A Low-cost and Compact X-band Near Field Antenna Measurement System

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Current and future mobile-device antennas, packaged and surrounded by circuits, render impractical conventional methods of antenna measurement that use bulky and expensive connectors. Furthermore, moving to the 5G millimeter-wave spectrum, far-field measurements require a large room if the device under test is large in comparison to the wavelength, e.g. a small-cell base station (Fredrik Rusek *et al*., *IEEE Signal Proc. Mag*., vol. 30, pp. 40-60, Jan. 2013). This is impractical and adds significant path loss (M. Alonso-delPino *et al*., *IEEE Antennas Wireless Propag. Lett.*, vol. 16, pp. 83–86, April, 2016). Therefore, a setup that can measure near-field amplitude and phase of both horizontal and vertical electric field components (in a planar system) without knowledge of the transmitted signal could be an ideal solution, especially for radiation pattern measurement of an autonomous antenna at mm-wave frequencies.

To address this challenge, we propose two interleaved arrays of slot antennas fabricated on each face of a single circuit board. On one face, there are horizontal and vertical slot antennas spaced by $\lambda/2$ to spatially sample both field polarizations emanating from an autonomous antenna. Slots on that face convert the received RF signal to a bipolar voltage, so illuminating the other face with LO (with a mixer bridging RF and LO slots) can downconvert the RF. The LO face slot antennas are 45 degrees to the RF antennas, and a simple diode quad mixer is located in the center of each slot. Narrow slits cut through the ground plane on each RF face antenna enable the IF signal to be routed to the edges of the board. Slot antennas are inherently balanced, eliminating transformers in the diode quad mixer circuit. As a prototype, we fabricated on FR4 two crossed-slot antennas having 10% bandwidth around 10 GHz, locating a diode quad mixer and testing the conversion efficiency. We then extend this single element to an array of slot mixers.