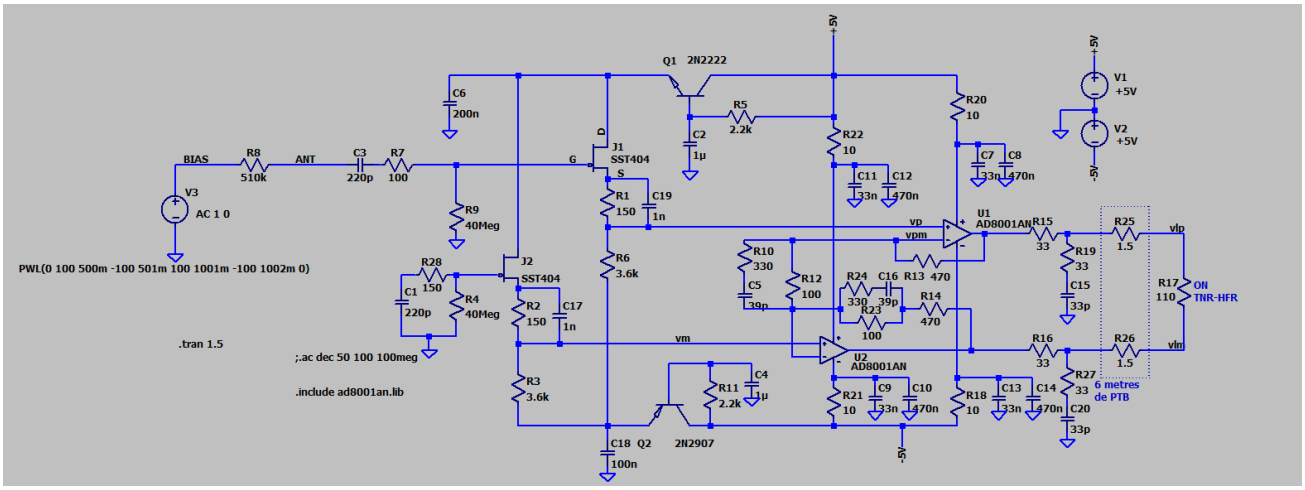
De: **Moustapha Dekkali** Moustapha.dekkali@obspm.fr
Objet: Re: Antenna 3 failure HF pre-amplifier latch up hypothesis
Date: 3 avril 2024 à 11:57
À: Guilhem Emmanuel (ALTRAN) emmanuel.guilhem.external@cnes.fr, Anders Eriksson Anders.Eriksson@irfu.se, Milan Maksimovic milan.maksimovic@obspm.fr, Anik De Groof Anik.DeGroof@esa.int, Walter Puccio wp@irfu.se, Xavier Bonnin Xavier.Bonnin@obspm.fr, roc sci-ops roc.sci-ops@sympa.obspm.fr, Niklas Edberg ne@irfu.se, Christopher Watson Christopher.J.Watson@esa.int, Pedro Osuna Alcalaya Pedro.Osuna@esa.int, antonio.vecchio@obspm.fr, Raulin Desi Desi.Raulin@cnes.fr, Lorfevre Eric Eric.Lorfevre@cnes.fr, SOL_FCT SOL-FCT@esa.int
Cc: Fossecave Herve (ALTRAN) Herve.Fossecave.external@cnes.fr, Sinibaldi Clement Clement.Sinibaldi@cnes.fr, Astier Pierre-Luc pierre-luc.astier@obspm.fr

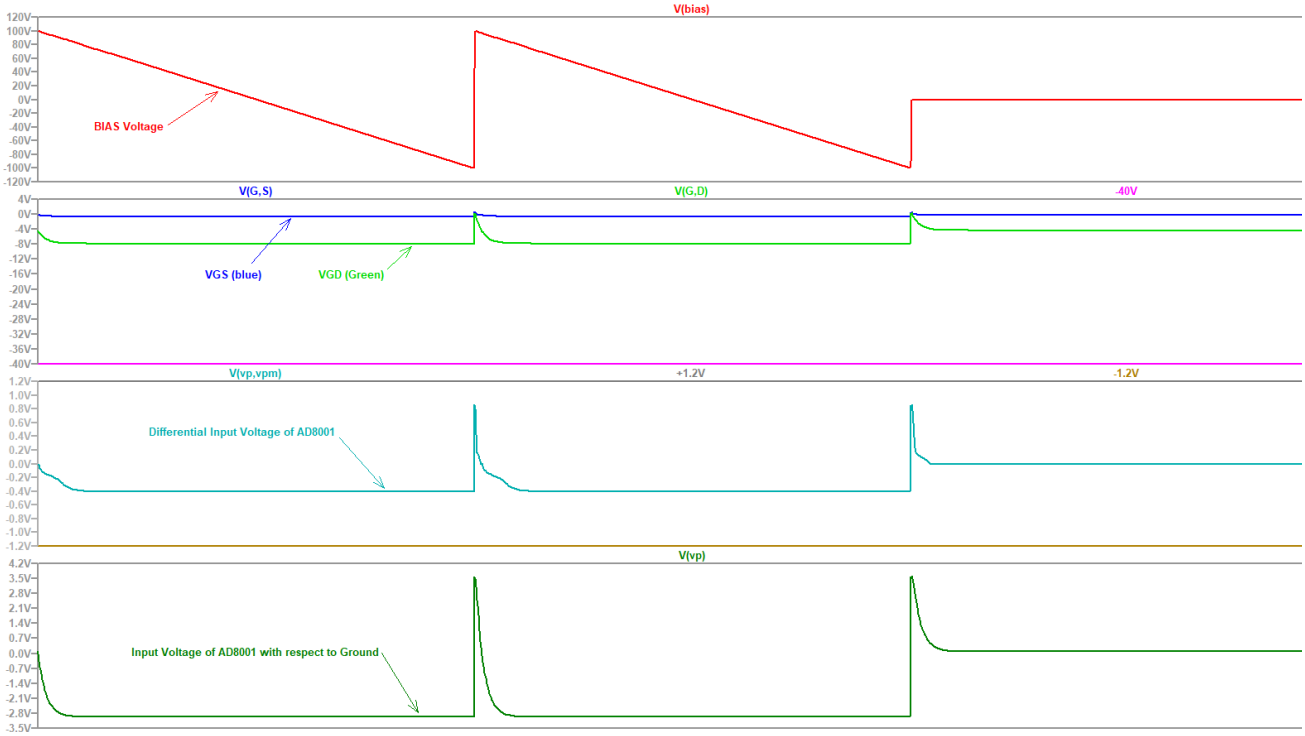
Dear All,

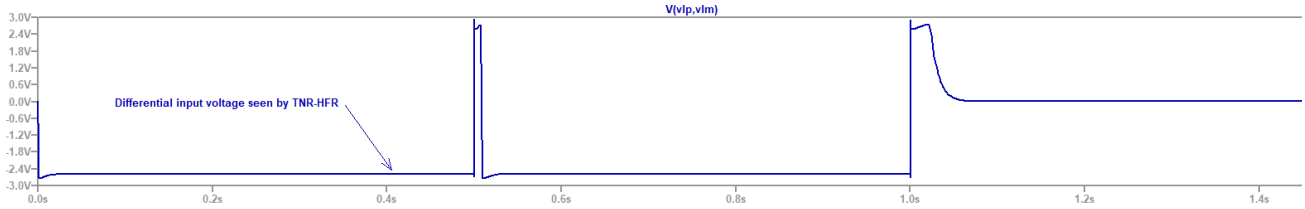
Here is a simulation provided by Pierre-Luc Astier. It is based on a **complete model** taking into account **all stages of the preamp**. The output impedance of the BIAS current source is also taken into account (set at 510 kohms).

At the preamp input, we apply a large ramp of +/-100V to simulate BIAS sweep transients, and this in the extreme worst case (the sweep used in flight is much more favorable).



The plots below give the responses of different intermediate signals from the HF preamp (VGS, VGD, differential and referenced to ground at the input of the AD8001 and at the output of the preamp).





What arises from this simulation is that the derating constraints are respected with large margins. Pierre-Luc will be present at the viso this afternoon and will be able to provide details if necessary.

One possible option to mitigate the problem (which is not necessarily a problem) would be to “smooth” the BIAS sweep : i.e. sweep consisting of an ascending ramp followed by a descending ramp. I think BIAS allows such a configuration (TBC).

See you very soon,
Moustapha

Le 02/04/2024 à 17:53, Guilhem Emmanuel (ALTRAN) a écrit :

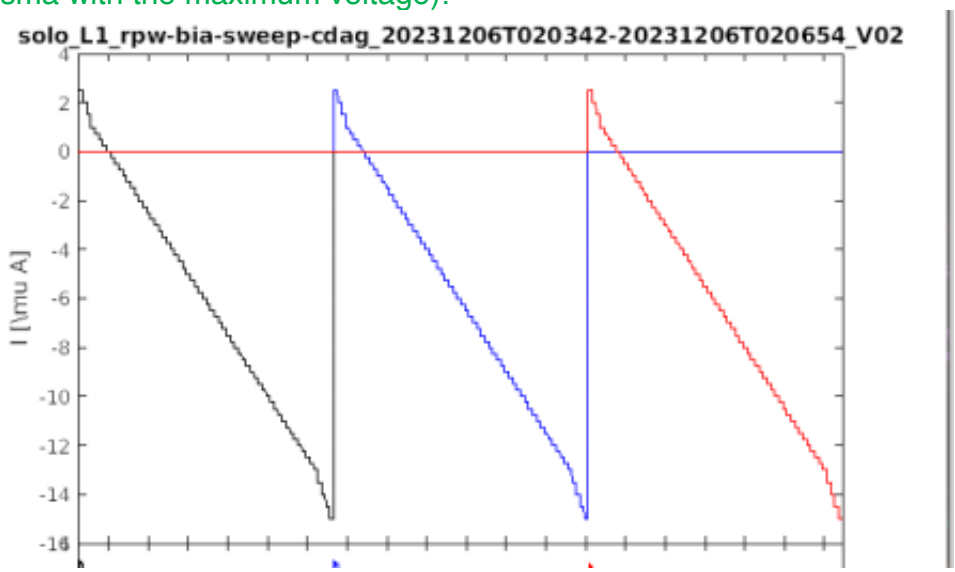
> Thank you Moustapha for your questions, and remarks.
>
> You have pointed some non-understood hypothesis in my proposal without any answer, I remind that the HF preamplifier failure is just an hypothesis.
>
> My answers in green.
>
> See you tomorrow
>
> -----Message d'origine-----
> De : Moustapha Dekkali <Moustapha.dekkali@obspm.fr>
> Envoyé : mardi 2 avril 2024 17:17
> À : Anders Eriksson <Anders.Eriksson@irfu.se>; Milan Maksimovic <milan.maksimovic@obspm.fr>; Anik De Groof <Anik.DeGroof@esa.int>; Guilhem Emmanuel (ALTRAN) <emmanuel.guilhem.external@cnes.fr>; Walter Puccio <wp@irfu.se>; Xavier Bonnin <Xavier.Bonnin@obspm.fr>; roc sci-ops <roc.sci-ops@sympa.obspm.fr>; Niklas Edberg <ne@irfu.se>; Christopher Watson <Christopher.J.Watson@esa.int>; Pedro Osuna Alcalaya <Pedro.Osuna@esa.int>; antonio.vecchio@obspm.fr; Raulin Desi <Desi.Raulin@cnes.fr>; Lorfevre Eric <Eric.Lorfevre@cnes.fr>; SOL_FCT <SOL-FCT@esa.int>
> Cc : Fossecave Herve (ALTRAN) <Herve.Fossecave.external@cnes.fr>; Sinibaldi Clement <Clement.Sinibaldi@cnes.fr>
> Objet : Re: Antenna 3 failure HF pre-amplifier latch up hypothesis
>
> Dear Emmanuel and All,
>
> The proposed analysis is interesting but, for my part, it raises some comments and as many questions.
>
> First, I would like to recall that HF preamps are not sensitive to latch-up. This was taken into account during the design and the latch-up immunity was verified by applying 100V transients to their input. And , we have never seen latch-up on the second version.
> Agree, we applied a lot of transient on the various flight models preamplifiers without any latch-up during integration phases. The maximum transient was 100μA*1MOhm=100V.
>
> In addition, a latch-up ise characterized by its persistence. When it occurs, it usually

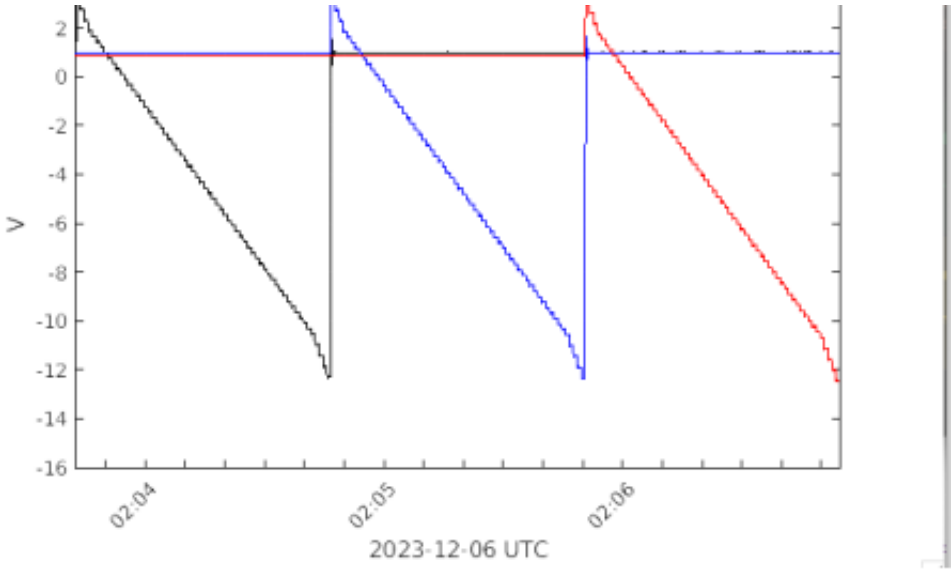
does not go away on its own. For this you need an on/off cycle. However, we note that the HF preamps systematically and almost instantly return to normal consumption after transients; which in my opinion excludes the the latch-up hypothesis.
Agree, after the latch-up the power consumption of the HF preamplifier raise down to nominal value, while the antenna 3 remain shorted, if the latchup state or saturation remains the power consumption should stay at the maximum level:

I confirm, that it seems that there is a link between the overconsumption of preamps (with a short duration) and BIAS sweeps. But I'm not sure to understand the approach adopted by Emmanuel... and it is therefore difficult for me to comment. However, here are some questions.

The high voltage is applied to the input of the HF PAs but they are AC coupled (protected by the series capacitance C100). Starting from the hypothesis that the BIAS sweep is progressive (current ramp), how can we find the transients that you simulate at the AD8001 input?

The BIAS Sweeps are not progressive, it starts directly by the maximum value, and after a ramp is applied to reach the minimum value. The transient seen by HF preamplifier reach several tens of volts. On the flowing figure we see the current and voltage function of time, on calibration resistance (I don't have the same figures for plasma with the maximum voltage):





In other words, I don't understand the conditions of the simulation. Why 25V pulses are applied to the OPAs input, while they are isolated by the JFET stage? Why is the period 100ns (i.e. 10 MHz)? What realistic situation does this correspond to?
See answer above.

If it is a question of simulating a transient due to the start-up of BIAS and its high voltage, this transient in essence is of short duration (at most of the order of one second before fading).
Agree, the strange thing is that the transient stade is maintained after the transient itself. That's why we propose a stress on AD8001d diode or others and a non nominal behavior.

I am discovering the DC measurements via LFR. A first remark: how can the LFR observe a DC level over such a long period (several hours) while the HF PAs are AC coupled over one hundred Hz?
The LFR measurement are done through BIAS amplifier and not HF preamplier, so we can deduce the DC voltage at antenna 3 input.

According to the estimates LFR measures 4V DC on V3. The load at the tip of the line being 110 Ohms, the excess consumption on PA#3 should be 26 mA (4V/110 ohms – 10mA) for several hours, while HKs show an excess current of 8 mA for about few seconds at most.
Agree see answer n°2, I don't have any explanation why we don't see an over current on HF preamplifier consumption, if it works correctly.

Note that simulation models have their limitations. They are quite faithful for functional aspects and can possibly provide indications on performances. On the other hand, I doubt that they can correctly reproduce marginal or non-linear phenomena, such as latch-ups or recovery after saturation.

All this should be clarified (and if possible recorded) to understand and avoid misinterpretations.

Best regards,
Moustapha

Le 02/04/2024 à 16:12, Anders Eriksson a écrit :
> Dear all,
>
> Thanks for the careful investigation which we look forward to discuss
> tomorrow (Yuri cannot attend, but Walter and I will be there). While
> the issue with rapidly changing voltage deserves consideration, we
> hope tomorrow's discussion can clarify how this failure hypothesis
> relates to some of the characteristics of the observed anomalies:
>
> (1) the first short happened during a sweep coinciding with a
> manoeuvre, more easily understood by an external mechanical short than
> by an internal electronics problem;
> (2) shorts have not only appeared during sweeps;
> (3) shorts are not perfect and show varying resistance to ground;
> (4) from the BIAS point of view, the suggested HF problem seems to be
> behind a capacitor and a transistor. As we see DC and AC both
> disappearing, it would seem both the transistor and the capacitor
> would have to fail, presumably giving irreversible changes in HF
> characteristics when the shorts disappear. Are these observed?
>
> Best regards,
> Anders
>
>
> On 02/04/2024 14:54, Milan Maksimovic wrote:
>>
>> Dear Anik,
>>
>> Just to let you know that we'll have a teleconf tomorrow at 2 PM to
>> discuss this hypothesis, which is still an hypothesis from what I
>> understand.
>>
>> If it appears that there is a danger to sweep while the HF
>> preamplifier is on, we clearly should take actions. In the mean time
>> and to be on the safe way, if there is a simple way to stop the
>> biasings fo a while we should do it.
>>
>> Xavier, you can maybe send the zoom link to our ESA colleagues and
>> they could attend the teleconf if they are available tomorrow.
>>
>> best regards
>>
>> Milan
>>
>>
>> Le 02/04/2024 à 14:26, Anik De Groof a écrit :
>>
>>> Dear Guilhem, dear RPW team,
>>>
>>> Thank you for the analysis of the Antenna 3 failure and the likely
>>> cause residing in the HF pre-amplifier.
>>>
>>> We can go through the details later, during the ARB, but the *most
>>> urgent for now* *is to have the instrument operating in a safe way*
>>> that avoids as much as possible failures on the other two antenna’s.
>>> I understand that the recent change in the Bias sweeps have avoided
>>> recurrent shorts on antenna 3, but the bias sweeps as set up now can

>>> potentially also be dangerous for ANT1 and ANT2. So we should take
>>> urgent action.
>>>
>>> The safest approach would be to switch the RPW instrument off until
>>> a proper solution has been worked out. But we are still running the
>>> coordinated RS windows so this would mean a loss of science that
>>> maybe can be avoided through intermediate solutions.
>>>
>>> Hence the following questions, also with MOC in the loop:
>>>
>>> * For ongoing STPs 303: is there an easy and safe way to stop the
>>>   BIAS sweeps as soon as possible? E.g.
>>>   o Can you send a PDOR to replicate the IOR commanding but
>>>   without sweeps?
>>>   *Question for MOC: * I assume this would mean a deletion of
>>>   commanding already onboard. Please confirm whether that
>>> would
>>>   be feasible/advisable. (assuming targeted deletion of the
>>>   sweep commands onboard would be out of the question)**
>>>   o Or would it be an alternative to turn the HF preamplifier
>>>   off? It is also a quite drastic solution but would avoid
>>>   doing more sweeps with the preamplifiers on.
>>> * For upcoming STP304 (not yet onboard): Can you send PDORs
>>>   replicate the IOR commanding but without sweeps?
>>>   Or if you can send *urgently* a new IOR, we may be able to still
>>>   convert it to POR and send to MOC.
>>>
>>> Please advise what options are possible.
>>>
>>> Best regards
>>>
>>> Anik
>>>
>>> *From: *Guilhem Emmanuel (ALTRAN)
>>> <emmanuel.guilhem.external@cnes.fr>
>>> *Date: *Tuesday, 2 April 2024 at 11:18
>>> *To: *Walter Puccio <wp@irfu.se>, Xavier Bonnin
>>> <Xavier.Bonnin@obspm.fr>, roc sci-ops <roc.sci-ops@sympa.obspm.fr>,
>>> Anders Eriksson <Anders.Eriksson@irfu.se>, Niklas Edberg
>>> <ne@irfu.se>, Dekkali Moustapha <moustapha.dekkali@obspm.fr>, Anik
>>> De Groof <Anik.DeGroof@esa.int>, Christopher Watson
>>> <Christopher.J.Watson@esa.int>, Pedro Osuna Alcalaya
>>> <Pedro.Osuna@esa.int>, antonio.vecchio@obspm.fr
>>> <antonio.vecchio@obspm.fr>, milan.maksimovic@obspm.fr
>>> <milan.maksimovic@obspm.fr>, desi.raulin <desi.raulin@cnes.fr>,
>>> Lorfevre Eric <Eric.Lorfevre@cnes.fr>
>>> *Cc: *Fossecave Herve (ALTRAN) <Herve.Fossecave.external@cnes.fr>,
>>> Sinibaldi Clement <Clement.Sinibaldi@cnes.fr>
>>> *Subject: *Antenna 3 failure HF pre-amplifier latch up hypothesis
>>>
>>> Dear All,
>>>
>>> You can find in this email a summary of the Antenna 3 failure : the
>>> HF preamplifier hypothesis.
>>>
>>> During the ANT3 failure a “shortcut” between the antenna and the GND
>>> has been seen through BIAS measurements and PA HF preamplifier

>>> measurements.
>>>
>>> The HF preamplifier is located next to LF preamplifier in the same
>>> box, linked to the antenna via a stud.
>>>
>>> *_Evaluation of the shortcut resistance_*:
>>>
>>> BIAS data analysis
>>>
>>> According to BIAS Specification
>>> (RPW-SYS-MEB-BIA-SPC-00001-IRF_Iss01_Rev06) The BIAS current can be
>>> set in the following range:
>>>
>>> Bias current range -100mA to 100mA In 16384 steps
>>>
>>> During the anomaly the maximum voltage of the sweep is 20V
>>> corresponding to 100μA witch leads to a plasma resistance of 200kOhm.
>>>
>>> On the anomaly the BIAS sweep resolution is 38 steps, it is
>>> equivalent to a 5.kOhm minimum resolution.
>>>
>>> We can only assess that the shortcut resistance is lower than 5kOhm.
>>>
>>> HF preamplifier data analysis
>>>
>>> According Walter Pucio email (2/2/2024) the resistance was evaluated
>>> to 25Ohms, but he took the assumption of an antenna base capacitance
>>> around 25e-6pF.
>>>
>>> The measurement done on QM antenna shoes a base capacitance of
>>> SOLO-SY-TN-271-CNES of 75pF including FET capa (25pF).
>>>
>>> Thanks (very much) to Walter formula we can evaluate the resistance
>>> of 60Ohm instead of 25Ohms.
>>>
>>> This analysis shows that what we call a short cut can be a
>>> resistance of an order of magnitude close to the HF preamplifier
>>> input resistances (150Ohm).
>>>
>>> *_Evaluation of the shortcut potential difference_*
>>>
>>> According to LFR F3 measurement during the anomaly we can determine
>>> the DC potential in Antenna 3:
>>>
>>> V2-V3= 2 V
>>>
>>> V1-V2 = -4 V
>>>
>>> V1 =2 V
>>>
>>> V2=6 V
>>>
>>> V3 = 4 V
>>>
>>> So the shortcut potential value is close to 4V.
>>>
>>> *_Historic latch-up_*
>>>

>>>
>>> During RPW integration a latch-up of HF preamplifier has been see on
>>> EM model, during the BIAS sweeps. The transistors or JFET Amplifier
>>> in the HF preamplifier front end turns to short cut while a high
>>> voltage was applied by BIAS during the sweeps. The electronic
>>> architecture was not identical :
>>>
>>> HF preamplifier input section on EM model :
>>>
>>> Due to this unexpected latchs up the input section was simplied, but
>>> some transistors remains:
>>>
>>> With this modification, on ground, the input transistors never
>>> latch-up again.
>>>
>>> *_Application to flight anomaly:_*
>>>
>>> Status:
>>>
>>> The anomaly occurs during BIAS sweeps when a high voltage transient
>>> is applied at HF preamplifier input (~30V).
>>>
>>> During flight the resistance of the short cut during the anomaly is
>>> around 60Ohm and the potential is around 4V.
>>>
>>> **
>>>
>>> Hypothesis
>>>
>>> The transistor ST404 and the JFET AD 8001 are used out of the max
>>> ratings:
>>>
>>> ST404 : 40V
>>>
>>> AD8001 : 1,2V
>>>
>>> A repeated stress, like a SWEEP BIA,S every week can produce a
>>> damage at the AD8001 input. But the AD8001 input is protected by
>>> Diodes.
>>>
>>> One hypothesis is : the AOP is saturated, and stays block in
>>> saturation as long as a reset is applied.
>>>
>>> When the AD8001 is saturated a high current is driven in the +5V
>>> power line, And be set to 3,1V the maximum output swing of the
>>> preamplifier, This is more or less the voltage seen by the LF
>>> preamplifier (-4V calculated previously).
>>>
>>> Simulations on HF preamplifier (Done by H. Fossecave)
>>>
>>> A pluse of 25V is applied to AOP input (green curve)
>>>
>>> A saturation is seen at one preamplifier input (red curve), the
>>> differential curves are also saturation (blue curve) :
>>>
>>> At the end of the pulse the preamplifier returns to nominal mode, so
>>> the remaining saturation seen during the anomaly could be due to a
>>> stress of some components.

>>>
>>> *_perspectives_**_:_*
>>>
>>> All the HF preamplifiers are submitted to a Voltage differential on
>>> inputs above maximum ratings during BIAS sweeps. This bad use as not
>>> been identified during RPW development periods.
>>>
>>> The urgent action to be taken is to stop right now the BIAS sweeps
>>> as long as a solution has been implemented.
>>>
>>> Identified solutions :
>>>
>>> Easy to be set : Do the sweeps while the HF preamplifier is OFF
>>>
>>> More tricky : Update sweep table in order to moderate the amplitude
>>> of the sweeps. A command exists : TC_DPU_LOAD_BIAS_SWEEP. This
>>> command is a DAS command and not a BIAS setting, so the way to
>>> upload a new command is cooperation between LESIA operation team and
>>> IRFU Team. The SW description describes precisely the commands to be
>>> set : RPW-SYS-SSS-00013-LES
>>>
>>> Best regards,
>>>
>>> Emmanuel Guilhem with the help of Hervé Fossecave.
>>>
>>> Emmanuel Guilhem (CAP GEMINI)
>>> X-IFU
>>> Téléphone portable pro: (+ 00 33) 6 08 70 33 18
>>>
>>> Bureau : (+ 00 33) 5 61 28 76 04 E-mail :
>>> emmanuel.guilhem.external@cnes.fr
>>> <mailto:emmanuel.guilhem.external@cnes.fr>
>>>

>

--
+

Moustapha Dekkali
CNRS - Observatoire de Paris - LESIA
5 Place Jules Janssen
92195 Meudon

--
+

Moustapha Dekkali

CNRS – Observatoire de Paris – LESIA
5 Place Jules Janssen
92195 Meudon