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During EMC Test**

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

### 2.1 Purpose and Scope

Scope of this document is to give a first quick look analysis response of EMC tests RE/RS at system level. The tests are basically divided in two sets: the first one is dedicated to the Emission part where LFI will be switched on in nominal science production and the second one is the susceptibility tests where the satellite will be radiated by the frequencies chosen from the emission data.

The document is divided in two sections. The first section is related to the description of the work done that is to say the description of the LFI Log Book and the description of the performed tests. The second section is the summary of the results of each test coming from both real time and offline data analysis.

### 2.2 Test configuration

The test configuration is the following

SCOS 2 K HPCCS Version 2.0.787  
LFI Gateway Version V0R9P1  
TQL 3.1.2  
LIFE Machine version OM 3.00

LFI Personnel involved during the test is:

|                       |     |   |
|-----------------------|-----|---|
| LFI Manager           | AIV | Luca Stringhetti IASF Bologna <a href="mailto:stringhetti@iasfbo.inaf.it">stringhetti@iasfbo.inaf.it</a>  |
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## **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

### **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
- [RD6] Combined LFI EMC Tests at System Level  
PL-LFI-PST-PR-020



## 4 RE EMC Test Execution-First Day

For each modular block of procedure test results and conclusions are presented.

### 4.1 Switch on LFI in nominal science (Nominal Unit)

The test has been done using the nominal unit but the results could be used also for the redundant unit.

#### 4.1.1 Procedure/ Test sequence

| LFI RE/EMC: Switch on (Nominal Unit)              |   |                         |         |   | 1.09.00        |         |
|---|---|-------------------------|---------|---|----------------|---------|
| <b>Switch ON LFI</b>                              |   |                         |         | 1 | <b>0.39.00</b> |         |
|   | Go to Stand By Mode                         | OFF to standby          | 0.32.00 | 1 | 0.32.00        | 0.32.00 |
|   | Go to DAE Set Up Mode                       | Standby to DAE set up   | 0.07.00 | 1 | 0.07.00        | 0.39.00 |
| <b>LFI in Normal Science (Warm test Config..)</b> |   |                         |         | 1 | <b>0.30.00</b> |         |
|   | Setting Telemetry Rate                      | Nominal Values          | 0.02.00 | 1 | 0.02.00        | 0.41.00 |
|   | Event Packet Enabling                       |                         | 0.02.00 | 1 | 0.02.00        | 0.43.00 |
|   | Definition of science Processing Parameters | Naverage set to nominal | 0.02.00 | 1 | 0.02.00        | 0.45.00 |
|   | Definition of science Processing Parameters | Upload Optimized Values | 0.05.00 | 1 | 0.05.00        | 0.50.00 |
|   | Changing Processing Type to 5               |                         | 0.05.00 | 1 | 0.05.00        | 0.55.00 |
|   | Spu Connection                              |                         | 0.02.00 | 1 | 0.02.00        | 0.57.00 |
|   | Science Activation Type 5                   |                         | 0.04.00 | 1 | 0.04.00        | 1.01.00 |
|   | RCA Activation                              |                         | 0.02.00 | 1 | 0.02.00        | 1.03.00 |
|   | Set DAE Default configuration               |                         | 0.02.00 | 1 | 0.02.00        | 1.05.00 |
|   | Start Calibration Channel                   |                         | 0.02.00 | 1 | 0.02.00        | 1.07.00 |
|   | Start Monito function                       |                         | 0.02.00 | 1 | 0.02.00        | 1.09.00 |

At the end of the Procedure LFI IOT checked the functionality of the LFI instrument because this test corresponds also to the first switch on after the vibration tests.

#### 4.1.2 Results and Conclusions

The procedure has run on the 4<sup>th</sup> of February without any problem and the test has finished successfully.

Pass and Fail Criteria

|   |        |
|---|--------|
| No errors from the REBA HW Self check                       | PASSED |
| No un-expected event Packets                                | PASSED |
| REBA Power Consumption within the ranges of expected values | PASSED |
| EEPROM Check Sum passed                                     | PASSED |
| REBA synchronization achieved                               | PASSED |
| DAE Power Consumption within the ranges of expected values  | PASSED |



|  |            |
|--|------------|
| DAE Synchronization achieved   | PASSED     |
| The FEM I Drain Currents obtained from Telemetry are within the ranges expected (5%) | PASSED     |
| The DC voltages Outputs (Science Telemetry) are within the ranges expected. (10%)    | NOT PASSED |
| No unexpected features in FFT spectrum (Spike, Pop corn noise, currents drops...)    | On Going   |

| Id w.r.t WFT |       |       |       |       |
|--------------|-------|-------|-------|-------|
| CH           | <00>  | <01>  | <10>  | <11>  |
| CH27         | 0.13  | 0.73  | 0.13  | 0.07  |
| CH24         | 0.17  | 0.18  | 0.10  | 0.14  |
| CH21         | 0.10  | 0.28  | 0.22  | 0.47  |
| CH22         | 0.05  | 0.11  | 0.16  | 0.70  |
| CH23         | 0.22  | 0.26  | 0.23  | 0.22  |
| CH25         | 0.11  | 0.19  | 0.04  | 0.18  |
| CH28         | -0.06 | -0.06 | -0.18 | -0.12 |
| CH20         | 0.15  | 0.00  | 0.05  | 0.10  |
| CH19         | 0.05  | 0.05  | 0.20  | 0.00  |
| CH18         | 0.33  | -0.06 | 0.06  | 0.00  |
| CH26         | 0.15  | 0.08  | 0.07  | 0.11  |

LFI ON: drain currents w.r.t WFT

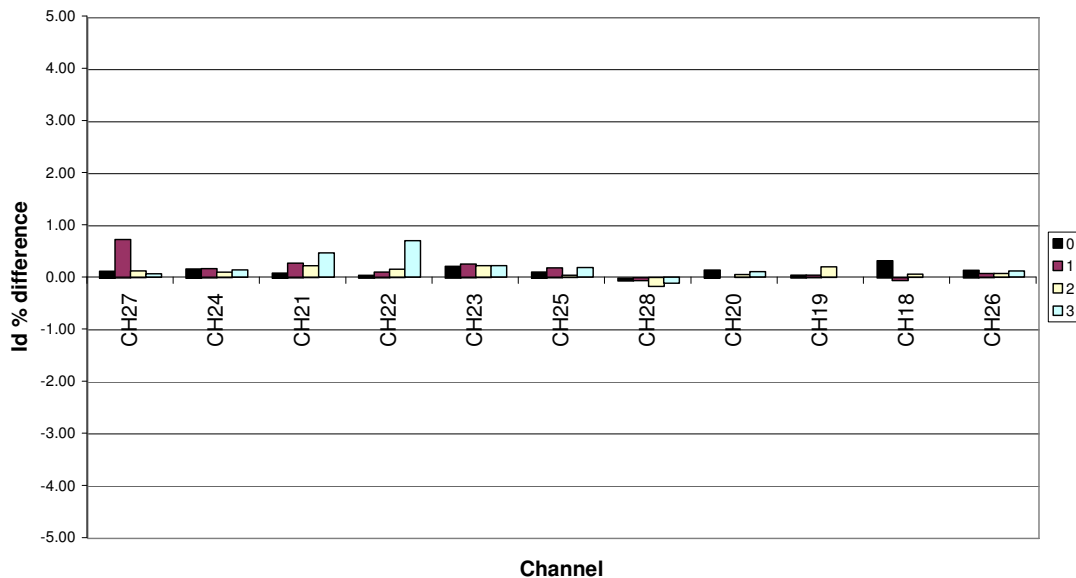


Figure 1 Drain currents Percentage variation respect to WFT with LFI – N on



| Id w.r.t RAA |       |      |       |      |
|--------------|-------|------|-------|------|
| CH           | <00>  | <01> | <10>  | <11> |
| CH27         | 0.19  | 0.07 | 0.19  | 0.13 |
| CH24         | 0.03  | 0.11 | 0.00  | 0.07 |
| CH21         | 0.15  | 0.62 | 0.34  | 0.62 |
| CH22         | 0.37  | 0.48 | 0.59  | 1.02 |
| CH23         | 0.72  | 0.63 | 0.62  | 0.33 |
| CH25         | 0.00  | 0.08 | -0.04 | 0.07 |
| CH28         | -0.12 | 0.06 | -0.12 | 0.00 |
| CH20         | 0.56  | 0.45 | 0.36  | 0.60 |
| CH19         | 0.42  | 0.56 | 0.35  | 0.15 |
| CH18         | 0.77  | 0.17 | 0.37  | 0.56 |
| CH26         | 0.11  | 0.00 | -0.11 | 0.00 |

LFI ON: drain currents w.r.t. RAA

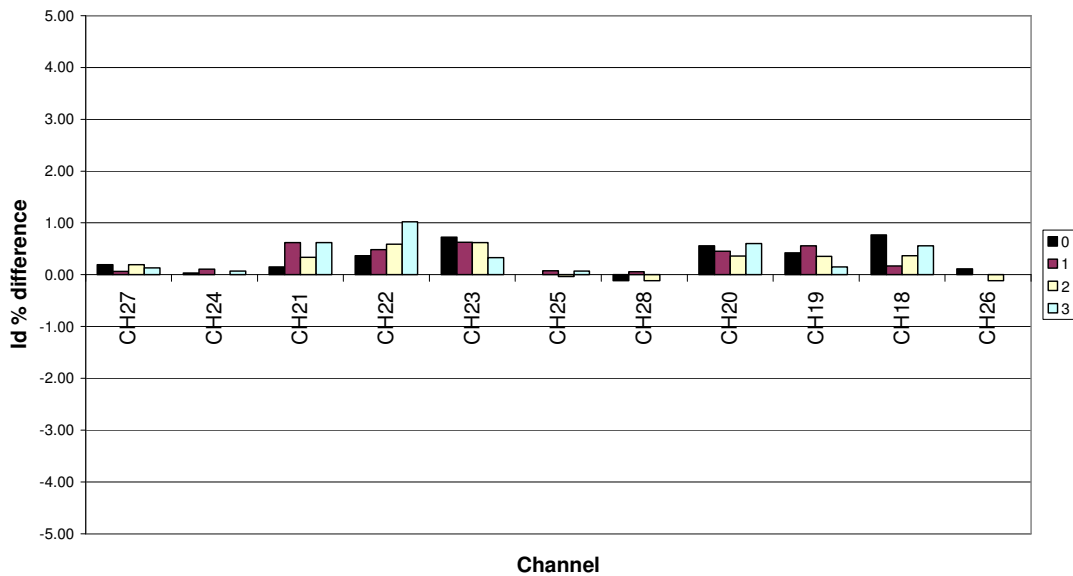


Figure 2 Drain currents Percentage variation respect toFM with LFI – N on



## 5 RS EMC Test Second day

### 5.1 Data Collection in type 5

During the night shift just after the SPIKE test Type 5 condition was recovered using a new Table for Scientific-Parameters for the REBA. The table is presented below.

| RCA # | ID | RD | SCOS     | GMF1   | GMF2    | Offset   | S-Quant |
|-------|----|----|----------|--------|---------|----------|---------|
| CH27  | 0  | 00 | LP068320 | 1.0043 | -0.2204 | -7335.16 | 2.95    |
|       | 1  | 01 | LP069320 | 0.9993 | -0.2236 | -7511.33 | 2.84    |
|       | 2  | 10 | LP070320 | 1.0018 | -0.2226 | -7186.45 | 3.48    |
|       | 3  | 11 | LP071320 | 0.9999 | -0.2226 | -6850.86 | 4.04    |
| CH24  | 4  | 00 | LP072320 | 1.0000 | -0.2207 | -5307.74 | 5.62    |
|       | 5  | 01 | LP073320 | 1.0000 | -0.2622 | -6128.72 | 5.34    |
|       | 6  | 10 | LP074320 | 1.0000 | -0.5414 | -7344.87 | 4.45    |
|       | 7  | 11 | LP075320 | 1.0000 | -0.4589 | -6124.59 | 4.7     |
| CH21  | 8  | 00 | LP076320 | 0.9997 | -0.2425 | -5150.08 | 5.47    |
|       | 9  | 01 | LP077320 | 1.0002 | -0.1944 | -5144.08 | 5.7     |
|       | 0A | 10 | LP078320 | 0.9997 | -0.2278 | -5204.64 | 5.48    |
|       | 0B | 11 | LP079320 | 1.0002 | -0.2366 | -5204.23 | 5.44    |
| CH22  | 0C | 00 | LP080320 | 0.9995 | -0.2216 | -5237.94 | 5.47    |
|       | 0D | 01 | LP081320 | 1.0001 | -0.2252 | -5257.99 | 5.43    |
|       | 0E | 10 | LP082320 | 0.9995 | -0.2287 | -5226.54 | 5.45    |
|       | 0F | 11 | LP083320 | 1.0006 | -0.2248 | -5257.35 | 5.43    |
| CH23  | 10 | 00 | LP083320 | 1.0007 | -0.2199 | -5347.01 | 5.36    |
|       | 11 | 01 | LP085320 | 0.9988 | -0.2222 | -5404.63 | 5.3     |
|       | 12 | 10 | LP086320 | 1.0002 | -0.2229 | -5437.54 | 5.26    |
|       | 13 | 11 | LP087320 | 0.9997 | -0.2214 | -5261.03 | 5.45    |
| CH25  | 14 | 00 | LP088320 | 1.0004 | -0.3157 | -6193.21 | 5.15    |
|       | 15 | 01 | LP089320 | 0.9991 | -0.286  | -6197.8  | 5.27    |
|       | 16 | 10 | LP090320 | 1.0001 | 0.0325  | -4088.08 | 7.08    |
|       | 17 | 11 | LP091320 | 1.0000 | -0.5027 | -7350.37 | 4.56    |
| CH28  | 18 | 00 | LP092320 | 0.9997 | -0.2242 | -6207.29 | 4.61    |
|       | 19 | 01 | LP093320 | 0.9948 | -0.2262 | -6566.17 | 4.19    |
|       | 1A | 10 | LP094320 | 0.9986 | -0.2248 | -6464.29 | 4.43    |
|       | 1B | 11 | LP095320 | 0.9964 | -0.2243 | -6323.65 | 4.53    |
| CH20  | 1C | 00 | LP096320 | 0.9991 | -0.2316 | -5329.14 | 5.34    |
|       | 1D | 01 | LP097320 | 1.0007 | -0.2272 | -5311.72 | 5.37    |
|       | 1E | 10 | LP098320 | 0.9994 | -0.2287 | -5344.55 | 5.33    |
|       | 1F | 11 | LP099320 | 1.0004 | -0.2385 | -5365.61 | 5.26    |
| CH19  | 20 | 00 | LP100320 | 0.9997 | -0.2587 | -6315.19 | 5.28    |
|       | 21 | 01 | LP101320 | 1.0003 | -0.2279 | -5273.21 | 5.4     |
|       | 22 | 10 | LP102320 | 0.9991 | -0.229  | -5318.08 | 5.36    |
|       | 23 | 11 | LP103320 | 1.0004 | -0.3078 | -6359.75 | 5.05    |
| CH18  | 24 | 00 | LP104320 | 0.9995 | -0.2476 | -5356.7  | 5.24    |
|       | 25 | 01 | LP105320 | 1.0012 | -0.2659 | -6522.04 | 5.08    |
|       | 26 | 10 | LP106320 | 1.0004 | -0.2213 | -5269.88 | 5.44    |
|       | 27 | 11 | LP107320 | 0.9993 | -0.2408 | -5296.18 | 5.33    |
| CH26  | 28 | 00 | LP108320 | 1.0001 | -0.5151 | -7361.86 | 4.52    |
|       | 29 | 01 | LP109320 | 0.9997 | 0.4507  | -2458.06 | 12.45   |
|       | 2A | 10 | LP110320 | 1.0001 | -0.3615 | -8207.98 | 5.01    |
|       | 2B | 11 | LP111320 | 0.9996 | -0.356  | -8223.79 | 5.02    |



At the end of the test the procedure for SPIKE Test was designed to recover the same configuration as was at the beginning of the test, but LFI was in a different configuration from what Expected.

- Calibration Channel was not enabled.
- Type one telemetry was not delivered
- Type 3 Telemetry is enabled on Group B but no output channel is enabled.

The wrong configuration is only a software configuration and does not effect the electrical behaviour of the instrument so it was decided to give the go-ahead to proceed with the EMC RS tests

### 5.1.1 Procedure/ Test sequence

TMH/TQL is set to acquire data during the injection of EM disturbance. Data are checked in real time through displays but fine analysis will be performed off Line. Data acquisition has been divided in different set of data that could be summarized in the following table.

| RS test in operational mode |                 |              |           |
|-----------------------------|-----------------|--------------|-----------|
| Freq ID                     | Freq val in MHz | Level in V/m | Test name |
| F1                          | 0.1             | 1            | TBD       |
| F2                          | 0.13            | 1            | AMB_131   |
| F3                          | 0.18            | 1            |           |
| F4                          | 0.25            | 1            |           |
| F5                          | 1               | 1            |           |
| F6                          | 2.5             | 1            |           |
| F7                          | 3.44            | 1            |           |
| F8                          | 10              | 1            |           |
| F9                          | 16              | 1            |           |
| F10                         | 20              | 1            |           |
| F11                         | 30              | 1            |           |
| F12                         | 35              | 1            |           |
| F13                         | 40              | 1            |           |
| F14                         | 46              | 1            |           |
| F15                         | 52              | 1            |           |
| F16                         | 60              | 1            |           |
| F17                         | 69              | 1            |           |
| F18                         | 80              | 1            |           |
| F19                         | 92              | 1            |           |
| F20                         | 100             | 1            |           |



### 5.1.2 Results and Conclusions

The Pass/Fail criteria from the Requirement doc are:

|  |                 |
|--|-----------------|
| No un-expected event Packets   | PASSED          |
| No Alarm/Error packet  | PASSED          |
| Power consumption as expected  | PASSED          |
| No new features (i.e.Spikes) visible in FFT  | See table below |
| The difference between the two signals for each radiometer output shall not exceed more than three times the standard deviation of the undisturbed signal. | See table below |

| Freq ID | Freq val in MHz | Spike  | Differential  | Comments |
|---------|-----------------|--|---|----------|
| F1      | 0.1             | <b>TBC</b><br>Data<br>Analysis on going (see note below on new Spike at 29Hz and spike at 35Hz in FFT) | <b>PASSED</b><br>All RCA < 1 $\sigma$<br>except RCA25<br>R1D0 and RCA 26<br>R1D1 < 1.5 $\sigma$ |          |
| F2      | 0.13            |  |   |          |
| F3      | 0.18            |  |   |          |
| F4      | 0.25            |  |   |          |
| F5      | 1               |  |   |          |
| F6      | 2.5             |  |   |          |
| F7      | 3.44            |  |   |          |
| F8      | 10              |  |   |          |
| F9      | 16              |  |   |          |
| F10     | 20              |  |   |          |
| F11     | 30              |  |   |          |
| F12     | 35              |  |   |          |
| F13     | 40              |  |   |          |
| F14     | 46              |  |   |          |
| F15     | 52              |  |   |          |
| F16     | 60              |  |   |          |
| F17     | 69              |  |   |          |
| F18     | 80              |  |   |          |
| F19     | 92              |  |   |          |
| F20     | 100             |  |   |          |



| Id w.r.t RAA |       |       |       |       |
|--------------|-------|-------|-------|-------|
| CH           | <00>  | <01>  | <10>  | <11>  |
| CH27         | 0.00  | -0.07 | 0.00  | 0.00  |
| CH24         | -0.21 | -0.14 | -0.14 | -0.07 |
| CH21         | 0.05  | 0.34  | 0.06  | 0.21  |
| CH22         | 0.26  | 0.32  | 0.37  | 0.48  |
| CH23         | 0.61  | 0.37  | 0.34  | 0.06  |
| CH25         | -0.30 | -0.23 | -0.18 | -0.22 |
| CH28         | -0.35 | -0.24 | -0.24 | -0.18 |
| CH20         | 0.25  | 0.05  | 0.15  | 0.40  |
| CH19         | 0.16  | 0.25  | 0.05  | 0.05  |
| CH18         | 0.55  | 0.00  | 0.12  | 0.34  |
| CH26         | -0.15 | -0.26 | -0.37 | -0.26 |

LFI ON: drain currents w.r.t. RAA

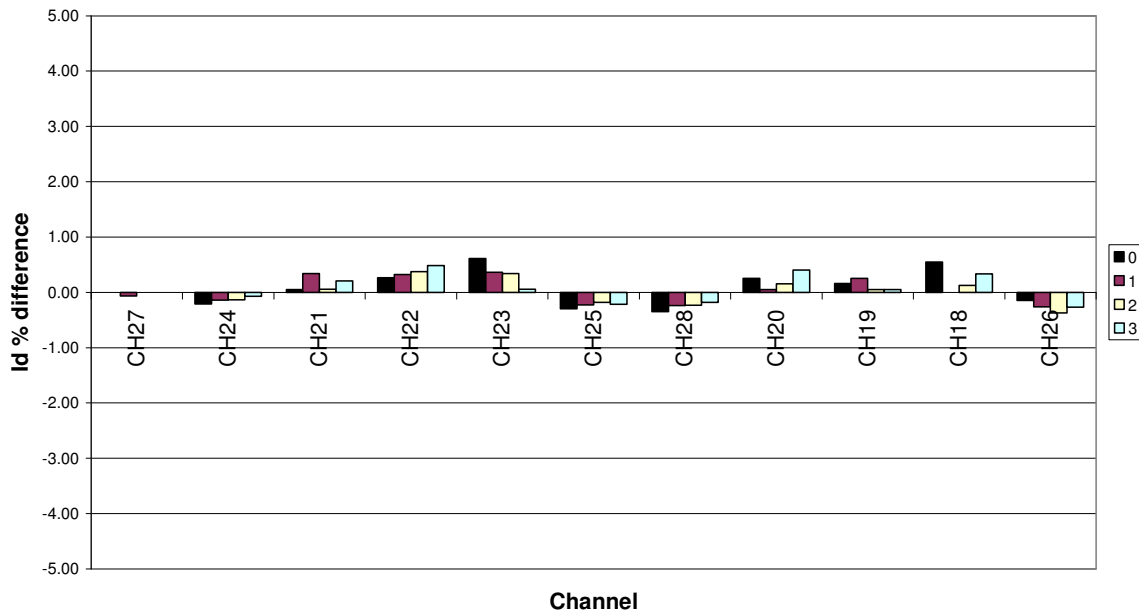


Figure 3 Drain currents Percentage variation respect to FM with LFI - N on at the end of the test



| Id w.r.t WFT |       |       |       |       |
|--------------|-------|-------|-------|-------|
| CH           | <00>  | <01>  | <10>  | <11>  |
| CH27         | -0.06 | 0.60  | -0.06 | -0.07 |
| CH24         | -0.07 | -0.07 | -0.03 | 0.00  |
| CH21         | 0.00  | 0.00  | -0.06 | 0.05  |
| CH22         | -0.05 | -0.05 | -0.05 | 0.16  |
| CH23         | 0.11  | 0.00  | -0.06 | -0.06 |
| CH25         | -0.19 | -0.11 | -0.11 | -0.11 |
| CH28         | -0.29 | -0.36 | -0.29 | -0.30 |
| CH20         | -0.15 | -0.40 | -0.15 | -0.10 |
| CH19         | -0.21 | -0.25 | -0.10 | -0.10 |
| CH18         | 0.11  | -0.22 | -0.18 | -0.22 |
| CH26         | -0.11 | -0.19 | -0.19 | -0.15 |

LFI ON: drain currents w.r.t WFT

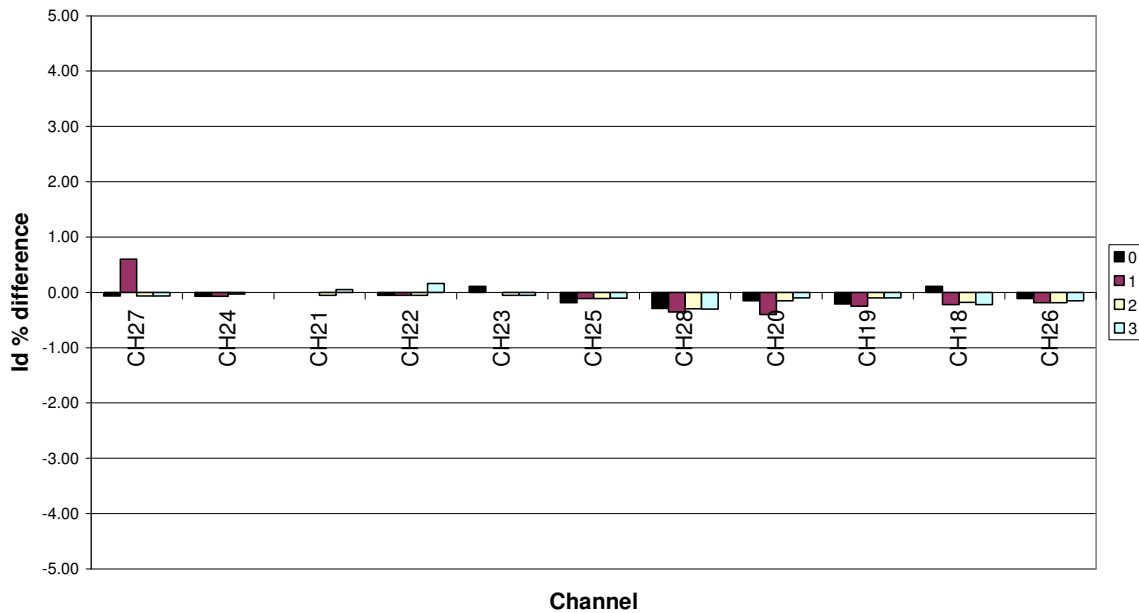
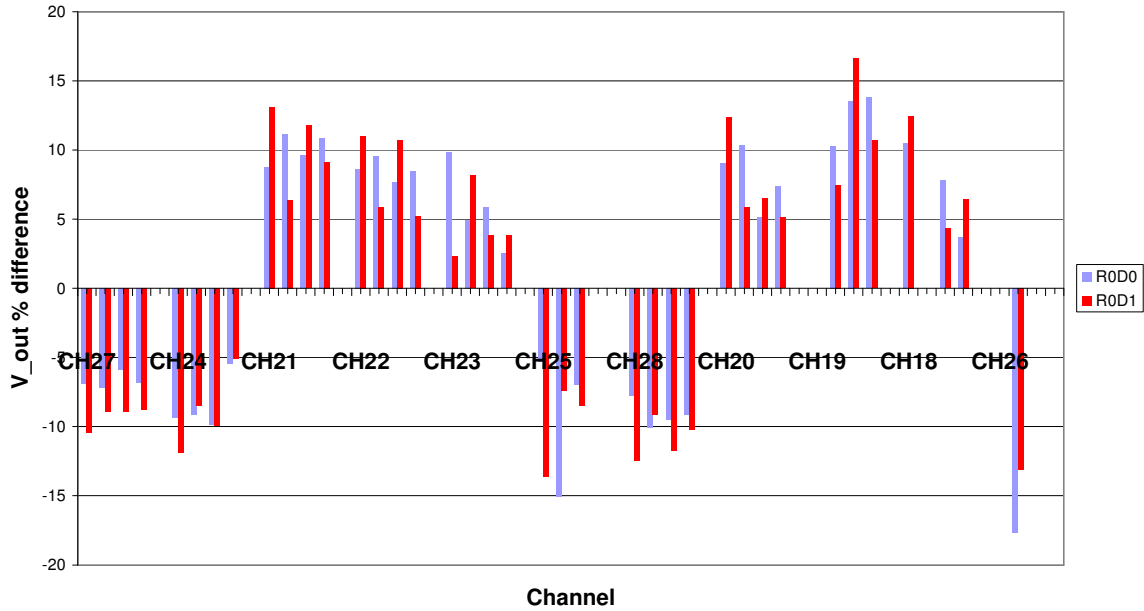


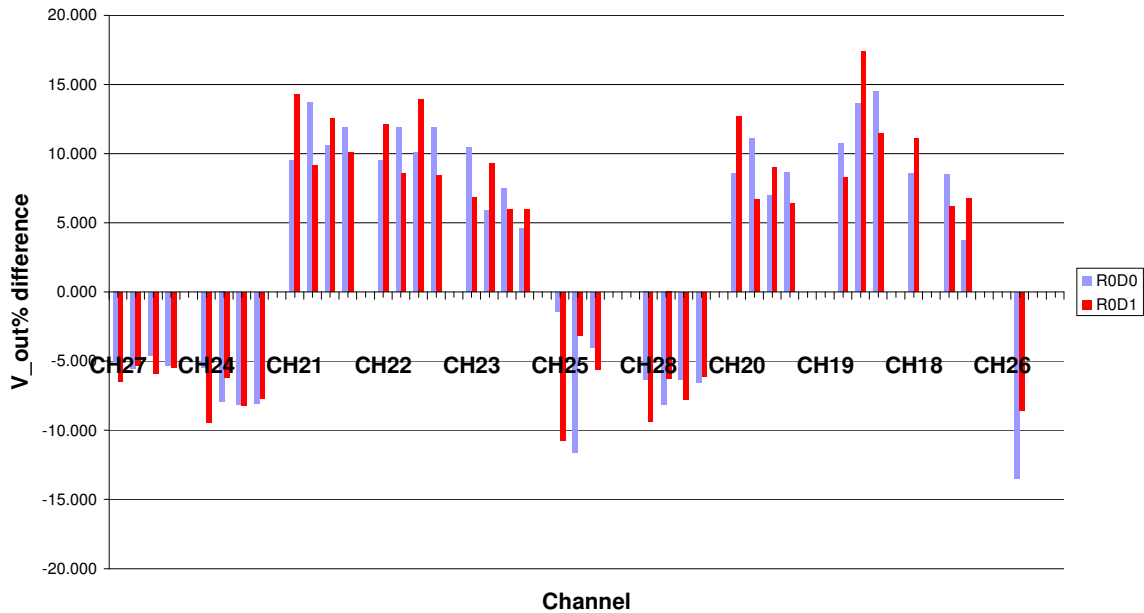
Figure 4 Drain currents Percentage variation respect to WFT with LFI – N on at the end of the test



LFI ON: scientific output w.r.t. RAA



LFI ON: scientific output w.r.t. WFT



From the two figures above you can see that the scientific output of the radiometers is sometimes surmounting the limit of the pass fail criteria. It could be



possible, from a quick analysis, that the reason of this could be found in a higher temperature of the BEU. This temperature is inside the soft limit, nevertheless LFI never operated at this temperature before. Indeed during previous tests there were at least 10 degree less at the same interface.



## 6 NEW FEATURES

Here below are presented unexpected features that are followed by already opened NCRs and that was agreed to monitor and new features found during this test.

### 6.1.1 Current drops in RCA 23 (OLD)

No current drops were found during the execution of the test.

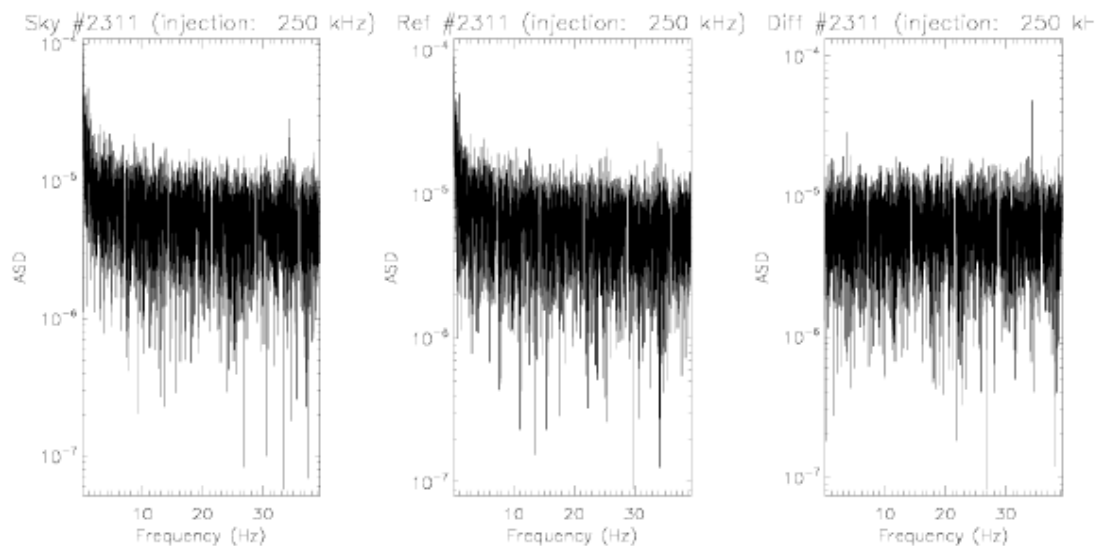
### 6.1.2 Scientific output crossing in RCA 25 (OLD)

No Crossing has been seen during the test, but in any case the voltage output remains under the threshold that we expect can trigger the feature.

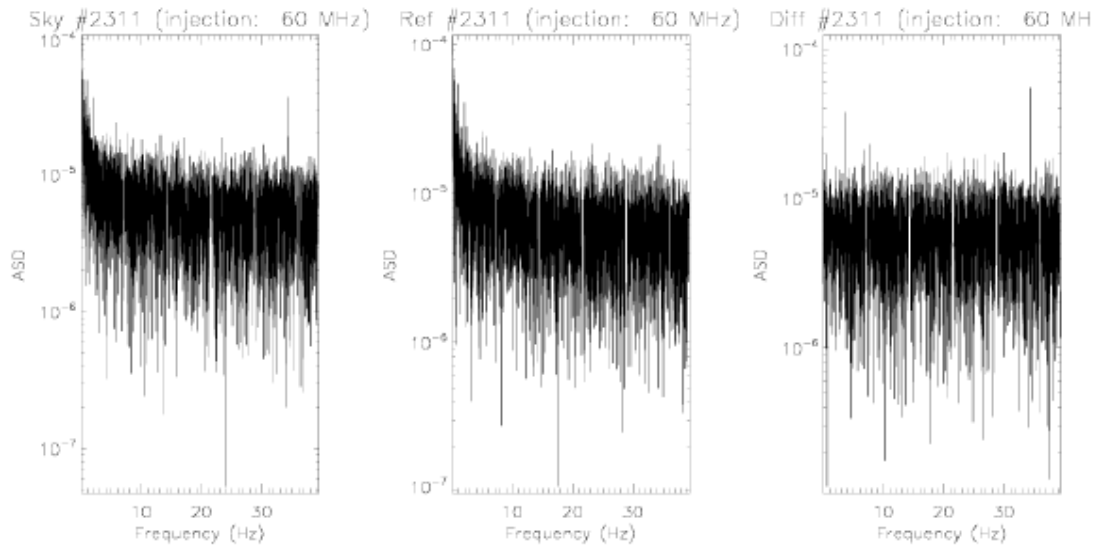
### 6.1.3 Spike. (NEW)

Even if the time when the disturbance signal is short, of the order of a few minutes, at higher frequency of the FFT the spectrum presents some features that were not expected. These features do not seem to be related to EMC tests because they appear even in the quiet zone, when no disturbance is injected.

## RCA23 R1D1



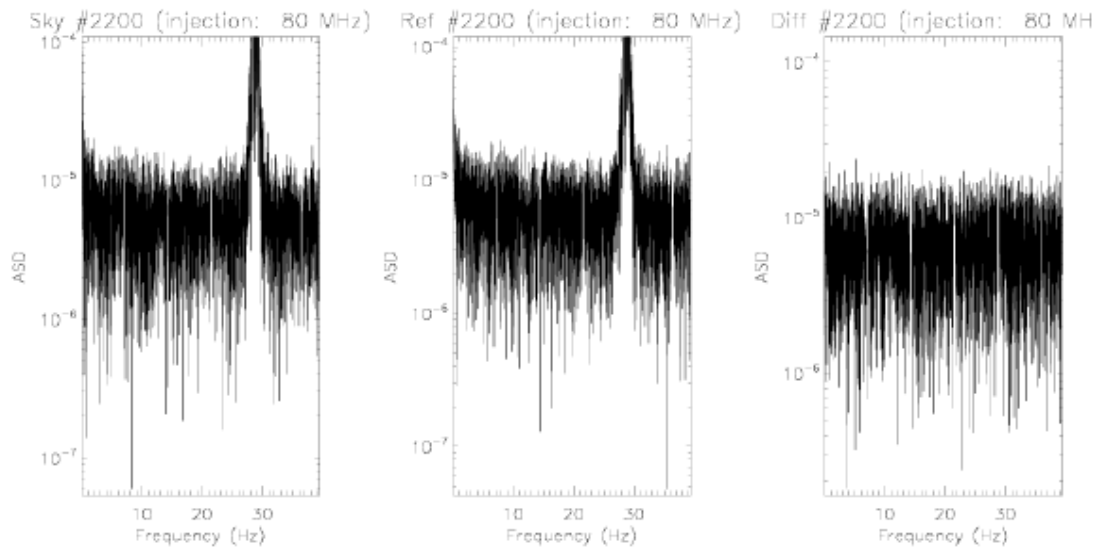
1. RCA 23 R1D1 during 250KHz injection



## 2. RCA 23 R1D1 during 60MHz injection

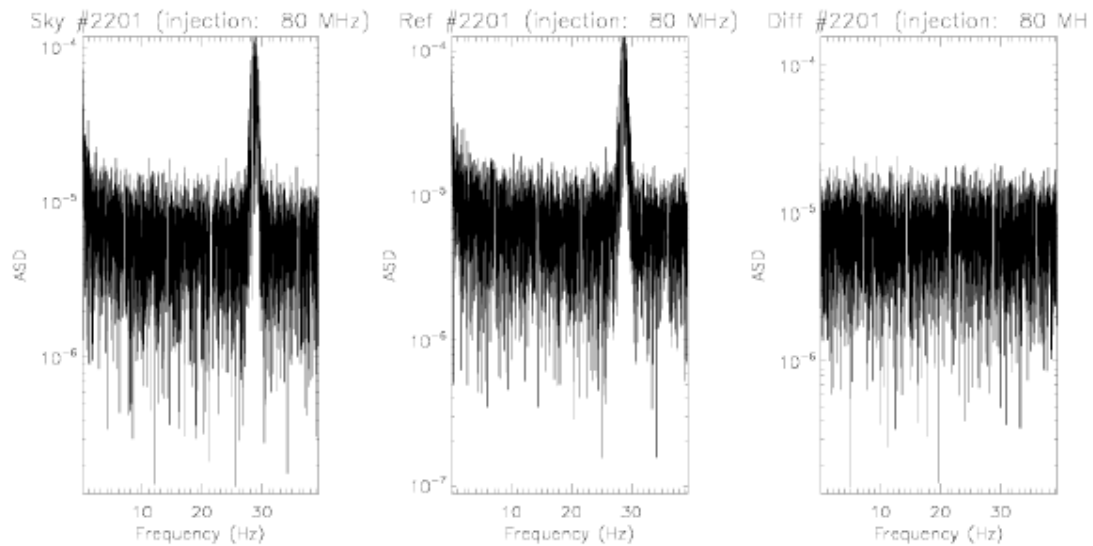
The spike is visible around 35 KHz and it is visible in the differential signal.

## RCA22 R0D0



## 3. RCA22 R0D0 During 80 MHz signal injection

## RCA 22 R0D1



#### 4. RCA 22 R1D1 during 80MHz injection

The Huge Spike is visible in all the condition with or without the signal injection so it seems to be not related to EMC condition.

The full report will be included as attachment to the final version of the test report