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Planck LFI

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	November 2007	All	First Draft of Document	
1.0	January 2008	-	First Issue of the Doc	
2.0	March 2008	Page 12	Original configuration after the upload of the Offset and the PS status changes has to be recovered.	
		Pag 13 Tab 2	Table of the DPRAM has been corrected after IST tests	

TABLE OF CONTENTS

1 ACRONYMS

AIV	Assembly, Integration, Verification
ASW	Application Software
CCS	Central Check-out System
CDMU	Central Data Management Unit
DPU	Digital Processing Unit
IST	Integrated Satellite Test
OBC	On Board Clock
OBT	On Board Time
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
TBD	To Be Defined
TBW	To Be Written
TC	Telecommand
TM	Telemetry
UFT	Unit Functional Test

2 INTRODUCTION

This document has been issued as a part of the activity performed under the ASI contract for Planck LFI phase E2.

2.1 Purpose and Scope

Scope of this document is to provide a description of an unexpected feature observed on RCA 25 during EMC Conducted test., During data analysis was found that the same behaviour was present in SFT data and in PLM SIT test data. This description shall be used to update the dedicated NCR, in order to monitor the problem through the System Test Campaign. The data shown here after have been collected during the EMC Conducted performed on 2nd October (AMB_108) PLM SIT performed on the 24th of October 2007 (AMB_0114) in Cannes and from the SFT performed 18th September (AMB_0099).

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Reference Documents

[RD01] Planck LFI User Manual Document
HP-LFI-PST-MA-001

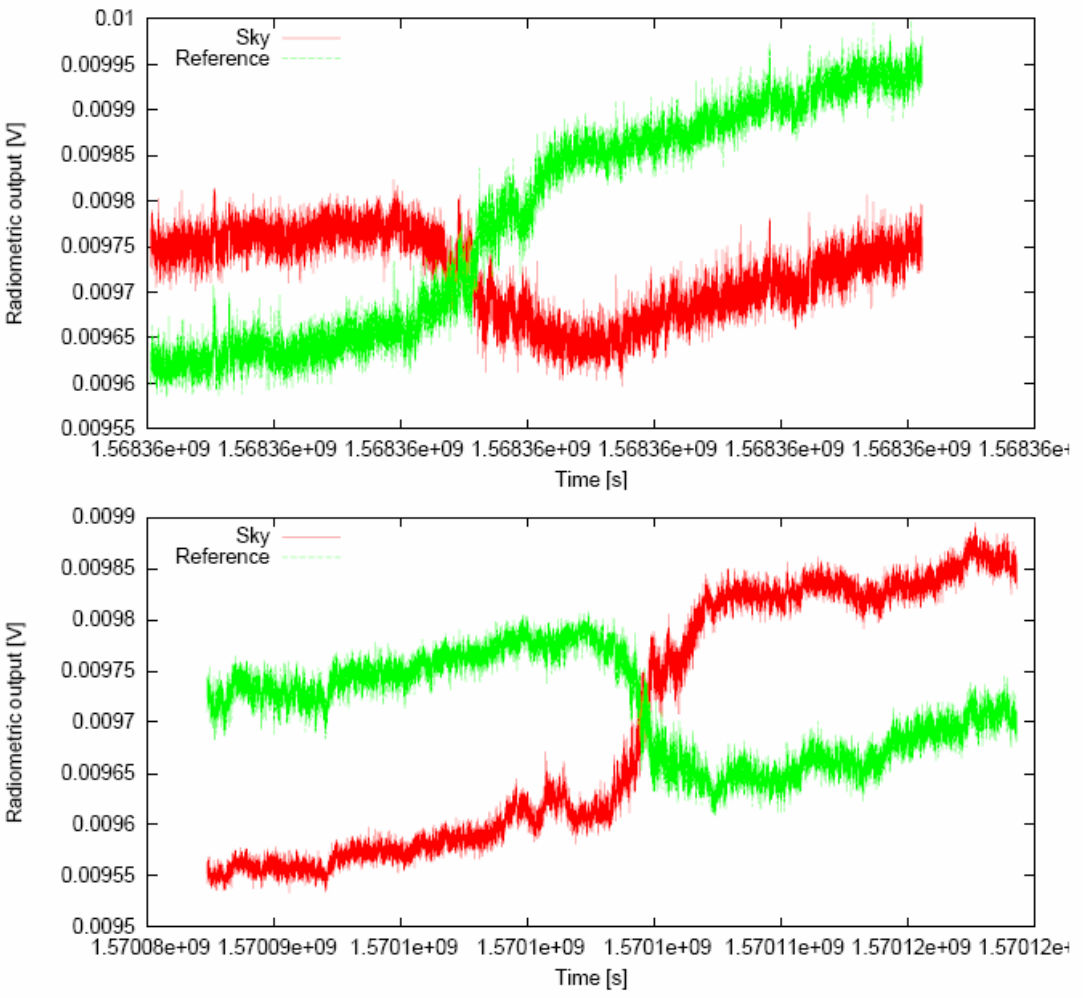
[RD02] Post Test Review PLM SIT
H-P-TASF-MN-9737

4 Description

In the tests done in Cannes during September/October 2007, a swap between the sky and the reference signals (apparently not straight addressable to an effective inversion of sky and ref temperatures) was observed in at least two tests (AMB_0099 and AMB_0108, twice in the first one): something similar was also observed during test AMB0114 (SIT) , although there the inversion is incomplete. In all the cases, the inversion did not exhibit immediately, but rather took place in a significant amount of time (ranging from a few minutes to a few hours). After the mixing was completed, the two signals were apparently stable.

A similar phenomenon was not observed in the paired radiometric channel (#2511) (although some effect seems to be present also in the coupled diode: however, it can be maybe addressed just to a thermal change in sky / ref signal): actually, it was never observed in the other LFI radiometers. Moreover, it was never observed in the previous QM/FM RCA/RAA test campaigns.

Figure 1 shows the output of detector #2510 during tests AMB_0099 and AMB_0108. The inversion between the sky and the reference was not immediate, but instead took some time to complete (five minutes for both inversions in AMB_0099, a couple of hours in AMB_0108).



The inversion problem as seen in tests AMB 0099 (above) and AMB 0108. The sky and reference output slowly crossed in some time, and then remained stable.

During test AMB_0099 the effect repeated twice following a very symmetric behaviour, as displayed in figure below. Inversions are indicated by the red arrows. Both channels (R1D0 and R1D1) are here displayed.The difference Sky-Ref is also displayed , for both the coupled channels, in Figure 2

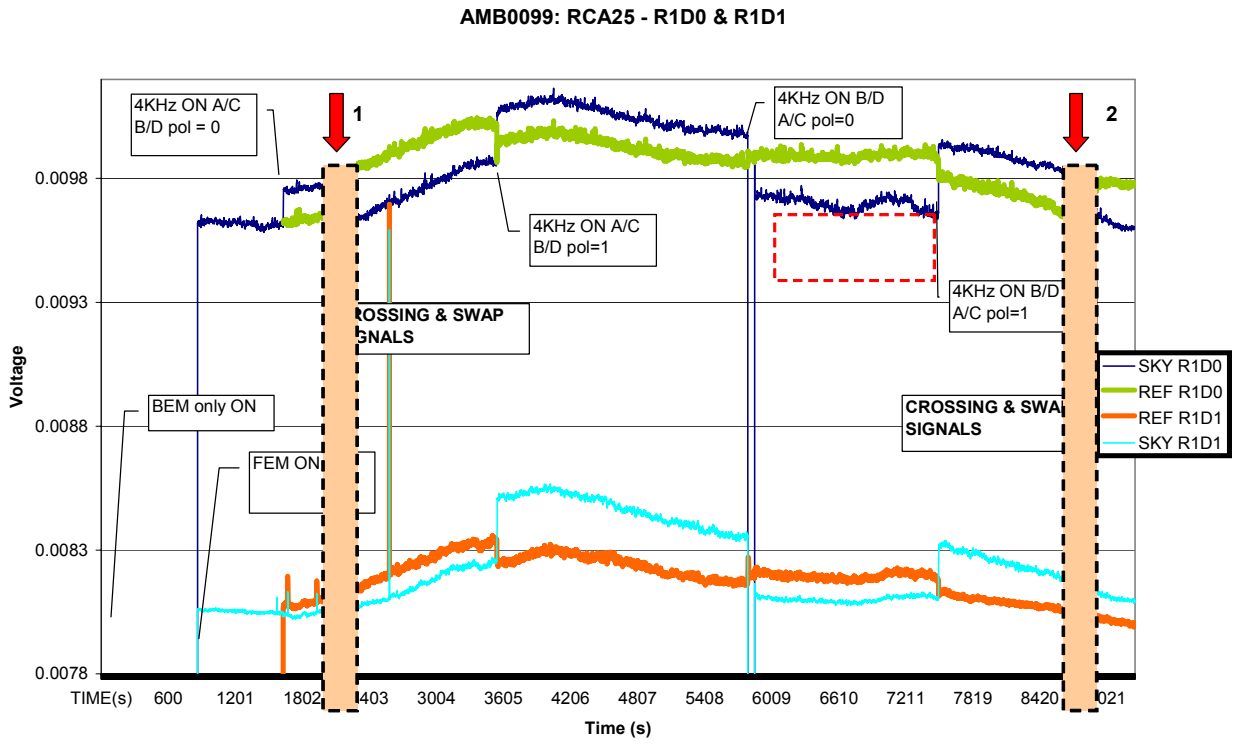


Figure 1 Test AMB_0099: inversions on sky and ref signals from RCA25R0D1 are highlighted by rectangles and arrows. Other changes, foreseen by the test , are commented by callouts. Signal from RCA25R1D1 seems to not be affected by the same effect.

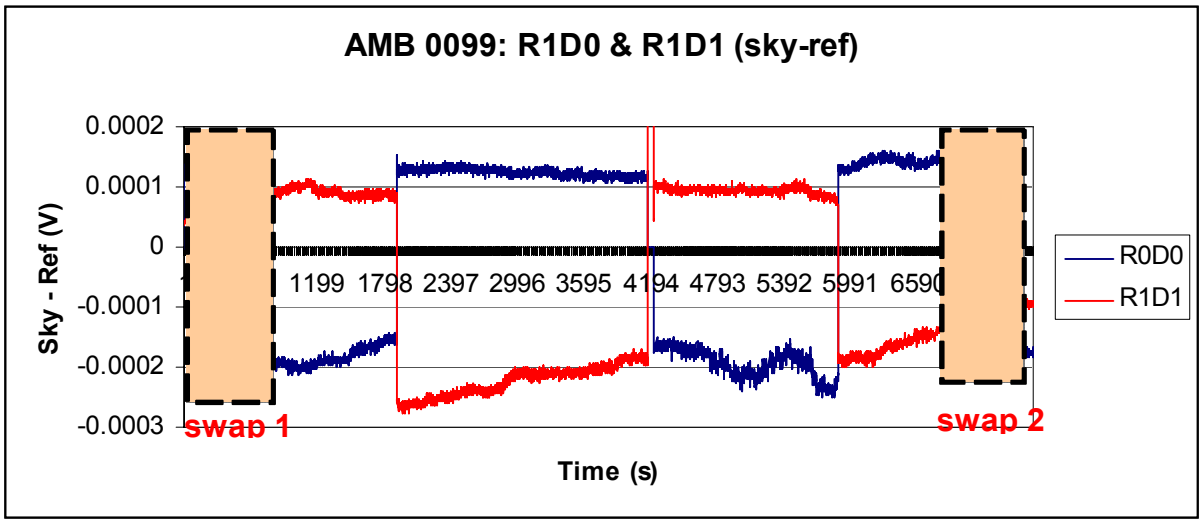


Figure 2 Test AMB_0099 : Difference sky - ref is shown for R0D1 and R1D1.

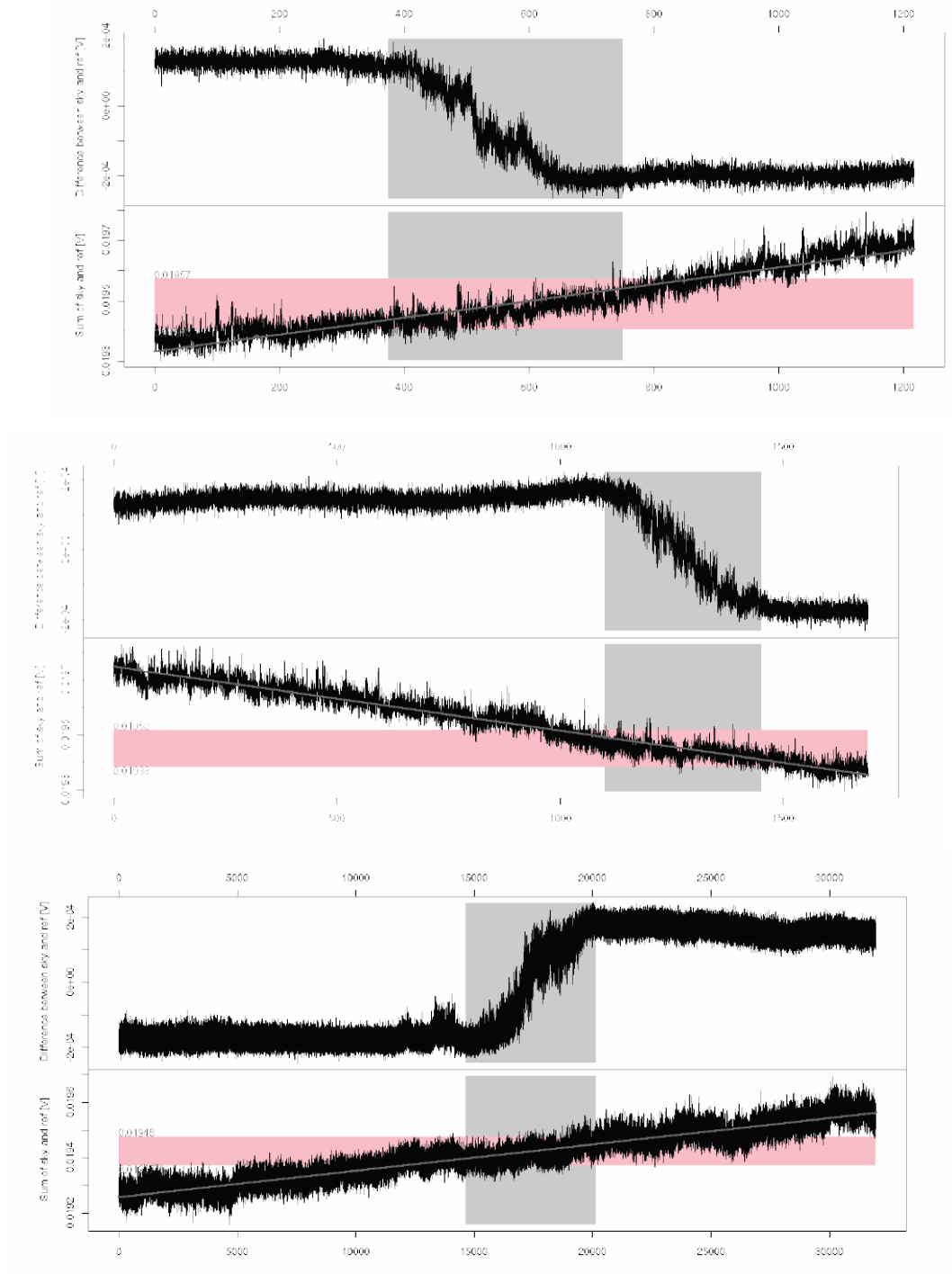


Figure 3 Difference and sum of the sky and reference signals for detector #2510 during tests AMB_0099 (top, middle) and AMB_0108 (bottom). The time window where the mixing happened is shown against a gray background. The pink rectangle indicates the voltage level of the sky+reference sum within the inversion time window. The thick gray line is a linear interpolation of the sum, and has been used to extract the boundaries of the pink rectangle.

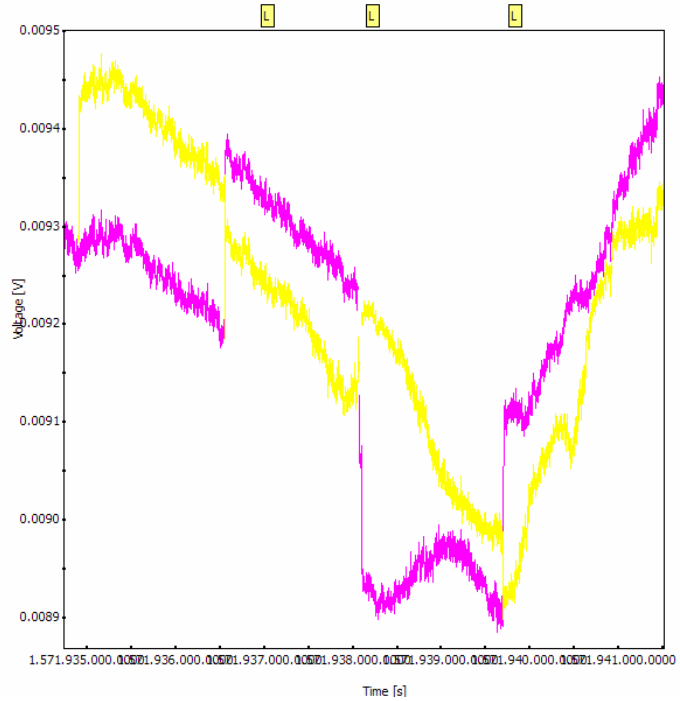


Figure 4 AMB_0114 (SIT) : RCA25 R1D0. Sky and ref signals seem to be going to invert but inversion is never reached. Here the Voltage is lower than the critical value found in the previous tests and producing the signal swap.

Moreover, the inversion effect seems to appear always when the absolute level of the sky/reference signals crosses some boundary. This is evident from **figure 2**: the three inversions were observed when the sky/reference signals were around 10 mV.

In **figure 2** the upper and lower bounds of the pink rectangle are given by the crossing between the slope of the line (linear fit of the summed signal) and the grey rectangle (time window of the inversion). The bounds have been enlarged by the standard deviation of the summed signal minus its linear fit, in order to compensate for the linear fit approximation. These bounds are reported in the following table:

Inversion	Time [s]	Min [mV]	Max [mV]	Range [mV]
AMB_0099(a)	375	19.40	19.57	0.17
AMB_0099(b)	350	19.38	19.52	0.14
AMB_0108	5500	19.37	19.48	0.11

Table 1

The swap seems to be compatible with a signal mixing (and not due to a real swap of thermal signals observed) , whatever be the cause producing it and the level of the radiometric chain where it happens. This statement is supported by a test (AMB_101) performed during the FM test campaign in Milan (2006). A thermal load (hand) was put in front of the FPU during warm functional test, in order to check

for some unwanted noise observed . In principle, if everything is fine, just the sky signal should increase : however, this is not what observed. Looking at Figure 5, Figure 6 and Figure 7 it is clear that , when the hand is put in front of the sky feed horn , an opposite effect is also observed in the Ref signal: however, the effect is also opposite with respect to what expected , since ref increases and ref decreases!

At the end of the same test we find the inverted situation: sky to increases and ref decreases , as suggesting that, also during this FM test, the two signals somehow swapped during the test. Moreover, it is to be noted that during this test, whichever be the state of phase switches, the blue line keeps always higher than the green line.

The same effect is not observed in the coupled diode, although the two diodes share the same Hybrids and amplifiers. So, in the case it was just an effect due to non-isolation, it should be seen simultaneously seen on both channels R0D1 and R1D0.

Moreover, in all other radiometers, the non isolation effect, if visible, exhibits always with the same sign on sky and ref, as displayed in Figure 7 Figure 8.

From these additional information, some indications come out:

a) a problem seems to be present already during tests performed at FM level.
b) The effect seems to be not directly addressable just to a non isolation in Hybrids
c) The effect seems to happen after the two signals left the second hybrid and are divided in the two channels (R1D0 and R1D1) , since is not apparently visible in both them.

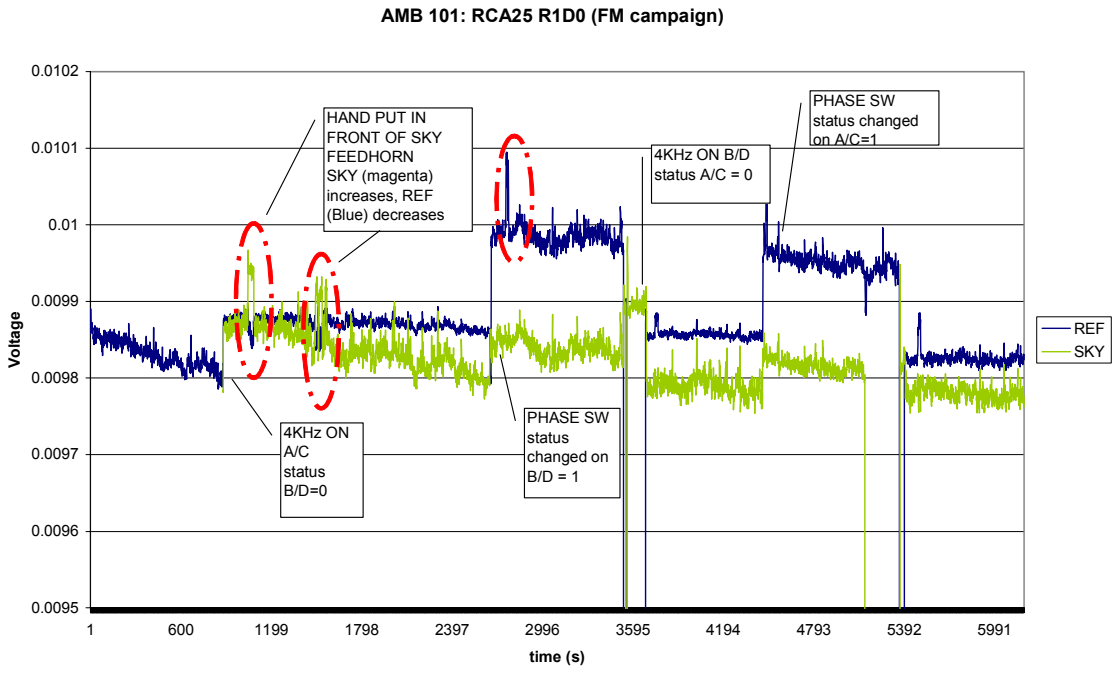


Figure 5 FM AMB_0101 : effect of a thermal load put in front of the FPU. The effect is opposite on sky and ref and the very strange thing is that it is mainly visible on ref (R1D0) instead of sky (R1D0), as was instead expected. At the end of the test (last step) the effect is correctly visible on sky. To be noted that the PH/SW change is never able to swap the two signals, as instead appears in the other channel R1D1 (Figure 7)

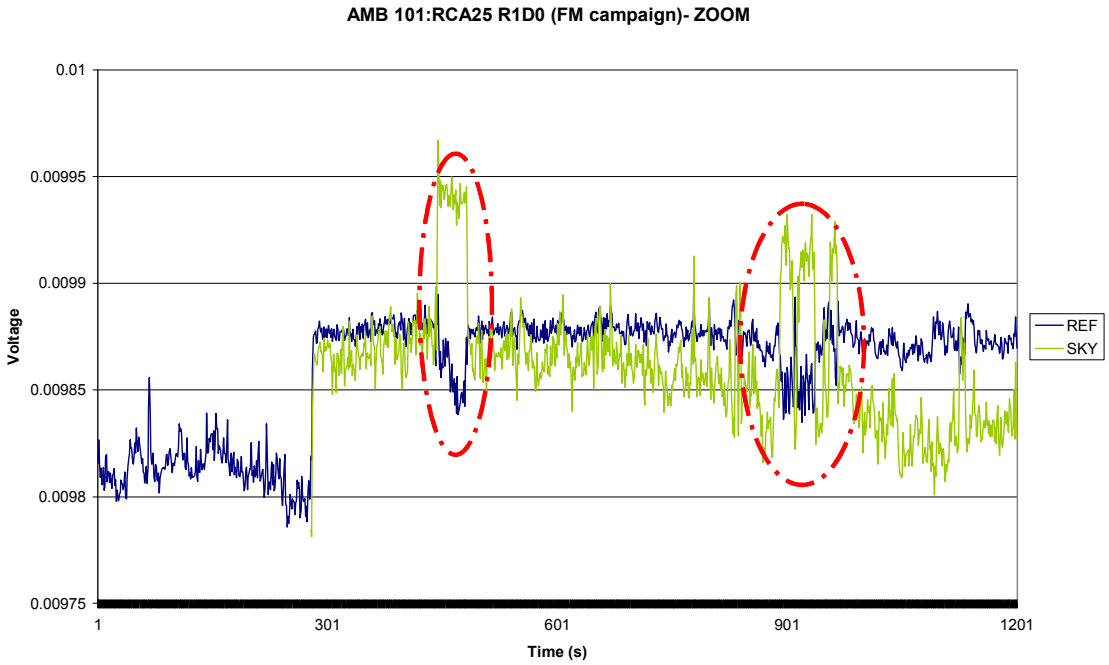


Figure 6 ZOOM on first part of above figure. The green line is sky

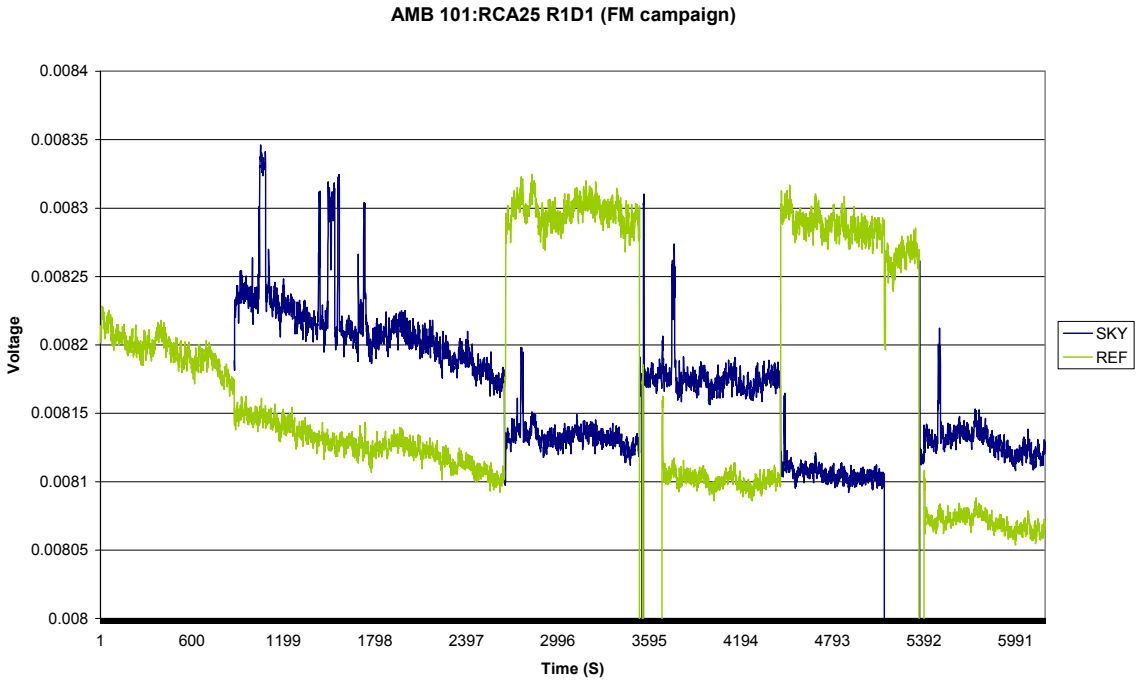


Figure 7 AMB_0101 Channel R1D1: none isolation effect is observed on Ref when a thermal load is put in front of the feedhorn (sky, blue line); the thermal load appears always on sky .

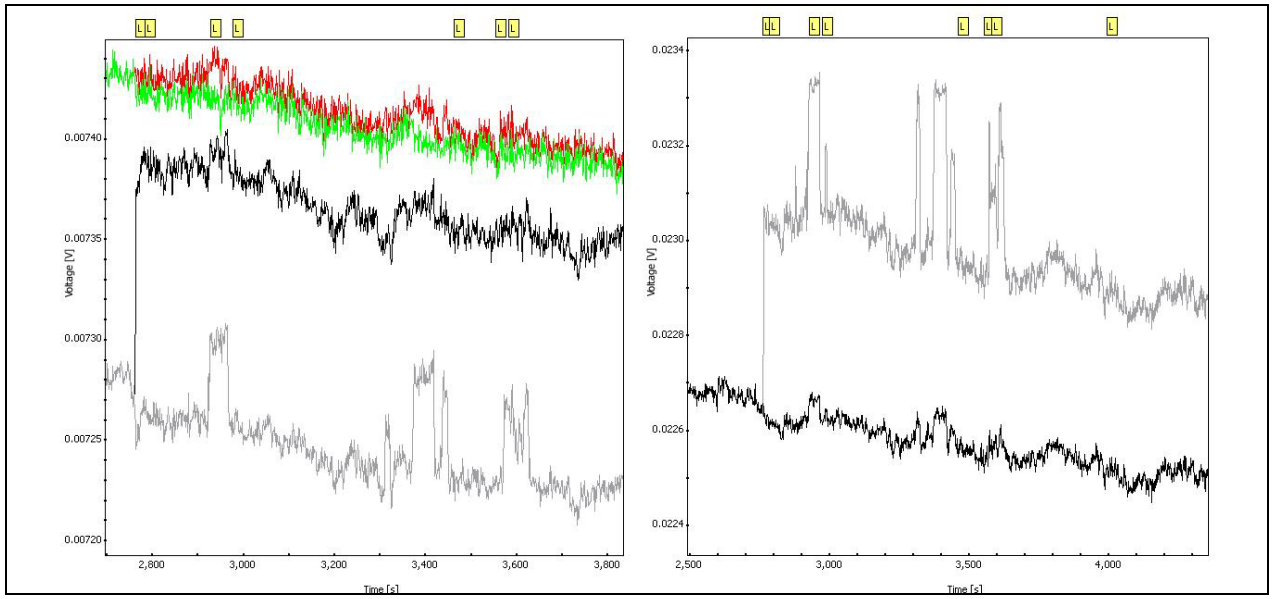


Figure 8 TEST FM AMB_0101: RCA24 (left panel) and RCA 26 (right panel) signal when a thermal load is put in front of the feedhorns. The non isolation, when present, is simultaneoulsly visible on both channels. The effect has the same sign on sky and ref an is always positive, corresponding to an increasing of both observed signals.

5 Possible causes

Let us analyse in detail what could cause a similar effect. The flow of the signal is divided in 4 sections, depending on the device attraversed / processing it.

FEM Cause

It exists a remote but , basing on this still incomplete analysis, non–null possibility that the cause be in the FEM. However, collecting all the information from the above tests, many evidences fight against this explanantion, since:

The effect is ‘apparently’ visible just on one of the coupled channels sharing the same hardware.

The effect seems to be ‘voltage dependent’: the FEM has not any turning point depending on the input signal (at least when , as it is here, is very below the compression point of amplifiers) able to swap two signals.

The effect duration is long and seems to be driven by thermal. Is hard to find something changing so slowly in the FEM, acting just on one leg and able to mix and swap sky and ref.

Putting a thermal load in front of the feed produces an opposite effect on sky and ref, as the two signals were mixed with opposite phase: a same effect was, up to now, never observed in the coupled leg nor in any of the other LFI 43 Channels.

BEM Cause

The inversion is observed in the same channel: it means that the diode involved in the BEM is the same. So, the BEM alone can never produce a similar effect.

- DAE Cause

It is worth to remember that during the RAA FM a dedicated NCR (NC4122) was opened to monitor some strange behaviour within the DAE that was triggered by a specific input load level: the feature found was described by a mismatches between SKY and REF signal in the application of the DAE offset. However, it is difficult to understand if those mismatches could have been caused by the same phenomenon originating the inversions, since its cause too has not been found so far.

- REBA Cause

The REBA acquires the stream of digital numbers coming from the ADC, separates them into two substreams (one for the sky and one for the reference samples) and then produces new shorter Type 1 datastreams by averaging consecutive samples.

In principle, some sort of mixing could also be caused by the REBA, if some malfunctioning occurs if the REBA is not able to distinguish between sky and reference samples during the production[1] of the Type 0 samples. However, this explanation would not explain why the mixing has always been observed only in channel #2510, considering that the REBA uses the same binning algorithm to create all the 44 Type 1 datastreams. Also, the apparent dependence of the inversion on the absolute level of the input load fights against the way the REBA works: the data entering the REBA have already been digitized, and therefore their absolute value should not make any difference to the binning algorithm.

1 Note that an erroneous change in the value of N_AVER (the number of Type 0 elements to bin in one Type 1 sample) due to some error would not produce a mixing, since the splitting between sky and reference samples is already done when the Type 0 streams are produced, and therefore no mixing can happen after this stage.

6 Conclusions

LFI never experienced such behaviour like that before in any of his previous tests campaign, so here are proposed two different ways to proceed in order to get the maximum data response to better understand the problem with minimum or in principle no impact to next system level tests.

Memory DUMP
At the beginning at the test LFI asks a memory DUMP of the DAE DPRAM. In this memory the scientific data are stored, and they stay there until they are sent to the REBA every time the buffer is full. There are two buffer2 (Ping/pong) and they are divided in frames and in each frame the SKY or REF is tagged by a specific hexadecimal field . If the phenomenon appears again LFI requires a second dump of the same memory to be compared with the first one. The procedure could be executed also with a manual stack because it contains only two TC to be sent, and no configuration change is requested to LFI.

The aim of this test is to identify where the cause of the problem is. Therefore, if the inversion of the signals is visible even in these data the cause must be sought in DAE, if not the cause must be found in the REBA unit..

OFFSET Change
LFI asks to send a TC that changes the Offset value of the DAE circuitry before the ADC. The offset is changed only on the RCA 25 and the procedure is exactly the one that will be performed also during the simulation of the DTCP during the RMS. What LFI asks to do is to repeat the TC sequence while the feature is happening. LFI IOT will be in charge to monitor the 2510 Channel in order to tell THALES/ESA when the TC could be sent.

Again as the point before the objective of the test is similar and it will help to understand better here is located the cause of the problem. If changing the DAE offset does not affect the inversion, the problem lies before the DAE offset (e.g. in the FEMs/BEMs). On the other hand
If changing the DAE offset affects the inversion, the problem is most likely to be caused by a voltage-dependent behavior of the ADC.

Once the test is performed and data are collected the original Offset value has to be uploaded (in warm temperature test should be always set to 255dec). The same procedure could be used but replacing all the parameters values with 255Dec.

P/S status change
If the cause could be ascribed to the FEM, it should be possible to induce the same effect on the other channel just changing the status of the PH/SW in the leg where 4KHz is off. It is still to be verified if this check is a necessary and sufficient condition to exclude the FEM or if this effect appear only under certain conditions (for example voltage unbalancing, FEM temperature, etc.)

Once the test is performed and data are collected the original P/S status configuration has to be recovered.

Thermal load
The same test as performed during FM AMB_0101 could allow to:
Disentangle between sky and ref when test starts
Disentangle between sky and ref during crossing (understanding if sky is transforming into ref)
Recognize signals after crossing

Recognize between no-isolation and mixing
Understanding if the effect is somehow related with a particular configuration of the phase switches.

Procedures are described in the following tables.

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.1	DAE DPRAM DUMP				
DPRAM 1	Send TC	LC214320	LP139320 =F600h LP140320 = 0000h LP141320 =0B40h	Dump memory TC(6,5) DPRAM Check (Ping Buffer)	No delay
DPRAM 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""	
		120066369		Save the packet slot 1	
DPRAM 3	Send TC	LC214320	LP139320 =F600h LP140320 = 1000h LP141320 =0B40h	Dump memory TC(6,5) DPRAM Check (Pong Buffer)	No delay
DPRAM 4	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""	
		120066369		Save the packet slot 2	

Table 2 Procedure for DPRAM Dump. Both buffers (Ping and Pong) are dumped.

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.1	**Configure RCA parameters (OFFSET RCA 25)**				
OFFSET RCA25 1	Send TC	LC121320	LP158320=C23h LP001320=255 [..] LP020320=255 LP021320=245 LP022320=245 LP023320=245 LP024320=245 LP025320=255 [..] LP044320=255 LP045320=FFFFh LP046320=FFFFh LP047320=FFF0h LP048320=0000h	Configure Offset: Offset is set to 255(DEC) to all the channels but RCA25 where a different Offset is applied.	
OFFSET RCA25 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""	
OFFSET RCA25 3	Send TC	LC150320	LP162320=1h LP164320=3h LP165320=1Ah LP163320=44Dh	Get DAE Configuration	
OFFSET RCA25 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""	
		121101369 AND070326	LM101326=255 [..] LM120326=255 LM121326=245 LM122326=245 LM123326=245 LM124326=245 LM125326=255 [..] LM144326=255	Check Parameters Offset	

Table 3 The offset of the RCA 25 is changed by 10mV.

STEP	Sequence		Sequence Value	Sequence Comments	Delay
	Action	TC/TM	TC/TM Value		
LFI_IST_4.1	Configure P/S polarization (All Channels)				
RCA UPD 1	Send TC	LC128320	LP159320=C26h LP049320=1h [..] LP059320=1h LP061320=FFF0h	Configure Pol A-C	
RCA UPD 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""	
RCA UPD 3	Send TC	LC150320	LP162320=1 LP164320=3h LP165320=1Ah LP163320=44Dh	Get DAE Configuration	
RCA UPD 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""	
		121101369 AND071322	LM301322 [..] LM311322	Check Parameters Pol A-C	
RCA UPD 5	Send TC	LC128320	LP159320=C27h LP049320=1h [..] LP059320=1h LP061320=FFF0h	Configure Pol B-D	
RCA UPD 6	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""	
RCA UPD 6	Send TC	LC150320	LP162320=1 LP164320=3h LP165320=1Ah LP163320=44Dh	Get DAE Configuration	
RCA UPD 7	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""	
		121101369 AND071322	LM321322 [..] LM331322	Check Parameters Pol B-D	

Table 4 Changing P/S status on A/C and B/D. The choice of which P/S is needed to be changed is dependent to which configuration of 4KHz switching is enabled. For example if A/C 4KHZ is enabled than the status shall be changed on B/D only.