Based on the design in Fig. 4, a typical case with ℓ = 30mm (~0.94 D) was implemented. The patch and substrate parameters are the same as those used for a simple patch design, as shown above. The measured input impedance and axial ratio are presented in Fig. 5. It is seen that the centre frequency of CP operation is decreased to 1587MHz, which is only ~63.4% times that of

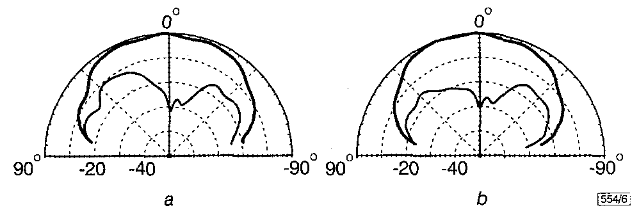

Fig. 6 *Measured radiation patterns in two orthogonal planes for antenna shown in Fig. 4*

a xy plane
b yz plane
f = 1587MHz
——— LHCP
- - - - - RHCP

the simple patch case. This decrease in the operating frequency corresponds to a 60% antenna size reduction, similar to that obtained using a cross slot of unequal slot lengths [3]. The 3dB axial ratio bandwidth is found to be 14MHz (or ~0.9%), which is less than that of the simple patch case (1.20%), largely due to the decrease in the electrical thickness of the substrate. It is also noted that the tuning stub in this design has a length of 8.5mm (~0.26 D), which is slightly larger than that in the simple patch design (6.9mm), although the operating frequency is significantly decreased. When compared to the very small slot-length difference (0.5mm or ~0.0075 times the disk diameter) required in the design using a cross slot of unequal slot lengths [3], the present compact CP design with a tuning stub can have much more relaxed manufacturing tolerances. Fig. 6 shows the measured radiation patterns in two orthogonal planes at the centre frequency. Again, good left-hand CP radiation is observed.

Conclusions: We have investigated the novel design of circularly-polarised microstrip antennas with a tuning stub. The proposed CP design has been sucessfully applied to a simple circular patch antenna and a compact circular patch antenna with a cross slot of equal slot lengths. Since the required tuning-stub length for CP operation is ~26% of the disk diameter studied here, and is relatively insensitive to the operating frequency variation, the stringent fabrication tolerances required in [3] are significantly relaxed in our proposed design.

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Folded reflectarray antenna

D. Pilz and W. Menzel

A novel folded reflectarray antenna is presented. This antenna combines a twist and focusing reflector concept in a single printed structure. Together with a printed grid, a low profile and high gain antenna results. A test antenna in the 20GHz range was designed, fabricated and tested.

Introduction: Reflector antennas provide high gain, low sidelobe levels and low losses; in many cases, however, their large depth limits their applications. Planar antennas, on the other hand, exhibit high losses when designed for narrow beam performance, especially at high frequencies. Cassegrain reflector antennas are a compromise for this problem, but have limitations concerning aperture blocking and ease of construction. A reduction of aperture blocking may be achieved using a polarising grid as subreflector and a twist reflector based on a grid structure placed on the surface of the main reflector, or combining a similar arrangement with a dielectric lens antenna [1]. Another development towards low weight and low-cost reflector antennas is based on printed reflector antennas, e.g. [2, 3].

In this Letter, beamforming is achieved by a planar printed structure, which, at the same time, acts as a twist reflector. As a consequence, the antenna consist of only two printed substrates, resulting in a simple, easy to fabricate, and low cost antenna with moderate depth, low weight and low losses.

Principle: The basic setup of the antenna presented here is given in Fig. 1. It consists of a feed with linear polarisation, a polarising grid and a reflectarray, which also acts as a twist reflector. A wave with an x-directed E-field is transmitted from the feed to the grid. It is reflected by the grid toward the reflectarray. There, rectangular metallic structures of different lengths and widths provide, at the same time, a prescribed phase shift and a twisting of the polarisation by 90°. Finally, the wave passes the grid and is radiated into free space.

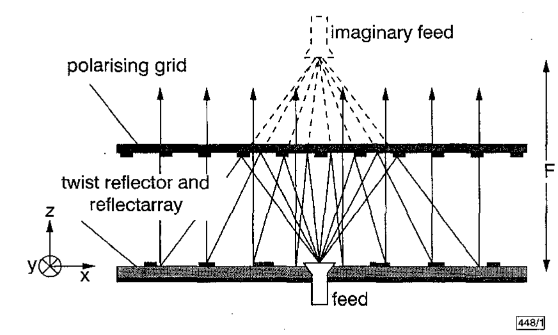

Fig. 1 *Principle of folded reflectarray antenna*

For the first test, a circular waveguide horn with an aperture diameter of 19 mm was used as the feed structure, resulting in a 3dB beamwidth of ~45° and an ~10dB illumination decay at the edges of the aperture. For better integration, a planar feed antenna printed directly on the twist reflector substrate can equally be used. The polarising grid was printed on a 0.254mm thick Duroid substrate with 0.12mm wide strips in a 0.6mm period. It was designed using a mode matching technique with a metallisation thickness of 17µm, resulting in a 22dB insertion loss for an E-field parallel to the strips, and a 19dB return loss for orthogonal polarisation at 20GHz. A novel printed circuit was employed as the twist reflector, which is described in detail in the next Section. The overall depth of the lens antenna presented here is 50mm, and the overall diameter is 130mm.

Twist reflector: The novel twist reflector employed for the antenna uses an array of dipoles printed on the front side of a substrate of given height, which is completely metallised on the back side. Commercially available microwave substrate materials can easily be used and the production cost can be kept low.

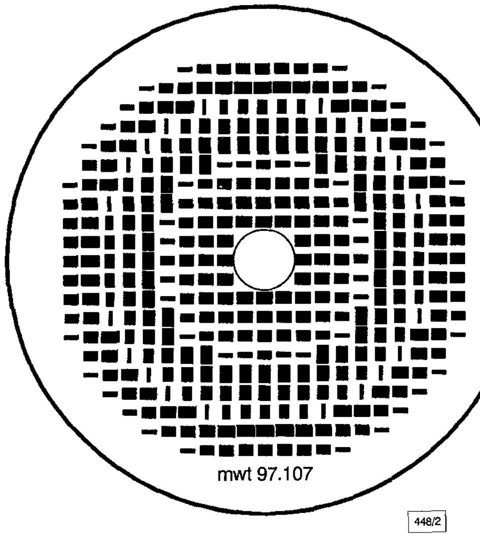

Fig. 2 *Layout of twisting reflectarray (not to scale)*

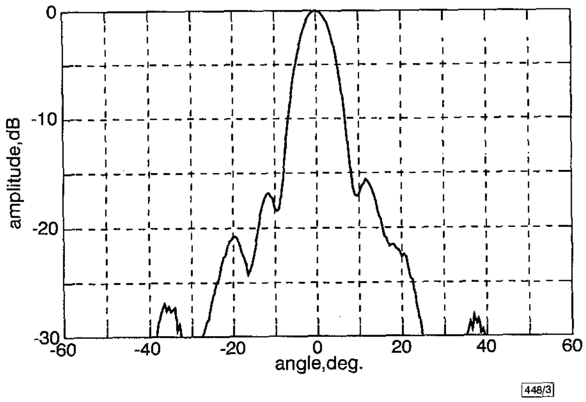

Fig. 3 *H-plane radiation pattern of antenna*

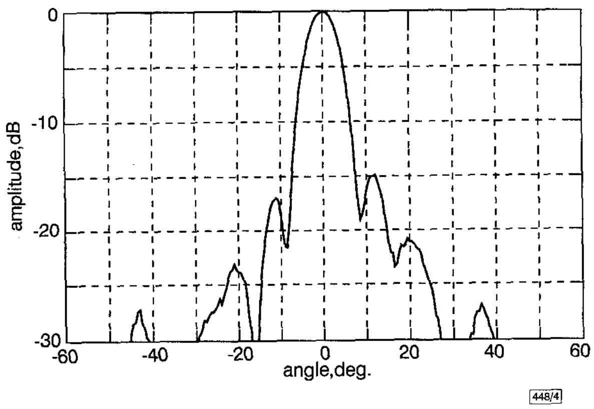

Fig. 4 *E-plane radiation pattern of antenna*

For a first approximate design of the structure, it is assumed that a plane wave is incident on a periodic array of dipoles. The polarisation of the incident wave is 45° with respect to the dipole axes. The field then is decomposed into components parallel to the dipole edges. For a twist reflector function, the dimensions of the dipoles have to be chosen in such a way that the two reflected components suffer a phase difference of their respective reflection coefficients of 180° relative to each other. This, however, can be achieved with different combinations of dipole lengths and widths, differing only in overall phase shift. This overall phase shift is now employed to locally adjust the proper phase shift to finally transform a spherical wave from the feed to a plane wave [4]. In this way, both focusing and polarisation twisting properties can be combined in a single printed structure.

For the determination of the reflection coefficient of the periodic planar structure a full wave analysis based on the spectral domain method was used [5]. The layout of the resulting nonperiodic structure is shown in Fig. 2.

Results: A prototype antenna has been realised for a centre frequency of 20GHz. The measured radiation patterns are shown in Figs. 3 and 4. The half power beamwidth is ~8° for both planes, compared to a theoretical value of 6.9°. The first side lobes can be found at a level of −15dB. The bandwidth is ~3GHz.

The procedure described above is only a first approximation. Specifically, at abrupt changes of the dipole dimensions, the approach based on periodic dipole arrays introduces remarkable phase errors [6] resulting in non-optimal radiation characteristics. Therefore an optimisation of the antenna is planned using a full wave calculation of the complete structure, based on [6].

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Oscillator stability and phase noise reduction in phase locked active microstrip patch antenna

J.W. Andrews and P.S. Hall

A phase locked loop (PLL) method for controlling a 4GHz active patch antenna was investigated in order to both frequency stabilise the oscillator and to reduce the phase noise; both these aims were achieved by optimising the PLL parameters. Experimental results showed that a phase noise reduction of up to 26dB was realised.

Introduction: Oscillator phase noise is a critical parameter in the design of communication systems. For example, Doppler radars determine the velocity of a target by calculating the small shifts in frequency that the return echoes have undergone; poor phase noise and oscillator stability in either the transmitter or the receiver can mask the target signal [1]. Angle modulated systems is another example where phase noise can be deleterious, especially at high data rates.

Techniques such as injection locking, tuned cavities [2] and dielectric resonators are commonly used to stabilise oscillators and to reduce their phase noise characteristics. In this Letter a PLL solution is implemented; as well as being effective in achieving the prime objectives, it has additional advantages such as facilitating frequency control and channel switching.