

Recent Development in Ultra-Wideband Tightly-Coupled Phased Arrays for Future Integrated Communications, Sensing and Imaging

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Ultra-wideband phased array antennas are promising for future multi-function systems integrating communications, sensing and imaging onboard smart terminals (airplane, UAV, cars, satellites, trains, ships...) in 6G and beyond. The past few decades saw rapid development of wireless communications, radar and imaging systems using more and more frequency bands, together with more and more antennas and arrays. As antenna is a key component of any wireless systems, it is necessary to develop one single ultra-wideband multi-polarized phased array capable of receiving and sending multiple beams over an ultra-wideband frequency range for multiple systems *e.g.* communications, sensing and imaging. Such an antenna could replace numerous separate antennas and arrays, hence leading to significant reduction in size, mass and complexity of antenna systems onboard smart terminals.

During recent decades, many research programs on this topic have been carried out. For example, Advanced Multifunction Radio Frequency Concept (AMRFC) Program, funded by US Office of Naval Research, aimed to demonstrate the integration of numerous types of shipboard radio frequency functions including radar, wireless communications, and electronic warfare utilizing a common set of wideband array antennas, signal and data processing, signal generation, and display hardware. Recently, the “Advanced Antenna Technology for a Smart World” Project, funded by Hong Kong Research Grant Council under the Area of Excellence (AOE) scheme, was launched. One of objectives of this AOE project is to develop compact-size ultra-wideband multi-polarization phased arrays for integrated communications, sensing and imaging in 6G and beyond.

This talk will provide a review of recent developments and future trends in ultra-wideband phased array antennas using tightly coupled dipole array (TCDA) techniques. TCDA has emerged as a very popular technique for realizing phased arrays with ultra-wideband performance and wide-angle scanning. Numerous designs and implementations of TCDA have been reported during the past few decades. TCDAs are primarily categorized into two types: vertically integrated and planar integrated. The vertically integrated structure encounters challenges due to high input impedance, necessitating complex feed networks, which result in significant losses, high processing accuracy requirements, and bulky volumes for low-frequency applications. To eliminate common-mode resonance, resistive materials are often loaded, but this reduces radiation efficiency and gain while increasing costs. The planar structure relies on PCB technology and is suitable for high-frequency applications, however, it requires filling with a support dielectric layer, leading to high costs. Additionally, it necessitates the design of broadband impedance matching circuits and dense shorting posts, adding to its complexity. Furthermore, the integration of shorting posts results in the emergence of low-frequency loop modes, which subsequently constrains bandwidth performance and deteriorates polarization isolation. In summary, TCDAs still confront a series of challenges and urgent problems to be solved, including reducing the profile of the antenna array, simplifying the feed structure, enhancing broadband high polarization isolation performance, achieving modular and planar layout, as well as addressing the lightweight and low wind load design of the array.

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