PIM considerations for board-to-board connector solutions

As wireless communication systems continue to evolve from 4G to 5G and beyond, the RF path continues to evolve, as well. The need for compact integration among RF subsystems, such as massive MIMO configurations, requires us to re-examine connectivity between remote radio units (RRU), filters and antennas. This connectivity traditionally involves the use of coaxial cable jumpers. A new challenge has surfaced for a board-to-board (B2B) connector solution capable of simultaneously connecting or mating multiple RF paths in a small (and sometimes inaccessible) area while maintaining the same RF performance characteristics of a traditional coaxial cable assembly.

Why PIM matters—and potential causes

Passive intermodulation (PIM) is the generation of interfering or unwanted signals in a passive circuit, component, or connection. These interfering signals can cause a severe decrease in the overall performance of a wireless communication system, impacting the throughput, efficiency, and coverage capability of the network. Some well-known PIM generators in mobile networks include unwanted debris or oxidation in the conducted RF path, loose metal-to-metal contacts in or near the RF path, and metal or ferromagnetic materials in proximity to the conducted or radiated RF path.

CommScope provides a wide variety of RF path solutions—many of which are purposely designed to effectively mitigate these potential PIM generators in legacy wireless networks. However, the board-to-board (B2B) connector solutions needed for next-generation RF system integration present a new set of challenges when battling PIM.

CommScope has been a pioneer in the efforts to combat PIM in all areas of the MNO's RF path. The company's efforts have resulted in innovative engineering solutions that reduce PIM in connectors, antennas and other components. It has also led to CommScope adopting PIM testing requirements that are among the industry's most rigorous.

Considerations for a B2B connector

Before discussing a board-to-board connector in detail, let's take a closer look at one of the most notorious PIM generators in an interface connection: loose metal-to-metal contacts in the connector or connector interface.

A typical coaxial connector consists of inner and outer metal conductors. When the inner and outer conductors of the plug and receptacle are mated, contact pressure must be maintained across the mating or contacting surfaces. In a traditional, single RF path connection, such as a 7-16 DIN or 4.3-10 connector interface, this can be achieved via a threaded coupling nut or an alternative coupling mechanism. The localized coupling force applies consistent contact pressure at the connector interface.

Figure 1: Connector 1.5-3.5

When an array of B2B connectors is required for next-generation applications, it becomes more difficult to control the coupling force of the multiple RF paths. In a typical configuration, the array of B2B plugs and receptacles to be mated is mounted on opposing parallel, rigid planar structures, such as printed circuit boards. However, variances are introduced when manufacturing the connector, installing it on the printed circuit board, and aligning it with the opposing circuit board. Therefore, it cannot be assumed that the multiple RF paths will perfectly align to allow for a simultaneous mating. To properly mate all connectors in this type of application, a degree of flexibility or float needs to be designed into the B2B solution.

Given the tolerances and alignment challenges mentioned above, the designed float needs to allow for movement in all axes. The radial and axial float is required to account for potential adjustment and alignment of the connectors in the xyz directions as the planar structures are brought together.

To solve the alignment issues, the float mechanisms must be integrated into the B2B design—allowing the connector components to move. Herein lies the challenge. The connector must maintain contact pressure across the mating surfaces of the inner and outer conductors; it must also allow the two conductors to float into alignment to assure the RF paths are properly mated.

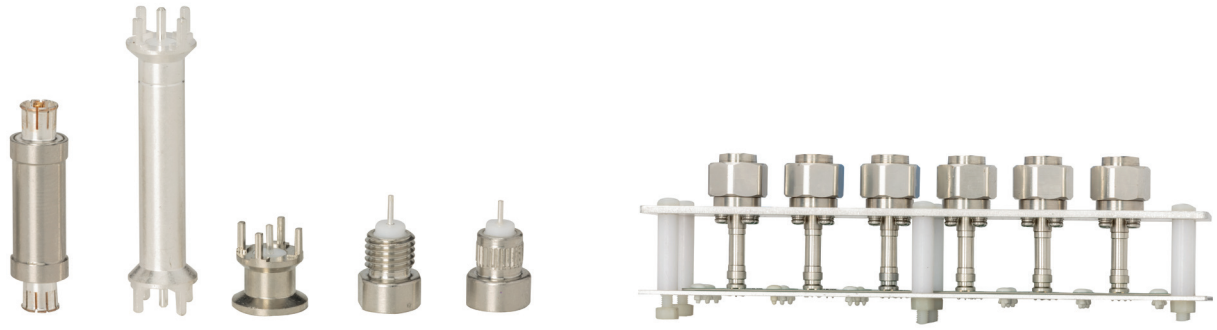


Figure 2: Connectors

Solutions for B2B connector applications

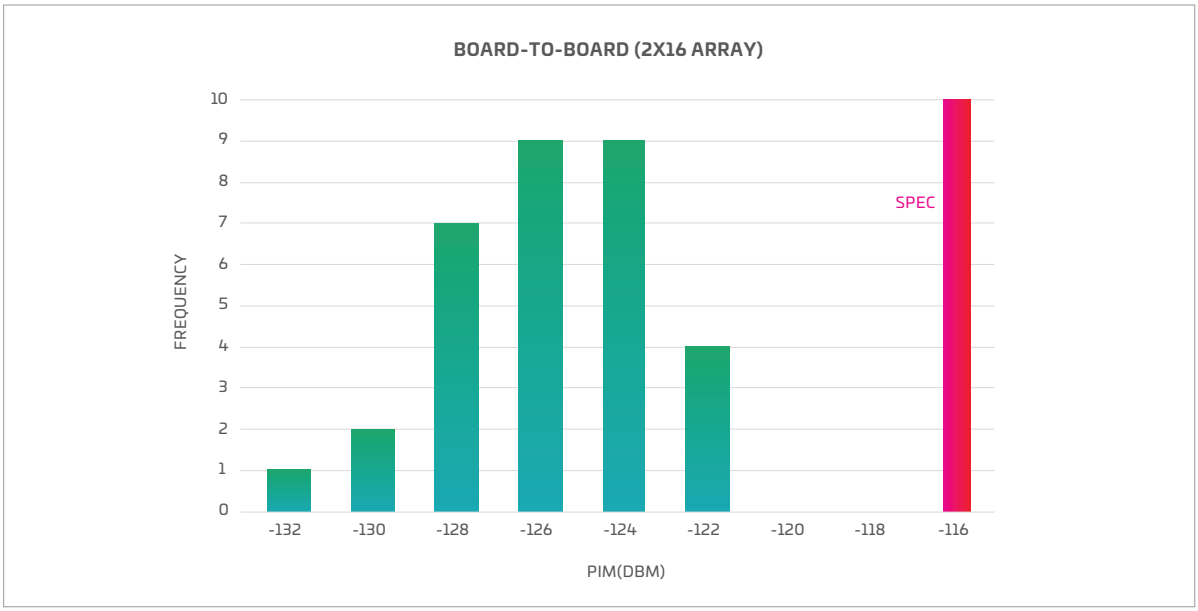
Various strategies exist for achieving the opposing design goals referenced above. They all involve some tradeoff of cost, performance, and manufacturability. Here are a few critical considerations when trying to engineer to an optimal solution.

First, try to fix as many points as possible when allowing for mating of the multiple RF paths. In other words, design for the minimal amount of float required at both the subsystem and connector level. This allows for a minimum movement of parts and maximum amount of repeatable contact pressure. This can become even more important when considering environmental effects such as vibration.

Second, look to secure the plug and/or receptacle on each planar surface with a robust and repeatable process. How the connectors are mounted to the PCB is not only important for alignment but also for performance, as compromised solder joints are another common source of PIM. Some solutions eliminate the receptable altogether via a spring-loaded, one-piece connector solution. However, this approach leaves the RF path susceptible to the alignment, environmental, and contact pressure concerns already discussed.

The third strategy when designing a B2B solution is to remove the axial force required in the RF path to maintain contact pressure on the conductors. Axial force is difficult to maintain in a B2B application. Relying on it to achieve lower PIM and return loss (RL)—across all alignment and environmental conditions—is extremely challenging.

The preferred approach is to design for radial contact in the RF/electrical path at the connector interface. While some axial and radial float will most likely be required by the application and connector solution, minimizing or eliminating dependence on axial contact pressure will help maintain performance among all RF paths.



Tackle PIM at the Source with CommScope

As 5G deployments increase and MNO networks grow more complex and crowded, PIM will continue to threaten network performance. Now, the use of space-efficient board-to-board configurations with higher signal integrity requirements presents network engineers with yet another PIM challenge. On-going work by OEMs such as CommScope has led to a deeper understanding of both the challenges and solutions for addressing PIM originating from board-to-board connectors. In this paper, we have briefly described a few of the strategies that can be used.

The presence of B2B-induced PIM underscores the importance of operators remaining vigilant regarding the potential for performance-eroding PIM. CommScope offers a variety of off-the-shelf and customizable products—including connectors, antennas, filters and tower-mounted amplifiers—that are all designed using the above insights and available to meet your board-to-board application. Please contact us for more information.

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