Analog Differential Signal Transmission: SEARAY™ SEAM8/SEAF8 10 mm Stack Height

July 2025

COPYRIGHTS, TRADEMARKS AND PATENTS

Updated Documentation

Please visit www.samtec.com to get access to the latest documentation.

Abstract

System on Chip (SoC) implementations with integrated data converters and RF front-end subsystems are being deployed in 5G/6G, phased array radar, SATCOM, FPGA cards, and test & measurement architectures. This paper describes the research, development, simulation, and measurements performed in a project to design the optimal breakout region (BOR) for the use of Samtec SEARAY™ 0.80 mm pitch SEAM8/SEAF8 10 mm stack height array connectors that simultaneously carry analog, digital, and/or power signals in an RF environment, as a replacement for traditional compression mount and threaded PCB connectors for RF signals.

Integration Leads to Innovation

Samtec is structured like no other company in the interconnect industry: we work in a fully integrated capacity that enables true collaboration. The result is innovative solutions and effective strategies supporting optimization of the entire signal channel.

For more information contact SIG@samtec.com

Introduction

Single-chip baseband system on chip (SoC) products with integrated data converters and RF front-end subsystems are being deployed in 5G/6G, phased array radar, SATCOM, FPGA cards, and test and measurement antennas-to-bits architectures. The development of these RFSoC devices challenges the traditional approach of using compression mount and threaded PCB connectors and cable assemblies to handle the RF signals. A simple alternative, using multiple-ganged connectors, still puts strain on form factors, weight, and financial budgets, especially as high-frequency RF channel counts increase in these SoC-based systems.

One approach is to take existing technology that was originally designed for high-performance, high-speed digital signaling and adapt it: array connectors. These connectors make it possible to route high-frequency, high-isolation RF signals as well as digital and power signals through a single connector. While these connectors are already proven in high-speed digital systems, using them for RF applications requires specific PCB stack-ups and launch optimizations in order to achieve the differential crosstalk and return loss performance required for frequencies up to 8 GHz and beyond.

This paper describes the research, development, simulation, and measurements performed to design the optimal breakout region (BOR) for the successful use of array connectors in an RF environment. **This paper specifically details the BOR for Samtec SEARAY 0.80 mm pitch SEAM8/SEAF8 10 mm stack height array connectors**.

Background

The industry is moving towards differential RF signaling to achieve the necessary noise performance at higher frequencies. Since differential signals are out of phase with each other, they have a natural noise rejection that single-ended designs do not have, essentially cancelling each other's unwanted EM fields [1]. The latest RFSoCs can handle differential RF signals, so this paper will focus on a connector BOR design using differential RF signals.

In addition, designers using these SoCs with integrated RF functionality are also looking for array connectors throughout their full system designs. This resulted in an extensive project providing reference design toolkits and characterization reports for a wide range of array connectors that were originally developed for digital applications. This project focused on redesigning the launch optimization for the RF signals, the break outs/pin outs throughout the connector, and then the stack ups and the laminates used.

Samtec Array Products

Samtec offers a variety of array connectors (Figure 1), initially designed and used in high-speed digital applications, which feature a range of pitches, stack heights, and configurations for maximum routing, grounding, and design flexibility. With these attributes, the array connectors are considered a great candidate for analog applications, which can require dozens, if not hundreds, of RF signal chains.

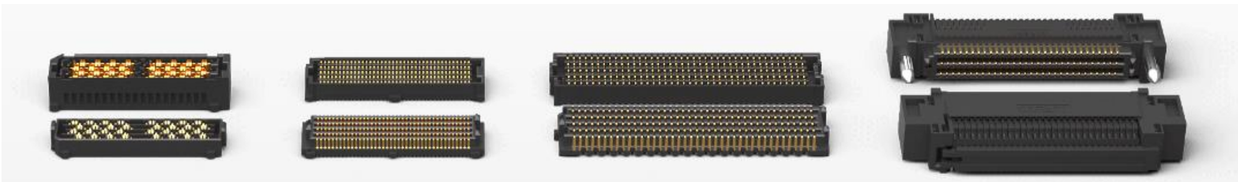

Figure 1: Samtec arrays include (left to right) NVAX (NovaRay®), SEAX (SEARAY), ADX6 (AcceleRate® HD), and SEAX8-RA (SEARAY 0.80 mm pitch Right-Angle).

The interconnects chosen for this application are intended to give customers flexibility with their design in both board real estate and stacking height. Please note that only specific stacking heights were examined and stacks not shown would require additional vetting per application.

Performance Goals

The design targets identified for this mixed-signal connector array project included:

- Maximize bandwidth for each product
- 100-ohm differential is the target unless otherwise stated
- Differential return loss of -12 dB up to 4 GHz; -10 dB up to max frequency
- Differential crosstalk isolation between channels: -70 dBc to max frequency

These performance requirements were based on the specifications from existing RFSoCs, such as the AMD Xilinx Zynq [2].

Design Details

Samtec's SEAM8/SEAF8 10 mm stack height interconnects sit on a 0.80 mm pitch for the vertical mate configuration with best analog performance using neighboring pins in-column (Figure 2).

Figure 2: Signal layout and port definition for SEAM8/SEAF8. Single-ended ports 3 & 4 (differential port 2) are used for observation, all other ports are aggressors.

The breakout region (Figure 3) uses via-in-pad to transition to stripline trace on layer 5, without backdrilling that leaves behind a 7.5 mil stub. I-TERA MT40 2x1067 is used for core and prepreg fills. The reference plane for the measurement and simulation results is 1.43 mm beyond the via transition on layer 5. RF pairs are isolated from each other by 6 grounds in-row and 4 or 2 grounds in-column. More details on the recommended BOR are available by request from sig@samtec.com.

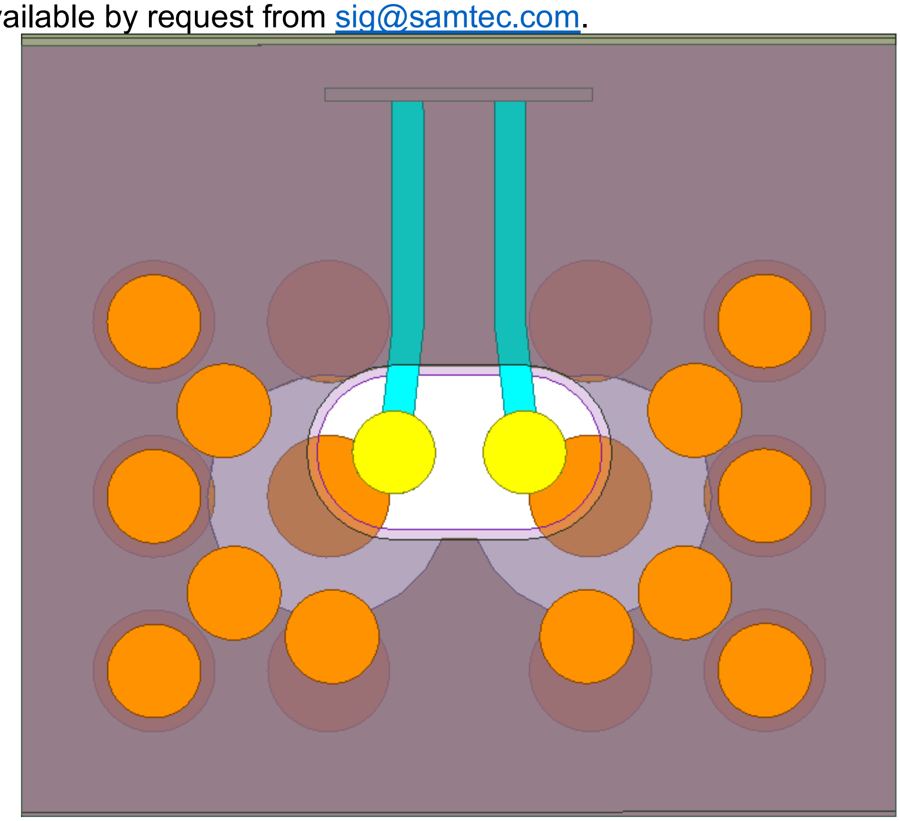

Figure 3 - Optimized BOR design for SEAM8/SEAF8.

Performance Results

Figures 4 and 5 show the differential return loss, VSWR, and crosstalk for the measured and simulated results of SEAM8/SEAF8 10 mm mated. The optimized BOR is XTALK limited to 8.2 GHz.

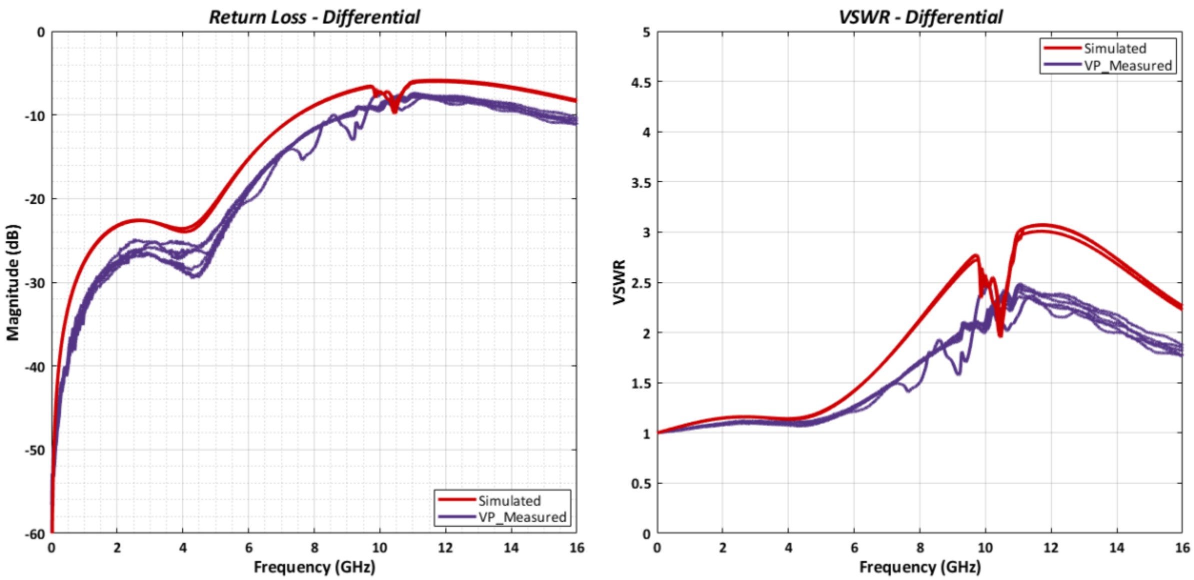

Figure 4 - Differential return loss and VSWR plots of simulated vs measured for SEAM8/SEAF8 10 mm.

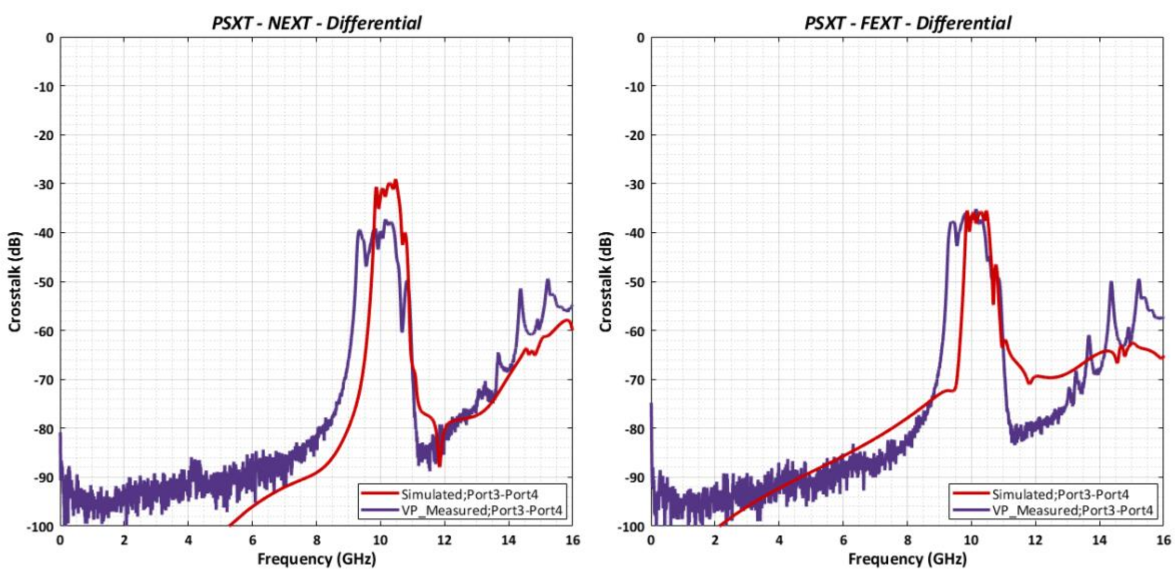

Figure 5 - Differential PowerSum NEXT and FEXT plots for SEAM8/SEAF8 10 mm.

Differential Signaling Summary

- Return Loss < -10 dB to ~8A GHz
- PowerSum XTAL < -70 dB to 8.2 GHz

More Information

For more information please see the full test report [3], ebrochure [4], and/or contact sig@samtec.com.

Resources

[1] M. Zhao. Differential Interfaces Improve Performance in RF Transceiver Designs Analog Dialogue 45-07, July (2011).

[2] Xilinx Zynq Data Sheet, p. 93.
[3] Samtec Analog Characterization Report: 0.80 mm SEARAY High-Speed High-Density Open-Pin-Field Array 10 mm Stack Height, Differential RF Analog Application, 2025.
[4] Samtec Analog over Array eBrochure, May 2023.