Flagship 1: Phased Array Demonstrator Beamforming-Based Coexistence

Nate Golding [nathan.golding@colorado.edu], Zoya Popovic [Zoya.Popovic@colorado.edu], Laila Marzall [Laila.Marzall@colorado.edu]
Department of Electrical, Computer, and Energy Engineering
University of Colorado at Boulder

BACKGROUND

Adaptive beamforming techniques are becoming increasingly popular due to their superior ability to provide precisely placed interference cancellation. Using adaptive beamforming provides an opportunity for improved spectrum sharing.

As such our phased array system seeks to provide a demonstration of the capabilities of such interference cancellation at 7-8.4GHz.

RESEARCH QUESTIONS

This work seeks to (1) Design adaptive beamforming techniques to demonstrate adaptive nulling and interference cancellation and (2) Design modulation generation, demodulation, and decoding to demonstrate link performance.

METHODS AND MATERIALS

Analog Devices Quad-MxFE provides 16-channel software defined direct RF transceivers.

Xilinx VCU118 FPGA evaluation board provides data transfer and control between the host computer and the data converter board.

MATLAB toolboxes provide assisted generation of WLAN (802.11) and 3GPP standard LTE protocols as well as other standard modulation schemes such as PSKs.

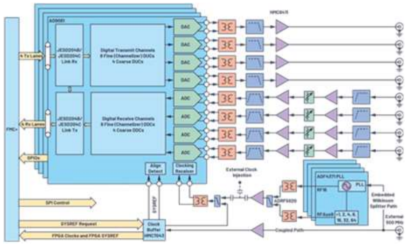

Figure 1. Analog Devices Quad MxFE Block Diagram

RESULTS

Adaptive beamforming (MVDR, LCMV) places nulls in *a priori* known interfering source directions with maximum directivity in desired source direction.

More complex techniques (Q/LCSS) place a null "trough" in an angular sector around the interfering direction, for scenarios in which interferer direction is not well known, or moves slightly with time

Link performance can be characterized at the PHY layer with bit error rate performance.

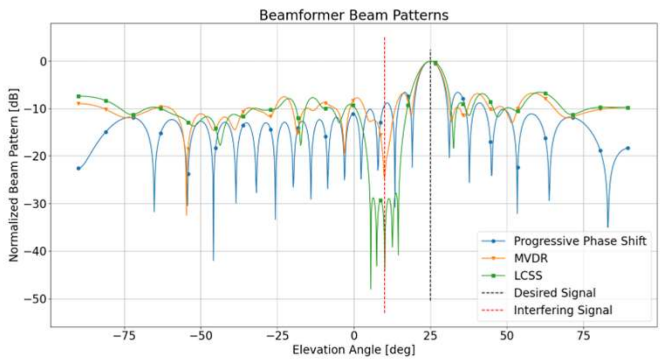

Figure 2 Resulting beam patterns for PPS (progressive phase shift), MVDR (minimum variance distortionless response), LCSS (linearly constrained sector suppressed)

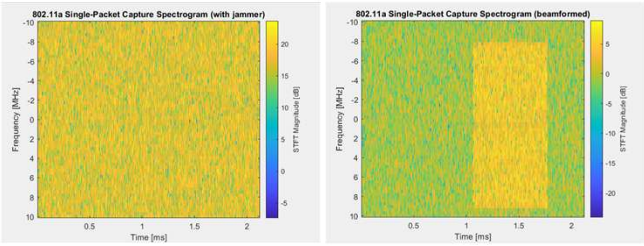

Figure 3. A spectrogram of a single 802.11a packet in the presence of a jammer of 10x the power before [left] and after [right] adaptive beamforming is applied.

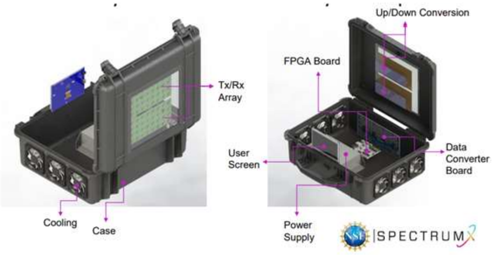

Figure 4. A preliminary depiction of the phased array demonstrator

CONCLUSION

Next Steps

- Future simulations will use tools such as HFSS to simulate coupling effects between antenna elements in the array and take those into account when performing adaptive beamforming.
- Beamforming and modulations testing performed at 3GHz with the MxFE, followed by integration with up/down conversion boards and testing at 7-8.4GHz.

ACKNOWLEDGEMENTS

This work has been supported in part through SpectrumX, the National Science Foundation (NSF) Spectrum Innovation Center, funded via Award AST 21-32700 and operated under Cooperative Agreement with NSF by the University of Notre Dame.

REFERENCES

[1] "QUAD-MxFE Platform." Analog Devices. Accessed: Apr. 4, 2025. [Online]. Available: https://www.analog.com/en/resources/evaluation-hardware-and-software/evaluation-boards-kits/quad-mxfe.html#eb-overview
[2] "AMD Virtex™ UltraScale+™ FPGA VCU118 Evaluation Kit." AMD. Access: Apr. 4, 2025. [Online]. Available: https://www.amd.com/en/products/adaptive-socs-and-fpgas/evaluation-boards/vcu118.html
[3] The MathWorks, Inc. (2024). MATLAB version: 24.2.0 (R2024b). Accessed: Apr 4, 2025. Available: https://www.mathworks.com.
[4] Harry L. Van Trees, "Optimum Waveform Estimation," in *Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory*. New York, NY, USA: John Wiley & Sons, Inc., 2002, pp. 428-710.