EDHPC 2023

High Efficiency, Versatile and Space Tolerant Point Of Load

DEFENCE AND SPACE

October 2023

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Lucien LECOCQ

AIRBUS

Space Electronics

450
France workforce

Paris

Toulouse

Governments, institutional and enterprises from multiple areas and fields

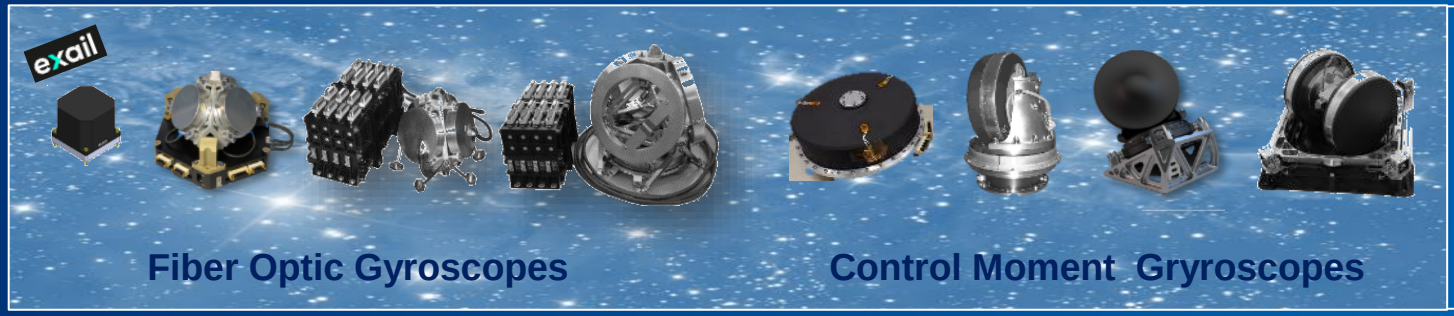
> 40%
Export

- Worldwide Electronics and Sensors / Actuators reference for Space
- New Space & Conventional Space solutions from design and technologies, up to manufacturing & test processes
- Pioneer and qualify space technologies for future spacecrafts, launchers & space systems
- Attractive for talents by offering key competences acquisition and efficient collective knowledge management

Space Electronics reliable & large unit portfolio

Power & Propulsion Units

Platform & Payload Processing Units

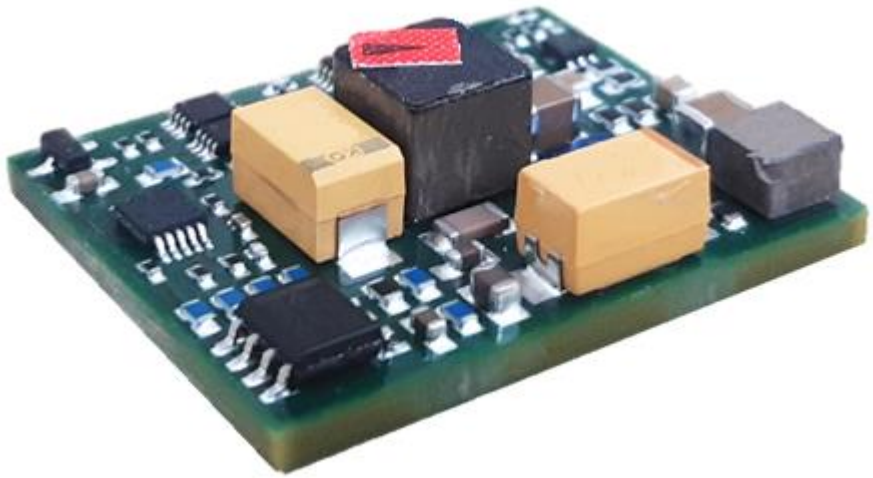


Sensors & Actuators

www.airbus.com/en/products-services/space/equipment

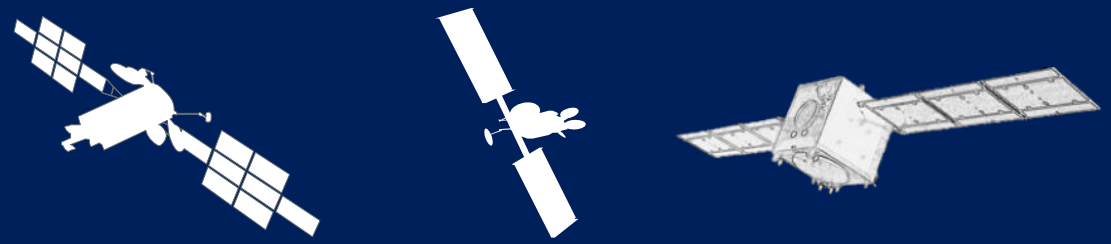
POLLUX

High Efficiency, Versatile and Space Tolerant Point Of Load



From Airbus Space Electronics France

Presentation agenda



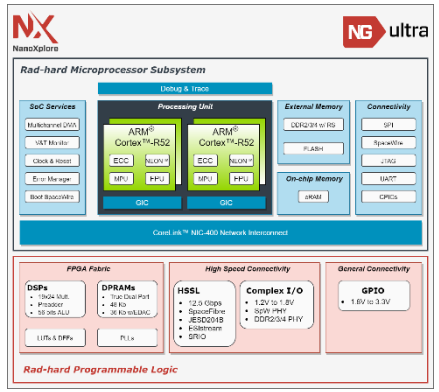
- Why High Efficiency, Versatile and Space Tolerant Point Of Load?
- Electrical features & performances
- Reliability & Radiation
- Successful implementation

AIRBUS

Why High Efficiency, Versatile and Space Tolerant Point Of Load?

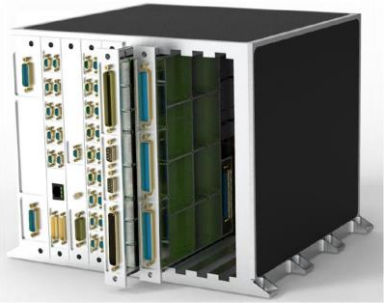
2 major trends on the Space market:

- Use of **next generation of FPGA & SoC** like NG-Ultra from NanoXplore
  ➔ Requiring **multiples rails** with **high current** and low voltage



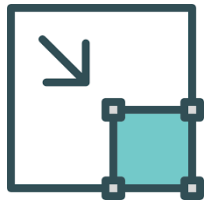
- **Standardization** initiative with **Advanced Data Handling Architecture** (ADHA) initiated by ESA and its partners
  ➔ **12V internal bus voltage** distributed to every board

  Supported by an internal Airbus initiative called Unified Avionics



Advanced Data Handling Architecture

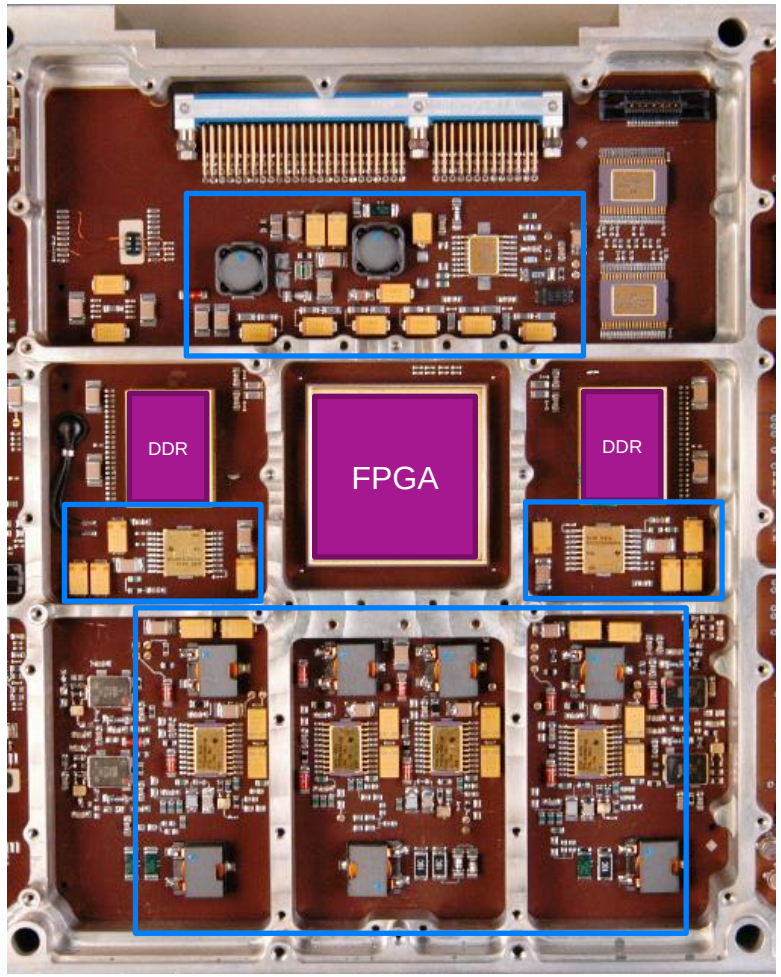
Necessity to **shrink the power supplies** of digital functions



Starting point

Starting point

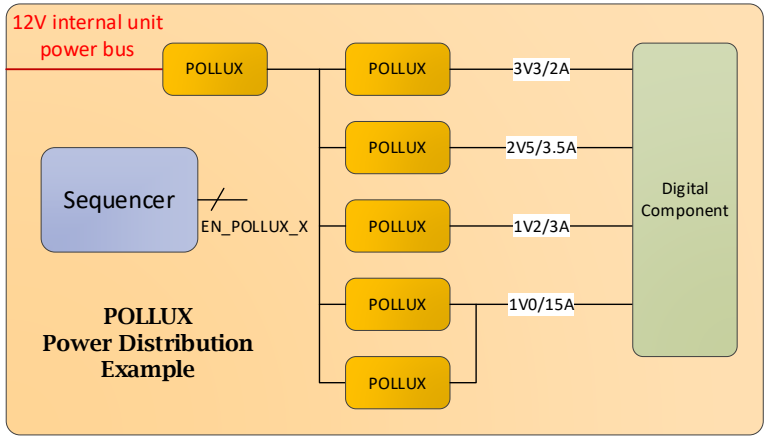
- Bulky secondary power solutions using **more than 60%** of the digital board
- **Not suited to 12V** power distribution



Power management solution for medium power FPGA
(Airbus DS legacy design)

Concept & Goals

Power management architecture



Example of Power management architecture for high power FPGA

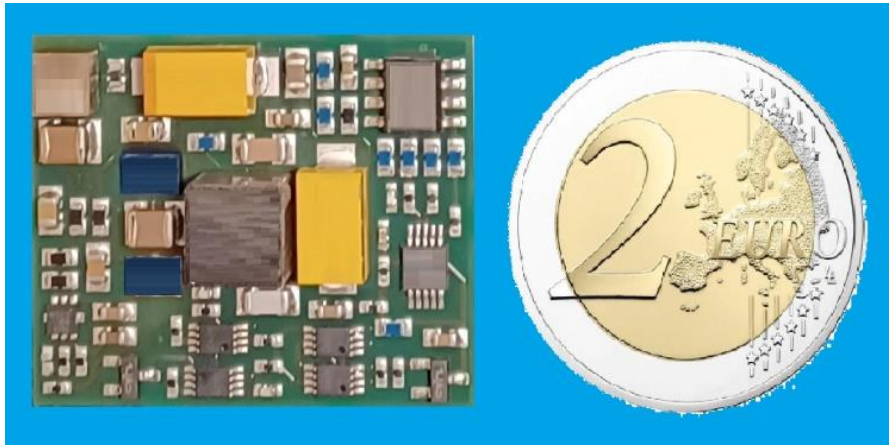
Target

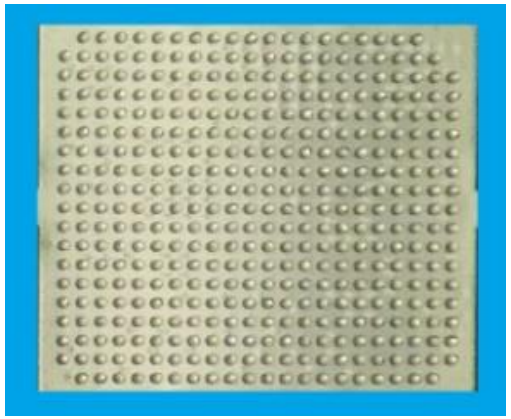
- A **single configurable design** that answers to every needs ➔ **Versatility**
- **Macro component** approach to ease its use (discrete Point of Load embedded on a dedicated PCB)
- **Small** to limit the footprint of the power management solution (~10% of the board)
- **Rad hard tolerant**: 60 MeV.cm²/mg & 50 krad
- **Class1 quality** and **competitive for New Space** applications

Macro component approach

The POLLUX

POLLUX design





25x30mm² Macro component with BGA assembly

Compatible for both high reliablity class 1 mission & New Space mission

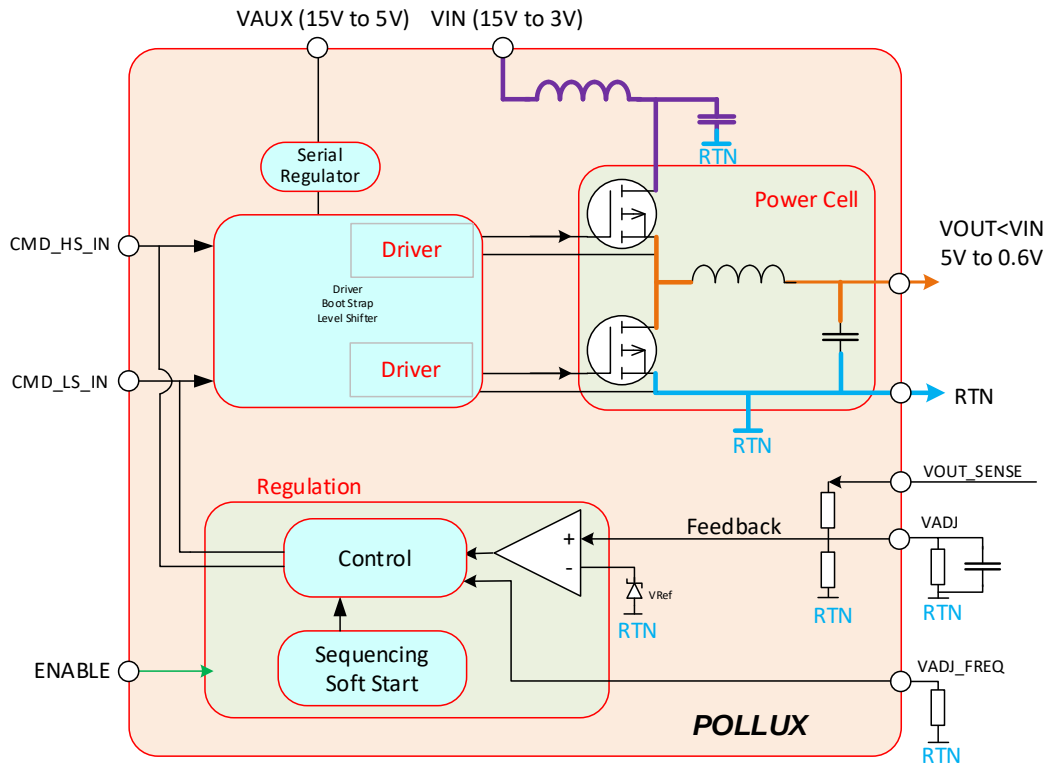
Electrical features & performances

POLLUX characteristics

- **COTS based**, upgraded for **Class 1** programme
- **25x30mm²** BGA assembly
- **GaN** power stage
- Max output power **up to 30W** (10A output current)
- **Parallelizable**
- **Adjustable Vout 0.6V to 5V** with external resistor
- **Wide input voltage range (3V to 15V)**
- **High accuracy +/-3% in EoL**
- **High efficiency up to 95%**
- Adjustable Soft start with external capacitor
- Operating frequency 500kHz, adjustable with external resistor

Environment

- Main board temperature -35°C to 85°C
- Radiation TID & SEE :
  - SEL, SEB, SEFI LETth > 60 MeV.cm²/mg
  - Recoverable SETs within specifications
  - Total Ionizing Dose 50 krad
- 15 years mission



POLLUX block diagram

Enablers

Enablers

- Use of **GaN** technology
  - Much better Figure of Merit than MOSFET
    - Lower ON resistance
    - Lower switching losses

➔ **Higher efficiency**

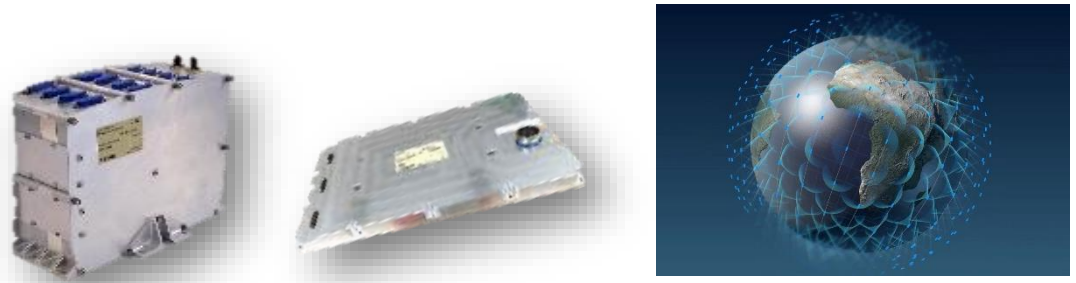
➔ **Higher power density**

- Use of **Commercial-Off-The-Shelf** parts (COTS)
  - Expertise built on Airbus DS strong heritage with OneWeb & OneSat
  - COTS components, carefully selected after extensive radiation and reliability tests
  - Specific mitigation techniques are implemented in the design to guarantee reliability and robustness equivalent to any Hi-Rel design

[EDHPC2023] Denis Galiana et al., "ADS SpE Fr - New Space Electronics for OneSat Avionics"

➔ **Smaller parts**

➔ **Cost effective solution**

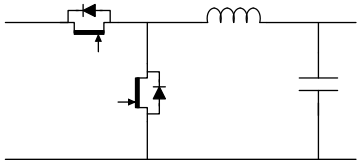


Oneweb constellation products (OBC & PPU)

OBC for Onesat the new Airbus Telecom plateform (OneSat CDMU)

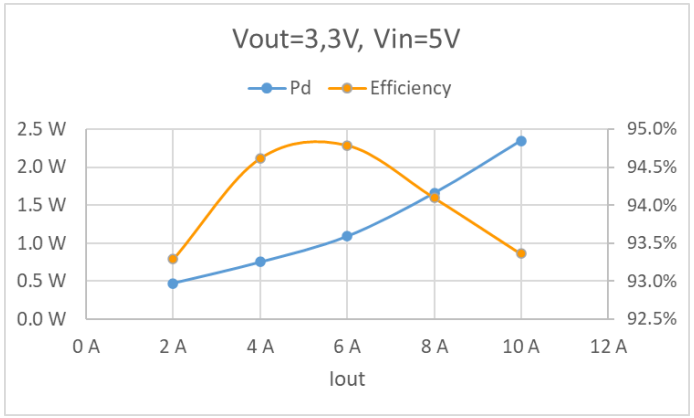
Design & performances

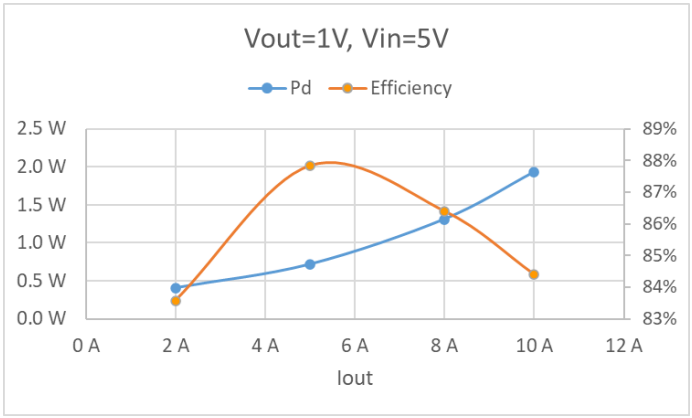
Buck topology with synchronous rectifying



- Simple & Efficient

➔ High efficiency up to **95%**

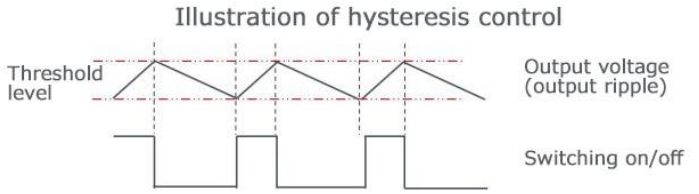




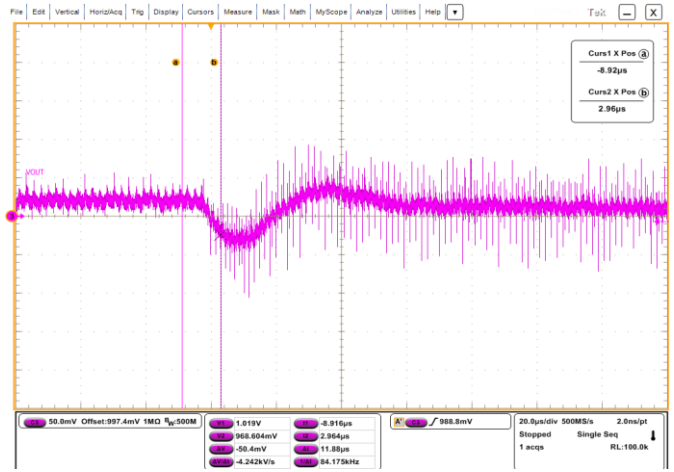
Hysteretic control

- High bandwith → very good dynamic response

➔ **Very good response to load step**



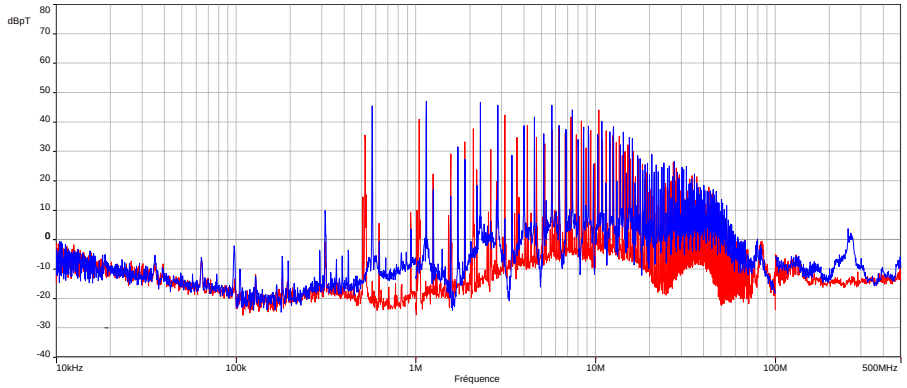
0A to 10A load step (with no extra output capacitor)
→ ΔVout < 50mV



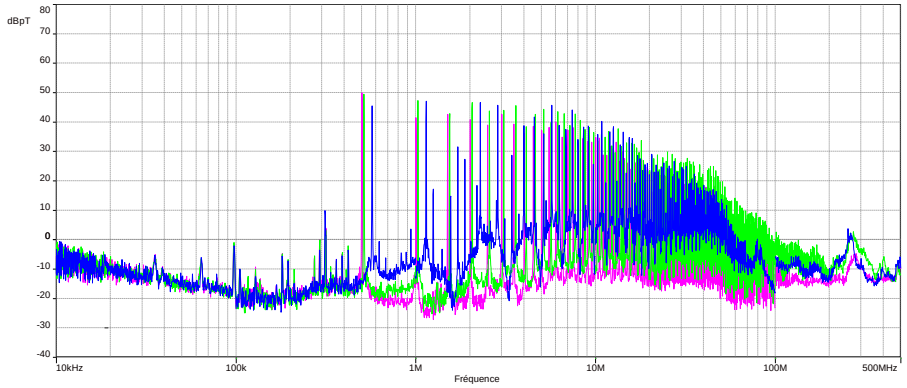
Design & performances

EMC

- Good radiated EMC performances



Comparison with a solution based on MOSFET
POLLUX versus **MOSFET IC design**



POLLUX - EMC results for different operating points
3V3 to 1V @ 5A
12V to 5V @ 5A
12V to 5V @ 2A

EMC performances as good as classical design based on MOSFET IC

Reliability & Radiation

A **special care** is taken with regards to GaN technology as it is a **new technology** and as there is **no standard** yet

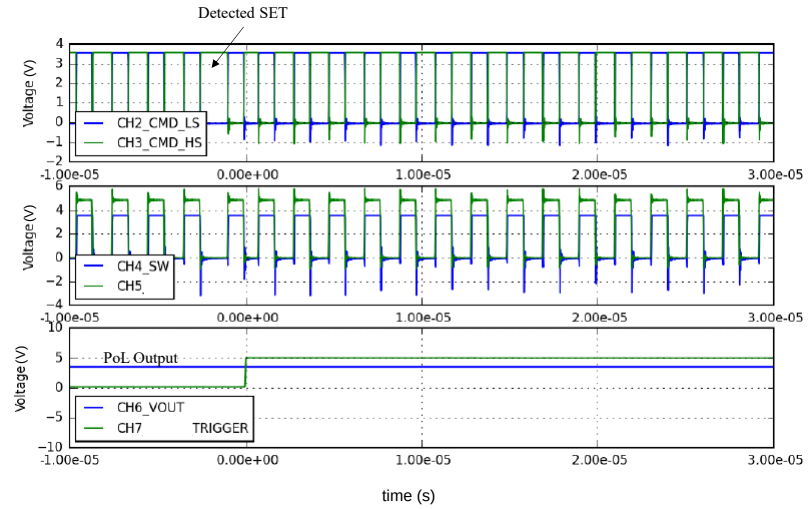
- Dedicated screening put in place for all GaN parts to guarantee the right reliability at technology level
- Power Cell life test qualification where the GaN is tested in his application environment : « Test as we fly »

[EDHPC 2019] Marco Carbone et al., "Overview of GaN FET Technology, Reliability, Radiation and Market for future Space Application"

POLLUX **full design** as been evaluated in radiation (TID and SEE)

- All parts have been evaluated in SEE individually
- Design mitigation techniques have been implemented
- « Test as we fly » has been done in SEE

➔ **SET free** at output level & performances guaranteed up to **50 krad**



Specific actions put in place to guarantee both **reliability & robustness** at **technology & application level**

Industrialization

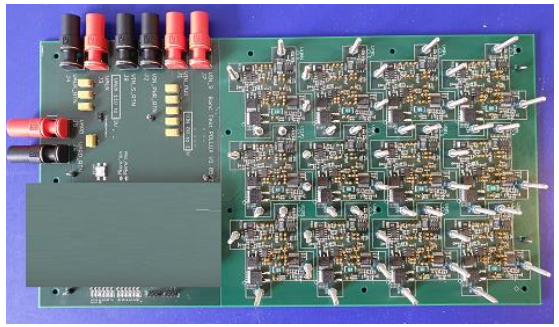
Optimized industrialization flow including manufacturing & test

- POLLUX are manufactured in **panel** with a **full automated** assembly process
  Taking benefit of the full automated production line in Airbus Space Electronics in Elancourt

POLLUX manufacturing panel

Full automated production line in Airbus Space Electronics in Elancourt

- **Automated test** bench at panel level for burn in & acceptance tests



POLLUX Automated test bench

➔ **Cost optimization**

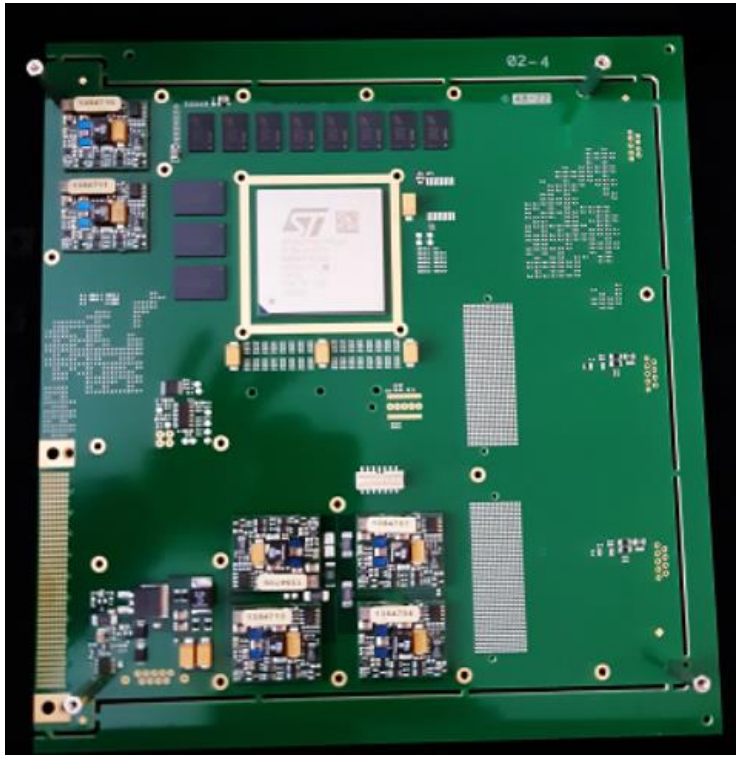
Successful implementation

POLLUX has been **implemented successfully** on the **core of Airbus next generation processing board** called Mytikas

- Mytikas = NG-Ultra FPGA + DDR4 + Flash

➔ **Compatible with very high density layout**

➔ Power solutions **footprint reduced by a factor of 6**



Mytikas demonstrator

[EDHPC 2023] Frédéric Neveu et al., "Mytikas Demonstrator"

POLLUX is a **key enabler** for **compact high performance processing board**

Conclusion

Thank you for your attention

For further information please contact us:

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www.airbus.com/en/products-services/space/equipment