Magnetic Field Distributions at Close Proximity of a Tapered Slot Antenna

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Abstract : The magnetic field distribution at close proximity of a linearly tapered slot antenna was measured for several frequencies ranging from 2.3 to 10.8 GHz. These results provide some insight into the radiation mechanism of this type of antenna.

INTRODUCTION

A tapered slot antenna (TSA) is an endfire, travelling wave antenna which possesses most of the attractive features of a microstrip antenna, such as low cost, easy fabrication and low profile. The TSA is also capable of moderate gain and very broad bandwidth, but does not have the versatility of the microstrip antennas in design for multifunction operations such as dual frequency, dual polarization etc. Previous work on TSA has been mainly focused on its performance characteristics [1,2]. Up to this date, there is still no established guideline for designing TSA because of lack of understanding exactly how the antenna radiates its energy. The radiation mechanism of the TSA has been attributed to leaky waves by some researchers and surface waves by others [3,4]. This ambiguity has impeded the progress in the development of these antennas for potentially much broader applications. As an attempt to better understand the radiation processes in the TSA, we have measured the magnetic field distributions at close proximity of a linearly tapered slot antenna (LTSA). In this paper, we will present and discuss the results of this measurement.

EXPERIMENT

As shown in Figure 1, the LTSA was excited with a ground-signal microwave probe (Picoprobe Inc.) and the magnetic field strength measurement was made by moving a coaxial probe along the LTSA. Both the probes were connected through flexible coaxial cables to a HP8510C network analyzer which recorded the relative field strength. The LTSA with length $L = 2.54$ cm and semi-flare angle $\alpha = 10^\circ$ was fabricated on 10 mil thick RT/Duroid of relative dielectric constant $\epsilon_r = 10.5$. The coaxial probe was constructed from a semirigid coaxial cable with the center conductor extended to form a circular loop and soldered to the outer conductor. The magnetic field distribution of a LTSA at different frequencies was measured with the coaxial probe held perpendicular to the magnetic field line at a distance of approximately 1 mm away from the antenna surface by a x-y-z positioner. The following magnetic field components: (1) H_z along z, (2) H_y along z, (3) H_y along x, and (4) H_x along x were measured.

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These field components are excited by radiations from leaky waves and surface waves of a planar guiding structure.

RESULTS AND DISCUSSIONS

Figures 2 and 3 show the plots for the relative amplitudes of H_x and H_y along x respectively at discrete frequencies ranging from 2.3 GHz to 10.8 GHz. The measurement probe starts at the feeding end of the LTSA and moves along the center at 0.0635 cm increments. Results exhibit standing wave patterns along the longitudinal direction of the LTSA. The attenuation in amplitude as the wave propagates down the antenna indicates that power is progressively leaked away. At higher frequencies, more cycles appear as a result of smaller wavelength. Variation of the relative amplitudes of H_y and H_z along z are shown in Figures 4 and 5 respectively. These measurements start at the center about 0.508 cm from the feeding end of the LTSA and moves laterally in steps of 0.0635 cm. Results indicate that the magnetic field line of H_y starts out with maximum amplitude and then decreases with distance in the direction toward the conducting plane. For H_z along z , a null exists at the center for all frequencies tested indicating that a phase reversal occurs at that point. The variation of the relative amplitude H_y as a function of distance normal to the surface was also measured. Results, shown in Figure 6, indicate that the waves decay exponentially away from the surface with a higher rate of decay at a higher frequency. These results confirm that the radiation mechanism for a TSA with a supporting dielectric is predominantly surface waves.

CONCLUSION

The magnetic field components at close proximity of a LTSA has been measured and presented. Results indicate that, in general, both the resonance and traveling wave mechanisms contribute to the radiation in the TSA. For a TSA with a supporting dielectric, the radiation mechanism is predominantly surface waves which decay exponentially away from the surface.

References :

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Fig. 1 Experimental setup.

Fig. 2 Relative magnitude of H_x along x.

Fig. 3 Relative magnitude of H_y along

Fig. 4 Relative magnitude of H_y along z .

Fig. 5 Relative magnitude of H_z along z .

Fig. 6 Relative magnitude of H_y as a function of distance normal to the antenna surface.