Wideband, Scanning Spiral Array for Simultaneous Transmit and Receive (STAR)

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The radio frequency (RF) spectrum has become increasingly congested and there is strong interest in spectrally efficient techniques such as Simultaneous Transmit and Receive (STAR). STAR allows systems to concurrently transmit as well as receive across the entire channel's bandwidth and therefore double data capacity (D. Bharadia et al., ACM SIGCOMM 2013, 375). Alternatively, the bandwidth can be reduced by half while maintaining the same data rate. A key challenge with STAR is suppressing transmit/receive (Tx/Rx) coupling that interferes with the receiver. As expected, Tx/Rx coupling lowers the signal to noise plus interference ratio, reducing communication reliability. Therefore, we must always maintain high isolation between the Tx/Rx paths to suppress self-interference (SI). STAR systems overcome SI through the following techniques: isolated Tx/Rx antennas, RF/analog filters, and digital filters (K. Scherer et al., 2015 IEEE Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 520-521).

We present a low profile wideband slot spiral antenna array with high Tx/Rx isolation and beam steering capability for STAR systems. To our knowledge, this is the first wideband spiral array with scanning. In order to design and fabricate such an array, we must overcome several key challenges that limit the array's bandwidth. First, to place the four-arm spiral antennas into a $\lambda/2$ spaced array, we need to miniaturize the spiral elements. Second, to maintain high isolation, it is necessary to ensure symmetry in the spiral arms, balun, and coaxial cable feeds. Third, we must maintain symmetry during fabrication to ensure high isolation.

Each 4-arm spiral element consists of two arms for Tx and another two for Rx. Our miniaturized array element is based upon a previously developed single element two-arm square spiral (B. Kramer et al., IEEE Transactions on Antennas and Propagation, vol. 53, no. 7, pp. 2193-2199). To suppress grating lobes, the element spacing is kept at $\lambda_{HIGH}/2$. Full wave infinite array simulations show the port-to-port Tx/Rx isolation is >40dB at boresight across a 3 GHz bandwidth from 2-5GHz (2.5:1). This level of port-to-port isolation reduces to about 30dB when scanning down to 30°. In addition, VSWR is < 2 and axial ratio < 3dB. A 3×3 array prototype was fabricated and tested. Results will be shown at the conference.