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NEW BROADBAND PRINTED ANTENNA ARRAY

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Abstract. Broadband printed dipoles of different shapes are investigated. Because of the least resistance fluctuation with frequency, trapezoidal dipole has been chosen. Two-dimensional array with printed trapezoidal dipoles operating at 4-10 GHz frequency range is designed and realized. Feeding network and radiating elements are in the same plane, so that the array is realized on the single dielectric substrate. Reflector plate is placed behind a substrate with antenna elements. Achieved antenna gain in the whole frequency range is within 20.5 and 24.8dB, VSWR is less then 2.1 and maximum loss about 3dB.

Key words: Antenna, antenna array, printed antenna, VSWR, radiating element, monopole array.

1. Introduction

It is well known that printed antenna structures have many advantages over conventional antennas. However, the basic problem in designing and realization of broadband antenna arrays is choice of a radiating element, as well as a feeding network.

Results of investigations of three different shapes of printed dipoles are presented in this work. The least variation of the resistance in a wide frequency range was in the case of trapezoidal dipole. Two-dimensional array with 8×8 printed trapezoidal dipoles fed by symmetrical (balanced) microstrip has been realized and measured results are presented here.

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2. Choice of a broadband printed radiating element

Different types of printed dipoles: triangular (Fig.1a), triangular with cap (Fig.1b) and trapezoidal (Fig.1c) on dielectric substrate have been investigated [1]. As a first step, the impedance measurement of the isolated printed monopoles of the three above-mentioned forms has been performed. Measuring results are shown in Fig.2.

It is obvious that printed trapezoidal monopole has the least variation of the real, as well as of the imaginary part of the impedance between values of relative lengths $H/\lambda = 0.2$ and $H/\lambda = 0.5$ (the values of length H normalized with respect to operating wavelength) which are suitable for applications because of the most convenient radiation pattern in E-plane. These relative lengths correspond to the ratio $f_{max}/f_{min} = 2.5$. Naturally, the same conclusion is valid for printed trapezoidal dipoles.

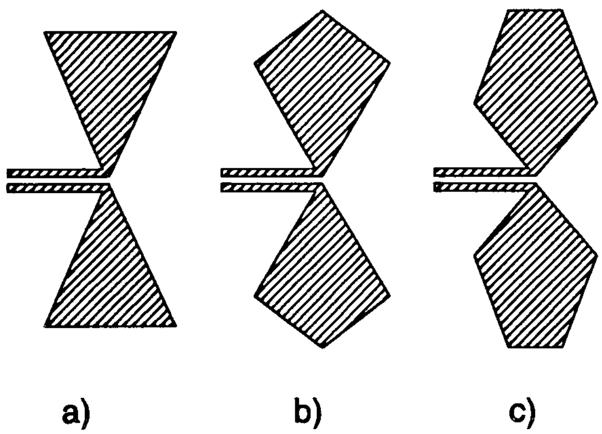

Fig. 1. Different shapes of printed dipoles:
a) Triangular, b) Triangular with cap, c) Trapezoidal.

To evaluate the impedances of trapezoidal dipoles taking into account the mutual coupling effect, as well as the influence of the reflector plate, a model with four trapezoidal monopoles on dielectric substrate ($h = 0.76$ mm, $\varepsilon_r = 2.17$) and reflector plate has been constructed shown in Fig 3.

The impedance of monopole 2 (or 3) has been measured, since it is coupled both with monopole 1 and 3 (or 2 and 4). Measured results are presented in Fig. 4.

Trapezoidal dipoles can be fed by coplanar stripline (CPS), Fig.1c. or by balanced microstrip, Fig. 5.

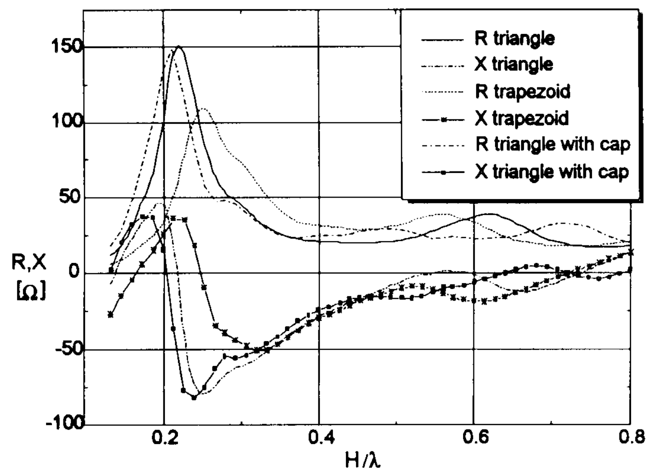

Fig. 2. Variation of real and imaginary part of the impedance of isolated printed monopoles vs. H/λ.

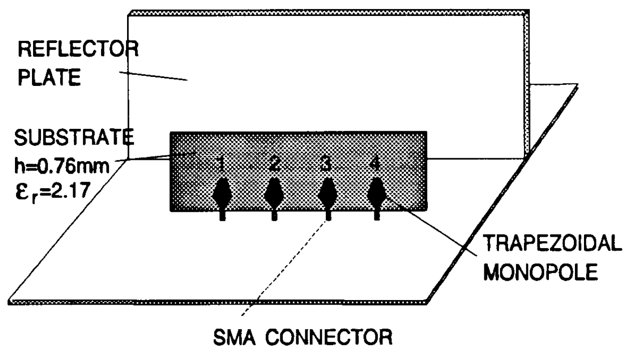

Fig. 3. Trapezoidal monopole array with reflector plate.

Feeding the linear array of dipoles can be simply realized with CPS, Fig. 6. However, feeding the two-dimensional planar array by CPS can not be realized on the same dielectric substrate. If a feeding network with symmetrical microstrip is applied (Fig. 5.), both array and feeding network can be realized on the same substrate. In such case, each half of the dipoles is on the opposite sides of the dielectric (Fig. 7).

A two-dimensional antenna array with 64 (8×8) trapezoidal dipoles with uniform amplitude and phase distribution has been designed using the software package [2]. Spacing between adjacent elements in H and E-plane, as

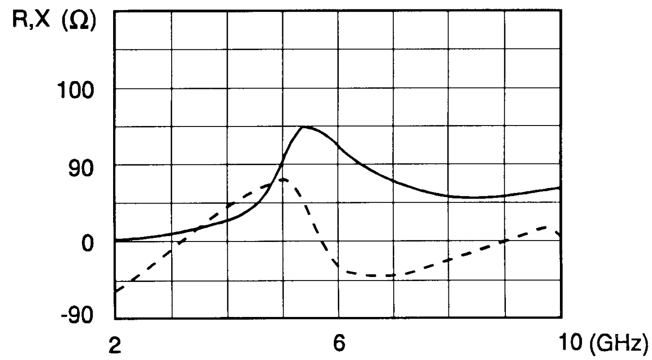

Fig. 4. Real and imaginary part of the impedance of trapezoidal monopole vs. frequency.

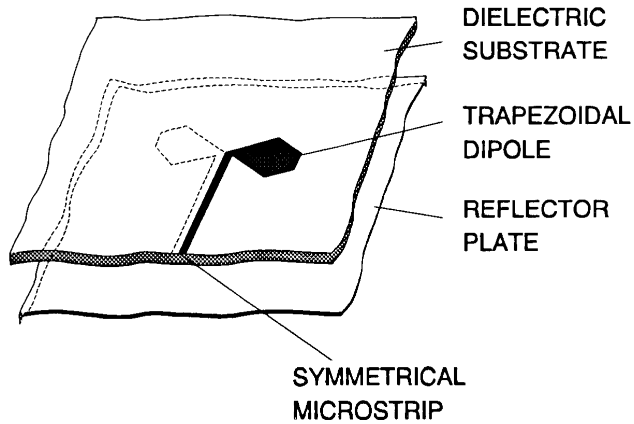

Fig. 5. Trapezoidal dipole fed by symmetrical (balanced) microstrip.

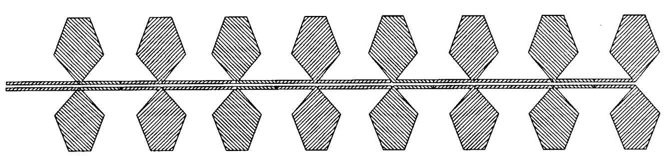

Fig. 6. Linear array fed by CPS.

well as reflector spacing has been chosen so that we could obtain at least 10 dB sidelobe suppression in 4-8 GHz frequency range and at least 6 dB in 8-10 GHz range. In design procedure, the radiation pattern of the isolated element has been replaced with measured radiation pattern of trapezoidal dipoles.

The antenna array is shown in Fig. 7.

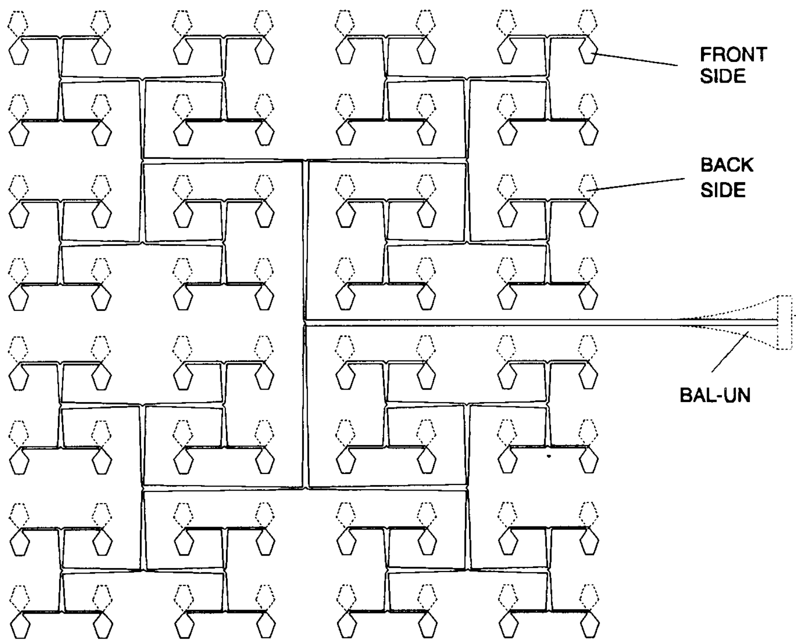

Fig. 7. Two-dimensional array with 64 (8×8) trapezoidal dipoles.

Based on experimental results for the impedance of trapezoidal dipoles above reflector plane, the optimum reference impedance providing minimum VSWR in the whole operating frequency range has been defined. We have found that this value is about 75 W for 10mm reflector spacing. Transformation of the impedance of the feeding network has been performed by linear tapering of balanced microstrip. Balanced to non-symmetrical microstrip transition (BAL-UN) has been performed on the antenna port.

3. Results

Measured results of the main characteristics of the array are given in Table 1. Directivity is theoretically defined. VSWR in the whole frequency range is less than 2.1.

Table 1.

Function [GHz]		4	6	8	10
Beamwidth [^{o}]	H–plane	19	13	10	8
	E–plane	20	14	10	8
Highest side-lobe level [dB]	H–plane	-12	-10	-9	-7
	E–plane	-14	-13	-12.5	-12
Directivity [dB]		22.4	25.3	26.8	27.8
Gain [dB]		20.5	22.5	24.3	24.8
Total loss [dB]		1.9	2.8	2.5	3.0

4. Conclusion

Three different shapes of printed radiating elements (triangular, triangular with cap and trapezoidal) have been investigated. According to our investigations, we have found that impedance variation of the trapezoidal dipole is the best. A two- dimensional antenna array with trapezoidal dipoles has been designed and fabricated. A gain within 20.5 and 24.8dB, VSWR less than 2.1, and maximum loss below 3dB have been obtained in the frequency range 4-10 GHz (1.5 octave). To the author's knowledge, a planar antenna with similar characteristics in the class of printed antenna structures has not been realized so far.

REFERENCES

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