Interface Control Document (ICD)

DEC/MEC - SPU

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1.0	17/03/2000	All pages updated – after OBS meeting 3/2000
1.1	10/04/2000	5, 6, 7, 8
1.2	18/04/2000	Modifications due to packet size limitation (p 1,2,5,6,7,8,9,11,12)
2.0	23/11/2000	All pages modified; bolometers added
2.1	13/02/2001	7 -> 11, new packet format (4 bytes alignement)
3.0	07/09/2001	pages 7 -> 11, new packet format
3.1	5/11/2001	pages 7 -> 11, APID->SPUID, AID->DBID, CRDC in photometry packet
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3.5	29/07/2004	Include changes from ECP-CSL-080704-01: Modified the description of CRECR in spectroscopy packets Modified the description of CRDC in photometry packets Added a description of the layout of pixels in spectroscopy packets.

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List of Abbreviations

AC	Alternating Current
ADC	Analog-to-Digital Converter
ADP	Acceptance Data Package
AIV	Assembly Integration & Verification
ASA	Austrian Space Agency
ASI	Italian Space Agency
AVM	Avionic Model
CDR	Critical Design Review
CIDL	Configuration Item Data List
CNES	French Space Agency
CoI	Co-investigator
CSL	Centre Spatial de Liège
DAC	Digital-to-Analog Converter
DEC/MEC	(PACS) Detector & Mechanism Controller
DC	Direct Current
DDR	Detailed Design Review
DLR	German Aerospace Agency
DPU	(PACS) Digital Processing Unit
EEPROM	Electrically Erasable PROM
EM	Engineering/Electrical Model
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
ESA	European Space Agency
ESOC	European Space Operations Centre
ESTEC	European Space Research and Technology Centre
FIRST	FarInfrared and Submillimetre Telescope
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare
GSE	Ground Support Equipment
HIFI	Heterodyne Instrument for FIRST
HK	HouseKeeping
H/W	Hardware
I/F	Interface
ICC	Instrument Control Centre
ICD	Interface Control Document
IID-A	Instrument Interface Document - Part A
IID-B	Instrument Interface Document - Part B
IIDR	Instrument Intermediate Design Review
ILT	Instrument-Level Test
IR	Infrared
ISVR	Instrument Science Verification Review
LOU	Local Oscillator Unit (of HIFI)
MRB	Material Review Board
NA	Not Applicable
NASA	National Aeronautic and Space Administration (U.S.A.)
NCR	Non Conformance Report
OBS	On-Board Software
PACS	Photoconductor Array Camera and Spectrometer
PDR	Preliminary Design Review
PFM	Proto-Flight Model
PI	Prime Investigator
PRODEX	Programme de Développement d'Expériences Scientifiques
PROM	Programmable ROM
QM	Qualification Model
RAM	Random Access Memory
ROM	Read-Only Memory
S/C	SpaceCraft
SPIRE	Spectral and Photometric Imaging REceiver
SPU	(PACS) Signal Processing Unit
S/S	Sub-System
S/W	Software
SPC	Science Programme Committee (ESA)
STM	Structural/Thermal Model
SVM	SerVice Module
TB	Thermal Balance (Test)
TBC	To Be Confirmed
TBD	To Be Defined
TRB	Test Review Board
TRR	Test Readiness Review
TV	Thermal Vacuum (Test)
TVC	Thermal-Vacuum Chamber
URD	User Requirement Document
WP	Work Package

Table of Contents

1 Scope

1.1 Introduction

The Photodetector Array Camera and Spectrometer (PACS) is an imaging spectrometer-photometer which forms part of the science payload of the Herschel Telescope (formerly called FIRST), an ESA cornerstone mission (CS4) to be launched in 2007.

A presentation of the Herschel mission and status is available at URL: http://sci.esa.int/herschel/.

1.2 Purpose

MPE document [RD4] identifies critical interfaces between separately developed subunits of the PACS instrument.

The purpose of this ICD is to document the interface between the DEC/MEC (CSL responsibility) and the SPU (TU Wien and IAC responsibility).

There is no mechanical/thermal interface between the SPU and the DEC/MEC.

Interfaces between the DEC/MEC or SPU and the HERSCHEL satellite are not addressed here. They are controlled by AD1 and RD1.

2 Documents

2.1 Applicable Documents

[AD1]	ESA PT-IID-A-04624	FIRST/PLANCK Instrument Interface Document - Part A
[AD2]	ESA PT-RQ-04410	PA Requirements for FIRST/PLANCK Scientific Instruments

2.2 Reference Documents

[RD1]	ESA PT-PACS-02126	Instrument Interface Document - Part B - Instrument "PACS"
[RD2]	PACS-ME-PL-002	PACS Design, Development and Verification Plan
[RD3]	PACS-ME-PL-005	Operating Modes of the PACS Instrument
[RD4]	PACS-ME-ID-001	PACS Instrument Interface Requirement Document
[RD5]	PACS-CR-RD-001	DPU/ICU On-board Software URD
[RD6]	no ref.	Contribution to the PACS SPU Concept (TUW)
[RD7]	VIG4.1R200	Virtuoso user guide – Eonic systems
[RD8]	PACS-CL-TN-005	DEC/MEC Software preliminary specification
[RD9]	BSSC(96)2	Guide to applying the ESA software engineering standards to small software projects
[RD10]	PACS-CL-SP-001	DEC/MEC software User Requirements Document
[RD11]	PACS-CL-ID-003	DEC/MEC to DPU interface description
[RD12]	no ref.	FIRST instrument commanding concepts (draft) K J KING
[RD13]	PACS-TW-TN-001	Raw data transmission protocol (TUW – D. Hönigmann)
[RD14]	43299-IM-RP-4	FIRSA interfacing – Interface specification to the driving unit (IMEC)
[RD15]	DSPM-DAS-1402-E	Specification of the Open Heterogeneous Multiprocessor Architecture
[RD16]	DIPSAPII-DAS-31-06	SMCS332 User Manual
[RD17]	DIPSAPII-DAS-31-07	SMCS-lite user manual
[RD18]	ECSS E 50 12	SpaceWire standard draft Issue C (original ref UoD-DICE-TN-9201)
[RD19]	1355-1995 (ISO/IEC 14575)	IEEE Standard for Heterogeneous InterConnect (HIC)
[RD20]	PACS-CL-ID-005	DEC/MEC Commands and HK lists
[RD21]	PACS-TW-GS-001	SPU HLSW Specification Document
[RD22]	PACS-IM-ID-001	Interface specifications for the PACS CREs
[RD23]	FPL-IC-1214-03-CRS	Planck LFI REBA Herschel PACS FPU ICD (Crisa)
[RD24]	SAp-PACS-Cca-0046-01	BOLC to DMC Electrical ICD
[RD25]	PACS-CL-SR-002	DEC/MEC User Manual
[RD26]	PACS-MA-SP-001	PACS Cryo Harness Specification

2.3 Procedures and Standards

[PS1]	ECSS-Q-20	Space Product Assurance, Quality Assurance
[PS2]	ECSS-Q-60A	Electrical, Electronic and Electromechanical Components
[PS3]	ECSS-Q-70A	Materials, Mechanical Parts and Processes
[PS4]	ECSS-M-40A	Configuration Management

[PS5] ECSS-E-40-DR Space Engineering - Software

3 Definitions

3.1 Interface Basic Description

The DEC/MEC is the only interface between the instruments physical components (mechanisms and detectors) and the other data handling units (DPU and SPU).

The following information must be transmitted from DEC/MEC to SPU :

- Photoconductor array data packets
- Bolometer array data packets

The format of these packets will be described in section 4.4.

3.2 Interface configurations

There are two physical interfaces between DEC/MEC and SPU (identified as the "red" and "blue" channels). They are identical, the data formats specified in this manual apply to both. The DEC/MEC software shall have the capability to handle both simultaneously.

The Bolometer detector arrays are used in the instrument photometry mode, while the Photoconductor arrays are used in the instrument spectrometry mode. Therefore the SPU interfaces shall transport EITHER photoconductor data packets OR Bolometer data packets.

Parameters in the DMC header updated via DPU command are interpreted by SPU.

4 Electrical Interface

4.1 Scope

As far as applicable, this section shall contain the following information :

- A list of all connectors external to instrument units defining the connector identifier, the function and the connector type/specification;
- A drawing for each connector defining the pin function and the type of interface circuit;
- A detailed circuit drawing for each interface circuit type to ensure interface compatibility;
- A table of signal characteristics for each interface circuit type with numerical parameter values for nominal and failure cases to ensure interface compatibility and to ensure that failures cannot propagate.

4.2 Connector Listing

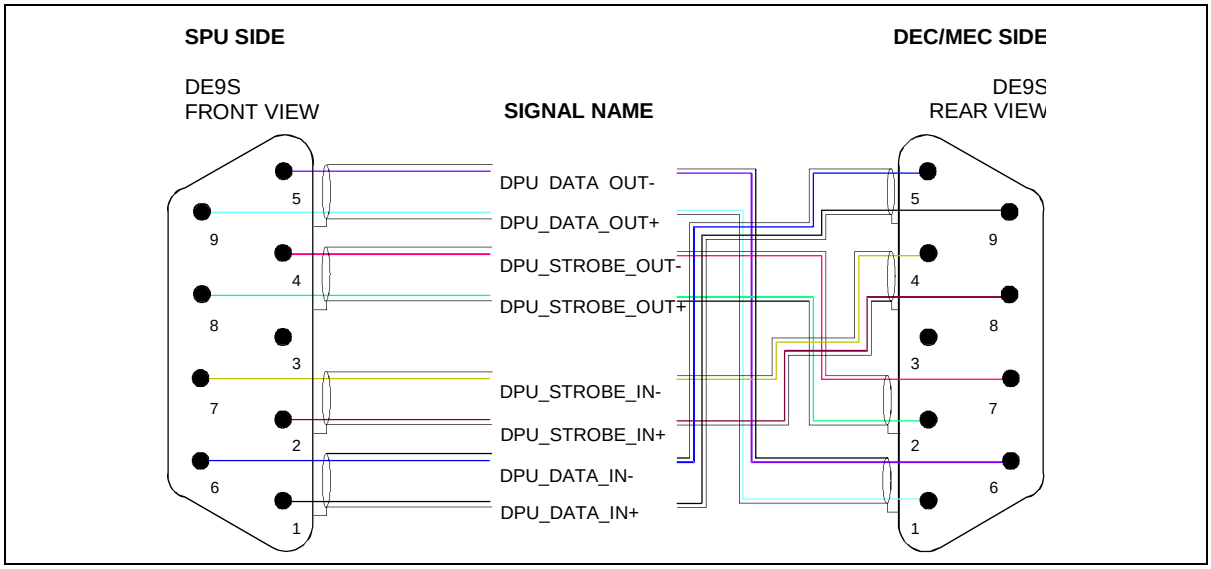
Table 4.1 - SPU-to-DEC/MEC Connector List.

SPU		DEC/MEC		Features	
Identifier	**Type/Spec**	**Identifier**	**Type/Spec**	**Nr. Of Contacts***	**Function**
(SPU1)J22	MDM9S	**J02**	MDM9S	9 (8)	communication line SWL SPU – DEC/MEC (nominal)
(SPU1)J32	MDM9S	**J05**	MDM9S	9 (8)	communication line LWL SPU – DEC/MEC (nominal)
(SPU2)J22	MDM9S	**J102**	MDM9S	9 (8)	communication line SWL SPU – DEC/MEC (redundant)
(SPU2)J32	MDM9S	**J105**	MDM9S	9 (8)	communication line LWL SPU – DEC/MEC (redundant)
(SPU1)J15	DAM15P	**J10**	DAM15P	15(11)	Housekeeping lines (nominal)
(SPU2)J15	DAM15P	**J110**	DAM15P	15(11)	Housekeeping lines (redundant)

4.3 Connector Configurations

4.3.1 SPU-to-DEC/MEC Communication Links

See [RD23]



	Function	Type	I	V	R		Function
1	data_in+	SGN				**9**	data_out+
6	data_in-	SGN				**5**	data_out-
2	strobe_in+	SGN				**8**	strobe_out+
7	strobe_in-	SGN				**4**	strobe_out-
3	(out shields)	-	-	-	-	**3**	(out shields)
8	strobe_out+	SGN				**2**	strobe_in+
4	strobe_out-	SGN				**7**	strobe_in-
9	data_out-	SGN				**1**	data_in+
5	data_out+	SGN				**6**	data_in-
SPU		¬ **length: 1m (TBC)** ®				**DEC/MEC**	

Note : pin 3 connection as per Spacewire standard.

4.3.2 SPU-to-DEC/MEC Housekeeping

ANA HOUSEKEEPING definition at SPU side, cable is pin to pin				
CONNECTOR: sub D 15 **TYPE: DAM15PNMB1AON**		15 PIN		
PIN NUMBER		*SIGNAL NAME*	*IN/OUT*	COMMENTS
1		TH_SPU_SWLa	OUT	SPU SWL Thermistor
	9	TH_SPU_SWLb	OUT	
2		TH_SPU_LWLa	OUT	SPU LWL Thermistor
	10	TH_SPU_LWLb	OUT	
3		TH_PSUa	OUT	PSU Thermistor
	11	TH_PSUb	OUT	
4		VCC_CUR_HK_P	OUT	VCC Secondary supply current telemetry
	12	VCC_CUR_HK_N	OUT	
5		VCC_VOL_HK	OUT	VCC Secondary supply voltage telemetry
	13	DGND	OUT	
6		15VP_CUR_HK_P	OUT	15VP Secondary supply current telemetry
	14	15VP _CUR_HK_N	OUT	
7		15VP _VOL_HK	OUT	15VP Secondary supply voltage telemetry
	15	AGND	OUT	
8		CHASSIS	OUT	

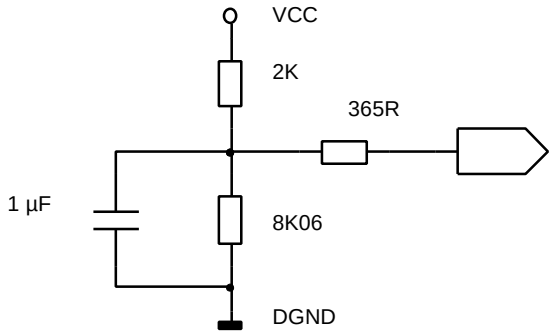
Note : VCC voltage telemetry referenced to DGND

4.4 Housekeeping signals specification

PACS/SPU unit grounding concept is based on a single secondary output (5V) referenced internally to equipment chassis. So all the analog direct telementries are referenced to this return. Considering the receiver return must also be connected to chassis, no optoisolation is required.

4.4.1 VCC Voltage TM:

The interface diagram is as follows:



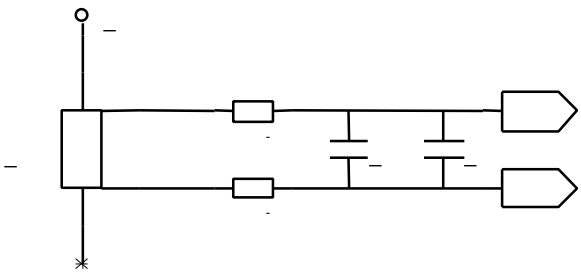
According to the figure and considering usual DC/DC converter performances, the output levels can be computed for VCC=4.5V and for VCC=5.5V. The current delivered is limited by the output resistance, that is less than 2Kohms (1.967Kohms nominal).

Signal pin is provided in the external connector. A common pin directly connected to internal ground is also provided.

Measurement shall be differential with DGND, high impedance.

4.4.2 VCC Current TM:

The interface diagram is as follows:

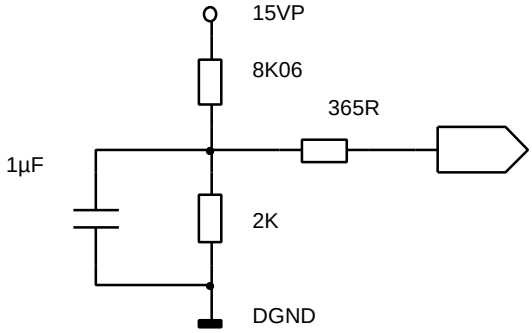


The Full Scale Range is around 100mV for 6.66A as maximum current. The current delivered is limited by the 1Kohm serial resistors.

Signal and return lines are provided in the external connector. The interface must be differential analog acquisition type, there is a common mode voltage of VCC (5V nominal)

4.4.3 15VP Voltage TM:

The interface diagram is as follows:



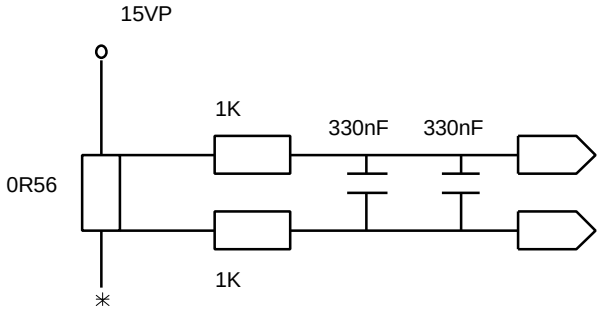
According to the figure and considering usual DC/DC converter performances, the output levels can be computed for 15V +/- expected variation. The current delivered is limited by the output resistance, that is less than 2Kohms (1.967Kohms nominal).

Signal pin is provided in the external connector. A common pin directly connected to internal ground is also provided.

Measurement shall be differential with DGND, high impedance.

4.4.4 15VP Current TM:

The interface diagram is as follows:



The Full Scale Range is around 100mV for 6.66A as maximum current. The current delivered is limited by the 1Kohm serial resistors.

Signal and return lines are provided in the external connector. The interface must be differential analog acquisition type, there is a common mode voltage of 15VP (15V nominal)

4.4.5 Thermistors TM:

The interface consists directly on both 526-31-BS09-153 thermistor terminals.

5 Communication Description

5.1 DEC/MEC - SPU Communication Link

5.1.1 Hardware

Baseline is 1355 but running at reduced speed (nominal link speed 10 Mbps) according to Spacewire standard draft C using LVDS transceivers.

The low level link is supposed to deliver strings of data bytes delimited by « end of message » or "end of packet" control characters.

In the Virtuoso OS terminology, this would be called “raw link” mode.

5.1.2 Communication principles

The SPU protocol principles are the following :

- The communication is unidirectional, all messages are issued by DEC/MEC.

5.2 Packet formats

Different packet formats are needed according to the instrument mode : photometry or spectrometry.

5.2.1 Spectrometry packets

SPUID	0x00000001	Observation Configuration	Compression Parameters	Science Data
1 word[1]	1 word	13 words	1 word	234 words

Spectrometry or Photoconductor packets contain :

1. The SPUID identifying the channel (Blue SPU (2) or Red SPU (3)). By this way, it also identifies the detector array which is the source of the data (see redundancy issue below)
2. The type of packet (= 0x01 for photoconductor packet)
3. A set of parameters describing the observation configuration :

Parameter	*Description / use*	*Useful bytes*	*Used bytes*	*Format*	*Unit*	*Remark*
OBSID	Observation Identification	4	4	-	-	
BBID	Building Block Identification	4	4	-	-	
LBL	Label	1	4	-	-	
TMP	Timing Parameters	6	8			
VLD	Notifies if the science data is valid (0xff) or invalid (0x00)	1	4			
CPR	Chopper position as encoded by MEC	3	4		Chopper encoder increments	From MEC servo software
WPR	Wheel position as encoded by MEC	1	4		Filter number	From MEC servo software
GPR	Grating position as encoded by MEC	3	4		Grating encoder increments	From MEC servo software
CRCRMP	Current ReaDout Count : Current value of the readouts counter, starts from Nr and decrements, value of 0 signals a destructive readout and the end of an integration interval	2	4			Nr-1 .. 0

[1] 1 word = 32 bits

RRR	Readouts in ramp (Nr) Readback : Number of readouts within the same integration ramp (i.e. between successive capacitor resets)	2	4			1 .. 1024 (nominal 8)
CRDC	number of readouts since the last SET_TIME command to DMC	4	4			
CRECR	CRE Control Readback	2	4			The definition of this field is the same as DMC_DECR_CR_ST_2 that can be found in DMC SUM [RD25]

4. Compression Parameters : 2 bytes (1 word used in the packet) of parameters provided by the DPU (format is described in [RD21]).

5. The science data : 26*18 pixels coded in 16 bits (= 234 words of 32bits). Format is given below.

	16msb		16lsb	
32bits words number	CRE NB	PIX NB	CRE NB	PIX NB
0	1	NC	14	NC
1	2	NC	15	NC
2	3	NC	16	NC
3	4	NC	17	NC
4	5	NC	18	NC
5	6	NC	19	NC
6	7	NC	20	NC
7	8	NC	21	NC
8	9	NC	22	NC
9	10	NC	23	NC
10	11	NC	24	NC
11	12	NC	25	NC
12	13	NC	NC	NC
13	1	1	14	1
14	2	1	15	1
15	3	1	16	1
16	4	1	17	1
17	5	1	18	1
18	6	1	19	1
19	7	1	20	1
20	8	1	21	1
21	9	1	22	1

22	10	1	23	1
23	11	1	24	1
24	12	1	25	1
25	13	1	NC	NC
26	1	2	14	2
27	2	2	15	2
28	3	2	16	2
29	4	2	17	2
30	5	2	18	2
31	6	2	19	2
32	7	2	20	2
33	8	2	21	2
34	9	2	22	2
35	10	2	23	2
36	11	2	24	2
37	12	2	25	2
38	13	2	NC	NC
39	1	3	14	3
40	2	3	15	3
41	3	3	16	3
42	4	3	17	3
43	5	3	18	3
44	6	3	19	3
45	7	3	20	3
46	8	3	21	3
47	9	3	22	3
48	10	3	23	3
49	11	3	24	3
50	12	3	25	3
51	13	3	NC	NC
52	1	4	14	4
53	2	4	15	4
…	…	…	…	…
…	…	…	…	…
219	12	16	25	16
220	13	16	NC	16
221	1	DUMMY	14	DUMMY
222	2	DUMMY	15	DUMMY
223	3	DUMMY	16	DUMMY
224	4	DUMMY	17	DUMMY
225	5	DUMMY	18	DUMMY
226	6	DUMMY	19	DUMMY
227	7	DUMMY	20	DUMMY
228	8	DUMMY	21	DUMMY
229	9	DUMMY	22	DUMMY
230	10	DUMMY	23	DUMMY

231	11	DUMMY	24	DUMMY
232	12	DUMMY	25	DUMMY
233	13	DUMMY	NC	NC

NC = Not connected

DUMMY = Dummy resistor

Note:

To be able to identify correctly CRE modules, here is some additional information (according to [RD26]:

For Red DEC, CRE NB 1 is the one connected to Out_1_1 (pin 2) on J12 on the PACS FPU.

For Red DEC, CRE NB 25 is the one connected to Out_25_2 (pin 8) on J15 on the PACS FPU.

For Blue DEC, CRE NB 1 is the one connected to Out_1_3 (pin 2) on J22 on the PACS FPU.

For Blue DEC, CRE NB 25 is the one connected to Out_25_4 (pin 8) on J25 on the PACS FPU.

5.2.2 Photometry packets

SPUID	0x00000002	Observation Configuration	BSID	Compression parameters	Science Data
1 word	1 word	12 words	1 word	1 word	256 words

Photometry or Bolometer packets contain :

1. The SPUID identifying the channel (Blue SPU (2) or Red SPU (3)). By this way, it also identifies the detector array which is the source of the data.
2. The type of packet (= 0x02 for bolometer packet)
3. A set of parameters describing the science data :

Parameter	*Description / use*	*Useful bytes*	*Used bytes*	*Format*	*Unit*	*Remark*
OBSID	Observation Identification	4	4	-	-	
BBID	Building Block Identification	4	4	-	-	
LBL	Label	1	4	-	-	
TMP	Time	6	8			
VLD	Notifies if the science data is valid (0x000000FF) or invalid (0x00000000)	1	4			
CPR	Chopper position as encoded by MEC	3	4		Chopper encoder increments	From MEC servo software
WPR	Wheel position as encoded by MEC	1	4		Filter number	From MEC servo software
BOLST	BOLC status word as described in [RD24]	2	4			
CRDC	the number of OBT clock ticks since the last SET_TIME command to DMC	4	4			
CRDCCP	Current ReaDout Count in Chopper Position. This counter is reset each time the chopper start moving.	1	4			

DBID	Data Block ID. Contains the ID of the block of detector arrays whose data are included in this packet. 1 = Array 1 and 2 2 = Array 3 and 4 3 = Array 5 and 6 4 = Array 7 and 8 5 = Array 9 and 10	1	4			

4. BSID : a 1 byte field (1 word used in the packet) contains information for the bolometers.
6. Compression Parameters : 2 bytes (1 word used in the packet) of parameters provided by the DPU (format is described in [RD21]).
5. The science data : 2 times 256 pixels coded in 16 bits words. The data are arranged column by column; one array after the other.

Note : in this table a "detector array" is an array of 16 by 16 pixels, the complete bolometer assembly contains 10 such units (2 for the "red" channel and 8 for the "blue" channel)

In the nominal case, arrays 1 to 8 making up the "blue" channel would be sent to the "blue" SPU while arrays 9 and 10 making up the "red" channel would be sent to the "red" SPU.

5.3 Redundancy issues

The following functions have been included to enable degraded operation with a failed SPU processor or a failed DEC/MEC to DPU link without switching over to the redundant chain, or to equalise processing load on the SPU by applying a flexible scheme of distributing the data from 2 detector arrays to the 2 SPU channels.

5.3.1 Spectrometry mode

- The DEC/MEC software may reconfigure itself under DPU command in such a way that any list of detector arrays will be sent to any SPU interface (including both arrays sent to one interface)
- The SPUID field will always identify the originating detector array (either red or blue) regardless to which SPU channel the data are sent. One packet will contain data from one detector array only. Depending on the timing parameters programmed, any number of "red" channel packets may be followed by any number of "blue" channel packets.
- The DEC hardware may detect a failed supply group module (not transmitting readouts) and replace the missing data by copies of the corresponding data from the healthy module. In that case "odd" and "even" data would be identical, and the message format would be preserved.

5.3.2 Photometry mode

- The DEC/MEC software may reconfigure itself under DPU command in such a way that any list of detector arrays will be sent to any SPU interface (including all 10 arrays sent to one interface)
- The SPUID field will always be the one of the SPU channel receiving the data, although the data packets may contain data from either detector channel