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Inside the Microwave Connector: Materials and Construction

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This month's tutorial is an overview of RF/microwave connector specifications for materials and dimensional manufacturing tolerances, intended to familiarize engineers with important non-electrical parameters

At first glance, the construction of RF/microwave connectors seems quite straightforward. Physical dimensions are dictated largely by the desired combination of RF characteristics—characteristic impedance, power handling (current capacity and voltage breakdown), and compatibility with typical cables. The choice of body metal, plating, and dielectric material will depend on environmental requirements—water, corrosion, temperature, air pressure (altitude), mating-unmating cycles, shock and vibration. Of course, construction must be compatible with interface standards for the mating methods: threaded, bayonet, friction fit, etc.

For non-critical, general-purpose use, the specifications might stop at this point, but there are many additional requirements and refinements to basic specs that must be considered for specific applications.

Example: MIL-STD-348B Type N Connector

The most comprehensive set of mechanical specifications for RF/microwave connectors is MIL-STD-348B [1]. I've chosen the common "series N" connector to illustrate the requirements called out in this important document.

Refer to the outline drawings in Figure 1 and the list of dimensions in Table 1. These show the physical dimensions and mechanical tolerances for this connector. Note that the

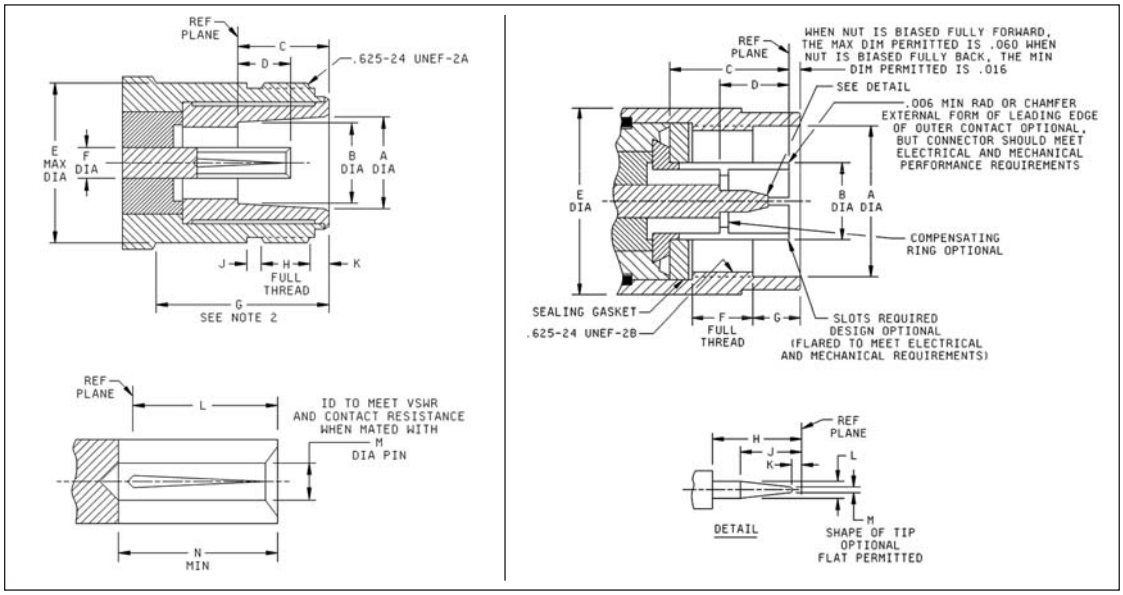

Figure 1 · Outline drawings for the series N connector interface from MIL-STD-358B (1); female (left) and male (right).

interface between the connectors is defined, not the body of the connector behind the mating section, which can vary considerably to accommodate various types of cables and mounting methods. The connectors may also be configured with straight or angled bodies, and as adapters between series N and other connector types.

Dim. Ltr.	Inches (mm)	
	Min.	Max.
A	.250 (6.35)	--------
B	--------	.1808 (4.59)
C	--------	.135 (3.43)
D	.130 (3.30)	--------
E	.015 (0.38)	.045 (1.14)
F	.0355 (0.90)	.0370 (0.94)
G	--------	.015 (0.38)
H	---------	.100 (2.54)
J	.000 (0.00)	.010 (0.25)
K	.050 (1.27)	---------

Dim. Ltr.	Inches (mm)	
	Min.	Max.
A	.208 (5.28)	.216 (5.49)
B	.1810 (4.60)	--------
C	.218 (5.54)	--------
D	.170 (4.32)	--------
E	.015 (0.38)	.045 (1.14)
F	.049 (1.24)	.051 (1.30)
G	.000 (0.00)	.010 (0.25)
H	.074 (1.88)	.078 (1.98)
J	.043 (1.09)	.047 (1.19)
K	.000 (0.00)	.010 (0.25)
L	.0355 (0.90)	.0370 (0.94)
M	.105 (2.67)	--------
N	.168 (4.27)	--------

Table 1 · Guide to dimensions and manufacturing tolerances of series N connector interfaces of Figure 1; female (left) and male (right).

Connector Materials

MIL standards for RF/microwave connectors (MIL-PRF-39012, MIL-DTL-3655D, and others) include the following requirements for materials:

- Connector bodies are mainly brass, with some types specified as beryllium copper.
- Brass bodied connectors must be silver plated over a copper underplate.
- Beryllium copper bodied connectors must be gold plated to a minimum of 50 microinches (1.27 µm) over a copper flash plating.
- Standard connectors must be made with materials classified as non-magnetic.
- Nickel plating is not to to be used on connector bodies, due to passive intermodulation (PIM) potential.
- Dissimilar metals are not allowed to be in contact with each other.
- Center contact springs must be made from beryllium copper.
- Critical contacts—male pins and socket contacts—must be gold plated to a minimum of 50 microinches (1.27 µm) over a nickel underplating of 50 microinches (1.27 µm).
- Non-critical portions of the mating surfaces must be plated as needed to meet performance specs, but may *not* be silver plated.
- Insulation in standard connectors is specified as FEP fluorocarbon or polytetrafluoroethylene (PTFE). PTFE parts may be molded from resins, and either type may be used for extruded/molded parts.
- For connectors with a sealed interface, the gasket material is typically silicone rubber.

Notes: The above list includes standard connectors only. Special applications may require other materials, such as stainless steel for connector bodies (not electrical mating surfaces), neoprene gasketing, higher-performance dielectric materials, and different plating materials and/or thicknesses.

Connector Testing

The most extensive part of all MIL specifications is testing to verify compliance with the performance specifications. Although this tutorial concerns the construction of connectors, readers are advised to review the specified test methods. They provide valuable insight into the reasons for the various specifications, and provide a basis for testing of non-military connectors as well.

Commercial Connectors

Many high performance commercial microwave applications use connectors with the same specifications as MIL types. However, connectors for general-purpose applications use a wide range of materials to achieve lower cost and more more efficient high-volume manufacturing.

Among other materials found in lower-cost connectors are metal alloys suitable for casting, including zinc-based metals. Machined connectors mainly use brass, but plating selections vary widely.

Dielectric materials in low-cost commercial connectors may include polyethylene and polystyrene, possibly glass-filled for high voltage breakdown performance.

For almost all non-military applications designated as “microwave” (as opposed to “RF” or “general purpose”) a connector based on MIL specifications is the best choice. These connectors will provide consistent electrical performance and mechanical reliability. Using a common specification also assures uniform performance among products from different vendors.

Summary

This tutorial is a brief overview of the dimensional and materials specifications for microwave connectors. RF/microwave engineers will be familiar with electrical specifications such as VSWR, power handling and voltage breakdown. This article also provides a look at additional requirements for manufacturing tolerances and selection of materials for connector bodies and mating contacts.

Reference

1. MIL-STD-348B, Dept. of Defense Interface Standard, Feb. 2009 draft.