Ultra Wideband Tightly Coupled Dipole Arrays with Low-Cost Beamformers

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Tightly Coupled Antenna Array were introduced around 2009 as a way to expand the Current Sheet Arrays (CSA) beyond their 4:1 bandwidth or so. Over the past 10 years, TCDA design, scalability and fabrication have been established through the dissertations of several outstanding PhD students at Florida International Univ. and The Ohio State Univ. These TCDA arrays are the first ever conformal apertures to achieve over 30:1 contiguous bandwidth, and even 50:1 bandwidth across 200MHz to over 90GHz. This paper provides an overview of several key developments that led to the highly successful conformal TCDA arrays. We will also discuss low-cost, wide angle digital beamforming, a typical challenge for wideband arrays.

A key challenge in developing wideband arrays is the cancellation of the ground plane inductance. For TCDAs, this is done by introducing strong capacitance using the overlapping dipoles at the array's aperture. As noted by C.H. Walter in his 1965 "*Travelling Wave Antennas*" book, periodic unit cells with a suitable combination of inductors/capacitors (L/C) can lead to the formation of novel propagation modes. In his 2003 book, B. Munk provides initial thoughts for the combinations of L/C unit cells to achieve a real antenna impedance of ~180Ω at each unit cell across a 4:1 bandwidth of the CSA array. However, many more concepts had to be introduced to achieve >10:1 contiguous bandwidth and to allow for low angle scanning arrays. These include: 1) Circuit realization of the array unit cells for design optimization, 2) Removal of substrate modes across the contiguous bandwidth, 3) Slow wave theory [1] to miniaturize antenna elements, reaching less than λ/40 of element-to-element separation for low angle scanning; notably, a separation of λ/40 also implies a 20:1 bandwidth without the onset of side lobes when scanning. 3) Wideband feeds and higher impedance matching, 4) Low weight and low cost superstrates using frequency selective surfaces (FSS) as depicted in Figure 1, 5) FSS loading with reconfiguration in the substrate to increase bandwidth, and 6) Low cost egg crate fabrication method.

At the meeting, we will discuss the above techniques and their integration to achieve wideband arrays. We will also present novel low cost and low power beam formers using near 98% less power.

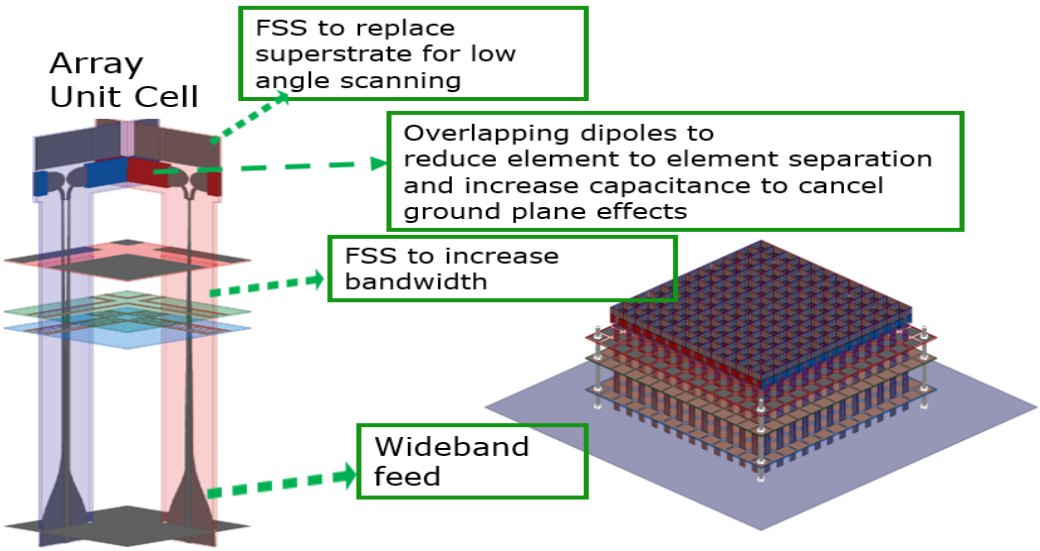

Figure 1. Components of the Tightly Coupled Dipole Arrays (TCDAs). TCDAs have been demonstrated to operate across 200MHz to 90GHz. Their scalability and scanning down to 75° has also been established.

References

[1] J. L. Volakis and K. Sertel, "Narrowband and Wideband Metamaterial Antennas Based on Degenerate Band Edge and Magnetic Photonic Crystals," *IEEE Proceedings*, Vol. 99(10), pp. 1732-1745, Oct. 2011