TECHNIQUES FOR SCANNING THROUGH BROADSIDE WITH PERIODIC LEAKY-WAVE ANTENNAS

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Periodic leaky-wave antennas are useful for beam scanning applications, since one of their natural characteristics is that the beam scans with frequency. In fact, by using a suitable design, a single beam can be produced that scans from backward endfire to forward endfire as the frequency increases. The antenna is usually designed so that the dominant $n = 0$ space harmonic (or Floquet wave) is a slow wave that does not radiate over the frequency range of interest, with radiation occurring through the $n = -1$ space harmonic.

One of the well-known limitations of these types of antennas is that the beam degrades as it is scanned through broadside. This seriously limits the versatility of these types of antennas. The beam degradation is due to an "open stopband" at broadside. Near the frequency at which the beam points to broadside, a stopband usually occurs on open (radiating) structures, due to contradirectional coupling between forward and backward space harmonics. Within the stopband region the attenuation constant of the leaky mode changes rapidly, and usually drops sharply to zero exactly at the frequency for which $\beta_0 p = 2\pi$, where p is the period and β_0 is the phase constant of the dominant $n = 0$ space harmonic. At this frequency the leaky mode turns into a perfect standing wave, and there is no propagation of power down the waveguiding structure or radiation from the structure. Techniques to mitigate the open stopband are thus of great importance, since they would enable a continuous beam scan through broadside.

In this presentation, several methods for reducing or eliminating the open stopband at broadside for printed periodic leaky-wave antennas will be reviewed. One of these is the use of a metamaterial leaky-wave antenna structure, as proposed by Eleftheriades [G. V. Eleftheriades, A. K. Iyer, and P. C. Kremer, "Planar Negative Refractive Index Media using Periodically Loaded Transmission Lines," *IEEE Trans. Microwave Theory Tech.*, vol. 50, pp. 2702–2712, Dec. 2002], and by Caloz and Itoh [L. Liu, C. Caloz, and T. Itoh, "Dominant mode leaky-wave antenna with backfire-to-endfire scanning capability," *Electron. Lett.*, vol. 38, pp. 1414–1416, Nov. 2002]. This structure is quasi-uniform, and radiates from the $n = 0$ space harmonic. Full-wave simulations reveal that this type of structure can eliminate the open stopband, when it is properly optimized by full-wave simulations. However, it is also shown that novel types of "classical" leaky-wave antennas that radiate from the $n = -1$ space harmonic can also be designed that eliminate the open stopband. Two different types of printed planar periodic leaky-wave antennas will be introduced that have this interesting feature. One design uses a U-shaped stub within the unit cell. The other design is based on impedance transformers, which ensures a continuous Bloch wave impedance as the beam is scanned through broadside.