Record of Meeting	esa FIRST PROJECT	Doc.: PT/8147 Page: 1

Subject: FIRST /PLANCK POWER EMC Working Group Mtg

Location: ESTEC (AF 205) tel 4201. **Date:** 5/9/00.

Purpose / Objective: Am 5.1.

AGENDA

1) Status of Action Items
2) Power consumptions of Experiments
3) Status of IID-B's
4) What can be learnt from previous missions, eg can we get information on Boomerang--
5) Convertor Synchronisation
6) HIFI/LFI Space plasma effects at L2.(Alain Hilgers 14:00hrs)
7) Specific experiment topics --eg Sorption Cooler, pulsed vs linear controller, power consumptions and dissipations in electronics and cooler, model of power bus impedance from spacecraft to cooler electronics, JPL comments on EMC spec
8) AOB

Next Meeting is 26 Oct 2000.

Participant	Organisation	Participant	Organisation
B JACKSON	ESA.		
A. Ciccolella	..	J. Paul Chabaud	
S. Thuerey (Pt time)	..		
A. Nabe	SRON		
M. Rumitz			
C. Butler.			
C. Ponzoni	Laben.	(Apologies received from Colin Cunningham who was unable to attend)	
R. Pons			

Record of Meeting	esa FIRST PROJECT	Doc.: PT/847 Page: 1.

1) Open AI's

AI 1 ISN to provide block diagram of SCE, SCC.
AI 2 " " " thermal dissipations,
AI 4 " " " Updated power budget

C. Butler reported that the Sorption Cooler power reported in the Sorption Cooler ICD is still correct! These figures include the proportional power component and the variation in main bus voltage from 26-29V.

2) Power Budget.

All instrument teams confirmed that the power figures given in the ICD iss 1's are correct.

3) IID B's.

As for (2) above

4) Lessons learnt from previous missions.

LFI may be similar to payload to be flown on MAP spacecraft (to be launched ± sept 2001)
MAP has Radiometers with feedhorns – useful for

understanding coupling between feedhorns & may have similar electrostatic problems.

5) <u>Convertor Synchronisation.</u>

– See email of A. Nuber (attach 1). ESA confirmed that the convertor synchronisation signal is 'ground free' and the experiment does not need to provide transformer isolation.

– Synchronisation frequency – the 'old' wording of the IID-A allowed the experimenters to run the convertors at 131 kHz <u>BUT</u> the new wording (as released in the ITT) requires them to run at 65 kHz!

(Previously the convertors were 'push-pull' and therefor required a 1:1 mark space ratio. – convertors as proposed by the experiments will be P.W.M. and may run at 131 kHz or 65 kHz).

<u>It was agreed</u> that experiment convertors may run at 65 kHz or 131 kHz (± 10%).

Note the convertor sync signal is the same as

the spacecraft On Board Clock (OBC)
(LFI signal distribution is shown in attach. 2).
This will require a change to the wording in the IID-A as released with the ITT, as given in attach 1

One converter sync signal per experiment OR/
" " " " per LCL

Note The converter sync signals are cold redundant & expts will receive one MAIN as well as one RED signal. Only one will be active during nominal operation BUT the experiment shall not suffer damage (ie be able to survive!) if both main & redundant clock signals are provided simultaneously.
(NB. LFI IID-B para 5.9.6.2.1 requires 4 sync signals.)

6) Space Plasma effects at L2.

See attach 3.

7) JPL + SRON comments on EMC Spec.

Response to comments of A. Nabe see attach 4.1

" " JPL " 4.2.

Provided by A. Ciccolella + A. Garutti attach 4-3

A. Nabe will send A. Ciccolella documentation for digital signal interfaces

(AI) 22/9/00

Attach 1

"Albert Naber" <A.P.Naber@sron.nl> on 14-07-2000 13:43:32

To: Bernard Jackson/estec/ESA@ESA
cc: Antonio Ciccolella/estec/ESA@ESA
Subject: Dc/DC converter sync.

Bernard,

I get some questions from the subsystems.

- Is it true that the transformer is not located in the experiment? In ISO it was.
- What are the characteristics of the transformer? A real square wave gives a lot of hramonics. What are the rise/fall times, etc. of the signal.
  We need the transformer information in any case, either for the experiments or for the testequipment.

Kind regards,
Albert

Wording in IID-A as released in ITT.

Experiment converters are required to be synchronised by a spacecraft supplied clock with a frequency of 131.072 KHz ± 0.1% ~~and operate at half the synchronisation frequency.~~

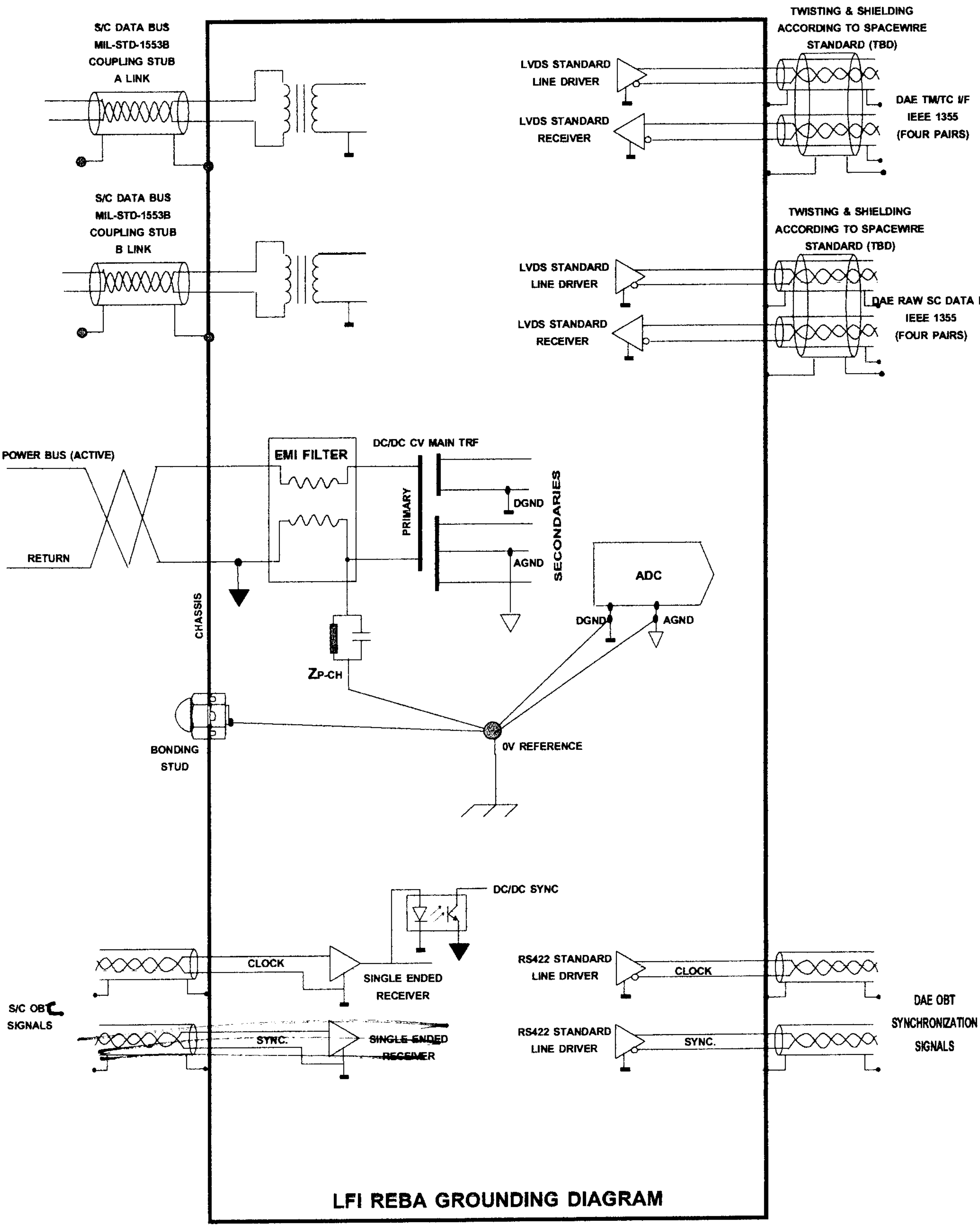
In the absence of a clock signal the converters shall be free running at nominal frequency ~~65.536 KHz ± 10%.~~ ± 10 %.

The synchronisation signal (squarewave, 5 V) is provided ground free (transformer coupled).

The experiment input impedance is assumed to be 5 k ohm in parallel to 200 pF.

////// // proposed to be deleted. in next issue of IID-A.

Attach 2.



LFI REBA GROUNDING DIAGRAM

Attach 3.1

Interaction of Solar Wind Particles With Spacecraft Surface at L2: Information Relevant to First/Planck Spacecraft

A. Hilgers

ESA-ESTEC/TOS-EMA

18-08-2000

Summary

The solar wind environment of the First/Planck spacecraft at L2 is about the same as for a spacecraft at L1, e.g., SOHO. Particle fluxes of the order of 10^{12} particles per square meters of both ions (with energy of the order of 1 keV) and electrons (with energy of the order of 1 eV) are expected. Electrostatic potential of the order of a few volts positive, for the sunlit surfaces and possibly a few tens of volt negative, for surfaces exposed to the space environment but shielded from the solar wind ions and the solar photons, can be expected. Fluctuations of the surface voltages of the order of one volt or more are expected to occur over time scales of more than a minute due to the change of the environment or more than a second due to the spacecraft rotation. A sudden electrostatic discharge due e.g. to sudden gas release over charges surfaced could induce some change of potential over milli to micro-second time scale.

Solar wind properties at L2

The Lagrangian point, L2, is located at about 1.5 10^6 km behind Earth along the sun-Earth axis. This distance is much smaller than the Sun-Earth distance ($\sim 1.5\,10^8$ km) and much larger than the tailward extension of the Earth magnetosphere. Therefore one expects the solar wind environment to be typically the same at L2 as it is at L1 where it is rather well known thanks to the measurements from various spacecraft including, e.g., IMP series, Wind, SOHO and ACE.

Around Earth the solar wind is essentially constituted of protons with a speed of typically 300 to 600 km s^{-1} and occasionally as high as 1000 km s^{-1} and a density typically between 1 and a few tens of cm^{-3}. There may be from 1 to 10% of Alpha particles and a few percent of minor ions (essentially C, N, O , Ne, Mg, Si and Fe). The ion and electron temperature is typically of the order of 1 eV but can be sometimes as high as 100 eV.

Possible solar wind effects on First/Planck surfaces

A first effect of the solar wind for First/Planck spacecraft is the bombardment of surfaces facing the sun by protons with kinetic energy of the order of 1 keV and a flux of the order of 10^{12} to 10^{14} particle per m^{-2} on the surfaces perpendicular to the solar wind velocity. These ions may erode surfaces (especially the minor heavy ions) or create X-ray background or false count in photon detectors sensitive to the energy deposited by such ions.

The flux of electrons to surfaces is also of the order of 10^{12} particle per m^{-2} but it is primarily due to their thermal motions with a temperature of the order of 1eV and is therefore isotropic.

A second noticeable effect is that surfaces are exposed to an electric current due to the solar particle flux which, in combination with the photo-electric current, induce an electrostatic potential.

For a surface with an electrostatic potential ϕ with respect to the ambiant plasma and perpendicular to the solar wind and the sun axis the typical electron current density can be expressed as

$$j_e = n_e e\sqrt{\frac{kT_e}{2\pi m_e}}(1+\frac{e\phi}{kT_e}) \text{ if } \phi > 0 \text{ and } j_e = n_e e\sqrt{\frac{kT_e}{2\pi m_e}}\exp\left(+\frac{e\phi}{kT_e}\right) \text{otherwise}$$

the ion current density as

$$j_i = n_i e v_i \text{ for } \phi \ll 1 \text{ kV}$$

and the photo-electron current density as

$$j_{ph} = j_o \exp - \frac{e\phi}{kT_{ph}} \text{ if } \phi > 0 \text{ and } j_{ph} = j_o \text{ otherwise}$$

where, k is the Boltzmann constant, n_e is the electron density, n_i is the ion density, T_e is the elctron temperature, m_e is the electron mass, v_i is the solar wind speed, T_{ph} is the photo-electron temperature and j_o is the saturation current of the surface photo-emission.

For typical solar wind density, temperature and speed and typical photo-emissivity of surfaces, $j_e \sim 10^{-7}$ to 10^{-6} Am^{-2}, $j_i \sim 10^{-7}$ to 10^{-6} Am^{-2} and $j_{ph} \sim 10^{-6}$ to 10^{-5} Am^{-2}. It must be reminded that j_i and j_{ph} can drop to zero depending of the orientation of the surfaces.

The typical potential of the surfaces exposed to these currents is found by a current balance equation. The potential can be as high as 10 to 15 Volts for highly photo-emittive surfaces in high speed solar wind and of a few volts for non photo-emitted surfaces. For surfaces shielded from the solar wind and from the photons but still exposed to the electron flux, the potential can a priori become very negative.

However, for surfaces open to space one can expect that there would be some residual ions reflected by spacecraft surfaces. The more deep in the spacecraft these surfaces will be the lower the residual ion density will be. Typical reflection coefficient for ions in the keV energy range is of the order of 10^{-2} to 10^{-3}. If one compute the current balance using an ion density of 10^{-3} times the solar wind density one finds a potential of -6 V for $T_e = 1$ eV and -70 V for $T_e = 10$ eV. Conductivity through or over material surface should also mitigate the negative charging.

The fluctuation of the solar wind parameters are important over rather long time scales, e.g., minutes to hours. The electron density fluctuation has been found to be typically of a few percent at the time scale of ~ 0.1 s and even smaller at lower time scales [*Celnikier et al.* 1983, 1987]. Therefore, significant change (i.e. > 1 V) of surface potential at time scales of less than a minute could only be induced by spacecraft rotation and would therefore occur over a time scale of a second.

Sudden electrostatic discharges of charged surfaces may occur due for instance to sudden gas release (thruster or residual outgasing) or electrostatic breakdown. In this case the potential may change over a time scale of the order of a millisecond to micro-second.

References

[1] *http://earth.agu.org/revgeophys/ogilvi00/node2.html/*

[2] Celnikier et al., A&A, *126*, 293, 1983.

[3] Celnikier et al., A&A, 181, *138*, 1987.

4.1

"Albert Naber" <A.P.Naber@sron.nl> on 13-07-2000 12:59:32

To: Antonio Ciccolella/estec/ESA@ESA, Bernard Jackson/estec/ESA@ESA
cc: chabaud@cesr.fr, Roger.Pons@cesr.fr, valerie@dns1.ias.u-psud.fr, Antonio Garutti/estec/ESA@ESA, F.Hommes@fokkerspace.nl, marco@ifctr.mi.cnr.it, silvestri.r@laben.it, rumitz@mpe.mpg.de, crc@roe.ac.uk, "Bert-Joost van Leeuwen" <Bertl@sron.nl>, "Martin Frericks" <Martinf@sron.nl>, "Nick Whyborn" <Nick@sron.nl>, "Piet de Groene" <Pietg@sron.nl>, "Wim van Leeuwen" <Wimvl@sron.nl>, butler@tesre.bo.cnr.it
Subject: Re: Electronic version of Power / EMC mtg minutes PT07974 and IIDinterface handout

---

Hi Bernard and Antonio,

Here are some comments to the minutes and the IID handouts.

MINUTES:
In the minutes the following is missing:
It was decided that DC/DC converter synchronisation is a requirement for FIRST/Planck.
This decision was taken at the beginning of the meeting, with the following arguments:
If necessary synchronisation can be deleted in a late stadium of the project.
On the other hand it can not be implemented later on.

This decision started the discussion about the converter synchronisation frequency, as reflected in the minutes.

POWER REQUIREMENTS

1.2.2 Riple and spikes
Frequency, rise and fall times for riple and spikes are not given.

1.4 Bus impedance
In the figure the position of the labels should be near the corresponding curves.
Now the upper label belongs to the lower curve. (For black and white print-out this is not clearly visible)

1.5.2 and 1.5.3 Power demand, Long peak and Short peak
It is almost impossible to test this.

1.6 Experiment converter synchronisation
This requirement should be applicable to all units with DC/DC converters in FIRST/Planck.

The experiment input impedance.
It is not clear to us if this is a transformer coupling within the experiment or not.
If not then the 5k Ohm and 200pF will have as reference the primary power return line.

EMC

3.3.1 Signal interface grounding
Which PSS is dictated here?

4..9 LISN
The figures 4.1 and 4.2 are missing.

Kind regards,

JPL Comments on EMC portions of FIRST Planck IID-A

Subject: JPL Comments on EMC portions of FIRST Planck IID-A

Reference: ESA document SCI-PT-IIDA-04624, dated 21/07/2000

General Comments:

- The detailed test measurement requirements provided unnecessarily constrain the available EMC measurement methods that could be used.
- Most of the limits provided seem to be reasonable, although one incorporates excessive margin (i.e., an 80-dB margin between AC radiated magnetic field emissions and susceptibility).
- Compliance with all requirements stated as "shall" would make the cost of EMC testing prohibitive.

5.9.5.2.1 Signal Characteristics
Rise time and duration not stated for 0 to 29-volt fluctuating voltage.

5.9.5.3.1 Transient
Rise time not stated.

5.9.5.3.2 Ripple and Spikes
140 mVpp main bus ripple: No frequency range specified.
240 mVpp Commutation Spikes: No rise time or duration specified.

The purpose of these requirements is not evident. These are benign levels considering the susceptibility requirements in Section 5.14.3.1.1.

5.9.5.7 Instrument Converter Synchronisation
Last line: "The instrument converter input impedance…."

5.10.3.4 Isolation between Primary Power lines and the Structure of the Hosting Spacecraft
50 nF shunt capacitance requirement appears to be very low and in conflict with the implementation of common mode filters. In the past, JPL (Cassini) specified a maximum of 0.1 microfarad, but waivers were frequently required.

The same values appear in the MSFC generic EMC requirements document.

Waivers could be avoided if the wording for the capacitance statement were changed to "should" rather than "shall".

5.10.3.5 Isolation between Primary Power lines and Secondary Power Lines
Same comment as above, except the requirement is more restrictive by an order of magnitude (5 nF).

The 5 nF value appears to be in conflict with the 50 nF stated in Section 3.10.3.10.

R. Kuberry
8/17/00

5.14.1.2 Signal Isolation
Suggest that all the "shall" wording be changed to "should". This is not readily verifiable by test.

5.14.1.3 Signal Reference
Note that this requirement may necessitate an external verification arrangement, such as an isolated terminal or a connector with a shorting cap.

5.14.3.1.1 Conducted Emission..... Figure numbering is in error.

5.14.3.1.2 Conducted Emission....... Same comment as above.

5.14.3.2 (and 5.14.3.4 and 5.14.3.5) Conducted Susceptibility...
These sections call for a technique called "bulk current injection". This technique is not in use at JPL and does not have universal acceptance. It also requires special equipment to implement. The text should be changed to allow for alternative techniques.

5.14.3.11 H Field Radiated Emission
The 80 dB margin to the susceptibility seems excessive, especially since there is no science magnetometer.

5.14.3.12 Arc Discharge
Considering the mission environment, this level appears to be high. In any event this test must not be performed at the system level due to the ESD susceptibility of the HFI detectors. Refer to the note in Section 9.5.6.1.4.3.

9.5.6 EMC Verification and Testing
A properly documented EMC test report provides adequate reference to the detail test procedure, test conditions, and test equipment, so that the results can be replicated and/or evaluated by another test agency.

There are too many "shall" statements in this Section. It is too restrictive, imposes methods that are hardware-specific, and contains procedural detail that is excessive. Implementation to the detail presented will become a serious cost driver. This Section should be provided only as a guideline.

9.5.6.2 Test Facility....
"Any condition, method not covered by these requirements or deviation to them shall be agreed with ESA." This is too restrictive and may impose schedule delays. It should be acceptable to use conventional EMC test methods as long as they are adequately described in the approved test procedure. Unanticipated events, which may necessitate "red line" changes in the course of testing, should not have to await approval by ESA.

R. Kuberry
8/17/00

9.5.6.2.1 Ambient EM Levels

This requires the unit under test to provide a resistive load to interface with the GSE.

9.5.6.3 Measuring Equipment/Instrument

A properly documented EMC test report provides adequate reference to the detail test procedure, test conditions, and test equipment so that the results can be replicated and/or evaluated by another test agency.

Since the hardware cognizant engineer and his manager sign-off on the test procedure, additional levels of approval should not be necessary.

9.5.6.3.1 Measurement Receivers/Spectrum Analyzers

The blanket requirement for the use of input pre-selectors on modern spectrum analyzers is not realistic. An experienced EMC test conductor would be aware of the test environment and any potential adverse effects due to overloading.

9.5.6.3.2 Computer Controlled Receivers

"A detailed description of the operations that are directed by software for computer controlled receivers, shall be included in the test plan. Verification techniques used to demonstrate proper performance of the software shall also be included."

This could be a document in itself! It should only be of concern if there were some major issue with the reported test results.

9.5.6.3.3 Detector Function

Same comment as above for Section 9.5.6.3.1. There are techniques for susceptibility tests which do not require the use of a spectrum analyzer.

As long as the instruments are calibrated and the units of measurement are provided, it should not be necessary to modify an existing measurement system to comply with an alternate expression of values.

9.5.6.3.4 Current Probes

If a commercial EMC current probe is used, this step is unnecessary.

9.5.6.3.5 Test Antennas

If commercial calibrated antennas and established procedures are used, this is overkill.

The same comment applies to Sections **9.5.6.3.6** through **9.5.6.3.11**.

9.5.6.4.1 Measuring Equipment Calibration

Agencies should be free to establish their own calibration program.

Is MIL STD-45662A appropriate if an agency is ISO compliant ?

R. Kuberry
8/17/00

9.5.6.4.3 Measurement Bandwidths

These values are equipment-specific parameters.

9.5.6.5 Test set-up arrangement

This whole Section imposes a number of constraints , expressed as "shalls", on the unit under test, which may not be practical to implement.

9.5.6.9 Line Impedance Stabilisation Network (LISN)

Figures 4.1 and 4.2 are missing or not properly referenced.

9.6.5.10 Test Config.....

These are standard procedures for the most part.

Astrid Heske 25-08-2000 11:43

To: butler@tesre.bo.cnr.it
cc: Bernard Jackson/estec/ESA@ESA, Thomas Passvogel/estec/ESA@ESA
Subject: Comments on EMC portion of IID-A sent 23/08/00 by JPL

Dear Chris,

I am referring to the comments from Parker Cowgill to you, which I received in copy.
These are valuable comments which should be discussed/considered in future EMC working group meetings.

N.B. Given the submission date, I don't think JPL expected these comments to be incorporated for the ITT issue.

Kind regards,

Astrid

"Chris Butler" <butler@tesre.bo.cnr.it> on 28-08-2000 09:19:54

Please respond to "Chris Butler" <butler@tesre.bo.cnr.it>

To: Bernard Jackson/estec/ESA@ESA
cc: santos@isn.in2p3.fr, valerie@ias.u-psud.fr, charra@ias.u-psud.fr, Thomas Passvogel/estec/ESA@ESA, "Silvestri Roberto" <rsilvestri@batman.laben.it>, "Carlo Ponzoni" <cponzoni@batman.laben.it>, Antonio Garutti/estec/ESA@ESA, Antonio Ciccolella/estec/ESA@ESA, Astrid Heske/estec/ESA@ESA, lfispcc@tesre.bo.cnr.it
Subject: I: Comments on EMC portion of IID-A sent 23/08/00 by JPL

```
Dear Bernard,
I agree with Astrid. It would be useful if we could discuss the JPL points
on EMC at the next F/P EMC WG on 5/9/00.
Kind regards, Chris Butler

-----Messaggio originale-----
Da: aheske@estec.esa.nl <aheske@estec.esa.nl>
A: butler@tesre.bo.cnr.it <butler@tesre.bo.cnr.it>
Cc: bjackson@estec.esa.nl <bjackson@estec.esa.nl>; tpassvog@estec.esa.nl
<tpassvog@estec.esa.nl>
Data: venerdì 25 agosto 2000 11.41
Oggetto: Comments on EMC portion of IID-A sent 23/08/00 by JPL


>Dear Chris,
>
>
>I am referring to the comments from Parker Cowgill to you, which I
received
>in copy.
>These are valuable comments which should be discussed/considered in
>future EMC working group meetings.
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>N.B. Given the submission date, I don't think JPL expected these comments
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>
>Kind regards,
>
>Astrid
>
>
```

- EMC_cmts_on_IIDA.doc

Subject: ESA Response to JPL Comments on EMC portions of FIRST Planck IID-A

Reference: ESA document SCI-PT-IIDA-04624, dated 21/07/2000
JPL Comments on EMC portions of FIRST Planck IID-A, dated 17/08/2000

General Comments:

- The detailed test measurement requirements provided unnecessarily constrain the available EMC measurement methods that could be used.

The detailed test measurement requirements specified in the IID-A reflect standard verification techniques and performances that, usually, most of the commercially available test instruments fulfil. The requirements either meet MIL-STD-461, which is the reference document, or are even more relaxed. So any EMC Lab, qualified to run MIL-STD-461 measurements, will easily meet per se the detailed test requirements reported in the IID-A. The requirements are reported for the sake of completeness and as a handy reference for users that are not familiar with EMC verification. Furthermore, this also ensures coherence with the test results obtained by different EMC Laboratories. In the light of the above rationale, ESA cannot share the JPL view.

- Most of the limits provided seem to be reasonable, although one incorporates excessive margin (i.e., an 80-dB margin between AC radiated magnetic field emissions and susceptibility).

The margin between AC radiated magnetic field emission and susceptibility is not 80 dB.
The emissions are specified at 1 m distance, while the susceptibility is meant as the value of the magnetic field at the DUT envelope. This leads to consider 5 cm distance from the source of radiation as it is done by MIL-STD-461C for the Radiated Susceptibility – H field requirement. Assuming a cubic decay law of the magnetic field, which is typical of the magnetic dipole source, we have a scaling factor between the two requirements that can be evaluated as $20 \text{ Log } (1/0.05)^3 = 60 \text{ Log } 20 = 78$ dB.
Therefore the margin is:

$140\ dB_{pT}$ (susceptibility)-[78 dB (scaling factor) +$60\ dB_{pT}$ (emission)]=2 dB

and not 80 dB as JPL states.
Since it is unlikely that the B-Field will exceed the specified limit, ESA considered the reduced 2 dB margin in the specifications to avoid overtesting the DUT during magnetic susceptibility.

- Compliance with all requirements stated as "shall" would make the cost of EMC testing prohibitive.

Please substantiate the generic statement above. A test campaign comprehensive for all the requirements specified here at Subsystem/Payload level would cost roughly 30 K$ inclusive of the preparation, facility, personnel, reports etc. with the current rates of the ESA Laboratory.

5.9.5.2.1 Signal Characteristics

Rise time and duration not stated for 0 to 29-volt fluctuating voltage.

See Antonio Garutti's Answer

5.9.5.3.1 Transient

Rise time not stated.

See Antonio Garutti's Answer

5.9.5.3.2 Ripple and Spikes

140 mVpp main bus ripple: No frequency range specified.
240 mVpp Commutation Spikes: No rise time or duration specified.

The purpose of these requirements is not evident. These are benign levels considering the susceptibility requirements in Section 5.14.3.1.1.

See Antonio Garutti's Answer

5.9.5.7 Instrument Converter Synchronisation
Last line: "The instrument converter input impedance□."

See Antonio Garutti's Answer

5.10.3.4 Isolation between Primary Power lines and the Structure of the Hosting Spacecraft

50 nF shunt capacitance requirement appears to be very low and in conflict with the implementation of common mode filters. In the past, JPL (Cassini) specified a maximum of 0.1 microfarad, but waivers were frequently required.

The same values appear in the MSFC generic EMC requirements document.

Waivers could be avoided if the wording for the capacitance statement were changed to "should" rather than "shall".

The requirement in matter is derived from the ESA Power Standard (Doc. ESA-PSS-02-10), which is applicable to the First/Planck Programme.
Please find below an excerpt the ESA Power Standard, which provides the rationale for the requirement (tables and calculation are omitted).

The specified values for the DC and AC isolation are based on the following compromise.

The impedance between the electrical reference and the unit case compared with the impedance of the ground wire[1] should be:

1. Very large for DC and low frequencies in order to minimize currents in ground loops, which minimize at the same time the generation of magnetic field.
2. Very small for frequencies greater than, say, 5 MHz in order to minimize the voltage drop between references due to common mode currents.

[1]The ground wire is a wire that connects the unit electrical reference to the system central ground reference or to a secondary distributed ground reference.

Please consider that the Cassini power system was based on a RTG, while the specifications of the MSFC address requirements applicable to equipment connected to a fuel cell-based power system (i.e. the Shuttle). Both the mentioned power systems are different from what it is foreseen for First/Planck (regulated bus) and are relevant to different missions. So comparison of requirements for different spacecraft is not pertinent in this context.

In addition, having a capacity of 0.1μF between power lines and chassis implies to inject a large measure of common mode onto the spacecraft structure. Not only this increases the voltage difference between two ground references, but also it generates radiated emission at spacecraft level that could impair the performance of payload sensors' that are sensitive to electromagnetic radiation.

The control of the common mode emissions on power lines with large capacitors to the ground is beneficial just for meeting the requirement at equipment level. It can generate the described drawbacks at system level, for which a retrofix is not always practical, nor possible.
The acceptance of a waiver depends on the impact that out-of-specs have on the overall spacecraft system's performances.

5.10.3.5 Isolation between Primary Power lines and Secondary Power Lines

Same comment as above, except the requirement is more restrictive by an order of magnitude (5 nF).

The 5 nF value appears to be in conflict with the 50 nF stated in Section 3.10.3.10.

This requirement addresses the parasitic capacity in series between the primary and secondary power in a DC/DC converter that provides galvanic isolation. This requirement, met by most of the good quality converters, is to avoid that common mode from the secondary power propagates back to the primary leads.

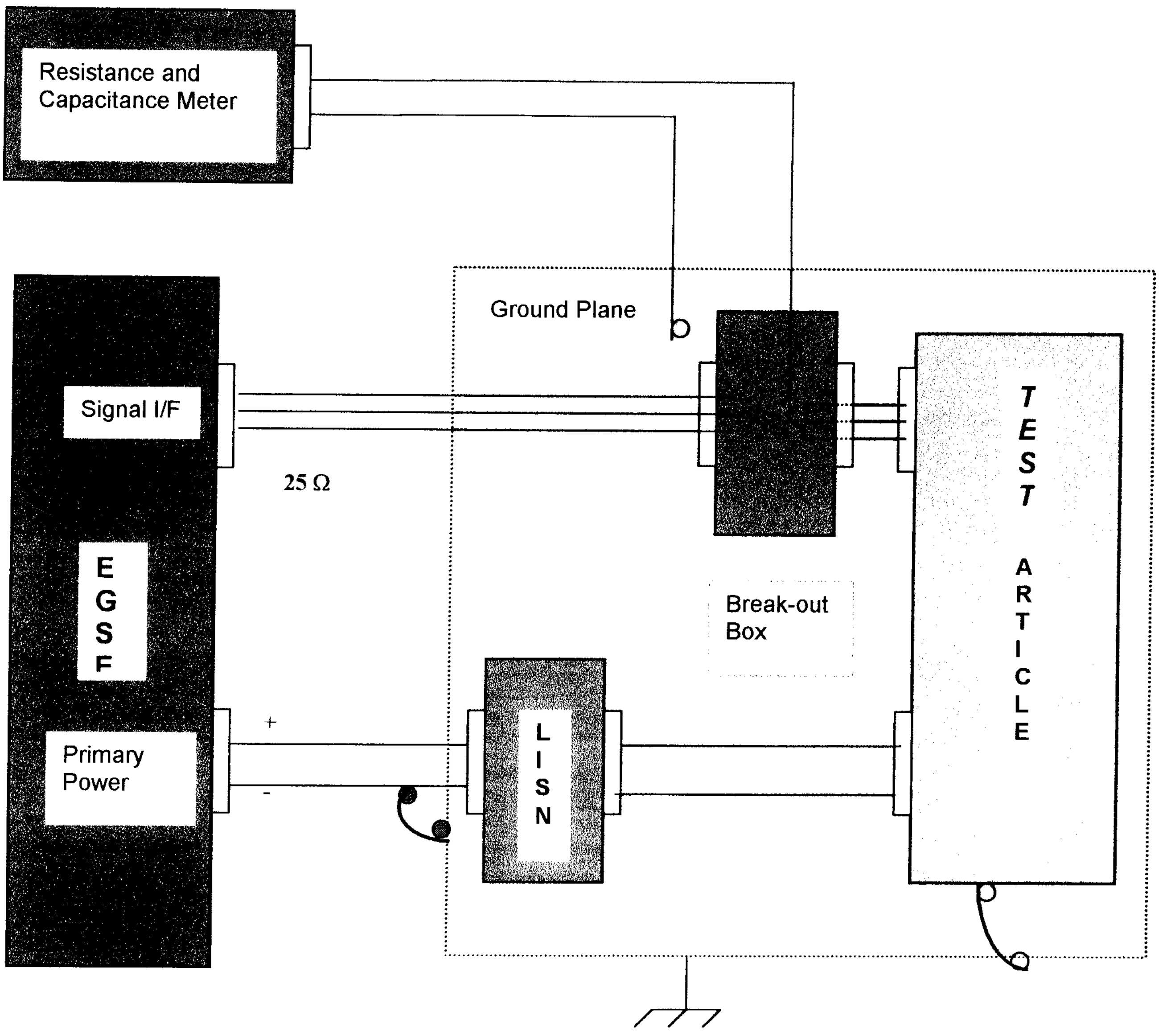
5.14.1.2 Signal Isolation

Suggest that all the "shall" wording be changed to "should". This is not readily verifiable by test.

The intended test set up and the test procedure is shown here below.
This measurement is matter of few minutes and can be easily performed. Also, this requirement is meant to control common mode by designing appropriately the signal interfaces. If the experiments manufacturer has information on the common mode isolation of the amplifiers used, than this requirement may be verified by analysis. Slowly varying signals will certainly not contribute to common mode but they can be sensitive to it especially is extreme measurements are involved.

Signal Lines:

The designated ungrounded signal lines shall be tied together electrically. The impedance between the now common lines and the Test Article chassis shall be measured by applying a low fixed level AC voltage in the specified frequency range to the interface under test and adjusting a serial resistor to 50% voltage drop. The final value of the resistor is equal to the absolute value of the common mode isolation.



5.14.1.3 Signal Reference

Note that this requirement may necessitate an external verification arrangement, such as an isolated terminal or a connector with a shorting cap.

The verification method this requirement underlines is by "Review of Design", not by test.
The requirement simply indicates what can be used as a reference ground for signals (i.e. certainly not the primary power return). This can be inferred from the circuit schematics of the experiment.

5.14.3.1.1 Conducted Emission□..Figure numbering is in error.

OK, will be corrected

5.14.3.1.2 Conducted Emission....... Same comment as above.

OK, will be corrected

5.14.3.2 (and 5.14.3.4 and 5.14.3.5) Conducted Susceptibility...

These sections call for a technique called "bulk current injection". This technique is not in use at JPL and does not have universal acceptance. It also requires special equipment to implement. The text should be changed to allow for alternative techniques.

Bulk current injection is a widely implemented non-intrusive technique for common mode susceptibility verification, for both power and signal lines. Bulk current injection is a MIL-STD-461 requirement and test method. Any EMC Lab working with MIL specifications usually has the necessary instruments to perform the test. BCI does not require break-out box but an injection probe (e.g. Solar 9144, price around 2000 $) in addition to the EMC conventional instrumentation. If it is still felt to have problems with this test, we are open to discuss alternative techniques, proposed by JPL, to verify this requirement.

5.14.3.11 H Field Radiated Emission

The 80 dB margin to the susceptibility seems excessive, especially since there is no science magnetometer.

See the second answer given in "General Comment".

5.14.3.12 Arc Discharge

Considering the mission environment, this level appears to be high. In any event this test must not be performed at the system level due to the ESD susceptibility of the HFI detectors. Refer to the note in Section 9.5.6.1.4.3.

The ESD test shall not take place at system (spacecraft) level, as well as when detectors inherently sensitive to ESD are entailed. This was already the baseline before JPL comments. However, the ESD requirement is applicable for standalone equipment not containing detectors (e.g. power supplies, electronic boxes etc.). 5.6 mJ is not at all a big deal if the devices under test have a well- established and implemented grounding. The requirement covers also the possible human-generated discharge during equipment handling, which can achieve the indicated energy. Please clarify the statement “Considering the mission environment, this level appears to be high”.

9.5.6 EMC Verification and Testing

A properly documented EMC test report provides adequate reference to the detail test procedure, test conditions, and test equipment, so that the results can be replicated and/or evaluated by another test agency.

There are too many "shall" statements in this Section. It is too restrictive, imposes methods that are hardware-specific, and contains procedural detail that is excessive. Implementation to the detail presented will become a serious cost driver. This Section should be provided only as a guideline.

See the first answer to the General Comments of JPL.

9.5.6.2 Test Facility□.

"Any condition, method not covered by these requirements or deviation to them shall be agreed with ESA." This is too restrictive and may impose schedule delays. It should be acceptable to use conventional EMC test methods as long as they are adequately described in the approved test procedure. Unanticipated events, which may necessitate "red line" changes in the course of testing, should not have to await approval by ESA.

There is nothing exotic in the test proposed. They reflect very much the MIL-STD-461 and do not re-invent the wheel. Of course, unanticipated events can justify little deviation from the test procedure without ESA approval. However, ESA and/or the Prime contractor have the right to agree the test procedure before the test activity takes place.

9.5.6.2.1 Ambient EM Levels

This requires the unit under test to provide a resistive load to interface with the GSE.

This requires that an external resistive load, which absorbs the equivalent power of the experiment, will replace the unit under test. So the unit under test have not to contain per se the resistive load. In several occasions, GSE generated electromagnetic disturbances (both conducted and radiated) exceeding the instrument specifications of two orders of magnitude.

9.5.6.3 Measuring Equipment/Instrument

A properly documented EMC test report provides adequate reference to the detail test procedure, test conditions, and test equipment so that the results can be replicated and/or evaluated by another test agency.

Since the hardware cognizant engineer and his manager sign-off on the test procedure, additional levels of approval should not be necessary.

See the first answer to the General Comments of JPL.

9.5.6.3.1 Measurement Receivers/Spectrum Analyzers

The blanket requirement for the use of input pre-selectors on modern spectrum analyzers is not realistic. An experienced EMC test conductor would be aware of the test environment and any potential adverse effects due to overloading.

The “blanket requirement” is reported as it is from MIL-STD-461 and it must be a reason for it. Not always EMC measurements are performed in laboratories under configuration control, like presumably is your case. This requirement flags the possibility that the problem described occurs.

9.5.6.3.2 Computer Controlled Receivers

"A detailed description of the operations that are directed by software for computer controlled receivers, shall be included in the test plan. Verification techniques used to demonstrate proper performance of the software shall also be included."

This could be a document in itself! It should only be of concern if there were some major issue with the reported test results.

Some laboratories, instead of using commercial standard software for computer controller receivers, do instrumentation control software ad hoc by themselves. If you have commercially standard software (e.g. HP), there is no additional documentation required. It will be sufficient to mention it in the test procedure or test report, in the section where you declare the type of instruments used in the frame of the test activity.

9.5.6.3.3 Detector Function

> Same comment as above for Section 9.5.6.3.1. There are techniques for susceptibility tests which do not require the use of a spectrum analyzer.
>
> As long as the instruments are calibrated and the units of measurement are provided, it should not be necessary to modify an existing measurement system to comply with an alternate expression of values.

In ESA and, more in general in the frame of the European Industry, we usually monitor what we are injecting. Monitoring is done through the appropriate probes connected a spectrum analyzer.
By the way, the content of the referred paragraph reflects the common EMC calibration practice following the MIL-STD and by all means does not intend to modify existing measurement techniques to comply with another expression of values. On the contrary, if detectors are used that do not provide readings as the standard dictates, the appropriate correction factors shall be applied. This allows degrees of freedom, certainly not restricts the applications!

9.5.6.3.4 Current Probes

> If a commercial EMC current probe is used, this step is unnecessary.

EMC laboratories, which are under configuration control, always have the transfer impedance of the current probe available, as well as the antenna factors.

9.5.6.3.5 Test Antennas

> If commercial calibrated antennas and established procedures are used, this is overkill.
>
> The same comment applies to Sections **9.5.6.3.6** through **9.5.6.3.11**.

These are the conventional antennas used for EMC and prescribed by MIL-STD, plus others that ESA accepts to be used as a replacement. So not only this is not overkill, but is relaxed with respect to the widely accepted EMC standard.

9.5.6.4.1 Measuring Equipment Calibration

> Agencies should be free to establish their own calibration program.

No, sorry. Why then Standards are established? How can you guarantee uniformity in measurements performed in different Labs?

> Is MIL STD-45662A appropriate if an agency is ISO compliant ?

MIL STD-45662A is the universally accepted method of calibration for EMC probes and instrumentation performing MIL-STD like measurements, as it occurs in Space Industry everywhere. A qualified EMC Lab will surely calibrate the instrumentation accordingly to the mentioned document.

9.5.6.4.3 Measurement Bandwidths

These values are equipment-specific parameters.

No, in general EMC instrumentation can tune the receiver bandwidth. In fact, the previously used narrowband/broadband discrimination (now not any more necessary) was possible only due to this capability. We provided a wide range of the acceptable values to ensure coherence with the measurements of different Labs. And there is a large degree of freedom in that.

9.5.6.5 Test set-up arrangement

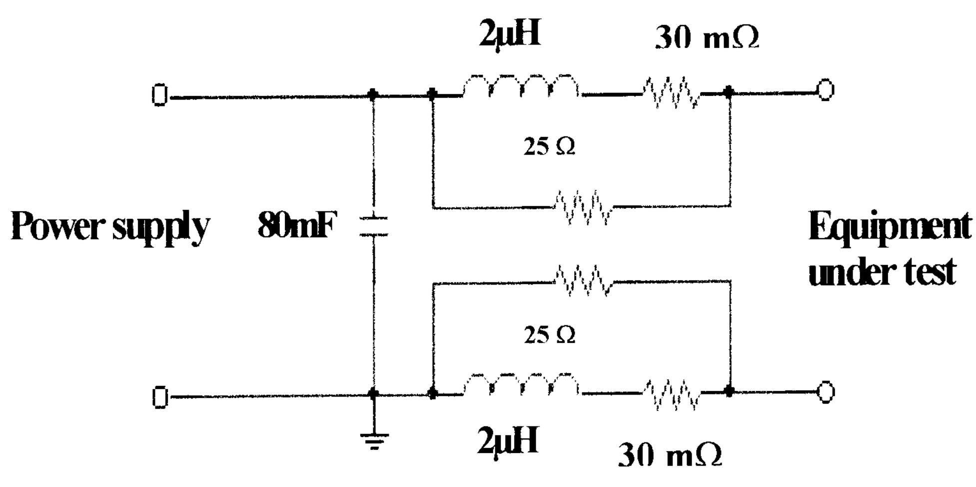
This whole Section imposes a number of constraints, expressed as "shalls", on the unit under test, which may not be practical to implement.

See the first answer to the General Comments of JPL.

9.5.6.9 Line Impedance Stabilisation Network (LISN)

Figures 4.1 and 4.2 are missing or not properly referenced.

You are right. We provide the LISN used to generate the requirements here below:



9.6.5.10 Test Config□..

These are standard procedures for the most part.

Coherently with the previous ESA answers, this statement confirms that there is nothing exotic in what it is specified in IID-A from a EMC point of view.

Ann 5.1

FIRST / Planck EMC Working Group

Meeting 4,

5 Sept 2000

Agenda

1) Status of Action Items
2) Power consumptions of Experiments
3) Status of IID-B's
4) What can be learnt from previous missions, eg can we get information on Boomerang--
5) Convertor Synchronisation
6) HIFI/LFI Space plasma effects at L2.(Alain Hilgers 14:00hrs)
7) Specific experiment topics --eg Sorption Cooler, pulsed vs linear controller, power consumptions and dissipations in electronics and cooler, model of power bus impedance from spacecraft to cooler electronics, JPL comments on EMC spec
8) AOB

Working Group Tasks

- Identification and assessment of potential EMI sources and susceptors
  To be done by questionnaire to be prepared for the instrument teams
- Support instrument teams in the identification of critical elements that require special attention, and in the completion of the questionnaire
- Establish draft instrument grounding concepts
- Prepare instrument return and grounding diagrams
- Establish guidelines for instrument harness design, shielding and routing
- Prepare input for industrial phase modelling.

FIRST/Planck EMC working group members)

Chair :	**B. Jackson**
ESA functional support:	**A. Ciccolella EMC**
	A. Garutti

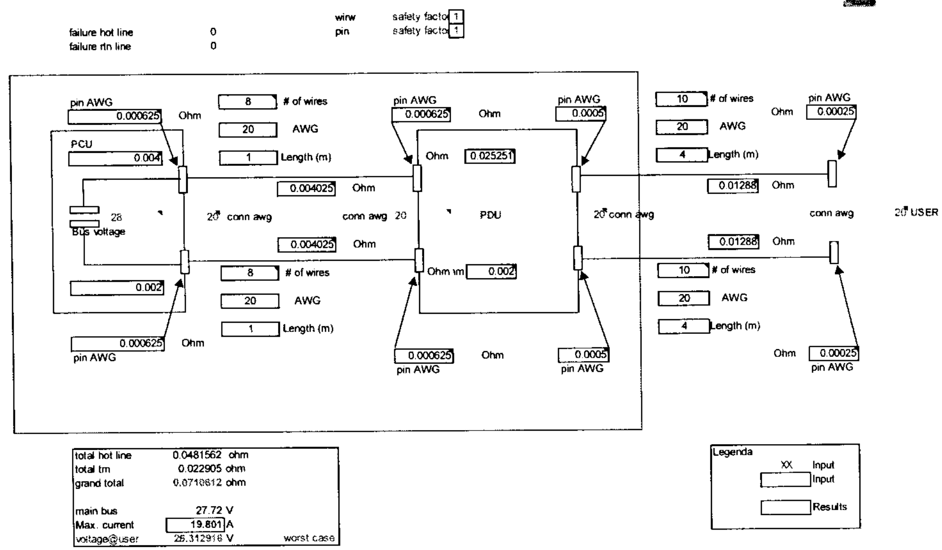
Instrument team representatives:

HFI	**R. Pons, Jean Paul Chabaud**
SPIRE	**Colin Cunningham**
PACS	**M. Rumitz**
LFI	**C. Butler, Roberto Silvestri, Marco Bercanelli, Christophe Vescovi**
HIFI	**Albert Naber, Bert Joost van Leeuwen**

FIRST/Planck EMC Working Group Meetings

Proposed dates:-

Kick off:	CW 11,	17.3.2000
PM#2:	CW 19,	11.5.2000
PM#3:	CW 27,	6.7.2000
PM#4:	CW 35,	5.9.2000
PM#5:	CW 43,	26.10.2000
PM#6:	CW 51,	19.12.00 ← TBC
PM#7:	CW 08,	



5.2.