Waveguide Narrow Wall Longitudinal Slot Array for High Power

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The array consists of two identical waveguide narrow wall longitudinal slot arrays (single arrays) with a common broad wall. The single arrays are such that the slots in one guide alternate with those in the other and the phase in one guide is shifted from the other appropriately. The dominant mode E-field's value is minimum on the narrow wall of each single array; hence the array is capable of handling high powers. Each slot (array element) is equivalent to a fictitious magnetic dipole oriented along the waveguide axis. The waveguide slot array is to be front-mounted (approximately vertically) on a land vehicle to obtain the desired orientation for the radiation pattern and polarization. Each single array has 4 slots and an end structure. The design objectives are: to maximize the peak directivity of the fan beam radiation pattern and to minimize the reflection coefficient at the mouth of the waveguide. The simulated antenna array (shown in figure 1) was designed to operate in the X-band at 10GHz. The final design of the array at 915MHz can then be obtained by appropriately up scaling the dimensions of this array.

The designed end structure has its length very close to the first resonant length and a flare out in the narrow dimension along with a gradual taper in the broad wall thus closing on itself, resulting in a very low reflection coefficient and very similar radiation pattern to the rest of the slots. Since theoretical analysis is not tractable when the slot dimensions are not electrically small, the design process was started in HFSS with single slot simulations. By varying the slot dimensions, the resulting two port S-parameters and E-field phase at the center of the slot were recorded with and without a waveguide taper in the narrow wall of the waveguide. This data was then exported to an optimization routine written in MATLAB. The routine uses microwave network analysis to design a uniform linear array with a minimal input reflection coefficient. The data from each single slot simulation was treated as data from a lossy two port network, the lossy element being the radiating slot. The routine then simulates the mutual coupling between the elements through the waveguide to optimize for the three design criteria: (1) equal radiated power from each element, (2) a progressive phase variation between the array elements, and (3) minimum reflected power at the mouth of the waveguide. The design variables are the slot dimensions, distance between the slots, and narrow wall taper.

Although each slot is designed to radiate the same amount power, the ratio of the power radiated to the power available for any slot is different. It is also difficult to satisfy the three design criteria for the same values of the design variables; hence a best compromise might be necessary. At 10GHz the optimized slot lengths (widths) ranged from 14mm to 15mm (1.5mm to 4.5mm). The optimal spacing between the slots was $11\lambda_g/16$. A full wave analysis of the array with these optimized values was performed in HFSS and the results agreed well with the MATLAB results for the design criteria. Experimental verification of the radiation pattern and S-parameters of the array elements is under way.

Figure 1. Waveguide narrow wall longitudinal slot array.