

Space photonics research projects: SIPHODIAS and optical transceiver characterization

Aintzane Lujambio Genua | 07.03.2023

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Space photonics research projects

Outline

- 1. Introduction**
- 2. SIPHODIAS**
- 3. Study on optical transceivers**
- 4. Next steps**
- 5. Conclusions**

Introduction

Space photonics in ALTER TECHNOLOGY

Use of photonics in space is a clear trend.

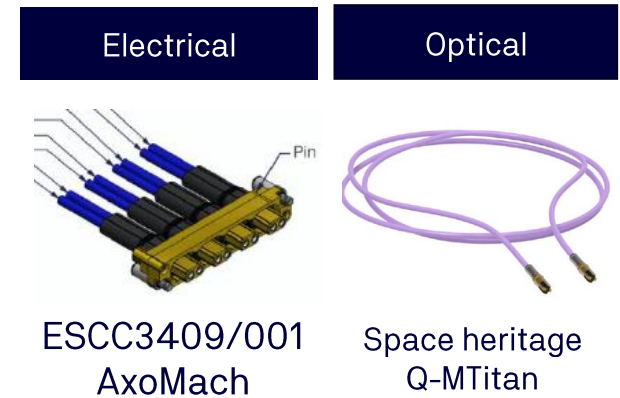
Numerous benefits:

- High-speed multi-gigabit data communication capabilities
- Higher immunity to interference
- Significant size and mass reduction (wire vs optical)

ALTER is participating in several activities focused on space photonics.

- SIPHODIAS project, funded by the European Commission H2020 program.
- Study on reliability of non-hermetic optical transceivers funded by an ESA.

| | Electrical | Optical | % decrease |
|--------------------------------------|------------|---------|------------|
| Cables required | 512 | 4 | 99.2 |
| Cable mass (kg) | 34.8 | 0.56 | 98.4 |
| Cable volume (cm³) | 10.000 | 113 | 98.8 |
| Connector mass (kg) | 3.84 | 0.114 | 97.0 |
| TRx mass (kg) | - | 0.05 | - |
| Total mass (kg) | 38.64 | 0.724 | 98.1 |



SIPHODIAS

Space-grade opto-electronic interfaces for photonic digital and analog satellite VHTS payloads

Funding:

- European Union's Horizon 2020 research and innovation program under grant agreement No. 870522.

Ambition:

- Develop **high-speed/bandwidth electro-photonic I/O interfaces**, critically needed for successful introduction of photonics-enabled, hybrid (digital and analogue) telecom P/L solutions

Objectives:

- Develop high speed >100 Gb/s radiation hard (RH) **optical transceiver modules**
- Develop high performance **E/O and O/E microwave-photonic modules**
- Demonstrate TRL-7 space photonic modules and **sub-system validation**

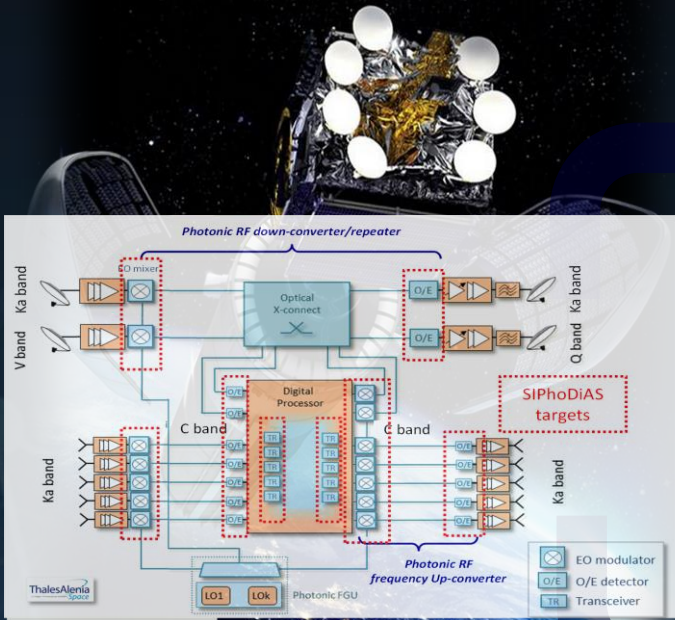
space-siphodias.eu



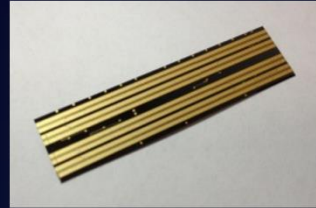
European
Commission

Horizon 2020
European Union funding
for Research & Innovation

SIPHODIAS



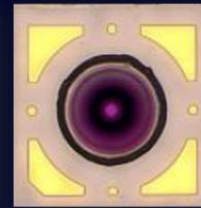
aXenic



Microwave photonics

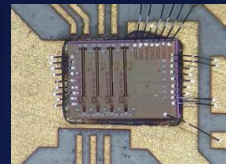
GaAs MZM & InP PD
40+ GHz BW

albis



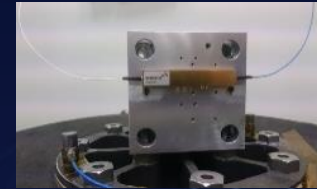
High-speed VCSEL OTRx

Digital photonics



ThalesAlenia
Space

Evaluation testing



Sub-system AIT



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LEO SPACE PHOTONICS

Project coordinator

LEO SPACE PHOTONICS



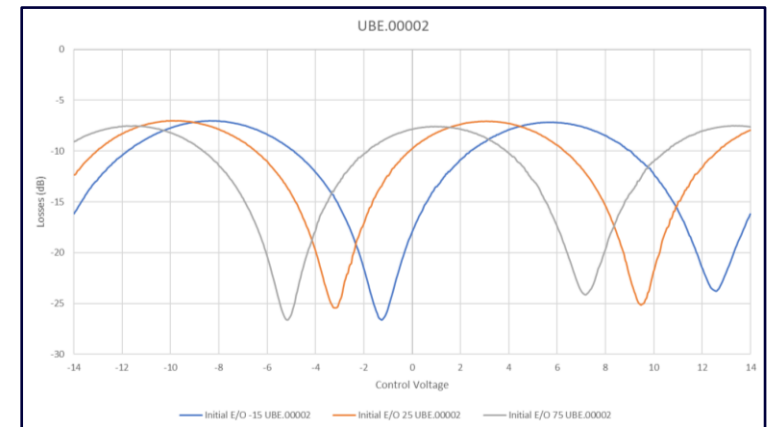
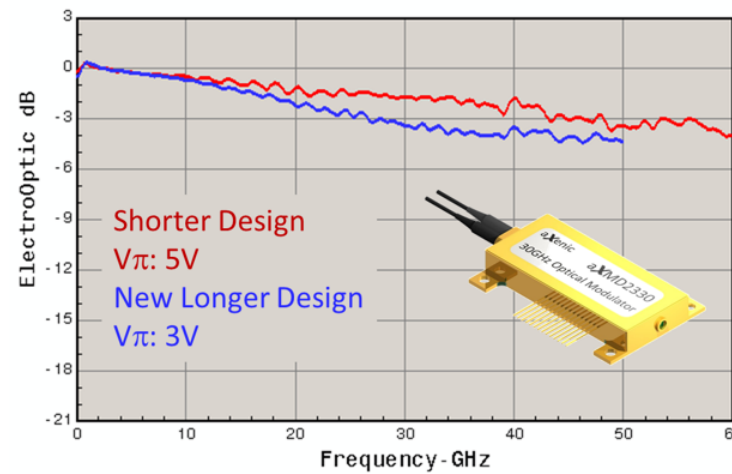
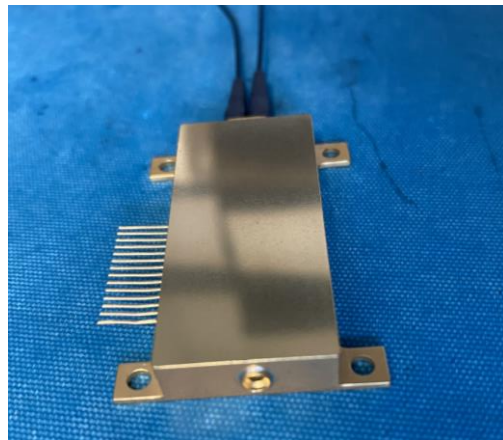
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SIPHODIAS

Microwave photonics

- >40 GHz BW, aligned with requirements of Ka- and V-band microwave photonic payload
- Input/output supplied through polarization maintaining SMF
- SMPM RF input connector

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|--------------------------------|-----------------|------|------|------|------|
| Optical Insertion Loss | IL | | | 7 | dB |
| Bias Electrode V _{pi} | V _{pi} | | 7.5 | 10 | V |
| Extinction Ratio | ER | 20 | 23 | | dB |



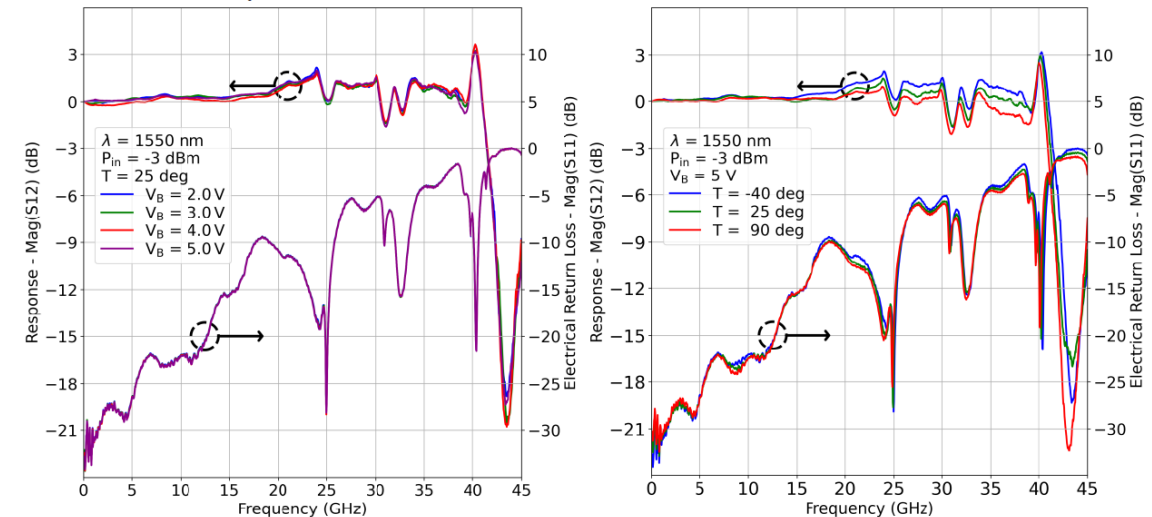
SIPHODIAS

Microwave photonics

- Designed for 40 GHz BW, aligned with requirements of Ka- and Q-band microwave photonic payload
- SMF pigtail input (FC/APC)
- RF output through K-connector
- Small size: 9 mm x 9 mm x 14.9 mm



| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|-----------|------|------|------|---------------|
| Operating wavelength | λ | 1.54 | | 1.58 | μm |
| DC Responsivity ($V_{DC} = 3\text{ V}$) | R | 0.5 | 0.6 | | A/W |
| 3-dB bandwidth | BW | 40 | | | GHz |



SIPHODIAS

Microwave photonics

Preliminary qualification has been successfully completed on both devices

- Mechanical testing
- Temperature cycling
 - 100 cycles -40/85°C
 - No bias
- Life test
 - 1000h under operational conditions
- Radiation (gamma and protons)
 - Gamma up to 100 krad
 - Protons fluence up to 5e11 p/cm²
- Final DPA/constructional analysis

Mechanical shock

| Frequency (Hz) | Shock response spectrum (g) / Q = 10 |
|--|--------------------------------------|
| 100 | 30 |
| 500 | 200 |
| 3000 | 1000 |
| 10000 | 1000 |
| Number of events: 3 shocks per axis. Both the Z-axis directions | |
| Number of events: 3 shocks per axis / min overall tolerance: -0 dB | |



Sine vibration

| Level and frequency (all axis) | |
|--------------------------------|-------|
| Range (Hz) | Level |
| 30 - 100 | 30g |
| 100 - 200 | 15g |
| Sweep rate : 1 octave/min | |

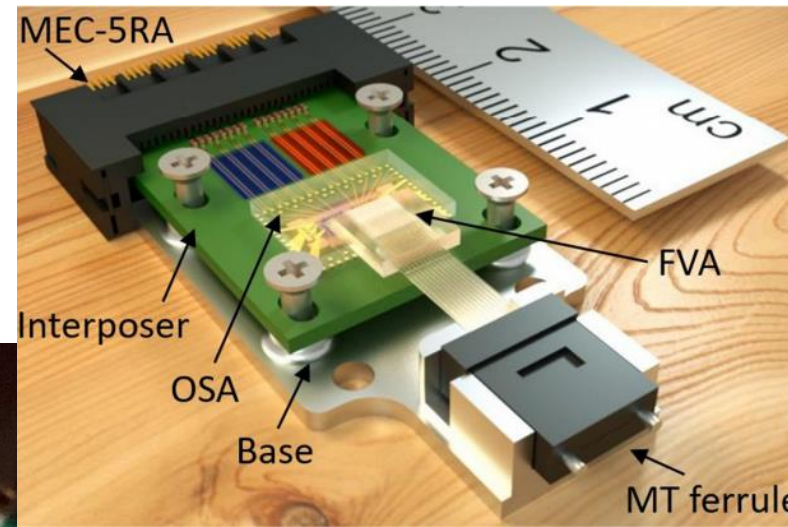
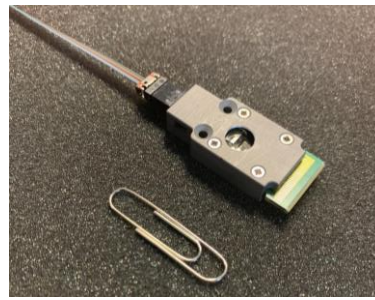


Random vibration

| Perpendicular to the mounting plane | | Parallel to the mounting plane | |
|-------------------------------------|-------------------------|--------------------------------|-------------------------|
| Range (Hz) | PSD level | Range (Hz) | PSD level |
| 20 - 80 | +4 dB/oct | 20 - 100 | +6 dB/oct |
| 80 - 800 | 3.54 g ² /Hz | 100 - 800 | 0.78 g ² /Hz |
| 800 - 2000 | -4 dB/oct | 800 - 2000 | -3 dB/oct |
| Global : 70 gRMS | | Global : 33.8 gRMS | |
| 5 min per axis | | | |

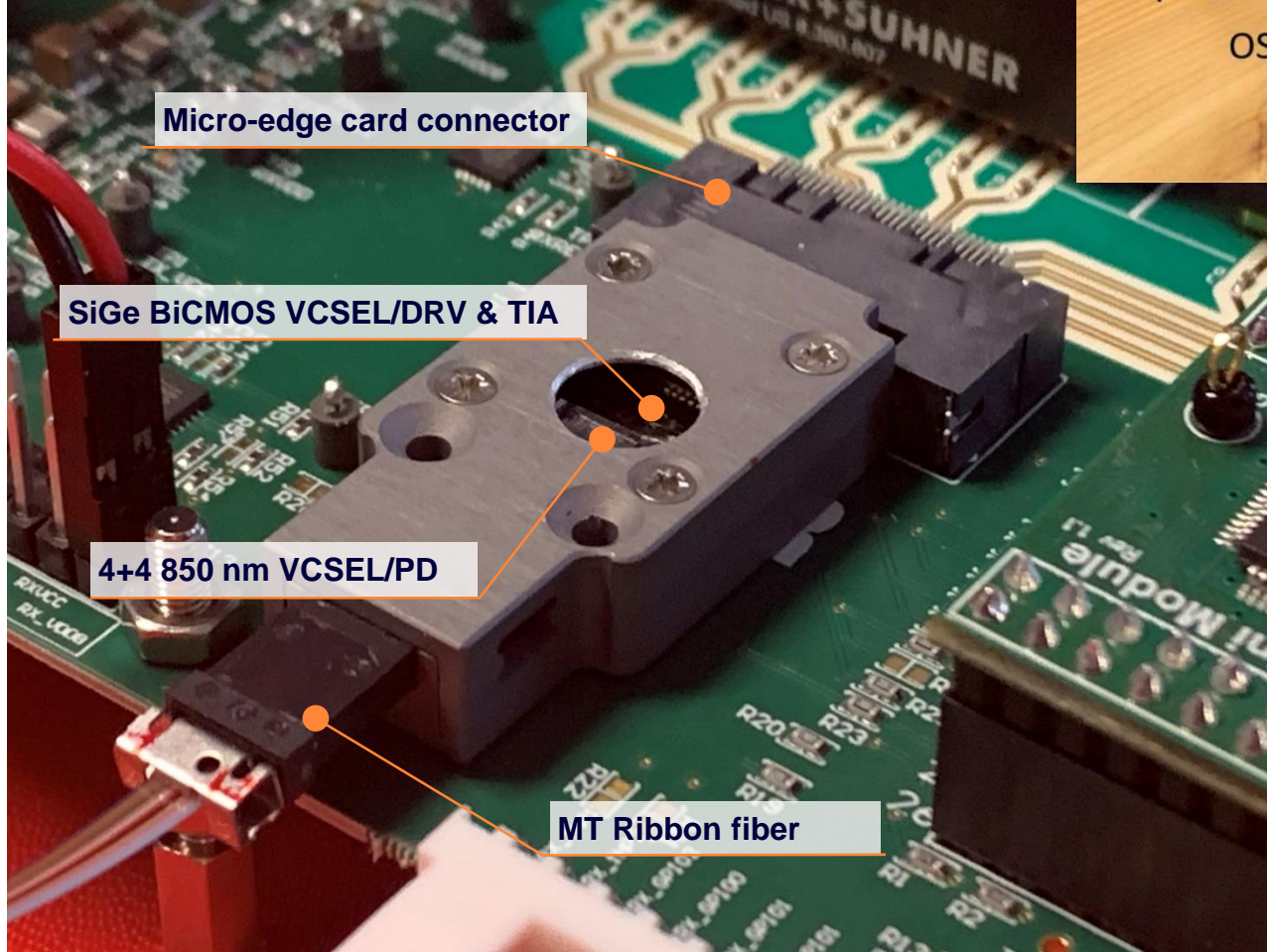
SIPHODIAS

OTRX Module



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- All flip-chip assembly

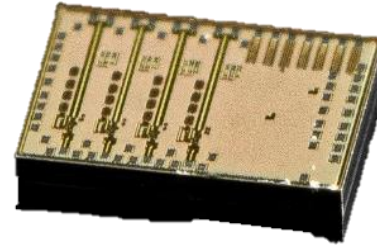


OTRx mechanical & electrical specs

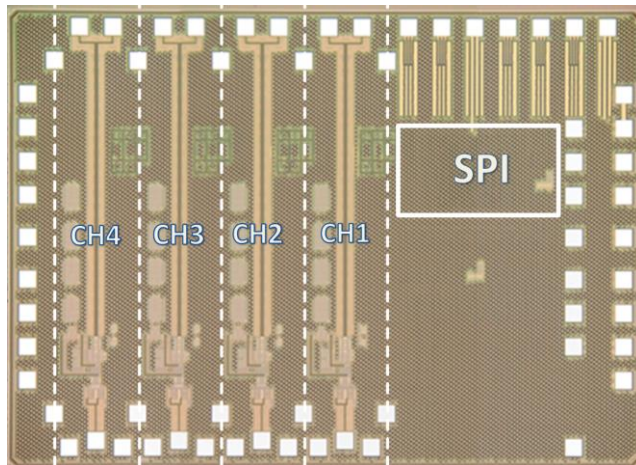
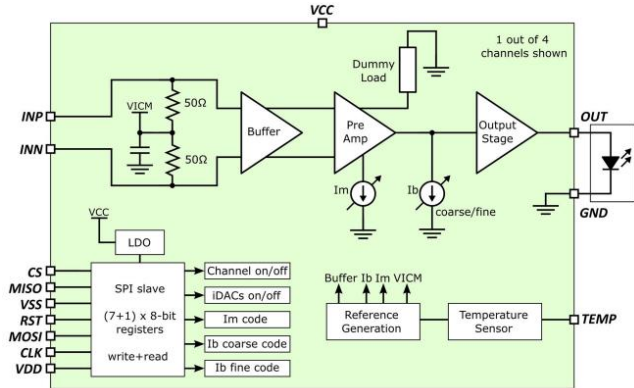
| | |
|----------------------|----------------------------|
| Package size (LxWxD) | 39.4 x 17 x 7.2 mm |
| Module footprint | 670 mm ² |
| Module mass | 6.4 grams (ex MEC & fiber) |
| Power supply | 3.3 V |
| Power consumption | 178 mW/channel |
| Target efficiency | < 7 mW/Gb/s |

SIPHODIAS

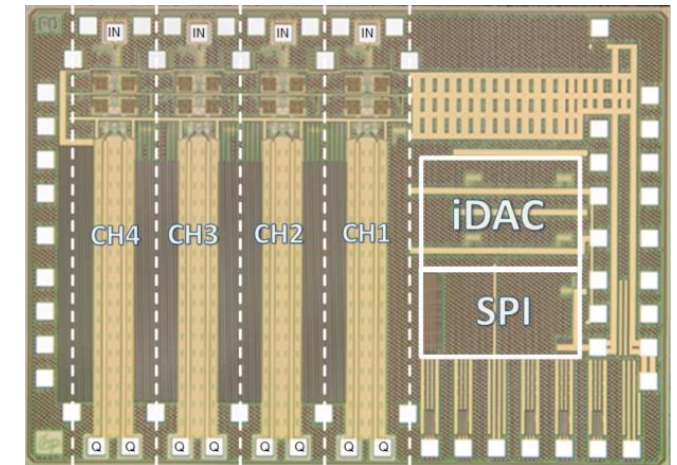
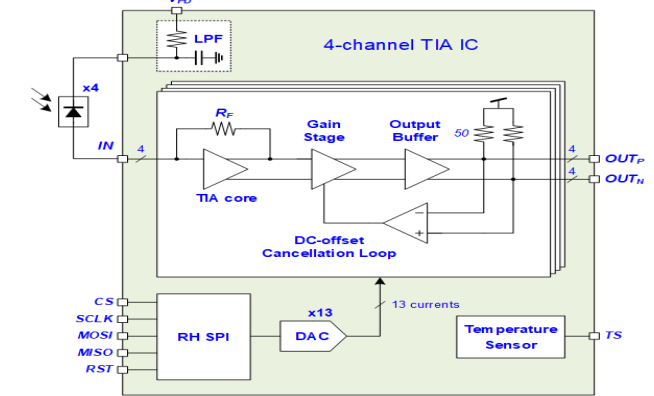
OTRX Chipset



Quad ch. VC SEL DRV IC



Quad ch. TIA IC

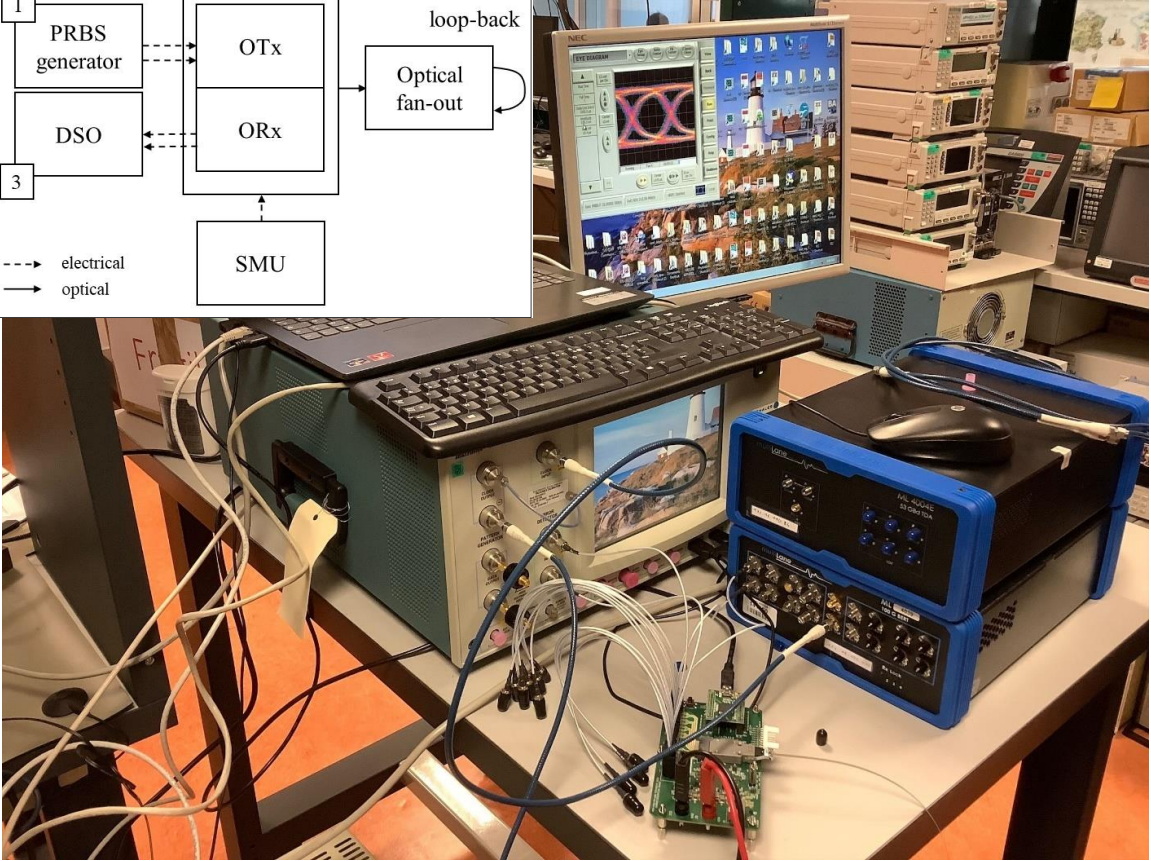
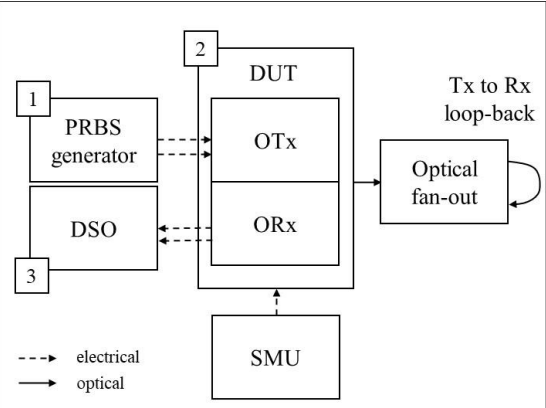


- IHP SG13RH process
- Single 3.3V power supply
- RH bandgap circuit
- RH SPI IP + DAC
- Temperature sensor
- Programmable 4-channel O/P

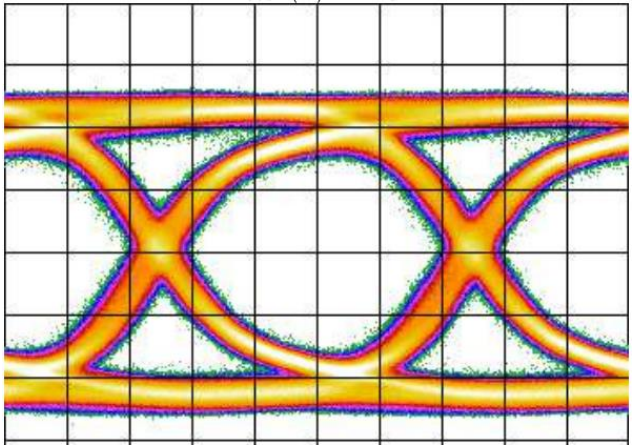
- VCSEL DRV: 70 mW/ch
- TIA: 108 mW/ch

SIPHODIAS

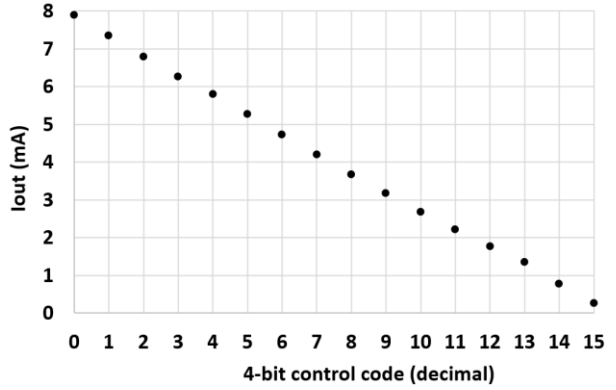
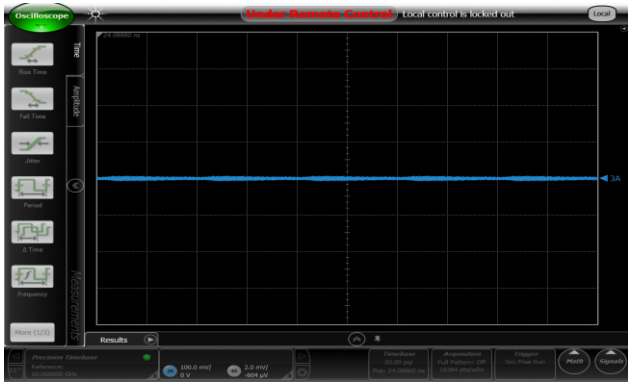
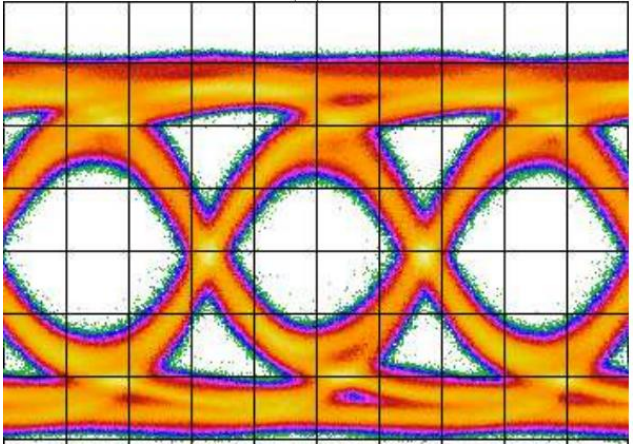
OTRX full functional preliminary results



10 Gb/s



14 Gb/s



SIPHODIAS

Current status

Project completion has been extended for six months to complete final activities

- Analysis of MZM and PD qualification results is on-going
- Microwave photonics sub-system demonstration is on-going
- Second run of chipsets has been manufactured for later sub-system demonstration
- OTRX preliminary qualification will be completed

space-siphodias.eu



Study on optical transceivers

Reliability assessment of non-hermetic optical transceivers

Funding:

- ESA contract No. 4000133320/20/NL/FE

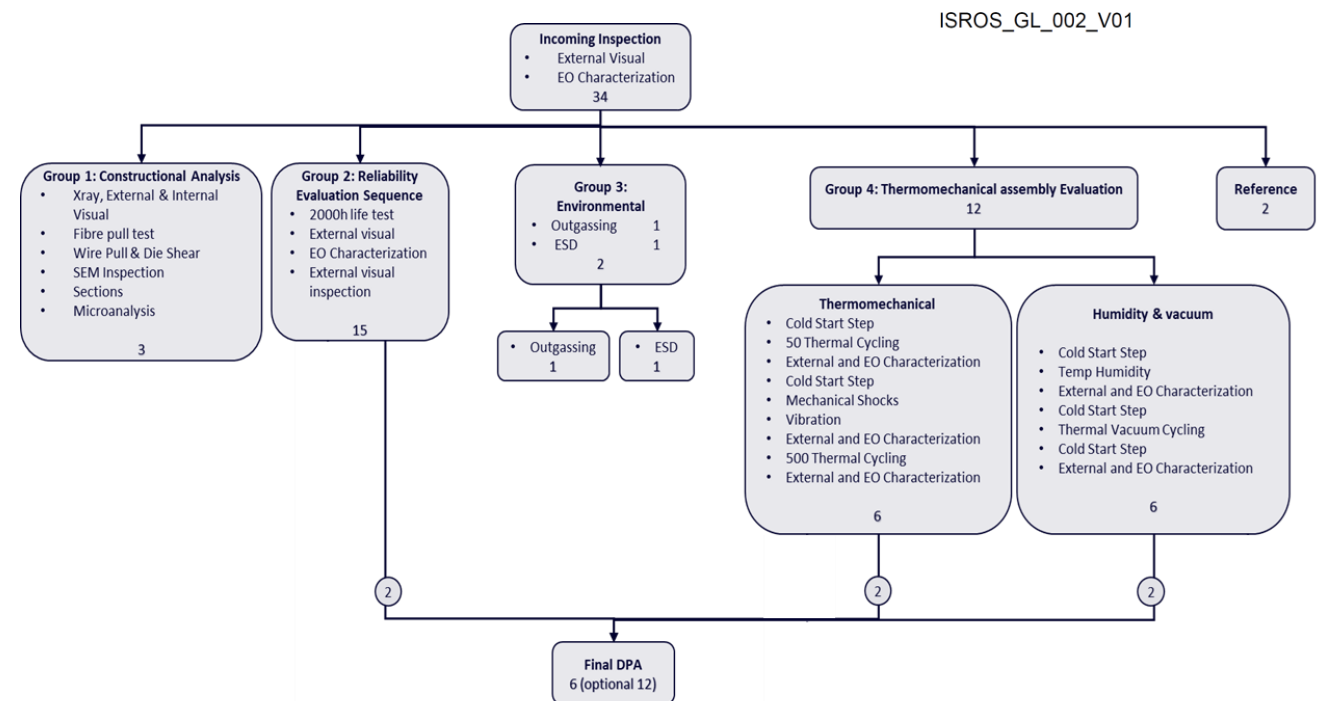
Ambition:

- To **assess the reliability** of a number of commercial non-hermetic optical transceivers for use in space.

Objectives:

- Test samples selection from **European manufacturers** (at least two)
- Special emphasis to **moisture** ingress.

Reliability assurance guideline for digital optical transmitter, receiver and transceiver modules



Study on optical transceivers

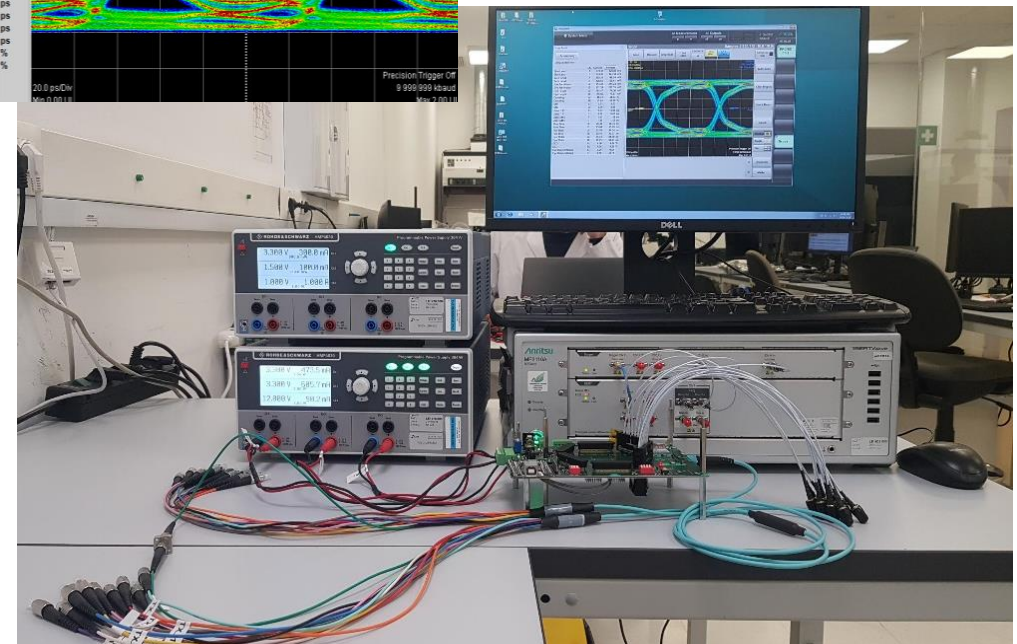
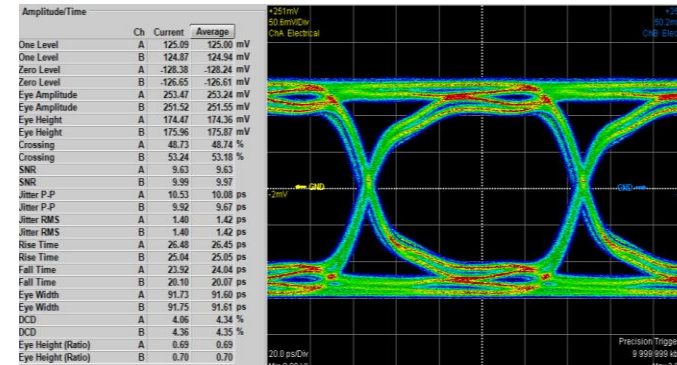
Optical transceiver characterization

Three devices were selected for evaluation

- Amphenol's 25 Gbps ruggedized SCFF (1 ch)
- Amphenol's Leap[®] OBT transceiver (12 ch)
- Aritech's Opto-fire[™] 16009 (4 ch)

Characterization is focused on dynamic performance:
BER and full eye-diagram characterization

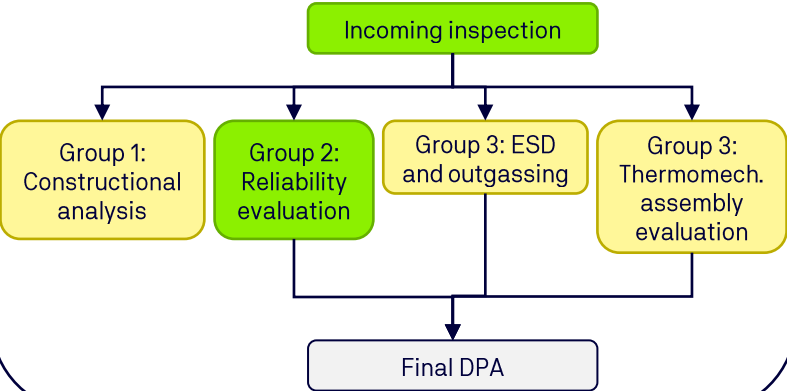
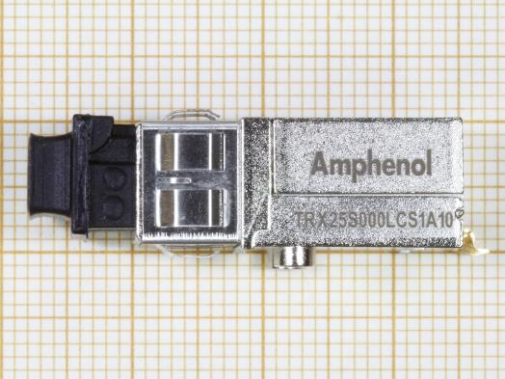
- BER
- Measurement of eye amplitude, eye height and eye width
- Measurement of jitter, rise and fall times



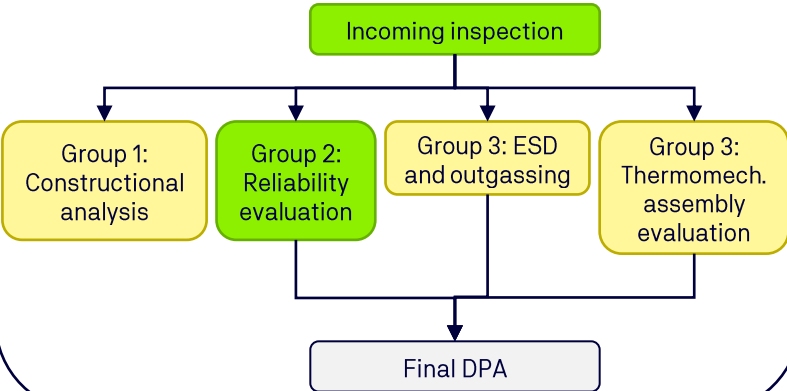
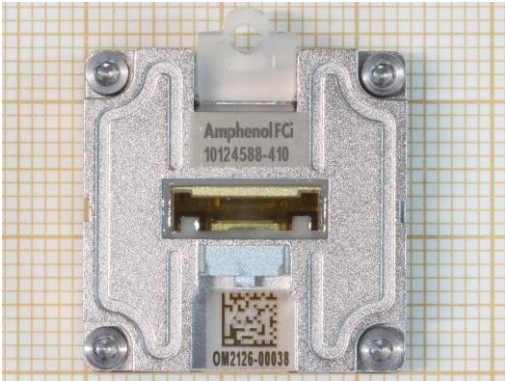
Study on optical transceivers

Current status

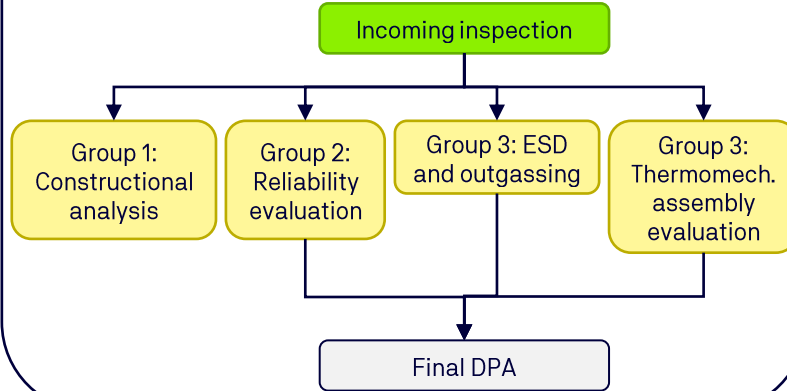
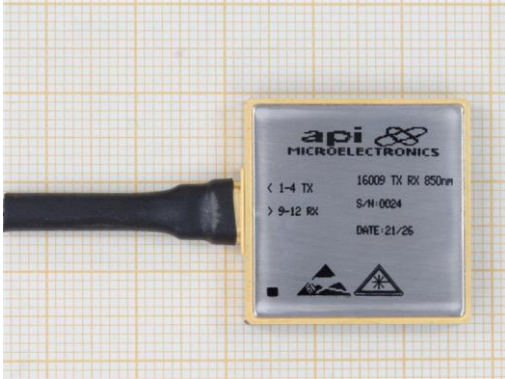
25Gbps ruggedized SCFF (1 ch)



Leap® OBT (12 ch)



Opto-fire™ 16009 (4 ch)



Next steps

Current and future activities in ALTER TECHNOLOGY

Space photonics is one of the strategic lines of ALTER TECHNOLOGY

Design activities:

- A photonic design center has been opened in UK
- One of the developments will focus on the evolution of SIPHODIAS OTRX module into a configurable platform
 - 4-12 channels per device
 - Up to 56 Gbps per channel

Testing activities:

- Total dose radiation test on OBT transceiver under DLR technical advisor contract



Conclusions and acknowledgements

Two space photonics research projects have been presented:

- SIPHODIAS: an European project where key electro-optical elements have been developed and validated.
- A study on reliability of non-hermetic optical transceivers funded by ESA.

Other current and future activities on space photonics have been presented.

Acknowledgements:

- European Union (EU) for funding through the “Horizon 2020” framework, H2020 SPACE SIPHODIAS GA number 870522
- European Space Agency (ESA) for funding through ESA contract No. 4000133320/20/NL/FE



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Thank you!

Aintzane Lujambio Genua
aintzane.lujambio@altertechnology.com

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