INSTITUT FÜR
DATENVERARBEITUNGSANLAGEN

Phoenix and Cluster II
RAPID

Instrument User's Guide

Issue 2
Revision 8
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by

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Change Report

Issue	Rev.	Pg.	Date	Changes	Orig.
1	0-3			Original versions w/o change reports	AM
1	4		13.4.94	Insertion of this change report Description of commands ZERECALS and ZEREACTS added Sections OPERATIONAL CONSTRAINTS, ALTERNATIVE, COMPLEMENTARY and REMARKS added for each command Parameter definition corrected in command ZERSETPN ERDIFIND: corrected ERDSSINT: corrected EDIPABTS: assignment to tables added ERISAREF: description corrected Section 1: spelling corrected for I-SPCT and I-MTRX some minor corrections of spelling and grammar	Rj
2	0		14.12.94	Document name changed from „Software User's Guide“ to „Instrument User's Guide“ Document converted from TeX to Word for Windows Page numbering starts with each chapter now Descriptions added to all HK items Logic inverted for HK item ERDDEADT EDB format replaced with 24.08.94 version New page headers and feet Redundant schematics pp 7,10,13,27,29 deleted Decompression table corrected, Algorithm added Clarifications in sections 3.1 and 4.0 Corrections in grammar and spelling Section 1.2.1: Description of idle period included Section 1.0: In case of failure the HK bytes own the value C0hex and not 0Chex New definition of content descriptor CD1, bit 4 BM3 EDB description: Position of „Long EDB counter“ is 90Ah and not 910h ERISTACP, ERISTALB, ERISTOCP, ERISTOLB : Accumulation interval is 1 sector beginning from 24.08.94	Rj
2	1	2-7 2-14 2-15 3-29 3-39 3-49 3-50 3-68 4-1 4-14	28.02.95	EDB SYNC Marker corrected: 3D changed to 8B Typo corrected: Line 3, „low“ changed to „high“ Order of IM elements incorrect, changed according to description on page 2-14 Missing validity HK item ERDSSINT added Typo corrected: EDERATE... changed to ERERATE... Section validity: Location of EDB status bit specified Spelling of complementary command corrected Missing command parameter 01h added Description extended ERDDPUCU: Parameter assignment corrected ERDDECODE changed to ERDECODE throughout Section 3	Rj

Issue	Rev.	Pg.	Date	Changes	Orig.
2	2		10.11.95	Section 5.3 added: RAPID PATCH A Section 2: NM bitrate is 1024 bps Section 2.2: Table for CD2 description added Review of descriptions in section 2. 2.4 and 2.2.5 Styling of tables in section 3.3 Addings in the validity section of the commands:ZERELUTS, ZEREPTBS, ZERIRCKS Description of command ZERELUTS extended Code value corrected for command ZEREPTBS 10h→16h Refinements in description of command ZERETSTE BERPLCAS: Last command word contains CRC ZERCTSTN: Operational contraints added, parameter 09h is not existent (corrected), slight changes in the description ZERFCLKS: Change to expected 16 kHz clock possible, but FGM clock is fixed at 1kHz. Remark added ZERSLOPS: description clarified, parameter table added, change of ZERSLOPS description also in 3.3.2 and 3.3.4 ZERTCLKS: Operational constraint added ZERTMODS: clarification in VALIDITY section ZERTRMDS: IIMS command ZERWDENS, ERDWATEN: Validation of ZERWDENS in ERDWATEN is not possible Section 4.1: HK frame period is 5.1522s; FFh values are inserted externally into HK frames, when RAPID is off ERDCMDER, ERDCMDIV, ERDCMDVD: activation time is one HK frame (5.1522s) ERDEDBCR: This is the EDB counter (or index) decreased by 1 Update of HK item ERESENID ERDLICMD, ERDLVCMD: Default is 0ffh ERECMDRT: Table added Minor corrections of spelling and grammar throughout the text	AM/Rj Rj
2	3	 5-4 2-8 2-13 3-15 3-23 3-24 4-5 4-54 2-14	28.01.97	This is now a document for Phoenix/RAPID Patch code A now incorporated in program code, deleted from documentation Description D5: 0 denotes table a, 1 denotes table b Section 2.2.4: Every 176 -> 167, every 82->88, recommendation added. Typo: Highbyte 3 reads C3, not 83h Description for lowbytes 1,2 and 3 clearified Parameters 0d to 14 not useful anymore Parameter EREFXLUT added to table Description of parameter EREFXLUT added Data format description corrected	Rj

Issue	Rev.	Pg.	Date	Changes	Orig.
2	4		15.10.98	Title changed again. Now this document describes both the Phoenix and Cluster II versions of RAPID. The differences between them are marked in the text.	Rj
		2-1		typo corrected	
				I-3DD: Cluster II FMs have 8 times higher efficiency than the Phoenix FM	
		2-3		I-3DD: Cluster II FMs have 8 times higher efficiency than the Phoenix FM	
		2-5		I-3DD: Cluster II FMs have 8 times higher efficiency than the Phoenix FM	
		2-8		typo corrected	
		2-9		Structure of IFFT1 data: The sector based description with sectors is only useful (and understandable) for someone who is familiar with the internal test event generation during IFFT. For this reason the test event energy level and the status of the BD electronics now is given for each of the four EDBs.	
				Lower table: TAC was missing at offset 14h	
		2-13		Correction: “Channel **168** is not available in NM” now reads “Channel **167 itself** is not available in NM”	
		3-20		2 typos corrected	
		3-22		clarification: CRC is calculated from lowbytes 1 to n	
		3-32		typo corrected: byETTstValue -> byETstValue	
		3-43		ZERELUTS: Completely revised for Phoenix and Cluster II units	
		4-5		EREFXLUT: the correct mask is **08** (and not 04)	
		4-37		ERDPATAC: typo corrected:	
		4-58		ERESENID: Only LS values 0,8 and 9 are defined	
		5-3		Section 5.3.1 replaced with new patch code A which is only for the Phoenix version of RAPID.	cd
		2-8		Table for IES/EPP look-up table updated to the different integration times between the Phoenix and the Cluster II versions of RAPID.	
		3-40		Table for ZERECMDS changed	
		4-53		Table for ERECMDRT changed	
2	5		08.02.99	Now the integration times in the IES are the same for both Phoenix and the New Cluster II versions of RAPID (2 µs, 5 µs, 15 µs and 50 µs).	cd
		2-8		In description of CD2, D4..D0 different integration times for Phoenix and the New Cluster II FMs deleted.	
		3-40		ZERECMDS: entries for different integration times between Phoenix and the New Cluster II-FMs deleted.	
		3-43		ZERELUTS: entries for different integration times between Phoenix and the New Cluster II-FMs deleted.	
				IES integration time table: type corrected	
				Description changed.	
		4-53		ERECMDRT: entries for different integration times between Phoenix and the New Cluster II-FMs deleted.	

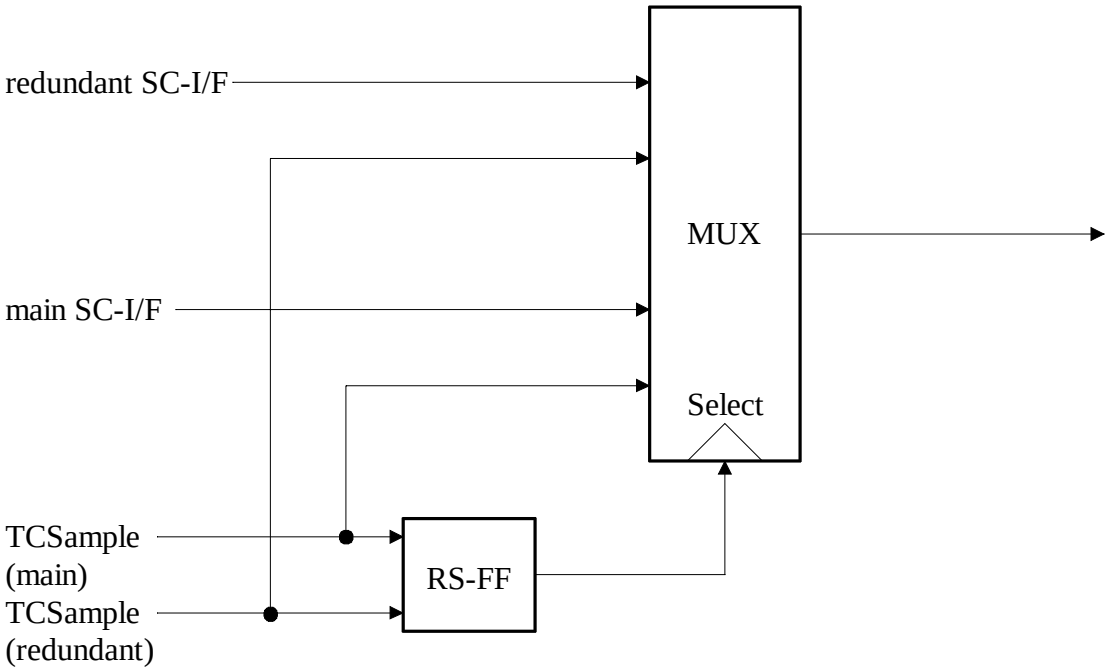
Issue	Rev.	Pg.	Date	Changes	Orig.
2	6	5-4	26.04.99	Section 5.3.1 description is clearer now.	cd
		5-5		typo corrected	
		5-7		typo corrected	
		5-8		typo corrected	
		5-8		Section 5.3: Patch Code B added	
		5-10		Section 5.3: Patch Code Cx added	
		4-3		typo corrected	
		4-27		ERDIELIE: bit position in table corrected	
		4-29		ERDIFIND: interpretation of value corrected: SMOD=0 serial measurement mode; SMOD=1 parallel measurement mode	
		4-45		ERDSSINT: interpretation of value corrected FLAG=0 external sector clock (default); FLAG=1 artificial sector clock	
2	7	5-10	15.02.00	Section 5.3: Patch Code Cx updated	cd
		3-69		ZERWDENS: Validity and remarks updated	
		4-3		typo corrected	
		4-53		ERDWATEN: description updated	
2	8	3-13	22.05.01	BERCTIMS: interpretation of lowbyte corrected	cd
		3-31		ZERCLCFS: remark entry updated	
		3-33		ZERCTSTN: remark entry updated	
		3-51		ZERIRCKS: remark entry updated	
		5-4		Section 5.3 (Patches) deleted	

Contents

1 Description of the RAPID S/C Interface

1.1 Control of the spacecraft interface

The CLUSTER spacecraft provides a main and a redundant spacecraft interface for each experiment. On RAPID these two interfaces are connected with an input multiplexer that selects one of them. After first POWER ON the main channels are selected. To force RAPID to listen to a specific channel, the telecommand sampling line of that channel must be activated, e.g. by sending a telemetry mode change command.



The actually used spacecraft interface can be identified by the HK-parameter ERDSCMXS (1=main interface, 0=redundant interface). This information is stored in the non volatile RAM to select the correct interface after a watchdog reset or a power down by latch-up. In case of missing science sampling signals and missing reset pulses after about 80 seconds the DPU tries to send data on the other interface.

During normal operation there are two 512 byte FIFOs for science data sending. They are controlled by hardware which always switches one of them into the addressing space of the DPU and the other one to the access of the shifter for servicing the telemetry interface. These two FIFOs are toggled each time that the second one has been read completely. An interrupt is

generated and the DPU has to refill it during the next about 1000 ms in burst mode or 4000 ms in normal mode.

For HK data there is only one FIFO that is cleared after every RESET pulse from the spacecraft and filled with a 40 bytes HK block before the sampling of HK data starts. If the RESET pulse line fails, the DPU waits for about 80 seconds before it starts to write HK data into the FIFO, asynchronously with respect to the spacecraft telemetry acquisition frame. In this failure case about 16 blocks of 40 bytes with the value C0hex are sent before the following normal HK data. When the RESET pulse is available again, the telemetry switches back to synchronous operation. In that moment a few HK frames are lost.

1.2 Instrument specific time constants

1.2.1 Initialisation

After power-on RAPID enters an idle period, in which it remains for about 2 minutes. No information from the instrument is available during this time, only a subset of telecommands are accepted.

After the idle period the instrument performs an automatic initialisation. Beside other tasks tables of the IIMS classification unit and the IES/EPP lookup table are recalculated. Telecommands are fully accepted now.

1.2.2 Measurement times

IIMS: Due to the fact that the IIMS hardware classification only has one counting memory there are dead times necessary to read out the counting rates. This always happens at the beginning of each sector. The measurement time is determined by a timer which enables both the classification and the majority of 45 rate counters for 3 * 65ms (default) in serial mode or 195ms (default) in parallel mode. These measurement times can individually be set by the BERCTIMS command.

The measurement time of a small subset of counters is not fixed, but is identical to the (varying) sector duration (e.g. EDI-Y, OVF-Y, BDI-Y, see description below).

IES: Events from the IES are counted in a double buffered counter array, providing the means for writing into one and reading from the other array at the same time. Thus the electron pre-processing works without a significant dead time. The IES measurement time is as long as the spin period. A change of the EPP lookup table or the integration constant in the IES (performed on telecommand or by instrument-internal automatism) will be performed asynchronously to the measurement time and thus can corrupt up to three EDBs.

2 EDB formats

RAPID supports three different telemetry formats:

NM Nominal modes (NM[1-3]) and burst mode 2 (BM2), with the same allocated bitrate of 1024.8 bits/second. This mode is active most of the operation time of the instrument. The DPU formats EDBs of 512 Bytes per spin; spin period: 4s ± 10%.

BM1 Burst mode 1 (BM1), with an allocated bitrate of 4620.92 bits/second. In this mode EDBs have a size of 2304 bytes, which allow a greater resolution in time of measurement data.

BM3 Burst mode 3 (BM3), has a bitrate of 1925.38 bits/second. This mode is intended to read out scratch memories of the instrument. For RAPID there is a scratch memory of 64 Kbytes. It takes about 4 3/4 minutes to dump that memory content through telemetry. Inside that scratch memory there are 28 burst mode EDBs with additional CRCs stored. 14 collected before and 14 after that time when the FGM sends a trigger pulse (bit 41) in the serial data stream via the inter experiment link (IEL).

2.1 EDB data in NM and BM telemetry modes

NM-EDB data

	Bytes	Bytes per Spin	Accumulation period per counter [spins]	Transfer time [spins]
DE 20 ions, 3 bytes each	60	60	1	1
SGL0 2 counters	4	1	4	4
SGL1 3 counters	3	1	4	4
SGL2 18 counters	18	3	4	8
SGL3 22 counters	22	1	4	32
H-SPCT	8	8	1	1
I-SPCT	16	4	4	4
I-PAD	6	96	1/16	1
I-3DD (Phoenix FM)	288	144	1/16	32
I-3DD (New Cluster II FMs)	288	144	8/16	32
MTRX	2048	8	64	256
E-PAD	6	96	1/16	1
E-3DD	72	72	1	1
m	0.5	8	1/16	1
m-signs	1/8	2	1/16	1
Sync marker	3	3	-	1
Subcommutation INDEX	1	1	-	1
Content descriptors	2	2	-	1
E/T-CAL	2	2	-	1
512				

NM[1-3],BM2 EDB structure (512 bytes)

Position	Length	Content
000h	3	1. sync marker (14 6f 2e)
003h	1	Subcommutation INDEX (EDB number)
004h	1	Content descriptor 1 (see section 2.2)
005h	2	E/T-calibration result of last spin
007h	2	m-signs
009h	1	SGL0 rates (STA0-7,STA8-15,STO0-7,STO8-15)
00Ah	60	20 direct events (E,T,S/D)
046h	8	H-SPCT
04Eh	4	I-SPCT
052h	1	SGL1 rates ENY,TCR,TAC,-
053h	3	SGL2 rates EDI1,EDI2,EDI3, BDI1,BDI2,BDI3, EDI11,EDI12,EDI13, EDI14,EDI21,EDI22, EDI23,EDI24,EDI31, EDI32,EDI33,EDI34
056h	1	SGL3 rates -,-,OVF1,OVF2,OVF3, sDIR-S1,sDIR-S2,sDIR-S3,sDIR-3S, TAC-S1,TAC-S2,TAC-S3, TAC11,TAC12,TAC13,TAC14, TAC21,TAC22,TAC23,TAC24, TAC31,TAC32,TAC33,TAC34
057h	96	I-PAD
0B7h	144	I-3DD
147h	8	MTRX
14Fh	1	Content descriptor 2 (see section 2.2)
150h	96	E-PAD
1B0h	72	E-3DD
1F8h	8	m

(all values of position and length in bytes!)

BM1-EDB data

	Bytes	Bytes per Spin	Accumulation period per counter [spins]	Transfer time (spins)
DE 106 ions, 3 bytes each	318	318	1	1
SGL1 3 counters	5	80	1/16	1
SGL2 18 counters	18	9	2	2
SGL3 22 counters	22	3	2	8
H-SPCT	8	8	1	1
I-SPCT	16	4	4	4
I-PAD	6	96	1/16	1
I-3DD (Phoenix FM)	288	576	1/16	8
I-3DD (New Cluster II FMs)	288	576	8/16	8
MTRX	2048	32	64	64
E-PAD	-	-	-	-
E-3DD	72	1152	1/16	1
m	0.5	8	1/16	1
m-signs	1/8	2	1/16	1
Sync marker	9	9	-	1
Subcommutation INDEX	1	1	-	1
Content descriptors	2	2	-	1
E/T-CAL	2	2	-	1
spare	2	2	-	1
2304				

BM1 EDB structure (2304 Bytes)

Position	Length	Content
000h	3	1. sync marker (14 6f 3d)
003h	1	Subcommutation INDEX (EDB number)
004h	1	Content descriptor 1
005h	2	E/T-calibration result of last spin
007h	2	m-signs
009h	1	spare
00Ah	318	106 direct events (E,T,S/D)
148h	8	H-SPCT
150h	4	I-SPCT
154h	1	Content descriptor 2
155h	1	spare
156h	80	SGL1 rates 16*[ENY,TCR,TAC,STA,STO]
1A6h	9	SGL2 rates EDI1, EDI2, EDI3, BDI1, BDI2, BDI3, EDI11, EDI12, EDI13, EDI14, EDI21, EDI22, EDI23, EDI24, EDI31, EDI32, EDI33, EDI34
1AFh	3	SGL3 rates -, -, OVF1, OVF2, OVF3, sDIR-S1, sDIR-S2, sDIR-S3, sDIR-3S, TAC-S1, TAC-S2, TAC-S3, TAC11, TAC12, TAC13, TAC14, TAC21, TAC22, TAC23, TAC24, TAC31, TAC32, TAC33, TAC34
1B2h	96	I-PAD
212h	3	2. sync marker (4c 43 e2)
215h	576	I-3DD
455h	32	MTRX
475h	3	3. sync marker (54 e1 e1)
478h	1152	E-3DD
8F8h	8	m

BM3-EDB data

	Bytes	Bytes per Spin	Accumulation period per counter [spins]	Transfer time (spins)
DE 106 ions, 3 bytes each	318	318	1	1
SGL1 3 counters	5	80	1/16	1
SGL2 18 counters	18	9	2	2
SGL3 22 counters	22	3	2	8
H-SPCT	8	8	1	1
I-SPCT	16	4	4	4
I-PAD	6	96	1/16	1
I-3DD (Phoenix FM)	288	576	1/16	8
I-3DD (New Cluster II FMs)	288	576	8/16	8
MTRX	2048	32	64	64
E-PAD	-	-	-	-
E-3DD	72	1152	1/16	1
m	0.5	8	1/16	1
m-signs	1/8	2	1/16	1
Sync marker	9	9		1
Subcommutation INDEX	1	1		1
Content descriptors	2	2		1
E/T-CAL	2	2		1
Check sums	10	10		1
Long EDB counter	4	4		1
Spare	24	24		1
2340				

BM3 EDB structure (2340 bytes)

Position	Length	Content
000h	3	1. sync marker (14 6f 8B)
003h	1	Subcommutation INDEX (EDB number)
004h	1	Content descriptor 1
005h	2	E/T-calibration result of last spin
007h	2	m-signs
009h	1	spare
00Ah	318	106 direct events (E,T,S/D)
148h	8	H-SPCT
150h	4	I-SPCT
154h	1	Content descriptor 2
155h	1	spare
156h	80	SGL1 rates 16*[ENY,TCR,TAC,STA,STO]
1A6h	9	SGL2 rates EDI1,EDI2,EDI3,BDI1,BDI2,BDI3,EDI11,EDI12, EDI13,EDI14,EDI21,EDI22,EDI23,EDI24,EDI31,EDI32,EDI33,EDI34
1AFh	3	SGL3 rates -,-,OVF1,OVF2,OVF3,sDIR-S1, sDIR-S2,sDIR-S3,sDIR-3S, TAC-S1,TAC-S2,TAC-S3, TAC11,TAC12,TAC13, TAC14,TAC21,TAC22, TAC23,TAC24,TAC31, TAC32,TAC33,TAC34
1B2h	96	I-PAD
212h	3	2. sync marker (4c 43 e2)
215h	576	I-3DD
455h	32	MTRX
475h	3	3. sync marker (54 e1 e1)
478h	1152	E-3DD
8F8h	8	m
900h	1	CRC for EDB bytes 003h - 009h
901h	1	CRC for EDB bytes 00Ah - 147h
902h	1	CRC for EDB bytes 148h - 153h
903h	1	CRC for EDB bytes 154h-1A5h
904h	1	CRC for EDB bytes 1A6h-1B1h
905h	1	CRC for EDB bytes 1B2h-211h
906h	1	CRC for EDB bytes 215h-454h
907h	1	CRC for EDB bytes 455h-474h
908h	1	CRC for EDB bytes 478h-8F7h
909h	1	CRC for EDB bytes 8F8h-8FFh
90Ah	4	32 bit EDB counter
90Eh	22	spare

2.2 EDB data in special telemetry modes

There are some special operation modes beside the normal science modes of the RAPID instrument to perform some hardware tests. The results of these tests are sent within at least parts of the normal EDBs through the spacecraft interface, e.g. test data for the IIMS classification only use the IIMS part of the EDB. To mark these test data the corresponding bits in the content descriptors are set.

Content descriptor 1 (CD1)

(MSB) D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
IIMS-SIM ACTIVE	IES-IF ACTIVE	IES-CAL ACTIVE	FGM DATA	CLASS TEST	RAM CHECK	EPP TEST	IFFT

D7 A 1 in this flag shows that IIMS classification particle simulation procedure is active. That means that events are written into test registers at the input stage and a normal classification is performed on that test data.

D6 Reflects the state of the IES/EPP Interface. 0 means that the interface is disabled, in normal instrument measurement modes this will never happen.

D5 A 1 shows that the IES is in calibration mode. All energies from electron sensor system are shifted to the middle of the measurement range.

D4 A 1 shows that at least one magnetic field vector from CLUSTER/FGM was received in every sector, and included into data processing.

D3 A 1 indicates that the EDB contains IIMS classification hardware test data.

D2 A 1 indicates that the whole EDB is filled with memory dump data from the DPU, within the address range that was specified by the *BERRCADS* command. This range is dumped cyclically until it will be disabled by *ZERIRCKS* command.

D1 A 1 shows that the EPP part of the EDB is filled with results from the EPP hardware test program.

D0 A 1 shows that the in-flight functional test of the IIMS sensor system is active. This test will only be performed in the nominal mode! In that mode the IIMS-part of the NM EDB is filled with test data, defined below.

Content descriptor 2 (CD2)

(MSB) D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
IES DE meas.	EPP test proc on	IES table a/b	EPP LUT4	EPP LUT3	EPP LUT2	EPP LUT1	EPP LUT0

D7 A 1 indicates that the EDB contains IES direct event data (histogram data). Within about 20 spins the histogram of the energy distribution for all nine sensor IDs measured over one spin each are transmitted.

D6 A 1 shows that the EPP test event generation procedures are active. These procedures generate test events that are written into the input registers of the EPP.

D5 E-PAD data formatting mode (0:a, 1:b). Determines the 3rd direction with respect to the B-field from which data are formatted into the EDB.

D4-0 IES/EPP look-up table number. Please refer to the following table:

LUT #	Description
0h	Predefined LUT for IES integration time: 2 µs
1h	Predefined LUT for IES integration time: 5 µs
2h	Predefined LUT for IES integration time: 15 µs
3h	Predefined LUT for IES integration time: 50 µs
11h	Histogram mode LUT for IES strip 1
12h	Histogram mode LUT for IES strip 2
13h	Histogram mode LUT for IES strip 3
14h	Histogram mode LUT for IES strip 4
15h	Histogram mode LUT for IES strip 5
16h	Histogram mode LUT for IES strip 6
17h	Histogram mode LUT for IES strip 7
18h	Histogram mode LUT for IES strip 8
19h	Histogram mode LUT for IES strip 9
else	for instrument test purposes only, not during normal operation

2.2.1 IFFT mode EDB format

IFFT consists of two parts. The first part determines the noise and switching levels in the energy channels. For that test only some rate counters have to be read out and put into the EDB. The second part of IFFT tests linearity and classification unit. While IFFT is active (only in NM mode!) the EDB format during both parts is the same, except for the content of the IFFT1/2 data block (bytes 20h - 14eh).

IFFT EDB structure (512 Bytes)

Position	Length	Content
0	3	1. sync marker (14 6f 2e)
3	1	Subcommutation INDEX (EDB number)
4	1	Content descriptor 1
5	1	IFFT spin counter
6	1	IFFT2 event counter (DEs, I-Matrix)
20h	256	IFFT data block
14Fh	1	Content descriptor 2
150h	96	E-PAD
1B0h	72	E-3DD
1F8h	8	m

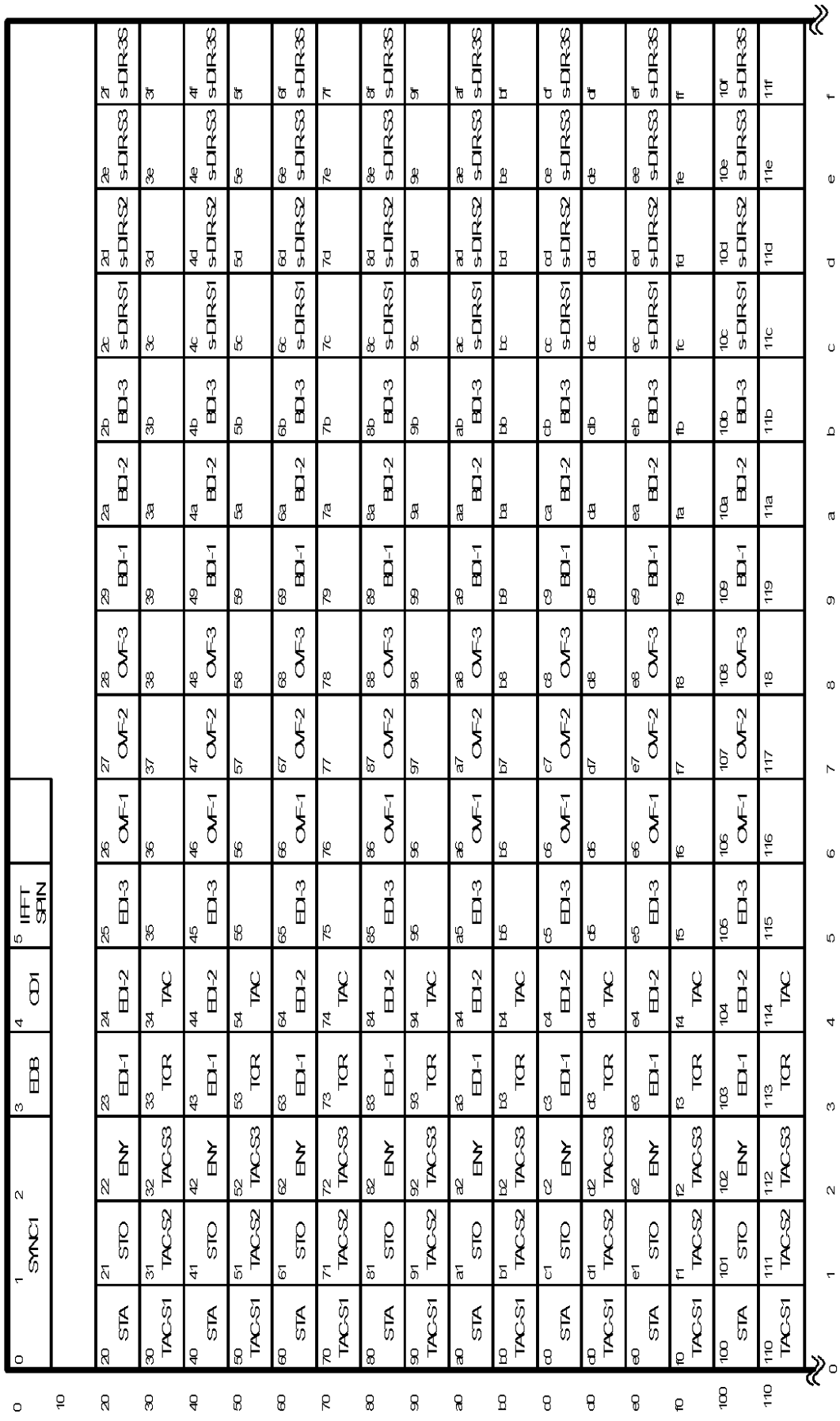
2.2.2 Structure of IFFT1 data

IFFT1 data will be sent over 4 spins with the IFFT spin counter reading 1 to 4. The IFFT1 test results are placed in the EDB starting at position 20h and are sorted as follows:

EDB offset	IFFT spin cntr = 1	IFFT spin cntr = 2	IFFT spin cntr = 3	IFFT spin cntr = 4
from 20h to 3Fh	E= 00h, BD off	E= 08h, BD off	BD=E= 00h	BD=E= 08h
from 40h to 5Fh	E= 01h, BD off	E= 09h, BD off	BD=E= 01h	BD=E= 09h
from 60h to 7Fh	E= 02h, BD off	E= 0Ah, BD off	BD=E= 02h	BD=E= 0Ah
from 80h to 9Fh	E= 03h, BD off	E= 0Bh, BD off	BD=E= 03h	BD=E= 0Bh
from A0h to BFh	E= 04h, BD off	E= 0Ch, BD off	BD=E= 04h	BD=E= 0Ch
from C0h to DFh	E= 05h, BD off	E= 0Dh, BD off	BD=E= 05h	BD=E= 0Dh
from E0h to FFh	E= 06h, BD off	E= 0Eh, BD off	BD=E= 06h	BD=E= 0Eh
from 100h to 11Fh	E= 07h, BD off	E= 0Fh, BD off	BD=E= 07h	BD=E= 0Fh

Each of the 8 blocks displayed above has the following internal structure:

00h	STA	STO	ENY	EDI-1	EDI-2	EDI-3	OVF-1	OVF-2
08h	OVF-3	BDI-1	BDI-2	BDI-3	sDIR-S1	sDIR-S2	sDIR-S3	sDIR-3S
10h	TAC1	TAC2	TAC3	TCR	TAC	-	-	-
18h	-	-	-	-	-	-	-	-


IFFT EDB Part 1
0 1 SYNC1 2 3 EDB 4 CD1 5 IFFT SPIN
20 21 STA 22 ENY 23 EDI-1 24 EDI-2 25 EDI-3 26 OMF-1 27 OMF-2 28 OMF-3 29 EDI-1 2a EDI-2 2b EDI-3 2c s-DIRS1 2d s-DIRS2 2e s-DIRS3 2f s-DIRS3
30 31 TAC-S1 32 TAC-S2 33 TCR 34 TAC 35 36 37 38 39 3a 3b 3c 3d 3e 3f
40 41 STA 42 ENY 43 EDI-1 44 EDI-2 45 EDI-3 46 OMF-1 47 OMF-2 48 OMF-3 49 EDI-1 4a EDI-2 4b EDI-3 4c s-DIRS1 4d s-DIRS2 4e s-DIRS3 4f s-DIRS3
50 51 TAC-S1 52 TAC-S2 53 TCR 54 TAC 55 56 57 58 59 5a 5b 5c 5d 5e 5f
60 61 STA 62 ENY 63 EDI-1 64 EDI-2 65 EDI-3 66 OMF-1 67 OMF-2 68 OMF-3 69 EDI-1 6a EDI-2 6b EDI-3 6c s-DIRS1 6d s-DIRS2 6e s-DIRS3 6f s-DIRS3
70 71 TAC-S1 72 TAC-S2 73 TCR 74 TAC 75 76 77 78 79 7a 7b 7c 7d 7e 7f
80 81 STA 82 ENY 83 EDI-1 84 EDI-2 85 EDI-3 86 OMF-1 87 OMF-2 88 OMF-3 89 EDI-1 8a EDI-2 8b EDI-3 8c s-DIRS1 8d s-DIRS2 8e s-DIRS3 8f s-DIRS3
90 91 TAC-S1 92 TAC-S2 93 TCR 94 TAC 95 96 97 98 99 9a 9b 9c 9d 9e 9f
a0 a1 STA a2 ENY a3 EDI-1 a4 EDI-2 a5 EDI-3 a6 OMF-1 a7 OMF-2 a8 OMF-3 a9 EDI-1 aa EDI-2 ab EDI-3 ac s-DIRS1 ad s-DIRS2 ae s-DIRS3 af s-DIRS3
b0 b1 TAC-S1 b2 TAC-S2 b3 TCR b4 TAC b5 b6 b7 b8 b9 ba bb bc bd be bf
c0 c1 STA c2 ENY c3 EDI-1 c4 EDI-2 c5 EDI-3 c6 OMF-1 c7 OMF-2 c8 OMF-3 c9 EDI-1 ca EDI-2 cb EDI-3 cc s-DIRS1 cd s-DIRS2 ce s-DIRS3 cf s-DIRS3
d0 d1 TAC-S1 d2 TAC-S2 d3 TCR d4 TAC d5 d6 d7 d8 d9 da db dc dd de df
e0 e1 STA e2 ENY e3 EDI-1 e4 EDI-2 e5 EDI-3 e6 OMF-1 e7 OMF-2 e8 OMF-3 e9 EDI-1 ea EDI-2 eb EDI-3 ec s-DIRS1 ed s-DIRS2 ee s-DIRS3 ef s-DIRS3
f0 f1 TAC-S1 f2 TAC-S2 f3 TCR f4 TAC f5 f6 f7 f8 f9 fa fb fc fd fe ff
100 101 STA 102 ENY 103 EDI-1 104 EDI-2 105 EDI-3 106 OMF-1 107 OMF-2 108 OMF-3 109 EDI-1 10a EDI-2 10b EDI-3 10c s-DIRS1 10d s-DIRS2 10e s-DIRS3 10f s-DIRS3
110 111 TAC-S1 112 TAC-S2 113 TCR 114 TAC 115 116 117 18 119 11a 11b 11c 11d 11e 11f
0 1 2 3 4 5 6 7 8 9 a b c d e f
0 10 20 30 40 50 60 70 80 90 a0 b0 c0 d0 e0 f0 100 110

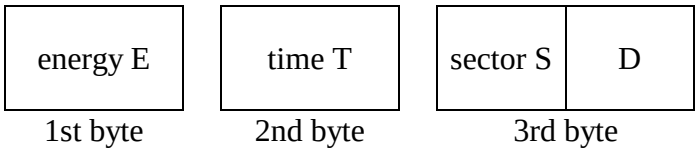
2.2.3 Structure of IFFT2 data

For the second part of IFFT there are three sensor systems to be tested. This test takes one spin per sensor system to stimulate sensor system and collect data from it. Sending of data is done within two spins, the first of them is used for sending the measured values energy- and time-of-flight-response from the sensor system. In the second spin the classification results (MTRX) of these test data are sent. So the whole IFFT2 processing is done in six spins (IFFT spin counter 5 to 0Ah). The number of valid data items in the 255 bytes IFFT data block is determined by the IFFT2 event counter (byte 6).

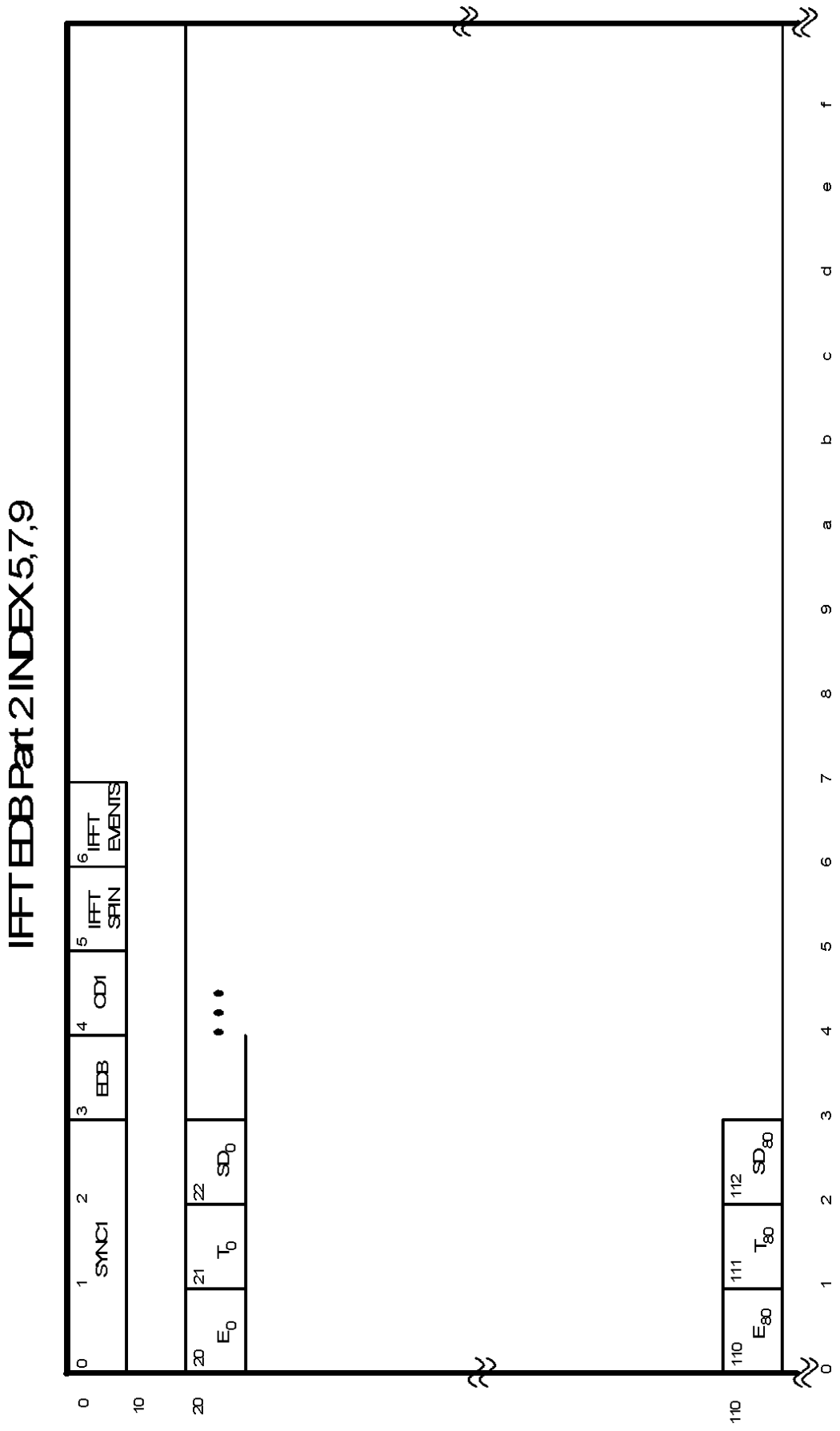
IFFT spin counter 5,7,9

IFFT data block at 20h in the EDB is filled with Direct Events, the number of valid items is determined by the IFFT2 event counter. Each DE contains the particle information energy, time-of-flight, azimuthal and polar entry direction, coded in three bytes.

Direct Event



D	meaning
0	sDir-S1, Dir-X 0
1	sDir-S1, Dir-X 1
2	sDir-S1, Dir-X 2
3	sDir-S1, Dir-X 3
4	sDir-S2, Dir-X 0
5	sDir-S2, Dir-X 1
6	sDir-S2, Dir-X 2
7	sDir-S2, Dir-X 3
8	sDir-S3, Dir-X 0
9	sDir-S3, Dir-X 1
10	sDir-S3, Dir-X 2
11	sDir-S3, Dir-X 3
12	EDI-1, no sDIR-3S
13	EDI-2, no sDIR-3S
14	EDI-3, no sDIR-3S
15	unknown direction


IFFT EDB Part 2 INDEX 5,7,9
SYNC1
EDB
CD1
IFFT SRN
IFFT EVENTS
E0
T0
SD0
E80
T80
SD80
0
1
2
3
4
5
6
20
21
22
110
111
112
0
10
20
110
0
1
2
3
4
5
6
7
8
9
a
b
c
d
e
f

IFFT spin counter 6,8,A

IFFT data block at 20h in the EDB is filled with a compressed format of the matrix. Also in these EDBs the IFFT2 event counter specifies how many data items must be considered. A data item consists of two 16 bit words (4 bytes, high byte is transmitted first!) and describes the amount of events classified to a EA/A class:

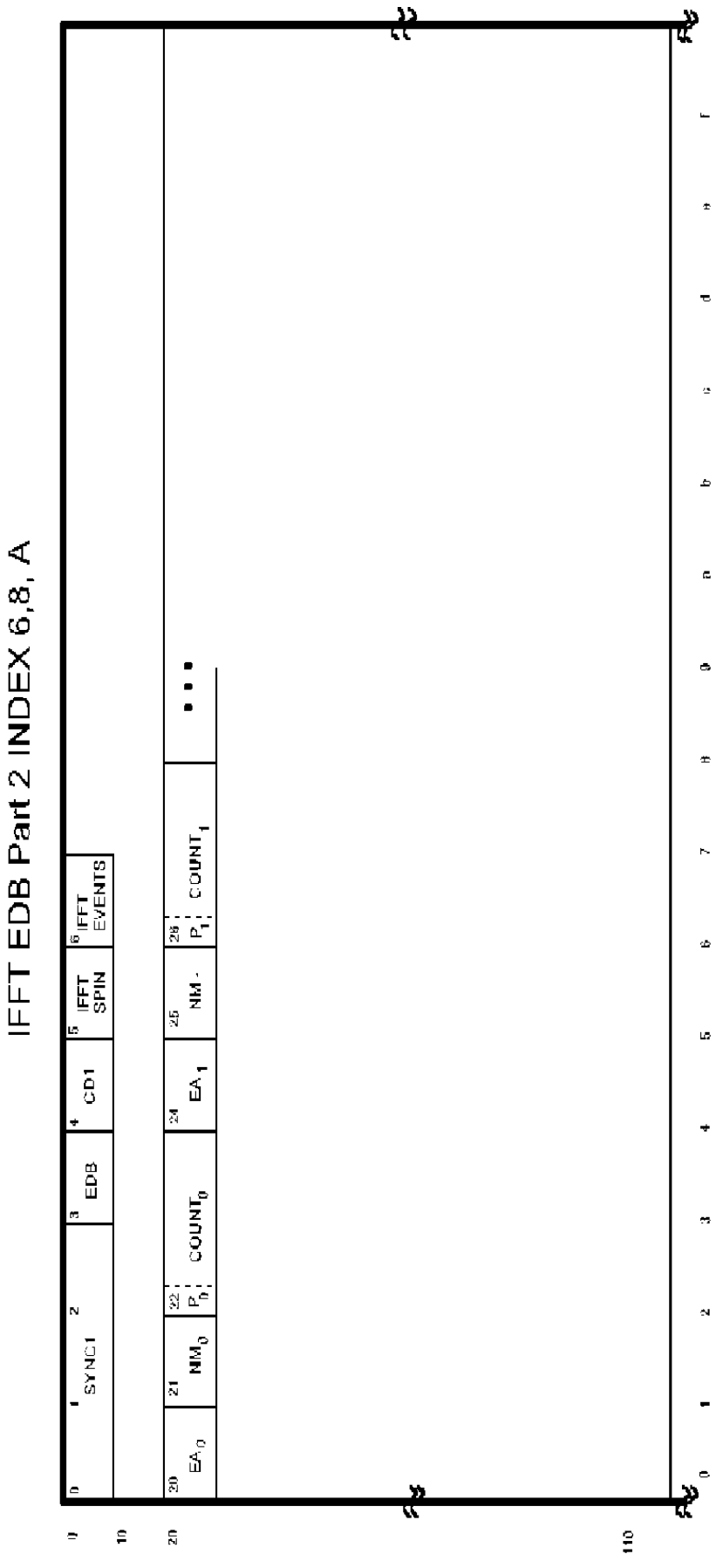
compressed description of the ion matrix

MSB LSB

E/A class (EA)	mass class (A)	1st word

P	amount of events	2nd word

The MSB in the second word represents the even parity of the second word only.


IFFT EDB Part 2 INDEX 6,8, A
0
1 SYNC1
2
3 EDB
4 CD1
5 IFFT SPIN
6 IFFT EVENTS
20 EA0
21 NM0
22 P0
COUNT0
24 EA1
25 NM1
26 P1
COUNT1
0
10
20
110

2.2.4 IES histogram mode

On telecommand (ZERETSTE 60h) RAPID enters a direct event measurement mode at the next spin boundary being an integer multiple of 20h. For each of the 9 IES detector strips a measurement with full resolution of 256 energy steps is done by changing the look-up table in the EPP. The accumulation time is 1 spin (about 4 seconds). Transmission of these data takes two spins because in normal telemetry mode the section in the EDB starting from E-PAD until the end (E-PAD, E-3DD and m-data) is used, providing only 167 bytes. When transmission starts the IES-DE-Measurement flag of content descriptor 2 (bit 7) in the EDB becomes active. The first byte in the IES data part of the EDB contains the strip ID of the data just being sent. In NM mode all 24 bit counters of the EPP are compressed to 8-bit values, in BM1,3 the 24 bit counters are sent directly, low byte first, then middle and high byte. This data is sent in burst mode twice (the same data for even and odd spins, due to internal memory usage), so that it takes the same time as NM data sending. In NM the first 167 counters are sent at even EDB counter index, the last 88 counters in the following odd EDB. Channel 167 itself is not available in NM. After sending all data for all detector strips the instrument returns to normal science acquisition mode with the formerly selected LUT.

It is recommended to operate the histogram mode in BM telemetry.

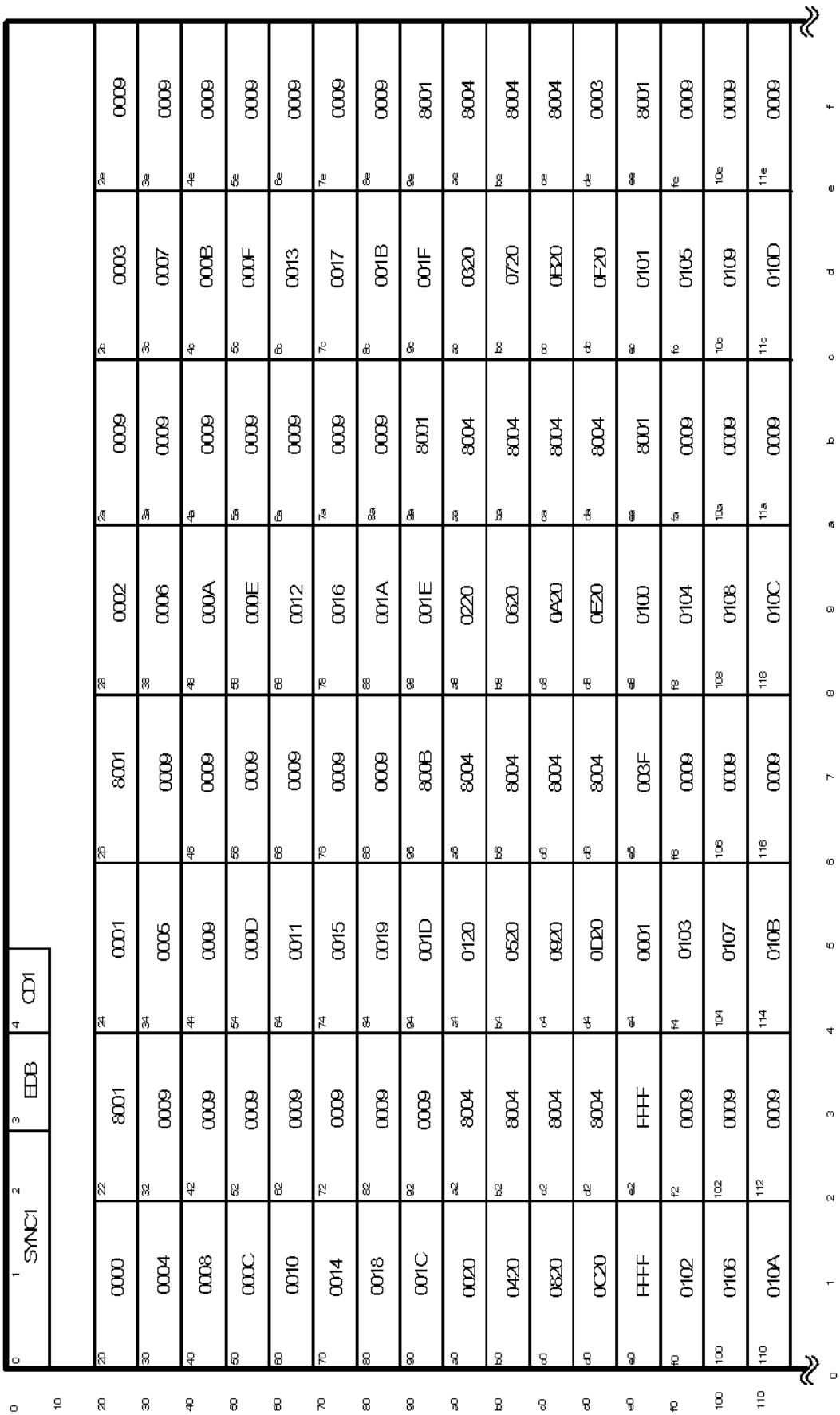
2.2.5 IIMS classification test mode

For RAPID/IIMS a special H/W-classification test procedure is implemented, activated by the command ZERCTSTN. The test results are transmitted in two consecutive NM EDBs and should contain a predefined, fixed pattern. The IIMS classification test was designed for tests during DPU development, when the IIMS was not available. The test mode in principle is also possible with IIMS installed to the RAPID instrument, but it is not intended to perform it in the final RAPID assembly. Thus, the following description of expected test results is only included for completeness reasons.

CLASS TEST EDB structure (512 Bytes)

position	length	content
0	3	1. sync marker (14 6f 2e)
3	1	Subcommutation INDEX (EDB number)
4	1	Content descriptor 1
5	1	CLASS TEST STATE
20h	256	CLASS TEST results data block
14Fh	1	Content descriptor 2
150h	96	E-PAD
1B0h	72	E-3DD
1F8h	8	m

class test EDB 1



class test EDB 2

	0	1	2	3	4
0	SYNC1			EDB	CD1
10					

	0/1	2/3	4/5	6/7	8/9	a/b	c/d	e/f
20	20 010E	22 0009	24 010F	26 0009	28 0110	2a 0009	2c 0111	2e 0009
30	30 0112	32 0009	34 0113	0009	38 0114	3a 0009	3c 0115	3e 0009
40	40 0116	42 0009	44 0117	46 0009	48 0118	4a 0009	4c 0119	4e 0009
50	50 011A	52 0009	54 011B	56 0009	58 011C	5a 0009	5c 011D	5e 800B
60	60 011E	62 8001	64 011F	66 8001	68	6a	6c	6e
70	70	72	74	76	78	7a	7c	7e
80	80	82	84	86	88	8a	8c	8e
90	90	92	94	96	98	9a	9c	9e
a0	a0	a2	a4	a6	a8	aa	ac	ae
b0	b0	b2	b4	b6	b8	ba	bc	be
c0	c0	c2	c4	c6	c8	ca	cc	ce
d0	d0	d2	d4	d6	d8	da	dc	de
e0	e0	e2	e4	e6	e8	ea	ec	ee
f0	f0	f2	f4	f6	f8	fa	fc	fe
100	100	102	104	106	108	10a	10c	10e
110	110	112	114	116	118	11a	11c	11e

0 1 2 3 4 5 6 7 8 9 a b c d e f

2.2.6 RAM check mode

For test purposes it is possible to dump the contents of the DPU memory. After switching to this RAM check mode the DPU stops science data formatting and starts filling the normal EDB frames with RAM check data. To define the memory area to be seen in the data the BERRCADS command has to be send. It sets the boundaries of the region to be transmitted. The ZERIRCKS command starts/stops the RAM check mode. To identify an EDB as RAM check EDB the corresponding bit in the content descriptors is set.

NM RAM check EDB

In normal telemetry modes 256 Bytes of the EDB are used for RAM check data. This area starts at position 20h in the EDB.

NM RAM check EDB structure (512 Bytes)

position	length	content
0	3	1. sync marker (14 6f 2e)
3	1	Subcommutation INDEX (EDB number)
4	1	Content descriptor 1
5	1	E-calibration result of last spin
6	1	T-calibration result of last spin
10h	3	Address of lower boundary for RAM check (high, medium, low)
14h	3	Address of upper boundary for RAM check (high, medium, low)
18h	3	Start address of RAM check data in this EDB (high, medium, low)
20h	256	RAM check data block
14Fh	1	Content descriptor 2
150h	96	E-PAD
1B0h	72	E-3DD
1F8h	8	m

BM RAM check EDB

In burst mode EDBs 2048 RAM check bytes are transmitted. This data block starts at position 20h in the EDB. Only one (the first) sync marker of the BM-EDB is transmitted in burst mode RAM check EDBs.

BM1 RAM check EDB structure (2304 Bytes)

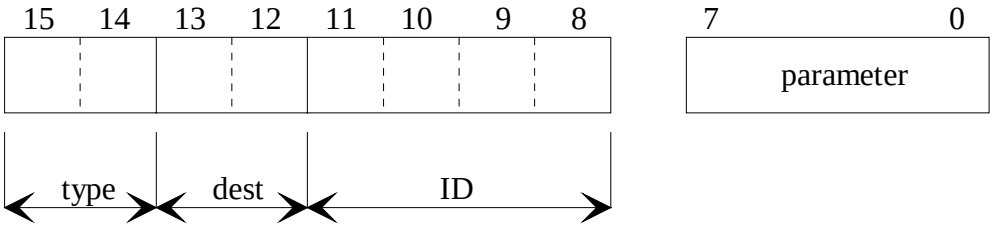
position	length	content
0	3	1. sync marker (14 6f 3d)
3	1	Subcommutation INDEX (EDB number)
4	1	Content descriptor 1
5	1	E-calibration result of last spin
6	1	T-calibration result of last spin
10h	3	Address of lower boundary for RAM check (high, medium, low)
14h	3	Address of upper boundary for RAM check (high, medium, low)
18h	3	Start address of RAM check data in this EDB (high, medium, low)
20h	2048	RAM check data block

3 Command reference

3.1 Structure of RAPID Memory Load Commands

Every command to the DPU has the structure as shown below. It consists of one or more 16 bit values which are divided into two parts:

- the parameter byte (least significant byte in the 16 bit word)
- and the command description byte (MSB, bits 8-15)



type

Code	Description
00	Single word command
01	Block command start
10	Block command data
11	Block command end

dest

Code	Description
00	DPU
01	IES
10	IIMS
11	(not used)

The MSB includes all information about the command type, destination and the command to be executed. The command type (single word or block command) is coded in bits 14 and 15.

- Single commands are defined to switch an H/W device (e.g. relay) on/off or to change a DPU variable. A maximum of 8-bit can be provided to the DPU via the parameter byte.
- Block commands are used to transmit more than eight bit information to the DPU. They are interruptable by single commands (e.g. telemetry mode changes).

The accidental use of command destination of 11 (not used) will lead to the rejection of that command by the DPU.

A complete block command sequence always includes

- BLOCK START The parameter byte contains the number of following BLOCK DATA words
- BLOCK DATA The parameter byte contains eight bit data for the DPU
- BLOCK END Parameter byte contains check byte, calculated for BLOCK DATA parameter bytes

The check byte is built by calculating a CRC value according to the following program in C language:

```
#include <stdio.h>
#include <stdlib.h>

int main(argc,argv)
int argc ;
char **argv;
{

  int i ;
  unsigned char byInput,byI, byBitLoop, byCRC ;
  char * * ppcDummy ;

  if(argc==1)
  {
    printf("\n");
    printf("              **** CRC generator ***                    \n");
    printf("\n");
    printf(" Syntax: GENCRC [byte1 [byte2 [byte3 [... ]]]]\n");
    printf(" Purpose: Generate CRC value from a list of input values.\n");
    printf("          Input values are interpreted as hexadecimal.   \n");
    printf("\n");
    printf(" Institut fuer Datenverarbeitungsanlagen, TU Braunschweig, Germany");
    return 1;
  }

  /* ------------------------------------------------
     loop over parameters
     ------------------------------------------------ */

  byCRC=0;
  printf("Sequence: ") ;

  for (i=1; i<argc; i++)
  {
    byInput = (unsigned char) strtol(argv[i],ppcDummy,16) ;
    printf("0x%2.2X ",byInput) ;

    for (byBitLoop=0;byBitLoop<8;byBitLoop++)
    {
       byI =  byInput ^ byCRC ;

       byCRC = byCRC * 2 ;
       if( byI > 127 )
         byCRC = byCRC ^ 0x21 ;

       if(byInput > 127)
         byInput = byInput * 2 + 1 ;
       else
         byInput = byInput * 2 ;
      }
```

```
  }
  printf("  CRC: 0x%2.2X",byCRC) ;
  return 0 ;
}
```

3.2 Command verification

To verify command receiving and execution there are three flags transmitted in the house keeping frame to show that at least one command was received:

- **ERDCMDER** is set to 1 in the next HK frame after command receiving if a command error has been detected. Command errors are undefined command codes (return code 0Fh) or block commands with wrong length given in the parameter byte (return code 0Eh).

- **ERDCMDIV** is set to 1 in the next HK frame after an invalid command has been received. Invalid commands are correct command codes with parameters out of range (return code depends on the called function), rejected commands due to other circumstances like IFFT commanding while it is already running or telemetry mode isn't NM[1-3]. Another possibility for an invalid command is a block command with an board calculated CRC, that is different from the transmitted CRC (return code 0Fh).

- **ERDCMDVD** is set to 1 in the next HK frame whenever a valid command was received.

3.3 Tables of DPU commands

3.3.1 Table of block commands

DPU commands					
CMD NAME	CODE	PAR	Execution time	FUNCTION	PROCEDURE
BERIORDS	40	03	next sector	read a word or byte from a port	RdPort
BERIOWRS	41	05	next sector	write a word or byte from a port	fWrPort
BERJOBS	42	03	next sector	store/delete job in job manager	fJob
BERDSTIS	43	02	next sector	set double sector time	fwSetDSecTime
BERMLDCS	44	xx	next sector	memory load command	fParLdB
BERPLADS	45	03	next sector	set program load address	fwSetLdPrgAdr
BERPLCAS	46	xx	next sector	parameter load command	fParLdA
BERRCADS	48	06	next sector	set RAM check address	fwSetRAMChkAdr

IIMS commands					
CMD NAME	CODE	PAR	Execution time	FUNCTION	PROCEDURE
BER3MUXS	60	02	next spin	MUX control in SCU	fwSetSCUMUX
BERCTIMS	61	0a	next spin	set time values (dead time ...)	fwSetSerParTime
BERDTIFS	62	02	next sector	time between two shots in IFFT	fwSetShotTime
BERDWINS	63	02	next spin	set DIR window in SCU-ASIC	fwSetDWin
BEREWINS	64	02	next spin	set energy window in SCU-ASIC	fwSetEWin

3.3.2 Table of single commands

DPU commands					
CMD NAME	CODE	PAR	Execution time	FUNCTION	PROCEDURE
ZERASECN	00	0 or 1	next sector	artificial sector clock on/off	fwSwitchArtSecClk
ZERCFGSS	01	0 or 1	next sector	load/store configuration image	fwSnapshot
ZERCLCFS	02	00	immediately	clear command FIFO	--
ZERCTSTN	03	0 or 1	next sector	classification test on/off	fwClassTestOn
ZERIRCKS	04	0 or 1	next spin	internal RAM check on/off	fwIRAM
ZERLUSWN	05	xx	next sector	load LU-detector switches	fwLdLUSwitches
ZERPDISE	06	0 or 1	next sector	enable/disable patches	fwSwitchPatches
ZERPINIS	07	00	next sector	patch initialization	fwInitPatches
ZERSRELS	08	xx	next sector	control power switching relays	fwSetRelReg
ZERSSECS	09	xx	next sector	set sun sector	fSunSecSet
ZERSSUNS	0a	xx	next sector	sun pulse position	fSunSet
ZERWDENS	0b	0 or 1	next spin 64n+32	enable/disable watchdog	fSwitchWD
ZERFCLKS	0c	0 or 1	next sector	set FGM clock (1 kHz/ 16 kHz)	fwSetFGMClk
ZERTCLKS	0d	0x	next sector	select clock source for timer 1	fwSetT1Clk
ZERTMODS	0e	0x	next spin	select telemetry mode	fwSetTMMode
ZERSETPN	0f	0x	next spin	set priority code for IIMS DEs	fSetClassPrio

IES commands					
CMD NAME	CODE	PAR	Execution time	FUNCTION	PROCEDURE
ZEREIFCD	10	00	next sector	disable IES interface	fwDisableIES
ZEREIFCE	11	00	next sector	enable IES interface	fwEnableIES
ZERELUTS	12	xx	next spin	select LUT in EPP	fwEPPLUTSel
ZERETSTD	13	00	next sector	disable EPP test mode	fwDisableIESTest
ZERETSTE	14	0x	next sector	enable EPP test mode	fwEnableIESTest
ZERECMDS	15	xx	next spin	send IES command byte	fwSendIESCmdByte
ZEREPTBS	16	0 or 1	next spin	select E-PAD table 3a or 3b	fwSetEPAD3
ZEREACTS	17	xx	next spin	set EPP accumulation time	fwEPPAccu
ZERECALS	18	0 or 1	next spin	enable/disable Calibration mode	fwSelIESCal

IIMS commands					
CMD NAME	CODE	PAR	Execution time	FUNCTION	PROCEDURE
ZERALEVS	20	0x	next spin	set STA MCP target level	fStartLev
ZERALIMS	21	0x	next sector	set STA MCP voltage limit	fStartLim
ZERDEFSE	22	0 or 1	next sector	en-/disable defl. HV stepping	fwDEFENA
ZERDLEVS	23	0x	next spin	set defl. plate target level	fDefLev
ZERDLIMS	24	0x	next sector	set defl. plate voltage limit	fDefLim
ZEREBCHE	25	xx	next spin	set E/B-detector control	fwSetEBSwitches
ZERHDSLE	26	0x	next spin	set head mask for MUX channels	fwSetHeadmask
ZERIFFTE	27	0 or 1	in single shot gap	run In-Flight-Functional-Test	fwIFFTON
ZERPLEVS	28	0x	next spin	set STO MCP target level	fStopLev
ZERPLIMS	29	0x	next sector	set STO MCP voltage limit	fStopLim
ZERSLOPS	2a	0x	next spin	change TAC slope	fwSetTACConv
ZERSMODS	2b	0 or 1	next spin	set serial/parallel measurement	fwTOGMOD
ZERSTASE	2c	0 or 1	next sector	en-/disable STA MCP HV stepping	fwSTAENA
ZERSTOSE	2d	0 or 1	next sector	en-/disable STO MCP HV stepping	fwSTOENA
ZERTRMDS	2e	0x	next spin	set event trigger mode	fwSetTrigMod

3.3.3 Table of block commands sorted by name

CMD NAME	DEST	CODE	PAR	FUNCTION	PROCEDURE
BER3MUXS	IIMS	60	02	MUX control in SCU	fwSetSCUMUX
BERCTIMS	IIMS	61	0a	set time values (dead time ...)	fwSetSerParTime
BERDSTIS	DPU	43	02	set double sector time	fwSetDSecTime
BERDTIFS	IIMS	62	02	time between two shots in IFFT	fwSetShotTime
BERDWINS	IIMS	63	02	set DIR window in SCU-ASIC	fwSetDWin
BEREWINS	IIMS	64	02	set energy window in SCU-ASIC	fwSetEWin
BERIORDS	DPU	40	03	read a word or byte from a port	fRdPort
BERIOWRS	DPU	41	05	write a word or byte from a port	fWrPort
BERJOBS	DPU	42	03	store/delete job in job manager	fJob
BERMLDCS	DPU	44	xx	memory load command	fParLdB
BERPLADS	DPU	45	03	set program load address	fwSetLdPrgAdr
BERPLCAS	DPU	46	xx	parameter load command	fParLdA
BERRCADS	DPU	48	06	set RAM check address	fwSetRAMChkAdr

3.3.4 Table of single commands sorted by name

CMD NAME	DEST	CODE	PAR	FUNCTION	PROCEDURE
ZERALEVS	IIMS	20	0x	set STA MCP target level	fStartLev
ZERALIMS	IIMS	21	0x	set STA MCP voltage limit	fStartLim
ZERASECN	DPU	00	0 or 1	artifical sector clock on/off	fwSwitchArtSecClk
ZERCFGSS	DPU	01	0 or 1	load/store configuration image	fwSnapshot
ZERCLCFS	DPU	02	00	clear command FIFO	--
ZERCTSTN	DPU	03	0 or 1	classification test on/off	fwClassTestOn
ZERDEFSE	IIMS	22	0 or 1	enable/disable defl. HV stepping	fwDEFENA
ZERDLEVS	IIMS	23	0x	set defl. plate target level	fDefLev
ZERDLIMS	IIMS	24	0x	set defl. plate voltage limit	fDefLim
ZEREACTS	IES	17	xx	set EPP accumulation time	fwEPPAccu
ZEREBCHE	IIMS	25	xx	set E/B-detector control	fwSetEBSwitches
ZERECALS	IES	18	0 or 1	enable/disable Calibration mode	fwSelIESCal
ZERECMDS	IES	15	xx	send IES command byte	fwSendIESCmdByte
ZEREIFCD	IES	10	00	disable IES interface	fwDisableIES
ZEREIFCE	IES	11	00	enable IES interface	fwEnableIES
ZERELUTS	IES	12	xx	select LUT in EPP	fwEPPLUTSel
ZEREPTBS	IES	16	0 or 1	select E-PAD table 3a or 3b	fwSetEPAD3
ZERETSTD	IES	13	00	disable EPP test mode	fwDisableIESTest
ZERETSTE	IES	14	0x	enable EPP test mode	fwEnableIESTest
ZERFCLKS	DPU	0c	0 or 1	set FGM clock (1kHz/16kHz)	fwSetFGMClk
ZERHDSLE	IIMS	26	0x	set head mask for MUX channels	fwSetHeadmask
ZERIFFTE	IIMS	27	0 or 1	run inflight funtional test	fwIFFTON
ZERIRCKS	DPU	04	0 or 1	internal RAM check on/off	fwIRAM

CMD NAME	DEST	CODE	PAR	FUNCTION	PROCEDURE
ZERLUSWN	DPU	05	xx	load LU-detector switches	fwLdLUSwitches
ZERPDISE	DPU	06	0 or 1	enable/disable patches	fwSwitchPatches
ZERPINIS	DPU	07	00	patch initialization	fwInitPatches
ZERPLEVS	IIMS	28	0x	set STO MCP target level	fStopLev
ZERPLIMS	IIMS	29	0x	set STO MCP voltage limit	fStopLim
ZERSETPN	DPU	0f	0x	set priority code for IIMS DEs	fSetClassPrio
ZERSLOPS	IIMS	2a	0x	change TAC slope	fwSetTACConv
ZERSMODS	IIMS	2b	0 or 1	set serial/parallel measurement	fwTOGMOD
ZERSRELS	DPU	08	xx	control power switching relays	fwSetRelReg
ZERSSECS	DPU	09	xx	set sun sector	fSunSecSet
ZERSSUNS	DPU	0a	xx	sun pulse position	fSunSet
ZERSTASE	IIMS	2c	0 or1	en-/disable STA MCP HV stepping	fwSTAENA
ZERSTOSE	IIMS	2d	0 or 1	en-/disable STO MCP HV stepping	fwSTOENA
ZERTCLKS	DPU	0d	0x	select clock source for timer 1	fwSetT1Clk
ZERTMODS	DPU	0e	0x	select telemetry mode	fwSetTMMode
ZERTRMDS	IIMS	2e	0x	set event trigger mode	fwSetTrigMod
ZERWDENS	DPU	0b	0 or 1	enable/disable watchdog	fSwitchWD

3.4 Detailed Description

The following section describes the commands that the DPU can execute. Each command description is split up into different subsections:

FUNCTION	COMMANDNAME Description of command purpose
CODE	Binary coding of the commands; these are the eight upper bits of the command word that is sent to the DPU
PARAMETER	This section describes the parameter bits of the command word (Bits 7 - 0) and the following command words for block commands.
DESCRIPTION	This section gives a comprehensive textual description of what the command does.
RETURNS/ VALIDITY	This section describes the effects on HK parameters of commands that are accepted and executed by the DPU. The description has the form: HK parameter name (byte position in HK frame, bits in HK byte [, subcommutation depth]). These HK parameters can be used for command confirmation beside the valid and invalid command flags and the command counter in HK data. For all block commands the on board calculated block CRC over the received block data bytes can be compared with the expected one from HK parameter ERDLCCRC(39,7-0,21/32). For rejected commands the return code (HK: ERDECODE) is explained.
OPERATIONAL CONSTRAINTS	Condition to be satisfied before the command could be sent.
ALTERNATIVE	Another command that fulfils the same function.
COMPLEMENTARY	A command that gives the reverse effect.
REMARKS	General remarks about the command.

BER3MUXS

FUNCTION Control of multiplexers in IIMS/SCU

CODE/ PARAMETER

Word	Highbyte	Lowbyte	
0	60h	02h	
1	A0h	bit 0: E1	(0 enabled, 1 disabled)
		bit 1: T1	(0 enabled, 1 disabled)
		bit 2: D1	(0 enabled, 1 disabled)
		bit 3: E2	(0 enabled, 1 disabled)
		bit 4: T2	(0 enabled, 1 disabled)
		bit 5: D2	(0 enabled, 1 disabled)
		bit 6: E3	(0 enabled, 1 disabled)
		bit 7: T3	(0 enabled, 1 disabled)
2	A0h	bit 0: D3	(0 enabled, 1 disabled)
		bit 7 - 1:	don't care
3	E0h	CRC	

DESCRIPTION This command sets the control word for the internal SCU digital multiplexers (programm variable wSCUDigMux). The control word will be sent to the sensor electronics at every spin boundary.

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY
ERDEMUX1: 0=enabled 1=disabled
ERDDMUX1: 0=enabled 1=disabled
ERDTMUX1: 0=enabled 1=disabled
ERDEMUX2: 0=enabled 1=disabled
ERDDMUX2: 0=enabled 1=disabled
ERDTMUX2: 0=enabled 1=disabled
ERDEMUX3: 0=enabled 1=disabled
ERDDMUX3: 0=enabled 1=disabled
ERDTMUX3: 0=enabled 1=disabled

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BER3MUXS

REMARKS NONE

BERCTIMS

FUNCTION Set IIMS measurement and dead time values

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	61h	0Ah
1	A1h	LSB of serial classification time for head 1
2	A1h	MSB of serial classification time for head 1
3	A1h	LSB of serial classification time for head 2
4	A1h	MSB of serial classification time for head 2
5	A1h	LSB of serial classification time for head 3
6	A1h	MSB of serial classification time for head 3
7	A1h	LSB of parallel classification time
8	A1h	MSB of parallel classification time
9	A1h	LSB of sector dead time
10	A1h	MSB of sector dead time
11	E1h	CRC

DESCRIPTION This command sets the time for serial classification with head 1 (wSerialTime1), head 2 (wSerialTime2) and head 3 (wSerialTime3). It sets the time for parallel classification (wParallelTime) too. In addition it sets the sector dead time, this is the time beween begin of a new sector and start of the classification (parallel or serial for head 1). The instrument sets the dead time error flag, if the sector dead time is too short in one or more sectors of a spin. The time values can be calculated according to following rule:

time = wTime * 8 µs

wTime is element of wSerialTime1, wSerialTime2, wSerialTime3, wParallelTime, wDeadTime

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length
In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERCTIMS

REMARKS The sum of measurement time and dead time must be within the minimum sector length ($t_{spinnominal}$/16 - 10%)

BERDTIFS

FUNCTION Time between two shots in inflight functional test mode.

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	62h	02h
1	A2h	LSB of time (wIFFTTime, low byte)
2	A2h	MSB of time (wIFFTTime, high byte)
3	E2h	CRC

DESCRIPTION This command sets the time between two shots to the sensor in inflight functional test mode. The time value can be calculated according to following rule:

time = wIFFTTime * 8 us , time > 2 ms

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERDTIFS

REMARKS NONE

BERDSTIS

FUNCTION Set double sector time

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	43h	02h
1	83h	LSB of double sector time
2	83h	MSB of double sector time
3	C3h	CRC

DESCRIPTION This command loads the double sector time This time will be used in artificial sector clock mode. A high priored timer controls the sector clock. The timer will be loaded with the half sector time (wDouble SecTime/2). This command is helpful, if the spinrate changes, and the instrument runs in artificial sector clock mode.

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERDSTIS

REMARKS Useful only, if sector reference clock from S/C is not available.

BERDWINS

FUNCTION Set window of direction bits in SCU-ASIC

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	63h	02h
1	A3h	bit 4 - 0: start value of direction window bit 7 - 5: don't care
2	A3h	bit 4 - 0: stop value of direction window (byDWindowStop) bit 7 - 5: don't care
3	E3h	CRC

DESCRIPTION This command sets the start and the stop values for the direction window of the SCU-ASICS. The window will be sent to the sensor at every spin boundary.

RETURNS **In the case of rejection**:
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY ERDDWIST
ERDDWISP

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERDWINS

REMARKS NONE

BEREWINS

FUNCTION Set window of energy bits in SCU-ASIC

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	64h	02h
1	A4h	bit 4 - 0: start value of energy window (byEWindowStart) bit 7 - 5: don't care
2	A4h	bit 4 - 0: stop value of energy window (byEWindowStop) bit 7 - 5: don't care
3	E4h	CRC

DESCRIPTION This command loads the start and the stop values for the energy window of the SCU-ASICS. The window will be sent to the sensor at every spin boundary.

RETURNS **In the case of rejection**:
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY ERDEWIST
ERDEWISP

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BEREWINS

REMARKS NONE

BERIORDS

FUNCTION

Read from a port or register of the DPU or SCU. Only for trouble shooting.

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	40h	03h
1	80h	low byte of port address
2	80h	high byte of port address
3	80h	0: read 8 bit register or port 1: 16 bit register or port
4	C0h	CRC

DESCRIPTION

The BERIORDS command is a special command for trouble shooting. It should not be used for normal commanding. With this command it is possible to read from registers or ports of the DPU or SCU. After reading a port, the result will be stored in the variables "byInDummy" or "wInDummy" for 8/16 bit registers/ports. Note: Not all register could be used for reading and writing. The instrument reads and writes most of the registers/ports cyclically.

RETURNS

In the case of rejection:

ERDECODE: 0Eh: wrong command length

In the case of acceptance:

see section VALIDITY

VALIDITY

-

OPERATIONAL CONSTRAINTS

NONE

ALTERNATIVE

NONE

COMPLEMENTARY

BERIOWRS

REMARKS

Can be used for comparison of HK item with DPU registers contents, if necessary.

BERIOWRS

FUNCTION Write to a port or register of the DPU or SCU. Only for troubleshooting!

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	41h	05h
1	81h	low byte of word value or byte value to write
2	81h	high byte of word value to write
3	81h	low byte of port address
4	81h	high byte of port address
5	81h	0: 8 bit register or port 1: 16 bit register or port
6	C1h	CRC

DESCRIPTION The BERIOWRS command is a special command for trouble shooting. It should not be used for normal commanding. With this command it is possible to write to registers or ports of the DPU or SCU.For 8 bit port IO the content of block[1] is ignored. Note: Not all registers could be used for reading and writing. The instrument reads and writes most of the registers/ports cyclically.

RETURNS **In the case of rejection:**

ERDECODE: 0Eh: wrong command length

In the case of acceptance:

see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS On PI`s approval only. Extreme care required!

ALTERNATIVE NONE

COMPLEMENTARY BERIORDS

REMARKS Should be used in conjunction with a memory load to the RAM area that mirrors the register contents.

BERJOBS

FUNCTION Store or delete a job in the job manager

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	42h	03h
1	82h	high byte of pointer
2	82h	low byte of pointer
3	82h	bit 7: store/delete flag 0: delete pointer 1: store pointer 6 - 0: job manager level: 0: execution immediate 1: execution every sector 2: execution in next sector 3: execution after reception of a command byte 4: execution every spin 5: execution in next spin 6: execution every 64th spin 7: execution in next 64th spin 8: execution immediate with lowest priority 9 - 127: invalid level
4	C2h	CRC

DESCRIPTION The BERJOBS command stores or deletes a pointer in the job manager. The job manager controls task executions. He runs jobs in different levels. Higher priored jobs (level with small numbers) interrupt jobs in lower levels. The jobs, which have to run, are determined in tables or FIFOs of pointers. The difference between table and FIFOs is following: The job in a table will be executed after every trigger of the job manager level (level 1, every sector). The job in a FIFO will be executed once, if the level gets a trigger. (level 2, one sector). An immediate FIFO will be triggered, if a pointer is stored in it. This command can store a job in a table (level 1, 4 and 6), in a FIFO (2, 3, 5 and 7), or in an immediate FIFO (level 0 and 8) or delete it from these tables.

RETURNS	**In the case of rejection:** ERDECODE: 08h: invalid job manager level 09h: pointer not deleted 0Ah: pointer not stored 0Eh: wrong command length **In the case of acceptance:** see section VALIDITY
VALIDITY	-
OPERATIONAL CONSTRAINTS	On PI`s approval only.
ALTERNATIVE	NONE
COMPLEMENTARY	BERJOBS
REMARKS	Can lead to an instrument reset, if incorrectly used.

BERMLDCS

FUNCTION RAPID memory load command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	44h	n: number of bytes for memory load (0 - 79)
1	84h	xx
. . .	. . .	. . .
n	84h	xx
n+1	C4h	CRC (calculated from lowbytes 1 to n)

DESCRIPTION Starting at the current program load address (see LDPRGADR command), the parameter bytes of the BERMLDCS command are written to memory. This command has no effect on the current program load address, i.e. a second BERMLDCS command will start writing at the same location as its predecessor.

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS Issue BERPLADS before BERMLDCS.

ALTERNATIVE NONE

COMPLEMENTARY NONE

REMARKS Multipurpose command (RAM patching, program upload)

BERPLADS

FUNCTION Set the program load address

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	45h	03h
1	85h	bit 7 - 4: 0 bit 3 - 0: bit 19 - 16 of physical memory address
2	85h	bit 7 - 0: bit 15 - 8 of physical memory address
3	85h	bit 7 - 0: bit 7 - 0 of physical memory address
4	C5h	CRC

DESCRIPTION The BERPLADS command sets the program load start address for memory load command BERMLDCS in the DPU.

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERPLADS

REMARKS Issue before BERMLDCS

BERPLCAS

FUNCTION Parameter Load command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	46h	n: number of bytes for memory load (1 - 79)
1	86h	xx: parameter type (0 - 20)
2	86h	xx: data bytes
. . .		
n	C6h	CRC

DESCRIPTION The BERPLCAS command is a special DPU memory load command by which a fixed set of operating parameters can be downloaded. It's main difference to the BERPLADS command is that it deals with 'logical' addresses (parameter numbers) instead of physical memory addresses. This makes the command usage independent of the software version, since the physical addresses of parameters change depending on the software version.

type	length (bytes)	description
00:	3	parameter load address
01:	2	time between two IFFT shots
02:	2	IIMS SCU multiplexer
03:	1	SCU direction window start
	1	SCU direction window stop
04:	1	energy/backdetector switches
05:	1	Latch-Up detector switches
06:	1	SCU energy window start
	1	SCU energy window stop
07:	2	double sector time
08:	1	TAC conversion time
09:	1	SCU trigger mode
0a:	1	SCU head mask
0b:	10	measurement times (serial 1-3, parallel, dead
0c:	4	ram check boundaries
0d-14 :		not used

RETURNS **In the case of rejection:**

ERDECODE: 03h: invalid number of bytes
0Dh: invalid parameter type
0Eh: wrong command length
0Fh: invalid parameter type (21-255)

In the case of acceptance:

see section VALIDITY

VALIDITY	-
OPERATIONAL CONSTRAINTS	NONE
ALTERNATIVE	VARIOUS
COMPLEMENTARY	VARIOUS
REMARKS	This command is an alternative for 13 other commands.

BERRCADS

FUNCTION Set RAM check addresses

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	48h	06h
1	88h	bit 7 - 0: bit 23 - 16 of RAM check low bound
2	88h	bit 7 - 0: bit 15 - 8 of RAM check low bound
3	88h	bit 7 - 0: bit 7 - 0 of RAM check low bound
4	88h	bit 7 - 0: bit 23 - 16 of RAM check up bound
5	88h	bit 7 - 0: bit 15 - 8 of RAM check up bound
6	88h	bit 7 - 0: bit 7 - 0 of RAM check up bound
7	C8h	CRC

DESCRIPTION This command sets the upper bound (dwIRAMUp) and the lower bound (dwIRAMLo) of the RAM check mode.

RETURNS **In the case of rejection:**
ERDECODE: 0Eh: wrong command length

In the case of acceptance:
see section VALIDITY

VALIDITY ERDRCHKL
ERDRCHKU

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY BERRCADS

REMARKS NONE

ZERALEVS

FUNCTION STA MCP high voltage target level set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	20h	bit 3 - 0: set STA MCP HV target level (0 - 15) bit 7 - 4: don't care

DESCRIPTION The ZERALEVS command sets a new STA MCP high voltage target level. It starts the stepping process. Every spin will the current level will step to the target level. It is not possible to set a target level, which is greater than the high voltage limit.

Note: It is not possible to set a new target level, if the STA MCP high voltage is disabled (→ZERSTASE (37,5,0/4)) or the deflection HV-relays is off (→ERDRELS2(2,6)).

RETURNS **In the case of rejection:**

ERDECODE: 05h: start MCP HV is not disabled
06h: target level > limit
07h: stepping process cannot be started

In the case of acceptance:

see section VALIDITY

VALIDITY ERDSTMHC

OPERATIONAL CONSTRAINTS HV relay must be on,
ERDSTMVL must be above or equal the intended level,
ERDSTMCP must be enabled

ALTERNATIVE NONE

COMPLEMENTARY ZERALEVS

REMARKS NONE

ZERALIMS

FUNCTION STA MCP high voltage limit set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	21h	bit 3 - 0: set STA MCP HV limit (0 - 15) bit 7 - 4: don't care

DESCRIPTION The ZERALIMS command sets a new start MCP high voltage limit. It sets the STA MCP high voltage target level, if the new limit is smaller than the target level. In this case the current high voltage level steps down to the new target level. It does one step every spin. If the new limit is greater than the target level, only the new limit will be set.

RETURNS **In the case of rejection:**

ERDECODE: 0Ch: already stepping
0Dh: limit > 15

In the case of acceptance:

see section VALIDITY

VALIDITY ERDSTMVL

OPERATIONAL CONSTRAINTS PI`s approval required

ALTERNATIVE NONE

COMPLEMENTARY ZERALIMS

REMARKS NONE

ZERASECN

FUNCTION Artifical sector clock switch on/off

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	00h	01h: on 00h: off

DESCRIPTION The command ZERASECN switches the artificial sector clock on/off. The DPU measures the current time between two sectors. After switching on, a high priority timer replaces the sector pulses from the spacecraft. After switching off, the DPU synchronizes to the spacecraft sector pulse again and switches back after it has received 32 sector pulses. Note: The artificial sector clock can not be switched off, if there are no sector pulses from the spacecraft!

RETURNS **In the case of rejection**:

ERDECODE: ERDSSINT "0" = "external" normal sector clock
"1" = "internal" artificial sector clock

In the case of acceptance:

see section VALIDITY

VALIDITY ERDSSINT

OPERATIONAL CONSTRAINTS To be used if S/C sector clock becomes permanently unreliable.

ALTERNATIVE NONE

COMPLEMENTARY ZERASECN

REMARKS NONE

ZERCFGSS

FUNCTION Load/store configuration image

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	01h	00h: store configuration 01h: load configuration

DESCRIPTION The command ZERCFGSS loads/stores the classification image. The most important variables will be stored in the non-volatile RAM. This instrument state can be loaded in later time.

RETURNS **In the case of rejection:**

ERDECODE:
- 01h: buffer too small, config. could not be stored.
- 02h: buffer too small, config. could not be loaded.
- 03h: CRC failure, configuration could not be loaded.
- 04h: CRC failure, sensor could not be configured

In the case of acceptance:

see section VALIDITY

VALIDITY -

HK parameters: ERDCFGER
- bit 0: 1 = configuration error
- bit 1: 1 = snapshot configuration error
- bit 2: 1 = load configuration error
- bit 3: 1 = load snapshot configuration error

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERCFGSS

REMARKS NONE

ZERCLCFS

FUNCTION Clear command FIFO.

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	02h	01h

DESCRIPTION The ZERCLCFS command directly clears the command FIFO. This command should be used only, if the instrument is not commandable.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS To be used only, if a deadlock in the instrument`s command interpreter has occured.

ALTERNATIVE NONE

COMPLEMENTARY NONE

REMARKS This command is not implemented.

ZERCTSTN

FUNCTION Classification test on/off

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	03h	01h .. 08h

DESCRIPTION The command ZERCTSTN is used to generate test events for the IIMS classification unit.

With parameter 01h the command will be executed at the next spin boundary. An IIMS classification hardware test will be performed. In this test ETD combinations are written into the classification input registers and are classified in the same way as real events from the sensor system. The test results are collected and transmitted in two EDBs and have to be compared with the expected results.

When commanding parameters 02h to 08h a test event generation procedure will be enabled which, additional to normal measurement, is performed within the sector dead time.

3	generates 16 events per sector; T=bySecNo, E=(AAh,ABh,...55h,56h,...)
4	1 event per sector; E=byETstValue (default=7) T=byTTstValue (default=2ah), D=awTest2R6Tab[bySecNo]
5	the same as procedure 4, except for D: D=wDTstValue
6-8	test events for bin-boundaries (H,He,CNO) D=wDTstValue

RETURNS **In the case of rejection:**

ERDECODE: 01h: job was not accepted
0Ch: test mode already active

In the case of acceptance:

see section VALIDITY

VALIDITY EDB content descriptor 1 (CD1), ERDSTAT1

OPERATIONAL CONSTRAINTS This command has been exclusively designed for on-ground bench test without IIMS SCU. The use of this command with installed SCU would need additional commanding in before and shall not be done without the PI's prior approval. This command works only in Normal Mode!

ALTERNATIVE	NONE
COMPLEMENTARY	ZERCTSTN
REMARKS	Commanding BM3-mode switches Classification Test off.

ZERDEFSE

FUNCTION Deflection high voltage stepping enable/disable

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	22h	01h: enable 00h: disable

DESCRIPTION The command ZERDEFSE enables/disables the setting of a new target level for the deflection plate high voltage. It is not possible to set a new deflection voltage target level, if the deflection high voltage is disabled.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDHVSE: 1 = enabled
0 = disabled

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERDEFSE

REMARKS NONE

ZERDLEVS

FUNCTION Deflection plate high voltage target level set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	23h	bits 3 - 0: set deflection plate HV target level (0 - 15) bits 7 - 4: don't care

DESCRIPTION The ZERDLEVS command sets a new deflection plate high voltage target level. It starts the stepping process. Every even spin the current level steps one step to the target level. It is not possible to set a target level, which is greater than the high voltage limit.

Note: It is not possible to set a new target level, if the deflection plate high voltages are disabled.

RETURNS **In the case of rejection:**

ERDECODE: 04h: HV-relays is off
05h: deflection plate HV is disabled
06h: target level > limit
07h: stepping process cannot be started

In the case of acceptance:

see section VALIDITY

VALIDITY ERDDPHCL

OPERATIONAL CONSTRAINTS HV relay must be on,
ERDDPHCL must be above or equal intended level,
ERDDHVSE must be enabled

ALTERNATIVE NONE

COMPLEMENTARY ZERDLEVS

REMARKS NONE

ZERDLIMS

FUNCTION Deflection plate high voltage limit set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	24h	bit 3 - 0: set deflection plate HV limit (0 - 15) bit 7 - 4: don't care

DESCRIPTION The ZERDLIMS command sets a new deflection plate high voltage limit. It sets the deflection plate high voltage target level, if the new limit is smaller than the target level. In this case the current high voltage level steps down to the new target level. It does one step every second spin. If the new limit is greater than the target level, only the new limit will be set.

RETURNS **In the case of rejection:**

ERDECODE: 0Ch: already stepping
0Dh: limit > 15

In the case of acceptance:

see section VALIDITY

VALIDITY ERDDPHLD

OPERATIONAL CONSTRAINTS PI`s approval required

ALTERNATIVE NONE

COMPLEMENTARY ZERALIMS

REMARKS NONE

ZEREACTS

FUNCTION Set EPP accumulation time

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	17h	0...255

DESCRIPTION This command has no effect anymore!

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY NONE

REMARKS NONE

ZEREBCHE

FUNCTION Control of energy and backdetector power supply

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	25h	bit 0: E1 (0 enabled, 1 disabled) bit 1: BD1 (0 enabled, 1 disabled) bit 2: E2 (0 enabled, 1 disabled) bit 3: BD2 (0 enabled, 1 disabled) bit 4: E3 (0 enabled, 1 disabled) bit 5: BD3 (0 enabled, 1 disabled) bit 7 - 6: don't care

DESCRIPTION This command loads the control byte (byEBDSwitch) of the energy and backdetector switches for the sensor. The control byte will be sent to the sensor at every spin boundary.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY
ERDEDET1
ERDBDET1
ERDEDET2
ERDBDET2
ERDEDET3
ERDBDET3

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY ZEREBCHE

REMARKS NONE

ZERECALS

FUNCTION IES calibration mode

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	18h	00h: IES calibration mode off 01h: IES calibration mode on

DESCRIPTION In the IES calibration mode the pedestal is shifted to an energy range that is visible in the scientific data. With the IES calibration mode off the pedestal is visible in the HK items ERERATE1 to ERERATE9.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERERATE1
ERERATE2
.
.
.
ERERATE9
status bit 5 in EDB flag byte 1

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERECALS

REMARKS NONE

ZERECMDS

FUNCTION Send IES command.

CODE/ PARAMETER

Word	High-byte	Low-byte	IES integration time
0	15h	00h:	2 µs
		80h:	5 µs
		40h:	15 µs
		C0h:	50 µs

DESCRIPTION The parameter byte will be sent to the IES at the next spin boundary.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERECMDRT

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERECMDS

REMARKS NONE

ZEREIFCD

FUNCTION Disable IES interface

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	10h	00h

DESCRIPTION This command disables the interface between EPP and IES. The interface drivers on EPP side go to tristate status.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZEREIFCE

REMARKS NONE

ZEREIFCE

FUNCTION Enable IES Interface

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	11h	00h

DESCRIPTION This command enables the interface between EPP and IES.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZEREIFCD

REMARKS NONE

ZERELUTS

FUNCTION Select LUT quadruple or single LUT for the IES electron preprocessor

CODE/

PARAMETER

Word	High-byte	Low-byte	Phoenix FM LUT quadruple	New Cluster II FMs LUT quadruple
0	12h	80h:	default set (20°C)	n.a. (Phoenix LUT)
		81h:	n.a.	n.a.
		82h:	n.a.	n.a.
		83h:	n.a.	n.a.
		84h:	n.a.	n.a.
		85h:	n.a.	n.a.
		86h:	n.a.	n.a.
		87h:	n.a.	n.a.
		88h:	n.a.	test set 1 (P=1,S=1)
		89h:	n.a.	test set 2 (P=50,S=1)

DESCRIPTION After first time instrument power on every RAPID FM has to be provided the correct LUT quadruple by using the command ZERELUTS and the respective parameter according to the above table. By default the LUT quadruple 80h is used. Please note that selecting the LUT quadruple does not include the selection of a specific LUT from the LUT quadruple. This selection has to be done with an additional ZERELUTS command from the next tables.

CODE/

PARAMETER

Word	High-byte	Low-byte	IES integration time
	12h	00h:	2 µs (automatic)
		01h:	5 µs (automatic)
		02h:	15 µs (automatic)
		03h:	50 µs (automatic)
		40h:	2 µs (fixed)
		41h:	5 µs (fixed)
		42h:	15 µs (fixed)
		43h:	50 µs (fixed)

DESCRIPTION After selection of an LUT quadruple a member LUT of this quadruple has to be selected. The difference between the LUTs bases on the specific adaption on the possible IES integration times (2-50 µs). These can be selected by using the parameter bytes 00h to 03h (automatic switching enabled, default) and 40h to 43h (automatic switching disabled). When using the automatic switching feature the detection of pile-up effects in the sensor leads to a automatic temporary switching back to shorter integration times. This automatism can be disabled by using the fixed-type LUTs. Because in the final FM S/W the LUTs are not included, uploading of these LUTs is necessary before measurement.

CODE/ PARAMETER

Word	Highbyte	Lowbyte	Selected E-histogram LUT
	12h	51h:	E-histogram for detector strip 1
		52h	E-histogram for detector strip 2
		53h:	E-histogram for detector strip 3
		54h:	E-histogram for detector strip 4
		55h:	E-histogram for detector strip 5
		56h	E-histogram for detector strip 6
		57h:	E-histogram for detector strip 7
		58h:	E-histogram for detector strip 8
		59h:	E-histogram for detector strip 9

DESCRIPTION For measuring an E-histogram with maximum resolution the events from a single IES detector strip are accumulated in unique counters. Measurement results from other than the selected detector strips are accumulated in the counter with the highest number (255). This mode together with the strip number is selected by using parameter 51h - 59h according to the above table.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY LUT ID in bits D4-D0 of EDB content descriptor 2 (CD2) and of ERDSTAT2, selected sensor and temperature range in ERESENID.

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERELUTS

REMARKS NONE

ZEREPTBS

FUNCTION Select E-PAD table

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	16h	00h: table 3a 01h: table 3b

DESCRIPTION For selection of the 3rd direction ID in NM E-PAD data, two different selection tables are defined (3a, 3b). This command selects the table to be used.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERIPADTS, bit D5 of EDB content descriptor 2 (CD2) and of ERDSTAT2

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZEREPTBS

REMARKS NONE

ZERETSTD

FUNCTION Disable EPP test mode

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	13h	00h

DESCRIPTION Stops generating of test events and disables special test event formatting into the EDB. The instrument returns to normal science aquisition mode.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERETSTE

REMARKS NONE

ZERETSTE

FUNCTION Enable EPP test mode

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	14h	00h: no test event generation 01h: 1 test 02h: E-3DD test 03h: E-PAD test 04h: HK rates test 20h: perform DE measurement 40h: format histogram data into EDB 80h: execute EPP test

DESCRIPTION Test mode 80h loads a histogramming LUT for ID0 into the EPP memory and generates for each energy step and each ID one event. Then the ram scalers are read and sent via telemetry. To save transmission bandwith for middle and high bytes of the 24 bit counters are only these transmitted that differ from zero (see description of EPP test EDB). After that test the former LUT is reloaded and normal measurement restarts automatically.

Test mode 40h disables normal science data formatting. Instead of that the contents of the 256 counters summed over the whole spin are sent in the EDB. Test mode 20h performs Direct Event measurement: For each sensor ID (1 - 9) the 256 energy steps are measured and transmitted in the EDB. This takes 18 spins to perform that measurement. After that test the former LUT is reloaded and normal measurement restarts automatically. No additional command ZERETSTD is necessary, even if this mode is combined with e.g. DE measurement (→ 60h).

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERETSTD

REMARKS NONE

ZERFCLKS

FUNCTION Set FGM clock frequency

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Ch	bit0=0:slow clock (1 kHz) bit0=1:fast clock (16 kHz) bit1=0:disable FGM interface bit1=1:enable FGM interface

DESCRIPTION The ZERFCLKS command controls the FGM data processing. The value of bit 0 switches the expected FGM clock frequency between 1 kHz and 16 kHz. Bit 1 determines whether the received data should be used by the DPU or not.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERFCLKS

REMARKS The final FGM instrument delivers data with a fixed clock of 1kHz.

ZERHDSLE

FUNCTION Set head mask for multiplexer channels

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	26h	bit 0: 0: disable head 1, 1: enable head 1 bit 1: 0: disable head 2, 1: enable head 2 bit 2: 0: disable head 3, 1: enable head 3 bit 7 - 3: don't care

DESCRIPTION This command sets the multiplexer head mask (byHeadMask). With this command it is possible to mask heads out. E.g. one head is out of order and parallel classification will be used.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDHMASK

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY ZERHDSLE

REMARKS NONE

ZERIFFTE

FUNCTION Run inflight functional test for IIMS

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	27h	01h

DESCRIPTION The command ZERIFFTE will run the inflight functional test on the next single shot calibration pause. That means it could last up to 48+9 spins until the IFFT command will be executed.

The inflight functional test is splitted in two sections:

Part 1:

2 spins: it sends 16 * 162 shots to the calibration unit. The backdectors are enabled.

2 spins: it sends 16 * 162 shots to the calibration unit. The backdetectors are disabled.

Part 2:

6 spins: it sends 81 shots to the calibration unit in sector 9 at every odd spin. At even spins the the calibration results (Direct Events) are sent in the EDB; odd spin EDBs contain the compressed ion matrix of the IFFT data.

Note: IFFT commands are only accepted in Normal Mode! During the inflight functional test mode the measurement is interrupted.

RETURNS **In the case of rejection:**
ERDECODE: 0Ch: IFFT already active

In the case of acceptance:
see section VALIDITY

VALIDITY ERDIFCAL
EDB content descriptor CD1 bit 0

OPERATIONAL CONSTRAINTS In nominal telemetry mode only

ALTERNATIVE NONE

COMPLEMENTARY NONE

REMARKS NONE

ZERIRCKS

FUNCTION Switch internal RAM check for telemetry

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	04h	00h: disable RAM check 01h: enable RAM check

DESCRIPTION This command enables/disables the RAM check for telemetry. With this RAM check it is possible, to check the memory contents of the DPU. It is possible to check more than 64k byte (check over segment boundaries). The internal RAM check uses the science data area in the EDB. The upper and lower boundaries of the RAM check can be set with the memory load command BERRCADS. The DPU sends the lower RAM check boundary, the upper RAM check boundary, the address of the first of the following 256 check bytes (2048 in BM1/3) in every EDB. After enabling the RAM check begins at the RAM check start address. If the current address is greater than the upper RAM check boundary, the RAM check continues at the lower boundary in the next EDB.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDRAMCK, bit 2 in EDB content descriptor 1, bit 2 in ERDSTAT1

OPERATIONAL CONSTRAINTS Issue BERRCADS first

ALTERNATIVE NONE

COMPLEMENTARY ZERIRCKS

REMARKS RAM check should only be used in NM.

ZERLUSWN

FUNCTION Load LU-detector switches

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	05h	bit 0: sensitive LU check for processor (0 off, 1 on) bit 1: sensitive LU check for memory (0 off, 1 on) bit 2: sensitive LU check for counters (0 off, 1 on) bit 3: sensitive LU check for class mem (0 off, 1 on) bit 4: LU check for processor (0 off, 1 on) bit 5: LU check for memory (0 off, 1 on) bit 6: LU check for counters (0 off, 1 on) bit 7: LU check for class mem (0 off, 1 on)

DESCRIPTION This command loads the control byte for latch up servicing. The latch up detector is disabled, if all LU check bits are set 0. After reset or power up, the latch up detector is disabled. The LU sensitive measurement can only be done, if the main latch up detector and the sensitive measurement is enabled. A sensitive measurement will be done about every four seconds at the end of sector 5. Only the selected channels (memory, processor, ...) will be measured for latch ups. After 32 measurement spins the instrument enables the sensitive measurement mode, if the instrument started after power up, or switch to the previous state, if the instrument started after watchdog reset or latchup.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDLUDE1
ERDLUDE2
ERDLUDE3
ERDLUDE4
ERDLUMS1
ERDLUMS2
ERDLUMS3
ERDLUMS4

OPERATIONAL CONSTRAINTS On PI`s approval only

ALTERNATIVE	BERPLCAS
COMPLEMENTARY	ZERLUSWN
REMARKS	NONE

ZERPDISE

FUNCTION Enable/disable patches

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	06h	00h: disable 01h: enable

DESCRIPTION The command ZERPDISE enable/disable software patches. The enable command loads a table of pointers to patch code out of the non volatile RAM. The disable command sets this table to the default pointers.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDPATAC

OPERATIONAL CONSTRAINTS On PI`s approval only

ALTERNATIVE NONE

COMPLEMENTARY ZERPDISE

REMARKS NONE

ZERPINIS

FUNCTION Patch table reset

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	07h	00h

DESCRIPTION This command initializes the patch pointer table in non volatile RAM with default addresses.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS On PI`s approval only

ALTERNATIVE NONE

COMPLEMENTARY NONE

REMARKS NONE

ZERPLEVS

FUNCTION STO MCP high voltage target level set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	28h	bits 3 - 0: set STO MCP HV target level (0 - 15) bits 7 - 4: don't care

DESCRIPTION The ZERPLEVS command sets a new STO MCP high voltage target level. It starts the stepping process. Every spin the current level will step to the target level. It is not possible to set a target level, which is greater than the high voltage limit.

Note: It is not possible to set a new target level, if the stop MCP high voltage is disabled.

RETURNS **In the case of rejection:**

ERDECODE: 05h: start MCP HV is not disabled

06h: target level > limit

07h: stepping process cannot be started

In the case of acceptance:

see section VALIDITY

VALIDITY ERDSPMHC

OPERATIONAL CONSTRAINTS HV relay must be on,
ERDSPMVL must be above or equal intented level,

ERDSPMCP must be enabled

ALTERNATIVE NONE

COMPLEMENTARY ZERPLEVS

REMARKS NONE

ZERPLIMS

FUNCTION STO MCP high voltage limit set command

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	29h	bit 3 - 0: set STO MCP HV limit (0 - 15) bit 7 - 4: don't care

DESCRIPTION The ZERPLIMS command sets a new STO MCP high voltage limit. It sets the STO MCP channel plate high voltage target level, if the new limit is smaller than the target level. In this case the current high voltage level steps down to the new target level. It does one step every spin. If the new limit is greater than the target level, only the new limit will be set.

RETURNS **In the case of rejection:**

ERDECODE: 0Ch: already stepping

0Dh: limit > 15

In the case of acceptance:

see section VALIDITY

VALIDITY ERDSPMVL

OPERATIONAL CONSTRAINTS On PI`s approval required

ALTERNATIVE NONE

COMPLEMENTARY ZERPLIMS

REMARKS NONE

ZERSETPN

FUNCTION Set priority code for IIMS DEs

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Fh	00h: priorities 3,2,1,0 01h: priorities 3,2,1 02h: priorities 3,2 03h: priority 3

DESCRIPTION The ZERSETPN sets the limit value for ion species that have to be stored in DE memory of IIMS classification. These values are given by the classification tables. They permit to suppress not interesting direct events in regions of high event rates. After power on priority code is set to zero.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSETPN

REMARKS NONE

ZERSLOPS

FUNCTION Change slope of time-to-amplitude converter

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	2Ah	bit 1 - 0: TAC slope bit 7 - 2: don't care

DESCRIPTION This command changes the internal slope of the IIMS time-to-amplitude converter with respect to its nominal value (0%). The TAC slope will change at the next spin boundary.

Lowbyte	TAC slope
00h	0%
01h	+10%
02h	-20%
03h	-10%

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDTCFAC

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY ZERSLOPS

REMARKS NONE

ZERSMODS

FUNCTION Select serial or parallel measurement mode

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	2Bh	00h: serial 01h: parallel

DESCRIPTION This command switches between serial and parallel classification. In serial classification the measurement time splitted into 3 areas, one area for each head. In parallel mode all heads are enabled during the whole measurement time.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDIFIND

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSMODS

REMARKS NONE

ZERSRELS

FUNCTION Switches the power relay for IIMS HV supplies

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	08h	bit 1: IIMS HV power supplies (STA, STO, DEF) (1 on) bit 5: IIMS HV power supplies (STA, STO, DEF) (1 off)

DESCRIPTION This command modifies the content of the relay control register. Setting of bit 1 will switch power on, setting of bit 5 will switch power off. If power on and off are commanded in the same command word, the command will be rejected.

RETURNS **In the case of rejection:**
ERDECODE: 0Bh: relays status not changed

In the case of acceptance:
see section VALIDITY

VALIDITY ERDRELS2: 1 = HV-relay on

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSRELS

REMARKS This command shall be used for "Emergency HV off". In this case, HV limit values should be set to zero before the next ZERSRELS ON.

ZERSSECS

FUNCTION Set sun pulse sector

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	09h	bit 3 - 0: sun pulse sector bit 7 - 4: don't care

DESCRIPTION With the ZERSSECS command the RAPID DPU can be commanded to synchronize its sector counter such that the sun reference pulse is received in a specific sector.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDSPSEC

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSSECS

REMARKS NONE

ZERSSUNS

FUNCTION Set sun pulse position

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Ah	bit 7 - 0: sector boundary position

DESCRIPTION The ZERSSUNS command modifies the position of the sector boundaries with respect to the sunpulse. The resolution is 1/256th of the sector angle. Note that offset specifies the sun pulse position offset relatively to the start of the deadtime at the end of the sun sector.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDSPPOS

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSSUNS

REMARKS NONE

ZERSTASE

FUNCTION STA MCP high voltage stepping enable/disable

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	2Ch	01h: enable 00h: disable

DESCRIPTION The command ZERSTASE enables/disables the setting of a new target level for the STA MCP high voltage. It is not possible to set a new start MCP voltage target level, if the start MCP high voltage is disabled.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDSTMCP

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSTASE

REMARKS NONE

ZERSTOSE

FUNCTION STO MCP high voltage stepping enable/disable

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	2Dh	01h: enable 00h: disable

DESCRIPTION The command ZERSTOSE enables/disables the setting of a new target level for the STO MCP high voltage. It is not possible to set a new stop MCP voltage target level, if the stop MCP high voltage is disabled.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDSPMCP

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE NONE

COMPLEMENTARY ZERSTOSE

REMARKS NONE

ZERTCLKS

FUNCTION Selects clock rate for timer 1

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Dh	00h: spacecraft HFC 01h: 1 MHz 02h: 125 kHz 03h: 16 kHz

DESCRIPTION The ZERTCLKS command selects the channel of a 4 to 1 multiplexer in the spacecraft interface which switches the clock source for timer 1 on the microprocessor board.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY -

OPERATIONAL CONSTRAINTS PI´s approval required

ALTERNATIVE NONE

COMPLEMENTARY ZERTCLKS

REMARKS NONE

ZERTMODS

FUNCTION Select EDB format

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Eh	00h: NM1-3 01h: BM1 02h: BM2 03h: BM3

DESCRIPTION The ZERTMODS command switches between the four different telemetry modes. In NM[1-3] and BM2 512 byte EDBs are generated. BM1 has an allocated bitrate which is about 4 times higher than that in Normal Mode. So the EDB size is 2304 bytes. In BM3, the readout mode of the scratch memory, where burst mode EDBs are collected, RAPID sends EDBs with 2340 bytes: 2304 bytes of them are burst mode EDBs, the other bytes are checksums over parts of the EDBs.

Note: telemetry mode changes only appear on commands to the DPU, even in burst mode 3.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDTMMOD
Third byte in EDB synchron marker sequence (EDB byte offset 2)

OPERATIONAL CONSTRAINTS EDB format should correspond to S/C telemetry mode

ALTERNATIVE NONE

COMPLEMENTARY ZERTMODS

REMARKS NONE

ZERTRMDS

FUNCTION Set IIMS event trigger mode

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	2Eh	bit 2 - 0: event trigger mode (bySCUTrigMode) 000: E + T Trigger Mode 001: E + (D*T) Trigger Mode 010: E * D * T Trigger Mode 011: E * T Trigger Mode 100: E Trigger Mode 101: T Trigger Mode 110: invalid 111: invalid bit 7 - 3: don't care

DESCRIPTION This command sets the IIMS event trigger mode. The factor will be sent to the sensor at every spin boundary.

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDTRIGM

OPERATIONAL CONSTRAINTS NONE

ALTERNATIVE BERPLCAS

COMPLEMENTARY ZERTRMDS

REMARKS NONE

ZERWDENS

FUNCTION Enable/Disable the watchdog

CODE/ PARAMETER

Word	Highbyte	Lowbyte
0	0Bh	00h: disable WD 01h: enable WD

DESCRIPTION The ZERWDENS command enables/disables the DPU watchdog. The watchdog looks for incrementing spin counters and the serving of the telemetry interfaces. If the spin counter does not increment anymore, the watchdog initiates a hardware reset (if enabled). If no telemetry requests are received, the watchdog toggles the spacecraft interfaces (main/redundant).

RETURNS **In the case of rejection:**
ERDECODE: -

In the case of acceptance:
see section VALIDITY

VALIDITY ERDWATEN

OPERATIONAL CONSTRAINTS On PI`s approval only

ALTERNATIVE NONE

COMPLEMENTARY ZERWDENS

REMARKS NONE

4 HK parameters

4.1 Introduction

The following chapter describes all housekeeping data that are sent by the DPU in the 40 bytes HK frame, sampled by the spacecraft every 5.15122 seconds. These parameters are sorted in two different ways: the first table shows that parameters sorted by their position in the 40 bytes block. The second section is the most detailed one. All parameters are listed in alphabetical order and their meanings are explained.

Validity / Redundancy

HK frames do not include dedicated identifier bytes. To judge the validity of a HK frame it is necessary to have a closer look into the HK data themselves. Four types of HK frames exist:

1 HK frames with a diversity of byte values
1 HK frames completely filled with zero bytes
1 HK frames completely filled with FFh bytes
1 HK frames completely filled with the byte value C0h

Only type 1 HK frames contain valid RAPID HK information. Type 2 to 4 HK frames indicate that no RAPID HK information is available. The occurence of the latter HK frame types can have different reasons:

Type 2 HK frames: a) S/C has requested HK data from RAPID, but no valid data is available. RAPID sends zeroes.
Type 3 HK frames: a) RAPID power supply is off. The FFh values are inserted externally.
Type 4 HK frames: a) S/C collects data from RAPID without prior reset pulse
b) RAPID is in idle mode directly after power on (for 2 min)
c) RAPID power is on, but RAPID cannot provide HK data because of S/W crash or H/W failure

Since the space inside the available 40 bytes of the HK frame is rather limited there are no redundant or alternative parameters. It is of course possible to draw conclusions from a combined examination of both science and HK data to replace information that might have got lost with a certain HK parameter. Since RAPID is a single box experiment all information originate from this box.

Following power-on RAPID enters an idle period for about 2 minutes. The HK frames are completely filled with the value C0hex. After that period the first valid HK frames are sent. The information in HK then becomes valid for the first time:

- HK byte 36: after 2 HK frames
- HK byte 37: after 4 HK frames
- HK byte 38: after 8 HK frames

- HK byte 39: after 32 HK frames

4.2 Table of HK parameters sorted by positions in HK frame

Name	Byte	Index	Mask	Description
ERDHKFCR	0		1F	HK_FRAME_COUNTER
ERDTRIGM	0		E0	EVENT TRIG MODE
ERDCMDER	1		01	TCMD_ERROR
ERDCMDIV	1		02	TCMD_INVALID
ERDCMDVD	1		04	TCMD_VALID
ERDTMMOD	1		18	TELEMETRY_MODE
ERDSSINT	1		20	INTERNAL_SEC_CLK
ERDIFIND	1		40	IIMS_SENSOR_MODE
ERDRAMCK	1		80	RAM_CHECK-MODE
ERDSPSTG	2		01	CHPS_STOP_STEPG
ERDSTSTG	2		02	CHPS_START_STEG
ERDDFSTG	2		04	DEFPS_STEPPING
ERDSCMEM	2		08	SCR_MEMEMORY_CPTRD
ERDLRES	2		30	LAST_DPU_RESET
ERDRELS2	2		40	HV-RELAY_STATUS
ERDLUSEN	2		80	LUDET_SENS_MODE
ERICALEN	3		FF	ENERGY_CAL_PULSE
ERICALTF	4		FF	TIME_CAL_PULSE
ERDEDET1	5		01	ENERGY_DET1_OFF
ERDBDET1	5		02	BACK_DET_1_OFF
ERDEDET2	5		04	ENERGY_DET2_OFF
ERDBDET2	5		08	BACK_DET_2_OFF
ERDEDET3	5		10	ENERGY_DET3_OFF
ERDBDET3	5		20	BACK_DET_3_OFF
ERDTCFAC	5		C0	TAC_SLOPE
ERDEMUX1	6		01	EMUX_HEAD_1_OFF
ERDTMUX1	6		02	TMUX_HEAD_1_OFF
ERDDMUX1	6		04	DMUX_HEAD_1_OFF
ERDEMUX2	6		08	EMUX_HEAD_2_OFF
ERDTMUX2	6		10	TMUX_HEAD_2_OFF
ERDDMUX2	6		20	DMUX_HEAD_2_OFF
ERDEMUX3	6		40	EMUX_HEAD_3_OFF
ERDTMUX3	6		80	TMUX_HEAD_3_OFF
ERDDMUX3	7		01	DMUX_HEAD_3_OFF
ERDIFCAL	7		02	INFLIGHT_CAL_ON
ERDDEADT	7		04	DEADTIM_TIMEOUT
ERDPATAC	7		08	PATCHCODE_ACTIVE
ERDECODE	7		F0	ERROR_CODE_(CMD)

Name	Byte	Index	Mask	Description
ERDDWISP	9,8		80,0F	DIR_WINDOW_SP
ERDLUDE1	8		10	MPB_LU_ENA
ERDLUDE2	8		20	MPBMEM_LU_ENA
ERDLUDE3	8		40	COUNTER_LU_ENA
ERDLUDE4	8		80	CLASSMEM_LU_ENA
ERDEWISP	10,9		E0,03	ENERGY_WINDOW_SP
ERDDWIST	9		7C	DIR_WINDOW_ST
ERDEWIST	10		1F	ENERGY_WINDOW_ST
ERISTAHV	11		FF	START_MCP_HV
ERISTOHV	12		FF	STOP_MCP_HV
ERIDEFHV	13		FF	DEF_PLATE_HV
ERDLVCMD	14		FF	LAST_VALID_CMD
ERDSVCMD	15		FF	SECOND_LAST_CMD
ERDLICMD	16		FF	LAST_INVALID_CMD
ERECMDRT	17		FF	IES_CMD_ANSWER
ERIPITCH	18		FF	PITCH_ANGLE_IIMS
ERDFGMCR	19		7F	FGM_VECTOR_SPCNT
ERDIELIE	19		80	IEL-IF State
ERDEDBCR	20		3F	EDB_COUNTER
ERDIESIE	20		40	IES-IF State
ERIPADTS	20		80	E-PAD-Table 3a/b
ERISTACP	21		FF	STA1_COUNT_RATE
ERISTALB	22		FF	STA2_COUNT_RATE
ERISTOCP	23		FF	STO1_COUNT_RATE
ERISTOLB	24		FF	STO2_COUNT_RATE
ERIENYCP	25		FF	ENY1_COUNT_RATE
ERIENYLB	26		FF	ENY1_COUNT_RATE
ERERATE1	27		FF	IES_STRIP_1_RATE
ERERATE2	28		FF	IES_STRIP_2_RATE
ERERATE3	29		FF	IES_STRIP_3_RATE
ERERATE4	30		FF	IES_STRIP_4_RATE
ERERATE5	31		FF	IES_STRIP_5_RATE
ERERATE6	32		FF	IES_STRIP_6_RATE
ERERATE7	33		FF	IES_STRIP_7_RATE
ERERATE8	34		FF	IES_STRIP_8_RATE
ERERATE9	35		FF	IES_STRIP_9_RATE

Subcommutated HK items:

Name	Byte	Index	Mask	Description
ERDEBIAS	36	(ERDHKFCR MOD 1)=0	FF	BIAS E DETECTOR
ERDBBIAS	36	(ERDHKFCR MOD 1)=1	FF	BIAS B DETECTOR

Name	Byte	Index	Mask	Description
ERDLUMS1	37	(ERDHKFCR MOD 4)=00	01	MPB_LU_SENS
ERDLUMS2	37	(ERDHKFCR MOD 4)=00	02	MPBMEM_LU_SENS
ERDLUMS3	37	(ERDHKFCR MOD 4)=00	04	COUNTER_LU_SENS
ERDLUMS4	37	(ERDHKFCR MOD 4)=00	08	CLASSMEM_LU_SENS
ERDSPMCP	37	(ERDHKFCR MOD 4)=00	10	STOP MCP STEP
ERDSTMCP	37	(ERDHKFCR MOD 4)=00	20	START MCP STEP
ERDDHVSE	37	(ERDHKFCR MOD 4)=00	40	DEFL_HV_STEP
ERDWATEN	37	(ERDHKFCR MOD 4)=00	80	WATCHDOG ENABLED
ERDDPHCL	37	(ERDHKFCR MOD 4)=01	0F	DEFL_HV_CURLEV
ERDDPHLD	37	(ERDHKFCR MOD 4)=01	F0	DEFL_HV_LIMIT
ERDSTMVL	37	(ERDHKFCR MOD 4)=02	0F	START_MCP_LIMIT
ERDSPMVL	37	(ERDHKFCR MOD 4)=02	F0	STOP_MCP_LIMIT
ERDSTMHC	37	(ERDHKFCR MOD 4)=03	0F	START_MCP_CURLEV
ERDSPMHC	37	(ERDHKFCR MOD 4)=03	F0	STOP_MCP_CURLEV

Name	Byte	Index	Mask	Description
ERDGNDRF	38	(ERDHKFCR MOD 8)=00	FF	GROUND REFERENCE
ERIP5VRF	38	(ERDHKFCR MOD 8)=01	FF	+5VOLT REFERENCE
ERIM5VRF	38	(ERDHKFCR MOD 8)=02	FF	-5VOLT REFERENCE
ERIP12RF	38	(ERDHKFCR MOD 8)=03	FF	+12V REFERENCE
ERIM12RF	38	(ERDHKFCR MOD 8)=04	FF	-12V REFERENCE
ERISAREF	38	(ERDHKFCR MOD 8)=05	FF	SAFE/ARM
ERISTREF	38	(ERDHKFCR MOD 8)=06	FF	SENSOR TEMP
ERIHKTRF	38	(ERDKKFCR MOD 8)=07	FF	HKB TEMP

Name	Byte	Index	Mask	Description
ERDLEDBC	39	ERDHKFCR=0-3	FF	LONG EDB COUNTER
ERESENID	39	ERDHKFCR=4	FF	IES SENSOR ID
ERDPGMLA	39	ERDHKFCR=5-7	FF	PGM LOAD ADDRESS
ERDSPINC	39	ERDHKFCR=8-11	FF	SPIN COUNTER
ERDCFGER	39	ERDHKFCR=12	0F	CONFIG ERROR
ERDFLAP1	39	ERDHKFCR=12	10	FLAP1_STATUS
ERDFLAP2	39	ERDHKFCR=12	20	FLAP2_STATUS
ERDFLAP3	39	ERDHKFCR=12	40	FLAP3_STATUS
ERDIELCS	39	ERDHKFCR=12	80	IEL CLK STATUS
ERDSTAT1	39	ERDHKFCR=13	FF	DPU STATUS 1
ERDRCHKL	39	ERDHKFCR=14-16	FF	RAM CHK LOWER
ERDSTAT2	39	ERDHKFCR=17	FF	DPU STATUS 2
ERDRCHKU	39	ERDHKFCR=18-20	FF	RAM CHK UPPER
ERDLCCRC	39	ERDHKFCR=21	FF	LAST CRC
ERDICCNT	39	ERDHKFCR=22	FF	INVALID CMD CNT
ERDVCCNT	39	ERDHKFCR=23	FF	VALID CMD CNT
ERDCECNT	39	ERDHKFCR=24	FF	CMD ERROR CNT
ERDTOERC	39	ERDHKFCR=25-26	FF	TIMEOUT ERR CNT
ERDFRPRT	39	ERDHKFCR=27-28	FF	FREE PROC TIME
ERDDPUCU	39	ERDHKFCR=29	03	DPU CURRENT
EREFXLUT	39	ERDHKFCR=29	08	IES AUTOSWT
ERDSPPOS	39	ERDHKFCR=30	FF	SUN POSITION
ERDSPSEC	39	ERDHKFCR=31	0F	SUN SECTOR
ERDHMASK	39	ERDHKFCR=31	70	IIMS HEAD MASK
ERDSCMXS	39	ERDHKFCR=31	80	SCIMULTIPLEXER

4.3 Detailed description of HK parameters in alphabetic order

ERDBBIAS BIAS_B_DETECTOR

type: A
conditioned by: (ERDHKFCR MOD 1)=1
HKByte: 36
mask: FF

MSB	HK36[01]						LSB
BB7	BB6	BB5	BB4	BB3	BB2	BB1	BB0

The back detector bias voltage is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 55.4$.

ERDBDET1 BACK_DET_1_OFF

type: D
conditioned by:
HKByte: 5
mask: 02

MSB	HK05						LSB
						BD1	

BD1=0 : Back detector 1 power supply is ON
BD1=1 : Back detector 1 power supply is OFF

ERDBDET2 BACK_DET_2_OFF

type: D
conditioned by:
HKByte: 5
mask: 08

MSB	HK05						LSB
				BD2			

BD2=0 : Back detector 2 power supply is ON
BD2=1 : Back detector 2 power supply is OFF

ERDBDET3 BACK_DET_3_OFF

type: D
conditioned by:
HKByte: 5
mask: 20

MSB	HK05						LSB
		BD3					

BD3=0 : Back detector 3 power supply is ON
BD3=1 : Back detector 3 power supply is OFF

ERDCECNT CMD ERROR CNT

type: R
conditioned by: ERDHKFCR=24
HKByte: 39
mask: FF

MSB	HK39[24]						LSB
CNT7	CNT6	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

Count of all command errors since last reset (see also ERDCMDER).

ERDCFGER CONFIG ERROR

type: R
conditioned by: ERDHKFCR=12
HKByte: 39
mask: 0F

MSB	HK39[12]						LSB
				D3	D2	D1	D0

Once in every spin a backup of the current configuration of the instrument is stored in the Status RAM. In the case of a latch-up or watchdog reset the last backup configuration is used to reconfigure the instrument.

If e.g. there is not enough available space inside the Status RAM a *backup configuration storage error* would occur.

D0=0 no backup configuration storage error
D0=1 backup configuration storage error

The current configuration can be stored in a separate (user configuration) section of the Status RAM by issuing the command ZERCFGSS 0. If e.g. there is not enough available space inside the Status RAM a *user configuration storage error* would occur.

D1=0 no user configuration storage error
D1=1 *user configuration storage error*

Once in every spin the current configuration of the instrument is stored in the Status RAM. In the case of a latch-up or watchdog reset the last backup configuration is used to reconfigure the instrument.

If e.g. there was no configuration stored inside the Status RAM a *backup configuration load error* would occur.

D2=0 no backup configuration load error
D2=1 backup configuration load error

The current configuration can be stored in a separate section of the Status RAM. If it is desired to reconfigure the instrument with this basic configuration, this can be done by a single command (ZERCFGSS 1).

If e.g. no user configuration was stored inside the Status RAM a *user configuration load error* would occur.

D3=0 no user configuration load error
D3=1 user configuration load error

ERDCMDER TCMD_ERROR

type: D
conditioned by:
HKByte: 1
mask: 01

MSB	HK01						LSB
							CMDERR

This flag becomes active (1) for one HK frame, if the last command was not defined or the command length was wrong.

ERDCMDIV TCMD_INVALID

type: D
conditioned by:
HKByte: 1
mask: 02

MSB	HK01						LSB
						INVCMD	

This flag becomes active (1) for one HK frame, if

- the return value of the last command was not 0 or if
- the command was rejected because of a wrong block CRC or if
- the DPU was in a state when it cannot accept that respective command (e.g. the command ZERIFFTE cannot be executed in BM1 or BM3).

The reason for the command rejection can be concluded from the HK item ERDECODE.

ERDCMDVD TCMD_VALID

type: D
conditioned by:
HKByte: 1
mask: 04

MSB	HK01						LSB
					VALCMD		

This flag becomes active (1) for one HK frame after a command has been accepted for execution by RAPID. The execution time may be much later than the acceptance time (e.g. for the command ZERIFFTE).

ERDDEADT DEADTIM_TIMEOUT

type: D
conditioned by:
HKByte: 7
mask: 04

MSB	HK07						LSB
					DEAD		

If was not possible to finish all the tasks that have to be done in the dead time of one of the sectors during the last spin, this flag becomes active. The instrument is optimised in it's sector length, so this should not happen. If e.g. after the introduction of a code patch in the sector dead time, the flag becomes active too often (check *ERDTOERC*) one should consider to increase the sector dead time length .

DEAD=0 Sector dead time length is OK
DEAD=1 At least once in last spin the sector dead time length was too short.

ERDDFSTG DEFPS_STEPPING

type: D
conditioned by:
HKByte: 2
mask: 04

MSB	HK02						LSB
					STDEF		

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

STDEF=0 Deflection HV is <u>not</u> stepping
STDEF=1 Deflection HV is stepping

ERDDHVSE DEFL_HV_STEP

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 40

MSB	HK37[00]						LSB
	EDEF						

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

EDEF=0 Deflection high voltage stepping disabled
EDEF=1 Deflection high voltage stepping enabled

ERDDMUX1 DMUX_HEAD_1_OFF

type: D
conditioned by:
HKByte: 6
mask: 04

MSB	HK06						LSB
					DMX1		

DMX1=0 Direction multiplexer for sensor 1 enabled
DMX1=1 Direction multiplexer for sensor 1 disabled

ERDDMUX2 DMUX_HEAD_2_OFF

type: D
conditioned by:
HKByte: 6
mask: 20

MSB	HK06						LSB
		DMX2					

DMX2=0 Direction multiplexer for sensor 2 enabled
DMX2=1 Direction multiplexer for sensor 2 disabled

ERDDMUX3 DMUX_HEAD_3_OFF

type: D
conditioned by:
HKByte: 7
mask: 01

MSB	HK07						LSB
							DMX3

DMX3=0 direction multiplexer for sensor 3 enabled
DMX3=1 direction multiplexer for sensor 3 disabled

ERDDPHCL DEFL_HV_CURLEV

type: R
conditioned by: (ERDHKFCR MOD 4)=01
HKByte: 37
mask: 0F

MSB	HK37[01]						LSB
				DEF3	DEF2	DEF1	DEF0

There are 16 different values that can be written into the Deflection HV register inside the SCU. The current level is the level that is just being written into that register. The current level normally is less or equal the limit level of the HV, but can be greater during stepping, if the limit level has been decreased.

ERDDPHLD DEFL_HV_LIMIT

type: R
conditioned by: (ERDHKFCR MOD 4)=01
HKByte: 37
mask: F0

MSB	HK37[01]						LSB
DEF3	DEF2	DEF1	DEF0				

There are 16 different values that can be written into the Deflection HV register inside the SCU. The limit level is the maximum possible level for the target level. If the limit level is programmed as being less than the target level, the HV is being stepped down to the new limit level.

ERDDPUCU DPU CURRENT

type: R
conditioned by: ERDHKFCR=29
HKByte: 39
mask: 03

MSB	HK39[29]						LSB
						P1	P0

DPU power consumption compared to 4,5 Watt
P1=1 RAPID power consumption is less than 80%
P1=0 RAPID power consumption is greater than 80%
P0=1 RAPID power consumption is less than 100%
P0=0 RAPID power consumption is greater than 100%

ERDDWISP DIR_WINDOW_SP

type: D
conditioned by:
HKByte: 9,8
mask: 80,0F

MSB	HK09						LSB
DSTO0							

MSB	HK08						LSB
				DSTO4	DSTO3	DSTO2	DSTO1

The end time of the window for detecting the direction information from a sensor is programmed into a register of the SCU ASIC.

ERDDWIST DIR_WINDOW_ST

type: D
conditioned by:
HKByte: 9
mask: 7C

MSB	HK09						LSB
	DSTA4	DSTA3	DSTA2	DSTA1	DSTA0		

The start time of the window for detecting the direction information from a sensor is programmed into a register of the SCU ASIC.

ERDEBIAS BIAS E DETECTOR

type: A
conditioned by: (ERDHKFCR MOD 1)=0
HKByte: 36
mask: FF

MSB	HK36[00]						LSB
EB7	EB6	EB5	EB4	EB3	EB2	EB1	EB0

The energy detector bias voltage is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 55.4$.

ERDECODE ERROR_CODE_(CMD)

type D
conditioned by:
HKByte: 7
mask: F0

MSB	HK07						LSB
ERR3	ERR2	ERR1	ERR0				

This HK item contains the error code of the last invalid command. The error code can be used to find the reason for the rejection of a command. Up to 16 reasons are provided:

00	no command error code available
01,02	(invalid error codes)
03	Command decoder: Wrong command length
04	HV: Power supply is OFF
05	HV: Stepping is DISABLED
06	HV: Target value > Upper limit
07	Job manager: Job not started
08	Job manager: Invalid trigger level
09	Job manager: Job not deleted
10	Job manager: Job not stored
11	Syntax error
12	Already active
13	Out of range
14	Wrong command length
15	Undefined command

ERDEDBCR EDB_COUNTER

type: R
conditioned by:
HKByte: 20
mask: 3F

MSB	HK20						LSB
		CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

Copy of the EDB counter subtracted by 1. With this HK item it is possible to identify the source values for the single-shot calibration results in the EDB.

ERDEDET1 ENERGY_DET1_OFF

type: D
conditioned by:
HKByte: 5
mask: 01

MSB	HK05						LSB
							ED1

The power of each of the three energy detectors can be on or off. Latter state is only useful, if a malfunction of one energy detector occurs.

ED1=0 Energy detector 1 enabled
ED1=1 Energy detector 1 disabled

ERDEDET2 ENERGY_DET2_OFF

type: D
conditioned by:
HKByte: 5
mask: 04

MSB	HK05						LSB
					ED2		

The power of each of the three energy detectors can be on or off. Latter state is only useful, if a malfunction of one energy detector occurs.

ED2=0 energy detector 2 enabled
ED2=1 energy detector 2 disabled

ERDEDET3 ENERGY_DET3_OFF

type: D
conditioned by:
HKByte: 5
mask: 10

MSB	HK05						LSB
			ED3				

The power of each of the three energy detectors can be on or off. Latter state is only useful, if a malfunction of one energy detector occurs.

ED3=0 energy detector 3 enabled
ED3=1 energy detector 3 disabled

ERDEMUX1 EMUX_HEAD_1_OFF

type: D
conditioned by:
HKByte: 6
mask: 01

MSB	HK06						LSB
							EMX1

The analog EAN and digital EDI signals from the sensors can be masked or unmasked. The masking does not affect the counting of the EDI information in the H/W rate counters inside the DPU.

EMX1=0 energy multiplexer 1 enabled
EMX1=1 energy multiplexer 1 disabled

ERDEMUX2 EMUX_HEAD_2_OFF

type: D
conditioned by:
HKByte: 6
mask: 08

MSB	HK06						LSB
				EMX2			

The analog EAN and digital EDI signals from the sensors can be masked or unmasked. The masking does not affect the counting of the EDI information in the H/W rate counters inside the DPU.

EMX2=0 energy multiplexer 2 enabled
EMX2=1 energy multiplexer 2 disabled

ERDEMUX3 EMUX_HEAD_3_OFF

type: D
conditioned by:
HKByte: 6
mask: 40

MSB	HK06						LSB
	EMX3						

The analog EAN and digital EDI signals from the sensors can be masked or unmasked. The masking does not affect the counting of the EDI information in the H/W rate counters inside the DPU.

EMX3=0 energy multiplexer 3 enabled
EMX3=1 energy multiplexer 3 disabled

ERDEWISP ENERGY_WINDOW_SP

type: D
conditioned by:
HKByte: 10,9
mask: E0,03

MSB	HK10						LSB
ESTO2	ESTO1	ESTO0					

MSB	HK09						LSB
						ESTO4	ESTO3

The end time of the window for detecting an EDI signal from a sensor, programmed into a register of the SCU ASIC.

ERDEWIST ENERGY_WINDOW_ST

type: D
conditioned by:
HKByte: 10
mask: 1F

MSB	HK10						LSB
			ESTA4	ESTA3	ESTA2	ESTA1	ESTA0

The start time of the window for detecting an EDI signal from a sensor, programmed into a register of the SCU ASIC.

ERDFGMCR FGM_VECTOR_SPCNT

type: R
conditioned by:
HKByte: 19
mask: 7F

MSB	HK19						LSB
	CNT6	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

This HK item represents the amount of received FGM vectors in the last spin period.

ERDFLAP1 FLAP1_STATUS

type: R
conditioned by: ERDHKFCR=12
HKByte: 39
mask: 10

MSB	HK39[12]						LSB
			FLAP1				

Status of the IIMS sensor 1 flap.

FLAP1=0 Flap 1 is closed
FLAP1=1 Flap 1 is open

ERDFLAP2 FLAP2_STATUS

type: D
conditioned by: ERDHKFCR=12
HKByte: 39
mask: 20

MSB	HK39[12]						LSB
		FLAP2					

Status of the IIMS sensor 2 flap.

FLAP2=0 Flap 2 is closed
FLAP2=1 Flap 2 is open

ERDFLAP3 FLAP3_STATUS

type: D
conditioned by: ERDHKFCR=12
HKByte: 39
mask: 40

MSB	HK39[12]						LSB
	FLAP3						

Status of the IIMS sensor 3 flap.

FLAP3=0 Flap 3 is closed
FLAP3=1 Flap 3 is open

ERDFRPRT FREE PROC TIME

type: R
conditioned by: ERDHKFCR=27-28
HKByte: 39
mask: FF

MSB	HK39[27]						LSB
T15	T14	T13	T12	T11	T10	T9	T8

MSB	HK39[28]						LSB
T7	T6	T5	T4	T3	T2	T1	T0

When all tasks within one spin are finished the instrument enter the idle state. This HK item represents the free processor time per spin in milliseconds.

ERDGNDRF GROUND REFERENCE

type: A
conditioned by: (ERDHKFCR MOD 8)=00
HKByte: 38
mask: FF

MSB	HK38[00]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The ground line voltage is monitored in this value. The measured analog value can be calculated from the digital value by:

U_{analog} = (2.5V - $U_{digital}$ * 5V / 256) * 2 . Standard value is 80hex.

ERDHKFCR HK_FRAME_COUNTER

type: C
conditioned by:
HKByte: 0
mask: 1F

MSB	HK00						LSB
			HKCR4	HKCR3	HKCR2	HKCR1	HKCR0

This HK item is an index counter, used for subcommutation of the HK frame data.

ERDHMASK IIMS HEAD MASK

type: R
conditioned by: ERDHKFCR=31
HKByte: 39
mask: 70

MSB	HK39[31]						LSB
	HD2	HD1	HD0				

Three MUX control lines are supplied by the DPU and are used for masking all multiplexers of a given IIMS sensor head.

HD0=0 IIMS sensor head 1 disabled
HD0=1 IIMS sensor head 1 enabled
HD1=0 IIMS sensor head 2 disabled
HD1=1 IIMS sensor head 2 enabled
HD2=0 IIMS sensor head 3 disabled
HD2=1 IIMS sensor head 3 enabled

ERDICCNT INVALID CMD CNT

type: R
conditioned by: ERDHKFCR=22
HKByte: 39
mask: FF

MSB	HK39[22]						LSB
CNT7	CNT6	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

The amount of received invalid commands since the last reset are transferred in this byte (see also ERDCMDIV).

ERDIELCS IEL CLK STATUS

type: D
conditioned by: ERDHKFCR=12
HKByte: 39
mask: 80

MSB	HK39[12]						LSB
ICLK							

The IEL can be operated with two different clock speed (command ZERFCLKS).

ICLK=0 IEL clock 1kHz assumed
ICLK=1 IEL clock 16kHz assumed

ERDIELIE IEL-IF State

type: D
conditioned by:
HKByte: 19
mask: 80

MSB	HK19						LSB
ENA							

The IEL can be disabled or enabled by command (ZERFCLKS).

ENA=0 IEL data are not used
ENA=1 IEL data are used

ERDIESIE IES-IF State

type: D
conditioned by:
HKByte: 20
mask: 40

MSB	HK20						LSB
	ENA						

The interface to the IES sensor can be disabled or enabled.

ENA=0 IES interface disabled
ENA=1 IES interface enabled

ERDIFCAL INFLIGHT_CAL_ON

type: D
conditioned by:
HKByte: 7
mask: 02

MSB	HK07						LSB
						CAL	

This flag shows the state of the in-flight functional test (IFFT) of IIMS. With IFFT active RAPID sends special calibration result EDBs.

CAL=0 In-flight functional test (IFFT) inactive
CAL=1 In-flight functional test (IFFT) active

ERDIFIND IIMS_SENSOR_MODE

type: D
conditioned by:
HKByte: 1
mask: 40

MSB	HK01						LSB
	SMOD						

In the serial (SCAN) mode each IIMS sensor is selected sequentially (1->2->3) within the sector. Only one IIMS sensor is active at a given time.

In the parallel (FIND) mode all three IIMS sensors are active at the same time during the sector.

SMOD=0 Serial measurement mode for IIMS
SMOD=1 Parallel measurement mode for IIMS

ERDLCCRC LAST CRC

type: R
conditioned by: ERDHKFCR=21
HKByte: 39
mask: FF

MSB	HK39[21]						LSB
CRC7	CRC6	CRC5	CRC4	CRC3	CRC2	CRC1	CRC0

On board calculated CRC for the last received block command.

ERDLEDBC LONG EDB COUNTER

type: R
conditioned by: ERDHKFCR=0-3
HKByte: 39
mask: FF

MSB	HK39[00]						LSB
EDB31	EDB30	EDB29	EDB28	EDB27	EDB26	EDB25	EDB24

MSB	HK39[01]						LSB
EDB23	EDB22	EDB21	EDB20	EDB19	EDB18	EDB17	EDB16

MSB	HK39[02]						LSB
EDB15	EDB14	EDB13	EDB12	EDB11	EDB10	EDB9	EDB8

MSB	HK39[03]						LSB
EDB7	EDB6	EDB5	EDB4	EDB3	EDB2	EDB1	EDB0

The long EDB counter gives information about the amount of trasmitted EDBs since turn-on.

ERDLICMD LAST_INVALID_CMD

type: R
conditioned by:
HKByte: 16
mask: FF

MSB	HK16						LSB
CMD7	CMD6	CMD5	CMD4	CMD3	CMD2	CMD1	CMD0

In this HK item the command code (not the error code) of the last invalid command is transmitted. Since the command code 00h is a valid code, the default value of ERDLICMD is FFh.

ERDLRES LAST_DPU_RESET

type: D
conditioned by:
HKByte: 2
mask: 30

MSB	HK02						LSB
		LR1	LR0				

If possible, the DPU stores the coded information about the cause of a reset into the non-volatile RAM. After the next power-up this information is transmitted in the following two bits.

0 Last reset was caused by normal power off
1 Last reset was caused by the watchdog
2 Last reset was caused by a latch-up
3 invalid

ERDLUDE1 MPB_LU_ENA

type: D
conditioned by:
HKByte: 8
mask: 10

MSB	HK08						LSB
			LU1				

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In this HK item the status of the LU-detector for the processor with its peripherals (MPB) is shown.

LU1=0 latch-up detector for MPB devices not active
LU1=1 latch-up detector for MPB devices active

ERDLUDE2 MPBMEM_LU_ENA

type: D
conditioned by:
HKByte: 8
mask: 20

MSB	HK08						LSB
		LU2					

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In this HK item the status of the LU-detector for the main memory is shown.

LU2=0 latch-up detector for MPB memory devices not active
LU2=1 latch-up detector for MPB memory devices active

ERDLUDE3 COUNTER_LU_ENA

type: D
conditioned by:
HKByte: 8
mask: 40

MSB	HK08						LSB
	LU3						

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In this HK item the status of the LU-detector for the IIMS rate counters is shown.

LU3=0 latch-up detector for counter devices not active
LU3=1 latch-up detector for counter devices active

ERDLUDE4 CLASSMEM_LU_ENA

type: D
conditioned by:
HKByte: 8
mask: 80

MSB	HK08						LSB
LU4							

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In this HK item the status of the LU-detection for the IIMS classification memory is shown.

LU4=0 latch-up detector for IIMS classification memories not active
LU4=1 latch-up detector for IIMS classification memories active

ERDLUMS1 MPB_LU_SENS

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 01

MSB	HK37[00]						LSB
							LUS1

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In the case of a local latch-up, the overcurrent may not be large enough to trigger the main latch-up detector. For this reason a sensitive measurement is done during a short period of stand-by of the instrument. In this HK item the status of the sensitive LU-detection for the processor with its peripherals (MPB) is shown.

LUS1=0 latch-up detector for MPB devices not in sensitive mode
LUS1=1 latch-up detector for MPB devices sensitive mode active

ERDLUMS2 MPBMEM_LU_SENS

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 02

MSB	HK37[00]						LSB
						LUS2	

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In the case of a local latch-up, the overcurrent may not be large enough to trigger the main latch-up detector. For this reason a sensitive measurement is done during a short period of stand-by of the instrument. In this HK item the status of the sensitive LU-detection for the main memory is shown.

LUS2=0 latch-up detector for MPB memory devices not in sensitive mode
LUS2=1 latch-up detector for MPB memory devices sensitive mode active

ERDLUMS3 COUNTER_LU_SENS

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 04

MSB	HK37[00]						LSB
					LUS3		

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In the case of a local latch-up, the overcurrent may not be large enough to trigger the main latch-up detector. For this reason a sensitive measurement is done during a short period of stand-by of the instrument. In this HK item the status of the sensitive LU-detection for the IIMS rate counters is shown.

LUS3=0 latch-up detector for counter devices not in sensitive mode
LUS3=1 latch-up detector for counter devices sensitive mode active

ERDLUMS4 CLASSMEM_LU_SENS

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 08

MSB	HK37[00]						LSB
				LUS4			

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In the case of a local latch-up, the overcurrent may not be large enough to trigger the main latch-up detector. For this reason a sensitive measurement is done during a short period of stand-by of the instrument. In this HK item the status of the sensitive LU-detection for the IIMS classification memory is shown.

LUS4=0 latch-up detector for IIMS classification memories not in sensitive mode
LUS4=1 latch-up detector for IIMS classification memories sensitive mode active

ERDLUSEN LUDET_SENS_MODE

type: D
conditioned by:
HKByte: 2
mask: 80

MSB	HK02						LSB
LUS							

The latch-up detector inside the DPU detects overcurrents by latch-ups, that could thermally damage or destroy the instrument. In the case of a local latch-up, the overcurrent may not be large enough to trigger the main latch-up detector. For this reason a sensitive measurement is done during a short period of stand-by of the instrument. In this HK item the status all enabled sensitive LU-detection circuits is shown.

LUS=0 latch-up detector sensitive mode off
LUS=1 latch-up detector sensitive mode on for all enabled circuits

ERDLVCMD LAST_VALID_CMD

type: A
conditioned by:
HKByte: 14
mask: FF

MSB	HK14						LSB
CMD7	CMD6	CMD5	CMD4	CMD3	CMD2	CMD1	CMD0

This HK item contains the command code of the most recently accepted command. Since the command code 00h is a valid code, the default value of ERDLVCMD is FFh.

ERDPATAC PATCHCODE_ACTIVE

type: D
conditioned by:
HKByte: 7
mask: 08

MSB	HK07						LSB
				PCH			

This HK item shows the state of code patches.
PCH=0 Patch code not active
PCH=1 Patch code active

ERDPGMLA PGM LOAD ADDRESS

type: R
conditioned by: ERDHKFCR=5-7
HKByte: 39
mask: FF

MSB	HK39[05]						LSB
PLA23	PLA22	PLA21	PLA20	PLA19	PLA18	PLA17	PLA16

MSB	HK39[06]						LSB
PLA15	PLA14	PLA13	PLA12	PLA11	PLA10	PLA9	PLA8

MSB	HK39[07]						LSB
PLA7	PLA6	PLA5	PLA4	PLA3	PLA2	PLA1	PLA0

This HK item represents the start address for uploading data (code, tables, variables). It will not change after data has is been uploaded (with command BERPLCAS), but only be affected by the command BERPLADS.

ERDRAMCK RAM_CHECK_MODE

type: D
conditioned by:
HKByte: 1
mask: 80

MSB	HK01						LSB
RCM							

By the means of RAM check it is possible to look inside the DPU program RAM and ROM. The memory contents is written into the EDB.

RCM=0 RAM check mode not active
RCM=1 RAM check mode active

ERDRCHKL RAM CHK LOWER

type: R
conditioned by: ERDHKFCR=14-16
HKByte: 39
mask: FF

MSB	HK39[14]						LSB
RCL23	RCL22	RCL21	RCL20	RCL19	RCL18	RCL17	RCL16

MSB	HK39[15]						LSB
RCL15	RCL14	RCL13	RCL12	RCL11	RCL10	RCL9	RCL8

MSB	HK39[16]						LSB
RCL7	RCL6	RCL5	RCL4	RCL3	RCL2	RCL1	RCL0

By the means of RAM check it is possible to look inside the DPU program RAM and ROM. The memory contents is written into the EDB. This HK item contains the lower boundary of the RAM check area.

ERDRCHKU RAM CHK UPPER

type: R
conditioned by: ERDHKFCR=18-20
HKByte: 39
mask: FF

MSB	HK39[18]						LSB
RCU23	RCU22	RCU21	RCU20	RCU19	RCU18	RCU17	RCU16

MSB	HK39[19]						LSB
RCU15	RCU14	RCU13	RCU12	RCU11	RCU10	RCU9	RCU8

MSB	HK39[20]						LSB
RCU7	RCU6	RCU5	RCU4	RCU3	RCU2	RCU1	RCU0

By the means of RAM check it is possible to look inside the DPU program RAM and ROM. The memory contents is written into the EDB. This HK item contains the upper boundary of the RAM check area.

ERDRELS2 HV-RELAY_STATUS

type: D
conditioned by:
HKByte: 2
mask: 40

MSB	HK02						LSB
	STAT						

This HK item represent the status of the supply voltage for the IIMS HV section by means of the status of the supply relay.

STAT=0 HV relay is off
STAT=1 HV relay is on

ERDSCMEM SCR_MEMORY_CPTRD

type: D
conditioned by:
HKByte: 2
mask: 08

MSB	HK02						LSB
				SCMEM			

A reserved area of the instrument's memory (scratch memory) is cyclically filled with BM EDBs. Upon a trigger signal the contents of this portion remains unchanged (frozen) after given delay.

SCMEM=0 Scratch memory not frozen
SCMEM=1 Scratch memory frozen

ERDSCMXS SCI MULTIPLEXER

type: R
conditioned by: ERDHKFCR=31
HKByte: 39
mask: 80

MSB	HK39[31]						LSB
STAT							

This HK item shows which one of the two S/C interfaces is currently active.

STAT=0 Redundant spacecraft interface in use
STAT=1 Main spacecraft interface in use

ERDSPINC SPIN COUNTER

type: R
conditioned by: ERDHKFCR=8-11
HKByte: 39
mask: FF

MSB	HK39[08]						LSB
SPIN31	SPIN30	SPIN29	SPIN28	SPIN27	SPIN26	SPIN25	SPIN24

MSB	HK39[09]						LSB
SPIN23	SPIN22	SPIN21	SPIN20	SPIN19	SPIN18	SPIN17	SPIN16

MSB	HK39[10]						LSB
SPIN15	SPIN14	SPIN13	SPIN12	SPIN11	SPIN10	SPIN9	SPIN8

MSB	HK39[11]						LSB
SPIN7	SPIN6	SPIN5	SPIN4	SPIN3	SPIN2	SPIN1	SPIN0

Each rotation of the S/C is counted inside the DPU and sent to earth as the S/C spin number. After every reset the S/C spin number starts at 0. The DPU internal length of this counter is 32 bit.

ERDSPMCP STOP MCP STEP

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 10

MSB	HK37[00]						LSB
			ESTO				

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

ESTO=0 Stop MCP HV stepping is disabled
ESTO=1 Stop MCP HV stepping is enabled

ERDSPMHC STOP_MCP_CURLEV

type: R
conditioned by: (ERDHKFCR MOD 4)=03
HKByte: 37
mask: F0

MSB	HK37[03]						LSB
STO3	STO2	STO1	STO0				

There are 16 different values that can be written into the Stop MCP HV register inside the SCU. The current level is the level that is just being written into that register. The current level normally is less or equal the limit level of the HV, but can be greater during stepping, if the limit level has been decreased.

ERDSPMVL STOP_MCP_LIMIT

type: R
conditioned by: (ERDHKFCR MOD 4)=02
HKByte: 37
mask: F0

MSB	HK37[02]						LSB
STO3	STO2	STO1	STO0				

There are 16 different values that can be written into the Stop MCP HV register inside the SCU. The limit level is the maximum possible level for the target level. If the limit level is programmed as being less than the target level, the HV is being stepped down to the new limit level.

ERDSPPOS SUN POSITION

type: R
conditioned by: ERDHKFCR=30
HKByte: 39
mask: FF

MSB	HK39[30]						LSB
SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0

Describes the position of the sun pulse with respect to the sector boundaries. Each sector is divided into 256 equal parts. A value of 0 means that the sun pulse appears at the sector beginning, 127 defines the middle and 255 the end.

ERDSPSEC SUN SECTOR

type: R
conditioned by: ERDHKFCR=31
HKByte: 39
mask: 0F

MSB	HK39[31]						LSB
				SS3	SS2	SS1	SS0

In this HK item the number of the sector is transmitted, in which the signal from the sun detector is received.

ERDSPSTG CHPS_STOP_STEPG

type: D
conditioned by:
HKByte: 2
mask: 01

MSB	HK02						LSB
							STSTO

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

STSTO=0 Stop MCP HV is not stepping
STSTO=1 Stop MCP HV is stepping

ERDSSINT INTERNAL_SEC_CLK

type: D
conditioned by:
HKByte: 1
mask: 20

MSB	HK01						LSB
		FLAG					

The sector clock for the DPU is derived from the sector clock information from the S/C (external sector clock). In the case of a hardware failure in this section of the S/C, HEP-LD automatically switches to an artificial generation of this sector clock, using an internal timer unit. If the sector clock information from S/C retrieves, the instrument switches back to external sector clock automatically. It is possible to command the use of the artificial sector clock (ZERASECN).

FLAG=0 external sector clock (default)
FLAG=1 artificial sector clock

ERDSTAT1 DPU STATUS 1

type: R
conditioned by: ERDHKFCR=13
HKByte: 39
mask: FF

MSB	HK39[13]						LSB
STAT7	STAT6	STAT5	STAT4	STAT3	STAT2	STAT1	STAT0

HK-copy of the content descriptor 1 (CD1) inside the EDB.

ERDSTAT2 DPU STATUS 2

type: R
conditioned by: ERDHKFCR=17
HKByte: 39
mask: FF

MSB	HK39[17]						LSB
STAT7	STAT6	STAT5	STAT4	STAT3	STAT2	STAT1	STAT0

HK-copy of the content descriptor 2 (CD2) inside the EDB.

ERDSTMCP START MCP STEP

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 20

MSB	HK39[00]						LSB
		ESTA					

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

ESTA=0 Start MCP HV stepping is disabled
ESTA=1 Start MCP HV stepping is enabled

ERDSTMHC START_MCP_CURLEV

type: R
conditioned by: (ERDHKFCR MOD 4)=03
HKByte: 37
mask: 0F

MSB	HK37[03]						LSB
				STA3	STA2	STA1	STA0

There are 16 different values that can be written into the Start MCP HV register inside the SCU. The current level is the level that is just being written into that register. The current level normally is less or equal the limit level of the HV, but can be greater during stepping, if the limit level has been decreased.

ERDSTMVL START_MCP_LIMIT

type: R
conditioned by: (ERDHKFCR MOD 4)=02
HKByte: 37
mask: 0F

MSB	HK37[02]						LSB
				STA3	STA2	STA1	STA0

There are 16 different values that can be written into the Start MCP HV register inside the SCU. The limit level is the maximum possible level for the target level. If the limit level is programmed as being less than the target level, the HV is being stepped down to the new limit level.

ERDSTSTG CHPS_START_STEG

type: D
conditioned by:
HKByte: 2
mask: 02

MSB	HK02						LSB
						STSTA	

To change the current state of a high voltage a S/W switch must be enabled for the respective high voltage.

If a high voltage currently is changing its value, the respective stepping flag becomes active.

STSTA=0 Start MCP HV is not stepping
STSTA=1 Start MCP HV is stepping

ERDSVCMD SECOND_LAST_CMD

type: R
conditioned by:
HKByte: 15
mask: FF

MSB	HK15						LSB
CMD7	CMD6	CMD5	CMD4	CMD3	CMD2	CMD1	CMD0

This HK item contains the command code of the second last accepted command.

ERDTCFAC TAC_SLOPE

type: D
conditioned by:
HKByte: 5
mask: C0

MSB	HK05						LSB
TA1	TA0						

The TAC slope can vary between -20% and +10% of the default value (0%).

current TAC slope

0	0%
1	+10%
2	-20%
3	-10%

ERDTMMOD TELEMETRY_MODE

type: D
conditioned by:
HKByte: 1
mask: 18

MSB	HK01						LSB
			MODE1	MODE0			

In this HK item the DPU shows which telemetry mode it believes to be in. Accordingly it will format EDBs suitable for these modes, i.e. Normal Mode EDBs in telemetry modes NM and BM2, Burst Mode 1 EDBs in telemetry mode BM1 and Burst Mode 3 EDBs in telemetry mode BM3.

0	NM[1-3]
<	BM1
2	BM2
3	BM3

ERDTMUX1 TMUX_HEAD_1_OFF

type: D
conditioned by:
HKByte: 6
mask: 02

MSB	HK06						LSB
						TMX1	

The time channel from the IIMS sensor 1 can be masked or unmasked.

TMX1=0 time multiplexer 1 enabled
TMX1=1 time multiplexer 1 disabled

ERDTMUX2 TMUX_HEAD_2_OFF

type: D
conditioned by:
HKByte: 6
mask: 10

MSB	HK06						LSB
			TMX2				

The time channel from the IIMS sensor 2 can be masked or unmasked.

TMX2=0 time multiplexer 2 enabled
TMX2=1 time multiplexer 2 disabled

ERDTMUX3 TMUX_HEAD_3_OFF

type: D
conditioned by:
HKByte: 6
mask: 80

MSB	HK06						LSB
TMX3							

The time channel from the IIMS sensor 3 can be masked or unmasked.

TMX1=0 time multiplexer 3 enabled
TMX1=1 time multiplexer 3 disabled

ERDTOERC TIMEOUT_ERR_CNT

type: R
conditioned by: ERDHKFCR=25-26
HKByte: 39
mask: FF

MSB	HK39[25]						LSB
CNT15	CNT14	CNT13	CNT12	CNT11	CNT10	CNT9	CNT8

MSB	HK39[26]						LSB
CNT7	CNT6	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

A counter accumulates the amount of sectors with a too short dead time.

ERDTRIGM EVENT_TRIG_MODE

type: D
conditioned by:
HKByte: 0
mask: E0

MSB	HK00						LSB
TM2	TM1	TM0					

The trigger mode register inside the IIMS SCU ASIC can hold one of six possible states. The trigger mode defines the information that is needed of one event to trigger the IIMS classification of RAPID.

event trigger mode		
0	energy or direction	E+T
1	energy or (direction and time)	E+(D*T)
2	energy and direction and time	E*D*T
3	energy and time	E*T
4	energy	E
5	time	T
6	invalid	
7	invalid	

ERDVCCNT VALID_CMD_CNT

type: R
conditioned by: ERDHKFCR=23
HKByte: 39
mask: FF

MSB	HK39[23]						LSB
CNT7	CNT6	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

The HK item contains the amount of received valid commands since power-on.

ERDWATEN WATCHDOG_ENABLED

type: D
conditioned by: (ERDHKFCR MOD 4)=00
HKByte: 37
mask: 80

MSB	HK37[00]						LSB
WD							

A watchdog routine checks the incrementing of the spin counter. If for a specific period of time there is no incrementing of the spin counter a hardware reset is initiated.

WD=0 Watchdog function disabled
WD=1 Watchdog function enabled

ERECMDRT IES_CMD_ANSWER

type: R
conditioned by:
HKByte: 17
mask: FF

MSB	HK17						LSB
CMD7	CMD6	CMD5	CMD4	CMD3	CMD2	CMD1	CMD0

This HK item contains the command answer of the IES sensor system.

Value	IES integration time
00h:	2 µs
80h:	5 µs
40h:	15 µs
C0h:	50 µs

EREFXLUT IES_AUTOSWT

type: D
conditioned by: ERDHKFCR=29
HKByte: 39
mask: 04

MSB	HK39[29]						LSB
				ASWT			

This HK item displays, if the IES autoswitching algorithm is enabled (0) or not (1)

ERERATE1 IES_STRIP_1_RATE

type: R
conditioned by:
HKByte: 27
mask: FF

MSB	HK27						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 1 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE2 IES_STRIP_2_RATE

type: R
conditioned by:
HKByte: 28
mask: FF

MSB	HK28						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 2 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE3 IES_STRIP_3_RATE

type: R
conditioned by:
HKByte: 29
mask: FF

MSB	HK29						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 3 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE4 IES_STRIP_4_RATE

type: R
conditioned by:
HKByte: 30
mask: FF

MSB	HK30						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 4 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE5 IES_STRIP_5_RATE

type: R
conditioned by:
HKByte: 31
mask: FF

MSB	HK31						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 5 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE6 IES_STRIP_6_RATE

type: R
conditioned by:
HKByte: 32
mask: FF

MSB	HK32						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 6 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE7 IES_STRIP_7_RATE

type: R
conditioned by:
HKByte: 33
mask: FF

MSB	HK33						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 7 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE8 IES_STRIP_8_RATE

type: R
conditioned by:
HKByte: 34
mask: FF

MSB	HK34						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 8 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERERATE9 IES_STRIP_9_RATE

type: R
conditioned by:
HKByte: 35
mask: FF

MSB	HK35						LSB
ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0

This HK item contains the compressed sum of counts of the IES sensor strip 9 below the lower measurement threshold. In this area the strip's pedestal is located. The accumulation time for this value is 1 spin.

ERESENID IES_SENSOR_ID

type: D
conditioned by: ERDHKFCR=4
HKByte: 39
mask: FF

MSB	HK39[04]						LSB
0	0	0	0	LS3	LS2	LS1	LS0

This HK item contains the number of a LUT quadruple from the DPU PROM with an inherent ID number and the selected temperature range for the IES sensor used on that RAPID unit. The assignment of IDs to real sensor numbers is fixed with the final assembly of the IES detectors to the RAPID flight models and is shown in the following table.

LS	Phoenix FM	Cluster II FMs
0	20°C	20°C from Phoenix
1	n.a.	n.a.
2	n.a.	n.a.
3	n.a.	n.a.
4	n.a.	n.a.
5	n.a.	n.a.
6	n.a.	n.a.
7	n.a.	n.a.
8	n.a.	test set 1 (P=1;S=1)
9	n.a.	test set 2 (P=50;S=1)

ERICALEN ENERGY_CAL_PULSE

type: A
conditioned by:
HKByte: 3
mask: FF

MSB	HK03						LSB
E7	E6	E5	E4	E3	E2	E1	E0

The result from the energy channel that was received after the IIMS single-shot calibration in the last spin is transmitted in this value.

ERICALTF TIME_CAL_PULSE

type: A
conditioned by:
HKByte: 4
mask: FF

MSB	HK04						LSB
T7	T6	T5	T4	T3	T2	T1	T0

The result from the time channel that was received after the IIMS single-shot calibration in the last spin is transmitted in this value.

ERIDEFHV DEF_PLATE_HV

type: A
conditioned by:
HKByte: 13
mask: FF

MSB	HK13						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The range for the Deflection HV is from 0 to 10000V and is converted into 256 digital steps. The relationship between analog voltage and digital value is nonlinear.

ERIENYCP ENY1_COUNT_RATE

type: R
conditioned by:
HKByte: 25
mask: FF

MSB	HK25						LSB
ENY7	ENY6	ENY5	ENY4	ENY3	ENY2	ENY1	ENY0

This HK item contains the compressed IIMS ENY rate that was accumulated over 4 spins

ERIENYLB ENY1_COUNT_RATE

type: R
conditioned by:
HKByte: 26
mask: FF

MSB	Hk26						LSB
ENY7	ENY6	ENY5	ENY4	ENY3	ENY2	ENY1	ENY0

This HK item contains the uncompressed low byte of the IIMS ENY rate counter that has accumulated over 4 spins.

ERIHKTRF HKB_TEMP

type: A
conditioned by: (ERDHKFCR MOD 8)=07
HKByte: 38
mask: FF

MSB	HK38[07]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The sensor temperature is monitored in this value. The measured analog value can be calculated from the digital value by:

$T_{analog} = (2.5V - U_{digital} * 5V / 256) * 40°C/V$.

ERIM12RF -12VREFERENCE

type: A
conditioned by: (ERDHKFCR MOD 8)=04
HKByte: 38
mask: FF

MSB	HK38[04]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The -12V power supply line is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 6.379$.

ERIM5VRF -5VOLT REFERENCE

type: A
conditioned by: (ERDHKFCR MOD 8)=02
HKByte: 38
mask: FF

MSB	HK38[02]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The -5V power supply line is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 2.5026$.

ERIP12RF +12V REFERENCE

type: A
conditioned by: (ERDHKFCR MOD 8)=03
HKByte: 38
mask: FF

MSB	HK38[03]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The +12V power supply line is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 6.552$.

ERIP5VRF +5VOLT REFERENCE

type: A
conditioned by: (ERDHKFCR MOD 8)=01
HKByte: 38
mask: FF

MSB	HK38[01]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The +5V power supply line is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 2.5724$.

ERIPADTS E-PAD-Table 3a/b

type D
conditioned by:
HKByte: 20
mask: 80

MSB	HK20					v	LSB
a/b							

This bit shows whether EPP Lookup table 3a (coded 0) or table 3b (coded 1) is in use for data formatting.

ERIPITCH PITCH_ANGLE_IIMS

type: R
conditioned by:
HKByte: 18
mask: FF

MSB	HK18						LSB
P13	P12	P11	P10	P03	P02	P01	P00

Calculated IIMS look direction orthogonal to the magnetic field vector that was received by the IEL. Look directions could be between 0 and 11. For every sector there must be calculated a new value. So there are 16 values to be sent to the ground station. Two values fit into one byte. To get a complete set of directions calculated in one spin one has to collect eight HK frames.

(ERDHKFCR MOD 8)=0 Dir(sector 1),Dir(sector 0)
(ERDHKFCR MOD 8)=1 Dir(sector 3),Dir(sector 2)
(ERDHKFCR MOD 8)=2 Dir(sector 5),Dir(sector 4)
(ERDHKFCR MOD 8)=3 Dir(sector 7),Dir(sector 6)
(ERDHKFCR MOD 8)=4 Dir(sector 9),Dir(sector 8)
(ERDHKFCR MOD 8)=5 Dir(sector 11),Dir(sector 10)
(ERDHKFCR MOD 8)=6 Dir(sector 13),Dir(sector 12)
(ERDHKFCR MOD 8)=7 Dir(sector 15),Dir(sector 14)

ERISAREF SAFE/ARM

type D
conditioned by: (ERDHKFCR MOD 8)=05
HKByte: 38
mask: FF

MSB	HK38[05]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The status of the Safe/Armed plug is monitored in this value. The measured analog value can be calculated from the digital value by:

$U_{analog} = (2.5V - U_{digital} * 5V / 256) * 2$.

An analog voltage of about 5V is synonymous with a non installed Safe/Armed plug, i.e. the HV can rise to the destination level and is not limited to 5% of the maximum value. This is the default in orbit and cannot change.

ERISTACP STA1_COUNT_RATE

type: R
conditioned by:
HKByte: 21
mask: FF

MSB	HK21						LSB
STA7	STA6	STA5	STA4	STA3	STA2	STA1	STA0

This HK item contains the compressed IIMS STA rate that was accumulated in 1 sector from 2 spins in BM or 4 spins in NM.

ERISTAHV START_MCP_HV

type: D
conditioned by:
HKByte: 11
mask: FF

MSB	HK11						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The range for the Start MCP HV is from 0 to about 4kV and is converted into 256 digital steps. The relationship between analog voltage and digital value is nonlinear.

ERISTALB STA2_COUNT_RATE

type: R
conditioned by:
HKByte: 22
mask: FF

MSB	HK22						LSB
STA7	STA6	STA5	STA4	STA3	STA2	STA1	STA0

This HK item contains the uncompressed low byte of the IIMS STA rate counter that has accumulated 1 sector from 4 spins in NM or 2 spins in BM.

ERISTOCP STO1_COUNT_RATE

type: R
conditioned by:
HKByte: 23
mask: FF

MSB	HK23						LSB
STO7	STO6	STO5	STO4	STO3	STO2	STO1	STO0

This HK item contains the compressed IIMS STO rate that was accumulated in 1 sector from 2 spins in BM or 4 spins in NM.

ERISTOHV STOP_MCP_HV

type: A
conditioned by:
HKByte: 12
mask: FF

MSB	HK12						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The range for the Stop MCP HV is from 0 to about 4kV and is converted into 256 digital steps. The relationship between analog voltage and digital value is nonlinear.

ERISTOLB STO2_COUNT_RATE

type: R
conditioned by:
HKByte: 24
mask: FF

MSB	HK24						LSB
STO7	STO6	STO5	STO4	STO3	STO2	STO1	STO0

This HK item contains the uncompressed low byte of the IIMS STO rate counter that has accumulated in 1 sector from 4 spins in NM or 2 spins in BM.

ERISTREF SENSOR TEMP

type: A
conditioned by: (ERDHKFCR MOD 8)=06
HKByte: 38
mask: FF

MSB	HK38[06]						LSB
HK7	HK6	HK5	HK4	HK3	HK2	HK1	HK0

The sensor temperature is monitored in this value. The measured analog value can be calculated from the digital value by:

$T_{analog} = (2.5V - U_{digital} * 5V / 256) * 40°C/V$.

5 Appendix

5.1 Decompression table

Compressed	Decompressed	Compressed	Decompressed	Compressed	Decompressed	Compressed	Decompressed
0	0	20	32	40	128	60	512
1	1	21	34	41	136	61	544
2	2	22	36	42	144	62	576
3	3	23	38	43	152	63	608
4	4	24	40	44	160	64	640
5	5	25	42	45	168	65	672
6	6	26	44	46	176	66	704
7	7	27	46	47	184	67	736
8	8	28	48	48	192	68	768
9	9	29	50	49	200	69	800
A	10	2A	52	4A	208	6A	832
B	11	2B	54	4B	216	6B	864
C	12	2C	56	4C	224	6C	896
D	13	2D	58	4D	232	6D	928
E	14	2E	60	4E	240	6E	960
F	15	2F	62	4F	248	6F	992
10	16	30	64	50	256	70	1024
11	17	31	68	51	272	71	1088
12	18	32	72	52	288	72	1152
13	19	33	76	53	304	73	1216
14	20	34	80	54	320	74	1280
15	21	35	84	55	336	75	1344
16	22	36	88	56	352	76	1408
17	23	37	92	57	368	77	1472
18	24	38	96	58	384	78	1536
19	25	39	100	59	400	79	1600
1A	26	3A	104	5A	416	7A	1664
1B	27	3B	108	5B	432	7B	1728
1C	28	3C	112	5C	448	7C	1792
1D	29	3D	116	5D	464	7D	1856
1E	30	3E	120	5E	480	7E	1920
1F	31	3F	124	5F	496	7F	1984
hex	**dec**	**hex**	**dec**	**hex**	**dec**	**hex**	**dec**

Compressed	Decompressed	Compressed	Decompressed	Compressed	Decompressed	Compressed	Decompressed
80	2048	A0	8192	C0	32768	E0	524288
81	2176	A1	8704	C1	36864	E1	589824
82	2304	A2	9216	C2	40960	E2	655360
83	2432	A3	9728	C3	45056	E3	720896
84	2560	A4	10240	C4	49152	E4	786432
85	2688	A5	10752	C5	53248	E5	851968
86	2816	A6	11264	C6	57344	E6	917504
87	2944	A7	11776	C7	61440	E7	983040
88	3072	A8	12288	C8	65536	E8	1048576
89	3200	A9	12800	C9	73728	E9	1179648
8A	3328	AA	13312	CA	81920	EA	1310720
8B	3456	AB	13824	CB	90112	EB	1441792
8C	3584	AC	14336	CC	98304	EC	1572864
8D	3712	AD	14848	CD	106496	ED	1703936
8E	3840	AE	15360	CE	114688	EE	1835008
8F	3968	AF	15872	CF	122880	EF	1966080
90	4096	B0	16384	D0	131072	F0	2097152
91	4352	B1	17408	D1	147456	F1	2359296
92	4608	B2	18432	D2	163840	F2	2621440
93	4864	B3	19456	D3	180224	F3	2883584
94	5120	B4	20480	D4	196608	F4	3145728
95	5376	B5	21504	D5	212992	F5	3407872
96	5632	B6	22528	D6	229376	F6	3670016
97	5888	B7	23552	D7	245760	F7	3932160
98	6144	B8	24576	D8	262144	F8	4194304
99	6400	B9	25600	D9	294912	F9	4718592
9A	6656	BA	26624	DA	327680	FA	5242880
9B	6912	BB	27648	DB	360448	FB	5767168
9C	7168	BC	28672	DC	393216	FC	6291456
9D	7424	BD	29696	DD	425984	FD	6815744
9E	7680	BE	30720	DE	458752	FE	7340032
9F	7936	BF	31744	DF	491520	FF	7864320
hex	**dec**	**hex**	**dec**	**hex**	**dec**	**hex**	**dec**

5.2 Decompression algorithm

input: 8 bit integer

output: 24 bit integer

exponent, mantisse : integer variable

exponent=input / 16

mantisse=input AND 15

if (exponent<2) then

    output=input

else

    output=(mantisse+16)* $2^{(exponent-1);}$

fi

if (exponent>=12) then

    exponent=input / 8

    mantisse=input AND 7

    output=(mantisse+8)* $2^{(exponent-12)}$

fi