

Learning Phased Array Antennas with Professor Shafai: Leading to the Innovative Flat Panel Phased Array Antenna Research

Satish K. Sharma

Department of Electrical and Computer Engineering, San Diego State University, San Diego, CA, 92182-1309, USA (ssharma@sdsu.edu)

Phased array antennas are in great demand for satellite and wireless communication applications. They provide electronic beam steering by controlling/varying progressing phase shifts (C. A. Balanis, “*Antenna Theory: Analysis and Design*”, 4th ed., John Wiley & Sons, Inc., 2016). My journey with phased array antennas started in 1999 when I joined the University of Manitoba as a Post-doctoral Fellow under the tutelage of Professor Shafai. Here, I worked on a waveguide-based Ka-band phased array antenna to enhance the scan range using wide-angle-impedance-matching (WAIM) dielectric sheets (S. K. Sharma, A. Sebak, and L. Shafai, “Scan Range Enhancement using WAIM sheets for Infinite Planar Waveguide Phased Array Antennas”, *International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM 2000)*, July 30-August 2, 2000, pp. 213-216, and “Parametric Studies of WAIM Sheets for Waveguide Phased Array Antennas”, *ANTEM 2000*, pp. 459-462). Further, I also explored a phased array antenna using the far-field phase shift concept by tuning the radiating elements (L. Shafai, S. K. Sharma, Leili Shafai, M. Daneshmand, and P. Mousavi, “Phase Shift Bandwidth and Scan Range in Microstrip arrays by the Element Frequency Tuning”, *IEEE Transactions on Antennas & Propagation (TAP)*, Vol. 54, May 2006, pp. 1467-1473). These antenna projects with Professor Shafai offered me theoretical understanding, simulation, and hands-on experience.

I continued my phased array antenna research journey at San Diego State University. We have designed these antennas by creating innovative antenna apertures, beamforming networks, and beamforming algorithms. However, these antennas were connected using phase-matched RF cables and connectors (N. Labadie, et. al, “A Novel Approach to Beam Steering using Arrays Composed of Multiple Unique Radiating Modes”, *IEEE TAP*, Vol. 63, July 2015, pp. 2932 – 2945, N. Labadie, et. al, “Investigations on the use of Multiple Unique Radiating Modes for 2D Beam Steering”, *IEEE TAP*, Vol. 64, Nov 2016, pp. 4659-4670, and B. Babakhani, et. al, “A Frequency Agile Microstrip Patch Phased Array Antenna with Polarization Reconfiguration”, *IEEE TAP*, Vol. 64, No. 10, October 2016, pp. 4316-4327).

For the last eight years, we have been designing the most innovative flat panel phased array antennas using commercial beamforming integrated chips (RFICs) providing wide-angle beam steering and dual slant linear, dual circular, and polarization reconfigurable features covering wide-bandwidths at Ku/K/Ka-bands. Additionally, we have demonstrated high data throughput testing using these flat panel antennas in lab environment, outdoor 1 Km link, and over a 100,000 ft high-altitude balloon (Jia-Chi Chieh, et. al, “Development of Flat Panel Active Phased Array Antennas using 5G Silicon RFICs and Ku- and Ka-bands”, *IEEE ACCESS*, Oct 21, 2020, Vol. 8, pp. 192669-192681, R. Banerjee, et. al, “Investigations of Heat Sink Property of a Novel Dual Linear Polarized Low Cross-Polarization X-Band Phased Array Antenna Employing Silicon RFICs Based Beamforming Network”, *IEEE Open Journal of Antennas and Propagation*, Vol. 3, pp. 523-537, April 2022, C. Laffey, et. al, “1λ Spaced Dual Radiating Modes Based Phased Array Antenna Using Silicon RFICs With Grating Lobe Cancellation”, *IEEE TAP*, Vol. 70, December 2022), Page(s): 12328 – 12333, R. Banerjee, et. al, “A 22–28 GHz Polarization-Reconfigurable Flat-Panel 8 × 8 Tx/Rx Phased Array Antenna With Uniquely Arranged Novel Radiating Elements for CubeSat Communication”, *IEEE TAP*, Vol. 71, May 2023, Page(s): 4138 – 4152, and S. Das, et. al, “A Flat-Panel 8 × 8 Wideband K-/Ka-Band Dual Circularly Polarized Phased Array Antenna for CubeSat Communications”, *IEEE TAP*, Vol. 71, May 2023, Page(s): 4153 - 4166). This phased array antenna research journey will be presented during the symposium honoring Professor Shafai.