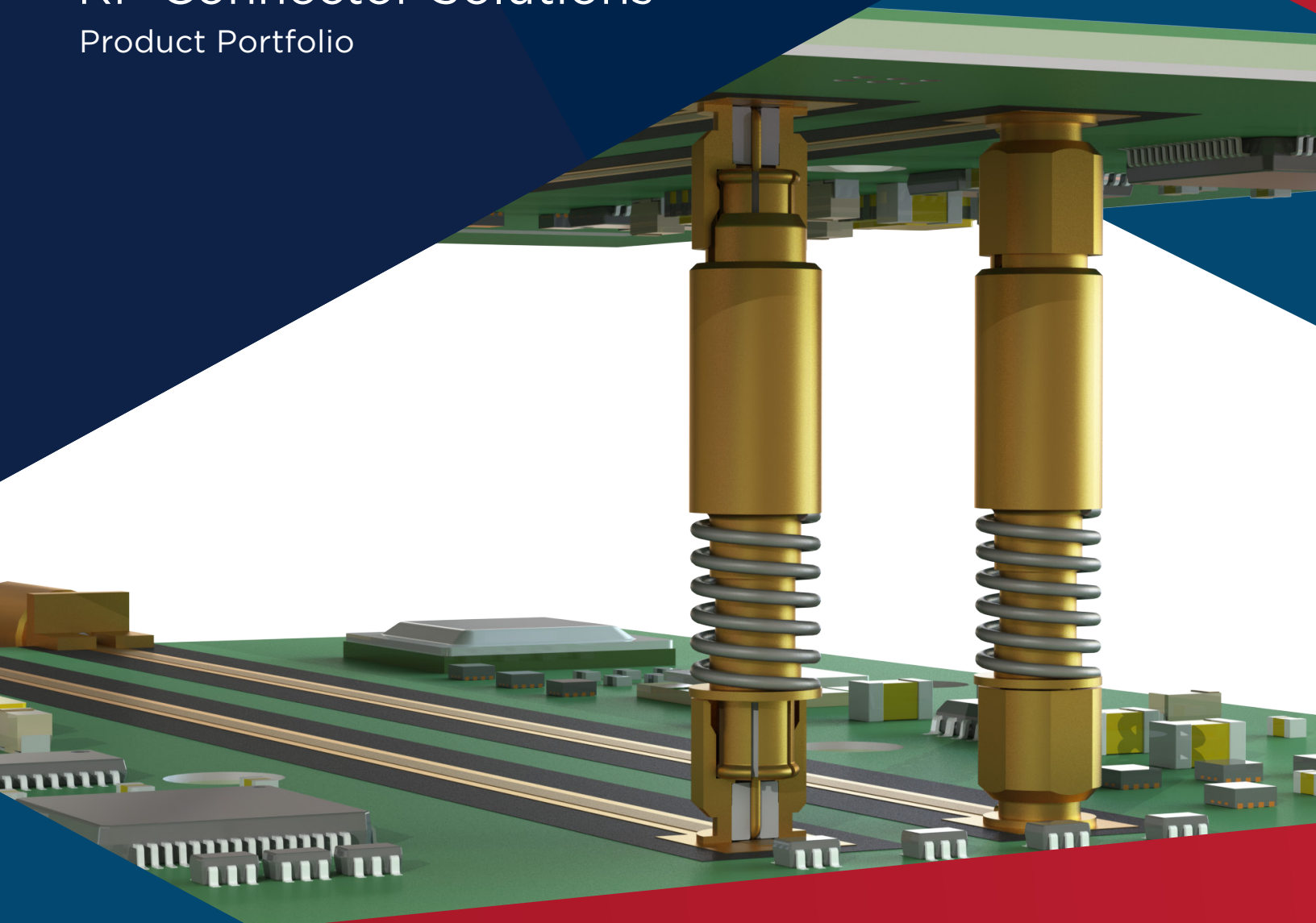
Amphenol SV MICROWAVE

Board-to-Board

RF Connector Solutions

Product Portfolio



ANATOMY OF A BOARD-TO-BOARD RF CONNECTION

A 'Board-to-Board' (or B2B) RF connection is defined as a means for transmitting an RF signal between two parallel RF printed circuit boards (PCB) using RF connectors. This document will focus on making a B2B connection using SV's SMP and SMPM series connectors. This configuration consists of two PCB surface mount male connectors and a female-female adapter, or "bullet". Some of the key terms for defining this connection include:

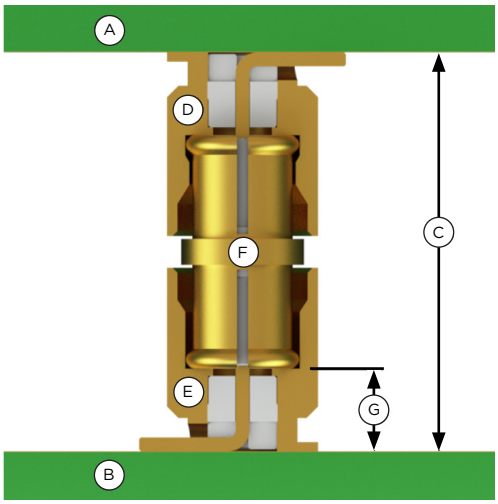


Figure 1: Cross Section Example of Board to Board Interconnect

A. Top RF PCB
B. Bottom RF PCB
C. Board-to-Board Distance
D. Top PCB RF connector (commonly 'Full Detent')
E. Bottom RF PCB connector (commonly 'Smooth Bore')
F. RF adapter or 'Bullet'
G. Reference Plane or 'RP' height of connector

The primary goal of any B2B RF connection is to transfer the signal between PCBs while sacrificing as little RF power as possible. This translates to the best VSWR/Return Loss and Insertion Loss possible.

Radial Misalignment and Axial Misalignment are two key conditions that must be kept within tolerance in order for the connection to perform optimally. These key misalignment features and their tolerances are described below

The Radial Misalignment of the B2B connection is best calculated as an angle rather than an X-Y position of the center of the bullet relative to the PCB connectors - the angular expression removed bullet length as a variable. Therefore, the longer the bullet, the larger the X-Y position offset allowed.

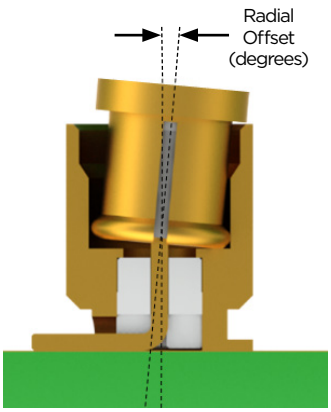


Figure 2: Radial Misalignment Measurement

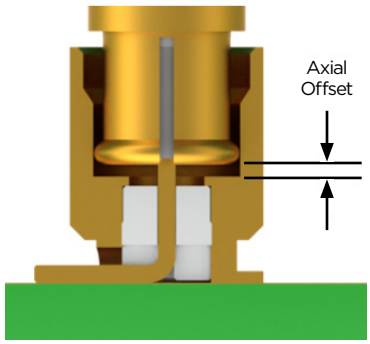


Figure 3: Axial Offset Measurement

Axial Misalignment is calculated as the distance between the Reference Plane and the closest point of the bullet.

Generally accepted limits for Radial and Axial Misalignment for SMP and SMPM bullets is:

SERIES	RADIAL MISALIGNMENT TOLERANCE	AXIAL MISALIGNMENT TOLERANCE
SMP	± 3°	.000 - .010"
SMPM	± 3°	.000 - .010"

Table 1: Radial and Axial Misalignment Operating Range

ANATOMY OF A BOARD-TO-BOARD RF CONNECTION

The below plots show typical VSWR variation from DC to 18 GHz for an SMP Female-Female bullet under radial and axial misalignment conditions.

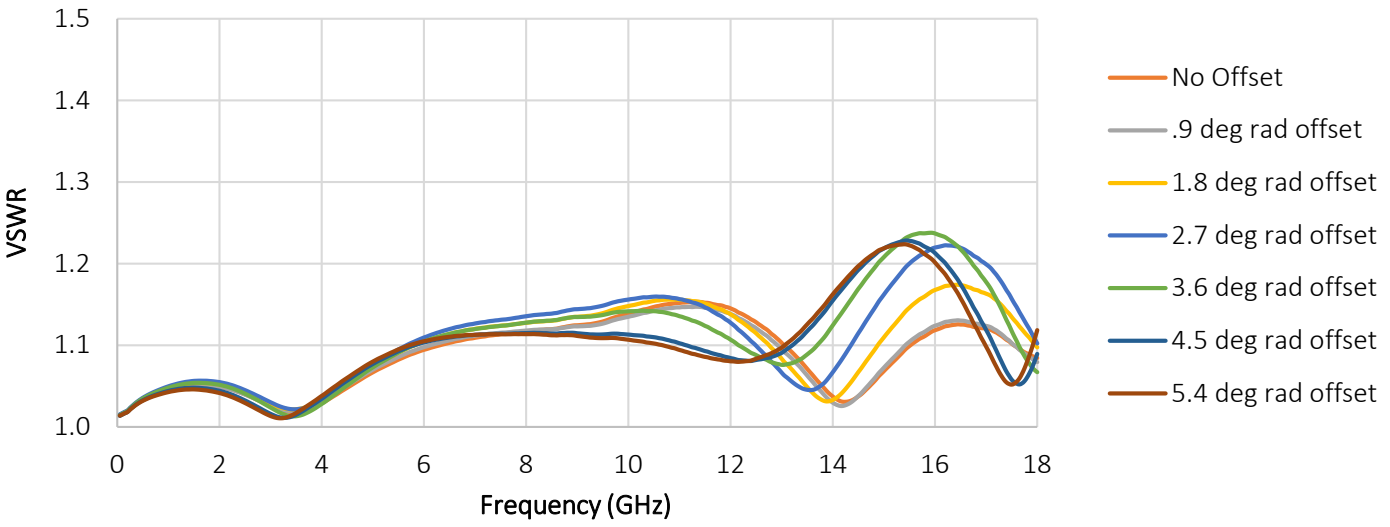


Figure 4: Effect of Radial Misalignment (degrees) on VSWR for an SMP Female-Female Bullet

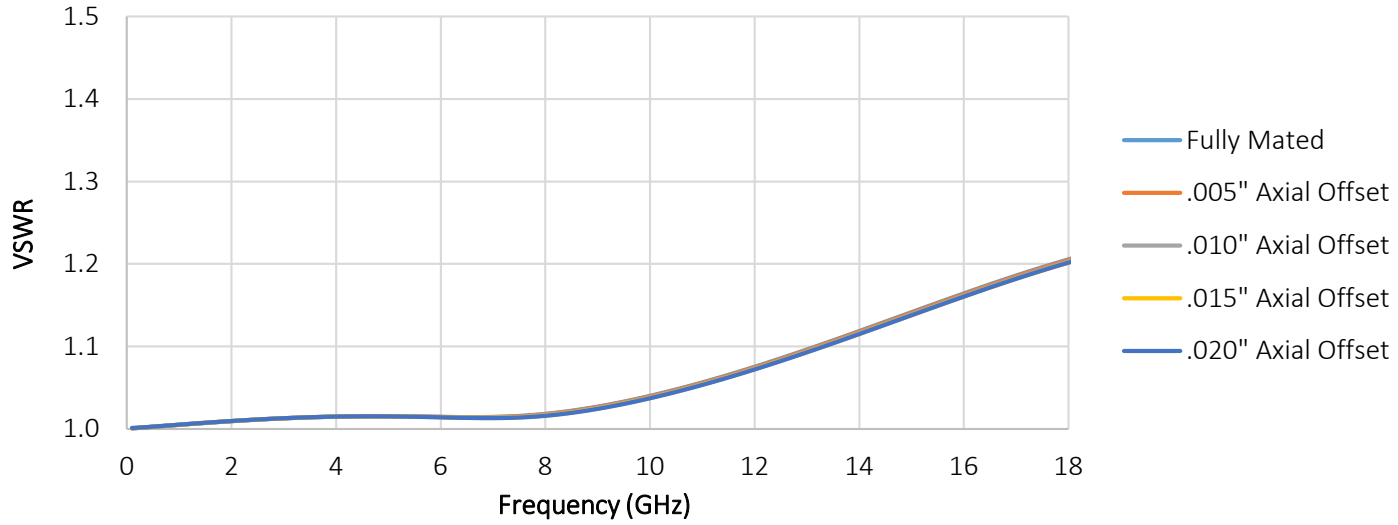


Figure 5: Effect of Axial Misalignment on VSWR for an SMP Female-Female Bullet

FIXED AND SPRING BULLETS

Accurate selection of B2B RF connectors should involve a tolerance stackup analysis. SMP style connectors are designed to operate within acceptable levels of axial and radial misalignment (see Table 1 on page 2). If the system tolerance is within these limits, then the electrical performance will be within rated specifications, if outside these limits then significant power loss may be experienced.

For systems with larger axial misalignment, designers may choose to select 'spring bullets' to help absorb some of the misalignment. Spring bullets compress axially while maintaining a near constant geometry for signal transmission, allowing for a larger tolerance range. However, they typically are more expensive and have more return/insertion loss than their fixed counterparts due to their more complex internal geometry.

Figure 6: SMP
"Spring Bullet" (OAL 0.769")
(PN 1112-4144)

Figure 7: SMP
"Fixed Bullet" (short, OAL 0.255")
(PN 1290-4008)

Figure 8: SMP
"Fixed Bullet" (long, OAL 0.769")
(PN 1290-4007)

The length of a bullet is defined as the difference between the Reference Plane of each end. SV's spring bullets are designed to perform electrically and mechanically when within the compression range specified on the datasheet. The below Figures show the definition of the Reference Plan (or RP) and the effect compression has on the electrical performance of the bullet.

Figure 9: SMP Spring Bullet Compression Distance Definition (PN 1112-4146)

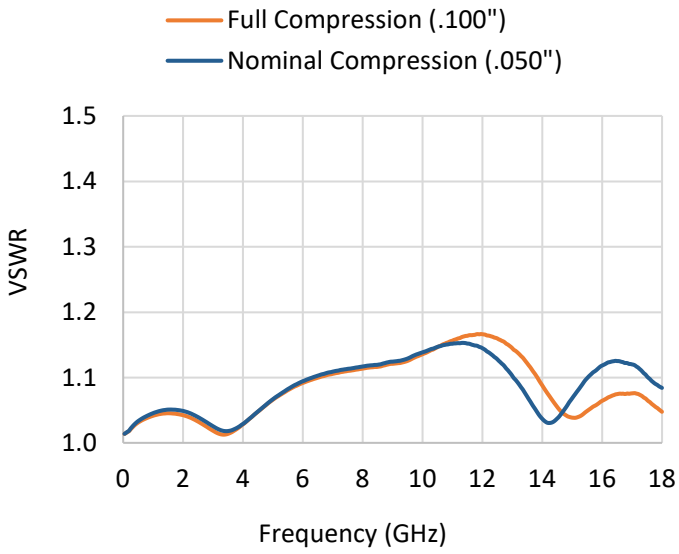


Figure 10: Effect of Compression on Electrical Performance of an SMP Spring Bullet (1112-4146)

VERTICAL PCB CONNECTOR LAUNCH TYPES

Figure 11: SMP Surface Mount Male with R/A Contact (PN 1211-40001)

Figure 12: SMP Surface Mount Male (PN 1211-20016)

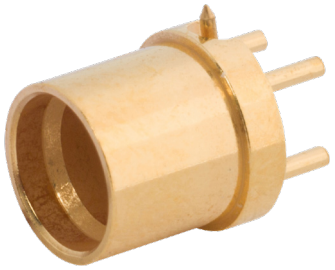
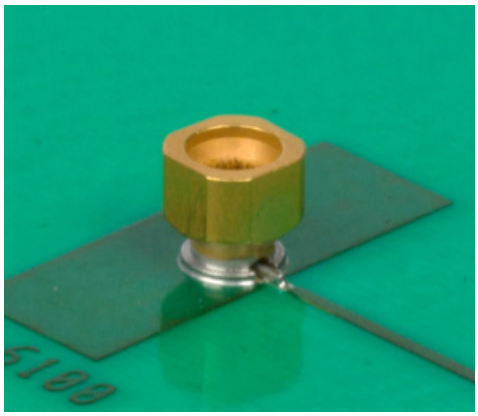


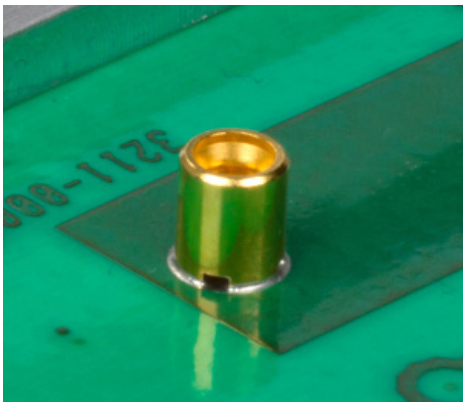
Figure 13: SMP Surface Mount Male Thru-Hole (PN 1211-40110)

A variety of vertical SMP style RF connectors can be used in B2B applications. Selecting the right one depends on your launch type (typically Microstrip, Stripline or CPW) and other mechanical considerations such as torque resistance.



The image to the right shows a surface mount SMP male connector with a right angle center contact. These connectors are useful when a surface trace is desired (CPW or Stripline). The right angle contact and 'mousehole' exit enable a smooth 50 Ω transition to the PCB trace.

The surface mount male with center conductor flush to the PCB surface is another common PCB connector. With this connector, the contact makes perpendicular contact with the trace.



This connector is commonly used in Stripline applications, though SV can add a 'mousehole' to this connector type as well for CPW or Microstrip applications.

This connector design utilizes open channels on the underside of the connector to assist with flux and solder bi-product gas escape during the reflow process.

Among other options are surface mount connectors with thru-hole legs. Thru-hole legs can be useful both for locating connectors relative to the footprint during assembly and to provide torque resistance when mating and demating.

Figure 13 (left) is an SMP connector with a right angle center contact and thru-hole legs for microstrip or CPW applications.

PCB CONNECTOR CENTER PIN CAPTIVATION

Plastic Based Insulators

Plastic based insulators are often the lowest cost, shortest lead time solution for PCB RF connectors. They are easily CNC machined and provide a low dielectric constant for ideal return loss and insertion loss. SV Microwave has various plastic insulator types available in our PCB mount connector portfolio.

INSULATOR MATERIAL	DIELECTRIC CONSTANT	HARDNESS (SHORE D)	CTE PPM/°C	ADVANTAGE / DISADVANTAGE
Teflon (PTFE)	2.02	55	135	Low Cost / High CTE
Ultem 1000	3.15	109	56	Low CTE / High Dielectric Constant
Torlon 4203	4.20	86	31	Low CTE / High Dielectric Constant
Corning 7070	4.60	403	3.2	Very Low CTE / High Dielectric Constant, Long Lead Time, High Cost

Table 2: Common Insulator Material Properties

Glass-Seal Insulators

Depending on the insulator material and the reflow profile, it is possible for plastic based insulators to reach their thermal deflection point and expand then contract as they cool down. In some instances this can result in variability of the center pin height when it doesn't return to its original position or pushes the connector away from the board radially or axially. For a given length, glass captivates center contacts more securely and without additional geometry, enabling minimum RP to PCB distances.

To mitigate this issue, glass based insulators are used (typically Corning #7070). Corning #7070 has a much lower CTE than plastic based insulators and thus handles the reflow cycle with minimal mechanical variability. Commonly glass insulators will be fused to Kovar connector bodies and center pins due to the similar CTE between glass (3.2 PPM/°C) and Kovar (5.1 PPM/°C).

It is important to note that in the case of PCB mounted connectors we are only using glass for its thermal and captivation properties, not for hermeticity. Therefore, some of the conventional glass-to-metal seal issues like cracks and non-uniformities do not affect performance in the application.

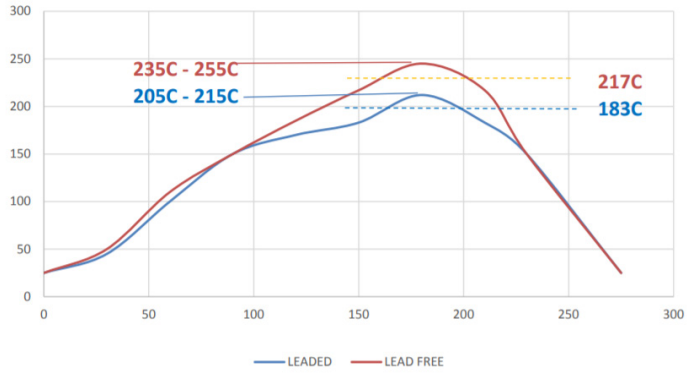


Figure 14: Solder Paste Reflow Profile (typical) Lead Based and Lead Free Solder

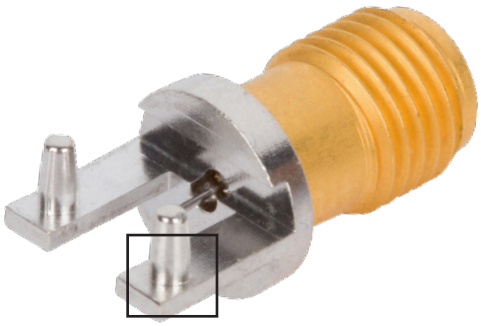
MATERIAL	@ 215°C (LEAD SOLDER)	@ 255°C (LEAD FREE SOLDER)
PTFE	0.0026"	0.0032"
Ultem 1000	0.0011"	0.0013"
Torlon 4203	0.0006"	0.0007"
Corning 7070	0.0001"	0.0001"

Table 3: Linear Thermal Expansion of .100" Long Insulator vs. Room Temp

PRE-TINNED PCB CONNECTORS

SV Microwave provides a pre-tinning option on all of our PCB connectors. Just a few of the advantages of having connectors pre-tinned by the OEM are:

1. SV's proprietary de-golding and pre-tinning process removes 99% of the gold in the soldering area and is compliant with J-STD-001 requirements
2. SV's process accurately controls the thickness of the solder to 3 microns
3. Removing gold from solder joint eliminates 'gold embrittlement' and produces a stronger, more reliable bond between connector and PCB
4. The high precision process reduces solder build-up and fillets at corners to ensure the connector sits flush to the PCB in thru-hole applications
5. SV's engineering team accounts for pre-tinning at the connector design stage, creating barrier features to optimize the pre-tinning process and ensure gold will not migrate into the solder joint
6. Pre-tinning the connectors on the assembly line saves time, money and yields a superior product



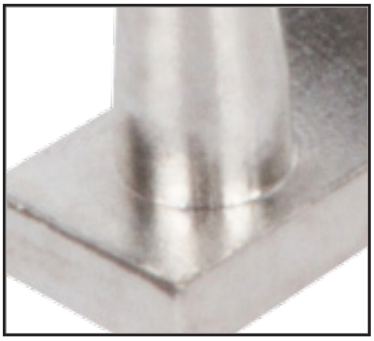
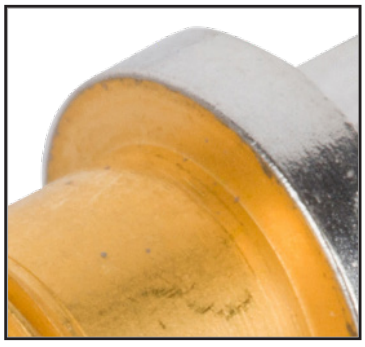


Figure 15: Zoom View of Fillet Area at Thru-Hole Location

- Bodies and contacts can be pre-tinned at the piece part level ensuring solder will not be unevenly applied in transmission line
- No need to send parts to an expensive 3rd party for pre-tinning after procurement
- Parts are delivered ready to install. SV's automated system can pre-tin 10k+ parts per day



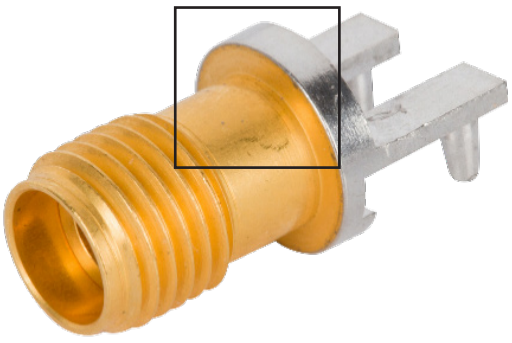


Figure 16: Zoom View of Solder Barrier by Design

Figure 17: Pre-tinned SMP Surface Mount Connector (PN 1211-40080)

BOARD-TO-BOARD CALCULATION AND PRODUCT SELECTION

Example #1 – Fixed Bullet Board to Board Application

In this example we will look at an application that tightly constrains the B2B distance thus enabling the use of a fixed SMP bullet.

Design Conditions:

Distance Between PCBs (C) =	.440 ± .010”
Solder Paste Thickness =	.003 ± .001”
RF Trace Type =	CPW
Top Connector 1211-40003 RP =	.090 ± .001”
Bottom Connector 1211-40001 RP =	.090 ± .001”

PCB Connector Selection:
1211-40001 (SB) and 1211-40003 (FD) are surface mount SMP connectors with right angle center contacts. These are an ideal choice for CPW or Microstrip traces at this B2B spacing

Bullet Allowance Calculation:

Based on this information, it is possible to calculate the distance and tolerance between the Reference Plane (RP) of each connector. Based on that number we can select a standard length bullet from SV’s Price List selection or determine if a custom length is required.

Attribute	Key Dimension
Distance Between PCBs =	.440 ± .010”
Top Connector 1211-40003 RP =	-.090 ± .001”
Solder Paste Thickness (Top) =	-.003 ± .001”
Bottom Connector 1211-40001 RP =	-.090 ± .001”
Solder Paste Thickness (Bottom) =	-.003 ± .001”
Bullet Allowance =	.254 ± .014”

Bullet Selection:
Given the design conditions, Price List Bullet item 1290-4008 is a possible solution as the OAL of .2545 ± .0015” is very close to the Bullet Allowance length

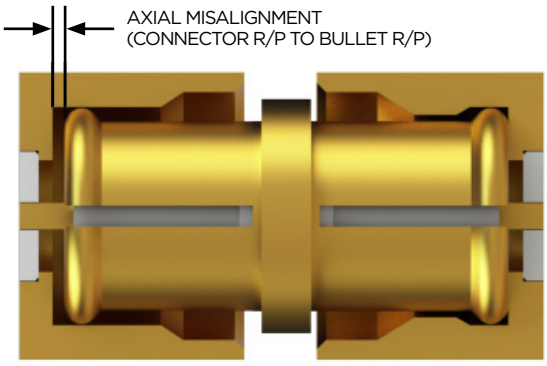
With the Bullet Allowance calculation and the Overall Length of the bullet (with tolerance), we can determine the max and min axial misalignment conditions by design:

Max Axial Misalignment Condition

Bullet Allowance Max =	.268”
Bullet Length Min =	.253”
Max Axial Misalignment =	CPW

Min Axial Misalignment Condition

Bullet Allowance Min =	.240”
Bullet Length Max =	.256”
Min Axial Misalignment =	-.016”



In this case at Max Axial Misalignment there will be .015” separation between the RPs of the bullet and the PCB connector. While this may still make contact, it is not ideal since the max axial misalignment is outside the recommendation of .010” max. SV would recommended to tighten up the B2B design tolerance or move to a spring bullet design.

BOARD TO BOARD CALCULATION AND PRODUCT SELECTION

Example #2 – Spring Bullet Board to Board Application

In this example we will look at an application with high axial tolerance on the B2B distance thus requiring an SMP Spring Bullet to accommodate.

Design Conditions:

Distance Between PCBs (C) =	.900 ± -.030”
ROHS Compliant =	Yes
Solder Paste Thickness =	.003 ± .001”
RF Trace Type =	Stripline
Top Connector 1211-40003 RP =	.052 ± .001”
Bottom Connector 1211-40001 RP =	.052 ± .001”

PCB Connector Selection:
Since the system requires ROHS compliance with a max solder reflow oven temp of up to 255°C, SV recommends using glass seal SMP PCB connector PN 1211-20015 and 1211-20016

Bullet Allowance Calculation:

The distance and tolerance between the Reference Plane (RP) of each connector is calculated below. Based on that number we can select a spring bullet with an overall length at nominal compression that is as close as possible to the Bullet Allowance distance.

Attribute	Key Dimension
Distance Between PCBs =	.4900± -.030”
Top Connector 1211-40003 RP =	-.052 ± .001”
Solder Paste Thickness (Top) =	-.003 ± .001”
Bottom Connector 1211-40001 RP =	-.052 ± .001”
Solder Paste Thickness (Bottom) =	-.003 ± .001”
Bullet Allowance =	.790 ± .034”

Bullet Selection:
For this application we need a bullet with nominal length near .790” and that can accommodate up to .034” of axial tolerance. SV PN 1112-4146 with nominal length .800” and ± .050” travel is a good choice

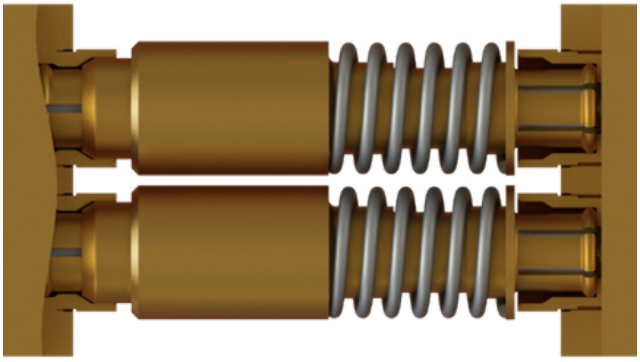
With the Bullet Allowance calculation and the Overall Length of the bullet (with tolerance), we can determine the max and min axial misalignment conditions by design:

Max Axial Misalignment Condition

Bullet Allowance Max =	.824”
Bullet Length Fully Compressed =	.750”
Bullet Length Uncompressed =	.850”
Max Allowance in Range?	Yes

Min Axial Misalignment Condition

Bullet Allowance Min =	.756”
Bullet Length Fully Compressed =	.750”
Bullet Length Uncompressed =	.850”
Max Allowance Within Range?	Yes



MULTI-MATING SMP FIXED AND SPRING BULLETS

SMP fixed and spring bullets can be useful in applications where multiple B2B interconnects are required to mate simultaneously. In order for the bullet to mate successfully without crashing, the loose end of the bullet must hit the 'target' within the acceptable range.

SV recommends using 'Full Detent' PCB connectors on the PCB where the bullets are to be retained. On the opposite PCB connector, 'Smooth Bore' PCB connectors can be used if the bullets are well constrained. A 'Catchers Mitt' style 'Smooth Bore' interface can be used to help scoop bullets in a multi-mating application.

SV also uses an 'alignment' ring on the female interface of select connectors to further help align the female connector to the male during mating.

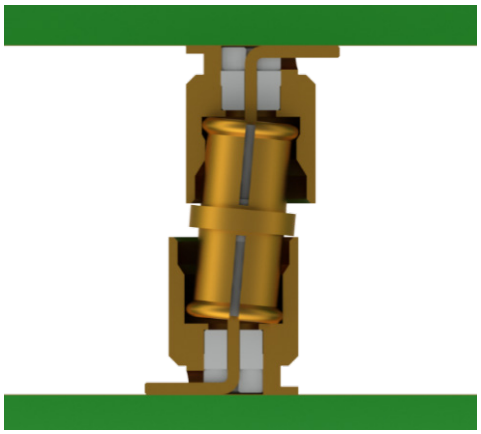


Figure 18: Typical B2B Connection with Full Detent (top) and Smooth Bore (bottom) PCB Connectors

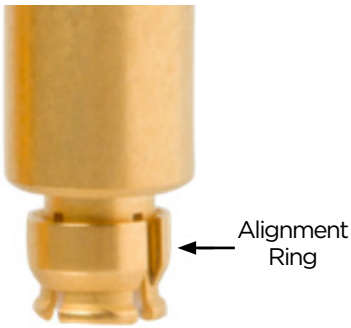


Figure 19: Alignment ring on SMP connector for stabilization during multi-mating

Factors to consider when multi-mating B2B connectors are insertion/withdrawal force required and minimum center to center spacing requirements. While the FD side will be individually mated, the SB or CM side will experience the combined mating force of all the connectors which could potentially warp or damage a PCB when mated if proper board stiffeners are not in place.

Figure 20: Unconstrained Spring Bullets in Multi-Mating Application

Figure 21: Constrained Spring Bullets with Alignment Ring

SERIES	MAX INSERTION FORCE SB (PER CONNECTOR)	MAX INSERTION FORCE FD (PER CONNECTOR)
SMP	3 lbs	7 lbs
SMPM	2.5 lbs	4.5 lbs

SERIES	MAX INSERTION FORCE SB (PER CONNECTOR)	MAX INSERTION FORCE FD (PER CONNECTOR)
SMP	.5 lbs	9 lbs
SMPM	1.5 lbs	6.5 lbs

Table 4: Insertion/Withdrawal Forces

SMP BOARD-TO-BOARD PRODUCT

Below are just a few Board-to-Board product examples. Did you know that SV has over 25k unique product designs? Many of these can be found on our website and with our distribution channel partners, but many more can be accessed through our Applications Engineering team at Applications@svmicro.com.

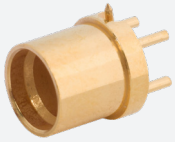
SMP Male Surface Mount Connector with Right Angle Contact

1211-40001 (SB)
1211-40004 (LD)
1211-40003 (FD)

SMP Male Surface Mount Connector with Right Angle Contact Pre-Tinned

1211-40087 (SB)
1211-40088 (LD)
1211-40089 (FD)

SMP Male Thru-Hole Connector with Right Angle Contact



1211-40108 (SB)
1211-40109 (LD)
1211-40110 (FD)

SMP Male Thru-Hole Connector with Right Angle Contact Pre-Tinned

1211-40080 (SB)
1211-40081 (LD)
1211-40082 (FD)

SMP Male Thru-Hole Connector with Straight Contact

1211-40111 (SB)
1211-40112 (LD)
1211-40113 (FD)

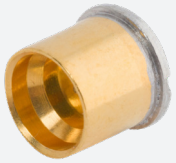
SMP Male Thru-Hole Connector with Straight Contact Pre-Tinned

1211-40114 (SB)
1211-40115 (LD)
1211-40082 (FD)

SMP Male Surface Mount Glass Seal

1211-20015 (SB)
1211-20018 (LD)
1211-20016 (FD)

SMP Male Surface Mount Glass Seal Pre-Tinned



1211-20019 (SB)
1211-20020 (LD)
1211-20021 (FD)

SMP Fixed Length Bullet

1290-4008 (.225")
1290-4009 (.396")
1290-4007 (.769")

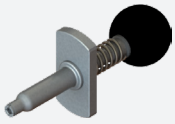
Custom Lengths Available on Request

SMP Spring Bullet

1112-4144 (.650")
1112-4145 (.725")
1112-4146 (.800")
1112-4147 (.875")
1112-4148 (.950")

Custom Lengths Available on Request

SMP Bullet Insertion/Removal Tool



500-12-000

SMPM BOARD-TO-BOARD PRODUCT

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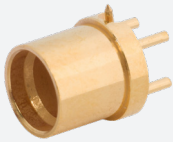
SMPM Male Surface Mount Connector with Right Angle Contact

3287-6101 (SB)
1287-6100 (FD)

SMPM Male Surface Mount Connector with Right Angle Contact Pre-Tinned

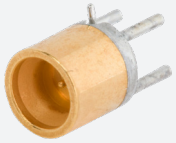
3211-40106 (SB)
3211-40107 (FD)

SMPM Male Thru-Hole Connector with Right Angle Contact



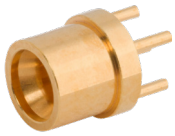
1211-40108 (SB)
1211-40109 (LD)

SMPM Male Thru-Hole Connector with Right Angle Contact Pre-Tinned



3211-40093 (SB)
3211-40094 (FD)

SMPM Male Thru-Hole Connector with Straight Contact



3211-40140 (SB)
3211-40141 (FD)

SMPM Male Thru-Hole Connector with Straight Contact Pre-Tinned

1211-40114 (SB)
1211-40115 (LD)

SMPM Male Surface Mount Glass Seal

3211-20027 (SB)
3211-20028 (FD)

SMPM Male Surface Mount Glass Seal Pre-Tinned

3211-20033 (SB)
3211-20034 (FD)

SMPM Fixed Length Bullet

1132-4010 (.166")
1132-4021 (.180")
3290-4002 (.211")
3290-4003 (.327")

Custom Lengths Available on Request

SMPM Fixed Length Bullet Pre-Tinned

1132-4113 (.600")
1132-4114 (.690")
1132-4115 (.780")
1132-4116 (.870")
1132-4117 (.960")

Custom Lengths Available on Request

SMPM Bullet Insertion/Removal Tool

500-32-007

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Amphenol SV MICROWAVE

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