

Parallel Optics: The Next Leap for Embedded System

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Objective

Discuss parallel optics role in boosting embedded system performance

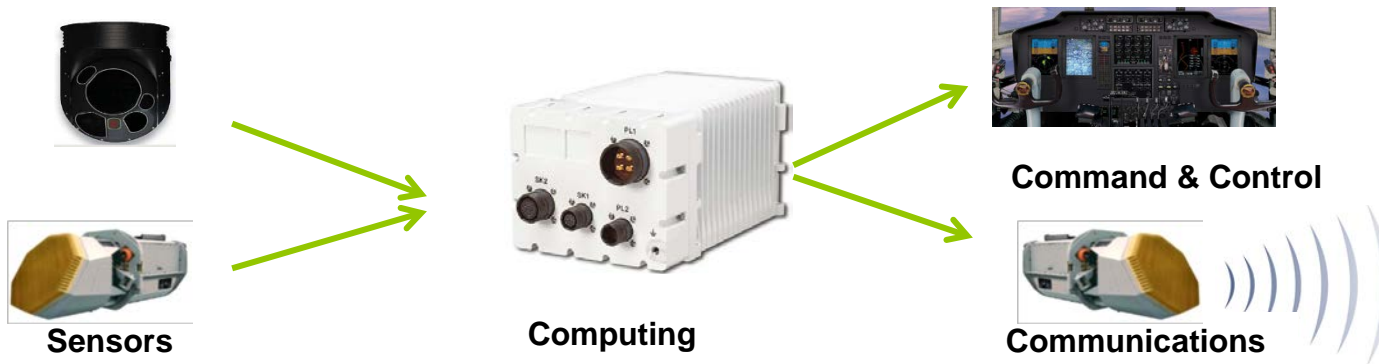
Topics

1. C4ISR Embedded Tech Trends
2. Rugged Optics Construction
3. Optical Module Types
4. System Performance - BER
5. Rugged Optics Performance
6. Rugged Optics Requirements
7. Future Optical Modules

C4ISR Embedded Tech Trends

C4ISR To Reach \$133B by 2020*

Eyes and Ears Everywhere



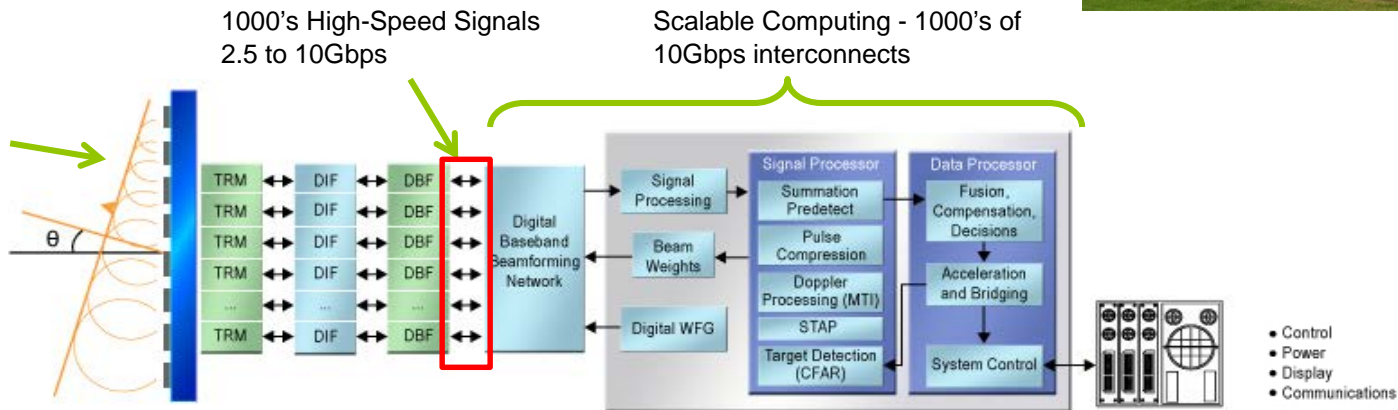
* MarketsandMarkets

ISR Trend

- Higher resolution sensor arrays – high BW interfaces
- Enormous signal processing - scalable computing
- Lower SWaP-C – CAPEX/OPEX
- Rugged – temperature, shock, vibration, moisture ...



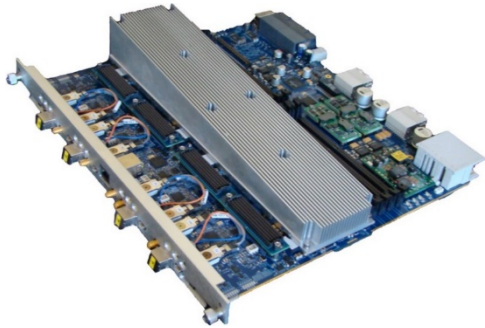
Antenna Array
1000 to 20,000 Elements



Parallel Optics – The Embedded Leap

Performance

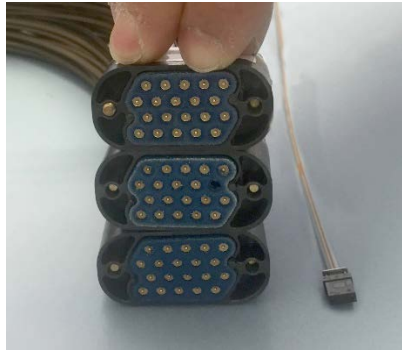
- Scalable BW – up to 28G
- Signal integrity – BER of 10^{-15}
- Low loss – 0.003 dB/m (OM3 @10G)
- Reach – 300 m (OM3 @10G)



480G full duplex I/O

SWaP-C

- Small – 125 μ m diameter fiber
- Light weight – <1.5 g/m (OM3)
- High I/O density – 48 fibers in MT connector
- Lower power – 100 mW/10Gbps



Rugged

- -40 °C to 85 °C operation @ 10 Gbps
- MIL-STD-810xx Shock and vibration
- Moisture resistant
- EMI and nuclear radiation immune



Rugged Optics Construction

Rugged Optics Construction

Wide Temperature Range

- Use of thermally conductive construction to reduce temperature of sensitive parts
- Use of matched CTE materials to maintain laser alignment over wide temperatures

Moisture Resistance

- Sealed optics to avoid moisture from affecting optical transmission

Surface mount

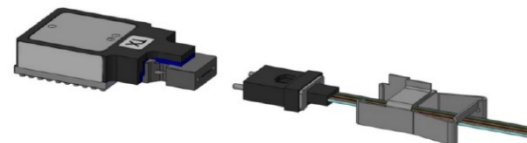
- SMT construction provides strong resistance to shock and vibration via low CG and solder attach
- SMT support heat sinking to host board to reduce height

Optical Connector

- MT connector enables pick-and-place part
- MT connector simplifies manufacturability – no pigtail

Cable

- Low-mass cable and retainer tolerates high shock and vibration



High temp materials/simple structure = reliable performance in harsh environments

Optical Module Types

Optical Module Types

Embedded Parallel Optic Transceiver

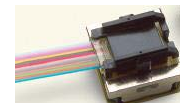
- Embedded optics on board
- Low SWaP-C
- High I/O density
- Best signal integrity and low power
- Low power density – distributed across board
- Package options: SMT, Socket, Fiber pigtail, integrated
- Suitable for harsh environments

External Pluggable MSA Modules

- Field replaceable
- Flexible: 100 m to 10 km versions
- Industry standards (multisource agreements)
- Used mostly in Telecom/Datacom
- Not designed for harsh environments
- Low cost - failure acceptable – mesh network recovery
- Bigger, lower I/O density



LightABLE



MicroPod



SNAP12



Firefly



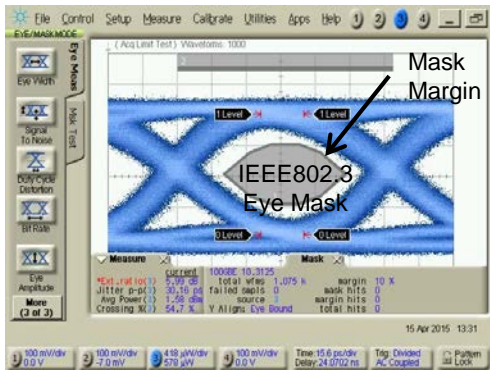
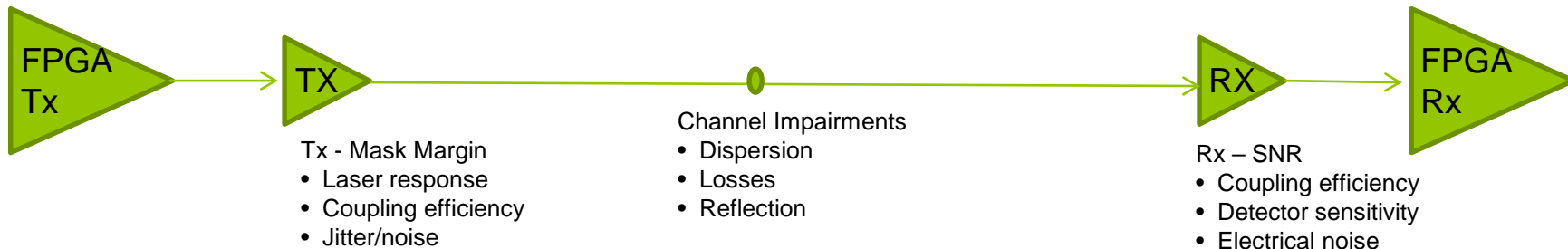
QSFP



CFP

System Performance - BER

System Performance - BER



10G Challenge

- Laser response slows significantly below -30 °C causing eye to close at 10G
- The closing eye has a significant impact on BER
- IEEE802.3ab specifies a BER of 10^{-12} - high performance systems expect 10^{-15}

Rugged Optics Requirements

Rugged Optics Requirements

Operating Temperature

- -40 °C to 85 °C or wider
- Considerations: **BER at 10G** – due to laser response over temperature

Storage Temperature

- -57 °C to 125 °C
- Considerations: **Reliability** – mechanical stress, laser alignment

Shock and Vibration

- MIL-STD-810xx – aircraft, land vehicles, gun shock
- Considerations:
 - Socket with low wipe contact is a concern
 - Mechanical attach strength – SMT vs socket

SWaP-C

- SMT offers low height without bulky heat sinks for tightly stacked blades
- Embedded optics typically consumes 100 mW/10G channel
- Weight is typically 5 g

Moisture

- Seal to avoid moisture from obstructing optics
- For example, rapid decompression condenses air moisture

Rugged Optics Requirements

Bit Error Rate (BER)

- IEEE802.3ab for 10G Ethernet is specified as 10^{-12}
- High performance systems expect 10^{-15} to avoid power hungry FEC, CDR, or equalizers.
- Higher the BW, lower the expected BER!

Link Budget

- Link budget is the loss that can be tolerated between the transmitter and the receiver for a certain BER
- Main sources of loss are connector return loss and mode dispersion for multimode fiber
- Tx output should be derated based on mask margin – jitter power penalty

Rugged Optics Requirements

Manufacturability

Surface Mount

- Rugged construction to survive high solder reflow temperature
- Compatible with standard high volume pick and place machines
- No pig tail cable
- Flexible cable termination (MT, FC, LC, 38999, ...)
- Cables can be replaced independently of the part
- Suitable for rugged low profile boards

Pluggable

- Supports low cost construction
- Requires heat sink – not suitable for low profile cards
- Supports pigtail cable option

Pigtail

- 0.5 dB less loss due to one less connector
- Entire part must be replaced if cable is broken

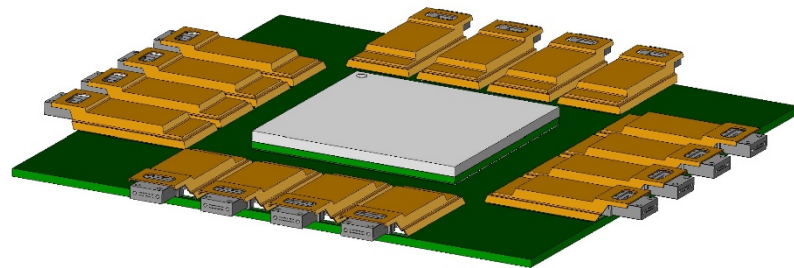
Integrated Connector

- Example: SNAP12
- No cable to manage
- Socket not suitable for rugged environment

Embedded Modules Future

Future Optics

1. -55 °C to 95 °C, 10G modules
2. Lower profile optical modules (3 mm)
3. 12 full duplex channel @10G modules
4. 28G - 4 full duplex channel modules
5. Light on chip – FPGA integrated with optical I/O



Parallel Optics Takeaways

- High performance and less SWaP-C
- Proven, rugged, reliable
- Winning edge



Thank You