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Substrate-Integrated Folded Waveguide Slot Antenna

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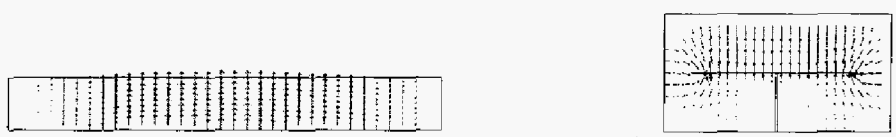
INTRODUCTION

In recent years a number of researchers have proposed novel techniques for fabricating rectangular waveguide using microwave integrated circuit techniques. These so-called substrate integrated guides have been fabricated using multilayer LTCC [1], multi- [2] and single-layer [3] microwave laminates and photoimageable thick films [4]. All of these structures result in dielectric filled rectangular waveguide and as such have a width reduction of $\varepsilon_r^{-1/2}$ over conventional waveguide. Furthermore, by their very nature they are easily integrated with planar transmission lines and circuits, allowing hybrid waveguide/microstrip systems to be fabricated on a single substrate. Several researchers have investigated slot antennas [5] and arrays [6] in substrate-integrated guide. In this paper we show a slot antenna in a folded substrate-integrated waveguide. These waveguides have half the width of the other types of substrate-integrated waveguide [7]. As such the present structure allows arrays of slot antennas to be more highly integrated.

STRUCTURE

Fig. 1 shows the structure of the folded waveguide together with conventional waveguide. We see that the fundamental mode of the folded structure resembles that of the TE_{10} in conventional guide folded round under itself. It has been shown that for the correct choice of parameters the propagation characteristics of the folded guide follow exactly that of conventional guide but are of half the width [8].



(i) (ii)

Fig. 1. Cross-sectional view and fundamental mode electric field of i) Rectangular waveguide, ii) Equivalent folded waveguide

Fig. 2 shows the structure of the folded waveguide slot antenna. The antenna was fabricated using a substrate of dielectric constant $\varepsilon_r = 2.33$. The multilayer structure consisted of two layers of thickness 3.15 mm with the central metal etched on the bottom substrate. The side and central walls of the guide were fabricated using metallised vias of diameter 0.35 mm and pitch 0.5 mm. The other dimensions are shown in table 1. As with conventional waveguide slot antennas, the resonant frequency is predominantly dependent on the length of the slot whereas the equivalent shunt conductance and therefore match is predominantly dependent on the displacement from the centre of the guide. These were both optimised for minimum return loss at 9.3 GHz using the finite element method giving a slot length of 13 mm and a displacement of 1 mm. The slot was 0.5 mm wide and position ¾ of a guided wavelength from the terminating waveguide short. The waveguide was fed by an SMA connector via a 50 Ω stripline of width 2.48 mm. An optimised tapered transition was used to convert the stripline mode into a folded waveguide mode [8].

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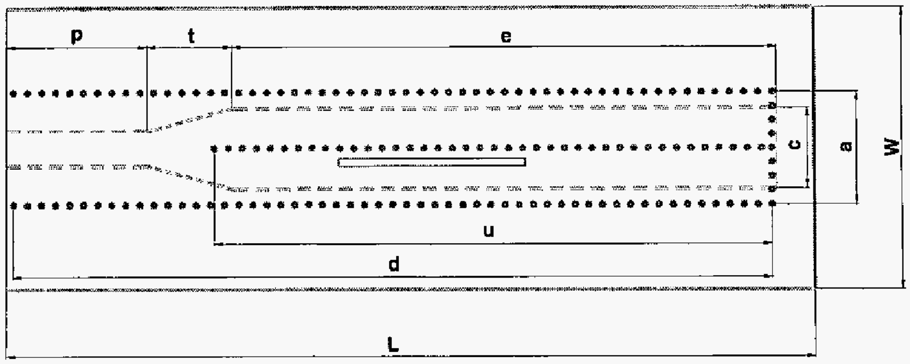

Fig. 2. Structure of folded waveguide antenna.

L	W	d	a	u	c	e	t	p
57.70	20.00	54.00	8.00	39.75	5.75	39.00	6.00	10.00

Table 1. Dimensions of folded waveguide slot antenna

RESULTS

Fig. 3 shows the simulated and measured return loss of the slot antenna. The measured results were obtained using an Anritsu 3739C network analyser with coaxial calibration. We see that the match is almost -18 dB at resonance with a -10 dB bandwidth of 400 MHz. Fig. 4 shows the radiation pattern of the antenna in both the H and E plane. The simulated gain was 6.5 dB.

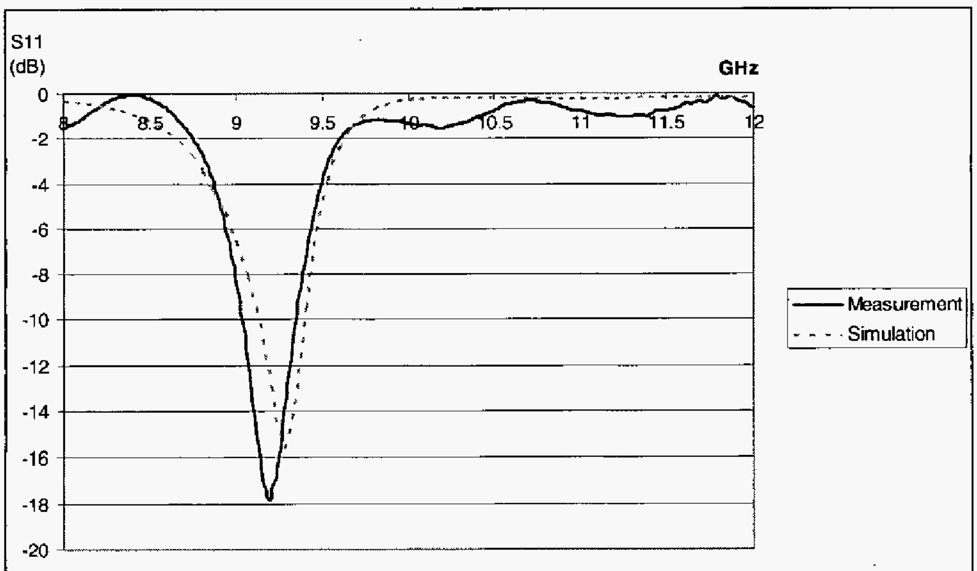

Fig. 3. Measured and simulated return loss

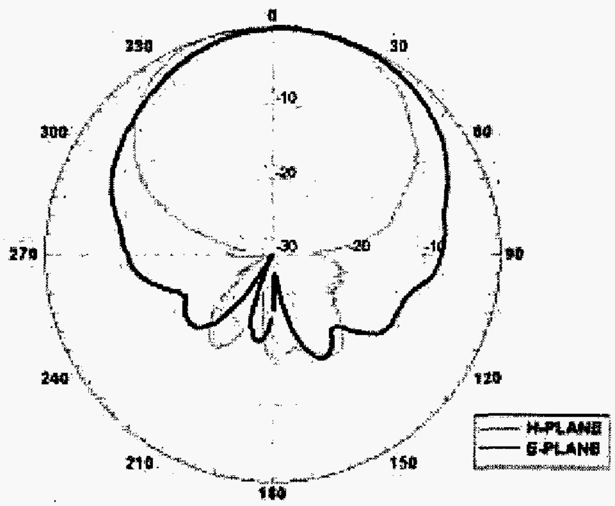

Fig. 4. Measured radiation pattern

CONCLUSIONS

A slot antenna in folded substrate integrated waveguide has been presented and shown to have good performance at 9.3 GHz. The structure is cheap to manufacture and due to the miniaturized nature of the folded waveguide could form part of a dense array of antennas.

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