Wideband Pattern-Reconfigurable Simultaneous Transmit and Receive (STAR) Antenna

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Simultaneous Transmit and Receive (STAR) allows for more efficient frequency management compared to conventional systems; however, achieving high isolation between transmitting and receiving channels can be challenging. Co-channel STAR is the most problematic mode as typically utilized techniques such as time, polarization, and spatial multiplexing deplete the communication resources and the maximum benefit of true full-duplex cannot be reached. Total system isolation >100-110 dB is desired to overcome the noise floor of the receiver in low power applications. Generally, this high level of isolation is achieved by combining antenna level decoupling techniques with analog and digital isolation levels. This contribution is focused on the antenna level isolation with the goal of >40 dB for an end-fire, directional, wideband antenna with 2:1 VSWR bandwidth and co-channel, nearly identical radiation patterns. The same configuration with a simple mechanical reconfiguration can be utilized in omnidirectional mode.

The design of a 4-element circular array for a STAR system operating in the 15 to 40 GHz range is proposed first. For the initial study, the monopole antennas are realized by 2.92mm probe connectors with the extended male pin acting as a monopole. Initial design with the circular array between $\lambda/4$ and $\lambda/2$ radius at 30 GHz lacked omnidirectionality with a near 30 dB difference between max and null at horizon. To increase the omnidirectionality, a new design with an electrically connected metallic post at the center of the array is engineered. The post acts like the director of a Yagi-Uda antenna, improving the omnidirectionality to a 2 dB difference between max and null at horizon. Additionally, the post reduces the mutual coupling between the diagonal elements with initial improvement around 5 dB, which enhances the impedance match, improves efficiency, and minimizes the impact of beamforming network (BFN) imbalances on the system isolation. The BFN consists of a quadrature hybrid and three 180° hybrids to isolate the orthogonal circular modes used in the co-channel operation; Mode 0: {0°, 0°, 0°, 0°}; Mode 1: {0°, 90°, 180°, 270°}; and Mixed Mode: {0°, 90°, 0°, 90°}. The proposed mode multiplexing technique is based on the system implemented in (E.A. Etellisi, M.A. Elmansouri, D.S. Filipović, USNC-URSI Natl. Radio Sci. Meeting, 2018).

To achieve end-fire, directional operation, a mechanically steerable half-reflector configuration is integrated with the above discussed circular array. As the reflector moves, the STAR operation is achieved with minimum deterioration in isolation and high level of envelop correlation coefficient. Impact of feed-blockage, misbalances, and manufacturing tolerances on the achieved STAR performance will also be presented.