Broadband Antenna Arrays Using Frequency Selective Feeding Networks

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While recent developments in electronic warfare applications call for multi-octave spectrum coverage, the realization of the necessary RF hardware remains a great challenge. This is particularly critical for the antenna elements of these systems, due to input-reflection and radiation characteristics being frequency dependent. Despite recent progress in the design of broadband antennas (e.g, Vivaldi, spiral and broadband monopoles) and antenna arrays, most of these concepts optimize frequency bandwidth (BW) for low input reflection (<10 dB) while their radiation characteristics and most importantly their half-power beamwidth (HPBW) vary significantly with frequency. This is shown in Fig. 1(a) for the example case of a four-element half-wave dipole antenna array (omnidirectional cut) whose total length is $0.55\lambda_{low}$ (uniform element spacing $0.183\lambda_{low}$)—λ_{low} is the wavelength at the low-end of the frequency range. The HPBW varies from 23.9º-76.8º (105%) for a 3:1 BW and from 17.9º-76.8º (124%) for a 4:1 BW.

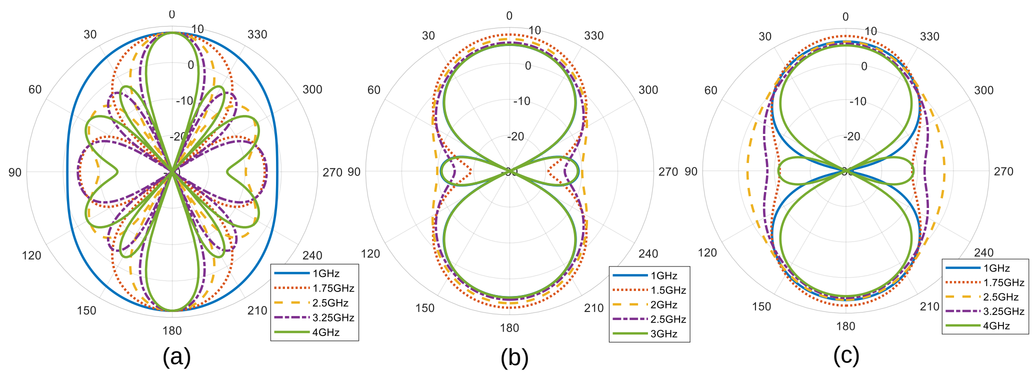

Fig. 1: Gain patterns of: (a) uniformly-spaced and uniformly-fed elements. (b) uniformly-spaced and non-uniformly-fed elements. (c) non-uniformly-spaced and non-uniformly-fed elements.

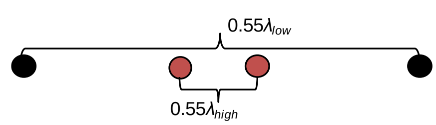

Fig. 2: Non-uniformly-spaced elements.

Taking into consideration these limitations, this paper presents a study on the design of linear antenna arrays with constant HPBW. For proof-of-concept demonstration purposes, a four-element array and passive RF feeding networks are considered. The proposed approach is based on: i) feeding networks with frequency dependent characteristics—non-uniform feed—and ii) non-uniform element spacing. The proposed feeding network shifts power from the outer array elements to the inner ones as a function of frequency with the goal of maintaining constant HPBW and low side-lobe level (<15 dB). This in practice translates to the outer elements being fed by a first-order low-pass filter whereas the inner elements are fed by a first-order high-pass filter. Fig. 1(b) shows the effect of incorporating low-/high-pass filtering in the antenna feeding network, which results in a constant HPBW of 54º within a 3:1 BW while Fig. 1(c) demonstrates the effect of non-uniform feed and non-uniform element spacing—the inner elements' spacing is ¼ of the outer, as shown in Fig. 2—which results in a constant HPBW of 54º for a 4:1 BW. Further results on this study for even-/odd- number of elements, alternative element spacing and the effect of coupling will be shown at the conference.