

Advanced Phased Array Antenna Systems for 6G Non-Terrestrial Networks: Enabling Next-Generation Global Connectivity

Sonika P. Biswal⁽¹⁾, and Satish K. Sharma⁽²⁾

(1) VVDN Technology Pvt. Ltd, IMT Manesar, Gurugram, India, 122050

(2) Department of Electrical and Computer Engineering, San Diego State University, 5500 Campanile Drive, San Diego, CA, 92182-1309, USA (ssharma@sdsu.edu)

Emerging technologies for 6G Non-Terrestrial Networks (NTNs) focus on achieving seamless global connectivity while optimizing spectral and energy efficiency (C. T. Nguyen, et. al, “Emerging Technologies for 6G Non-Terrestrial-Networks: From Academia to Industrial Applications”, arXiv:2403.07763, Mar 2024). The high mobility of NTN platforms, such as satellites, HAPS, and UAVs, necessitates advanced antenna systems capable of precise beam tracking to ensure stable connections with both terrestrial and non-terrestrial nodes (G. K. Kurt, M. G. Khoshkholgh, S. Alfattani, A. Ibrahim, T. S. Darwish, M. S. Alam, H. Yanikomeroglu, and A. Yongacoglu, “A vision and framework for the high altitude platform station (HAPS) networks of the future,” IEEE Commun. Surv. Tutor., vol. 23, no. 2, pp. 729–779, 2021). These systems must also support the generation of multiple simultaneous beams to enhance spectrum utilization and improve user coverage. Phased array antennas have emerged as a key solution, a foundational technology enabling seamless, high-performance communication in 6G NTNs.

This paper presents the study of advanced phased array antenna systems as a critical enabler for the next generation of Non-Terrestrial Networks (NTNs), particularly in the emerging 6G communication systems. This investigation explores the design scope and challenges of advanced phased array antennas tailored for NTN platforms, including low-earth orbit (LEO) satellites, high-altitude platform systems (HAPS), and unmanned aerial vehicles (UAVs). Their capability encompasses offering electronically steerable beams, supporting multi-beam operations, and adapting to dynamic environments. For this purpose, a novel hemispherical antenna array (HAA) design is being considered for 3GPP NTN FR2-0/FR2-1 (K- and Ka-band). This involves strategically distributing the antenna elements across the hemisphere, ensuring proper alignment of the user with the specific element, thus achieving maximum gain for all users. Considering the enabling high-capacity, low-latency, and energy-efficient communication, the advanced phased array antenna system is proven to be a cornerstone for realizing the full potential of 6G NTNs (S. K. Sharma and J.-C. S. Chieh, Multifunctional Antennas and Arrays for Wireless Communication Systems. NJ, USA: Wiley, Apr. 2021.). The simulated results and analysis of the designed HAA will be presented during the symposium.