ELECTRICAL INTERFACES COMPATIBILITY ANALYSIS FOR THE COMS AOCS

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ABSTRACT ... The aim of this analysis is to verify the electrical compatibility of the interfaces which exist between COMS(Communication, Ocean and Meteorological Satellite) AOCS(Attitude Orbit Control Subsystem) equipments and external equipments. For each interface, this study checked the compatibility between equipments for the power links, commands, digital telemetry, analog telemetry and failure condition. In addition with this interface compatibility verification, this study outputs the electrical and manufacturing constraints to be applied at harness level.

KEY WORDS: COMS, AOCS, electrical interfaces compatibility

1. INTRODUCTION

The interfaces between AOCS equipments and external equipments are identified in the Figure 1 [1]. It deals with Linear Analogue Sun Sensors (LIASS) and Bi-Axis Sun Sensors (BASS), Infra-Red Earth Sensors (IRES), Fibre Optical Gyroscopes (FOG), and momentum wheels (WDE, Wheels Drive Electronics, and RDR). For each interface, the following aspects have been studied in order to check the compatibility between equipments:

- Power links: the electrical analysis is focused on DC voltage and current compatibility. Electrical perturbations and transient are also addressed if necessary.
- Commands: the electrical analysis is mainly focused on the command voltage level and duration and the maximum load connected to the command driver.
- Digital telemetry: the electrical analysis is mainly focused on the definition of low and high levels and their correct decoding.
- Analog telemetry: the electrical analysis is mainly focused on the compatibility between the acquisition channel and the sensor operational range and on the study of AC perturbations.
- Failure conditions: the impact of failures is studied in order to check the robustness of the interface circuits and the absence of failure propagations at both ends.

In addition with this interface compatibility verification, one of the outputs of this study is electrical and manufacturing constraints to be applied at harness level:

- Maximum voltage drop for power links
- Twisted wires or shielding for analog signals

Depending on the nature of the analog signal, the AC perturbations are checked using the normalized criteria telemetry in order to identify the most sensitive analog interfaces. When immunity problems are identified, AC perturbations are modelled more realistically then the analysis performs more accurately:

- CM(Common Mode) perturbations: the AC perturbation is modelled with a sinusoidal voltage source, its amplitude is adjusted at a level of 1 Vp and the AC analysis is performed on the frequency range 0 to 10 MHz. The acceptability criterion is to have an attenuation of more than 48 dB wrt(with respect to) the full scale in order to be in line with telemetry resolution requirements which corresponds for the EPS to the 8^{th} bit.
- DM(Differential Mode) perturbations: the AC perturbation is modelled with a sinusoidal voltage source, its amplitude is adjusted at a level of 1 Vp or less depending on the telemetry nature and the AC analysis is performed on the frequency range 0 to 10 MHz. The acceptability criterion is identical to CM perturbation analysis.
- Harness coupling: the AC perturbation is modeled by a transformer in series with the perturbed wire. The transformer has a coupling ratio of 1 and is connected to a sinusoidal current source of 1 mAp amplitude in the frequency range 10 kHz to 10 MHz. The acceptability criterion is identical to CM perturbation analysis. Twisting of wires ensures an attenuation of 40 dB (50 turns/m).

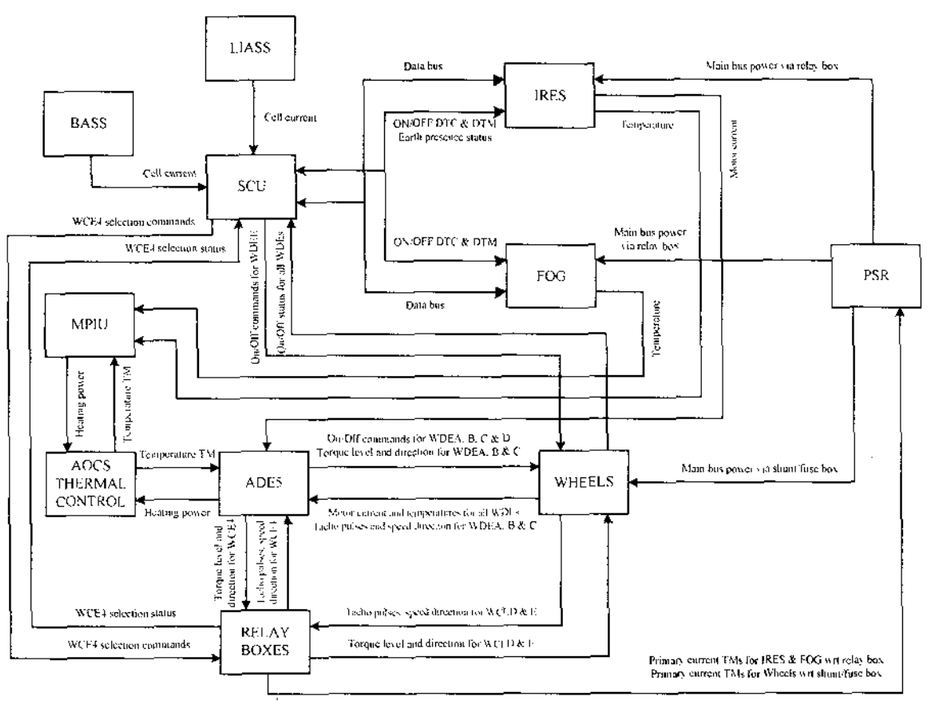

Figure 1. COMS AOCS interfaces.

2. INTERFACES COMPATIBILITY CHECK

2.1 LIASS and BASS Interfaces

Telemetry interfaces:

No electronics is implemented within the LIASS and BASS sensors. The electronics acquisition chain is located in the SCU (Spacecraft Computer Unit) (SAE : Sensor Acquisition Electronics). Each LIASS and BASS sun sensor is directly connected to the SCU interface. This interface includes a transconductance amplifier. The operational TM (TeleMetry) range is largely compatible with the ADC (Analogue to Digital Conversion) characteristics of the SCU. The hardness of the interface to AC perturbations is performed by the output RC first order filter which has a cut-off frequency of 165 Hz. The AC analysis with a DM is shown in Figure 2 and gives a maximum perturbation level of up to 0 dBV for frequencies lower than 10 kHz and up to -40 dBV for higher frequencies. These levels are not acceptable in terms of sensitivity to harness coupling and implies the need for twisted wires. Shielding wires are also required as these signals are critical for the satellite attitude control and have a low current level. The SCU interface for LIASS does not support a wrong connection to a ±16 V. The test stimulation for BASS is performed with a voltage source, the resistance in series with the test input permits to make the voltage to current transformation (500 Ω RM1206 resistors). The maximum test stimulation is limited to 11 V (RM1206 derated power : 250 mW). The connection to ground is compatible with the interfaces at both sides.

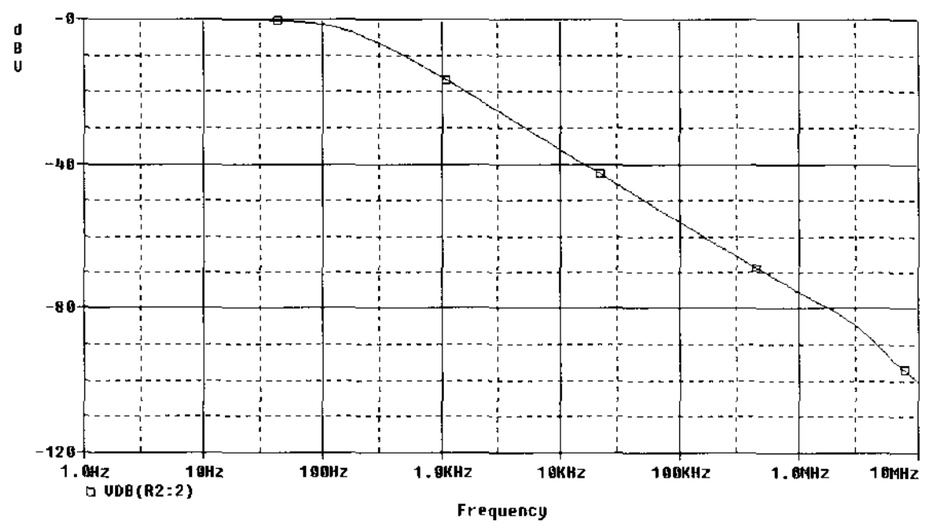

Figure 2. AC perturbations with differential mode in LIASS.

2.2 IRES Interfaces

Power interfaces:

The IRES converter is compatible with a wide voltage range (20 to 52 V) and is largely compatible with the power bus voltage range even in case of degraded mode (down to 35 V). Moreover a diode in series with the power line prevents from damaging of the equipment in case of an inversion of polarity. The input of the converter is protected with an external P600L 2 A fuse within the harness. The IRES power return is done through the structure to reduce the common mode voltage between the primary and secondary voltages of the equipment.

Command interfaces:

The IRES ON/OFF commands are sent by the SCU TC (TeleCommand) matrix and drive simultaneously two relays (TL12 and GP250) inside the IRES. The maximum command current is 190 mA, this value is largely compatible with the SCU TC current capability (650 mA). The minimum operate time is 12 ms for GP250 and 7 ms for TL12, this value is largely compatible with the SCU command driver characteristics (48 ms) and the required derating rules of 100%. The switching voltage has to be in the range 8.4 to 14.8 V for GP250 relays and 9 to 16 V for TL12 relays. The computed values are 12.5 to 15.8 V and are therefore compatible with the minimum TC voltage level (14 V) but are marginally non compliant for the maximum TC level (17 V). This non compliance is nevertheless acceptable since this voltage level is only applied during 48 ms and can not stress relay coils in these conditions.

Telemetry interfaces:

The Earth Presence signal is connected to an SCU MRE (Monitoring & Reconfiguration Electronics) input. The voltage provided by the IRES is in the range 0 to 5 V range whereas the SCU accepts a range from 0 to 15 V. The interface is then fully compatible. The AC analysis with a CM perturbation gives a maximum perturbation level of up to -40 dBV. This level is acceptable and demonstrates the robustness of the interface with regard to CM perturbations. The AC analysis with a DM gives a maximum perturbation level of up to 0 dBV for frequencies lower than 100 kHz (first order filter with a cut-off frequency at 370 Hz) and up to -40 dBV for higher frequencies. These levels are acceptable. Furthermore, this perturbation level of 1 Vp is not realistic since the IRES 5 V supply voltage ripple is lower than 40 mVp (attenuation of more than –28 dB). The AC analysis with a harness coupling is shown in Figure 3 and gives a maximum perturbation level of up to 0 dBV. This figure is not acceptable and requires the use of twisted wires to reduce coupling effects (attenuation of more than -40 dB for a wire of 1.0 m). Twisted and shielded wires will be used to minimise electric field coupling effects.

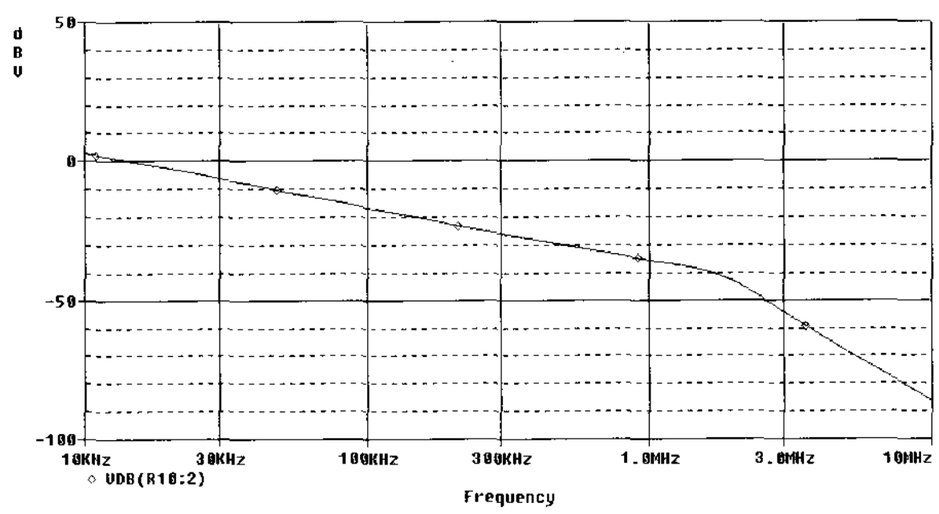

Figure 3. Earth presence harness coupling perturbations.

2.3 FOG Interfaces

Power interfaces:

The GEU (Gyro Electronic Unit) converter is compatible with a wide voltage range (22 to 50V) and is largely compatible with the power bus voltage range even in case of degraded mode (down to 35V). The primary power switching provides by TCs. No protection in case of an inversion of polarity in the power line. The input of the converter is protected with an external P600L 3 A fuse within the harness. The primary under voltage detection (UVD) automatically switches OFF the converter when the power voltage is lower than the triggering voltage value 17.79 V to 19.05 V. The converter automatically restarts as soon as the power bus voltage is higher than the rearming voltage value 18.41 V to 20.19 V when relay of primary power switching is closed.

Command interfaces:

The GEU ON/OFF commands are sent by the SCU TC matrix and drive a GP250 relay inside the GEU. The maximum command current is 145 mA, this value is largely compatible with SCU current capability (650 mA). The minimum operate time is 12 ms, this value is largely compatible with the SCU command driver characteristics (48 ms) and the required derating rules of 100%. The switching voltage has to be in the range 8.4 to 14.8 V. The computed values are 11.8 to 15.8 V. These values are compatible with the min TC voltage level (14 V) but marginally non compliant for the max TC level (17 V). This non compliance is nevertheless acceptable since this voltage is only applied during 48 ms and can not stress relay coils in these conditions.

Telemetry interfaces:

One internal temperature is monitored externally with FENWALL 15K thermistor located within the converter. This thermistor is acquired by MPIU (Modular Payload Interface Unit) TTI (Telecommand and Telemetry Interface) temperature acquisition channel. The operational TM voltage range is largely compatible with the ADC characteristics of the MPIU. The results of the AC analysis give a maximum perturbation level of –18 dBV. This figure needs to be improved and are attenuated with twisted wires to reduce coupling effects (attenuation of more than -40 dB for a wire of 1.0 m).

2.4 Wheels Interfaces

The connection between the ADE5/WCE and the five wheels is depicted in Figure 4. The configuration is composed of 5 momentum wheel assemblies (RDR 68). The MWA (Momentum Wheel Assembly) is composed of a momentum wheel (MW) and its associated wheel drive electronic (WDE). The WDEs are commanded by the ADE5 (Actuator Drive Electronics) with the power provided directly by the 50 V primary bus to the wheels electronics. RDR1, RDR2 and RDR3 (XZ plane RDR) are fully cross-strapped, they are connected to ADE5/WCE (Wheel Control Electronics) prime (A) and redundant (B). These wheels can either be commanded by their corresponding command path A or B. RDR4 and RDR5 (Ysat RDR) are connected to the fourth nominal and redundant command path (WCE4-A and WCE4-B) through their cross-strapping relays.

Power interfaces:

The wheel converter is compatible with a wide voltage range (24 to 51 V) and is largely compatible with the power bus voltage range even in case of degraded mode (down to 35 V). The wheel inrush current is shown in Figure 5. The required energy during inrush is 0.001 A^2s. The input power is protected with an external P600L 6 A fuse within the harness. The fuse can survival 4.1 A^2s energy according to the manufacturer data sheet. The fuse has enough margin ratio with DIET (Design Interface Environment and Test for Equipment) criteria (more than 4 margin ration for transients energy).

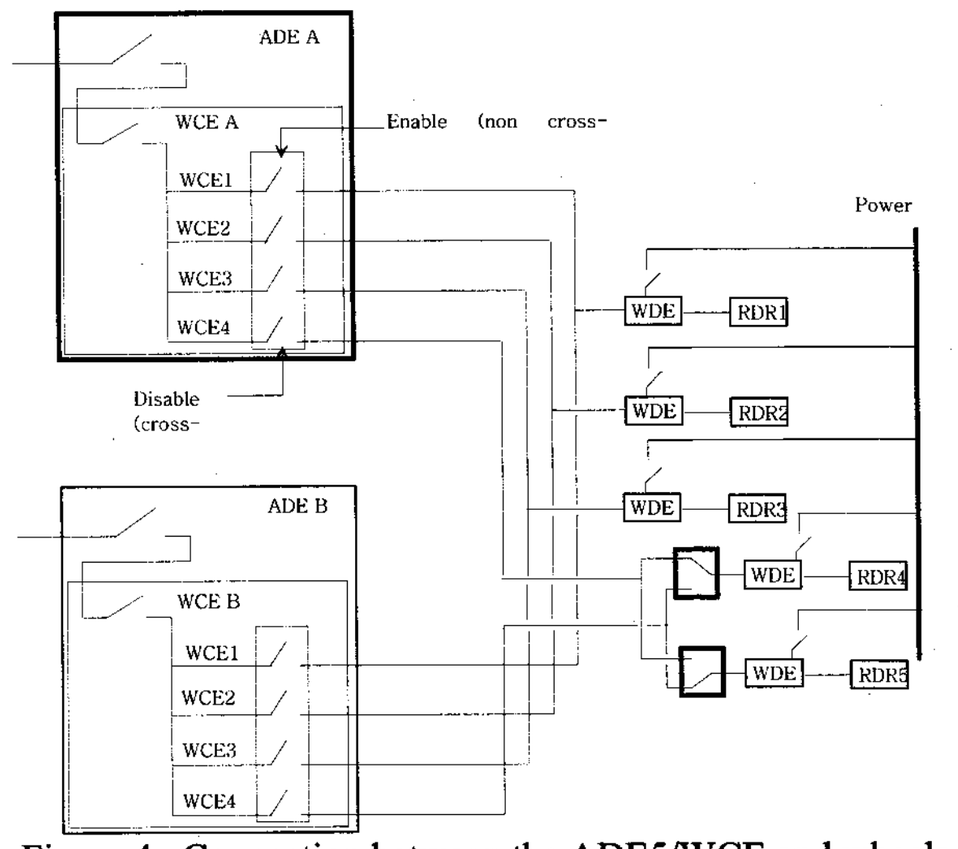

Figure 4. Connection between the ADE5/WCE and wheels.

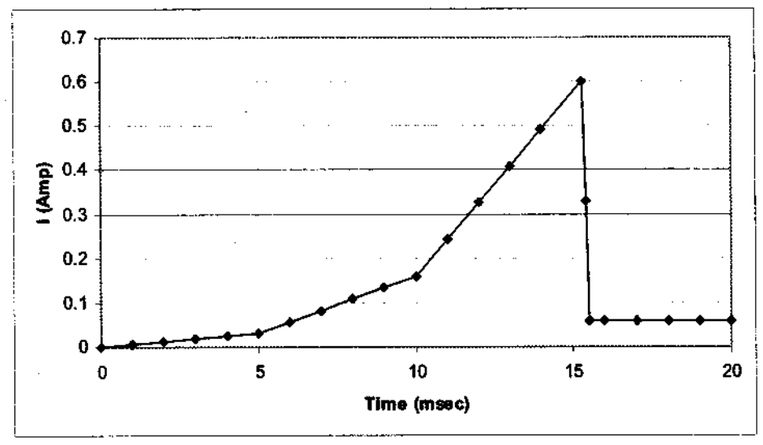

Figure 5. Wheel inrush current.

Command interfaces:

The analogue torque command interface is composed of a trans-impedance amplifier which is linked to a RC filter connected to a follower amplifier. Each ADE5A and ADE5B WCE torque command interface is connected to a dedicated wheel input, both inputs are connected together at follower amplifier input level. The ADE5 interface delivers output voltage in the range 0 to 11 V while the MWA interface accepts voltage in the range 0 to 17 V with a saturation at 10 V. The MWA voltage range has been enlarged to cope with DC common mode compensated by the close loop command, the interfaces are then fully compatible. The immunity to DM or CM perturbations is lower than –20 dBV at 10

kHz (-5 dBV at 1 kHz) and less than –50 dBV at 200 kHz. The levels are completely acceptable as the wheel close loop command is performed at low frequency and frequencies from 1 kHz to 200 kHz (BDR and ASR switching frequency range) are attenuated by the inertia of the wheel. The AC analysis gives a maximum perturbation level of up to 0 dBV. This level is acceptable as the wheel close loop command is performed at low frequency and high frequency perturbations are attenuated significantly by the inertia of the wheel. The interfaces at both sides withstand a maximum fault voltage of up to 50 V and a direct connection to ground.

Telemetry interfaces:

The ON/OFF status of the MWA is given by a secondary voltage equal to 13 V and is acquired by a bilevel acquisition channel of the SCU. The interface is on MWA side supports without damage a wrong voltage connection of up to 16 V. The interface is on SCU side supports also without damage a ±16 V wrong voltage connection. Both interfaces are compatible with a connection to ground.

WCE and wheels interconnection:

These interconnections between the WCE functions and WDEs of RDR wheels are shown in Figure 6 and are specific to the five wheels configuration applicable for COMS. These interconnections permit to control with ADE5A and ADE5B WCE4 function, RDR D or RDR E wheels.

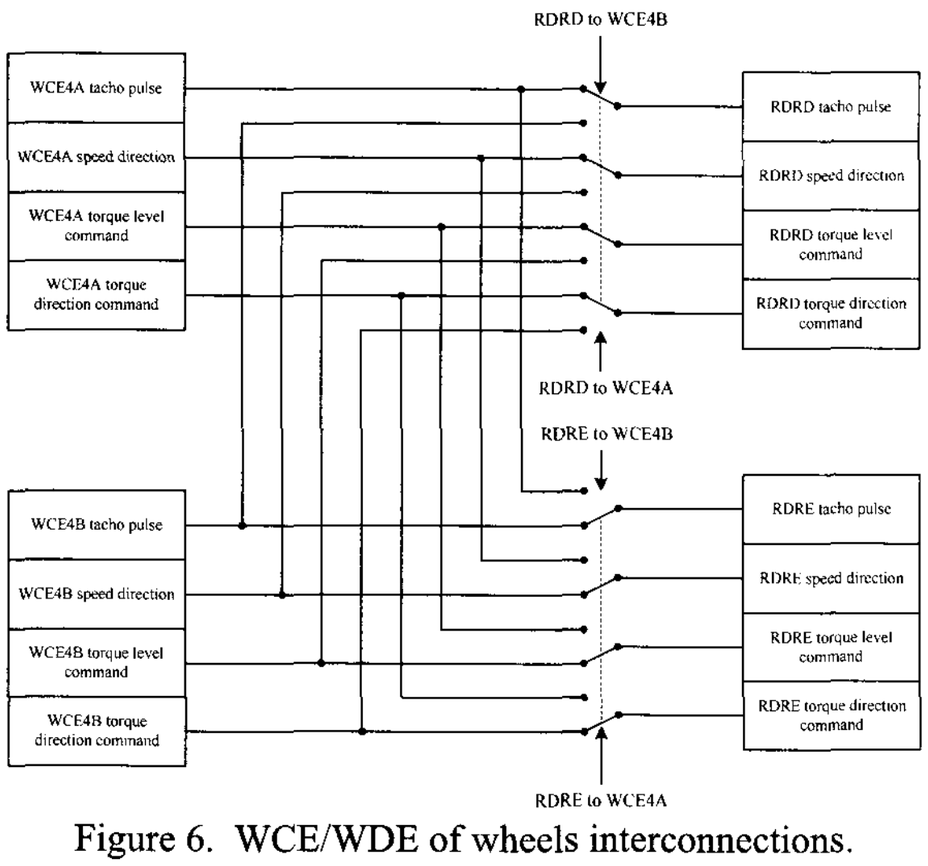

Figure 6. WCE/WDE of wheels interconnections.

3. SYNTHESIS AND CONCLUSIONS

The results of this electrical compatibility analysis performed on AOCS interfaces have demonstrated the correct sizing and level of robustness of the AOCS interface circuits.

- Command interfaces: The analysis of the AOCS command interfaces is satisfactory. The only points to be mentioned are the maximum voltage levels of TL12 and GP250 relays which are slightly exceeded (less than 2 V) during the TC pulses (49 ms max), this derogation is acceptable. Harness requirements in terms of voltage drop or double insulation are also addressed.
- Digital acquisition interfaces: The analysis of status interfaces is satisfactory. Shielded wires shall be used for tacho pulses, twisted and shielded wires shall be used for earth presence status.
- Analog acquisition interfaces: The analysis of the AOCS analog interfaces is satisfactory. All AOCS analog acquisition interfaces shall use twisted and shielded wires except temperatures, IRES motor current and wheel motor current (only twisted pairs).

Some flight interfaces are by nature more sensible to AIT (Assembly, Integration and Test) errors and shall be subjected to a particular attention:

- AOCS temperature TM: These lines are only compatible with a maximum fault voltage of 25 V.
- Wheels, FOG and IRES shunts: All these lines are protected by fuse, a short to ground will lead to the blowing of the corresponding fuse (signal protection fuse with 0.375 A P600L for wheels, IRES and FOG).
- BASS and LIASS sensors interfaces: The SCU SAE interfaces are only compatible with a maximum fault voltage of 11 V (for test interfaces : 16V for LIASS, 11V for BASS).
- IRES earth presence interface: The IRES interfaces are only compatible with a maximum fault voltage down to -5 V.
- IRES and wheel motor current interfaces: The IRES interface is only compatible with a maximum fault voltage of 16 V, the wheel motor current interface is not compatible with a negative voltage.
- Bolometer test interfaces for IRES optical simulation: this interface is only compatible with a max voltage of 20 V.
- Wheel torque direction interfaces: These interfaces are only compatible with a maximum fault voltage of 16 V.
- Wheel ON/OFF status interfaces: These interfaces are only compatible with a maximum fault voltage of 16 V.
- Wheel speed direction and tacho interfaces: These interfaces are only compatible with a maximum fault voltage of 22 V.
- Tacho test interfaces: These interfaces are only compatible with a maximum fault voltage of 7 V.

The maximum voltages given hereabove permit to ensure component derating rules even in case of AIT errors and by consequence include comfortable margins with regard to rated values.

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