HERSCHEL/SPIRE

DETECTOR CONTROL UNIT
EM/QM1
PRELIMINARY TEST PLAN

	Function	Name	Date	Visa
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DOCUMENT STATUS and CHANGE RECORD

Date	Issue	Affected pages
26/11/2002	Draft	Creation
14/02/2003	1.0	All

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1 INTRODUCTION

1.1 PURPOSE

Following the tests performed on LIA_P, LIA_S, BIAS, DAQ-IF and DCU_BP boards, the purpose of this document is to detail the tests that will be performed on assembled DCU unit with dedicated laboratory test equipments : at this stage, we shall use neither the Local Test Unit nor the Focal Plane Unit simulator but a dedicated generator so simulate the signals. These tests are referenced in [A4] as *QM1-DCU-T0*.

The purpose of these tests is thus to check that the functional/performance requirements expressed in Herschel "SPIRE Detector Subsystem Specification Document SPIRE – JPL-PRJ-000456" are fulfilled.

This document follows a specific order:

- First, the test configuration that will be used,
- Followed by the functional/performance tests on assembled DCU EM/QM1,
- Then, the performance tests on DCU EM associated with Bolometers,
- Finally, the cross-matrix showing in which test the requirements are tested.

As a matter of fact, this document describes the functions and performances that will be tested in the frame of the Engineering Model. It will be used a guideline for the tests performed with the Local Test Unit and the Focal Plane Unit simulator (tests referenced in [A4] as *QM1-DCU-T1, QM1-DCU-T2* and *QM1-DCU-T3*).

1.2 APPLICABLE DOCUMENTS

[A1]	Herschel SPIRE Detector Subsystem Specification Document	SPIRE –JPL-PRJ-000456
[A2]	DRCU Subsystem Specification	SAp-SPIRE-Cca-25-00
[A3]	DCU Design Document	SAp-SPIRE-FP-0063-02
[A4]	DRCU AIV PLAN	SAp-SPIRE-HT-0082-02

1.3 REFERENCE DOCUMENTS

[R1]	DCU LIA_P TEST PLAN	SAp-SPIRE- FP-0064-02

2 Test configuration on assembled DCU

2.1 Boards configuration

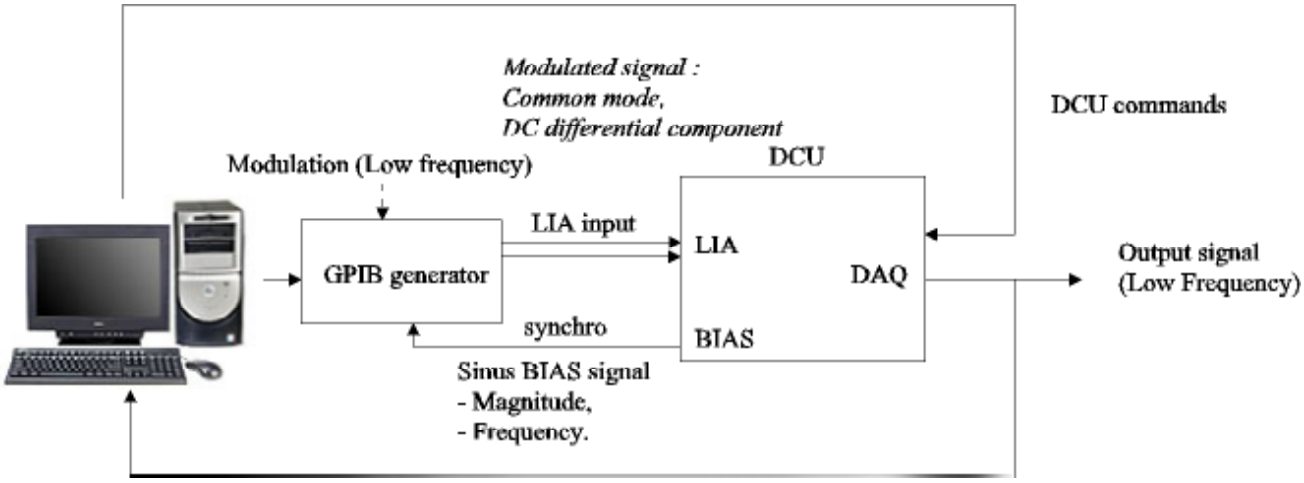
For the preliminary tests, we shall work on an assembled DCU EM that contains the DCU_BP board, one LIA_P board, 1 LIA_S board, 1 DAQ IF, 1 BIAS.

The complete DCU QM1 will, in addition include one more LIA_P board and two more LIA_S boards.

The test harnesses are connecting wires, specifically developed for EM tests, fit with tests equipments. These are not flight type harnesses.

2.2 Test configuration

The test configuration for DCU EM functional tests will be as follows:



DCU EM functional tests configuration

We shall command the DCU by sending commands to DCU DAQ interface (FPGA). Simultaneously, we generate a modulated signal at LIA input using a phase locked GPIG generator. The signal at LIA input is then synchronized with the BIAS output signal.

2.3 LIA Input signal (all channels)

The signal that will be generated for tests purpose as LIA inputs will be sinus signals over [50 Hz – 300 Hz] modulated by a signal over [0,03 Hz – 5 Hz] for photometer and [0,03 Hz – 25 Hz] for the spectrometer (The spectrum analysis at DAQ-IF output will be performed over [0,03 – 5 Hz] for photometer and [0,03 – 25 Hz] for spectrometer).

The generated signals have the following characteristics :

Modulated differential voltage :

$\mathbf{V_D} = \mathbf{m_{BIAS}} \sin(2.\pi.f_{BIAS}.t) . (1-n/\mathbf{m_{BIAS}}) . \sin(2.\pi.f_{SOURCE\ low\ frequency}.t) + \mathbf{U_{DV}}$

$\mathbf{U_{DV}}$ = 5 mV maxi : continuous differential voltage,

$\mathbf{m_{BIAS}}$: magnitude of the sinus BIAS = 10 mV rms.

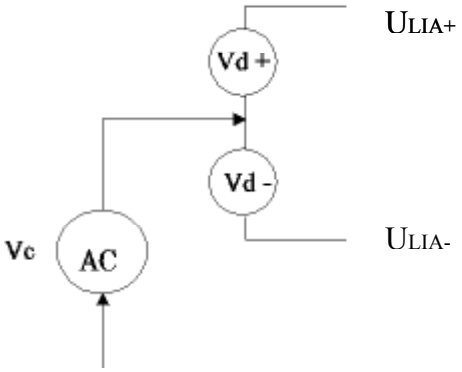
$\mathbf{V_{d+}} = V_D/2$

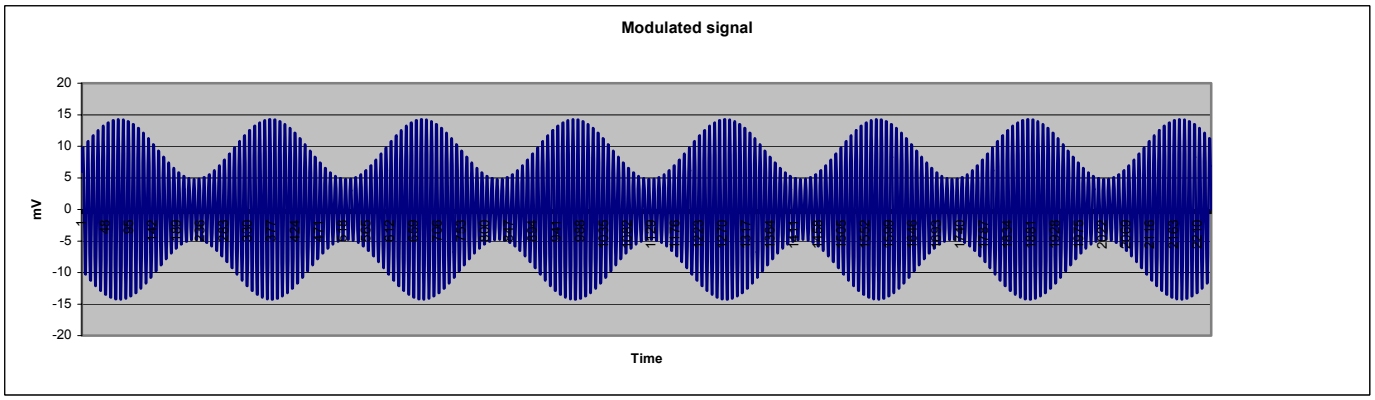
$\mathbf{V_{d-}} = -V_D/2$

$\mathbf{U_{LIA+}} = \mathbf{V_{d+}} + \mathbf{Vc}$

$\mathbf{U_{LIA-}} = \mathbf{V_{d-}} + \mathbf{Vc}$

Vc = 1 V DC maxi : common mode





Representation of the modulated signal

Note : with reference to BDA-DRCU-22 , the maximum level at LIA input is

- *11 mV (photo)*
- *17 mV(spectro)*

We shall test the characteristics considering a modulation level belonging to [0, max level].

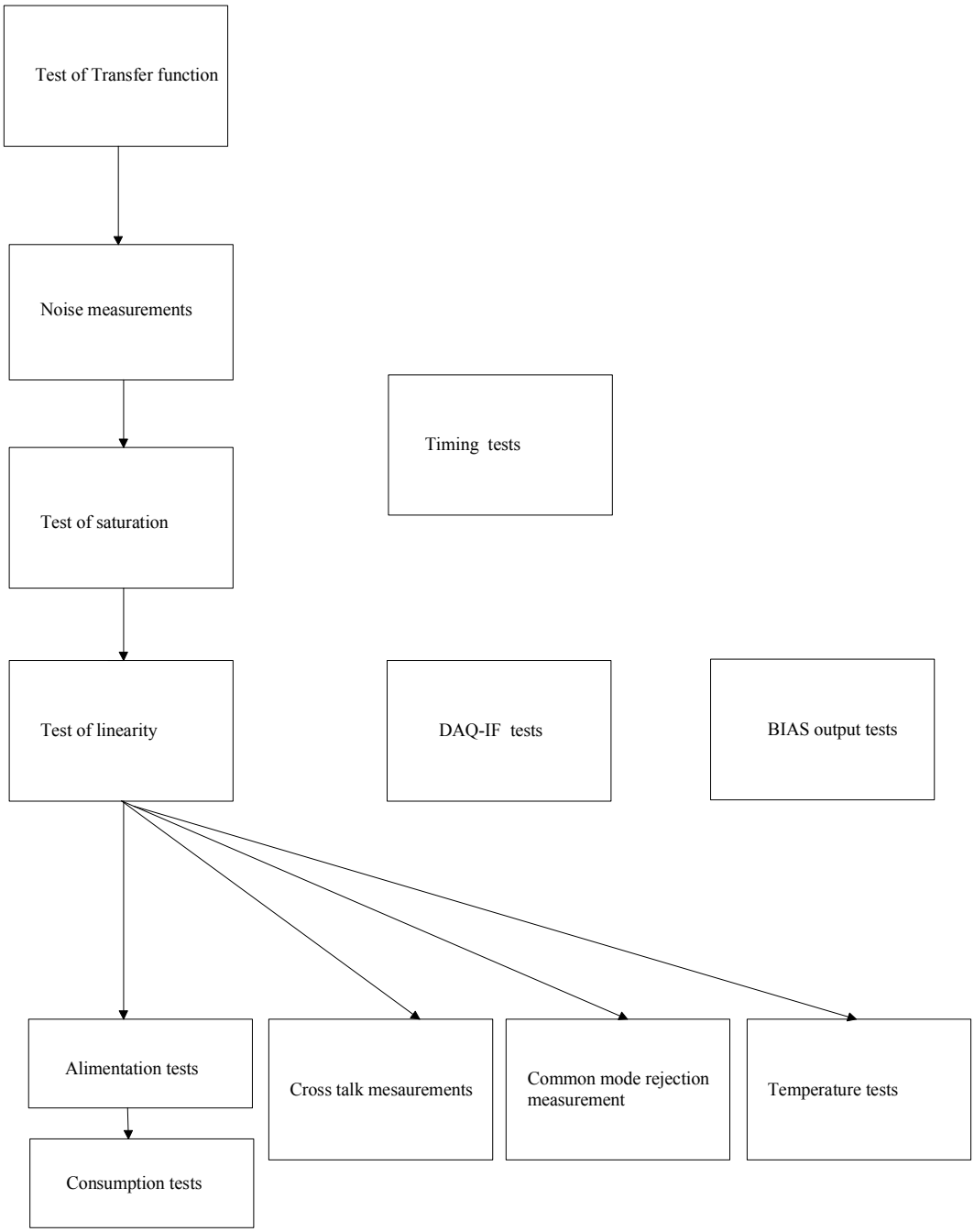
The test conditions will be as described above :

- Common mode : 1 V DC maxi,
- Continuous differential voltage : 5 mV DC (TBC),
- Magnitude of sinus BIAS : 10 mV rms.

3 Functional tests on DCU EM

3.1 Test flow chart

The thereafter flow chart represents the tests that will be performed on DCU EM/QM1 so as to check the requirements expressed in [A1].



Test flow chart

3.2 Test of transfer function

In this section, we define the tests concerning the cut off frequency, the overall gain and the offset function. For the test to be performed, we shall define the sinus BIAS frequencies tested and the sinus BIAS magnitude.

The common mode level will be set at 1 V DC and the continuous differential voltage will be set at 0 V for these tests.

All measurements will be performed with the signal al DAQ output analyzed by the PC.

Cut off frequency

We test the cut off frequency under the following conditions :

- BIAS magnitude = 10 mV rms,
- BIAS frequency = 150 Hz

We check ***BDA-DRCU 13*** and ***BDA-DRCU 14 (refer to test table 3.1)***.

Overall gain

We test the overall gain under the following conditions :

- BIAS magnitude = 10 mV rms,
- BIAS frequencies = 50, 100, 150, 200, 250, 300 and 350 Hz

We will check that the gain specification is fulfilled for all spectrometer and photometer channels:

Measurements will be made on all channels with reference to the input modulation signal.

Offset function

We will test the capacity of decoding increased output signals levels (offset function) at BIAS frequency = 150 Hz and BIAS magnitude varying between 0 and max level in an appropriate way so as to test the 16 levels; measurements will be made on all channels (the offset being the same on all channels).

We check ***DRCU REQ-38***

For each offset value (16 levels) we shall modify the bias magnitude over its min/max specified range and check the output on all channels.

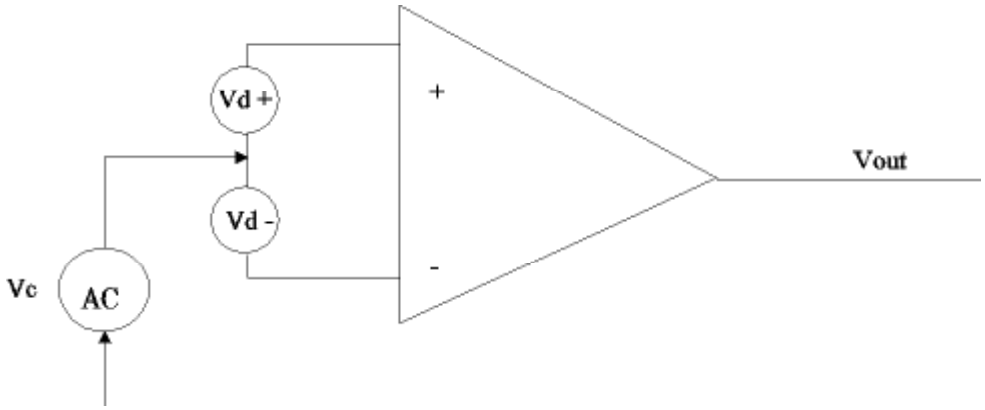
The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	min value	max value	Comment	Specification
Photometer low pass filter cut-off frequency	PhLPFfreq	5 Hz- 1%	5 Hz + 1%	288 channels	BDA-DRCU 13
Spectrometer low pass filter cut-off frequency	SpLPFfreq	25 Hz- 1%	25 Hz + 1%	72 channels	BDA-DRCU 14
Photometer overall gain	PhG	5187 - 0.5%	5187 + 0.5%	288 channels	[A3]
Spectrometer overall gain	SpG	2320 - 0.5%	2320 + 0.5%	72 channels	[A3]
DC compensation offset	DCoffset	0 V	5 V	16 levels	DRCU REQ 38

Test table 3.2

3.3 Common mode rejection measurement

With reference to ***BDA-DRCU-11 (resp. DRCU REQ-32)***, we shall check that the less performing channel with respect to common mode rejection (as identified during boards tests) is compliant with the specification of – 60 dB over [50 – 300 Hz].



The test configuration is as follows : we choose Vd = 0 and we test the common mode filtering (Vout measurement) at numeric DAQ-IF output.

We measure Vout/Vc and we divide by the gain to refer it to the input.

The test configuration is the one described above, with input signal being the common mode applied on both +/- inputs.

We define further the common mode level and frequencies applicable for the tests :

- Common mode AC level : maximum differential input AC level + common mode DC level (1V),
- Over following frequencies : 50, 100, 150, 200, 250 and 300 Hz.

Measurements will be made on all channels.

The tested parameter as well as its range is given in the hereafter table :

Parameter Description	Parameter Name	Min value	Max value	Comment	Specification
Common mode rejection ratio	CMRR	-60dB	-	288 + 72 channels	DRCU REQ 32

Test table 3.3

3.4 Cross Talk measurement

We shall test whether cross talk effects appear by checking the DAQ-IF output levels (pixel by pixel) when only some LIA channels have signal applied to their input.
The cross talk requirements are given in ***BDA-DRCU-25***.

We shall inject the un-modulated bias signal to all the LIA input channels one of the input signal being modulated at maximum signal frequency (5 Hz and 25 Hz respectively for photometer and spectrometer). We check digital data at DAQ-IF output. The ratio of output signals for un-modulated channels over modulated channel shall less than 0.05 % according to ***BDA-DRCU-25***.

In order to avoid too many measurements, and from the analysis held on individual boards, we may select the channels that may induce cross talk on others.

The tested parameter as well as its range is given in the hereafter table :

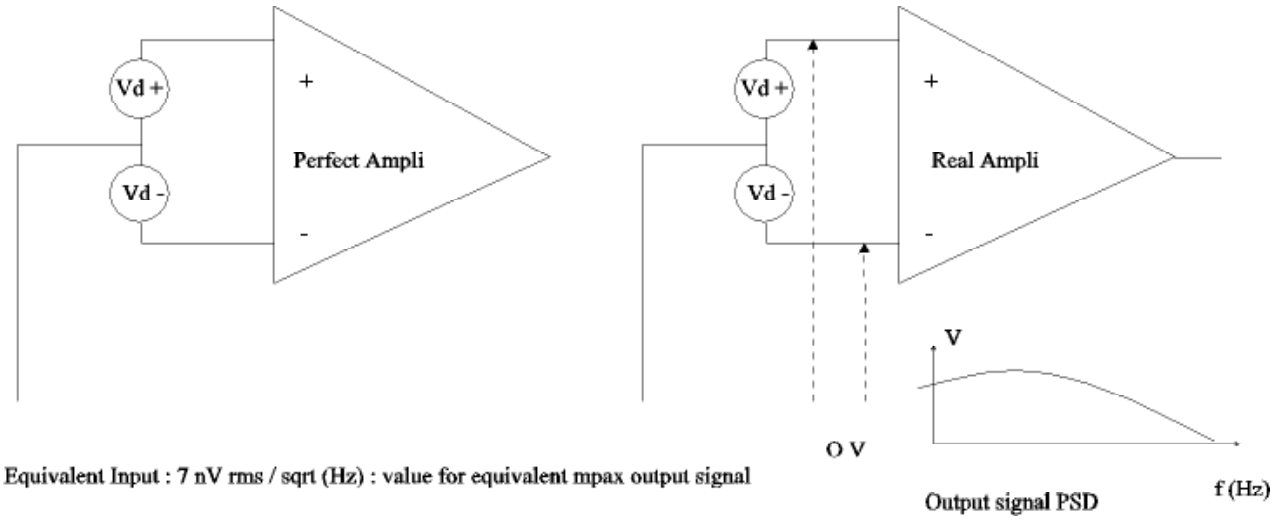
Parameter Description	Parameter Name	Min value	Max Value	Comment	Specification
Channel to channel Cross talk ratio	CTr	-	0.05 %	288 + 72 channels	BDA DRCU 25

Test table 3.4

3.5 Noise measurements

We shall check the specification of 7nV/√Hz expressed in ***BDA-DRCU-01***.

For this, we shall create a short circuit at LIA input :



The analysis shall be made over [0,03 – 5 Hz] for photometer and [0,03 – 25 Hz] for spectrometer considering sinus BIAS frequency range of [50 – 300 Hz]

Noise measurements shall be performed on all LIA channels.

By performing FFTs on DAQ_IF output digital data for each channel we shall verify the noise spectrum. By computing the rms noise on the DAQ_IF output digital data we shall determine the in band total noise.

The tested parameter as well as its range is given in the hereafter table :

Parameter Description	Parameter Name	Min Value	Max Value	Comments	Specification
Channel input noise	ChN	-	7 nV/√Hz	288 + 72 channels	BDA DRCU 01

Test table 3.5

Note : in both cases, it is possible that the signal level at DAQ-IF output be less than the first level (16 bits ADC converter).

3.6 DCU input impedance / capacitance

Checked by design and analysis.

3.7 Tests of saturation

With reference to ***BDA-DRCU-22***, we shall test the saturations on LIA-P and LIA-S channels according to the maximum specified levels of 11 mV rms and 17 mV rms respectively (we increase the magnitude of the bias beyond the maximum level and we check saturation level at digital output while keeping a fixed magnitude of modulation). For this, we will modify in an appropriate way the magnitude of the bias signal.

For BIAS magnitude varying between 0 to 20 mV and 0 to 25 mV respectively for the photometer and the spectrometer channels we inject a signal of 1 mV (tbc) at 5 and 25 Hz. We check digital signal amplitude variation. The maximum input signal is reached when signal amplification varies by more than +/-0.5% with respect to its nominal value (cf. gain values given in [A3]).

Measurements shall be made on all channels.

It is also interesting to perform these tests with maximum DC and common mode levels according to ***BDA-DRCU-01***.

The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	Min Value	Max Value	Comments	Specification
Photometer channel saturation level (mV)	Spsat	11 mV	-	288 channels	BDA DRCU 01
Spectrometer channel saturation level (mV)	Phsat	17 mV	-	72 channels	BDA DRCU 01

Test table 3.7

Applying directly Vbias at LIA input (0,5 V magnitude sinus), we shall check that the nearby amplification channel remain functional.

3.8 Tests of linearity

To test the linearity, two test configurations are proposed :

1 - In the first configuration, we will modify in an appropriate way the magnitude of the sinus BIAS signal and check that the 16 bits ADC converter generates signals in accordance with these variations.

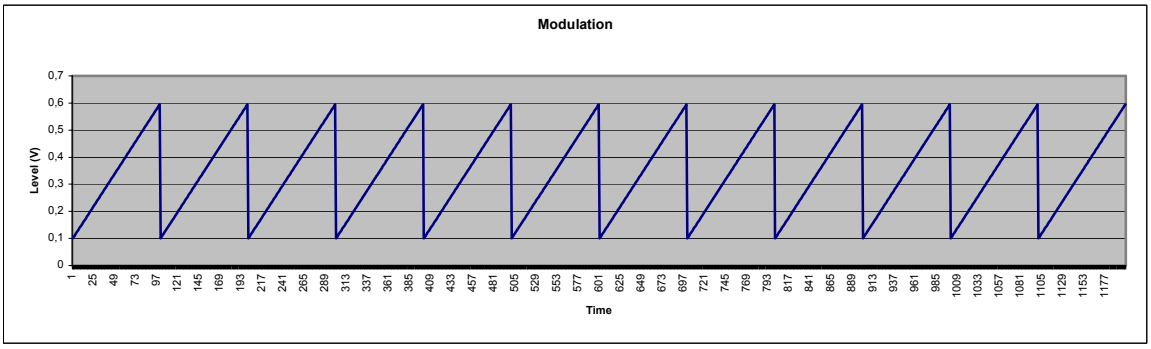
In such a configuration, no modulation is applied to the sinus BIAS.

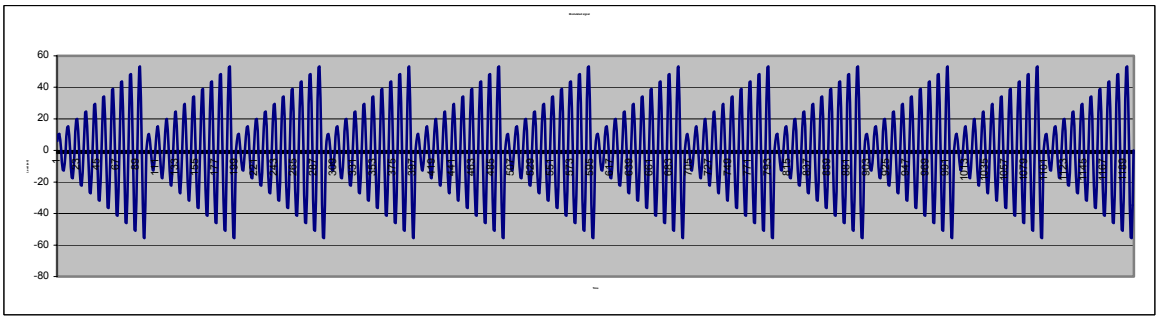
This test of linearity can be performed by changing the sinus BIAS magnitude over 0 to 25 mV rms,

These tests shall be performed on all channels with the sinus BIAS frequency = 150 Hz.

2 - The following second tests configurations, we apply a modulated signal to test the linearity :

- The first proposal is to modulate the sinus BIAS with a triangular signal and check that the output signal corresponds statistically to the modulation signal (in that case, we can choose the frequency of the modulation (between 0 and 5 hz for photometer; between 0 and 25 Hz for spectrometer),





modulated signal

This test of linearity can be performed by setting the sinus BIAS magnitude to 25 mV rms and changing the frequency of the modulation signal (with maximum level = 20 mV rms).

- The second proposal is to modulate the sinus BIAS with white noise and check (statistically) the white noise at DAQ-IF output (L. Vigroux proposal).

These tests shall be performed on all channels with the sinus BIAS frequency = 150 Hz.

We here notice that these tests allow to test the way the encoder works.

The test configuration is the one described in § 2.2 with the PC commanding the appropriate signal to the GPIB generator**.**

The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	Min Value	Max Value	Comments	Specification
Photometer channels output levels (mV)	PhLevel (*input level*)	0 mV	-	288 channels	BDA DRCU 22
Spectrometer channels output levels (mV)	SpLevel (*input level*)	0 mV	-	72 channels	BDA DRCU 22

Test table 3.8

The result shall be a function representing the evolution of the output levels on on channels depending on what in applied at LIA input.

3.9 Tests of the sinus bias signals for bolos and temp (BIAS output)

There exists three kinds of BIAS outputs (photometer, spectrometer and temperature). The test principle is identical for all channels. We shall check the output signal (frequency, magnitude, noise) by mean of the following tests :

- Bias generation frequency range is checked at design level: for this test we shall check only the frequency stability over the temperature range. Measurements shall be done at the following temperatures : 0°C, +25 °C and +50 °C. These measurements shall be done with nominal bias frequency of 150 Hz.

- Bias amplitude variation shall be checked between 0 and 200 mV (0 to 500 mV specifically for TC channels) with an accuracy of 1/256 of the full scale. These measurements shall be done with nominal bias frequency of 150 Hz.

- Noise measurement shall be done in differential mode with Bias frequency of : 50, 100, 150, 200, 250 and 300 Hz. Amplitude will be set to its maximum of 200 mV rms (photometer and spectrometer channels) and 500 mV rms (temperature channels).

Amplitude and frequency are measured by means of appropriate AC voltage and frequency controller while noise is measured by means of a spectrum analyser.

The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	Min value	Max value	Comment	Specification
Bias frequency stability	Bfreq	0	5 Hz	Specified precision : 5 Hz	BDA DRCU 05
Bias amplitude	LIABmag	0	200 mV	precision 0.2 / 256 V	BDA DRCU 05
Bias amplitude (TC)	TCBmag	0	500 mV	precision 0.5 / 256 V	BDA DRCU 05
Bias noise	Bnoise	0	20 nV/√Hz		BDA DRCU 05

Test table 3.9

3.10 Tests on JFETS commands (BIAS output)

Requirements on JFETS are listed in ***BDA DRCU 06, BDA DRCU 07, BDA DRCU 08, BDA DRCU 09 and BDA DRCU 10*** (resp. ***DRCU REQ-35, 36 and 37***).

We shall check the JFETS signals (frequency, magnitude, noise) by mean of the following tests :

- Vdd and Vss current generation is checked at design level: for this test we shall check only the stability over the temperature range. Measurements shall be done at the following temperatures : 0°C, +25 °C and +50 °C. These measurements shall be done with nominal bias frequency of 150 Hz.

- Vdd variation shall be checked between 1.5 V and 4 V and Vss between -5 to 0 V with an accuracy of 1/256 of the full scale. These measurements shall be done with nominal bias frequency of 150 Hz.

- Noise measurement shall be done in differential mode with Bias frequency of : 50, 100, 150, 200, 250 and 300 Hz. For these tests, levels will be set to their maximum of 4V (Vdd) and –5 V (Vss).

- With reference to ***BDA-DRCU-10***, we shall test that the listed parameters associated with DC JFET heater Bias can be commanded as specified. Signal level variation shall checked over the 0 to 5V and 0 to 3 V (respectively for the photometer and the spectrometer ranges) with no load. Then for signal level of 0.1 V, 2.5 V and 5 V maximum current capability shall be checked by connecting a resistive load with the appropriate value.

More generally, we shall check all JFETS commands (and all output levels over 8 bits) using the dedicated command interface.

Amplitude is measured by means of appropriate DC voltage controller while noise is measured by means of a spectrum analyser.

The tested parameters as well as their range is given is the hereafter table :

Parameter Description	Parameter Name	Min value	Max value	Comment	Specification
DC JFET BIAS current generation		1 mA	5 mA		BDA DRCU 08
Vdd accuracy		1.5 V	4 V	precision 2.5 / 256 V	BDA DRCU 07
Vss accuracy		-5 V	0 V	precision 5 / 256 V	BDA DRCU 06
Vdd noise		0	0.3 µV/√Hz		BDA DRCU 08
Vss noise		0	13 µV/√Hz		BDA DRCU 08
Photometer DC JFET heater Bias Voltage		0 V	5 V	Max = Nominal value	BDA DRCU 10
Spectrometer DC JFET heater Bias Voltage		0 V	3 V	Max = Nominal value	BDA DRCU 10
Photometer DC JFET heater Bias current		0 mA	25 mA	Max = Nominal value	BDA DRCU 10
Spectrometer DC JFET heater Bias current		0 mA	10 mA	Max =Nominal value	BDA DRCU 10

Test table 3.10

3.11 DAQ-IF tests

The measurements (reference ***DRCU REQ-38***) will be performed at variable sampling frequencies to check the susceptibility of the acquisition over the frequency (nominal frequencies are 16 Hz for photometer and 80 Hz for bolometer).

The only test to perform is to check the amplification noise performances over the sampling frequency range (minimum, nominal, maximum).

Parameter Descritption	Parameter Name	Min Value	Max Value	Comments	Specification
Channel input noise depending on sampling frequency	ChN(sf)	-	7 nV/√Hz	288 + 72 channels	BDA DRCU 01

Test table 3.11

Note : DAQ-IF tests have up to now been performed at 100 Hz.

3.12 Alimentation tests

We will test the susceptibility of the DCU performances with respect to the alimentation (+/- 9 V analogic and 5 V numeric). We consider that the 5V alimentation stability will be sizing with respect to the performances. Therefore, we will only test the susceptibility to the 5V alimentation.

We here recall that post regulators on back planes make the DCU not sensible to the +/- 9 V analogic supply variations.

We shall only test relevant characteristics under non nominal alimentation conditions so as to evaluate the susceptibility :

- Transfer function

  We shall test the susceptibility of the following parameters :
  - Transfer Function,
  - Noise

To set the downgraded alimentation (5 V) values, we refer to the specifications concerning the end of life alimentation performances (2,5 % max level).

We shall then perform the tests with 4,8 V, 5V and 5,2 V.

The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	min value	max value	Comment	Specification
Photometer low pass filter cut-off frequency	PhLPFfreq	5 Hz- 1%	5 Hz + 1%	288 channels	BDA-DRCU 13
Spectrometer low pass filter cut-off frequency	SpLPFfreq	25 Hz- 1%	25 Hz + 1%	72 channels	BDA-DRCU 14
Photometer overall gain	PhG	5187 - 0.5%	5187 + 0.5%	288 channels	[A3]
Spectrometer overall gain	SpG	2320 - 0.5%	2320 + 0.5%	72 channels	[A3]
DC compensation offset	DCoffset	0 V	5 V	16 levels	DRCU REQ 38
Channel input noise	ChN		7 nV/√Hz	288 + 72 channels	BDA DRCU 01

Test table 3.12-1

- BIAS

  We shall test the susceptibility of the output signal magnitudes
  We shall then perform the tests with 4,8 V, 5V and 5,2 V.

  The tested parameters as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	Min value	Max value	Comment	Specification
Bias amplitude (LIA)	LIABmag	0	200 mV	precision 0.2 / 256 V	BDA DRCU 05
Bias amplitude (TC)	TCBmag	0	500 mV	precision 0.5 / 256 V	BDA DRCU 05
DC JFET BIAS current generation		1 mA	5 mA		BDA DRCU 08
Vdd accuracy		1.5 V	4 V	precision 2.5 / 256 V	BDA DRCU 07
Vss accuracy		-5 V	0 V	precision 5 / 256 V	BDA DRCU 06
Photometer DC JFET heater Bias Voltage		0 V	5 V	Max = Nominal value	BDA DRCU 10
Spectrometer DC JFET heater Bias Voltage		0 V	3 V	Max = Nominal value	BDA DRCU 10
Photometer DC JFET heater Bias current		0 mA	25 mA	Max = Nominal value	BDA DRCU 10
Spectrometer DC JFET heater Bias current		0 mA	10 mA	Max =Nominal value	BDA DRCU 10

Test table 3.12-2

To set the downgraded alimentation (5 V) values, we can refer to the specifications concerning the end of life alimentation performances (2,5 % max level).
As an example, we could perform the tests with 4,8 V, 5V and 5,2 V.

To perform these tests, we need two generators with triple outputs (+5 V, +9 V, -9 V) with adjustable values on all outputs (following end of life specification of 2,5 %).

Note : up to now, the voltage is generated by fixed regulators and therefore is not adjustable. For the tests, we shall manage :

- ⇨ *To provide an adjustable alimentation*
- ⇨ *To gather information concerning regulators (noise spectrum)*

3.13 Consumption tests

We shall perform consumption tests, which induces :

i. To test the DCU consumption (at different temperature levels),
ii. To get an ammeter connected in line to check consumption.

Note : A Precise criterion for the DCU consumption does not exist (DRCU consumption only).

3.14 Temperature tests

With reference to ***BDA-DRCU 19***, we shall tests the susceptibility of some parameters when temperature varies.

We need a device to simulate temperature variations (it needs to dispose of a sufficient volume to get the DCU with its connections inserted inside).

We will test the noise and gain performances over the following temperature values : 0°C, +25 °C and +50 °C

The tested parameter as well as their range are given in the hereafter table :

Parameter Description	Parameter Name	Min Value	Max Value	Comments	Specification
Channel input noise	ChN		7 nV/√Hz	288 + 72 channels	BDA DRCU 19
Photometer overall gain	PhG	5187 - 0.5%	5187 + 0.5%	288 channels	[A3]
Spectrometer overall gain	SpG	2320 - 0.5%	2320 + 0.5%	72 channels	[A3]

Test table 3.14

3.15 Timing tests

We shall test out accurately the timings of when digital samples are taken w.r.t. commands sent by DPU . We shall also measure phase shifts right through system and plot timing delay from DCU input amplitude change to digital output step.

4 DCU EM with JPL bolometers performance tests

Before the DCU EM performance tests to be performed with JPL bolometers, it is necessary that:

⇨ The bolometers be tested with JPL dedicated electronic devices. This means that the noise level at bolometers/JFETS output be compliant with the requirements.

⇨ The assembled DCU has undergone successfully the tests listed in chapter 3.

⇨ Before to go further, we shall,

- get informed about the availability of the tested JPL FPU (cryostat + bolometers),
- get informed about the number of available (tested) bolometers.

In case such a DCU and FPU tested configuration is available, the DCU can be connected to it so as to perform the performance tests listed below.

We note that the FPU configuration will allow limited performance tests : the bolometers with not be irradiated and no chopper device will be available.

As a consequence, we will simulate the variation of the resistance by generating a Sinus BIAS signal with a step in amplitude : this will induce a variation of the bolometer's resistances correlated with the power dissipated inside.

This kind of measurement will be performed :

- At different BIAS frequencies [50, 300 Hz],
- With different amplitude step values.

The other kind of test will consist in checking, for each pixel available, the sync optimal phase value. This optimal phase should be the same for each bolometer. To check this, we will identify the optimal phase for each tested pixel.

5 TRACEABILITY MATRIX

The hereafter matrix identifies, for each requirement, the test that allows to verify it :

Requirement ID	Description	Element	test
BDA-DRCU-01	The DRCU signal processing electronics shall have less than 7 nV/√Hz as seen post demodulation, after digitization. Noise is referred to the input over the frequency range 0.05 to 25 Hz. This performance must be accomplished with a bias input signal to the DRCU of 10 mVrms AC, 5 mV DC, 1 V DC common-mode offset, with an input load of 7 kOhms.	LIA	Noise mesurements
BDA-DRCU-03	Input capacitance to be less than 100 pF, measured from the DRCU DxMA connector pins without the harness.	DCU	Design
BDA-DRCU-04	Input impedance to be larger than 1 MΩ from 50 – 300 Hz.	DCU	Design
BDA-DRCU-05	The DRCU shall provide 5 BDA bias signals, adjustable from 0 to 200 mV rms, and 1 bias signal for temperature readout adjustable from 0 to 500 mV rms. - The temperature readout biases are to be divided from a common oscillator, - Each bias shall be adjustable with 8 bit precision - The frequency of each bias shall be adjustable between 50 and 300 Hz, with a precision of 5 Hz Voltage noise on the bias lines, within the modulated band (50 – 300 Hz), measured at the DRCU DxMA connector, shall be < 20 nV/√Hz	BIAS	Tests sinus bias for commands for bolos and temp (BIAS output)
BDA-DRCU-06	The DRCU shall provide 15 commandable JFET source voltages with 256 levels. The range of Vss is from 0 V to – 5 V.	BIAS / JFET	Tests on JFETS commands
BDA-DRCU-07	Vdd shall be adjustable from 1.5 to 4 V	BIAS / JFET	Tests on JFETS commands
BDA-DRCU-08	Vdd and Vss lines individually must source 1 mA to 5mA. Noise on Vss < 1 µV/√Hz, and noise on Vdd < 0.3	BIAS / JFET	Tests on JFETS commands

	µV/√Hz within modulated band (50, 300 Hz) measured at the DRCU DxMA connector.		
BDA-DRCU-09	Each Vdd and Vss supplies must be commandable ON/OFF for spectrometer and photometer independently without overshoot. Each Vdd and Vss are turned on and off together..	BIAS / JFET	Tests on JFETS commands
BDA-DRCU-10	The DRCU shall provide 2 double wired JFET heater lines with adjustable amplitude and duration. The supplies must be able to provide 5 V and 25 mA (photometer), 3 V and 10 mA (spectrometer). Each heater line is commandable ON / OFF, with a minimum duration of 10 s.	BIAS / JFET	Tests on JFETS commands
BDA-DRCU-11	The common-mode rejection is –60 dB (50 – 300 Hz).	LIA	Common mode rejection measurement
BDA-DRCU-12	The DRCU shall provide a dynamic range at the ADC sufficient to maintain the noise performance of the detectors under maximal signal conditions. This is estimated to be 16 ADC telemetry bits.	LIA	Design
BDA-DRCU-13	The signal bandwidth of the photometer channels shall be 0.03 Hz to 5 Hz. The 5 Hz cutoff should have a precision of 1 %.	LIA	Test of transfer function
BDA-DRCU-14	The signal bandwidth of the spectrometer channels shall be 0.03 Hz to 25 Hz. The 25 Hz cutoff should have a precision of 1 %.	LIA	Test of transfer function
BDA-DRCU-15	The sampling of the photometer channels shall be synchronized with the bias, at a rate selectable between νbias/2 to νbias/256.	DCU	Design
BDA-DRCU-16	The sampling of the spectrometer channels shall be synchronized with the bias, at a rate selectable between νbias/2 to νbias/256.	DCU	Design
BDA-DRCU-17	The DRCU shall provide two adjustable power supplies for temperature control using a heater located at the 300 mK stage. This supply must provide at least	DCU	Design

	300 mV and 50 µA.		
BDA-DRCU-18	Noise performance BDA-DRCU-01 shall be maintained under bias range 50 – 300 Hz.	DCU	
BDA-DRCU-19	DRCU noise performance (BDA-DRCU-01) to be maintained under a warm electronics thermal drift of 1 K / hour (TBC).	LIA	Temperature tests
BDA-DRCU-21	Thermal requirement on JFET power is dV/V < 500 ppm / K for Vdd and Vss		
BDA-DRCU-22	The DRCU shall not saturate at an input voltage as large as 11 (TBC) mV_{rms} at input (photometer), 17 (TBC) mV_{rms} at input (spectrometer). DRCU channels shall remain functional if one input signal goes to Vbias.	LIA	Tests of saturation Tests of linearity
BDA-DRCU-23	The conducted RF on all lines connecting to the bolometers or JFETS, originating in th DRCU, shall be less than 0.1 nA ms as measured over a frequency range of 0 –10 GHz. (This assumes an attenuation of 40 dB by the RF filters).		
BDA-DRCU-23	BIAS, JFET power, and readout electronics for the spectrometer arrays are to run from separate dedicated power supplies, with independent, isolated grounds.		Design
BDA-DRCU-25	The electrical cross-talk between channels in the DRCU shall be less than 0.05 % (TBC). The electrical cross-talk shall be verified by varying the input signal on one channel and measuring the response in other channels. The input signal level to each channel must be representative.	LIA	Cross Talk measurement
BDA-DRCU-26	Each signal input to the LIA module must be connected to ground by a diode. This provides both protection and allows the JFETs to turn on without the JFET heater.	LIA	Design

Note :

If this last requirement is met, we need to characterize small signal impedance versus d.c. offset. Note that JFETs may be running at up to say -0.8V DC on sources. In such a case we have to answer these questions :

- *what do these diodes do to JFET dissipation with various BDA failures?...into DCU FMECA ?.*
- *Are low level A.C. RF currents likely to be rectified by these room temperature diodes, or are MAT02s bad enough for this anyway...needs analysis and possibly test.*