DESIGN OF A TAPERED CHAMBER FEED USING THE FDTD METHOD

Kwan-Ho Lee, Chi-Chih Chen, and Robert Lee
ElectroScience Laboratory
Department of Electrical and Computer Engineering
1320 Kinnear Road, Columbus, OH 43212 USA
Lee.146@osu.edu

Introduction

The development of tapered chamber systems has been gaining popularity in recent years because of its relatively small size and inexpensive cost. Typical tapered chamber designs available in industry work from 500 MHz to 40 GHz; however, the major limitations are at the lower frequencies. It is very difficult to develop a good system below 400 MHz. A critical component to push these systems to lower frequencies is the design of the antenna feed structure. Recently our group proposed a new feed design, which we called the dual polarimetric aperture matched blade mode bowtie (ABB) antenna [1]. This antenna allowed the chamber to operate down to 200 MHz, but there was concern about significant attenuation of the signal at the lower frequencies. In this work, we present an improved design that addresses many of the deficiencies of the original ABB antenna. Much of the development of this new design was accomplished through an understanding of the antenna characteristics based upon numerical simulations. In this work, all of the simulations were performed with our own finite difference time domain (FDTD) code. Numerical results will be presented in this paper to demonstrate the capabilities of the new feed design. Finally, the feed was constructed, and measurement results are presented for this antenna.

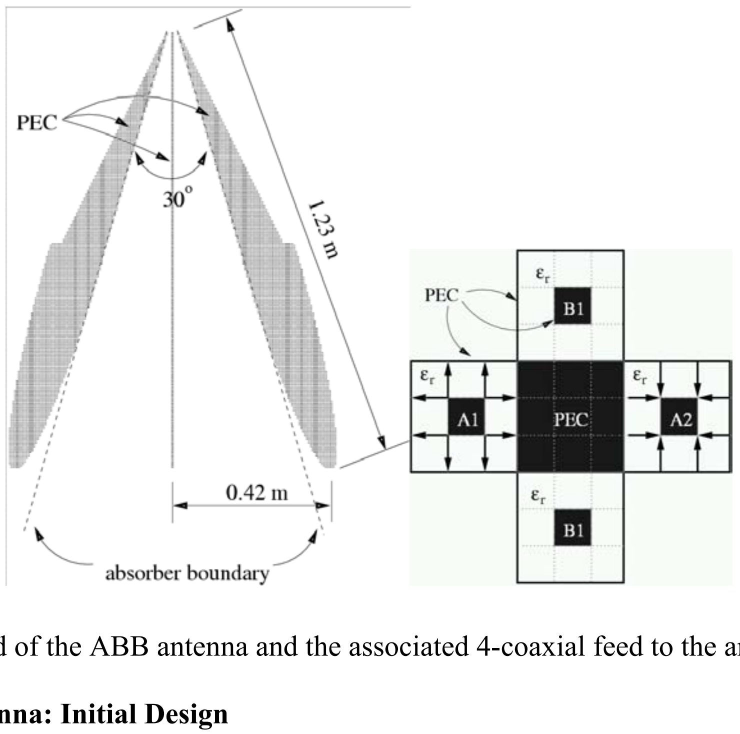

Figure 1. FDTD grid of the ABB antenna and the associated 4-coaxial feed to the antenna.

Blade Bowtie Antenna: Initial Design

The geometry for the initial design of the feed in [1] is shown in Figure 1. This figure also contains the actual FDTD grid used in the simulation. It should be noted that the dual polarimetric nature of the feed requires four blades located 90 degrees apart, but in the figure only two blades are shown for ease of viewing. The blades on the feed structure flows smoothly into the absorber. This

ISBN: 4-88552-207-2 C3055©IEICE

antenna generated fields that are uniform in magnitude and phase within a relatively large region of the tapered chamber over a wide frequency band. However, a major problem with this design is the low level of radiated power at low frequencies within the tapered chamber produced by the feed. With the use of the FDTD code, the scattering parameters of the feed are calculated and presented in Figure 2. Note the drop off in S_{21} below 500 MHz. There are two main reasons for this drop off. One cause is the lossy absorber, which is placed directly against the ABB feed antenna. The second cause is the small opening at the apex of the cone. Due to the small opening the apex of the cone acts as a waveguide operating below cutoff. To reduce the effect of the absorber, the absorber material was removed from the feed region of the ABB antenna. Various absorber configurations were considered with progressively more absorber material removed from the apex region (Cases 1 through 4) in the FDTD simulation. In Figure 3, the electric field is plotted 5 feet from the apex within the tapered chamber. Within the figure, the ABB is represented by the color brown, and the absorber is given in yellow. Note that as more absorber material is removed, the higher the value of the field. At the lower frequencies, we gained over 30 dB between Case 1 and Case 4 without significantly affecting the field distribution within the tapered chamber.

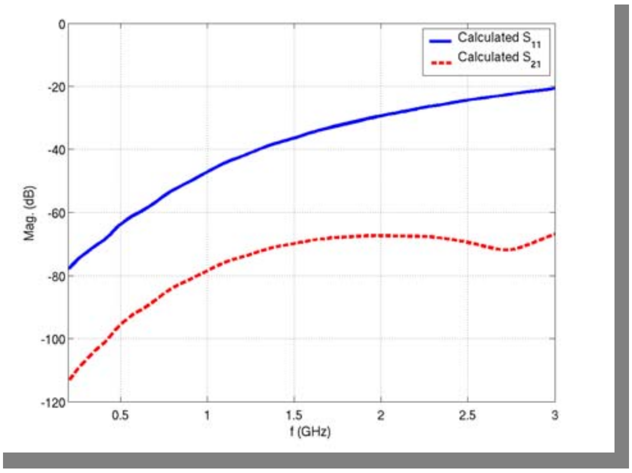

Figure 2. Plot of the scattering parameters of the ABB antenna.

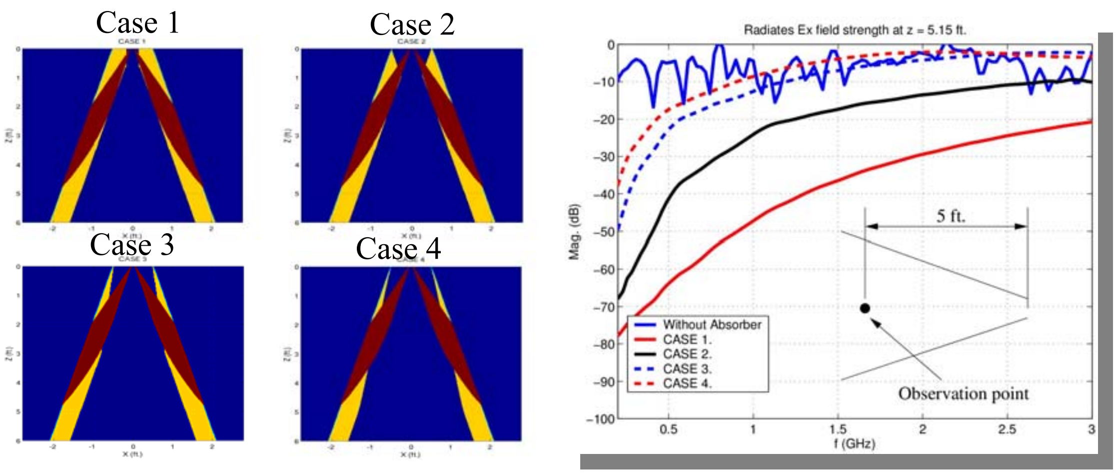

Figure 3. Plot of the electric field 5 feet from the apex of the tapered chamber for the four cases displayed. The brown represents the ABB antenna and the yellow represents the absorber.

To address the second cause of the field drop off, we use the concept of a ridge waveguide. In a ridge waveguide, the ridge does not really change the cutoff frequency of the guide. Thus, by placing a ridge in the blades of the ABB, we are able to place the blades close to each other without having such a low cutoff frequency in the apex region. The modified blade geometry is shown in Figure 4 along with the resulting plot of the electric field 5 feet from the apex. The field drop off has been virtually eliminated down to 200 MHz. To demonstrate the uniformity of the field distribution near the field structure, we plot both the magnitude (Figure 5) and phase (Figure 6) of the electric field in the FDTD simulation at 200 MHz and 500 MHz. Based on the excellent simulation results, we constructed the improved ABB antenna. In Figure 7, a comparison of the magnitude of the H-plane patterns between measurements and simulations is provided at a number of frequencies. The results are close, validating the design based on simulations.

Conclusions

An improved design of the ABB feed antenna was presented. The new design was primarily achieved through the use of numerical simulation tools to understand how the antenna performed as various parameters were changed. The simulations also provided significant physical insight into determining the causes for the poor radiated power from the antenna. By modifying the absorber layout around the ABB and by adding a ridge to the blades of the antenna, superior performance was achieved. Meaurements of the resulting antenna confirmed the performance predicted from the simulations.

Reference

[1] K.H. Lee, C-C. Chen, F. Teixeira and R. Lee, "Numerical Study of a UWB Dual-Polarized Feed Design for Enhanced Tapered Chambers ", IEEE AP-S International Symposium, Columbus, OH, June 2003.

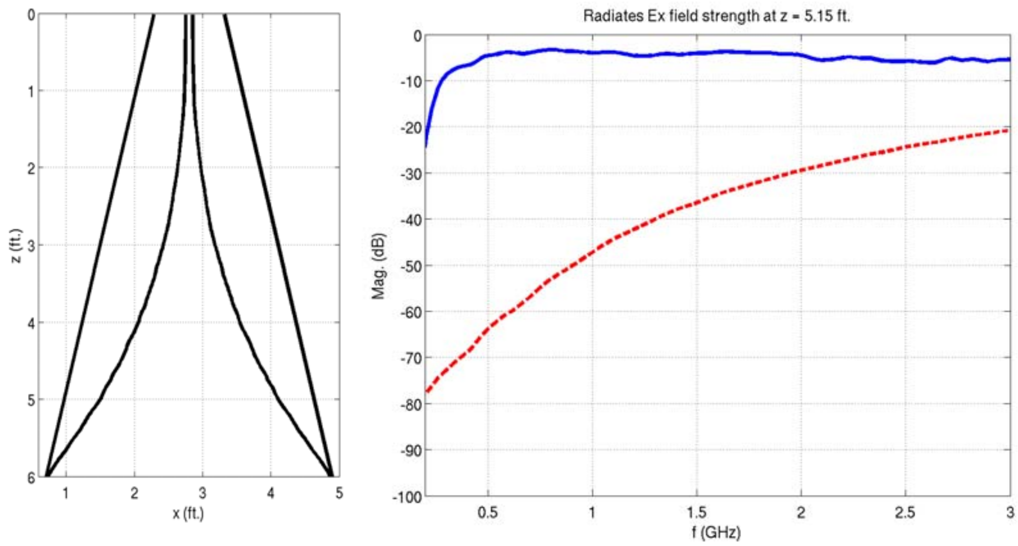

Figure 4. Improved design of the blades (left) and the resulting electric field 5 feet from the apex. The blue curve represents the improved design results, and the red curve represents the initial design.

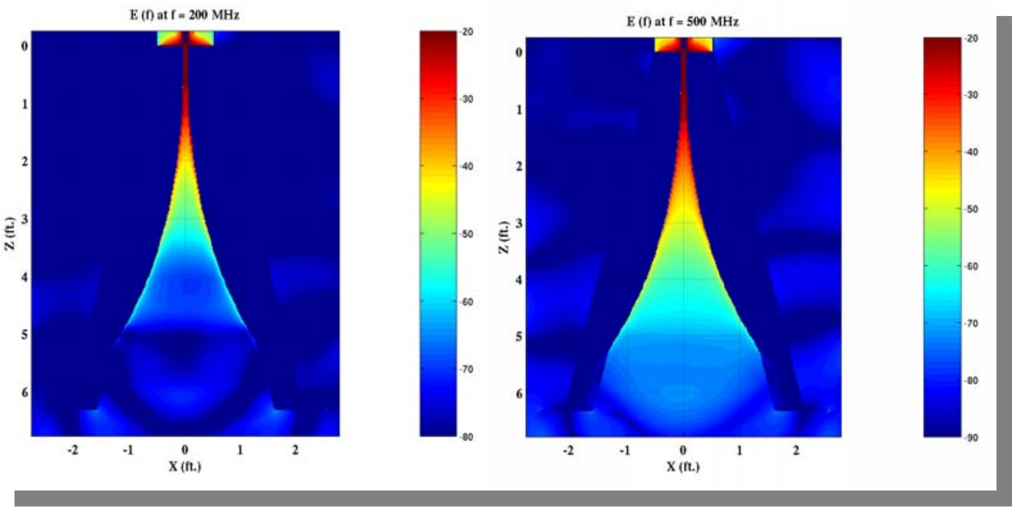

Figure 5. Plot of the magnitude of the electric field distribution near the feed at 200 MHz (left) and 500 MHz (right).

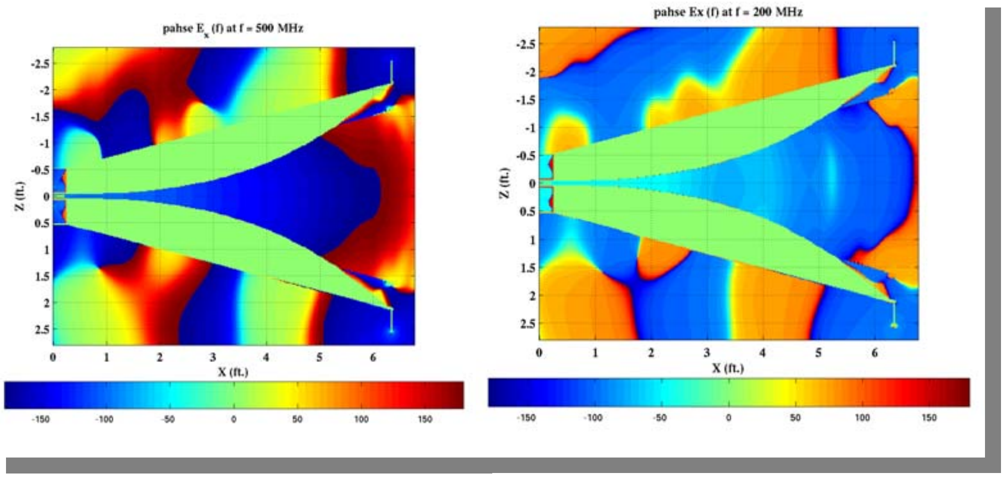

Figure 6. Plot of the phase of the electric field distribution near the feed at 200 MHz (left) and 500 MHz (right).

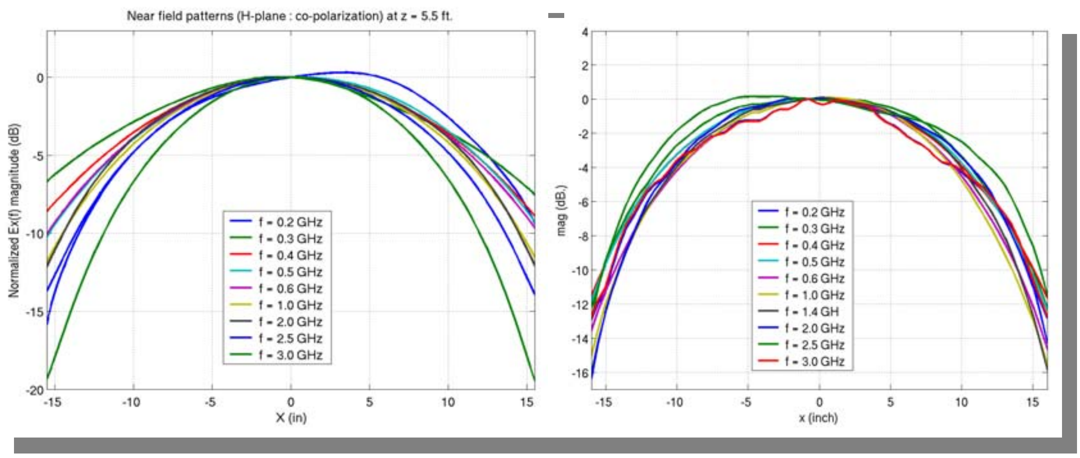

Figure 7. Plot of the H-plane field 5.5 feet from the apex from measurements (left) and simulation (right).