Joint Time and Frequency Design of Ultra-wide Band Tightly Coupled Circularly Polarized Spiral Arrays

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Antenna arrays have been used from HF band through terahertz frequencies for applications including communications, radar, imaging, and electronic warfare, just to mention a few. Traditional approach in designing wideband arrays is to miniaturize the unit cell and reduce the coupling so that the greatest scanning coverage without appearance of grating lobes is achieved. Recent research papers and reports have shown that the coupling between the antenna elements can be exploited to achieve not only increased scanning impedance bandwidth but also greater coverage without the appearance of grating lobes. That said, weather narrowband or wideband, the overall performance of any antenna array is related to the array topology, unit cell performance including the spacing and coupling between the neighboring unit cells.

In this paper, the above mentioned factors are considered to achieve a wideband spiral array design with simultaneously good time and frequency-domain performance. First, a detailed array factor study is conducted to choose the array configuration. The performance of finite size rectangular, circular, and hexagonal arrays is investigated. A conclusion relevant to the optimum array configuration is presented. Then, a performance comparison between two- and four-arm spiral arrays is introduced. The effect of multi arming and spiral topology on the overall performance of the array is discussed. The combined power spiral antenna topology which joins a conventional Archimedean spiral at the inner part and the novel power spiral topology at the outer part is used as a unit cell for the two-arm spiral antenna array. The frequency- and time- domain performance improvements achieved with combined power spiral compared to a well-designed regular Archimedean spiral antenna are discussed. A four-arm Archimedean spiral antenna with a simplified mode 1 beam-former network is proposed and then considered to reduce the complexity of the commonly used four-arm spiral array feeding network. Finally, the effect of coupling between the spiral elements is analyzed. Despite its negative effect on the axial ratio performance, the tight coupling is considered for this design to reduce the size of the array and improve the bandwidth of operation. The proposed array shows low-dispersion behavior and good frequency-domain characteristics and can be considered for traditional and ultra-wideband (UWB) pulsed radar and sensing applications.