

	DRCU SUBSYSTEM SPECIFICATION	 SAp-SPIRE-CCa-25-00 Issue: 0.2 Date :14/06/00
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DRCU
SUBSYSTEM SPECIFICATION

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List of Acronyms

ADC	Analogue to Digital Converter
AMUX	Analogue Multiplexer
BSM	Beam Steering Mirror
DPU	Data Processing Unit
DCE	Detector Control Electronics
DCU	Detector Control Unit
DMUX	Digital Multiplexer
DRCU	Detector Readout & Control Unit
FPU	Focal Plane Unit
FTS	Fourier Transform Spectrometer
JFET	Junction Field Effect Transistor
LIA	Lock-in amplifier
LPF	Low Pass Filter
MCE	Mechanisms Control Electronics
MCU	Mechanisms Control Unit
PDU	Power Distribution Unit
SMEC	Spectrometer Mechanism Control
SCE	Sub-system Control Electronics
SCU	Sub-system Control Unit
SMPS	Switch Mode Power Supply
SNR	Signal over Noise Ratio
S/W	Software
TBC	To Be Confirmed
TBD	To Be Defined
WIH	Warm Interconnect Harnesses

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1 Introduction

1.1 Purpose

The purpose of this document is to explicit the DRCU Specification in term of performances and design. However this document is voluntary limited to specification common to all the subsystem. In other words this means sub-system specific requirement will not be part of this document since this specifications are given by the Subsystems Specification Documents.

1.2 Scope

The scope of this document comprises all the electronics included in the DRCU.

1.3 Applicable Documents

AD1	SPIRE Instrument Requirements Documents	SPIRE/RAL/N/0034
AD2	Warm Electronics Requirement Document	
AD3	FIRST/PLANCK Instrument Interface Document Part A	PT-IID-A-04624
AD4	FIRST/PLANCK Instrument Interface Document Part B	PT-SPIRE-02124
AD5	DRCU Mechanical Interface Control Drawing	
AD6	Component Selection, procurement, and Control for ESA Spacecraft and Associated Equipment, ESA.	PSS-01-60
AD7	Material and Process Selection and Quality Control for ESA Spacecraft and Associated Equipment, ESA.	PSS-01-70
AD8	Derating Requirements and Application Rules for Electronic Components. ESA	
AD9	Reliability Prediction for Electronic Equipment	MIL-HDBK-217
AD10	SPIRE Instrument Command	SPIRE-RAL-DOC-000
AD11	DRCU/DPU Electrical Interface Control Drawing	
AD12	FIRST L-2 Radiation Environment	FT-04040

1.4 Reference Documents

RD1	Operating Modes for the SPIRE Instrument	
RD2	Detector Subsystem Specifications	
RD3	FTS Subsystem Specifications	
RD4	BSM Subsystem Specifications	
RD5	Cooler Subsystem Specifications	
RD6	DPU Subsystem Specifications	

2 General description

2.1 Overview

The DRCU is an electronic unit housed in a box connected between the FPU and the DPU. This unit along with the DPU and the WIH constitutes the system called “SPIRE Warm Electronics”. The DRCU includes the front end electronics of the following sub-systems :

- Detector
- Fourier Transform Spectrometer
- Beam Steering Mirror
- Cooler
- Calibrators
- Shutter
- Thermometry & Analogue Housekeeping

each sub-system being associated with “cold functions” located in the FPU and high level control functions located in the DPU OBS.

The DRCU is housing 3 sub-units which are :

- the DCU including the Detector Control Electronics
- the MCU including the Mechanisms (FTS+BSM) Control Electronics
- the SCU including the Sub-system Control Electronics

The SCU function is manifold : it is in charge of interfacing FPU sub-systems such as the cooler heaters, the calibrators and the thermometry sensors plus housekeeping parameters with the DPU. This function covers the sensors biasing, the signal amplification and the digitisation of the analogue parameters. The SCU is also in charge of providing all the sub-systems with secondary power supply lines from the S/C 28 V interface by means of a DC/DC converter SMPS. This SMPS is associated with supply current monitoring capability for safety purpose. As illustrated below the DRCU has electrical interfaces with :

- the FPU
- the DPU
- the PDU (S/C)

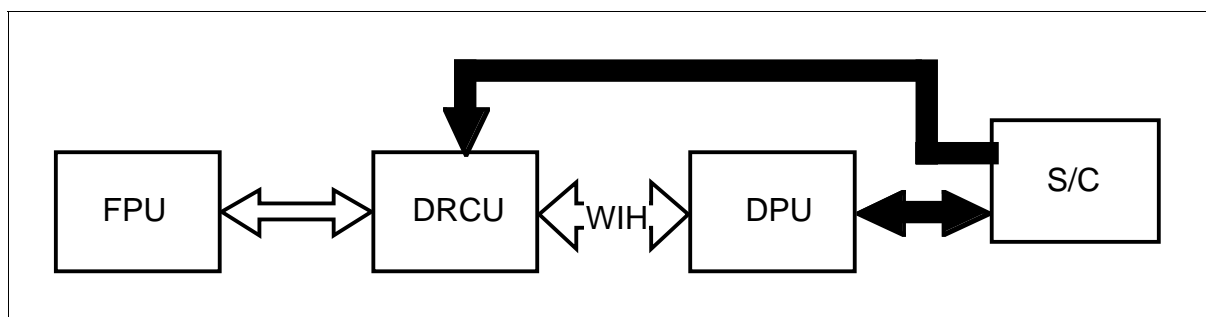


Figure 2.1-a

2.2 Overall Architecture

A complete DRCU block diagram including the interfaces is shown figure 2.2.3-a.

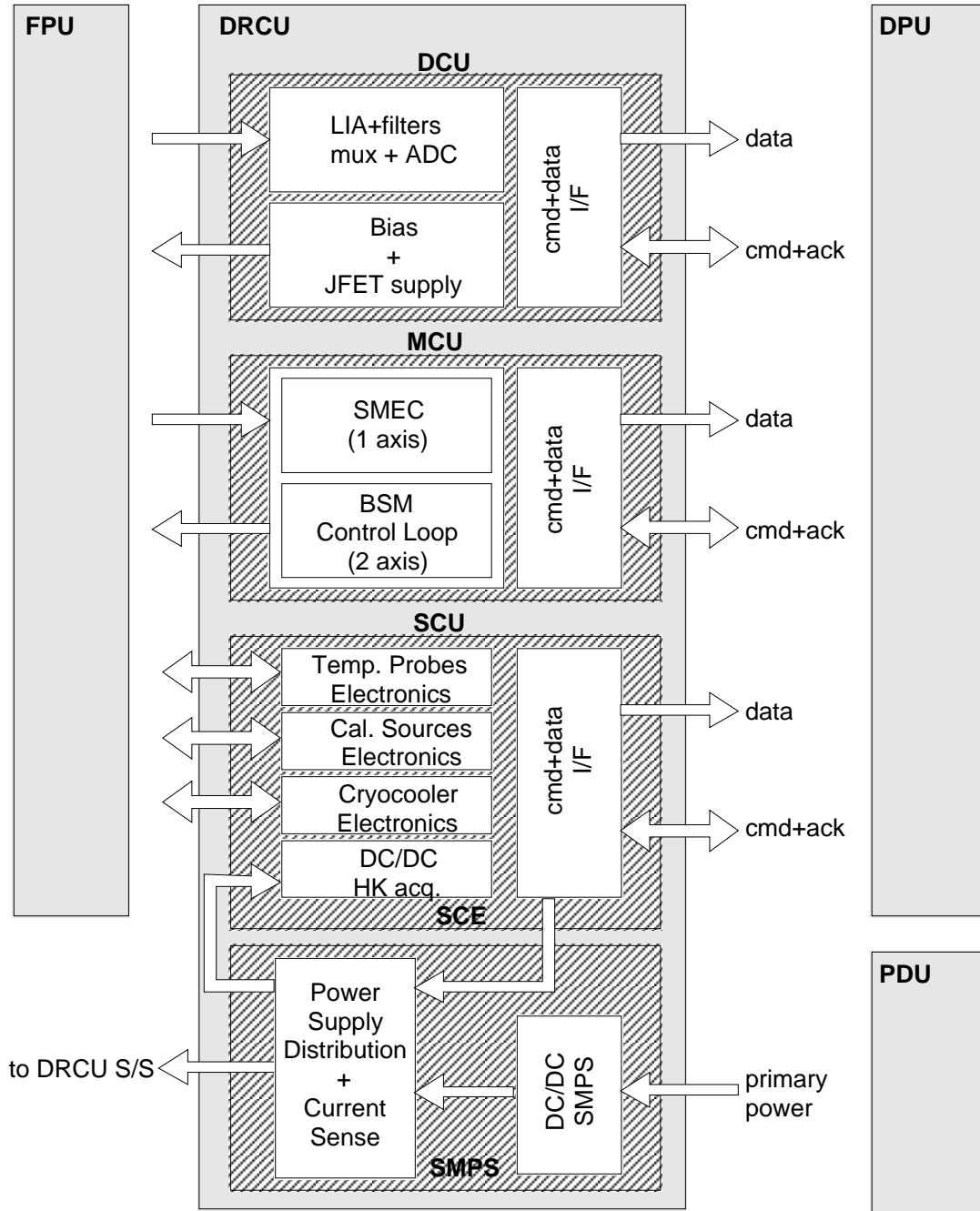


Figure 2.2-a - DRCU block diagram

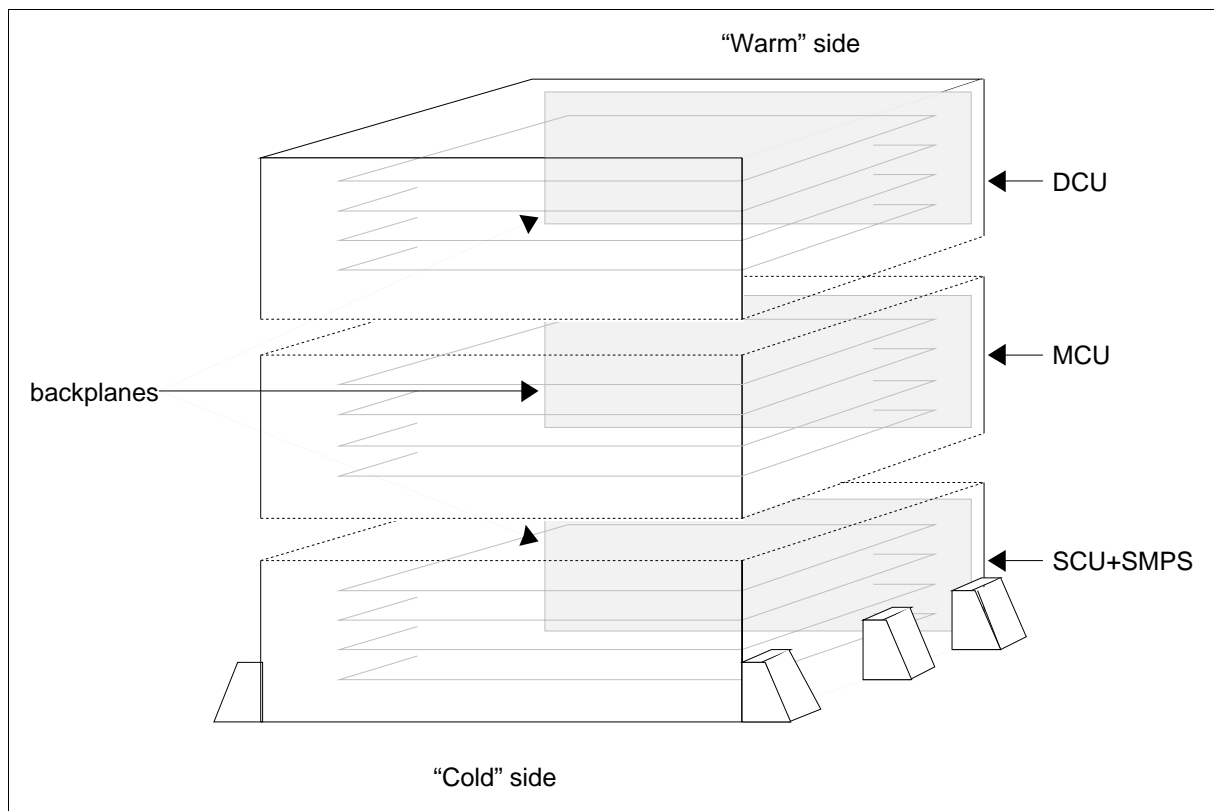
3 Physical Characteristics

3.1 Weight

DRCU REQ-01 : The total weight of the DRCU shall be compliant with the value given in the AD05.

3.2 Dimension

A single box (TBC) will content all the electronics boards of the 3 sub-units. Internal sub-unit connections are insured by back-planes printed circuit boards. Since no electrical interface is foreseen between the sub-unit no connection between these back-planes is required : a sub-unit is testable independently from the two other sub-units.



DRCU REQ-02 : The envelope of this box shall be compliant with the value given in the AD05.

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The board geometry is common to all the sub-systems and sub-unit. This common board design includes stiffeners and defines printed circuit board circuit size, back connector position, front panel geometry and board locks.

This design defines the standard DRCU board geometry. However adaptation of this geometry could be applied in specific cases : i.e. for the DC/DC converter and distribution board. The geometry allows placement of SMD parts on the both sides of the board.

DRCU REQ-03 : The standard board geometry is defined as shown in figure 3.2-a.

3.3 Centre of gravity

DRCU REQ-04 : The centre of gravity shall be compliant with the value given in the AD05.

3.4 Thermal Capacity

DRCU REQ-05 : The thermal capacity shall be compliant with the value given in the AD05.

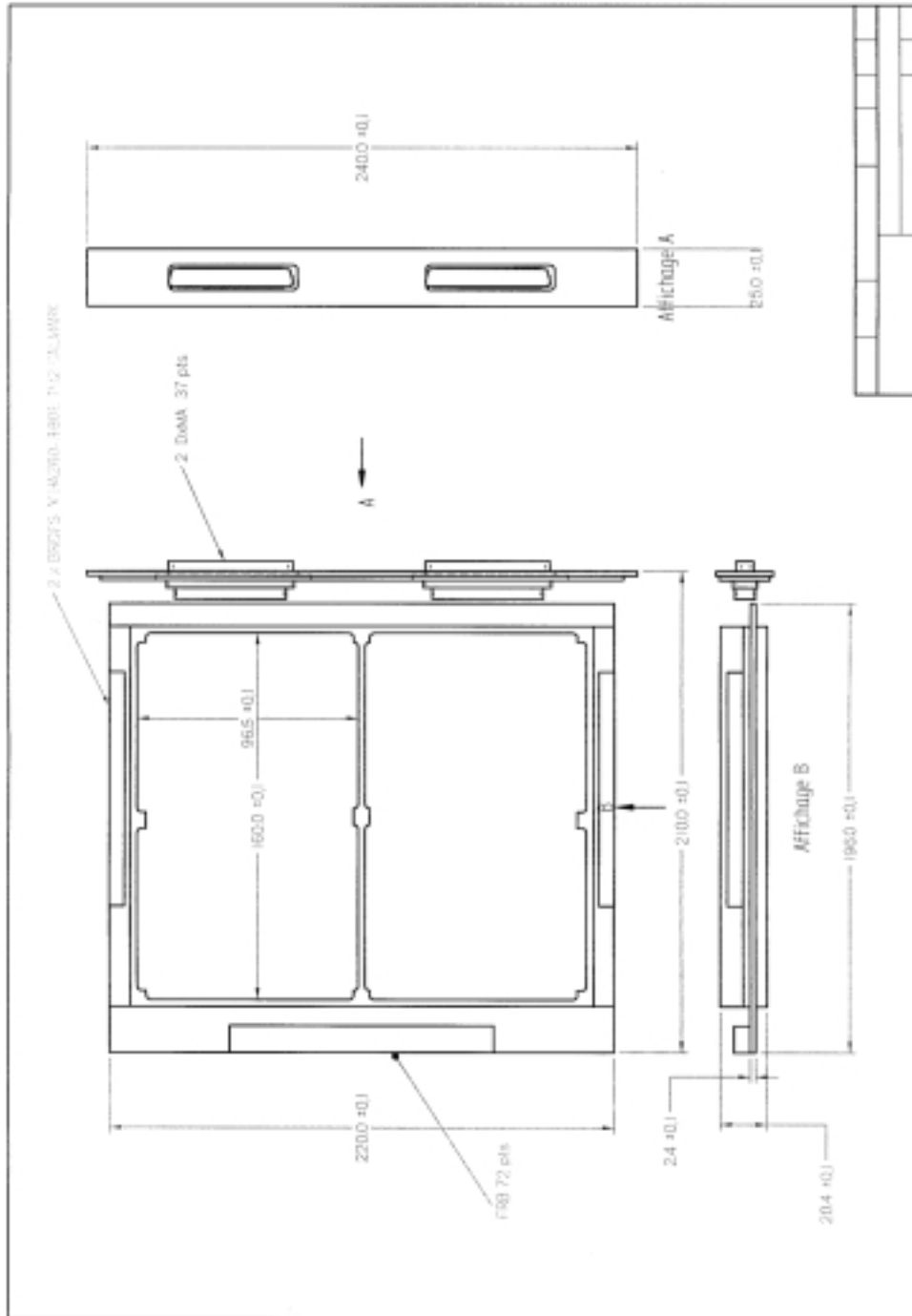


Figure 3.2-a

4 Performance requirements

4.1 Functional description

The DRCU has the following functions sorted by sub-unit :

4.1.1 DCU Functions

The **Detector Control Unit** supports all the functions related to the detector operation. This covers :

- | | |
|--|-------------|
| • the detector bias generation | DCU-FUNC-01 |
| • the bolometer signal processing | DCU-FUNC-02 |
| • the bolometer signal digitisation | DCU-FUNC-03 |
| • the timing cycling | DCU-FUNC-04 |
| • the JFET box biasing | DCU-FUNC-05 |
| • the low level command decoding | DCU-FUNC-06 |
| • the low level command acknowledge | DCU-FUNC-07 |
| • the relative time generation | DCU-FUNC-08 |
| • the housekeeping parameters digitisation | DCU-FUNC-09 |
| • the digitised data (bolometers + hk param. + rel. time label) transfer | DCU-FUNC-10 |

Complete DCU specification is given in RD2.

4.1.2 MCU Functions

The **Mechanisms Control Unit** supports all the functions related to the FTS and Beam Steering mirrors operation. This covers :

- | | |
|--|-------------|
| • the FTS mirror position measurement | MCU-FUNC-01 |
| • the FTS mirror actuator powering | MCU-FUNC-02 |
| • the FTS mirror position motion + speed control | MCU-FUNC-03 |
| • the FTS mirror position digitisation | MCU-FUNC-04 |
| • the FTS mirror actuator current digitisation | MCU-FUNC-05 |
| • the BSM positions (2 axis) measurement | MCU-FUNC-06 |
| • the BSM actuators (2 axis) powering | MCU-FUNC-07 |
| • the BSM positions control | MCU-FUNC-08 |
| • the BSM actuator current digitisation | MCU-FUNC-09 |
| • the low level command decoding | MCU-FUNC-10 |

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- the low level command acknowledge MCU-FUNC-11
- the digitised data (position + currents + rel. time label) transfer MCU-FUNC-12

Complete MCU specification is given in RD3/RD4.

4.1.3 SCU + SMPS Functions

The Sub-system Control Unit supports various functions essential to achieve full performances of the detector :

- the cryo-cooler recycling heater biasing, SCU-FUNC-01
- the cryo-cooler gas switches heaters biasing, SCU-FUNC-02

- the calibrators biasing, SCU-FUNC-03
- the calibrators temperature measurement SCU-FUNC-04

It also implements

- cold instrument temperature channels, SCU-FUNC-05
- analogue housekeeping channels, SCU-FUNC-06

Finally the SMPS sub-system is in charge of :

- sub-unit secondary power supply generation, SCU-FUNC-07
- sub-unit power switching, SCU-FUNC-08
- sub-unit current monitoring. SCU-FUNC-09

4.2 Functional requirements

4.2.1 SCU

4.2.1.1 Thermometry Module

The “Thermometry” sub-system shall have the following channels :

Probe type	Number	
	Prime	Redundant
Diode	9	11
Germanium	1	3

Table 5.2.1.1-a Thermometry channels summary

All the channels are sampled at the same rate.

DRCU REQ-06 : The DRCU shall implement totally independent prime and redundant thermometry channels according to the table 5.2.1.1-a.

DRCU REQ-07 : This rate shall be between **15 Hz and 80 Hz** (programmable by means of a low level command) according to the instrument mode (photometer or spectrometer).

DRCU REQ-08 : All the channels shall be sampled within 3 ms.

Note : under-sampling, if required is done by the DPU S/W.

4.2.1.1.1 Diode probe interface

The following specifications are common to all the diode probe channels :

Temperature range	1 K to 300 K	max. range
Wiring	4 wires	2 for bias / 2 for measure
Forward voltage range	0.6 V to 1.8 V	
Bias current range	1 μ A to 10 μ A	fixed value – depend on generic type
Bias current stability	0.1 %	
Digit. dynamic range	4096	

Table 4.2.1.1.1-a Interface Definition

DRCU REQ-09 : The SCU shall be designed in accordance with Table 4.2.1.1.1-a

DRCU REQ-10 : Bias currents shall be individually and by a low level command switched off.

4.2.1.1.2 Germanium probe Interface

The following specifications are common to all the diode probe channels :

Temperature range	0.2 K to 10 K	max. range
Wiring	4 wires	2 for bias / 2 for measure
Resistance range	10 Ω to 400 Ω 10 Ω to 10kΩ	Lakeshore probe Oxford Instrument probe
Bias current range	1 μA to 10 μA	fixed value – depend on generic type
Bias current stability	0.1 %	
Digit. Dynamic range	4096	TBC

Table 4.2.1.1.2-a Interface Definition

DRCU REQ-11 : The SCU shall be designed in accordance with Table 4.2.1.1.2-a.

DRCU REQ-12 : Bias currents shall be individually and by a low level command switched off.

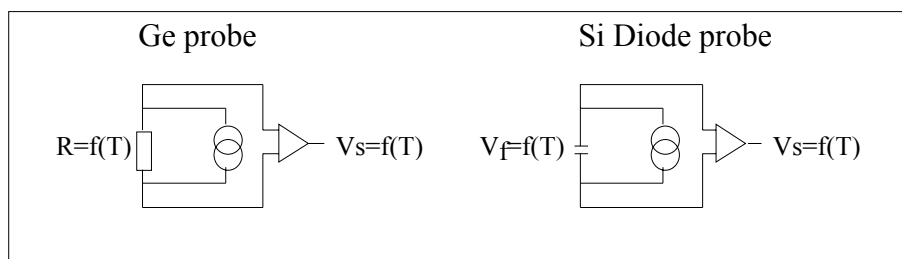


Figure 4.2.1.1.2 - Functional connection to temperature probes

4.2.1.1.3 Other Probes

Additional thermometry channels are defined but are not included in the SCU. They concern detector temperature monitoring, warm electronics units external temperature monitoring and warm electronics units internal temperature monitoring.

- The detector temperature monitoring is done by resistance measurement of blind bolometers. For homogeneity reasons these channels are handled by additional analogue channels of the DCU.
- External temperature channels of the units are directly connected to the S/C by means of discrete signal interfaces.
- Unit Internal temperature channels of DRCU sub-units are handled locally by the concerned sub-systems.

Each sub-system includes temperature housekeeping channels of critical electrical system area; i.e. high temperature or high power dissipation parts (DC/DC converter switching transistor, ...).

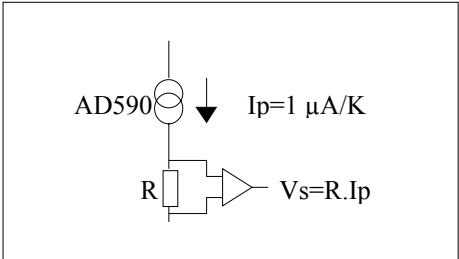
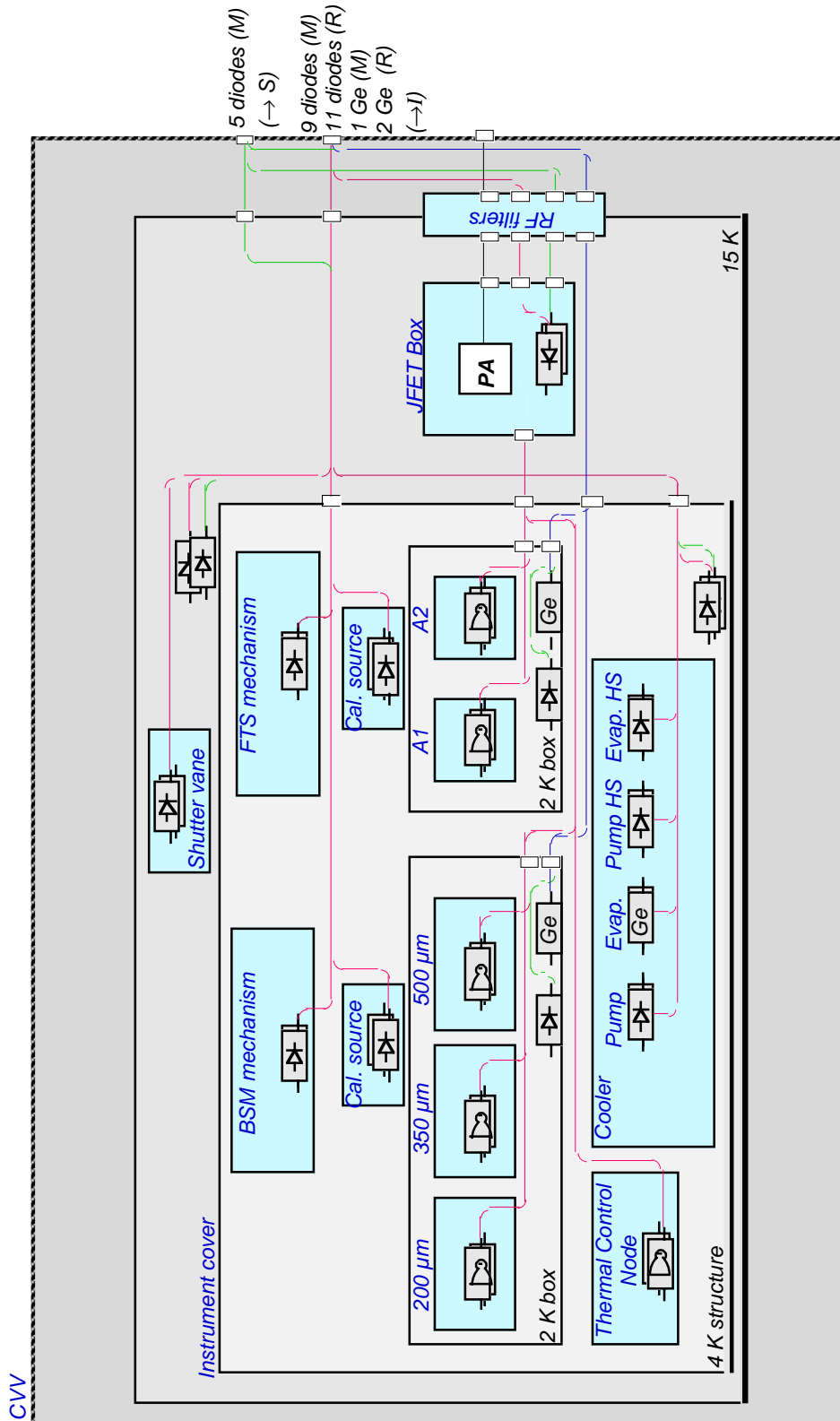


Figure 4.2.1.1.3-a Unit internal temperature monitoring



4.2.1.2 Calibrators Module

4.2.1.2.1 Photometer

The photometer calibrator consists of a heater mounted in an integrating cavity on the BSM structure. The SCU has to bias this heater with a variable amplitude and frequency waveform. The following table summarises the bias characteristics :

Bias Current	0 to 1 mA	in 256 steps
Bias waveform	Rectangular	duty cycle variable
Waveform frequency	≤ 5 Hz	Spec. for DPU
Waveform resolution	100 ms	Spec. for DPU
Stability	0.1%	over 24 hours
Heater resistance	10kΩ	+60 Ω lead resistance (x2 ?)
Maximum voltage	10 V	

DRCU REQ-13 : The SCU shall have two independent photometer calibrator interfaces and associated electronics : 1 for the prime configuration + 1 for the redundant configuration.

DRCU REQ-14 : Bias current shall be controlled by a low level command.

Note : The SCU is not required to store the current waveform. Waveforms are generated step by step by the DPU S/W by sending low level commands regularly (with requirement on the timing accuracy).

4.2.1.2.2 Spectrometer

The spectrometer calibrator consists of a heater mounted on blackened plate associated with a second heater mounted as in the photometer calibrator. The SCU has to supply those heaters with a variable amplitude bias and to monitor the blackened plate temperature (already included in the “Thermometry” sub-system).

The following table summarises the bias characteristics :

Bias Current	0 to 1 mA	in 256 steps
Bias waveform	DC	
Waveform frequency	NA	
Stability	0.05%	0.5 Hz to 25 Hz freq. band
	0.1%	over 1 hour
	0.1%	over 24 hours
Heater resistance	10kΩ	+60 Ω lead resistance (x2?)
Maximum voltage	10 V	

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DRCU REQ-15 : The SCU shall have two independent spectrometer calibrator interfaces and associated electronics : 1 for the prime configuration + 1 for the redundant configuration.

4.2.1.3 Cooler Module

The cooler consists of an evaporator filled with helium 3. After full evaporation the gas has to be pumped by active charcoal heated by a resistor. Additional gas switches enable to connect / disconnect the cooler with the super fluid helium tank.

The following table gives the characteristics of the various heaters :

Type	Number	Heater Resistance	Lead Resistance	Power	Max. Voltage
Gas switch	2	TBD	TBD	0 / 200 μ W	TBD
Charcoal pump	1	TBD	TBD	200 to 500 mW	28 V

DRCU REQ-15 : The SCU shall have two independent cooler heaters interfaces and associated electronics : 1 for the prime configuration + 1 for the redundant configuration.

DRCU REQ-16 : Heaters power shall be selectable by a low level command.

Note : Temperature probes (x4 TBC) are part of the cooler sub-system (already included in the “Thermometry” sub-system).

4.2.1.4 Analogue Parameters Acquisition Module

In addition to the temperature monitoring of FPU components the SCU have to monitor analogue parameters; those parameters are :

- sub-systems supply current
- sub-systems supply voltage
- SCU & SMPS DC/DC converter internal temperature channels (see §4.2.1.1.3)

DRCU REQ-17 : The Analogue Parameters Acquisition module shall have the following characteristics :

Current channels number	$18 + V_{BSM}$
Current resolution	1 %
Voltage channels number	$18 + V_{BSM}$
Voltage resolution	1 %

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Sampling Rate	15 to 80 Hz
Temperature channel Number	≥ 2 - TBC
Temperature Range	-40°C to 88 °C
Temperature resolution	0.5°C

DRCU REQ-18 : Sampling shall be selectable by means of a SCU low level command.

DRCU REQ-19 : Temperature channels : at least one in the SMPS + one in the SCU.

4.2.1.5 Distribution Board Control Module

DRCU REQ-20 : The SCU shall include the necessary functions to drive the latching relays of the Power Distribution Board :

Driver Number	5	
Driver Voltage	≤ 9 V	depends on relay types
Driver Current	TBD	depends on relay types

DRCU REQ-21 : Distribution Board relays status shall be configurable by means of a SCU low level command.

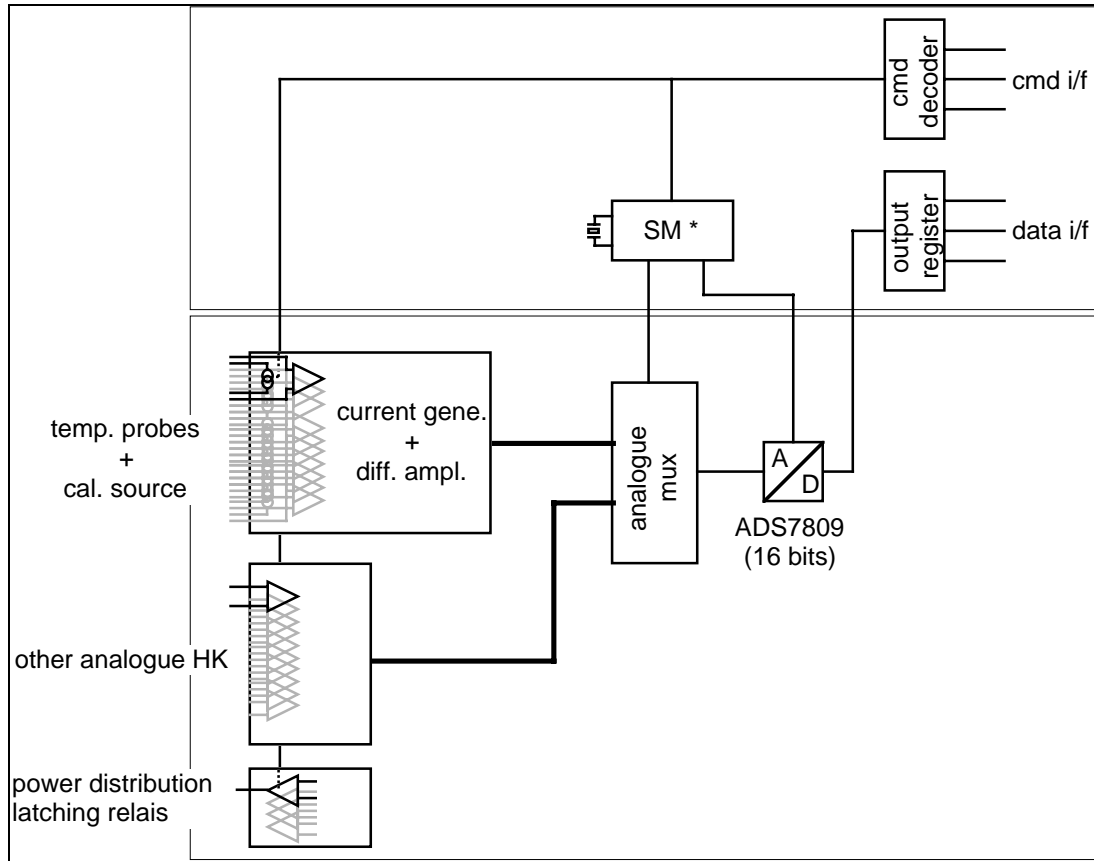
4.2.1.6 Housekeeping Parameters list

DRCU REQ-22 : The SCU shall read the housekeeping parameter listed below.

Parameter Name	Word size (bits)	Comments
TH-2		
TH-4		
F_Temp		
F BBC T		
PHSWT M		
EHSWT M		
CH T M		
SH T M		TBC
P BBC M		
P BBC T		

4.2.1.7 SCU block diagram

A typical functional diagram is shown for information by the following figure. The SCU is design around a Configurable State Machine in charge of sequencing the parameter acquisition according to low level commands.



4.2.2 DCU

The DCU is divided into 3 functional entities :

- the Analogue Module which comprises LIAs and analogue multiplexers,
- the Bias Generator and JFET power supply Generator,
- the Data Acquisition and Interface Module.

4.2.2.1 Analogue Module

An Analogue Module comprises analogue channels for processing the signals generated by the cold electronics (bolometers + JFET follower) based on Lock-in Amplifiers. After demodulation and filtering the signals are applied to differential multiplexers before being digitised in the Data Acquisition and Interface Module.

DRCU REQ-23 : The Analogue Module shall have the following characteristics :

Number of channels	288 56 8 - TBC	Photometer Spectrometer Thermometry
Interface Type	balanced signal + shield	
Signal AC amplitude	$7.4 \cdot 10^{-3}$	Dark condition
Signal DC level	$5 \cdot 10^{-3}$	JFET V_{OSmax}
Signal resolution	$9.8 \cdot 10^4$	Max bolo SNR
Base band signal bandwidth	5 Hz 25 Hz 5 Hz	Photometer Spectrometer Thermometry
JFET o/p impedance	6.2k Ω	
Noise allocation	4 nVrms/rt(Hz) 0.64pArms/rt(Hz)	

Physically, the Analogue Module is implemented on xx boards of xx LIA channels each interfacing with the Data Acquisition and Interface Module.

4.2.2.2 Bias Generator and JFET power supply Generator

This module generates a sine modulation for bolometers biasing and provides JFET power supply.

DRCU REQ-24 : The Bias Generator shall have the following characteristics :

Number of channels	1 – TBC	
Number of interfaces	6 – TBC	1 per JFET module
Interface Type	balanced signal	
Modulation amplitude	0 - 100 mV	in 256 steps
Modulation frequency	200 Hz +/- TBD Hz	in 32 steps
Load impedance	Rbolo + Cwire	
Sync. Signal phase	TBD °	Used by LIAs

DRCU REQ-25 : The JFET power supply Generator shall have the following characteristics :

Number of interfaces	6 – TBC	
Interface Type	Shielded twisted pair	
Nominal Voltage	+TBD V -TBD V	
Voltage Stability	+/- TBD %	
Voltage Noise		
Nominal Current	4.5 mA	$I_{dJFET} \times 704$
Max. Current	TBD	JFETs warm-up period ?

4.2.2.3 Data Acquisition and Interface Module

The Data Acquisition Module shall have the following characteristics :

ADC resolution	16 bits	
Total acquisition time	$\leq 3ms$	see AD10
Input Signal DC level	1.71 V	
DC offset resolution	3 bits	
Input signal AC	2.5 V	

The Interface Module shall transfer fixed size data packet to the DPU via the fast data interface according to AD (ICD). The rate of the transfer and the number of packet to be transferred shall be selectable by means of a DCU low level command.

Note : the transfer rate is identical to the bolometer sampling rate (only one low level command is defined to set both rates).

DRCU REQ-26 : The interface Module shall support at least four different data packets :

- Temperature channels only,
- Photometer channels and Temperature channels,
- Spectrometer channels,
- Test pattern.

This data packet shall be compliant with definition given in AD11 (EICD).

4.2.2.4 Functional Diagram

A functional block diagram is shown for information in the next figure.

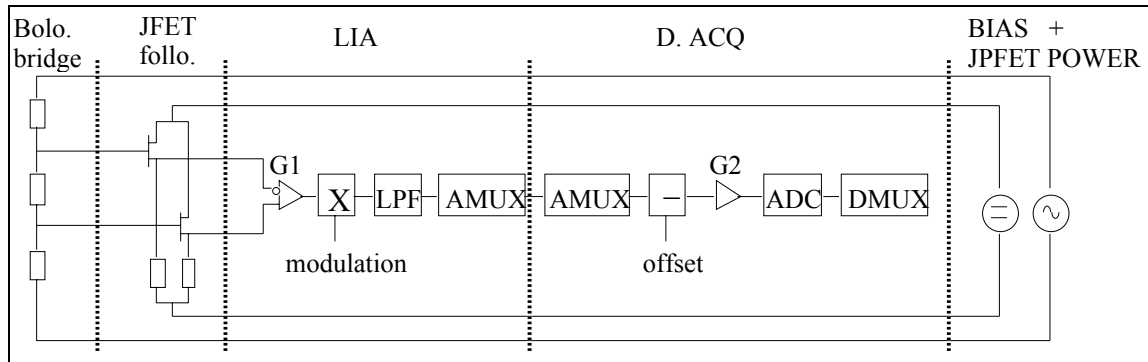


Figure 5.2.6.4-a - DCU functional block diagram

4.2.2.5 Housekeeping Parameters List

DRCU REQ-27 : The SCU shall read the housekeeping parameter listed bellow.

Parameter Name	Word size (bits)	Comments
		Bias Amplitude
		ADC Offset

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4.2.3 MCU

The DCU is divided into 3 functional entities :

- the MAC Module,
- the SMEC Module,
- the BSM Module.

4.2.3.1 MAC Module

The MAC Module is in charge of FTS mirror motion control and Beam Steering Mirror position control (2 axis). A S/W running on a DSP based embedded computer executes the digital servo loop .

The MAC module interfaces with the SMEC and BSM Module by mean of analogue signals : ADC and DAC are located on the MAC Module.

The MAC includes also an interface circuits to transfer mechanism relative data and housekeeping as well as to receive low level commands from the DPU.

DRCU REQ-28 : Both data and command interfaces shall be compliant with AD11 (EICD).

DRCU REQ-29 : The MCU shall implement two electrically independent MAC Modules (1 prime + 1 redundant).

4.2.3.2 SMEC Module

The SMEC supports the analogue functions required to control the FTS mechanism motion. It implements a power amplifier to drive the mirror, sensors (position, current) amplifier, ... All high level the input or output analogue signals are connected to the converters (A to D and D to A) of the Mac Module.

DRCU REQ-30 : The MCU shall implement two electrically independent SMEC electronics (1 prime + 1 redundant) each connected to a MAC (without criss crossing) and to a set of actuators/sensor located in the FPU.

4.2.3.3 BSM Module

TBW

4.2.3.4 Housekeeping Parameter list

DRCU REQ-31 : The MCU shall read the housekeeping parameter listed bellow.

Parameter Name	Word size (bits)	Comments
F_Posn_M		FTS pos. sensor
F_Drive_M		FTS drive coil current
CH_DR_M		BSM drive coil current

4.2.4 SMPS DC/DC converter

4.2.4.1 Secondary power lines definition

DRCU REQ-32 : Each DC/DC converter (1 prime + 1 redundant) shall have the following isolated outputs :

Sub-system Name	Supply Name	Voltage	Current (Average)	Current (Peak)
MCU				
MAC board	+Vdigm	+5	1.6	2.7
	+Vadcm	+15	0.09	-
	-Vadcm	-15	0.077	-
SMEC board	+Vampm	+8	0.01	0.1
	-Vampm	-8	0.01	0.1
	+Vanam	+15	0.05	-
	-Vanam	-15	0.05	-
BSM board	Vbsm?			
DCU				
LIA boards	+Vanad	+9		
	-Vanad	-9		
BIA board	+Vbiad	+9		
	-Vbiad	-9		
DAQ+I/F board	+Vdigd	+5		
	+Vadcd	+9		
	-Vadcd	-9		
SCU				
DAQ+I/F+Calib.	+Vdigs	+5		
	+Vadcs	+9		
	-Vadcs	-9		
Cooler	+Vpumps	≤+28		

4.2.4.2 Primary power line

Each SMPS DC/DC converter shall have an independent electrical interface with the satellite power bus.

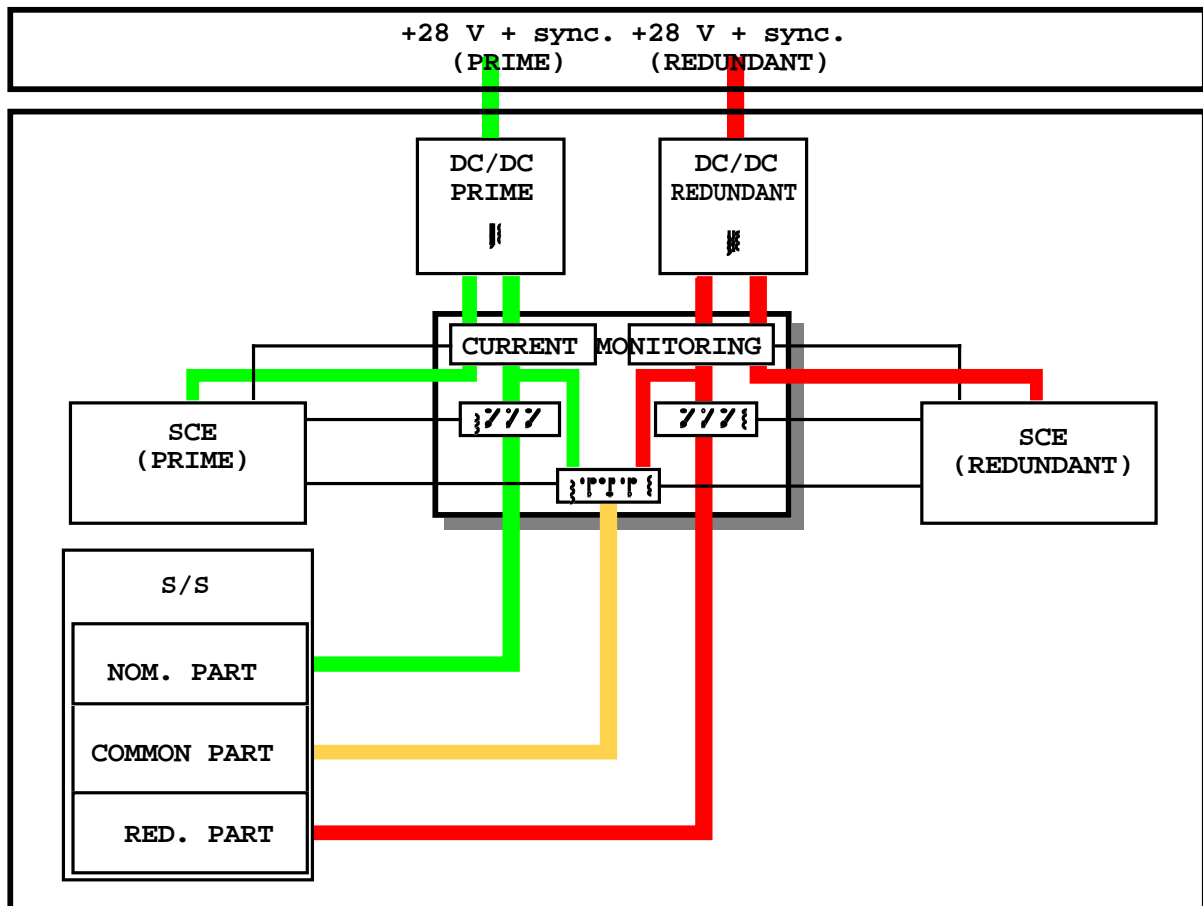
The interface shall be compliant with the requirement listed in AD3 (IID-A) §5.9.5.4. and with the signal characteristics AD3 (IID-A §5.9.5.2 and 5.9.5.3) as summarised below :

Nominal voltage	28 V \pm 1%
DC/DC operating range	26-30 V
	0 to 30 V
Synchronisation signal	
Amplitude	5.0 V +/- 20%
Waveform	square
Frequency	131.072 Hz
Interface	transformer coupled 5 k Ω // 200 pF

4.2.4.3 Distribution Board

A Distribution Board is associated to the DC/DC converter to enable the SCU switching on/off every sub-system (except DCU). The distribution board encompasses also a sub-system current monitoring function to the DRCU.

The following figure shows the conceptual design of this sub-system : sub-systems are powered by the DC/DC converter secondary lines through latching relays.



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DRCU REQ-33 : The distribution board shall be able to break independently the following group of secondary power lines :

Group Name	Supply Line list	Corresponding Functions
G1	{+Vbiad,-Vbiad}	Bolo. Bias + JFET power
G2	{+Vanad,-Vanad,+Vdigd,+Vadcd,-Vadcd}	Analogue Module + Data Acq / Interface module
G3	{Vdigm,+Vadcm,-Vadcm}	MAC
G4	{+Vdigm,+Vadcm,-Vadcm,+Vampm,-Vampm,+Vanam,-Vanam}	SMEC
G5	{VBSM?}	BSM

Note : an additional group (G0) including {+Vdigs,+Vadcs,-Vadcs,+Vpumps} is defined.

DRCU REQ-34 : This group shall be connected directly to the relevant secondary power lines without any intermediate relay.

In case of failure of the corresponding electronics a swap between prime and redundant configuration is mandatory.

In order to avoid complete loss of the analogue channels and/or ADC in the case a short circuit occurs in one of the electronic parts, channel subset have to be defined and individually protected by current limiters.

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4.3 Modes of Operation

4.3.1 General

DRCU REQ-35 : The Modes of Operation of the DRCU shall be :

- Off
- Initialisation
- Running

4.3.2 Off Mode

DRCU REQ-36 : In this mode the DRCU shall be completely OFF. The DRCU do not receive power from either the Prime or Redundant Primary Power line.

4.3.3 Initialisation Mode

This mode is defined as intermediate between the Off Mode and the Running Mode. When in Initialisation Mode the S/W based functions are booting : S/W and H/W integrity are checked then S/W starts execution.

Note : this mode and its definition is restricted to DRCU sub-units including S/W. Other sub-units will switch directly to the Running Mode.

DRCU REQ-37 : The DRCU sub-unit shall enter this mode whenever a power-on occurs.

DRCU REQ-38 : When all the activities corresponding to the Initialisation Mode have been successfully completed the DRCU sub-unit shall enter the Run Mode.

DRCU REQ-39 : In the case the Initialisation Mode can not be executed entirely the DRCU sub-unit shall respond to a low level command with a “initialisation failure” acknowledge.

DRCU REQ-40 : The DRCU sub-unit shall enter this mode whenever a S/W crash occurs.

4.3.4 Run Mode

This mode is the nominal status of the DRCU.

DRCU REQ-41 : The DRCU has its full functionality when in this mode.

4.4 Relation to SPIRE Modes of Operation

SPIRE Mode of Operation	DRCU Mode of Operation	Note
OFF	OFF	
ON	OFF	
INIT	INIT	
REDY	RUN	
STBY	RUN	
OBSV	RUN	
COOL	RUN	
SAFE	OFF	TBC

According to RD1.

4.5 Transition between Modes of Operations

Here below is shown the transition diagram relevant to the mode of operation of the DRCU.

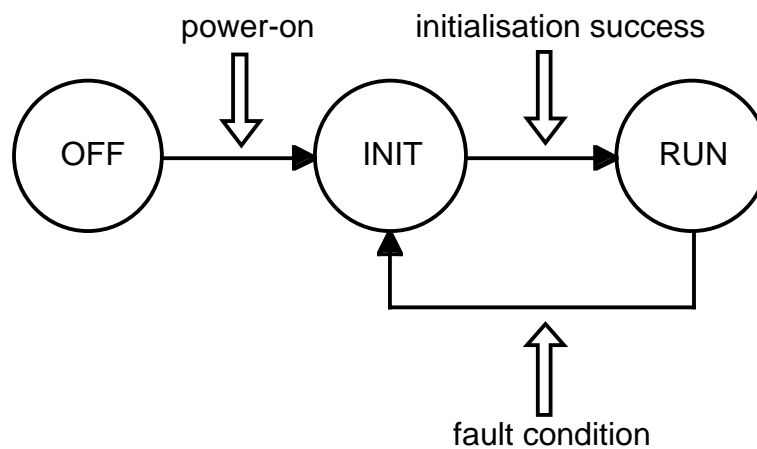


Figure 5.5-a EMCRC Mode of Operation Transition Diagram

4.6 Cross reference of capabilities

Below is a summary of the DRCU capabilities with respect to the DRCU Modes of Operation.

Mode of Operation	DCU Functions	MCU Functions	SCU Functions
OFF	-	-	-
INIT	DCU-FUNC-01 to -10	MCU-FUNC-10 to -11	SCU-FUNC-01 to -09
RUN	DCU-FUNC-01 to -10	MCU-FUNC-01 to -12	SCU-FUNC-01 to -09

4.7 Failure detection isolation and recovery

4.7.1 Failure Detection

DRCU REQ-42 : The DRCU shall provide capabilities to detect internal failures.

4.7.2 Failure Isolation

From an electrical point of view the DRCU shall be designed in such a way to match the following requirements :

DRCU REQ-42 : Any failure within the DRCU shall not induce any failure to other units.

DRCU REQ-43 : Any failure within the DRCU shall not provoke incorrect execution of operations by other units up-stream the DRCU (e.g. issuing of wrong parameters).

DRCU REQ-44 : Any first failure of one hot redundant part of the DRCU shall not induce any failure to the other hot redundant parts of the unit (if any).

DRCU REQ-45 : Any first failure of one cold redundant part of the DRCU shall not induce any failure to the other cold redundant part of the unit.

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5 DRCU Interfaces

5.1 Mechanical Interface

DRCU has mechanical interface only with SVM of the S/C. This interface is described in the relevant “Mechanical Interface Control Drawing” document.

5.2 Thermal Interfaces

DRCU has thermal interface only with the S/C : the heat due to the unit power dissipation is exclusively evacuated by conduction to the payload structure through the box feet.

DRCU-REQ-46 : The unit power dissipation shall be limited by the value given in the AD4 §5.9.3.

This unit power dissipation corresponds to the DRCU sub-unit dissipation summed with the SMPS DC/DC converter loss.

5.3 Electrical interfaces

5.3.1 Interface with S/C

The DRCU interfaces with S/C only by means of a primary power interface including a ‘+28 V / return’ couple and SMPS synchronisation clock. This interface is doubled, each set of lines being connected to one of the two DRCU SMPS (1 prime + 1 redundant).

5.3.2 Interface with DPU

The DRCU interfaces with the DPU by means of 3 high speed data interfaces and 3 low speed command lines for direct data/command transfer between the DPU and the 3 DRCU sub-units.

The sub-units will transfer scientific raw data and housekeeping parameters via the high speed data interface at a unique (predefined by a low level command) rate.

DRCU-REQ-47 : Each sub-unit shall have two (1 prime + 1 redundant) of both interface (high speed + low speed).

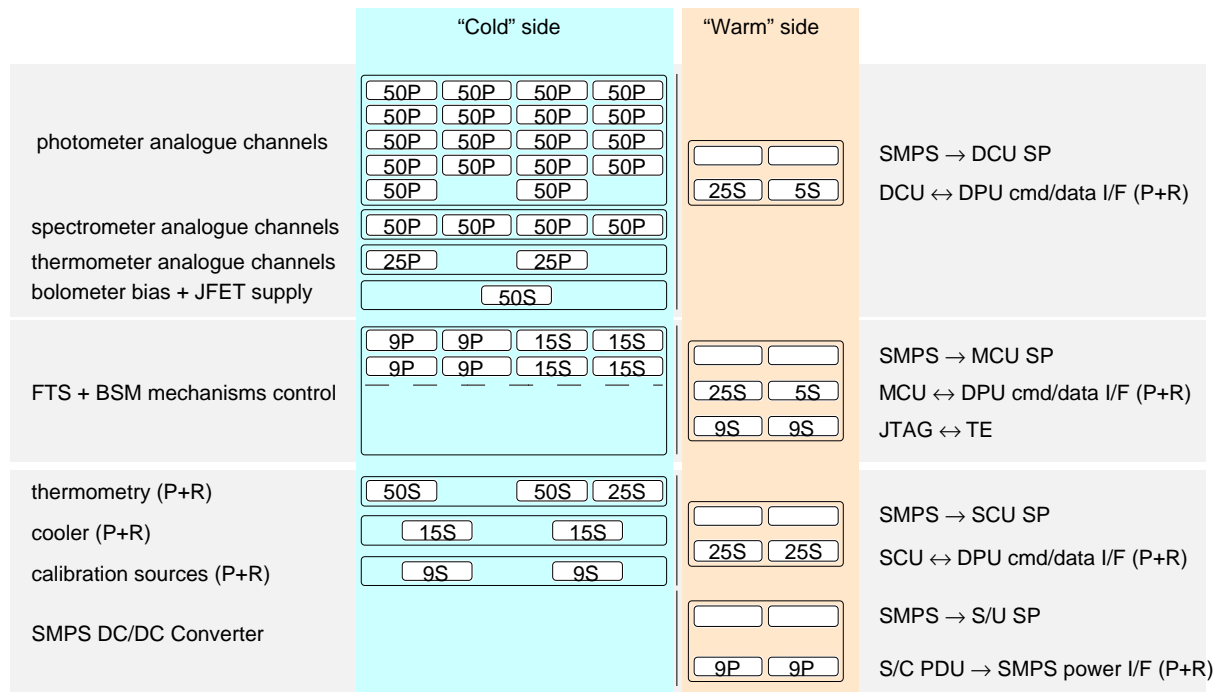
Data and command transfer shall be compliant with AD11.

5.3.3 Interfaces with FPU

All the DRCU sub-units have interfaces with the FPU. Interfaces between the FPU and the DRCU are exclusively analogue and are typically : sensors biases, actuator power, sensors signals. Each analogue interface is specific of the considered sub-system : its description is given in the respective “Subsystem Specification” documents.

The following drawing shows an overall connectors configuration for the DRCU including a “cold” side for the electrical interfaces with the FPU and a “warm” side for the electrical interfaces with DPU or S/C.

Note : the “warm” side supports also the power distribution harness bundle between the SMPS and the sub-units.



DRCU REQ-48 : The minimum distance between shall be compliant with AD03 §x.x.x.

6 EMC Requirements

DRCU REQ-49 : The DRCU shall cope with the EMC requirements stated in AD3

7 Environmental Requirements

DRCU REQ-50 : The unit shall operate with the temperatures illustrated here below:

Operating		Min. Switch-On	Non-Operating	
Min.	Max.		Min.	Max.
-15° C	+45° C	-30° C	-35° C	+60° C

DRCU REQ-51 : The DRCU shall cope with the environmental requirements stated in AD3.

DRCU REQ-52 : The DRCU shall cope with the radiation environment described in AD12.

8 Reliability

DRCU REQ-53 : The reliability of the EMCR shall be equal to or greater than **TBD** for a period of 4.25 years.

DRCU REQ-54 : The method for reliability calculations shall comply with AD9.

9 Design and Construction

DRCU REQ-55 : All processes, materials and parts shall comply with AD6 and AD7 applicable documents.

DRCU REQ-56 : Electronics design shall comply with AD8.

DRCU REQ-57 : Test Equipment and Ground Support Equipment shall comply with MIL-STD-1542.

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10 Identification and Labelling

TBW

11 Precedence

[DRCU REQ-58](#) : The requirements concerning the Failure Detection and Failure Isolation capabilities shall have precedence on any other requirement.

12 Unit Requirement Verification

DRCU REQ-59 : The requirements of this specification shall be verified by inspection (I) or analysis (A) or test (T) or by a combination thereof as shown by the following matrix.

Requirement	Analysis	Test	Inspection
DRCU REQ-01			
DRCU REQ-02			
DRCU REQ-03			
DRCU REQ-04			
DRCU REQ-05			
DRCU REQ-06			
DRCU REQ-07			
DRCU REQ-08			
DRCU REQ-09			
DRCU REQ-10			
DRCU REQ-11			
DRCU REQ-12			
DRCU REQ-13			
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DRCU REQ-17			
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DRCU REQ-38			
DRCU REQ-39			
DRCU REQ-40			
DRCU REQ-41			
DRCU REQ-42			
DRCU REQ-43			
DRCU REQ-44			
DRCU REQ-45			
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DRCU REQ-54			
DRCU REQ-55			
DRCU REQ-56			
DRCU REQ-57			
DRCU REQ-58			

13 Traceability Matrix versus System Requirements

Instrument Level Requirements	DRCU requirement
IRD-PHOT-R11	
IRD-PHOT-R13	
IRD-MODE-R01	
SPIRE.WE.FUN	