DEC/MEC Software
User Requirements Document
(URD)

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Prepared by : J.-M. Gillis

Verified by : A. Mazy, P. Franco

Authorised by : E. Renotte - Local Project Manager

Approved by : H. Feuchtgruber - S/W Syst. Eng.

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List of Abbreviations

AIV	Assembly Integration & Verification
ASIC	Application Specific Integrated Circuits
AVM	Avionic Verification Model
BOLA	Bolometer Amplifier
BOLC	Bolometer Controller
CoI	Co-investigator
CPP	Common Part Procurement
CPU	central Processing Unit
CQM	Cryogenic Qualification Model
CRE	Cold Read-out Electronics
DEC	DEtector Controller
DEC/MEC	Detector & Mechanism Controller
DPU	Digital Processing Unit
DSP	Digital Signal Processor
ECSS	European Cooperation for Space Standardisation
EEPROM	Electrically Erasable PROM
EGSE	Electrical Ground Support Equipment
EM	Engineering/Electrical Model
FM	Flight Model
FPGA	Field Programmable Gate Array
FPU	Focal Plane Unit
FMECA	Failure Modes Effects and Criticality Analysis
FS	Flight Spare
GSE	Ground Support Equipment
HFI	High Frequency Instrument (Planck)
HIFI	Heterodyne Instrument for Far Infrared
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
ILT	Instrument-Level Test
IR	Infrared
LFI	Low Frequency Instrument (Planck)
LOU	Local Oscillator Unit (HIFI)
LSB	Least Significant Bit
MEC	Mechanism Controller
MSB	Most Significant Bit
NA	Not Applicable
OBS	On-Board Software
PACS	Photodetector Array Camera and Spectrometer
PFM	Proto-Flight Model
PI	Prime Investigator
PROM	Programmable ROM
QM	Qualification Model
RAM	Random Access Memory
ROM	Read-Only Memory
S/C	SpaceCraft
SPIRE	Spectral and Photometric Imaging REceiver
SPU	Signal Processing Unit
S/S	Sub-System
SSD	Software Specification Document
S/W	Software
STM	Structural/Thermal Model
SVM	SerVice Module
TBC	To Be Confirmed
TC	TeleCommand
TM	TeleMetry
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 Space Observatory (formerly called FIRST), an ESA cornerstone mission (CS4) to be launched in 2007 on Ariane 5.

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

HERSCHEL will host on-board three instruments: HIFI, PACS and SPIRE. The instruments are completely different from each other in many respects, but each of them has an embedded computing unit, called DPU or ICU, responsible for the interface between the spacecraft and the instrument. One institute (IFSI) will provide these three units (hardware and software) and take care of commonality aspects. In addition, PACS will have two other computing units, the SPU (provided by IAC and UVIE) and the DEC/MEC (provided by CSL)

This document contains the User Requirements on the DEC/MEC On-Board Software.

1.2 Purpose

The user requirements in a software development lifecycle are the result of the problem understanding phase and reflect the needs of the "users" who will finally use the software. This document aims at collecting and at clarifying these needs in order to correctly implement them. In our case, the software to be developed will have the main purpose of handling the mechanisms and detector arrays of the PACS instrument, under control of the DPU.

The DEC/MEC On-Board Software URD is organized as follows:

Section 1 (this section) contains the introduction, with a brief description of the purpose of the software, and provides the reader with the "reading tools" (list of acronyms, references and so on).

Section 4 provides a general description of the world the software operates in, the constraints it has to satisfy and the functions it has to perform.

Section 5 is the formal list of the requirements upon which the software will be accepted.

The PACS project DEC/MEC software design, development and validation activities from prototype to flight model will be done at CSL.

Note :

The DEC/MEC software is of the "deeply embedded" variety. Its specifications are highly dependent on the hardware with which it will be incorporated. It is impossible to develop embedded software without sufficient understanding of the underlying hardware. Therefore the hardware specifications are listed below as applicable documents.

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
[AD3]	PACS-ME-RS-004	PACS Science Requirements Document
[AD4]	PACS-ME-RS-005	PACS Instrument Requirements Document
[AD5]	IFSI/OBS/PL/2000-01	DPU/ICU On-board Software Product Assurance Plan
[AD6]	PACS-CL-PL-007	DEC:MEC Software PA Plan

2.2 Reference Documents

[RD1]	ESA PT-PACS-04624	Instrument Interface Document - Part A - Instrument "PACS"
[RD2]	ESA PT-PACS-02126	Instrument Interface Document - Part B - Instrument "PACS"
[RD3]	PACS-ME-PL-002	PACS Design, Development and Verification Plan
[RD4]	PACS-ME-PL-005	Operating modes of the PACS instrument
[RD5]	PACS-CR-RD-001	DPU/ICU on board software user requirements document
[RD6]	unreferenced	Contributions to the PACS SPU concept – the software point of view (TUW – D. Hönigmann)
[RD7]	VIG4.1R200	Virtuoso user guide – Eonic systems
[RD8]	PACS-CL-SR-001	DEC/MEC Software Specification Document (SSD)
[RD9]	BSSC(96)2	Guide to applying the ESA software engineering standards to small software projects
[RD10]	ECSS-E-40-DR	Space engineering - Software
[RD11]	PACS-CL-ID-003	DPU to DEC/MEC interface control document
[RD12]	PACS-CL-ID-004	DEC/MEC to SPU interface control document
[RD13]	unreferenced	FIRST instrument commanding concepts (draft) K J KING
[RD14]	PACS-TW-TN-001	Raw data transmission protocol (TUW – D. Hönigmann)
[RD15]	43299-IM-RP-4	FIRSA interfacing – Interface specification to the driving unit (IMEC)
[RD16]	PACS-ME-RS-003	Black Body and Filter Wheel Requirements specification (MPE)
[RD17]	SAp-PACS-CCa-0046-01	BOLC to DMC Electrical Interface Control Document
[RD18]	PACS-CL-RS-005	programmable logic requirements specification
[RD19]	PACS-ME-LI-005	List of PACS Housekeeping and Telecommands
[RD20]	PACS-CL-SR-002	DEC/MEC User Manual (incl. Housekeeping and Telecommand List)

3 General Description

3.1 PACS System Overview

The PACS instrument has two modes of operation : spectrometry and photometry.

It performs photometry simultaneously in two bands, covering ~1.5'×1' and ~3'×1.5' on the sky, using two bolometers arrays of 16 x 32 and 32 x 64 pixels. The arrays operate at 0.3 K.

PACS performs spectrometry with a resolving power R in the range 1500-2000 (Δv in the range 150-200 km s^{-1}) and an instantaneous coverage of ~1500 km s^{-1} and simultaneous imaging of a ~45"×45" field of view, resolved into 5×5 pixels. PACS employs two 25×16 Ge:Ga detector arrays covering two IR bands. The photoconductor arrays operate at 1.7 K.

In this programme the CSL is responsible for the design, production and unit-level verification of :

- the Grating Assembly;
- the Mechanism Control Electronics;
- the Detector Control Electronics;
- the Warm Interconnecting Harness.

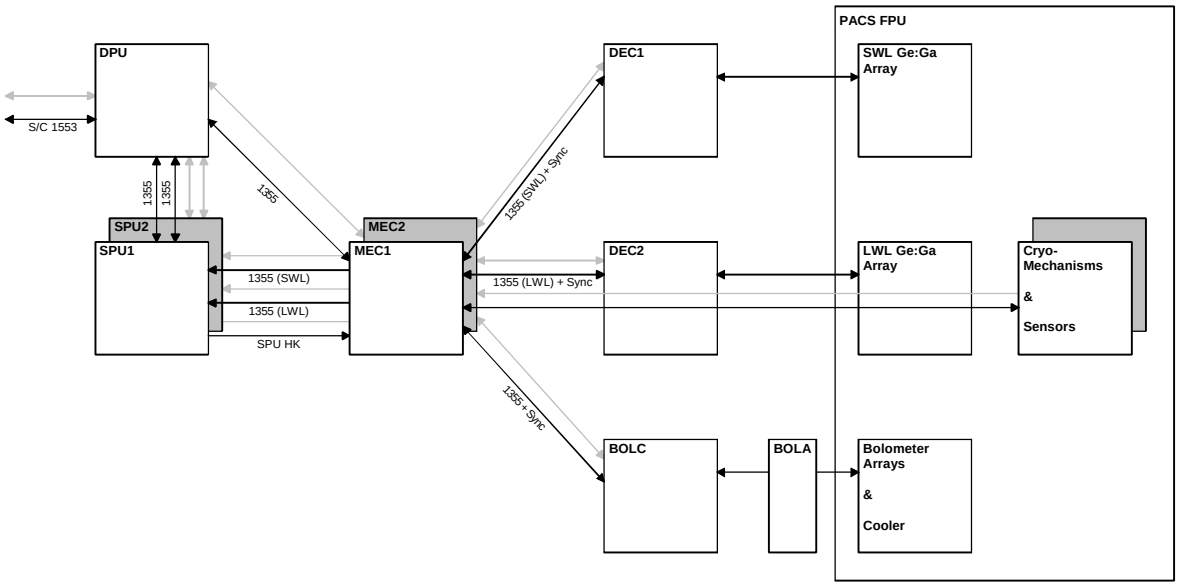
3.2 Instrument electrical architecture

The following drawing shows the HERSCHEL payload, the PACS instrument and PACS warm electronics.

In the PACS Warm Electronics, the following units are shown :

Unit name	Function	Interfaces with other Warm Electronics units	Interfaces with FPU components
DPU	Instrument controller	Spacecraft, DEC/MEC, SPU	no
SPU	Signal processing (data compression)	DPU, DEC/MEC	no
DEC/MEC	Detectors and mechanisms interface	DPU, SPU, BOLC	Grating, chopper, filter wheels, calibration sources, photoconductor arrays
BOLC	Bolometer and cooler control unit	DEC/MEC, BOLA	Bolometers arrays cooler
BOLA	Bolometer Buffer Amplifier Unit	BOLC	Bolometer arrays

The following sections describe briefly the functions of the different units. One should refer to the corresponding hardware design documents for implementation and interfacing details.



3.3 DEC/MEC functions

The DEC/MEC is the interface between the instruments data handling units (DPU and SPU) and the FPU physical components (mechanisms and detector arrays). The functions of the DEC/MEC are briefly described below.

3.3.1 Commanding

Normally, the DEC/MEC can be commanded by the DPU in “direct mode”, where the DPU can request any available function, such as moving a mechanism, changing the detector timing, etc to be executed "immediately" (as soon as possible taking into account hardware speed of response).

At other times defined by the DPU programming or ground control, the DEC/MEC can be put by the DPU in an autonomous data acquisition sequence execution mode.

3.3.2 Data acquisition session

The following section describes the sequence of events (both hardware and software) that have to be handled by the instrument during a data acquisition session.

- pointing the object to be observed

This function will be managed by the spacecraft, according to a fixed predefined schedule.

- setting instrument mode

This function will be managed by the DPU which will select the photometry or spectrometry mode and transmit the needed operating parameters.

- acquiring images

This function will be managed by the DEC/MEC. The DPU will send a « file » of instructions to perform autonomously a number of acquisitions (detector integration cycles) while controlling the mechanisms in the cold focal plane. The syntax will allow a limited subset of the direct commands to be stored and replayed later.

The DEC/MEC shall send continuously the housekeeping measurements at regular intervals, also during sequence execution.

The DPU shall be allowed to abort the sequence at any point.

3.3.3 Instrument mode

The following settings are considered part of the « instrument mode ». They have to be commanded by the DPU before putting the DEC/MEC in its autonomous data acquisition mode, and may not be changed during acquisition.

- detectors parameters
  on / off, integration capacitor select, clock frequency, number of clock periods between readouts, number of readouts per ramp
- spectrometry or photometry (activating appropriate detector arrays)
- sequence parameters (chopper movement, grating movement, valid frames count)
- filter wheels positions
- black bodies (calibration sources T°)
- cooler operation

3.4 DPU functions

The DPU Software implements the "high-level" instrument functions, which should not be duplicated in the subordinate controllers DEC/MEC and SPU. The following section describes the DPU software functions of interest to the DEC/MEC developer.

The text is extracted from the DPU user requirements document [RD5]

Dialogue with subsystems and check of health status of the instrument (autonomous functions). On the base of HK parameters DPU/ICU can ask OBDH to switch off part or whole instrument.

A check will be performed on some of the parameters and, if the corresponding critical values are reached, the OBS will start the pre-defined autonomous functions in order to prevent any damage to the instrument. Depending on the severity of the detected anomaly, the measurement could even be reset and/or DPU/ICU could ask OBDH to switch off some subsystems.

The communications toward OBDH will be structured in packets which will contain all data: scientific measurements, HK parameters, reports of event as well as the request of switching off a subsystem or the whole instrument.

Furthermore, the OBS has to manage the uploading and downloading of (part of) the processor memory: this will allow to upgrade the OBS as well as all the subsystems parameters tables. Some subsystems run their own programs which will likely need upgrades: OBS will be in charge of receiving these patches and passing them to the appropriate subsystem.

For each instrument basic operating modes will be defined. The OBS will be able to handle the instrument behavior in all of them. The modes are described in the corresponding IID-B

Ground Contact : during the routine science mission phase, ground station contact and real time control will take place during a few hours per day (2 TBC). This means that the science operations will be done outside a ground control. They will be performed from a schedule but autonomously. In particular, the instruments will need on-board monitoring and autonomous features to recover from non nominal situations: this might require to switch off parts or the whole instrument.

The main functions of the [DPU] OBS are:

- *Acceptance of instrument commands from the ground via OBDH;*
- *Execution of predefined commanding sequences;*
- *Instrument health/status monitoring;*
- *Science data packetisation (and acquisition, in the case of HIFI);*
- *Transmission of data (science and HK) from the instrument to the OBDH;*
- *Implementation of predefined procedures on detection of instrument anomalies: the instrument shall be able to adjust parameters and/or switch operating mode and/or activate redundancy when an anomaly occurs.*

In addition, the [DPU] OBS shall provide the following SW oriented functions:

- *The ability to load, via TCMs, replacement and/or additional SW modules;*
- *Self test and SW verification facilities; Memory load and dump, EEPROM write and check.*

3.5 SPU functions

The SPU software implements the analysis of the raw data transmitted by the DEC/MEC, and outputs compressed data to the DPU for transmission to ground.

The SPU receives data and status information from the DEC/MEC, and commands from the DPU.

It returns processed data to the DPU, and has nothing to say to the DEC/MEC.

4 Environment and constraints

4.1 Operating system

The DEC/MEC software shall be implemented as a set of tasks under a real-time operating system (VIRTUOSO[tm]) running on a 21020 DSP processor. [1]

4.2 Hardware

The DEC/MEC hardware (as viewed by the software) will consist of :

- a processor module with DSP CPU, RAM, ROM, EEPROM, Clock, start-up and power save logic, and 6 IEEE1355 « spacewire » serial bi-directional communication links.
  - In the AVM model, this module will consist of the DASA MOSAIC020 board
  - In the EM and further models, this module will consist of the CRISA DSP board, identical to the SPU processor board, with an additional "mezzanine" board for 3 links + CSL timing logic.
- Two « DEC » modules, in charge of the detector arrays timing and data acquisition, each one using a 1355 link for communication with the processor board. The DEC modules themselves will have no CPU.
- One « interface » module, containing the input and output circuits for the instrument mechanisms and housekeeping sensors, interfaced through the back-plane and appearing as a set of registers to the software.

4.3 Interfaces

The external interfaces will be implemented by 1355 links, possibly at reduced speed or unidirectional, according to the actual needs :

- a 10 Mbps bi-directional interface with the DPU will be used to receive commands and operation sequences, and transmit status and housekeeping data
- two 10 Mbps unidirectional interfaces with the SPU, each one being dedicated to the data from one of the detector arrays (called hereafter « blue » or “short wavelength” and « red » or “long wavelength”)
- one 10 Mbps bi-directional interface with the controller of the bolometers array and cooler

Additionnally, the hardware units exchange synchronisation signals by means of master clocks (MEC to DEC) and readout synchronisation signals (DEC and BOLC to MEC)

[1] VIRTUOSO is a real time operating system from the company EONIC SYSTEMS, now property of WindRiver

4.4 Microprocessor (DSP) constraints

1. Program bus: 48 bits
2. Data bus: 32 bits
3. Memory dimensions 128 Kw of data memory + 128 Kw of program memory (TBC)
4. Clock speed 18 MHz

4.5 Users characteristics

For general purpose commanding and housekeeping functions, the natural "user" of the software will be the DPU OBS software. In flight configuration, the DEC/MEC software is invisible. There is no human interface. The DEC/MEC is handled through the DPU.

For the specific case of the data acquisition sequences, the DPU will transfer the list of instructions from ground to DEC/MEC without translation or checking. Therefore, the syntax for the generation of sequence files will have to be part of the user documentation.

4.6 Operational environment

The DEC/MEC will interface with the DPU through a serial interface (IEEE-1355 / Spacewire). The communications with the other subsystems will be done either through IEEE-1355 serial interfaces or specific interfaces as described in the specific subsections. All interfaces will use LVDS hardware and the 10 Mbps data rate.

4.7 Development environment

The software will be developed using the following environment:

- Virtuoso 4.X as operating system (Virtuoso is a trademark of Eonic Systems nv)
- AxyomSys 3 as structured analysis based CASE tool (AxyomSys is a trademark of Structured Technology Group, Inc.)
- SIGMA 4 33MHz ADSP 21020 development board for SW testing (the Sigma board is manufactured by BittWare research systems)
- MOSAIC020 DSP board (the board is manufactured by DASA)

4.8 DEC/MEC software functions

4.8.1 Direct commands

The DEC/MEC software shall receive commands from the DPU, which it will execute immediately after reception and validity check.

The command list and syntax is defined in the DPU to DEC/MEC ICD [RD11].

The commands shall include the following types :

- write to DEC/MEC memory (for parameters lists, mechanisms set-points, etc…)
- read from DEC/MEC memory
- request to perform a mechanical action
- write a “sequence of operations” to DEC/MEC memory, for execution at a later time

The execution of a command shall not block the transmission of housekeeping packets, and the DEC/MEC software shall accept some subset of the commands list (such as "abort sequence") while a command is executing. (to be detailed in the software user manual)

4.8.2 Sequencer operation - spectrometer mode

The succession of events in the sequence will be fixed, the timing of each event and the number of events will be programmable by loading a list of parameters before starting the execution of the sequence

The duration of the sequence execution will depend on the combination of parameters values but will be finite (the sequence will terminate after some calculable time)

There will be no possibility of deadlock : each elementary operation will be non blocking or protected by a time-out, and failure in any operation will be reported to the DPU

The software shall always remain able to accept a DPU command to abort the execution of the sequence.

4.8.2.1 Basic timing facts of the photoconductors arrays operation

Note : this section can only be understood with reference to the DEC hardware specification contained in [AD4] and background information from IMEC

A “readout” is the action of receiving a set of pixel values from a detector array. It is also the name of the data set itself. The detectors integrate the light and produce a value linearly varying with time, until reset by the hardware. Once the timing parameters are programmed, the detectors perform continuously the integration / reset cycle. One cycle is called an integration ramp (or just “a ramp”)

One can program the hardware to take a number of readouts during the ramp, called “non destructive readouts”, and a last one occurring just before the reset and called “destructive readout”.

In the following sections, the following names are used :

Ri is the readout interval,

Nr is the number of readouts per integration ramp,

Tr is the time per readout (expressed in CRE clock periods)

Master clock frequency : the frequency of the (very stable) main oscillator from which all detectors timings are derived. The nominal value is 131 KHz, supplied by the spacecraft as "OBT CLOCK"

CRE clock : the timing signal generated by the DEC module and distributed to the CRE devices.

The interval between readouts and the duration of a readout can be computed from the detectors parameters and will be fixed for the duration of the sequence :

The nominal interval between readouts is 1/256 second

The duration of a readout is 22 CRE clock periods from the CRE point of view.

If Tr > 22 then there are (TR-22) CRE clock pulses when the detectors are integrating and no transmission takes place from CRE to DEC.

The nominal CRE clock frequency (in flight) is fixed at 8192 Hz.

For test purposes, the timing logic will be able to generate TBD submultiples of 8192 Hz.

4.8.2.2 Integration cycle

Each « ramp » is sampled with Nr-1 non destructive readouts followed by one destructive readout. For thermal stability reasons, the parameters should be set before starting the sequence and not modified during execution. In flight, Nr will not be less than 8.

The DEC hardware will continue executing integration cycles until instructed otherwise by new parameters.

There is no idle time, i.e. Ni integration cycles are executed with the same parameters. The number of ramps performed at the same chopper position is under software control, i.e. it is up to the MEC software to count the ramps and decide to move the chopper, while the DEC timing hardware will continue performing readouts until instructed otherwise.

4.8.2.3 Mechanisms repositioning

After Nr * Ni readouts have been performed, the last one being a destructive readout, the following events should occur according to the sequence executed by the MEC software :

the DEC continues performing integration cycles while the software moves the chopper,

the software has reset the « readout valid » bit in the header,

the following readouts are transmitted to the SPU but the status bits in the header allow to reject the invalid readouts,

the software may set the « readout valid » bit again at any integration cycle boundary (nominally the next one).

The same procedure applies for the grating as for the chopper.

If both detector arrays are used simultaneously, they should be programmed with the same parameters, except possibly the Nr parameters, where one could be an integer multiple of the other.

In that case, the mechanisms synchronisation function should use the slowest one (with the longest integration ramp)

4.8.3 Sequencer operation - photometer mode

The handling of bolometer data acquisition is the same as the photoconductors handling, except for the following :

- the grating will not be used in photometry mode
- the readout interval will be fixed at 40 Hz
- the number of readouts between chopper movements will be nominally 4
- there is no integration ramp, all readouts are assumed the same
- the "invalid" bit would not be used (TBC by DEC/MEC - SPU ICD)
- the software will manage a "readout counter" for the bolometer

5 User Requirements

5.1 Development and Quality Requirements

DECMEC-UR-00 :

Each requirement shall be uniquely identified by its ID code according to the following template: DECMEC-UR-nnnn.

DECMEC-UR-01 :

The DEC/MEC shall be designed as a “coprocessor” for the DPU. The DPU shall have as much visibility as possible on the internal state and operations of the DEC/MEC.

DECMEC-UR-02 :

The DEC/MEC software shall be modular. Independent functions shall be implemented in separate tasks. The DEC/MEC shall continue to operate properly even if a specific hardware component or mechanism and its associated software task is not present, does not answer or fails prior or during any sequence.

DECMEC-UR-03 :

The DEC/MEC software shall only use such Virtuoso operating system functions that have been declared “safe” by ESA. No condition or combination of conditions shall result in a “deadlock” or unknown state

DECMEC-UR-04 :

The DEC/MEC software design shall use static allocation of variables and a fixed number of tasks, and generally refrain from using techniques that can result in an unknown or random amount of resources being used.

DECMEC-UR-05 :

There shall be an appropriate interface defined with the ground segment, such that the way to designate commands and parameters is perfectly documented, as well as the way to perform software patching.

DECMEC-UR-06 :

The DEC/MEC software shall be designed to allow “patching” i.e. TBD parts of the software shall be replaceable in flight by downloading code through the DPU without requiring modification to the remaining part of the software.

5.2 General functional

5.2.1 Switch-on requirements

DECMEC-UR-07 :

The DEC/MEC shall perform a check of its processor and memory after switch-on, up to the point where correct reception and execution of DPU commands is ensured. If this point is not reached, the DEC/MEC software should "hang" without initialising the communication links, to ensure it will be noted "failed" by the DPU software. The reporting of further defects shall be done according to ICD.

DECMEC-UR-08 :

The DEC/MEC software shall put all mechanisms and both DECs in a defined electrical state at switch-on (detector arrays OFF, all mechanisms unpowered, all thermal regulations inactive), by writing initial values to all command outputs.

Note : the software should not rely on the hardware initializing itself in the required state.

DECMEC-UR-09 :

At DEC/MEC switch-on, there shall be no command to move the mechanisms. Even if they are not in a known position, they will not be moved (e.g. to seek a reference mark) without a DPU command.

DECMEC-UR-10 :

After switch-on, the DEC/MEC shall start its housekeeping task and wait for a command from the DPU

Note : the DEC/MEC shall not by itself check its health or the health of its dependent modules, e.g. by comparing a list of HK parameters with pre-defined value. This is a DPU responsibility.

DECMEC-UR-11 :

If there is no command from the DPU (or the DEC/MEC hardware senses the 1355 link being "down") within a TBD time-out after power-on, the DEC/MEC shall attempt to restart the link as per 1355 or Spacewire specification, and signal itself ready to accept commands.

DECMEC-UR-12 :

The DEC/MEC start-up operations shall not last more than TBD seconds (before it is able to accept a DPU command)

Note : a short integrity check of the basic DSP board operation is allowed, see UR 07.

DECMEC-UR-13 : Disallowed by ESA

~~After a successful switch-on, the DEC/MEC will accept its user program from HERSCHEL solid state mass memory routed through DPU (TBC)~~

5.2.2 Switch-off requirements

DECMEC-UR-14 :

The DEC/MEC software shall be designed to handle all possible cases arising from the switching off of the hardware at any time, even while a mechanism is operating.

DECMEC-UR-15 :

~~The DEC/MEC shall signal to the DPU in its housekeeping data set the time intervals when a voluntary switch-off is allowed. The exact procedure for switch-off shall be documented.~~

DECMEC-UR-16 :

In the event of an accidental switch-off of the DEC/MEC (e. g. by the operation of a spacecraft circuit breaker) at a time when it has not been allowed due to on-going mechanical operations, it shall be possible to recover full functionality after specific recovery actions have been commanded by the DPU. The list of such actions shall be documented.

5.2.3 Housekeeping requirements

DECMEC-UR-17 :

The DEC/MEC shall autonomously sample a set of measurement variables using the available hardware. It shall send the measurements to the DPU at regular intervals without DPU intervention.

Note : IFSI requirement.

DECMEC-UR-18 :

The DEC/MEC shall be able to provide the nominal HK data set (with a pre-defined content) at a normal reporting rate of 0.5 Hz TBC (one complete data set every 2 seconds)

DECMEC-UR-19 : deleted - see UR22

~~The DEC/MEC shall be able to modify, accordingly to dedicated DPU commands, the pre-defined list of HK parameters to be included into the HK TM data set, as well as the reporting frequency.~~

DECMEC-UR-20 : deleted - see UR22

~~The DEC/MEC shall be able to provide (read back) the values of all commandable parameters related to the housekeeping function, i.e. the list of HK parameters and the interval (TBC)~~

DECMEC-UR-21 :

The DEC/MEC shall provide only actual values of the HK parameters and not changes (or delta values) since the last readout: the *filtered* reporting mode is not allowed

DECMEC-UR-22 :

For diagnostic purposes, it will be possible to generate HK messages containing oversampled data.

The sampling rate and the list of channels shall be configured by the DPU

The maximum sampling rate shall be 256 samples per second (TBC)

There shall be a mode where the sampling rate is given by the red DEC readout interval (TBC)

There shall be a mode where the sampling rate is given by the blue DEC readout interval (TBC)

There shall be a mode where the sampling rate is given by the BOLC readout interval (TBC)

The DEC/MEC may limit the number of parameters available in this mode.

Note (from IFSI applicable to PACS and SPIRE): *each subsystem is in charge of generating its own internal HK parameters. The DPU shall transmit the request to the specific subsystem, shall read the value with the requested frequency and shall generate the corresponding TM packets. No check will be made that the subsystem actually sampled the parameter with the correct frequency*

DECMEC-UR-23 :

The DEC/MEC shall provide a subset of the housekeeping along with the science data, to allow further data processing without the necessity to refer to the housekeeping and extract the needed parameters at the correct times. The set of subsystem parameters, all sampled at a known time relative to the detector sampling time, to be included in the science data shall be listed in the DEC/MEC to SPU interface document (ICD)

DECMEC-UR-24 :

The housekeeping data set shall contain the measurement of 1.7 K level and 4K level temperature sensors (2 x 2 units per detector array, acquired through DEC modules)

DECMEC-UR-25 :

The housekeeping data set shall contain all measurements acquired through the BOL module

DECMEC-UR-26 :

The housekeeping data set shall contain the measurement of 15 K level temperature sensors (2 units)

DECMEC-UR-27 :

The housekeeping data set shall contain the measurement of mechanisms temperature sensors (5 units: chopper, grating, filter wheel 1, filter wheel 2, calibration source housing)

DECMEC-UR-28 :

The housekeeping data set shall contain the measurement of SPU temperature (3 sensors , technical details in applicable ICD)

DECMEC-UR-29 :

The housekeeping data set shall contain the measurement of SPU secondary voltage and current (2 channels , technical details in applicable ICD)

DECMEC-UR-30 :

The housekeeping data set shall contain the measurement of CRE voltages and currents

Note : these measurements are defined in the hardware description documents [AD4] and existing IMEC documentation

DECMEC-UR-31 :

The housekeeping data set shall contain the measurement of DEC/MEC voltages and currents (estimated 10 channels, according to hardware design)

DECMEC-UR-32 :

The housekeeping data set shall contain the measurement of MEC internal temperatures (1 sensor located on the DSP chip, 1 sensor on the DC/DC converter TBC)

5.2.4 Synchronization requirements

There is no synchronization requirements on the software : there is no time / date maintained internally by the DEC/MEC. All operations are either commanded by the DPU and immediately executed, or stored as a sequence file which execution is triggered by the DPU and step by step synchronized by the detectors arrays timing hardware.

A time stamping scheme has been outlined in "Proposal for time stamping the science data" in reply to action n° 01 from OBS meeting 03/2000 and updated in subsequent OBS meetings.

The final specification shall be taken from the applicable ICD.

An instrument synchronisation requirement and mechanical jitter avoidance mechanism is implemented in the DEC/MEC hardware. The software operation is time-locked via the interrupt mechanism. The technical details shall be taken from :

Programmable logic specification
DSP to MIM (mechanisms interface module) ICD
Crisa Hardware/Software ICD

5.2.5 Testing and maintenance requirements

DECMEC-UR-33 :

The DEC/MEC hardware and software shall be testable by the DPU through the use of the normal commands and additional test-specific commands if needed.

DECMEC-UR-34 :

Self test and software verification facilities shall be provided, including the generation of dummy data for replacing the detectors readouts, also in flight.

DECMEC-UR-35 :

It shall be possible to modify the DEC/MEC software, either by modifying the code in non-volatile memory or by patching the code in working memory.

DECMEC-UR-36 :

Functionally distinct memory areas shall be assigned to the following categories: code; fixed data; variables and parameters.

DECMEC-UR-37 :

It shall be possible to load, dump and check the contents of either a contiguous memory area or of several non contiguous memory areas: the DPU shall be able to read from, write to and checksum areas of, the DEC/MEC memory blocks

Note (from IFSI): the DPU will not be in charge of detecting data corruption in the memory area of other subsystems

DECMEC-UR-38 :

An “are you alive” function shall be provided for testing the end-to-end connection between ground and DEC/MEC, on request originating from OBDH and transmitted through the DPU

Note (from IFSI applicable to PACS and SPIRE): It is here assumed that other subsystems will provide their own “are you alive” functions that can be requested independently from DPU. However it is also possible that the “are you alive” function is thought only at instrument level, in the sense that this function is requested from ground only to DPU which sends “are you alive” request to the other sub-systems. In this case this requirement shall be re-stated.

In this URD the sending of housekeeping data at regular intervals is considered an adequate life sign.

5.2.6 Autonomous functions requirements

There are no requirements for autonomous reaction to events (anomalies, etc…) at the level of the DEC/MEC. All autonomy functions will be implemented at the DPU OBS level.

The following requirements specify the DEC/MEC software functions that are needed to support the execution of the DPU autonomy functions.

DECMEC-UR-39 :

The DPU OBS is required to transmit reports of normal progress of operations/activities generated by any onboard function. Therefore, for long execution processes, such as the execution of an acquisition sequence, the DEC/MEC shall report to the DPU in the HK data set or by other means TBD the start and the end of the process as well as any suitable intermediate status, either periodically or at pre-defined steps in the execution (TBC)

DECMEC-UR-40 : deleted OBS meeting 16/3/2000

~~The DEC/MEC software shall reject a DPU command or abort an operation if it can determine that a DEC/MEC controlled action would be unsafe, based on internally available data, the contents of the command, simple static rules embedded in the code, and possibly DPU-modifiable parameter values.~~

~~*Examples of such situations*~~

~~- *attempt to move a mechanism beyond its known constructive range of operation*~~
~~- *attempt to program a set-point outside of a predefined safe operating range*~~

~~*Example of a situation that can not be handled by the DEC/MEC software :*~~

~~- *attempt to set the detector integration time to a value that would result in saturation of the detector, knowing the incident flux (which the DEC/MEC software cannot measure)*~~

~~*Note : this is redundant with ground control and with DPU operation, both should be designed to avoid sending unsafe commands.*~~

5.2.7 DPU Interface requirements

DECMEC-UR-41 :

The DEC/MEC shall support all the operative modes described in [RD4]. This will be done by providing commands available to the DPU for putting the instrument in the required mode. The DEC/MEC software itself shall not have modes.

DECMEC-UR-42 :

The DEC/MEC shall receive commands from the DPU through the IEEE 1355 link according to a specific protocol described in [RD11]

DECMEC-UR-43 : deleted OBS meeting 16/3/2000

~~The DEC/MEC shall be able to decode commands and acknowledge or reject a command according to command formatting rules and its own current state~~

DECMEC-UR-44 : deleted OBS meeting 16/3/2000

~~The DEC/MEC shall allow the DPU to read back the command and authorize or drop execution~~

~~*Note : check with IFSI whether this requirement is still needed and which commands are concerned*~~

DECMEC-UR-45 :

The DEC/MEC shall accept the following command types from DPU : "Read/Write" and "Trigger"

DECMEC-UR-46 :

A "Read/Write" command shall correspond to a reading or writing operation performed by the DPU OBS in the DEC/MEC memory space visible from DPU

DECMEC-UR-47 :

Any command of type "Read/Write" shall uniquely identify the target memory area by specifying the starting address and range

DECMEC-UR-48 :

The DPU OBS will check, and the DEC/MEC software shall ensure, that writing operations are not executed on "Read only" parameters

DECMEC-UR-49 :

Specific messages shall be available for sending a set of housekeeping measurement values to the DPU

The (unsolicited) HK message shall be distinct from the other responses from DEC/MEC to DPU

DECMEC-UR-50 :

Commands shall be available for activating or deactivating different hardware components (black bodies, detector arrays, bolometers cooler)

DECMEC-UR-51 :

The current state of all components that can be started / stopped shall be available in a "status" section of the housekeeping data set (to enable verification by the DPU)

DECMEC-UR-52 :

Commands shall be available for downloading and reading back parameters and operations sequence at the appropriate location ("operations sequence" is defined below)

DECMEC-UR-53 :

The DEC/MEC shall be able to receive from the DPU a list of instructions (contents, syntax and maximum size are TBD) called "operations sequence" or "sequence file"

DECMEC-UR-54 :

Specific "trigger" type commands shall be available for starting, stopping, aborting the execution of the operation sequence under DPU command

DECMEC-UR-55 :

~~The command for starting the execution of a sequence will contain an identifier generated by the DPU (on board time at the start of the sequence, TBC). The software shall label all science data generated during that sequence with the supplied identifier.~~

DECMEC-UR-56 : deleted OBS meeting 16/3/2000

~~The DEC/MEC software shall have the capability to reject assigning a value to an internal parameter if the value is out of bounds. The bounds for each parameter shall be modifiable by DPU commands.~~

5.3 Instrument control requirements

5.3.1 Operation sequencing

DECMEC-UR-57 :

The DEC/MEC shall be able to keep a list of instructions called "operations sequence" or "sequence file"in its internal storage for future execution. Contents, syntax and maximum size are TBD.

Note : it is not required to store several different lists of instructions at the same time

DECMEC-UR-58 :

The DEC/MEC shall be able to execute the sequence of instructions by performing the actions sequentially or as directed by embedded specific sequence control instructions such as « repeat n » etc.

DECMEC-UR-59 :

In spectrometry mode, the DEC/MEC shall derive the timing of execution from the photoconducting detector arrays controller : the sequencer must synchronise its operations on the reception of the last

« frame » sampled from an integration ramp (called the « destructive readout »). The highest rate specified for this event is 32 times per second (256 readouts/s and 8 readouts/ramp)

Note : The detector arrays are not always active (transmitting readouts). The software shall handle in a consistent way (to be documented in the software design document) the case when both detector arrays are inactive, i.e. transmitting no readouts.

DECMEC-UR-60 :

In spectrometry mode, if both detector arrays are commanded to operate, the DEC/MEC software shall ensure that the detectors integration ramps start synchronously (within 2 µs TBC).

Note : The timing parameters set by the operators through the DPU will be such that one detector array integration time is the same as the other detector array integration time, or an integer multiple thereof. Checking that condition is not of the DEC/MEC software responsibility.

DECMEC-UR-61 :

In spectrometry mode, during the execution of a sequence, the synchronization event for the mechanisms, i.e. the time when the software is allowed to start a mechanism operation, shall be as follows :

- if only one detector array is active, then the synchronization event is the destructive readout terminating an integration ramp of that detector array.
- if both detector arrays are active and have the same timing parameters, then the synchronization event is the destructive readout terminating an integration ramp, taken from one of the arrays.
- if both detector arrays are active and have different integration times, then the synchronization event is the destructive readout terminating the slowest (or longest) integration ramp
- If no detector array is active, or if outside a data acquisition sequence, then the mechanisms can move at any time

Note : requirement 60 ensures that all detectors terminate an integration ramp at the same time.

DECMEC-UR-62 :

During execution of a sequence, the software shall be able to handle some types of instructions that require new parameter values to be computed and transmitted to other software modules controlling the mechanisms.

Example of such instructions are :move the chopper to an absolute position with dithering enabled.

In that example, the sequencer software shall compute a pseudo random number, add it to the chopper set-point contained in the instruction, and transmit the result to the software module in charge of controlling the chopper motion.

DECMEC-UR-63 :

In all modes, the movements of the mechanisms shall be triggered by the synchronisation condition specified in UR 61, in addition with a hardware flag specifying the exact sampling interval when the movement should begin.

According to the detector controller currently in use (DEC blue, DEC red or BOLC) the software shall configure the synchronisation hardware to use the appropriate input signal. A TBD settling period shall be allowed after selection of a new synchronisation source, before starting a data acquisition sequence.

DECMEC-UR-64 :

It is wished that the detectors stay active even during mechanisms operation within a sequence, in order to keep them in thermal equilibrium. The DEC/MEC software shall communicate to the SPU software which readouts have occurred during mechanisms operation, e.g. by setting an "invalid readout" flag, so that the SPU software will not handle them as science data.

DECMEC-UR-65 :

The DEC/MEC software executing the sequence of instructions shall report its state and the current location in the sequence to the DPU by means of the housekeeping data set

DECMEC-UR-66 :

At any time during sequence execution the DPU shall be able to abort the sequence.

DECMEC-UR-67 :

The software shall keep the following parameters unchanged during sequence execution. They shall be considered as part of the « instrument mode ».

- photoconducting detectors arrays parameters : on / off, integration capacitor select, clock frequency, number of clock periods between readouts, number of readouts per ramp, biases.
- Bolometers arrays parameters (according to applicable BOLC to DEC/MEC ICD)
- imaging mode : spectrometry or photometry
- sequence parameters (chopper movements, grating movements, valid frames count, etc…)
- filter wheels positions
- calibration parameters (in flight calibration through chopper/black bodies/flip mirror)

Note : modifications to these parameters should be commanded by the DPU before putting the DEC/MEC in its autonomous data acquisition mode.

DECMEC-UR-68 :

The software shall implement a command for moving the grating to an absolute position expressed in encoder steps from the reference mark

That command shall be available in "direct" mode (executed when received from the DPU) and as part of a sequence

DECMEC-UR-69 :

The software shall implement a command for moving the grating to a relative position expressed in encoder steps from the current position

That command shall be available in "direct" mode (executed when received from the DPU) and as part of a sequence

DECMEC-UR-70 :

The software shall implement a command for moving the chopper to an absolute position expressed in encoder steps from a TBD reference.

That command shall be available in "direct" mode (executed when received from the DPU) and as part of a sequence

DECMEC-UR-71 :

The software shall implement a command for moving the chopper to a relative position expressed in encoder steps from the current position

That command shall be available in "direct" mode (executed when received from the DPU) and as part of a sequence

DECMEC-UR-72 :

The software shall implement a command for modifying the chopper position by a TBD "dither" amount expressed in encoder steps. The dither is a configurable pseudo random amount added to the absolute or relative setpoint.

That command shall be available as part of a sequence.

Note : An example of a list of commands (sequence file) for a possible acquisition scenario is contained in the "DEC/MEC software preliminary specification" [RD 8]

5.3.2 Grating control

DECMEC-UR-73 :

The DEC/MEC software shall implement a position servo closed-loop algorithm with an update rate of 8192 Hz - other (lower) rates shall be possible.

DECMEC-UR-74 :

The DEC/MEC software shall implement the conversion of the torque command into the currents for the 0° and 90° coils taking into account the angle readout (« electronic commutation »)

DECMEC-UR-75 :

The DEC/MEC software shall contain a trajectory generator for implementing the optimal move between successive set-point values generated by the execution of a sequence

Note : the trajectory computation will be defined by design knowing the mechanical parameter, the current baseline is a linear ramp to limit the setpoint rate of change to a safe value.

DECMEC-UR-76 :

The DEC/MEC software shall read out the angle encoder and perform plausibility (range) check, report status and housekeeping data to the DPU in the housekeeping data set

Note : the software is not required to perform calibration or linearity corrections or conversion from encoder units to actual angle units. The DPU software can specify the grating set-points in encoder units

DECMEC-UR-77 :

The software shall have an origin seek mode to recover the knowledge of the grating absolute angular position after power ON

DECMEC-UR-78 :

The software shall have a degraded mode where the grating motor will be controlled in open loop by sine and cosine waveforms at a programmable rate, in the event of an angle encoder failure

Note : the grating angular speed would have to be limited and the home position would be a mechanical stop (" hard limit")

DECMEC-UR-79 :

The software shall contain a specific procedure for unlocking and relocking the launch lock under DPU command

DECMEC-UR-80 :

The DEC/MEC software shall turn on or off the grating position control when commanded by the DPU. In the "off" state, all components located in the cold focal plane unit (motor, encoder, limit switches, reference position detector) shall dissipate no power.

DECMEC-UR-81 :

The DEC/MEC software shall have a "parking" procedure that shall ensure that the grating is brought to rest at a TBD parking position.

Note : the procedure may include specific actions on the hardware, according to hardware specifications, such as short-circuiting the motor coils.

DECMEC-UR-82 :

The DEC/MEC grating servo software shall accept a list of parameters that can be modified in flight by downloading values through the DPU interface

5.3.3 Chopper control

DECMEC-UR-83 :

The DEC/MEC software shall implement a position servo closed loop algorithm with an update rate of 8192 Hz - other (lower) rates shall be possible.

DECMEC-UR-84 :

The DEC/MEC software shall implement a degraded mode where broken sections of the coil are bypassed by hardware switches (technical details in Chopper to DEC/MEC ICD and DEC/MEC electronics design documents)

DECMEC-UR-85 :

The DEC/MEC software shall implement the conversion of the torque command into the coil current, taking into account which section(s) of the coil are in use (see previous UR)

DECMEC-UR-86 :

The DEC/MEC software shall contain a trajectory generator for implementing the optimal move between successive set-point values generated by the execution of a sequence.

Note : the trajectory computation will be defined by design knowing the mechanical parameters.

DECMEC-UR-87 :

The DEC/MEC software shall read out the angle encoder and perform range check, report status and housekeeping data to the DPU in the housekeeping data set

Note : the software is not required to perform calibration or linearity corrections or conversion from encoder units to actual angle units. The DPU software can specify the chopper set-points in encoder units (to be checked with project)

DECMEC-UR-88 :

The software shall have specific procedures for ~~launch lock and~~ cool down states (TBC)

~~*Note : The launch lock function may be implemented by short-circuiting the coil*~~

Note : the cool down state may be implemented by driving the chopper at end of range against a cooling bar arranged as a mechanical stop.

DECMEC-UR-89 :

The DEC/MEC software shall turn on or off the chopper position control when commanded by the DPU. In the "off" state, all components located in the cold focal plane unit (coil, encoder) shall dissipate no power.

Note : there is no "parking" procedure specified as the chopper will be brought back to the central position by the elasticity of its bearings

DECMEC-UR-90 :

The DEC/MEC chopper servo software shall accept a list of parameters that can be modified in flight by downloading values through the DPU

5.3.4 Black bodies control

DECMEC-UR-91 :

The Black bodies control software shall implement a temperature control closed loop algorithm (technical details in the "calibration sources to DEC/MEC ICD") with an update rate of 1 s or slower

Note : there are two independent calibration sources.

DECMEC-UR-92 :

The software shall contain a trajectory generator for implementing the optimal move between successive set-point values transmitted by the DPU

Note : The black bodies temperature set-points are not expected to be changed during a data acquisition sequence.

Note : the optimal trajectory computation will be defined by design knowing the thermal time constant and other relevant parameters.

DECMEC-UR-93 :

The software shall turn on or off the temperature control by DPU command for each black body independently

DECMEC-UR-94 :

The software shall include an image of the actual temperature in the housekeeping data set

Note : when a black body is turned off, there shall be no temperature measurement, to avoid dissipating power in the cold focal plane (TBC with project)

Note : the DEC/MEC software shall work with raw data (volts or ohms) and perform no conversion to temperature units. The sensor calibration table can be implemented on ground.

DECMEC-UR-95 :

The temperature control software parameters shall be modifiable in flight by downloading values through the DPU.

5.3.5 Wheels control

DECMEC-UR-96 :

The Wheels control component of the DEC/MEC software shall handle 2 filter wheels with 2 positions each.

Note : the software is not required to move more than one wheel at a time

DECMEC-UR-97 :

The software shall be able to handle wheels that are identical as far as the drive is concerned, but differ by the number and location of the stop positions.

DECMEC-UR-98 :

The software shall implement a positioning algorithm where the motor coils are driven in open loop by sine and cosine waveforms at a TBD speed and sample rate (method not yet validated !!!)

Note : There are only a small number of valid set-points for each wheel, spaced 180° apart and the trajectories can be limited to performing a constant number of steps at constant speed.

DECMEC-UR-99 :

The software shall implement a trajectory generator for implementing the optimal move between successive set-point values transmitted by the DPU

Note : the trajectory computation will be defined by design knowing the mechanical parameters.

DECMEC-UR-100 :

The software shall implement the readout of limit switches, autonomously terminate the move when a stop position is reached, report status and housekeeping data to the DPU.

DECMEC-UR-101 :

When not commanded to move by the DPU, the wheels shall be in the “off” state, all components inside the cold focal plane unit shall dissipate no power (motors, position detectors)

DECMEC-UR-102 :

There shall be a command that shall cause the software to momentarily power up the limit switches to determine the current positions of the wheels and report them to the DPU in the housekeeping data set. If a position can not be determined because a wheel is not at one of its stop points or a position detector has failed, the software shall indicate the condition to the DPU

DECMEC-UR-103 :

The software shall contain an initialisation procedure, by which the wheels will be brought to a known stop position from any starting position, known or unknown.

DECMEC-UR-104 :

The wheels shall only be driven outside of acquisition sequences (while detector arrays, grating and chopper are inactive)

Note : to be reviewed with project. There is a possibility that the filter will have to change for some grating position range. Also to be reviewed : the electronics design might share the same drive components between several mechanisms which are not meant to be used simultaneously.

DECMEC-UR-105 :

The software shall have a degraded or test mode where the wheels shall move a fixed number of steps so commanded by the DPU, without checking the limit switches.

DECMEC-UR-106 :

The wheels control software parameters shall be modifiable in flight by downloading values through the DPU

5.4 Detector control and data handling requirements

5.4.1 Photoconducting detector array parameters

DECMEC-UR-107 :

The software shall be able to turn on/off each detector array individually on DPU request

Note : when a detector array is turned off, the corresponding controller module (DEC) is also turned off to conserve power, and all data stored in the DEC hardware, such as the timing parameters, are lost.

DECMEC-UR-108 :

The software shall be able to transmit one or more parameters from a specified set to each detector array, through a 1355 link, in the format acceptable to the detector control electronics as specified in [AD4]

Note : the hardware may impose restrictions on some aspects of the parameters transmission, such as timing, order, etc.

DECMEC-UR-109 :

There shall be two separate sets of parameters in the data memory, one per detector array. The requirement that some parameters have the same value for both detector arrays will be handled at a higher level (ground or DPU)

DECMEC-UR-110 :

The transmission of a set of parameters shall be synchronised with the detector arrays operation : if a DEC is not active, the parameters shall be transmitted immediately, otherwise the parameters transmission shall be triggered by the event « readout received » from that array (TBC)

To ensure synchronisation, the software may perform a master reset of the DEC modules before transmitting timing parameters. This is not necessary for bias and supply parameters.

DECMEC-UR-111 :

The software shall not check for consistency of the parameters values received through the DPU interface. Parameters values are supposed to be checked prior to command upload from ground.

DECMEC-UR-112 :

~~The software shall implement a closed-loop regulation of the detector debiasing, if required by the hardware design. The sampling rate shall not be higher than 1 Hz.~~

~~*Note : the formula will be supplied by the hardware design team*~~

DECMEC-UR-113 :

~~If required by the hardware design, the software shall implement a closed-loop regulation of the short wavelength detector array temperature at 2.2 K, with an update interval > 1 second.~~

Note : the baseline is to implement a number of fixed power levels, and let the DPU select the level appropriate to bring the detector array housing to 2.2 K in open loop. [CONFIRMED]

5.4.2 Photoconducting arrays image acquisition and SPU interface

DECMEC-UR-114 :

The Image acquisition part of the DEC/MEC software shall be able to handle two detector arrays working simultaneously at a maximum rate of 256 readouts/second/array

Note : a readout will contain 26 X 18 pixels + TBD housekeeping words (each of 16 bits)

Note : the rate given is the maximum in flight and the software should have enough performance margin.

DECMEC-UR-115 :

The data from a detector array will come in the form of a message on the 1355 link from the corresponding DEC module. The hardware is not designed to respond to a software command. The software shall wait for the messages and handle them as they come.

DECMEC-UR-116 :

When a message will arrive, the software shall detect the type of readout (non destructive or destructive) and generate a “readout received” internal event for that detector array, which will mark the time when a new set of parameters can be transmitted.

DECMEC-UR-117 :

In the case of a destructive readout from the detector array with the longest integration time, the software shall generate the "synchronisation" internal event which will be used by other parts of the software to synchronise themselves with the array operation (detector control, mechanisms control, etc…)

DECMEC-UR-118 :

The software shall implement a time-out and report an error condition to the DPU in the housekeeping data set if the message is not received at the rate defined by the corresponding detector array timing parameters

DECMEC-UR-119 :

The software shall decode the status information contained in the DEC message and make it available to the other tasks and to the DPU in the housekeeping data set

DECMEC-UR-120 :

The software shall extract the raw detector array image from the DEC message and format it for transmission to the SPU through the 1355 link

Note : depending on the hardware, some data manipulation may be needed, such as bit or word reordering, modifying the header part, etc…

The output format is specified in [RD12]

DECMEC-UR-121 :

Under DPU control the software shall be able to enter a degraded mode where data from both detector arrays are output to only one SPU link

DECMEC-UR-122 :

In the message to the SPU there shall be a flag telling the SPU software that the readout is invalid. The software shall mark "invalid" enough readouts from each detector array to cover the interval during which the mechanisms are moving.

DECMEC-UR-123 :

The data frames shall be marked invalid when a detector array is powered up, at least until thermal stabilisation is achieved.

DECMEC-UR-124 :

The data shall be marked valid by explicit DPU command after the detectors have stabilised and the satellite is pointing to the science target.

Note : this is a DPU or ground control decision, not a DEC/MEC software decision. The action would normally be performed by an instruction in the acquisition sequence file.

5.4.3 Bolometers array parameters and commands

Note : there is no power-on command to the bolometer array, the BOLC subsystem us fed directly from the spacecraft.

DECMEC-UR-125 :

The software shall be able to receive from the DPU, and transfer to the FPBCU, the commands defined in [RD17]

Note : Commands are composed of a 4-bit target identifier, a 4 bit parameter identifier, and an 8-bit parameter value. [RD17] specifies the following classes of commands :

Bolometer commands (targets 0...10)

Temperature control commands (target 11)

Clock sequencer commands (targets 12-13)

DECMEC-UR-126 :

Commands shall be transmitted to the FPBCU whenever they are received from the DPU. The software shall not perform any check.

DECMEC-UR-127 :

Commands shall be considered part of the instrument mode (not used inside acquisition sequences)

5.4.4 Bolometers arrays image acquisition and SPU interface

DECMEC-UR-128 :

The image acquisition part of the DEC/MEC software shall be able to handle two detector arrays working simultaneously at a maximum rate of 40 readouts/second

Note : a readout will contain

- *data from the first bolometer as 2 arrays of 16 by 16 16-bit pixels (16 x 32 pixels)*
- *data from the second bolometer as 8 arrays of 16 by 16 16-bit pixels (32 x 64 pixels)*
- *TBD housekeeping words*
-

DECMEC-UR-129 :

The data from both detector arrays will come in the form of a message on the 1355 link from the BOL controller module. The hardware is not designed to respond to a software command. The software shall wait for the messages and handle them as they come.

DECMEC-UR-130 :

Synchronization is required between the bolometers readout time and the mechanisms operation.

DECMEC-UR-131 :

The software shall implement a time-out and report an error condition to the DPU in the housekeeping data set if the message is not received at the rate defined by the corresponding detector array timing parameters

DECMEC-UR-132 :

The software shall extract the raw detector array image from the DEC message and format it for transmission to the SPU through the 1355 link

Note : depending on the hardware, some data manipulation may be needed, such as bit or word reordering, modifying the header part, etc…

The output format is specified in [RD12]

DECMEC-UR-133 :

Under DPU control the software shall be able to enter a degraded mode where data from both detector arrays are output to only one SPU link

DECMEC-UR-134 :

In the message to the SPU there shall be a flag telling the SPU software that the readout is invalid. The software shall mark "invalid" enough readouts from each detector array to cover the interval during which the mechanisms are moving.

DECMEC-UR-135 :

The data frames shall be marked invalid when a detector array is powered up, at least until thermal stabilisation is achieved.

DECMEC-UR-136 :

The data shall be marked valid by explicit DPU command after the detectors have stabilised and the satellite is pointing to the science target.

Note : this is a DPU or ground control decision, not a DEC/MEC software decision. The action would normally be performed by an instruction in the acquisition sequence file.