ALTERNATIVE IMPLEMENTATION OF RECONFIGURABLE METAMATERIAL-BASED LEAKY-WAVE APERTURES

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The backward wave propagating capability in left-handed metamaterials (LHMs) is commonly used in leaky-wave antennas. By combining forward and backward wave propagation, a metamaterial-based leaky-wave antenna has an advantage for full space scanning, while a conventional leaky-wave antenna can scan only a half space. In addition, when varactor diodes are loaded on this periodic antenna, it provides additional functions while maintaining a full space scanning capability.

The radiation direction can be controlled by the varactor diodes voltage at a fixed frequency. Furthermore, the beamwidth can also be controlled in two different electronic manners. In this paper, the two methods will be discussed and compared to each other.

In both methods, the beamwidth controllability is possible because the propagation constant of each unit cell can be independently controlled. The first way to control beamwidth is achieved by distributing a non-uniform beamdirection from each unit cell. Each beam is combined into a total beam pattern based on an array factor. In the second method, beamwidth control can be achieved by changing the radiation aperture size. A leaky-wave aperture can be made non-radiating if the operating point of structure is in the slow wave region but can be made radiative if the operating point is in the fast wave region. Therefore, the radiation aperture size is determined by the size of the structure that is in the fast wave region. Due to the independent electronic controllability of each unit cell, any portion of the structure can be made either radiative or non-radiative region.

In terms of radiation efficiency, the first method is more efficient because all unit cells radiate so that a higher gain is achieved with the same beamwidth. In the second method, the gain is lower since only a portion of the structure radiates. Directivity is lower also. However, in the second method, the non-radiating aperture can be used as either a phase delay or phase advance line. In the proposed structure, it is shown to be used as a phase advance line operating in the slow wave region. A wide phase tuning range is observed in the left-handed region. The integration of a phase shifter and a leaky-wave antenna simplifies a scanning array system. The bias ranges of the varactor diodes are different in both cases. In the first case, variable bias is given depending on the location of the unit cell. In the second case, a uniform bias is given over the nonradiating section, while a differently uniform bias is applied over the radiating section for a given radiation direction.

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