Each of the four data sections (IE, IO, QE, QO) contains NQ code elements which are packed as a number of 16bit words.

In case the NQ code elements of a section do not end at a 16 bit word boundary, filler bits will be padded in the section up to the next word boundary.

For specific data format types specific sections also contain interleaved control information needed for the decoding process. The details for this are described in the decoding section 4.

Finally, the total number of octets in the User Data Field must be divisible by 4. In case the cumulated number of 16bit words in the four data sections would become an odd number two filler octets will be attached at the end of the User Data Field to make its length a multiple of 4 octets.

4 User Data Field Decoding

4.1 General

4.1.1 Notations used for Decoding

NRL	Normalised Reconstruction Level
SF	Sigma Factor
$THIDX$	Threshold Index
BRC	Bit Rate Code
H_{Code}	Huffman Code (Sign + Huffman coded Magnitude)
M_{Code}	Magnitude Code
M_{Value}	Magnitude Value
S_{Code}	Sample Code
S_{Value}	Sample Value
NQ	Number of Quads
NB	Number of BAQ Blocks
NW	Number of (16bit) Words
$Sign$	Sign
b	BAQ Block Index
k	Number of Quantisation Levels for Quantisation of Magnitude

4.1.2 Principle of Decoding

The principle of decoding a compressed radar sample (I- or Q-component) is shown in Fig. 4-1.

For "Bypass" or "Decimation Only" user data (format types A and B) a specific radar sample value reconstruction is not needed since the magnitude code (M_{Code}) of the sample is identical with the magnitude value (M_{Value}).

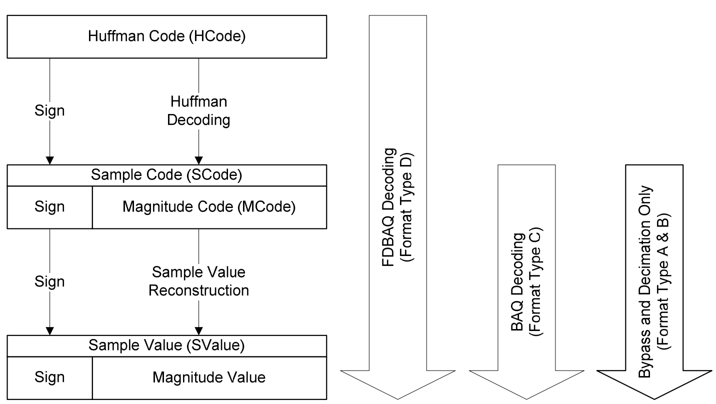


Fig. 4-1: Principle of Decoding of Compression Code

4.2 Decoding of Data Format Type A and B (“Bypass” or “Decimation Only”)

The Data Format Type A and B is described in Table 4.2-1.

IE SCode 1	IE SCode 2	IE SCode 3	...			...	IE SCode NQ	Dummies
10 bits	10 bits	10 bits	...			...	10 bits	**Filler Bits**
	Word 1 (16bit)		...	Word 2 (16bit) ...	... ...	...	Word NW (16bit)	
IO SCode 1	IO SCode 2	IO SCode 3	...			...	IO SCode NQ	Dummies
10 bits	10 bits	10 bits	...			...	10 bits	**Filler Bits**
	Word 1 (16bit)		...	Word 2 (16bit) ...	... ...	...	Word NW (16bit)	
QE SCode 1	QE SCode 2	QE SCode 3	...			...	QE SCode NQ	Dummies
10 bits	10 bits	10 bits	...			...	10 bits	**Filler Bits**
	Word 1 (16bit)		...	Word 2 (16bit) ...	... ...	...	Word NW (16bit)	
QO SCode 1	QO SCode 2	QO SCode 3	...			...	QO SCode NQ	Dummies
10 bits	10 bits	10 bits	...			...	10 bits	**Filler Bits**
	Word 1 (16bit)		...	Word 2 (16bit) ...	... ...	...	Word NW (16bit)	

Table 4.2-1: Packetisation for Data Format Type A and B

The number NW of 16bit words in each channel is the same and is given by:

$$NW = ceil\left[\frac{10}{16} \cdot NQ\right]$$

The 10bit sample code (SCode) consists of 1 bit sign followed by 9 bit Magnitude Code (MCode).

The reconstruction of a sample value in each of the IE, IO, QE, QO channels is:

$$S_{Value} = (-1)^{Sign} \cdot M_{Code} \cdot$$

Example:

SCode(binary) = 10 1011 1100 bin

SCode w/o sign = MCode = 188

Sign =1

SValue = -188

Sample Alignment:

The sequence of the complex samples in the PRI rangeline will be obtained by arranging the sample values of the 4 channels (IE,IO,QE,QO) in the following way:

$$complex\_S_{Value}(2 \cdot j - 1) = [IE\_S_{Value}(j); QE\_S_{Value}(j)]$$
$$complex\_S_{Value}(2 \cdot j) = [IO\_S_{Value}(j); QO\_S_{Value}(j)]$$
$$\text{for} \quad j = 1,2,3 \ldots NQ$$

4.3 Decoding of Data Format Type C ("Decimation + BAQ")

The Data Format Type C is similar to that of as described in section 4.2. However, the SCodes are shorter due to BAQ compression.

In addition, within the channel data sections, the BAQ encoded data are organised in BAQ blocks. Each BAQ block has an 8-bit Threshold Index associated with it that is included in the QE channel data.

The arrangement of the format type C data is shown in Table 4.3-1.

The number NB of BAQ Blocks is

$$NB = ceil\left[\frac{2 \cdot NQ}{256}\right]$$

The number NW of 16bit words in the IE, IO and QO channels is:

$$NW_{IE,IO,QO} = \begin{cases} ceil\left[\frac{3 \cdot NQ}{16}\right] & \text{for 3bit BAQ} \\ ceil\left[\frac{4 \cdot NQ}{16}\right] & \text{for 4bit BAQ} \\ ceil\left[\frac{5 \cdot NQ}{16}\right] & \text{for 5bit BAQ} \end{cases}$$

The number NW of 16bit words in the QE channel is different from that of the other channels since it includes the 8bit Threshold Index value for each BAQ block:

$$NW_{QE} = \begin{cases} ceil\left[\frac{3 \cdot NQ + 8 \cdot NB}{16}\right] & \text{for 3bit BAQ} \\ ceil\left[\frac{4 \cdot NQ + 8 \cdot NB}{16}\right] & \text{for 4bit BAQ} \\ ceil\left[\frac{5 \cdot NQ + 8 \cdot NB}{16}\right] & \text{for 5bit BAQ} \end{cases}$$

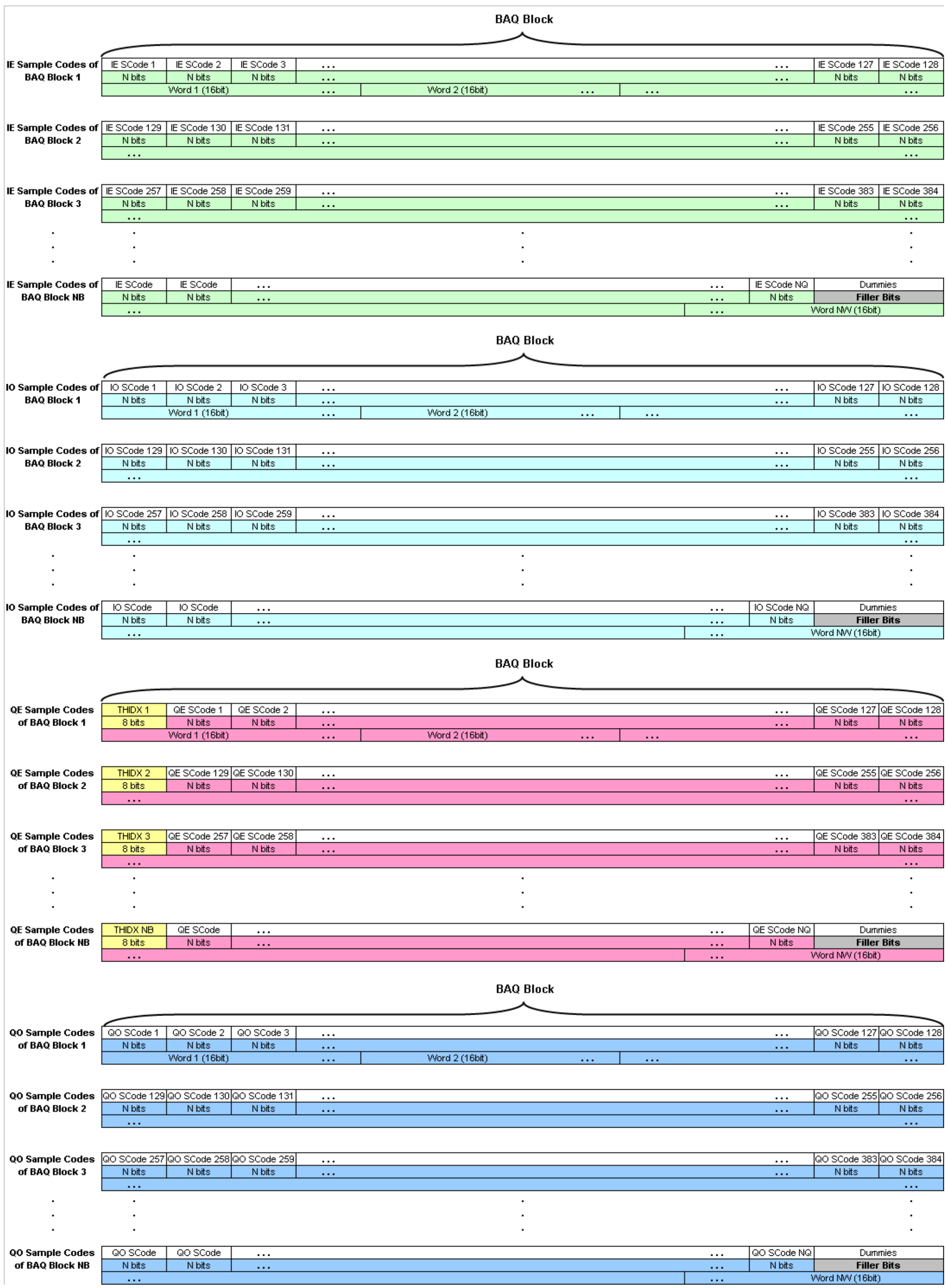


Table 4.3-1: Packetisation of Format Type C User Data Field (for N bit BAQ with N∈[3; 4; 5])

The proposed decoding scheme of the User Data Field of a Space Packet is shown in Fig. 4-2 with the SCode extraction shown in Fig. 4-3 and sample value reconstruction shown in Fig. 4-4.

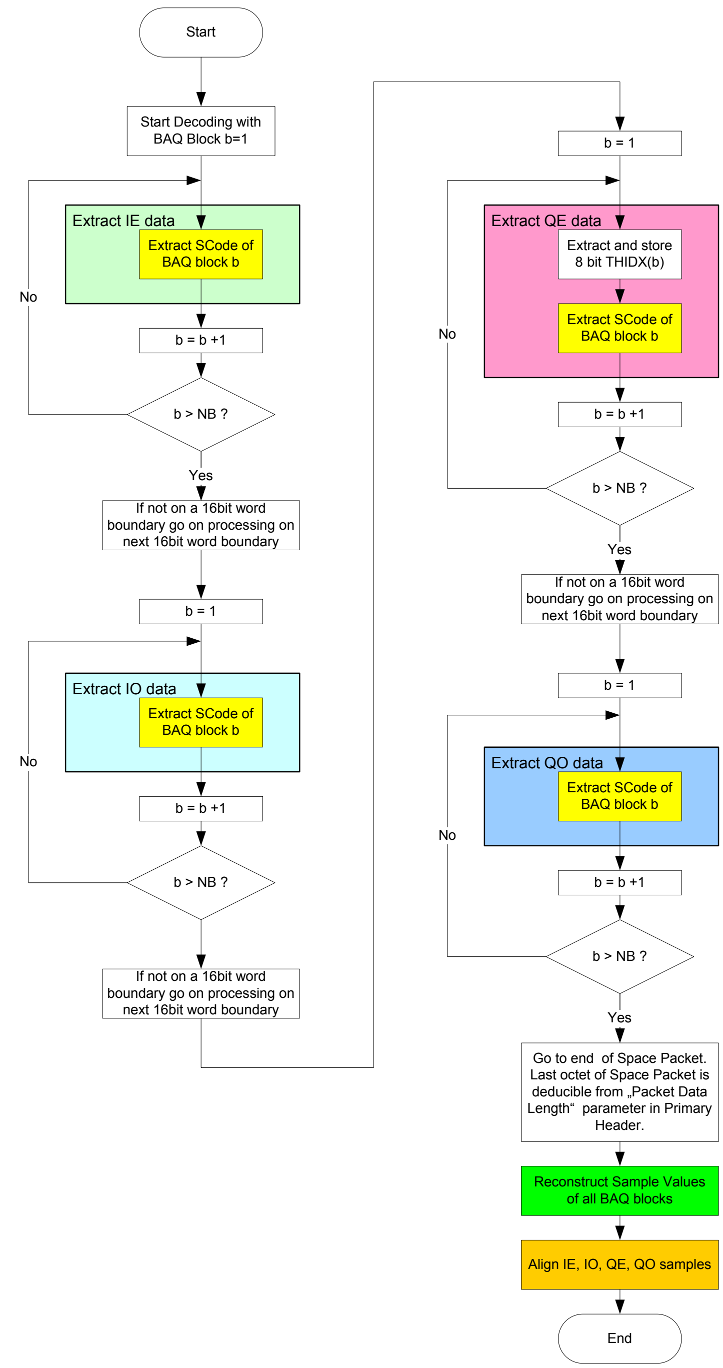


Fig. 4-2: Proposed Decoding of Data Format Type C

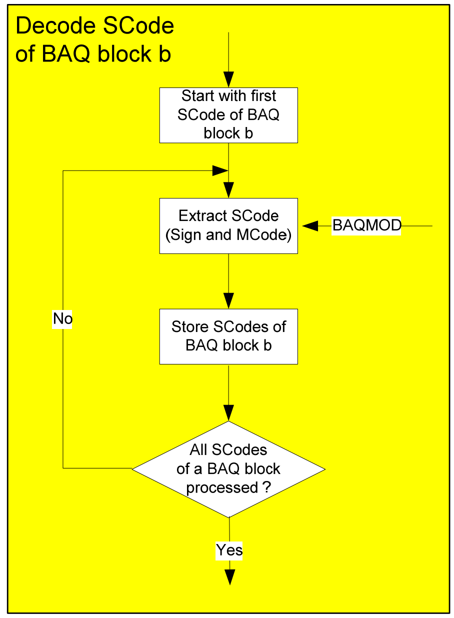


Fig. 4-3: SCode Extraction per BAQ Block b

Each of the NB BAQ blocks contains 128 SCodes except the last BAQ block which contains $NQ - 128 \cdot (NB - 1)$ SCodes.

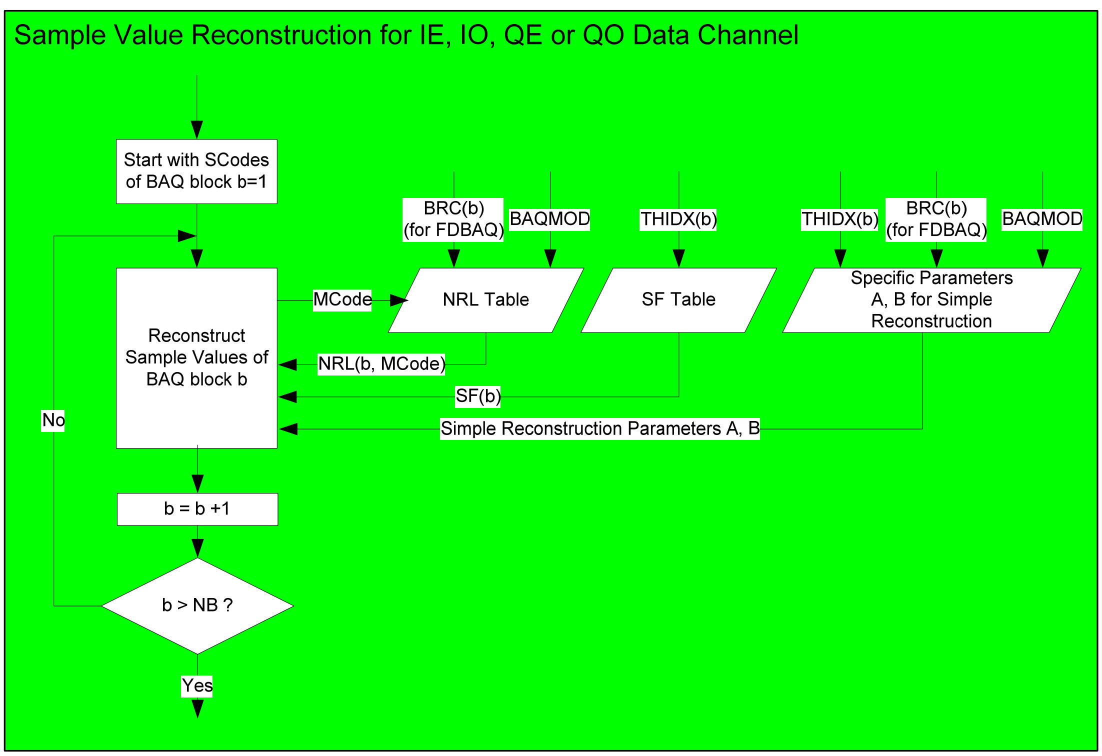


Fig. 4-4: Sample Value Reconstruction from SCode

The sample value reconstruction in Fig. 4-4 is performed either as a Simple Reconstruction or a Nominal Reconstruction depending on the value the Threshold Index *THIDX* of the BAQ block *b*.

The detailed sample reconstruction law for all BAQ modes is defined as follows:

$$S_{Value} = \begin{cases} \text{for 3bit BAQ} & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 6 : \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 3 \\ (-1)^{Sign} \cdot A3_{THIDX} & \text{for } M_{Code} = 3 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 6 : (-1)^{Sign} \cdot NRL_{BAQMOD=3, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\ \text{for 4bit BAQ} & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 9 : \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 7 \\ (-1)^{Sign} \cdot A4_{THIDX} & \text{for } M_{Code} = 7 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 9 : (-1)^{Sign} \cdot NRL_{BAQMOD=4, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\ \text{for 5bit BAQ} & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 16 : \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 15 \\ (-1)^{Sign} \cdot A5_{THIDX} & \text{for } M_{Code} = 15 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 16 : (-1)^{Sign} \cdot NRL_{BAQMOD=5, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \end{cases}$$

The values $A3_{THIDX}$, $A4_{THIDX}$ and $A5_{THIDX}$ depend on the value *THIDX* and are defined in the Annex section 5.2.1.

The values NRL and SF are to be addresed in the corresponding tables in the Annex section 5.2.2.

Example 1 (normal reconstruction):

3bit BAQ (BAQMOD=3)

THIDX=130

SCode = 6

SCode(binary) = 110 bin

Sign =1

MCode=2

NRL=1.344

SF=100.58

$$S_{Value} = (-1)^1 \cdot 1.344 \cdot 100.58 = -135.1795$$

Example 2 (simple reconstruction):

5bit BAQ (BAQMOD=5)

THIDX=13

SCode = 27

SCode (binary) = 11011 bin

Sign =1

MCode=11

$$S_{Value} = (-1)^1 \cdot 11 = -11$$

Example 3 (simple reconstruction):

5bit BAQ (BAQMOD=5)

THIDX=13

SCode = 15

SCode (binary) = 01111 bin

Sign =0

MCode=15

$$S_{Value} = (+1)^0 \cdot A5_{THIDX=13} = 17.7598$$

Sample Alignment:

The sequence of the complex samples in the PRI rangeline will be obtained by arranging the sample values of the 4 channels (IE, IO, QE, QO) in the following way:

$$complex\_S_{Value}(2 \cdot j - 1) = [IE\_S_{Value}(j); QE\_S_{Value}(j)]$$
$$complex\_S_{Value}(2 \cdot j) = [IO\_S_{Value}(j); QO\_S_{Value}(j)]$$
$$\text{for} \quad j = 1,2,3 \ldots NQ$$

4.4 Decoding of Data Format Type D ("Decimation + FDBAQ")

The data of format type D is also structured in BAQ blocks as described in section 4.3.

However, the format type D data is Huffman encoded which introduces a non-predictable variable length HCode in each BAQ block.

The arrangement of the format type D data is shown in Table 4.4-1. Values for HCode lengths and numbers NW are given with "question marks" in the table because they are not predicitable and have to be determined during the Huffman decoding process (see Fig. 4-6, Fig. 4-7, Fig. 4-8, Fig. 4-9, Fig. 4-10, Fig. 4-11).

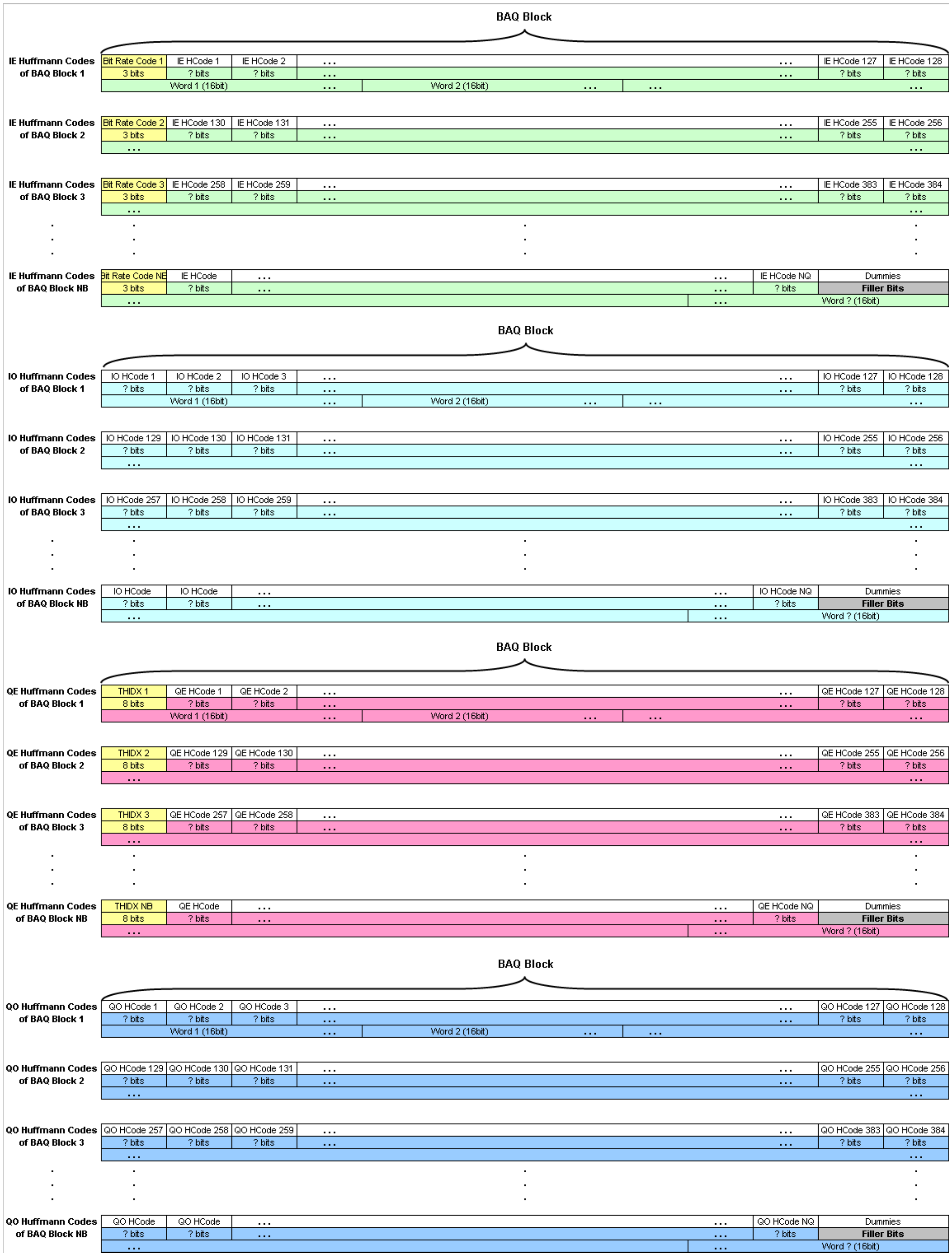


Table 4.4-1: Packetisation of Format Type D User Data Field

The proposed decoding scheme of the User Data Field of a Space Packet is shown in Fig. 4-5 with the HCode decoding shown in Fig. 4-6 and with the applicable Huffman decoding trees in Fig. 4-7 to Fig. 4-11.

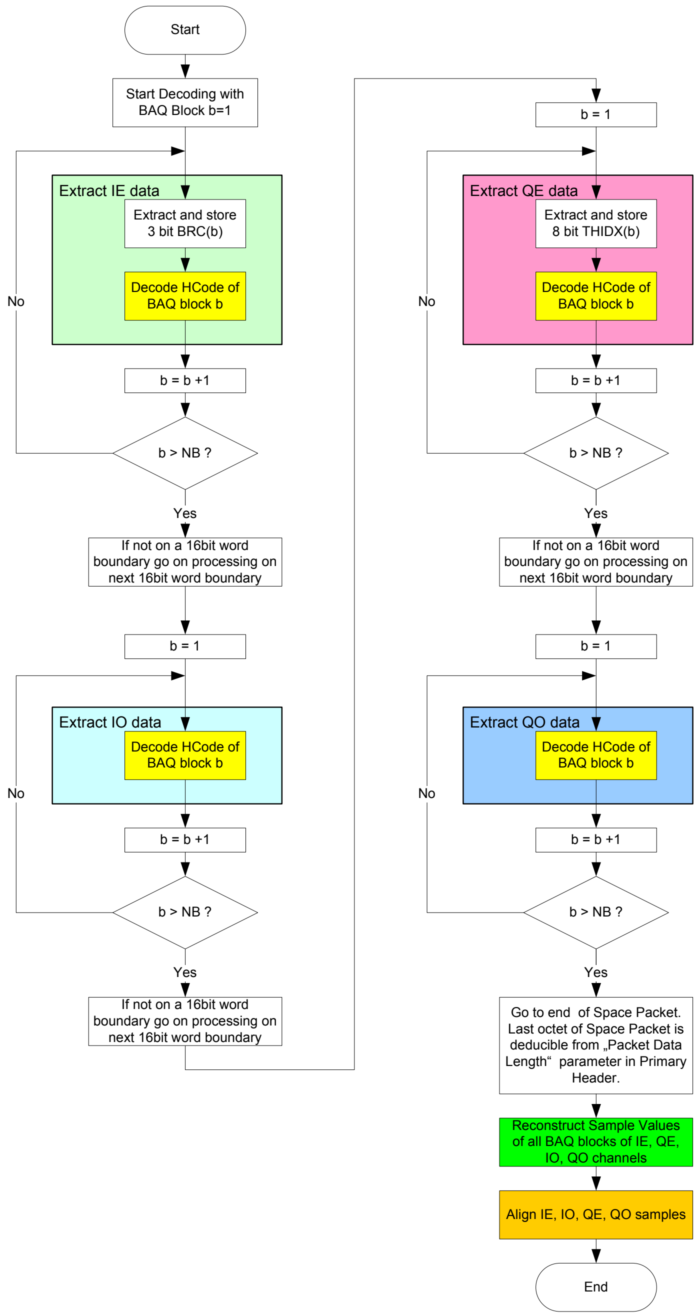


Fig. 4-5: Proposed Decoding of Data Format Type D

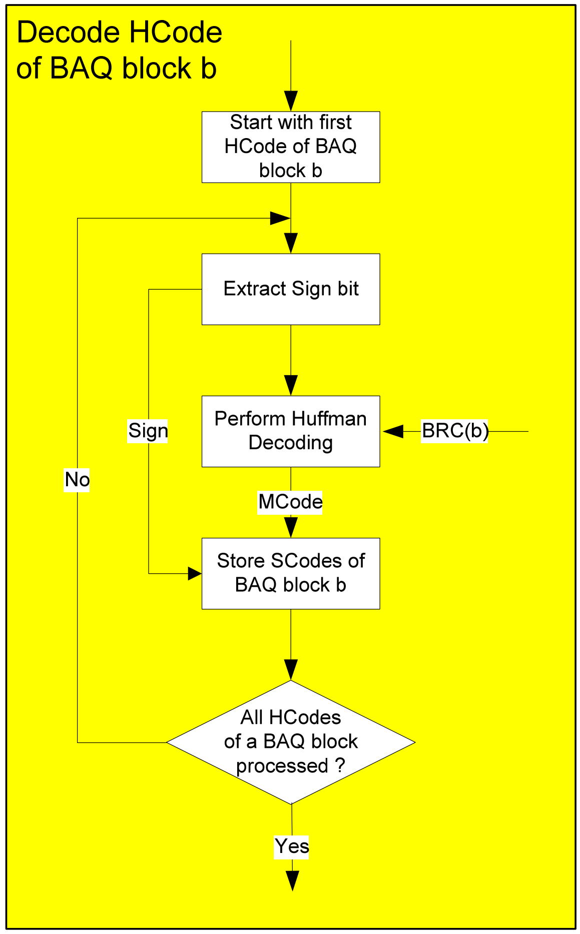


Fig. 4-6: Huffman Decoding of BAQ Block b

Each of the NB BAQ blocks contains 128 HCodes except the last BAQ block which contains $NQ - 128 \cdot (NB - 1)$ HCodes.

The Huffman binary decoding trees are shown for the five applicable values of BRC in Fig. 4-7 to Fig. 4-11.

The relevant MCode can be recovered by stepping through each bit of the HCode (without sign) and following the same bit pattern in the top-down binary Huffman decoding tree accordingly until the relevant MCode is being deteced.

The detection of a MCode indicates the end of a HCode pattern. The next bit then indicates the sign bit of the next following HCode pattern, etc…

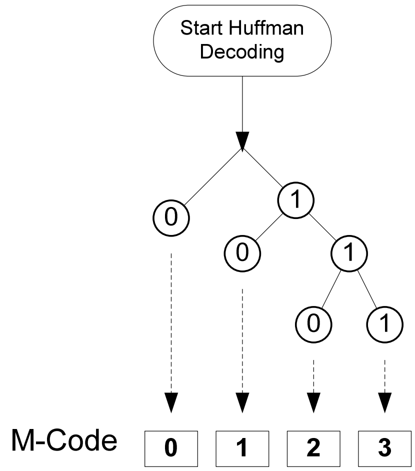


Fig. 4-7: Huffman Decoding for BRC=0, (k=4)

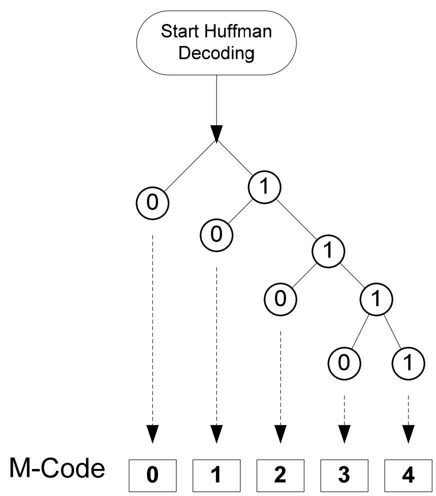


Fig. 4-8: Huffman Decoding for BRC=1, (k=5)

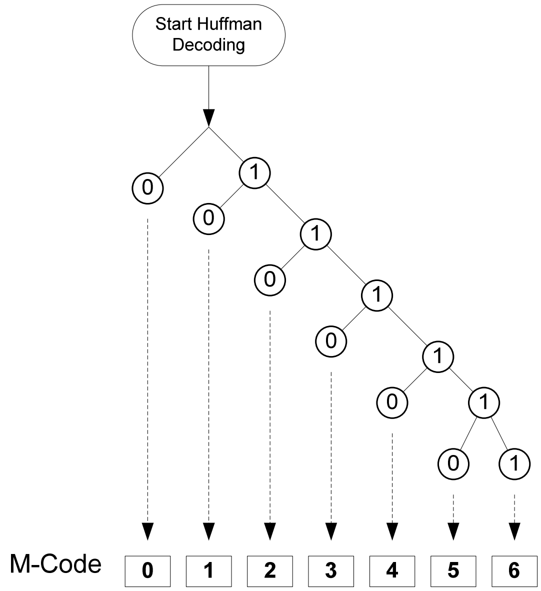


Fig. 4-9: Huffman Decoding for BRC=2, (k=7)

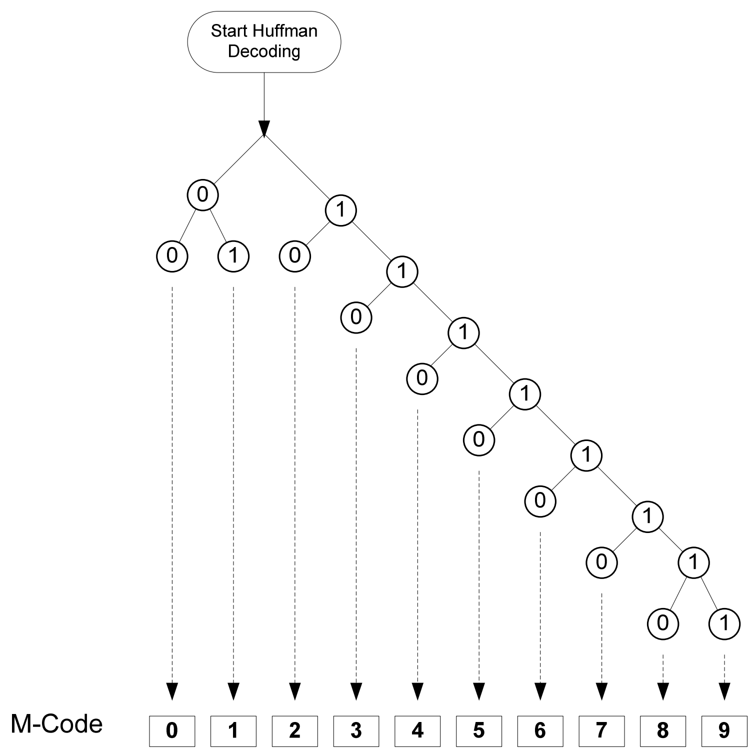


Fig. 4-10: Huffman Decoding for BRC=3, (k=10)

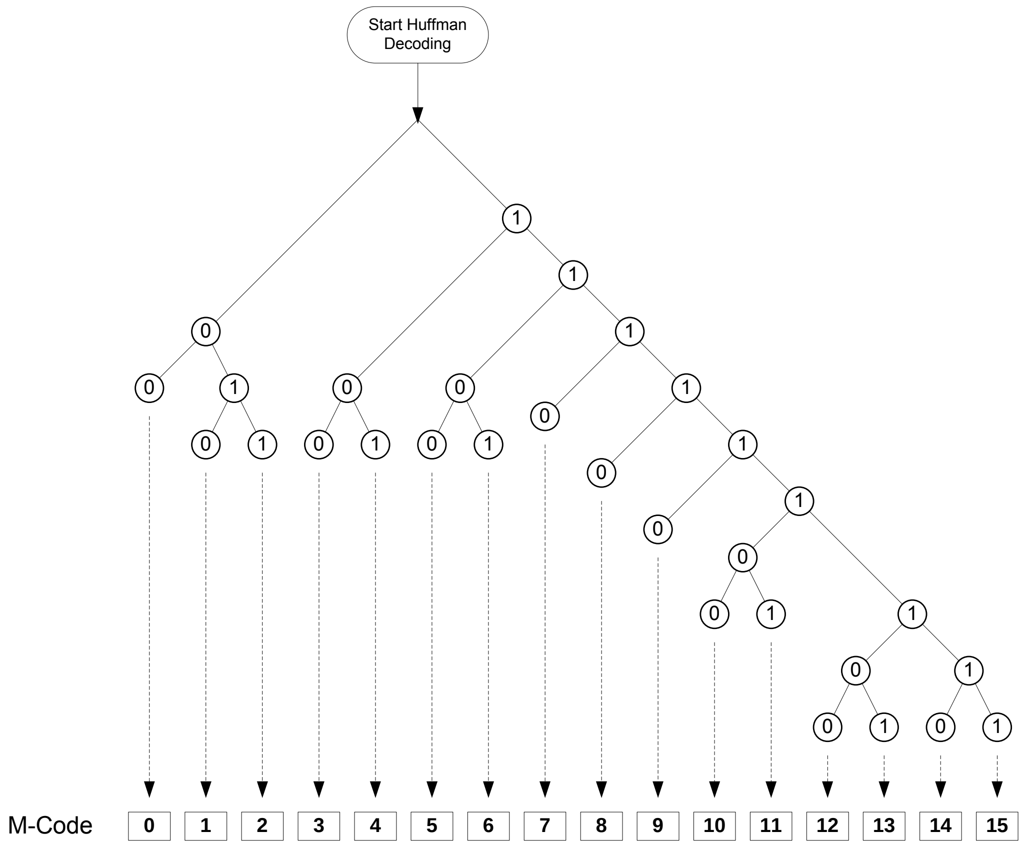


Fig. 4-11: Huffman Decoding for BRC=4 (k=16)

The sample reconstruction from SCode (Sign and MCode) follows the similar flow as shown in Fig. 4-4 of section 4.3.

The detailed sample reconstruction law for each bitrate of the FDBAQ mode (indicated by the *BRC* value) is defined as follows:

$$
S_{Value} = \begin{cases}
\text{for BRC(b)} = 0 & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 2: & \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 3 \\ (-1)^{Sign} \cdot B0_{THIDX} & \text{for } M_{Code} = 3 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 2: & (-1)^{Sign} \cdot NRL_{BRC(b)=0, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\
\text{for BRC(b)} = 1 & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 2: & \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 4 \\ (-1)^{Sign} \cdot B1_{THIDX} & \text{for } M_{Code} = 4 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 2: & (-1)^{Sign} \cdot NRL_{BRC(b)=1, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\
\text{for BRC(b)} = 2 & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 3: & \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 6 \\ (-1)^{Sign} \cdot B2_{THIDX} & \text{for } M_{Code} = 6 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 3: & (-1)^{Sign} \cdot NRL_{BRC(b)=2, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\
\text{for BRC(b)} = 3 & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 5: & \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 9 \\ (-1)^{Sign} \cdot B3_{THIDX} & \text{for } M_{Code} = 9 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 5: & (-1)^{Sign} \cdot NRL_{BRC(b)=3, M_{Code}} \cdot SF_{THIDX(b)} \end{cases} \\
\text{for BRC(b)} = 4 & \begin{cases} \text{Simple Reconstruction for } THIDX(b) \le 7: & \begin{cases} (-1)^{Sign} \cdot M_{Code} & \text{for } M_{Code} < 15 \\ (-1)^{Sign} \cdot B4_{THIDX} & \text{for } M_{Code} = 15 \end{cases} \\ \text{Normal Reconstruction for } THIDX(b) > 7: & (-1)^{Sign} \cdot NRL_{BRC(b)=4, M_{Code}} \cdot SF_{THIDX(b)} \end{cases}
\end{cases}
$$

The values $B0_{THIDX}$, $B1_{THIDX}$, $B2_{THIDX}$, $B3_{THIDX}$ and $B4_{THIDX}$ depend on the value *THIDX* and are defined in the Annex, section 5.2.1.

The values NRL and SF are to be addresed in the corresponding tables in the Annex section 5.2.2.

Example 1 (normal reconstruction):

BRC = 2, k=7

THIDX=239

HCode(binary) = 011 1110 bin

Sign = 0

HCode(binary) w/o Sign = 11 1110 bin

MCode=5

NRL=2.5084

SF=237.19

$S_{Value} = (-1)^0 \cdot 2.5084 \cdot 237.19 = 594.96$

Example 2 (simple reconstruction):

BRC = 3, k=10

THIDX=3

HCode(binary) = 1 1111 1111 bin

Sign = 1

HCode(binary) w/o Sign = 1111 1111 bin

MCode=9

$$S_{Value} = (-1)^1 \cdot 9 = -9$$

Example 3 (simple reconstruction):

BRC = 3, k=10

THIDX=5

HCode(binary) = 1 1111 1111 bin

Sign = 1

HCode(binary) w/o Sign = 1111 1111 bin

MCode=9

$$S_{Value} = (-1)^1 \cdot 9.4531 = -9.4531$$

Sample Alignment:

The sequence of the complex samples in the PRI rangeline will be obtained by arranging the sample values of the 4 channels (IE, IO, QE, QO) in the following way:

$$complex\_S_{Value}(2 \cdot j - 1) = [IE\_S_{Value}(j); QE\_S_{Value}(j)]$$
$$complex\_S_{Value}(2 \cdot j) = [IO\_S_{Value}(j); QO\_S_{Value}(j)]$$
$$\text{for } \; j = 1,2,3 \ldots NQ$$

5 Annexes

5.1 Support Tables for Computation of Number of Samples after Decimation

There are two look-up-tables needed to compute the number of complex samples after the decimation (or in the Space Packet):

- Table of values “D” which will be addressed by values “C” (see 3.2.5.12) and the Filter No. (see 3.2.5.4).
- Table of values “FilterOutputOffset” which will be addressed by the Filter No.

The tables are shown in Table 5.1-1 and Table 5.1-2.

The Filter No. is equivalent to the header parameter “$RGDEC_{code}$” (see 3.2.5.4).

	Values D												
	for Filter No.												
Values C	0	1	2[1]	3	4	5	6	7	8	9	10	11	12…16[2]
0	1	1		1	0	0	0	0	0	0	0	0	
1	1	1		1	1	1	0	0	1	0	0	1	
2	2	2		2	1	1	1	0	1	1	0	1	
3	3			2	2	1		0	2	1	0	1	
4				3	2	2		0	2	1	0	2	
5				3	3	2		1	3	2	0	2	
6				4	3	3			3	2	0	3	
7				4	4	3				2	1	3	
8				5	4					2	1	3	
9										3	1	4	
10										3	1	4	
11										3	1		
12										4	1		
13										4	1		
14										4	1		
15										5	1		
16											2		
17											2		
18											2		
19											2		
20											2		
21											2		
22											2		
23											2		
24											3		
25											3		

Table 5.1-1: Table of Values D

[1] not applicable
[2] not applicable

	Filter No.												
	0	1	2	3	4	5	6	7	8	9	10	11	12…16
Filter Output Offsets	87	87	n/a	88	90	92	93	103	89	97	110	91	n/a

Table 5.1-2: Table of Filter Output Offset Values

Note, that the filters and the corresponding values "Filter Output Offset" are configurable parameters in the SES Radar Database.

For information: The values "Filter Output Offset" depend on the length N_F of each filter:

$FilterOutputOffset = 80 + \frac{N_F}{4}$ (the value N_F for each filter is given in section 3.2.5.4)

5.2 Sample Reconstruction Tables

5.2.1 Table for Simple Reconstruction Method

For certain *THIDX* values simple reconstruction will be applied. The simple reconstruction is described as part of reconstruction laws in the sections 4.3 and 4.4. The simple reconstruction law needs additional parameters A or B which are defined for the relevant *THDIX* values of the different compression modes in the following Table 5.2-1.

	BAQ 3bit	BAQ 4bit	BAQ 5bit	BRC = 0 (k = 4)	BRC = 1 (k = 5)	BRC = 2 (k = 7)	BRC = 3 (k = 10)	BRC = 4 (k = 16)
THIDX	***A3*** for M_{Code}=3	***A4*** for M_{Code}=7	***A5*** for M_{Code}=15	***B0*** for M_{Code}=3	***B1*** for M_{Code}=4	***B2*** for M_{Code}=6	***B3*** for M_{Code}=9	***B4*** for M_{Code}=15
0	3.0000	7.0000	15.0000	3.0000	4.0000	6.0000	9.0000	15.0000
1	3.0000	7.0000	15.0000	3.0000	4.0000	6.0000	9.0000	15.0000
2	3.0000	7.0000	15.0000	3.0000	4.0000	6.0000	9.0000	15.0000
3	3.3749	7.000	15.0000	n/a	n/a	6.0423	9.0000	15.0000
4	3.8201	7.2905	15.0000	n/a	n/a	n/a	9.1476	15.0000
5	4.2769	7.6413	15.1238	n/a	n/a	n/a	9.4531	15.1238
6	4.7520	8.0286	15.3742	n/a	n/a	n/a	n/a	15.3742
7	n/a	8.4386	15.6549	n/a	n/a	n/a	n/a	15.6549
8	n/a	8.8585	15.9566	n/a	n/a	n/a	n/a	n/a
9	n/a	9.2979	16.2853	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	16.6331	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	16.9914	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	17.3695	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	17.7598	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	18.1543	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	18.5644	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	18.9827	n/a	n/a	n/a	n/a	n/a

Table 5.2-1: Simple Reconstruction Parameter Values A, B

5.2.2 Tables for Normal Reconstruction Method

Compressed radar samples for which the Simple Reconstruction Scheme will not apply will be decompressed by the Normal Reconstruction Scheme. The Normal Reconstruction scheme needs values of the Normalized Reconstruction Levels (NRL) and the Sigma Factors (SF). These values are defined in the following subsections.

5.2.2.1 Normalised Reconstruction Levels (NRL)

The selected NRL values represent the reconstructed sample values normalised to standard deviation = 1. Up-scaling to the true standard deviation as measured in the SAR raw data will be performed with the Sigma Factors in Table 5.2-3.

The NRL table is listed in Table 5.2-2 and will be addressed by the Magnitude Code of the quantised radar sample and the BAQ mode (see 3.2.5.1)

- in case of **BAQ compression :**

  indicated by $BAQMOD_{Code}$= 3 or 4 or 5 (indicating 3bit, 4bit or 5bit BAQ)

- in case of **FDBAQ compression** (indicated by $BAQMOD_{Code}$= 12 or 13 or 14):

  by the BRC value which is part of the IE channel data of the User Data Field

	Normalised Reconstruction Levels (NRL)							
	BAQ			FDBAQ				
Magnitude Code (M_{code})	3-Bit	4-Bit	5-Bit	BRC = 0 (k = 4)	BRC = 1 (k = 5)	BRC = 2 (k = 7)	BRC = 3 (k = 10)	BRC = 4 (k = 16)
0	0.24512	0.12838	0.065904	0.35644	0.29961	0.22794	0.16887	0.11257
1	0.75605	0.38804	0.19811	1.0698	0.89898	0.68385	0.50661	0.33771
2	1.344	0.65673	0.33145	1.7846	1.4987	1.1398	0.84436	0.56285
3	2.152	0.94232	0.46677	2.5881	2.0992	1.5959	1.1821	0.78799
4	n/a	1.2562	0.60501	n/a	2.7998	2.0521	1.5199	1.0131
5	n/a	1.616	0.74724	n/a	n/a	2.5084	1.8577	1.2383
6	n/a	2.069	0.8947	n/a	n/a	3.084	2.1955	1.4634
7	n/a	2.7326	1.0487	n/a	n/a	n/a	2.5333	1.6886
8	n/a	n/a	1.2116	n/a	n/a	n/a	2.8712	1.9137
9	n/a	n/a	1.3866	n/a	n/a	n/a	3.3476	2.1389
10	n/a	n/a	1.5767	n/a	n/a	n/a	n/a	2.364
11	n/a	n/a	1.7874	n/a	n/a	n/a	n/a	2.5892
12	n/a	n/a	2.0291	n/a	n/a	n/a	n/a	2.8143
13	n/a	n/a	2.3184	n/a	n/a	n/a	n/a	3.0395
14	n/a	n/a	2.6918	n/a	n/a	n/a	n/a	3.2646
15	n/a	n/a	3.2617	n/a	n/a	n/a	n/a	3.6492

Table 5.2-2: Normalised Reconstruction Levels

5.2.2.2 Sigma Factors (SF)

The Sigma Factors are used for up-scaling the sample values normalised to standard deviation = 1 to original power levels in the BAQ block. The Sigma Factors are listed in Table 5.2-3 and will be addressed by *THIDX* which is part of the QE channel data of the User Data Field.

THIDX	SF	THIDX	SF	THIDX	SF	THIDX	SF	THIDX	SF	THIDX	SF
0	0.00	47	29.45	94	58.91	141	114.37	188	173.27	235	232.18
1	0.63	48	30.08	95	59.53	142	115.62	189	174.53	236	233.43
2	1.25	49	30.71	96	60.16	143	116.87	190	175.78	237	234.69
3	1.88	50	31.33	97	60.79	144	118.13	191	177.03	238	235.94
4	2.51	51	31.96	98	61.41	145	119.38	192	178.29	239	237.19
5	3.13	52	32.59	99	62.04	146	120.63	193	179.54	240	238.45
6	3.76	53	33.21	100	62.98	147	121.89	194	180.79	241	239.70
7	4.39	54	33.84	101	64.24	148	123.14	195	182.05	242	240.95
8	5.01	55	34.47	102	65.49	149	124.39	196	183.30	243	242.21
9	5.64	56	35.09	103	66.74	150	125.65	197	184.55	244	243.46
10	6.27	57	35.72	104	68.00	151	126.90	198	185.81	245	244.71
11	6.89	58	36.35	105	69.25	152	128.15	199	187.06	246	245.97
12	7.52	59	36.97	106	70.50	153	129.41	200	188.31	247	247.22
13	8.15	60	37.60	107	71.76	154	130.66	201	189.57	248	248.47
14	8.77	61	38.23	108	73.01	155	131.91	202	190.82	249	249.73
15	9.40	62	38.85	109	74.26	156	133.17	203	192.07	250	250.98
16	10.03	63	39.48	110	75.52	157	134.42	204	193.33	251	252.23
17	10.65	64	40.11	111	76.77	158	135.67	205	194.58	252	253.49
18	11.28	65	40.73	112	78.02	159	136.93	206	195.83	253	254.74
19	11.91	66	41.36	113	79.28	160	138.18	207	197.09	254	255.99
20	12.53	67	41.99	114	80.53	161	139.43	208	198.34	255	255.99
21	13.16	68	42.61	115	81.78	162	140.69	209	199.59		
22	13.79	69	43.24	116	83.04	163	141.94	210	200.85		
23	14.41	70	43.87	117	84.29	164	143.19	211	202.10		
24	15.04	71	44.49	118	85.54	165	144.45	212	203.35		
25	15.67	72	45.12	119	86.80	166	145.70	213	204.61		
26	16.29	73	45.75	120	88.05	167	146.95	214	205.86		
27	16.92	74	46.37	121	89.30	168	148.21	215	207.11		
28	17.55	75	47.00	122	90.56	169	149.46	216	208.37		
29	18.17	76	47.63	123	91.81	170	150.71	217	209.62		
30	18.80	77	48.25	124	93.06	171	151.97	218	210.87		
31	19.43	78	48.88	125	94.32	172	153.22	219	212.13		
32	20.05	79	49.51	126	95.57	173	154.47	220	213.38		
33	20.68	80	50.13	127	96.82	174	155.73	221	214.63		
34	21.31	81	50.76	128	98.08	175	156.98	222	215.89		
35	21.93	82	51.39	129	99.33	176	158.23	223	217.14		
36	22.56	83	52.01	130	100.58	177	159.49	224	218.39		
37	23.19	84	52.64	131	101.84	178	160.74	225	219.65		
38	23.81	85	53.27	132	103.09	179	161.99	226	220.90		
39	24.44	86	53.89	133	104.34	180	163.25	227	222.15		
40	25.07	87	54.52	134	105.60	181	164.50	228	223.41		
41	25.69	88	55.15	135	106.85	182	165.75	229	224.66		
42	26.32	89	55.77	136	108.10	183	167.01	230	225.91		
43	26.95	90	56.40	137	109.35	184	168.26	231	227.17		
44	27.57	91	57.03	138	110.61	185	169.51	232	228.42		
45	28.20	92	57.65	139	111.86	186	170.77	233	229.67		
46	28.83	93	58.28	140	113.11	187	172.02	234	230.93		

Table 5.2-3: Sigma Factors

5.3 Calibration Signal Acqusition Timing

The timing for acquisition of calibration signals is based on a fixed timing depending only on the Tx pulse length TPL of the transmitted pulses selected in a data take. It does not depend on the commanded parameters $SWST$ and SWL.

The timing is shown in Fig. 5-1.

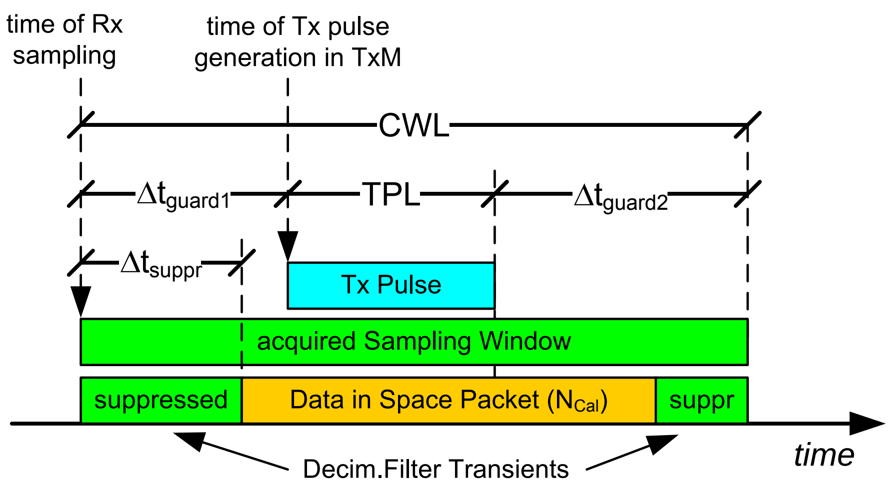


Fig. 5-1: Timing of Calibration Signal Sampling Window (CWL) [1]

In a calibration PRI the value CWL will be automatically selected by the Instrument to

$CWL = TPL + CWL\_Delta$ (in time units)

CWL_Delta is a Mission Parameter defined in the Instrument Radar Database [IRD 07].

$\Delta t_{guard1} = t9 - t26$

$t9$ and $t26$ are also Mission Parameters defined in the Instrument Radar Database [IRD 07].

With this it follows from Fig. 5-1 :

$\Delta t_{guard2} = CWL - TPL - \Delta t_{guard1} = CWL\_Delta - t9 + t26$

It can be seen that Δt_{guard2} is always a fixed value as defined by Mission Parameters and independent of the Tx pulse length.

It has to be noted that the Tx pulse signal will not be sampled at its generation time in the TxM module since the Tx signal has to propopagate through the Instrument signal pathes (e.g. those of the antenna) before being received, digitized and processed in the RxM module. For this reason Δt_{guard2} is applied to cover this signal latency.

The number of captured calibration samples in the Space Packet can be expressed as

[1] the figure shows the timing of Tx Pulse generation and Rx Sampling without taking into consideration electronical roundtrip delays of the Tx pulse via SAS and SES. These may cause a different position of the Tx Pulse signal within the Space Packet than indicated in the figure. The Instrument timing is adjusted to compensate for these delays.

$$N_{Cal} = 2 \cdot \left(L \cdot \mathrm{int}\left[\frac{B}{M} \right] + D + 1 \right)$$

with parameters L and M according to 3.2.5.4

with $B = 2 \cdot (TPL_{code} + CWL\_Delta_{code}) - FilterOutputOffset - 17$

with FilterOutputOffset according to Table 5.1-2

D is to be addressed as function of C in Table 5.1-1 with $C = B - M \cdot \mathrm{int}\left[\frac{B}{M} \right]$

The Decimation Filter suppresses the FIR filter transients in the acquired sampling window. The captured data in the Space Packet correspond to the data sampled Δt_{suppr} after the start of the acquired sampling window.

$\Delta t_{suppr} = \dfrac{320}{8 \cdot f_{ref}}$ in units of [us] with $f_{ref} = 37.53472224$ [MHz]