Space Capabilities
We Are Interconnect

At Carlisle Interconnect Technologies, we do more than make interconnect technologies for a spectrum of industries. We deliver the critical connections and products that make amazing performances possible.

Carlisle Operating System (COS)

Driving the Industry Forward

We’re leading the way with our Carlisle Operating System (COS). COS is our standardized methodology using the tools of Lean Manufacturing and Six Sigma to drive continuous improvement for our customers and our business. It promotes the systems and culture of safety, employee involvement, quality, and on-time delivery — all of this with our customers in mind.

The COS methodology is woven into our leadership fabric and everything we do. This thought process is both supported and driven by our top leadership and ensures the sustainability of our successes with our customers and our business. Every CarlisleIT location participates with the goal of continuous improvement at all facilities.

With COS, companies working with CarlisleIT know they’re partnering with the world-class interconnect manufacturer dedicated to providing comprehensive, next-level solutions they can’t get anywhere else.

Nine Key Metrics

- MDI - Managing for Daily Improvement
- TPM - Total Preventative Maintenance
- Culture
- Supply Chain
- Environment
- Safety
- Quality
- Delivery
- Cost

The COS Operational Excellence program recognizes and rewards facility performance with a specific and defined level of achievement, providing each facility a road map for continuous success. The program allows CarlisleIT to monitor and track performance to ensure we’re achieving our performance goals.
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CarlisleIT in Space

Carlisle Interconnect Technologies’ broad range of Interconnect Solutions has been ensuring mission success for decades in the space industry. From launch vehicles to satellites, and spacecraft to ground support equipment, CarlisleIT’s RF Connectors, Cable Assemblies, Filter Connectors, Seamless Wire, Fiber Optics, and more, provide high performance and reliability in the most demanding and harshest of environments.

Here at CarlisleIT, we design and test our products to meet the requirements of extreme vibration during launch, thermal cycling, outgassing, and radiation once payloads are operational in orbit. In space, there is no option to repair or replace interconnect products; they need to work the first time, every time!

Whether your mission is headed into the unknown of deep space or a Low Earth Orbit constellation, CarlisleIT has you covered.

That’s Performance with Purpose

Over 40 Years of Supporting Some of the Space Industry’s Most Innovative & Ground-Breaking Devices, Programs, & Missions

<table>
<thead>
<tr>
<th>National Space Agency Programs Produced by:</th>
<th>Qualified for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA</td>
<td>Europa</td>
</tr>
<tr>
<td>JAXA</td>
<td>LUCY</td>
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<td>ESA</td>
<td>Orion Artemis</td>
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<td>Cosmic 2</td>
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Deep Space Missions:

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<th>Voyager</th>
<th>MAVEN</th>
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<tr>
<td>Cassini</td>
<td>Mars Rover 2020</td>
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GEO Orbit Telecommunications Satellites

Qualified for:

<table>
<thead>
<tr>
<th></th>
<th>GRACE</th>
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<tbody>
<tr>
<td>GOES</td>
<td></td>
</tr>
<tr>
<td>JPSS</td>
<td></td>
</tr>
<tr>
<td>James Webb Telescope</td>
<td></td>
</tr>
</tbody>
</table>
Space-Grade Assembly Processes

- Burr-free connector components verified at 10x magnification along the entire internal and external surface area with the ability to inspect up to 1000x magnification as required
- Connector component plating quality controls exceeding industry standards
- Proprietary degolding processes, meeting the requirements of NASA-STD-8739.3 and J-STD-001ES
- Thermal stabilization of components prior to assembly
- Class 10,000 Clean Room environment for the construction of spaceflight connectors and cable assemblies
  - Real-time X-ray to ensure proper connector-to-cable assembly and solder fill and workmanship to the stringent requirements of the space customer
  - 100% inspection of all electrical and mechanical requirements
  - Hand cleaning of all assemblies to include connector interfaces prior to packaging
- ESD-safe packaging purged and backfilled with nitrogen before being heat-sealed

Multipactor-Resistant Connector Designs

- Many custom and standard connector designs available for multipactor sensitive applications
- Custom connector designs for multipactor applications designed in accordance with NASA, aerospace, and ESA guidelines

Radiation Resistance

- UTiFLEX® cable assemblies for spaceflight applications offered with FEP and TEFZEL® jackets
- Standard UTiFLEX FEP jacketed cable designs proven to resist up to 30 Mrads of radiation and TEFZEL jacketed designs up to 100 Mrads

Minimized Passive Intermodulation Interference

- Cable and connector materials and finishes carefully selected to minimize effects due to passive intermodulation
- Excellent thermal stability
- Micro-Coax offers a wide selection of cables which optimize loss and phase stability versus temperature, along with excellent mechanical stability over a wide range of thermal extremes

Non-Outgassing Materials

- CarlisleIT spaceflight cable assemblies are manufactured with parts and materials with a maximum Total Mass Loss (TML) of 1% or collectible volatile condensable material level of 0.1% when tested per ASTM E-595

Key Characteristics

- Electrical testing for AC, DC, RF, fiber optic-based products, including EMC
- Mechanical testing facilities for shock, vibration, crush resistance, and flex
- Environmental testing to various MIL-Def standards
- Overmolding capability
- 2D and 3D form board mockups
- Trainers and operations are space-certified
  - IPC-A-620 (including space addendum)
  - IPC-J-STD-001 (including space addendum)
  - IPC-A-610
  - IPC-A-600
  - NASA-8739.1 polymetric applications
  - NASA-8739.2 surface mount
  - NASA-8739.3 soldering
  - NASA-8739.4 crimping and wiring
  - NASA-8739.5 fiber optic terminations
- Assembly test capabilities
  - X-ray, electrical length
  - Skew
  - Impedance (characteristic, differential, common mode)
  - Insertion loss, return loss/VSWR
  - TDR (time domain reflectometry)
  - Eye pattern, jitter
  - Bit error rate testing (BERT) crosstalk
  - Propagation delay
  - Rise time, fall time, rise time degradation
  - Continuity/DC resistance
  - Hipot/dielectric strength
ARACON® fiber combines the strength, light weight, and flexibility of genuine DuPont® Kevlar® with the electrical conductivity and corrosion resistance of nickel and solderability of silver. When braided or woven, the natural tendency for the fine, lightweight fiber is to spread out for high optical coverage. This translates into superior shielding effectiveness when compared to copper wire.

ARACON braids are available in standard sizes ranging from 0.062" to 2" inner diameter with both a nickel and silver finish. Also available are blends of ARACON with plated copper wire. The blended braids enhance lower frequency shielding performance and provide additional lightning protection, while still offering substantial weight savings compared to the traditional full-metal shield.

**Features and Benefits**

**Reliable**
- Military and spaceflight qualified
- Will perform in the harshest environments

**Industry-Leading Electrical Conductivity**
- Low transfer impedance
- Better RF shielding

**Lightweight**
- Up to 80% lighter weight than copper in typical applications
- Save fuel, more payload

**Stronger Than Steel**
- Built on DuPont Kevlar
- No more broken wires during installation

### WEIGHT: ARACON-BRAIDED EMI SHIELD

<table>
<thead>
<tr>
<th>Inner Diameter</th>
<th>Nickel-Plated 100%</th>
<th>Nickel-Plated Blend</th>
<th>Silver-Plated 100%</th>
<th>Silver-Plated Blend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125” (3.18 mm)</td>
<td>62%</td>
<td>43%</td>
<td>66%</td>
<td>49%</td>
</tr>
<tr>
<td>0.250” (6.35 mm)</td>
<td>62%</td>
<td>44%</td>
<td>66%</td>
<td>49%</td>
</tr>
<tr>
<td>0.500” (12.70 mm)</td>
<td>62%</td>
<td>43%</td>
<td>66%</td>
<td>48%</td>
</tr>
<tr>
<td>0.750” (19.05 mm)</td>
<td>63%</td>
<td>45%</td>
<td>67%</td>
<td>50%</td>
</tr>
<tr>
<td>1.00” (25.40 mm)</td>
<td>81%</td>
<td>72%</td>
<td>83%</td>
<td>75%</td>
</tr>
<tr>
<td>1.50” (38.10 mm)</td>
<td>81%</td>
<td>72%</td>
<td>83%</td>
<td>75%</td>
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</tbody>
</table>

### RESISTIVITY: ARACON-BRAIDED EMI SHIELD

<table>
<thead>
<tr>
<th>Inner Diameter</th>
<th>Nickel-Plated 100%</th>
<th>Nickel-Plated Blend</th>
<th>Silver-Plated 100%</th>
<th>Silver-Plated Blend</th>
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<tr>
<td>0.125” (3.18 mm)</td>
<td>75.9</td>
<td>26.8</td>
<td>75.9</td>
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<td>0.250” (6.35 mm)</td>
<td>36.7</td>
<td>9.1</td>
<td>36.7</td>
<td>9.1</td>
</tr>
<tr>
<td>0.500” (12.70 mm)</td>
<td>17.8</td>
<td>4.4</td>
<td>17.8</td>
<td>4.4</td>
</tr>
<tr>
<td>0.750” (19.05 mm)</td>
<td>11.9</td>
<td>5.6</td>
<td>11.9</td>
<td>2.9</td>
</tr>
<tr>
<td>1.00” (25.40 mm)</td>
<td>8.5</td>
<td>4.3</td>
<td>8.5</td>
<td>2.4</td>
</tr>
<tr>
<td>1.50” (38.10 mm)</td>
<td>5.7</td>
<td>1.3</td>
<td>5.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Capabilities**
- Manufacturing
- Electro-less and electrolytic plating
- Braiders: 8, 16, 24, 64, 72, and 96 carrier
- Class 10,000 clean room
- Fully equipped metallurgical laboratory
- Tensile tester
- Transfer impedance test set
- RF shielding test to 18 GHz
- Environmental testing – thermal and corrosion
- Optical, X-ray, and SEM material analysis
Performance Summary

Thermal Environments
- Operating range: -65 °C to 150 °C intermittent exposure to 200 °C
- Thermal aging: 150 °C for seven days
- Thermal shock: 50 cycles full operating range

Altitude
- Operating sea level to vacuum; no change in DC resistance
- Low-outgassing material

Corrosive Environments
- Nickel material meets 500 hr salt fog and 48 hr sulfur dioxide
- Broad range of resistance to fluid immersion

Lightning Susceptibility
- Level 3 to Level 5 multistrike capability per ANSI/EIA 364-75 and RTCA DO-160
- Capability exceeds 25kVA Waveform 5B

Flammability
- Does not burn when tested per FAA, Boeing, and Airbus methods

Smoke Density and Toxicity
- Complies with FAA, Boeing, and Airbus requirements

Flexibility
- Life cycle of over 50,000 cycles over 180° arc

Learn more: CarlisleIT.com/products/aracon-fiber
UTiFLEX® is a complete line of high-performance flexible microwave cables built by CarlisleIT. The entire UTiFLEX product line is constructed using a low or ultra-low-density PTFE dielectric, offering excellent loss characteristics, outstanding phase stability, and unsurpassed flexibility compared to standard flexible cables — all without sacrificing mechanical integrity. CarlisleIT has greatly increased connector reliability through a unique connector attachment that withstands mechanical and thermal stresses far better than standard connectors.

With UTiFLEX assemblies, the connector is no longer the weak link in your flexible cable assembly.

**Microwave Cable for Almost Any Application**

» Versatile low-loss cables offer outstanding performance in almost any environment.
» Low-loss cables have the lowest insertion loss available to 18, 26.5, 40, 50, 65 GHz.
» Miniature cables are a superior alternative to traditional RG or semi-rigid cables.
» Ultra-Light cables provide up to 25% weight savings for spaceflight applications.

**Key Features**

» Low VSWR (1.25:1 to 40 GHz typical)
» Excellent shielding effectiveness
» Precision phase matching
» ARACON® outer shield for superior weight savings
» Ultra-Light cables

**Space Qualified**

» J-STD-001 Space Addendum Certified assemblers and inspectors
» Class 10,000 clean room assembly processes
» Low-outgassing materials (1% TML, 0.1% CVCM per ASTM E-595)
» Radiation resistant up to 100 Mrads
» Real-time X-ray capability
UTiFLEX Ultra-Light cable assemblies are optimized for spaceflight applications. They provide the lightest weight, lowest insertion loss, and best radiation resistance in a flexible cable construction. The cables utilize CarlisleIT’s ARACON for the outer shield, an ultra-low-density PTFE for the dielectric, and a DuPont™ TEFZEL® jacket. If required, cable assemblies are manufactured in a Class 10,000 clean room by certified solder technicians.

**MECHANICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>UTIFLEX TYPE</th>
<th>MCJ088D</th>
<th>MCJ142A</th>
<th>MCJ185A</th>
<th>MCJ205A</th>
<th>MCJ311A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer Diameter</td>
<td>0.088”</td>
<td>0.142”</td>
<td>0.185”</td>
<td>0.205”</td>
<td>0.310”</td>
</tr>
<tr>
<td></td>
<td>(2.24 mm)</td>
<td>(3.61 mm)</td>
<td>(4.70 mm)</td>
<td>(5.21 mm)</td>
<td>(7.87 mm)</td>
</tr>
<tr>
<td>Center Conductor Type</td>
<td>Solid</td>
<td>Solid</td>
<td>Solid</td>
<td>Solid</td>
<td>Solid</td>
</tr>
<tr>
<td>Maximum Weight</td>
<td>3.6 g/ft (11.8 g/m)</td>
<td>8.8 g/ft (28.9 g/m)</td>
<td>12.4 g/ft (40.7 g/m)</td>
<td>16 g/ft (52.5 g/m)</td>
<td>35 g/ft (114.8 g/m)</td>
</tr>
<tr>
<td>Minimum Bend Radius</td>
<td>0.25” (6.35 mm)</td>
<td>0.38” (9.65 mm)</td>
<td>0.38” (9.65 mm)</td>
<td>0.5” (12.70 mm)</td>
<td>1.25” (31.75 mm)</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS**

- **Impedance**: 50 Ω
- **Frequency Range**: DC - 18 GHz
- **Velocity of Propagation**: 80%
- **Capacitance**: 25.5 pF/ft (83.7 pF/m)
- **Shielding Effectiveness @ 1 GHz**: > 100 dB

**Maximum Insertion Loss**

<table>
<thead>
<tr>
<th></th>
<th>@ 1 GHz</th>
<th>@ 10 GHz</th>
<th>@ 18 GHz</th>
<th>@ 26.5 GHz</th>
<th>@ 32 GHz</th>
<th>@ 40 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.20 dB/ft (0.66 dB/m)</td>
<td>0.10 dB/ft (0.33 dB/m)</td>
<td>0.08 dB/ft (0.26 dB/m)</td>
<td>0.07 dB/ft (0.23 dB/m)</td>
<td>0.05 dB/ft (0.16 dB/m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.66 dB/ft (2.17 dB/m)</td>
<td>0.33 dB/ft (1.06 dB/m)</td>
<td>0.27 dB/ft (0.89 dB/m)</td>
<td>0.23 dB/ft (0.75 dB/m)</td>
<td>0.15 dB/ft (0.49 dB/m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.89 dB/ft (2.92 dB/m)</td>
<td>0.44 dB/ft (1.44 dB/m)</td>
<td>0.36 dB/ft (1.18 dB/m)</td>
<td>0.32 dB/ft (1.05 dB/m)</td>
<td>0.21 dB/ft (0.66 dB/m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.54 dB/ft (1.77 dB/m)</td>
<td>0.44 dB/ft (1.44 dB/m)</td>
<td>0.39 dB/ft (1.28 dB/m)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.60 dB/ft (1.97 dB/m)</td>
<td>0.49 dB/ft (1.61 dB/m)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.68 dB/ft (2.23 dB/m)</td>
<td>-</td>
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</table>

**Phase Stability vs. Flexure**

<table>
<thead>
<tr>
<th></th>
<th>@ 10 GHz</th>
<th>@ 18 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2º</td>
<td>2º</td>
</tr>
<tr>
<td></td>
<td>2º</td>
<td>3º</td>
</tr>
<tr>
<td></td>
<td>2º</td>
<td>6º</td>
</tr>
<tr>
<td></td>
<td>1º</td>
<td>2º</td>
</tr>
<tr>
<td></td>
<td>3º</td>
<td>5º</td>
</tr>
</tbody>
</table>

**Phase Stability vs. Temperature**

See figure on next page

**Power Handling**

See figure on next page

**VSWR**

Refer to Connector Selection Guide

* Cable wrapped once around a 3” diameter mandrel

**ENVIRONMENTAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>-150 ºC to 165 ºC</th>
<th>-150 ºC to 165 ºC</th>
<th>-150 ºC to 165 ºC</th>
<th>-150 ºC to 165 ºC</th>
<th>-150 ºC to 165 ºC</th>
</tr>
</thead>
</table>

Silver-Plated Copper Wire or Silver-Plated Copper Clad Steel Wire
Ultra-Low-Density PTFE Dielectric
Silver-Plated ARACON Shield
Black TEFZEL Jacket

DuPont™ and TEFZEL® are trademarks or registered trademarks of E.I. du Pont de Nemours and Company.

» Learn more: CarlisleIT.com/products/cable-assemblies-harnesses/utiflex/
TVAC Miniature Low-Loss Cable Assemblies

Thermal vacuum testing is a risk mitigation strategy utilized in some high-rel applications, notably space equipment such as satellites. CarlisleIT TVAC test assemblies are thermal vacuum compatible for use with TVAC chambers. These assemblies utilize high-performance, ultra-low-loss UTiFLEX cable and are produced to exacting space-grade standards utilizing low-outgassing materials and vented connectors.

Key Characteristics

» Low outgassing per ASTM E-595 (<1% TML and <0.1% CVCM)
» Temperature Range: -65 °C to 165 °C (typical, consult factory for individual types)
» Ideal phase performance due to ultra-low-loss dielectric materials
» Superior cable mechanical stability and connector captivation techniques to address increasing thermal extremes of the space market
» Clean-room manufacturing and real-time X-ray upon request
» High-power configurations available. All high-power TVAC assemblies are manufactured in a clean-room environment to full space-grade standards; consult CarlisleIT for specific power/frequency requirements
» Individually bagged to prevent post-assembly contamination
» Vented connectors

<table>
<thead>
<tr>
<th>PART NUMBER DESIGNATION (EXAMPLE)</th>
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</thead>
<tbody>
<tr>
<td><strong>Base Part Number</strong></td>
</tr>
<tr>
<td>UFB142A-0-XXXX-20V20V TV</td>
</tr>
</tbody>
</table>

XXXX is cable assembly length in 0.1” increment.
Length Tolerance = -0 / +0.5” (XXXX <= 100”)
Length Tolerance = -0 / + 0.5% (XXXX >= 100”)

If absolute phase matching is required, then add “AM” code. For phase matched assemblies, length tolerance is not applicable.

» Learn more: CarlisleIT.com/products/cable-assemblies-harnesses/utiflex/
Semi-rigid coaxial cables are available in a wide variety of sizes, materials, and characteristic impedances. To be considered a semi-rigid coaxial cable, the cable must employ a solid metallic tube for the outer conductor. Most semi-rigid coaxial cables are less than 0.250” in diameter; however, some select cables are as large as 0.500”. A silver-plated copper center conductor, polytetrafluoroethylene (PTFE) dielectric, and copper outer conductor are the most common materials. Impedances are available from 5 to 100 Ω. Typical maximum operating temperatures range from 125 °C to 250 °C.

Key Characteristics
Semi-rigid coaxial cables are used to transmit and receive microwave signals up to 110 GHz. These cables are the best pure microwave transmission medium available in the world.

» RF shielding in excess of -130 dB
» Lowest attenuation and lightest weight for any given geometry
» Unequaled impedance control and VSWR performance
» Smallest overall diameters available in a microwave cable
» Very tight bend radii allow utilization in the tightest configurations
» Environmentally sealed with no concern over jacket cuts or abrasions
» Numerous connector options available off-the-shelf from many different suppliers

Because semi-rigid coaxial cables can be precisely formed, they allow maximum packaging efficiency with no wasted space. While semi-rigid cables will hold their shape once formed, most are still pliable enough to provide some flexibility during system integration.

Semi-rigid coaxial cables are the benchmark against which all other coaxial cables are compared.

Learn more: CarlisleIT.com/products/cable-assemblies-harnesses/ rf-microwave-cable-assemblies
I. The Problem

Microwave cable assemblies have an electrical length that varies with temperature. Often it is advantageous for this length to vary minimally or linearly with temperature.

The electrical length of the cable assembly is primarily dependent on the choice of the dielectric material. The dielectric of choice for many microwave cable applications is typically a form of Polytetrafluoroethylene (PTFE). While PTFE generally exhibits excellent electrical and mechanical properties, at around 19 °C it experiences a structural phase change. This results in dramatic dimensional changes that affect the electrical phase length of cable assemblies. Figure 1 depicts the typical phase versus temperature performance for flexible cables manufactured from ultra-low-density PTFE. This type of abrupt phase length versus temperature performance can pose challenges for system designers who require linear or minimal phase change with temperature.

II. The Design

A. Design Approach

The UTiPHASE™ series of flexible cable was developed utilizing a CarlisleIT Fluoropolymer Dielectric Technology. The cables’ sizes were chosen to be consistent with current CarlisleIT flexible cable offerings in order to utilize existing proven connector options for assemblies.

B. Materials

1. The Center Conductor types, which are either silver-plated copper (SPC) or silver-plated copper-weld steel (SPCW), meet the requirements of MIL-DTL-17.

2. The Dielectric used on the cables detailed here consists of a CarlisleIT Fluoropolymer.

3. The Outer Conductor is silver-plated copper (SPC) per ASTM B-298.

4. The Outer Shields are either silver-plated copper (SPC) per ASTM B-298; ARACON® (silver-plated poly paraphenylene terephthalamide) for up to 15% weight savings; or high-strength, high-conductivity copper alloy (HSSPC) per UNS C17510, silver coated per ASTM B-298.

5. The Outer Jacket is either extruded fluorinated ethylene propylene (FEP) per MIL-DTL-17. Type IX: or ethylene tetrafluoroethylene (ETFE) in accordance with ASTM D-3159.

Table I lists the center conductor materials, outer shield, and outer jackets for the UTiPHASE cables discussed in this section.
C. Physical Dimensions

The physical dimensions of each cable size were selected to be consistent with Carlisle Interconnect Technologies’ UTIFLEX flexible cable product line to enable using the same connectors.

Table II lists the outer diameter and nominal weight for the UTiPHASE cables discussed in this section.

<table>
<thead>
<tr>
<th>UTiPHASE Part Number</th>
<th>Center Conductor Material</th>
<th>Outer Shield Material</th>
<th>Outer Jacket Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCX088D</td>
<td>SPCW</td>
<td>ARACON</td>
<td>ETFE</td>
</tr>
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<td>SPCW</td>
<td>HSSPC</td>
<td>FEP</td>
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<td>ETFE</td>
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<td>SPC</td>
<td>SPC</td>
<td>FEP</td>
</tr>
</tbody>
</table>

Table I

III. The Solution

Multiple lots of cable were tested for electrical length from -65 °C to 100 °C with startling results. The abrupt phase change and total change inherent in PTFE dielectrics was eliminated.

Figure 3 shows the typical phase change for UTiPHASE cables versus flexible cables with ultra-low-density PTFE dielectric.

Figure 4 shows the typical phase change for UTiPHASE cables versus flexible cables with various PTFE dielectrics.

IV. Conclusion

The UTiPHASE series of cables can be used wherever flexible cables that exhibit minimal or linear phase change with temperature are needed.
High-Frequency Assemblies

- MCJ088D 70 GHz S-parameters over temperature
- Increasing operational frequency for qualified MCJ0888D cable
- 1.85 mm interfaces maintain connector interface control and baseline electrical performance through 200 thermal cycles, -50 °C to 100 °C, and post 200 thermal cycle S-parameters versus temperature

Examples of Highly Engineered Solutions for Your Space Application

Precision-formed ends for optimal electrical performance
Frequency-Optimized Cable Assemblies

- MCJ115A 55 GHz flexible cable assembly configurations
- Improved dB/ft (dB/m) versus 0.088” diameter to address V-band operation

**UTIFLEX PRODUCT SPECIFICATION**

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Item Number</th>
<th>Rev.</th>
</tr>
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<tbody>
<tr>
<td>CABLE SPECIFICATION</td>
<td>MCJ115A</td>
<td>B 1950151</td>
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<table>
<thead>
<tr>
<th>Environmental Properties</th>
<th></th>
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<tbody>
<tr>
<td>Where applicable after each test, the assembly shall show no damage, insertion loss and VSWR shall remain within the specified limits, and connector interface dimensions remain within the specified limits of MIL-PRF-18592.</td>
<td></td>
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</tbody>
</table>

**Mechanical / Physical Properties**

<table>
<thead>
<tr>
<th>Mechanical / Physical Properties</th>
<th>Temperature Range (°C)</th>
<th>Center Conductor Diameter (Millimeters)</th>
<th>Outer Conductor Diameter (Millimeters)</th>
<th>Jacket Diameter (Millimeters)</th>
<th>Jacket Wall Thickness (Millimeters)</th>
<th>Weight (grams/ft)</th>
<th>Weight (grams/m)</th>
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</thead>
<tbody>
<tr>
<td>Thermal Shock</td>
<td>MIL-STD-810, Method 107, 20 cycles, 35 ± 10 °C for 168 hours</td>
<td>0.06</td>
<td>0.08</td>
<td>0.004</td>
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<tr>
<td>Aging Stability</td>
<td>MIL-STD-202, Method 1004.1</td>
<td>-65 to 125</td>
<td>-65 to 125</td>
<td>-65 to 125</td>
<td>-65 to 125</td>
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<tr>
<td>Vibration</td>
<td>MIL-STD-202, Method 204, Test Condition B</td>
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<td>High Pressure</td>
<td>MIL-STD-202, Method 300, Test condition B</td>
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<td>Low Pressure</td>
<td>MIL-STD-810, Method 100, Temperature 6, 20°C</td>
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<td>Humidity</td>
<td>MIL-STD-202, Method 106, Temperature 2, 20°C</td>
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<td>Salt Fog</td>
<td>MIL-STD-810, Method 509, Procedure 1</td>
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<td>Sand and Dust</td>
<td>MIL-STD-810, Method 510, Procedure 1</td>
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<td>Water Errosion Resistance</td>
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<td>Cold Bend Test</td>
<td>MIL-STD-17, Paragraph 4.8.17</td>
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<td>Outgassing</td>
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<tr>
<td>Radiation Resistance</td>
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<tr>
<td>Electrical Properties</td>
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<td>Impedance (Ohms)</td>
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<tr>
<td>Voltage of Propagation (ft/μs)</td>
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<tr>
<td>Capacitance (pF/ft)</td>
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<tr>
<td>Conductivity (kΩ/s)</td>
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<tr>
<td>Corona Extinction (MV/m @ 50Hz)</td>
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<tr>
<td>Dielectric Withstanding (MV/m @ 50Hz)</td>
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<tr>
<td>Insulation Loss Stability by Temperature</td>
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</tr>
</tbody>
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**Specifications subject to change. Please contact Carlisle Interconnect Technologies for the latest document revision.**

**Copyright Carlisle Interconnect Technologies**

Carlisle Interconnect Technologies
200 Jones Blvd.
Pottstown, PA 19464
Examples of Highly Engineered Solutions for Your Space Application

Example Layout: Micro-Miniature Harness

- MCJ088D cable, 2.2 mm (0.088") diameter
- 2x1 HC2 stripline PCB connector housing
- Micro-D bulkhead plug per MIL-DTL-81353/1 with 8x1 SMP-f
- 40 GHz operation, phase match +/-0.5\degree/\text{GHz}
Example Layout: Micro-Miniature Harness

- UGF055D cable, 1.4 mm (0.055") diameter
- 2x (4x1) SMPM-f CoreGD vertical housing
- 6x1 SMPM-m PCB interconnect
- Micro-D bulkhead plug per MIL-DTL-81353/1 with 8x1 SMP-f
- 40 GHz operation
16-Position SMPS Board-to-Board Interconnect

LOCATION FOR STAKING BOLT

DETENT AND CATCHER’S MITT

CATCHER’S MITT

ASSEMBLE HOOD WITH BOLTS (QTY 4) TO CONNECTOR

ALIGNMENT DOWEL PINS

.060-80 UNF-2A 0.218 (7/32) LONG QTY 4

.060-80 UNF-2A 0.125 LONG QTY 4

PCB

WP350B16-AKH-4CC SHROUD, CATCHER’S MITT (0.650 X 0.650 SQUARE) (THRU MOUNTING HOLE)

WP350B16-AKH-2CC SHROUD, DETENT (THRU MOUNTING HOLE .218 BOLT)

WP350B16-AKH-3CC SHROUD, CATCHER’S MITT (0.650 X 0.650 SQUARE) (THREADED MOUNTING HOLE)

WP138-AKH-1CC SPRING ADAPTER (0.816+/-0.030 LENGTH) QTY 16 (1 SHOWN FOR CLARITY)

WP138-AKH-1CC SPRING ADAPTER (0.816+/-0.030 LENGTH) QTY 16 (1 SHOWN FOR CLARITY)

WP350B16-AKH-1CC SHROUD, DETENT (0.520 X 0.520 SQUARE) (THRU MOUNTING HOLE .125 BOLT)

CARLISLE INTERCONNECT TECHNOLOGIES

SMPS LAYOUT

OPTION 1: COMPRESSION

UPDATED: 02/06/2020
The introduction of push-on blind-mateable connectors, such as the SMP, galvanized the RF/microwave industry as their use enabled designers to increase package density. This created the ability to stack PC boards, while also simplifying the assembly and test of these designs.

Carlisle Interconnect Technologies advances the design of the traditional push-on connectors with our SMP-L connectors by adding a patent-pending locking mechanism referred to as Secure-Lok™ to the standard SMP interface. Susceptibility to vibration and other environmental factors has historically limited designers to using threaded connectors such as the SMA, Type N, etc. Secure-Lok makes the SMP-L series of push-on connectors ideal for rugged military and commercial applications. SMP-L connectors and cables provide a strong retention force and are also available in sealed IP67 compliant options.

**Features**

- Frequency range: DC - 40 GHz
- Unique locking mechanism in a push-on configuration
- Superior ruggedability and performance compared to standard push-on connectors
- Fully compatible with SMP standard product line
- IP67-compliant options available

Learn more: [CarlisleIT.com/prod-info/smp-l-secure-lok-interconnect-series/](http://CarlisleIT.com/prod-info/smp-l-secure-lok-interconnect-series/)
Carlisle Interconnect Technologies (CarlisleIT) designed the SMPM Connector product line to further improve package density of RF/Microwave systems. With an interface about 30% smaller than its predecessor, the SMPM Connector is now an industry standard (as outlined in the MIL-STD-348 document) for RF/microwave applications and has enabled design engineers to increase design performance and complexity while improving form factor.

The durable construction and ability to tolerate radial and axial misalignment allows for a blindmate interconnect solution capable of withstanding multiple engagement/disengagement cycles without degradation in electrical performance.

Due to its high-frequency performance and blindmate configuration, the SMPM Connector is a standard interface in many applications including:

» Antennas
» Broadband
» Wireless
» Military
» Instrumentation

Features

» DC - 65 GHz frequency range
» 50 Ω impedance
» Blindmate configuration
» MIL-PRF-39012 compliant
» Ability to withstand radial/axial misalignment
» Board-mount, field replaceable, bullets, hermetic, and cable connector configurations
» Custom connectors available

Specifications

Parameter | Specifications
--- | ---
Impedance | 50 Ω
Frequency Range | DC - 65 GHz*
VSWR | 1.02 + 0.012 x F (GHz)
Insertion Loss | 0.04 x √F (GHz)
DWV | 325 Vrms
Insulation Resistance | 5000 MQ (min)
RF High Pot | 190 Vrms @ 5 MHz
Force to Engage | Detent 6.5 lb. (max)
| Smooth Bore 2.5 lb. (max)
Force to Disengage | Detent 4 lb. (min)
| Smooth Bore 1.5 lb. (min)
Radial Misalignment | +/- .010"
Axial Misalignment | 0.000/0.010"
Temperature Range | -55 °C to 165 °C
Thermal Shock | MIL-STD-202, Method 107, Cond C
Moisture Resistance | MIL-STD-202, Method 106, except step 7b
Vibration | MIL-STD-202, Method 204, Cond D
Shock | MIL-STD-202, Method 213, Cond I

Learn more: [CarlisleIT.com/prod-info/smpm-interconnect-series/](http://CarlisleIT.com/prod-info/smpm-interconnect-series/)
Carlisle Interconnect Technologies’ (CarlisleIT) Octax®-Solo 10 Gbps Ethernet Connector is a single-port, standalone connector designed for a wide variety of aerospace and military applications. The Octax connector:

» Uses innovative inserts that isolate each twisted pair and contact, virtually eliminating near-end crosstalk
» Features cable and twists that are maintained extremely close to the contacts, minimizing characteristic impedance mismatch
» Delivers 10x the transmission speed (10 Gbps signal) and 2x the density compared to Quadrax-type solutions

### Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigabit and 10 Gb Ethernet data transfer speed</td>
<td>• Allows for higher data quantities to transfer at quicker speeds covering a variety of 1 Gb applications and emerging 10 Gb needs</td>
</tr>
<tr>
<td>Field repairable</td>
<td>• Designed for easier and less costly on-site termination repair</td>
</tr>
<tr>
<td>Uses standard 22D crimp contacts (M39029)</td>
<td>• Standard off-the-shelf contacts are readily available and requires no special tooling</td>
</tr>
<tr>
<td>Small form factor</td>
<td>• Critical space savings for highly dense applications</td>
</tr>
<tr>
<td>Anti-decoupling/self-locking mechanism for rugged environments</td>
<td>• Connector will not disconnect/uncouple in a high-vibration application</td>
</tr>
</tbody>
</table>

### Suggested Applications

» Single-port 10 Gbps Ethernet connector (compatible with CarlisleIT gigabit series Ethernet cables)
» Aerospace and military
  » Avionics
  » IFEC
  » High-definition video displays
  » Data loading
» Any high-speed Ethernet application

### Part No. and Description

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCTAX-SOLO-FMR</td>
<td>Flange mount receptacle connector</td>
<td>Ni PTFE</td>
</tr>
<tr>
<td>OCTAX-SOLO-JNR</td>
<td>Jam nut receptacle connector</td>
<td>Ni PTFE</td>
</tr>
<tr>
<td>OCTAX-SOLO-IR</td>
<td>Inline (flange-less) receptacle connector</td>
<td>Ni PTFE</td>
</tr>
<tr>
<td>OCTAX-SOLO-P</td>
<td>Plug connector</td>
<td>Ni PTFE</td>
</tr>
<tr>
<td>OCTAX-SOLO-FM-PCB*</td>
<td>Straight PCB flange mount receptacle connector</td>
<td>Ni PTFE</td>
</tr>
<tr>
<td>OCTAX-SOLO-FMR-W</td>
<td>Flange mount receptacle connector</td>
<td>CADMIUM OD</td>
</tr>
<tr>
<td>OCTAX-SOLO-JNR-W</td>
<td>Jam nut receptacle connector</td>
<td>CADMIUM OD</td>
</tr>
<tr>
<td>OCTAX-SOLO-IR-W</td>
<td>Inline (flange-less) receptacle connector</td>
<td>CADMIUM OD</td>
</tr>
<tr>
<td>OCTAX-SOLO-P-W</td>
<td>Plug connector</td>
<td>CADMIUM OD</td>
</tr>
</tbody>
</table>

* Jam nut design also available

» Learn more: CarlisleIT.com/prod-info/octax-solo/
Carlsile Interconnect Technologies’ (CarlisleIT) CoreGD™ is a high-performance, multi-port, interconnect system that offers excellent signal integrity for complex layouts and crowded PCBs used in a variety of applications.

It is a low-cost solution optimized for applications with demanding bandwidth up to 65 GHz, pushing the envelope up to 100 GHz.

» Commercial off-the-shelf interconnect system available today
» Designed into evaluation and validation test systems to analyze key parameters like insertion loss, crosstalk and frequency response
» High-performance interconnect solution, at a significantly lower cost compared to similar competitive solutions
» CoreGD technology can be readily integrated into custom, hybrid RF + Digital + Power interconnect solutions to meet uniquely demanding requirements
» Multiple position offerings available (2, 4, 6, 8, 10).

### Features

<table>
<thead>
<tr>
<th>Frequency range: DC to 65 GHz SSMP (SMPM); DC to 100 GHz WMP (SMPS), preliminary</th>
<th>• Broad frequency range covers a variety of applications today, current and emerging needs of tomorrow, reducing overall cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch: 4 mm SSMP (SMPM); 2.5 mm WMP (SMPS), preliminary</td>
<td>• Test in dense environments and save PCB space with small pitch offerings</td>
</tr>
<tr>
<td>Field replaceable</td>
<td>• Save time and cost with quick and easy repair of damaged cable components in cable assembly</td>
</tr>
<tr>
<td>Simplified pre-tinned Surface Mount Technology (SMT)</td>
<td>• Reduce mount install time of board connectors and associated costs</td>
</tr>
<tr>
<td>Innovative design overcomes push-on interface performance consistency</td>
<td>• Eliminates electrical length or phase variation under vibration, shock, or other movement, ensuring stable and reliable signals</td>
</tr>
<tr>
<td>Multi-port offering (2, 4, 6, 8, 10) including stackable, side-to-side, and back-to-back</td>
<td>• Selection of appropriate standard position loading reduces time to market and supports flexible designs driving to lowest cost solutions</td>
</tr>
<tr>
<td>Available configurations: » Vertical mount and board-to-board stack » Edge mount</td>
<td>• Availability of multiple configurations enables optimum performance at the lowest total cost</td>
</tr>
</tbody>
</table>

» Learn more: CarlisleIT.com/prod-info/coregd/
Why Filters in a Connector?

Theory and Types

If your circuitry is suffering the ill effects of interference from radio waves, stray transmissions, electric power lines, or electric motor noise, you are experiencing EMI (electromagnetic interference). This leads the circuit designer to consider EMI filters. A second issue, EMP (electromagnetic pulse), is driven from the catastrophic effects of extremely high voltage and short duration pulses of energy. Traditionally, concern for nuclear attack was high priority. Now, in the military and aerospace environments, protection from lightning strikes and similar high-energy sources is a top priority. Protection from this sudden, unwanted overvoltage situation is more commonly referred to as TVS (transient voltage suppression).

EMI and EMP are looking for a path to your circuits, and that path is usually an antenna or a cable set running to the circuit that is acting as an antenna. The key warrior against EMI is a capacitor element. Typically, we battle transient voltage with a Zener diode. Where is the best place to put these elements? Often military and avionics boxes house the critical circuitry. If the cable set is the antenna, then the best placement for the filter is at the cable/box interface, preventing the unwanted signals from entering the system. A multi-pin filter or TVS connector is the ideal solution.

Typical ‘Pi’ Filter Construction

1. **Shell** – Plated aluminum alloy
2. **Capacitors** – Ceramic, planar
3. **Contacts** – Brass for pin contacts; copper alloy for socket contacts; finish gold plate
4. **Insulators** – High-grade thermoplastic/thermoset or epoxy glass laminate
5. **Interfacial/Peripheral Seal** – Typical construction is fluorosilicone
6. **Solder**
7. **Inductors** – Ferrite beads
8. **Ground Spring** – Beryllium copper plated, 360° orientation inside of shell
9. **Epoxy**

Learn more: CarlisleIT.com/products/connectors-accessories/filter-connectors/
CarlisleIT’s Circular Filter Connectors meet the requirements of their specific connector MIL-SPECS, including shock and vibration at temperature. These low-pass filter connectors include the most popular circuits, C, CL/LC, Pi, and T. They are constructed using planar filter technology for maximum strength and high performance, from low to high frequencies. Multiple capacitance values, circuits, feedthroughs, and/or grounds can be incorporated into the arrangement to produce the desired performance. All thermal processes are profiled and controlled, cleanliness checked, and electrical testing of 100% of the contacts is done to ensure a quality product.

**Performance, Benefits, and Certifications**
- Planar design
- Sealed (for aqueous cleaning)
- Ferrite immobilization
- Can offer solderless designs
- Space qualified
- Can incorporate filtering plus transient voltage suppression

### Rectangular Filter Connectors
**For EMI Protection**

CarlisleIT D-Sub and Micro-D Filter Connectors meet all the requirements of MIL-PRF-24308 and MIL-PRF-83513, while providing filtering in accordance with the attenuation curves noted here. MIL-PRF-24308 connectors (standard and high density) and MIL-PRF-83513 are manufactured in all layouts offering maximum contact density in a minimum of space.

Both series of connectors are offered with the standard variations in mounting hardware, standard straight or right angle contacts and PCB, solder cup, and crimp termination.

**Performance, Benefits, and Certifications**
- Planar design
- Machined shells
- Ferrite immobilization
- Space qualified
- Can incorporate filtering plus transient voltage suppression
- Can meet DO-160 lightning requirements

» Learn more: [CarlisleIT.com/products/connectors-accessories/filter-connectors/]
CarlisleIT offers the LITEflight® EP (Enhanced Performance) family of aerospace-grade fiber optic cables.

The new LITEflight EP series provides all the performance and benefits of its predecessor necessary to function in the harsh environments of your aerospace and military applications but with lower loss, tighter bend radius, improved thermal stability, and better handling during termination and installation. Unlike tight structure cables, the LITEflight EP semi-loose structured cables are compatible with all commercially available fiber optic termini and connectors. LITEflight EP is available in multiple sizes, configurations, and temperature ratings to 260 °C in order to meet the most demanding application requirements.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Typical Value</strong></td>
<td><strong>Typical Value</strong></td>
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<tr>
<td>Outside Diameter</td>
<td>1.8 mm</td>
<td>1.8 mm</td>
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<tr>
<td>Cable Weight</td>
<td>4.6 kg/km</td>
<td>4.6 kg/km</td>
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<tr>
<td><strong>Minimum Bend Radius</strong></td>
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<tr>
<td>Short Term (Installation)</td>
<td>6.0 mm</td>
<td>6.0 mm</td>
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<tr>
<td>Long Term (Operation / Storage)</td>
<td>9.0 mm</td>
<td>9.0 mm</td>
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<tr>
<td><strong>Attenuation</strong></td>
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<tr>
<td>850 nm</td>
<td>2.8 dB/km</td>
<td>2.9 dB/km</td>
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<tr>
<td>1300 nm</td>
<td>0.6 dB/km</td>
<td>0.8 dB/km</td>
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<tr>
<td>Temperature Cycling</td>
<td>0.10 dB/30 m</td>
<td>0.10 dB/10 m</td>
</tr>
<tr>
<td>Thermal Shock</td>
<td>0.10 dB/30 m</td>
<td>0.10 dB/10 m</td>
</tr>
<tr>
<td>Buffer Push-In Force</td>
<td>2.0 N/.45 mm</td>
<td>2.0 N/.45 mm</td>
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<tr>
<td><strong>Cable Kink Resistance</strong></td>
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<tr>
<td>6.3 mm Loop Diameter</td>
<td>0.18 dBΔ</td>
<td>0.19 dBΔ</td>
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</table>

*All testing performed in accordance with EN-3745 or ARINC 802 methods.

» Learn more: CarlisleIT.com/prod-info/liteflight-ep
Seamless™ PTFE Wire Insulation Wrap

Our Seamless™ technology has been designed and used on several space applications. It is available in a variety of sizes and configurations, including ultra-light weight, ultra-high strength, thermocouple, single or multi-conductor, shielded, unshielded, matched impedance, and even qualified to International SSQ 21655 Space Station MIL-STD-1553 databus specification.

Seamless™ PTFE Wire Insulation Wrap

Seamless Comparison Charts

<table>
<thead>
<tr>
<th>Product Characteristics</th>
<th>Seamless Tape-Wrap /80 - /92</th>
<th>Seamless Tape-Wrap /180 - /192</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrape Abrasion</td>
<td>★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Hydrolytic Resistance</td>
<td>★★</td>
<td>★</td>
</tr>
<tr>
<td>Wet Arc Propagation Resistance</td>
<td>★★★</td>
<td>★★</td>
</tr>
<tr>
<td>UV Laser Marking</td>
<td>★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Strips Easily and Cleanly</td>
<td>★★</td>
<td>★★</td>
</tr>
</tbody>
</table>

Better ★★                           Best ★★★

Seamless and Seamless-T Products Exceed AS22759/92 and /192 Requirements

**Scrape Abrasion**
- 23°C: 2065 cycles (Seamless/92), 3044 cycles (Seamless-T/192)
- 150°C: 965 cycles (Seamless/92), 344 cycles (Seamless-T/192)

**Marking Contrast**
- Initial: 61% (Seamless/92), 67% (Seamless-T/192), Requirement: 55%
- 168 hours thermal aging: 37% (Seamless/92), 52% (Seamless-T/192), Requirement: 40%

**Wet Arc Propagation Resistance**
- 98.7% (Seamless/92), Requirement: 93.3%
- 98.7% (Seamless-T/192)

Learn more: CarlisleIT.com/products/wire-cable/seamless
Global Manufacturing. Local Support.

Wherever you are, so are we. With manufacturing centers around the globe, our highly qualified team of engineers is up to any challenge. Our extensive worldwide manufacturing capabilities, coupled with end-to-end local project management and engineering support, allow us to design, build, test, and certify your product in-house, saving you the time and hassle of managing multiple vendors.