FIRST/PLANCK

INSTRUMENT INTERFACE DOCUMENT

PART B

INSTRUMENT "HET"

PT-HET-02125 (DRAFT 2)
(Created with WP for Windows version 6.1)
(Files at P:\hs\pi\wp\het-2125\he-**-**.wpw)

Prepared by: H. Schaap
FIRST Scientific Instr. Eng.
ESA/ESTEC, Noordwijk

Approval	
FOR INSTRUMENT : --	FOR ESA: -- Dr. Th. Paßvogel FIRST Payload System Manager ESA/ESTEC, Noordwijk

HET/ESA/R/0009.01

FIRST/PLANCK

INSTRUMENT INTERFACE DOCUMENT

PART B

INSTRUMENT "HET"

PT-HET-02125 (DRAFT 2)
(Created with WP for Windows version 6.1)
(Files at P:\hs\pi\wp\het-2125\he-**-**.wpw)

Prepared by: H. Schaap
FIRST Scientific Instr. Eng.
ESA/ESTEC, Noordwijk

Approval	
FOR INSTRUMENT : --	FOR ESA: -- Dr. Th. Paßvogel FIRST Payload System Manager ESA/ESTEC, Noordwijk

DOCUMENT CHANGE RECORD

Revision Status			Pages affected
Rev	Date	Approval	
Draft	May 1996		All (First Working Draft)
Draft 1	July 1997		All
Draft 2	27 August 1997		Comments H.vd. Stadt dd 17-06-97 incorporated. Mainly chapters 4 and 5.

DISTRIBUTION LIST

RECIPIENT	AFFILIATION	# of Copies
Th. de Grauw N. Whyborn	SRON. Groningen, NL SRON. Groningen, NL	
Prime Contractor		
A Robson	ESA/ESOC/MOD	
G. Pilbratt J. Tauber	ESA/ESTEC/SA ESA/ESTEC/SA	
M. Anderegg B. Collaudin P. Estaria F. Felici B. Guillaume M. von Hoegen Th. Paßvogel H. Schaap J.A. Steinz F. Vandenbussche FIRST Project file	ESA/ESTEC/PIP ESA/ESTEC/YCT ESA/ESTEC/PT ESA/ESTEC/PL ESA/ESTEC/PT ESA/ESTEC/PTQ ESA/ESTEC/PT ESA/ESTEC/PT ESA/ESTEC/PI ESA/ESTEC/PLS ESA/ESTEC/PT	

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of the Instrument Interface Documents (IIDs) is to define and control the overall interface between each of the FIRST/PLANCK scientific instruments and the FIRST/PLANCK spacecraft.
The IIDs consist of two parts, IID-A and IID-B.
Spacecraft performances, capabilities and requirements imposed on the instruments are described in part A of the documents, whilst instrument requirements on the spacecraft as well as instrument capabilities and performances are described in part B. The IID-B is in fact the successor to the Payload Definition Document (PDD)
There is one part A and there are just as many parts B, as there are instruments.

The IIDs are living documents.
The ESA Project team is responsible for updating and distributing the parts B. Updating takes place at regular intervals as a result of discussions and in agreement with the instrument teams.
As for the part A, after the initial issue by the ESA Project team it will be handed-over to the Contractor, who will take care of further updates and distribution.
Both IID-A and the IID-Bs will be part of the AO.

Chapter 4 of each of the IID-B documents consists of two parts.

The first part, from para 4 up to and including para 4.6.5 is devoted to descriptive information and background data necessary to enable a full and mutual understanding of the interface constraints between the spacecraft and instruments. This part is not to be considered as containing any requirement whatsoever, nor to imply any particular interpretation or meaning other than the one explicitly stated in the other chapters of this document and is therefore not applicable in any contractual sense.

The second part from para 4.7 onwards contains information relative to the scientific performance of the instrument. This part is to be considered as containing information which needs to be verified by test, analysis or a combination of the two and shall serve the purpose of demonstrating that the instrument will operate as intended for the particular mission.
Para 9.5 "Scientific Performance Verification" of the IIDs provides more information on this subject.

The IIDs will not cover any of the interfaces of the Instrument Control Centres (ICCs), the Data Processing Centres (DPCs) or the FIRST Science Centre (FSC)

2. APPLICABLE/REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

2.2 REFERENCE DOCUMENTS

3. KEY PERSONNEL AND RESPONSIBILITIES

3.1 KEY PERSONNEL

3.1.1 Acting Principal Investigator:

for the purpose of IID definition and the interface with ESA.

Dr. Th. de Grauw
SRON-Groningen
PO Box 800
9700 AV Groningen
The Netherlands

Telephone (Institute) : +31 50 3634074
Telephone (Home) : +31
Telefax : +31 50 3634033
E-mail : thijsdg@sron.rug.nl

3.1.2 Acting Project Manager :

for the purpose of IID definition and the interface with ESA.

Dr. N. Whyborn
SRON-Groningen
PO Box 800
9700 AV Groningen
The Netherlands

Telephone (Institute) : +31 50 3634052
Telephone (Home) :
Telefax : +31 50 3634033
E-mail : nick@sron.rug.nl

3.2 RESPONSIBILITIES

INSTITUTE	RESPONSIBILITIES

NAME	RESPONSIBILITY	TELEPHONE FAX EMAIL	ADDRESS

4. INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

The underlying idea behind coherent detection is to frequency translate the passband of the astronomical signal under observation to a much lower frequency. This is done by mixing the astronomical signal with a locally generated very stable monochromatic signal, the Local Oscillator (LO) signal, and extracting the difference frequency, the Intermediate Frequency (IF), for further processing. Such a system is known as a heterodyne (superheterodyne) receiver.

Heterodyne detection offers two important advantages. It enables observations of astronomical signals at frequencies so high that no amplifiers are available at the signal frequency. In addition, it provides isolation between the signal input and the very high gain amplifier system needed to further condition the signal. The price that has to be paid is that the mixing process itself (generally) involves a conversion loss of signal, and that a suitable LO signal has to be generated.

The mixer element must be as non-linear as possible, currently in ground-based submillimetre observatories Schottky diodes and Superconductor-Insulator-Superconductor (SIS) junctions are being used. The SIS is preferable because of its higher sensitivity, much lower LO power requirements, and possibly lower conversion loss; in the model payload described here only SIS mixers are used. A good coupling must be achieved between the sources of the astronomical and LO signals, normally by quasi optical means, and the mixing element which can be mounted either in a waveguide structure or in an "open" mount.

The IF signal is very weak and must be amplified close to the mixer before it can be passed on to other equipment. After further amplification and signal conditioning, the signal is analysed in a spectrometer which measures the signal strength in typically about 1000 frequency channels. The choice of IF frequency is dependant on the required IF bandwidth with sensitivity decreasing with increasing IF frequency. Typically the achievable bandwidth for low noise transistor amplifiers is 20-40%. In FIRST the required bandwidth is 2 GHz with a goal of 4 GHz which dictates an IF frequency of about 10 GHz.

The SIS mixing element must be physically cooled down to about 4 K or lower. This means that in the case of a cryostat spacecraft, the mixer array should be strapped to the superfluid helium cryogen tank. For best sensitivity the first IF amplifier must also be cooled to about 15 K. However, the subsequent electronics (IF chain), as well as the spectrometer, can be operated at ambient temperature ("warm"). Internal calibration loads are necessary.

4.2 SCIENTIFIC RATIONALE

Very high spectral (velocity) resolution necessitates the use of heterodyne techniques. A velocity resolution of a fraction of a kms $^{-1}$ is required, which corresponds to R ($= \nu/\delta\nu = \lambda/\delta\lambda$) $\sim 10^{6}$. Spectral coverage, preferably continuous, from the atomic carbon C^{0} (CI) line at 492 GHz to at least the para-H_2O $1_{11} - 1_{00}$ ground-state line at 1113 GHz, nominally to 1200 GHz. Sensitivity must be state-of-the-art, the sensitivity of HET observations will be limited by the instrument itself, not by the telescope background.

4.3 OVERALL CAPABILITIES

The HET instrument was designed with versatility in mind, since the model payload is just an example of a possible instrument. It is a multichannel receiver which, depending on how the various channels are allocated in frequency, could be configured as either a multifrequency receiver covering a wide frequency band, or alternatively, some channels could be allocated to the same frequency for redundancy and/or multibeam operations over a somewhat more limited total spectral range.

The instrument consists of an optical beam system coupling the astronomical signal from the telescope to the mixer array after combining it with the LO signal. The optical system also performs the function of chopping, and contains a system for calibrating the radiometer temperature scale.

Since the bandwidth of currently available mixers in the submillimeter range can be as high as 25 %, we have chosen a limited number of 5 frequency bands to give full spectral coverage between roughly 480 GHz and 1.2 THz.
Each frequency band is covered by 2 mixers for the 2 orthogonal polarisations. The total number of mixers will be 10, distibuted over 5 mixer assemblies for the 5 bands.
In addition a 6^{th} high frequency band is foreseen for limited bands around 1.8 and 2.5 THz. This will be a separate assembly with 2 hot-electron bolometer mixers.

All mixers are cooled to 2 K by a strap to the helium tank.

The low noise IF pre-amplifiers are mechanically mounted on the nominally 15 K plate close to the mixer array and are operated at 15 K. The optic unit includes a calibrator, which is also mounted on the 15 K plate. The second stage of the IF system is mounted on the radiation cooled CVV of the cryostat and is operated at 80-313 K. The unit containing the LO sources is located on the outside of the payload module, and operated at its equilibrium temperature. The rest of the IF chain and the back end spectrometers are housed in ambient temperature ("warm") compartments of the spacecraft payload and service modules. The back end spectrometers are of two types. The combination of 2 High Resolution Spectrometers (HRS) and 2 Wide Band Spectrometers (WBS) allows a spectral resolution to be selected between 250 KHz and 2.5 MHz, and offers up to 2000 (possibly 4000) spectral resolution channels.

4.4 HARDWARE DESCRIPTION

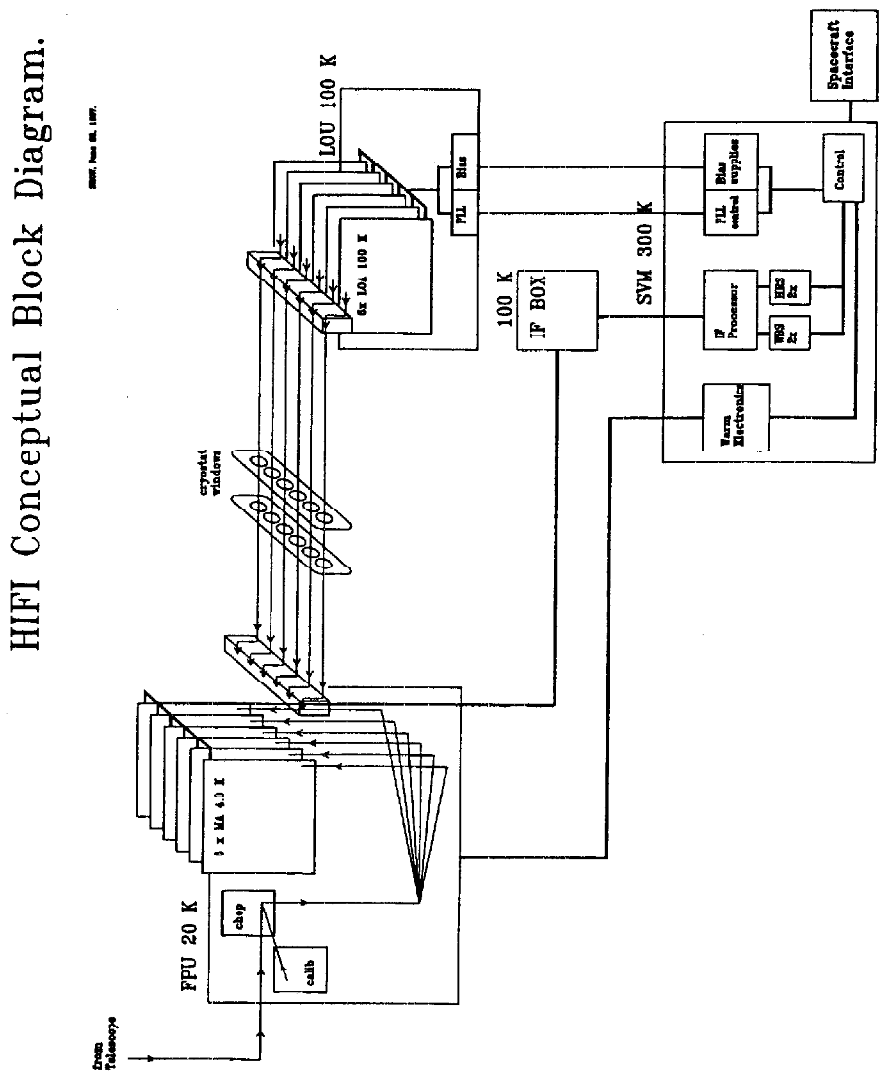


Figure: TBD HET functional block diagram

The HET instrument consists of:

1. A cold focal-plane unit, containing optics and the first stage of the IF pre-amplifiers mounted on the nominally 15 K plate, and 12 superconducting mixers at 2-4.5 K. (Add M3 ?? TBC)

2. The LO unit which is located radially outside of the payload module (PLM) and connected via a system of mirrors and windows to the focal plane unit.

3. The second stage of the IF system located on the outside of the PLM but within 2 m of the cold IF pre-amplifiers.

4. The PLL control for the LO unit, to be located in the service module (SVM) but within 5 m of the LO unit.

5. The ''warm'' IF processor, to be located in the SVM but within 5 m of the second stage IF amplifiers.

6. The spectrometers, 2 HRS, and 2 WBS for the 2 polarisations, located in the SVM, not more than 5 m away from the ''warm'' IF amplifiers.

7. The instrument control electronics, located in the SVM.

8. The FPU control electronics, located in the SVM.

9. Interconnecting harnesses, connecting the socalled "warm" boxes.

4.5 SOFTWARE DESCRIPTION

TBD

4.6 OPERATING MODES

4.6.1 Primary operating modes

TBD

4.6.2 Parallel / Serendipitous mode

TBD

4.6.3 Stand-by mode

TBD

4.6.4 Off mode

TBD

4.6.5 FPU operations at ambient temperature

TBD

4.7 INSTRUMENT SCIENTIFIC PERFORMANCE

This part is to be considered as containing information which needs to be verified by test, analysis or a combination of the two and shall serve the purpose of demonstrating that the instrument will operate as intended for the particular mission.
Para 9.5 "Scientific Performance Verification" of the IIDs provides more information on this subject.

4.7.1 Optical parameters

TBD

4.7.2 Spectral resolution

TBD

4.7.3 Modes of operation

TBD

4.7.4 Sensitivity

TBD

5. INTERFACE WITH SATELLITE

5.1 IDENTIFICATION AND LABELLING

Each individual instrument unit is allocated two unique identification codes:

- a project code which is the normal reference used for routine identification in correspondence and technical descriptive material.

- a spacecraft code allocated by the spacecraft contractor in accordance with the computerised configuration control system to be implemented, and used in particular for connector and harness identification purposes. The project code is part of the spacecraft code.(See IID-A, chTBD)

The project codes allocated to this instrument are:

Project code	Instrument unit
HET1	Focal Plane Unit (approx.15 K)
HET2	Local Oscillator (approx. 100 K)
HET3	PLL Control (approx. 300 K)
HET4	IF2 Amplifier (approx. 100 K)
HET5	IF3 Processor (approx. 300 K)
HET6 A, B	High Resolution Spectrometers (approx.300 K)
HET7 A, B	Wide Band Spectrometers (approx. 300 K)
HET8	Instrument Control Electronics (approx. 300 K)
HET9	FPU Control Electronics (approx. 300 K)
HET10	"Warm" Interconnect Harness (approx. 300 K)

5.2 COORDINATE SYSTEM

Compliant with requirements in IID-A. Unit specific definition shown in External Configuration Drawings.

5.3 LOCATION AND ALIGNMENT

Figures 1 and 2 show the concept of the location of the HET Focal Plane Unit (FPU) on the Optical Bench (OB) and the concept of the location of the Local Oscillator. (LO)

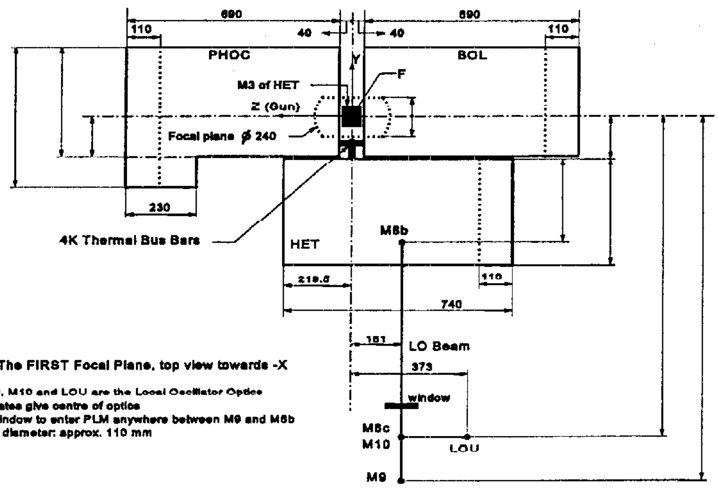


Fig. 1: The FIRST Focal Plane, top view towards -X

M8c, M9, M10 and LOU are the Local Oscillator Optics
Coordinates give centre of optics
Beam window to enter PLM anywhere between M9 and M8b
Window diameter: approx. 110 mm

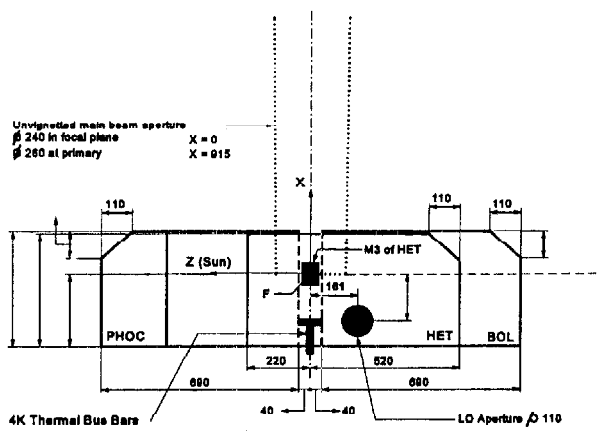


Fig. 2: The FIRST Focal Plane, side view towards +Y

5.3.1 Instrument Location

5.3.1.1 Inside cryostat

To reduce cable losses the following requirements for distance between individual units applies:

- ~~Between~~ HET1 and ~~HET4~~ ~~≤ 2 metres~~

5.3.1.2 Outside cryostat

To reduce cable losses the following requirements for distance between individual units applies:

- Between HET2 and HET3 ~~≤ 5 metres *~~

~~* As short as possible~~

5.3.1.3 On SVM

~~To reduce cable losses the following requirements for distance between individual units applies:~~

- ~~Between HET4 and HET5 ≤ 5 metres *~~
- ~~Between HET5 and HET6A,B/ HET7A,B ≤ 3 metres~~

~~* As short as possible~~

5.3.1.4 On PLANCK module

NA

5.3.2 Instrument Alignment

There are no alignment and/or alignment stability requirements except for the focal plane unit HET1 and the local oscillator HET2.

5.3.2.1 Absolute Requirements

The required alignment tolerances for HET1, including all cold optics and M3, are as given below for HET1. For HET2 the alignment tolerances include mirrors M8, M9 and M10. The HET2 tolerances are relative to HET1
Please note that the alignment for HET2 with respect to HET1 must also be satisfied for ground tests of e.g. the coupling of HET2 to the mixers.

The absolute alignment requirements to the Optical Bench at operating conditions are as follows:

Unit	Δx	Δy	Δz	θx	θy	θz
HET1	±6 mm	±1 mm	±1 mm	±1°	±0.2°	±0.2°
HET2	±10 mm	±0.3 mm	±0.3 mm	±0.4°	±0.5°	±0.5°

5.3.2.2 Stability Requirements

For HET1 rotations are about the centre of mirror M3 and stabilities are as shown in the table below for HET1.
For HET2 rotations are about TBD and stabilities are as shown in the table below for HET2.

The alignment stability requirements at operating conditions are as folllows:

Unit	Δx	Δy	Δz	θx	θy	θz
HET1	±0.6 mm/hr	±0.1 mm/hr	±0.1 mm/hr	±0.1 °/hr	±0.02 °/hr	±0.02 °/hr
HET2	±1 mm/hr	±0.03 mm/hr	±0.03 mm/hr	±0.04 °/hr	±0.05 °/hr	±0.05 °/hr

5.4 EXTERNAL CONFIGURATION DRAWINGS

TBD

5.5 SIZES AND MASS PROPERTIES

The table below shows for each unit its size, mass (one unit) and the number of units:

Project code	Instrument unit	# of	Dimensions (mm)	Mass (kg)
HET1	Focal Plane Unit	1	< 400 x 300 x300 TBC	<19 TBC
HET2	Local Oscillator	1	> 240 x120 x140 TBC	> 5 TBC
HET3	PLL Control	1	450 x150 x100	5
HET4	IF2 Amplifier	1	150 x150 x30	1
HET5	IF3 Processor	1	150 x100 x100	3

HET6 A,B	High Resolution Spectrometers	2	150 x130 x100	2
HET7 A,B	Wide Band Spectrometers	2	150 x130 x50	2
HET8	Instrument Control Electronics	1	160 x150 x100	3
HET9	FPU Control Electronics	1	TBD	TBD
HET10	"Warm" Interconnect Harness	1		1
TOTAL				45 +TBD TBC

Note that dimensions and mass do/do not include margins. The S/C shall apply a margin of TBD %.

5.6 MECHANICAL INTERFACES

5.6.1 Inside cryostat

The Focal Plane Unit will have 4 (TBC) holes for fixation by bolts to the Optical Bench. One of these holes is the reference hole, as marked in the External Configuration Drawing. The interface is such as to allow unit alignment and alignment-stability requirements to be fullfilled.

5.6.2 Outside cryostat

Units mounted outside the cryostat will have attachment points for fixation to a platform. Units with a mass <1.5 Kg will not have more than 4 of these points. For units with a mass >1.5 Kg and units with a specific structural, dynamic or thermal requirement for more than 4 attachment points, the number will have to be approved by the Project.

5.6.3 On SVM

Units mounted on the SVM will have attachment points for fixation to the equipment platform. Units with a mass <1.5 Kg will not have more than 4 of these points. For units with a mass >1.5 Kg and units with a specific structural, dynamic or thermal requirement for more than 4 attachment points, the number will have to be approved by the Project.

5.6.4 On PLANCK module

NA

5.6.5 Cooler valves and piping

NA

5.7 THERMAL INTERFACES

5.7.1 Inside cryostat

The various instrument stages require 3 different temperatures. This will be achieved by strapping the stages to various "cold" parts of the cryostat.
These cryostat parts are:

- The He II tank for temperatures at the 2K level
- A wheel-shaped heat-exchanger cooled by the He-flow from the tank for the 4K level
- A connection to the He-ventline for the 15K level

The table below shows the required temperatures at the interface of the instrument unit with the cryostat or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. K	Max. K	°C	°C	Min. °C	Max. °C
HET1	NA	25	NA	NA		+ 60 * TBC + 85 ** TBC

* Continuous temperature limit.
** Short-duration temperature limit for bake-out during a maximum of TBD hours.

5.7.2 Outside cryostat

The table below shows the required temperatures at the interface of the instrument unit with the mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. °C	Max. °C	°C	°C	Min. °C	Max. °C
HET2	60 K	200 K *	60 K		60 K	+ 60

* +40 °C allowed for functional tetsting.

5.7.3 On SVM

The table below shows the required temperatures at the interface of the instrument unit with the mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. °C	Max. °C	°C	°C	Min. °C	Max. °C
HET3	- 10	+ 40	- 30	+ 50	- 50	+ 60
HET4	60 K	200 K *	60 K		60 K	+ 60
HET5	- 10	+ 40	- 30	+ 50	- 50	+ 60
HET6 A, B	- 10	+ 40	- 30	+ 50	- 50	+ 60
HET7 A, B	- 10	+ 40 **	- 30	+ 50	- 50	+ 60
HET8	- 10	+ 50	- 30	+ 50	- 50	+ 60
HET9	- 10	+ 50	- 30	+ 50	- 50	+ 60
HET10						

* +40 °C allowed for functional tetsting.
** +20 °C allowed internally (Laser diode) HET to take care of this internal temperature requirement.

5.7.4 On PLANCK module

NA

5.8 OPTICAL INTERFACES

5.8.1 Focus location

TBD

5.8.2 Straylight

Instrument straylight model TBD.

5.9 POWER

5.9.1 Inside cryostat

The tables and models below show the heat dissipation of the units mounted inside the cryostat:

Project code	Instrument unit	Power Dissipation (W)
HET1	Cold Focal Plane Unit	See:Thermal Table and Thermal Model

5.9.1.1 Thermal model HET 1

TBD

5.9.1.2 Thermal Table HET1

Temp. level K	"15 K" level K	Non-operating mW	Operating mW	Serendipity mW
2	_	0.11	0.12	_
				_
4	10			_
4	15			_
4	20	_		_
15	_	0	25.0	_

Please note that 4K heatloads depend on "15 K" level.

5.9.2 Outside cryostat

5.9.2.1 Thermal model HET2

TBD

5.9.2.2 Thermal model HET4

TBD

5.9.2.2 Thermal table HET2, HET4

The table below shows the heat dissipation of the units mounted outside the cryostat:

Project code	Instrument unit	Power Dissipation (W)
HET2	Local Oscillator	8*
HET4	IF2 Amplifier	0.2 *
TOTAL		8.2

* = Value with 4 operating channels

5.9.3 On SVM

The table below shows the heat dissipation of the units mounted on the SVM:

Project code	Instrument unit	Power Dissipation (W)
HET3	PLL Control	28 *
HET5	IF3 Amplifier (Ambient temperature)	1.6 *
HET6 A, B	High Resolution Spectrometers	30 **
HET7 A, B	Wide Band Spectrometers	20 **
HET8	Instrument Control Electronics	3
HET9	FPU Control Electronics	
HET10	"Warm" Interconnect Harness	
TOTAL		81.6

* = Value with 4 operating channels
** = Value for 1 spectrometer

5.9.4 On PLANCK module

NA

5.9.5 Load on main-bus

The power load on the 28V. main-bus for this instrument is as follows:

Operating mode	Average BOL (W)	Average EOL (W)	Peak (W)

Primary mode	TBD	90.8	TBD
Parallel/Serendipity mode	NA	NA	NA
Stand-by mode	TBD	TBD	NA

5.9.6 Keep Alive Line (KAL)

TBD

5.9.7 Interface circuits

TBD

5.10 CONNECTOR, HARNESS, GROUNDING, BONDING

5.10.1 Connectors

No information available.

5.10.2 Harness

5.10.2.1 S/C Harness

The S/C harness provides the interconnection between the instrument and two other subsystems i.e. the Power subsystem and the Datahandling subsystem.
The harness is supplied through the S/C Contractor.
On the instrument side, pin functions are specified in Annex A to this document.

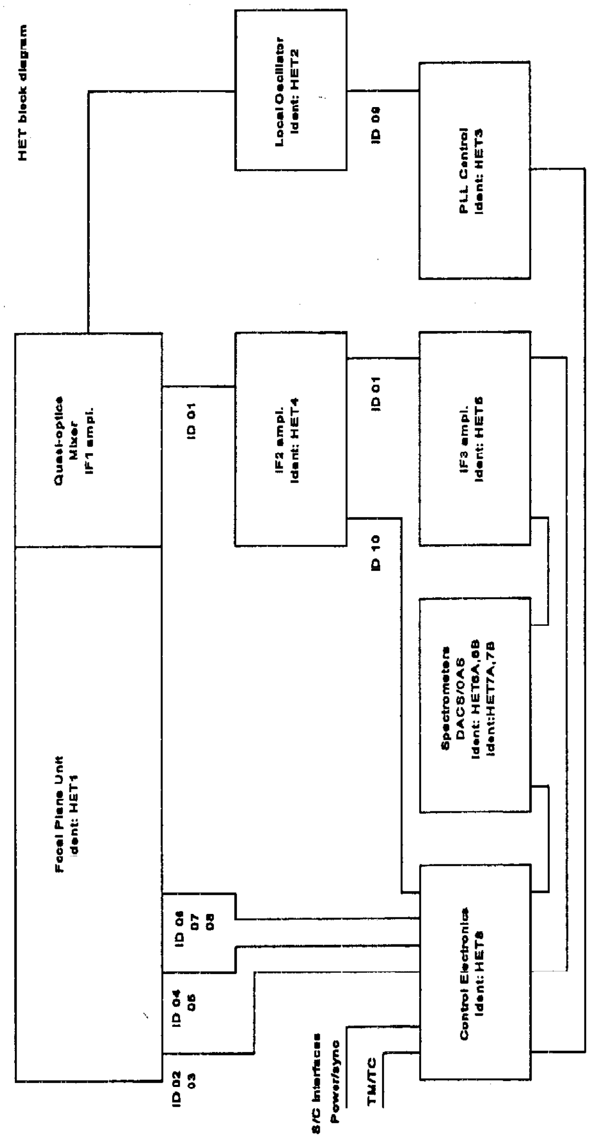
5.10.2.2 Instrument Harness

The "warm" harness i.e the interconnect harness between the various "warm" instrument units will be delivered by the instrument teams, manufactured to agreed requirements as specified in the IID-A under item 5.10.2.2.
Pin functions and wiring characteristics are specified in Annex A to this document.
The Contractor will specify length and routing as soon as an SVM lay-out is available. A Configuration Drawing will be included under item 5.4

5.10.2.3 Cryo Harness

The cryo harness, interconnecting the 15 to 300 K instrument parts, will be delivered through the S/C Contractor, manufactured to agreed requirements.
The cryo harness interconnecting the 4 to 15 K instrument parts is considered part of the instrument and therefore to be manufactured by the instrument teams.
Pin functions are specified in Annex A to this document.

The blockdiagram and the tables below show the cryo harness composition both for the 4 to 15 K and the 15 to 300 K interfaces. Figure 3: HET block diagram



HET cryo-harness list for 4 to 15 K interface level

	Instrument:HET		Date	19/Jun/97				
	4 to 15 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(mA)	(t * T)	volt. (V)	
2	Mixer	24	0	TBD	0.3	1	10	Brass AWG 38
3	Sensors	4	0	TBD	0.1	1	10	Brass AWG 38
4	Electromagnet	24	0	TBD	50	1	10	Brass AWG 30
1	IF coaxial (shield, insul.)	0	12					
1	IF coaxial (BeCu inner core)	12	0					
	Total to instrument	64	12					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t = part of T in which signal is active.

HET cryo-harness list for 15 to 300 K interface level

	Instrument:HET		Date	19/Jun/97				
	15 to 300 K interface	Type of	cable	Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(mA)	(t * T)	volt. (V)	
2	Mixer	24	0	30	0.3	1	10	Brass AWG 38
3	Sensors	16	0	30	0.1	1	10	Brass AWG 38
4	Electromagnet	24	0	5	50	1	10	Brass AWG 30
5	Optics actuator	32	0	30	7.5	1	10	Brass AWG 38
6	Optics sensor	24	0	30	0	1	10	Brass AWG 38
7	Heater	4	0	30	0.2	1	10	Brass AWG 38
8	IF1 amplifier bias	50	0	30	5	1	10	Brass AWG 38
9a	Local oscil. coax	20	20		0		10	TBD
9b	Gunn bias	20	10		300		30	TBD
9c	PLL amplifier bias	20	0		50		30	TBD
9d	Multiplexer bias	80	0		1		30	TBD
9e	Gunn tuning	20	1		0.1		30	TBD
9f	Local oscil. temp. sensors	4	0		0.1		10	TBD
10	IF2 amplifier bias	50	0	30	20	1	10	TBD
1	IF coaxial (shield, insul.)	0	12					
	Calibrator??							
	Chopper??							
	Multiplier??							
1	IF coaxial (BeCu inner core)	12	0					
	Total to instrument	400	43					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t= part of T in which signal is active.

5.10.3 Grounding

5.10.4 Bonding

5.11 DATA HANDLING

5.11.1 Telemetry

Housekeeping data rate	2 Kbps
Science data rate	40 Kbps TBC

5.11.2 Timing and synchronisation signals

No information available

5.11.3 Telecommand

No information available.

5.11.4 Interface circuits

No information available.

5.12 ATTITUDE AND ORBIT CONTROL/POINTING, ON-TARGET-FLAG

5.12.1 Attitude and orbit control

At present no requirements other than those in the System Specification.

5.12.2 Pointing

TBD

5.12.3 On-target-flag (OTF)

TBD

5.13 ON-BOARD HARDWARE/SOFTWARE AND AUTONOMY FUNCTIONS

5.13.1 On-board hardware

TBD

5.13.2 On-board software

TBD

5.13.3 Autonomy functions

TBD

5.14 EMC

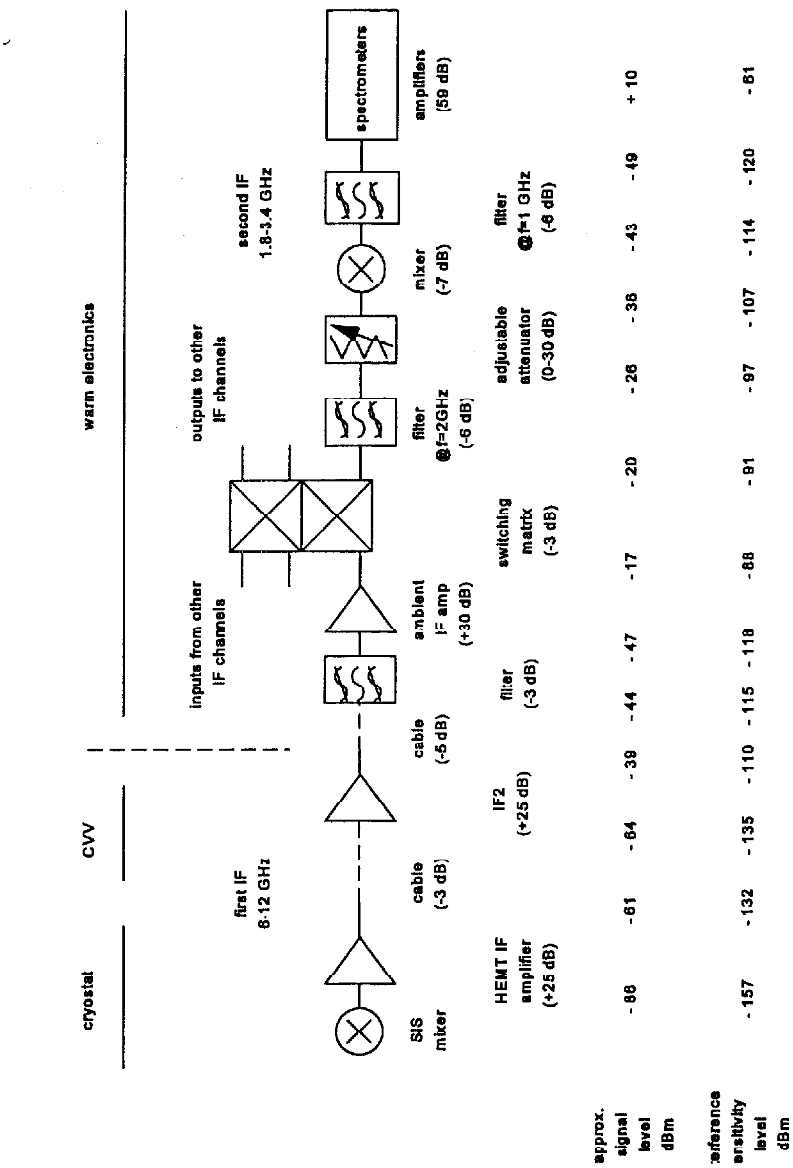
5.14.1 Conducted Emission/Susceptibility

No information available.

5.14.2 Radiated Emission/Susceptibility

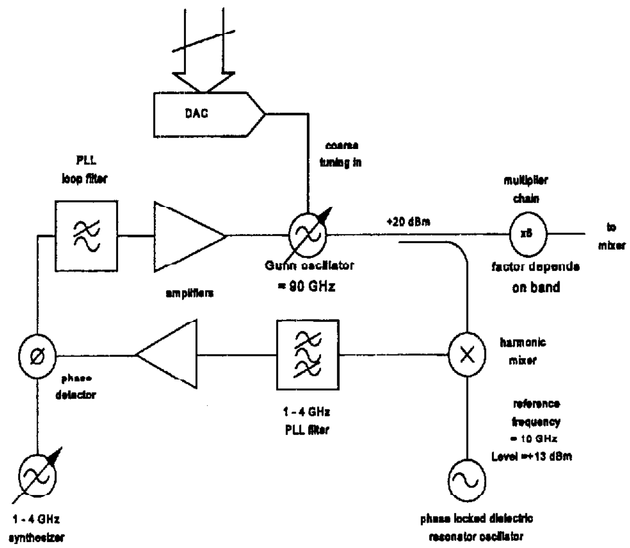
Harmonics of the S/C downlink frequency (2 GHz) will fall into the IF passbands of the HET instrument.
Levels acceptable to HET are typically - 157 dBm. @ 6 - 12 GHz.(SIS mixers) and TBD dBm. @ TBD GHz. (Hot Electron Bolometer mixer)
Referring to the antenna radiation level @ 2 GHz. a total attenuation of 170 dB between the antenna and the internals of the HET instrument seems to be required for the instrument to function as to be expected.

Figure 4: HET IF block diagram



HET IF block diagram showing possible IF gain distribution for one channel
N.D. Whyborn, 4 July 1996. Redrawn H.P. Schaap 28 April 1997

Also HET originated frequencies (PLL and Spectrometers) fall into the S/C uplink frequency band. Steps should be taken to avoid particular frequencies in these HET units or alternatively the instruments shall meet the requirement levels (TBD) for Conducted and Radiated Emission (CE and RE) for FIRST



Possible system for a Gunn oscillator
N.D.Whyborn, 4 July 1996
Redrawn H.P.Schaap, 28 April 1997

Figure 5: Gunn oscillator

5.14.3 Frequency Plan

TBD

5.15 DELIVERABLE ITEMS

5.15.1 Instrument Models

5.15.2 Electrical Ground Support Equipment (EGSE)

5.15.3 Mechanical Ground Support Equipment (MGSE)

5.15.4 System Test Software

5.15.5 Hardware for the Observatory Ground Segment

5.15.6 Software for the Observatory Ground Segment

5.15.7 Instrument Software Simulator

5.15.8 Test Reference Data

5.15.9 Instrument Characterisation Data

5.15.10 Technical Documentation

5.15.11 Transport and Handling Provisions

********The info below has to be merged in chapter 5.15.11************

5.15.1 Transport container

5.15.1.1 Focal Plane Unit

For the EQM, FM and FS units, special transport containers will be provided.
The containers will be vacuum tight and will be purged and slightly over-pressurised with dry nitrogen gas. The containers will be equipped with a mounting platform supported by a shock absorber.
Shock recorders will be mounted at a TBD location.
The containers are made of TBD material and have dimensions of TDB.
The mass of the containers is TBD kg.

5.15.1.2 Electronic units and interconnecting harness

For the EQM, FM and FS units, special transport containers will be provided.
The containers will be slightly over-pressurised with dry nitrogen gas.
Hygrometry will be recorded with witness devices.
The containers will be equipped with a mounting platform supported by a shock absorber.
Shock recorders will be mounted at a TBD location.
The containers are made of TBD material and have dimensions of TDB.
The mass of the containers is TBD kg.

5.15.2 Cleanliness

5.15.2.1 Focal Plane Unit

The Focal Plane Unit/JF~~ET Module~~ container must only be opened in a cleanroom environment of class 100 with a relative humidity of 50 %.

5.15.2.2 Electronic units and interconnecting harness

The Warm Electronics container must only be opened in a cleanroom environment of class 100 000 with a relative humidity of 50 %.

5.15.3 Physical handling

5.15.3.1 Focal Plane Unit

Condensation shall be avoided at all times.

Connection and disconnection of the instrument units during integration will be allowed under the following conditions:

- Take usual precautions against electrostatic discharge by grounding the operator.
- Before connecting, eliminate the electrostatic charges by a short-circuit device, to be provided with the instrument.
- Before connection or disconnection, be sure of the continuity between electrical and mechanical grounds.

Maximum rates of FPU warm-up and cool-down shall not exceed those specified in TBD.

5.15.3.2 Electronic units and interconnecting harness

Standard handling precautions shall be observed.

5.15.4 Purging

TBD

5.15.5 Mechanism positions

For reasons of possible damage caused by vibration during transport, environmental testing and launch mechanisms shall be placed in the TBD position. This position is shown in table TBD.

6. GROUND SUPPORT EQUIPMENT

7. INTEGRATION, TESTING AND OPERATIONS

7.1 Integration

7.1.1 FPU integration

TBD

7.1.2 "Warm-box" integration

TBD

7.2 Testing

TBD

7.3 Operations

8. PRODUCT ASSURANCE

9. DEVELOPMENT AND VERIFICATION

9.1 GENERAL

9.2 MODEL PHILOSOPHY

9.3 MECHANICAL VERIFICATION

9.4 THERMAL VERIFICATION

9.5 VERIFICATION OF SCIENTIFIC REQUIREMENTS

9.6 ELECTRICAL TESTING

9.7 EMC TESTING

10. MANAGEMENT, PROGRAMME, SCHEDULE