



Optoelectronics - A review of Fundamentals for Space

March 27, 2025



Teledyne Micropac
Aerospace & Defense Electronics



Company Update

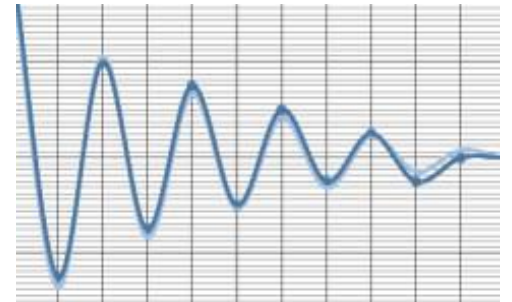
Micropac + Teledyne



Teledyne Micropac
Aerospace & Defense Electronics

TELEDYNE TECHNOLOGIES Parent Company

- » Diversified high-technology company
- » Broad, balanced portfolio of highly-engineered products
- » Proven track-record; hands-on management; consistent performance



Global Presence >250 worldwide facilities



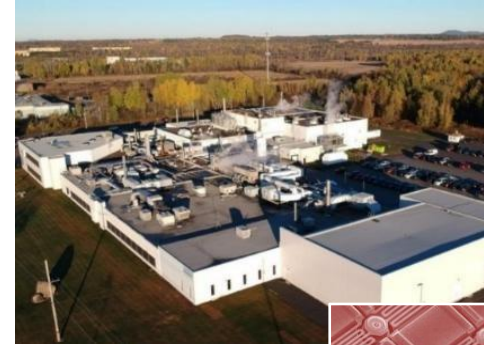
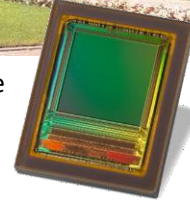
El Segundo, CA, US:
Commercial Aviation



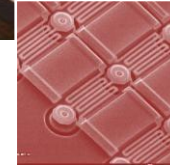
Chelmsford, UK: Vacuum
Products, CCDs



Grenoble, FRA: Image
Sensors
and SIP



Bromont, QC, CAN:
MEMS



San Diego, CA, US:
Underwater Systems



Elkridge, MD, US:
Ground Vehicles



Taby, SWE:
Thermal Cameras



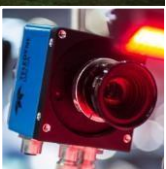
Goleta, CA, US:
Cooled and
Uncooled Cores



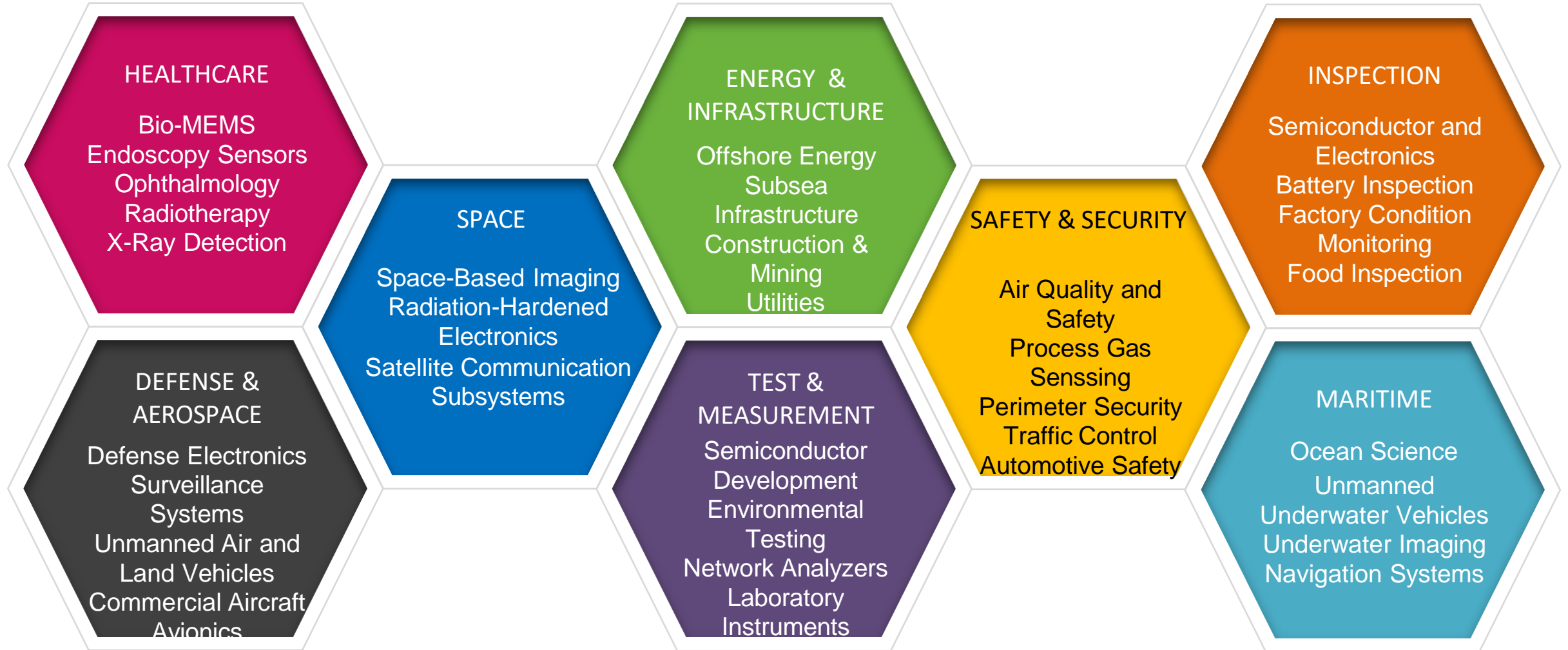
Huntsville, AL, US:
Engineered Systems



Waterloo, ON, CAN:
Machine Vision Cameras



End-Use Markets and Main Applications



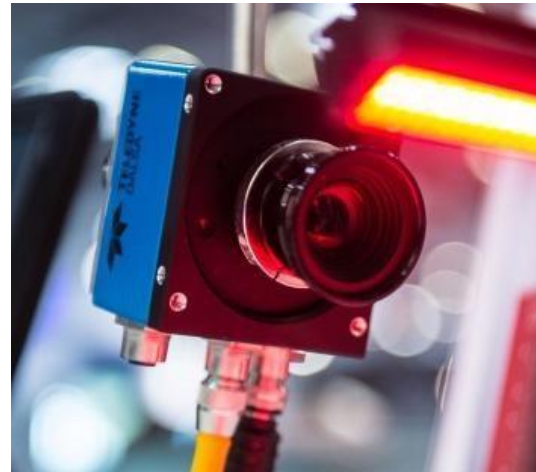
TELEDYNE TECHNOLOGIES

Reporting Segments



Instrumentation

Oscilloscopes, Protocol Analyzers
Air and Water Quality Analyzers
Marine Instrumentation, Sonar,
Acoustic Doppler Current Profilers, AUVs



Digital Imaging

Image Sensors, Cameras, Image
Processors, Software,
X-Ray and RF Systems, Lidar, GIS,
MEMS, Chipsets



Aerospace & Defense Electronics

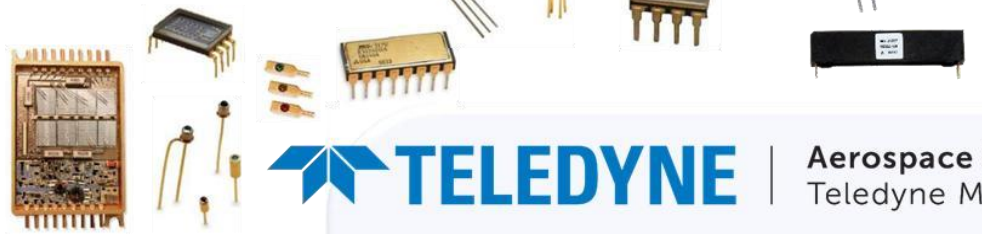
Avionics, Communication Components and
Subsystems, Interconnects



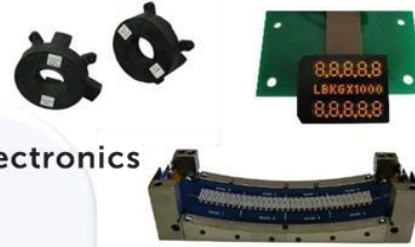
Engineered Systems

System Engineering, Advanced
Manufacturing, Energy Systems, Turbines

High Reliability Components



Engineering Design & Manufacturing Services



TELEDYNE

Aerospace & Defense Electronics
Teledyne Micropac

Microelectronics-Optoelectronics Displays-Sensors-EDMS

1655 State Hwy 66
Garland, TX 75040

972-272-3571

www.micropac.com

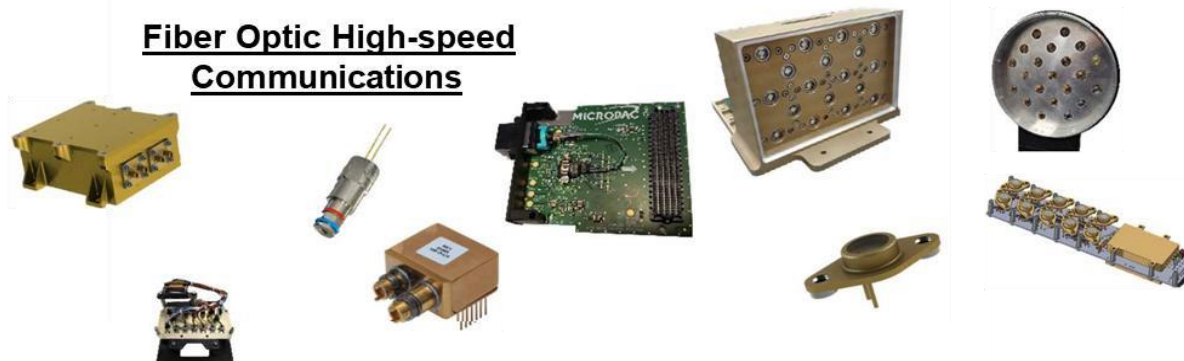
- High Reliability, Mission Critical Applications
- Markets – Space, Military, Medical, and Industrial
- Capabilities Include Design Through Manufacturing & Test
- AS9100D □ MIL-PRF-38534 □ MIL-PRF-19500
- Select APQP processes per AS:9145
- Radiation / Harsh Environments
- Components □ Packaging □ Modules □ Assemblies

Power Distribution Units



Illumination

Fiber Optic High-speed Communications



Fundamentals

1. Space Mission

- Space Economics, Standards, Device and Screening selection

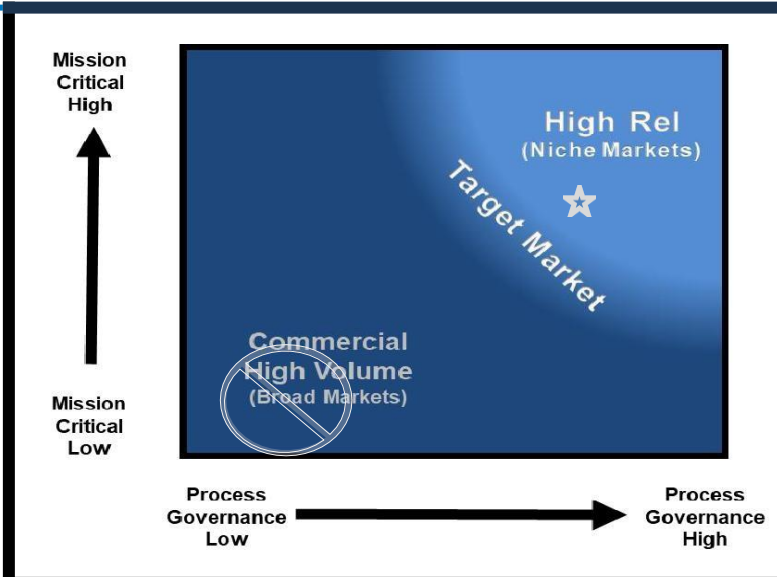
2. Optocouplers

- Optoelectronics for isolation in power supply and slow speed control switching

3. Optical Transceiver for Data Transport

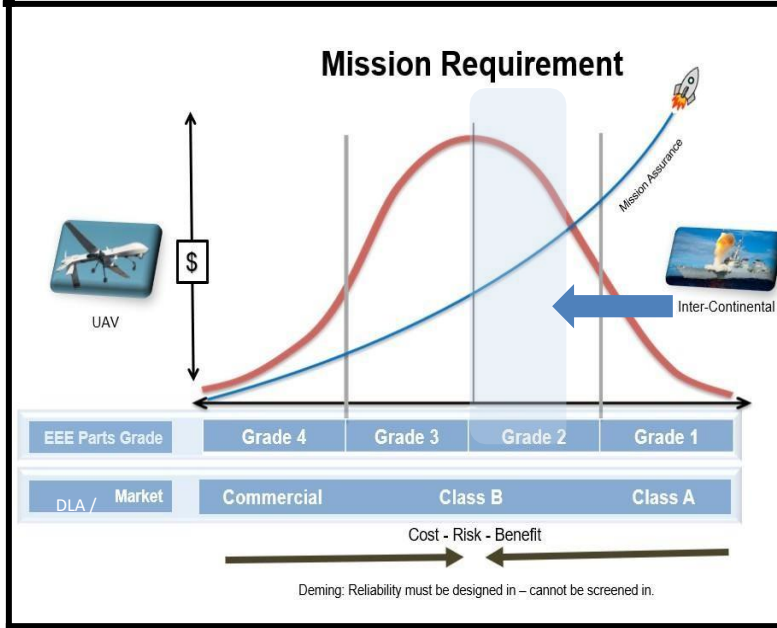
- Fiber Optics Elements improves EMC/EMI resilience, offers lowers power consumption, uses less connectors and is much lighter in weight the traditional cable solutions

New Mission Requirements Afford New Levels of Governance



Strategic Intent
 Leverage DLA component and Class K hybrid business models to offer highly integrated & high reliability solutions into mission critical target markets

Certified Supply Chain Partner

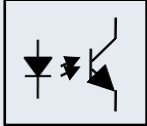


SWaP-CTR
 Size, Weight, and Power + Cost, Time to Market & Reliability

Upgrade Optocoupler Mission Assurance Levels

Context of Flow across Mission Requirements

Device / Subsystem

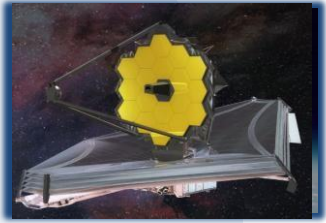


66xxx-base device

SWAP-C-T-R REQUIREMENTS



UAV



FLIGHT UNITS
Full Mission Assurance
Device Readily Available

HERO PRODUCTS
EM Units
Bench testing
Device Readily Available

Commercial & JANTX

JANTXV

JANS



66138-009



66266-103



66095-001

66138-809

JANTXV

66224-189

JANTXVR

66266-105

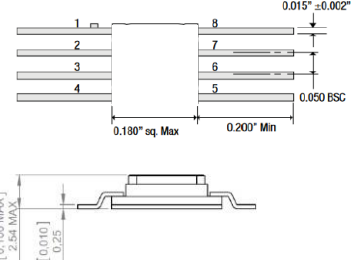
66212-105

66224-309 JANS

66224-329 JANSR

66266-300

66212-300



DLA Certified Optocoupler: New opportunities within the spec guidelines

Leverage Certifications into New Offerings

Commercial

JANTX

JANTXVR

JANTXV

JANS

The documentation and process conversion measures necessary to comply with this document shall be completed by 25 April 2018.

INCH-POUND
MIL-PRF-19500/548J
W/AMENDMENT 2
25 January 2018
SUPERSEDING
MIL-PRF-19500/548J
W/AMENDMENT 1
27 January 2017

PERFORMANCE SPECIFICATION SHEET

COUPLER, OPTOELECTRONIC, SEMICONDUCTOR DEVICE, SOLID STATE, THROUGH HOLE AND SURFACE MOUNT, TYPES 4N47, 4N48, AND 4N49, QUALITY LEVELS: JAN, JANTX, JANTXV, AND JANS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

The requirements for acquiring the product described herein shall consist of this specification sheet and MIL-PRF-19500.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for solid state optically coupled isolators in which a gallium aluminum arsenide diode light source is optically coupled to a silicon NPN phototransistor. Four levels of product assurance (JAN, JANTX, JANTXV, and JANS) are provided for each type as specified in MIL-PRF-19500.



MIL-PRF-19500R
24 July 2021
SUPERSEDING
MIL-PRF-19500P
w/AMENDMENT 4
18 May 2018

MIL-PRF-19500R

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the general performance requirements for semiconductor devices. Product assurance is provided by effective screening, conformance inspection, and process controls to mitigate risk. Mission assurance and standardization of parts are the highest priorities. This specification establishes a heritage program of semiconductor devices the military and space community can rely on to be dependable and available. Detail requirements and characteristics are specified in the specification sheets. Revisions to this specification and specification sheets are structured to assure the interchangeability of devices of the same part type regardless of manufacturing date code or conformance inspection (CI) completion date. Four quality levels for hermetic encapsulated devices are provided for in this specification, differentiated by the prefixes JAN, JANTX, JANTXV, and JANS. Three quality levels for non-hermetic encapsulated devices are provided for in this specification, differentiated by the prefixes JANP, JANPTX, and JANPTXV. Eleven radiation hardness assurance (RHA) levels are provided for the JANPTXV, JANTXV and JANS quality levels. These are designated by the letters E, K, U, M, D, P, L, R, F, G, and H following the quality level portion of the prefix. Two quality levels for unencapsulated devices (die) are provided for in this specification, differentiated by the prefixes JANHC and JANKC.

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BJT Diode construction and packaging factors

RHA Optocouplers



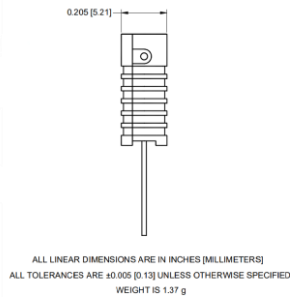
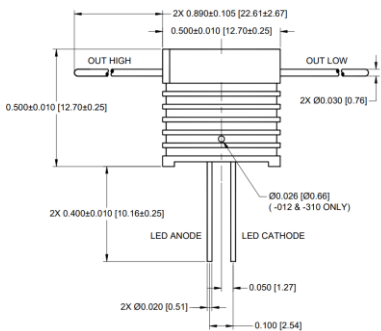
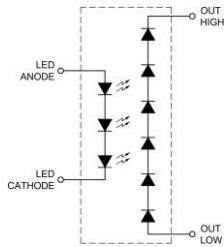
- JANTXVR4N4x & JANSR4N4x
- Certified to MIL-PRF-19500/548 after
 - TID at 100 krad
 - ELDRS at 100 krad
 - 1-MeV Neutron at 1×10^{12} n/cm²
- 1kV electrical Isolation



Certified Die Bank at TXV Level
New Construction Method improve performance and extend lif

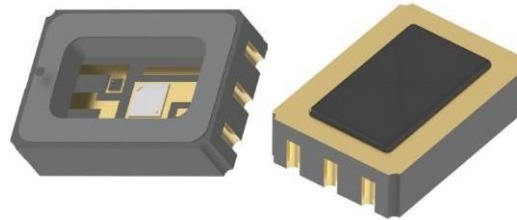
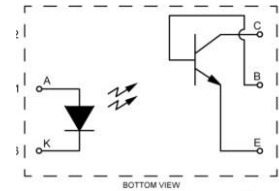
High Voltage Isolator

Drop-in Replacement – Backward Compatible



- Leverage non-hermetic packaging into certifications
- Retain same footprint

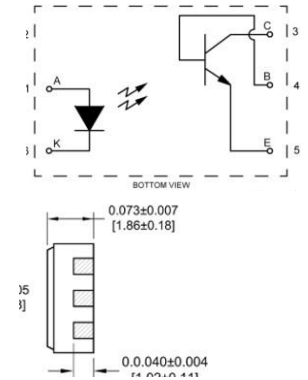
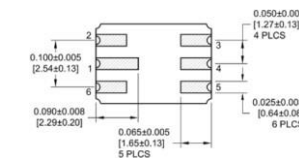
Drop-in Replacement – Backward Compatible



- Certified Die Bank
- Simplified Ordering

SUPPLEMENTAL OPTIONS:

INCLUDED:



Radiation Certified Specification Compliance

Electrical test parameters for the 66224-329 (U) and 66224-339 (BU) optocouplers

Parameter	Description	Test Condition	Min	Max	Units
IR	LED reverse leakage current	$V_R=2\text{ V}$		100	μA
V _F	LED forward voltage	$I_F=10\text{ mA}$	0.8	1.5	V
V _{CEO}	Collector to emitter breakdown voltage	$I_F=0, I_B=0, I_C=1\text{ mA}$	40		V
V _{CEO} *	Collector to emitter breakdown voltage	$I_F=0, I_B=0, I_C=1\text{ mA}$	60		V
V _{CBO}	Collector to base breakdown voltage	$I_F=0, I_E=0, I_C=100\text{ }\mu\text{A}$	45		V
V _{CBO} *	Collector to base breakdown voltage	$I_F=0, I_E=0, I_C=100\text{ }\mu\text{A}$	60		V
V _{EBO}	Emitter to base breakdown voltage	$I_F=0, I_C=0, I_E=100\text{ }\mu\text{A}$	7.0		V
I _{C(OFF)}	Off-state collector current	$I_F=0, I_B=0, V_{CE}=20\text{ V}$		100	nA
h _{FE}	DC current gain	$I_F=0, V_{CE}=5\text{ V}, I_C=10\text{ mA}$	100.0		
I _{C(ON)1}	On-state collector current	$I_F=1\text{ mA}, V_{CE}=5\text{ V}$	2.0	10.0	mA
I _{C(ON)2}	On-state collector current	$I_F=10\text{ mA}, V_{CE}=5\text{ V}$	5.0		mA
V _{sat}	Collector to emitter saturation voltage	$I_F=2\text{ mA}, I_C=2\text{ mA}$		0.3	V

* Denotes the breakdown voltages specifically for the JANSR4N49BU

Standard DLA Specs offer context for Performance Requirements

MIL-PRF-19500R
APPENDIX E

TABLE E-II. RHA levels and requirements. 1/ 2/

RHA designation	Radiation level		Neutron fluence (n/cm ²) 4/
	Total ionizing dose (TID) (rad(Si))		
	High dose rate	Low dose rate	
E		3×10^4	
K		5×10^4	
U		1×10^5	
M	3×10^3		
D	1×10^4		
P	3×10^4		
L	5×10^4		
R	1×10^5		
F	3×10^5		
G	5×10^5		
H	1×10^6		

1/ See E.6.5.

2/ The highest level may be qualified without qualifying any lower level.

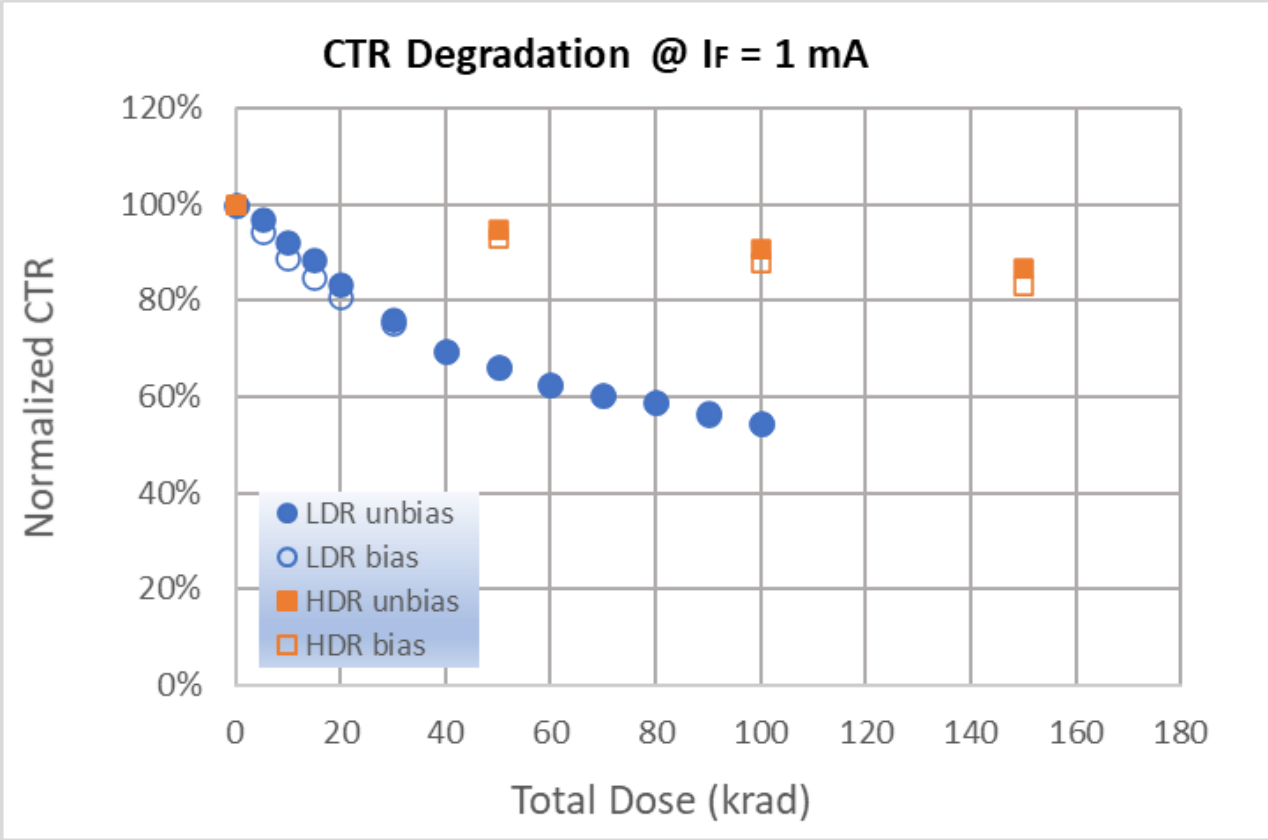
3/ Test in accordance with test method 1019 of MIL-STD-750.

4/ Test in accordance with test method 1017 of MIL-STD-750. Unless otherwise specified in the specification sheet, the minimum neutron fluence shall be 2×10^{12} n/cm².

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Same Die – Different Effects: Comparing HDR & LDR Effects on BJT Technology

Low Dose Rate Needs Mitigation



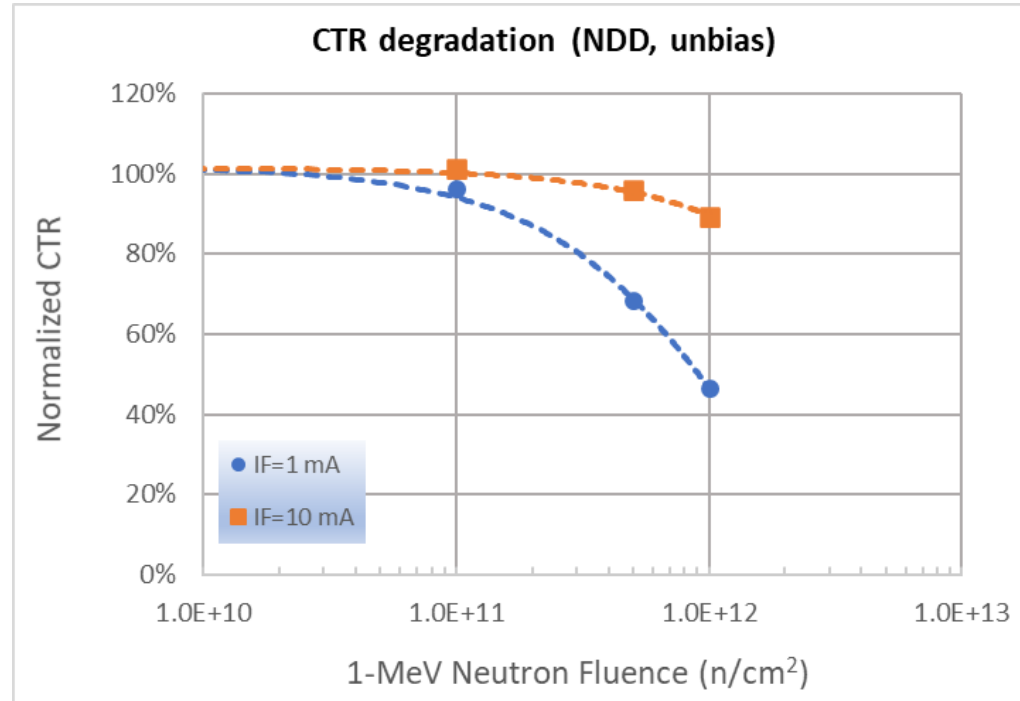
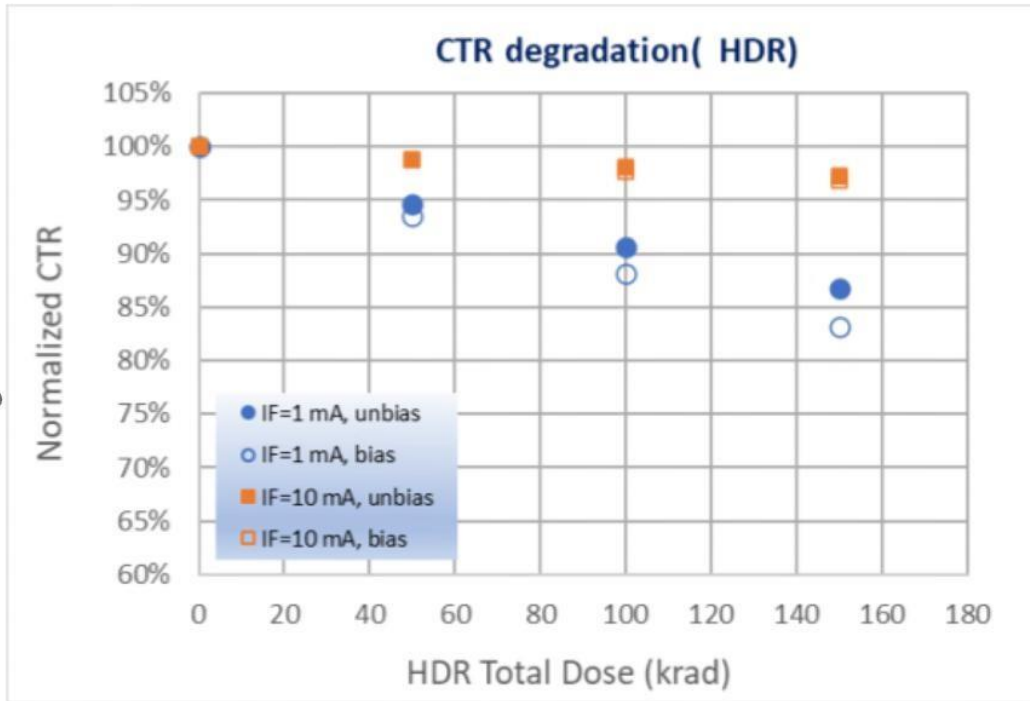
Higher degradation is seen for the LDR irradiation tests.

All of the devices still met datasheet performance after 100 krad.

JANSR4N49U / JANSR4N49BU comparison of CTR degradation at $I_F = 1$ mA between HDR and LDR irradiation for the biased and unbiased conditions.

Same Die – Different Effects: Impact of Neutron & Effect of Drive Current

Use Condition Offers Mitigation



About 55% loss in CTR for 1-MeV Neutron fluence at 1×10^{12} n/cm²


The devices still met datasheet performance after this test.

JANSR4N49U (66224-329) / JANSR4N49BU (66224-339) with normalized CTR versus neutron fluences for different LED forward currents.

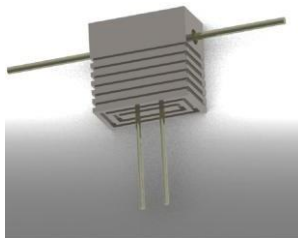
Same Technology with different packaging High Voltage – Environmental Flow

Screening Flow offers mitigation choices

-306	TRAX INTERNATIONAL CORP (MOMMA), SCREENED TO SPACE LEVEL, MODIFIED MIL-PRF-38534 WITH MODIFIED GROUP C SUBGROUP 2	NON-VENTED CASE
-310	Mii 12KV STANDARD SCREENED TO SPACE LEVEL, MODIFIED MIL-PRF-38534 PER SCD Mii 07062017	VENTED CASE

INTERPRET THIS DWG PER STANDARDS IN MIL-STD-100 UNLESS OTHERWISE NOTED ALL DIMENSIONS ARE IN INCHES DECIMAL .XX ± .01 .XXX ± .005 FRACTIONS ± 1/64 ANGULAR ± 0° 30' MATERIAL	CONTR NO APPROVAL DWN L RAPOPORT 3-8-13 CHK D YOUNG 3-11-13 APPRD C CALETKA 3-11-13 APPRD L WILLIAMS 3-11-13 DESIGN ACTIVITY APPROVAL B SPITZER 3-11-13 CONTRACTOR APPROVAL	 MICROPAC INDUSTRIES, INC. 905 E. WALNUT ST. GARLAND, TEXAS 75040 RADIATION TOLERANT SINGLE CHANNEL, HIGH VOLTAGE OPTOCOUPLER, IN A 4 PIN 0.5 x 0.5 CUSTOM PACKAGE
	SIZE A	FCSM No 31757
DO NOT SCALE DWG		SHEET 1 of 33

New Device Available
Information provided upon request



ENVIRONMENTAL SCREENING TRAVELER # 4

THIS TRAVELER APPLIES TO THE FOLLOWING DASH #'S ONLY: -300 -301 -306 -310 -311 -318
ASSEMBLE PER MIL-PRF-38534; TEST PER MIL-STD-883

OPERATION	MII DOCUMENT #	REV	START DATA				STOP DATA				QTY REJ	CONDITIONS
			QTY	TIME	DATE	OPER	QTY	TIME	DATE	OPER		
TEMPERATURE CYCLE <u>1/ 2/</u>	PS 90117											-40°C TO +100°C 10 CYCLES MINIMUM 10 MINUTES DWELL 11 MINUTES MAXIMUM DWELL
CONSTANT ACCELERATION	PS 90125											3 kg Y1 AXIS ONLY
25°C ELECTRICAL TEST <u>1/</u>	PS 90131/ QE 66356-3XX											RECORD DATA
HTRB <u>2/</u>	PS 90130											TIME: 120 HOURS TEMP: +100°C V _{DD} = 8 KV I _F = 0 mA INPUT GROUNDED
25°C ELECTRICAL TEST <u>3/</u>	PS 90131/ QE 66356-3XX											RECORD DATA
BURN-IN 1 <u>2/</u>	PS 90130											TIME: 120 HOURS TEMP: +100°C V _{DD} = 8 KV I _F = 20 mA
25°C ELECTRICAL TEST <u>3/</u>	PS 90130/ QE 66356-3XX											RECORD DATA
BURN-IN 2 <u>2/</u>	PS 90130											TIME: 240 HOURS TEMP: +50°C V _{DD} = 8 KV PD = 1.5 W PULSED P _{AVG} = 0.15W P _W = 5 mS 10% DUTY CYCLE
25°C ELECTRICAL TEST <u>3/</u>	PS 90131/ QE 66356-3XX											PDA = 2% OR 1 DEVICE (whichever is greater) RECORD DATA
-40°C ELECTRICAL TEST	PS 90131/ QE 66356-3XX											RECORD DATA
+80°C ELECTRICAL TEST	PS 90131/ QE 66356-3XX											RECORD DATA
NEXT TRAVELER	# 6											

Time and Temperature Matters!

NOTES: 1) TEMPERATURE CYCLING TO BE PERFORMED IN SUN CHAMBER. 2) RAMP RATE IS 5°C PER MINUTE MAXIMUM. 3) TESTING MUST BE COMPLETED WITHIN 96 HOURS AFTER REMOVAL FROM BURN-IN.

HTRB #s _____ BI BOARDS #s _____



Configuration Menu

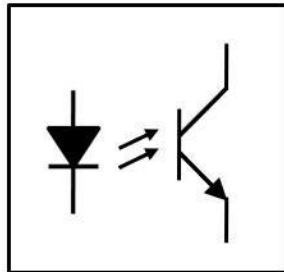
-Isolation CDA

(Common Device Architecture)

DLA Certified JANSR

6 pin LCC avail now

6 pin Gull Wing next



6Pin LCC

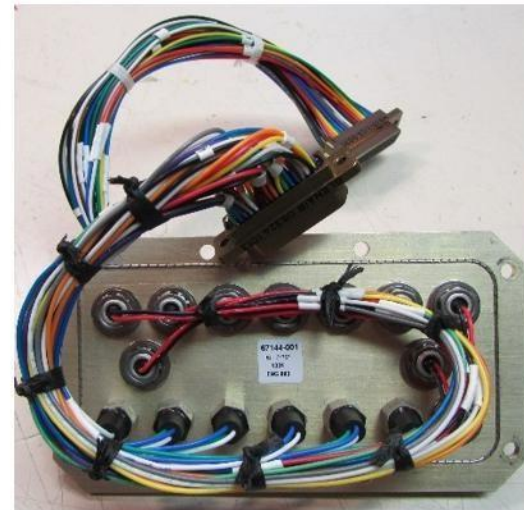
TO-5



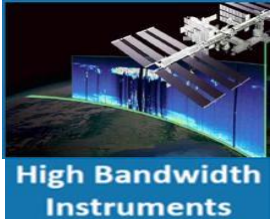
ISOLATION OFFERINGS

CUSTOMER FOCUSED
Solutions Through Technology

Blocking Voltage <input type="checkbox"/> 1,500V <input type="checkbox"/> 4,000V <input type="checkbox"/> 8,000V <input type="checkbox"/> 12,000V <input type="checkbox"/> up to 25,000V Depends upon device selected	Mission Assurance Level <input type="checkbox"/> JANS <input type="checkbox"/> JANTXV <input type="checkbox"/> JANTX <input type="checkbox"/> Commercial
Dark (Leakage) Current <input type="checkbox"/> Varies per device and per condition	Output Type - <input type="checkbox"/> Phototransistor <input type="checkbox"/> TTL <input type="checkbox"/> Photo Darlington <input type="checkbox"/> Totem Pole
Current Transfer Ratio <input type="checkbox"/> 0.01% up to 1000% <input type="checkbox"/> Drive Currents from <5mA up to 80mA <input type="checkbox"/> Continuous or Periodic Duty Cycle	Footprint Type <input type="checkbox"/> LCC <input type="checkbox"/> Thru-Hole TO-5, TO-46, TO-18 <input type="checkbox"/> Bulkhead Panel <input type="checkbox"/> Wires or not. Connector or not.
Reverse Breakdown Voltage <input type="checkbox"/> Varies per device and per condition	Transition Time <input type="checkbox"/> Varies per device and per condition

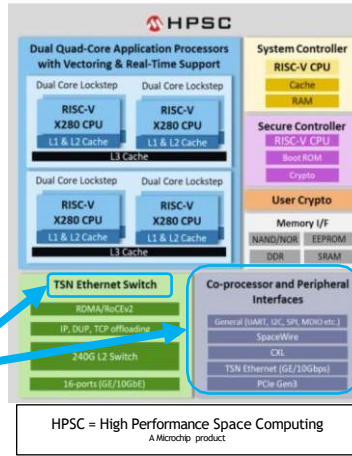


Standard Single Fiber / Parallel Fiber & Low Power Media Converter Products



Use Cases driving new chip for Chassis and Edge computing engines

Micropac part interface here



HPSC = High Performance Space Computing
A Microchip product



Micropac link here to serve long term Ecosystem: Microchip, AMD & Others.
 Supports Ethernet Links!
 Eval Kit Now Available!

Capable for TSN or Other Ethernet
 10GBASE-KR - Backplane
 10GBASE-SR - Front Panel

More info and expertise here:
<https://micropac.com/solutions/high-speed-fiber-optic-communication>

Standard Product – EVK Available Now

TELEDYNE Aerospace & Defense Electronics
Teledyne Micropac

Product Brief
67185 - EP1
 PCB Mount Fiber Optic Converter
 10 Gbps, MMF, 3.3V
20Mb to 10Gb PCB Mount Fiber Optic Transceiver

Block Diagram
 Micropac PCB Micro-Mount Converter

PCB Micro-Mount Optical Converter

Small Area on host card
1"x1"x0.5"

TELEDYNE Aerospace & Defense Electronics
Teledyne Micropac

Product Brief
67187-EP1
 High Speed Optical Transceiver on Interposer
Parallel fiber - 4 port
 Small Area on host card
1"x1"x0.5"

Block Diagram
 Micropac Interposer Mounted Optical Transceiver

High Speed Optical Transceiver on Interposer

COTS Solutions!!



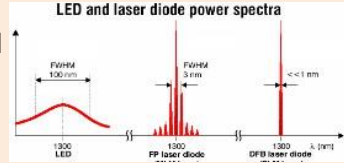
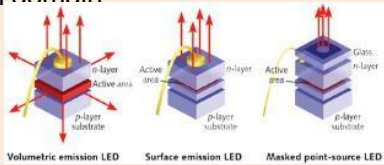
Fundamentals: Optical Elements Laser and Diodes

COTS Solutions Available


Deeper Tech Training Available

- Data transmission, telemetry, control and EMI management can all be improved through the use of signals in the optical domain
- Sources [W/A]
 - LED's – Incoherent light
 - Volumetric – light is everywhere best for illumination
 - Surface emitting – top emitting more directional
 - Point source – masked for optimal fiber coupling
 - Edge emitting, Resonant cavity – Super Luminescent Diode higher power and lower current for communication (near coherent)
 - Lasers – Coherent light
 - VCSEL(*DBR) – Vertical Cavity Surface-Emitting Laser diode – couples well to optical fibers
 - Laser diode - Fabry Perot, Quantum well
 - **DFB – Single Mode, Long distance


* Distributed Bragg Reflector
 ** Distributed Feed Back




- Detectors [A/W]
 - PN Photo Diode – older technology
 - PIN Diode – most common (intrinsic region added)
 - Avalanche photodiode – very good for low light detection, high bias Voltage
 - Schottky photodiode – higher speed, improved time response
 - Phototransistors - converts the light energy into an electric current or voltage with amplification




Transceiver
67170 – Space Wire
Flight Heritage



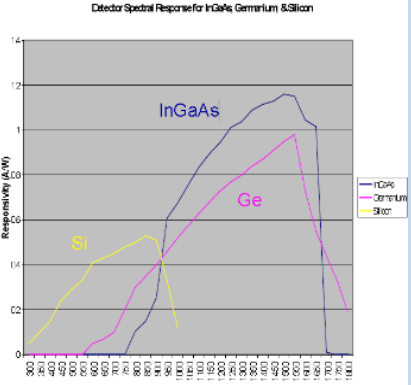
TO-46
61082
Silicon



ST
66215
Silicon



SMA
66204
Silicon



A/W – Amps / Watt

Optical Ethernet Use cases are expanding

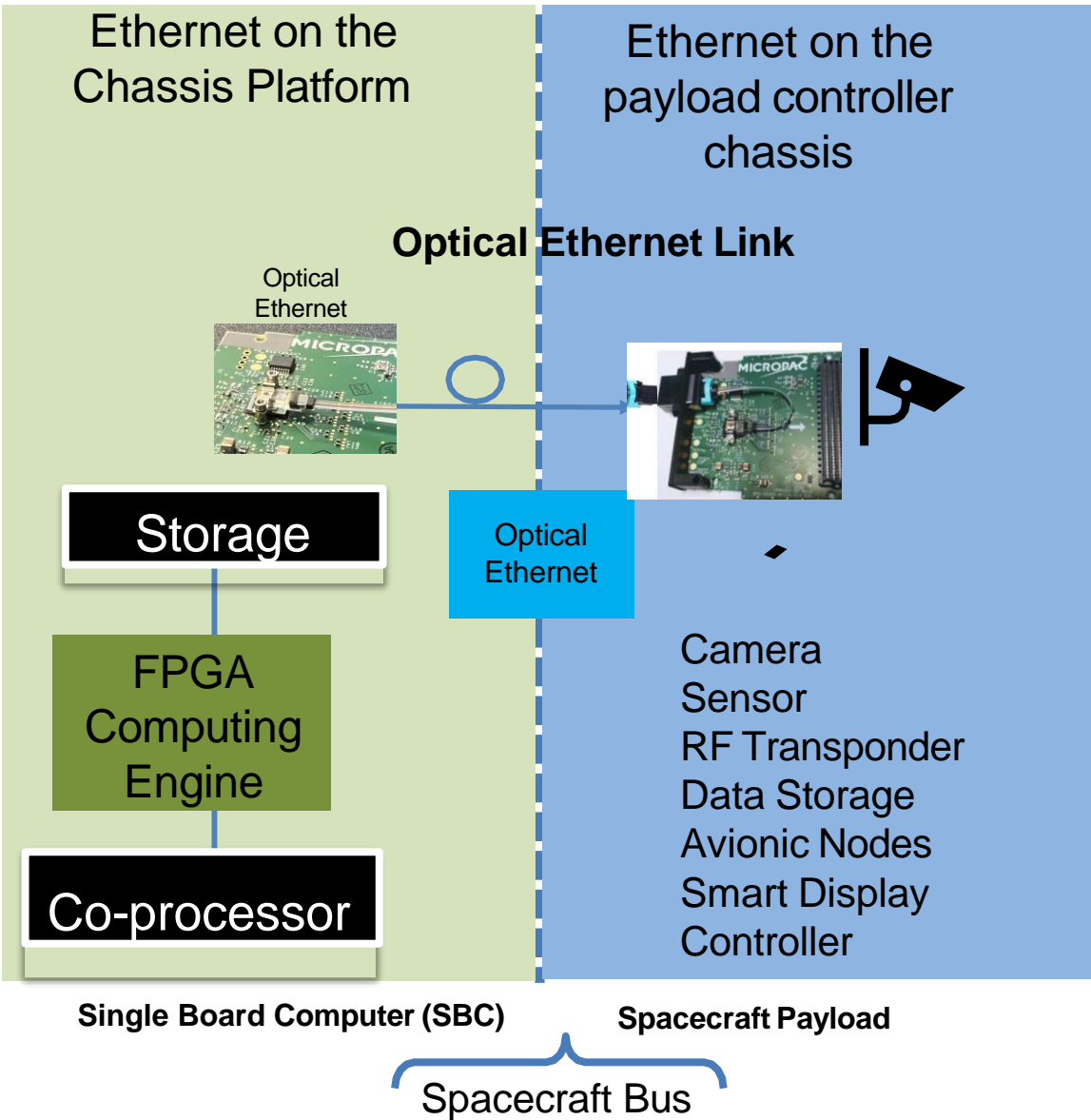
Use Case Expansion COTS Solutions Available

Photonic Interface within 2 Ecosystems is confirmed!



HPSC – PIC 64 High Performance Space Computer –
NASA/JPL Microchip PIC
Space VPX , Power VITA 46.11, VITA 48.0, VITA
62.0, and VITA 78.0
XMC

AMD – Versal and Derivatives
3U & 6U Open VPX



RHA Optocouplers



- JANTXVR4N4x & JANSR4N4x
- Certified to MIL-PRF-19500/548 after
 - TID at 100 krad
 - ELDRS at 100 krad
 - 1-MeV Neutron at 1×10^{12} n/cm²
- 1kV electrical Isolation



10Gb FMC Mezzanine Card



- 850 nm VCSEL Transmitters
- 4 Optical Ports per Plug-In Card
- Common I²C Interface for IPMI & TCVR
- +3.3VDC Operation
- Higher Optical Sensitivity Enabling Reduced Power Consumption



62220 White LED



- Optimized For Max Lumen Output
- 115° Viewing Angle
- Long Operating Life
- Thru-hole & Wired Panel Mount Options
- Electrically Neutral Thermal Path
- Space Heritage



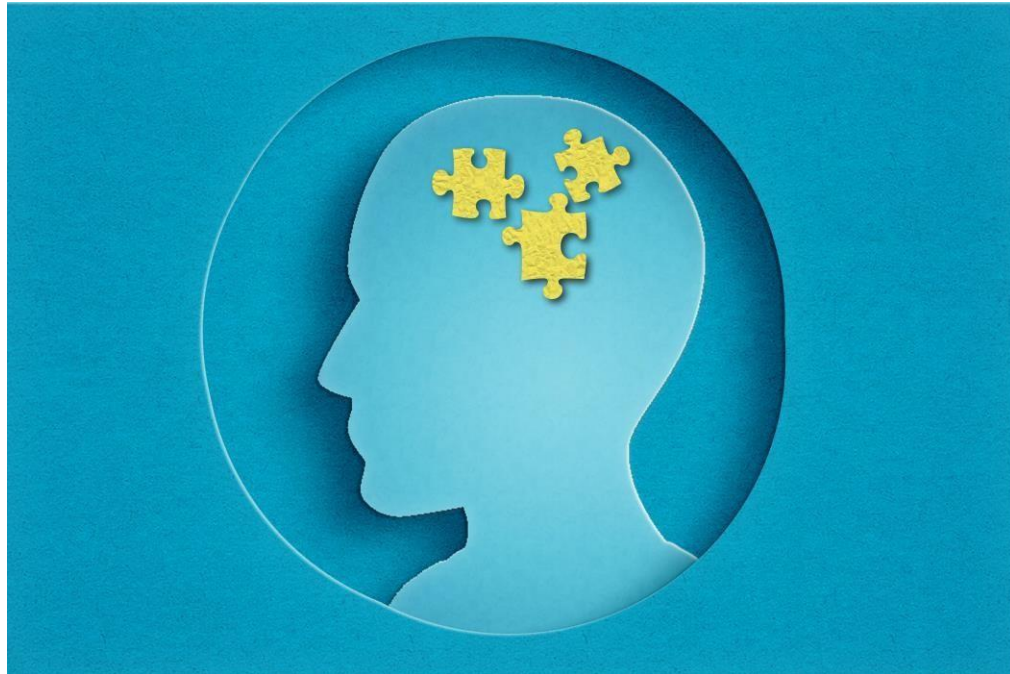
Engineering, Design & Manufacturing Services



- Requirements Review & Compliance
- Detailed Engineering Design
- Manufacturing & Assembly
- Control Quality & Testing
- Product Certification & Shipping
- Customer Support & Maintenance



Thank You!



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