Design and Measurements of a 20-60 GHz Phased Array

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There is a continual desire to develop active electronically steerable antennas (AESAs) with wider bandwidths, higher operating frequencies, increased polarization diversity, higher radiated power levels, etc. Radiating apertures with high efficiency, decades of bandwidth, and dual polarizations have been developed previously (R. W. Kindt and W. R. Pickles, IEEE Trans. on Antennas and Propagation, 58, 3568-3575, 2010). However, these arrays typically operate below 20 GHz, where unit cells are on the order of centimeters in size. At these length scales, nearly arbitrary geometries can be fabricated with high precision using low cost techniques. However, there is also a strong desire to develop AESAs at mm-wave frequencies, which enables higher communication data rates and higher resolution radar. However, reducing the operating wavelength from centimeter to millimeter regimes introduces significant design challenges. In particular, the wavelength is only ~10-100 times larger than the minimum feature size that can be fabricated using standard printed-circuit-board (PCB) or low temperature co-fired ceramic (LTCC) processing techniques, which limits the design freedom.

Here, an AESA architecture is proposed that operates from 20-60 GHz and scans up to 60^o from broadside. The array consists of linearly polarized Vivaldi elements with 2 mm cell size. Infinite array simulations suggest a VSWR<2.5:1 at broadside and at scanning up to 60^o in the E, H, and D-planes. The worst case simulated cross-polarization is less than -12 dB, which occurs when scanning to 60^o in the D-plane.

A fixed-beam (broadside) version of the array is fabricated using standard PCB techniques. The fabricated prototype consists of 64 radiating elements, as well 2 dummy elements along all edges to minimize edge effects. The 8x8 array structure consists of vertical cards, each containing 8 linearly polarized radiating elements, as shown in Fig. 1. The radiating elements are connected to a single feed using a corporate power divider to enable experimental validation. The measured patterns in the E and H planes are shown in Fig. 2. The realized gain and radiation patterns agree well with infinite simulation results. In the future, transmit-receive modules will be integrated into every element of the array to enable electronic beam steering.

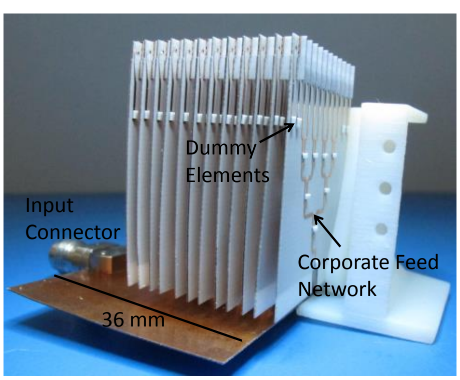

Figure 1. Fabricated fixed-beam version of the array

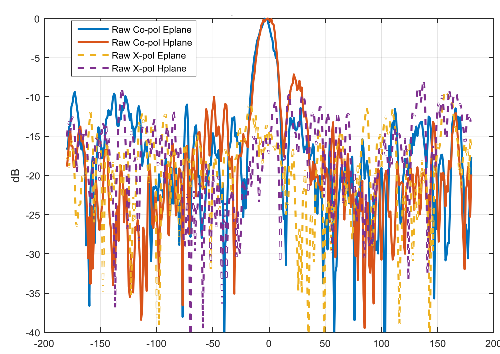

Figure 2. Measured E and H plane patterns of the passive array at 61.4 GHz.