HUBER+SUHNER

Excellence in Connectivity Solutions

High Density Interconnect Solution for Space Applications Requiring High Electrical Stability

Introduction

Current Industry Trends

- The design of space-flight payload electronics systems has been progressively and actively moving toward the reduction geometric size and mass design constraints.
- Concurrently, space-flight payload electronics systems performance requirements are becoming more challenging as their operating frequencies continue to increase.
- The ability to meet these design goals is limited by the availability of equally compact coaxial interconnect solutions that can meet the reliability and durability requirements of a space vehicle.
- The development of miniaturized passive components solutions is required to support these emerging applications.

Introduction

Traditional Threaded Coaxial Connector Solutions

- The typical solution that has been historically chosen to reduce the size and mass of the coaxial connections has been the Sub-Miniature Type A (SMA) connector.
- The threaded SMA connector interface provides reliable and durable mechanical and electrical performance when subjected to space vehicle dynamics.
- However, based upon the size of the SMA connector and the assembly clearances that are necessary to properly mate and de-mate the connector pair, the minimum connector center-line spacing is 19mm.

Introduction

Traditional Threaded Coaxial Connector Solutions

- The connector pitch of 19mm then drives the minimum surface area of any RF module wherein multiple SMA connectors are mounted.
- The surface must be of sufficient size to contain the panel mount dimensions for each connector, provide the necessary assembly clearances, and structurally sustain the mechanical loads due to space vehicle dynamics.
- These factors severely limit the potential to reduce the geometric size and mass of RF components that utilize the SMA interface.
- The SMA connector has become too bulky to be a solution for many new space-flight applications and is also unable to provide a connector solution for applications in new higher frequency bands.

Introduction

Traditional Threaded Coaxial Connector Solutions

- Connector solutions have been designed to meet the new higher frequency bands of today's space-flight applications but the selection of interface types is significantly lower.
- Applications operating in the K and Ka frequency bands have utilized the familiar 2.9mm and 2.4mm precision connector interfaces.
- While offering outstanding electrical and mechanical performance, these interfaces suffer from the shortcomings of having the same form factor for mass and geometric size as the SMA connector interface.

Push-On Style Connector Capabilities

Traditional Push-On Coaxial Connector Solutions

- The inability to further reduce the size and mass of traditional threaded coaxial connectors in applications requiring higher operating frequencies lead to the development of several push-on style RF connector interfaces.
- Two of the most prominent solutions in the space-flight passive components industry are the Sub-Miniature Push-On (SMP) and Sub-Miniature Push-On Micro-Miniature (SMPM) connector designs.
- The dimensions and performance of these connector interfaces are defined within industry standards MIL-STD-348 and MIL-PRF-31031.
- This style of coaxial interconnect has successfully reduced the mass of the connection and the connector pitch distance through the removal of the threaded retention mechanism.

Push-On Style Connector Capabilities

SMPM Connector Mechanics

- Our analysis of the existing RF connector push-on technology will be focused on the SMPM connector design as this is the smaller of the two designs and a true micro-miniature solution.
- The SMPM has gained significant traction in space-flight applications due to its small form factor (2.8mm diameter) and capability to operate up to 65 GHz.
- This style of coaxial interconnect has also successfully reduced the mass of the connection and the connector pitch distance through the removal of the threaded retention mechanism and its obligatory mounting clearances and additional components.

Push-On Style Connector Capabilities

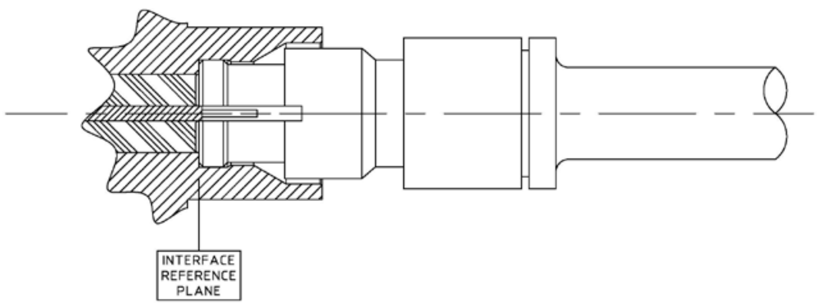

Figure 1

SMPM Connector Mechanics

- The SMPM connector utilizes a slotted, hardened Beryllium Copper body whose fingers are flared.
- The body fingers are inserted through a tapered annular retention step and “snap in” to the detent bore to provide positive contact between the connector interface reference planes and a 22 N retention force.

Push-On Style Connector Capabilities

SMPM Connector Mechanics

- The SMPM connector is designed to float and move while mated to compensate for any stresses connector misalignment, cable mass behind the connector, and tolerance variation.
- This movement is an inherent part of the SMPM connector design as the Beryllium Copper fingers used in the push-on connection must flex to perform the mating cycle but also serve as the structural support for the connector junction.
- These degrees of freedom of movement allow the SMPM connector to meet the specified mechanical durability and mating life performance.
- However, acceptable industry standard manufacturing tolerances create a cumulative allowance for angular and axial interface reference plane separation.

Push-On Style Connector Capabilities

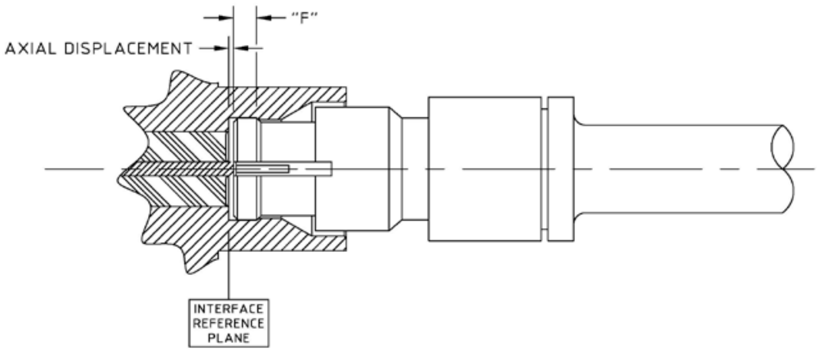

Figure 2

SMPM Connector Design

- Dimension F of MIL-STD-348 specifies the length of the pads at the tips of the Body fingers.
- The length of these pads determines how much positive force is at the reference plane and the amount of axial float of the connector.
- Dimension F only specifies a maximum length for this feature.

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Push-On Style Connector Capabilities

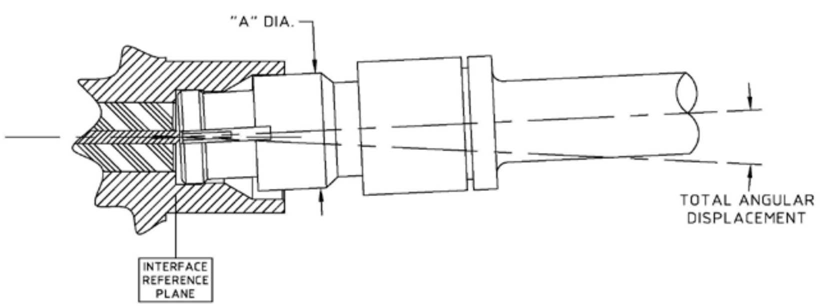

Figure 3

SMPM Connector Design

- Dimension A of MIL-STD-348 specifies the outside diameter of the SMPM connector Body.
- The diameter of this Body feature determines the range of angular float of the connector while mated.
- Dimension A only specifies a maximum diameter for this feature.

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Push-On Style Connector Capabilities

SMPM Connector Design

- These two modes of interface reference plane separation pose a significant risk to the reflection, amplitude, and phase stability of an electronic system while subjected to space vehicle environment dynamics.
- This reference plane separation is of particular concern for systems that require electrical length matching or precision signal delay times from the coaxial interconnect components.
- The reference plane separation that occurs under accelerations due to vibration and shock creates a coaxial air line of unpredictable length which adds electrical length and signal delay at each mated connector.

Push-On Style Connector Capabilities

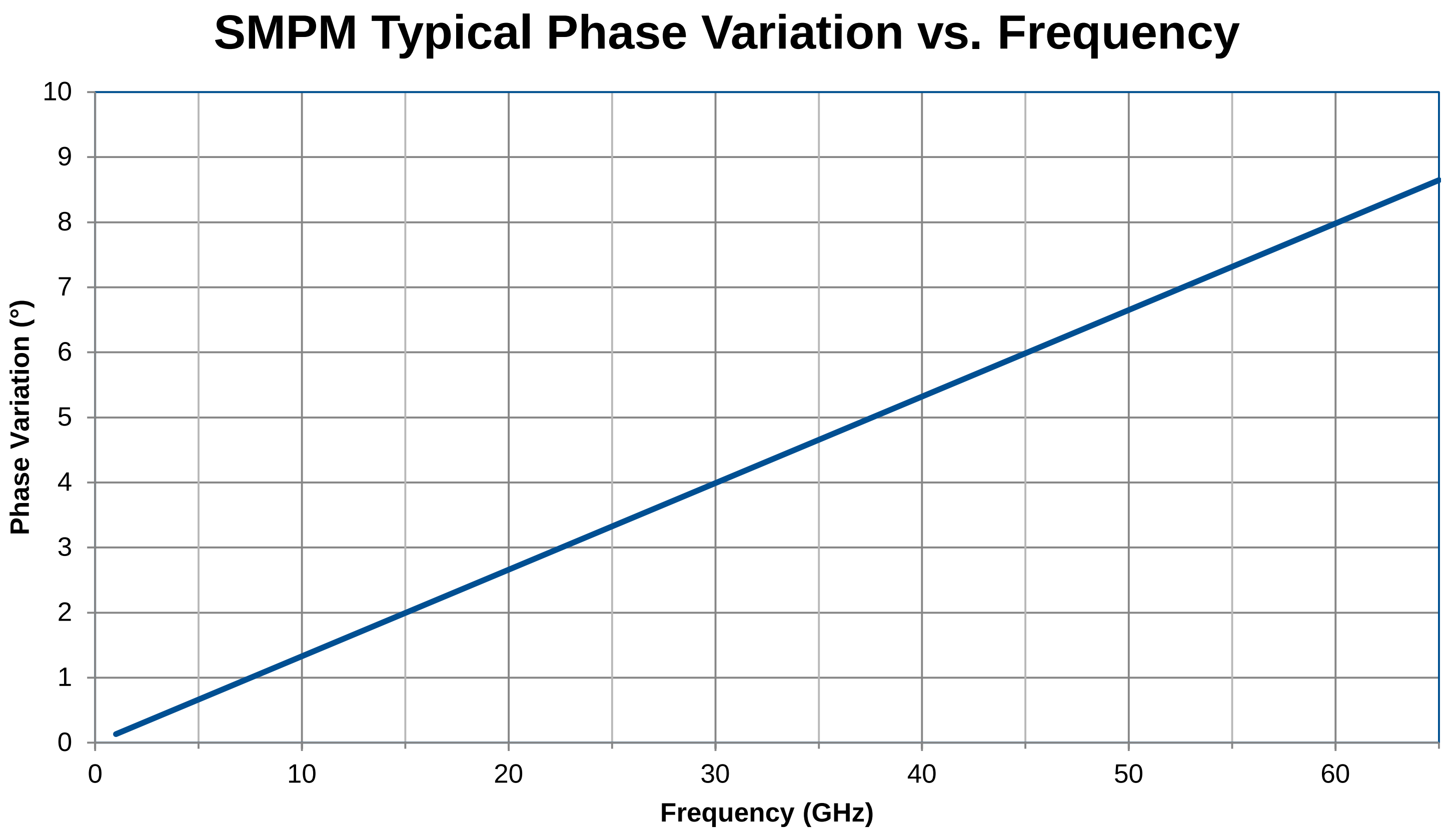

Figure 4

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SMPM-T Interface Connector Design

SMPM-T Design Concept and Objectives

- Based upon the lack of a robust RF connector solution with a smaller geometric size and mass than existing threaded connector interfaces, a feasibility study was performed to evaluate the development of an open-source, industry standard solution.
- The design objectives were to develop a connector interface that provides the electrical and mechanical stability of a threaded connector, a connector center-line pitch of 5mm, incorporates a standard industry interface, and provides excellent RF performance at operating frequencies up to 67 GHz.
- The result of the engineering simulations, analysis, and development is the Sub-Miniature Push-On Micro-Miniature Threaded (SMPM-T) interface.

SMPM-T Interface Connector Design

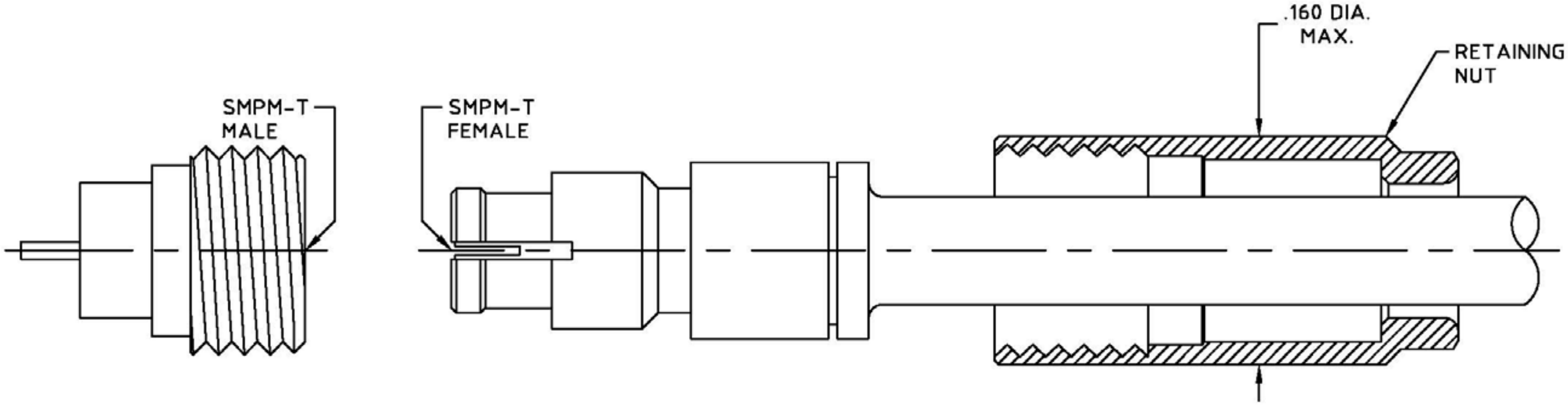

Figure 5

SMPM-T Interface Connector Design

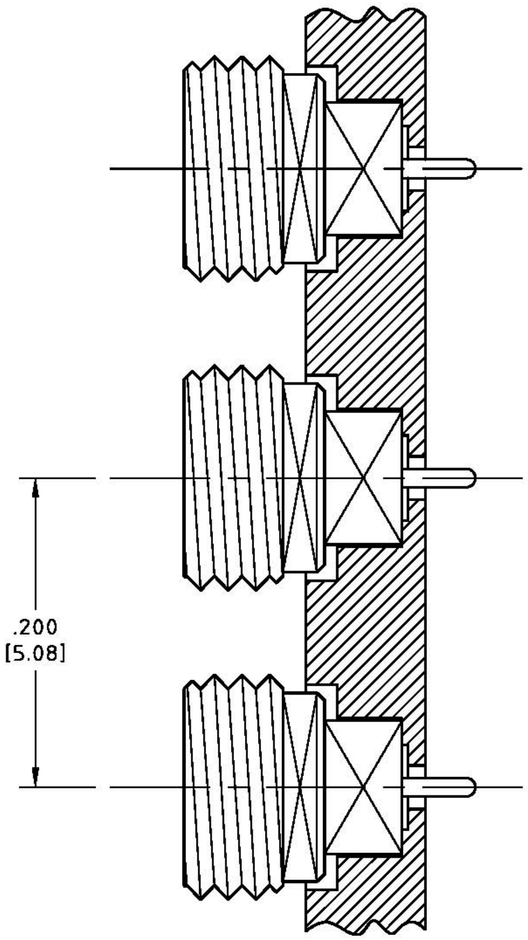

Figure 6

SMPM-T Size Reduction

- The increased connection matrix density provides a 75% reduction in the connector center-line spacing in comparison to SMA panel mount connectors.
- The connector center-line spacing allows for a 5mm pitch, thereby reducing the size of RF modules with multiple connections on a single surface.
- The SMPM-T connector pair is 85% less mass than an SMA pair.

SMPM-T Interface Connector Design

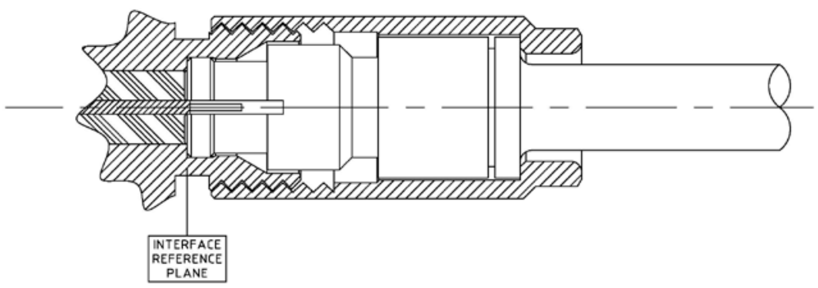

Figure 7

SMPM-T Performance

- The threaded connector Nut, with the specified applied torque, provides constant positive axial force at the interface reference planes and removes any possibility for separation during vibration or shock.
- The removal of a C-clip reduces the connector Body rotation to less than 5° during the mating cycle and removes the need for additional anti-torque features.

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SMPM-T Interface Connector Design

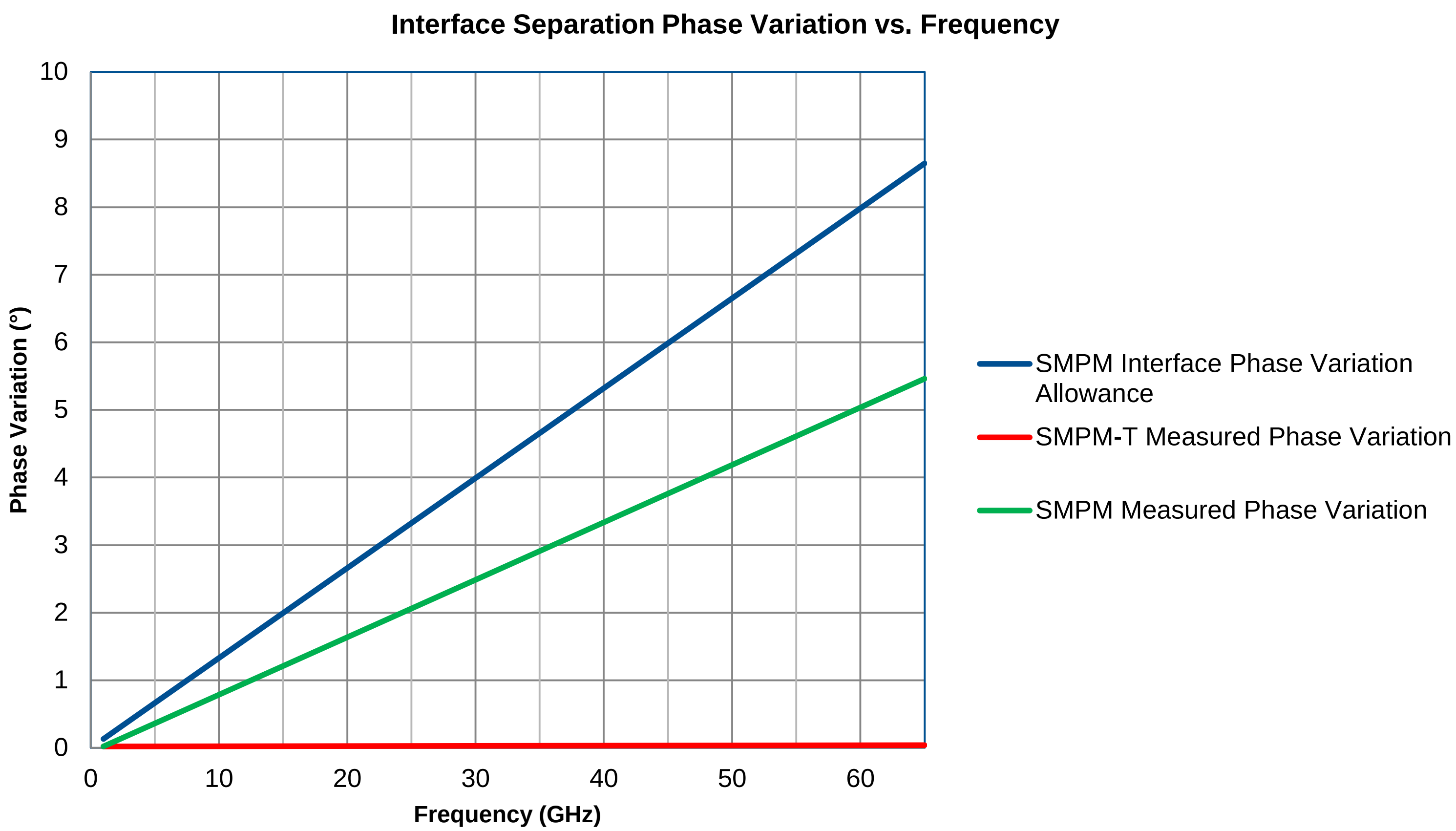

Figure 8

SMPM-T Interface Connector Design

SMPM-T Connector Performance Advantages

- The retractable coupling Nut gives the user the option to mate this connector with traditional SMPM or the new SMPM-T interfaces to increase system test and analysis throughput.
- The addition of the coupling Nut promotes the use of the Smooth Bore SMPM-T interface by providing absolute connector retention. The Smooth Bore interface has 30% less disengagement force and can prevent printed circuit board delamination and connector separation from the PCB during the de-mating cycle.
- The Smooth Bore interface increases the mating cycle life of the connector from 100 cycles to 1,000.
- The additional coupling Nut also improves the RF Shielding performance of the SMPM-T connector.

SMPM-T Interface Connector Design

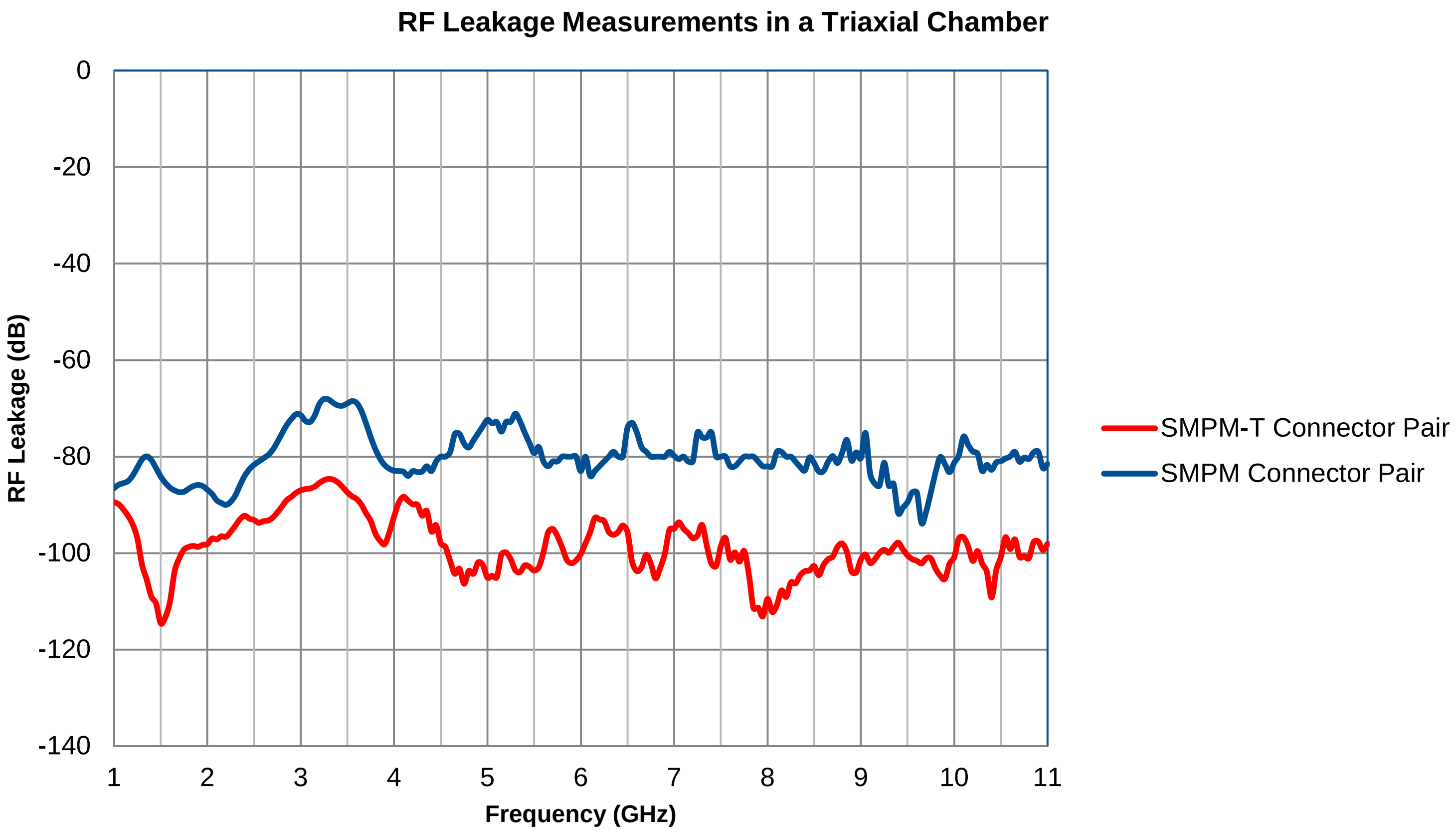

Figure 9

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SMPM-T Component Solutions

SMPM-T Connector Solutions

- The successful performance of the SMPM-T connector and inherent advantages of the interface design have lead to its utilization in the design of an extensive array of component solutions.
- The SMPM-T connector portfolio includes panel mount hermetic feed-thru, surface mount PCB, edge mount PCB, reverse mount PCB, and through hole PCB style connectors.
- PCB connectors have been developed for both coplanar waveguide and microstrip applications with operating frequencies up to 67 GHz.
- SMPM-T connector solutions have been developed for space-flight applications that incorporate tin-alloy plating and/or solder coating to remove gold embrittlement issues in PCB solder joints.

SMPM-T Component Solutions

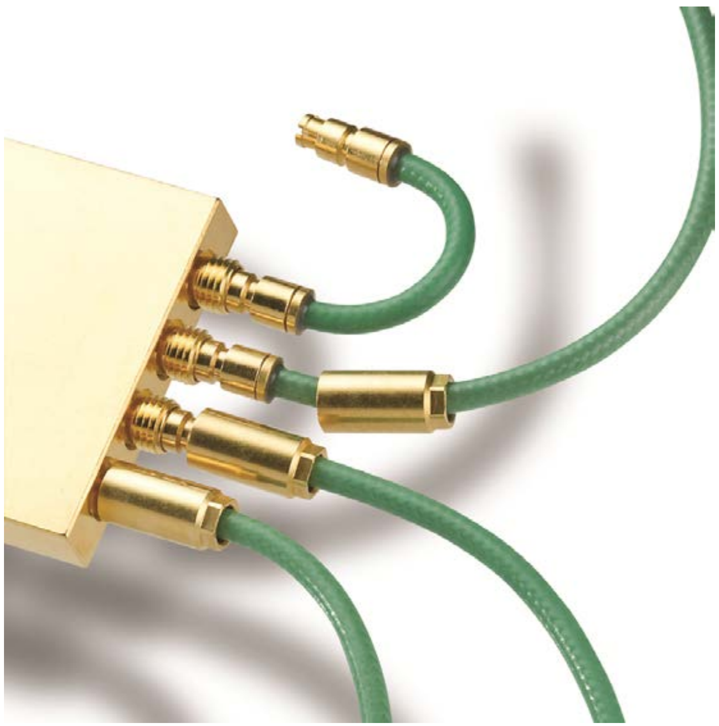

Figure 10

SMPM-T Cable Assemblies

- The SMPM-T connector has been designed for coaxial cable assembly solutions using microbend® style flexible cable.
- The cable assemblies offer 35% lower attenuation than .047 semi-rigid cable assemblies.
- The cable minimum bend radius is 1.5mm for ultra flexible performance in congested installation environments.

SMPM-T Component Solutions

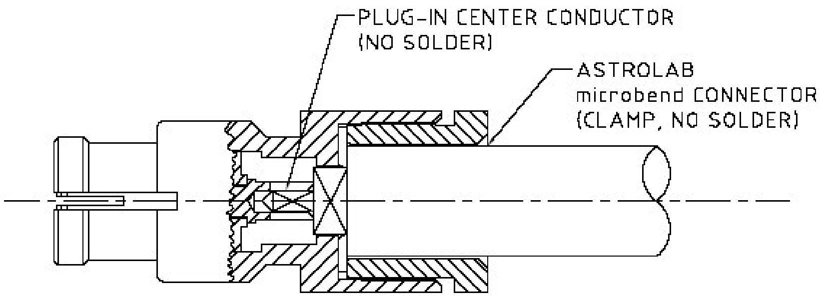

Figure 11

SMPM-T Cable Assemblies

- The SMPM-T microbend® cable connector incorporates solderless center and outer conductor junctions with the cable.
- This removes the possibility of any solder wicking into the cable providing fully flexible cable immediately behind the cable/connector junction.
- This junction has a higher FITS reliability than a solder joint.

SMPM-T Testing Heritage

SMPM-T Connector Screening and Qualification Profile

- SMPM-T connector screening testing was performed in accordance with MIL-PRF-39012, Groups A & B, Tables III and V as well as NASA EEE-INST-002, Section C2, Table 2E, Level 1.
- SMPM-T connector qualification testing was performed in accordance with MIL-PRF-39012, Table II and NASA EEE-INST-002, Section C2, Table 3E, Level 1.
- The SMPM-T connector successfully passed all of the screening and qualification tests of both of these standards.

SMPM-T Testing Heritage

SMPM-T Cable Assembly Screening and Qualification Profile

- Due to the lack of a cable assembly screening and qualification test profile definition in industry standards, a study was performed of both current and obsolete specifications issued by both government and commercial standards organizations.
- An integrated screening and qualification test profile was developed that created test profiles to set performance requirements and specification limits for the proper assembly workmanship of the cable/connector junction.
- The final test profile was based upon a combination of U.S. Government, ESA, NASA, NAS, and ASTM standards.

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SMPM-T Testing Heritage

SMPM-T Connector Screening and Qualification Profile

- SMPM-T cable assembly screening testing was performed in accordance with MIL-DTL-17, Groups A & B, Tables V & VI, MIL-PRF-39012, Groups A & B, Tables III and V, MIL-PRF-55427, Groups A & B, Tables II and IV, ECSS-Q-70-20, NAS 410, and NASA EEE-INST-002, Section C2, Table 2E, Level 1 and Section W1, Table 2C, Level 1.
- SMPM-T cable assembly qualification testing was performed in accordance with MIL-DTL-17, Table IV, MIL-PRF-39012, Table II, MIL-PRF-55427, Table I, NAS 410, and NASA EEE-INST-002, Section C2, Table 3E, Level 1 and Section W1, Table 3C, Level 1.
- The SMPM-T connector successfully passed all of the screening and qualification tests of both of these standards.

SMPM-T Testing Heritage

TEST PARAMETER	TEST METHOD	PERFORMANCE LEVEL
Random Vibration	MIL-STD-202, Method 214	46.3 G rms
Sine Vibration	MIL-STD-202, Method 204	28 G peak
Mechanical Shock	MIL-STD-202, Method 213	11,000 G peak
	MIL-STD-883, Method 2002	1,500 G peak
Thermal Shock	MIL-STD-202, Method 107	210 cycles: -55°C/+125°C
Constant Acceleration	MIL-STD-883, Method 2001	3,000 G

Table 1

Conclusion

SMPM-T Connector Solution

- The SMPM-T is the smallest threaded coaxial connector available utilizing an industry standard interface.
- The SMPM-T connector offers a 75% size and 85% mass reduction in comparison to the SMA connector.
- The SMPM-T connector is a design solution for current and future space-flight electronics systems that need to operate at ever increasing frequencies while continuing to reduce in geometric size and mass.
- The SMPM-T connector has the proven capability to meet existing space-flight payload performance requirements for electrical, mechanical, and environmental performance.

Many thanks

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