Advanced Wide-Range Continuous Beamwidth Control in Dual-Polarized MM-Wave Antenna Arrays for 5G and beyond

Fan Chao Zeng[1], Can Ding[1] and Y. Jay Guo[1]
[1] University of Technology Sydney, 15 Broadway, Ultimo NSW 2007
email: fanchao.zeng@student.uts.edu.au; can.ding@uts.edu.au; jay.guo@uts.edu.au.

Beamwidth is a crucial characteristic of antenna radiation, determining signal coverage at specific distances. Diverse applications demand different beamwidths: narrow beams for tracking and communications, and wide beams for broadcasting and cellular system access. Frequent adjustments in beamwidth are necessary in certain scenarios. For instance, in autonomous driving, radars require wide beamwidths on highways for object detection, but need narrow beamwidths in urban areas for precise detection, ensuring safe, real-time decision-making [1]. In wireless communication, antennas with adjustable beamwidths are vital in 5G and 6G applications, facilitating network adaptation to spatial user variations dynamically [2].

This paper introduces a reconfigurable mm-wave wide-range continuous beamwidth control (WCBC) antenna array system based on the polarization-mixing method. As shown in Fig. 1, the system consists of two modules: an antenna module with four dual-polarized patch antennas and a control module with six phase shifters. Through simulation and measurement, the system's performance is rigorously verified. It excels in both scanning mode and beamwidth control modes. In scanning mode, it functions like a traditional phased array, producing tilted beams with H and V polarizations. In beamwidth control modes, it combines H and V polarizations to create wider beams, adjustable from 21° to 100° using only six phase shifters. Moreover, the beamwidth control modes enable the generation of orthogonal beams, ensuring polarization diversity despite the resultant polarization is spatially variable after polarization mixing. Notably, this design not only eliminates the need for intentional amplitude control but also proves to be resilient to amplitude errors in excitation, as confirmed by the error analysis. This design also significantly reduces power consumption, a crucial factor in mm-wave applications. Thanks to these advantages, such as wide-range beamwidth control, beam scanning, cost-effectiveness, and low power consumption, the developed WCBC system presents itself as a promising solution for applications in wireless sensing and cellular communication, particularly in mm-wave bands.

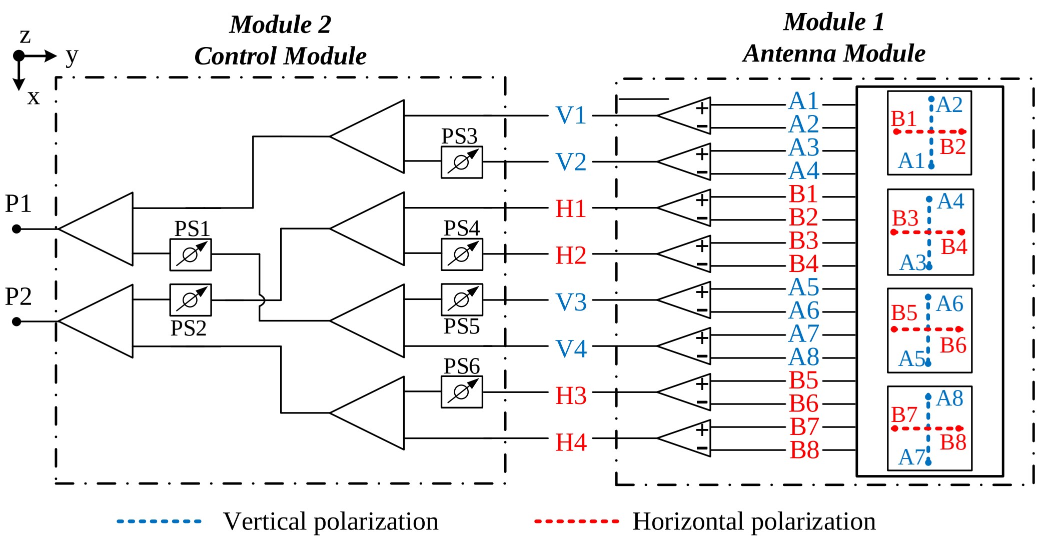

Fig. 1: Schematic diagram of the proposed WCBC antenna array system.

[1] Tagliaferri, Dario, et al. "Sensor-aided beamwidth and power control for next generation vehicular communications." IEEE Access 9 (2021): 56301-56317.
[2] Service Requirements for the 5G System—Stage 1 (rel. 15), Dec. 2017, [online] Available: http://www.3gpp.org/ftp//Specs/archive/22_series/22.261/22261-f30.zip.