TITLE: **Planck-LFI CPV: CRYO_02 functionality test** (P_PVP_LFI_0003_01)

DOC. TYPE: **Test Report**

PROJECT REF.: **PL-LFI-PST-RP-064** PAGE: **I of IV, 11**

ISSUE/REV.: **1.0**

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	15 June 09	All	First draft issue	0.1
0.2	1 July 2009	All	Second draft issue	0.2
1.0	10 July 2009	All	First issue of document	1.0

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1 ACRONYMS

AIV	Assembly, Integration, Verification
ASW	Application Software
BEM	Back End Module
BEU	Back End Unit
CCS	Central Check-out System
CDMU	Central Data Management Unit
CPV	Calibration Performance Verification
CSL	Centre Spatiale de Liège
DAE	Data Acquisition Electronics
DPU	Digital Processing Unit
EGSE	Electrical ground Support Equipment
FEM	Front End Module
I-EGSE	Instrument EGSE
IST	Integrated Satellite Test
OBC	On Board Clock
RAA	Radiometer Array Assembly
REBA	Radiometric Electronic Box Assembly
S/C	Spacecraft
SCOE	Spacecraft Control and Operation System
SCS	Sorption Cooler System
SPU	Signal Processing Unit
SUSW	Start- Up Software
SVM	Service Module
TBC	To Be Checked
TBW	To Be Written
TC	Telecommand
TM	Telemetry
UFT	Unit Functional Test

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

[AD1] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3

[AD2] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1

[AD3] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1, Annex 3, ICD 750800115

[AD4] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3 Annex 10

[AD5] Data analysis and scientific performance of the LFI FM instrument, PL-LFI-PST-AN-006 3.0

[AD6] Planck-LFI TV-TB test report: executive summary, PL-LFI-PST-RP-040 1.1

[AD7] Testing plan of the LFI instrument during the Planck Commissioning and CPV phase, PL-LFI-PST-PL-043 (4.2)

2.2 Reference Documents

[RD1] Planck Instrument Testing at PFM S/C levels, H-P-3-ASP-TN-0676, Issue 1.0

[RD2] Planck LFI User Manual, PL-LFI-PST-MA-001 Issue 2.1

[RD3] Quick look and data analysis of LFI from CRYO-02 functional test (Ph-5-03-b0 of TV/TB tests) PL-LFI-PST-RP-046

3 Introduction

This document describes the activities performed during the CRYO_02 functionality test. This test consists in two hours data acquisition in which the radiometers are run in switching mode and during which all the four possible phase switch configurations are tested.

The objective of this test is to verify that the radiometers are functional from the point of view of the front-end amplifiers and that the pseudo-correlation differential scheme is effective in reducing 1/f noise instabilities.

Therefore we perform two independent sanity checks:

1. that drain currents are comparable with those measured during the same test performed in CSL (± 5%), and
2. that the 1/f noise knee frequency is reduced to less than 1 Hz after differencing sky and reference load datastreams.

Important notice: the check on knee frequency is done just to verify that there is a reduction operated by the switching scheme. The requirement is that the knee frequency is reduced from several Hz to values less than 1 Hz. Because this test is run in conditions that are far from being nominal (before tuning, with the 4K reference load at 20 K and not stability-optimised) no comparison must be made with 1/f scientific requirements.

4 Test Execution

4.1 Test configuration

The test configuration is the following

SCOS 2K EGSE 3.1 Release 1.2
RTSILib version 1.0
RTSI Client version 1.2
LEVEL1 (TMH/TQL) version 5.1
LIFE Machine version OM 3.00
IDIS 2.7.3.4

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Industry support	Paola Battaglia

4.2 Pass-fail criteria, verification matrix

CPV	**P_PVP_LFI_0003_01**	
June, 16 2009 02:20z	**DoY 167**	**OD 33**
Duration	**2:00:34**	
Test name:	**Cryogenic functional test CRYO_02**	
Test objectives:	This test is the same test performed on ground at cryogenic temperature during TV-TB test campaign in CSL, with exactly the same biases, and front end module at 20 K stable temperature (TSA tuned).	

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected events packets	Yes				
TC procedure	Yes				
Power consumption as expected	Yes				
Current consumption from FEMs as expected	Yes		Drain current from LFI26M2 is marginally above the limit of ± 5% with respect the CSL value. No problems in the radiometric response, however, have been noticed		
Data saved and stored at DPC	Yes				

4.3 Procedure/ Test sequence and environmental conditions

4.3.1 Test procedure

The test has been run during OD33 (June 16th 200), starting at 2:20 AM (UTC) and lasting 2 hours and 34 seconds later.

The test procedure (serving also as a checklist) is reported in the following table.

Step	Description	START REF.	DURATION	Time (local)	RCA	YES	NO	Notes
8	CRYO-2 (UM section 13.1.2.5)	0:00:00						
8.1	Disable A/C 4kHz	0:00:00	0:00:02		All	Yes		
8.2	Disable B/D 4kHz	0:00:02	0:00:02		All	Yes		
8.3	Set A/C P/S Status (0)	0:00:04	0:00:02		All	Yes		
8.4	Set B/D P/S Status (0)	0:00:06	0:00:02	2009/06/16 04:20:03	All	Yes		
8.5	Set Cryo values on all RCAs (CSL values)	0:00:08	0:00:06	2009/06/16 04:20:05	All	Yes		See sheet attached with CRYO02 biases at CSL and in CPV
8.6	Enable A/C 4kHz	0:00:14	0:00:02	2009/06/16 04:20:11	All	Yes		Check tables here with phase switches configurations during different steps
8.7	Acquire Data	0:00:16	0:30:00	2009/06/16 04:20:13		Yes		
8.8	Set B/D P/S Status (1)	0:30:16	0:00:02	2009/06/16 04:50:13	All	Yes		
8.9	Acquire Data	0:30:18	0:30:00	2009/06/16		Yes		

				04:50:15				
8.10	Disable A/C 4kHz	1:00:18	0:00:02	2009/06/16 05:20:15	All	Yes		
8.11	Set A/C P/S Status (0)	1:00:20	0:00:02	2009/06/16 05:20:17	All	Yes		
8.12	Set B/D P/S Status (0)	1:00:22	0:00:02	2009/06/16 05:20:19	All	Yes		
8.13	Enable B/D 4kHz	1:00:24	0:00:02	2009/06/16 05:20:21	All	Yes		
8.14	Acquire Data	1:00:26	0:30:00	2009/06/16 05:20:23		Yes		
8.15	Set A/C P/S Status (1)	1:30:26	0:00:02	2009/06/16 05:50:23	All	Yes		
8.16	Acquire Data	1:30:28	0:30:00	2009/06/16 05:50:25		Yes		
8.17	Disable B/D 4kHz	2:00:28	0:00:02	2009/06/16 06:20:25	All	Yes		
8.18	Set A/C P/S Status (0)	2:00:30	0:00:02	2009/06/16 06:20:27	All	Yes		
8.19	Apply Default DAE Configuration as current configuration	2:00:32	0:00:02	2009/06/16 06:20:29	All			

4.3.2 Temperatures

Table 17 – Main temperatures (average value) during the CRYO-02 test in CSL and during CPV

	CSL	CPV
Tsky (K)	4.27	2.76
Tref (K)	23.25	21.52
TFEU (K)	19.85 – 20.79	19.60 – 20.43
TBEU (C)	9.86 – 30.75	15.11 – 37.15

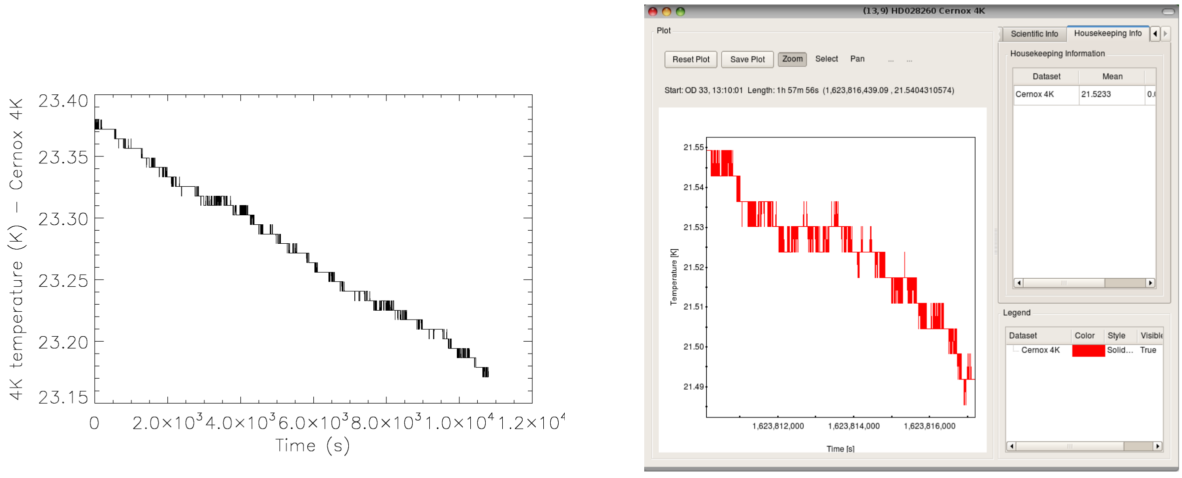

Figure 1 – Reference load temperature during CRYO-02 test in CSL (left) and during CPV (right)

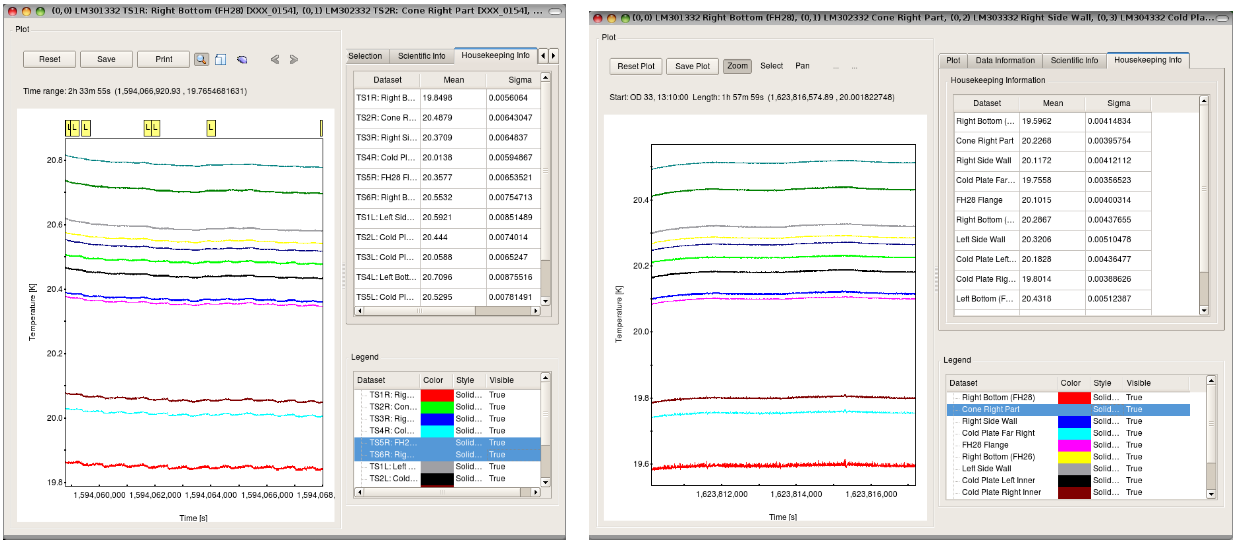

Figure 2 – Front-end temperature during CRYO-02 test in CSL (left) and during CPV (right)

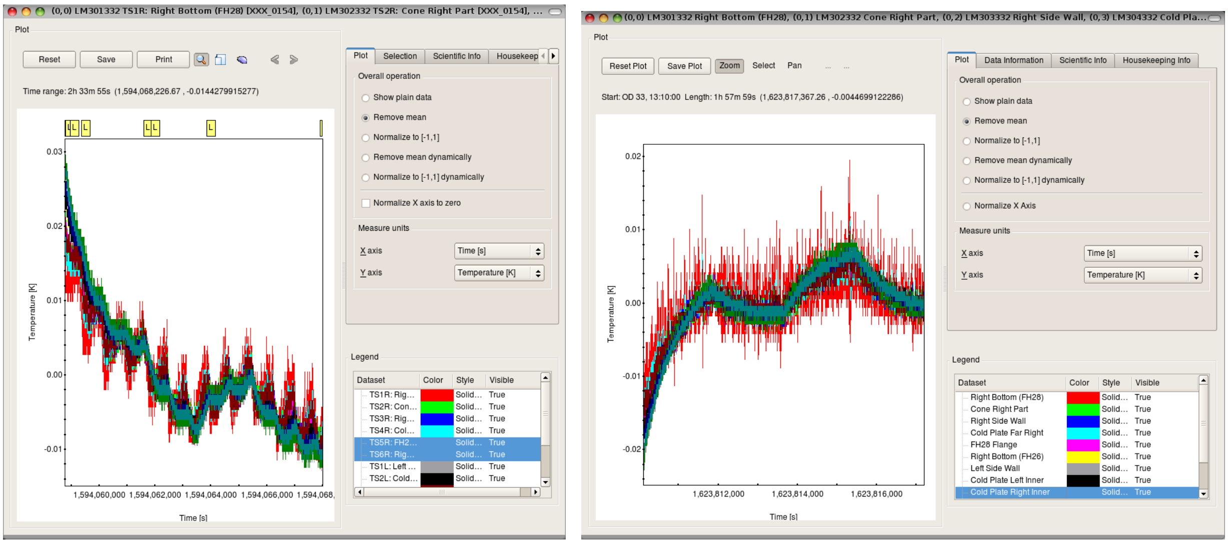

Figure 3 – Front-end temperature stability during CRYO-02 test in CSL (left) and during CPV (right)

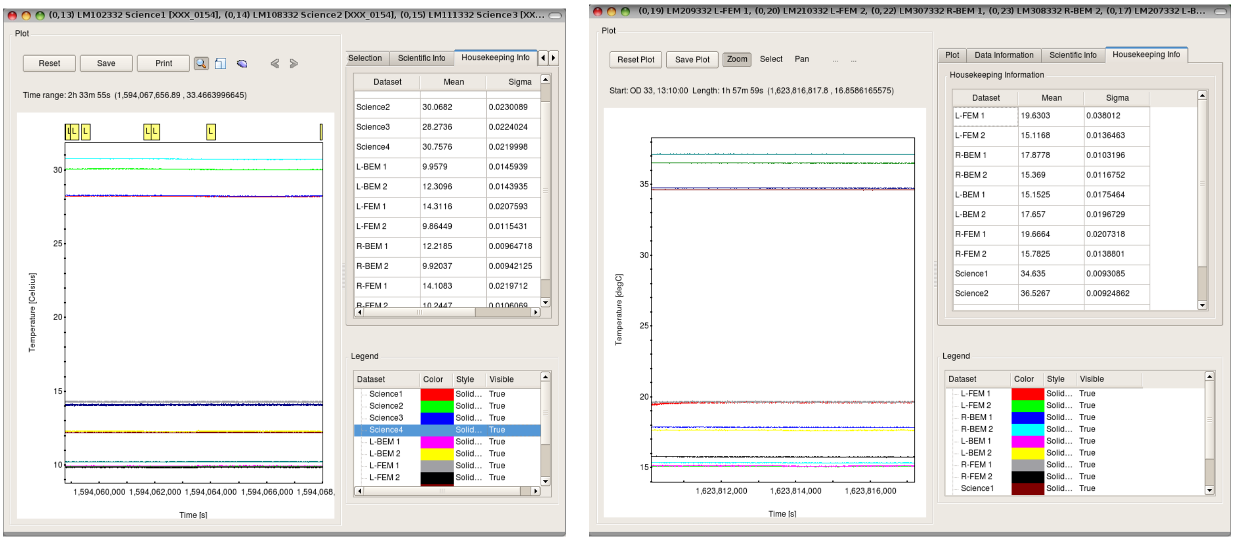

Figure 4 – Back-end temperature during CRYO-02 test in CSL (left) and during CPV (right)

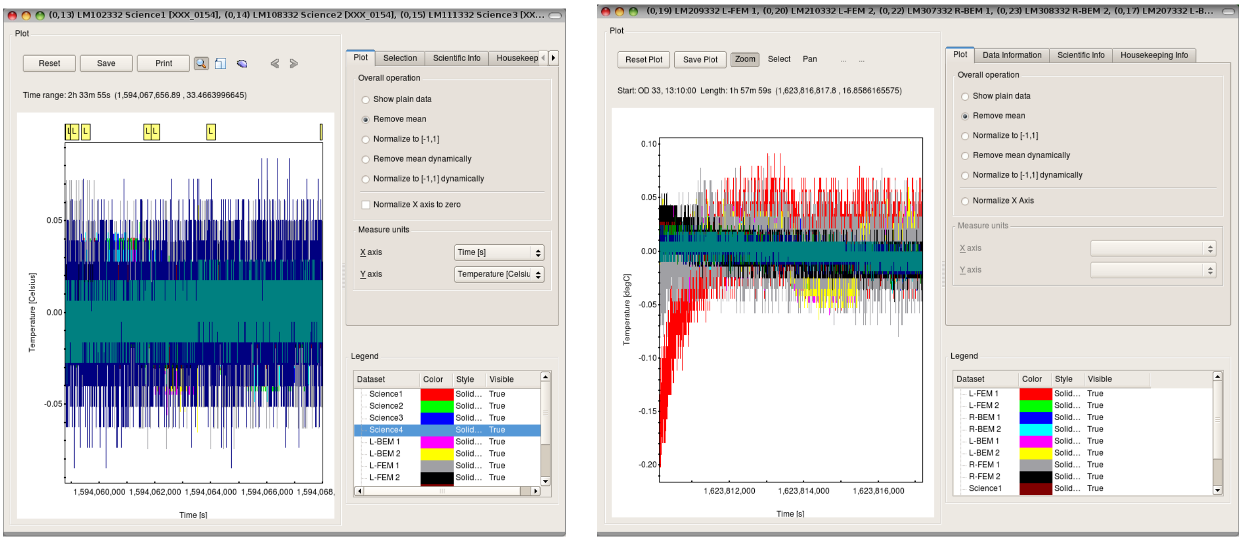

Figure 5 – Back-end temperature during CRYO-02 test in CSL (left) and during CPV (right)

4.3.3 Bias and DAE configuration

The test has been run in the same bias configuration that was used for CSL, i.e. the set of biases that resulted from the tuning activity performed during instrument-level tests. The biases for all 44 ACAs and phase switches are reported in the following table.

RCA	FEM arm	vg1	vg2	vd	I1	I2
	S2	200	204	114	255	255
LFI18	S1	200	196	138	255	255
	M1	195	189	126	255	255
	M2	198	196	125	255	255
	S2	220	201	125	255	255
LFI19	S1	215	204	120	255	255
	M1	215	198	124	255	255
	M2	220	196	126	255	255
	S2	198	201	127	255	255
LFI20	S1	210	211	132	255	255
	M1	225	204	121	255	255
	M2	231	206	127	255	255
	S2	201	213	132	255	255
LFI21	S1	196	197	136	255	255
	M1	201	207	141	255	255
	M2	210	187	136	255	255
	S2	220	199	130	255	255
LFI22	S1	204	184	128	255	255
	M1	179	204	125	255	255
	M2	178	176	130	255	255
LFI23	S2	186	223	122	255	255
	S1	197	166	118	255	255
	M1	223	182	120	255	255
	M2	226	195	119	255	255

	M2	227	204	183	91	255
LFI24	M1	226	204	200	152	252
	S2	219	225	152	96	255
	S1	219	213	157	87	234
	M1	222	221	184	124	255
LFI25	M2	224	212	185	89	255
	S1	226	216	167	93	255
	S2	219	220	166	121	255
	M2	232	219	170	136	255
LFI26	M1	232	221	169	118	255
	S2	232	217	169	114	255
	S1	228	226	172	159	255
	M1	240	108	156	148	210
LFI27	M2	245	108	157	169	214
	S1	238	86	157	138	192
	S2	250	126	156	148	184
	M1	243	101	157	153	180
LFI28	M2	240	112	156	169	214
	S1	235	88	157	138	192
	S2	245	121	158	148	184

The DAE gain values were all set to 0 (corresponding to a physical value of 1) while the DAE offsets were optimised in order to avoid saturation. The DAE offset values used in this test are listed in the following table.

RCA	DAE channel	DAE offset in CSL	DAE offset in CPV
	M-00	0	2
LFI18	M-01	0	2
	S-10	204	1
	S-11	204	1
	M-00	214	0
LFI19	M-01	204	0
	S-10	255	0
	S-11	224	0
	M-00	204	1
LFI20	M-01	204	1
	S-10	153	1
	S-11	143	1
	M-00	194	0
LFI21	M-01	204	0
	S-10	255	0
	S-11	255	0
	M-00	255	0
LFI22	M-01	255	0
	S-10	255	0
	S-11	255	0
LFI23	M-00	173	1
	M-01	122	1

	S-10	255	0
	S-11		
		255	0
	M-00	255	0
LFI24	M-01	255	0
	S-10	255	0
	S-11	255	0
	M-00	255	0
LFI25	M-01	255	0
	S-10	255	0
	S-11	255	0
	M-00	255	0
LFI26	M-01	255	0
	S-10	255	0
	S-11	255	0
	M-00	21	2
LFI27	M-01	0	2
	S-10	51	1
	S-11	92	2
	M-00	102	1
LFI28	M-01	41	2
	S-10	112	1
	S-11	143	1

4.3.4 Phase switch configuration

The test consisted in four acquisitions of ½ hour each in which the following four phase switch configurations have been exercised:

	Switching	A/C pos	B/D pos
Acquisition 1	A/C	0	0
Acquisition 2	A/C	0	1
Acquisition 3	B/D	0	0
Acquisition 4	B/D	1	0

4.3.5 Non nominal features

The procedure was executed correctly without anomalies.

4.4 Data Analysis

4.4.1 Drain current comparison with CSL

In Fig. 6 we show a comparison of drain currents measured during CPV and in CSL during the CRYO-02 test for the four phase switch configurations. The percentage variation is defined as [Id(CPV) – Id(CSL)] / Id(CSL). Where no bars are displayed it means that the drain current variation was less than 0.1 mA.

The results show that all the drain currents (with the exception of LFI26M2) have been found reproducible within ±2%.

The case of LFI26M2 is the only noticeable exception, as for this amplifier we have recorded a drain current that was about 8.6 % (~1 mA) higher than in CSL. Although the reason of this discrepancy has not been understood yet the LNA shows full functionality as proved by the CRYO-01 drain current verification tests.

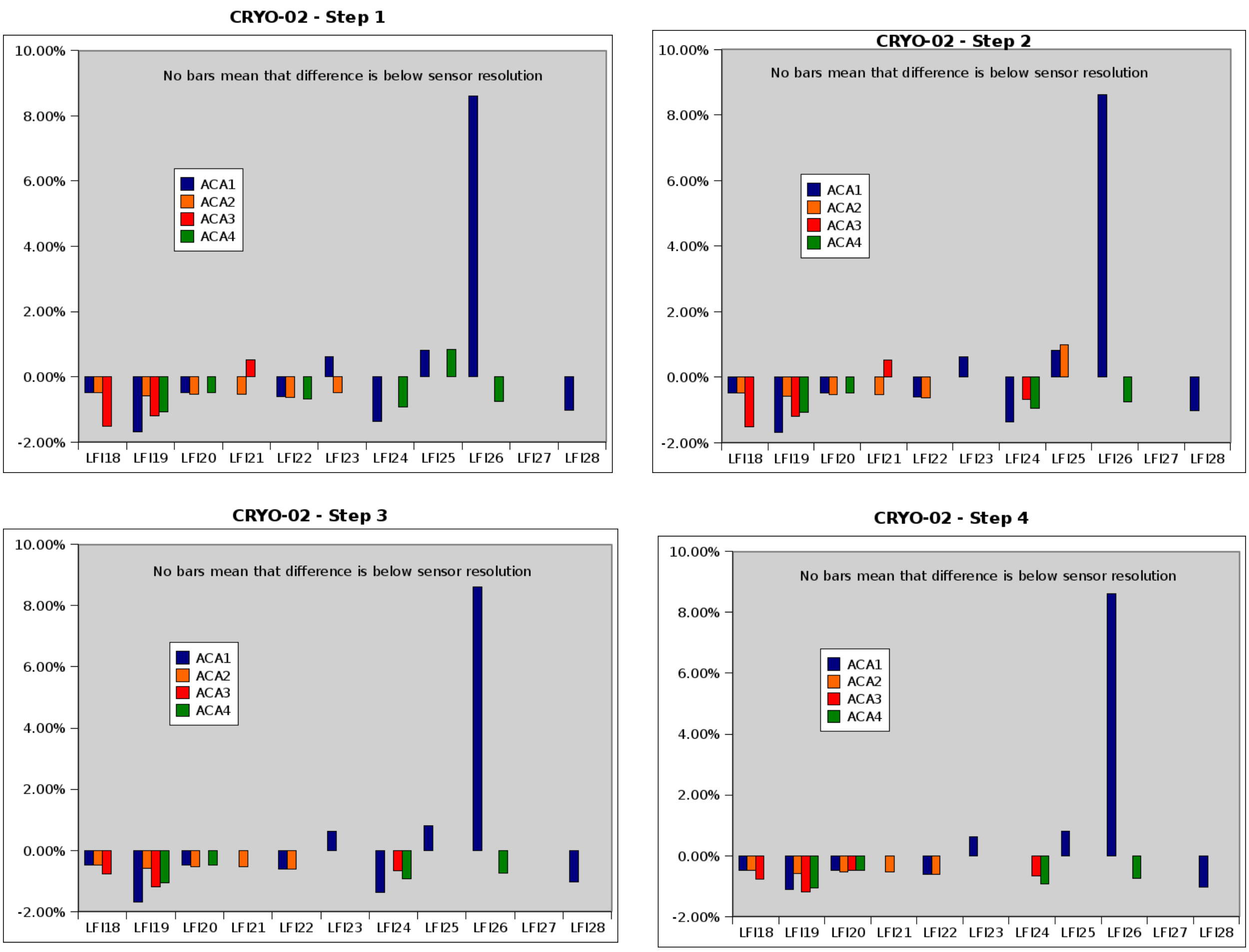

Fig. 6 – Comparison of drain currents measured during CRYO-02 test in CPV and in CSL. The percentage variation is defined by (Id(CPV) – Id(CSL))/Id(CSL). Where no bars are displayed it means that the drain current variation was less than 0.1 mA

4.4.2 Knee frequency analysis

Knee frequencies have been calculated from differenced datastreams from all 44 detectors in the four tested switch configurations. Results are summarised in Fig. 7 and the complete differenced spectra are provided in Appendix 1.

From the results we can conclude the following:

- Knee frequencies from differential datastreams are all below 1 Hz, several of them being of the order of tens to few hundred mHz;
- knee frequencies measured during CPV are consistent with those measured in CSL. In this case the consistency is not sought at a level of few %, but of a factor 2 – 3;
- the radiometer LFI23M still displays anomalous behaviour when its switching configuration is in B/D switching. This anomaly was already seen in CSL and can be avoided by setting the phase switch in the A/C switching condition.

In summary the LFI receivers behave correctly when operating in nominal switching condition.

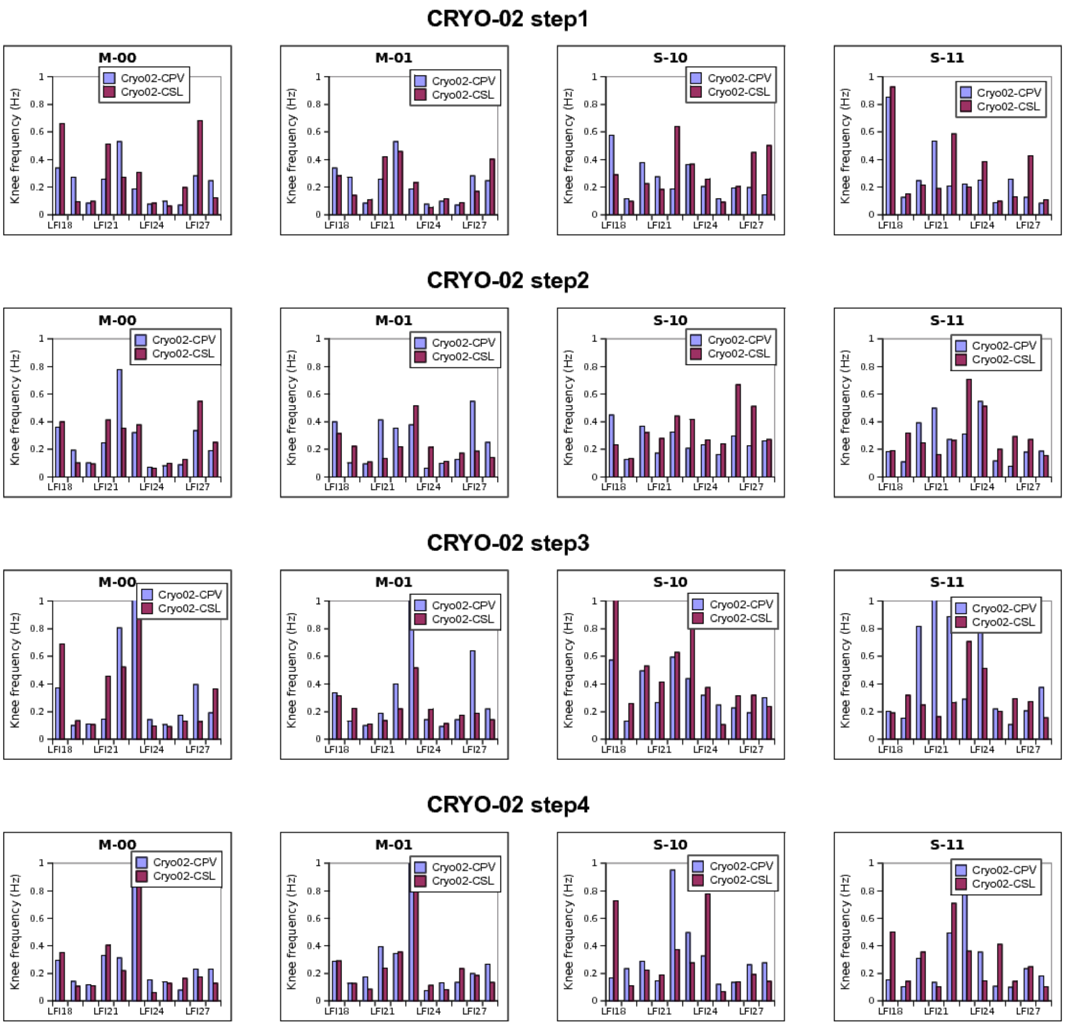

Fig. 7 – Knee frequencies of differenced data streams acquired during CRYO-02 in the four phase switch configurations

4.4.3 Known anomalies

- The radiometer LFI23M does not work correctly when its switching configuration is in B/D switching. In this case the residual knee frequency after differencing is of several Hz
- The receiver LFI28 inverts the sky-ref tag when the switch configuration is in B/D switching, A/D = 0

4.4.4 New anomalies

- The ACA LFI26M2 displays a drain current which is ~8.6 % higher than what has been measured in CSL

4.5 Conclusions and recommendations

The CRYO-02 functionality test proved full functionality of the LFI in switching conditions. Also known anomalies regarding LFI23M and LFI28 have been reproduced.

The only anomaly is the drain current of LFI26M2 which has displayed a discrepancy of about 8.6 % (about 1 mA) with respect to CSL. There is no reason to believe that this unexpected discrepancy indicates a loss of functionality in this channel.

We recommend, nevertheless to monitor this channel in future tests, in particular looking for:

- Changes in drain current not linked to a bias changes
- Anomalous channel isolation
- Anomalous knee frequency