Connector Selection

CARLISLE
INTERCONNECT TECHNOLOGIES

FOR LOW SIGNAL REFLECTIONS AND LOSS

Summary

There is a perception in the industry that the use of precision airline connectors (i.e. 2.4 mm, 2.92 mm, 3.5mm, etc.) yields lower signal reflections and associated system losses. Although most of the airline connectors were conceived for low reflections and metrology use, there is little or no theoretical basis to support their superiority over properly designed dielectric loaded connectors (i.e. SMA, SSMA, etc.).

Moding Frequency and Reflective Performance

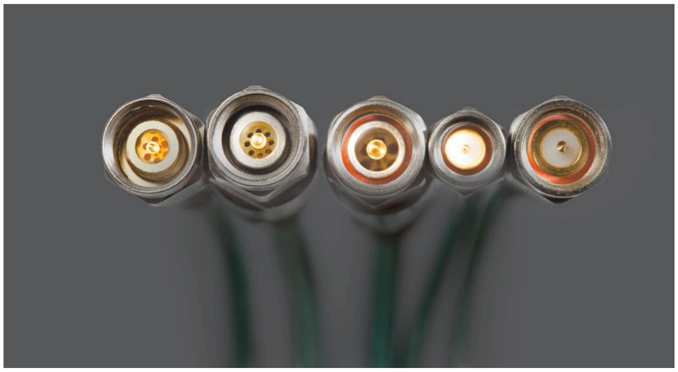
The frequency limitation (moding frequency) of a connector is independent of its reflective properties. The upper frequency limitation of a connector is a function of the conductor dimensions and dielectric constant of the loading material. The reflective properties or VSWR of a connector is a function of impedance control only. Precision airline connectors have a clear theoretical frequency limitation that is inversely proportional to the size of the connector. The upper frequency limitation of non airline connectors has a similar theoretical basis, but is not as clear because the interface specifications (i.e. MIL-STD-348) offer the connector designer more freedom in the selection of the internal line sizes. See chart below:

Controlling Impedance and Design Topology

Connector Series	Moding Frequency (GHz)
2.4 mm SMA	55.4 GHz
2.92 mm 45.5 GHz	GHz
3.5 mm 37.9 GHz	1 GHz
24 – 34 GHz	10 GHz
SSMA 36 – 40 GHz	18 GHz

Impedance control can be related to any combination of design topology factors, including:

» The Design Parameters
» Process Control (controlling the design parameters)
» The Mating Interface



Impedence Factors Explained

1. Design Topology

Controlling the impedance within the connector starts with the design topology. The best design topology will be the one that transitions the primary to secondary interface with the fewest and/or most gradual steps on the inner and outer conductors. Every time a conductor is stepped, there will be an inherent impedance discontinuity that must be compensated for. Given real world manufacturing tolerances,these compensations will never be perfect. Furthermore, the sensitivities of the compensation regions are proportional to the ratio of the conductor step. In other words, stepping an inner conductor by a ratio of 1.5:1 is preferred over a 2:1 step. The System Designer can help maximize his/her performance by selecting cables and connectors that are dimensionally similar to each other. Compare these two scenarios:

Scenario 1

Primary Interface (Connector)	Secondary Interface (Cable-to-Connector)	Step Ratio
Type SMA	Flexible Type UFB120A	1.9:1
Outer Conductor, I.D.= .161 in	Outer Conductor, I.D. = .083 in.	
Inner Conductor, O.D. = .050 in.	Inner Conductor, O.D.=.0296 in.	1.7:1

Scenario 2

Primary Interface (Connector)	Secondary Interface (Cable-to-Connector)	Step Ratio
Type SMA	Flexible Type UFB120A	
Outer Conductor, I.D.= .138 in	Outer Conductor, I.D. = .083 in.	1.7:1
Inner Conductor, O.D. = .060 in.	Inner Conductor, O.D.=.0296 in.	2.0:1

Based on dimensional analysis, scenario #1 (SMA) offers greater potential for matching the cable in question. The sensitivity of the 2:1 step (inner conductor) in scenario #2 (3.5 mm) would lead the Connector Designer to add an intermediate step. Although less sensitive, this additional step will add another impedance mismatch to the connector and increase reflections accordingly. The outer conductor steps can not be ignored, but are generally easier to control given the larger size of the related geometry.

2. Design Parameters

One of the key considerations for the Connector Designer is the dimension and tolerance of the design parameters. For high performance, the Designer must understand what parameters affect the impedance and determine how tightly they need to be controlled. Though not an exact science, one must consider:

The VSWR goals of the end user

- The total number of discontinuities for the given design topology
- The process control available from manufacturing
- The acceptable yield

There is no direct relationship between a given connector series and the amount of impedance control applied to the design. There are manufacturers of high performance SMA connectors that apply greater impedance control than other manufacturers of 3.5 mm designs. As a result, they can provide an SMA design with superior VSWR performance. If a superior design topology is selected, the same impedance controls will yield either lower VSWR or higher yields for a given VSWR specification.

3. Process Control

Controlling the design parameters during manufacturing will involve: (as a minimum)

Machine Capability

- Skill of the set-up person and the diligence of the machine operators
- Capability of the plating process
- Tooling design and quality
- Assembler skill and training

No two manufacturers will have the same capability in all areas. The manufacturer with the best combination of these process controls will be capable of manufacturing the lowest VSWR connectors for a given design or the highest yield for a given design.

The Mating Interface

The geometry of the mating interface also plays a key role in the performance of the connector. Generally, the industry believes that the lowest reflections are associated with connectors that have the smallest contact recession at the interface. Although there is some good theory to support this premise, one must not treat all connector types equally. Some connector interfaces offer less impedance control than one might think. For example:

Example A

Connector Interface	Contact Recession/Mismatch Properties
Type 3.5 mm	
Outer Conductor, I.D.= .138 in	Typical Contact Recession = .002 in
Inner Conductor, O.D. = .060 in.	Nominal Impedance = 50 ohms
Mating Pin, O.D. = .0365 in.	Mismatch Impedance = 80 ohms

Example B

Connector Interface	Contact Recession/Mismatch Properties
Type SMA	
Outer Conductor, I.D. = .161 in.	Typical Contact Recession = .005 in
Inner Conductor, O.D. = .050 in.	Nominal Impedance = 50 ohms
Mating Pin, O.D. = .0365 in.	. Mismatch Impedance = 70 ohms (89 ohms if dielectric is recessed)

Although the 3.5 mm interface (Example A) offers greater control of the center contact recession, the actual impedance of the associated mismatch will be approximately 80 ohms. In the case of the SMA, (Example B) the center contact recession is usually greater, but the impedance of the mismatch is typically lower, approximately 70 ohms. If the SMA connector's dielectric is recessed simultaneously, then the mismatch impedance could be higher, but this condition would be rare for properly designed SMA's. Thus, by controlling the dielectric recession, the theoretical impedance mismatch of an SMA interface will be lower than that of a 3.5 mm interface, resulting in lower signal reflections.

Conclusion(s)

System Designers should consider host geometry when specifying connectors for low VSWR. The relationship between the primary (connector) and secondary (cable) interface dimensions will affect the design topology of the connector and the ultimate VSWR potential of the design. The design parameters and the process controls of the manufacturer influence connector performance to a much greater degree than the series or designation of the connector.