

Single-Polarized, Dielectric-Free, Vivaldi Tapered Slot Phased Array: Performance Prediction

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A single-polarized, dielectric-free, balanced-fed Vivaldi tapered slot array with backside reflector is a promising antenna candidate for large, broadband phased arrays with high performance. In contrast to antennas on dielectric substrates, the dielectric-free configuration is cheaper and easier to fabricate. This work reflects a preliminary study of such a phased array antenna to be potentially employed in the THousand Element Array project (THEA) for an advanced radio telescope.

The metal fin elements are intended for use with receivers that require a balanced input simulated with a delta gap voltage generator across the slotline near the square cavity (Fig. 1). The array's active input impedance has been calculated versus the geometrical parameters, frequency band and scan angular directions. The program used here for computing the active input impedance of the array is based on the Green's-function full-wave moment-of-method (MoM) formulation [1]. It treats the infinite phased array by analyzing the unit cell in detail and by using the geometrical periodicity in the array structure. We use the FORTRAN computer code called TSAAIR for analyzing Tapered Slot Antennas with AIR dielectric [1].

To apply effectively the MoM code, a Matlab code has been recently developed to automate the process of mesh generation for roof-top basis functions with rectangular and parallelogram patch support covering the fin area. The Matlab mesh generator code enables good fitting of the slot geometry and maintains continuity of surface current everywhere on fin surface, including the borders between neighboring array elements. A sample of the mesh used for numerical analysis is presented in Fig. 2 for the antenna with square shape of the slotline resonator cavity.

To improve the array's broadband behavior, we have changed some of the geometrical parameters in array following the guidelines presented in [2] for dielectric-filled antennas. The key parameters for improving performance are the size of the resonator cavity and the exponential factor for the slot profile. The performance of an optimized design is shown in Fig. 3. Further improvement in antenna impedance matching can be achieved with a simple compensation of the input reactance by a series capacitor. Such a design is compatible with the

placement of low-noise input amplifiers directly in the slotline region of the fin element. By using a series capacitance of 8 pf and a characteristic impedance of 120 ohms, VSWR < 1.7 for more than 6:1 frequency range (0.25 - 1.6 GHz) at broadside scan angle.

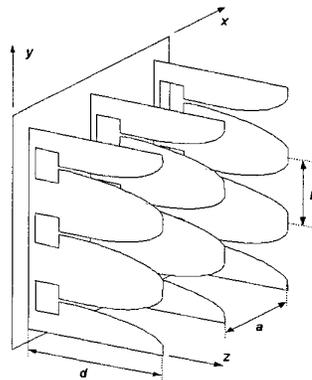
Conclusions

Preliminary results demonstrate that tapered slot antenna arrays without dielectric, i.e., with air dielectric, can yield excellent wideband performance. These antennas can be easily scaled to operate in arbitrary frequency ranges with same relative bandwidth coverage. Antennas that use microwave substrates generally experience restrictions to frequency scaling because available substrates are produced in discrete thicknesses. The metal fin arrays also do not suffer some of the resonance effects that occur in the dielectric region of stripline versions. Furthermore, metal fin arrays do not require expensive microwave dielectrics and should be less expensive to fabricate.

References

- [1] D. H. Schaubert, "TSAAIR - Analysis of Tapered Slot Antennas with Air Dielectric", Report, Elec. & Comp. Eng. and Applied Technology Center, University of Massachusetts, Amherst, MA, December 1991.
- [2] J. Shin, D. H. Schaubert, "A Parameter Study of Stripline-Fed Vivaldi Notch-Antenna Arrays", IEEE Trans. on Antennas and Propagation, Vol. 47, No. 5, May 1999, pp. 879-866.

Figure 1. A small portion of infinite, single-polarized, balanced-fed dielectric-free Vivaldi fin slotted phased array with backside reflector.



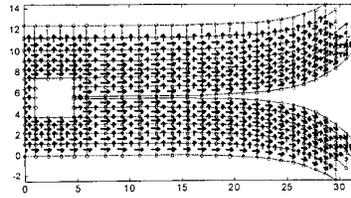


Figure 2. A sample of fin mesh for parallelogram-supported roof-top modes.

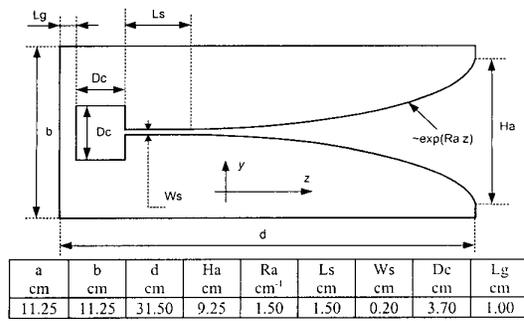


Figure 3. Dimensions of optimized antenna element.

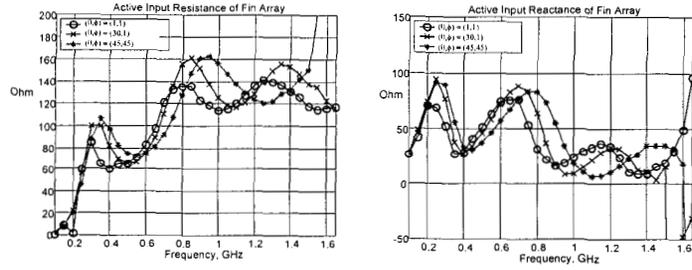


Figure 4. Active input impedance of infinite array for three scanning directions with optimized fin geometry.

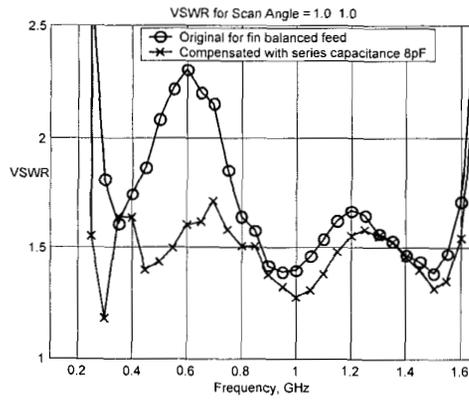


Figure 5. VSWR improvement resulting from 8 pF series capacitance at the feed point.