Unique Geometry for a Concentric Dual Band Array Antenna at S- and X-Band

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As the military continues to move towards multi-mode and multi-mission system functionality, the need for scalable multi-band antenna technology continues to grow. Currently, these missions are performed by a host of radar systems that are challenging to upgrade, costly to maintain, and difficult to network for realizing multi-mission capabilities. As part of the solution to these challenges, we have developed a concentric antenna design that incorporates a number of modes in that it gives the flexibility to radiate in two frequency bands (S- and X-band) as well as either horizontal or vertical polarization.

The S-band radiating element is a microstrip square annular ring antenna, while the X-band element is the combination of an inner patch coupled to an annular ring slot. This concentric antenna design was previously demonstrated by Dorsey and Zaghloul (M. Dorsey and A. Zaghloul, IET Microw. and Ant. Prop., 7, 283–290, 2013). Orthogonal linear polarizations are achieved by two orthogonal pin feeds at each band. In the case of the S-band element, the pin feed directly excites the annular ring, but for the X-band element, the pin feed excites a patch whose energy couples to the radiating annular ring slot.

This paper attempts to incorporate the dual band and dual polarization design of Dorsey and Zaghloul into a rectangular array. However, the dual band nature of the antenna leads to issues maintaining a half wavelength (λ) spacing between array elements. This stems from the differing values of λ at the two frequency bands. To mitigate this problem, we incorporate a concentric dual substrate approach to loading the dual band antenna. We utilize a substrate with increased permittivity (ε_r=5.0) under the S-band element and decreased permittivity (ε_r=2.3) under the X-band element. This enables us to shrink the footprint of the S-band element by 32% while maintaining the same resonance frequency. We now have enough space between our S-band elements to co-locate an additional X-band radiator. This unique approach allows us to maintain a $0.54\lambda_o$ spacing between S-band elements and a $0.7\lambda_o$ spacing between X-band elements. While still not ideal, this is an improvement over single substrate alternatives. Results of full wave simulations of a subarray of the dual band antenna (4x4 elements at S-band and 8x8 elements at X-band) will be presented. We will show the results of both uniform and binomial amplitude weighting distributions on the performance of the subarray. Furthermore, we will use these results to predict the performance of a much larger array based upon this geometry.