

OPTICS

MID-BOARD TRANSCEIVER
SOLUTIONS GUIDE

OPTICAL SOLUTIONS

Samtec is the industry-leading provider of mid-board optical transceiver solutions. This growing and comprehensive family of products provides reliable signal integrity over an extended distance in chip-to-chip, board-to-board, on-board and system-to-system connectivity. Optical products are offered with Samtec's Sudden Service® - full engineering support, online tools and a service attitude that is unmatched.

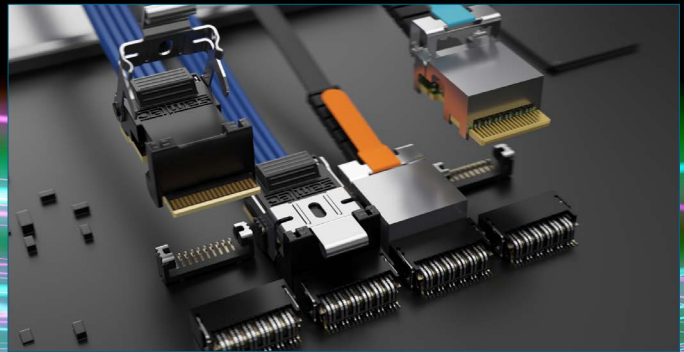
LOW POWER SOLUTION

Minimal power usage per module in a small footprint allows for high-density placement close to the IC for significant power savings in the overall system.



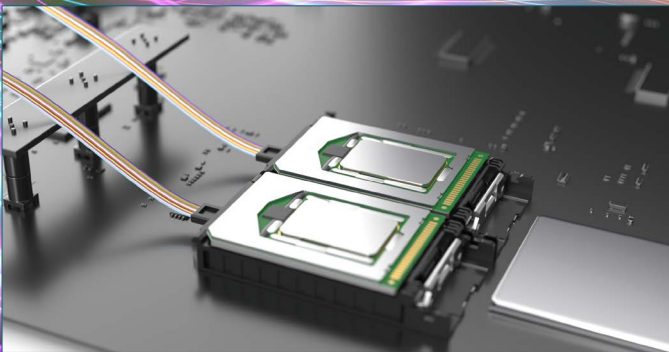
SMALL FORM FACTOR

Flexibility of copper and optical using the same micro connector allows for increased density, simplified PCB and reduced power dissipation.



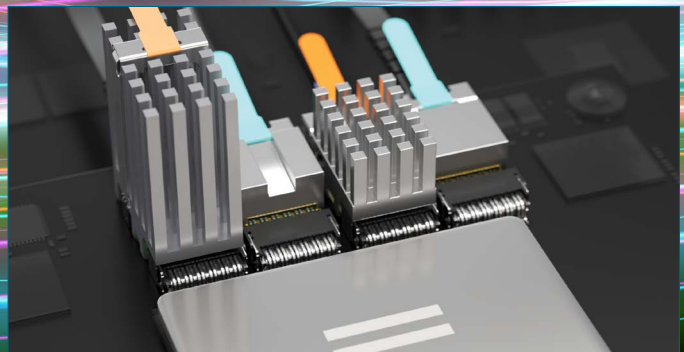
HIGH-PERFORMANCE VERSATILITY

Data connection is taken "off board" for up to 28 Gbps per lane with a path to 112 Gbps PAM4 via optical cable at greater distances - or copper for cost optimization.



INTEGRATED THERMAL MANAGEMENT

Variety of integral heat sinks or through-the-board cooling provides optimal thermal control for harsh environments and wide temperature ranges.



APPLICATIONS

Samtec mid-board optical transceivers are ideal for embedded and rugged applications, including phased array radar, ASIC emulation, medical imaging and embedded computing.



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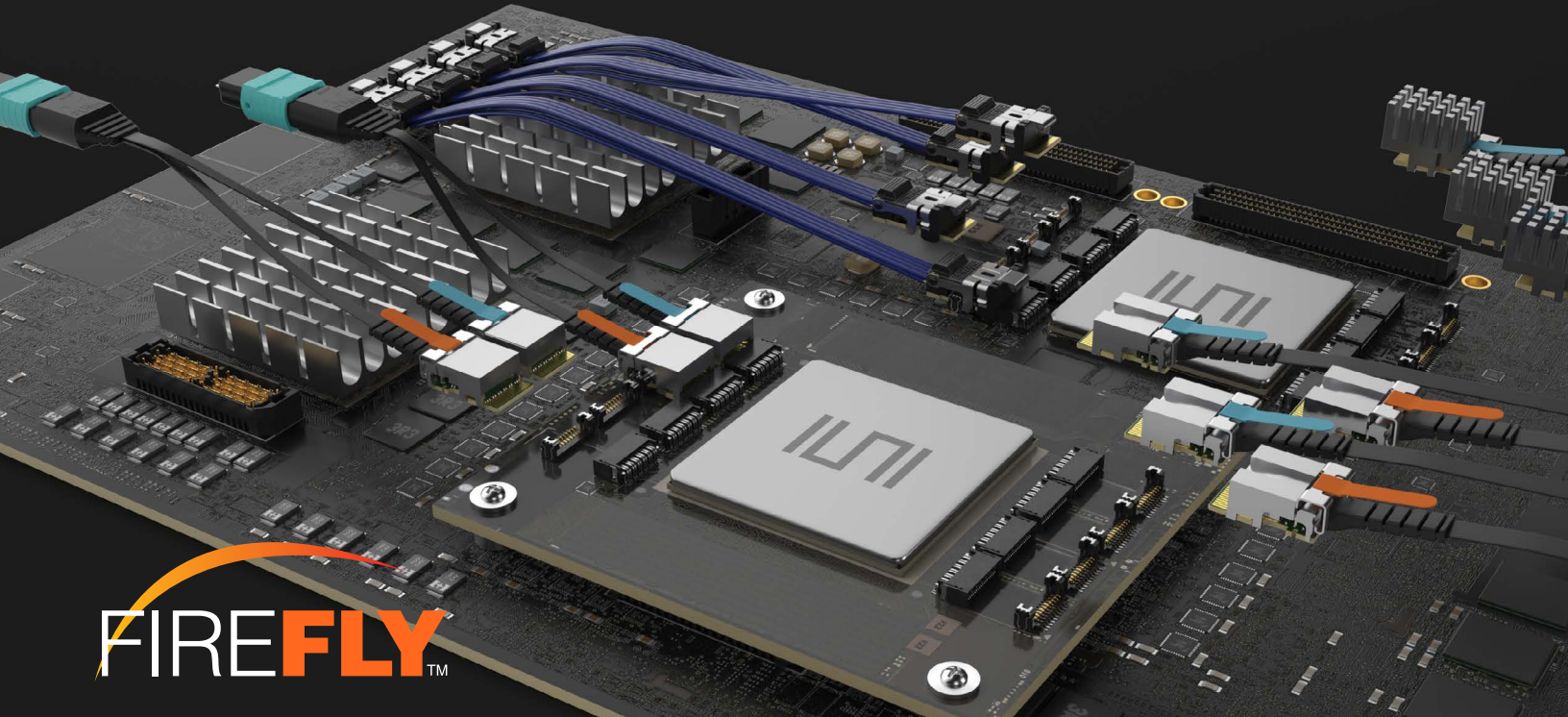
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FIREFLY™ EMBEDDED MID-BOARD TRANSCEIVERS



Data connection is taken "off board," simplifying board layout and enhancing signal integrity from IC to faceplate

- Up to 28 Gbps per channel via optical cable for greater reach
- Industry leading miniature footprint allows for higher density close to the data source
- Simple to use system with easy insertion/removal and trace routing, no through-holes, and a surface mount connector system
- Two-piece connector system: 0.50 mm pitch up to 20 Gbps (UEC5-1) or 20+ Gbps (UEC5-2) and 0.80 mm pitch (UCC8)
- Supports data center, HPC and FPGA protocols, including 10/40/100 Gb Ethernet, InfiniBand™, Fibre Channel, PCIe®, CXL® and Aurora

14 G b p s	x4 x12	25 G b p s	x4 x12
16 G b p s	x12	28 G b p s	x4
32 G b p s	x4 x12 (in development)		

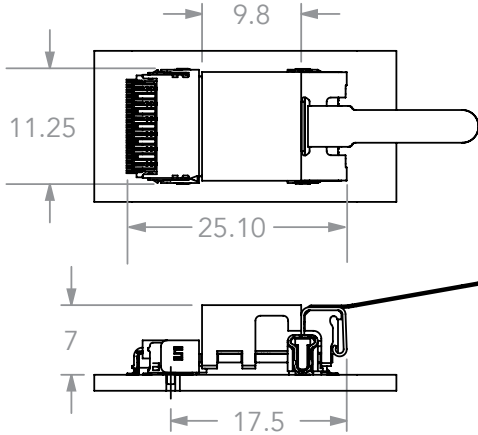
ECUO	WIDTH	DATA RATE	CABLE LENGTH	0	HEAT SINK	1	FIBER TYPE	END 2 OPTIONS*
	-B04 = 4 Tx + 4 Rx -T12 = 12 Tx -R12 = 12 Rx -Y12 = 12 Tx + 12 Rx -U12 = 12 Channel AOC (Unidirectional)	-14 = 14 Gbps per lane -16 = 16.1 Gbps per lane (N/A -B04) -25 = 25.7 Gbps per lane -28 = 28.1 Gbps per lane (-B04 only)	-"XXX" = Overall Length in Centimeters		-1 = Flat -2 = Pin-fin (-14 & -16 only) -3 = Flat with groove -4 = PCIe® Pin-fin (-14 & -16 only) -5 = 1.75 cm tall Pin-fin		-5 = Jacketed ribbon with boot -6 = Jacketed ribbon -7 = Loose tube with boot -8 = Loose tube	-Y12 requires -2X end option (Leave blank for -U12) 12 Fibers/24 Fibers -01/-21 = MTP® Male -02/-22 = MTP® Female -07/-27 = MXC® Internal Plug -0E/-2E = MPO Plus®, Male, bayonet

* These are standard options. See page 9 for other end options available.

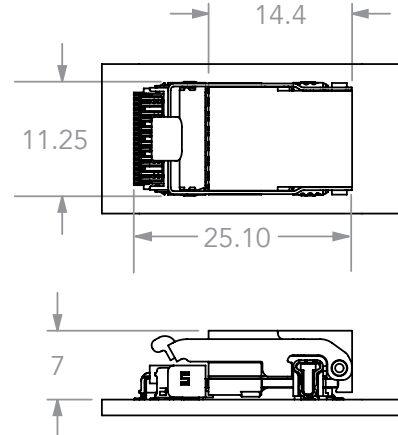
MTP® and MXC® are registered trademarks of US Conec Ltd. PCI-SIG®, PCI Express® and the PCIe® design marks are registered trademarks and/or service of PCI-SIG.

MECHANICAL & ELECTRICAL SPECIFICATIONS

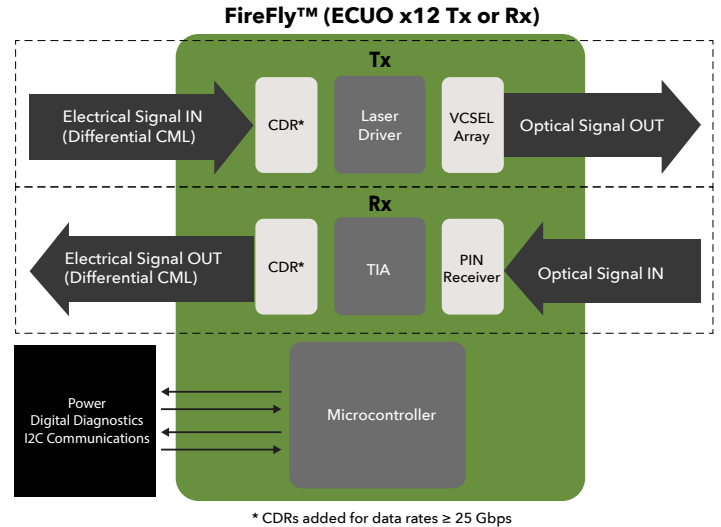
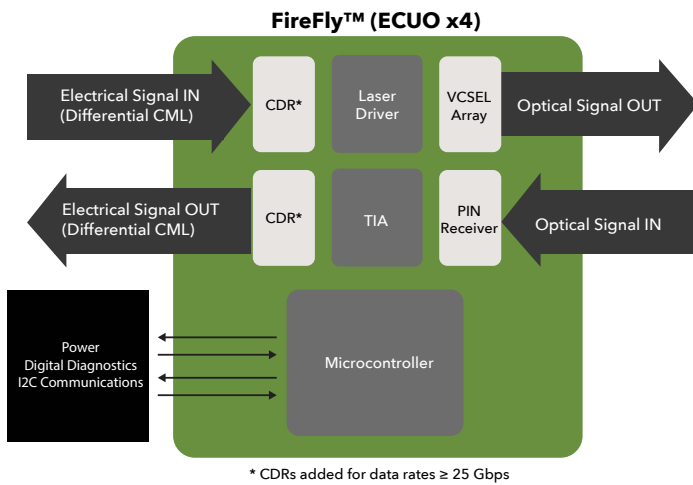
Contact OpticsTPS@samtec.com for technical support.



Dimensions of ECUO B04, X12, Y12 & U12 (flat heat sink; shown in mm)



Dimensions of ECUO X12 & Y12 25 Gbps only (flat heat sink; shown in mm)



DESCRIPTION	SPECIFICATION
POWER SUPPLY VOLTAGE	3.3 V (main), varies per series
POWER CONSUMPTION	2.5 W (max typical), varies per series
STORAGE TEMPERATURE	-40 °C to +85 °C
OPERATING TEMPERATURE	0 °C to +70 °C
RELATIVE HUMIDITY	5 to 85%
OPTICAL SENSITIVITY	5-10 dBm for BER $<$ 10^{-12} at PRBS31, varies per series
OPTICAL EXTINCTION RATIO	3 dBm
TRANSMITTER TYPE	850 nm VCSEL
RECEIVER TYPE	PIN Photodiode
OPTICAL CABLE	OM3 or OM4 fibers

FIREFLY™ RUGGED

MID-BOARD TRANSCEIVERS



Extended temperature range from -40 °C to +85 °C for military, aerospace and industrial applications

- Demonstrated error-free transmission during applied external vibrations and shock test to methods specified in MIL-STD-810
- Variety of integral heat sinks provide optimal cooling for thermal operating conditions
- Optional parylene conformal coating available (ETMO) for exposed military and aerospace applications; other rugged environment capabilities include tin whisker mitigation and fungal resistant
- Multiple end options available, including MT38999, MTP®, MXC®, Glenair® Series 79, VITA 66.X and other common rugged interfaces

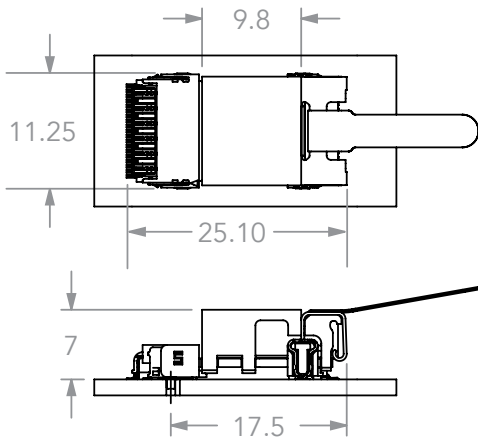
10 Gbps	x4 x12
12.5 Gbps	x12
25 Gbps	x4

SERIES	WIDTH	DATA RATE	CABLE LENGTH	COATING	HEAT SINK	FIRMWARE	FIBER TYPE	END 2 OPTIONS*
ETUO	-B04 = 4 Tx + 4 Rx	-10 = 10.3125 Gbps	-"XXX" = Overall Length in Centimeters	-0 =No Coating (ETUO)	-1 = Flat	-1 = Standard	-5 = Jacketed ribbon with boot	-Y12 requires -2X end option (Leave blank for -U12/AOC)
ETMO (-B04 only)	-T12 = 12 Tx -R12 = 12 Rx -Y12 = 12 Tx + 12 Rx -U12 = 12 Channel AOC (Unidirectional)	-12 = 12.5 Gbps (N/A -B04) -25 = 25.7 Gbps (-B04 only)		-2 =Protective Coating (ETMO)	-2 = Pin-fin -3 = Flat with groove -4 = PCIe® Pin-fin (-10 only) -5 = 1.75 cm tall Pin-fin (ETUO-B04 only)	-2 = Standard Secure (ETMO only) -3 = Dual Power (ETMO only) -4 = Dual Power Secure (ETMO only)	-6 = Jacketed ribbon -7 = Loose tube with boot -8 = Loose tube	12 Fibers/24 Fibers -01/-21 = MTP® Male -02/-22 = MTP® Female -07/-27 = MXC® Internal Plug -0A/-2A = VITA 66.X Ready -0C/-2C = MT38999 Male -0E/-2E = MPO Plus®, Male, bayonet (ETUO only)

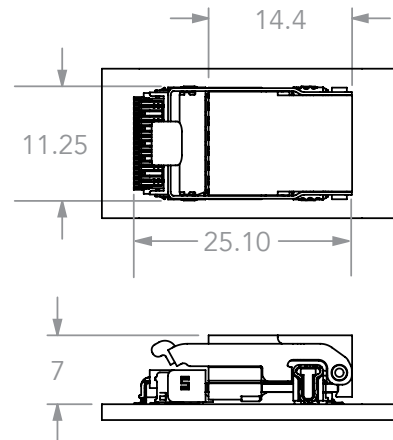
*These are standard options. See page 9 for other end options available.

MECHANICAL & ELECTRICAL SPECIFICATIONS

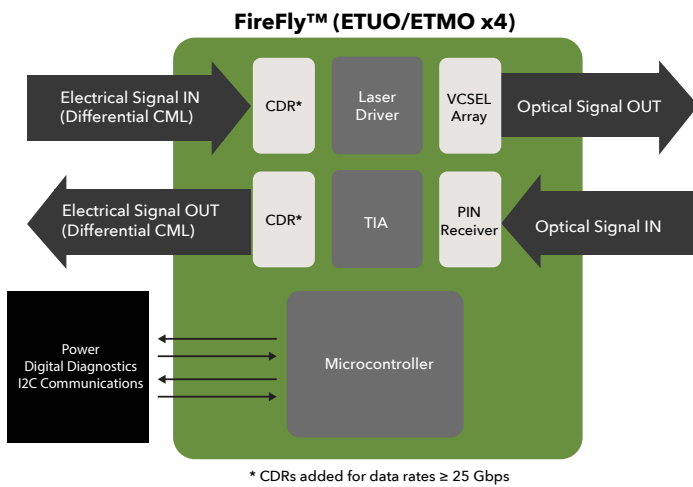
Contact OpticsTPS@samtec.com for technical support.



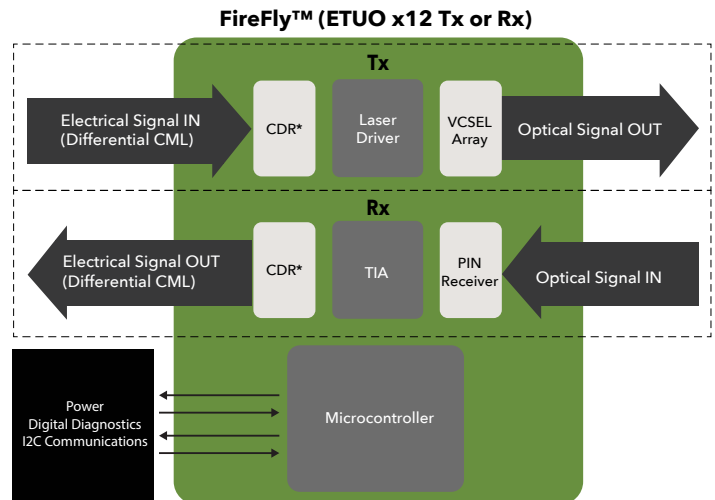
Dimensions of ETUO
(flat heat sink; shown in mm)



Dimensions of ETMO
(flat heat sink; shown in mm)



* CDRs added for data rates ≥ 25 Gbps



* CDRs added for data rates ≥ 25 Gbps

ETMO SERIES RUGGEDIZED TESTING

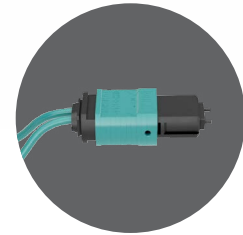
QUALIFICATION TESTING	Completed per Table D-XVI in MIL-PRF-38354
DAMP HEAT	1,000 hours 85 °C / 85% RH
HAST	264 hours 95 °C / 85% RH
SALT FOG	MIL-STD-883 TM 1009 Test Condition A
TEMPERATURE CYCLING	-55 °C to +95 °C, 100 cycles
LIFE TEST	2,000 hours at 70 °C
FIBER INTEGRITY	Telcordia GR-468
MECHANICAL SHOCK AND VIBRATION	MIL-STD-810H, Figure 514.7C-4 (Tactical Transportation, Telcordia GR-468)
OPERATIONAL VIBRATION	2 hour/axis of MIL-STD-883, Method 2026, Condition I, Letter G
OPERATIONAL SHOCK	3 shocks +/- direction per MIL-STD-810 Method 516 50G, 11 ms half sine
ESD	250 V HBM testing per MIL-STD-883 Method 3015

PCIe® -OVER-FIBER

MID-BOARD TRANSCEIVERS

PCIe® 5.0-OVER-FIBER

- Transmits PCIe® 3.0/4.0 data through FireFly™ mid-board optical transceivers up to 100 m (5.0 in development)
- Supports PCIe® protocol for low latency, power savings and guaranteed transmission
- Extended temperature version with a range of -40 °C to +85 °C
- Duplex auxiliary signals allow both transparent and non-transparent bridging
- PCIe® card electromechanical height compliant heat sink
- Micro optical engines allow for easy design into downstream systems, ultimately making these systems smaller
- Visit samtec.com/firefly for more information



MTP® connectors for high-density panel applications and minimal keep-out areas on the board

8
G T p s

PCIe® 3.0 x4
PCIe® 3.0 x8
PCIe® 3.0 x16

16
G T p s

PCIe® 4.0 x4
PCIe® 4.0 x8
PCIe® 4.0 x16

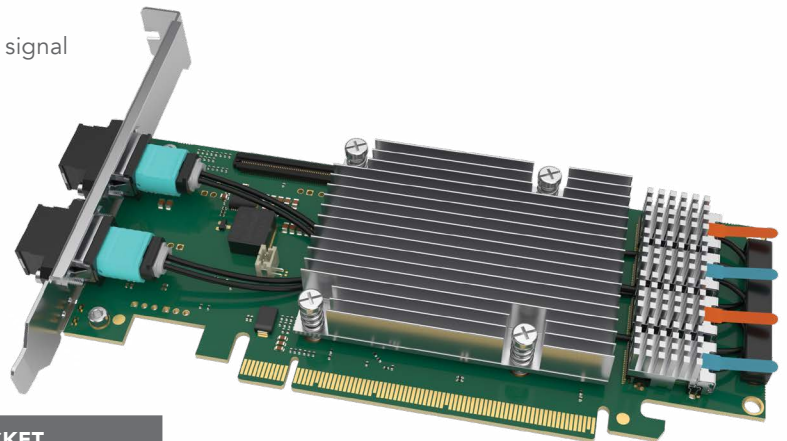
32
G T p s

PCIe® 5.0 x4
PCIe® 5.0 x8
PCIe® 5.0 x16
(in development)

PCUO	WIDTH	SPEED	CABLE LENGTH	0	HEAT SINK	1	FIBER TYPE	END 2 OPTIONS
	-04 = x4 Lanes -08 = x8 Lanes	-G4 = 4.0	-“XXX” = Overall Length in Centimeters		-1 = Flat -4 = PCIe® Pin-fin		-7 = Loose tube with boot -8 = Loose tube	(-04 width requires -01 option; -08 requires -21 end option) -01/-21 = MTP® Male

ADAPTOR CARD WITH FIREFLY™

- Uses PCUO FireFly™ mid-board optical transceiver for clear signal transmissions with increased reach and cost optimization
- Supports PCIe® 3.0/4.0 platform (5.0 in development)
- PCIe® x16 edge card connection
- Scalable configurations for cost optimized performance
- Transparent or non-transparent bridging for system flexibility and multi-processor support
- Reconfigurable host or target operation
- Visit samtec.com/firefly for more information



PCOA	SPEED	WIDTH	BRACKET
	-G3 = 3.0 -G4 = 4.0	-S4 = Single x4 -D4 = Dual x4 -Q4 = Quad x4 -S8 = Single x8 -D8 = Dual x8 or Single x16	-0A = Full Height

DESIGN FLEXIBILITY

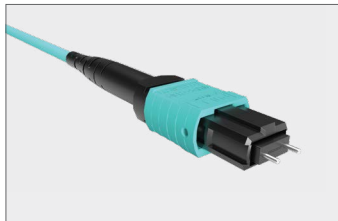
FireFly™ features a variety of design options. Many of these options are also available for Halo™. Contact OpticsOTP@samtec.com to discuss your application.

APPLICATION SPECIFIC PRODUCT CUSTOMIZATIONS

- Custom firmware
- Secure firmware
- Custom optical link budget
- Custom fiber mappings
- Custom optical connectors
- Custom assemblies with multiple FireFly™/optical connectors
- Contact OpticsOTP@samtec.com for assistance with your application needs



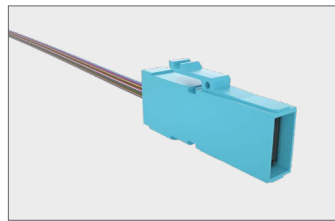
END OPTION FLEXIBILITY



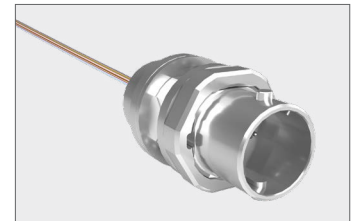
MPO (MTP®)



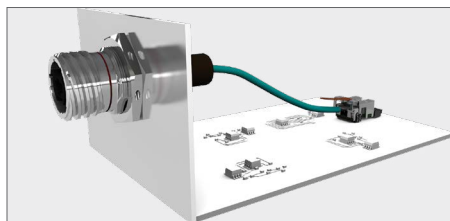
MT



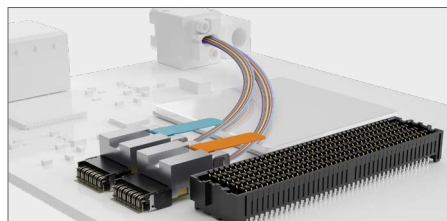
MXC®



U-SDI Interface



Amphenol® MT38999



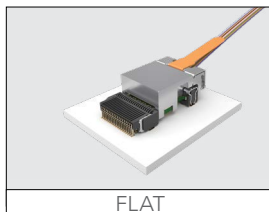
VITA 66.1/66.4 Interface



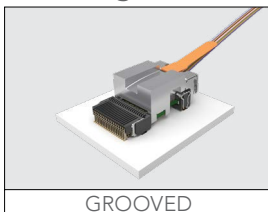
Glenair® Series 79 MT Connector

HEAT SINK FLEXIBILITY

Conduction Cooling

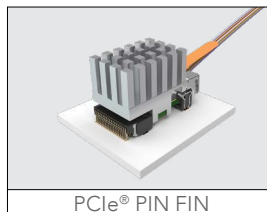


FLAT



GROOVED

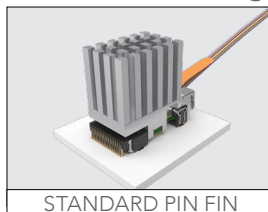
Groove allows ribbon cables to pass through so FireFly™ can be placed closer together



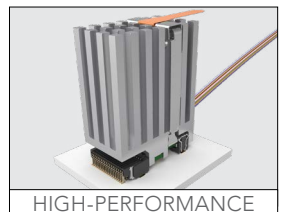
PCIe® PIN FIN

PCIe® card height compliant

Convection Cooling



STANDARD PIN FIN

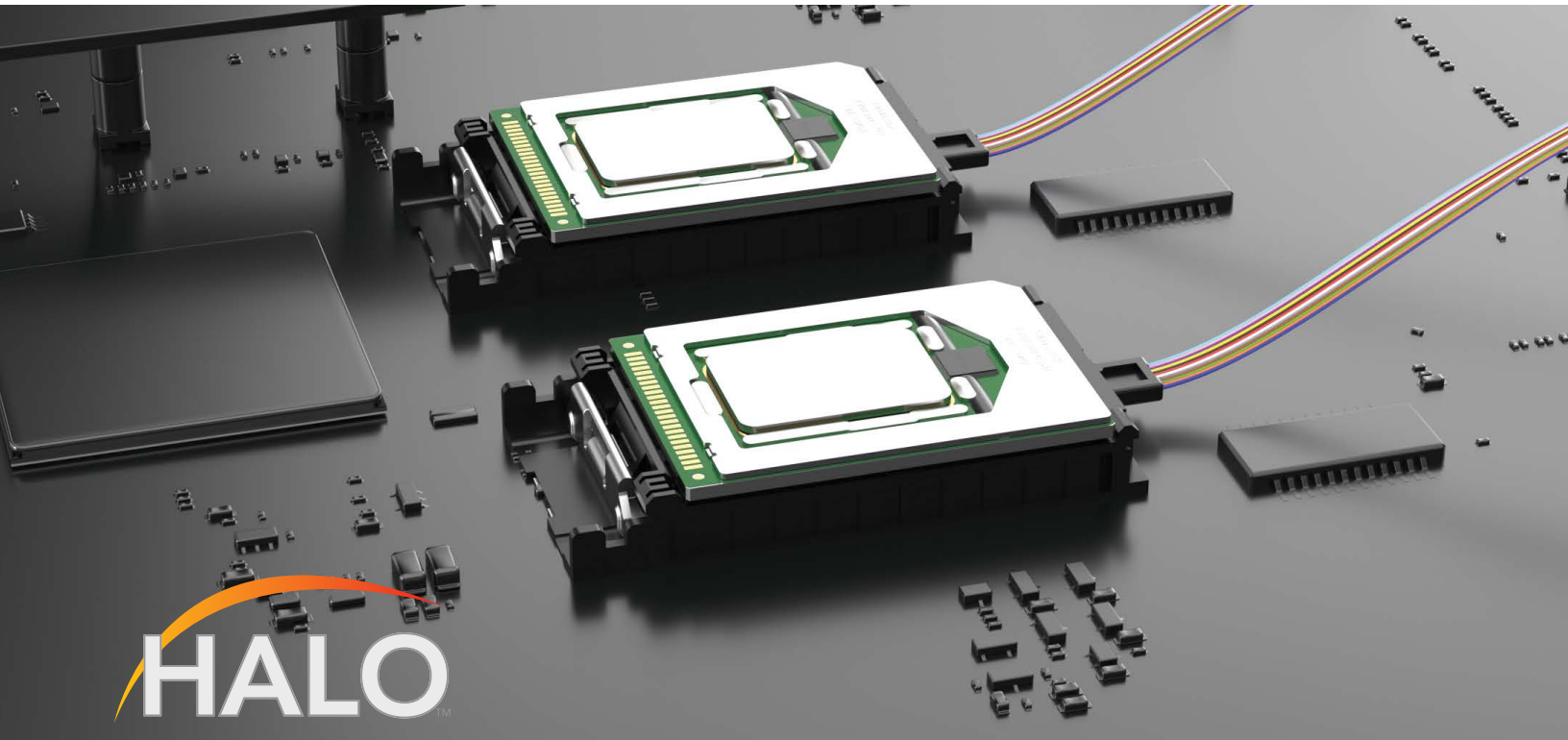


HIGH-PERFORMANCE

Accommodates applications with specific power and temperature requirements

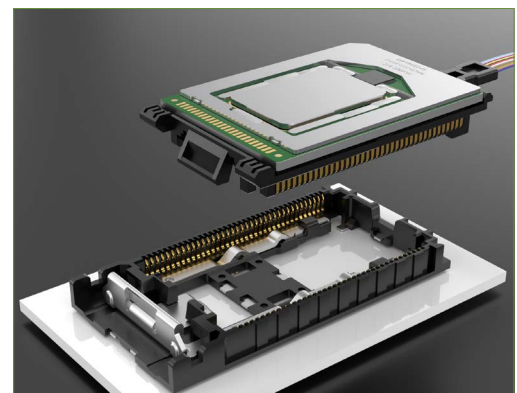
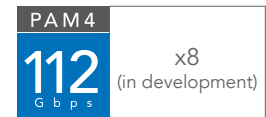
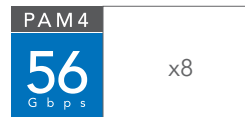
HALO™ NEXT GEN

MID-BOARD TRANSCEIVERS



Designed for next gen embedded applications demanding 56/112 Gbps PAM4 performance in low profile and ruggedized form factors

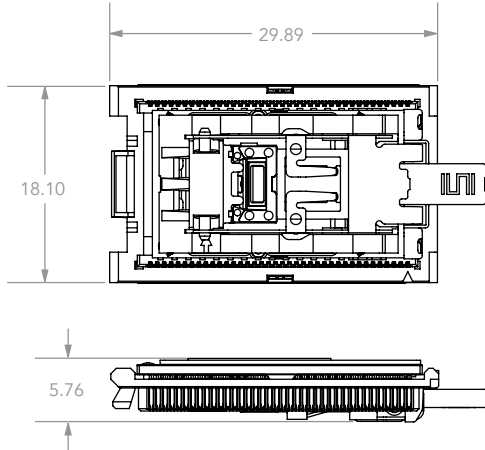
- Up to 16 channels (8 channel bidirectional); 112 Gbps PAM4 per lane
- Low profile with a 2-piece contact system
- Designed to withstand high shock and vibration
- Features a low center of gravity for a stable connection to the board
- Optically pluggable for easy field replacement
- Protocol agnostic
- Supports data center, HPC and FPGA Protocols, including 10/40/100/400/800 Gb Ethernet, InfiniBand™, Fibre Channel, PCIe®, CXL® and Aurora
- Variety of heat sink options for conduction, convection or liquid cooling thermal relief
- Rugged surface mount connector with integrated locking latch mechanism simplifies mating/unmating of the cable assembly
- Halo™ optical, copper and active copper systems are interchangeable using the same high-performance connector
- Design flexibility available; see page 9 for details or contact OpticsOTP@samtec.com



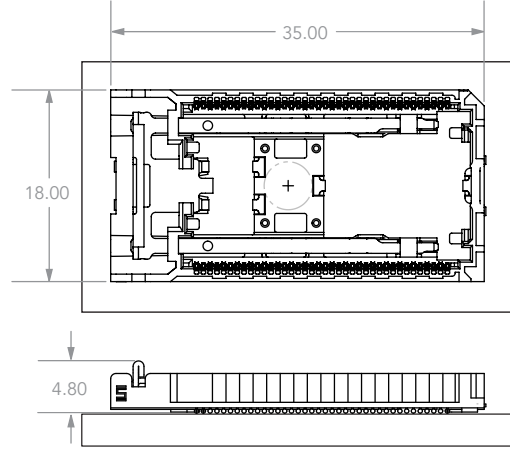
Halo™ ring connector with up to 76 pins in a single row around the perimeter for vertical mating with optical and copper systems

MECHANICAL & ELECTRICAL SPECIFICATIONS

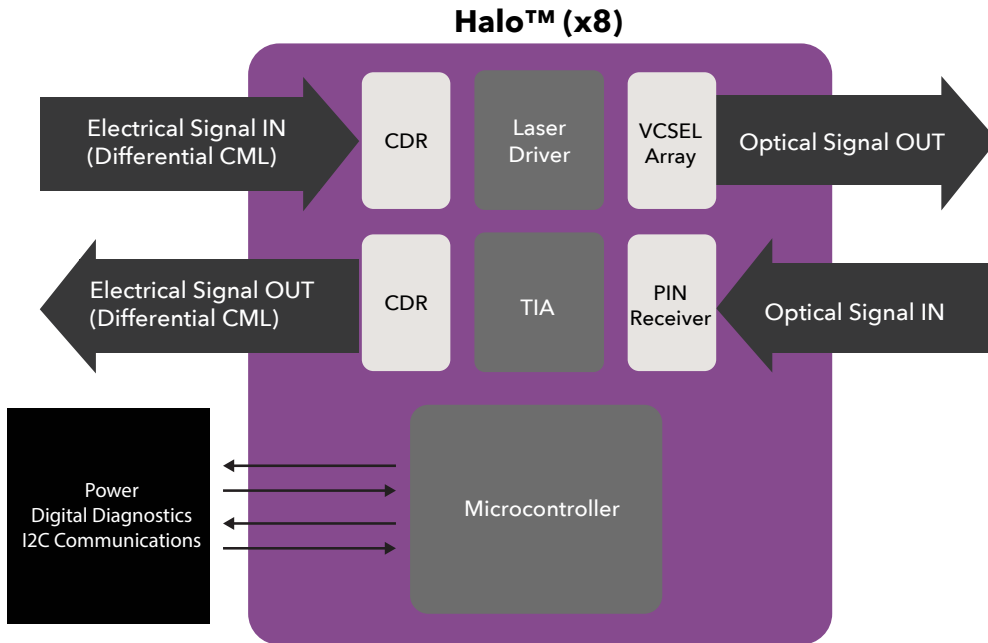
Contact OpticsTPS@samtec.com for technical support.



Dimensions of Halo™ cable system (shown in mm)



Dimensions of Halo™ ring connector (shown in mm)



DESCRIPTION	SPECIFICATION
POWER SUPPLY VOLTAGE	1.6 V, 3.3 V, 4.1 V
POWER CONSUMPTION	TBD
STORAGE TEMPERATURE	-40 °C to +85 °C
OPERATING TEMPERATURE	0 °C to +70 °C
RELATIVE HUMIDITY	5 to 85%
OPTICAL SENSITIVITY	TBD
OPTICAL EXTINCTION RATIO	TBD
TRANSMITTER TYPE	850 nm VCSEL
RECEIVER TYPE	PIN Photodiode

FIREHAWK™ SPACE

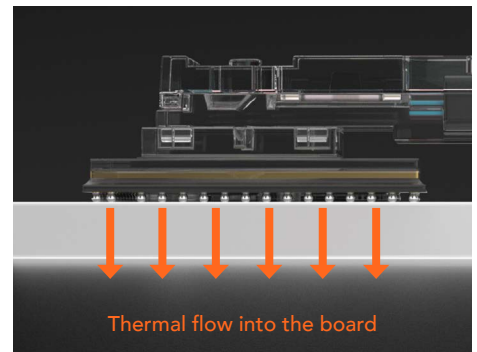
MID-BOARD TRANSCEIVERS



FireHawk™ CSSO is designed to withstand vibrations and radiation in space applications

- 0.4 grams total weight for optimal SWaP
- Rad-Hard for satellites: internal driver ASIC for the VCSELs and PIN receivers designed using radiation hardened by design guidelines
- Optical cabling reduces weight and size for longer connections in satellites
- Module management, controls and diagnostics through a Serial Peripheral Interface (SPI)
- 850 nm VCSEL transmitter
- 3.3 V supply voltage; 1.2 W (total power 4 Tx & 4 Rx active)
- -40 °C to +85 °C temperature range (+95 °C available)
- Automatic Gain Control (AGC) for high Rx dynamic range with reduced noise
- Individual channel power-down and squelch
- SI Evaluation Kit available, see page 17

10
G b p s x4

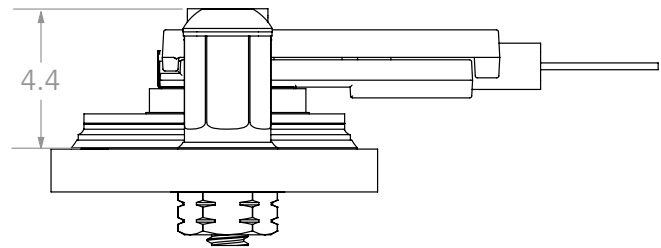
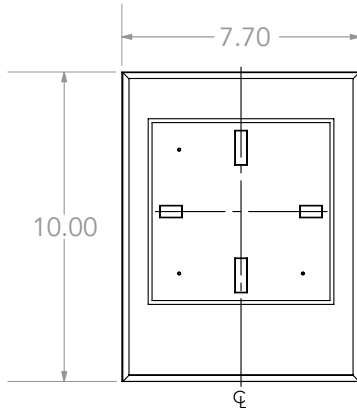


CSSO*	WIDTH	DATA RATE	ENVIRONMENT TYPE	0 0 1	BALL TYPE
	-B04 = 4 channel, bidirectional	-10 = 10 Gbps	-4 = Space		-2 = Tin Lead

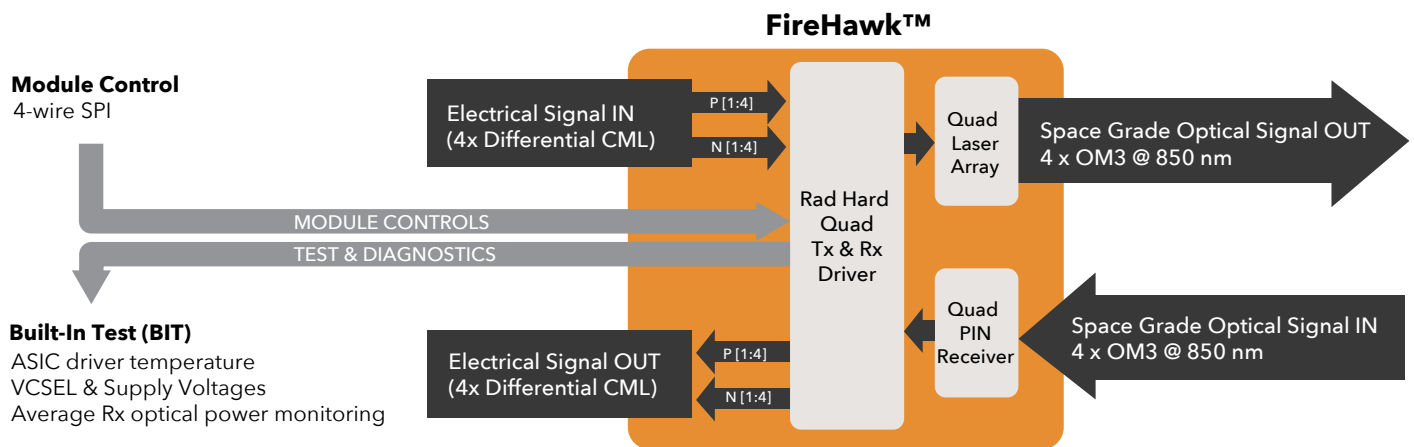
* For full assembly, purchase of RVCON® optical cable and CSSO mid-board optical transceiver are necessary. Contact Optics@samtec.com for assistance.

MECHANICAL & ELECTRICAL SPECIFICATIONS

Contact OpticsTPS@samtec.com for technical support.



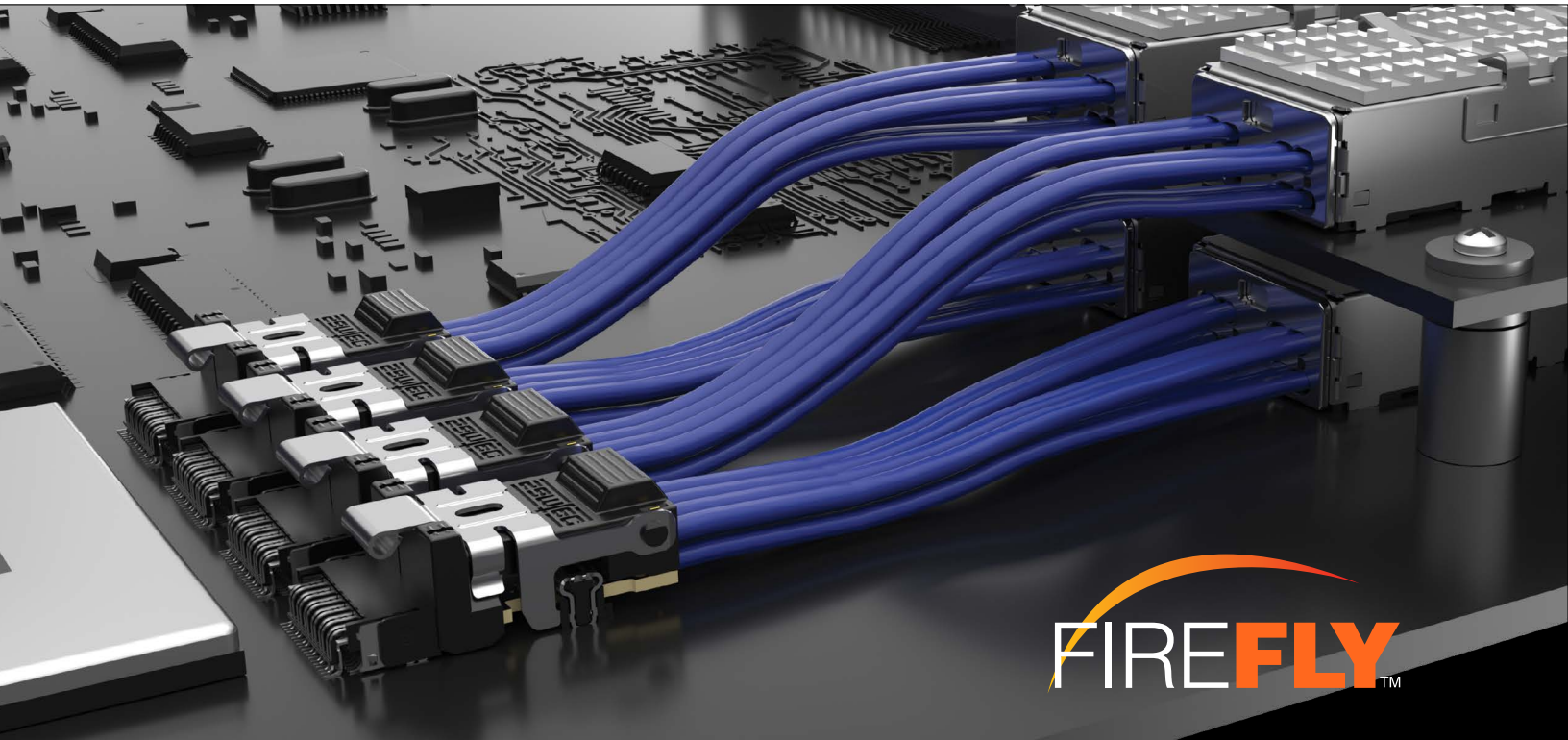
Dimensions of CSSO - Smallest footprint & lowest profile in the industry



DESCRIPTION	CONDITIONS	COMMENTS
ESD	JS-001-20170. 250 V. Class 1	ESD circuits designed for Class 2A
LATCH-UP	JESD78E. Class A	ESD circuits designed for Class 2A

DESCRIPTION	CONDITIONS	EXPOSURE LEVEL	UNITS
SINGLE EVENT EFFECT (HEAVY ION)	Single Event Latch-Up (SEL)	No single event Latch-up	77.8
	Single Event Upset (SEU)	No reset events	< 46
		No permanent damage	> 85.4
DISPLACEMENT DAMAGE (NEUTRON)	1 MeV equiv. neutron fluence	Pre and post irradiation test for Δ in Tx eye and Rx sensitivity	3.70E+11
TOTAL IONIZING DOSE (ELDRS)	Ionizing dose of biased and unbiased parts	Pre and post irradiation test for Δ in Tx eye and Rx sensitivity	63.75

FIREFLY™ COPPER



High-performance, high-density copper Flyover® solution

- Pin compatible with optical FireFly™ using the same connector system
- Low-cost solution for seamless integration of new and existing designs
- Standard copper to 14 and 28 Gbps performance
- PCI Express®-Over-FireFly™ copper supports 3.0 and 4.0 data transfer rates (5.0 in development)
- 100 Ω, 34 AWG or 36 AWG Eye Speed® twinax cable; 100 Ω, 34 AWG Eye Speed® ultra low skew twinax cable
- Variety of end 2 termination options
- Visit samtec.com/firefly or contact HDR@samtec.com for more information

14
G b p s

x4 Bidirectional
x8 Unidirectional
x12 Unidirectional

8
G T p s

PCIe® 3.0 x4
PCIe® 3.0 x8
PCIe® 3.0 x16

28
G b p s

x4 Bidirectional
x8 Unidirectional

16
G T p s

PCIe® 4.0 x4
PCIe® 4.0 x8
PCIe® 4.0 x16

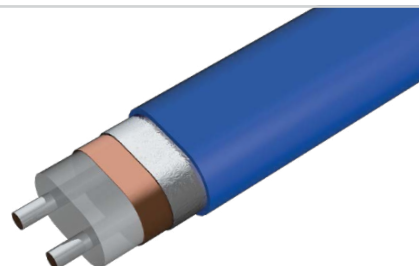
32
G T p s

PCIe® 5.0 x4
PCIe® 5.0 x8
PCIe® 5.0 x16
(in development)

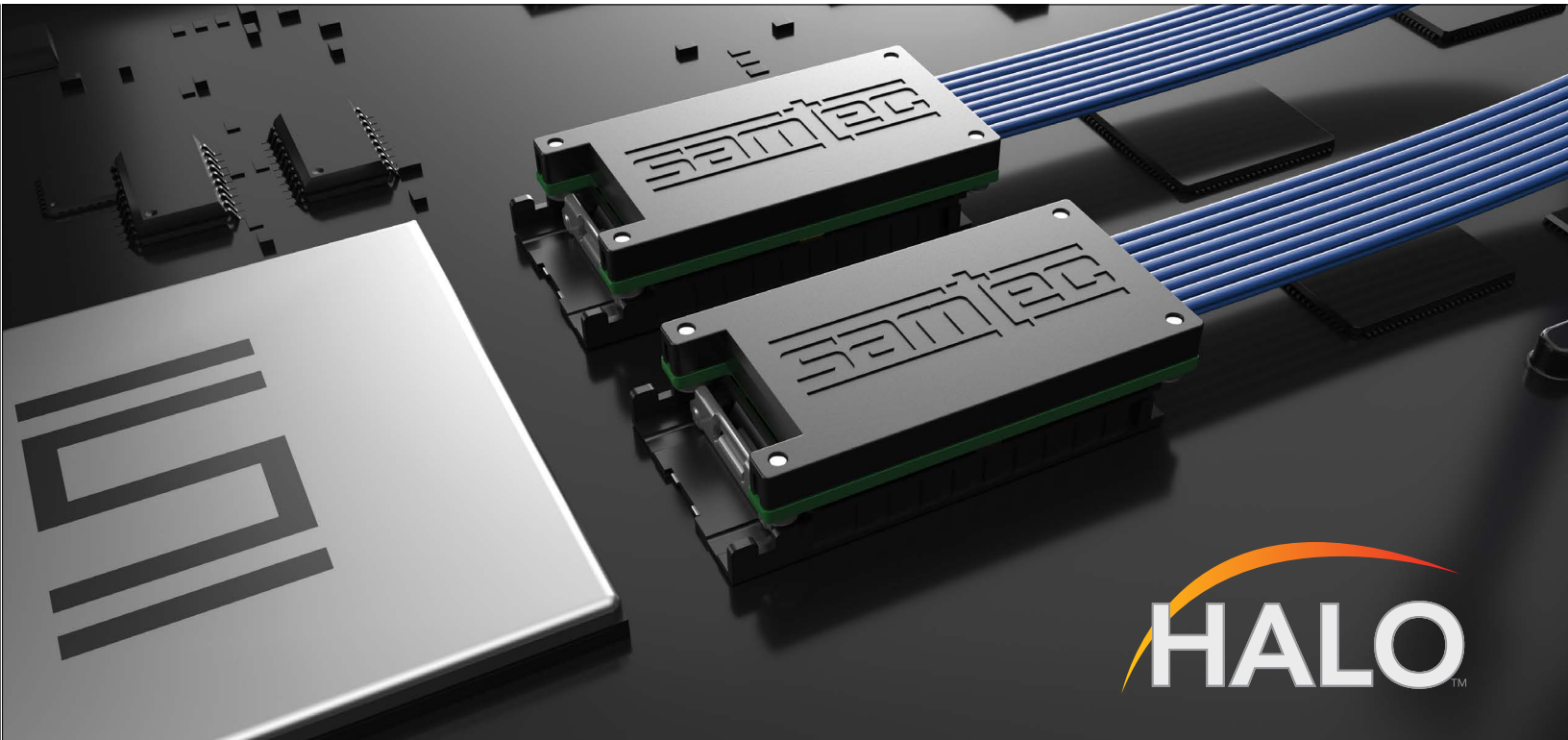
EYE SPEED® ULTRA LOW SKEW TWINAX CABLE

- Tight coupling between signal conductors
- Improved bandwidth (28-112+ Gbps) and reach
- Low skew (<3.5 ps/m) over extended lengths
- Visit samtec.com/eyespeed for more details

**EYE
SPEED**
TWINAX



HALO™ COPPER



Allows for interchangeability of Halo™ optical and copper with the same footprint and function

- Up to 16 channels; 112 Gbps PAM4 per lane (x8 bidirectional)
- Protocol agnostic
- Easily switch from electrical to optical transmission
- Low 6.5 mm profile for space savings
- 2-piece contact system designed to withstand high shock and vibration
- Eye Speed® Thinax™ 34 AWG ultra low skew twinax cable
- Supports data center, HPC and FPGA protocols; including 10/40/100 Gb Ethernet, InfiniBand™, Fibre Channel, PCIe®, CXL® and Aurora
- Rugged surface mount connector with integrated locking simplifies mating/unmating of the cable assembly
- Contact HDR@samtec.com for more information

PAM4	112 Gbps	x8 Bidirectional x16 Unidirectional
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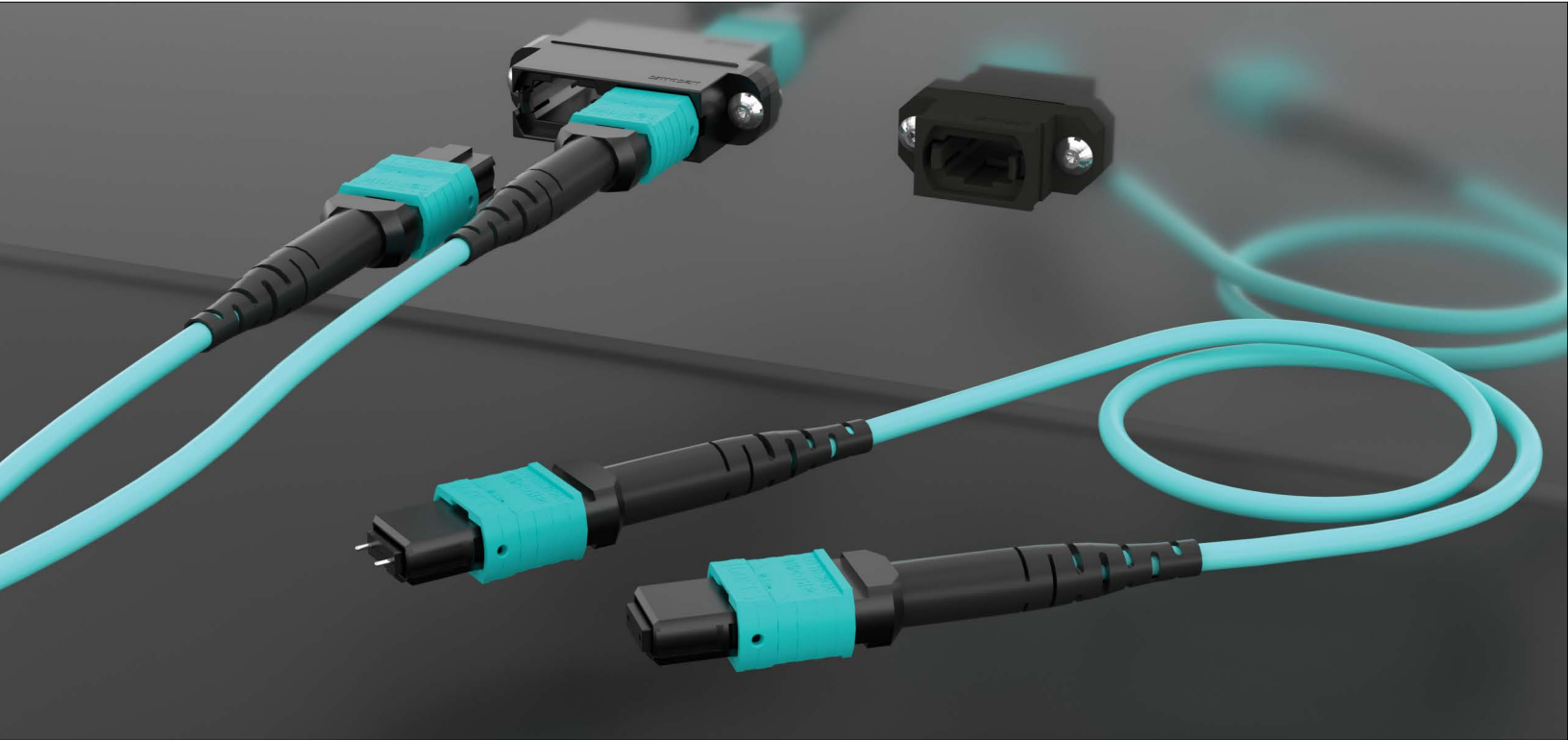
EYE SPEED® THINAX™ ULTRA LOW SKEW TWINAX CABLE

- 40% smaller cross sectional area
- Taped jacket miniaturizes the cable to match smaller, more dense connectors
- Allows for a smaller pitch within a row
- Visit samtec.com/eyespeed for more details

**EYE
SPEED**
THINAX™



PASSIVE OPTICAL SYSTEMS



Samtec's version of an MTP® patch cable compatible with industry standard MTP®/MPO connectors

- Choice of male or female MTP® end options; loopback options also available
- 12 or 24 fibers
- 3, 10 and 100 meter standard cable lengths; contact optics@samtec.com for custom lengths
- 3.00 mm round jacketed cable
- Compliant to TIA-604-5-D (FOCIS 5), TIA-568-C.3 and IEC-61754-7-1 specifications
- Mating optical adaptor in single or dual port
- Keying options for proper alignment
- Full flange for panel mount
- Dust caps available
- Visit samtec.com/passive-optics for more information

FOPC	END 1	END 2	CABLE LENGTH	FIBERS	CONSTRUCTION
	-01 = MTP® Male	-01 = MTP® Male	-003 = 3 Meters	-12, -24	-01 = 3 mm Round Jacket
	-02 = MTP® Female	-02 = MTP® Female	-010 = 10 Meters		
			-100 = 100 Meters		

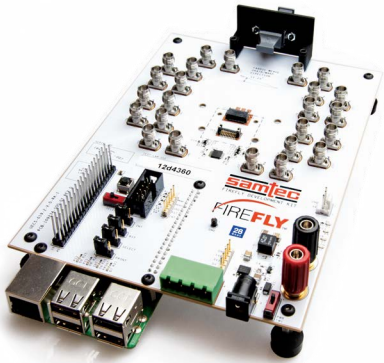
EVALUATION & DEVELOPMENT KITS

From concept and prototype to development and production, Samtec-designed and Partner-designed kits and boards simplify design and reduce time to market. For more information, please visit samtec.com/kits or contact KitsAndBoards@samtec.com.

28 Gbps FireFly™ Evaluation Kits

Samtec's 28 Gbps FireFly™ Evaluation Kits offer an easy-to-use platform for testing and real-time evaluation of the FireFly™ Micro Flyover System™. The kits support copper or optical FireFly™ in x4 or x12 configurations.

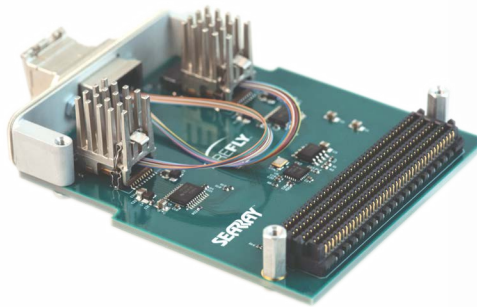
(Samtec P/N: REF-209623-01 and REF-230408-X.XX-01)



14 Gbps FireFly™ FMC Development Kit

Samtec's 14 Gbps FireFly™ FMC Development Kit is VITA 57.1 electrically compliant and provides up to 140 Gbps full-duplex bandwidth over 10 channels from an FPGA to an industry-standard multi-mode fiber optic cable.

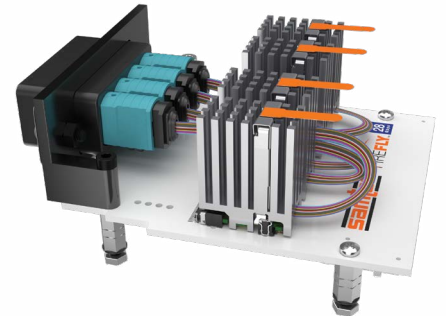
(Samtec P/N: REF-193429-01)



25/28 Gbps FireFly™ FMC+ Development Kit

Samtec's 25/28 Gbps FireFly™ FMC+ Module is VITA 57.4 electrically compliant and provides up to 400/448 Gbps full-duplex bandwidth over 16 channels from an FPGA to an industry-standard multi-mode fiber optic cable.

(Samtec P/N: REF-200772-XXX-XX-01)



FireHawk™ Evaluation Kits

Samtec's FireHawk™ Evaluation Kits allow for testing and evaluation of FireHawk™ rugged mid-board optical transceivers rated at 10 Gbps per lane in a x4 configuration.

(Samtec P/N: REF-231561-X.XX-XX)



Halo™ Evaluation Kit (In Development)

Samtec's Halo™ Evaluation Kit offers an easy-to-use platform for testing and real-time evaluation of the Halo™ system. The kit supports copper or optical Halo™ in x8 configurations.



Roadmap (In Development)

Samtec continues to expand our growing portfolio of mid-board optical transceiver evaluation and development kits.

- Switchless PCIe®-Over-FireFly™ Add-in Card

- Optical OCP OAI-EXP Modules

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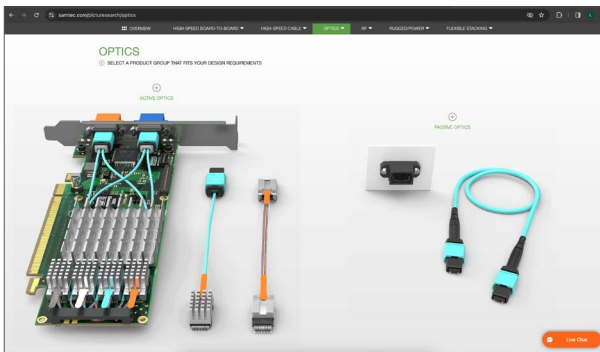
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 Application Support Group: asg@samtec.com
 Interconnect Processing Group: ipg@samtec.com

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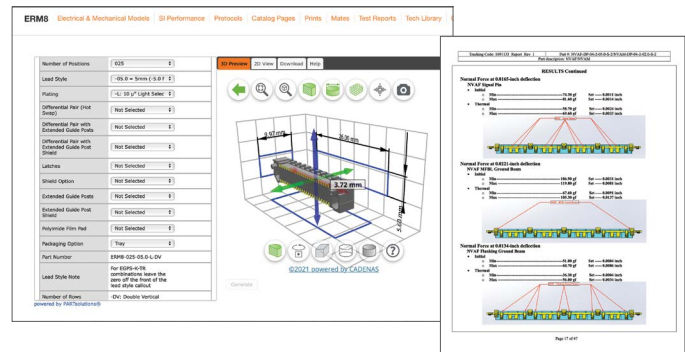
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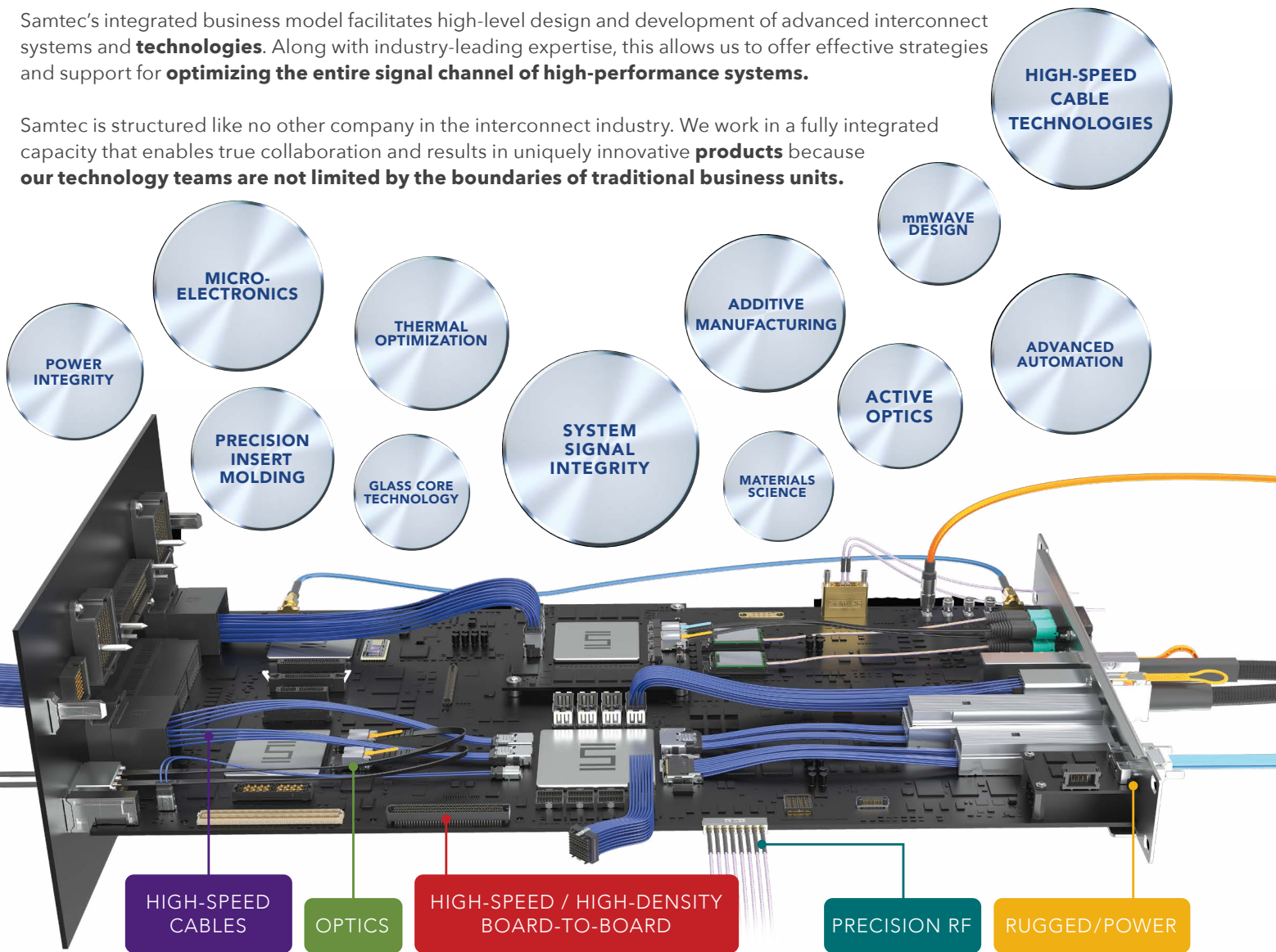
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FULL SYSTEM OPTIMIZATION FROM SILICON-TO-SILICON™

Samtec's integrated business model facilitates high-level design and development of advanced interconnect systems and **technologies**. Along with industry-leading expertise, this allows us to offer effective strategies and support for **optimizing the entire signal channel of high-performance systems**.

Samtec is structured like no other company in the interconnect industry. We work in a fully integrated capacity that enables true collaboration and results in uniquely innovative **products** because **our technology teams are not limited by the boundaries of traditional business units**.



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NEXT GENERATION CONNECTIVITY TO 224 Gbps & BEYOND

As bandwidth, scale and power requirements continue to challenge conventional engineering methods, Samtec strives to help **optimize the landscape of your entire system** - and develop solutions, together.

Samtec's industry-leading signal integrity expertise, full system optimization strategies, and innovative products and technologies help address the challenges of **next gen data transmission to 224 Gbps & beyond**.

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