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US-A-4 291 311
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IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, vol. AP-29, no. 1, January 1981, pages 3-24, New York, US; K.R. CARVER et al. "Microstrip Antenna Technology"

ELECTRONICS LETTERS, no. 17, no. 24, 26th November 1981, pages 914-916, London, GB; G. DUBOST "Short-or Open-circuited Dipole parallel to perfect Reflector Plane and embedded in Substrate and acting at Resonance"

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Description

This invention relates to microstrip antennas comprising a dielectric substrate having a conducting ground-plane on one face and a conducting sheet radiator on its other face coupled to a feeding arrangement.

The invention has a principal application to such antennas where the radiator is a circular patch or disc approximately half a wavelength in diameter at its resonant frequency, enabling the bandwidth thereof to be substantially increased. The antenna thus formed is particularly suitable for feeding circular reflectors having small focal-length/diameter (F/D) ratios, eg F/D = 0.3, and which require a low-cost, lightweight, low-profile, simple feed structure, instead of using eg horn feeds. A further advantage in such applications is the low axial ratio obtained, ie the maximum variation in signal amplitude over 360° polar co-ordinates, which is important where circular polarisation is used.

The invention provides a microstrip antenna as defined in the preamble of claim 1 and known from IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, vol. AP—29, no. 1, January 1981, pages 3—24, New York, US; K. R. CARVER et al. "Microstrip Antenna Technology", Figure 9 and page 10, column 2, lines 29 to 41, characterised by the features of the characterising portion of Claim 1.

The invention also provides a reflector antenna comprising a circular reflector, preferably of parabolic form, having the microstrip antenna as claimed in claim 1 located substantially at its focus to provide a feed.

To enable the nature of the present invention to be more readily understood, attention is directed, by way of example, to the accompanying drawings, wherein:

Fig 1 is a sectional elevation of an antenna embodying the present invention.

Fig 2 is plan view of the antenna of Fig. 1.

Fig 3 is a graph showing the return loss of a simple circular microstrip antenna.

Fig 4 is a graph showing the effect of modifying the antenna of Fig 3 in accordance with the present invention.

Fig 5 is a graph showing the co-polar and cross-polar radiation patterns of the embodiment of Fig 4 in the E- and H- planes.

Fig 6 is a graph showing the co-polar and cross-polar radiation patterns of a further example of the embodiment of Figs 1 and 2 in the E- and H- planes.

Fig 7 is a graph showing patterns as in Fig 6 but for the two diagonal (45°) planes.

Figs 1 and 2 show an antenna comprising a circular disc 1 of metallisation located centrally on a disc 2 of dielectric material backed by a conducting ground-plane 3. Separated by a uniform gap 5 from disc 1 is an annular ring 6 of metallisation whose outer edge extends round the edge of disc 2 to join the ground-plane. The disc 1 is connected to a coaxial feeder whose inner conductor 7 extends through disc 2, and whose outer conductor 8 is connected to the ground-plane 3. It is not essential for the outer edge of ring 6 to make continuous contact with the ground-plane 3 as shown, eg a ring of spaced pins extending through the dielectric material can be used, as will be apparent to those familiar with microstrip antennas.

The diameter of the disc 1 is approximately λm/2 at the operating frequency (where λm is the wavelength in the microstrip structure thus formed) so that the disc functions as a resonant radiator in a known manner, and the position of connection of conductor 7 to disc 1 is adjusted to match the antenna and feeder impedances at this frequency, as likewise known. The width of ring 6 is made approximately λm/4, this width and the width of gap 5 being adjusted experimentally to give the structure optimum bandwidth.

Figs 3—6 show results obtained with an antenna having the following dimensions etc:

Disc 1 diameter 19.5 mm
Ring 6 width 10.0 mm
Gap 5 width 2.75 mm
Disc 2 thickness 3.18 mm
Disc 2 relative permittivity 2.52
Feeder 7,8 impedance 50 ohms
Operating frequency ~ 5 GHz

Fig 3 shows the return loss of the antenna in the absence of ring 6, ie ring 1 alone, and Fig 4 shows the effect of adding the ring. The substantial increase in bandwidth (at −10 dB) in the latter case is clearly seen.

Fig 5 shows the co-polar radiation pattern in both the E- and H-planes about boresight (0°). The antenna is seen to have equal beam-widths in both planes at very wide angles from boresight (eg ± 60°). The low levels of cross-polarisation obtained (<-20dB) are also shown.

The width of the gap 5 is not critical and the optimum width is readily found by experiment. In the above example it was found that the stated width could be considerably increased without serious deterioration in performance, but could not be much reduced.

In a further example of the invention, the foregoing dimensions were unchanged except that the ring 6 width was 9 mm and the gap 5 width 2.25 mm. The centre frequency was 5.21 GHz. The coaxial feeder 7,8 was offset 0.33 of disc 1 diameter from its centre to obtain a 50 ohm match at resonance as opposed to 0.2

of disc diameter for the disc in isolation, ie without the ring 6. Measurements of the antenna amplitude and phase patterns were made in the principal (E- and H-) and diagonal (45°) planes at band-edge and centre frequencies, using improved measuring techniques. As in the earlier-described measurements, the antenna was not mounted on a large ground-plane conventionally used for microstrip patch antenna measurements.

Figs 6 and 7 show the measured amplitude patterns at band centre, in the principal and diagonal planes respectively, for an antenna suitable for feeding a prime focus fed reflector (ie having its feed located on-axis at its focal point) with F/D = 0.3. This corresponds to a beamwidth at the standard −10 dB level of 160°. θ is again the conventional polar co-ordinate. The patterns show good circular symmetry and cross-polarisation generally below −25 dB within the arc subtended by the reflector, although a maximum cross-polarisation of −22 dB occurs at the edge of the reflector arc. Good circular symmetry is also observed for patterns obtained at the band-edge frequencies with cross-polarisation levels below −21 dB as shown in Table 1, which is a comparison of maximum cross-polarisation levels in both principal and diagonal planes within arc $\theta = \pm 80°$.

TABLE 1

	Cross-polarisation	
Frequency GHz	Disc 1 + ring 6 dB	Isolated disc 1 dB
5.00	−21	−20
5.21	−22	−16
5.44	−22	−14

The minimum variation in phase occurred for a phase centre located on-axis 4 mm from the centre of disc 1. The maximum phase error at this position was <15°, with most of the error occurring at the edge of the reflector arc.

Table 1 also compares the cross-polarisation level of the present antenna with that of an isolated disc 1 operating at the same frequency and on a ground-plane equal to the ring 6 outer diameter. The radiation patterns for the isolated disc showed good circular symmetry for small ground-plane sizes, but with H-plane cross-polarisation >−20 dB for angles >25° from boresight (0°) which arises from diffraction from the edges of the ground-plane and overmoding in the disc. Table 1 indicates that the addition of ring 6 exerts considerable control of the sources of cross-polarisation, giving reduced levels within the arc subtended by the reflector.

TABLE 2

		Gain at band edges with respect to peak gain, dB	
Gap 5 width mm	−10dB return loss bandwidth %	Lower-edge frequency	Upper-edge frequency
2.5	6	−0.5	−0.5
2.25	8—9	−1	−1
2.0	10	−1	−3

Table 2 shows the results of bandwidth and approximate gain fall-off for different values of gap 5 width. For convenience the gap 5 widths were achieved by changing the disc 1 diameter which resulted in a 10% variation in frequency, but the latter was not considered to affect significantly the bandwidth and gain results. The accuracy of gain measurement was approximately ±0.5 dB. Bandwidths up to and greater than 10% were obtainable, but with some reduction in input return loss (not shown in Table 2) and a significant fall-off in gain at the upper band-edge frequency. The input return loss could not be greatly improved by repositioning the coaxial feeder. The increase in bandwidth is due to an additional resonance mode close to the fundamental mode, and it is considered that losses in this mode account for the reduction in gain at the higher frequency.

These results obtained with the further example confirm the improved performance over that of an isolated disc and its particular suitability, as stated, for feeding reflectors, with small F/D, which require a low-cost, lightweight, low-profile simple feed structure.

The λ m/4 ring can also be applied to circularly polarised circular resonant radiators, eg energised with a 90° phase difference at points on two orthogonal radii, where, as stated, the low axial ratio obtained is particularly valuable. The invention may also be applicable to other than circular half-wave resonant sheet radiators, eg to those of elliptical shape.

Claims

1. A microstrip antenna comprising: a dielectric substrate (2) having a circular conducting sheet radiator (1) on a first face thereof and a conducting ground plane (3) on a second face; said radiator (1) having a diameter of approximately half a wavelength at the operating frequency and acting as a half-wave resonator and having feed means (7, 18) connected thereto; and a closed annular conducting sheet (6) on said first face surrounding said radiator and having its inner edge spaced by a gap from the edge of said radiator to provide capacitative coupling across the gap between the respective edges, characterised in that; the annular sheet (6) has a width of approximately one quarter of a wavelength at the operating frequency and is connected to the ground plane at its outer edge and operates as a quarter wave resonator.

2. A reflector antenna comprising a circular reflector (1) having a microstrip antenna as claimed in claim 1 located substantially at its focus to provide a feed.

3. A reflector antenna as claimed in claim 2 wherein said reflector (1) is parabolic.

Patentansprüche

1. Mikrostreifenleiter-Antenne mit: einem dielektrischen Substrat (2), das auf seiner einen Seite einen kreisrunden leitenden Flächenstrahler (1) und auf dessen anderer Seite eine leitende Erdungsebene (3) aufweist, wobei der Strahler (1) einen Durchmesser von ungefähr der halben Wellenlänge bei der Betriebsfrequenz aufweist und als Halbwellenresonator dient und mit Speiseleitungsmitteln (7, 8) verbunden ist, und einer den Strahler umgebenden, geschlossen leitenden Ringfläche (6) auf der einen Seite, wobei die Innenkante von der Außenkante des Strahlers durch einen Spalt getrennt ist, um eine kapazitive Kopplung zwischen den beiden Kanten über den Spalt herzustellen, dadurch gekennzeichnet, daß die Ringfläche (6) eine Ringbreite von ungefähr einem Viertel der Wellenlänge bei der Betriebsfrequenz aufweist und an ihrer Außenkante mit der Erdungsebene verbunden ist und als Viertelwellenresonator dient.

2. Reflektorantenne mit einem kreisförmigen Reflektor (1), der eine ungefähr in dessen Brennpunkt angeordneten Mikrostreifenleiter-Antenne nach Anspruch 1 als Speisequelle aufweist.

3. Reflektorantenne nach Anspruch 1, dadurch gekennzeichnet, daß der Reflektor (1) parabolisch ist.

Revendications

1. Antenne à microbandes comprenant: un substrat diélectrique (2) comportant un élément rayonnant en feuille conductrice circulaire (1) sur une première face et un plan de base conducteur (3) sur une seconde face; ledit élément rayonnant (1) ayant un diamètre représentant environ la moitié d'une longueur d'onde à la fréquence de fonctionnement et agissant en tant que résonateur demi-onde et comportant des moyens d'alimentation (7, 18) qui lui sont reliés; et une feuille conductrice annulaire fermée (6) sur ladite première face et entourant ledit élément rayonnant, dont le bord interne est séparé par un interstice du bord dudit élément rayonnant pour obtenir un couplage capacitif à travers l'interstice entre les bords respectifs, caractérisée en ce que: la feuille annulaire (6) a une largeur d'environ un quart de longueur d'onde pour la fréquence de fonctionnement et est reliée au plan de base par son bord externe et fonctionne comme un résonateur quart-d'onde.

2. Antenne à réflecteur comprenant un réflecteur circulaire (1) comportant une antenne à microbandes selon la revendication 1, située sensiblement à son foyer pour déterminer l'alimentation.

3. Antenne à réflecteur selon la revendication 2, dans laquelle ledit réflecteur (1) est parabolique.

Fig.1.

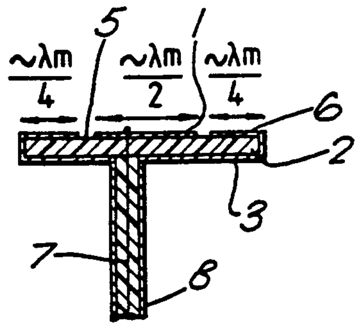
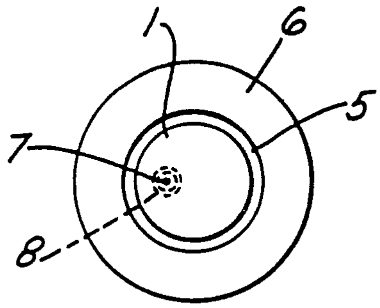


Fig.2.



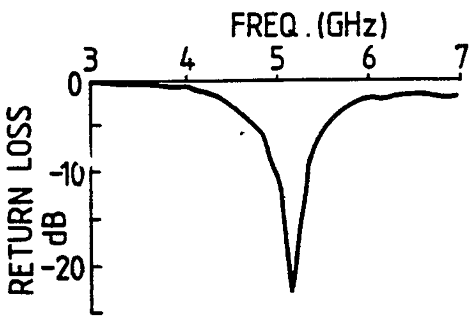


Fig.3.

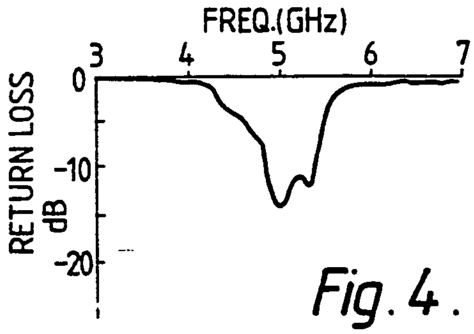


Fig.4.

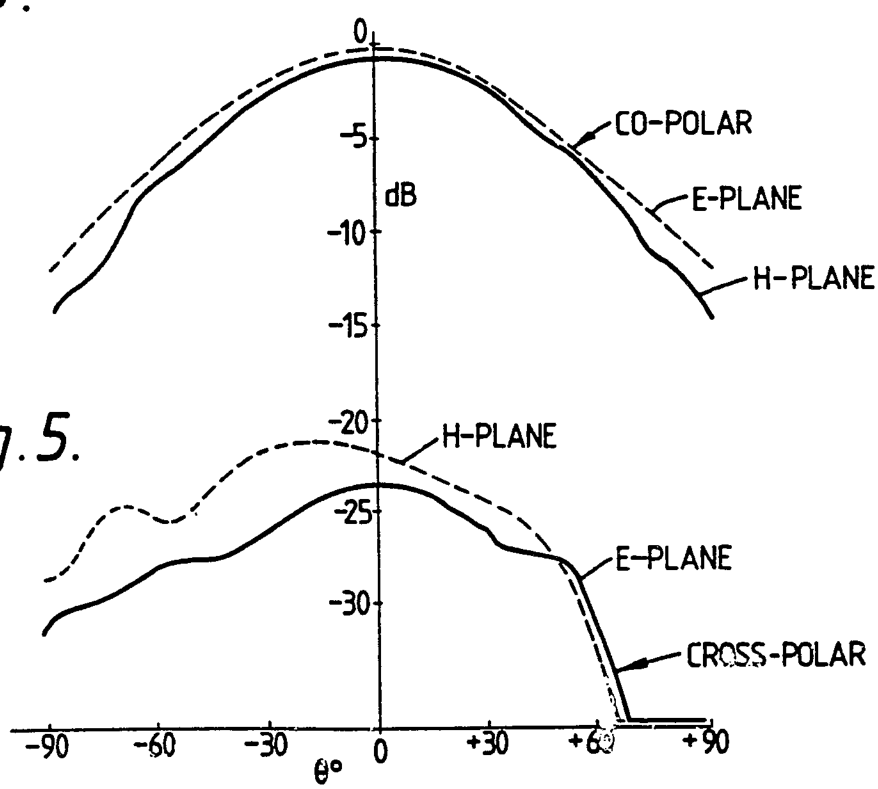


Fig.5.

Fig. 6.

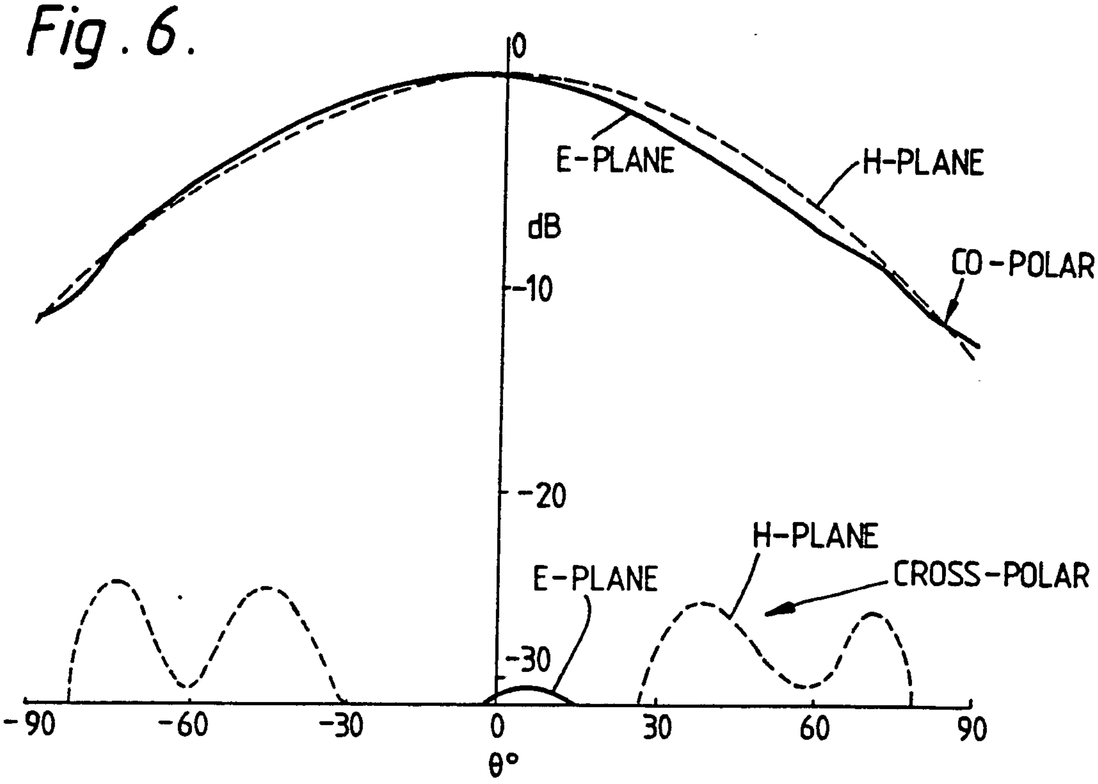
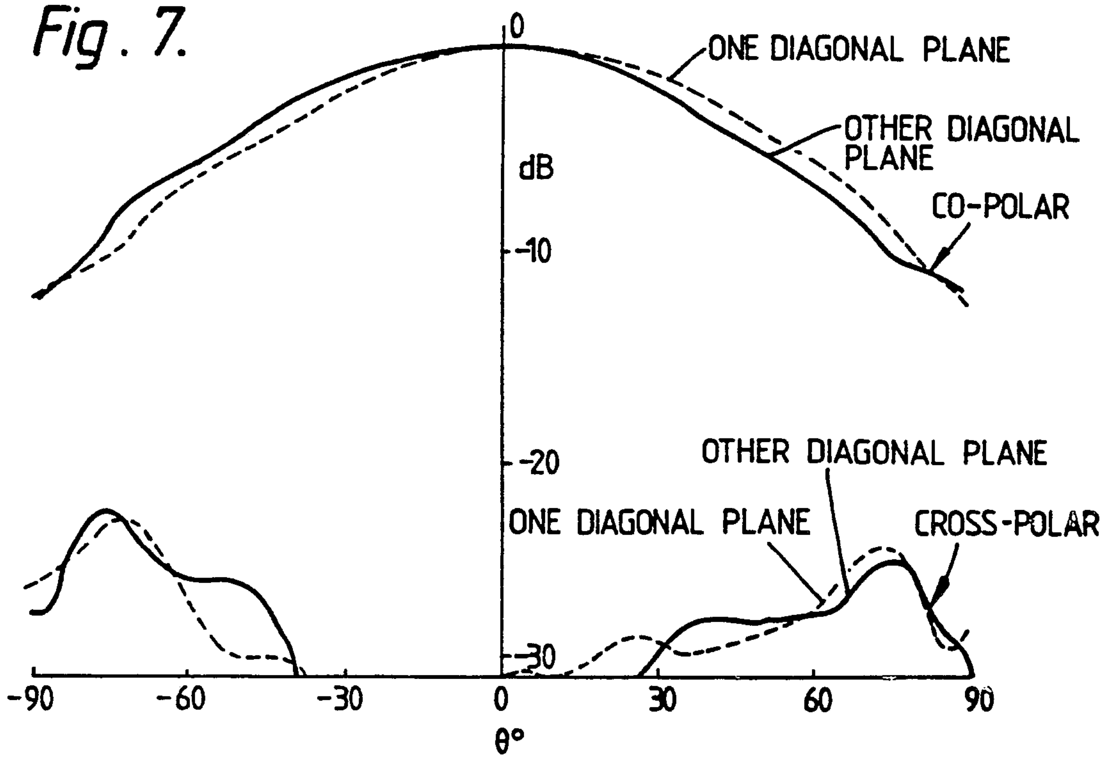

0
E-PLANE
H-PLANE
dB
CO-POLAR
-10
-20
H-PLANE
E-PLANE
CROSS-POLAR
-30
-90
-60
-30
0
30
60
90
θ°

Fig. 7.


0
ONE DIAGONAL PLANE
OTHER DIAGONAL PLANE
dB
CO-POLAR
-10
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OTHER DIAGONAL PLANE
ONE DIAGONAL PLANE
CROSS-POLAR
-30
-90
-60
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