High-Level Modeling of RF Power Amplifiers and Antenna Arrays for Efficient Over-the-Air Power Combination in RF Transceivers

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SUMMARY

Efficient RF amplification and power combination are key challenges in 5G/6G transceivers. In particular, Power Amplifier (PA) designs have to balance linearity and efficiency requirements to accommodate high Peak-to-Average Power Ratio (PAPR) waveforms, and power combining networks such as Wilkinson combiners introduce insertion losses, limiting the achievable energy efficiency of the RF Front-End (RFFE). This work explores Power Combination Over-the-Air (PCOA), where four sinusoidal components are individually amplified by an RF PA operating at near saturation, driving a 4×4 patch antenna array. Though beamforming, the components are spatially power combined, in the far-field. PCOA allows more efficient PAs to be used, reduces interference to other systems, and avoids circuit-based power combiner disadvantages. A high-level system model, Fig. 1, is developed to analyse the influence of per-component power control, PA sizing, and antenna array configuration on PCOA efficiency and directivity. Nonidealities such as noise, PA distortion, impedance mismatches, path loss, and mutual coupling are considered, providing insights into optimal PA output power levels, beamforming strategies, and array design trade-offs. Simulation results show that PCOA is well adapted to beamforming, Fig. 2, decreasing RFFE losses, making it a promising technique for next-generation transceivers.

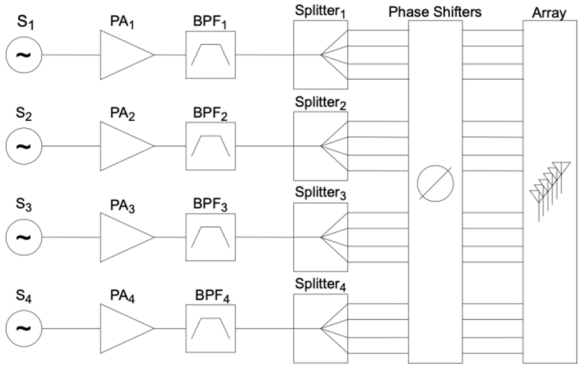
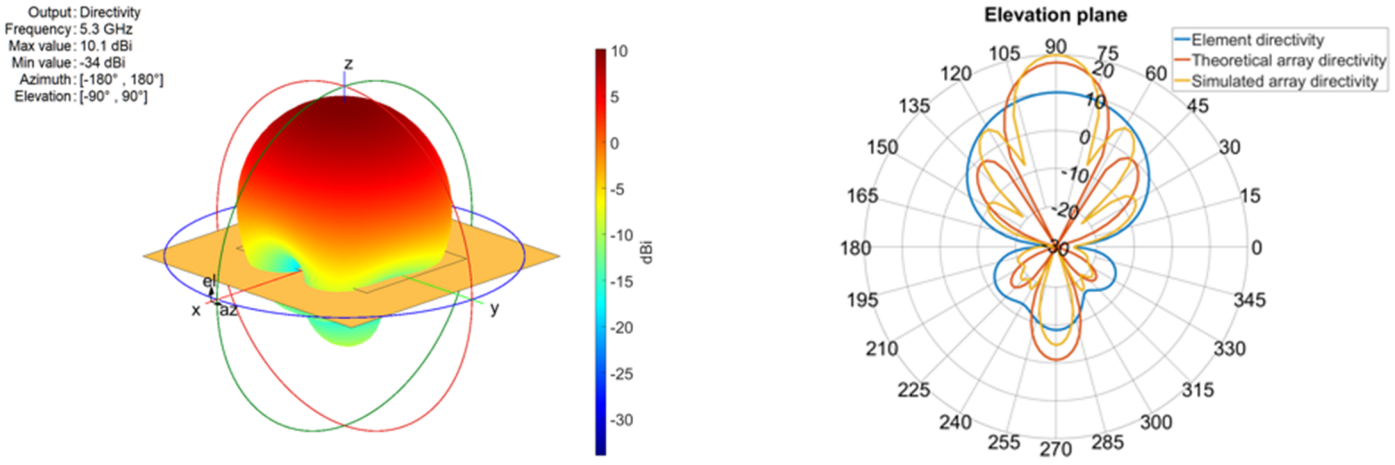


Fig. 1. Simplified transmitter block diagram.



a) b)

Fig. 2. a) Isolated Element directivity and b) array directivity-