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Lunar Gateway PMAD test results (GHPS for HALO and iHAB)
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CRISA

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The Challenge – Human-Rated High Power

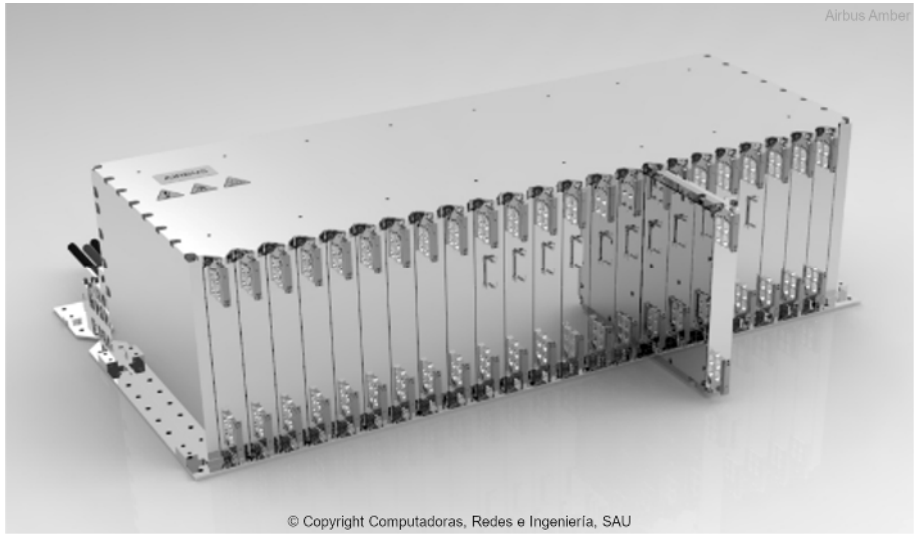
Humans in Space

A new era of human space exploration is emerging, led by institutional and private actors.

- **GHPS** (**Generic High Power System)** is the **Airbus Crisa** product developed in collaboration with **Northrop Grumman** to provide high power conditioning and distribution capabilities for crewed and exploration missions.
- GHPS has been conceived as a **standard product** for the new generation of crewed missions to:
  - **Moon** Gateway space station (and eventually lunar surface permanent base).
  - **Mars** human exploration.
  - **Earth** Orbit space stations.
  - Space planes.

Generic High Power System (GHPS) key features

- ❑ Designed for crewed exploration compliant with NASA standards
- ❑ In-flight maintainability and reparability
- ❑ Scalable up to 32kW regulated platforms up to 130V
- ❑ Isolated and bidirectional 120V and 28V Buses
- ❑ Smart and autonomous voltage regulation
- ❑ 120V and 28V power distribution:
  - ❖ Heaters
  - ❖ Latching Current Limiters (LCL)
  - ❖ High Current active LCL
  - ❖ Return switches



Human environment “on top”

Pressurized/ unpressurized operation

30% oxygen atmosphere

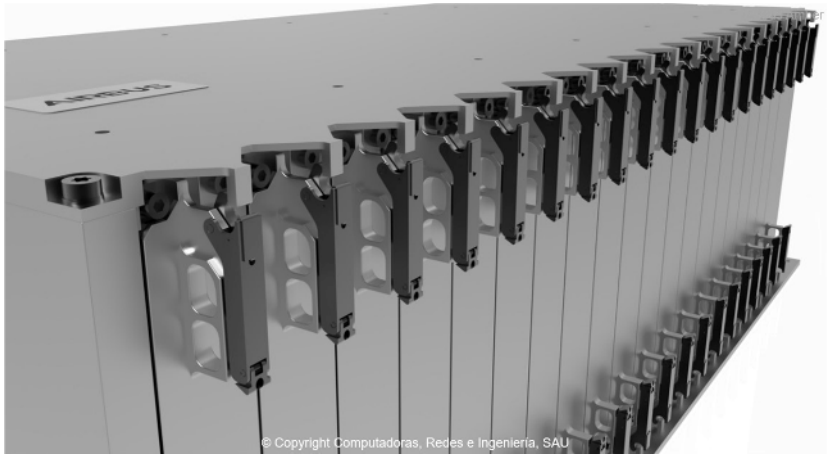
Human safety

Double failure tolerance

Spilled liquids

70% relative humidity

Heat evacuation vs. hot surfaces



MANTAINABILITY

- Easy manipulation through insertion / extraction levers
- All cards are replaceable in orbit by the crew
- A single card type can be used in different slots and boxes
- Cards are initialized by Master Controller with specific settings depending on the slot where they are inserted

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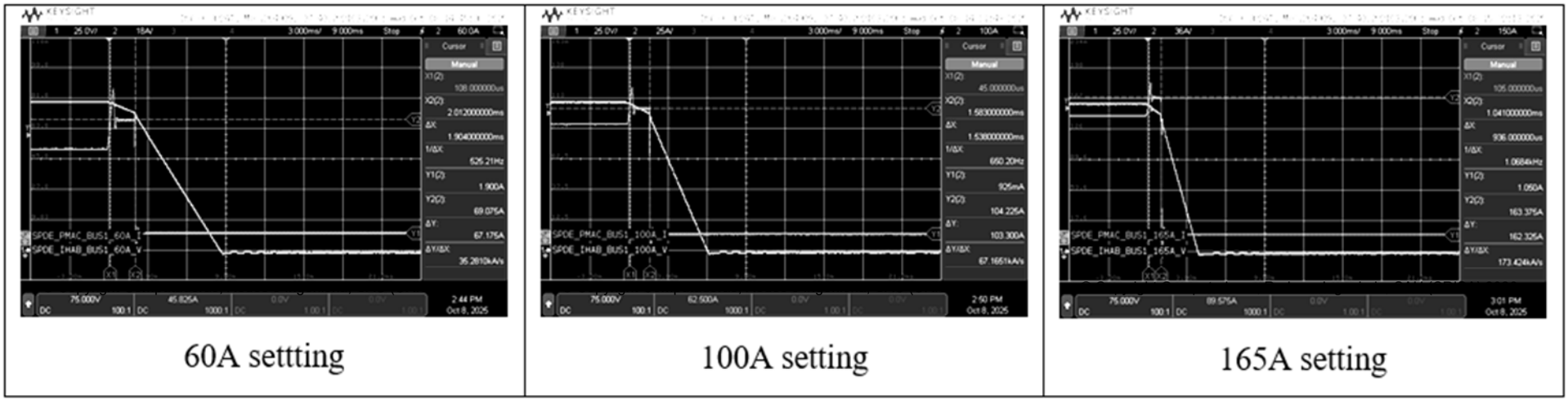
GHPS Test Results

Solid-State Based – The Primary Bus Switch (PBS) – Current Limitation

Key features:

- ✓ 20A to 165A current limit level in-flight adjusting to mission phase by command from the avionics.
- ✓ Bidirectional protection (two cards in series) and current monitoring.
- ✓ On/Off capability by command from the avionics.
- ✓ Rearming capability by command from the avionics.
- ✓ Digital status of command, actual output and consistency between actual and commanded statuses.
- ✓ Additional electronics to handle inrush charges at start up.
- ✓ Automatic trip-off time adjustment to current limit setting level.



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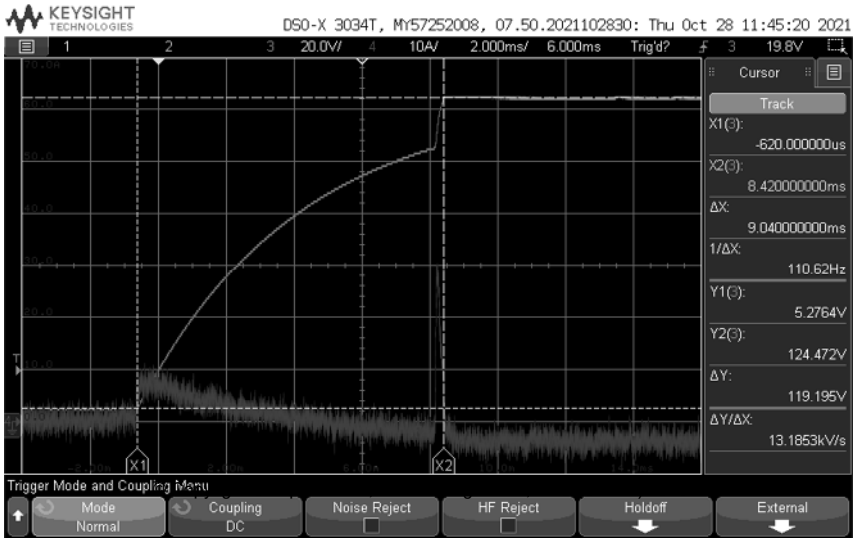
Solid-State Based – The Primary Bus Switch (PBS) – Inrush Charge

Key features:

- ✓ DBR: Dead Bus Recovery: function that will rise the voltage in a power bus while managing smoothly the dV/dt during the process
- ✓ Two phases:
  1. Exponential: driven by the DBR
  2. Linear: driven by the LCL current limitation



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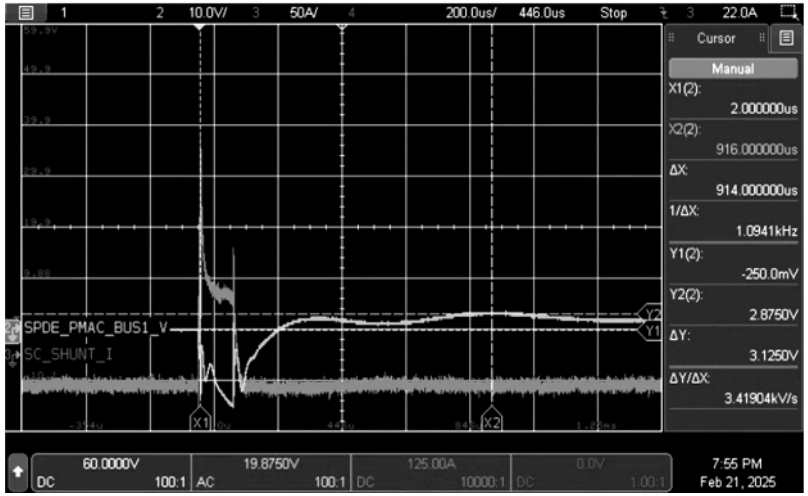
Solid-State Based – The Primary Bus Switch (PBS) – Input Overvoltage limit

NASA requirement: limit input overvoltage to less than 180 V.

For example: abrupt disconnection of the unit and harness energy dissipation.

Key features:

- ✓ After trip-off event of the PBS the input voltage transient is measured.



- ✓ 3 V transient

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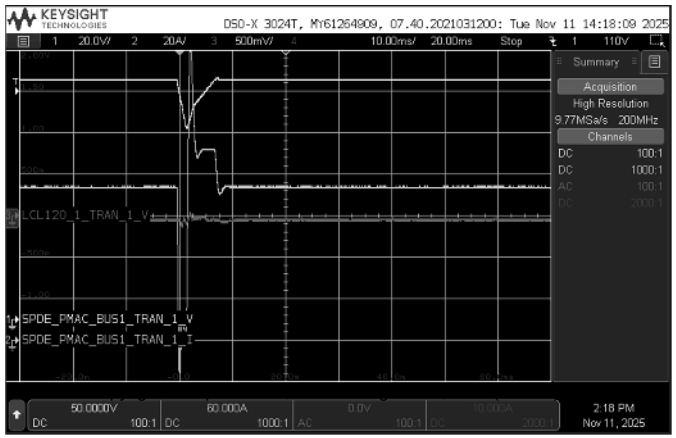
Solid-State Based – The Primary Bus Switch (PBS) – Input transients

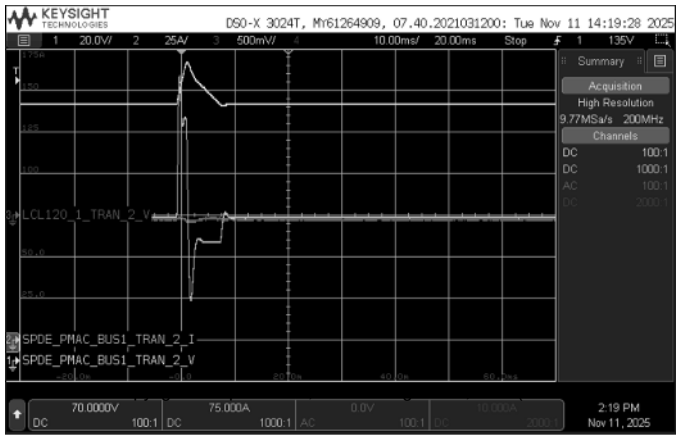
NASA requirement: compatible with 98V and 142V transients.

Key features:

- ✓ After trip-off event of the PBS the input voltage transient is measured.



Undervoltage transient



Overvoltage transient

- ✓ Plots show the immunity to those transients

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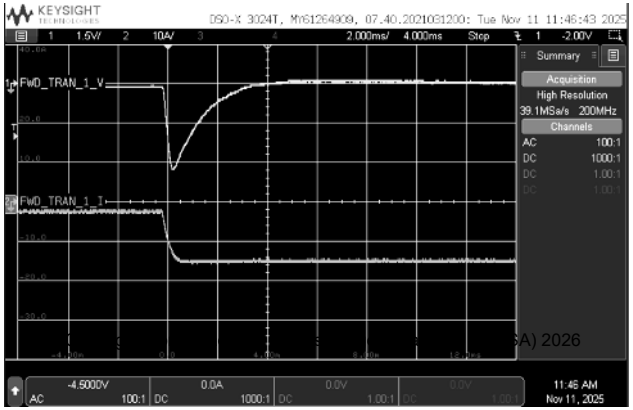
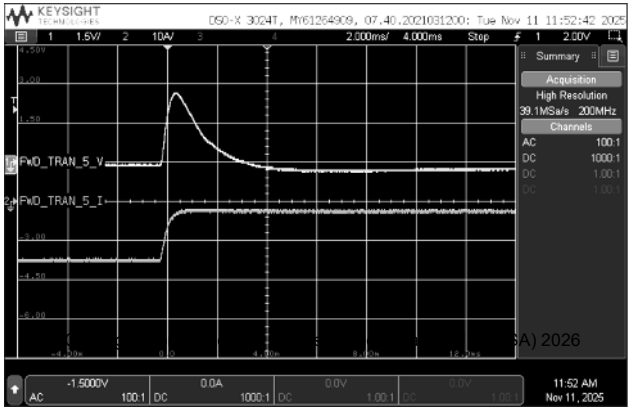
Universal 3 kW Isolation Converter – Transients

Key features:

- ✓ 3 kW power capability per card
- ✓ Possibility to parallel any number of cards
- ✓ Conductance control scheme control governed by a reliable one failure tolerant majority voter
- ✓ Fully digital control via FPGA

NASA requirement: requirements limit the voltage transient magnitude to +/-5 V.





✓ +/- 3 V transient over 15 A load steps. Measured over the docking interface.

NOTE: green signal is the current where the sign of the current is reversed.

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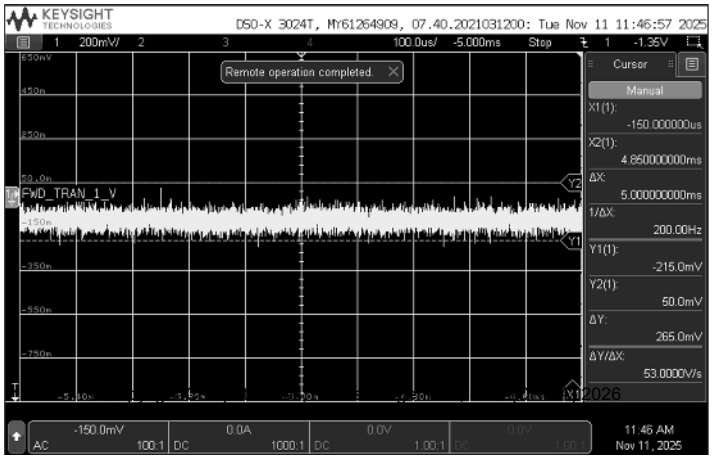
Universal 3 kW Isolation Converter – Ripple

NASA requirement: 1.75 Vpk in a 30 Hz to 1 MHz bandwith.



✓Measurement result = 265 mV.

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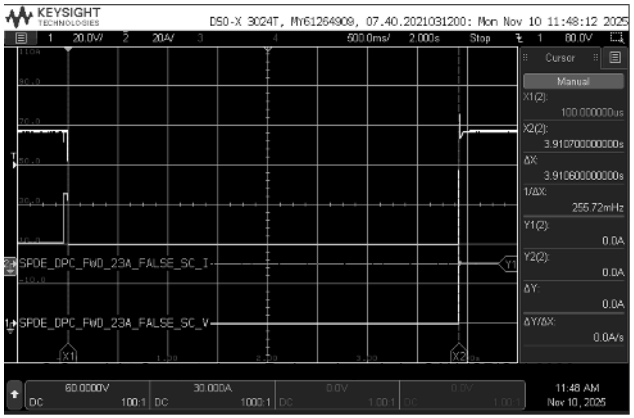
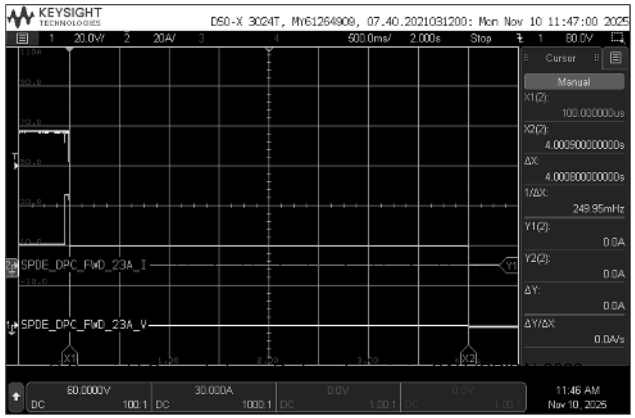
Universal 3 kW Isolation Converter – Abnormal voltage limits

NASA requirement: abnormal voltage limits for undervoltage and overvoltage. These requirements basically refer to the expected power source behavior in front of load failures and the required time window for eventual failure clearance. Power interface shall switch off in case that load failure persists for more than 4 seconds.





✓GHPS docking interface abnormal transient. Yellow trace is output voltage. Left plot: load failure below 4 seconds, converter resumes nominal operation. Right plot: load failure lasts more than 4 seconds, converter switches off.

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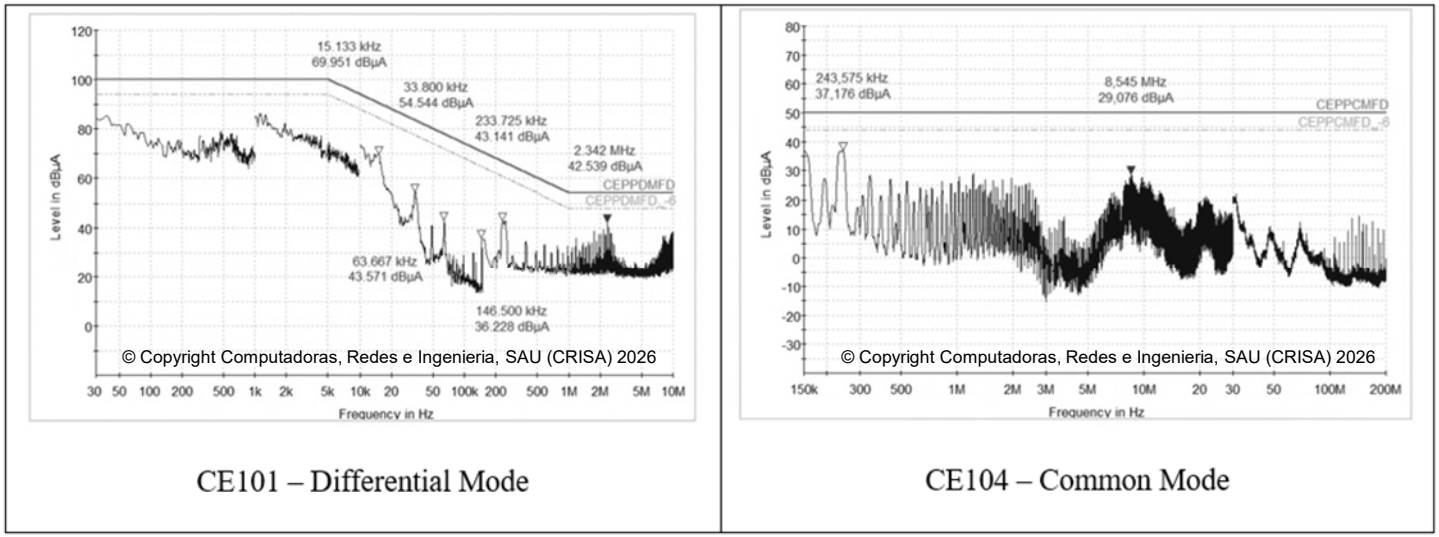
GHPS EMC Test Results

EMC Conducted Emissions and Susceptibility Test

- GHPS has undergone extensive EMC Conducted Emissions tests.
- according to requirements derived from MIL-STD-461-G, tailored to the GHPS application case power level.
- All DCDC conversion stages were operating when measuring conducted emissions, in order to maximize the time and frequency domain of the GHPS hardware.



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Conclusions

Conclusions

Key points regarding the **GHPS** (Gateway High Power Subsystem):

- ✓ **Design Philosophy:** A flexible and modular product specifically engineered for **human-rated** space missions.
- ✓ **Versatile Applications:** Features a wide portfolio of building blocks suitable for space stations, lunar rovers, and Moon surface bases.
- ✓ **Power Capacity:** Capable of handling power levels ranging from a few to **tens of kW**.
- ✓ **Mission Readiness:**
  - ❖ Successfully passed **Critical Design Review (CDR)** with NASA and ESA.
  - ❖ Engineering models have been **delivered** to customers.
  - ❖ The first **flight model** is currently in the Assembly, Integration, and Test (AIT) phase.
- ✓ **Proven Compliance:** Exhaustive testing on engineering models confirms full electrical and functional compliance with **NASA EPS requirements** for crewed missions and electromagnetic compatibility standards.

Thank you

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