ADVANTEST

Q&A: What Type of RF Connector Provides the Best Performance?

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Question:

There are a couple of different RF connectors available (like SMA or SMP) that I can use for RF projects, but which one provides the best RF performance?

Answer:

The answer to this question depends mainly on how the RF connectors are mounted on the interface board. Typically, the bandwidth of SMA and SMP connectors goes up to 18GHz, some proprietary versions are rated far above 20GHz. This performance is more than sufficient for most commercial RF applications. However, if you use an RF connector that simply connects to a microstrip line on the other side of a 0.2'' thick PCB, you may already experience a return loss of -10dB at 2GHz. This means only 90% of the power can be delivered, while the rest will be reflected at the input. Root cause for this loss is not the connector, but the characteristic impedance of the via, which is obviously far off 50Ohm. This means the via is the performance bottleneck.

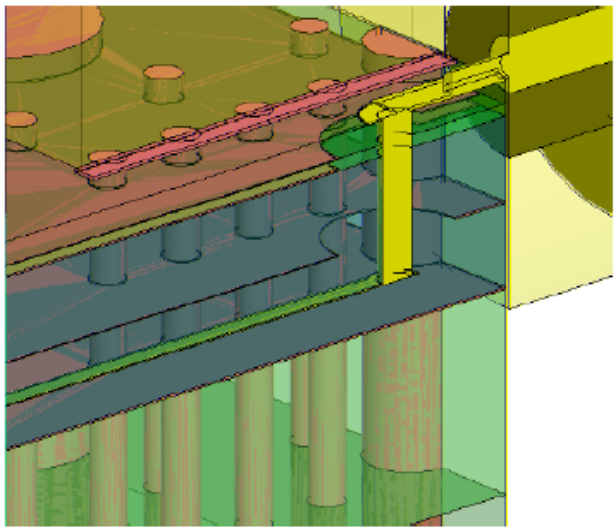
The impedance of a via can be approximated by the following simplified formulas (see H. Johnson, M. Graham, "High-Speed Digital Design", 1993, Prentice Hall):

$$Z_0 = \sqrt{\frac{L \ \ per \ \ unit \ \ length}{C \ \ per \ \ unit \ \ length}} \ \Omega$$

$$L \approx 0.002 \ \ l \left[2.3 \log\left(\frac{4\,l}{d} - 0.75 \right) \right] \mu H$$

$$C \approx \frac{0.56 \ \ \varepsilon_r \ T \ D_1}{D_2 - D_1} \ pF$$

The formulas demonstrate that the impedance depends on many different parameters like PCB thickness (l and T), inner and outer pad size (D1, D2), ε_r of the PCB and the diameter of the wire. Optimizing these parameters helps just to some little extent, because also the geometry of the surrounding GND planes need to be taken into account. Much better performance can be achieved, if additional GND vias are placed around the signal via. EM simulation tools must be used to generate the complex layout rules. If this is done properly, the return loss can be reduced below -30dB for the given example. Looking at the picture of the optimized layout below you can see that even the cutout area of the GND layer in the middle has a different dimension.



Another alternative is to use surface mounted SMP type of connectors. The return loss is typically below -25dB. Since this connector type can also be mounted through a slot to the opposite PCB side, it is possible to avoid the usage of vias. Even the direct connection of a semi-rigid RF cable through a PCB slot to a microstrip line (conductor is soldered on microstrip line) does not significantly provide better performance, while occupying much more space.

(Special thanks to Jose Moreira from Verigy for providing the layout picture of an optimized via.)