SPIRE-SAP-REP-001942

SPIRE INSTRUMENT

DCU EM/QM1

TEST REPORT

SPIRE-SAP-PRJ-00xxxx

SPIRE-SAP-REP-001942

Contributors: **F. PINSARD-DCU Engineer**

	Name and Function	Date	Signature
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Document change record

Issue/Revision	Date	Modified pages
1.0	15/09/2003	All: document creation - Draft

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List of Acronyms

ADC	Analog to Digital Converter
AMUX	Analog Multiplexer
BSM	Beam Steering Mirror
DAC	Digital to Analog Converter
DCE	Detector Control Electronics
DCU	Detector Control Unit
DMUX	Digital Multiplexer
DPU	Data Processing Unit
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
NA	Not Applicable
NC	Not connected
OEP	Optical Encoder Preamplifier
PDU	Power Distribution Unit
PSU	Power Supply Unit
S/S	Sub-System
S/W	Software
SCE	Sub-system Control Electronics
SCU	Sub-system Control Unit
SMEC	Spectrometer Mechanism Control
SMPS	Switching Mode Power Supply
SNR	Signal over Noise Ratio
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
WIH	Warm Interconnect Harnesses

Table of Contents

1. Introduction

1.1. Purpose

The purpose of this document is to give description and results for all functional and performance tests carried out on the DCU-QM1 after integration at CEA of all the boards constituting the model in the enclosure.
Tests have been driven by F. PINSARD (DCU design engineer).

1.2. Scope

The tests described here have been defined in accordance with the "DCU EM/QM1 Test Plan" (RD1). The purpose of both being to validate DCU design after integration.
These tests are complementary to those performed at board level during electronics development at JPL.
The purpose of thermal tests (at 0°C and +50°C) is to validate the functionality of the DCU electronics design against temperature variation. No performance shall be derived from these thermal measurements, the temperature coefficient of discrete components being generally not identical to those of further flight component based models.

1.3. Reference Documents

RD1	DCU EM/QM1 Test Plan	SAp-SPIRE-HT-0088-02 v1.0
RD2	DCU Design Document	SAp-SPIRE-FP-0063-02 v0.3

1.4. Applicable Documents

AD1	DRCU/DPU ICD	
AD2	DRCU specification Document	

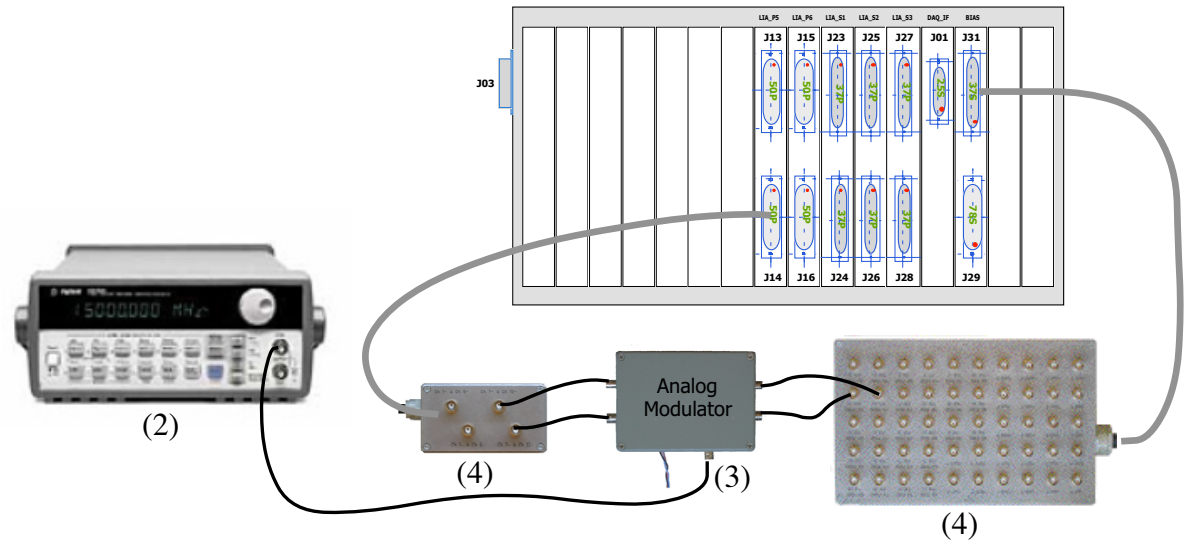
2. Analog channel transfer functions verification

2.1. Test setup:

2.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU (1)
- the LTU
- an arbitrary waveform generator (0/30 Hz sine signal)-(2)
- an analog modulator (3)
- DxMA to BNC breakout boxes (4)
- the SPIRE powerbench



2.1.2. Script and batch files

No FPU simulator script is required. Two sequences of command are executed by the LTU:

- TRFPh.txt
- TRFSp.txt

2.2. Test results

Data analysis tools:

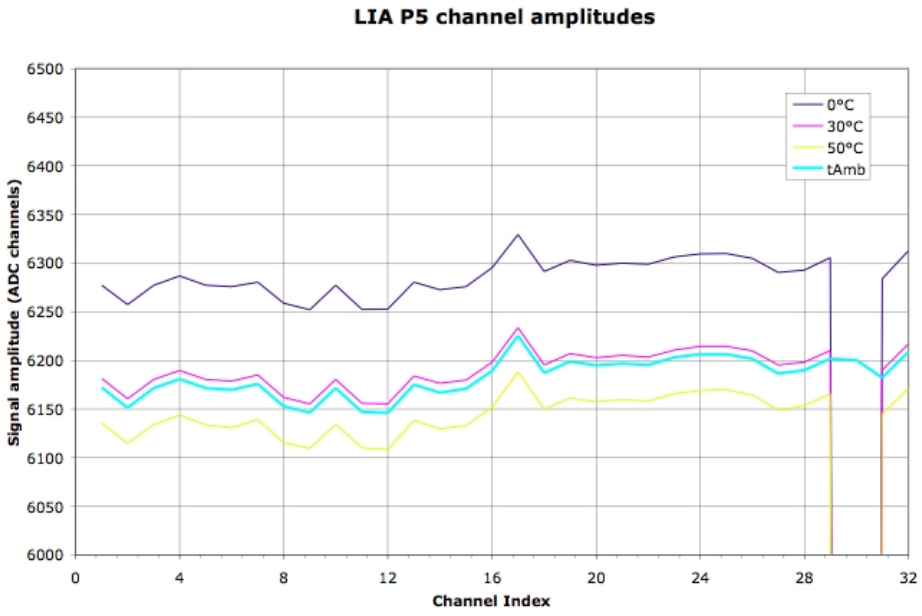
- see FP
- Photo/SpectroGains.xls

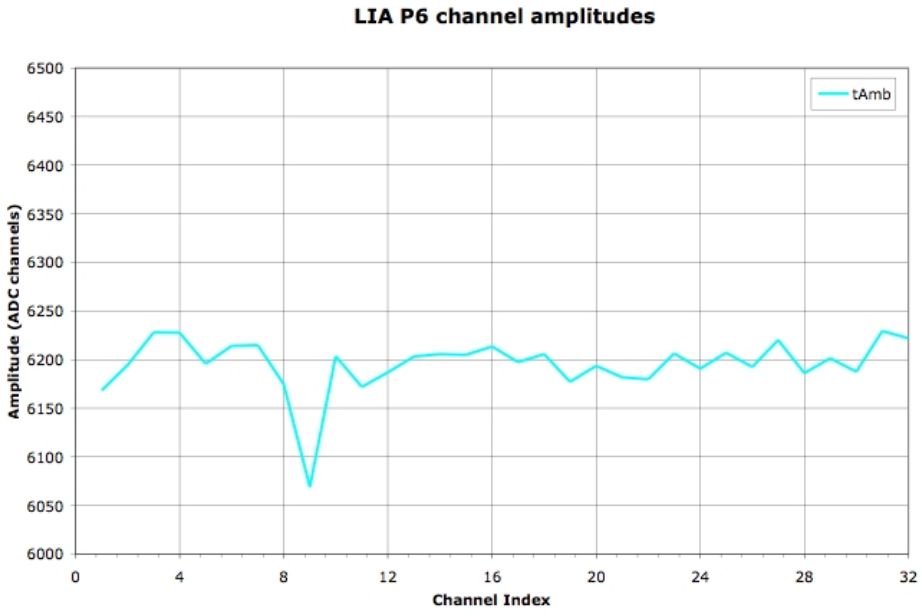
Settings:

- F_{signal} = 0.1 Hz
- A_{signal} = 300 mVpp
- F_{bias} = 204 Hz
- A_{bias} = 64 hexa

2.2.1. Absolute channel gains

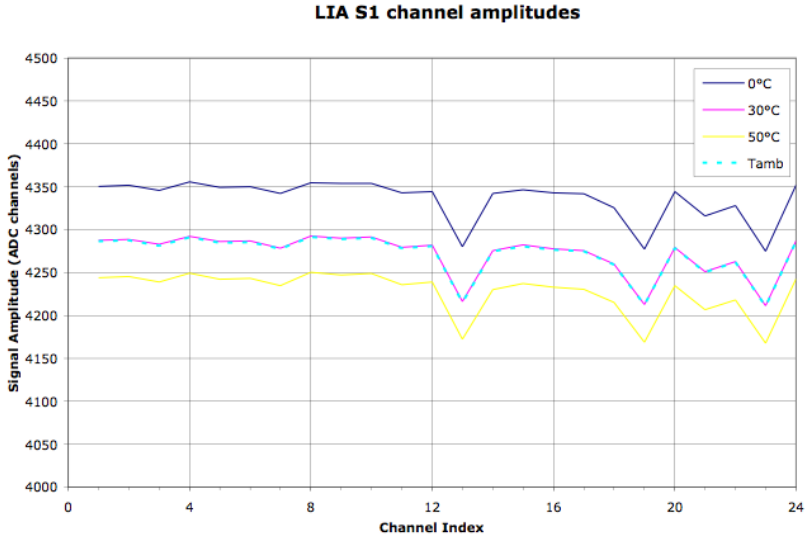
Photometer boards (LIA P5 & LIA P6)

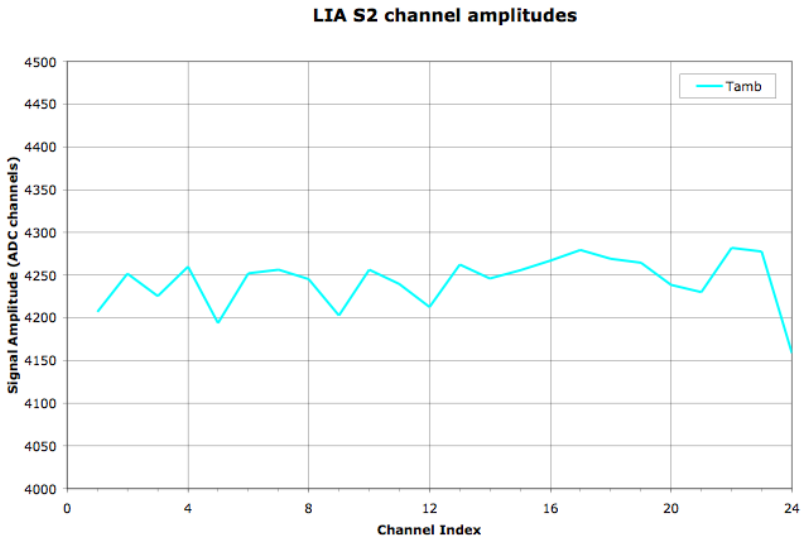


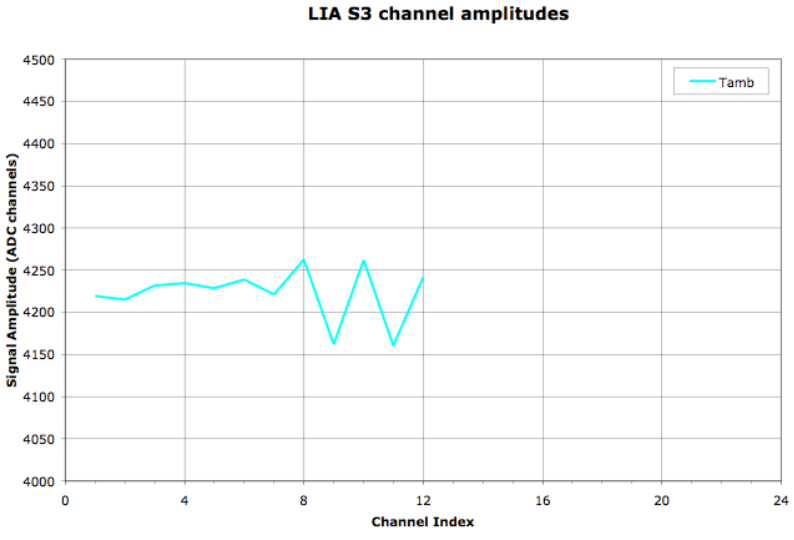


These figures show measured signal amplitudes for a modulated input signal common to all the LIA inputs. For LIA_P5 additional thermal test have been carried out to validate LIA_P design operation over the 0 to 50C temperature range.

Spectrometer boards (LIA S1 LIA S2 & LIA S3)



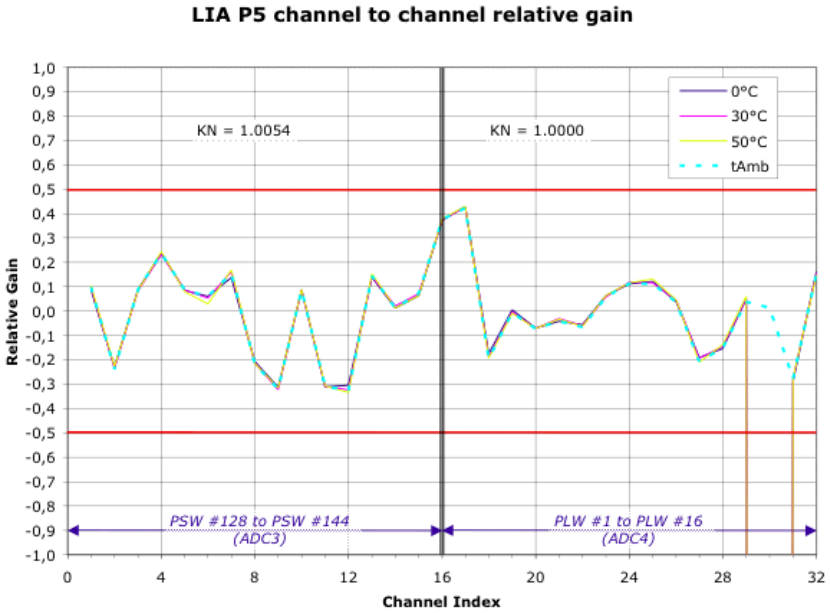


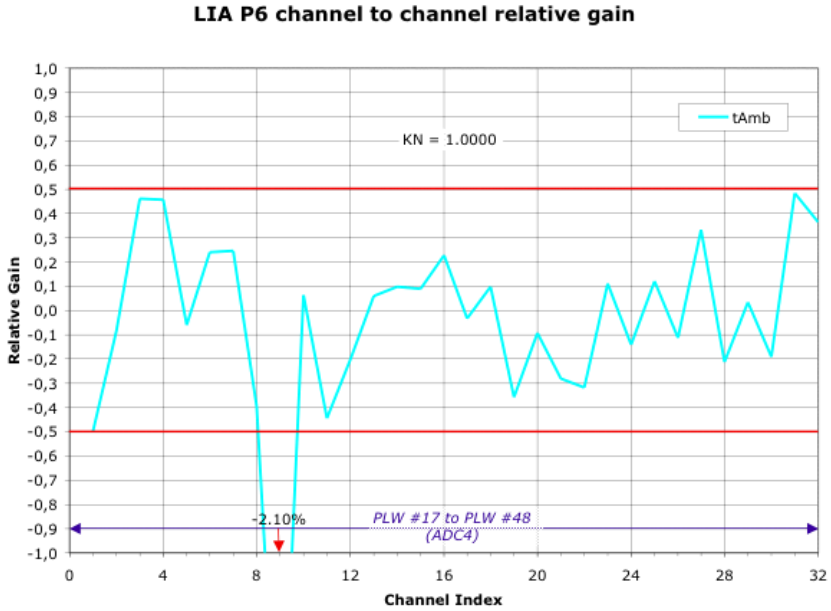


These figures show measured signal amplitudes for a modulated input signal common to all the LIA inputs. For LIA_S1 additional thermal test have been carried out to validate LIA_S design operation over the 0 to 50C temperature range.

2.2.2. Channel to channel gain matching

Photometer boards (LIA P5 & LIA P6)



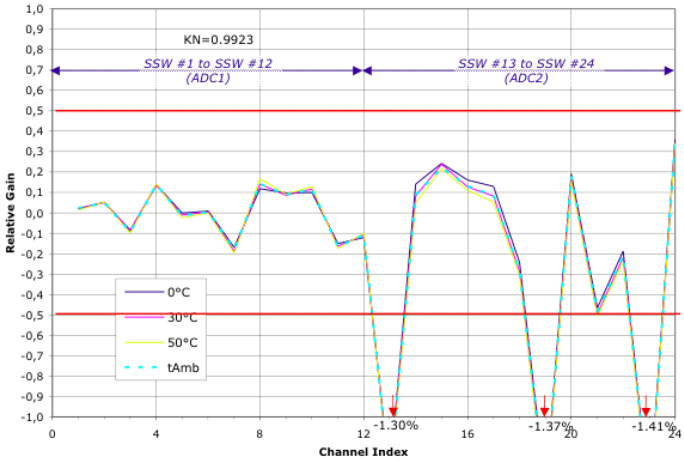


Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-PhG/SpG	P5	1	OK	KN=1.0054	
“	P5	2	OK	KN=1.0054	
“	P5	3	OK	KN=1.0054	
“	P5	4	OK	KN=1.0054	
“	P5	5	OK	KN=1.0054	
“	P5	6	OK	KN=1.0054	
“	P5	7	OK	KN=1.0054	
“	P5	8	OK	KN=1.0054	
“	P5	9	OK	KN=1.0054	
“	P5	10	OK	KN=1.0054	
“	P5	11	OK	KN=1.0054	
“	P5	12	OK	KN=1.0054	
“	P5	13	OK	KN=1.0054	
“	P5	14	OK	KN=1.0054	
“	P5	15	OK	KN=1.0054	
“	P5	16	OK	KN=1.0054	
“	P5	17	OK		
“	P5	18	OK		
“	P5	19	OK		
“	P5	20	OK		
“	P5	21	OK		
“	P5	22	OK		
“	P5	23	OK		
“	P5	24	OK		
“	P5	25	OK		
“	P5	26	OK		
“	P5	27	OK		
“	P5	28	OK		
“	P5	29	OK		
“	P5	30	OK	Connector failure: corrected	NCR147
“	P5	31	OK		
“	P5	32	OK		
RD1-PhG/SpG	P6	1	OK		
“	P6	2	OK		
“	P6	3	OK		
“	P6	4	OK		
“	P6	5	OK		
“	P6	6	OK		
“	P6	7	OK		
“	P6	8	OK		
“	P6	9	NOK		NCR148
“	P6	10	OK		
“	P6	11	OK		
“	P6	12	OK		
“	P6	13	OK		
“	P6	14	OK		
“	P6	15	OK		
“	P6	16	OK		
“	P6	17	OK		
“	P6	18	OK		

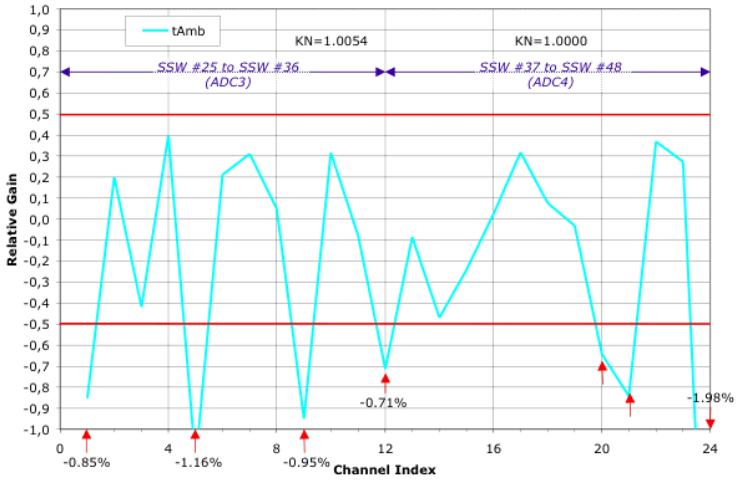
“	P6	19	OK		
“	P6	20	OK		
“	P6	21	OK		
“	P6	22	OK		
“	P6	23	OK		
“	P6	24	OK		
“	P6	25	OK		
“	P6	26	OK		
“	P6	27	OK		
“	P6	28	OK		
“	P6	29	OK		
“	P6	30	OK		
“	P6	31	OK		
“	P6	32	OK		

Spectrometer boards (LIA S1 LIA S2 & LIA S3)

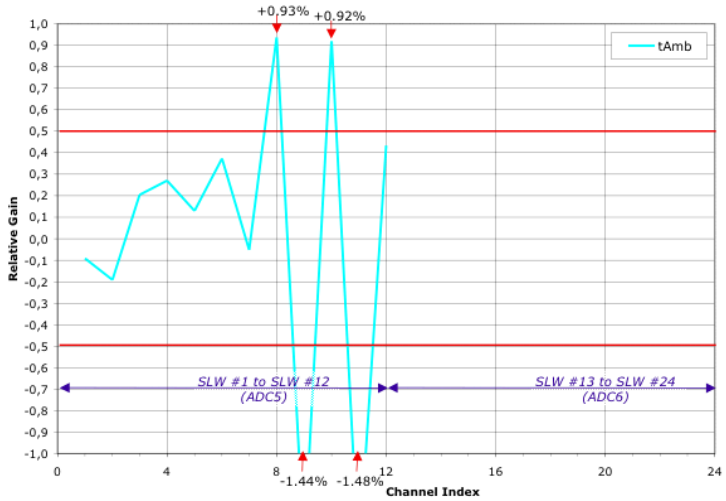
LIA S1 channel to channel relative gain



LIA S2 channel to channel relative gain



LIA S3 channel to channel relative gain



Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-PhG/SpG	S1	1	OK	KN=0.9923	
"	S1	2	OK	KN=0.9923	
"	S1	3	OK	KN=0.9923	
"	S1	4	OK	KN=0.9923	
"	S1	5	OK	KN=0.9923	
"	S1	6	OK	KN=0.9923	
"	S1	7	OK	KN=0.9923	
"	S1	8	OK	KN=0.9923	
"	S1	9	OK	KN=0.9923	
"	S1	10	OK	KN=0.9923	
"	S1	11	OK	KN=0.9923	
"	S1	12	OK	KN=0.9923	
"	S1	13	NOK		NCR152
"	S1	14	OK		
"	S1	15	OK		
"	S1	16	OK		
"	S1	17	OK		
"	S1	18	OK		
"	S1	19	NOK		NCR152
"	S1	20	OK		
"	S1	21	OK		
"	S1	22	OK		
"	S1	23	NOK		NCR152
"	S1	24	OK		
RD1-PhG/SpG	S2	1	NOK		NCR153
"	S2	2	OK		
"	S2	3	OK		
"	S2	4	OK		
"	S2	5	NOK		NCR153
"	S2	6	OK		
"	S2	7	OK		
"	S2	8	OK		
"	S2	9	NOK		NCR153
"	S2	10	OK		
"	S2	11	OK		
"	S2	12	NOK		NCR153
"	S2	13	OK		
"	S2	14	OK		
"	S2	15	OK		
"	S2	16	OK		
"	S2	17	OK		
"	S2	18	OK		
"	S2	19	OK		
"	S2	20	NOK		NCR153
"	S2	21	NOK		NCR153
"	S2	22	OK		
"	S2	23	OK		
"	S2	24	NOK		NCR153
RD1-PhG/SpG	S3	1	OK		
"	S3	2	OK		

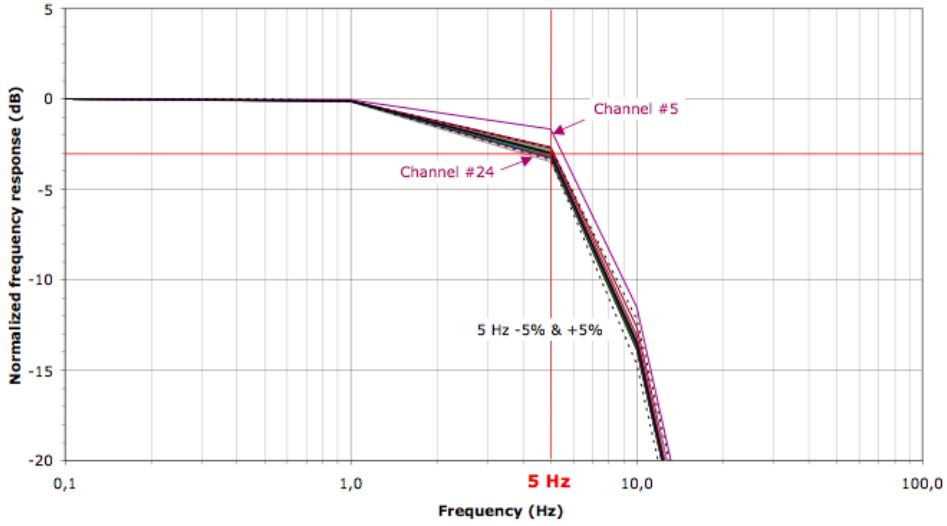
“	S3	3	OK		
“	S3	4	OK		
“	S3	5	OK		
“	S3	6	OK		
“	S3	7	OK		
“	S3	8	NOK		NCR154
“	S3	9	NOK		NCR154
“	S3	10	NOK		NCR154
“	S3	11	NOK		NCR154
“	S3	12	OK		
“	S3	13	NA		
“	S3	14	NA	No measurement available due wrong offset setting during test	FAxxx
“	S3	15	NA		
“	S3	16	NA		
“	S3	17	NA		
“	S3	18	NA		
“	S3	19	NA		
“	S3	20	NA		
“	S3	21	NA		
“	S3	22	NA		
“	S3	23	NA		
“	S3	24	NA		

2.2.3. Bessel low pass filter transfer functions

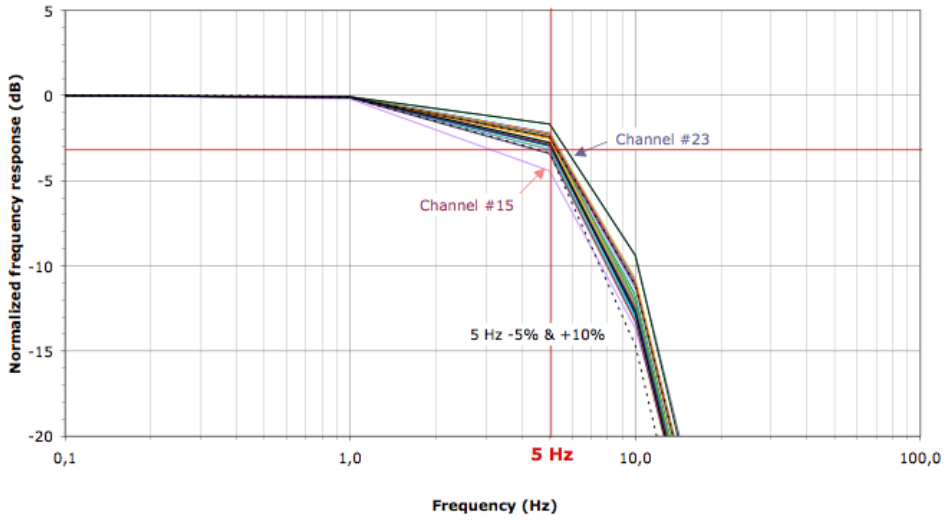
Photometer boards (LIA P5 & LIA P6)

The analog channel frequency response is checked by varying the frequency of the sine generated by the external arbitrary wave from generator between 0.1 and 30 Hz. The signal amplitude is measured directly by the DAQ_IF A to D converters. In order to avoid aliasing effect, the DAQ_IF sampling frequency is set at least at twice the maximum signal frequency (60 Hz).

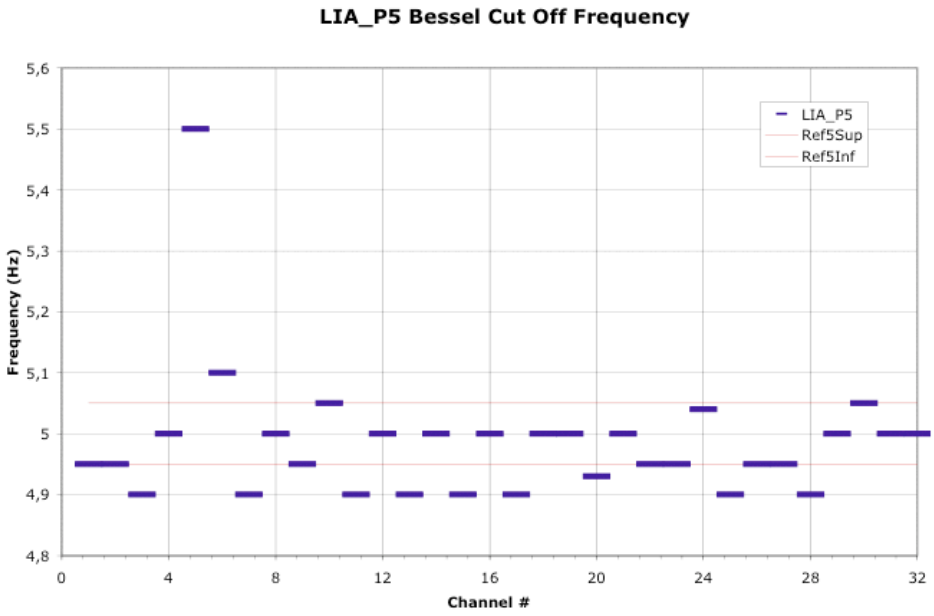
LIA P5 Channel transfer functions

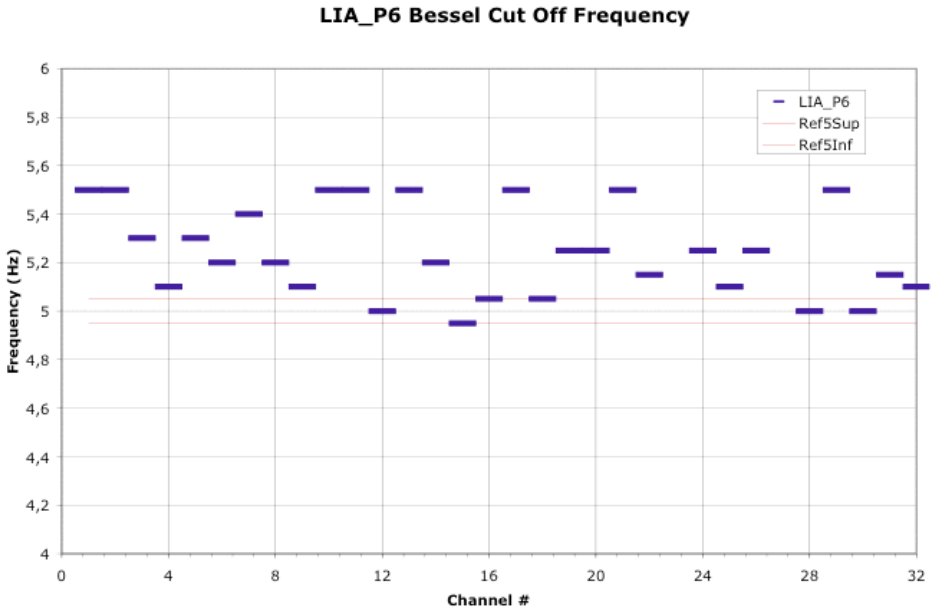


LIA P6 Channel transfer functions



LIA P cut-off frequencies

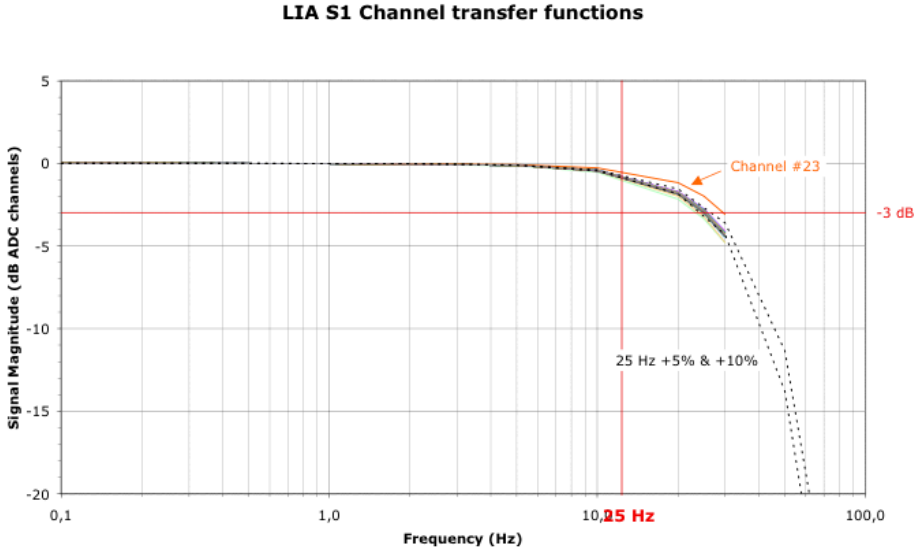


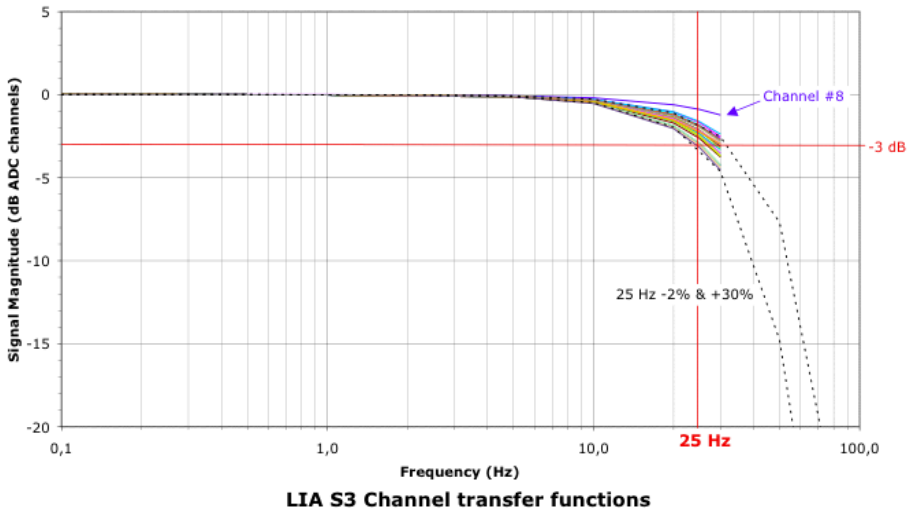


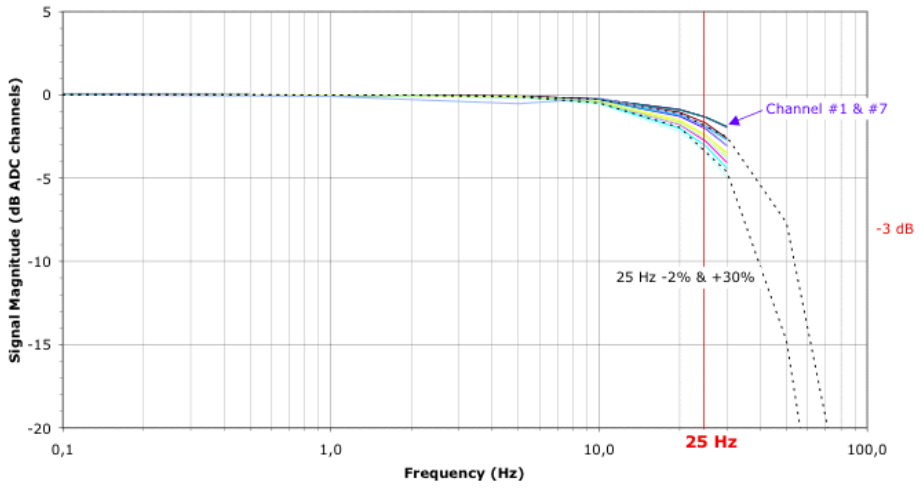
Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-PhLPFFreq	P5	1	OK		
	P5	2	OK		
	P5	3	NOK		NCR150
	P5	4	OK		
	P5	5	NOK		NCR150
	P5	6	NOK		NCR150
	P5	7	NOK		NCR150
	P5	8	OK		
	P5	9	OK		
	P5	10	OK		
	P5	11	NOK		NCR150
	P5	12	OK		
	P5	13	NOK		NCR150
	P5	14	OK		
	P5	15	NOK		NCR150
	P5	16	OK		
	P5	17	NOK		NCR150
	P5	18	OK		
	P5	19	OK		
	P5	20	NOK		NCR150
	P5	21	OK		
	P5	22	OK		
	P5	23	OK		
	P5	24	OK		
	P5	25	NOK		NCR150
	P5	26	OK		
	P5	27	OK		
	P5	28	NOK		NCR150
	P5	29	OK		
	P5	30	OK		
	P5	31	OK		
	P5	32	OK		
RD1-PhLPFFreq	P6	1	NOK		NCR150
	P6	2	NOK		NCR150
	P6	3	NOK		NCR150
	P6	4	NOK		NCR150
	P6	5	NOK		NCR150
	P6	6	NOK		NCR150
	P6	7	NOK		NCR150
	P6	8	NOK		NCR150
	P6	9	NOK		NCR150
	P6	10	NOK		NCR150
	P6	11	NOK		NCR150
	P6	12	OK		
	P6	13	NOK		NCR150
	P6	14	NOK		NCR150
	P6	15	OK		
	P6	16	OK		
	P6	17	NOK		NCR150
	P6	18	OK		

	P6	19	NOK		NCR150
	P6	20	NOK		NCR150
	P6	21	NOK		NCR150
	P6	22	NOK		NCR150
	P6	23	NOK		NCR150
	P6	24	NOK		NCR150
	P6	25	NOK		NCR150
	P6	26	NOK		NCR150
	P6	27	NOK		NCR150
	P6	28	OK		
	P6	29	NOK		NCR150
	P6	30	OK		
	P6	31	NOK		NCR150
	P6	32	NOK		NCR150

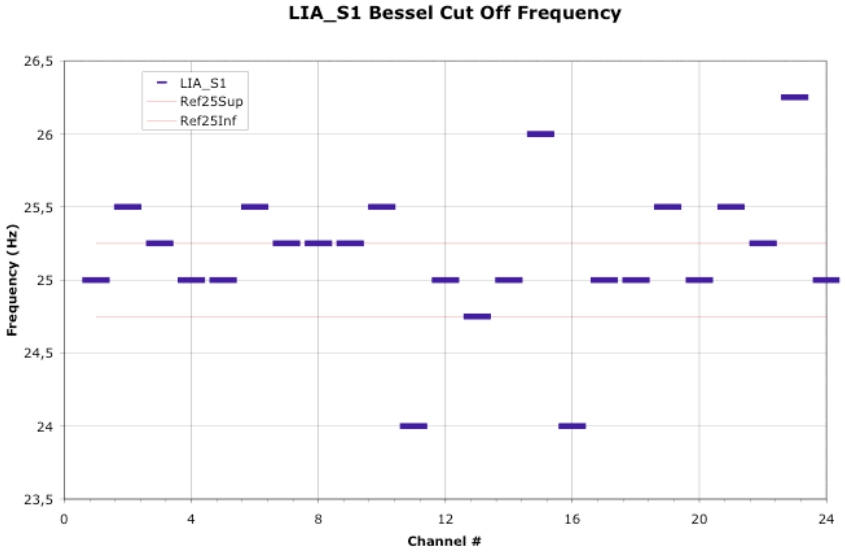
Spectrometer boards (LIA S1 LIA S2 & LIA S3)

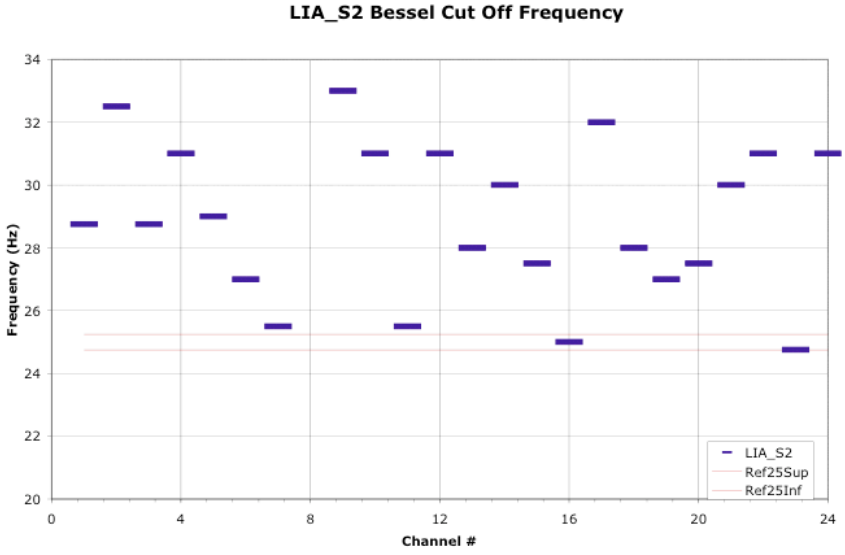


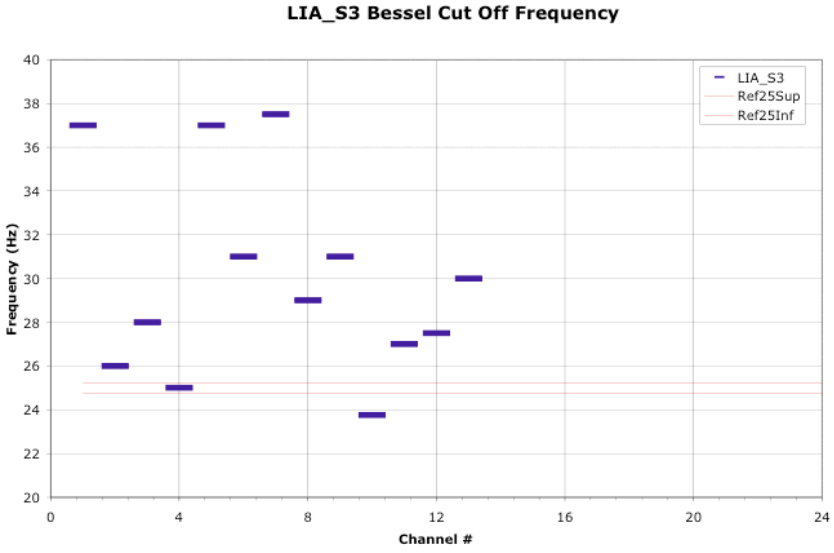




LIA S Cut-off frequencies







Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-SpLPFFreq	S1	1	OK		
	S1	2	NOK		NCR149
	S1	3	OK		
	S1	4	OK		
	S1	5	OK		
	S1	6	NOK		NCR149
	S1	7	OK		
	S1	8	OK		
	S1	9	OK		
	S1	10	NOK		NCR149
	S1	11	NOK		NCR149
	S1	12	OK		
	S1	13	OK		
	S1	14	OK		
	S1	15	NOK		NCR149
	S1	16	NOK		NCR149
	S1	17	OK		
	S1	18	OK		
	S1	19	NOK		NCR149
	S1	20	OK		
	S1	21	NOK		NCR149
	S1	22	OK		
	S1	23	NOK		NCR149
	S1	24	OK		
RD1-SpLPFFreq	S2	1	NOK		NCR149
	S2	2	NOK		NCR149
	S2	3	NOK		NCR149
	S2	4	NOK		NCR149
	S2	5	NOK		NCR149
	S2	6	NOK		NCR149
	S2	7	NOK		NCR149
	S2	8	NOK		NCR149
	S2	9	NOK		NCR149
	S2	10	NOK		NCR149
	S2	11	NOK		NCR149
	S2	12	NOK		NCR149
	S2	13	NOK		NCR149
	S2	14	NOK		NCR149
	S2	15	NOK		NCR149
	S2	16	OK		
	S2	17	NOK		NCR149
	S2	18	NOK		NCR149
	S2	19	NOK		NCR149
	S2	20	NOK		NCR149
	S2	21	NOK		NCR149
	S2	22	NOK		NCR149
	S2	23	OK		
	S2	24	NOK		NCR149
RD1-SpLPFFreq	S3	1	NOK		NCR149
	S3	2	NOK		NCR149
	S3	3	NOK		NCR149
	S3	4	OK		

	S3	5	NOK		NCR149
	S3	6	NOK		NCR149
	S3	7	NOK		NCR149
	S3	8	NOK		NCR149
	S3	9	NOK		NCR149
	S3	10	NOK		NCR149
	S3	11	NOK		NCR149
	S3	12	NOK		NCR149
	S3	13	NOK		NCR149
	S3	14	NA	No measurement available due wrong offset setting during test	
	S3	15	NA		
	S3	16	NA		
	S3	17	NA		
	S3	18	NA		
	S3	19	NA		
	S3	20	NA		
	S3	21	NA		
	S3	22	NA		
	S3	23	NA		
	S3	24	NA		

3. Noise performance verification

3.1. Test setup:

3.1.1. Hardware configuration

The involved equipments are:

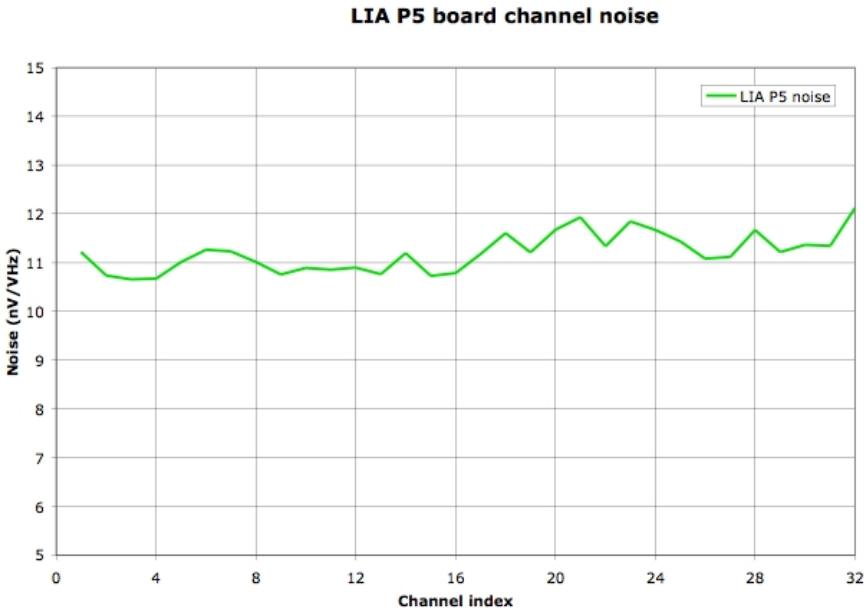
- the DCU with all inputs short circuited
- the LTU

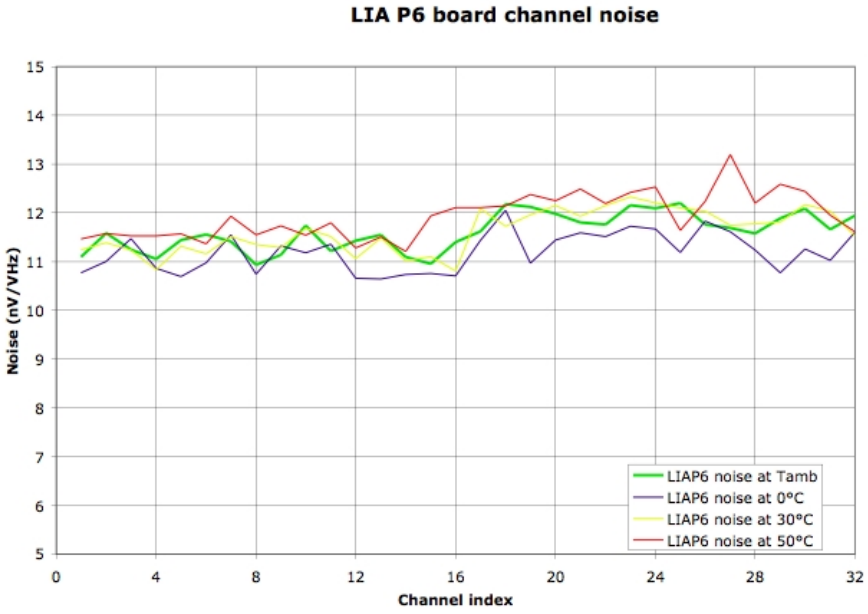
3.1.2. Script and batch files

The test sequence is basically limited to perform DCU data acquisition. In order to extend the characterisation of the analog channel noise, measurements have been performed over the 0 to 50°C temperature range. Effect of digital electronics and possible induced perturbations are checked by varying the sampling frequency and the bias frequency (demodulation sync signal been adjusted at each frequency).

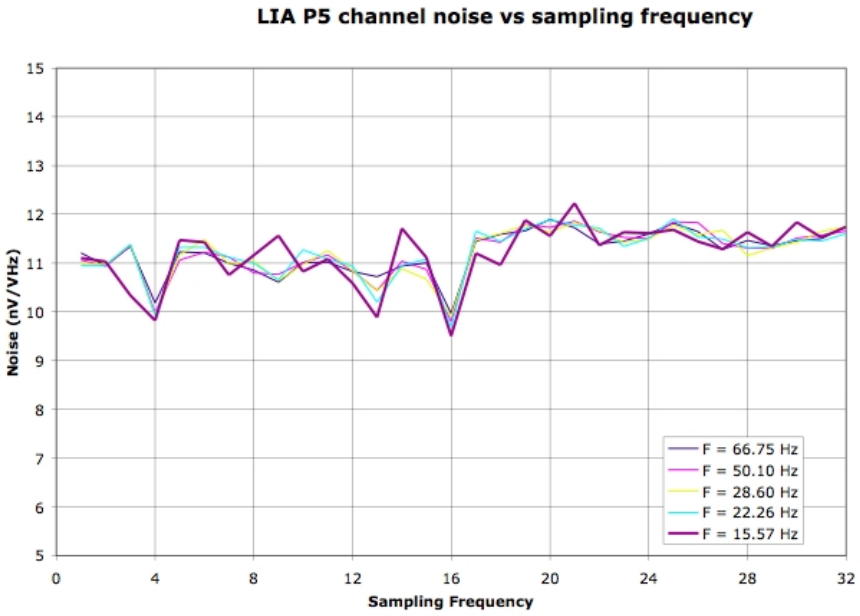
3.2. Test results

3.2.1. Photometer

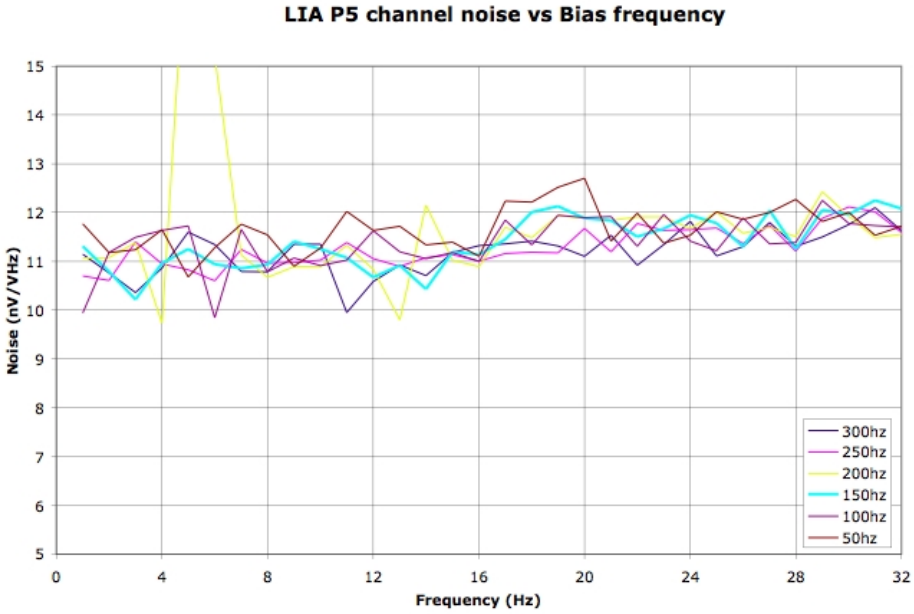




For the LIA P6 board noise measurement was performed at 0C, 30C and 50C. The effect of temperature variation is very limited.



The sampling frequency has no effect on the channel noise as shows above. This demonstrates proper decoupling of the digital function and of the interface with FPU in the DCU.



Note: again the plot shows no effect of the bias frequency on the analog channel performances. No coupling between analog electronics and bias synthesiser is found.

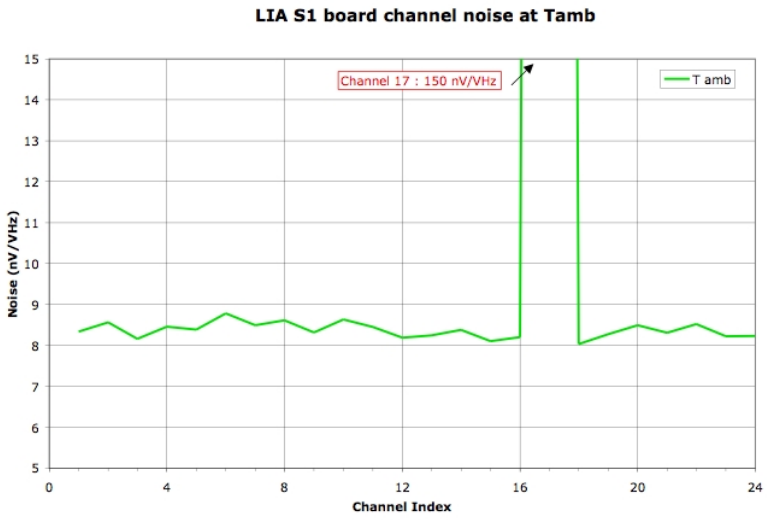
The data resulting of this test are stored within the following file(s)

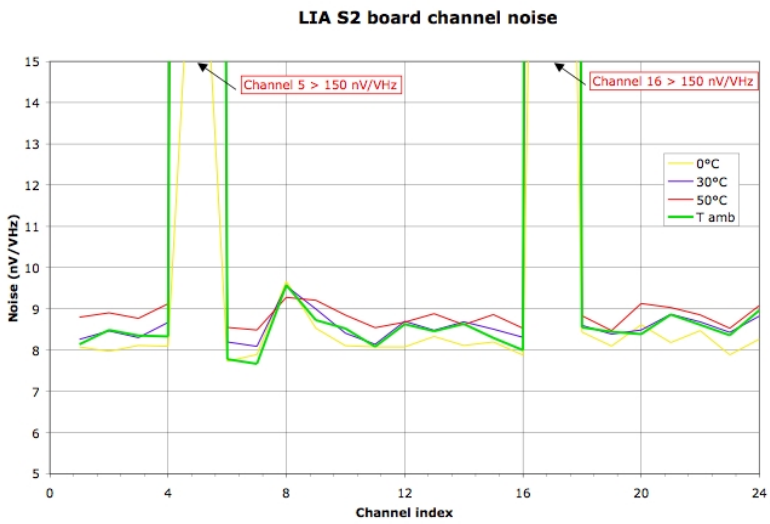
- DCUTm(2003.08.28_19.03.27).tm (photometer)
- DCUTm(2003.08.28_19.04.37).tm (spectrometer)

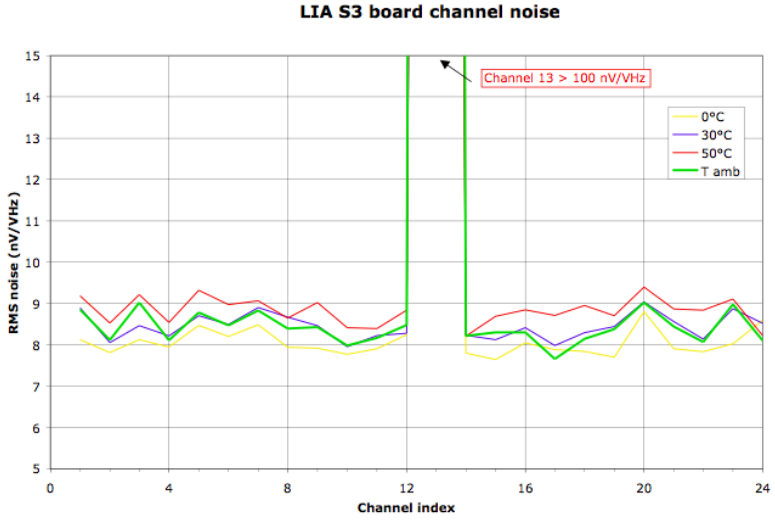
Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-ChN	P5	1	NOK		NCR110
	P5	2	NOK		NCR110
	P5	3	NOK		NCR110
	P5	4	NOK		NCR110
	P5	5	NOK		NCR110
	P5	6	NOK		NCR110
	P5	7	NOK		NCR110
	P5	8	NOK		NCR110
	P5	9	NOK		NCR110
	P5	10	NOK		NCR110
	P5	11	NOK		NCR110
	P5	12	NOK		NCR110
	P5	13	NOK		NCR110
	P5	14	NOK		NCR110
	P5	15	NOK		NCR110
	P5	16	NOK		NCR110
	P5	17	NOK		NCR110
	P5	18	NOK		NCR110
	P5	19	NOK		NCR110
	P5	20	NOK		NCR110
	P5	21	NOK		NCR110
	P5	22	NOK		NCR110
	P5	23	NOK		NCR110
	P5	24	NOK		NCR110
	P5	25	NOK		NCR110
	P5	26	NOK		NCR110
	P5	27	NOK		NCR110
	P5	28	NOK		NCR110
	P5	29	NOK		NCR110
	P5	30	NOK		NCR110
	P5	31	NOK		NCR110
	P5	32	NOK		NCR110
RD1-ChN	P6	1	NOK		NCR110
	P6	2	NOK		NCR110
	P6	3	NOK		NCR110
	P6	4	NOK		NCR110
	P6	5	NOK		NCR110
	P6	6	NOK		NCR110
	P6	7	NOK		NCR110
	P6	8	NOK		NCR110
	P6	9	NOK		NCR110
	P6	10	NOK		NCR110
	P6	11	NOK		NCR110
	P6	12	NOK		NCR110
	P6	13	NOK		NCR110
	P6	14	NOK		NCR110
	P6	15	NOK		NCR110
	P6	16	NOK		NCR110
	P6	17	NOK		NCR110
	P6	18	NOK		NCR110

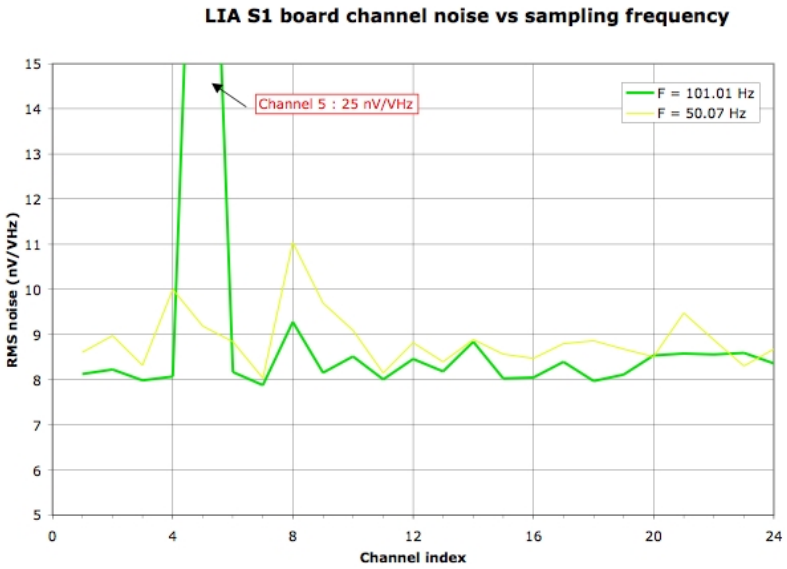
	P6	19	NOK		NCR110
	P6	20	NOK		NCR110
	P6	21	NOK		NCR110
	P6	22	NOK		NCR110
	P6	23	NOK		NCR110
	P6	24	NOK		NCR110
	P6	25	NOK		NCR110
	P6	26	NOK		NCR110
	P6	27	NOK		NCR110
	P6	28	NOK		NCR110
	P6	29	NOK		NCR110
	P6	30	NOK		NCR110
	P6	31	NOK		NCR110
	P6	32	NOK		NCR110

3.2.2. Spectrometer








LIA S1 board channel noise vs sampling frequency
Channel 5 : 25 nV/VHz
F = 101.01 Hz
F = 50.07 Hz
RMS noise (nV/VHz)
Channel index
15
14
13
12
11
10
9
8
7
6
5
0
4
8
12
16
20
24

Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-ChN	S1	1	NOK		NCR110
	S1	2	NOK		NCR110
	S1	3	NOK		NCR110
	S1	4	NOK		NCR110
	S1	5	NOK		NCR110
	S1	6	NOK		NCR110
	S1	7	NOK		NCR110
	S1	8	NOK		NCR110
	S1	9	NOK		NCR110
	S1	10	NOK		NCR110
	S1	11	NOK		NCR110
	S1	12	NOK		NCR110
	S1	13	NOK		NCR110
	S1	14	NOK		NCR110
	S1	15	NOK		NCR110
	S1	16	NOK		NCR110
	S1	17	NOK		NCR110/129
	S1	18	NOK		NCR110
	S1	19	NOK		NCR110
	S1	20	NOK		NCR110
	S1	21	NOK		NCR110
	S1	22	NOK		NCR110
	S1	23	NOK		NCR110
	S1	24	NOK		NCR110
RD1-ChN	S2	1	NOK		NCR110
	S2	2	NOK		NCR110
	S2	3	NOK		NCR110
	S2	4	NOK		NCR110
	S2	5	NOK		NCR110/129
	S2	6	NOK		NCR110
	S2	7	NOK		NCR110
	S2	8	NOK		NCR110
	S2	9	NOK		NCR110
	S2	10	NOK		NCR110
	S2	11	NOK		NCR110
	S2	12	NOK		NCR110
	S2	13	NOK		NCR110
	S2	14	NOK		NCR110
	S2	15	NOK		NCR110
	S2	16	NOK		NCR110
	S2	17	NOK		NCR110/129
	S2	18	NOK		NCR110
	S2	19	NOK		NCR110
	S2	20	NOK		NCR110
	S2	21	NOK		NCR110
	S2	22	NOK		NCR110
	S2	23	NOK		NCR110
	S2	24	NOK		NCR110
RD1-ChN	S3	1	NOK		NCR110
	S3	2	NOK		NCR110

	S3	3	NOK		NCR110
	S3	4	NOK		NCR110
	S3	5	NOK		NCR110
	S3	6	NOK		NCR110
	S3	7	NOK		NCR110
	S3	8	NOK		NCR110
	S3	9	NOK		NCR110
	S3	10	NOK		NCR110
	S3	11	NOK		NCR110
	S3	12	NOK		NCR110
	S3	13	NOK		NCR110/129
	S3	14	NOK		NCR110
	S3	15	NOK		NCR110
	S3	16	NOK		NCR110
	S3	17	NOK		NCR110
	S3	18	NOK		NCR110
	S3	19	NOK		NCR110
	S3	20	NOK		NCR110
	S3	21	NOK		NCR110
	S3	22	NOK		NCR110
	S3	23	NOK		NCR110
	S3	24	NOK		NCR110

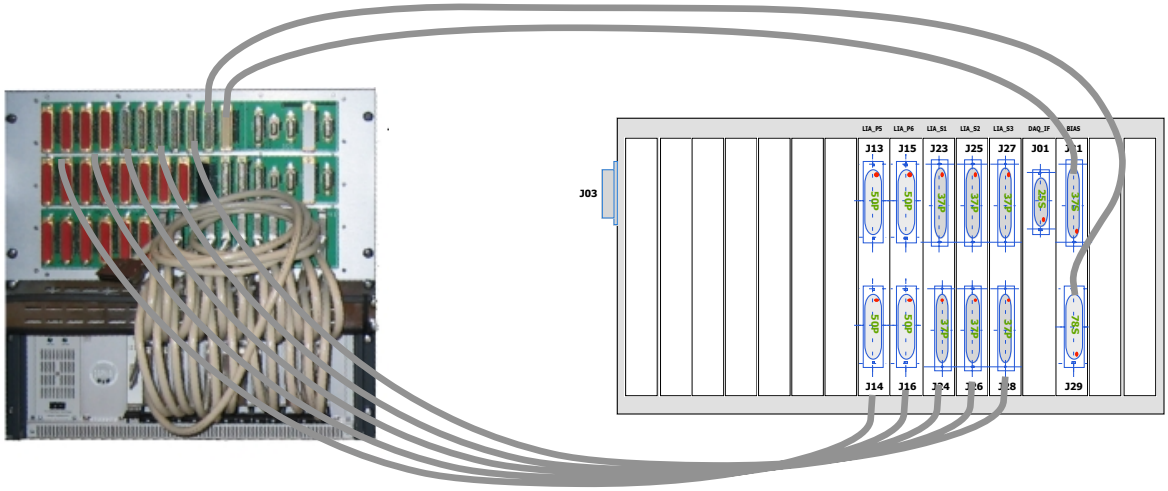
4. LIA channel to channel crosstalk verification

4.1. Test setup:

4.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator as image generator (in stand alone mode) -



4.1.2. Script and batch files

The sequence of command is limited to several commands required to configure and to initiate the frame transfer to the LTU. Additionally a specifically defined image is loaded in the FPU simulator. The pattern is defined to reveal all kind of channel-to-channel crosstalk within the LIA and the DAQ_IF analog stages. Signal amplitudes are 0.3 mV and 0.2 mV respectively for photometer and spectrometer.

LTU script file:
FPU sim. input and/or script file:

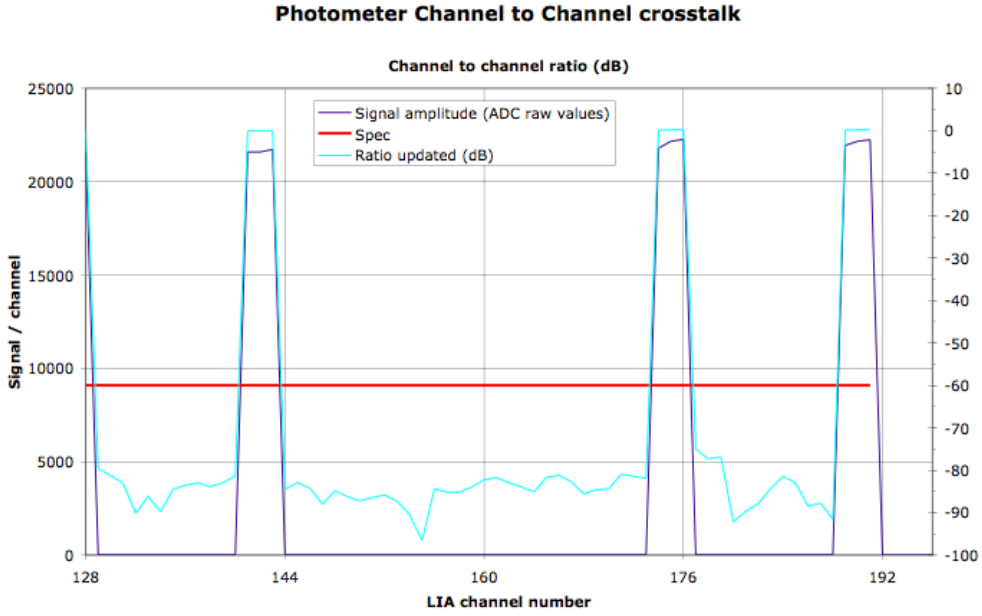
- Script_Spire_DCU_cross_talk2.spt
- SPIRE_test_cross_talk2.in

4.2. Test results

Data analysis utility:

- see FP
- Perf Crosstalk.xls

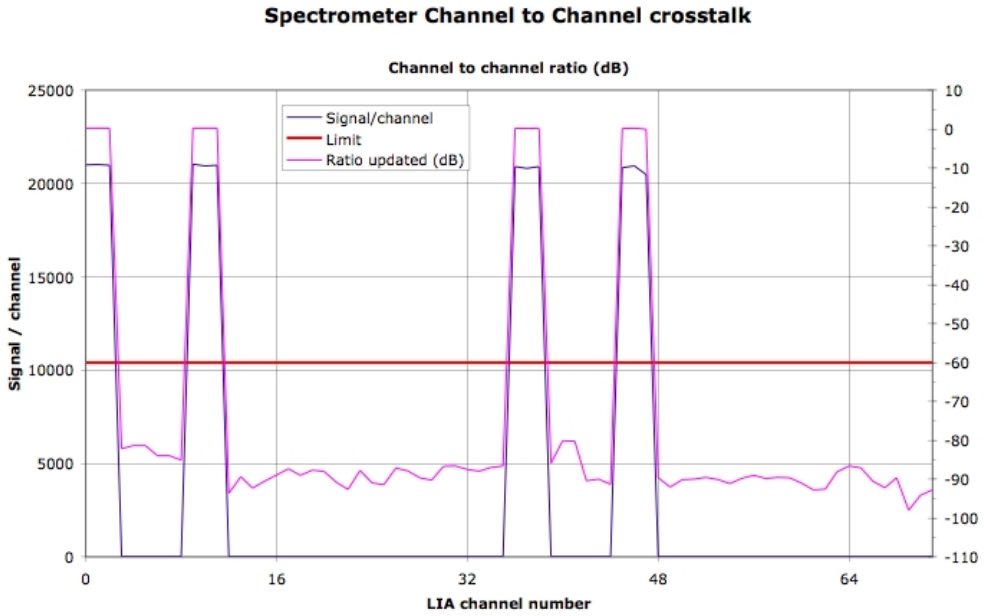
Photometer LIA



Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-CTr	P5	1	NA	Signal injection	
	P5	2	OK		
	P5	3	OK		
	P5	4	OK		
	P5	5	OK		
	P5	6	OK		
	P5	7	OK		
	P5	8	OK		
	P5	9	OK		
	P5	10	OK		
	P5	11	OK		
	P5	12	OK		
	P5	13	NA	Signal injection	
	P5	14	NA	Signal injection	
	P5	15	NA	Signal injection	
	P5	16	OK		
	P5	17	OK		
	P5	18	OK		
	P5	19	OK		
	P5	20	OK		
	P5	21	OK		

	P5	22	OK		
	P5	23	OK		
	P5	24	OK		
	P5	25	OK		
	P5	26	OK		
	P5	27	OK		
	P5	28	OK		
	P5	29	OK		
	P5	30	OK		
	P5	31	OK		
	P5	32	OK		
RD1-CTr	P6	1	OK		
	P6	2	OK		
	P6	3	OK		
	P6	4	OK		
	P6	5	OK		
	P6	6	OK		
	P6	7	OK		
	P6	8	OK		
	P6	9	OK		
	P6	10	OK		
	P6	11	OK		
	P6	12	OK		
	P6	13	OK		
	P6	14	NA	Signal injection	
	P6	15	NA	Signal injection	
	P6	16	NA	Signal injection	
	P6	17	OK		
	P6	18	OK		
	P6	19	OK		
	P6	20	OK		
	P6	21	OK		
	P6	22	OK		
	P6	23	OK		
	P6	24	OK		
	P6	25	OK		
	P6	26	OK		
	P6	27	OK		
	P6	28	OK		
	P6	29	NA	Signal injection	
	P6	30	NA	Signal injection	
	P6	31	NA	Signal injection	
	P6	32	OK		

Spectrometer LIA



Conformance matrix					
Requirement reference	LIA #	Channel #	Compliancy	Observation	NCR reference
RD1-CTr	S1	1	NA	Signal injection	
	S1	2	NA	Signal injection	
	S1	3	NA	Signal injection	
	S1	4	OK		
	S1	5	OK		
	S1	6	OK		
	S1	7	OK		
	S1	8	OK		
	S1	9	OK		
	S1	10	NA	Signal injection	
	S1	11	NA	Signal injection	
	S1	12	NA	Signal injection	
	S1	13	OK		
	S1	14	OK		
	S1	15	OK		
	S1	16	OK		
	S1	17	OK		
	S1	18	OK		
	S1	19	OK		
	S1	20	OK		
	S1	21	OK		
	S1	22	OK		
	S1	23	OK		
	S1	24	OK		
RD1-CTr	S2	1	OK		
	S2	2	OK		
	S2	3	OK		
	S2	4	OK		
	S2	5	OK		

	S2	6	OK		
	S2	7	OK		
	S2	8	OK		
	S2	9	OK		
	S2	10	OK		
	S2	11	OK		
	S2	12	OK		
	S2	13	NA	Signal injection	
	S2	14	NA	Signal injection	
	S2	15	NA	Signal injection	
	S2	16	OK		
	S2	17	OK		
	S2	18	OK		
	S2	19	OK		
	S2	20	OK		
	S2	21	OK		
	S2	22	NA	Signal injection	
	S2	23	NA	Signal injection	
	S2	24	NA	Signal injection	
RD1-CTr	S3	1	OK		
	S3	2	OK		
	S3	3	OK		
	S3	4	OK		
	S3	5	OK		
	S3	6	OK		
	S3	7	OK		
	S3	8	OK		
	S3	9	OK		
	S3	10	OK		
	S3	11	OK		
	S3	12	OK		
	S3	13	OK		
	S3	14	OK		
	S3	15	OK		
	S3	16	OK		
	S3	17	OK		
	S3	18	OK		
	S3	19	OK		
	S3	20	OK		
	S3	21	OK		
	S3	22	OK		
	S3	23	OK		
	S3	24	OK		

The above figures show the DCU output signal amplitudes for all the existing channels of LIA P and LIA S board. Pic amplitudes (channels 128-141/142/142-174/175/175-…) correspond to channels with signals. Signal amplitudes on all other channels correspond to residual signal induced by crosstalk effect.

Channel to channel rejection is better than 80 dB for both photometer and spectrometer.

This result is compliant with AD2 in which it is stated a channel-to-channel rejection better than 60 dB.
The data resulting of this test are stored within the following file(s)

- DCUTm(2003.08.28_18.44.34).tm (photometer)
- DCUTm(2003.08.28_18.45.44).tm (spectrometer)

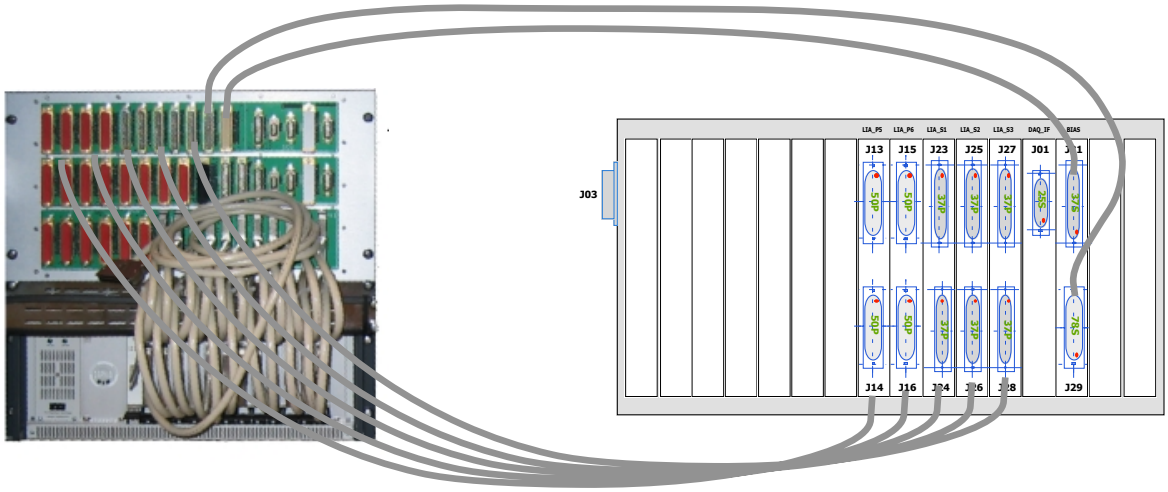
5. Photometer / Spectrometer demodulation phase control verification

5.1. Test setup:

5.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator as bolometer frame generator



5.1.2. Script and batch files

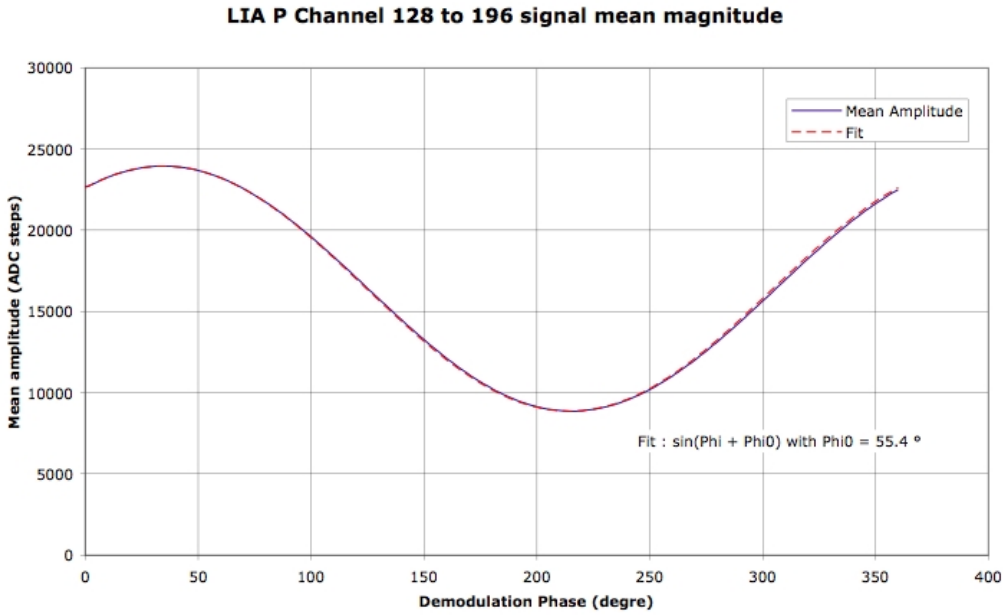
The purpose of the sequence of commands is to scan the phase range (0 to 360°) for the demodulation signal. The test is performed at a fixed bias frequency (200 Hz).

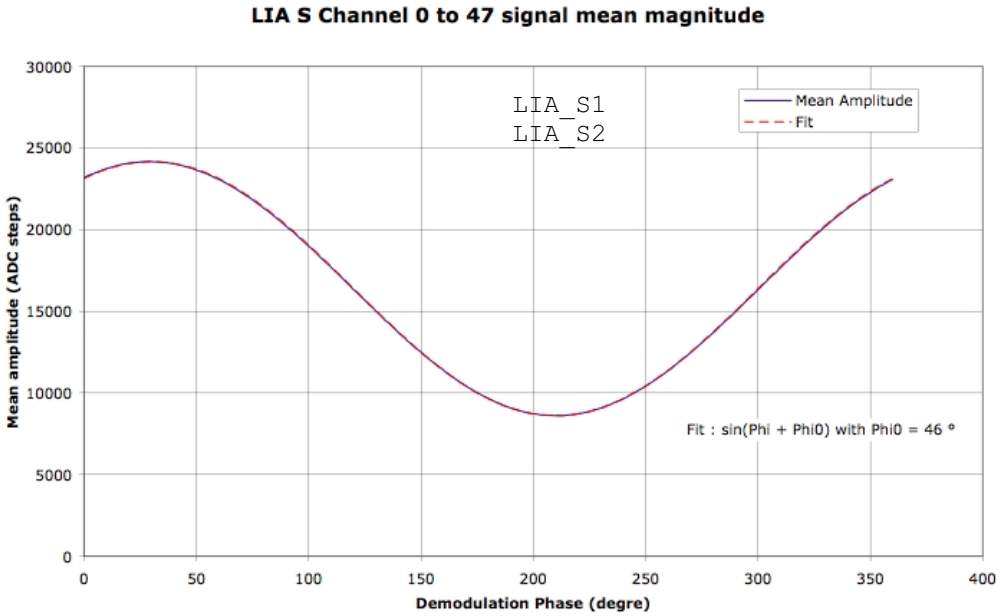
LTU script file: demod.txt
FPU sim. input and/or script file: SPIRE_test_P0.2_S0.3.in

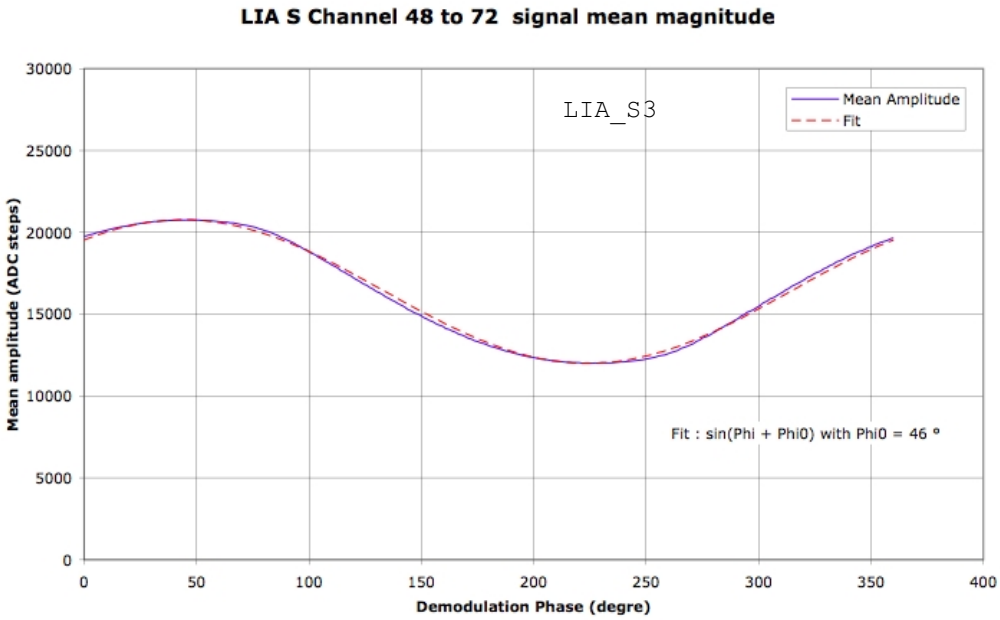
5.2. Test results

Data analysis utility:

- TMFileReader.vi
- DemodTestQM1.vi
- TestDemod.xls


LIA P Channel 128 to 196 signal mean magnitude
Mean Amplitude
Fit
Fit : sin(Phi + Phi0) with Phi0 = 55.4 °
Mean amplitude (ADC steps)
Demodulation Phase (degre)
30000
25000
20000
15000
10000
5000
0
0
50
100
150
200
250
300
350
400


LIA S Channel 0 to 47 signal mean magnitude
LIA_S1
LIA_S2
Mean Amplitude
Fit
Fit : sin(Phi + Phi0) with Phi0 = 46 °
Mean amplitude (ADC steps)
Demodulation Phase (degre)
30000
25000
20000
15000
10000
5000
0
0
50
100
150
200
250
300
350
400



The plots show the amplitude variation (respectively averaged for the channel 128 to 196 of the photometer and 0 to 47 & 48 to 72 for spectrometer). A fit is also plotted in order to determine the optimum phase. The curves show correct matching between measures and predicted law. In that case, the optimum phase is 55° for photometer and 46° for spectrometer.

The data resulting of this test are stored within the following file(s)

- DCUTm(2003.08.28_18.21.48).tm
- DCUTm(2003.08.28_18.22.34).tm

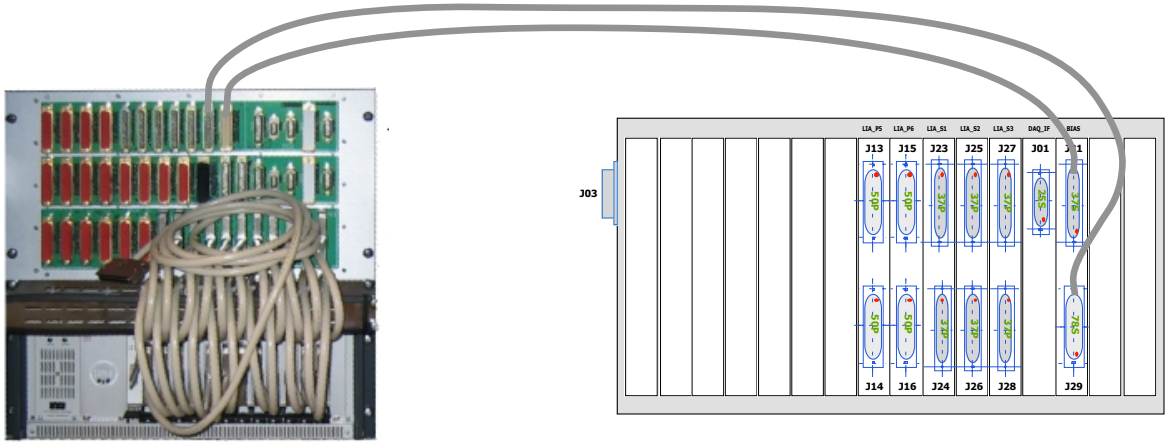
6. Bolometer Sine Bias functions verification

6.1. Test setup:

6.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator running in "slave" mode



6.1.2. Script and batch files

Several sequences of commands are defined to cover all the bolometer bias parameter:

- photometer bias frequency setting
- spectrometer bias frequency setting
- photometer bias amplitude setting
- spectrometer bias amplitude setting

LTU script file: Bias.txt
FPU sim. input and/or script file: SPIRE_bias_26-08-03.in

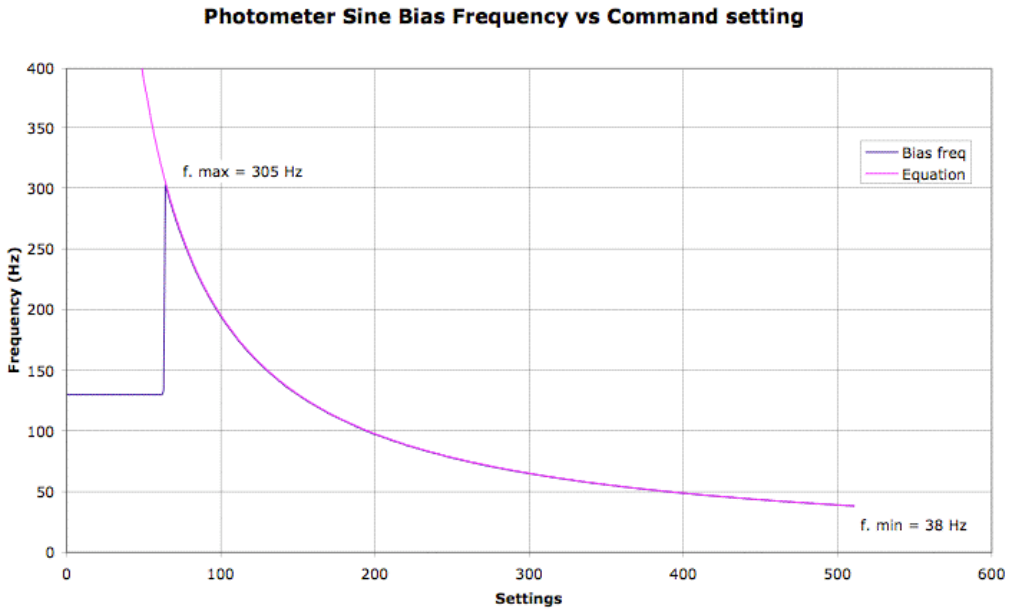
6.2. Test results

6.2.1. Photometer sine frequency range verification

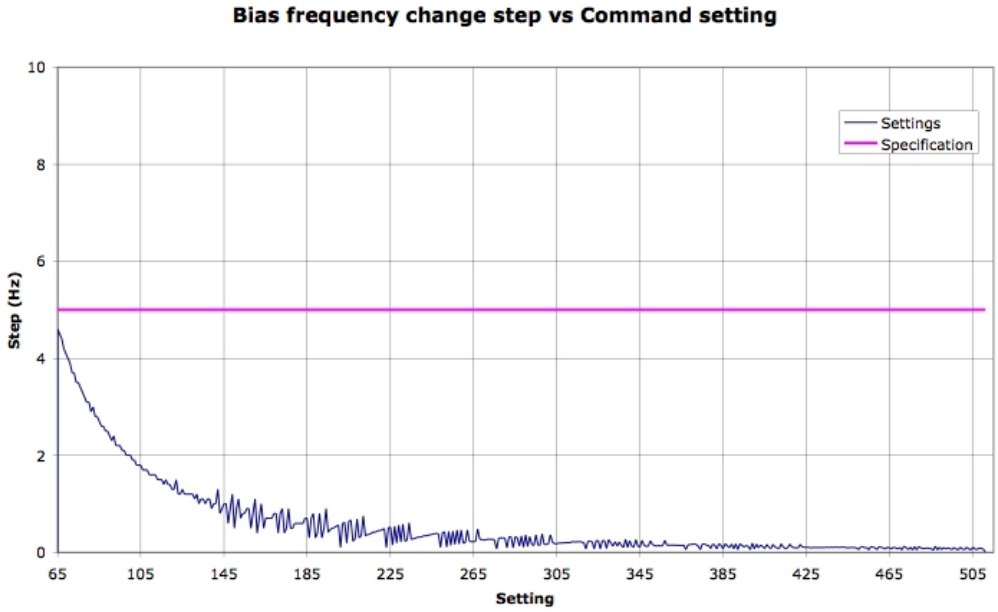
This test consists in commanding the bias sine generator of the DAQ_IF board and to verify the extension of range that no step are missing and that the frequency step remains within the required limit.

Data analysis utility(ies) :

- SimpleMesFileReader.vi
- FonctionnelBIASPhoto.xls



As shown on this figure the frequency, of the sine-wave varies from 38 Hz to 305 Hz and follows the expression given by AD1. Additionally, it is shown that for command parameter bellow 64, the command as no effect on the frequency which remains as set by the previous correct command.



This plot extracted from the previous measurement shows the frequency variation when incrementing the command parameter from 65 to 512. Maximum frequency step is for smaller parameters (highest frequency) but remains bellows 5 Hz as required by AD1.

The data resulting of this test are stored within the following file(s)

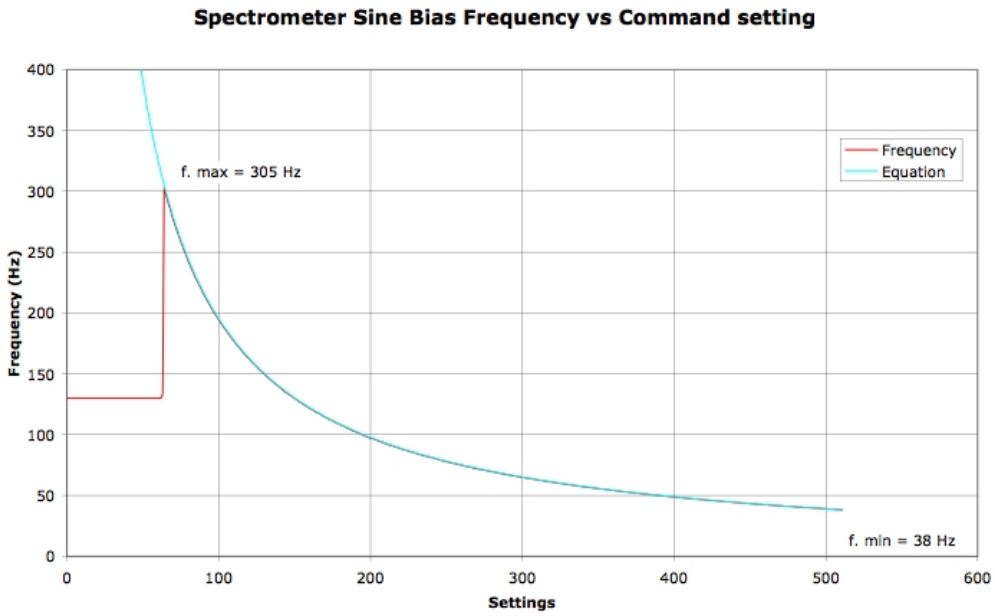
- SPIRE_bias_26-08-03_28_1.mes

6.2.2. Spectrometer sine frequency range verification

This test consists in commanding the bias sine generator of the DAQ_IF board and to verify the extension of range that no step is missing and that the frequency step remains within the required limit.

Data analysis utility(ies):

- SimpleMeasFileReader.vi
- FonctionnelBIASSpectro.xls



As shown on this figure the frequency of the sine-wave varies from 38 Hz to 305 Hz and follows the expression given by AD1. Additionally it is shown that for command parameter bellow 64 the command as no effect on the frequency which remains as set by the previous correct command.

The plot of the frequency steps is not given here but similarly to the photometer (the sine generator is identical for the photometer and spectrometer sine biases) the step remains bellow 5 Hz as required.

The data resulting of this test are stored within the following file(s):

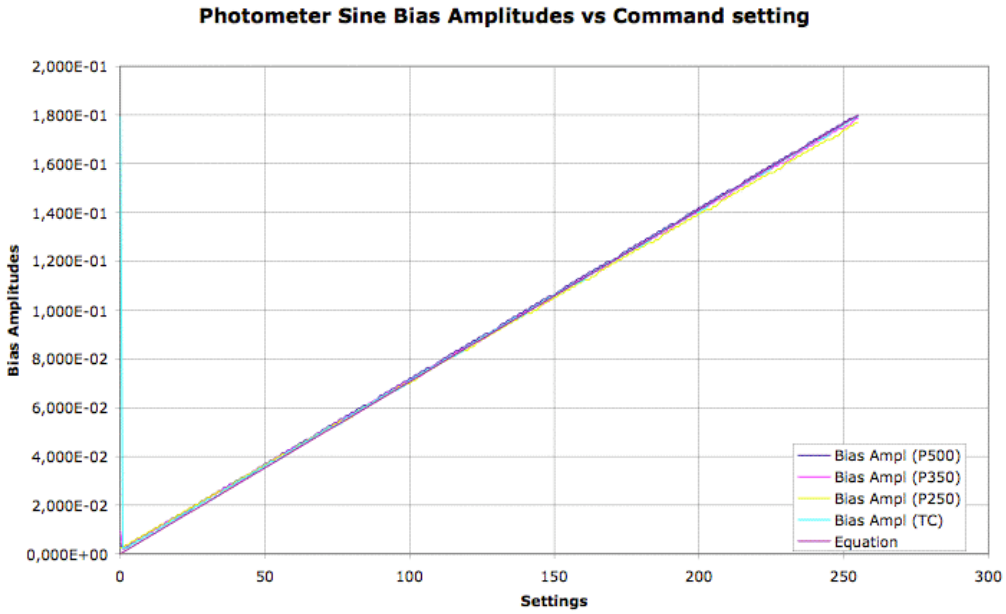
- SPIRE_bias_26-08-03_28_1.mes

6.2.3. Photometer bias amplitude control verification

This test consists in commanding the bias amplitude divider of the BIAS board and to verify the extension of range that no step is missing.

Data analysis utility(ies):

- SimpleMeasFileReader.vi
- FonctionnelBIASPhoto.xls



As show on this figure, the amplitude of the bolometer bias varies continuously from 0 to 180 mV.

Note 1 : due to the amplitude measurement scheme implemented by the FPU simulator the results are not significant at lower amplitude (for command parameter bellow 5). An additional measure done using of voltmeter gives value of less than 1mV.

Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-LIABmag	P	P500	NOK	Pic/pic instead of RMS	NCR155
RD1-LIABmag	P	P350	NOK	Pic/pic instead of RMS	NCR155
RD1-LIABmag	P	P250	NOK	Pic/pic instead of RMS	NCR155
RD1-LIATCmag	P	TC	NOK	200 mV instead of 500 mV	NCR124

The data resulting of this test are stored within the following file(s):

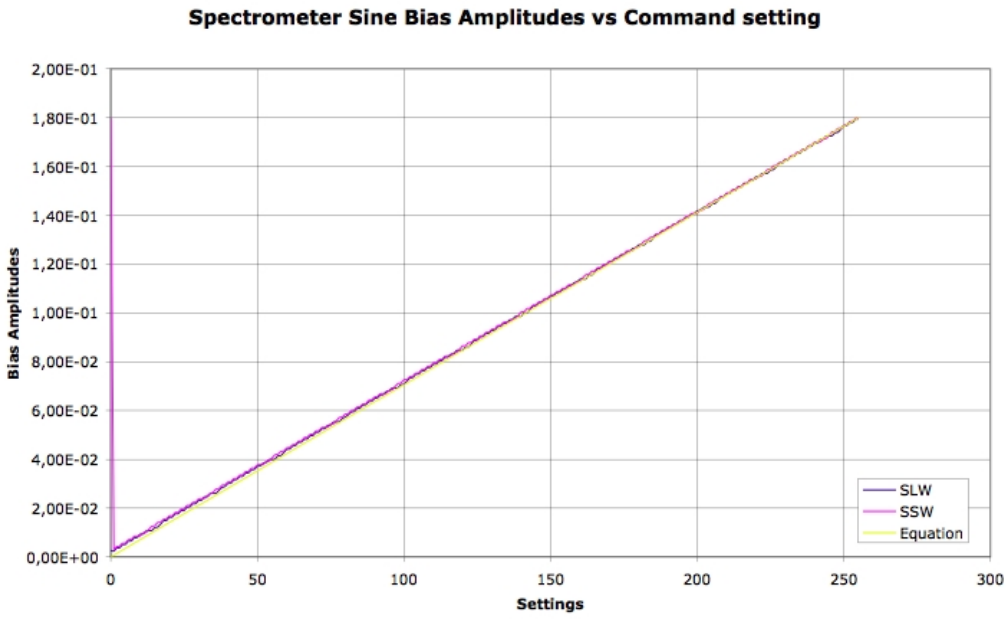
- SPIRE_bias_26-08-03_1_1.mes (P500 bias amplitude)
- SPIRE_bias_26-08-03_2_1.mes (P350 bias amplitude)
- SPIRE_bias_26-08-03_3_1.mes (P250 bias amplitude)
- SPIRE_bias_26-08-03_4_1.mes (TC bias amplitude)

6.2.4. Spectrometer bias amplitude control verification

This test consists of commanding the bias amplitude divider of the BIAS board and to verify the extension of the range and that no step is missing.

Data analysis utility(ies):

- SimpleMeasFileReader.vi
- FonctionnelBIASSpectro.xls



As shown by this figure the amplitude of the bolometer bias varies continuously from 0 to 180 mV.

Note : due to the amplitude measurement scheme implemented by the FPU simulator the results are not significant at lower amplitude (for command parameter bellow 5). An additional measure done using of meter gives value of less than 1mV.

Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-LIABmag	S	SSW	NOK	Pic/pic instead of RMS	NCR155
	S	SLW	NOK	Pic/pic instead of RMS	NCR155

The data resulting of this test are stored within the following file(s):

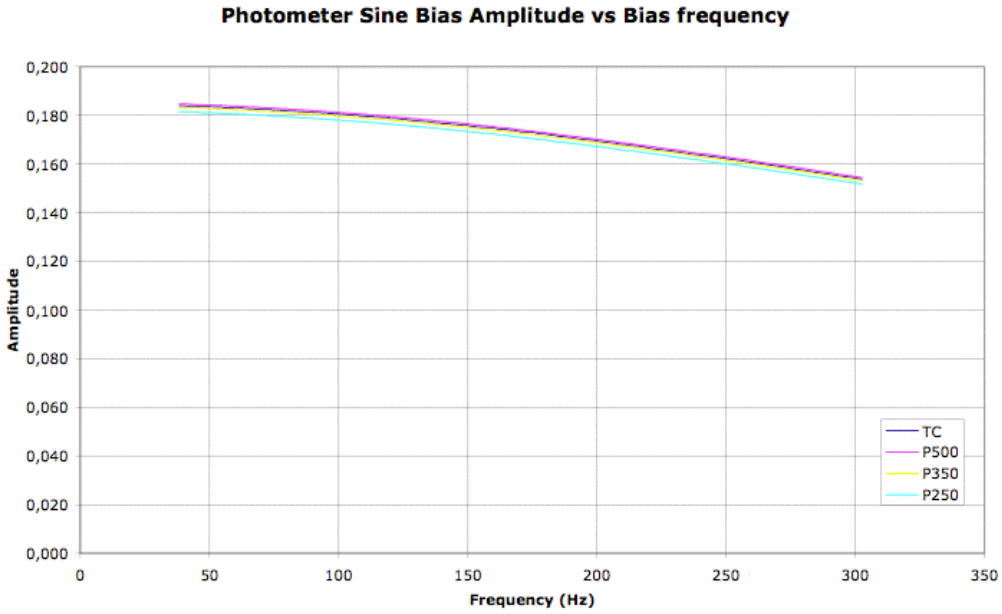
- SPIRE_bias_26-08-03_5_1.mes (SLW bias amplitude)
- SPIRE_bias_26-08-03_6_1.mes (SSW bias amplitude)

6.2.5. Photometer bias amplitude variation with frequency

Merged measurements from the previous tests, the amplitude variation of the sine wave can be easily represented.

Data analysis utility(ies):

- PhotoBiasAmplvsFreq.xls



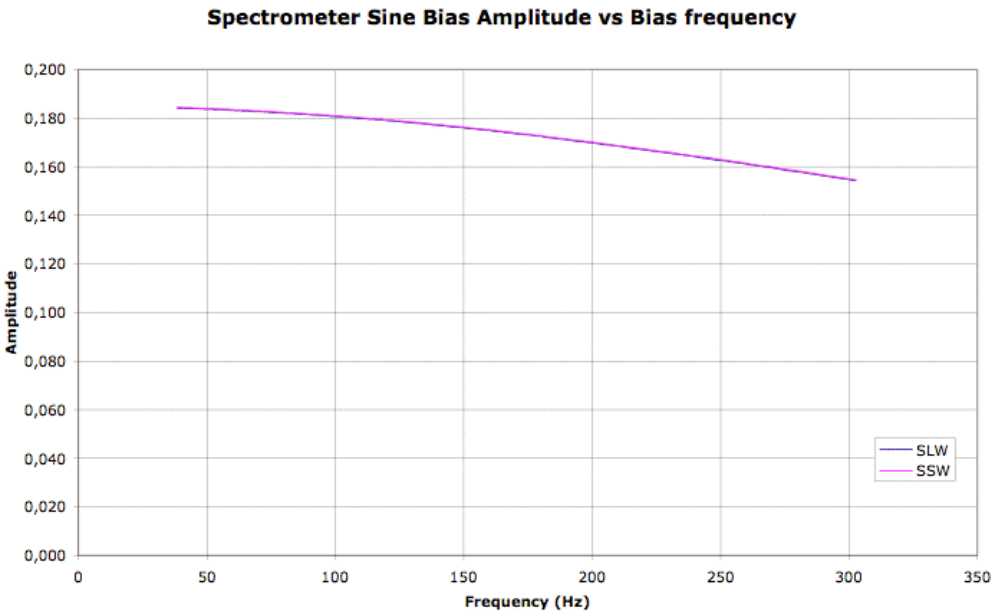
This figure shows a decrease in amplitude as frequency increases. The amplitude variation reaches 10%. This variation is due to the low pass filter which is implemented to limit the bias noise. However it is important to notice a similar behaviour for the 4 bias outputs (NCR151).

6.2.6. Spectrometer bias amplitude variation with frequency

By combining measurements from the previous tests, the amplitude variation of the sine wave can be easily extracted.

Data analysis utility(ies):

- SpectroBiasAmplvsFreq.xls



This figure shows a decrease in amplitude as frequency increases. The amplitude variation reaches 10%. This variation is due to the low pass filter which is implemented to limit the bias noise. However it is important to notice a similar behaviour for the 4 bias outputs (NCR151).

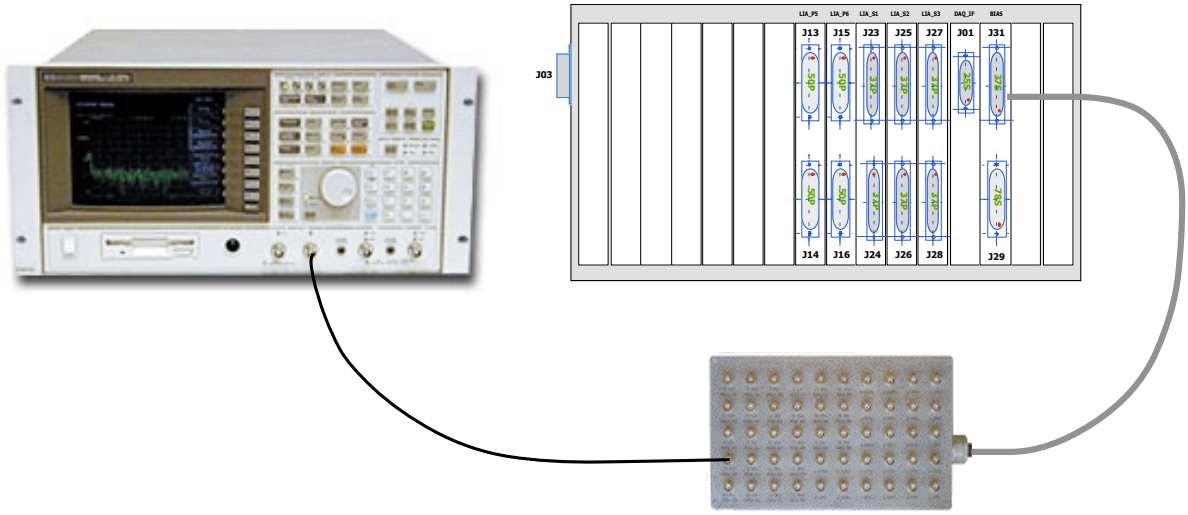
7. Bolometer sine bias performances verification

7.1. Test setup:

7.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- a spectrum analyser (HP89410A)

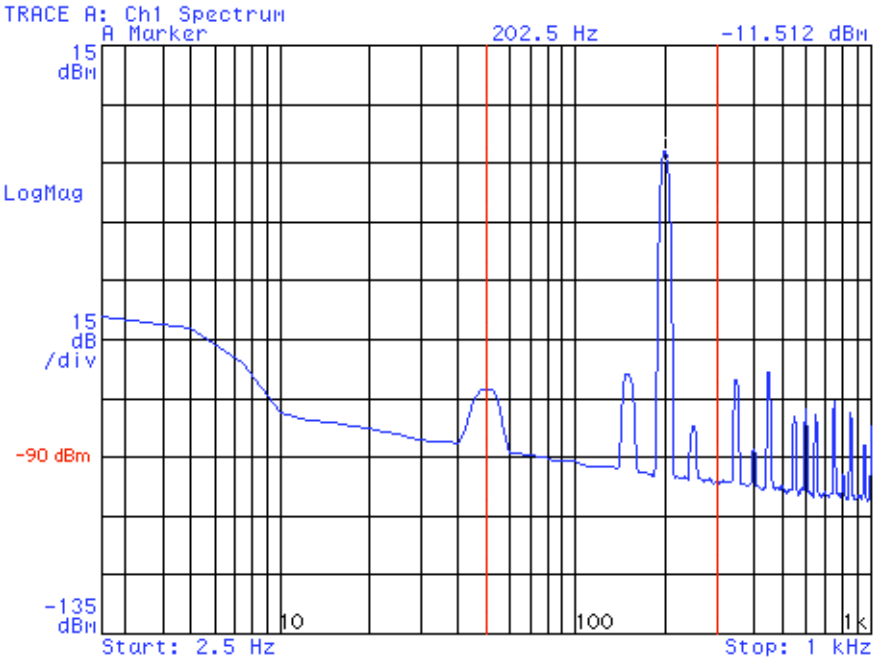


7.1.2. Script and batch files

No specific sequence of commands is required. Only commands for setting to their maximum the frequency and the sine amplitude are required.

7.2. Test result

The next plot shows the spectrum of the sine bias. Peaks at 50 150 and 250 Hz correspond to the main power frequency in Europe while the peak at 202 Hz corresponds to the bias frequency.



Noise expressed in dBm reaches -90 at 50 Hz (excluding the main power peak). This level is equivalent to 7.1 V or 2.2 V/VHz (considering a 10 Hz resolution bandwidth for the spectrum analyser).
The result is far above the requirement (20 nV/VHz) but other measurements conducted on the same BIAS board at JPL gave performance compliant with the specification.
Wrong test setup is likely the main cause of such poor result. In addition filtering capacitances have found to be mounted in reverse (+9V/-9V) after this test.

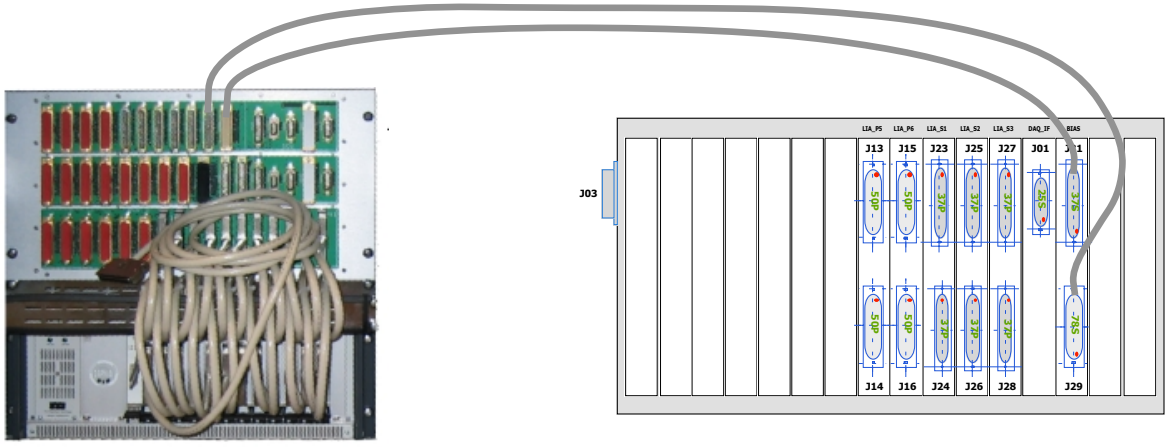
8. JFET Vss bias function verification

8.1. Test setup:

8.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator in slave mode



8.1.2. Script and batch files

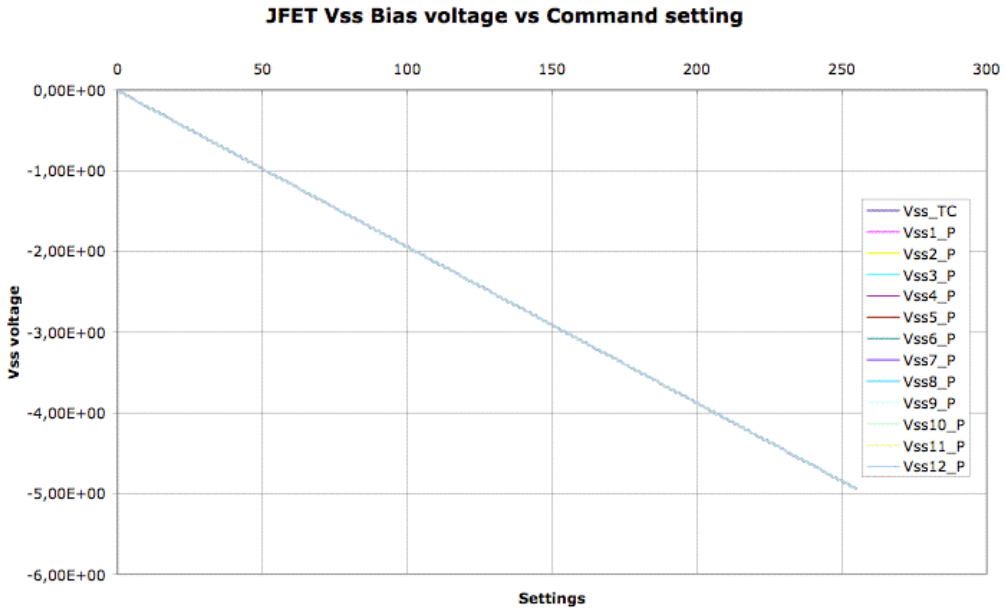
Several sequences of commands are defined to achieve full functional verification. However all individual sequences have been merged within a single file. Taking advantage of the FPU simulator capability, the measurements corresponding to single channel are stored within separated files. The sequence consists in setting the command parameter between its minimum and maximum values and triggering synchronously the signal levels as measured by the FPU simulator

LTU script file: Bias.txt
FPU sim. input and/or script file: SPIRE_bias_26-08-03.in

8.2. Test results

Data analysis utility(ies):

Photometer Vss bias



The figure shows the correct variation of the Vss voltage within the specified range specified by AD1. No missing step is found.

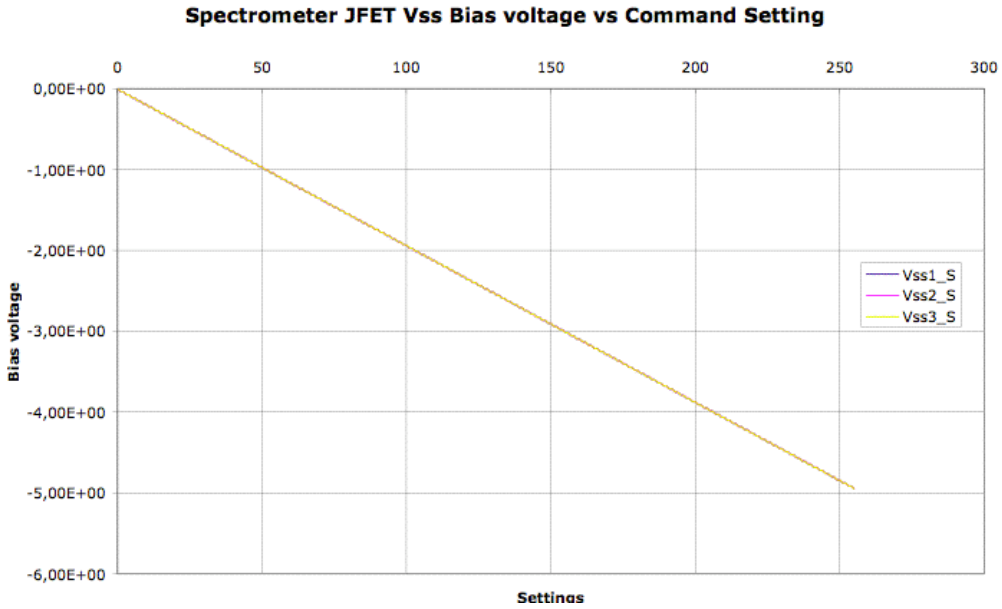
Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-Vss	P	Vss_TC	OK		
	P	Vss1_P	OK		
	P	Vss2_P	OK		
	P	Vss3_P	OK		
	P	Vss4_P	OK		
	P	Vss5_P	OK		
	P	Vss6_P	OK		
	P	Vss7_P	OK		
	P	Vss8_P	OK		
	P	Vss9_P	OK		

The data resulting of this test are stored within the following file(s)

- DCU_bias_26-08-03_24_1.mes (Vss_TC)
- DCU_bias_26-08-03_14_1.mes (Vss1_P)
- DCU_bias_26-08-03_15_1.mes (Vss2_P)
- DCU_bias_26-08-03_16_1.mes (Vss3_P)
- DCU_bias_26-08-03_17_1.mes (Vss4_P)
- DCU_bias_26-08-03_18_1.mes (Vss5_P)

- DCU_bias_26-08-03_19_1.mes (Vss6_P)
- DCU_bias_26-08-03_10_1.mes (Vss7_P)
- DCU_bias_26-08-03_11_1.mes (Vss8_P)
- DCU_bias_26-08-03_12_1.mes (Vss9_P)

Spectrometer Vss bias



The figure shows the correct variation of the Vss voltage within the specified range specified by AD1. No missing step is found.

Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-Vss	S	Vss1_S	OK		
	S	Vss2_S	OK		
	S	Vss3_S	OK		

The data resulting of this test are stored within the following file(s):

- DCU_bias_26-08-03_20_1.mes (Vss1_S)
- DCU_bias_26-08-03_22_1.mes (Vss2_S)
- DCU_bias_26-08-03_23_1.mes (Vss3_S)

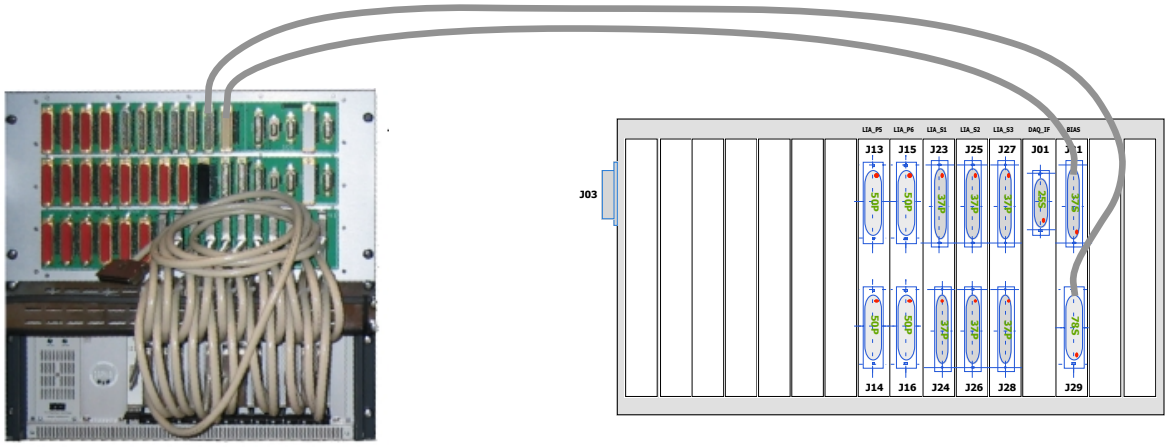
9. JFET Vdd bias function verification

9.1. Test setup:

9.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator in slave mode



9.1.2. Script and batch files

The command sequence principle consists in successively switching “on” the Vdd channel for both photometer and spectrometer.

LTU script file: Bias.txt
FPU sim. input and/or script file: SPIRE_bias_26-08-03.in

9.2. Test results

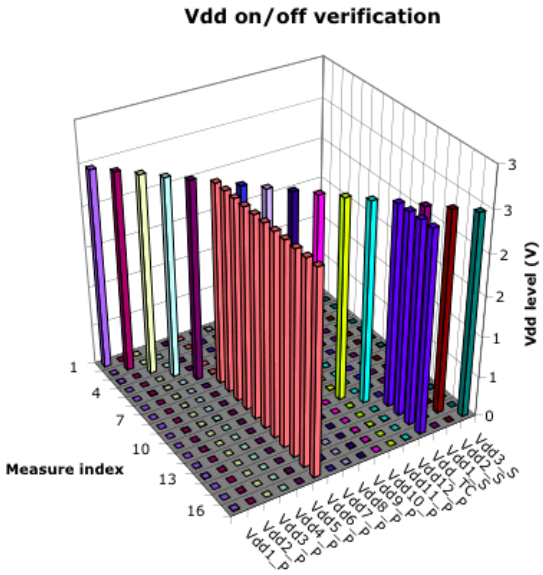
Data analysis tools:

- SimpleMeasFileReader.vi
- FonctionnelVdd.xls

The high/low level for each Vdd channel measured by the FPU simulator are given in the following table:

Channel	Vdd1_P	Vdd2_P	Vdd3_P	Vdd4_P	Vdd5_P	Vdd6_P	Vdd7_P	Vdd8_P
Vdd off	1,521E-03	1,521E-03	1,523E-03	7,617E-04	7,617E-04	2,282E-03	1,523E-03	1,523E-03
Vdd on	2,472	2,478	2,479	2,478	2,478	2,479	2,478	2,478

Channel	Vdd9_P	Vdd10_P	Vdd11_P	Vdd12_P	Vdd1_S	Vdd2_S	Vdd3_S	Vdd_TC
Vdd off	7,608E-04	1,522E-03	1,522E-03	1,523E-03	0,000E+00	7,617E-04	1,522E-03	7,610E-04
Vdd on	2,479	2,476	2,478	2,477	2,479	2,480	2,479	2,479



Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-Vdd	P	Vdd1_P	OK		
	P	Vdd2_P	OK		
	P	Vdd3_P	OK		
	P	Vdd4_P	OK		
	P	Vdd5_P	OK		
	P	Vdd6_P	OK		
	P	Vdd7_P	OK		
	P	Vdd8_P	OK		
	P	Vdd9_P	OK		
	P	Vdd10_P	OK		
	P	Vdd11_P	OK		
	P	Vdd12_P	OK		
	P	Vdd_TC	OK		
	S	Vdd1_S	OK		
	S	Vdd2_S	OK		
	S	Vdd3_S	OK		

The data resulting of this test are stored within the following file(s):

- DCU_bias_26-08-03_25_1.mes

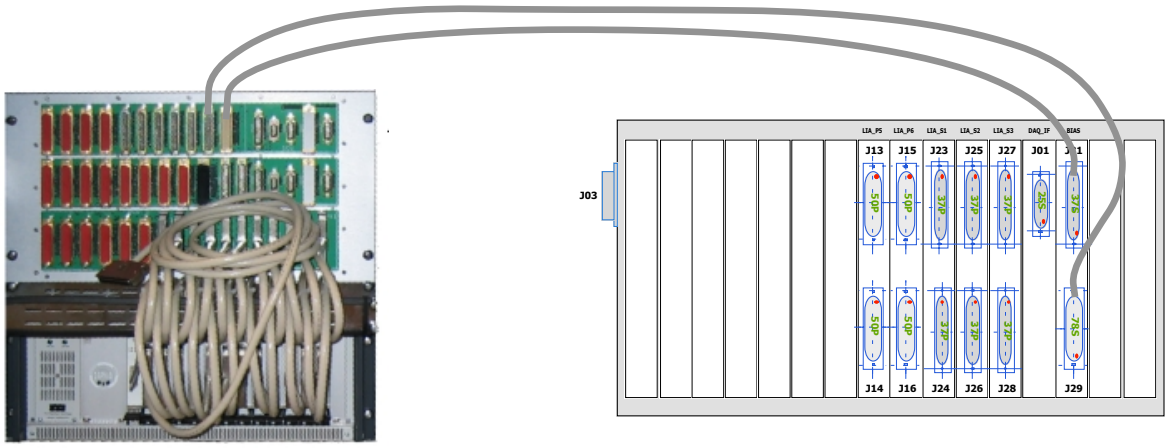
10. JFET Heater bias function verification

10.1. Test setup:

10.1.1. Hardware configuration

The following figure shows the H/W configuration required for this test. The involved equipments are:

- the DCU
- the LTU
- the FPU simulator in slave mode



10.1.2. Script and batch files

Several sequences of commands have been defined to achieve full function verification. However all individual sequences have been merged within a single file. Taking advantage of the FPU simulator capability, the measurements corresponding to single channels are stored within separated files. The sequence consists in setting the command parameter between its minimum and maximum values and triggering synchronously the levels as measured by the FPU simulator.

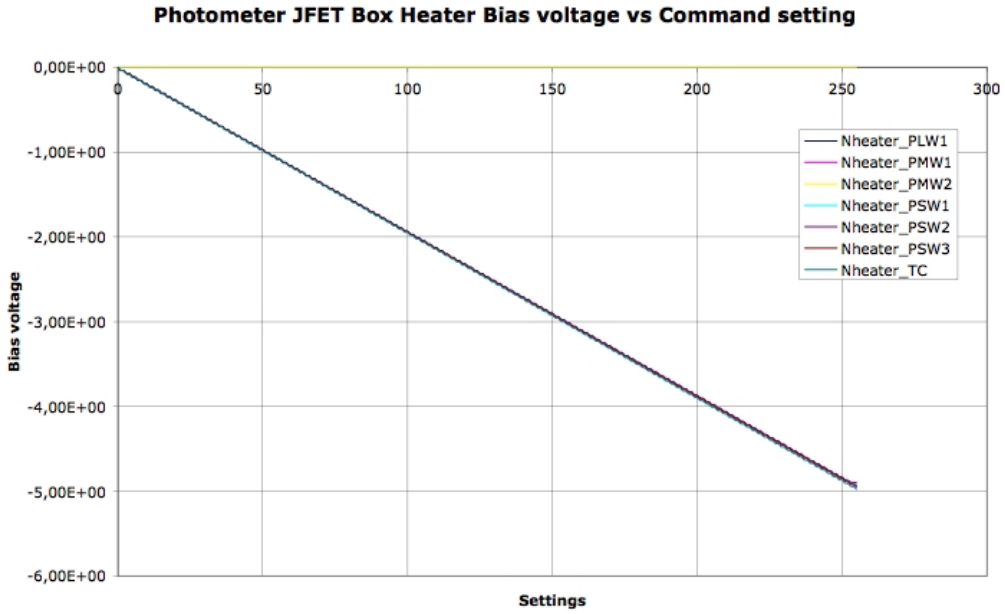
LTU script file: Bias.txt
FPU sim. input and/or script file: SPIRE_bias_26-08-03.in

10.2. Test results

Data analysis tools:

- SimpleMeasFileReader.vi
- BiasHeaterPhoto.xls
- BiasHeaterSpectro.xls

Photometer Heater bias



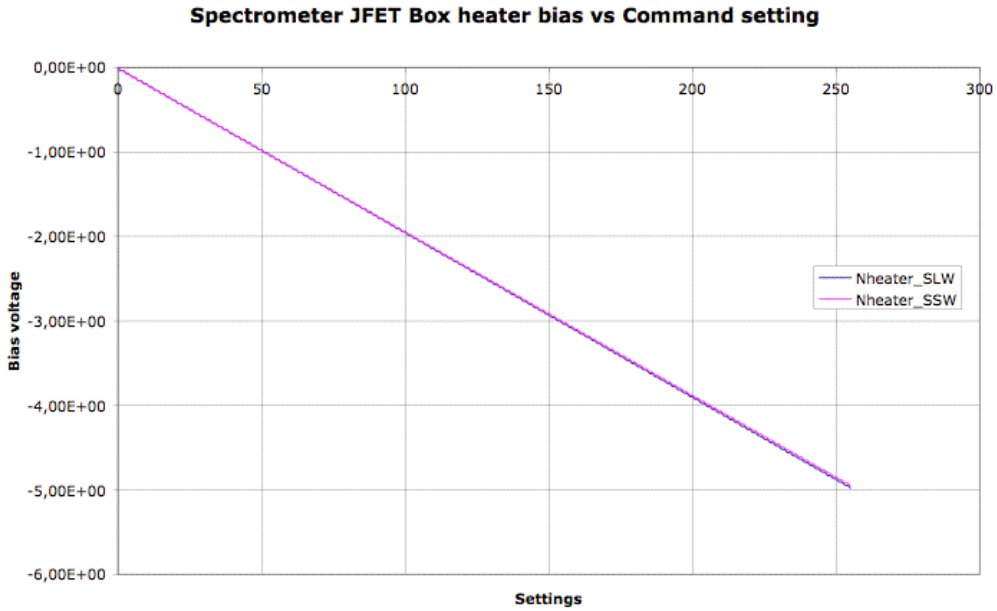
The figure shows the correct variation of the heater bias voltage within the specified range specified by AD1. No missing step is found.

Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-heater bias	P	Nheater_PLW1	OK		
	P	Nheater_PWW1	OK		
	P	Nheater_PMW2	NOK		NCR134
	P	Nheater_PSW1	OK		
	P	Nheater_PSW2	OK		
	P	Nheater_PSW3	OK		
	P	Nheater_TC	OK		

The data resulting of this test are stored within the following file(s)

- DCU_bias_26-08-03_7_1.mes

Spectrometer heater bias



The figure shows the correct variation of the heater bias voltage within the specified range specified by AD1. No missing step is found.

Conformance matrix					
Requirement reference	BIAS #	Channel #	Compliancy	Observation	NCR reference
RD1-heater bias	S	Nheater_SLW	OK		
	S	Nheater_SSW	OK		

The data resulting of this test are stored within the following file(s)

- DCU_bias_26-08-03_21_1.mes

11. Offset table uploading/downloading verification

11.1. Test setup:

11.1.1. Hardware configuration

The involved equipments are:

- the DCU
- the LTU

11.1.2. Script and batch files

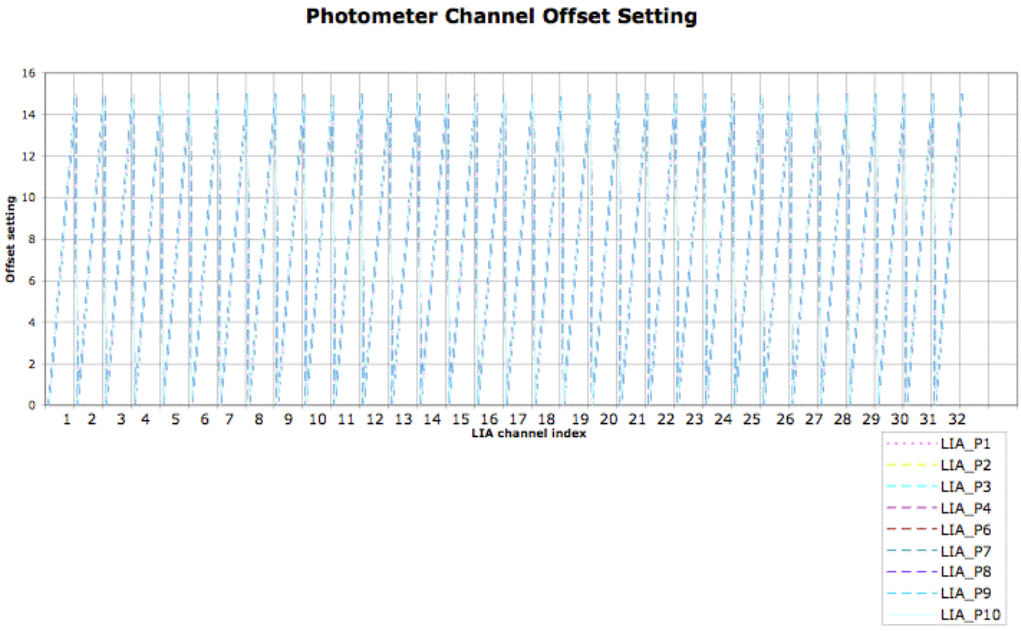
The principle of the sequence of command is to load individually the offset registers in the DCU with values between 0 and 15 and then to switch the DCU into “get offset” mode. Combination of successive frames acquisition shall gives a regular saw tooth with a magnitude of 16.

LTU script file : hk.txt

11.2. Test results

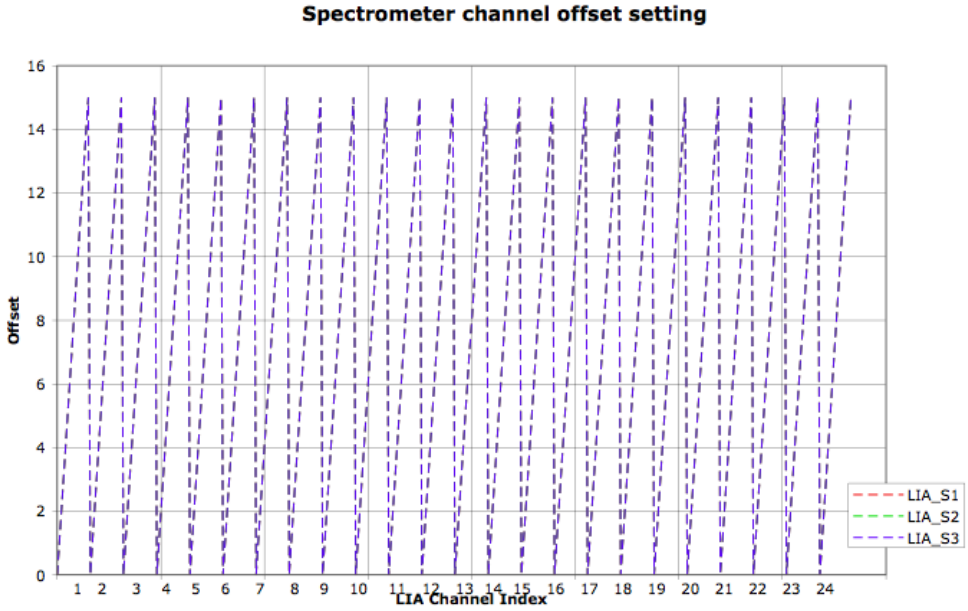
Data analysis utility

- TMFileReader
- OffsetAnalysis.vi
- FonctionnelOffset.xls



The data resulting of this test are stored within the following file(s)

- DCUTm(2003.08.26_19.14.13).tm
- DCUTm(2003.08.26_19.15.20).tm
- DCUTm(2003.08.26_19.16.26).tm
- DCUTm(2003.08.26_19.17.33).tm
- DCUTm(2003.08.26_19.18.40).tm
- DCUTm(2003.08.26_19.19.47).tm
- DCUTm(2003.08.26_19.20.54).tm
- DCUTm(2003.08.26_19.22.00).tm
- DCUTm(2003.08.26_19.23.07).tm



The data resulting of this test are stored within the following file(s)

- DCUTm(2003.08.26_19.24.14).tm
- DCUTm(2003.08.26_19.25.21).tm
- DCUTm(2003.08.26_19.26.27).tm

12. DAQ_IF frame generation verification

12.1. Test setup:

12.1.1. Hardware configuration

The involved equipments are:

- the DCU
- the LTU

12.1.2. Script and batch files

During all tests the frame, structure is checked either by the LTU acquisition software or by the analysis tools (i.e. TMFileReader.vi).

12.2. Test results

Frame length

The frame length is verified for all the data modes available. Both numbers of word within a single frame and "frame length" field are checked.

Data analysis utility(ies):

- TMFileReader.vi

Specification (from ICD)		From tests	
Frame type	Length	Number of word	"Frame Length" word
Full Photometer	294	294	294
Full Spectrometer	78	78	78
Photometer-LW	54	54	54
Photometer-SW	150	150	150
Photometer-Offset	294	294	294
Spectrometer-Offset	78	78	78

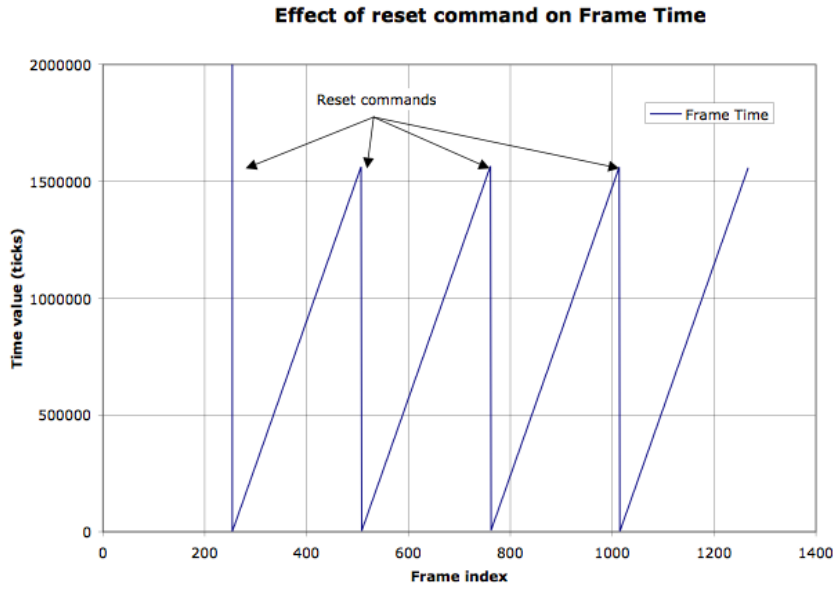
Frame parity

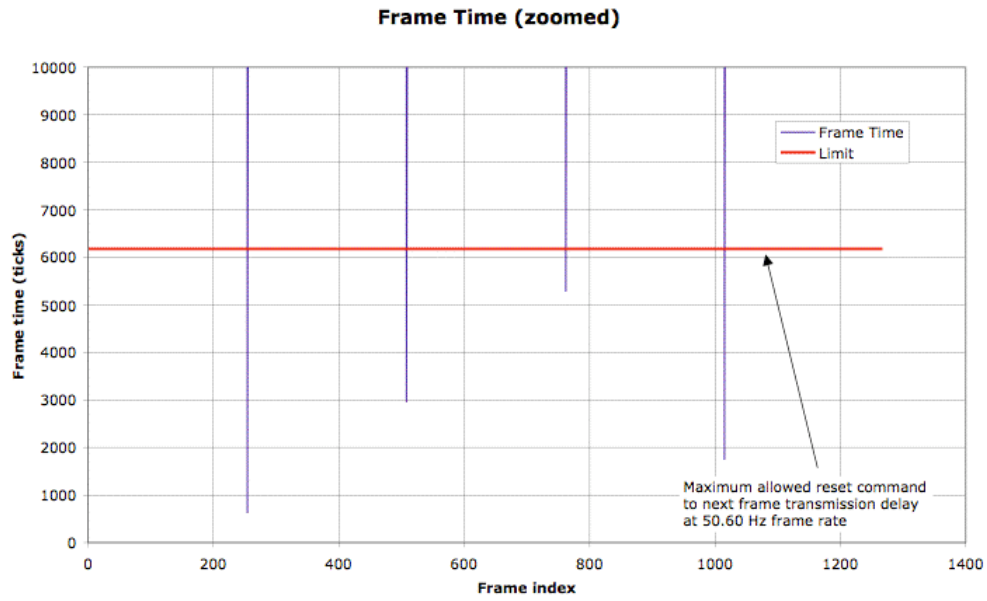
The frame parity is checked systematically by LTU data logging S/W and data analysis (TMFileReader.vi) softwares. Nominal operation did not reveal parity errors: errors occur only when interface is disturbed by external perturbations.

Frame time & reset frame time

The DCU time stamp counter is reset by command every 5 s.

LTU script file: RstTimeStamp.txt





The reset command being asynchronous with respect to the frame transfer the frame time is found different from 0. The maximum allowed frame time after a reset is given by:

$$F0\_time \leq 1/(50.60 * 3.2\ e\text{-}6) = 6175$$

The data resulting of this test are stored within the following file(s)

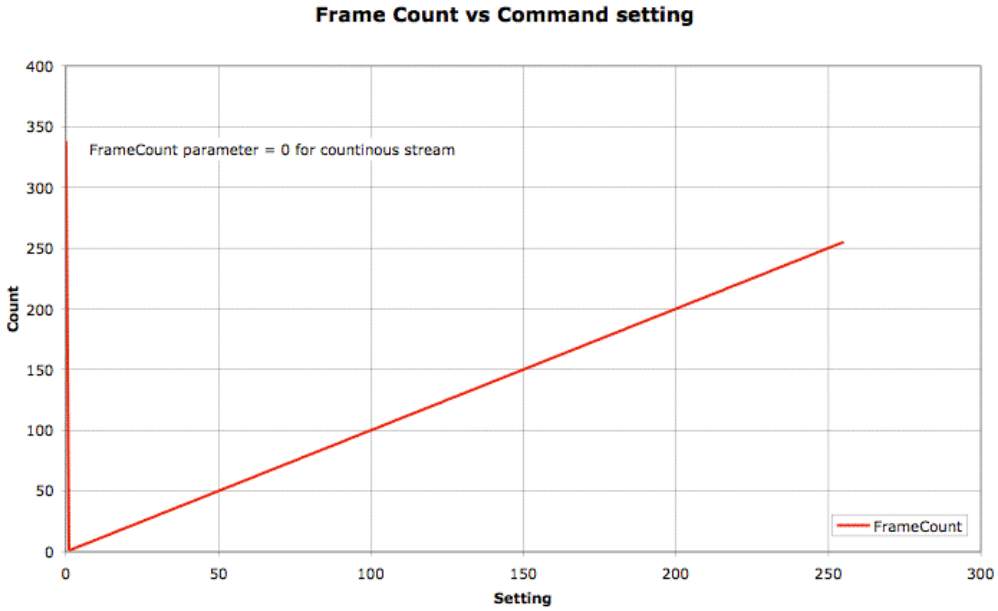
- DCUTm(2003.08.26_19.24.14).tm

Frame Count

LTU script file: NbFrame.txt

Data analysis utility:

- TMFileReader.vi
- FrameNumberChecking



The plot shows exact fit of the number of frame with the

The data resulting of this test are stored within the following file(s)

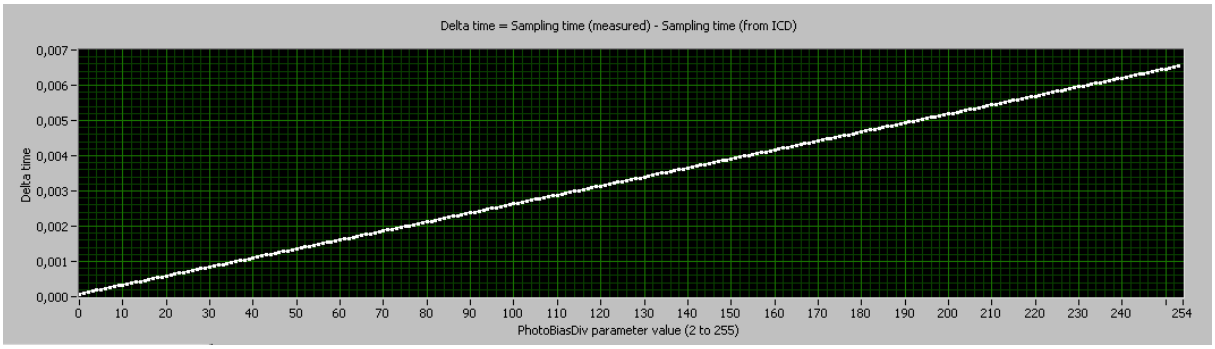
- FrameNb(2003.08.27_09.47.38).tm

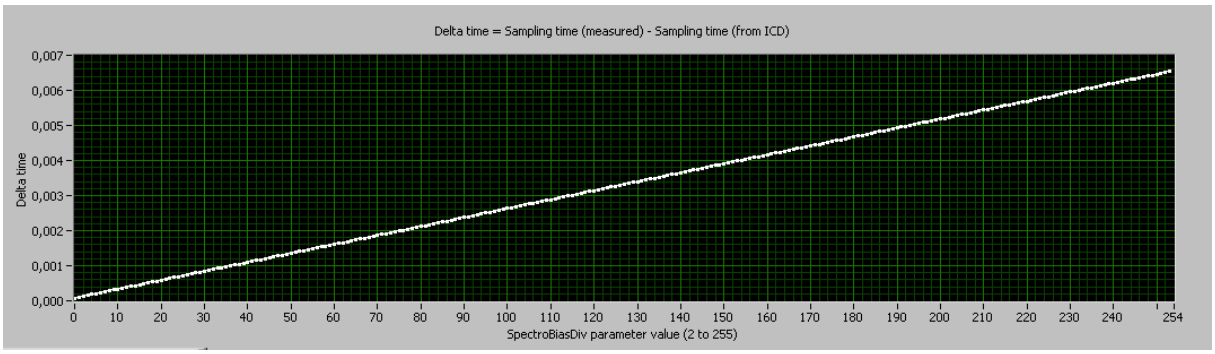
Sampling rate

LTU script file: NbFrame.txt

Data analysis utility:

- TMFileReader.vi
- TimingAnalysis.vi





The data resulting of this test are stored within the following file(s)

- DCUTm(2003.08.27_11.42.57).tm
- DCUTm(2003.08.27_12.04.20).tm

13. Housekeeping generation verification

13.1. Test setup:

13.1.1. Hardware configuration

The involved equipments are:

- the DCU
- the LTU

13.1.2. Script and batch files

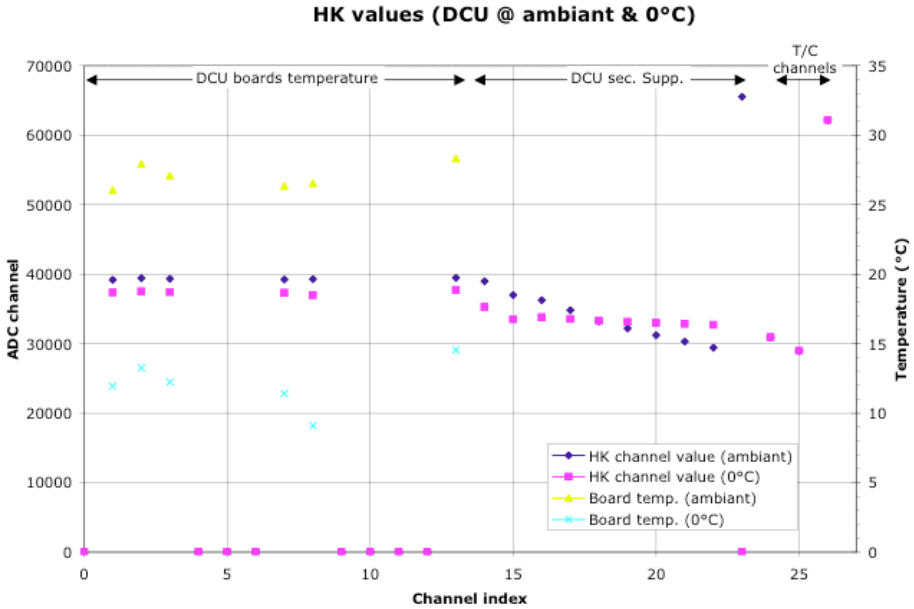
The sequence of commands includes only the GetHKChannel command. All the 28 housekeeping are scanned. To highlight timing and time constant incompatibility four samplings are requested successively for each parameter. In case of a default, an important variation of the value between the 1st and the next samplings is expected.

LTU script file : hk.txt

13.2. Test results

Data analysis utility:

- AckFileReader.vi
- HKChannel.xls



The figure gives results for a DCU at ambient temperature (20C) and at 0C

Assuming the following conversion law:

$$T = 7.689\ 10^{-3} * ADC - 273$$

the temperature of the boards is around 25C for an ambient temperature of 20C and 10C for an ambient temperature of 0C.

Conformance matrix					
Requirement reference	-	Channel #	Compliancy	Observation	NCR reference
RD1-DRCU REQ-30		LIA_B1_TEMP	NOK	Non existing board	
		LIA_B2_TEMP	NOK	Non existing board	
		LIA_B3_TEMP	NOK	Non existing board	
		LIA_B4_TEMP	NOK	Non existing board	
		LIA_B5_TEMP	OK		
		LIA_B6_TEMP	OK		
		LIA_B7_TEMP	NOK	Non existing board	
		LIA_B8_TEMP	NOK	Non existing board	
		LIA_B9_TEMP	NOK	Non existing board	
		LIA_B10_TEMP	OK		
		LIA_B11_TEMP	OK		
		LIA_B12_TEMP	OK		
		BIAS_TEMP	NOK		NCR126
		DAQ_I/F_TEMP	OK		
		PWR_STATUS	NOK		NCR125
		BDAQ_P5	NOK		NCR125
		BQAD_P9	NOK		NCR125
		BDAQ_N9	NOK		NCR125
		LIAP_P5	NOK		NCR125
		LIAP_P9	NOK		NCR125
		LIAP_N9	NOK		NCR125
		LIAS_P5	NOK		NCR125
		LIAS_P9	NOK		NCR125
		LIAS_N9	NOK		NCR125

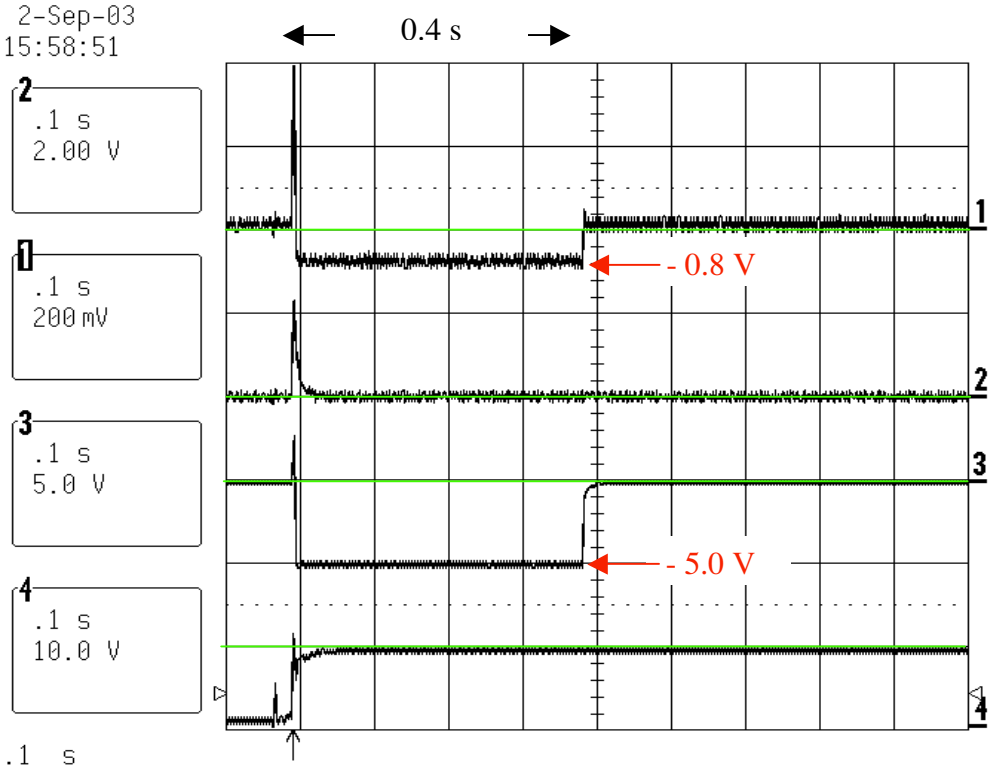
The data resulting of this test are stored within the following file(s)

- DCUAck(2003.09.03_12.00.03).tm (ambient temperature)
- DCUAck(2003.09.08_12.18.47).tm (0C)

14. Output toward FPU transient verification at power on

The purpose of this test is to check DCU analog outputs behaviour when switching on the power supplies of the DCU. All those signals are generated at BIAS board level. The bolometer sine bias, the JFET Vss and Vdd and the JFET heater bias. Only one trace is given for both Vss and heater bias since the generators are identical.

14.1. Test result



- green lines = 0 V reference level
- P9V_BDAQ is used for synchronisation purpose only

Conformance matrix					
Requirement reference	BIAS	Channel #	Compliancy	Observation	NCR reference
RD1-DRCU REQ-xx		Bias	NOK		NCR121
		Vss	NOK		NCR121
		Vdd	OK		