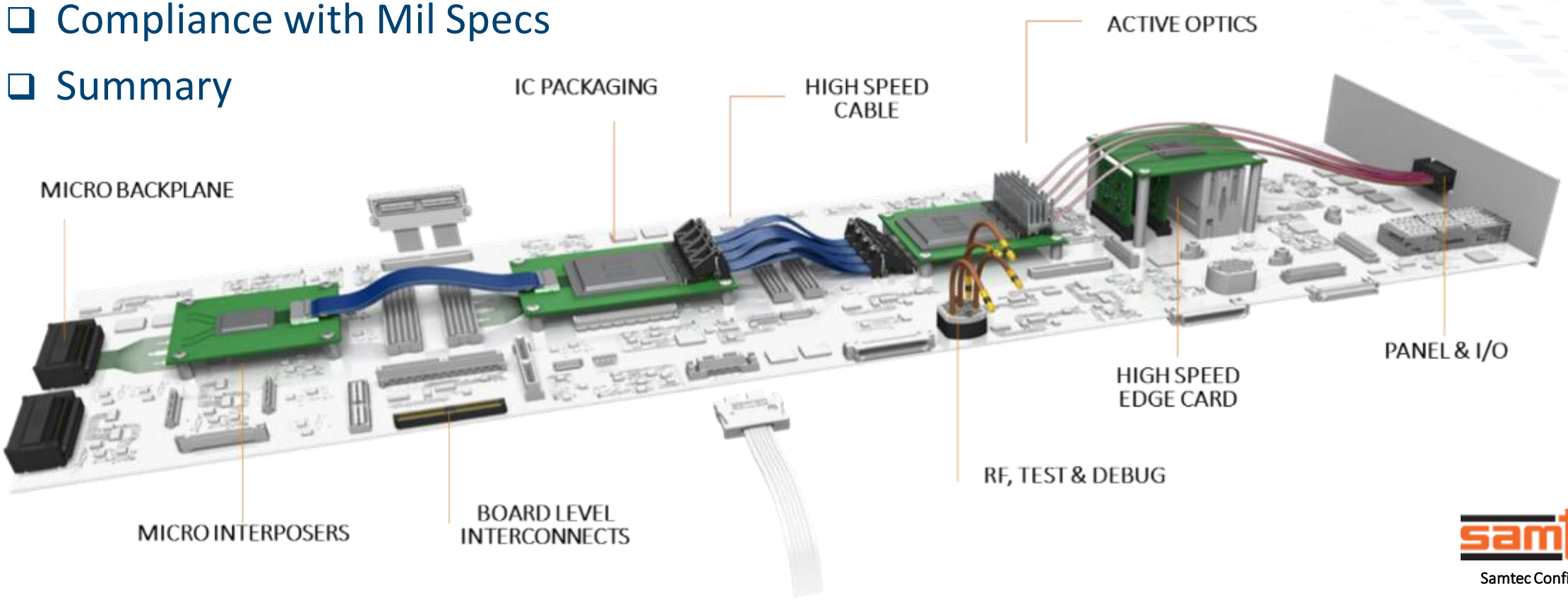
FIREFLY™ FOR EMBEDDED APPLICATIONS

Arlon Martin, Sr. Director, Marketing

FIREFLY™: DENSITY, SERVICEABILITY AND SCALABILITY

- Advantages of On-Board Optics (OBO)
- Firefly™ Application Examples
- Product Roadmap
- Compliance with Mil Specs
- Summary

Density
Serviceability
Scalability



SAMTEC ADVANTAGES

FireFly™ On Board Optics has a large commercial customer base

- FPGA, ATE, ASIC, Supercomputing, Vision, and Medical applications
- Optical PCIe

Our commercial FireFly business (COTS) gives us volume

- More experience and better statistics for reliability and lifetime
- Incentives to continually improve yields, processes and components
- Wide range of products (x4, x12) and speeds (up to 28G)
- Easier for us to ramp when volumes take off

Product portfolio includes extended temp and ruggedized products

- Mil/Aero is a strategic Samtec market segment
- Selling to military customers since 1980
- Offer a wide range of Mil/Aero products, including FLYOVER cables

WHY MINIATURE ON-BOARD OPTICS?

Bring optics on board, closer to the chipset

- No more electrical reach issues

Optical “flies over” to backplane or front panel

- Much denser than copper flyover

Highest density

- Miniature x12 channel engines in a 11.5 x 16 mm form factor
- Can arrange in multi-row arrays

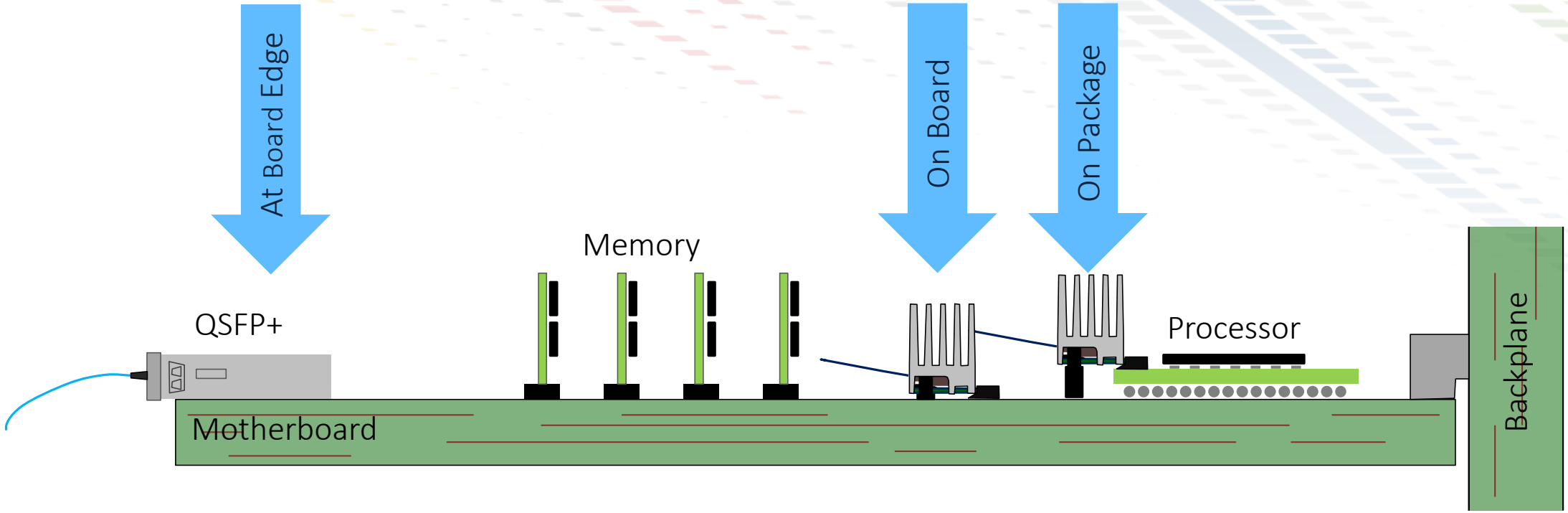
Many cooling options

- Traditional pin-fin heatsink
- Cold plate
- Immersion

Qualified to Telcordia and MIL standards

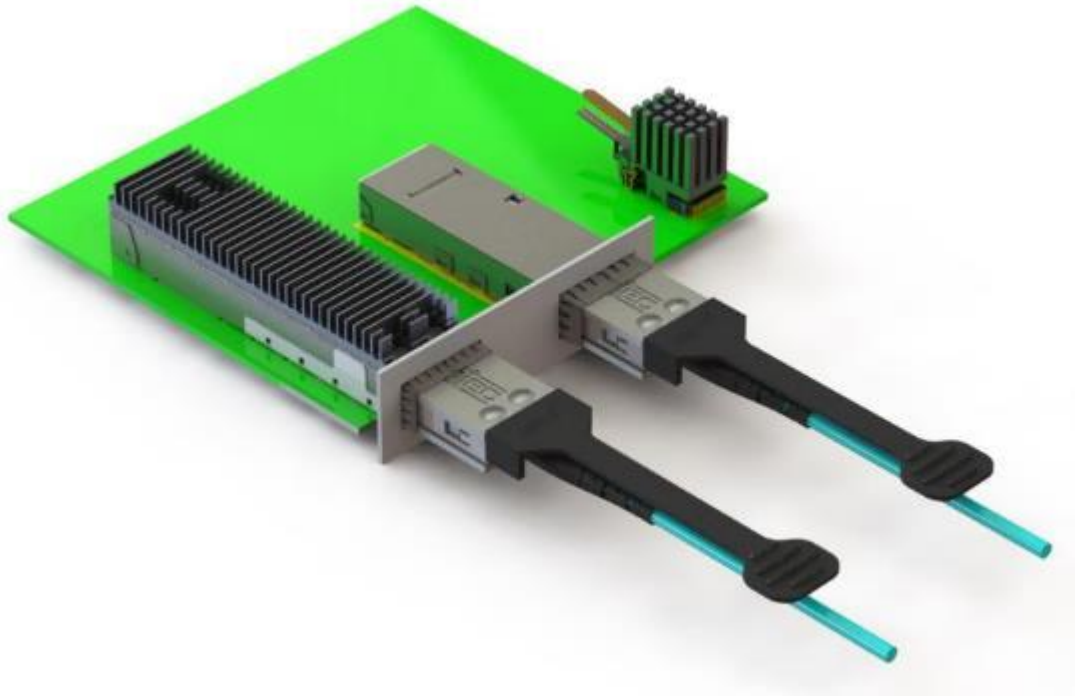
- Lots of reliability data

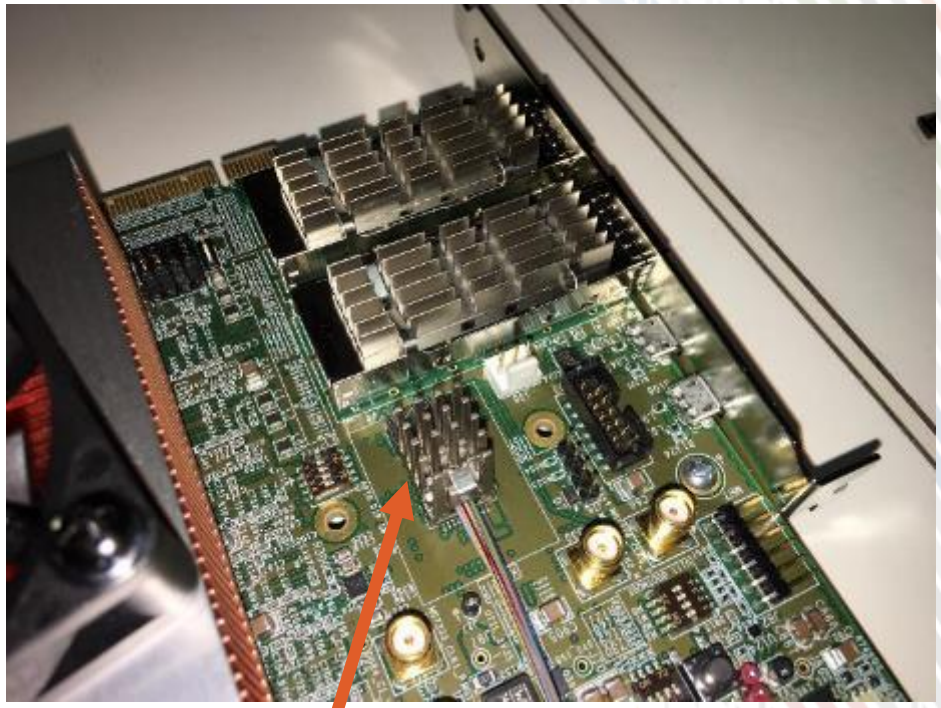
MID-BOARD OPTICS REDUCES POWER



Easier Layout, Higher Density, Better Signal Integrity, Lower Power

DENSITY: FIREFLY™ IS 4X SMALLER THAN QSFP

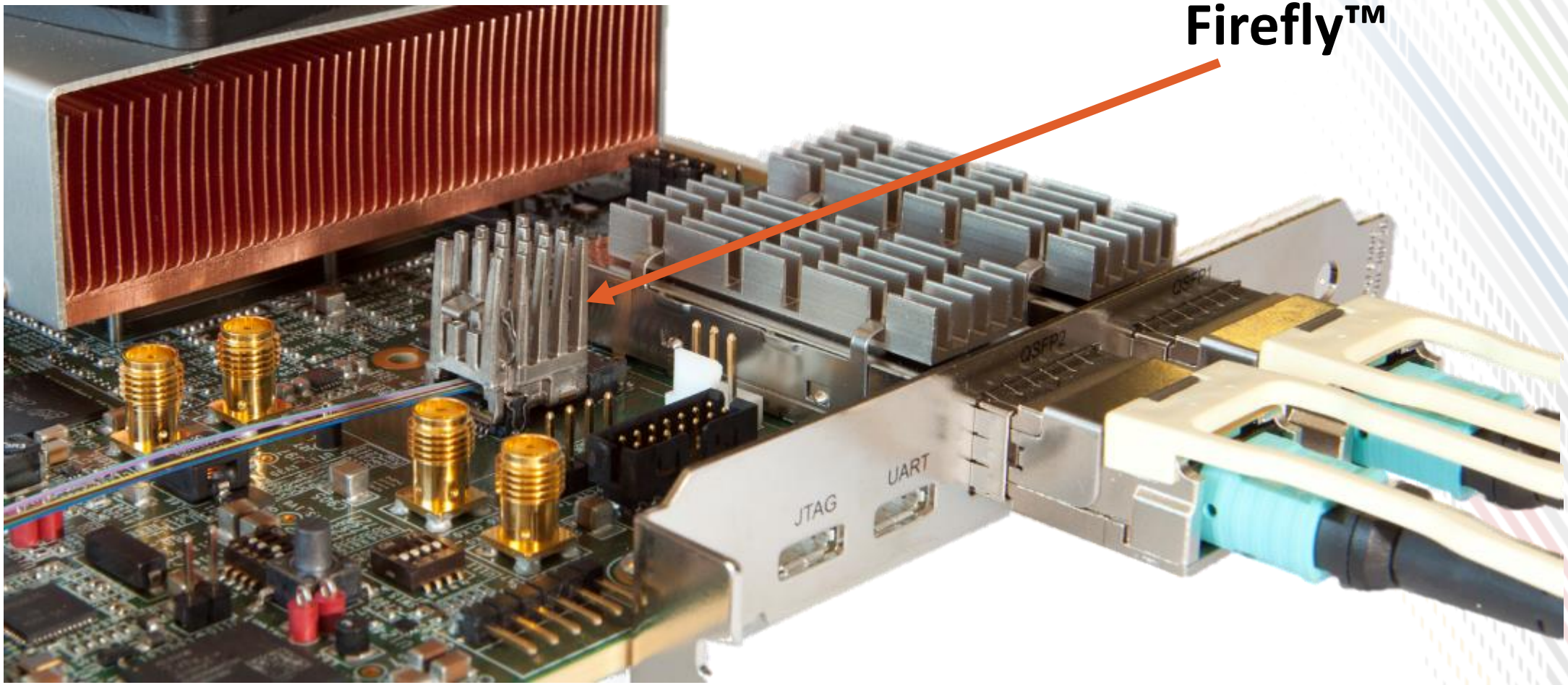




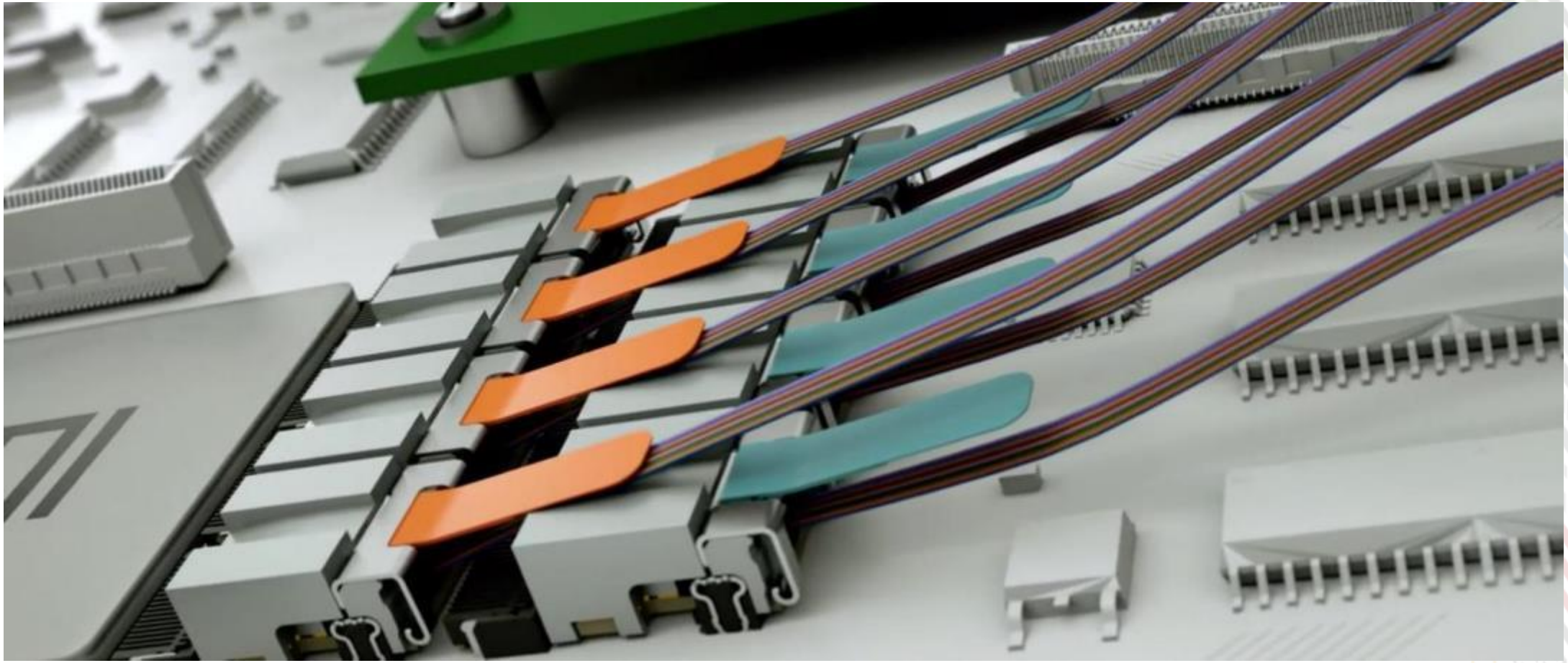
Firefly™

Mid-board optics dramatically improve board density.
Firefly is one of the smallest OBO modules.

HOST BOARD DENSITY APPLICATION EXAMPLE



MAXIMIZE DENSITY WITH ARRAYS OF FIREFLYS

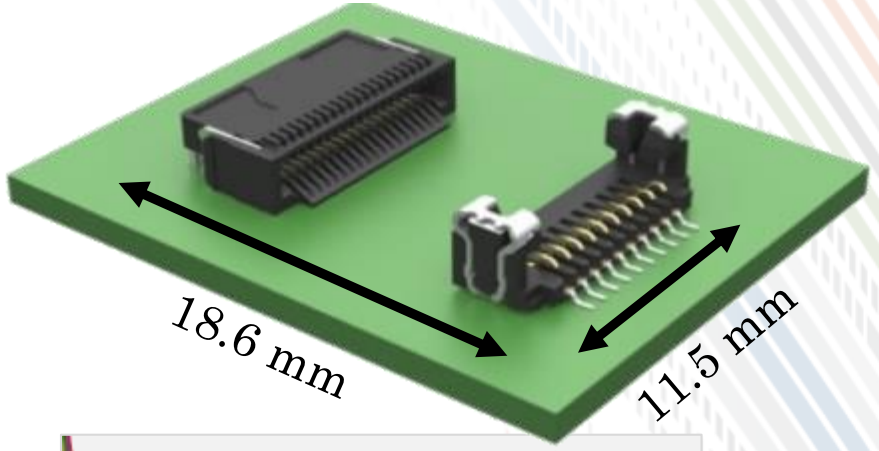


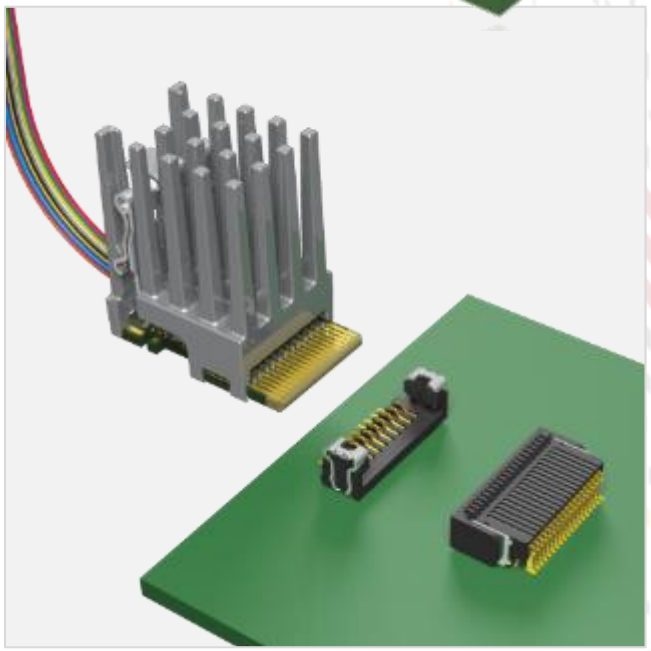
These heat sinks have grooves to facilitate fiber routing in dense layouts

INNOVATIVE CONNECTORS ENABLE ***SERVICEABILITY***

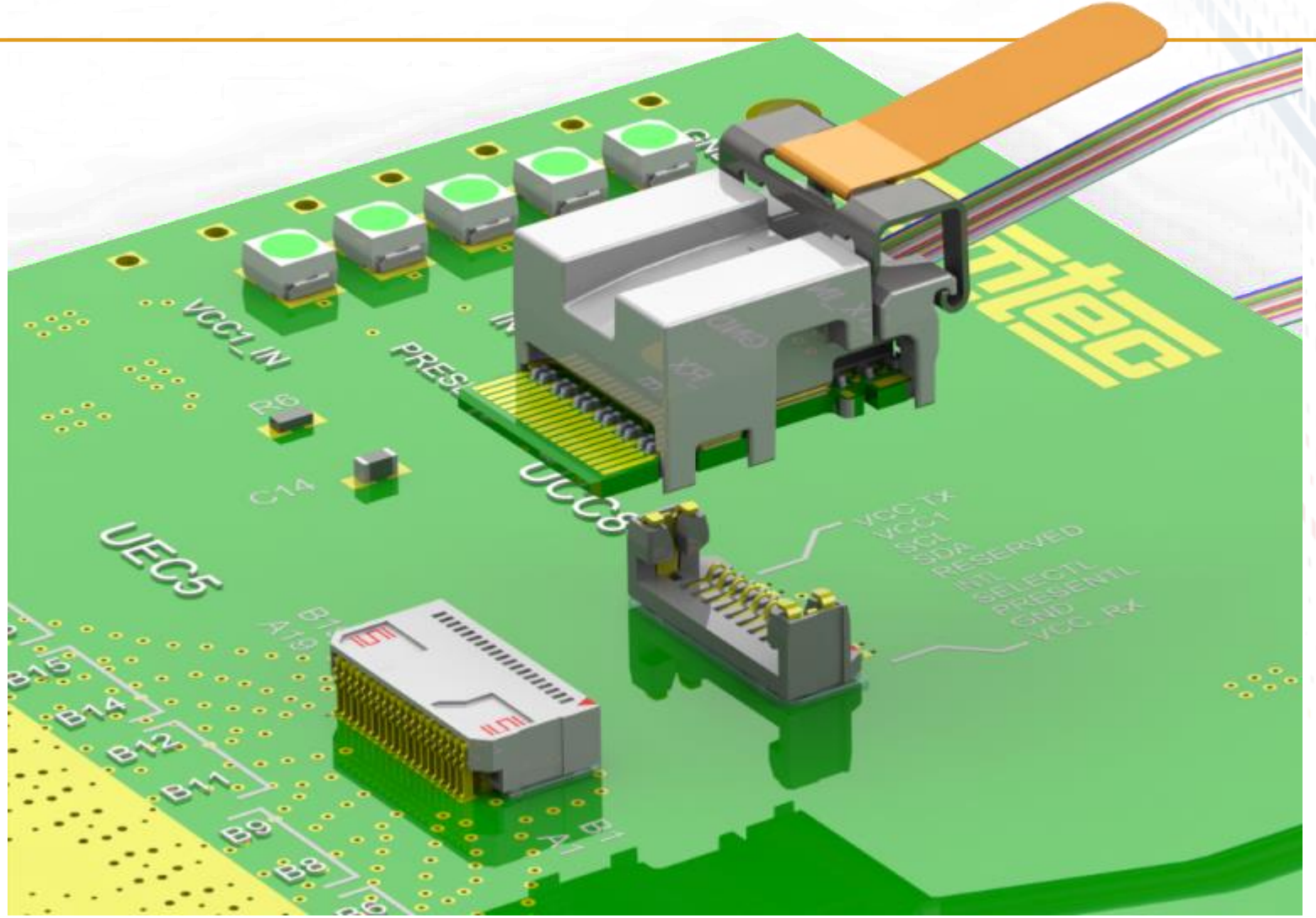
Two piece card-edge connector system

- UEC5 series – High Speed Data
  - 0.5 mm pitch
  - 12 differential pairs (GSSG)
  - Designed for 56 Gbps
  - Easy BreakOut Region layout
- UCC8 series – Power and Communication
  - 0.8 mm pitch
  - Power pins
  - Low speed control signals
  - Latching locking mechanism
  - Rugged weld tabs



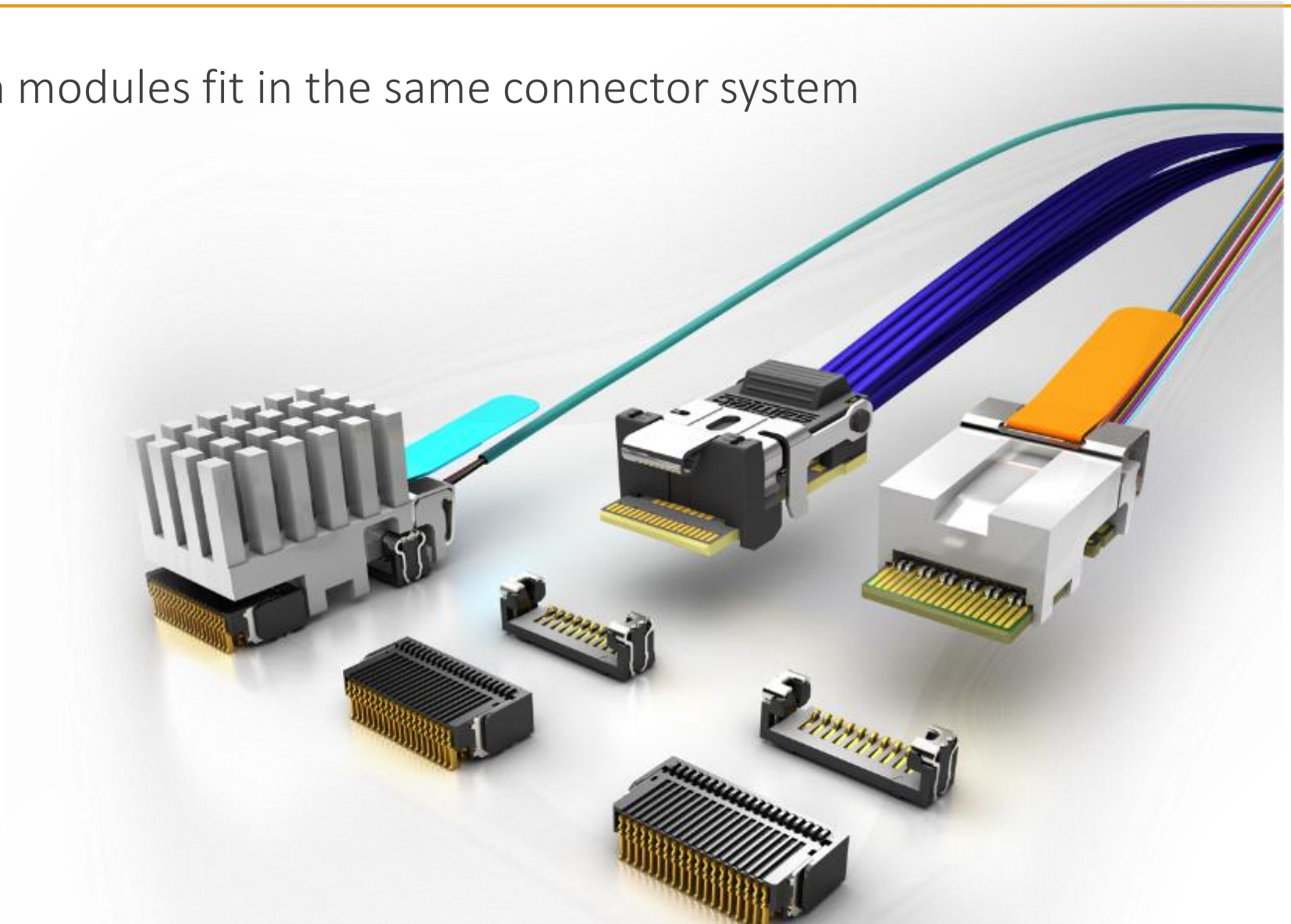


SERVICEABILITY: EASY TO ASSEMBLE; EASY TO REPLACE



SERVICEABILITY: INTERCHANGEABLE COPPER AND OPTICS

Both modules fit in the same connector system



Samtec is the only embedded optics company to offer both copper and optics in the same footprint.

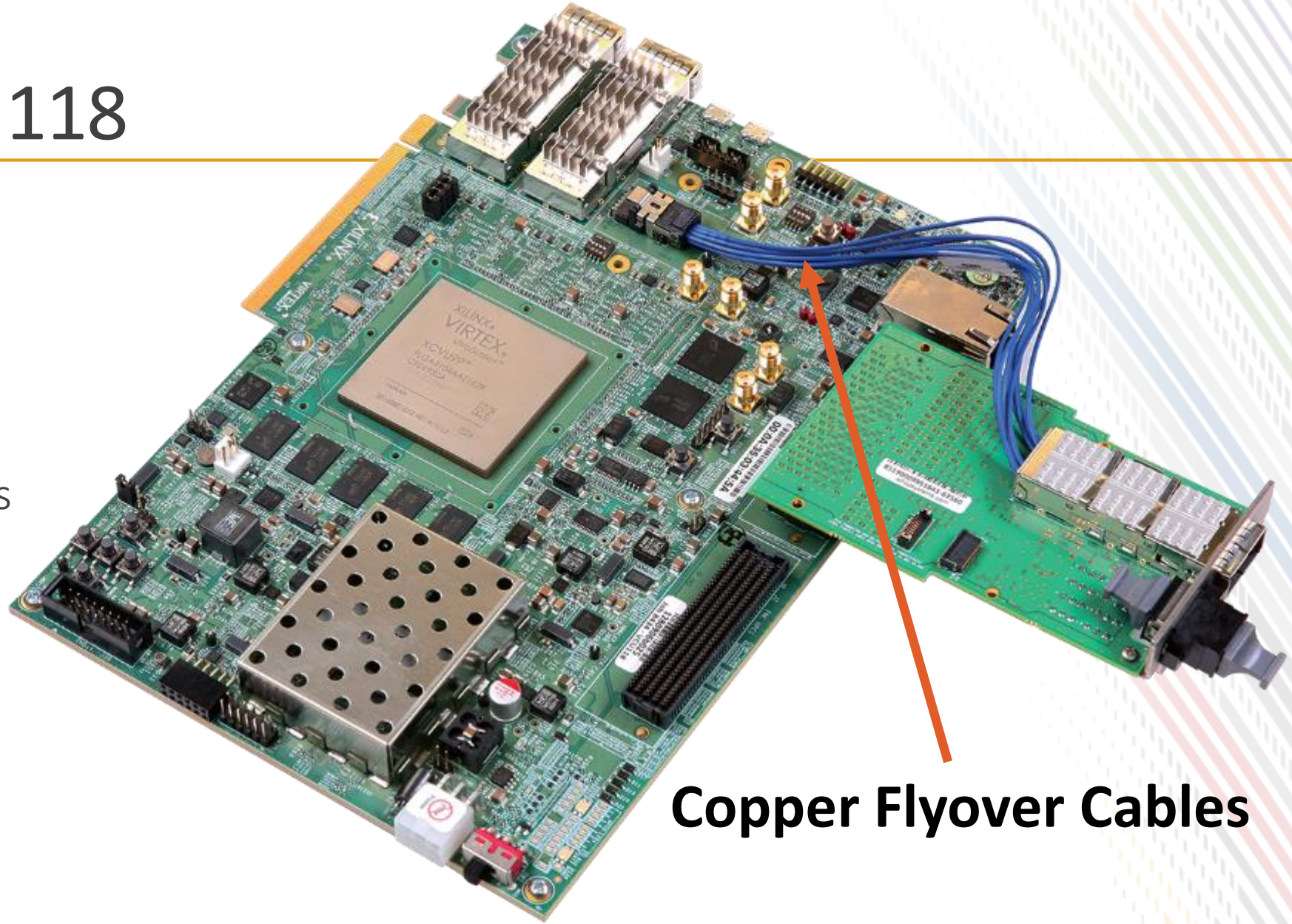
XILINX VCU118

Ultra scale+ FPGA

FireFly™ Footprint

Flyover QSFP

Regular QSFP cages



An application showing copper Flyover Cables with same mid-board connector

FIREFLY™ CONNECTED TO VITA 66.4 CONNECTOR

Vita 66.4 connector allows for blind mating to optical backplanes

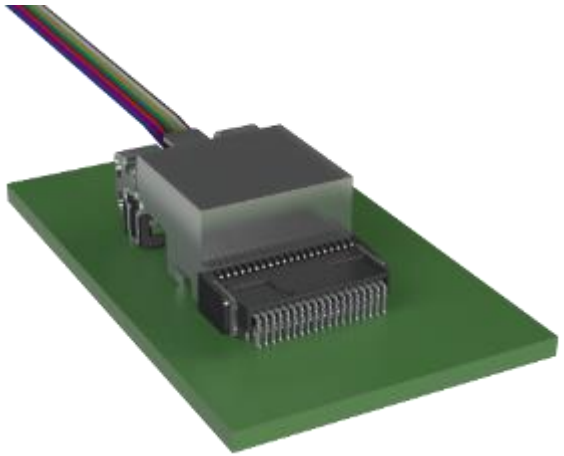
With Firefly, the optics can placed next to the FPGA/ASIC/processor

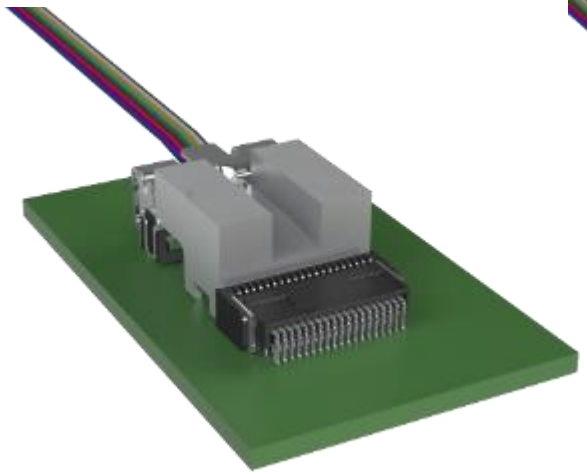
Maximizes board design flexibility

Provides better thermals

MANY HEATSINKING OPTIONS

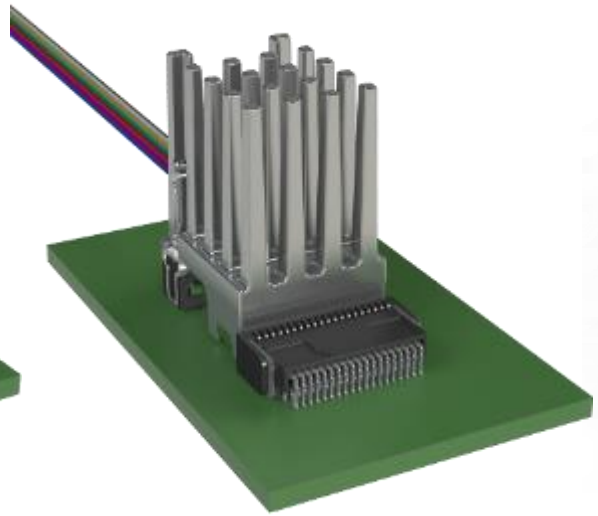
Conduction Cooling

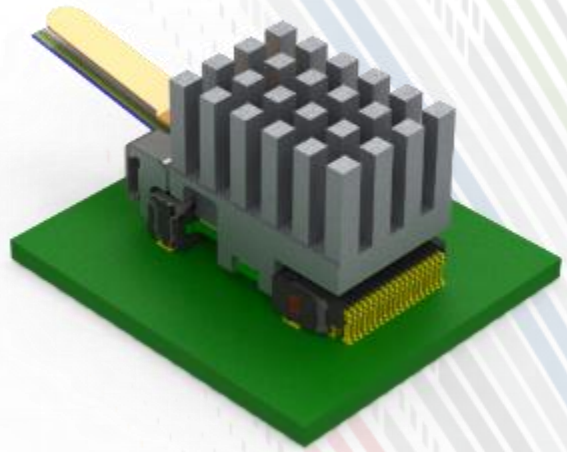




Grooves enable FireFly optical engines to be placed closer together

Convection Cooling



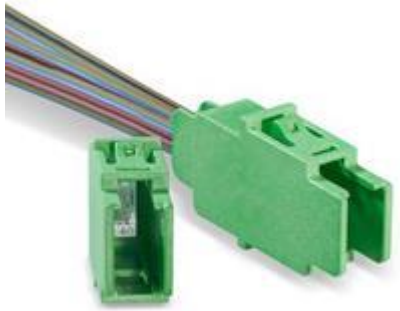


Lower profile is PCIe® CEM compliant

MANY OPTICAL CONNECTIVITY OPTIONS

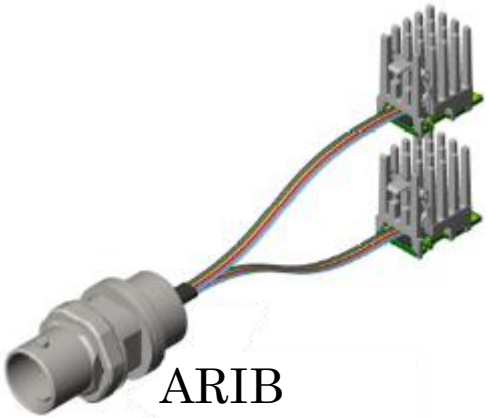
MT

MPO



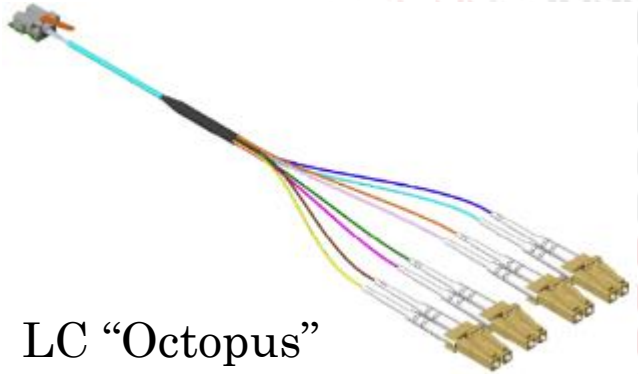
MXC

Density
Serviceability
Scalability



ARIB

Amphenol MT38999



LC “Octopus”

THE D38999 CONNECTOR FOR RUGGED APPS

ARINC 801 Termini

ARINC 801 Connector in D38999 Shell

Optik-D™ Series

Key ARINC 801 Termini Features:

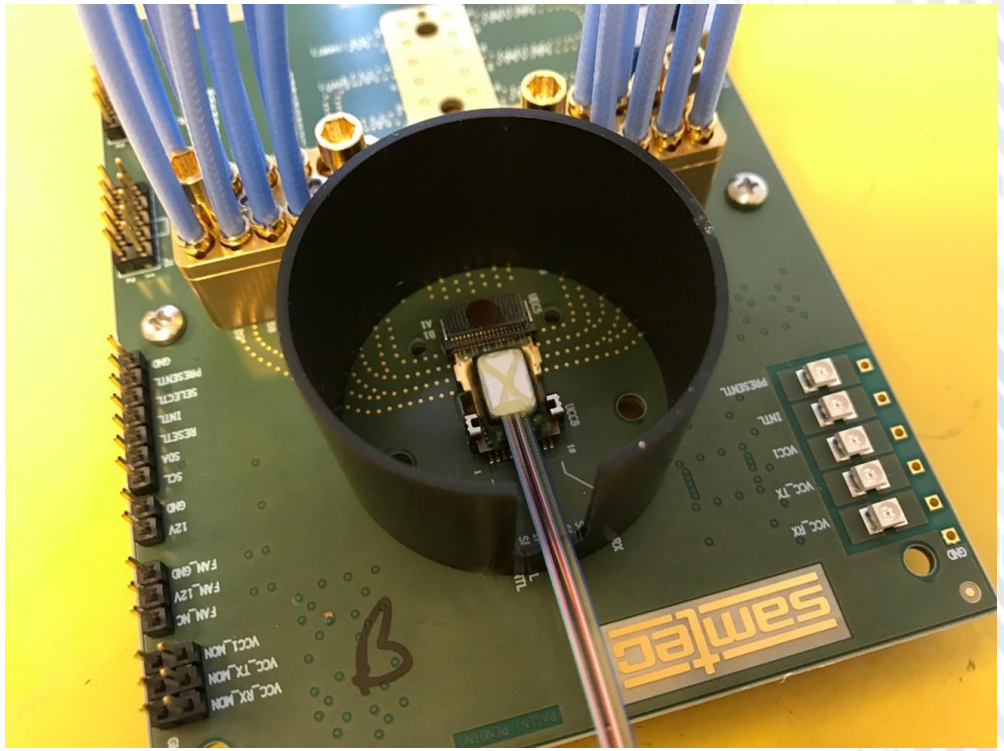
- Removable alignment sleeve insert for easy cleaning, low-insertion loss and return loss values
- Genderless terminus allows ease of use on either side of the connector
- Precision ceramic ferrules and sleeves ensure accurate fiber to fiber alignment
- Keyed to provide anti-rotation

SCUO IS AN IMMERSION COOLED FIREFLY™

Liquid immersion cooling applications are coming

Demonstrated capability and reliability

- Over pressure to 60 psi
- RF and optical performance
- Low Temperature Storage
- Long Term (>2000 hours) Submersion in Fluoroinert FC43
- Long Term (>2000 hours) submersion in Dioctyl Phthalate
    - This is a 3M recommended liquid that mimics contaminates found in cooling liquid during use



Density

Serviceability

Scalability

ETUO IS FULLY QUALIFIED FOR EXTENDED TEMP

FireFly™ Optical
ETUO 10G x12 Qualification

2 Qualification Requirements

2.1 Summary

Table 2 lists the tests specified by Telcordia, which are described in this document.

Type	Name	Standard	Condition	SS/AF	Result
Mechanical Integrity	Ex-situ Shock	GR-468-CORE 3.3.1.1.1	300 g, 3 ms, 5 times/direction	12/0	Pass
	Ex-situ Vibration	GR-468-CORE 3.3.1.1.2	Condition A: 20 g, 20 to 2000 Hz, 4 min/cycle, 4 cycles/axis	12/0	Pass
Fiber Integrity	Fiber Twist	GR-468-CORE 3.3.1.3.1	0.5 kg, 3 cm from housing, 10 cycles	22/0	Pass
	Fiber Side Pull	GR-468-CORE 3.3.1.3.2	0.25 kg, 22-28 cm from housing	22/0	Pass
	Cable Retention	GR-468-CORE 3.3.1.3.3	0.5 kg, >10 cm from housing, 1 minute	22/0	Pass
Endurance	Low Temperature Storage	GR-468-CORE 3.3.2.1	72 hours, -40 °C 24 hours, -55 °C (elected)	12/0	Pass
	High Temperature Storage	GR-468-CORE 3.3.2.1	2000 hours, 85 °C	11/0	Pass
	Temperature Cycling	GR-468-CORE 3.3.2.2	-40 to 85 °C, 10 °C/min, 100 cycles	12/0	Pass
	Unbiased Damp Heat	GR-468-CORE 3.3.2.3	85 °C / 85 % RH, 500 hours	11/0	Pass[1]
	High Temperature Operation	GR-468-CORE 3.3.3.1	85 °C, 2000 hours	11/0	Pass

Table 2: Qualification Tests Summary.

ETUO FIREFLY™ MODULES PASS MIL-STD-810G

FireFly™ ETUO 10G x12

Operational Shock and

Vibration Test Report

3 Results

No bit errors were seen on any sample during any of the applied stresses, as shown in Table 1. The total number of bits includes the time elapsed to perform the shock and vibration sequence on each test axis.

Sample	Axis	Channel	Bits	Errors	Bit Error Rate
1	Z	1	1.982×10^{13}	0	0.0
		12	1.982×10^{13}	0	0.0
	X	1	1.973×10^{13}	0	0.0
		12	1.975×10^{13}	0	0.0
	Y	1	1.991×10^{13}	0	0.0
		12	1.993×10^{13}	0	0.0
2	Z	1	1.979×10^{13}	0	0.0
		12	1.980×10^{13}	0	0.0
	X	1	1.970×10^{13}	0	0.0
		12	1.972×10^{13}	0	0.0
	Y	1	1.957×10^{13}	0	0.0
		12	1.957×10^{13}	0	0.0
3	Z	1	1.982×10^{13}	0	0.0
		12	1.983×10^{13}	0	0.0
	X	1	1.980×10^{13}	0	0.0
		12	1.981×10^{13}	0	0.0
	Y	1	1.957×10^{13}	0	0.0
		12	1.959×10^{13}	0	0.0
4	Z	1	1.974×10^{13}	0	0.0
		12	1.975×10^{13}	0	0.0
	X	1	1.987×10^{13}	0	0.0
		12	1.987×10^{13}	0	0.0
	Y	1	2.586×10^{13}	0	0.0
		12	2.586×10^{13}	0	0.0
5	Z	1	1.976×10^{13}	0	0.0
		12	1.977×10^{13}	0	0.0
	X	1	2.157×10^{13}	0	0.0
		12	2.158×10^{13}	0	0.0
	Y	1	1.975×10^{13}	0	0.0
		12	1.975×10^{13}	0	0.0

Table 1: Results

4 Conclusion

This test validates that both the FireFly™ transmit optical assembly and the UCC8/UEC5 connector system are robust to mechanical shock up to 11 ms / 20 g peak saw tooth shock and random vibration to a level of $W_0 = 0.061\ g^2/Hz$, per MIL-STD-810G.

The receive version of the FireFly™ module shares the same connectors and optical lens array; the PIN photodiode is of substantially larger aperture. Hence, the receiver version of the Firefly module will perform at least as well as the transmit version.

Gen 4 PCIe®-Over-fiber

FIREFLY™ OPTICAL CABLE SYSTEM (PCUO Series)

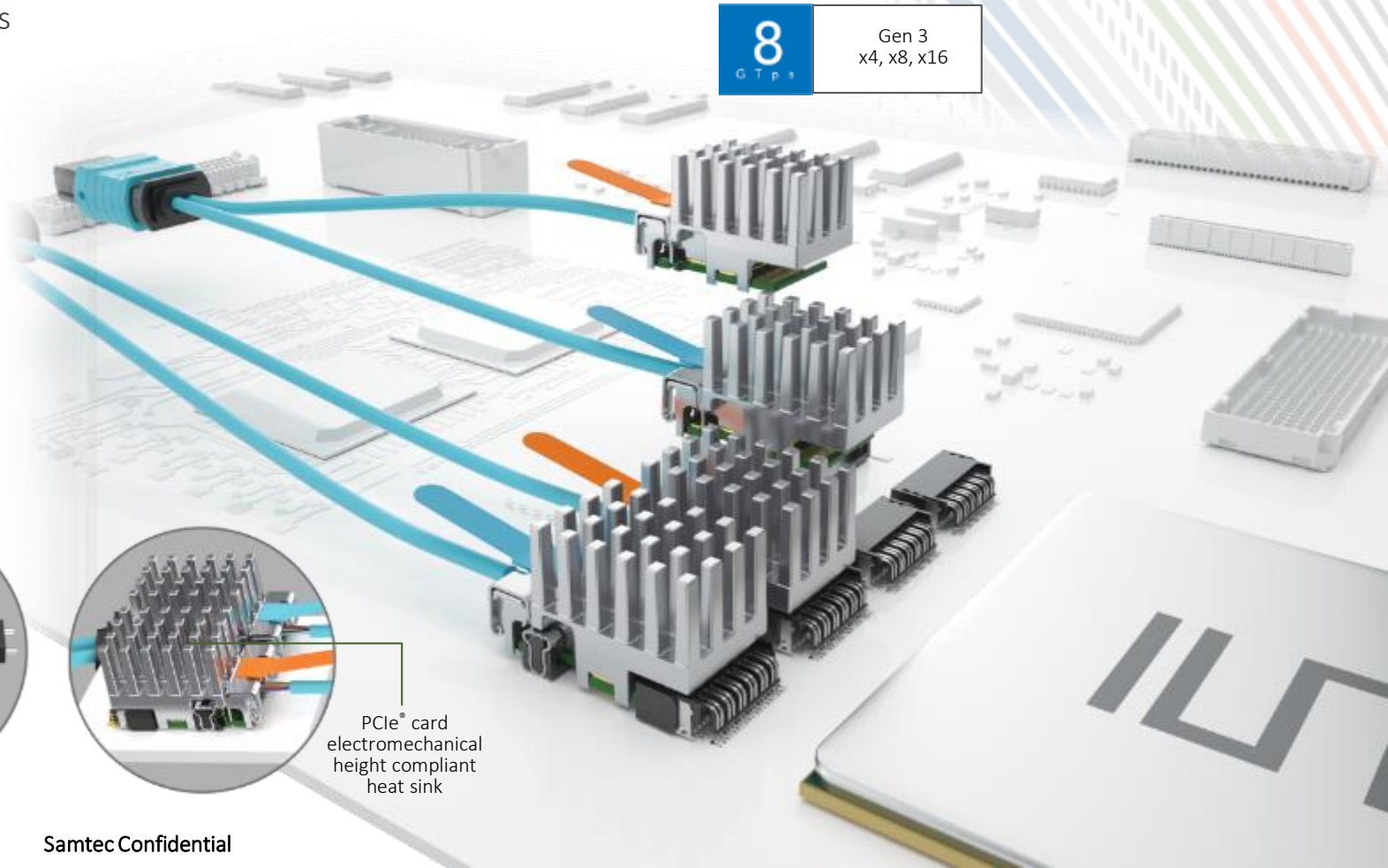
Transmits PCIe® signals at Gen 3 data transfer rates through FireFly™ optical up to 100 m

Supports PCIe® protocol for low latency, power savings and guaranteed transmission

Transparent and non-transparent bridging

Easy design into downstream systems, ultimately making them smaller

Gen 4 is now sampling



PCIE®-OVER-FIBER ADAPTOR CARD (PCOA-XX-XX-01)

PCIe® x16 edge card connector

Supports Gen 3 platform; Gen 4 in development

Scalable configurations for cost optimized performance

- x4: single, dual or quad
- x8: single or dual
- x16

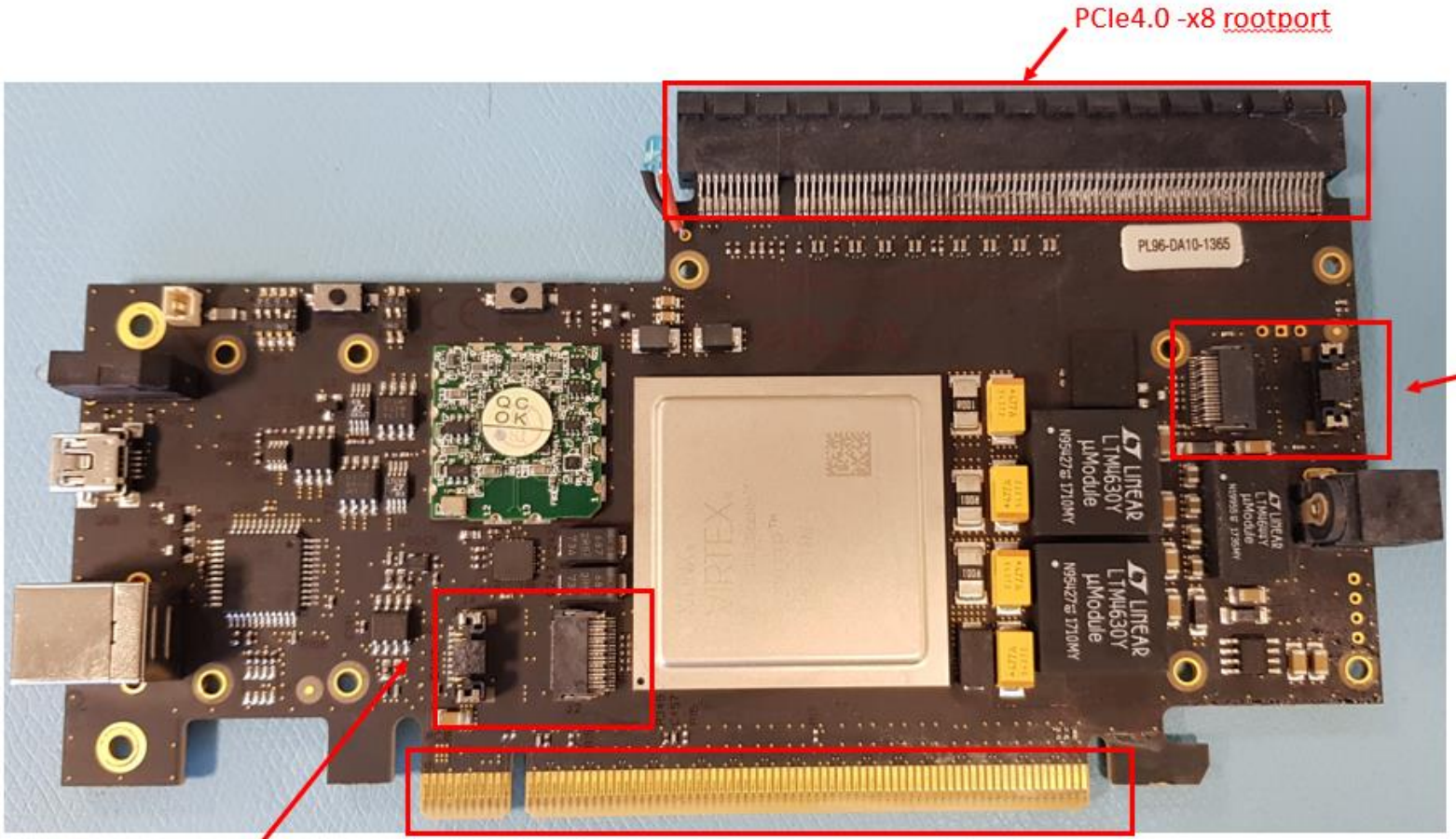
Includes four PCUO FireFly™ transceivers

Enables computer-to-endpoint over long distances

Computer to computer version available fromDolphin Interconnect Systems

PLDA PCIe Gen4 Switch

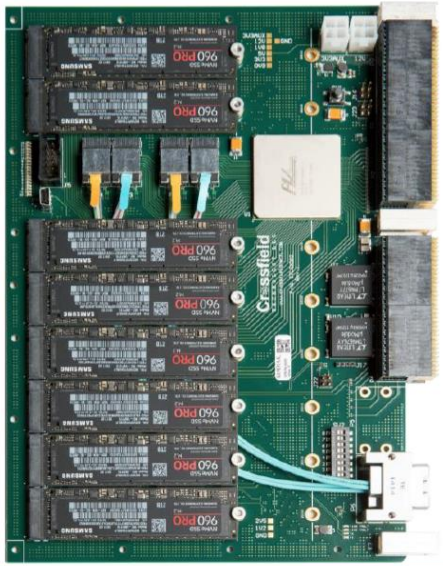
PLDA Gen4switch PCIe ports topology



VITA 65.1 Boards Using FireFly Modules

Crossfield Technology LLC — EMBEDDED SYSTEMS

6U VPX NVM Express SSM



Key Features

- VITA 65.1 OpenVPX / VITA 84 HOST Profile 12.2.1-15
- Eight NVMe M.2 slots supporting 2280/22110 M-key modules
- 4x4, 2x8 or 1x16 PCI Express Gen3 Expansion Plane
- 4x4, 2x8 or 1x16 PCI Express Gen3 Optical Plane
- Performance*:
  - 119 Gbps Sequential Read
  - 98 Gbps Sequential Write
  - 1.8M IOPS Random Read
  - 1.5M IOPS Random Write

Crossfield Technology LLC — CTLSX003

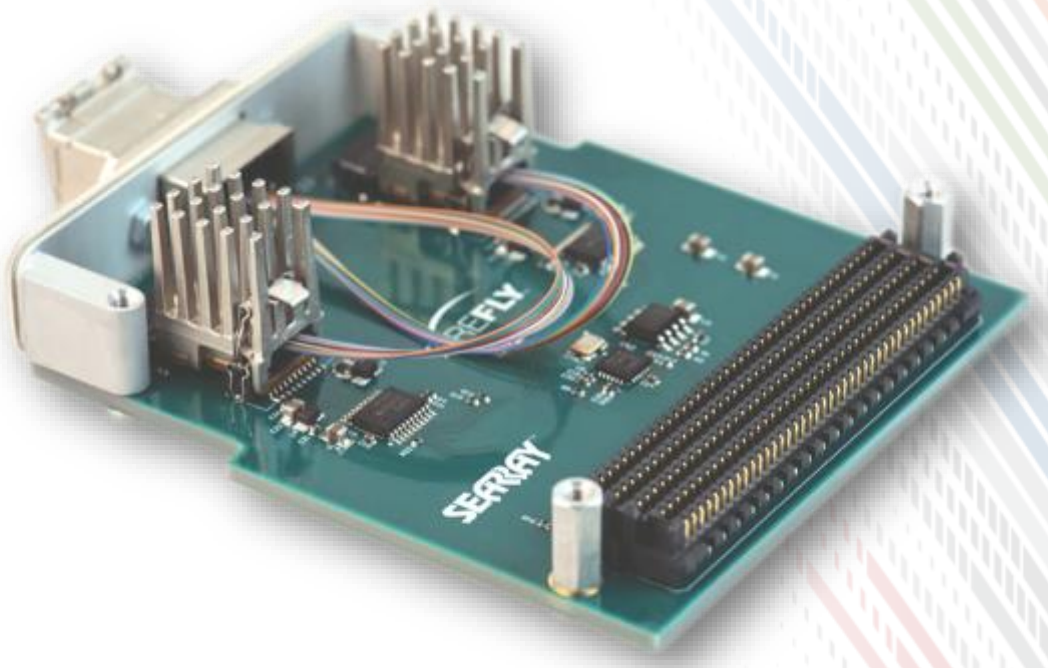
HOST, CMOSS and SOSA NVM Express SSM

Key Features

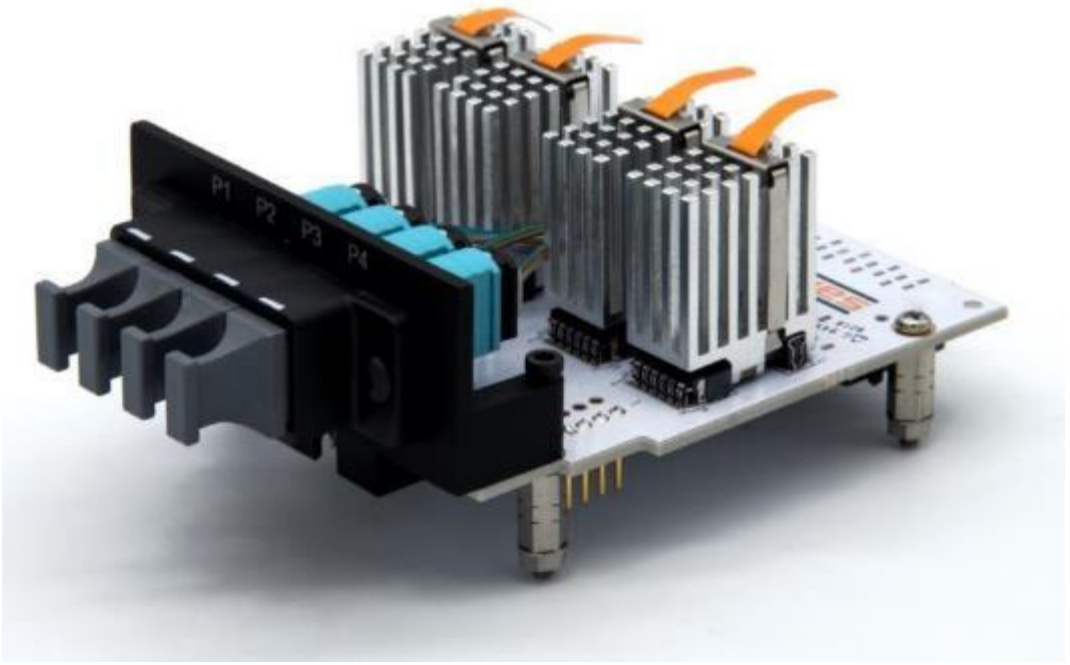
- VITA 65.1 OpenVPX / VITA 84 HOST Two M.2 PCIe Gen 3 NVMe slots supporting 2280/22110 M-key modules
  - **Enables rapid prototyping of evolving solid-state storage & memory technologies**
- Data Security
  - 256-bit AES and TCG Opal
- 2x4 or 1x8 PCIe Gen 3 links on P2 EP w/ Virtual Switching support
- 2x4 or 1x8 or 1x16 PCIe Gen 3 links P6 Optical Plane via VITA 66.1 connector
- Performance:
  - Expect near saturation of EP

VITA 57.1 FPGA MEZZANINE CARD (FMC)

- 10-lane bidirectional optical interface for FPGAs
- 100 m reach
- Lane speeds to 14 Gbps
- Supports any FPGA protocol
- Samtec FireFly optical engines (ECUO-Y12)
- 24 fiber MTP®/MPO connector



25/28 Gbps FireFly™ FMC+ Dev Kit



- VITA 57.4 FPGA FMC+ Mezzanine Card
- 16-lane bidirectional optical interface for FPGA
- 100 m reach
- Lane speeds to 28 Gbps
- Supports any FPGA protocol
- Four FireFly optical engines (ECUO-B04)
- SI optimized PCB traces via Samtec Final Inch®
- 24 fiber MTP®/MPO connector

Production FireFly™ Products

Series	Lanes	Gbps	Features
ETUO	4 + 4	10.3	Exceeds 802.3 40G Base SR Ethernet and InfiniBand QDR specifications Industrial temperature range for Mil/Aero
ETUO	12		
ECUO	12	14.1	Aligns with FDR InfiniBand and 14G FPGA speeds
ECUO	4 + 4		
ECUO	12	15.7	Maximizes FGPA interconnection
PCUO	x4 / x8 / 16	PCIe® Gen 3	x4 / x8 / x16, Transparent and Non-Transparent PCIe FireFly™
PCOA	x4 / x8 / 16	PCIe® Gen 3	x4 / x8 / x16, Transparent PCIe Extension Card

	Operating	Storage
	0°C to 70° C	-55 °C to 125° C
	-40 °C to 85° C	-55 °C to 125° C

FireFly™ Roadmap

Series	Lanes	Gbps	Features	Current Status	Production
ECUO	4+4	25	Exceeds specs IEEE 802.3ab for 100G SR4	Beta	Q3 18
ECUO	4+4	28	112 Gbps aligns with faster FPGAs	Beta	Q3 18
PTUO	4+4	8	PCIe® Gen3 expandable to x8 and x16	Alpha	Q4 18
PCUO	4+4	16	PCIe® Gen4 expandable to x8 and x16	Alpha	Q4 18
ETUO	12	12 / 12.5	Some mil/aero applications require 12G	Alpha	Q1 19
SCUO	12	14	Process optimized for submersible cooling	Alpha	Q1 19*
ECUO	12	16.1	FPGA optimized links	Alpha	Q2 19
ETUO	4+4	25/28	Industrial temp for mil/aero	(Alpha Q4 18)	Q3 19
ECUO	12	25/28	High Density links for Enhanced Ethernet	(Alpha Q2 19)	Q1 20
ETUO	12	25/28	Industrial temp for mil/aero	(Alpha Q2 19)	Q1 20

	Operating	Storage
	0°C to 70° C	-55 °C to 125° C
	-40 °C to 85° C	-55 °C to 125° C

* Timing dependent on market demand

FIREFLY™ ADVANTAGES EMBEDDED APPLICATIONS

- Density
  - Firefly is 4x more dense than QSFP
  - Heat sink grooves enable dense array placement
- Serviceability
  - Only FireFly has card-edge connector system
  - Only FireFly allows copper cabling in same footprint
  - Modules are easy to replace
- Scalability
  - Extensive product roadmap
  - More heat sink options
  - More connector and cabling options
  - Lane speeds to 28 Gbps and beyond
  - Commercial and industrial temp ranges

Density

Serviceability

Scalability

THANK YOU