Appendix

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Unless otherwise specified, all dimensions are in inches.
Southwest Microwave has been delivering S-Level (Space) and Hi-Rel connectors since 1991.

Use of Southwest Microwave connectors in these applications is important to achieving final systemic results. A list of S-Level / Hi-Rel customers using Southwest Microwave connectors include:

**Partial Customer List**

- Anaren
- Boeing Satellite
- Boeing Defense
- EADS Astrium
- Elta Electronics
- General Dynamics
- Harris Corp.
- Hughes Space
- India Space Application Center
- JPL
- L3 Narda
- L3 Communications
- L3 Satellite Networks
- Lockheed Martin
- Miteq
- Merrimac Industries
- Motorola
- Northrop Grumman
- NASA Langley
- Space Systems / Loral
- Tecnológica
- Teledyne
- TRW Space

**Features:**

- COTS (commercial-off-the-shelf) connectors can be up screened for space level jobs.
- **SuperSMA**™ to 165°C, all others rated to 135°C (Max operation 165°C).
- Industry lowest VSWR and RF leakage.
- All materials used in Southwest connectors are lot-traceable to raw material.
- All materials meet NASA’s requirements for outgassing.
- Center conductors rigidly captured with hi-temp mechanical bead.
S-Level and Hi-Rel Connectors
For Military & Spaceflight Applications

Southwest Microwave Recommended Test Plans  (see next page)
Southwest Microwave uses MIL-PRF-39012 as a reference for interface specifications and test methods. There are additional tests SMI recommends be performed in addition to MIL-PRF-39012 to ensure proper performance during the actual usage of the connectors. The most important of these is thermal shock to ensure the interface and the electrical performance are stable over the full temperature range. MIL-PRF-39012 does not require testing after temperature cycling.

COTS Considerations
Outgassing: All material used in connector assemblies meet NASA outgassing requirements. (See page 97)

Material Traceability: All material used in connector assemblies has traceability to raw material. This allows SMI to use any item in stock for space level applications.

Single Lot Control: SMI builds to stock in large quantities so small quantities requiring single lot control of all raw materials are usually available in stock.

Source Control Drawings (SCD): SMI has an extensive database of customer source control drawings for commercial and hi-rel applications. Due to extensive experience working with SCD’s, SMI is frequently asked to contribute technical material and assistance in their creation.

Space Screening: Test plans are generated in accordance with SCD requirements and most tests are performed in-house. Tests are performed and the results recorded in accordance with the test plan. The results are then combined with material certs and lot traceability information into a document called an Acceptance Test Report (ATR).

Destructive Physical Analysis (DPA): When DPA is required, SMI works with several quality labs that provide DPA services. SMI oversees the testing and integrates the DPA results into the ATR.

Qualification Testing: SMI can perform most of these tests in-house and will coordinate with outside labs for those other tests, such as shock and vibration that require special equipment. SMI will design and build the necessary tools to facilitate these tests.

Source Inspections: SMI has hosted many source inspections in coordination with several major space and hi-rel customers, and is familiar with what is required to facilitate and streamline them.

<table>
<thead>
<tr>
<th>CONNECTOR TYPE</th>
<th>FREQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>SuperSMA™</td>
<td></td>
</tr>
<tr>
<td>2.92 mm</td>
<td>27 GHZ</td>
</tr>
<tr>
<td>2.40 mm</td>
<td>40 GHZ</td>
</tr>
<tr>
<td>TNC</td>
<td>50 GHZ</td>
</tr>
<tr>
<td>N</td>
<td>18 GHZ</td>
</tr>
<tr>
<td>SSMA</td>
<td>36 GHZ</td>
</tr>
</tbody>
</table>

Southwest Microwave connectors are ideal in military and space flight applications where power management and low loss interconnects are critical. SMI connectors have the lowest VSWR in the industry, with typical VSWR of 1.10 : 1 (return loss of -26 dB) up to 50 GHz. SMI offers the additional advantage of low RF leakage of <-100 dB typical.
# SouthWest Microwave

## Recommended Acceptance Test Tables

### Table I - General Product Assurance
(Derived from Group A Requirements)

<table>
<thead>
<tr>
<th>Inspection Type (Visual and Mechanical Examination)</th>
<th>MIL-PRF-39012 Requirement Reference Paragraph</th>
<th>MIL-PRF-39012 Test Method Reference Paragraph</th>
<th>Recommended MIL-PRF-39012 Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>3.3</td>
<td>TABLE I</td>
<td>C of Cs</td>
</tr>
<tr>
<td>Finish</td>
<td>3.3.1</td>
<td>-----</td>
<td>C of Cs</td>
</tr>
<tr>
<td>Dissimilar Metals</td>
<td>3.3.2</td>
<td>MIL-STD-889</td>
<td>100%</td>
</tr>
<tr>
<td>Marking</td>
<td>3.29</td>
<td>MIL-STD-130</td>
<td>100%</td>
</tr>
<tr>
<td>Workmanship</td>
<td>3.30</td>
<td>-----</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Table II - Product Performance Assurance
(Derived from Group B Requirements with Thermal Shock Added)

<table>
<thead>
<tr>
<th>Inspection Type (Design and Construction Testing)</th>
<th>MIL-PRF-39012 Requirement Reference Paragraph</th>
<th>MIL-PRF-39012 Test Method Reference Paragraph</th>
<th>Recommended MIL-PRF-39012 Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration and Features</td>
<td>3.4</td>
<td>FIGURES</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>Contact Gaging (Mating Characteristics)</td>
<td>3.7</td>
<td>4.7.4</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>Contact Retention</td>
<td>3.12</td>
<td>4.7.9</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>VSWR</td>
<td>3.14</td>
<td>4.7.11</td>
<td>TABLE VI</td>
</tr>
<tr>
<td>Insertion Loss</td>
<td>3.27</td>
<td>4.7.24</td>
<td>TABLE VI</td>
</tr>
<tr>
<td>Connector Interfaces</td>
<td>3.4.3</td>
<td>MIL-STD-348</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>Thermal Shock</td>
<td>3.20</td>
<td>4.7.17</td>
<td>100%</td>
</tr>
<tr>
<td>Contact Gaging (Mating Characteristics)</td>
<td>3.7</td>
<td>4.7.4</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>Contact Retention</td>
<td>3.12</td>
<td>4.7.9</td>
<td>TABLE IV</td>
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<td>VSWR</td>
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</tr>
<tr>
<td>Connector Interfaces</td>
<td>3.4.3</td>
<td>MIL-STD-348</td>
<td>TABLE IV</td>
</tr>
<tr>
<td>Dielectric Withstanding Voltage</td>
<td>3.17</td>
<td>4.7.14</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Note:** SMI recommends testing before and after thermal shock to ensure proper operation in space environments.
S-Level and Hi-Rel Connectors
For Military & Spaceflight Applications

List of materials used by SMI:

A) PTFE Fluorocarbon Insulator
B) Vary Flex Epoxy Polyamide
C) *ULTEM 1000
D) **KEL-F

*ULTEM IS A TRADEMARK OF GENERAL ELECTRIC, INC. **KEL-F IS A TRADEMARK OF 3M COMPANY.
SuperSMA IS A TRADEMARK OF SOUTHWEST MICROWAVE, INC.
Appendix

Power Rating for Coaxial Connectors

Average Power Ratings for Coaxial Connectors

The following graph summarizes industry acceptable average power rating for a variety of coaxial connector types. The key characteristic that determines average power handling capabilities for mated coaxial connectors is its ability to pass high current and keep heat-rise to a moderate temperature. This heating directly relates to contact resistance. Contact resistance is a function of contact surface area. Therefore properly formed center contacts are critical. If connectors are long, then conductor length resistance may start to dominate. The average power rating decreases with frequency because the resistive losses increase with frequency.

High power failure is caused by the generation of heat at the contacting surfaces. When the contact resistance approaches surface resistance including skin effect, the ultimate power handling level will be approached. Application results are affected by heat-sinking of the connector plus the connector’s construction and use of higher-temperature materials. Another limiting factor is altitude because of the connector's increasing inability to dissipate heat as altitude increases. Power derating factors for temperature and altitude are provided on the following table.

Thus, there is not an absolute power handling figure for a connector type. Results may vary from supplier-to-supplier due to design, materials and manufacturing latitudes taken by each. Therefore published power ratings are typically conservative.

Extended Power Super SMA

Southwest Microwave’s “Extended Power Super SMA” connectors provide additional power handling capabilities above most standard SMA connectors because they operate reliably at higher temperatures (165°C) with moderate power (160W) or at higher/extended power (250W) at 125°C. The temperature rating as specified is the temperature that the connector will withstand and still meet the electrical specifications.

As a basic guideline, the Extended Power Super SMA will handle an additional 100W average power above what is represented in the following power chart for SMA. Therefore the recommended maximum power rating for Extended Power Super SMA connector is 250W CW at Ku-band (12.4–18.0 GHz), at a maximum temperature of 125°C.
Appendix

Power Rating for Coaxial Connectors

Coaxial Connector Average Power Handling Graph

- Type N (18 GHz)
- TNC (18 GHz)
- SMA (27 GHz)
- SSMA (36 GHz)
- 3.5 mm (33 GHz)
- 2.92 mm (40 GHz)
- 2.40 mm (50 GHz)

Average Power (Watts) vs. Frequency (GHz)
### Appendix

#### Power Rating for Coaxial Connectors

<table>
<thead>
<tr>
<th>TEMP °C</th>
<th>DERATING FACTOR</th>
<th>ALTITUDE X 1000 FT</th>
<th>DERATING FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.20</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>40</td>
<td>1.0</td>
<td>20</td>
<td>.80</td>
</tr>
<tr>
<td>80</td>
<td>.80</td>
<td>30</td>
<td>.70</td>
</tr>
<tr>
<td>120</td>
<td>.60</td>
<td>40</td>
<td>.60</td>
</tr>
<tr>
<td>160</td>
<td>.40</td>
<td>50</td>
<td>.50</td>
</tr>
<tr>
<td>200</td>
<td>.20</td>
<td>60</td>
<td>.40</td>
</tr>
<tr>
<td>240</td>
<td>.05</td>
<td>70</td>
<td>.30</td>
</tr>
</tbody>
</table>

**Example Calculation:**

At 120°C and 60,000 Ft:
- Derate average power by .60 x .40
- or average power x .24
Appendix

Power Rating for Coaxial Connectors

Peak Power

Peak Power limitation is due to high voltage break down. This break down is directly dependent upon the dielectric strength of the total device. This break down typically takes place where a short air path may exist. The peak power rating is not frequency dependent.

A typical calculation example:

\[ E_\delta = \frac{d}{2} \ln \left( \frac{D}{d} \right) - E_s \]

\[ E_s = \text{dielectric strength} \]
\[ = 25,000 \text{ volts/inch in air} \]
\[ = 300,000 \text{ volts/inch in TFE Fluorocarbon (Teflon)} \]

B. Peak Power

\[ P_{pk} = \frac{(E_\delta / \sqrt{2})^2}{Z_0} \quad \text{Perfect Load} \]

\[ P_{pk} = \frac{(E_\delta / \sqrt{2})^2}{4Z_0} \quad \text{Short or Open Circuit} \]

The above treatment covers situations for short duration pulses and is treated independently of corona initiation.
Appendix

Mounting Guidelines for Flange Mount Connectors

INSTALLATION PROCEDURE FOR FLANGE MOUNT MICROWAVE CONNECTORS
PRODUCED BY SOUTHWEST MICROWAVE

Microwave connectors by Southwest Microwave are uniquely designed to optimize transmission line parameters. This results in a cost-effective solution where higher frequency performance is important, along with repeatability and reliability.

MOUNTING CONSIDERATIONS

- Connector installation deserves the same care and attention that is provided for internal parts and the processing of circuits. The work and cost associated with precision etching, plating, semiconductor placement, etc., should be complimented by the same care in connector placement. Using inferior connectors on high performance products is not cost effective due to tuning required and performance degradation. Similarly, improper mounting may degrade the unique performance of a Southwest Microwave connector.

- Solid 360-degree metal-to-metal contact is required for both the pin-socket interface and the outer-coaxial-to-panel path. Positive electrical pathways insure a continuous coaxial transmission line. Reflection losses are minimized. This is basic microwave technology but it is sometimes ignored when only mechanical mounting is considered.
  - Never use conductive O-rings to mount connectors for microwave or millimeter wave applications. The space needed for the groove to hold the O-ring moves the O-ring away from the outer coaxial paths. Therefore, the result is not 50-ohms. Performance will be degraded for higher frequency applications.
  - These connectors are part of a microwave transmission line. If environmental or pressure sealing is required, Southwest Microwave should be contacted to assure that a proper connection is provided that will still provide 360 degree grounding and also include considerations for environmental or pressure sealing.

- Specific items to consider include:
  - Most connector flanges have slightly irregular surfaces due to bar stock cutoff, drilling of holes, etc.
  - Panels are not perfectly flat.
  - Prior to assembly, connectors should be tested back-to-back to confirm performance. If results differ in the application, then other parameters must be evaluated for cause.
  - If a hermetic seal is to be used with the connector, the seal must be installed first using the hole patterns, installation tools and fixtures as shown in Southwest Microwave’s product literature. Installation dimensions and tooling varies for different seals.
  - If accessories such as pins and dielectrics are to be used with the connector, the user should determine their own choices for installation of the pins, etc. If the pin is first installed into the connectors, then it should be attached to circuit after the
Appendix
Mounting Guidelines

PROPER INSTALLATION OF FLANGE MOUNT MICROWAVE CONNECTORS
PRODUCED BY SOUTHWEST MICROWAVE, Page 2.

connector is mounted. Alternatively, the pin first may be soldered in place. Care
must be taken to assure that the proper length of pin is available for insertion into the
connector. These parameters are “application specific” and are based upon user
dimensions not controlled by Southwest Microwave.

➢ The installer must remember that there is a raised 360-degree metal grounding ring
around the center coaxial area.

• The raised ring is intended to provide a high normal force for electrical grounding
  at the coaxial path.

• The raised area does not extend outward for the entire flange. It is possible to
  improperly mount the connector with one side lower than the other side if the
  installer is not careful.

INSTALLATION STEPS
(Note: The user is reminded to think about the actions involved with replacing a spare tire.
Lug nuts are snug in place and incremental tightening is done for opposing nuts during
repetitive cycles. Eventually, all nuts are tightening evenly.)

A. First, the connector is placed in position with the rear-pin (or other accessory)
   properly aligned.
B. Next, the mounting holes in the connector flange are aligned with the mounting holes
   in the panel or housing.
C. The screws must be installed using minimal force. Do NOT torque-down. Initially,
   do NOT fully secure the screws. The screws should be “snug” but still permit very
   slight minor movement of the connector.
D. It is important that the connector flange be kept parallel to the panel. It must not be
   cocked so that one edge is closer to the panel than the other edge. The raised 360-
   degree metal grounding ring must rest evenly against the panel.
   o If one side is torqued down tightly without balancing with the other side, then the
     opposite flange will lift up away from the panel.
   o This will cause the part of the 360-degree metal ring under the lifted side to also
     be lifted up and not lie flat against the panel. There will be an air gap under the
     raised side, preventing 360-degree grounding. The result is degraded
     performance.

Rev. A
PROPER INSTALLATION OF FLANGE MOUNT MICROWAVE CONNECTORS PRODUCED BY SOUTHWEST MICROWAVE, Page 3.

E. The screws are installed by applying force to opposite screws, until all hardware is properly secured. For connectors with more than 2 mounting screws, screws should be snugged and then incrementally tightened going from one screw to another in rotation.

For example, a possible sequence for screw-tightening a 4-hole mount connector could be the following:
Mating Microwave Connectors

Proper Procedure for Mating Microwave Connectors

1. Engage the two mating interfaces with slight pressure.

2. Hold the body of the male connector and turn only the coupling nut.
   - The coupling nut will engage the threads of the female connector.

3. Continue turning only the coupling nut.
   - The outer conductors will engage and align the connectors to each other.
   - Then the center conductors will engage.
   - Then the outer conductors (reference planes) will come together and the coupling nut will quit turning.

4. Use a torque wrench to apply the proper torque to complete the mating.

When the proper procedure for mating microwave connectors is followed, no rotational torque is applied to the center conductors. If the body of either connector is rotated, this is improper and can apply a rotational torque to the center conductor. All Southwest Microwave connectors have the center conductor rigidly captured to the outer housing. The center conductor captivation is, in most cases, accomplished with a high temperature plastic bead. This bead provides high axial retention at extended temperatures, but does not provide for any rotational resistance. Therefore proper mating is strongly recommended.
Appendix

RF Versus Microwave SMA Connectors

Issues and Opinions
by Jim Kubota
Southwest Microwave
Tempe, Arizona

The microwave community, for years, has been building amplifiers, switches, mixers, oscillators, antennas, and other components and subsystems using SMA connectors built to mechanical requirements MIL-C-39012 and interface dimensions per MIL-STD-348. Both specifications specify loose mechanical requirements and require no electricals after thermal cycling. Recent military programs require performance verification after environmental testing, especially temperature testing. These tests highlighted connector design deficiencies as well as poor connector selections by users.

Traditionally, an electrical engineer has the responsibility for the microwave component design, and the mechanical designer has the responsibility for the package. The packaging responsibility includes selecting the connector. Since the SMA is now the standard for miniature connectors, the designer simply calls out what appears to be mechanically convenient with no consideration for electrical performance. A buyer picks up the requirement for a SMA connector, calls around for competitive prices, and then places an order based on price. Then the fun begins in production where the problem of making the design requirements come together with an acceptable and consistently shippable product. Technicians assume the role to tune in or out the final product. The tuning process becomes an art and a means of separating good technicians from bad, instead of sorting marginal connector designs from good connector designs.

The final step is, when a technician cannot tune the device, the connector is replaced with another, finally rejecting the component.

In the last few years, a new high performance SMA connector has emerged. The new version of the SMA has been designed by microwave engineers. The original SMA connectors were designed by microwave engineers and cloned by copy houses. The copy houses place little or no emphasis on maintaining microwave performance. Thus, the products were sold by price, and the basic quality of the products deteriorated to the level of an RF connector. There was a time when well-known instrument companies provided test adapter calibration kits for SMAs. Due to the general product deterioration driven by copy houses, instrument companies no longer provide SMA test and calibration kits. The old design has become an "RF" connector, while the new design is a "Microwave" connector.

An RF connector is designed to conform mechanically. The main objective is ease of manufacture and low cost. It has straight walls on the inside of the connector housing, straight PTFE dielectric, and utilizes a barb captured contact. The flange versions have holes that are punched, which cause flanges to be deformed. Concave flanges are the result of fast production that can cause air gaps that disrupt outer conductor continuity and create a path for RF leakage.

A microwave connector is a precision machined connector designed to enhance the performance of microwave components. It has compensated steps in the connector housing matched to steps in the contact. The PTFE dielectric also has machined steps to match to the connector housing and contact. The contact is retained by an epoxy capture. Epoxy capture eliminates placing the dielectric under pressure. (The barb contact method causes the dielectric to be under constant pressure). The new innovative design allows minimal growth under temperature.

The flanged versions present a metal to metal contact to the component housing and hermetic feed through. This results in lower reflection loss and low RF leakage.

A well-designed microwave connector includes many other specifics that contribute to performance. Details which affect maintaining a practical coaxial transmission line at practical cost must be incorporated. The goal is to utilize design innovations that will enhance higher frequency performance, reliability after environment, and consistency from production lot to production lot.

Most of these details are not readily visible and therefore cannot be easily identified by visual or external inspection. Controlling interface dimension per MIL specification enhances endorsement towards RF since their limits are extremely loose and totally not acceptable for high microwave frequency use.

The details that microwave connector designers are concerned with are proper compensation (offset) at diameter transitions and verifying these offsets remain fixed during environment. Barbed contacts are difficult to set consistently and then move during thermal exposure.
RF Versus Microwave SMA Connectors

“MICROWAVE CONNECTOR”

CONNECTOR DESIGN AND PERFORMANCE OBJECTIVE

SMOOTH, UNINTERRUPTED TRANSMISSION LINE

THE PRACTICAL DESIGN

Another key parameter is socket contact fabrication and forming. Typically socket slots are not controlled (microwave energy travels on the surface). Sockets are over crimped (conical close) causing spreading, cracking, high wear, gold flaking, etc. Meeting insertion forces with a “duck bill” flat crimp, although it may comply with MIL Specification, is not the answer.

There are many other details that must be taken into consideration. Many times it is required to call out specific program requirements which have requirements above and beyond general military specifications. This results in the most cost effective method in meeting desired goals.

Many qualified microwave engineers are sometimes misled in assessing insertion loss contribution by the connector. With most microwave components and subsystems, the coaxial launch to the microwave circuit is the most difficult to minimize VSWR (return loss). If the typical VSWR is 1.6:1 VSWR (12.75 dB return loss), there is a quick conclusion a 1.3:1 connector would be more than adequate. This conclusion is based upon comparing the transmission loss of 1.1:1 to 1.3:1.

<table>
<thead>
<tr>
<th>VSWR</th>
<th>Transmission Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1:1</td>
<td>0.010 dB</td>
</tr>
<tr>
<td>1.3:1</td>
<td>0.075 dB</td>
</tr>
</tbody>
</table>

Difference 0.065 dB

0.065 dB is within measurement accuracy of precision vector network analyzers. But if either of these connectors phases with the 1.6:1 circuit launch, the loss figures change drastically.

Connector VSWR Launch VSWR

1.3:1 1.6:1

Combined VSWR Transmission Loss when phased

<table>
<thead>
<tr>
<th>VSWR</th>
<th>Transmission Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.08:1</td>
<td>0.569 dB</td>
</tr>
<tr>
<td>1.76:1</td>
<td>0.343 dB</td>
</tr>
</tbody>
</table>

0.226 increase in loss is usually significant to prevent product acceptance and loss in shipping dollars.

The price difference between an RF and microwave connector is about 20% or $1.00 in volume (1000). For the cost conscious designer, consider a $1.00 premium to pick up performance of 0.2 dB just from the connector. How much would you pay inside your package to pick up 0.2 dB? $10.00 to $100.00?

If the design is stabilized and in production, how much could you save in tuning time if you replaced your “RF” SMA connectors with “Microwave” SMA Connectors? $3.00, $30.00, or $300.00? If completed units are returned from the customer because insertion loss is 0.1 dB too high, the cost could soar.

If you are a project manager and are designing above 5 GHz, using a microwave connector would enhance the system and be cost effective. If purchasing makes the decision on buying connectors, they could be taught cost effectiveness between an RF — SMA vs. Microwave — SMA.
**PRODUCT TECHNOLOGY**

**SMA connectors set new EMI/RFI shielding standards**

Record low levels of RF leakage come from this new family of coaxial connectors. So low were the levels that a special test system was needed to gather specs.

Jim Kubota, Vice President, Microwave Products,

The coaxial RF connector is one of the more obvious places to look for EMI/RFI leakage in a component or system. Most connectors are guilty of about -75 to -85 dB leakage in extreme environments. In most cases this is fine. But when a requirement calls for more thorough shielding, the simplest solution is a new line of flange-mount SMA connectors (Fig. 1). These connectors have been tested with leakage of only -128 dB at 18 GHz and -154 dB at 6 GHz.

The connectors incorporate impedance-matched 50-ohm seals with very tight pin mounting. Each connector is designed to accept a specific pin diameter, either 0.012, 0.015, or 0.020 in. The measured VSWR is less than 1.15:1 through 18 GHz. Connectors are available in two- or four-hole flange-type mounts and can be replaced in the field without disturbing hermecticity.

The company's standard epoxy capture coaxial connectors have always exhibited good RF leakage characteristics (Fig. 2), about 15 dB better than comparable SMA types. This performance is owed to a small epoxy capture hole and a long RF leakage path created by thick connector walls. This 15-dB difference has been directly computed by using wedgeguide-cutoff theory attenuation figures.

**Improving test cavity**

The new "low-EMI" connectors, however, required a rethinking of test strategy to measure design leakage levels previously unheard of for an SMA connector. The evidence of this rethinking is shown in the basic test system architecture of Fig. 3. The actual test fixture appears in Fig. 4. The 18-GHz triaxial test fixture is, in principle, the same one outlined in MIL-C-38012.

Several refinements were made to the military-specification test system. For example, one common 7-mm input/short-circuit section and one common 7-mm output section are employed for all connector types tested. Only the intermediate section containing the device under test is changed from test to test. The 7-mm sections behave like TE11 mode filters below 18 GHz.

The cavity thus permits the measurement of leakage through most of the frequency range of the connector under test, up to 18 GHz. The mode filter absorbs higher-order mode resonances that previously limited the frequency range of a triaxial cavity to about 6 GHz.

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Appendix

EMI/RFI Shielding Standards

**PRODUCT TECHNOLOGY**

**EMI/RFI shielding standards**

3. The key to improving the sensitivity of the 18-GHz triaxial cavity test system was the introduction of low-noise preamplifiers, which boosted the usable dynamic range of the spectrum analyzer.

4. This 18-GHz triaxial test fixture features a removable cylindrical center section which is used to hold the device under test.

For SMA connectors and about 3.5 GHz for type N connectors. An improved detector system was also instrumental in making measurements down to $-154$ dB (at 6 GHz) with the triaxial test fixture. A standard portable model 494P spectrum analyzer (Tektronix, Inc., Beaverton, OR) with a catalog sensitivity specification of about $-95$ dB was used. The sensitivity of the analyzer was improved to better than $-135$ dB by means of a high-gain, low-noise preamplifier section. With a +15-dBm input, the total usable leakage range was typically $-155$ dB down to the noise level. It does not get much better than this low-level, broadband signal detection.

The new connectors must have good mating surfaces to meet their tested leakage specifications of $-154$ dB at 6 GHz, $-143$ dB at 8 GHz, $-138$ dB at 12 GHz, $-132$ dB at 15 GHz, and $-128$ dB at 18 GHz. That is, the RF leakage specification is highly dependent upon establishing a solid 360 deg. of metal-to-metal contact between connector halves. Once done, the “low-EMI” connectors promise leakage levels that lie beyond the measurement range of most engineers’ test equipment.
## Materials Commonality in Connectors

### Teflon™ Dielectric

- **N Connectors**
- **TNC Connectors**
- **Super SMA Connectors**
- **SSMA Connectors**

**Common Construction:**
- Housing: Stainless Steel, Passivated
- Contact: Beryllium Copper (BeCu) Gold Plated Per MIL-G-45204

**Teflon Construction:**
- Dielectric: PTFE Fluorocarbon Per ASTM D1710
- Center Contact Capture: Single Bead Capture with Ultem 1000 Per ASTM D5205
- Temperature Rating -55°C to +165°C

### Air Dielectric (Airline)

- **3.5 mm Connectors**
- **2.92 mm Connectors**
- **2.40 mm Connectors**
- **1.85 mm Connectors**

**Common Construction:**
- Housing: Stainless Steel, Passivated
- Contact: Beryllium Copper (BeCu) Gold Plated Per MIL-G-45204

**Airline Construction:**
- Center Contact Capture: Rigid Two Bead Capture with Ultem 1000 Per ASTM D5205 and KEL-F Per ASTM D1430 or PTFE Fluorocarbon Per ASTM D1710
- Temperature Rating -55°C to +135°C

Note: Direct Solder Cable Connectors May Differ. Check Catalog Sections for Data.

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## Connector Intermateability

<table>
<thead>
<tr>
<th>Connector Type</th>
<th>Compatible with</th>
</tr>
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<tbody>
<tr>
<td>1.85 mm</td>
<td>2.40 mm</td>
</tr>
<tr>
<td>2.40 mm</td>
<td>1.85 mm</td>
</tr>
<tr>
<td>2.92 mm</td>
<td>3.5 mm &amp; SMA</td>
</tr>
<tr>
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<td>2.92 mm &amp; SMA</td>
</tr>
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<td>SMA</td>
<td>2.92 mm &amp; 3.5 mm</td>
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