Parvus

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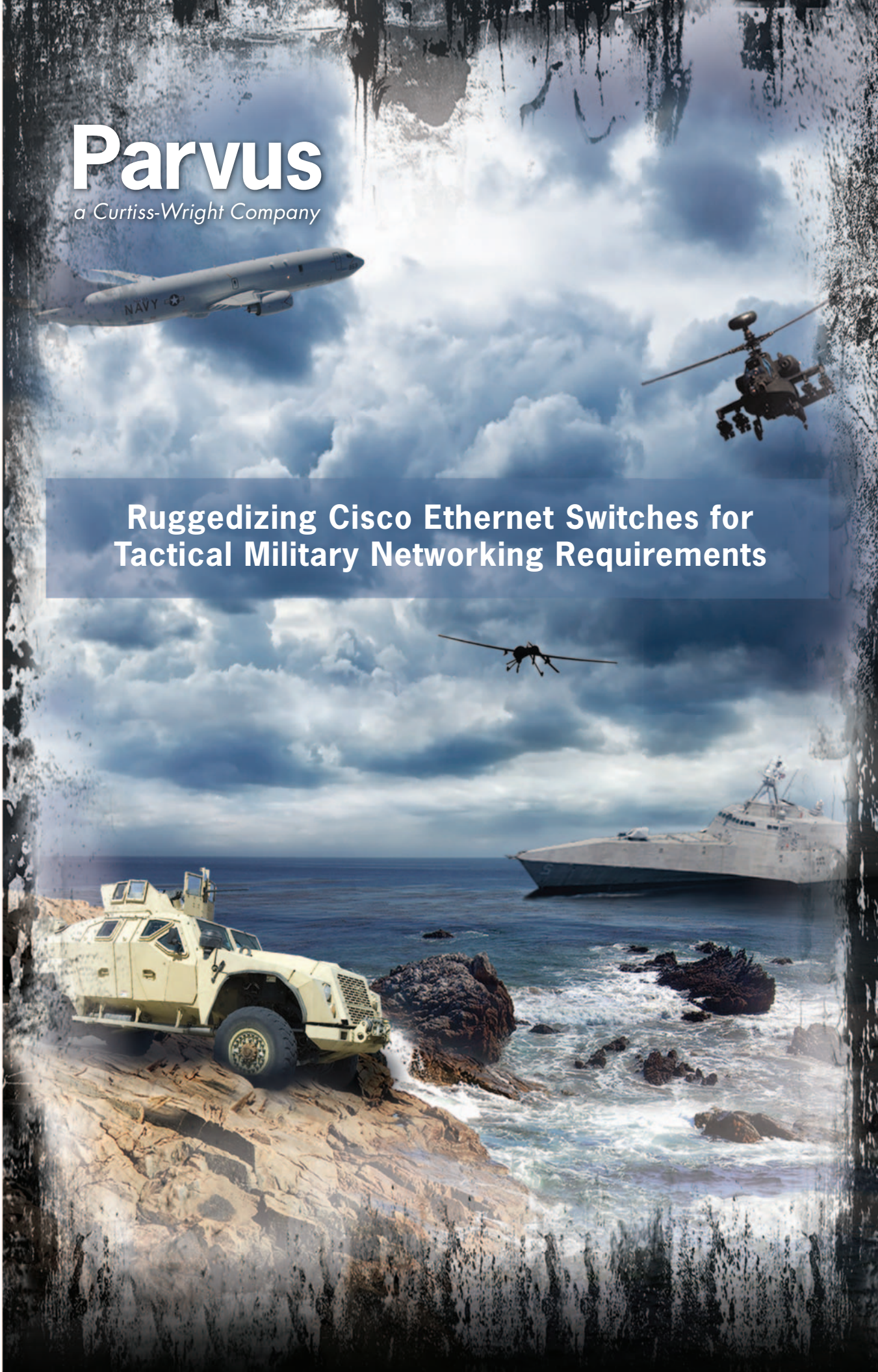
WHITE PAPER

Ruggedizing Cisco Ethernet Switches for Tactical Military Networking Requirements



Ruggedizing Cisco Ethernet Switches for Tactical Military Networking Requirements

Cisco is the undisputed world-wide leader in networking technologies as evidenced by their technological innovations and dominate market share. Credited with helping to define many of today's networking standards and protocols, Cisco is an active contributor to the standards committees within the Internet Task Force, IEEE, and other groups. The networking giant also maintains a sizeable foothold in the government technology scene as Cisco CEO John Chambers reported last year to Fox Business that the company has more than 70 percent market share in the public sector.

With the government's wide-spread adoption of Cisco products and its comprehensive feature set, military contractors are increasingly seeking Cisco-based rugged computing solutions for deployment in tactical military applications onboard land and air vehicles. However, although Cisco products contain superior networking capabilities, their original mechanical design is not always capable of enduring rugged military conditions. By adopting ruggedized Cisco switches and networking solutions, the government can provide a cost-effective method for implementing the latest networking technology that meets their stringent environmental compliance standards. Also, deploying ruggedized Cisco products reduces time to deployment on the battlefield as many military personnel are trained to operate Cisco's IOS network management software.

Key Concepts: "Rugged" systems are products that are designed from the ground up to meet the requirements of specific harsh environments. Conversely, the term "ruggedized" refers to a commercial product that was not originally intended for harsh-use application, but was enhanced to endure airborne, ground vehicle and/or shipboard deployments.

The following whitepaper outlines some of the ruggedization techniques Parvus employs to ensure Cisco products are military-ready and capable of enduring the world's harshest environments.

Rugged vs. Ruggedized

With military customers seeking the most robust, yet economical networking systems, a "ruggedized" commercial product can often be the best solution to meet the needs of a specific military application. The terms "rugged" and "ruggedized" are often used to describe electronics capable of enduring harsh environments; however, there is a strong distinction between the two terms that indicates how a product for military use was created.

"Rugged" systems are products that are designed from the ground up to meet the requirements of specific harsh environments. Conversely, the term "ruggedized" refers to a commercial product that was not originally intended for harsh-use application, but was enhanced to endure airborne, ground vehicle and/or shipboard deployments. Parvus' DuraNET 3000 product is an excellent example of how Parvus engineers ruggedized Cisco Systems' commercial Industrial Ethernet 3000 series switch for use in demanding military IP networking technology refresh applications.

Ruggedizing an Industrial Switch for Military Use

One of Cisco's latest Ethernet switches, the IE-3000, recently proved to be an ideal ruggedization candidate for military use, as this switch was designed for industrial Ethernet applications, including factory automation, energy and process control and intelligent transportation systems (ITSs). As its intended commercial use already exceeded traditional commercial environments, the Cisco IE-3000 switch included extended temperature and enhanced shock/vibration and surge ratings not typically offered by commercial networking gear.

	Ruggedized Switch	Commercial Switch
Target Applications	Helicopter, UAV, Wheeled Vehicles, Tracked Vehicles, Aircraft	Intelligent Transportation Systems, Factory Floor, Energy/Process Control
Thermal (Operating)	-40 to +71C (-40° to +160°F)	-40 to +70C (-40° to +158°F)
Cooling	Passive, Integrated Heat Spreaders	Passive, Integrated Heat Sinks
Enclosure	Sealed Aluminum Extrusion	Ventilated Plastic and Sheet Metal Box
Shock (Operating)	40G - MIL-STD-810G	20G
Shock (Storage)	75G - MIL-STD-810G	30G
Vibration	Jet-Helo-Tracked Vehicle Ranges - MIL-STD-810G	Industrial Ranges
Connectors	MIL-DTL-38999	RJ-45
Dust Ingress	Dust Tight (Similar to IP6X) - MIL-STD-810G	IP2X (Solid Object >12.5mm i.e. fingers)
Water Ingress	Water Immersion up to 1 Meter (similar to IPX7) - MIL-STD-810G	IP0X (no Water Protection)
MIL-STD Power	MIL-STD-1275 / 704 Compliant	Not Supported
Conformal Coating	Conformal Coated PCBs	No
EMI/EMC	MIL-STD-461F CE102, CS101, RE102, RS103	IEC61000, EN 50081, EN 50082-2, EN 61131-2, EN 61326-1

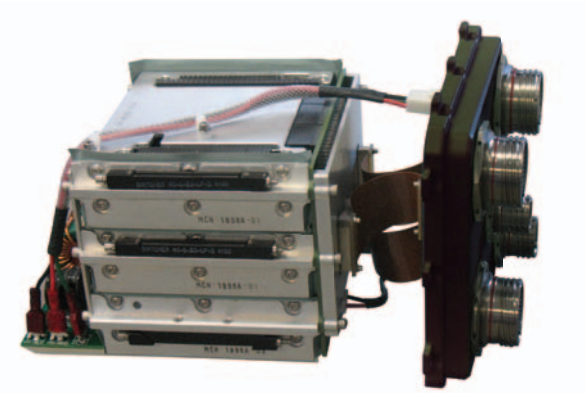
Optimizing the IE-3000 to Meet EMI Standards

Although the IE-3000 is considerably more rugged than the norm for a commercial product, military-level requirements dictated that engineers further optimize the switch by making mechanical enhancements for ingress protection against dust, water and EMI. The EMI compliance standard required for military use includes MIL-STD-461 for radiated and conducted emissions and radiated and conducted susceptibility.

Ruggedizing the IE-3000 to meet this rugged EMI standard required protection against input voltage inversion, voltage surges, and over-voltage spikes in accordance with MIL-STD-704 and 1275. This was accomplished through the implementation of a reverse voltage/overvoltage protection circuit. Engineers also implemented several improvements, such as designing a sealed enclosure with good EMI gaskets and creating proper test cables. Moreover, proper grounding techniques and good bonding between chassis surfaces were critical in creating an enclosure that acts as a faraday cage. Since external power leads are typically unshielded in test and application, they can be the single largest point of noise and susceptibility. By including a well-designed filter at the point where power enters the system, the ruggedized IE-3000 complies with EMI requirements as the filter prevents internal noise from exiting the system and protects sensitive electronics from external noise that otherwise might enter the system.

Connectors and Cables: Ensuring Stability for Possible Points of Failure

Like many commercial products, the IE-3000 includes RJ-45 network connectors. Although adequate for its original purposes, these RJ-45 connectors are notoriously prone to failure under extreme vibration and do not provide ingress protection against dust and water. Parvus engineers removed and replaced them with locking headers that ultimately terminated with circular MIL-DTL-38999 style connectors that not only protect against dust, water, vibration and shock, but bring ports to the outside world.



Board to Board Interfaces and Flex Cabling Terminate to DTL-38999 Connectors

Although a cableless design is optimal for rugged conditions, when ruggedizing an existing commercial product that includes cables, not all cables may be eliminated, so additional steps need to be taken ensure stability. Since the IE-3000 contains some cabling, engineers leveraged rigid flex circuits and board-to-board interfaces where possible and implemented cable braiding, tie-downs and other strain relief features to maximize reliability and prevent the cables from disconnecting or being severed in vibration or shock.

Ruggedizing Components to Survive Environmental Extremes

To further ruggedize the Cisco IE-3000, additional techniques were implemented to stabilize the components during shock and vibration. One such technique includes potting. Potting can be performed by completely encapsulating an electronic device or by staking it down, to provide protection against shock and vibration. For ruggedizing the IE-3000, potting was an essential procedure as it ensures security of sensitive designs, as well as creates a barrier against moisture, fungus, dust and corrosion. By enhancing circuit reliability by eliminating leakage from high-voltage circuits, potting protects against voltage arcs and short circuits and prevents the formation of tin whiskers.

Potting | Conformal Coating

Potting materials come in a multitude of varieties, the selection of which is determined by requirements including thermal, outgassing, electrical and thermal isolation or conduction capabilities, and manufacturing application requirements. The selection of the correct potting materials is a key engineering decision as it can determine the proper functioning of the components in a system.

Key Concepts:

Potting is an essential procedure as it ensures security of sensitive designs, as well as creates a barrier against moisture, fungus, dust and corrosion.

Conformal Coating improves and extends the working life of the board and helps ensure safety and reliability.

As a final step, engineers applied conformal coating material to the IE-3000's electronic circuitry to protect it from moisture, dust, chemicals and temperature extremes. This process improves and extends the working life of the board and helps ensure safety and reliability. These coatings "conform" to the contours of the board and its components, creating a thin protective layer that is both lightweight and flexible. For circuit boards that are not conformal coated, extreme environmental conditions could cause corrosion, mold growth and current leakage, resulting in board failure. Taking extra precautions to ensure that the board circuitry can endure harsh conditions is paramount in designing and building a ruggedized computing system that will last through the life of the product.

Thermal Management Techniques Ensure Rugged Performance

With heat issues often credited as the largest contributor to system failures, ruggedizing systems to meet these thermal challenges is a critical step. Thermal management for defense applications has always been a challenge due to the high operating temperatures of the latest processors and dense packaging needed for environmental ruggedness. Cisco's standard

IE-3000 switch relies on internal heat sinks and a vented case with passive air flow through the case to cool the unit. However, relying on convection cooling only inside a completely sealed box would have severe limits, so Parvus incorporated conduction cooling techniques to maximize the heat transfer, while the unit still remained fanless and passively cooled.

Robust Mechanical Frame Inside DuraNET 3000

To reduce weight and speed the system's heat transfer rate, engineers removed the entire standard Cisco finned heat sinks and replaced them with heat spreaders, a conduction cooling mechanism. The inclusion of heat spreaders, a thin sheet of metal incorporated on top of a device to help dissipate heat, significantly reduced thermal issues inside the IE-3000. These heat spreaders route heat through an internal rail/truss system that supports all of the circuit card assemblies from shock/vibration and dissipates the heat to the aluminum enclosure that incorporates finning on the outside to maximize surface area for cooling.

Further identifying any potential thermal management issues, engineers used thermal modeling software to analyze potential cooling issues, ensuring the new thermal devices included in the ruggedized Cisco IE-3000 iteration – called the "DuraNET 3000" – would meet specific military standards. Infrared imaging cameras were also used to locate any hot spots or thermal concerns. By running a variety of analyses, engineers quickly determined where potential points of failure could exist when subjected to the extreme temperatures encountered by the military.

Ruggedized Cisco Technology at Work

The ruggedization of the Cisco IE-3000 is but one of several Parvus products that has been ruggedized and hardened for harsh military and civil vehicle / aircraft installations. Other available router and switch models include the DuraMAR 5915, DuraNET 4948 and the DuraNET 2955. These enable prime contractors and civilian agencies to leverage the benefits available from Enterprise IOS-based routing and switching technology, while being encased in an ultra-rugged design for harsh military applications.

Thermal Plates for DuraMAR 5915 Router PC/104 Card Stack

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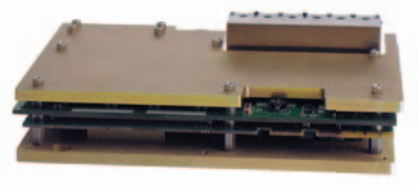
Specific applications of these ruggedized Cisco-based routers and switches include the DuraMAR network router subsystem installed as part of a satellite and communications upgrade for the Boeing 737 Business Jet. The DuraMAR router was an ideal choice for the 737 as this Cisco IOS-managed mobile network router provides an ultra-rugged chassis optimized for harsh vehicle and aircraft installations. Plus, the unit integrates Cisco Systems' mobile access router technology together with Parvus PC/104+ Gigabit Ethernet switch cards to expand LAN port count and consolidate switch and router functions into a single hardened subsystem designed to MIL-STD-810G and MIL-STD-461E environmental conditions.

The Parvus DuraNET 2955 Ethernet switch subsystem was also selected by a US prime defense contractor in support of a US Department of Defense (DoD) tactical communications program. A ruggedized Commercial of the Shelf (COTS) product based on Cisco Systems' 2955T-12 Ethernet switching technology, the Parvus DuraNET 2955 Ethernet switch subsystem leverages best-in-class switching and management technology from Cisco together with mechanical and electrical packaging enhancements from Parvus. These mechanical advancements allow the DoD to benefit from a robust COTS solution to provide local area network (LAN) connectivity to IP-enabled computing and net-centric devices.



Thermal Conduction Cooling Plates of the DuraNET 2955

Parvus' highest performance ruggedized switch product, the DuraNET 4948, is a ruggedized version of Cisco's Catalyst 4948E data center switch with forty-eight (48) downlink and four (4) uplink ports in a hardened 2U chassis qualified to meet MIL-STD-810 environmental and MIL-STD-461 EMI requirements. This powerful, multilayer switch enables demanding military and civil IP networking technology refresh programs to support deployment of data and multimedia services in wider thermal, shock, vibration, altitude, and humidity conditions than offered by the standard commercial Cisco version, perfect for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) applications.

Data Center Class DuraNET 4948 Switch

The DuraNET 4948 integrates redundant aircraft-grade power supplies, internal heaters, enhanced heatsinking, and upgraded cooling fans with efficient front-to-back chassis airflow management to reduce data center operating costs (by separating the inlet cold air and exhaust hot air). The unit comes equipped with rugged MIL-38999 connector interfaces, bringing out a total of 48 Gigabit Ethernet downlinks, plus three 10 Gigabit Ethernet uplinks (2 Copper/1 Fiber) and a Gigabit Fiber uplink.

Bringing It All Together

As evidenced by the creation of the DuraNET 3000, the process of ruggedizing a commercial product for military use is no small feat. However, ruggedized products can take advantage of the technological advancements made by the world's leading network manufacturers, and when combined with proven ruggedization techniques, offers a robust, cost-effective computing choice engineered to meet today's military requirements.

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DuraMAR 5915

- Ruggedized Cisco 5915 Router
- Modular & Optimized for Size, Weight, and Power (SWaP)
- Dual Router Uplinks, Plus up to 17 Switch Ports
- Firewall, VPN, and Hardware AES Encryption Acceleration
- C5915 Card Common Criteria and FIPS 140-2 Cert Pending
- MIL-STD-810G Environmental, MIL-STD-1275 / 704 Power
- MIL-STD-461F Filtering for Aircraft/Vehicles
- Operating Temp -40° to +71°C

DuraNET 4948

- Ruggedized Cisco Catalyst 4948E Ethernet Switch
- Enterprise IOS L2/L3 Services w/ 3DES & BGP Support
- High Density Connectivity: 52 Ports, 2U 19" Rack Mount
- Datacenter Class Throughput (176-Gbps Aggregated)
- Support for Access/Distribution Level L3 Routing
- 49x Gigabit Ethernet and 3x 10 Gigabit Ports
- MIL-STD-810G / MIL-STD-461F Qualified
- MIL-DTL-38999 Connectors
- Operating Temp -40° to +54°C

DuraNET 3000

- Ruggedized Cisco IE-3000 Ethernet Switch with 8 / 16 / 24x 10/100 Ethernet Ports + 2x GigE Uplinks
- Layer 2 LAN IOS or Layer 3 IP Services IOS w/ Routing Protocols - Static, RIP, OSPF, EIGRP, PIM
- -40° to +71°C Fanless Extended Temperature Operation; Chassis Sealed Against Water, Dust, EMI

DuraNET 2955

- Ruggedized Catalist 2955T-12
- 12x 10/100 Switched Ports, 2x Gigabit Ethernet Uplinks
- Web Browser, Command Line Interface, SNMPv3/2/1
- Manageable, Fault Tolerant, VLAN Support, IGMP Snooping
- Operating Temp: -40° to +71°C

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