Characteristics of Double Bands Dualmode Conical Horn Antenna by Using Generalized Transmission Equation

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1 Introduction

In order to achieve low cross-polarization, dualmode conical horn antenna utilizes a conical horn which excites at the throat region, in addition to the dominant TE_{11} mode, the higher-order TM_{11} mode with an appropriate amplitude and phase[1]. In this paper, we show that design and analysis of such a horn antenna become more accurate by using generalized transmission equation which was derived by Schelkunoff[2].

2 Design of dualmode conical horn

The generalized transmission equation is applicable to the analysis of a dualmode horn, because it can analyze transmission properties of any curved tapered waveguide if the mode function of the cross section is given. From this equation, the scattering matrixes including higher order modes are calculated and they are very accurate since the effects of higher order modes are also considered.

Fig. 1 lists design parameters of the dualmode conical horn for double bands, which is intended to operate at two discrete frequency bands rather than over a wide frequency band. It consists of four sections, that is, conical horn section, two higher mode converters and VSWR control section. The amount of generated TM_{11} mode depends on the shape of the higher mode converter A at lower frequency f_1, and at higher frequency f_2 it can be controlled by the higher mode converter B.

By selecting the diameter at each section suitably, we can design these sections as follows. First, the design parameters of conical horn section, α and D, are determined by required radiation pattern. The diameter D_A of the uniform waveguide at higher mode converter A is determined so that only TE_{11} and TM_{11} modes are propagated in the lower frequency band. And the diameter D_B is chosen so that only TE_{11} mode is propagated in the lower frequency band as shown in Table 1, then there is no TM_{11} mode contribution from higher

mode converter B. Therefore, it is possible to consider the left side of P4 in Fig. 1 as a uniform waveguide in design of the higher mode converter A.

Fig. 1 shows an equivalent circuit of the higher mode converter A and conical horn section. When C_{TM11}, which is the ratio of TM_{11} mode to TE_{11} mode at the aperture, is given, the design parameters l_{A1} and l_{A2} are determined explicitly as shown in [3].

In the design of higher mode converter B, we select the diameter D_B so that only TE_{11}, and TM_{11} modes are propagated in the higher frequency band, and the diameter Dv so that only TE_{11} mode is propagated as shown in Table 1. Then the equivalent circuit of P1 to P7 and the parameters correspond to those in Fig. 1. In this case, l_{B1} and l_{B2} are also determined by using the method as shown in [3].

The length of VSWR control section lv is determined so that the reflection at the port P2 in Fig. 1, which can be analyzed numerically, is canceled at the throat region.

3 Result of design and measurement

We have designed a dualmode conical horn. Fig.2 shows the measured and calculated radiation patterns at each frequency band. In the analysis, its characteristics have been calculated by using the generalized transmission equation considering 20 higher modes. From Fig.2, it is shown that the peak level of cross polarization is less than -29dB at both frequency bands, and the calculated pattern agrees with the measured one. If it is assumed that the effect of the manufacturing error is ±0.1mm, the error of cross polarization level becomes about ± 0.3dB.

Fig.3 shows the frequency characteristics of VSWR. This shows that VSWR of the horn is better than 1.15 at lower frequency band, and 1.1 at higher frequency band. The difference of the measured and the calculated is about 0.05, whose reason is considered that in the analysis, the reflection at the horn aperture is neglected.

4. Conclusion

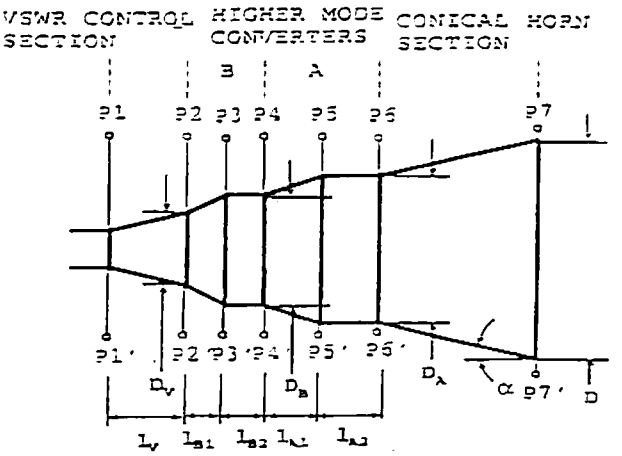
We showed the design and analysis of the double bands dualmode conical horn antenna by using the generalized transmission equation. Actualy we have designed the horn, whose cross polarization is better than -29dB and VSWR is better than 1.15.

References

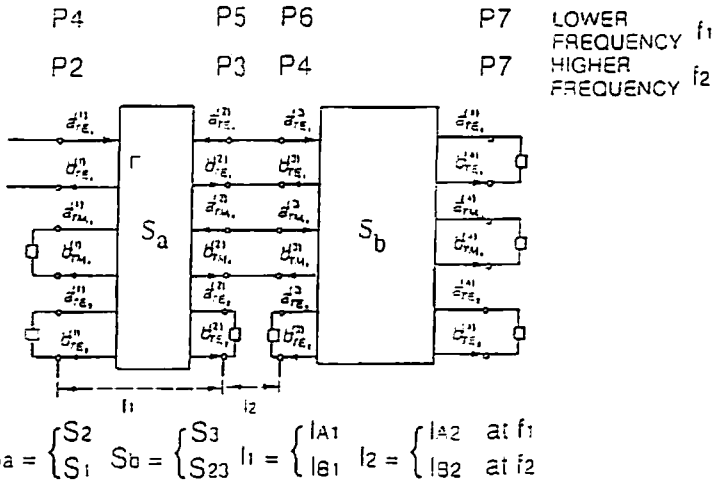
[1] P.D. Potter, "A New Horn Antenna with Suppressed Sidelobes and Equal Beamwidth", Microwave Journal,6,6,pp71-78, June 1961.

[2] S.A. Schelukunoff, "Generalized telegraphist's equation for waveguides", B.S.T.J.,31,4,pp.784-801, July 1952.

[3] M. Takabayashi, H. Deguchi, S. Makino, "Design of Dualmode Conical Horn Antennas with Flare-Angle Changes by Using Generalized Telegraphist's Equation", 1994 I.E.I.C.E. Spring National Convention, B-82.



(a) Double bands dualmode conical horn antenna and design parameters.

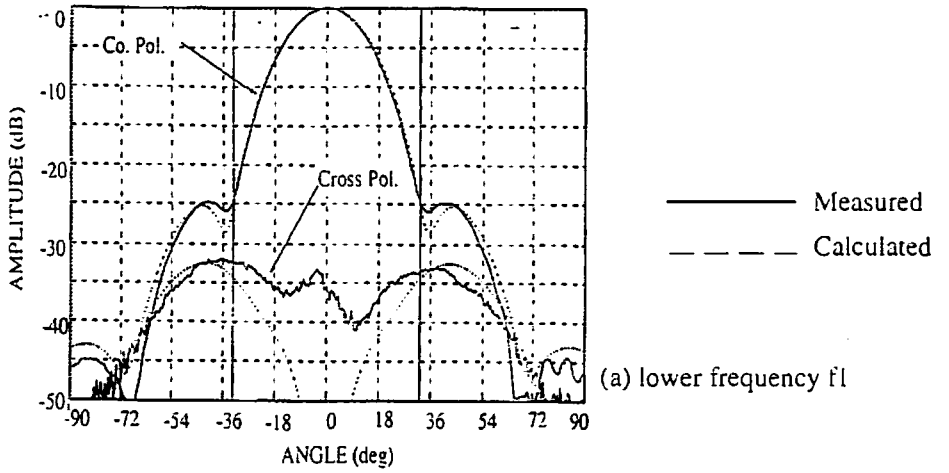


(b) Equivalent circuit in design.

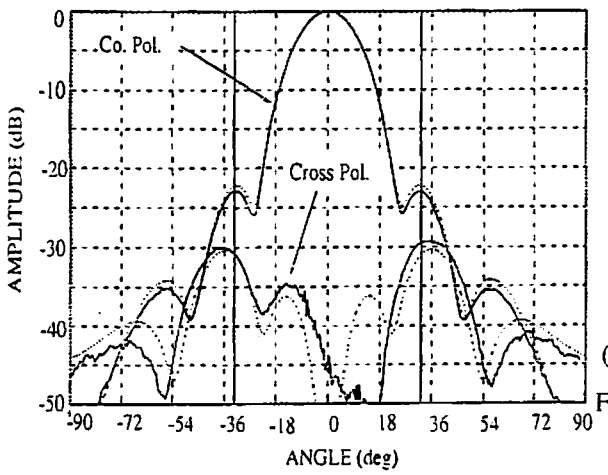
Figure 1; Double bands dualmode conical horn antenna and the equivalent circuit.

Frequency band	VSWR control section	Higher mode converter B	Higher mode converter A
f_1	TE_{11}	TE_{11}	TE_{11}, TM_{11}
f_2	TE_{11}	TE_{11}, TM_{11}	TE_{11}, TM_{11}

Table 1; Propagating modes at each section.

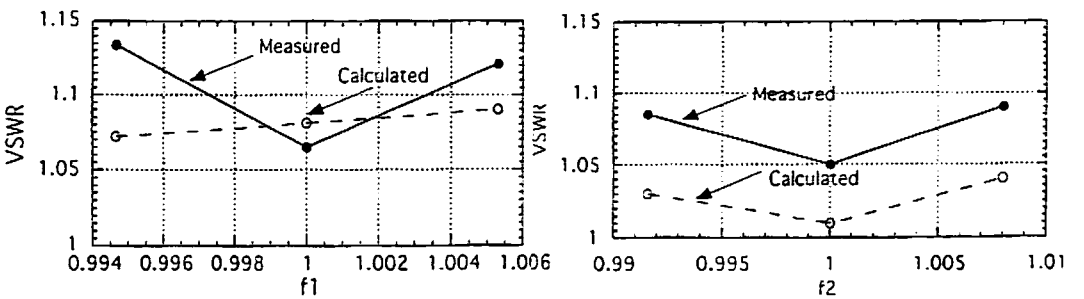


(a) lower frequency f1



(b) higher frequency f2

Figure 2; Radiation pattern of the designed horn



(a) lower frequency f1

(b) higher frequency f2

Figure 3; VSWR frequency characteristics