Success Story

# Defence Science Technology Group Australia and Partner Macquarie University Design a 94 GHz Hairpin Filter

"The measured vs. simulation results we achieved to 145 GHz strengthens our confidence in 3D planar simulation using AXIEM."

Leigh Milner, Defence Science Technology Group

## Company

The Defence Science and Technology (DST) Group (dst.defence.gov.au) is part of Australia's Department of Defence and is the second largest publicly funded R&D organization in Australia. DST Group invests in collaborations with industry and academia to leverage its research outcomes.

## Partner

Macquarie University, Sydney, Australia (mq.edu.au), is a hub of innovation and excellence and is quickly becoming one of Australia's leading research universities through heavy investment in research, learning and teaching, new facilities, and mutually beneficial relationships with industry.

**At-A-Glance**

**Application**
- Microwave Components
- Filters

**Software**
- NI AWR Design Environment
- Microwave Office
- AXIEM

**Benefits**
- Accurate EM analysis
- Fast design simulation times
- Excellent correlation to measurement

## Challenge

DST Group and Macquarie University collaborate on research projects that develop cutting-edge millimeter-wave integrated circuits (ICs). A recent project in gallium arsenide (GaAs) had available monolithic microwave IC (MMIC) wafer area to evaluate bandpass filter designs aimed at 94 GHz applications. The challenge was to investigate how well simulation agreed with measurement for a hairpin filter design. A fair comparison required a process with well-characterized RF properties and low manufacturing tolerances, a precisely calibrated on-wafer measurement to de-embed RF probing effects, and a simulation tool that would accurately predict the electromagnetic (EM) behavior of the filter.

## Solution

The filter's initial design was conducted in a schematic simulator using closed-form models. The layout of the filter was then extracted to AXIEM EM solver within the NI AWR Design Environment platform. For this design, EM ports were placed at the ends of the microstrip feeding lines and de-embedding options were enabled for the ports to move the reference plane to the edge of the filter, the same location as the measurement reference plane shown in Figure 1.

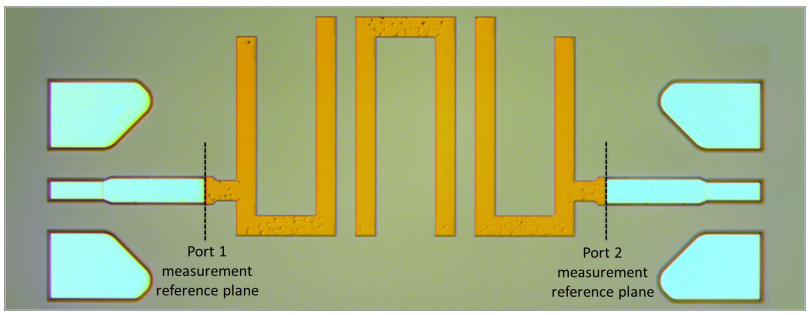


*Figure 1: Die image of the bandpass filter showing the position of measurement reference planes.*

Additionally, thick metal meshing was used within AXIEM EM solver to accurately account for the coupling between the lines, illustrated in Figure 2.

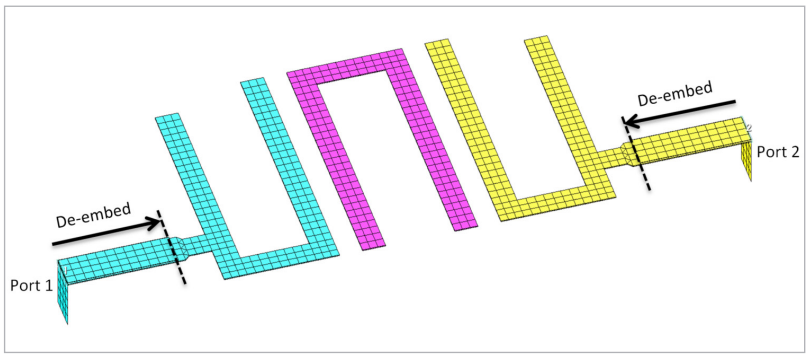


*Figure 2: AXIEM 3D view of the bandpass filter showing the position of reference planes.*

An accurate on-wafer measurement was conducted using a vector network analyzer (VNA) and probe station. The VNA calibration was performed using a short-open-load-through (SOLT) algorithm. Data for the algorithm was supplied from S-parameter files generated using AXIEM software.

Measured and simulated results for the 94 GHz hairpin filter are shown in Figure 3 and Figure 4. The combination of many factors, including the materials' RF properties, manufacturing tolerances, calibration, and 3D planar simulation in AXIEM EM solver, all contributed to the 145 GHz results achieved for the filter. The impedance match within the passband was better than -25 dB at 94 GHz. The predicted small notch (-5 dB at 144 GHz) was also present in the measurements. Three samples were measured to mitigate the probing errors, which also highlighted the low manufacturing tolerance of GaAs technology.

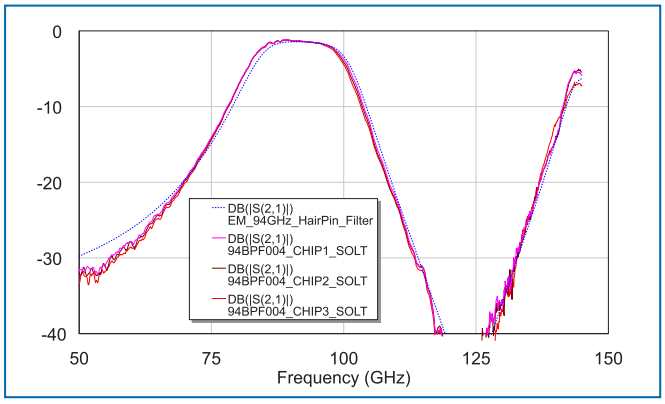


*Figure 3: Measured (three dies) and simulated $S_{21}$.*

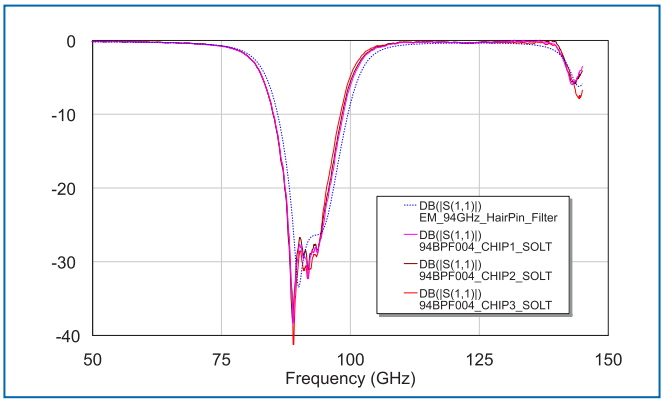


*Figure 4: Measured and simulated $S_{11}$.*

## Conclusion

The challenge of this design was to find out how well simulation agrees with measurement for a hairpin filter design. DST and Macquarie designers chose NI AWR Design Environment because the design required a simulation tool that could accurately predict the EM behavior of the filter and they knew that AXIEM offers the accuracy, capacity, and speed they needed to be confident in the simulation results.

MACQUARIE University

"The keys to obtaining the exceptional agreement between the broadband 145 GHz measured and simulated results for the hairpin filter were straightforward: getting it all right in terms of good calibration and measurement setup, and accurate EM simulation with AXIEM."

Sudipta Chakraborty, Macquarie University