INVESTIGATIONS ON MILLIMETER WAVE ANTENNAS IN FINLINE TECHNIQUE

Adalbert Beyer and Ingo Wolff
Duisburg University, Department of Electrical Engineering, Bismarckstrasse 81, D-4100 Duisburg 1, Federal Republic of Germany.

Abstract

This short paper presents steps of a theoretical and experimental investigation of millimeterwave antennas in finline technique. The antenna structures are calculated from the solution of the inhomogeneous finline problem. Several results are presented and discussed.

Introduction

In recent years, there has been an ever increasing demand for millimeterwave components which are both small in size and weight, and which also can be produced easily and therefore cheaply.

Since the finline is able to meet these demands, various applications of finlines, like couplers, filters, mixers, nonreciprocal elements and even antennas have been realized in the frequency range 20-170 GHz. In this paper a special form of a finline antenna shall be discussed.

Theoretical Background

In Fig. 1 the principal view of an antenna in finline technique in shown. The metal fins are printed on a thin dielectric

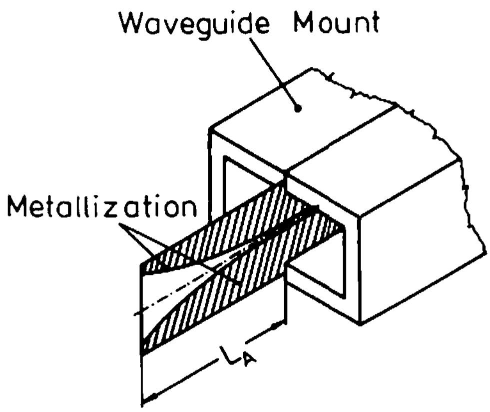


Fig. 1: Antenna structure in finline technique.

substrate, which bridges the metallic walls of a rectangular waveguide. This antenna is an endfire travelling-wave antenna [5]. It will be characterized by a phase velocity v_{ph} on the antenna, for which the following condition is valid:

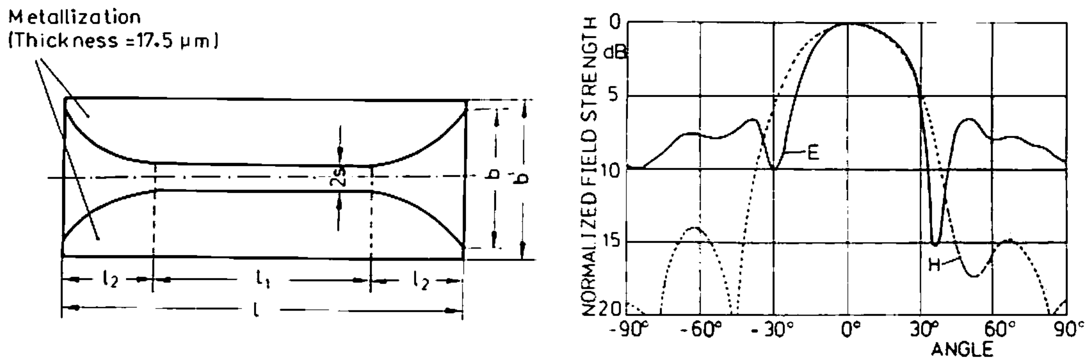
$$\frac{c_0}{v_{ph}} \geq 1. \qquad (1)$$

From the theory of travelling-wave antennas it is known that the ratio c_0/v_{ph} has an optimum value (c_0/v_{ph}=1.05-1.2) regarding the radiation properties of the antenna.

The radiation properties of the antennas in finline technique can be influenced by a change in the length of the radiator (L_A), the width of the slot (2s) as well as by changing the material parameters of the used substrate. These quantities must be optimized so that the condition (1) for the antenna is fulfilled.

In an earlier contribution [1] theoretical and experimental results for the transmission properties of inhomogeneous finlines were published. Additionally, an approximate theory was described [2] to find some design criteria for tapered antennas in finline technique. In the past, several papers have been published describing experimental and theoretical investigations of the Vivaldi- and the linear tapered antenna [3,4,5].

In the following it will be analyzed in how far optimum radiation characteristics can be established for the antennas in finline technique mentioned above. Starting with the knowledge of the theoretical investigations of an inhomogeneous finline as described in [1] several structures for antennas in finline technique have been optimized both theoretically and experimentally.



a) b)

Fig. 2: A two-taper section on RT/DUROID substrate material as an antenna.

a) The layout of the two-taper section (b'=4.55 mm, b=3.55 mm, ℓ=30 mm, ℓ_1=20 mm, ℓ_2=5 mm, 2s=0.1 mm, ε_r=2.22).

b) The radiation characteristics of a two-taper section antenna.

Fig. 2a) illustrates the layout of a two-taper section, which was used as an antenna in finline technique. After the optimization procedure, the best results with regard to a minimum main lobe width were achieved for a radiator length L_A=12.9 mm (Fig. 1). The 3 dB beam widths at the frequency 32 GHz in the E- and H-planes are 45° and 50°, respectively. In order to avoid a significant deformation of the radiation pattern due to the fact that besides the finline taper section the open end of the housing also forms a radiation source, the slot width 2s of the homogeneous finline section should be kept as small as possible (2s=0.1 mm). It has to be noted that the substrate material causes a beam focusing in the H-plane. The antenna shows a ratio c_0/v_{ph} of about 1.25, which is too large for a good travelling-wave antenna.

The Vivaldi-antenna in finline technique

For antenna applications in the millimeter wave range, the two-taper section in finline technique has some disadvantages:
- the 3 dB beamwidth is quite large (about 35°-50°),
- the side lobe supression is not satisfactory (about 7-10 dB).

The Vivaldi-antenna eliminates these difficulties; this new antenna in finline technique results from finline tapers with an end gap, which is larger than half of the wavelength ($\lambda_g/2$). The antenna pattern resulting from this arrangement is shown in Fig. 3a).

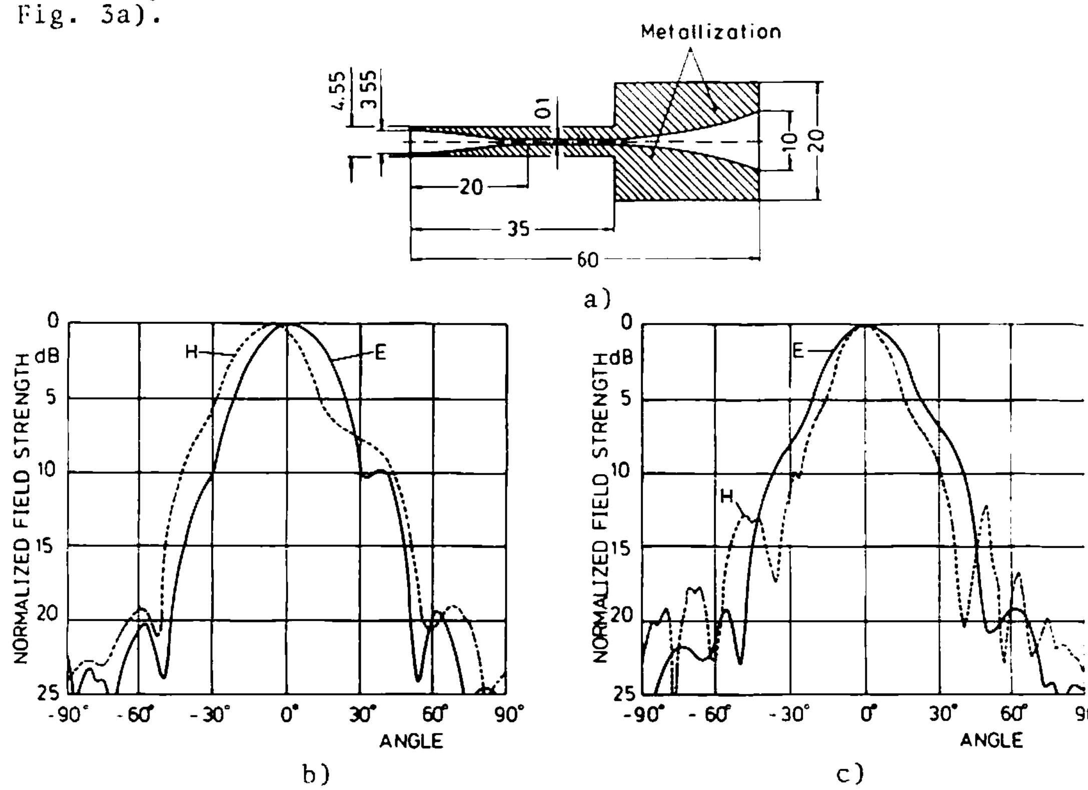


Fig. 3: Millimeter wave Vivaldi-antenna on RT/DUROID 5880 substrate with a thickness of 0.5 mm (f= 32 GHz).
a) The layout of a Vivaldi-antenna.
b) and c) The radiation characteristics of a Vivaldi-antenna in unilateral- and bilateral finline technique, respectively.

The unilateral finline is an asymmetrical structure, therefore its radiation patterns (Fig. 3b)) are asymmetrical, too. The 3 dB beamwidths in the E- and H-planes are 38° and 39°, respectively, while the side lobe supression is about 20 dB.

Fig. 3c) shows the radiation properties of the same antenna structure in bilateral finline technique. The radiation characteristics this time are symmetrical; the 3 dB beamwidths in the E- and H- planes are 30° and 25° and the side lobe supression is 18 dB in the E-plane and about 13 dB in the H-plane. This Vivaldi-antenna achieves almost an optimum value of the ratio c_0/v_{ph} which is about 1.05.

If more concentrated radiation characteristics are required antennas can be built with long linearly tapered structures in finline technique. This and a corresponding optimization process as well as its results will be discussed in our oral presentation.

Conclusions

It will be shown that finlines, already successfully used as waveguides, can also be employed as antenna structures. Using the theory of inhomogeneous finlines,a method has been developed which permits the optimization of antennas in finline technique. Different examples will illustrate the applicability of the method presented here.

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