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VIRTIS for Venus Express

VIRTIS SW INTERNAL INTERFACE CONTROL DOCUMENT

	NAME	FUNCTION	SIGNATURE	DATE
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DOCUMENT CHANGE RECORD

Issue	Date	Total Pages	Pages Affected	Description of Modification
1	16/12/03	47	ALL	Creation of the document for Venus Express. Starting from the document: **VIRTIS SW int ICD,** **Ref: VIR-GAL-IC-0028, issue 8,** **dated 27/08/03**, and adjusting it to Venus Express. The change bars of this issue shows the changes implemented for Venus Express. (the document was issued as disposition of NCR VVX-GAF-NC-007)

Table of Contents

1. INTRODUCTION

1.1. PURPOSE OF THE DOCUMENT

This SW Internal Interface Control Document (SW I-ICD) specifies the protocol and data format that the -M and -H PEMs inside the VIRTIS instrument shall follow to communicate with the DHSU through the Command Links and the Data Links as defined in RD.1. (see Fig.1)

The VIRTIS instrument is a 3 data channel imaging spectrometer included as payload in the VENUS EXPRESS mission.

This SW-I-ICD is prepared by GA together with the other teams involved in the project, i.e. Science team, LESIA, DLR. The document is checked by representatives of all the involved teams. It is responsibility of every team representative to propagate relevant information in order to keep this document consistent and up to date .

1.2. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

1.2.1. LIST OF DEFINITIONS

Internal acquisition cycle : for each detector, the reception of the START command starts the basic acquisition cycle i.e. the sequence of the following phases :

* delay (only for -M channels)
* exposure (called also integration)
* readout (i.e. sending science data)
* sending of H/K data
* idle

Internal repetition time : the time between two consecutive START command i.e. the duration of the internal acquisition cycle

1.2.2. LIST OF ACRONYMS AND ABBREVIATIONS

CCD	Charged Coupled Device
DHSU	Data Handling and Support Unit
DPU	Data Processing Unit
FIFO	First In First Out
H/C	HealthCheck
H/K	HouseKeepings
ICD	Interface Control Document
I-ICD	Internal Interface Control Document
I/F	InterFace
IR	InfraRed
ME	Main Electronics
MS	Most Significant
N.A.	Not Applicable
OBDH	On Board Data Handling
par.	paragraph
PDU	Power Distribution Unit
PEM	Proximity Electronic Module
RAM	Random Access Memory

RD	Reference Document
S/C	SpaceCraft
SEU	Single Event Upset
SW	SoftWare
TC	TeleCommand
TM	TeleMetry
V-H	VIRTIS-H
V-M	VIRTIS-M
V-X	V-H or V-M
VIRTIS	Visible and InfraRed Thermal Imaging Spectrometer
VIS	VISible
VVX	VIRTIS for VENUS EXPRESS

1.3. REFERENCES

RD.1.VIRTIS Internal Electrical ICD, VIR-GAL-IC-025, Issue 4
RD.2.VIRTIS REQUIREMENTS DOCUMENT, VIR-GAL-RS-001, Issue 1
RD.3.VIRTIS-M SCAN UNIT, VIR-GAL-TN-018
RD.4.VIRTIS-VEX SW USER REQUIREMENTS, VVX-GAF-UR-001, Issue 1
RD.5.VIRTIS-VEX OBDH SW ICD , VVX-GAF-IC-003, Issue 2
RD.6.VIRTIS-H SW ICD Contribution, VIR-DES-IC-1159 Issue 6
RD.7.PID-A MEX-MMT-SP-0007 Issue : 02 Rev. : 0001 Payload Interface Document
RD.8.VEX.T.ASTR.CR.0008 Issue 04 rev 1 Updated list of VIRTIS applicable documents

1.4. OVERVIEW OF THE DOCUMENT

The SW I-ICD is organised as follows. After this introduction and a chapter devoted to the timing and synchronisation aspects, the general concepts for the -M and -H sub/systems commanding are given, while the following chapter is dedicated to a more detailed description of each command format. The same two levels presentation applies to the output protocol, first defined in the general concept, then described more in detail. Figures are inserted in Appendix A.

2. TIMING AND SYNCHRONISATION

Fig.2 and Fig.3-6 show the timeline of the 2 sub/systems. The basic points are:

- VIRTIS-H and VIRTIS-M are independently operated; only when the internal repetition time is the same, the two START commands shall be given with a delay ≤ 1 ms.
- detectors work according to the commanded parameters that determine the duration of delay (where applicable) , exposure, readout and idle phases of each channel
- for -M:

  1. When VIRTIS-M is powered on or reset the Default mode is reached within 800 ms,: IR detector is OFF, CCD is idle, scan mirror is OFF and all PEM parameters are set to safe default values;
  2. when the IR detector is switched ON, the mode becomes Idle; this status is changed only when a command starts a different phase;
  3. VIRTIS-M is in Idle when both its channels are in Idle
  4. the delay values of the VIRTIS-M channels are used to obtain simultaneous exposures (i.e. with contemporary “middle points”)
  5. DHSU shall issue any other command than STOP READOUT to VIRTIS-M only when this is in Idle otherwise the command will be rejected
  6. DHSU shall issue the M-START command after all the commands necessary to set VIRTIS-M
  7. the V-M mirror requires about 300 ms (worst case) for a full motion (i.e. from -33° to +33° of electrical angle or vice-versa); a positioning time of 10 ms/deg can be considered.
  8. the cover executes one step in about 250 ms

  NOTE: there is only one difference, from a functional point of view, between Default and Idle modes: upon a M_START_EXPO command VIRTIS-M sends the real IR detector image only if status is Idle, while in Default it sends a digital reference IR image.

- for -H:

  1. As long as PEM-H does not receive any request, the detector is in “free run” (See Fig. 3)
  2. The free run mode consists in repeating the following sequence:
     integration time
     readout time
     idle time
  3. The aim of the idle time is to permit to close the shutter when required. This idle time is present even if there is no shutter closing requirement in order to let the detector run in a steady rhythm.
  4. The duration of the idle time will be fixed at **80 msec** (exact value: 156 * 512 = **79872 msec**
  5. A synchronisation request (HResync) (See Fig. 4) permits to start an integration time at a well known instant (just at the end of a “Detector_Clocks_Cycle_Reset” ” the duration of which ∈ **[0.5 ¸ 1.5 msec].**). After that, all periods can be localised by the DHSU.
  6. A HResync can be sent at any time (either during integration, readout, or idle time).
  7. A HSTART_S causes the following complete available data + HK to be sent to the DHSU (See Fig. 5)
  8. For the dark measure the HSET_Shutter must be sent during idle time in order to not loose a frame (See Fig. 6)

9. If a request (except HSTOP_Readout) is sent while data or HK are sent to the DHSU, the request is not taken into account and the flag HKRq_Req_during_Acq is set to 1.

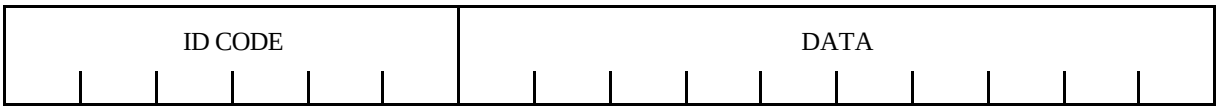
10. If the request HSTOP_Readout is sent while the data or the HK are sent, the sending is stopped and the flag HKDH_Stop_Readout_Flag is set to 1 by the DHSU.

11. If the request HSTOP_Readout is sent in an other moment, it is not taken into account.

3. VIRTIS-M AND VIRTIS-H COMMANDS

3.1. COMMAND CONCEPT

Commands are 16 bit words serially transmitted on the Command Links (1 for -M and 1 for -H) following the electrical definition reported in RD1. Each COMMAND WORD has the following format:



The ID CODE field (6 bits) is the identifier for the DATA field in the same word.

The DATA field (10 bits) contains the parameter value (or part of it) as indicated by the ID CODE . For parameters that can not be accommodated in one DATA field, two COMMAND WORDs shall be used, each with its ID CODE to determine unequivocally its DATA content.

In these cases, for VIRTIS-M, the Most Significant part of the parameter shall be set first, as on the reception of the Less Significant part, the PEM-M updates the parameter value. The setting of the sine/cosine values of the M mirror angle is then a special case : in fact the PEM-M updates the mirror commanding values when the Less Significant part of the COSINE is issued ; therefore the correct sequence is : M_MIRROR_SIN_M, M_MIRROR_SIN_L, M_MIRROR_COS_M, M_MIRROR_COS_L.

3.2. COMMAND MANAGEMENT

VIRTIS-H and VIRTIS-M shall be able to receive commands issued by the DHSU at any time with the timing reported in RD.1. Anyway, commands received outside the Idle phase shall be signalled to DHSU by setting a flag in the H/K block and (except for the STOP READOUT command, see below) ignored.

The readout (science + H/K or only H/K , if the H/K_REQUEST command has been issued) phase shall be considered complete (and therefore the Idle state active) by the DHSU when at least one of the following occurs:

- the expected number of words has been received by the DHSU
- a predefined time-out has expired on the DHSU.

After power on or after any reset, each PEM shall enter a “power-on” mode later described (chapter .3.5) that is a special case of the Idle state and during which no acquisition is performed.

Timing aspects of the command management are described in chapter 2.

3.3. ERROR MANAGEMENT

No systematic echo of the parameters/commands issued by DHSU is performed by the PEMs. The checking of the transmitted parameters shall be performed by DHSU using the status information contained in the H/K block. The relationship between the commanded words, transmitted by DHSU and the H/K words, transmitted by PEM, shall allow an easy and consistent verification.

Verification of the pixel map uploading is described in chapter 3.6.

In the H/K block a flag shall signal if a command has been received by the PEM outside the Idle phase.

If more words than expected are received from PEM-M by the DHSU,
- a STOP READOUT command shall be issued forcing the PEM_M in the Idle status;
- the PEM-M shall be reset.

3.4. VIRTIS-M COMMANDS AND PARAMETERS

VIRTIS-M IR commands:

- ◊ IR detector
  - M_IR_DETECTOR (On/Off)
- ◊ IR detector window
  - M_IR_WIN_MODE (full/reduced window)
- ◊ IR detector bias
  - M_IR_ VDETCOM_L
  - M_IR_ VDETCOM_M
  - M_IR_ VDETADJ_L
  - M_IR_ VDETADJ_M
- ◊ IR delay time
  - M_IR_DELAY
- ◊ IR integration time
  - M_IR_ EXPO

VIRTIS-M CCD commands:

- ◊ CCD detector window
  - M_PEM_CCD_WIN_X1
  - M_PEM_CCD_WIN_Y1
  - M_PEM_CCD_WIN_X2
  - M_PEM_CCD_WIN_Y2
- ◊ CCD delay time
  - M_CCD_DELAY
- ◊ CCD integration time
  - M_CCD_ EXPO

VIRTIS-M acquisition commands:

- ◊ IRFPA and CCD science data request
  - M_START_EXPO
- ◊ H/K data request
  - M_H/K_REQUEST
- ◊ Current readout stop
  - M_STOP_READOUT
- ◊ Nop
  - M_NOP_1

VIRTIS-M Calibration lamp commands:

- ◊ CCD Calibration lamp on/off + current value
  - M_CCD_LAMP
- ◊ IR Calibration lamp on/off+ current value
  - M_IR_LAMP

VIRTIS-M Shutter command:

- ◊ Shutter on/off + current
  - M_SHUTTER

VIRTIS-M-IR Annealing command:

- ◊ Annealing on/off + temp. limit
  - M_IR_ANNEALING

VIRTIS-M Mechanism commands:

- ◊ Mirror position
  - M_MIRROR_SIN_L
  - M_ MIRROR_SIN_M
  - M_MIRROR_COS_L
  - M_ MIRROR_COS_M
  - M_MIRROR_SWITCH
- ◊ M_COVER(Number of steps, direction, wave drive, Hall sensors enabling)

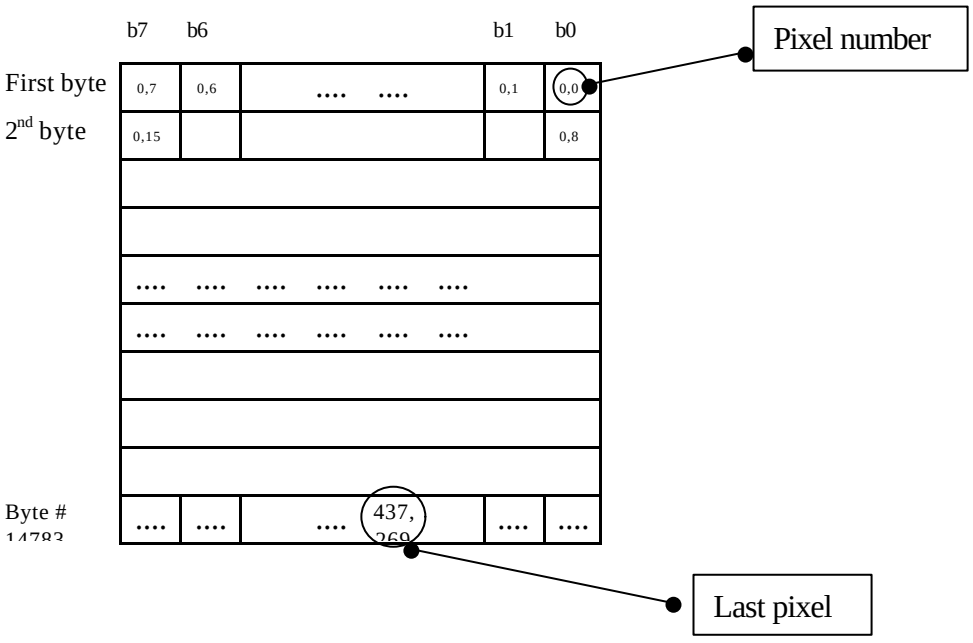
3.5. VIRTIS-M POWER-ON MODE

After power on or after any reset, V-M shall autonomo usly enter (within 800 ms) the Default mode, during which no acquisition is performed.. This mode could be maintained for ever, without problems for the electrical and optical characteristic of the detectors, as the PEM autonomously sets default “safe” values (see table in chapter 4.1). In this mode the IR detector and the Scan Mirror motor are Off .

3.6. PIXEL MAP LOADING

It is the "binary image" of every pixel of the VIRTIS-H detector where each pixel is represented by a bit of the map. If the bit is "0", it is a dark pixel (not to be acquired). If the bit is "1", it is a lighted pixel, which will be read and converted to digital. The map size is :

$$\text{MAP-BYTE-NUM} = \frac{\text{H-DET-ROWS} * \text{H-DET-COLUMNS}}{8} = \frac{270 * 438}{8} = 14783 \text{ bytes}$$



4. COMMAND DESCRIPTION

4.1. VIRTIS-M ID CODES AND DATA FORMAT

FUNCTION	NAME	DESCRIPTION	# BITS	Power ON Value (6)	Working value (6)	16 bit binary coding
VIRTIS-M IR Detector						
IR detector on/off	M_IR_DETECTOR	IR detector power on/off: code 0: detector off code 1: detector on	1	0	1 for real acquisition 0 for simulated data (7)	**1101** **10**00 0000 000B
IR detector window	M_IR_WIN_MODE	IR window mode: code 0: full window (438x270; Y1=0; Y2=269) code 1: reduced window (438x90; Y1=90; Y2=179)	1	0		**1001** **00**00 0000 000B
IR detector bias	M_IR_ VDETCOM_M	VDETCOM bias voltage Range: 2.012 ÷ 4.008 V (4) resolution: 0.487 mV (4) Most significant word	12 (4+8)	Msb= D009 Hex	3.2000 V (7) Msb= D009 Hex	**1101** **00**00 0000 VVVV
	M_IR_ VDETCOM_L	VDETCOM bias voltage less significant word		Lsb= 307E Hex	Lsb= 3088 Hex	**0011** **00**00 VVV V VVVV
	M_IR_ VDETADJ_M	VDETADJ bias voltage Range: 0 ÷ 4.996 V (4) resolution: 1.22 mV (4) Most significant word	12 (4+8)	Msb= B008 Hex	2.700 V (7) Msb= B008 Hex	**1011** **00**00 0000 VVVV
	M_IR_ VDETADJ_L	VDETADJ bias voltage less significant word		Lsb= 70A5 Hex	Lsb= 70A5 Hex	**0111** **00**00 VVV V VVVV
IR delay time	M_IR_DELAY	IR integration delay from the cycle beginning range: 0 ÷20.46 s resolution: 0.02 s	10	0.1 s	(7)	**1111** **00**VV VVV V VVVV
IR integration time	M_IR_ EXPO	IR integration (exposure) time range: 0 ÷20.46 s resolution: 0.02 s	10	0.02s	(7)	**0000** **10**VV VVV V VVVV
VIRTIS-M CCD						
CCD detector window	M_PEM_CCD_WIN_X1	x co-ordinate of the first element of the CCD window (5) range: 0 ÷ 1023	10	0	**72** (8)	**0010** **10**VV VVV V VVVV
	M_PEM_CCD_WIN_Y1	y co-ordinate of the first element of the CCD	9	0	**0** (8)	**1010** **10**0V VVV V VVVV

FUNCTION	NAME	DESCRIPTION	# BITS	Power ON Value (6)	Working value (6)	16 bit binary coding
		window (5) range: 0 ÷ 511				
	M_PEM_CCD_WIN_X2	x co-ordinate of the last element of the CCD window (5) range: 0 ÷ 1023	10	875	**947** (8)	**0110** **10**VV VVV V VVVV
	M_PEM_CCD_WIN_Y2	y co-ordinate of the last element of the CCD window (5) range: 0 ÷ 511	9	511	**511** (8)	**1110** **10**0V VVV V VVVV
CCD delay time	M_CCD_DELAY	CCD integration delay from the cycle beginning range: 0÷20.46s (min 0.1s) resolution: 0.02 s	10	0.1 s	(7)	**0001** **10**VV VVV V VVVV
CCD integration time	M_CCD_ EXPO	CCD integration (exposure) time range: 0 ÷20.46 s resolution: 0.02 s	10	0.02s	(7)	**1001** **10**VV VVV V VVVV
VIRTIS-M Acquisition						
Acquisition start	M_START_EXPO	Start integration (exposure) time and science data acquisition	0	---	---	**1000** **00**00 0000 0000
Housekeeping request	M_H/K_REQUEST	Housekeeping data acquisition and transmission	0	---	---	**0100** **00**00 0000 0000
Current readout stop	M_STOP_READOUT	Stop sending current data block	0	---	---	**1100** **00**00 0000 0000
Nop	M_NOP_1	Do nothing command (spare)	0	---	---	**0000** **00**00 0000 0000
VIRTIS-M Calibration lamps						
Calibration lamps	M_CCD_LAMP	CCD calibration lamp (bit 0 = ON/OFF; bit 1-2=current) code: xx0 value: lamp OFF code: 001 value: lamp ON/240 mA code: 011 value: lamp ON/244 mA code: 101 value: lamp ON/250 mA code: 111 value: lamp ON/254 mA (4)	1+2	OFF / 254 mA	(9)	**0101** **10**00 0000 0VVB
	M_IR_LAMP	IR calibration lamp bit 0= ON/OFF; (1 = ON; 0 = OFF); bit 1-4: current current value ((xxxx)+94)mA	1+4	OFF / 100 mA	(9)	**1000** **10**00 000V VVVB

FUNCTION	NAME	DESCRIPTION	# BITS	Power ON Value (6)	Working value (6)	16 bit binary coding
		range : 94÷109 mA (4) resolution : 1 mA (4) Example: code 00001 value: lamp ON/94mA code 11111 value: lamp ON/109mA				
VIRTIS-M Shutter						
Shutter	M_SHUTTER	shutter open/close (bit 0 =Open/Close; bit 1-4=current) code xxxx0 = shutter open code xxxx1= shutter closed current range : 45 ÷ 60 mA (4) current resolution : 1 mA (4)	1+4	open / Current value 51 mA	(7)	**1100** **10**00 000V VVVB
VIRTIS-M Annealing						
Annealing	M_IR_ANNEALING	IR annealing temperature limit (HHHHHH =High limit) range : +38° ÷ -13 °C resolution: 0.809 °C bit 0 = IR annealing heater on/off (on = 1 / off=0) Example: HHHHHH =00000 = +38 HHHHHH =11111 = -13	1+6	OFF / -13°C (code 1111110)	(7)	**0100** **10**00 0HHH HHHB

FUNCTION	NAME	DESCRIPTION	# BITS	Power ON Value (6)	Working value (6)	16 bit binary coding
VIRTIS-M Scan unit and Cover mechanism						
Mirror position	M_MIRROR_SIN_M	sin of mirror electrical angle (1) most significant word bit 4 (B) =is the sign (0=+) range: 0 ÷ 1; resolution: 1/4096	1+12 (4+8)	0 (code: 0 0000)	(7)	**0010** **00**00 000B VVVV
	M_MIRROR_SIN_L	sin of mirror electrical angle (2) least significant word		(code: 0000 0000)		**1010** **00**00 VVVV VVVV
	M_MIRROR_COS_M	cos of mirror electrical angle(1) most significant word range: 0 ÷ 1; resolution: 1/4096	12 (4+8)	1 (code: 1111)	(7)	**0110** **00**00 0000 VVVV
	M_MIRROR_COS_L	cos of mirror electrical angle(2) least significant word		(code: 1111 1111)		**1110** **00**00 VVVV VVVV
	M_MIRROR_SWITCH	Switch on/off scan mirror motor B=0 means ON B=1 means OFF	1	1 (off)	(7)	**0101** **00**00 0000 0000
Cover position	M_COVER	Drive by (NNN NNNN) steps the cover motor, with direction D (1=open direction, 0=close direction) and a wave drive W (1= one wave drive,. i.e. two phases; 0= half wave drive, i.e. one phase); Hall effect sensors enabling commanded by S (S=1 enabled; S=0 disabled) (3)	1+1+ 1+ 8	----	(7)	**0001** **00**DW SNNN NNNN

(1) Electrical angle range is about (-33°, + 33°) where electrical angle=36 * mechanical angle=18*optical angle.

(2) Two words commands shall be sent with the Most Significant Word first and the Least Significant Word second. Command execution starts when the second word has been received.

(3) Full cover range is 81 steps.

(4) Range, Resolution and Default Values are model depending (EQM, FM, FS). The reported values are relevant to VIRTIS-VEX FM01.

(5) CCD windows is commanded referring to CCD elements, not to pixels. The PEM performs a 2x2 binning of CCD elements, generating as output pixels. If the typical values M_PEM_CCD_WIN_X1=0, M_PEM_CCD_WIN_X2=875, M_PEM_CCD_WIN_Y1=0, M_PEM_CCD_WIN_Y2=512 are commanded, the acquired frame is 876x512 and the frame sent to ME by the PEM, after 2x2 binning, is 438x256.

(6) The power ON values indicate the values settled by PEM-M after POWER ON or RESET while the working values indicate the value that have to be commanded by M.E. in order to work whit the right calibrated values.

(7) These working values are defined by the FUNCTIONAL parameter set (see RD5).

(8) These working values are fixed values (defined after the VIRTIS-M channel FM model calibration) and have to be commanded by the M.E. after each every PEM power ON or PEM Reset and before to perform any kind of science acquisition (Science, Calibration or Test).

(9) These working values are defined by the CALIBRATION parameter set (see RD5).

4.2. VIRTIS-H ID CODES AND DATA FORMAT

In VIRTIS-H the commands are called **REQUESTS. 16 bits words sent to PEM-H constitute them. If exists, the parameter of the request is sent in the same word.**

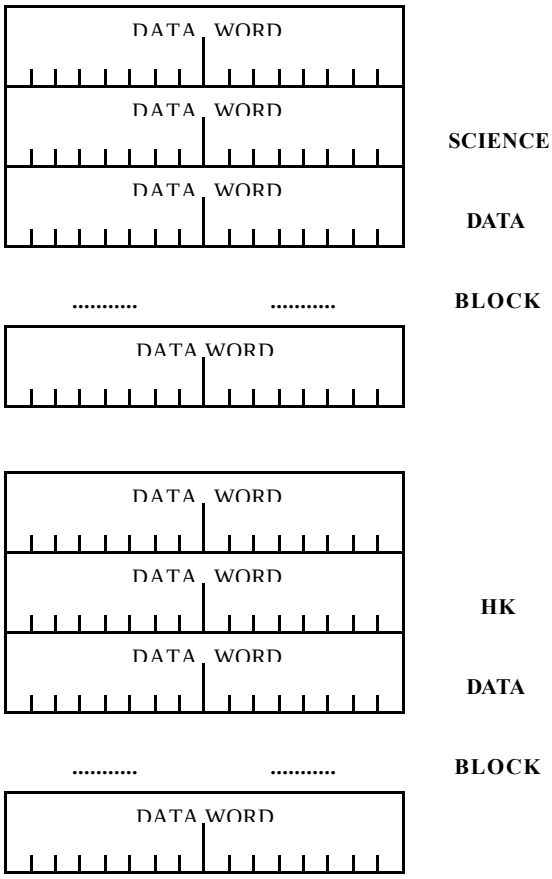
Request Name	Resulting state	Transmitted parameter	16 bits binary coding	
Configuration Requests			**Req. code**	**Parameter**
HSET_Bias	Program detector Bias	H_V_Bias	001000	00 *vvvv vvvv*
HSET_I_Lamp_Spect_T	Program I cal lamp 1	H_I_Lamp_Spect_T	001001	00 *vvvv vvvv*
HSET_I_Lamp_Spect_S	Program I cal lamp 2	H_I_Lamp_Spect_S	001001	00 *vvvv vvvv*
HSET_I_Lamp_Radio	Program I cal lamp 3	H_I_Lamp_Radio	001001	00 *vvvv vvvv*
HSET_I_Shutter	Program I shutter	H_I_Shutter	001010	00 *vvvv vvvv*
HSET_Int_Num1	Store Integration param1	H_Int_Num1	010100	*vv vvvv vvvv*
HSET_Int_Num2	Store Integration param2	H_Int_Num2	010101	00 *vvvv vvvv*
Pixel Map Requests				
HINIT_Pix_Map_Upld	Pixel Map Address Reset	Pixel Map Upload Request (reset Pixel Map address)	001110	00 0000 0000
HINIT_Pix_Map_Dnld	Pixel Map Address Reset	Pixel Map Dnload Request (reset Pixel Map address)	001110	00 0000 0000
HSET_Pix_Map_Data	Pixel Map byte write	H_Pixel_Map	001100	00 *vvvv vvvv*
HDNLD_Pix_Map_Data	Pixel Map byte read		001101	00 0000 0000
PEM Mode Requests				
HSET_PEM_Mode	Set the PEM mode:	***BB*** =00: Observation/ 8 orders ***BB*** =01: Observation/ all matrix ***BB*** =10: Simulation/ 8 orders ***BB*** =11 : simulation/ all matrix	011010	00 0000 00***BB***
Acquisition Requests				

Request Name	Resulting state	Transmitted parameter	16 bits binary coding	
HNOP	No Operation		000000	00 0000 0000
HSTART_S	Acquire a science block		000001	00 0000 0000
HSTART_HK	Acquire a HK block		000010	00 0000 0000
HSTOP_Readout	Stop current block		000011	00 0000 0000
HRESYNC	Synchronize detector		00100	00 0000 0000
Peripherals Control Requests				
HSET_Det/On	Switch on detector		010001	00 0000 0001
HSET_Det/Off	Switch off detector		010001	00 0000 0000
HSET_Shutter/On	Shutter On (closed)		011011	00 0000 0001
HSET_Shutter/Off	Shutter Off (open)		011011	00 0000 0000
HSET_Shutter_Status	Shutter status On/Off	Switch on or off both shutter status leds; **B** =1 ⇒ On, **B** =0 ⇒ Off	011111	00 0000 000**B**
HSET_FPA_Htr/On	Annealing Heater On		011100	00 0000 0001
HSET_FPA_Htr/Off	Annealing Heater Off		011100	00 0000 0000
HSET_Lamp_Spect_T/On	Cal lamp 1 On		011101	00 0000 0001
HSET_Lamp_Spect_S/On	Cal lamp 2 On		011101	00 0000 0010
HSET_Lamp_Radio/On	Cal lamp 3 On		011101	00 0000 0100
HSET_Cal/Off	Cal lamps Off	Switch off the 3 cal lamps	011101	00 0000 0000
HSET_Det_Temp/On	Temperature detector On		011110	00 0000 0001
HSET_Det_Temp/Off	Temperature detector Off		011110	00 0000 0000
Cover Mechanism Requests				
HSET_Cover	Cover drive	**Direction** D=1:Open; =0 Close **Wave** T=1: one wave T=0: half wave **Number of steps** *VV VVVV V* **Hall sensor disabled** S=1 enabled; S=0	010010	*VV VVVV VSTD*
DHSU/PEM-H Testing Requests				
HSET_Test_Init	Initialize test pattern	1st value of the test pattern (default = 0); 1024 values	010011	*VV VVVV VVVV*

5. VIRTIS-M AND VIRTIS-H OUTPUTS

5.1. OUTPUT CONCEPT

Output data blocks are groups of 16 bit words serially transmitted on the Data Links (1 for -M-VIS, 1 for -M-IR and 1 for -H) following the electrical definition reported in RD.1. The protocol is based on the following format:



The SCIENCE DATA block is transmitted during the readout phase, i.e. if a START command has been issued by DHSU. Its length and format depend on the channel operational mode.

Maximum SCIENCE DATA block size and transfer time for VIRTIS M are :

	max number of SCIENCE words	max acquisition and transfer time for SCIENCE
-M-VIS channel	438x256 = **112128**	1400 ms (1)
-M-IR channel	438 * 270 = **118260** 438*90 = **39420**	1210 ms (M_IR_WIN_MODE: full window) 482 ms (M_IR_WIN_MODE: reduced window)

(1) The transfer time is evaluated for the following physical CCD window:
M_PEM_CCD_WIN_X1 = **72;** M_PEM_CCD_WIN_Y1 = **0;** M_PEM_CCD_WIN_X2= **947;** M_PEM_CCD_WIN_Y2 = **511**

For VIRTIS-H, to calculate the Science data transfer times:

1 read pixel : 10 µsec

1 non-read pixel: 1 µsec

A fixed time of 40 µsec is added at the beginning of each line.

So, IF:

nreadpx = number of read pixels

Tread = time to read the data

THEN:

Tread = (438 x 270 –nreadpx) x 1 µsec + nreadpx x 10 µsec + 270 x 40 µsec

H_PEM_MODE	Number of SCIENCE words (16 b) in a frame	Transfer time for SCIENCE
0: Observation/ 8 orders 2: Simulation/ 8 orders	432 x 8 x 5 = **17280**	284.580 ms
1: Observation/ all matrix 3 : Simulation/ all matrix	438 x 270 = **118260**	1.193400 s

After a SCIENCE DATA block, the PEM always transmits a H/K DATA block. This block shall be transmitted also after a H/K REQUEST command.

The HK DATA block shall have fixed length (typical of each channel) and shall include information such as:

- sub-system status (e.g. shutter and scan unit status)
- internal parameter status
- temperature values
- voltage and current values

Data shall be transmitted in a fixed order (typical of each channel).

HK DATA sub-block size and transfer time are :

	number of HK words	total transfer time for HK DATA
-M-VIS channel	25	25 ms
-M-IR channel	20	23 ms
-H channel	7 + (12 +1) + (6 +2) + 8 words = 36 words 16 b	36 x 64µs = 2.304 ms

With reference to figure 2, it is possible to define for VIRTIS-M a read-out time T_{RO} (science data acquisition and transfer, H/K acquisition and transfer) as per the following table:

	M_IR_WIN_MODE	T_{RO}	Rationale
-M-VIS channel	-	1450 ms	1400 + 25 + margin
-M-IR channel	Full window	1400 ms	1210 + 23 + margin
-M-IR channel	Reduced window	600 ms	482 +23 + margin

Therefore, the time between two M_START_EXPO (internal repetition time, M_IRT) is constrained by:

M_IRT > M_CCD_DELAY+ M_CCD_EXPO+ T_{RO-VIS}

M_IRT > M_IR_DELAY+ M_IR_EXPO+ T_{RO-IR}

5.2. VIRTIS-M OUTPUT DATA

Outputs for both M channels are the SCIENCE DATA block and the H/K DATA block. The first is composed of the science data from the detectors while the second includes status and analogue H/K from the PEM.

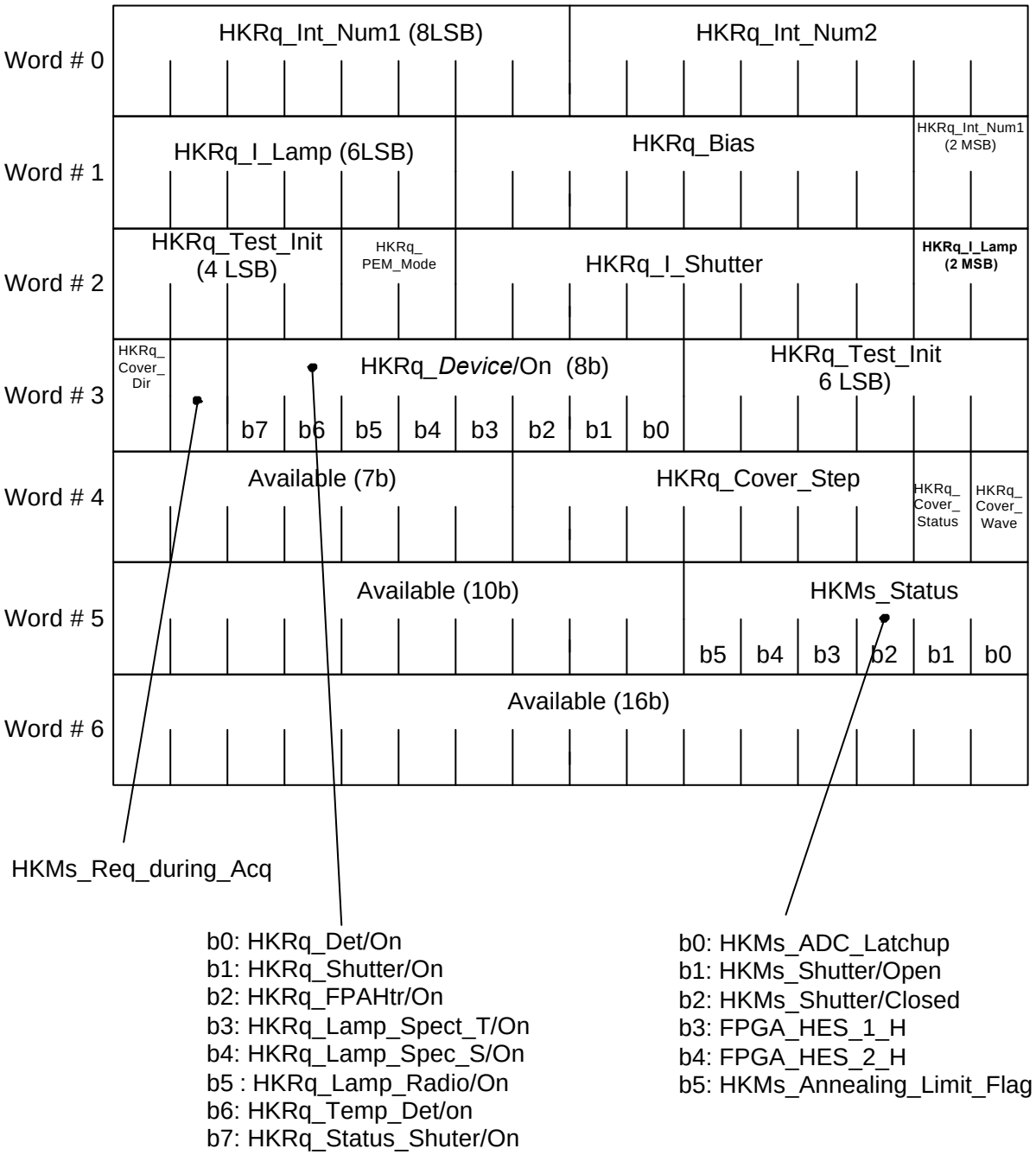
The allocation and the order of H/K data on the two -M channels are shown in the following tables while the format of each datum is described in Sect.6.

	IR CHANNEL H/K DATA BLOCK
#	NAME
1	M_IR_VDETCOM_HK
2	M_IR_VDETADJ_HK
3	M_IR_VPOS
4	M_IR_VPD
5	M_IR_TEMP_OFFSET
6	M_IR_TEMP
7	M_IR_TEMP_RES
8	M_SHUTTER_TEMP
9	M_GRATING_TEMP
10	M_SPECT_TEMP
11	M_TELE_TEMP
12	M_SU_MOTOR_TEMP
13	M_IR_LAMP_VOLT
14	M_SU_MOTOR_CURR
15	M_IR_WIN_Y1_OUT
16	M_IR_WIN_Y2_OUT
17	M_IR_DELAY_OUT
18	M_IR_EXPO_OUT
19	M_IR_LAMP_SHUTTER
20	M_IR_FLAG_ST

	CCD CHANNEL H/K DATA BLOCK
#	NAME
1	M_CCD_VDR_HK
2	M_CCD_VDD_HK
3	M_+5V_VOLT
4	M_+12V_VOLT
5	M_-12V_VOLT
6	M_+20V_VOLT
7	M_+21V_VOLT
8	M_CCD_LAMP_VOLT
9	M_CCD_TEMP_OFFSET
10	M_CCD_TEMP
11	M_CCD_TEMP_RES
12	RADIATOR_TEMP
13	LEDGE_ TEMP
14	OM_BASE_TEMP
15	H_COOLER_ TEMP
16	M_COOLER_ TEMP
17	M_CCD_WIN_X1_OUT
18	M_CCD_WIN_Y1_OUT
19	M_CCD_WIN_X2_OUT
20	M_CCD_WIN_Y2_OUT
21	M_CCD_DELAY_OUT
22	M_CCD_EXPO_OUT
23	M_MIRROR_SIN_HK
24	M_MIRROR_COS_HK
25	M_VIS_FLAG_ST

5.3. VIRTIS-H OUTPUT DATA

The following diagram shows the Digital HK words arrangement. Other information on H/K Data format can be found in sect. 6.3 while Science Data format is described in sect. 6.4



6. OUTPUT DESCRIPTION

6.1. VIRTIS-M HK DATA FORMAT

The format of the HK data for the VIRTIS-M channels is shown in the following tables.
All data are provided as 16 bit words.

For each H/K, the following table reports:

- transfer function from the 16-bit code (indicated as N) to the physical value, which units is indicated between square brackets
- minimum and maximum value.

Example: M_+5V_VOLT is a 16 bit data in the range (32768, 49970); applying the transfer function, one obtain the voltage in Volt; the min. value corresponds to (32768-32768)* $20/2^{16}$ = 0 V, the max. value corresponds to (49970-32768)* $20/2^{16}$ = 5,25 V.

Analogue House-Keeping list

In the following the list of analogue HK is provided.
The transfer function from the digital data N and the value in engineering units (Volt, Ampere, Ohm) is the following:

$$FdT = \frac{(N - 32768) \times \frac{20}{65535}}{G} + Offset$$

where the gain G, the offset and the engineering unit definition are provided in the following table. Note that temperatures need a further processing, as specified below.

FUNCTION	NAME	DESCRIPTION	Transfer function	N Min value	N Max value
Supply voltages	M_+5V_VOLT	+5V power supply voltage (Volt)	G=0.997 Offset=0	32440	50250
	M_+12V_VOLT	+12V power supply voltage (Volt)	G=0.496 Offset=0	32610	53410
	M_-12V_VOLT	-12V power supply voltage (Volt)	G=0.497 Offset=0	12090	33610
	M_+20V_VOLT	+20V power supply voltage (Volt)	G=0.25 Offset=0	32690	50050
	M_+21V_VOLT	+21V power supply voltage (Volt)	G=0.25 Offset=0	32690	52510
Detectors voltages	M_IR_VDETCOM_HK	IR VDETCOM bias voltage (Volt)	G=0.998 Offset=0	32440	46180
	M_IR_VDETADJ_VOLT	IR VDETADJ bias voltage (Volt)	G=0.997 Offset=0	32440	49430
	M_IR_VPOS	IR VPOS supply voltage (Volt)	G=0.997 Offset=0	32440	49920
	M_IR_VPD	IR VDP supply voltage (Volt)	G=0.997 Offset=0	32440	49920
	M_CCD_VDR_HK	CCD Vdr bias voltage (Volt)	G=0.25 Offset=0	43170	43500
	M_CCD_VDD_HK	CCD Vdd bias voltage (Volt)	G=0.404 Offset=0	54610	55010
Calibration lamps	M_IR_LAMP_VOLT	IR calibration lamp voltage (Volt)	G=0.398 Offset=0	32640	54940
	M_CCD_LAMP_VOLT	CCD calibration lamp voltage (Volt)	G=0.399 Offset=0	32640	54990

FUNCTION	NAME	DESCRIPTION	Transfer function	N Min value	N Max value
Temperatures	M_IR_TEMP	IRFPA temperature (DT407) (Kelvin)	G=4.970 Offset=0 (1)	39000	50100
	M_IR_TEMP_RES	measurement of the current flowing on the IRFPA temperature sensor (Ampere)	G=398.8 Offset=0	38650	39950
	M_IR_TEMP_OFFSET	Voltage offset in the IR temperature measurement chain (Volt)	G=1.994 Offset=0	32100	33500
	M_CCD_TEMP	CCD temperature (Kelvin)	G=$9.99*10^{-3}$ Offset=0	35780	55460
	M_CCD_TEMP_RES	measurement of the current flowing on the CCD temperature sensor (Ampere)	G=199.3 Offset=0	35710	36360
	M_CCD_TEMP_OFFSET	Voltage offset in the CCD temperature measurement chain (Volt)	G=1.998 Offset=0	32100	33500
	M_SHUTTER_TEMP	shutter temperature (Kelvin)	G=$9.98*10^{-3}$ Offset=0 (2)	35780	55460
	M_GRATING_TEMP	grating temperature (Kelvin)	G=$9.98*10^{-3}$ Offset=0 (2)	35780	55460
	M_SPECT_TEMP	spectrometer temperature (Kelvin)	G=$9.98*10^{-3}$ Offset=0 (2)	35780	55460
	M_TELE_TEMP	telescope temperature (Kelvin)	G=$9.98*10^{-3}$ Offset=0 (2)	35780	55460
	RADIATOR_TEMP	OM radiator temperature (Kelvin)	G=$9.99*10^{-3}$ Offset=0 (2)	35780	55460
	LEDGE_ TEMP	OM ledge temperature (Kelvin)	G=$9.99*10^{-3}$ Offset=0 (2)	35780	55460
	OM_BASE_TEMP	OM baseplate temperature (Kelvin)	G=$9.99*10^{-3}$ Offset=0 (2)	35780	55460

FUNCTION	NAME	DESCRIPTION	Transfer function	N Min value	N Max value
	M_COOLER_ TEMP	M-cooler temperature (Kelvin)	G=9.99*10^{-3} Offset=0 (2)	35780	55460
	H_COOLER_ TEMP	H-cooler temperature (Kelvin)	G=9.99*10^{-3} Offset=0 (2)	35780	55460
	M_SU_MOTOR_TEMP	scan unit motor temperature (Kelvin)	G=9.98*10^{-3} Offset=0 (2)	35780	55460
Mirror	M_SU_MOTOR_CURR	scan unit current (Ampere)	G=50 Offset=0	28000	38000

NOTE (1): Transfer function of M_IR_TEMP

First the sensor voltage V_s has to be obtained from the 16-bit code N, using the values specified in the table:

$$Vs = \frac{(N - 32768) \times \frac{20}{65535}}{G} + Offset$$

Then, the normalised sensor voltage has to be computed as:

$$V_n = ((V_s - V_L) - (V_U - V_S)) / (V_U - V_L)$$

where the parameters V_L and V_U are provided in table 6.1-1.

Then, the temperature [K] is obtained by applying the following formula:

$$T = \Sigma_{i=0,\,11}\, A(i) * P_i(V_n)$$

where A(i) are provided in table 6.1-1 and the functions $P_i(x)$ are the Chebychev polynomials, defined by the following recursive relations:

$$P_0(x) = 1$$
$$P_1(x) = x$$
$$P_{i+1}(x) = 2x * P_i(x) - P_{i-1}(x)$$

The parameters V_L V_U and A(i) have different values when V_s is less than or greater than 0.97550V, corresponding to a temperature of 100 K.

Parameter	$V_s > 0.97550$	$V_s \leq 0.97550$
V_L	0.923174	0.079767
V_U	1.13935	0.999614
A(0)	71.818025	287.756797
A(1)	-53.799888	-194.144823
A(2)	1.669931	-3.837903
A(3)	2.314228	-1.318325
A(4)	1.566635	-0.10912
A(5)	0.723026	-0.393265
A(6)	-0.149503	0.146911
A(7)	0.046876	-0.111192
A(8)	-0.388555	0.028877
A(9)	0.056889	-0.029286
A(10)	-0.116823	0.015619
A(11)	0.05858	0

Table 6.1.1: M_IR_TEMP transfer function coefficients

NOTE (2): Transfer function of M_CCD_TEMP, M_SHUTTER_TEMP, M_GRATING_TEMP, M_SPECT_TEMP, M_TELE_TEMP, RADIATOR_TEMP, LEDGE_ TEMP, OM_BASE_TEMP, M_COOLER_ TEMP, H_COOLER_ TEMP, M_SU_MOTOR_TEMP

First the sensor resistance R $[\Omega]_s$ has to be obtained from the 16-bit code N, using the values specified in the table:

$$R = \frac{(N - 32768) \times \frac{20}{65535}}{G} + Offset$$

Then, the temperature [°C] is obtained by solving the following equation:

$$R = R_0(1 + A*T + B*T^2 + C*(T-100)*T^3)$$

where the coefficients are:

A = 3.90802 10^{-3}
B = -5.80195 10^{-7}
C = 0 if R≥500 Ω (T≥0)
C = -4.2735 10^{-12} if R<500 Ω (T<0)

Status parameter list

FUNCTION	NAME	DESCRIPTION	# BITS	CODE
IR detector	M_IR_WIN_Y1_OUT	y coord. of the first pixel of the IR selected window	9	0000 000V VVVV VVVV
	M_IR_WIN_Y2_OUT	y coord. of the last pixel of the IR selected window	9	0000 000V VVVV VVVV
	M_IR_DELAY_OUT	IR integration delay from the cycle beginning (1 ADU= 0.02 s)	10	0000 00VV VVVV VVVV
	M_IR_EXPO_OUT	IR integration time (1 ADU= 0.02 s)	10	0000 00VV VVVV VVVV
CCD detector	M_PEM_CCD_WIN_X1_OUT	x coord. of the first pixel of the CCD selected window	10	0000 00VV VVVV VVVV
	M_PEM_CCD_WIN_Y1_OUT	y coord. of the first pixel of the CCD selected window	9	0000 000V VVVV VVVV
	M_PEM_CCD_WIN_X2_OUT	x coord. of the last pixel of the CCD selected window	10	0000 00VV VVVV VVVV
	M_PEM_CCD_WIN_Y2_OUT	y coord. of the last pixel of the CCD selected window	9	0000 000V VVVV VVVV
	M_CCD_DELAY_OUT	CCD integration delay from the cycle beginning (1 ADU= 0.02 s)	10	0000 00VV VVVV VVVV
	M_CCD_EXPO_OUT	CCD integration time (1 ADU= 0.02 s)	10	0000 00VV VVVV VVVV
Scan Unit	M_MIRROR_SIN_HK	Echo of commanded sin of electrical angle bit 12 (S) = sign (0=+; 1=-)	12+1	000S VVVV VVVV VVVV
	M_MIRROR_COS_HK	Echo of commanded cos of electrical angle	12+1	0000 VVVV VVVV VVVV
M_IR_LAMP_SHUTTER	M_IR_LAMP_CURR	Bit 0-3 (VVVV): last current value of IR calibration lamp; current = (VVVV+ 94) mA (*)	12	000- ---- 000- VVVV
	M_IR_LAMP_ST	Bit 4 (B): last actuated command of IR calibration lamp (on=1)	12	000- ---- 000B ----
	M_SHUTTER_CURR	Bit 8-11 (VVVV): last current value of shutter; current = (VVVV + 45) mA (*)	12	000- VVVV 000- ----
	M_SHUTTE_ST	Bit 12 (B): last actuated command of shutter (close=1)	12	000B ---- 000- ----
M_IR_FLAG_ST	M_IR_SCAN_FLAG	IRFPA scan flag; bit 0 (correct =1)	1	0--- 00-- 0--- ---B
	M_IR_H/K_FLAG	H/K acquisition flag of the IR channel bit 1 (complete =1)	1	0--- 00-- 0--- --B-
	M_IR_CMD_TIME_ERROR	Error flag: a command has been received out of the idle time : bit 2 (error=1)	1	0--- 0'-0 0--- -B--
	M_IR_CMD_WORD_ERROR	Error flag: bad command identifier or command value out of range: bit 3 (error=1)	1	0--- 00-0 0--- B---
	M_SCAN_CMD_WORD_ERROR	Error flag: bad command identifier or command wrong command sequence; bit 4 (error=1)	1	0--- 00-0 0--B ----
	M_IR_DETECT_ST	IR detector status flag bit 5 (on = 1, off=0)	1	0--- 00-0 00B- ----
	M_IR_ADC_LTC	IR channel AD converter latch-up status bit 6 (latch-up = 1, no latch-up=0)	1	0--- 00-0 0B-- ----
	M_IR_ANN_ST	IRPA annealing heater: last received command bit 9 (on = 1, off=0)	1	0--- 00B0 0--- ----
	M_COVER_ST	cover status	3	0BBB 00-0 0--- ----

		bit 12 - direction of last applied cmd - Close =0 Open = 1 bit 13 - Close position HES1 - Closed=0 not Closed = 1 bit 14 - Open position HES2 - Open=0 not Open = 1 Note: Close/Open information in telemetry are always valid; but HES2 data is updated only during a cover motion.		

M_VIS_FLAG_ST	M_CCD_SCAN_FLAG	CCD scan flag ; bit 0 (correct =1)	1	0000	000-	000-	---B
	M_VIS_H/K_FLAG	H/K acquisition flag of the visible channel bit 1 (complete =1)	1	0000	000-	000-	--B-
	M_VIS_CMD_TIME_ERROR	Error flag: a command has been received out of the idle time: bit 2 (error=1)	1	0000	000-	000-	-B--
	M_VIS_CMD_WORD_ERROR	Error flag: bad command identifier or command value out of range: bit 3 (error=1)	1	0000	000-	000-	B---
	M_VIS_ADC_LTC	VIS channel AD converter latch-up status bit 4 (latch-up = 1, no latch-up=0)	1	0000	000-	000B	-B--
	M_CCD_LAMP_ST	last command applied to the CCD calibrat. lamp: bit 8 (on = 1)	1	0000	000B	000-	----

NOTE : after power-on or reset , last cmd = 0, i.e. close
(*) The provided offset values in transfer functions are valid for FM

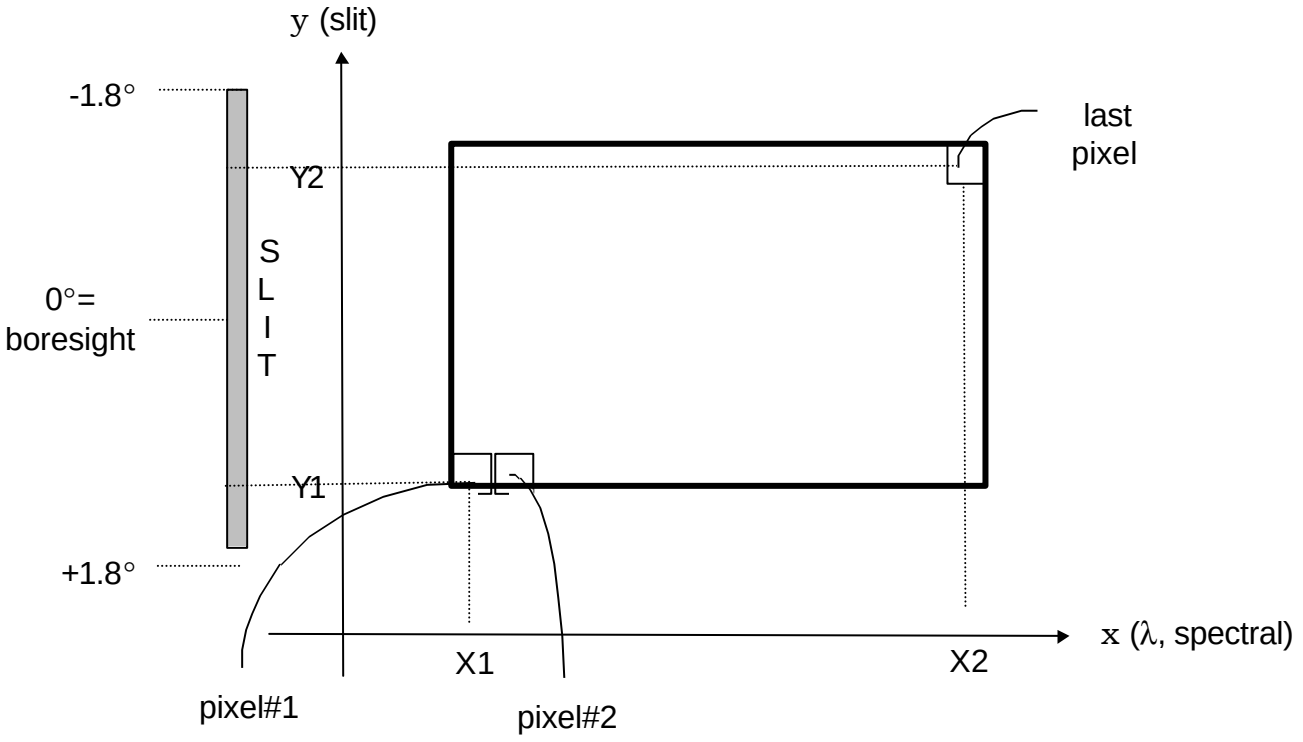
6.2. VIRTIS-M SCIENCE DATA FORMAT

SCIENCE data generated by the VIRTIS-M-VIS and for the VIRTIS-M-IR channels are streams of 16 bit words, each corresponding to 1 pixel . For M-VIS, one pixel (i.e. one word) is relevant to a binning (performed by the PEM) of 2x2 CCD elements. If the co-ordinates of the first pixel in the stream (pixel#1) are (X1,Y1) while (X2,Y2) are the co-ordinates of the last pixel, data are acquired from wavelength X1 to wavelength X2 and (from the spatial i.e. slit direction) from Y1 to Y2.

Detector data are acquired on a spectral basis i.e. spectrum by spectrum. The first spectrum spatial co-ordinate Y1 is relative to the greatest (positive) angular co-ordinate of the acquired portion of the slit and the last to the most negative angular position . In each spectrum data are read according to increasing wavelength. Therefore pixel#1 has the shortest λ(X1) while pixel#2 has the same Y and a longer wavelength.

For the VIS detector, we always have X1, X2, Y1 and Y2 settled in order to have a data output window size of 438 x 256 pixels (note that the PEM is commanded in CCD elements, not pixels).
i.e.
Typical values (default after power On) X1=0, X2=875, Y1=0 and Y2=511 -> VIS window of 438x256 sent by PEM
Calibrated values (working values for FM) X1=72, X2=947, Y1=0 and Y2=511 -> VIS window of 438x256 sent by PEM
The first pixel acquired by the M.E have to be considered always as the pixel 0,0
Of the 438 columns, only 432 are valid: they are discarded by the ME.

For the IR detector, we always have X1=0, X2=437, Y1=0 and Y2=269 -> IR window of 438x270 sent by PEM, but the first and the last pixels in each IR spectrum are not active pixels, therefore even if 438 pixels are received by the ME, only 436 holds meaningful values (from X1=1 to X2=436).
Anyway, of the 438 columns, only 432 are used and of the 270 row only 256 are used: they are discarded by the ME.



The characteristics of the science data from the PEM-M are the following

VISIBILE CHANNEL		
Data type	16 bit unsigned Increasing scale	Min: 0 ADU Max: 65535 ADU
Theoretic dynamic	16384÷65535 ADU	Zero point: 16384 ADU
Offset value	16372 ADU	Measured with a breadboard and the FM CCD
Saturation value	63500 ADU	Without any margin
Dark	0.1966 ADU/s	Note: 6.7945 e-/s
read -out noise (detector + electronics)	≈2 ADU	
Background noise	N/A	

IR CHANNEL		
Data type	16 bit unsigned Decreasing scale	Min: 65535 ADU Max: 0 ADU
Theoretic dynamic	65535 ÷ 0 ADU	Zero point: 65535 ADU
Actual dynamic	61000÷7500 ADU	Without any margin Zero point: 61000 ADU variable with polarisation
Offset value Typical	51000 ADU (that means 10000 ADU offset from the zero point)	Note: 3.2V±0.2V Without any margin
Min	61000 ADU	Note: 4V±0.2V Without any margin
Saturation value	7500ADU	Without any margin
Dark 70K 90K 100K	 75 ADU/s 169 ADU/s 1032 ADU/s	Note: 0.8 fA 1.8 fA 11 fA
Fixed pattern noise (detector + electronics)	1.5÷2 ADU	
Background noise	λ and $\sqrt{T_{expo}}$ depending	

NOTE: These values are taken from the data acquired and processed during the FM detector calibration sessions performed using PEM-M B/B electronics (FM rapresentative)

6.3. VIRTIS-H HK DATA FORMAT

Digital housekeeping (7 words of 16 bits)

Housekeeping Name	Meaning	# bits	Source	Remarks; corresponding req.
HKRq_Int_Num2	FPGA divider ratio for detector speed control	8	PEM Ctrler	**HSET_Int_Num2**
HKRq_Int_Num1	Integration time constant (8 LSB's/10)	10	PEM Ctrler	**HSET_Int_Num1**
HKRq_Bias	Detector Bias	8	PEM Ctrler	**HSET_Bias**
HKRq_I_Lamp	Calibration Lamp required current	8	PEM Ctrler	**HSET_I_Lamp_XX**
HKRq_I_Shutter	Shutter required current	8	PEM Ctrler	**HSET_I_Shutter**
HKRq_PEM_Mode	PEM-H Mode	2	PEM Ctrler	**HSET_PEM_Mode**
HKRq_Test_Init	Requested initial data in Test Mode (4 LSB's/10)	10	PEM Ctrler	**HSET_Test_Init**
HKRq_Det/On	Detector Power On/Off request	1	PEM Ctrler	**HSET_Det/On** or **HSET_Det/Off**
HKRq_Shutter/On	Shutter On or Off	1	PEM Ctrler	**HSET_Shutter/On** or **/Off**
HKRq_FPAHtr/On	Annealing On or Off	1	PEM Ctrler	**HSET_FPA_Htr/On** or **/Off**
HKRq_Lamp_Spect_T/On	Spectral Calibration Lamp Telescope On/Off	1	PEM Ctrler	**HSET_Lamp_Spect_T/On** o **HSET_Cal/Off**
HKRq_Lamp_Spect_S/On	Spectral Calibration Lamp Slit On/Off	1	PEM Ctrler	**HSET_Lamp_Spect_S/On** o **HSET_Cal/Off**
HKRq_Lamp_Radio/On	Radiometric Calibration Lamp On/Off	1	PEM Ctrler	**HSET_Lamp_Radio/On** or **HSET_Cal/Off**
HKRq_Temp_Det/On	Temp meas. by detector temp sensor On/Off req.	1	PEM Ctrler	**HSET_Det_Temp/On** or **Off**
HKRq_Status_Shutter/On	Shutter Status device ON or OFF	1	PEM Ctrler	**HSET_Shutter_Status/On** or **Off**
HKMs_Req_during_Acq	Request(s) have arrived during data acquisition	1	PEM Ctrler	Reply to any req rcvd during block gen.
HKRq_Cover_Dir	V-H cover has been commanded open/ closed	1	PEM Ctrler	**HSET_Cover**
HKRq_Cover_Wave	V-H cover motor wave one/half	1	PEM Ctrler	**HSET_Cover**
HKRq_Cover_Status	=1: cover status enabled; =0: disabled	1	PEM Ctrler	**HSET_Cover**

Housekeeping Name	Meaning	# bits	Source	Remarks; corresponding req.
HKRq_Cover_Step	V-H cover motor number of steps	7	PEM Ctrler	**HSET_Cover**
Available		7		
HKMs_ADC_Latchup	ADC Latch-up has occurred (1)	1	PEM	Caused by **LPSTATUS ADC**
HKMs_Shutter/Open	Shutter Status: Open = 0, not open = 1	1	Opt. Head	Reply to **HSET_Shutter/On**
HKMs_Shutter/Closed	Shutter Status: Closed = 0, not closed =1	1	Opt. Head	Reply to **HSET_Shutter/Off**
FPGA_HES_1-H	Cover Status: closed (*FPGA_HES_1-H=0*) not closed (*FPGA_HES_1-H=1)*	1	CME	Reply to **HSET_Cover (H_Cover_Dir = 1)**
FPGA_HES_2-H	Cover Status: open (*FPGA_HES_2-H=0*) not open (*FPGA_HES_2-H=1*)	1	CME	Reply to **HSET_Cover (H_Cover_Dir =0)**
HKMs_Annealining_Limit_Flag	The annealing security is active (the FPA temp is above the safe annealing temperature) 1 = Annealing authorised 0 = Annealing NOT authorised	1	PEM	Possible only with **HSET_FPA_Htr/On**
Available		10		
Available		16		

Analog Voltage Housekeeping (12 + 1 TBD)

Name	Function	Format	Info
HKMs_V_Line_Ref	V at beginning of last detector line	Signed 16 bits word	Voltage
HKMs_Vdet_Dig	V supply detector (digital)	Signed 16 bits word	Voltage
HKMs_Vdet_Ana	V supply detector (Analog)	Signed 16 bits word	Voltage
HKMs_V_Detcom	V Bias Detector (fixed)	Signed 16 bits word	Voltage
HKMs_V_Detadj	V Bias Detector (**HSET_Bias**)	Signed 16 bits word	Voltage
HKMs_V+5	V Pwr +5v (Logic)	Signed 16 bits word	Voltage
HKMs_V+12	V Pwr +12v (Analogic)	Signed 16 bits word	Voltage
HKMs_V+21	V Pwr +21v (Shutter, Heater)	Signed 16 bits word	Voltage
HKMs_V-12	V Pwr -12v (Analogic)	Signed 16 bits word	Voltage
HKMs_Temp_Vref	Vref Temp measurements	Signed 16 bits word	Voltage
HKMs_Det_Temp	FPA Temp by internal sensor	Signed 16 bits word	Temp→V
HKMs_Gnd	Ground reference	Signed 16 bits word	Voltage
TBD			

Analog Current Housekeeping (6 + 2 TBDs)

Name	Function	Format	Info
HKMs_I_VDet_Ana	I Detector (analog)	Signed 16 bits word	Current
HKMs_I_Vdet_Dig	I Detector (digital)	Signed 16 bits word	Current
HKMs_I_+5	I Pwr +5v (Logic)	Signed 16 bits word	Current
HKMs_I_+12	I Pwr +12v (Analog)	Signed 16 bits word	Current
HKMs_I_Lamp	I Calibration Lamp	Signed 16 bits word	Current
HKMs_I_Shutter/Heater	I Shutter/Heater	Signed 16 bits word	Current
TBD			
TBD			

Analog Temperature Housekeeping (8)

Name	Function	Format	Info
HKMs_Temp_Prism	Prism temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_Cal_S	Slit (Spectral) Lamp temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_Cal_T	Tel. Spectral & Radio Lamps temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_Shut	Shutter temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_Grating	Grating temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_Objective	Objective temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_FPA	FPA temp	Signed 16 bits word	PT100/3 w
HKMs_Temp_PEM	PEM temperature	Signed 16 bits word	PT100/3 w

DHSU Digital Housekeeping to add in the VIRTIS-H blocks (2 words)

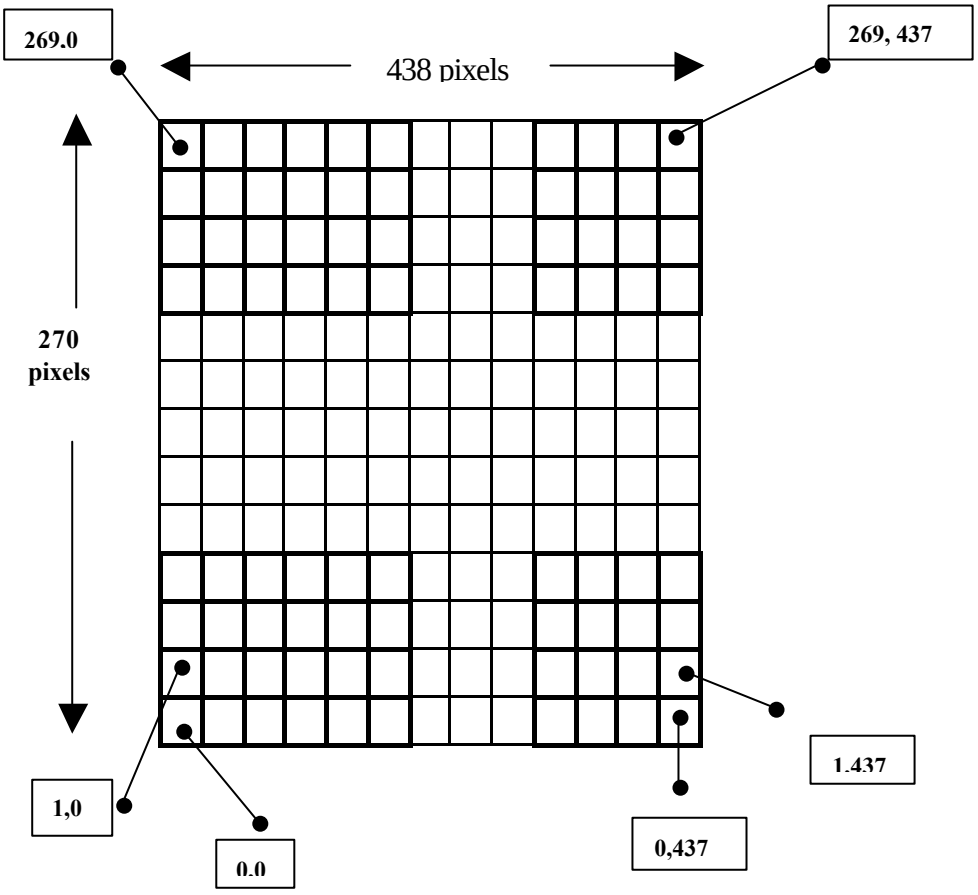
Housekeeping Name	Meaning	bits	Source	Res./Type	Remarks; corresponding req
HKDH_Last_Sent_Request	Last request sent to PEM -H	16	DHSU		Sent only once. If no new request, send 0. Never send **HSTART_S** nor **HSTART_HK!**
HKDH_Stop_Readout_Flag	Stop Readout request flag (during last block)	1	DHSU	flag	1= a HSTOP_Readout request has been sent

The full HK bloc that the DHSU must send to the OBDH is constituted of :

7 digital HKs : 7 words of 16 b
29 analog HKs: 29 words of 16 b
1 digital DHSU HK: 1 word of 16 b
1 digital DHSU HK: 1b.

6.4. VIRTIS-H SCIENCE DATA FORMAT

The dynamic range of the ADC is (+32767, -32768), 16 bits signed integer.
The level of dark/background is about 1000 ADU.
The dynamic range of the signal is about (1000, 30000) ADU.



6.4.1. TOTAL OUTPUT DATA

In H_PEM_Mode: 0: Observation/ 8 orders
2: Simulation/ 8 orders

SCIENCE: 432 * 8 * 5 = 17280 Words 16 b
then
Logical HK: 7 Words 16 b
then
Analog HK: 29 Words 16 b

in H_PEM_Mode: 1: Observation/ all matrix
3 : Simulation/ all matrix

SCIENCE: 438 * 270 = 118260 Words 16 b
then
Logical HK: 7 Words 16 b
then
Analog HK: 29 Words 16 b

APPENDIX A : Figures

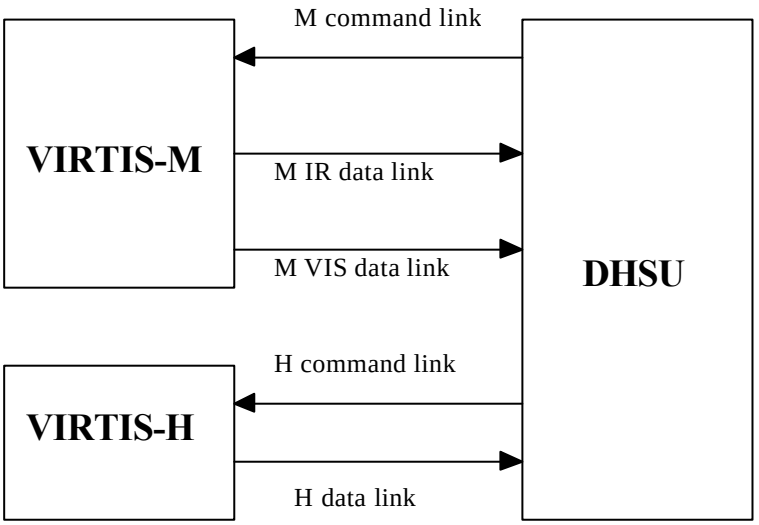
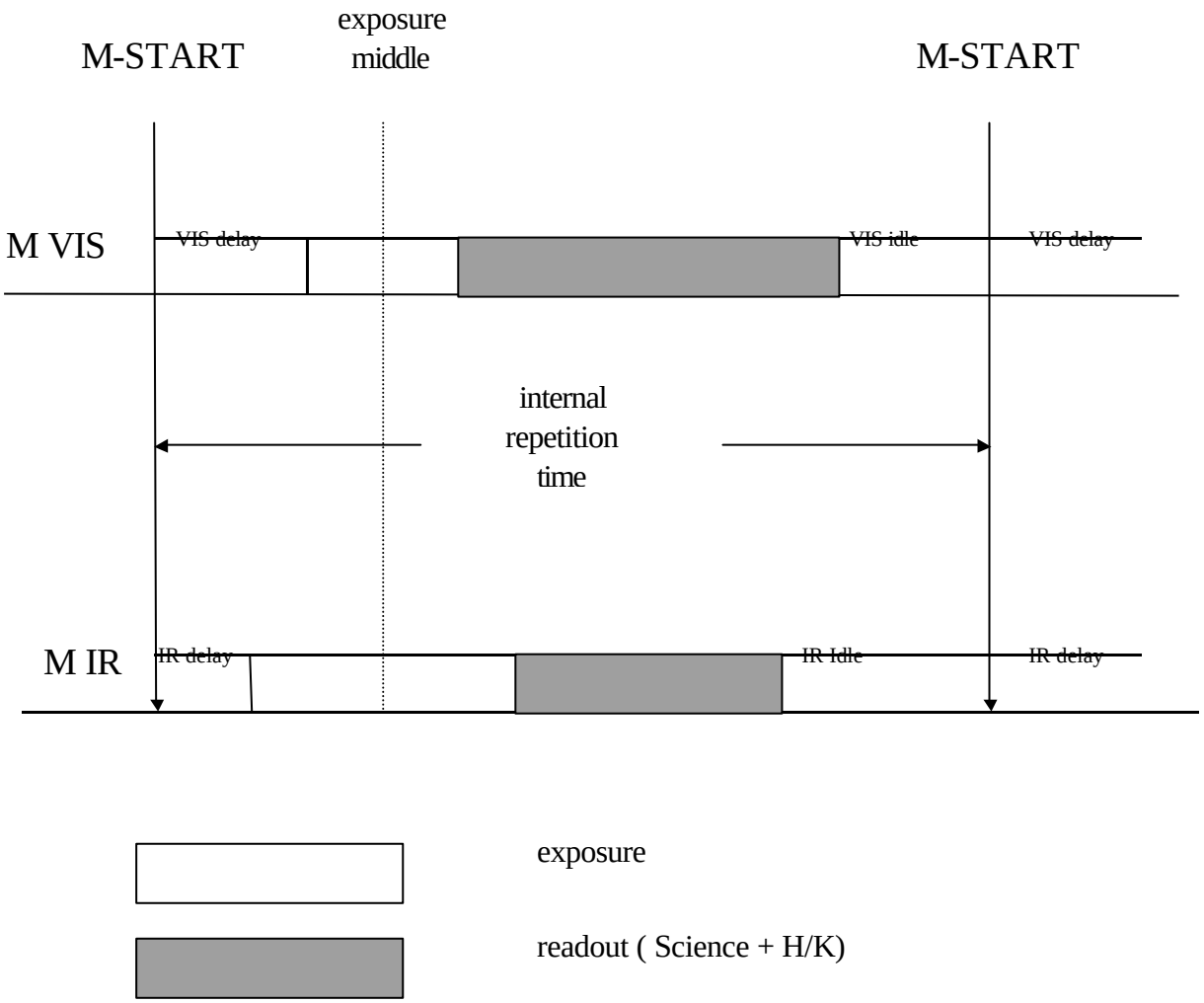


Fig.1



NOTE1: timing proportions are not significant and are given only as an example
NOTE2 : VIRTIS M is Idle when both channels are Idle

Fig.2 -M acquisition cycle timeline

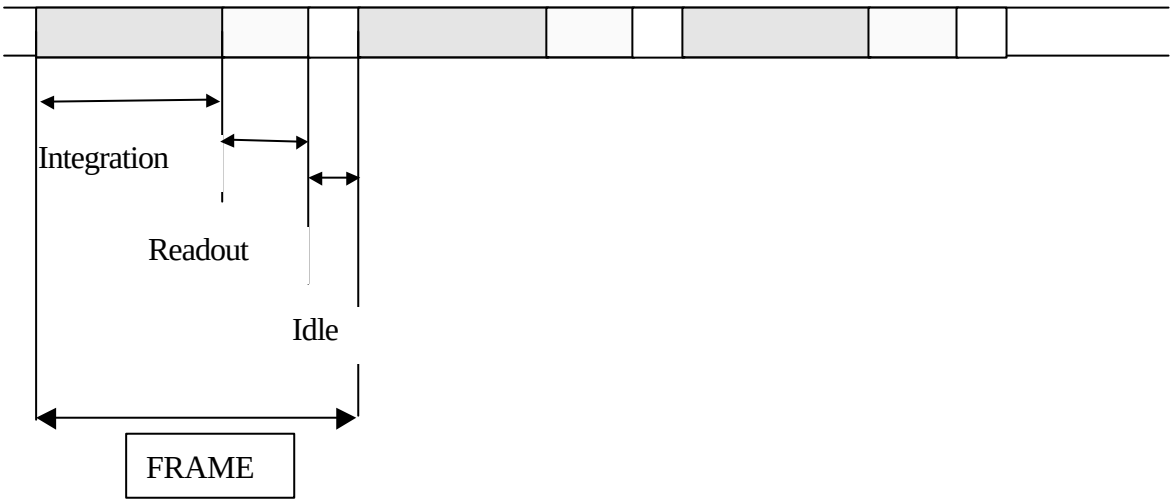


Fig.3 -H Free Run

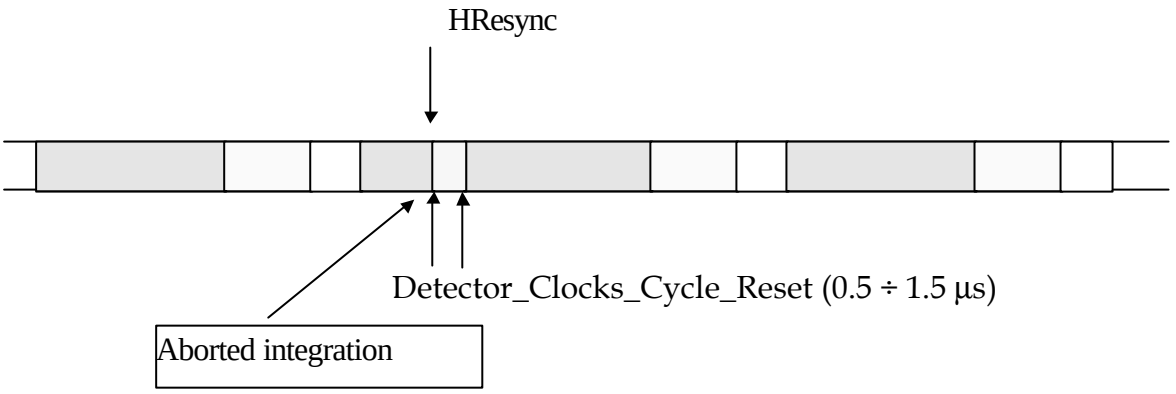


Fig.4 -H Resynchronization

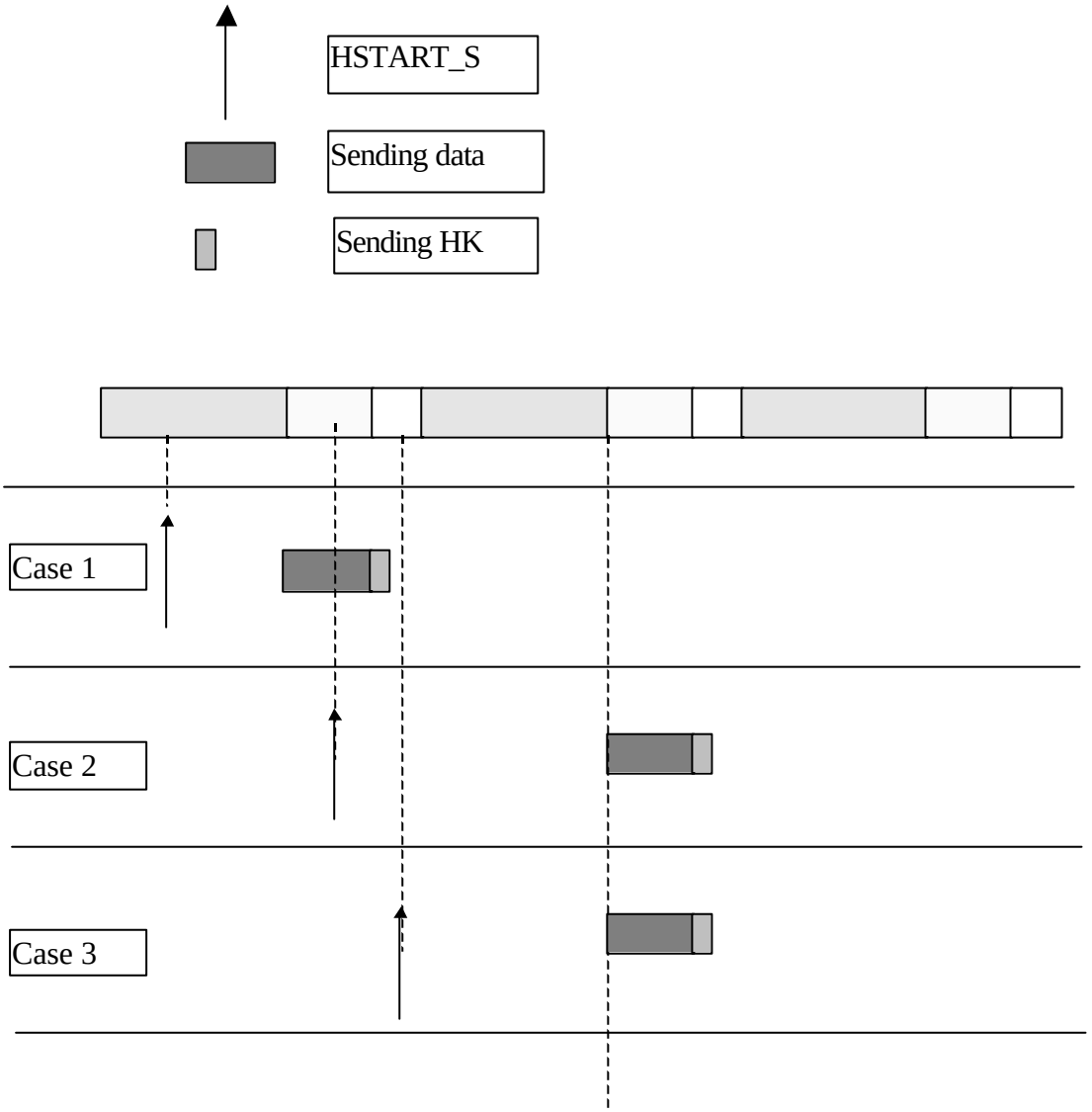


Fig.5 -H Sending data : 3 cases

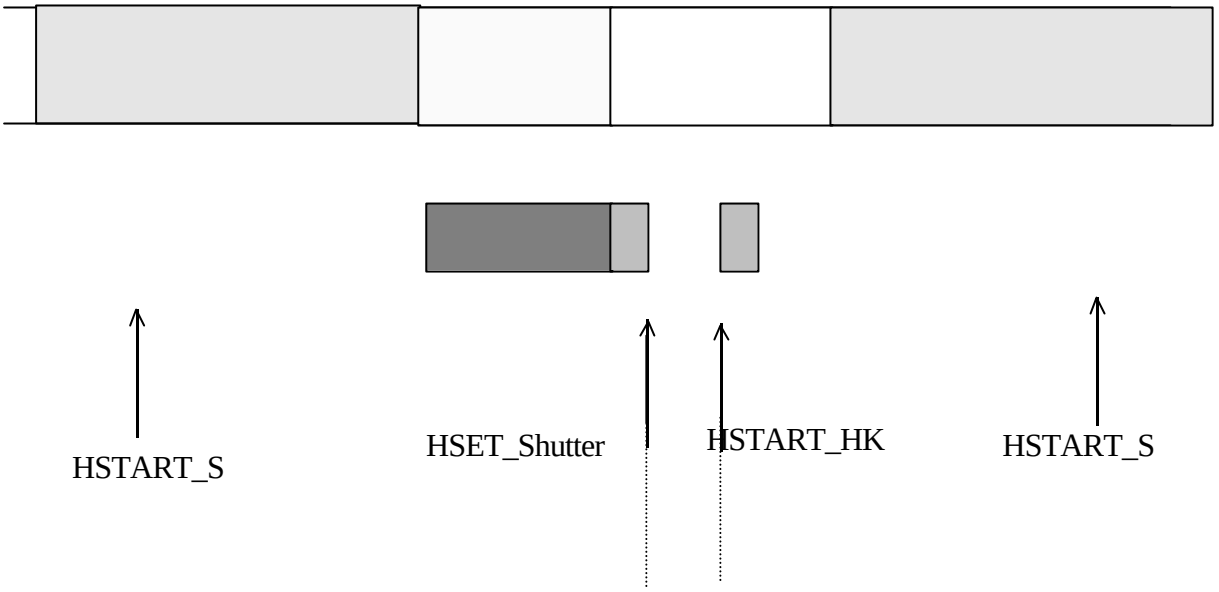


Fig.6 -H Dark measurement