TITLE: # Analysis of drain current and isolations anomalies in radiometer LFI24S observed during TV-TB tests in CSL

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	July	All	First Draft of Document	Draft
0.2	July	All	Second draft of document	0.2
0.3	July	All	Second draft of document	0.3
0.4	September	All	Fourth draft of document	0.4
1.0	September	All	First issue of document	1.0

Table of Contents

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
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
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 INTRODUCTION

This document summarises the analysis of an anomalous behaviour observed with the radiometer LFI24-S during the TV-TB tests in CSL.

This document has been issued in the frame of ASI contract that has been released for the activities of Planck-LFI Phase E2

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 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] TV Tests: LFI Test Under Cryogenic Vacuum, PL-LFI-PST-PR-021 2.2

3.2 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] LFI Warm Functional Test Procedure (WFT) - PL-LFI-PST-PR-017_2_1

[RD4] Combined LFI EMC Tests at System Level - PL-LFI-PST-PR-020

[RD4] Data Analysis Of LFI switch on and cryogenic functionality test CRYO_01 (Ph-5-01-c of TV/TB tests) - PL-LFI-PST-RP-XXX

4 Anomaly description

The anomaly that has been observed on LFI24-S shows in two different ways which appear to be correlated:

- the drain current of the ACA 24-S1 sometimes is about 30% higher than the expected value in cryogenic conditions (~15 mA compared to ~ 10 mA expected);
- in some cases the voltage outputs from detectors LFI24S-10 and LFI24S-11 (connected to ACAs LFI24S1 and LFI24S2) show complete lack of isolation, i.e. sky and reference load samples are not separated. These cases seem to be correlated with the anomalous drain current state. In this state the radiometer is lost from the scientific point of view.

4.1 Drain current anomaly

4.1.1 History

RCA 24 S1 has shown one to one correspondence between wrong Id, Isolation lack, low voltage. It seems to be able to pass from a state to another apparently without a precise reason. The wrong state has always the same current (Id about 15 mA) and induces also a change in S2 current systematically increasing it by about 0.5 mA.

In this paragraph we reconstruct the drain current anomaly of LFI24S along the CSL test campaign until July 15th, 2008. The problem never exhibited during the CSL test campaign until test named XXX_0151 , that is the LFI switch on with nominal bias, starting from 0 bias condition .

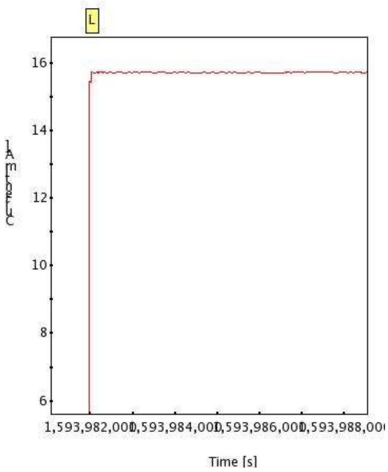


Figure 1 LFI switch on (XXX_0151) Id (S1): high current status

Before this test, RCA 24 was on with normal current on S1 (and high Vg2(M1) set to 234) until test XXX_0146. During this test , a problem occurred with RCA 28 that was switched on without using the foreseen Soft procedure. After XXX_0146 all RCAs have been set to 0 bias to perform spike tests with FEMs OFF.

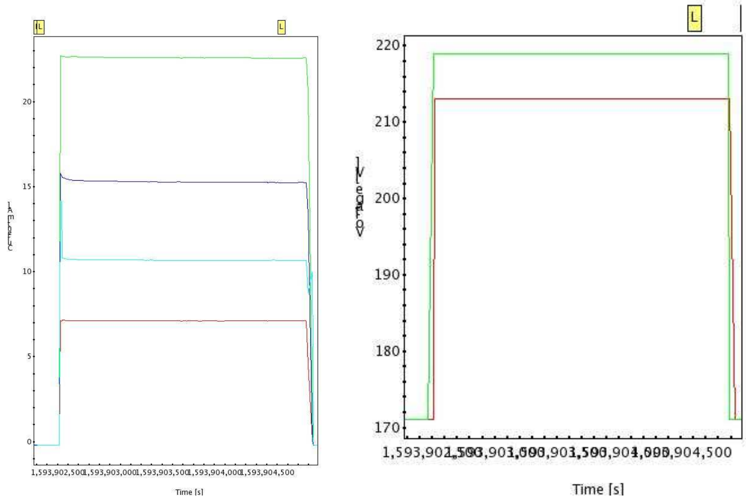


Figure 2 RCA 24 switch on from 0 bias condition (XXX_0146) Id (S1): normal current status

After XXX_0151, RCA 24 S1 remained ON until XXX_0153 (that is the Id-Vg Contingency procedure) in the high current state. Here, Vg1 is firstly varied, then Vg2. From Vg1 variation, it comes out that a change in Vg1 bias (Vg2 is firstly kept nominal set to 213) is able to push Id (S1) to normal values. Vg2 variation, performed further, does not produce any effect. Id remains nominal.

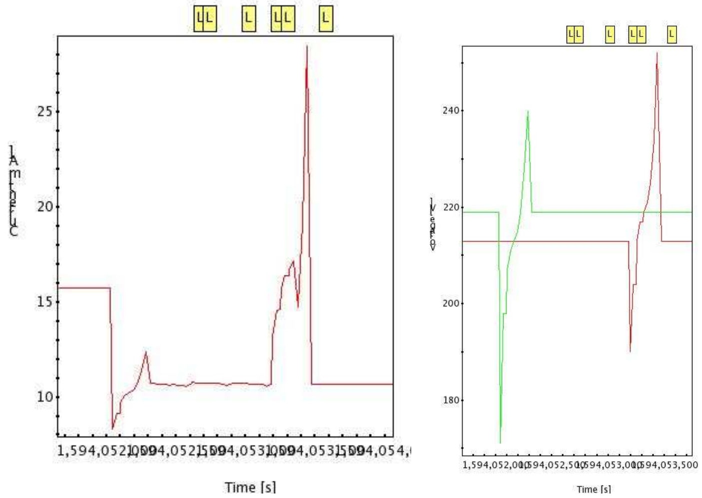


Figure 3 Contingency procedure on RCA 24: Vg1 is lowered from nominal (219) to off (171) (XXX_0153) Id(S1) changes from high values (>15mA) to normal values (also after Vg2 variation). Current remains nominal until the end of the entire procedure.

the successive steps of the above procedure (TEST XXX_0153) are:

START contingency with nominal bias (WRONG current, BAD iso)
Decrease Vg1 to 0 bias (171) with Vg2 nominal 213 (CORRECT current)
running Vg1 with Vg2 fixed to nominal (CORRECT current, GOOD iso)
restoring nominal Vg1 at the end of Vg1 Tun (CORRECT current, GOOD iso)
Decrease Vg2 to low bias (190) with Vg1 still 219 (WRONG current)
Running Vg2 with Vg1 fixed to nominal (WRONG current, STRANGE iso (anticorrelation sky ref)
Decreasing Vg2 from 252 to nominal (213) (CORRECT current, GOOD iso)

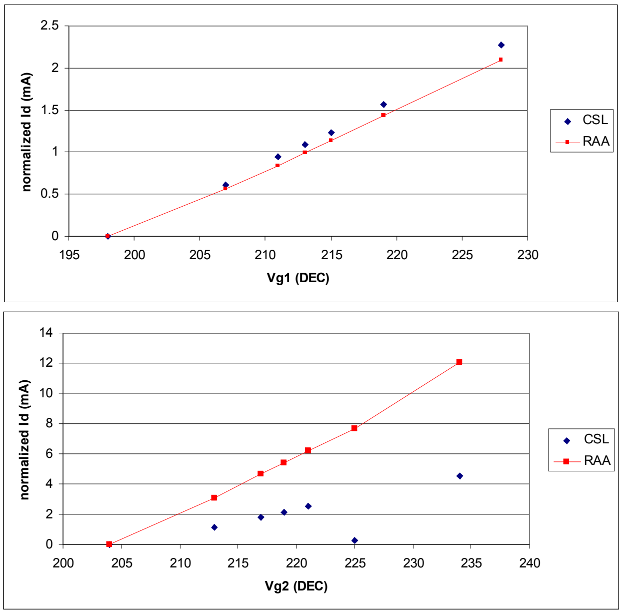


Figure 4 results from V1 and Vg2 vs Id contingency procedure

Everything remained still (but bias are no more changed along this period) until TUN_0051 that is the phase switch tuning . Here, S2 was firstly switched off and on again but nothing changes. Hence, S1 is set to 0 bias (Vg1, Vg2, VD, I1 and I2 are set to 0) and turned on again with nominal values. This switch on produces again a wrong condition in Id that comes back to >15 mA.

Along this test, many problems occurred with RCA 28 soft procedure.

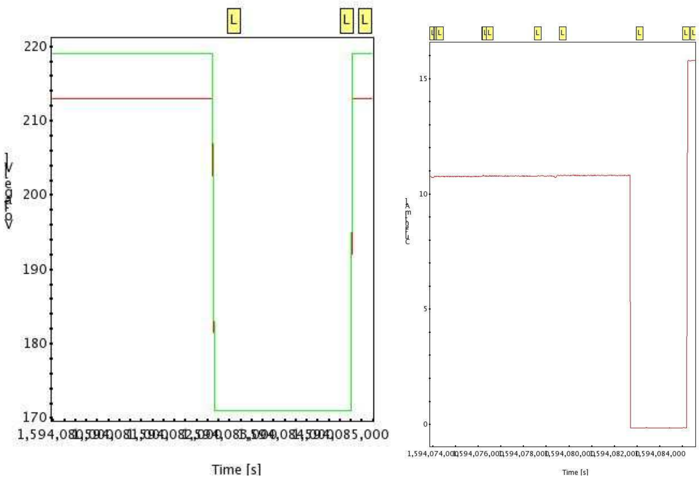


Figure 5 TUN_0051 : S1 is switched OFF and on again , causing wrong Id.

Id stays high until MATRIX tuning step 1 (TUN_0060), where bias changes are able to suppress anomalies and to recover anomalies:

- START : (WRONG current, BAD iso)
- Vg1 & Vg2 changes (WRONG current, BAD iso)

- Vg1 & Vg2 abrupt change (lowered to nominal, blue dots) (CORRECT current, GOOD iso)
- Vg1 & Vg2 changes (CORRECT current, GOOD iso)
- ACA switch off (Vg1 = Vg2 = 171, VD=0)

Vg1 & Vg2 to nominal values (WRONG current, BAD iso)

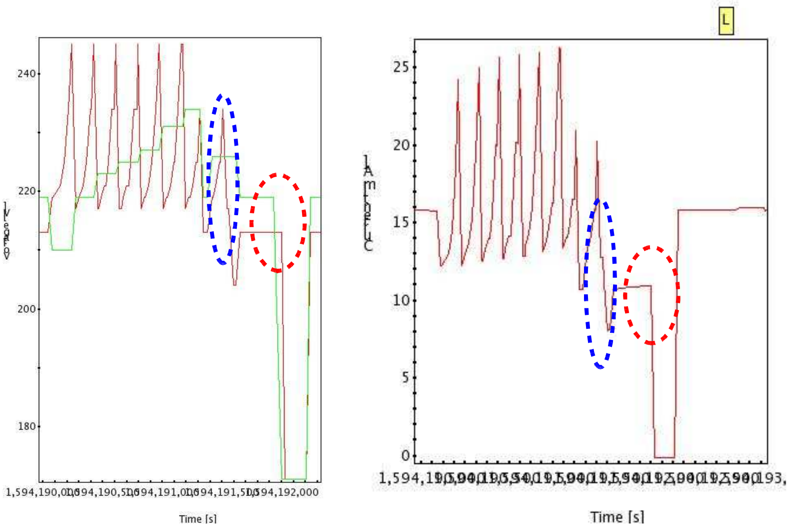


Figure 6 Matrix tuning step 1 (TUN_0060): current comes back to normal Vg1 and Vg2 are decreased to nominal bias; It turns again to high values after Vg1 and Vg2 are biased to 0 and switched on again to nominal

Nothing happen until TUNING 1.5 is performed , where the same sequence is repeated getting exactly the same results.

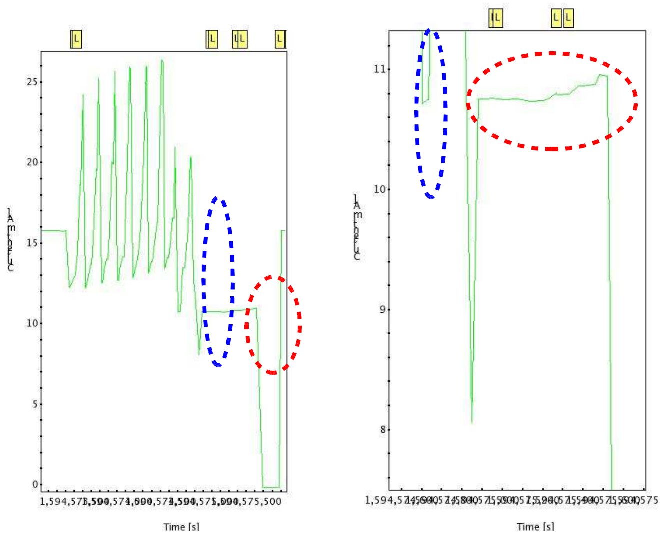


Figure 7 Matrix tuning step 1.5 (TUN_0071): current comes back to normal Vg1 and Vg2 are decreased to nominal bias; It turns again to high values after Vg1 and Vg2 are biased to 0 and switched on again to nominal

After this test , an attempt to exit the high current frame was done just changing the bias from nominal to another possible suitable couple individuated from the Matrix tuning 1.5 and then going to nominal bias again. What happens is that the change from [219-213] to [227-218] makes the current decrease (despite the Vg increasing) and the final change to nominal , from [227-218] to [219-213] push down again the current to nominal Id around 10 mA .

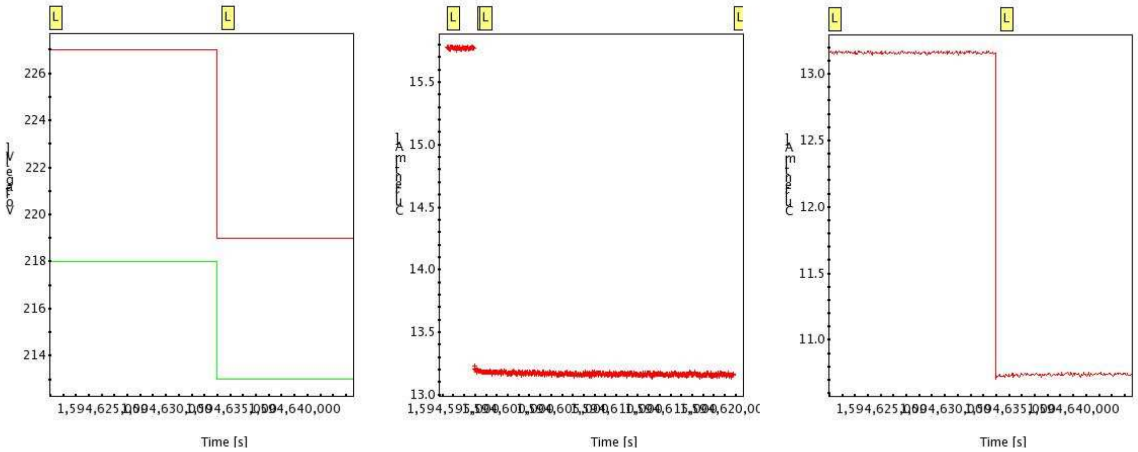


Figure 8 Bias are changed simultaneously on Vg1 and Vg2 from nominal to another bias pair (also higher in terms of voltages): makes the current decrease from anomalous status to believable values; the further change to nominal bias makes it decrease again to nominal expected Id.

4.2 Isolation anomaly

4.2.1 Case of observed non nominal isolation

In Figures 9 and 10 we show the voltage outputs relative to the LFI24 RCA (mean values have been removed) recorded from test XXX_0155 acquired during July 8th between 14:44 and 18:38 CET. In Fig.9 we show an example of a correct behaviour, where the receiver voltage output clearly distinguishes between sky and reference load temperature behaviours, while in Fig.10 we show the apparent problem we see in the voltage output from radiometer LFI24S, where both sky and reference load samples track the reference load temperature drift.

The same behaviour can be seen in Table 1, reporting the average voltage outputs from all the RCA detectors.

This behaviour (which we identify as "lack of isolation") could be caused by a failed amplifier or phase switch, or more simply by one of the two amplifiers being in an OFF condition. It is worth noticing that all the functionality tests conducted so far have not highlighted any apparent failure in the amplifiers and in the phase switches.

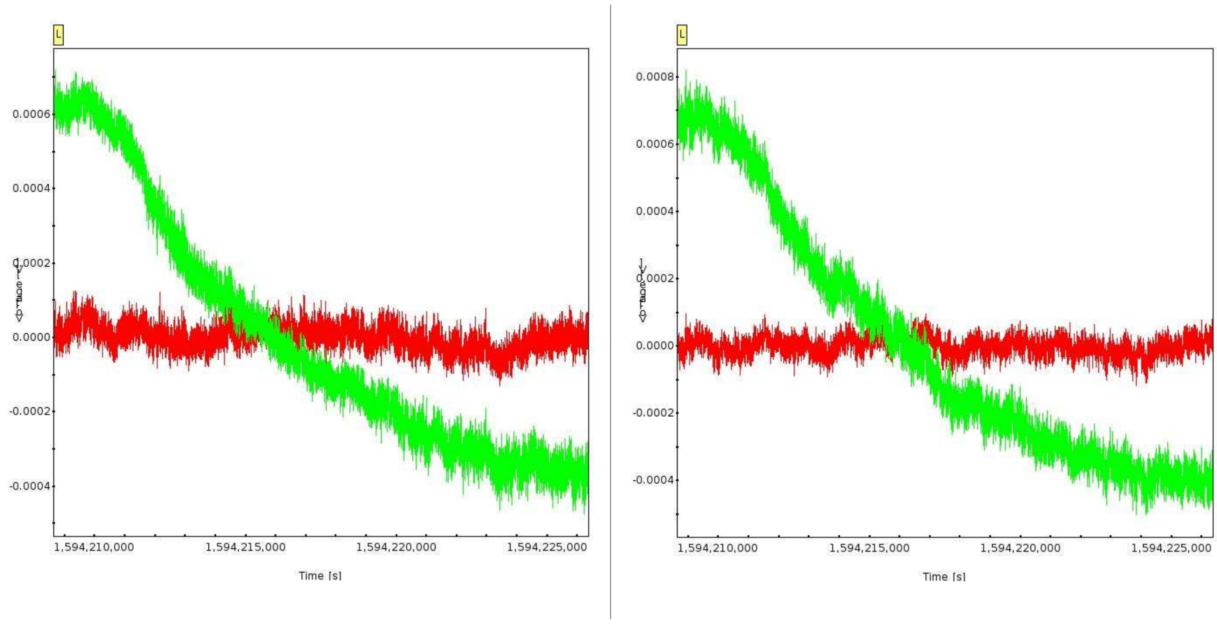


Fig. 9 -Voltage outputs (mean value removed) from LFI24S-00 and LFI24S-01. The reference load voltage output clearly tracks the 4K load temperature drift.

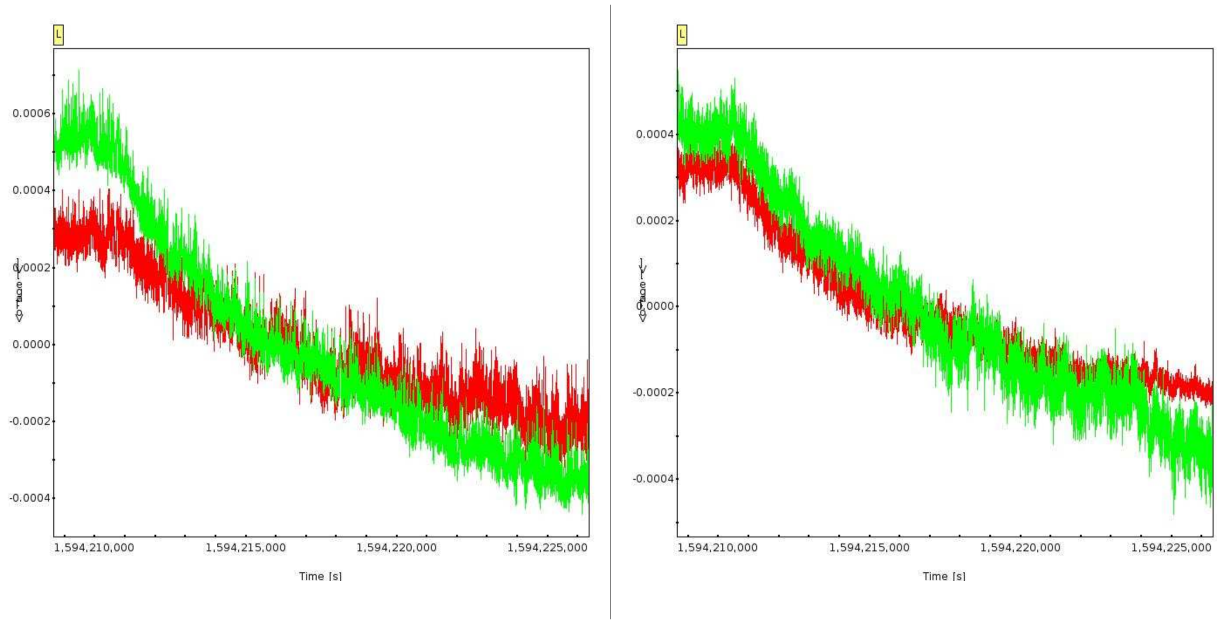


Fig. 10 -Voltage outputs (mean value removed) from LFI24S-10 and LFI24S-11. The lack of isolation is apparent (the reference load temperature drift is tracked by both voltage outputs).

In Table 2 we also report the drain current of LFI24S1 and LFI24S2 ACAs. The table clearly shows a non nominal (too high) drain current relative to LFI24S1

Table 1 - Voltage outputs from RCA LFI24. The separation is clear in detectors LFI24M-00 and LFI24M-01 while is almost non-existent in the other two detectors

	LFI24M-00	LFI24M-01	LFI24S-10	LFI24S-11

Vout (sky) (V)	0.0725571	0.069531	0.104733	0.114699
Vout (ref) (V)	0.116745	0.118643	0.12745	0.116911

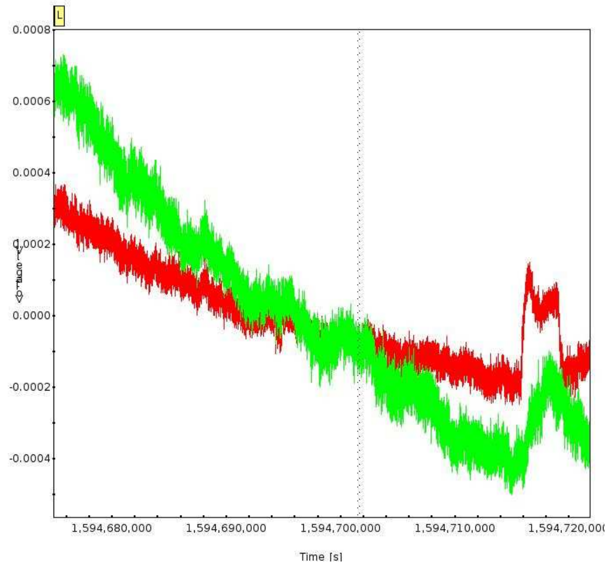
Table 2 - Drain currents relative to ACAs LFI24S1 and LFI24S2. Notice that the drain current from LFI2S1 is about 50% larger than the expected value

	LFI24S1	LFI24S2
Idrain (meas.) (mA)	15.78	15.83
Idrain (exp.) (mA)	9.85	13.90
Delta (%)	52%	8%

4.2.2 *Case with observed nominal isolation*

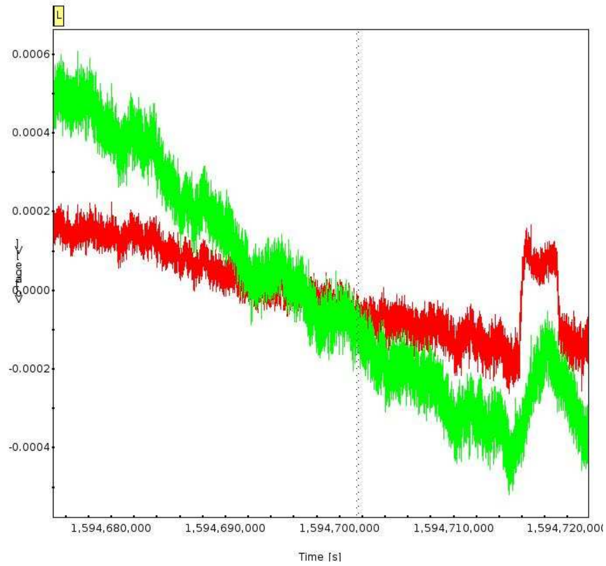
In Fig. 11 we show data from acquired from LFI24 taken from test XXX_0169 (13-14 July 2008, from 21:14 to 10:15 UTC). Data show a good functionality and isolation properties for all the detectors. All features in the data are explained in the figure caption.

LFI24M-00



LFI24S-10

LFI24M-01



LFI24S-11

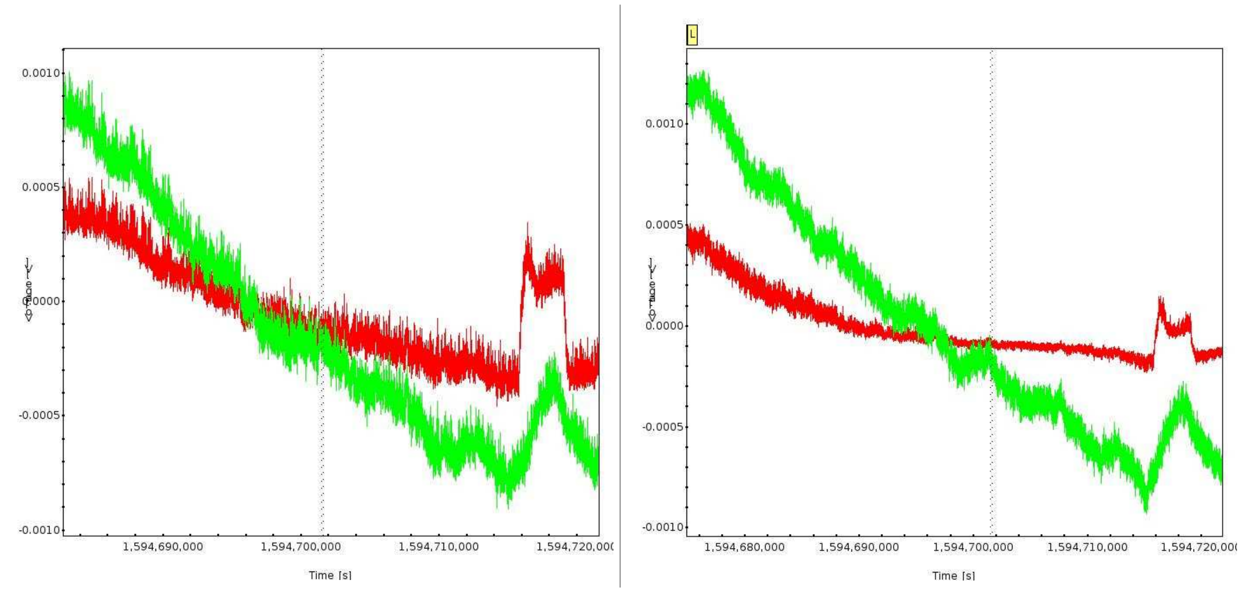


Fig. 11 -Voltage outputs (mean value removed) from all four diodes of LFI24. Features observed are: (i) bump in sky load data (red track) correlated with the helium refill of the optical shield, (ii) bump in the reference load data (green track) correlated with a contemporary operation of the 20K-4K heat switch, (iii) slope in the sky load data, correlated with a slow increase of the BEU temperature, (iv) slope in the reference load data, correlated with the decrease in the reference load temperature + the effect of the BEU temperature drift.

In this case the drain current is less than 10% off the expected value. **Note that the Vg1, Vg2 and Vd biases are exactly the same as in test XXX_0155** and correspond to the nominal LFI biases used during the CRYO_02 test

Table 3 - Drain currents relative to ACAs LFI24S1 and LFI24S2. Notice that the drain current from LFI2S1 is now less than 10% off compared to the expected value

	LFI24S1	LFI24S2
Idrain (meas.) (mA)	10.74	15.00
Idrain (exp.) (mA)	9.85	13.90
Delta (%)	9%	8%

4.2.3 Transition between non nominal and nominal behaviour

The transition between non nominal and nominal isolation behaviour has been observed during a dedicated test in which the bias voltages of LFI24S1 were moved off the nominal values to a value used during the matrix tuning phase. The test is XXX_0165 and was acquired between 12th and 13th July (22:17 – 06:11 UTC).

In Tab 4 and 5 we report the bias configuration of the radiometer LFI24S before and after the change, while in Fig. 12 we show the effect of the bias change on the voltage output. The change in isolation behaviour is apparent from left to right.

Important notice. After this test the bias voltages of LFI24S were restored to the nominal values listed in Tab. 4 but the nominal behaviour was maintained, as shown in the plots of Fig. .

Table 4 - Nominal biases for LFI24S before the change. In this situation the drain current for LFI24S1 is in the ***high*** *state and the isolation is missing*

	Vdrain	Vg1	Vg2	Idrain
LFI24S1	157	219	213	15.77
LFI24S2	152	219	225	15.83

Table 5 - Biases for LFI24S after the change. In this situation the drain current for LFI24S1 is in the ***normal*** *state and the isolation is good*

	Vdrain	Vg1	Vg2	Idrain
LFI24S1	157	**227**	**218**	15.77
LFI24S2	152	219	225	15.83

LFI24S-10 and LFI24S-11 before bias change

LFI24S-10 and LFI24S-11 after bias change

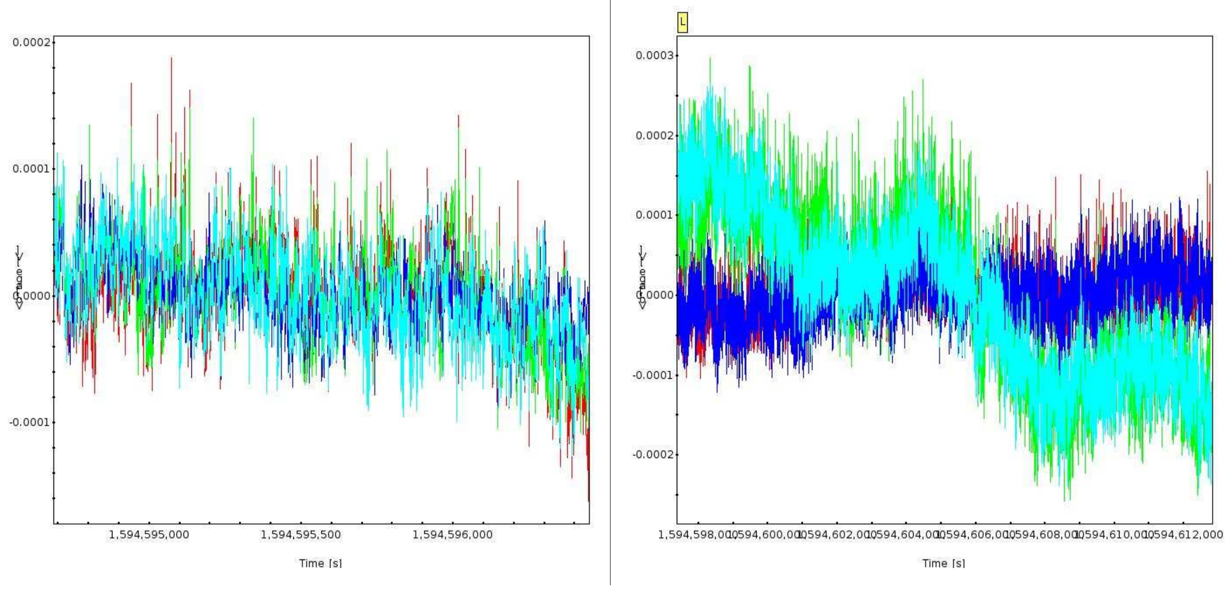


Fig. 12 -Voltage outputs (mean value removed) from the two diodes of LFI24S before and after the bias change. On the left it is clear that the traces are superimposed and there is no separation between the sky and reference samples ("lack of isolation"). On the right, after the bias change, a nominal situation has been recovered.

5 Problem investigations

5.1 First investigation

The first investigation on this issue has been aimed at identifying some repeatable configurations to trigger and remove the problem. The test has been performed in three different phases: in the first phase we analysed the instrument response to variations of Vg1, in the second phase we analysed the instrument response to variations of Vg2 and in the third phase we analysed the instrument response to simultaneous variations in Vg1 and Vg2. The detailed flow diagram of the test is reported In Figures 13 through 15. In red we indicate the actual path that has been followed. Notice that during Vg2 and Vg1+Vg2 tests at a certain point the path detours to the Vg1 test path. The Vg1 and Vg2 values that have been exercised are contained in the following table.

The non nominal behaviour (indicated with the acronym "Osc" in the flow diagram, that stands for "Oscillation") was judged both on the basis of the observed drain current and on the basis of the receiver isolation from the voltage output.

Table 6 - Bias values used in the investigation. The table lettering has been chosen just for communication purposes between IOT and TAS operator. In bold we indicate the default (start point) bias values. Values are given in decimal. Note that 171DEC correspond to 0 Volts

Table #	Vg1	Vg2
A	171	171
B	171	213
C	**219**	**213**
D	219	171
E	190	213
F	219	190
H	190	190

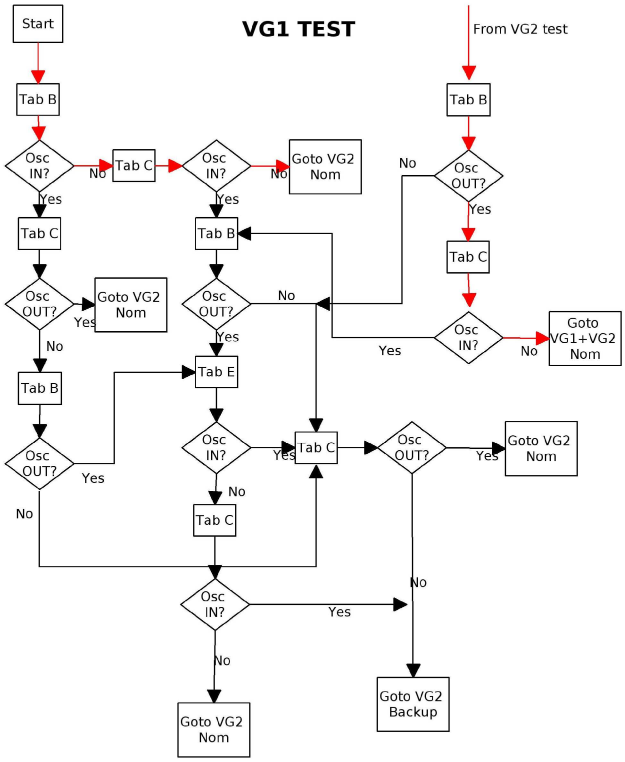


Fig. 13 - Flow diagram of the test performed by varying Vg1

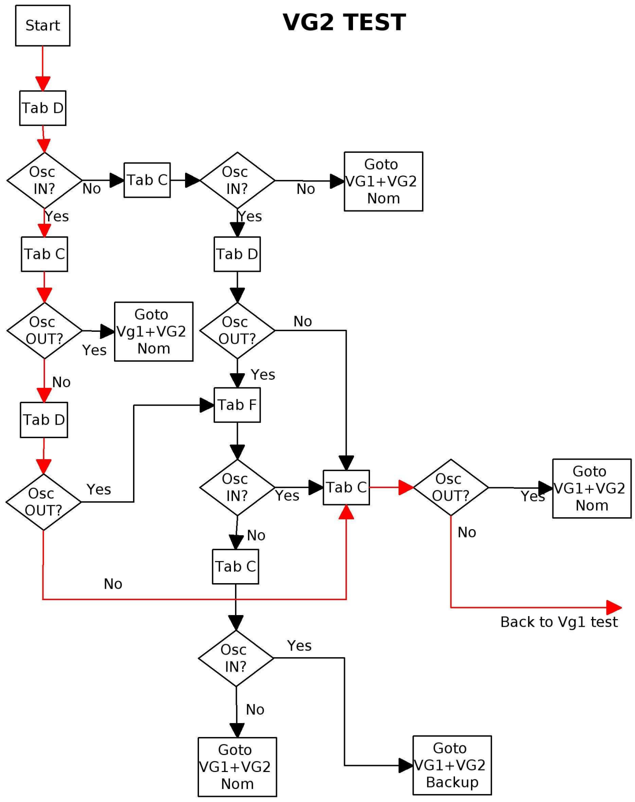


Fig. 14 - Flow diagram of the test performed by varying Vg1

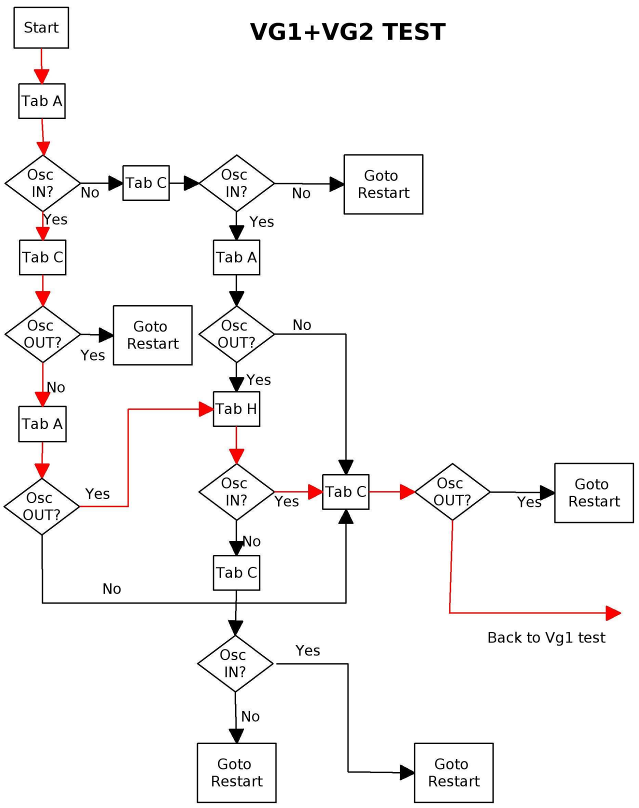


Fig. 15 - Flow diagram of the test performed by varying Vg1 and Vg2

Besides the test outlined in the above flow diagrams we also performed a Vg2 change in the following order starting from the nominal values in Table 6 when the receiver was in nominal conditions:

$$213 \rightarrow 209 \rightarrow 205 \rightarrow 209 \rightarrow 213$$

Non of these changes was able to trigger the anomaly. Furthermore we have repeated the actions triggering the anomaly after a switch-off – switch-on of the LFI front-end modules (DC/DC converters have not been switched off). The receiver LFI28 was biased using the *soft* switch on procedure described in [AD5]. No change has been observed

The activities in this first investigation can be summarised as follow

1. We have started with the radiometer LFI24S with nominal biases and without the anomaly present. In the amplifier under test showing the anomaly nominal biases are: Vd = 157 DEC, Vg1 = 219 DEC, Vg2 = 213 DEC
2. We have first changed Vg1 from 219 DEC to 171 DEC (corresponding to zero Volt) and back. Non anomaly has been induced
3. We have then changed Vg2 from 213 DEC to 171 DEC (corresponding to zero Volt). Anomalous currents and loss of isolation has been observed
4. Returning back with Vg2 from 171 DEC to 213 DEC did not recover the situation.
5. Switching Vg1 from 219 to 171 and then back to 219 recovered nominal situation (this was systematically repeated during the test)
6. We have changed both Vg1 and Vg2 (simultaneously) from nominal to 171 DEC and the problem was triggered again
7. Going back simultaneously with both biases back to nominal did not recover nominal behaviour
8. Applying step 5 successfully recovered nominal behaviour
9. We changed Vg2 from nominal (213) to 190 DEC. Again non nominal behaviour was triggered and recovered as usual via step 5
10. We changed Vg2 from 213 -> 209 -> 205 -> 209 -> 213. In none of these steps the anomaly was triggered

We can summarise the conclusions from this first investigation as follows:

1. Vg1 changes do not trigger the problem
2. Vg2 changes trigger the problem
3. Vg1 changes from nominal to 171 DEC and back when Vg2 is at nominal 213 DEC systematically recover nominal behaviour
4. also a change in Vg2 together with Vg1 induces anomalous behaviour. It can be recovered using step 5

5. To trigger the anomaly it is not necessary to move Vg2 to 171 (also a higher value, 190, triggers the anomaly)

6. Small changes in the proximity of the nominal bias do not trigger the anomaly.

7. A switch off / on of the LFI front-end amplifiers does not solve the problem

5.2 Second investigation

A second investigation of this problem was performed during July 16th with four main objectives:

1. Clearly define the conditions inducing the anomaly

2. Define a set of "safe" bias values to be used during the matrix ACA tuning test

3. Execute a *dry run* of the matrix tuning procedure limited to the LFI24S1 to verify that the new biases would not induce the anomaly

4. Verify the existence or disappearance of the anomaly after a full switch off of the instrument (including DC/DC converters)

This second investigation was run between July 16, 16:00 CET and July 17, 5:00 CET before the start of the ACA matrix tuning phase 2 test.

5.2.1 First test

In the first test we explored the Vg2 bias space of the LFI24S2 ACA in order to define whether the anomaly was triggered by definite absolute values in Vg2 or steps beyond a certain value in Delta V.

The bias space we have explored starts from Vg2 = 213 DEC (which is the nominal value) and goes down to Vg2 = 171 DEC (corresponding to 0 V) and up to 241 DEC. The Vg1 and Vd have been kept to their nominal values throughout the test.

In a first run we have moved Vg2 down with increasing steps always returning to the nominal value after each step. For example:

1. Starting point: Vg2 = 213 DEC.

2. Step down from Vg2 = 213 DEC to Vg2 = 211 DEC (Delta V = 2 DEC)

3. Check receiver behaviour

4. Go back to Vg2 = 213 DEC.

5. If no anomaly at step 2 then step down from Vg2 = 213 DEC to Vg2 = 209 DEC (Delta V = 4 DEC)

6. Check receiver behaviour

7. Go back Vg2 = 213 DEC

8. Repeat from 2 to 7 always doubling the Delta V until anomaly is observed.

Following the above procedure we observed the anomaly at Vg2 = 191. Then we stepped the Vg2 back to 213 DEC, recovered the nominal behaviour with a switch OFF/ON of the Vg1 and then moved, with a single step, the Vg2 to 193 DEC, i.e. the value immediately before the one giving the anomaly.

Then we made one small step of Delta V = 2 DEC to Vg2 = 191 DEC and also in this case the anomaly was induced. This clearly demonstrates that it is the absolute value, rather than the step, triggering the anomaly. We repeated the above procedure by stepping from Vg2 = 193 DEC to Vg2 = 187 DEC and the result was the same. Considering that during the previous tests also the value Vg2 = 190 DEC was seen to induce the anomaly **we can conclude the the step of the Vg2 changes are not important. What matters is the absolute value of Vg2 that must not be smaller than 193 DEC.**

Finally we performed some steps in the direction with Vg2 increasing from the starting value. No anomaly was triggered in this case.

Therefore from this test we can conclude that **the anomaly is triggered by values of Vg2 lower than 193 DEC, independently from the step. The anomaly can be always recovered by bringing Vg2 to a value larger or equal to 193 DEC and then switching OFF and ON the Vg1.**

Detailed values and results of this test are summarised in Tables 7 through 9.

Table 7 - bias steps exercised during the first part of the test. In red we indicate the value at which we observed the anomaly

Step #	Vg1	Vg2	Delta	Anomaly?	Idrain S1
0	219	213			10.75
1	219	211	-2	NO	9.99
2	219	209	-4	NO	9.26
3	219	207	-6	NO	8.52
4	219	205	-8	NO	7.88
5	219	203	-10	NO	7.2
6	219	201	-12	NO	6.6
7	219	199	-14	NO	6.03
8	219	197	-16	NO	5.52
9	219	195	-18	NO	5.04
10	219	193	-20	NO	4.6
11	219	191	-22	YES	13.28

Table 8 - bias steps exercised during the second part of the test. In red we indicate the value at which we observed the anomaly

Step #	Vg1	Vg2	Delta	Anomaly?	Idrain S1
0	219	213			10.75
1	219	193	-20	NO	4.6
2	219	191	-2	YES	13.28

Step #	Vg1	Vg2	Delta	Anomaly?	Idrain S1
0	219	213			10.75
1	219	193	-20	NO	4.6
2	219	187	-6	YES	12.99

Table 9 - bias steps exercised during the third part of the test.

Step #	Vg1	Vg2	Delta	Anomaly?	Idrain S1
0	219	213			10.75
1	219	215	2	NO	11.5
2	219	217	4	NO	12.25
3	219	219	6		
4	219	221	8		
5	219	223	10		
6	219	225	12	NO	15.28
7	219	227	14		
8	219	229	16		
9	219	231	18		
10	219	233	20		
11	219	235	22	NO	19.84
12	219	237	24		
13	219	239	26		
14	219	241	28	NO	23.11

5.2.2 Second test

According to the results of the previous test we have slightly modified the table containing the bias values for the matrix tuning excluding the (few) values of Vg2 less than 193. Then or each Vg1-Vg2 pair we have verified that no anomaly occurred. Then our conclusion has been that **it is possible to run the matrix tuning test without inducing the anomaly with a slightly modified bias table for LFI24S1.**

We need only to take care of the fact that at the beginning and at the end of the LFI24 tuning the RCA biases are set first to zero and then to nominal, thus inducing the anomaly. Therefore, until a new switch-in procedure is found or LFI24S1 we will have to take care of recovering the anomaly after the RCA is rebiased.

5.2.3 Third test

The last test had the objective to check if a switch off of the instrument (including the D/C D/C converters) and a subsequent switch on could recover the problem permanently.

Therefore we run the following procedure to perform the test. When we arrived at step 7 we noticed that the switch on of LFI24S1 again produced the anomaly. Therefore we did not proceed with the procedure as this was already a clear indication that **the switch off did not produce any effect**. After step 10 (when all the instrument was on) we removed the anomaly from LFI24 with the usual procedure.

	Name of Procedure	Reference [WFT] PR-017	Note	Time
	Initial configuration		Nominal LFI configuration: all power groups on, all biases on, 4KHz switching on B/D, P/S status A/C =1	
1	Start TQL session			
2	Initialization	Step 3 Tab 5.1.1 in [AD5]	All the parameters are set to their initial (“zero”) values.	2 Min
3	Science De- Activation	Tab.28 Pag 36, also reported below	De activate science	2 Min
4	RCA De-Activation	Tab 49 Pag 59, also reported below	Switch off science DC/DC converters. LFI in DAE set up mod	5 min
5	Science Activation	Tab.26 Pag 33, also reported below	Science packets start to arrive.	2 Min
6	RCA Activation	Tab.32 Pag 38, also reported below	Switch on science DC/DC converters	2 Min
7	Configure RCA Parameters	Tab 35 Pag 42	All RCAs are set to cryo nominal values but RCA28 that is left to zero current values.	Use table Cryo_biases_CH28_00.txt
8	Configure RCA Parameters	Tab 35 Pag 42	RCA28 is switched on with soft switch on procedure.	Use tables Cryo_biases_CH28_01.txt Cryo_biases_CH28_02.txt Cryo_biases_CH28_03.txt Cryo_biases_CH28_04.txt
9	Change PS status (A/C)	Tab 39 Pag 45	Change the PS status to 1 on A/C and check on TQL the change of the tag of sky and ref. Wait for IOT verification on I-EGSE	
10	4KHz Enabling (B/D)	Tab 40 Pag 46	Enable 4KHz switching on B/D. The separation of SKY and REF is seen as expected. Wait for IOT verification on I-EGSE	
11	Configure RCA Parameters	Tab 35 Pag 42	RCA 24 Vg2 under test is set to zero currents value	Table Cryo_biases_vg2_0_D.txt
12			Wait for IOT confirmation	
13	Configure RCA Parameters	Tab 35 Pag 42	RCA 24 Vg1 and Vg2 under test are set to defined values.Load table number xxx indicated by IOT.	Table Cryo_biases_xxx.txt 9 tables are defined and the choice among them will depend on the result of the previous step.
14			Wait for IOT confirmation.	
15			Repeat step 12 and 13 on the different tables until IOT will give the go ahead.	
16			When the loop is finished and all the tables required by IOT will be exercised, the IOT will ask to proceed to next step 16	
17	Stop TQL session		Wait for IOT confirmation	

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.0	Science de-activation				
SCIENCE DE 1	Send TC	LC066320		Stop DAE Science Processing	
SCIENCE DE 2	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	Less than 1 sec
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
SCIENCE DE 3	Send TC	LC018320		Stop REBA science	
SCIENCE DE 4	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	Less than 1 sec
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
SCIENCE DE 5	Check telemetry			Verify that TM(21,x) is no more arriving	
SCIENCE DE 6	Check			Verify that no science telemetry is acquired by TQL	

28. Tab. Science De-Activation

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.0	RCA De-Activation				
RCA OFF 1	Send TC	LC132320	LP063320=0h LP064320=0h LP065320=0h LP066320=0h LP112320=F000h	Switching off Science DC/DC converters	4 sec
RCA OFF 2	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
RCA OFF 3	Check Telemetry	120102369	LM421332=0h LM422332=0h LM423332=0h LM424332=0h	Check in the DAE Fast Synoptic	
RCA OFF 4	Check telemetry	120102369	LM202342=Ch	Check that LFI is in DAE set-up Mode	

49. Tab. RCA De-Activation

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.0	Science activation for Type 1				
Science T1 1	Check			TQL Machine on and TQL/TMH must be running	
Science T1 2	Send TC	LC007320		Start REBA Processing	
Science T1 3	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	Less than 1 sec
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
Science T1 4	Send TC	LC065320		Start DAE Science sequencer	
Science T1 5	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	Less than 1 sec
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
Science T1 6	Check		TM(21,3)	Verify the science telemetry are received	
Science T1 7	Check			Verify the production of science telemetry on TQL TMH	
Science T1 8		120202369 AND110369	LM597350=5h	Submode A	
			LM598350=1h	Submode B	
			LM560350=00h	SPU Det Mask A0	
			LM561350=00h	SPU Det Mask A1	
			LM562350=00h	SPU Det Mask A2	
			LM563350=00h	SPU Det Mask A3	
			LM564350=00h	SPU Det Mask A4	
			LM565350=00h	SPU Det Mask A5	
			LM570350=FFh	SPU Det Mask B0	
			LM571350=FFh	SPU Det Mask B1	
			LM572350=FFh	SPU Det Mask B2	
			LM573350=FFh	SPU Det Mask B3	
			LM574350=FFh	SPU Det Mask B4	
			LM575350=F0h	SPU Det Mask B5	
		120202369	LM587350= 2FFFh	SPU 1355 Status	
			LM586350=0h	SPU SMCS errors	
			LM588350=0h	SPU Communication Error	

26. Tab. Science Activation Type 1

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.0	RCA Activation				
RCA A 1	Send TC	LC132320	LP063320=1h LP064320=1h LP065320=1h LP066320=1h LP112320=F000h	Switching on Science DC/DC converters	4 sec
RCA A 2	Check Telemetry	120011342		Check the arrival of TM (1,1) "TC acceptance report-success"	
		120017342		Check the arrival of TM (1,7) "TC Execution report completed""	
RCA A 3	Check Telemetry	120102369 AND LA080369	LM421332=1h LM422332=1h LM423332=1h LM424332=1h	Check in the DAE Fast Synoptic	
			LM106332=5V±10%	Science1 V Out	
			LM109332=5V±10%	Science 2 V Out	
			LM112332=5V±10%	Science 4 V out	
			LM115332=5V±10%	Science 3 V out	

32. Tab RCA Activation (All Power group on)

5.3 Third investigation

This investigation was run on July 18-19th from 18:53 UTC to 1:59 UTC and has been recorded into dataset XXX_0182. The investigation consisted of the following tests (details of test sequences are reported in Appendix 1). In **bold** we indicate positive results (i.e. where we noticed a change in the oscillation behaviour)

5.3.1 Test #1

Goal: to reproduce the normal sequence step by step and check where the oscillation gets in

Result: oscillation is induced when Vd is biased after Vg1 and Vg2

5.3.2 Test #2

Goal: to test different bias sequences to find if we can bias the amplifier to nominal values without inducing the oscillation by inverting the order of Vg1 and Vg2

Result: oscillation is avoided if the amplifier is biased in the following order with the nominal bias voltages: Vg2, Vd, Vg1

5.3.3 Test #3

Goal: to test the impact of sightly different values for Vd on the onset of the oscillation

Result: for higher Vd values the oscillation is triggered at lower values of Vg2

5.3.4 Test #4

Goal: test if different values of Vd (137 and 157 DEC) in the nominal switch on sequence change or eliminate the oscillation

Result: non change is produced. Oscillation is always triggered

5.3.5 Test #5

Goal: to look for a correlation between ACA 24 S1 and 24 S2, showing some dependence on S1

Result: no correlation with S2 biasing was seen

5.3.6 Test #6

Goal: to look for a correlation between ACA 24 S1 and the Vd applied on ACA 27 M1 that was changed from 100 DEC to 157 DEC (nominal value) during the CSL test campaign)

Result: no correlation with LFI27M1 has been noticed

5.4 Fourth investigation

This test was run on August 4th from 9:44 to 12:00 UTC (during the SCS failure test) and was recorded in session XXX_0227. The goal was to check if the oscillation was also present at higher focal plane temperature to confirm the result observed during the first LFI switch-on that occurred at ~40K FPU temperature and no oscillation was observed.

In Fig. 16 we show the focal plane temperatures recorded during the test. From the figure the higher temperature (~1 K) compare to the nominal conditions is apparent.

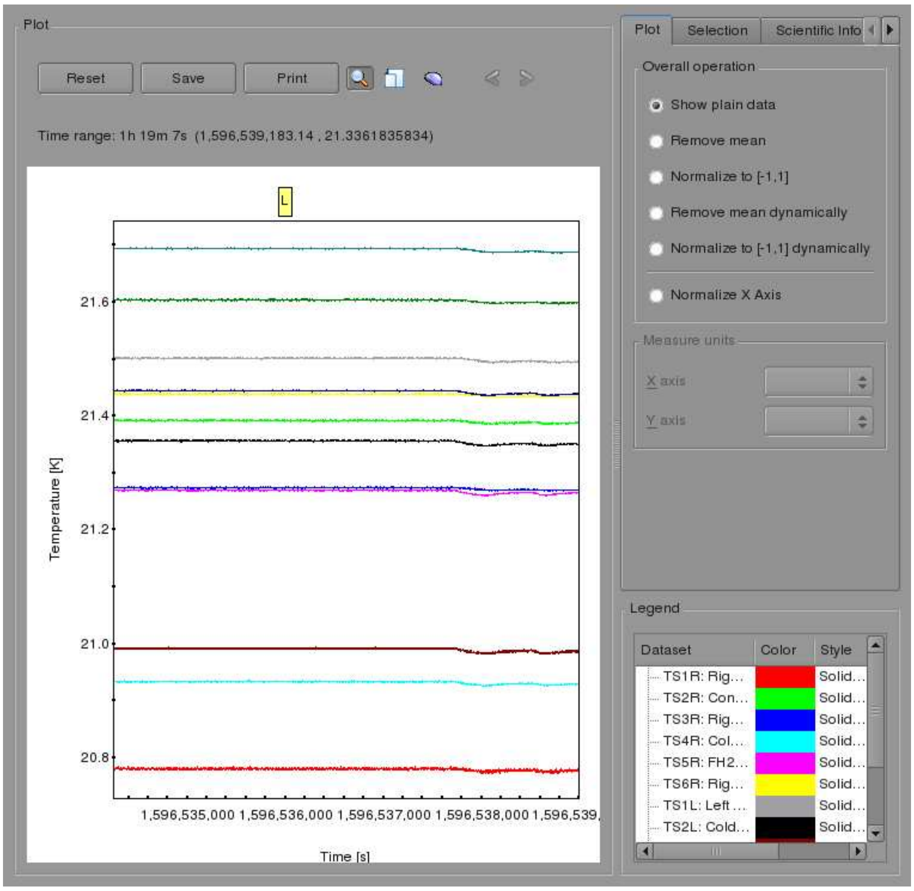


Fig. 16. Focal plane temperatures during session XXX_0227

In Fig. 17 we show the bias voltages of LFI24S1 during the test. From the figure we can see the test sequence, that consisted in switching off and on LFI24S1 twice according to the nominal procedure.

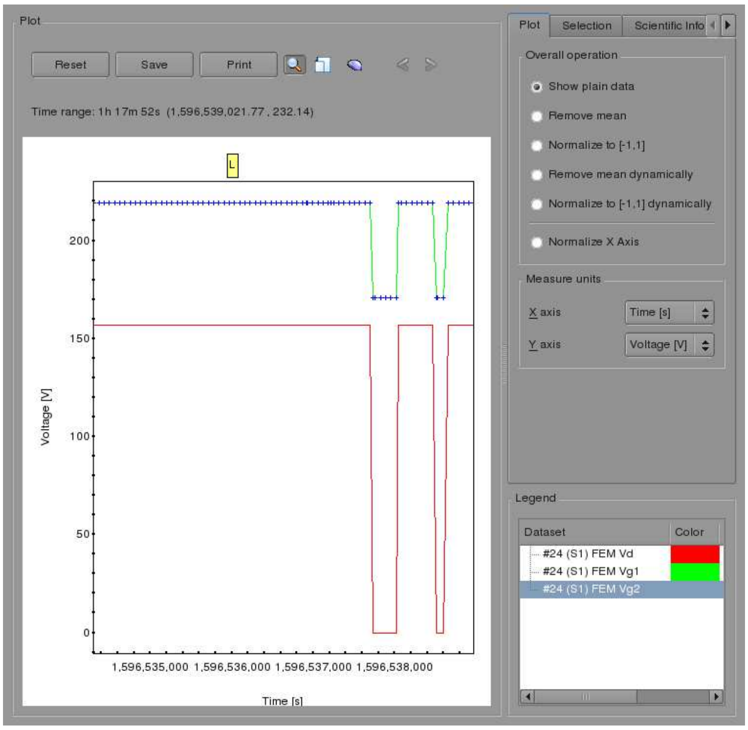


Fig. 17. Bias voltages during XXX_0227. The switch off and consequent switch on (which was repeated twice) is evident

In Fig. 18 we show the drain current of LFI24S1 during the test. This plot shows that the drain current returns to its nominal values after each switch on, confirming that in these conditions oscillation did not occur.

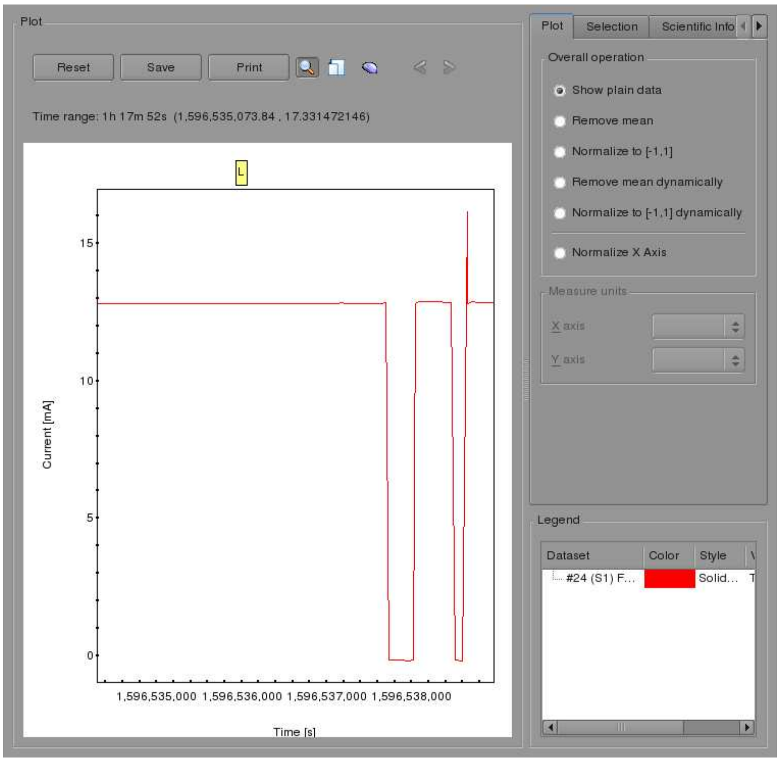


Fig 18. Drain current of LFI24S1 during XXX_0227

Also output voltages from detectors LFI24S-10 and LFI24S-11 show a normal behaviour during switch off and on procedures. Again a confirmation that no oscillation occurs

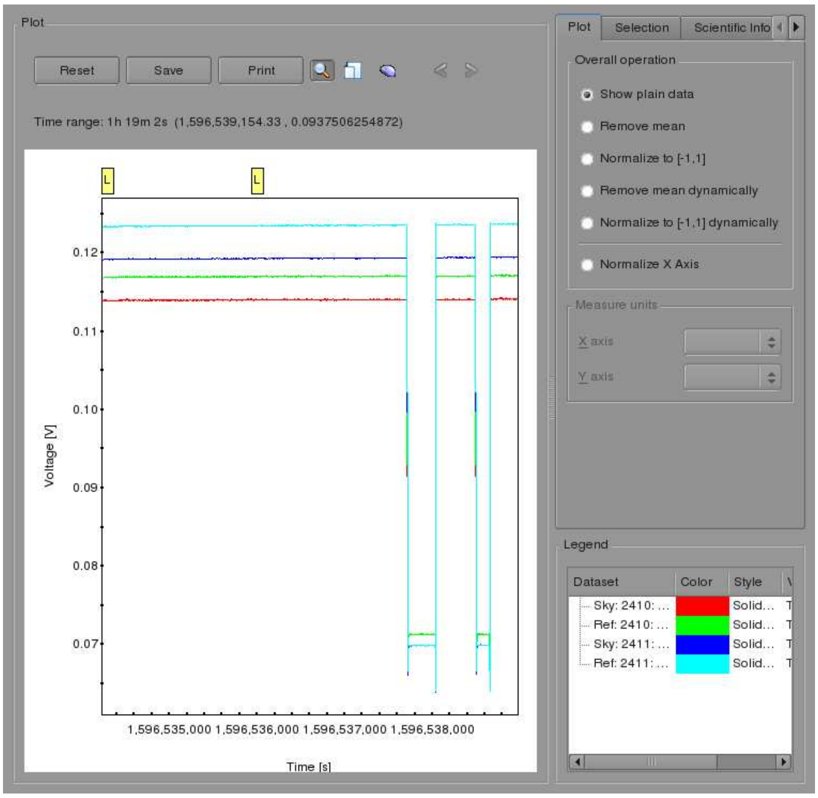


Fig. 19. Output voltage from LFI24S-10 and LFI24S-11 during test XXX_0227

6 Conclusions and recommendations

The extensive and tests and analyses performed on the anomaly of LFI24S1 amplifier (high drain current, low gain with consequent loss of isolation) clarified that the anomaly is due to gain oscillations in the amplifiers that can be controlled and avoided by a dedicated biasing procedure. Therefore this anomaly will not impact the flight operations of this amplifiers.

1. More detailed results and conclusions are detailed below.
2. The anomalous behaviour is consistent with a gain oscillation in the amplifier
3. The oscillation is triggered when the amplifier is biased with a Vg2 lower than 193 DEC after Vg1 has been biased.
4. The oscillation can be avoided biasing the amplifier in the nominal bias sequence (Vg1, Vg2, Vd) with a Vg2 larger than or equal to 193 DEC
5. The oscillation can be avoided by biasing the amplifier in the order Vg2, Vd, Vg1, independently from the value of Vg2
6. Once the oscillation is set it can be removed by setting Vg1 first to zero Volts (171 DEC) and then back to nominal
7. The anomalous behaviour arises only when the focal plane temperature is below 40K. Actually this limit could be even lower (~26K) as the anomaly never showed up during ILT tests (where the FPU was at ~26K). The correlation with FPU temperature has been verified both during the cooldown and during the warm up in CSL
8. The biasing procedure for LFI24S1 has been modified in order to avoid the oscillation