Title:

CDMS - SD2

Data Interface Control Document

Project: SHARK - ROSETTA LANDER

Contract: ASI-TS (WP 4510)

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CHANGE HISTORY RECORD

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Change description: First emission.

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Change description: Updated for new telecommand/ telemetry specification. Added also OCPL

Rev. C Reviewed by P.Bologna Date _____

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Change description:
- change SARE WRDC from 3 to 2
- add the check: TIME DURATION shall be #0
- add the drill, carousel reference systems
- updated the error handler procedure
- added the new command LANDG
- added the new commands DRTT, DRTC

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Change description: Added ONLY the full range of A/D converter at page 44

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Change description: Included the excel tables containing the SD2 database used by DLR- EGSE. Updated chapter 5 that now makes reference to the included tables.

Rev. F Reviewed by P.Bologna Date _____

O.M. 858 Approved by E.Re Date _____

Change description: Included oven Ids for the Flight Spare Model

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Rev. G Reviewed by P.Bologna Date _____

O.M. 867 Approved by E.Re Date _____

Change description: Included oven Ids for the GRM and Correct HK table

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1. INTRODUCTION

According to CDMS subsystem and instruments electrical interface definition (ref. AD1), this document defines the commands that CDMS transmits to SD2 and the telemetry data that SD2 transmits to CDMS. Specific commands, allowing SD2 Subsystem specific control and operations, are added with respect to the standard subsystem interface.

SD2 telemetry data consists of housekeeping data, scientific data and backup RAM data: they are specified in chapter 5.

SD2 operation error handling procedure is defined.

Reference systems for drill and carousel are listed in chapter 8.

This document specifies the syntax of commands and data exchanged from CDMS and SD2. The actions (checks, handling of drivers) performed by SD2 when a command/ data is received, are specified in the "SD2 Software- User Requirement Document", Doc No SHARK-URD-TS-067 and in the "SD2 Software- Software Requirement Document", Doc No SHARK-SRD-TS-073.

1.1 LIST OF ACRONYMS

ACT	Action Code
AMDT	Acquisition Mode Descriptor Table
BCK_Data	Backup-RAM Data
C-DPU	Common Digital Processing Unit
CDMS	Command & Data Management System
CE	Count Error Flag
CMD	Command
HITB	Historical Internal Tracking Buffer
HK	Housekeeping
HK_Data	Housekeeping Data
I/N	Immediate/Normal Command Type
ME	Memory Error Bit
RAM	Random Access Memory
SC_Data	Scientific Data
SD2	Sample Drill & Distribution System

SD2_SW	SD2 Software
SR	Service Request Flag
SSADR	Subsystem Address
SSCMD	Subsystem Command Word
T/R	Transmit/Receive Bit
TRQC	Transmit Request Code Word
WRDC	Word Count

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD1. CDMS Subsystem & Instruments Electrical Interface Definition (Extract from REID-A) and Generic Payload Control

AD2. Rosetta-Lander Interface Document Part B, ESA Doc.,

RO-EST-RS-3020/LID B.

AD3 SHARK-SA-TS-044

SD2 Electronic Unit Internal Interface Control Document

2.2 REFERENCE DOCUMENTS

RD1 SHARK-AB-TS-003 SD2 Sub-System specification

RD2 SHARK-DG-TS-006 SD2 Electronic Unit Specification (Preliminary)

3. DATA AND COMMAND INTERFACES GENERALITY

SD2 Subsystem utilizes a C-DPU board as micro-controller unit. The C-DPU interfaces directly the CDMS. Specific C-DPU software will be dedicated to manage the external interfaces and to command and control the SD2 subsystem specific boards.

According to CDMS system terminology, SD2 is as an 'intelligent' unit.

Data and command interchange with the CDMS occurs exclusively on word by word basis. A word is composed of 16 bits, MSB (bit15) first.

According to AD1, the communication between CDMS and SD2_SW is via four different types of words:

communication CDMS ® SD2 :

1. SSADR Subsystem Address Word to be received on the SSCMD line. This word defines the address of the Unit to which the CDMS command refers, the type of the command [***Action Code*** field], and either the number of following command words (data of the CDMS command) or the number of the data that SD2_SW shall transmit to CDMS
2. SSCMD Subsystem Command Word to be received on the SSCMD line. This word [or more] follows the previous one and contains command specification and details

communication SD2 ® CDMS:

3. SSTS Subsystem Status Word to be transmitted on SSDAT line. This word contains the SD2 status and shall be transmitted by SD2 to CDMS:
   - every time a SSADR is received from SD2, after reception of last SSCMD of the relevant SSADR (done automatically the BIOS)
   - every time SD2 needs to communicate with CDMS (for notifying that data are ready to be transmitted, ..)
4. SSDAT Subsystem Data Word to be transmitted on SSDAT line. This word [or more] is a generic data word transmitted back by SD2; it might contain the ***Request Code*** to specify the type of SD2 request.

The bit structure of the words is the following.

1)

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SSADR					T/R	ACT					WRDC				

SSADR Subsystem Address

T/R	Transmit/Receive bit
ACT	Action Code / Subaddress
WRDC	Word Count

SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit DATA															

2)
SSTS Subsystem Status Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SSADR					ME	CE	SR	1	0	0	0	BSY	SM	0	0

SSADR	Subsystem Address
ME	Message Error Flag
CE	Count Error Flag
SR	Service Request Flag
BSY	Busy Flag
SM	Sleep Mode Flag

SSDAT Subsystem Data Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit DATA															

A detailed description of Command and Data interfaces is reported in AD1.

In general, SD2 has not to produce large amount of experiment data. It is in charge to manage the comet drilling operation and samples distribution. So it is convenient to allocate a data RAM buffer to store cyclically the last acquired internal data. Providing this buffer with a sufficient data rate and time depth, it is possible to reconstruct the last physical operations of SD2.

The SD2_SW allocates the HITB (Historical Internal Tracking Buffer) of 32*256 words, which allows 256 acquisitions, each acquisition consisting of 32 words. This data buffer of SD2 will be handled by CDMS as scientific data (see Chapter 5.2).

A specific command for SD2 is dedicated to HITB management. (See Chapter 4.).

Commands sent from CMDS to SD2 are specified in Chapter 3.1 and 4.

Data sent by SD2 to CDMS are specified in Chapter 5.

3.1 ACTION AND REQUEST CODES

Referring to AD1 (ref. 3.3.5.1 and 3.3.5.2), communication between CDMS and SD2 is based on *Action* and *Request Codes*, that are reported in the tables 4.2.4-1 and 4.2.4-2 of [RD1]. It is foreseen that nominally only some *Action* should be sent to SD2; for the other ones, SD2 reacts by raising an error code and by performing the recovery action specified in chapter 7. Moreover, some *Request* will not be issued by SD2; actions not nominally implemented and requests never issued by SD2 are listed in the above specified tables.

When the Action code is RCMD, the CDMS will send in the next WRDC words a *Specific command.*

The *Specific commands* are detailed in chapter 4.

When an Action Code different from the below specified is received, the SD2_SW rejects it and sets the ME flag of status word to '1'.

Commands sent from CDMS that are not broadcast commands and that contain subsystem address SSADR different from SD2 address are ignored by SD2_SW since filtered by Common DPU hardware (FPGA).

4. SD2 SPECIFIC COMMANDS

In the following, specific commands of SD2 Subsystem are reported.

Their protocol is the following:

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SSADR					T/R	ACT					WRDC				

SSADR	Subsystem Address	'01101'	(SD2)
T/R	Transmit/Receive bit	'0'	(Receive Mode)
ACT	Action Code	'01000'	(RCMD)
WRDC	Word Count		

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CMD Code					I/N	10 bit DATA									

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit DATA															

.....

.....

#(WRDC –1) SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit DATA															

#WRDC SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit Comand Checksum															

In the #1 SSCMD word, the command code (CMD Code) is inserted in a 5 bits field. The list of command codes are reported in Table 4-1.

Two types of commands are foreseen: Normal and Immediate commands. Normal commands (bit I/N '0') are executed as received when the execution of previous specific command is finished; immediate commands (bit I/N '1') are executed immediately when received. Normal commands are stored into internal FIFO queue whose dimension is 100 words.

Due to critical operations (high power consuming, mechanical movements and interaction, etc.), the command validity checksum word is sent for all SD2 specific command as last command word.

Checksum word is calculated according to the following rule (possible overflow at any addition is always discarded):

$$\text{Checksum} = \sum_{n=1}^{(WRDC-1)} SSCMD(n)$$

When a command is received, SD2_SW performs the following checks:

- syntax checks: it is checked that each bit of the received command is according to the command specification (see next chapters)
- checksum check: SD2_SW evaluates the checksum of the received command and compares it with the checksum contained in the last command word

If either syntax or checksum check fails, SD2_SW will reject the command and notify the error both in the house-keeping data HK_Data and in the Scientific data. Moreover, it will execute the recovery action related to the detected error as specified in chapter 7.

Next sections detail the specific command format.

Mnemo	*CMD Code*	*I/N*	*WRDC*	*Command Description*
ZERO	00000	N	3	Perform zero condition and switch off all act. sections
ONOF	00001	N	2	Switch On/Off electronic actuation sections
ACRE	00010	N	2	Acquire values of resolver #1 and resolver #2
CAPO	00011	N	4	Perform carousel rotation to a defined position
CASI	00100	N	4	To move an oven to a scientific port
DRTR	00101	N	3	Perform drill translation to a defined position
DRGO	00110	N	3	Perform drill rotation for a defined time
DRST	00111	N	2	Perform drill rotation stop
MVCK	01000	N	3	Move volume checker
VCAC	01001	N	4	Activate volume checker
ABRT	01010	I	2	Abort Command
EMST	01011	I	2	Emergency Stop
EHEN	01100	N	2	Enable/disable error handling procedure
SARE	01101	N	2	Release sampling tube
RDAD	01110	N	3	Read the contents of specified board address and put it into Scientific Data
WRAD	01111	N	4	Write the specified word in the specified address
ENEM	10000	N	2	End of emergency
MHIT	10001	N	2	Managing HITB acquisition
LDMP	10010	N	6	Load a SD2 command sequence from CDMS memory to SD2 internal buffer
STARTOP	10011	N	2	Notifies that the specified operation is starting. The SD2 current status of BCK_Data is accordingly updated
STOPOP	10100	N	2	Notifies that the specified operation has been completed. The SD2 current status of BCK_Data is accordingly updated and the end-of-operation is notified to CDMS via SR flag
DELAY	10101	N	3	performs the required delay before to execute next command
LANDG	10110	N	10	loads the data relevant to the landing gear
DRTT	10111	N	4	Perform drill translation with timeout
DRTC	11000	N	4	Check drill translation, main or redundant

4.1 ZERO EXECUTE ZERO CONDITION

Description

It moves up the volume checker and positions to "zero" the carousel rotation and drill translation. It switches off all actuation sections of SD2 electronic interface boards.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME DURATION OF VOLUME CHECKER MOVEMENT															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

TIME DURATION: integer # 0; unit: 250 [ms]

4.2 ONOF ON/OFF SWITCHES

Description

It commands the ON or OFF switching of actuation sections of SD2 electronic interface boards. (Ref. to RD2).

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	H	G	F	E	D	C	B	A

A	Drill rotation driver	'1 = On, 0 = Off'
B	Sampler driver '1 = On, 0 = Off'	
C	Carousel rotation driver	'1 = On, 0 = Off'
D	Drill translation driver	'1 = On, 0 = Off'
E	Drill transl. driver 'redun.'	'1 = On, 0 = Off'
F	R/D converter of drill trans.	'1 = On, 0 = Off'
G	R/D converter of carous.	'1 = On, 0 = Off'
H	Volume checker driver	'1 = On, 0 = Off'

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- the specific command ONOF where B=1 (switch on the sampler driver) means that the sampling tube is activated in continuos mode. The sampling tube shall be stopped by means of ONOF B=0 (switch off the sampler driver).
- no mechanical check is performed by SD2SW when the ONOF command is received

- when the command is relevant to drill rotation driver, carousel rotation driver, drill translation driver, drill translation driver redundant, volume checker driver, SD2_SW clears also the register containing the driver speed and torque

4.3 ACRE RESOLVERS ACQUISITION

Description

It commands the acquisition of resolver of drill translation and carousel rotation.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	1	1	0	0	1	0	1	R2	R1

R1 Acquire resolver of carousel '1 = YES, 0 = NO'
R2 Acquire resolver of drill translation '1 = YES, 0 = NO'

#2 SSCMD Subsystem Command Word (CDMS → Unit)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

Either R1 or R2 shall be not zero

4.4 CAPO CAROUSEL TO A POSITION

Description

It performs carousel movement to a defined position. Before moving the carousel, the volume checker is moved up.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	0	SPEED					TORQUE			0	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
POSITION															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME DURATION OF VOLUME CHECKER MOVEMENT															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: Rotation speed; the 32 values of speed are according to:
  zero speed: '00000'
  maximum speed: '11111'
  It shall be #0.
- TORQUE field: Max. torque; the 8 values of torque are according to:
  miminum torque: '000'
  maximum torque: '111'
- POSITION: unit is arcminute; 0 position is the position allowing drilling (see chapter 8 for reference system definition); the allowed range for POSITION is [0,21600)
- TIME DURATION: integer # 0; unit: 250 [ms]

4.5 CASI CAROUSEL MOVEMENT TO A SCIENTIFIC PORT

Description

It performs carousel movement for positioning a defined oven to a scientific port. Before moving the carousel, the volume checker is moved up.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	0	SPEED					TORQUE			0	1

#2 SSCMD Subsystem Command Word (CDMS → Unit)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	SCIP		OVEN #				

OVEN# Oven Number
SCIP Scientific Port

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME DURATION OF VOLUME CHECKER MOVEMENT															

#4 SSCMD Subsystem Command Word (CDMS → Unit)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: '00000'
  maximum speed: '11111'
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: '000'
  maximum torque: '111'
- OVEN#: it shall be in the range 1<= OVEN <= 26
- SCIP: it is in the range 0 <=SCIP<=3
- TIME DURATION: integer # 0; unit: 250 [ms]

4.6 DRTR DRILL TRANSLATION TO A POSITION

Description

It performs drill translation movement to a defined position.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	1	0	SPEED					TORQUE			1	0

SPEED Rotation speed 32 values
TORQUE Max. torque 8 values

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
POSITION															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: ‘00000’
  maximum speed: ‘11111’
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: ‘000’
  maximum torque: ‘111’

- POSITION: unit is 1/100 mm; for the drill reference system, see chapter 8; the allowed range for POSITION is [0,62500]

4.7 DRGO DRILL ROTATION

Description

It performs start of drill rotation for a defined time.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	0	0	SPEED					TORQUE			DIR	0

SPEED	Rotation speed 32 values	
TORQUE	Max. torque	8 values
DIR	Rotation direction	‘0’=CW, ‘1’=CCW
		(see Chapter 8 for drill reference system)

#2 SSCMD Subsystem Command Word (CDMS → Unit)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME DURATION OF DRILL ROTATION															

#3 SSCMD Subsystem Command Word (CDMS → Unit)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: ‘00000’
  maximum speed: ‘11111’
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: ‘000’
  maximum torque: ‘111’

- TIME DURATION: integer # 0; unit: [s] so that the maximum allowed drill rotation is 18.2 hours

4.8 DRST STOP DRILL ROTATION

Description

It performs stop of drill rotation.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	0	1	0	1	0	1	0	1

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

4.9 MVCK MOVE VOLUME CHECKER

Description

It moves the volume checker to up/down position according to direction specified in the command.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	0	SPEED					TORQUE			DIR	1

SPEED	Rotation speed 32 values	
TORQUE	Max. torque	8 values
DIR	Rotation direction	‘0’=DOWN, ‘1’=UP
	(see Chapter 8 for volume checker reference system)	

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WAITING TIME FOR VOLUME CHECKER MOVEMENT COMPLETION															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: ‘00000’
  maximum speed: ‘11111’
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: ‘000’

maximum torque: ‘111’

- WAITING TIME: integer # 0; unit: 250 [ms]

4.10 VCAC ACTIVATE VOLUME CHECKER

Description

It moves the volume checker to perform sample measurement: first, move up, then move down and then move up again. The measure is performed at the end of second "move up"

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	SPEED					TORQUE			1	1

SPEED Rotation speed 32 values
TORQUE Max. torque 8 values

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WAITING TIME FOR COMPLETION OF EACH VOLUME CHECKER MOVEMENT															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WAITING TIME TO BE SPENT OVER THE OVEN BEFORE EXECUTING THE MOVING UP															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: '00000'
  maximum speed: '11111'
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: '000'
  maximum torque: '111'
- WAITING TIME: integer # 0; unit: 250 [ms]

4.11 ABRT ABORT COMMAND

Description

It stops the movement of all the currently active devices by performing a ramp down step-by-step speed control; at the end of motion, it flushes the specific command queue.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	1	0	1	0	0	1	0	0	0	1	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

4.12 EMST EMERGENCY STOP

Description

It powers down all the devices and flushes the specific command queue.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	1	1	0	0	1	1	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

4.13 EHEN ENABLE/DISABLE ERROR HANDLING PROCEDURE

Description

It performs the enable/disable of the recovey procedure related to the currently detected error

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	0	0	0	1	0	0	0	1	Rf	Hf	Sf

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum (repetition of #1 SSCMD)															

Rf	drill translation check	'0 = disabled, 1 = enabled'
Hf	Hard emergency	'0 = disabled, 1 = enabled'
Sf	Soft emergency	'0 = disabled, 1 = enabled'

Note:

- only the recovery actions related to errors whose severity is hard/soft selectable (see chapter 7) can be disables/enabled by means of the EHEN command

4.14 SARE RELEASE SAMPLING TUBE

Description

It commands the releasing of the sampling tube by means of a fixed duration current pulse of 50 ms

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	1	1	1	0	1	1	1	0	0	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

4.15 RDAD READ ADDRESS CONTENTS

Description

Reads the contents of the specified board address and put the address contents in the Scientific data ADRVAL

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	0	1	0	0	0	1	1	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADDRESS															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- ADDRESS shall be in the range 0x1A <= ADDRESS <= 0x1F

4.16 WRAD WRITE ADDRESS

Description

Writes the specified word in the specified address

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	1	0	1	1	0	1	1	1	0	1

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADDRESS															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WORD TO BE WRITTEN															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- ADDRESS shall be in the range 0x1A <= ADDRESS <= 0x1F

WARNING:

The WRAD allows a direct access to the boards registers: no check is performed by SD2SW when WRAD is received, neither mechanical correctness checks nor external mechanical correctness, nor correct command sequence.

The user is in charge to correctly use WRAD.

4.17 ENEM END OF EMERGENCY

Description

Allows to exit from SD2 emergency status. Note that when SD2 is in emergency status all the specific commands are rejected and only the end-ef-emergency and MHIT commands are accepted.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	0	1	1	0	1	1	0	0	1	1	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

4.18 MHIT MANAGING HITB ACQUISITION

Description

It specifies the HITB (Historical Internal Tracking Buffer) data acquisition. SD2_SW at its initialization starts the Scientific data collection at default frequency. When required, SD2_SW stops the data collection and starts the dump of collected data to CDMS. The MHIT command allows both to specify a new frequency of data collection, and to stop the data collection for starting the dump protocol.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	S/H	0	ACQ. Period							

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

S/H Start/Halt '1 = Start HITB collection with the period specified in ACQ.Period,

0 = Halt data collection and start HITB dump'

ACQ. Period Acquisition period of Scientific data: integer #0, unit [250 ms]. The ACQ.Period value zero is not valid when S/H is set to 1.

4.19 LDMP LOAD SD2 COMMAND SEQUENCE

Description

A sequence of SD2 specific commands can be stored into CDMS memory; the LDMP specific command allows to start the loading of the specified command sequence from CDMS memory into SD2 internal buffer and to execute it.
At the end of command sequence loading, the checksum (SD1 and SD2 words) is used to detect communication problems. If communication problems are detected, an error flag is signalled to HK_Data, the loaded command sequence is flushed and the loading of the command sequence re-starts again from beginning.
The loading of a command sequence can be aborted by means of ABRT or EMST specific commands.
During a command sequence loading only the specific commands ABRT and EMST are executed, all the other specific commands are rejected without aborting the loading.
When the loading is successfully completed, the specific commands contained in it are processed in FIFO order.
Neither standard commands nor the LDMP itself command are allowed within a command sequence stored into CDMS memory.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	1	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	1	1	1	1	0	1	1	1	1	0

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
OFFSET															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LENGTH															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum of the whole command sequence- S1															

#5 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Checksum of the whole command sequence- S2

#6 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum of command															

Note:

OFFSET: offset address where the command sequence is stored in CDMS memory; it shall be in the range 0<= OFFSET <= 1500
LENGTH: length, expressed as number of words, of the command sequence; it shall be in the range 0 <LENGTH<= 100
Moreover, OFFSET+LENGTH shall be <= 1500
S1, S2: checksum of the command sequence evaluated according to Adler32 algorithm

LDMP Protocol

Upon reception of LDMP command, SD2_FSW will perform the following:

1. SSTS Subsystem Status Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1			1								
SSADR					ME	CE	SR	1	0	0	0	BSY	SM	0	0

SSADR Subsystem Address
ME Message Error Flag
CE Count Error Flag
SR Service Request Flag
BSY Busy Flag
SM Sleep Mode Flag

2. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Request Code Word”

3. CDMS ← SD2

SD2_SW sends to CDMS the Request Code 0010 (Send Stored Telecommand Buffer Section)

4. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	1	0	0	1	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

ACT is "Transmit Offset length of stored telecommand buffer section"

5. CDMS ← SD2

SD2_SW sends to CDMS the offset (first word) and buffer length (max. 32 words)

6. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	1					
SSADR					T/R	ACT					WRDC				

ACT is "Receive stored telecommand buffer section
WRDC: according to buffer length at step 5

Steps 1..6 are repeated until the load of the SD2 command sequence from CDMS memory to SD2 internal buffer is completed.

4.20 STARTOP START OPERATION

Description

Some operations, like the drilling and sampling operation, consist of a sequence of the above defined specific commands. STARTOP notifies that simple commands following STARTOP up to STOPOP are relevant to a complex operation. If STARTOP is relevant to either drilling, sampling or carousel rotation, the SD2 current status (see "Telemetry data" chapter) is updated accordingly.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	1	OP							

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

OP: kind of operation '0' = drilling

'1' = sampling

'2' = carousel rotation

'3' = SD2 operation

4.21 STOPOP STOP OPERATION

Description

Some operations, like the drilling and sampling operation, consist of a sequence of the above defined specific commands. STOPOP notifies that an operation has been completed. When STOPOP is executed, if NOTIFY field holds '1', the CDMS is notified that an operation has been completed (via SR flag and OCPL Request Code). Moreover, if STOPOP is relevant to either drilling, sampling or carousel rotation, the SD2 current status (see "Telemetry data" chapter) is updated accordingly.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	0	1	NOT IFY	OP							

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

OP: kind of operation '0' = drilling
'1' = sampling
'2' = carousel rotation
'3' = SD2 operation

NOTIFY: notify CDMS the end of operation (via SR flag and OCPL Request Code)

'1' = notify CDMS

'0' = do not notify CDMS

4.22 DELAY DELAY

Description

It waits for the specified time before to process another specific command.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	1	0	1	1	1	1	1	0	1	1	1	1

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
delay time															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- delay time: integer # 0; unit: 250 [ms]

4.23 LANDG LOAD LANDING GEAR DATA

Description

It allows to load the data relevant to the landing gear: the range of the four areas forbidden to the drilling ([A,B] [C,D] [E,F] [G,H]) and the index of the Landing-gear housekeeping data containing the landing gear position

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	1	0	1	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	0	0	0	1	1	1	word_index				

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
A															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
B															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
C															

#5 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D															

#6 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

E

#7 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
F															

#8 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
G															

#9 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
H															

#10 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- word_index: index (starting from zero) of the word of Landing gear housekeeping data containing the Landing gear position; the allowed range for word_index is [0,31]
- A, B, C, D, E, F, G, H: unsigned integer; the only constraint is
  A<=B C<=D E<=F G<=H

4.24 DRTT DRILL TRANSLATION WITH TIMEOUT

Description

It performs drill translation movement to a defined position with timeout: the motion is completed either if the target position has been reached or because of the elapsed time. During the motion, no speed check is performed.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	1	0	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	SPEED					TORQUE			1	1

SPEED	Translation speed	32 values
TORQUE	Max. torque	8 values

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
POSITION															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: ‘00000’
  maximum speed: ‘11111’
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: ‘000’
  maximum torque: ‘111’
- POSITION: unit is 1/100 mm; for the drill reference system, see chapter 8; the allowed range for POSITION is [0,62500]

- TIME: max time duration of drill translation motion; unit is 250 [ms]

4.25 DRTC DRILL TRANSLATION CHECK

Description

Aim of the command is to check the device main/redundant used for the translation. It performs drill translation movement by powering the main/redundant winding according to input parameter; the motion is towards the defined position with timeout. If the time elapses before reaching the defined position, the check on the commanded driver is declared to be failed, and SD2 enters in emergency status. During the motion, no speed check is performed.

Command format

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	0	0	0	1	0	0
SSADR					T/R	ACT					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	0	SPEED					TORQUE			Device_Id	

#2 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
POSITION															

#3 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TIME															

#4 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Checksum															

Note:

- SPEED field: the 32 values of speed are according to:
  zero speed: ‘00000’
  maximum speed: ‘11111’
  It shall be #0.
- TORQUE field: the 8 values of torque are according to:
  miminum torque: ‘000’
  maximum torque: ‘111’

- Device_Id:
  - 0 means main drill translation powering
  - 1 means redundant drill translation powering
- POSITION: unit is 1/100 mm; for the drill reference system, see chapter 8; the allowed range for POSITION is [0,62500]
- TIME: max time duration of drill translation motion; unit is 250 [ms]

5. TELEMETRY DATA

SD2 provides the following telemetry data:

- housekeeping data
- scientific data
- backup RAM data

5.1 HOUSEKEEPING DATA

Each HK Data Word is a 16 bit word.

HouseKeeping data should be acquired by CDMS with a data word scanning period of 2 [s].

The SD2 Housekeeping Data are listed in Annex B.

Communication protocol

Every 2 [s], CDMS will send the following:

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	0	1	1	1	0	0	0	0	1
SSADR					T/R	ACT: RHFM					WRDC				

#1 SSCMD Subsystem Command Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
HK_Format_Count: 0..255															

SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	0	1	1	1	0	0	0	0	1
SSADR					T/R	ACT: THKD					WRDC				

When the THKD is received, SD2 provides the housekeeping data word numbered HK_Format_Count in an ad hoc address, where CDMS will read the data.

Only the lower 4 bits of HK_Format_Count are used by SD2 software (i.e. HK_Format_Count module 16).

5.2 SD2 SCIENTIFIC DATA

Each Scientific Data Word is a 16 bit word.

The 32 Words are periodically (the frequency is specified in the MHIT command; by default 4s) acquired up to a maximum of 256 acquisition, for an overall amount of 256*32*2= 16 Kb of Scientific Data.

The SD2 Scientific Data are listed in Annex A.

Communication Protocol:

At SD2_SW initialization, the collection of Scientific Data starts and the data are stored into the first 32 words of MHIT data. Every 250 [ms], next 32 words of MHIT are filled in.

When CDMS sends to SD2 the command MHIT with S/H bit set to 0 (see MHIT command specification), the SD2 stops the scientific data collection and starts the dump of the Scientific Data according to the following protocol

1. SSTS Subsystem Status Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1			1								
SSADR					ME	CE	SR	1	0	0	0	BSY	SM	0	0

SSADR Subsystem Address
ME Message Error Flag
CE Count Error Flag
SR Service Request Flag
BSY Busy Flag
SM Sleep Mode Flag

2. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Request Code Word”

3. CDMS ← SD2
SD2_SW sends to CDMS the Request Code 0100 (Science Data Ready)

4. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	1	0	1	0					
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Science Data Burst”
WRDC: either 4 or 32

5. CDMS ← SD2
SD2_SW sends to CDMS the WRDC Scientific Data

Steps 1..5 are repeated until the dump of the buffer relevant to MHIT is completed.

If dimension of the dumped buffer is not an integer multiple of 128 words, then when the dump is completed SD2 shall sent also the "Flush Last Science Data Packet" Service Request.

5.3 SD2 BACKUP RAM CONTENTS DEFINITION

The contents of SD2 Backup RAM buffer is the following:

Word #1:	SD2 Current Status
Word #2:	Actual Drill Depth
Word #3:	Carousel Position
Word #4:	Oven Number

Backup RAM data updating:

The SD2 Current Status shall contain the current SD2 status.

Actual Drill Depth shall contain the drill translation position when drill translation command is completed or stopped; during the drill translation, its value is 0xFFFF.

Carousel Position shall contain the carousel rotation position when carousel rotation command is completed or stopped; Oven Number shall contain the oven number specified in the CASI command when CASI command has been successfully completed, otherwise the oven number is "undefined" (value is 0). During carousel motion, the carousel position is 0xFFFF and the oven number is "undefined" (value is 0).

Word 1 : SD2 Current Status: See

Appendix A, word named OPST

Word 2 : Actual Drill Depth

See word PME1 of scientific data, Appendix A

Word 3 : Carousel Position

See word PME2 of scientific data, Appendix A

Word 4 : Oven Number

Unsigned integer in the range [0,26]; 1..26 indicates the oven number; '0' means undefined oven number

Communication Protocol:

The backup RAM data communication protocol is the following:

1. SSTS Subsystem Status Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1			1								
SSADR					ME	CE	SR	1	0	0	0	BSY	SM	0	0

SSADR Subsystem Address
ME Message Error Flag
CE Count Error Flag
SR Service Request Flag
BSY Busy Flag
SM Sleep Mode Flag

2. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is "Transmit Request Code Word"

3. CDMS ← SD2
SD2_SW sends to CDMS the Request Code 0110 (Write Backup RAM buffer Record)

4. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	1	0	1	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is "Transmit Pointer of Backup RAM Buffer Record"

5. CDMS ← SD2
SD2_SW sends to CDMS the Pointer to the data to be transmitted:
SSDAT Subsystem Data Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
SD2 Address					Pointer										

Pointer =0 means that the data shall be written in the first record of SD2 backup RAM

6. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Backup RAM Buffer Record”
WRDC: 32 (‘00000’ means 32)

7. CDMS ← SD2
SD2_SW sends to CDMS the 32 data.

Note:

Since the SD2 backup RAM data contains SD2 status and SD2 current operation status (asynchronous data), and the backup RAM transmission protocol foreseen to transmit a record (32 word) of backup RAM at a time, the steps 1 ..7 shall be performed every time one word of SD2 backup RAM changes value.

6. ACCESS TO BACKUP-RAM OF OTHER UNITS

SD2_SW needs the information relevant to the two tapping stations and to the landing gear position. They are provided respectively by COSAC, PTOLEMY and LANDG

The access to backup-RAM of other units follows the following protocol:

1. SSTS Subsystem Status Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1			1								
SSADR					ME	CE	SR	1	0	0	0	BSY	SM	0	0

SSADR Subsystem Address
ME Message Error Flag
CE Count Error Flag
SR Service Request Flag
BSY Busy Flag
SM Sleep Mode Flag

2. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Request Code Word”

3. CDMS ← SD2
SD2_SW sends to CDMS the Request Code 0111 (Read Backup RAM buffer Record)

4. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	1	0	1	1	0	0	0	0	1
SSADR					T/R	ACT					WRDC				

ACT is “Transmit Pointer of Backup RAM Buffer Record”

5. CDMS ← SD2
SD2_SW sends to CDMS the Pointer to the data to be transmitted:
SSDAT Subsystem Data Word (CDMS ← SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
UnitAddress					Pointer										

Pointer =0 means that the data shall be read from the first record of Unit backup RAM

6. SSADR Subsystem Address Word (CDMS → SD2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0
SSADR					T/R	ACT					WRDC				

ACT is “Receive Backup RAM Buffer Record”
WRDC: 32 (‘00000’ means 32)

6.1 ACCESS TO COSAC BACKUP-RAM

Tapping Station Status:

Command Word: 0x2000 (contents of UnitAddress field of Subsystem Data Word in the above defined step 5 is ‘00100’)

Contents (of first data word sent in previous defined step 6):

0xffff: tapping station open

0xaaaa: tapping station closed

0x0000: tapping station busy/undefined

6.2 ACCESS TO PTOLEMY BACKUP-RAM

Tapping Station Status:

Command Word: contents of UnitAddress field Subsystem Data Word in the above defined step 5 is ‘00110’

Contents (of first data word sent in previous defined step 6):

0xffff: tapping station engaged

0xaaaa: tapping station disengaged

6.3 ACCESS TO LANDG BACKUP-RAM

The access is necessary for acquiring the landing gear position

Command Word: contents of UnitAddress field Subsystem Data Word in the above defined step 5 is ‘10000’. Pointer: 0

The data word number “word_index” (see the specification of LANDG command) sent in previous defined step 6) contains the LANDG position to be compared with the forbidden ranges [A,B], [C,D], [E,F], [G,H], as defined in the LANDG command specification.

7. ERROR HANDLING PROCEDURE

The errors detected by the SD2_SW are split into six different categories, according to the error severity:

0 = ignore: the error is not echoed in telemetry and it is ignored by SD2_SW which continues the processing

1 = warning: the error is echoed in telemetry and it is ignored by SD2_SW which continues the processing

2 = redundancy_check: the error is echoed in telemetry; if the recovery action is enabled (see EHEN specific command, bit "Rf"), then SD2_SW switches from main to redundant and then, if the check fails again, from redundant to both windings; if the recovery error is not enabled, the error is ignored by SD2_SW which continues the processing

3 = soft selectable: the error is echoed in telemetry. If the recovery action is enabled (see EHEN specific command, bit Sf), then SD2_SW executes a *soft abort*. If the recovery action is not enabled, the error is ignored by SD2_SW which continues the processing

4 = soft always selected: the error is echoed in telemetry. The relevant recovery action is *soft abort*; it is always enabled and can not be disabled by means of EHEN specific command

5 = hard selectable: the error is echoed in telemetry. If the recovery action is enabled (see EHEN specific command, bit Hf), then SD2_SW executes a *hard abort*. If the recovery action is not enabled, the error is ignored by SD2_SW which continues the processing

6 = hard always selected: the error is echoed in telemetry. The relevant recovery action is *hard abort*; it is always enabled and can not be disabled by means of EHEN specific command.

The actions performed during a *soft abort* or *hard abort* are the following:

Soft abort:

- command the driver motion stop with a speed ramp down profile motion
- switch off all SD2 electronic interfaces
- flush the queue of normal specific commands
- the status changes to DEAD and the DEAD status is transmitted both in the HK_Data and in the SD2 backup-RAM

Hard abort:

- switch off all SD2 electronic interfaces
- flush the queue of normal specific commands

- the status changes to DEAD and the DEAD status is transmitted both in the HK_Data and in the SD2 backup-RAM

The error severity is hard coded in the error code according to the following format:

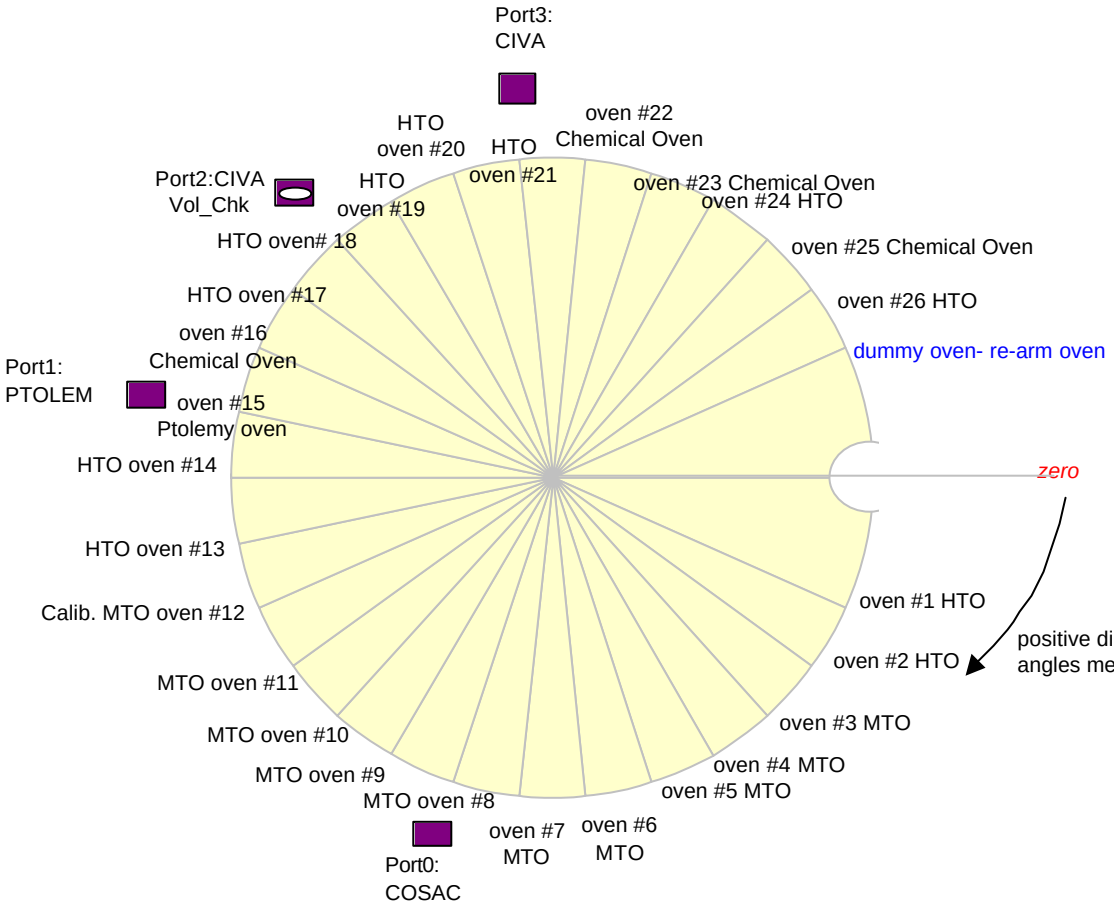
- an error code consists of one 16 bit word, 4 nibbles in hex format
- less significant nibble contains the error severity, and the other three nibbles contain the error id

So, the error 0x0056 (specific-command-word-count-failure) has id 5 and severity 6 (hard always selected).

8. SD2 REFERENCE SYSTEMS

Next figure depicts the carousel zero position, the oven positions, the scientific ports and

SD2 oven position-
carousel top view



the volume checker positions. The oven identifiers (part number) are repored in next figure.

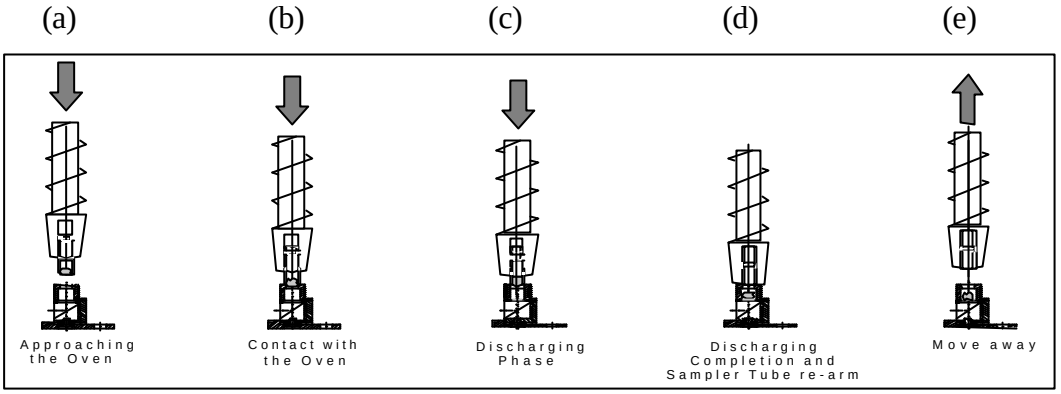
In the following tables, oven positions, scientific port positions, volume checker position with respect to the above depicted zero position are reported:

Oven Number	***Position [arcmin]***
1	1440
2	2160
3	2880
4	3600
5	4320
6	5040
7	5760
8	6480
9	7200
10	7920
11	8640
12	9360
13	10080
14	10800
15	11520
16	12240
17	12960
18	13680
19	14400
20	15120
21	15840
22	16560
23	17280
24	18000
25	18720
26	19440
Dummy oven	20160

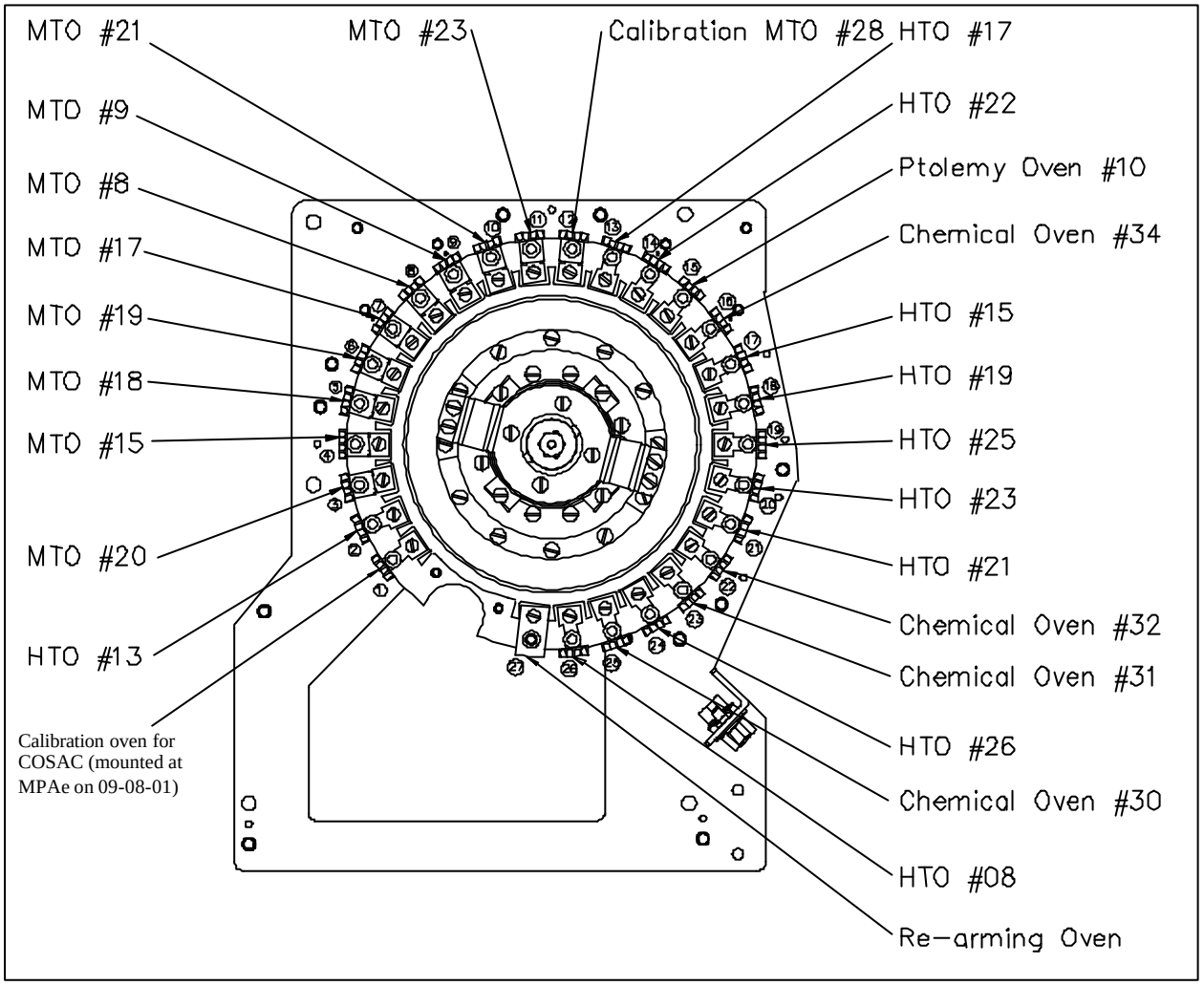
Port Number	***Position [arcmin]***
0- COSAC	6480
1- PTOLEMY	11520
2- CIVA	13680
3- CIVA	15840

Volume Checker	***Position [arcmin]***
	13680

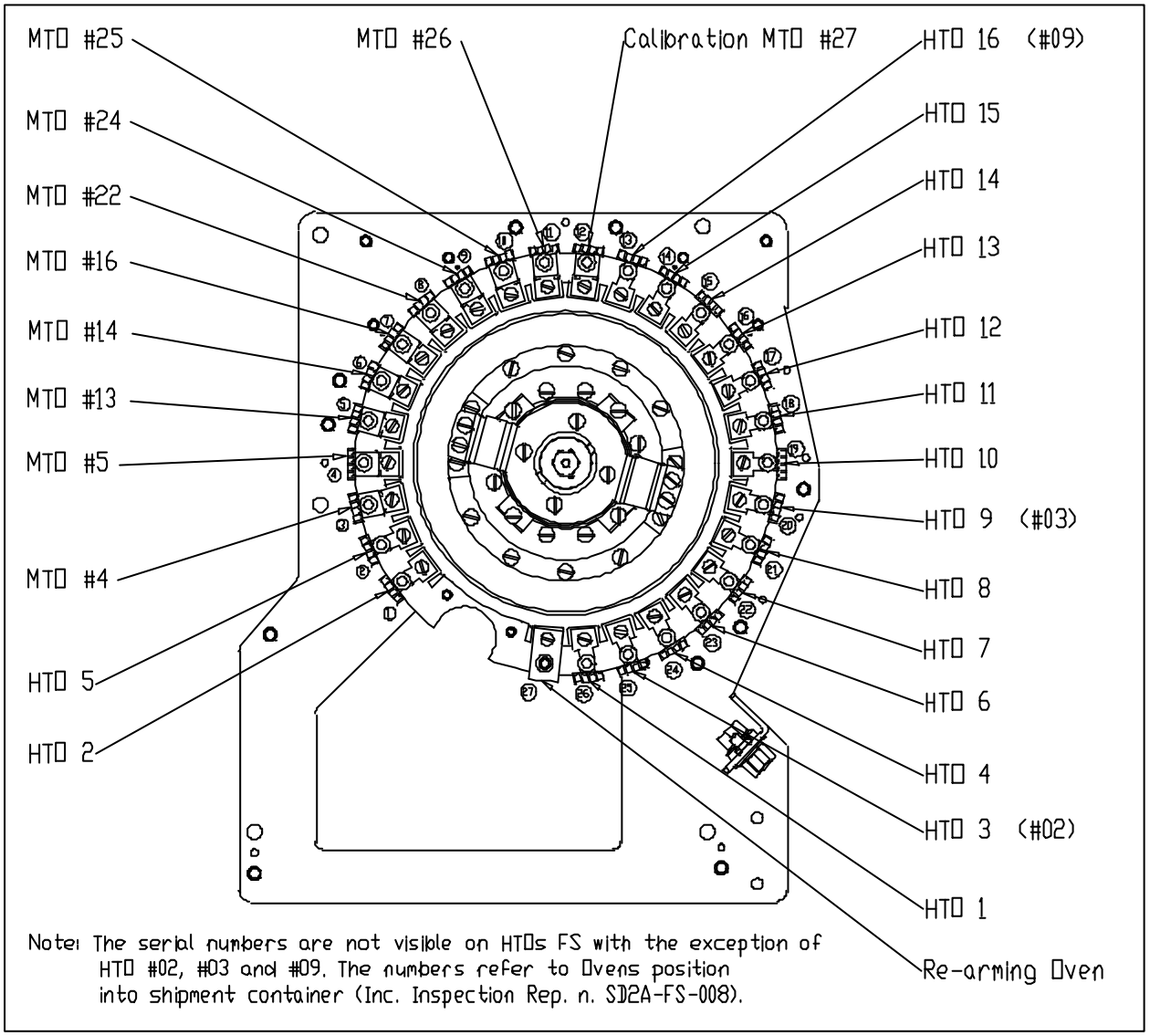
Next figures show the drill translation motion with respect to its zero position: in fig. (a) drill moves from 0 position towards an oven to 10.5 mm



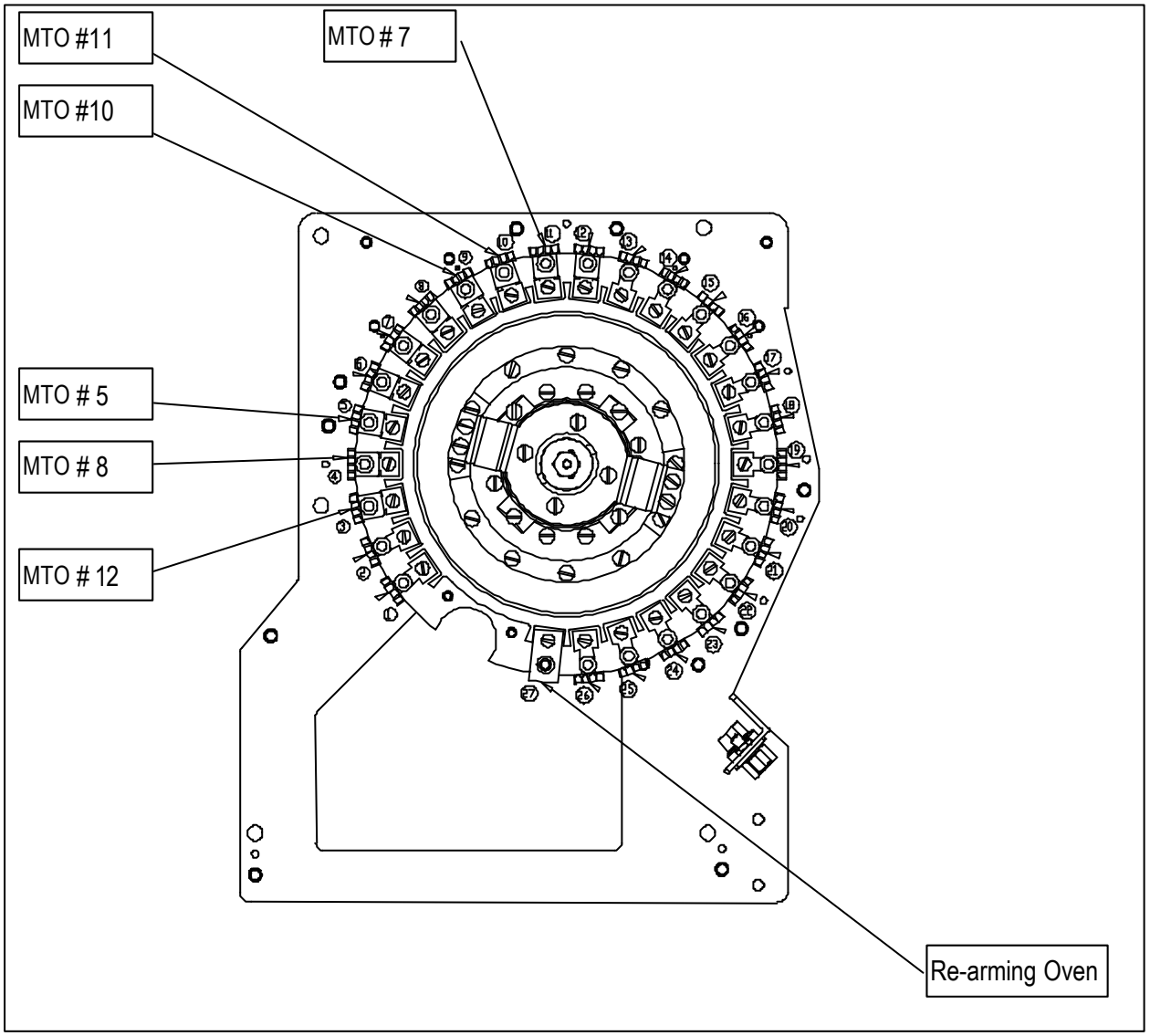
Oven identifiers (part number) for the FM carousel.



Oven identifiers (part number) for the FS carousel.


MTQ #25
MTQ #26
Calibration MTQ #27
HTQ 16 (#09)
MTQ #24
HTQ 15
MTQ #22
HTQ 14
MTQ #16
HTQ 13
MTQ #14
HTQ 12
MTQ #13
HTQ 11
MTQ #5
HTQ 10
HTQ 9 (#03)
MTQ #4
HTQ 8
HTQ 7
HTQ 5
HTQ 6
HTQ 2
HTQ 4
HTQ 3 (#02)
HTQ 1
Re-arming Oven
Note: The serial numbers are not visible on HTQs FS with the exception of HTQ #02, #03 and #09. The numbers refer to Ovens position into shipment container (Inc. Inspection Rep. n. SD2A-FS-008).

Oven identifiers (part number) for the GRM carousel.



The MTOs installed at positions 9, 10 and 11 can be used with the Volume Checker, Çiva, PTOLEMY, COSAC and for sample discharging .

The MTO installed at positions 3, 4 and 5 can be used only with the Volume Checker, Çiva and for sample discharging.

APPENDIX A: SD2 SCIENTIFIC DATA

APPENDIX B: SD2 HOUSEKEEPING DATA