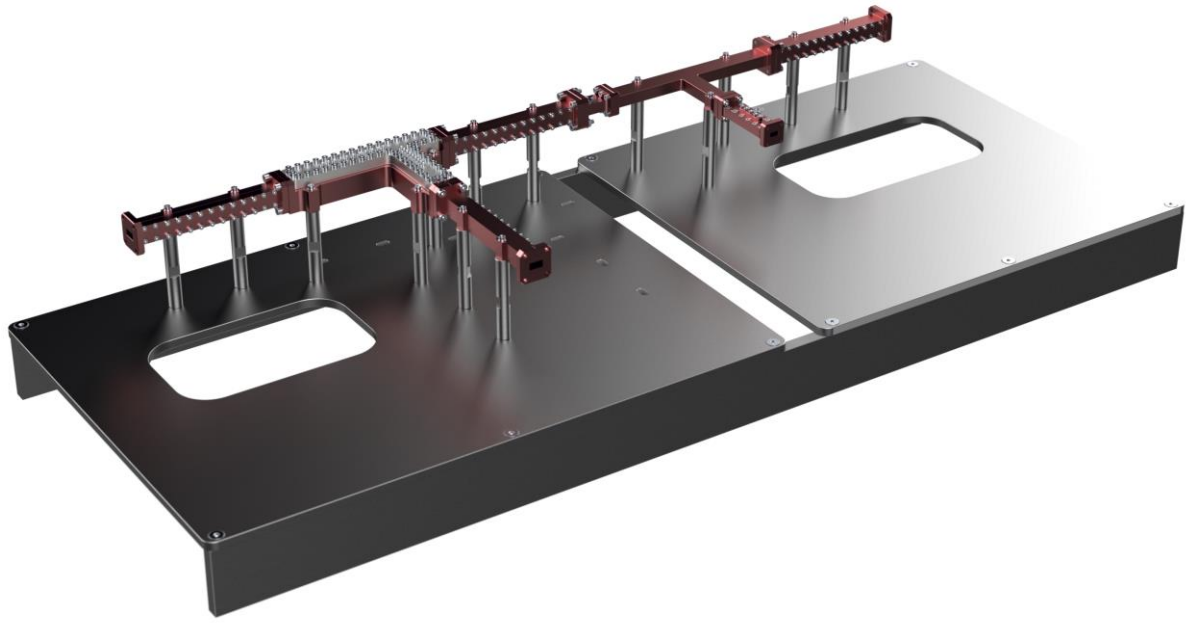
Case Study-Q1213 Waveguide Low PIM Test bench



Overview

Over time Phase 2 Microwave has developed several bespoke waveguide PIM measurement test solutions for the space industry. These test solutions are designed to comply with the customer specified requirements plus any additional requirements inherently implied in order to reliably achieve the PIM measurement levels required with enough margin to maintain good measurement stability and repeatability.

These test solutions include all of the filtering required to combine the carries and measure the PIM whilst eliminating the carriers from the Rx path to such a level that they no longer influence PIM levels being measured.

Challenge

As always with PIM measurement there are several key challenges that must be addressed, such as:

- Work with the customer to gain a good understanding of how and what the customer is trying to achieve and accounting for any unique challenges their test facility may present. These could be classed as the unspecified requirements.
- Establishing the correct amount of filtering required at each stage within the system so that the complete test facility gives stable and repeatable results and is fit for purpose.
- Careful selection of materials, interfaces and manufacturing processes.

- Careful selection of vendors so that the overall quality of the hardware is commensurate with low level PIM measurements.

The above bullet points are common to all PIM test solutions but in this particular case there were added challenges which required initiative approaches to be taken.

Firstly the Tx carries were in one waveguide band / size whilst the PIM products fell in another waveguide size / band which were several sizes apart. This meant the diplexer element of the measurement system called for by the customer had two different waveguide interfaces in which:

- The waveguide size specified by the customer for the Tx carries would propagate higher order modes in the PIM band which would potentially obscure the PIM products being measured.
- The waveguide size and band in which the PIM products were being measured was in cutoff to the Tx carriers.

This meant that the characterization using a single VNA setup of this diplexer became one of the main challenges.

The Tx combiner showed spurious higher order modes that occurred in the PIM measurement band, this could be an issue because the fidelity of the high power carriers was not known in this band, and it was important to avoid any potential mode conversion issues within the Tx combiner

The diplexer the carrier spacing was such that a lowpass approach best suited this requirement. Whilst the path through the diplexer which the PIM would be measured was best realized as more traditional waveguide bandpass filter. This presented a significant challenge to the mechanical realization of the diplexer. If normal machining techniques were going to be used it would mean that the diplexer would need to be made in serval parts each producing a potentially PIM unfriendly interface. So an alternative manufacturing technique would be required.

Solution

Working closely with the customer the design of critical interfaces where agreed along with material and surface finishes throughout the complete test bench. This meant that one potential PIM generation mechanism, namely the effect of dissimilar material, had been removed.

To allow each element of the test bench to be characterized using normal VNA test methods, using a single waveguide calibration, a unique waveguide size that covered both of the frequency bands was used. This required the design and manufacture of waveguide tapers converting the customer specified interfaces to this unique size along with the necessary waveguide standards required for a TRL calibration.

Additional filtering was included with the Tx Combiner to eliminate the higher order modes that could potentially obscure the PIM products being measured

A manufacturing process was selected which allowed the complete diplexer to be manufactured from a single piece of metal, hence removing any likelihood of poor PIM performance due to mechanical joints. The diplexer design was tailored to suit this process and a manufacturing tolerance yield

analysis was carried using accurate EM tools which resulted in all post manufacturing tuning / alignment being eliminated. These steps were facilitated by establishing a close working relationship with various vendors and appreciating their process requirements, limitations and achievable tolerances.

End Result

All parts for the complete test bench assembly were manufactures and carefully assembled.

The residual PIM of the complete test bench was verified by the customer at their test facility and was <-185dBc without the need for any rework.