Aperture-coupled microstrip line leaky wave antenna with broadside mainbeam

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A microstrip first higher order leaky wave antenna (LWA), centre-fed by an aperture-coupled microstrip with a broadside mainbeam, is presented. The measured bandwidth (23% for VSWR < 2:1) is in agreement with the leaky radiation band predicted. The experimental gain patterns, compared with those of a patch antenna fed by the same type of structure, reveal the difference between these two kinds of antenna. With increasing frequency, the radiation field of the LWA spreads into the H-plane, forming a flatter broadside pattern, which can be applied to long rectangular area communication.

Introduction: The leaky wave phenomenon caused by planar transmission lines has recently attracted the attention of researchers and circuit designers. The advantages of wider bandwidth, frequency-scanning capability, relaxed tolerance for manufacturing processes etc. make the printed leaky wave antenna (LWA) a candidate as an integrated device in the microwave and millimetre regimes [1]. One characteristic of the leaky travelling wave antenna is that the direction of the main beam is away from the broadside, which confines its applications. The long rectangular patch antenna with a centre microstrip feed, which is a leaky wave antenna in nature, has been investigated in [2]. However, the bandwidth is narrow and the leaky wave phenomenon is not clearly observed because the feed excites both the dominant mode and the first higher order mode of the microstrip simultaneously, and the patch length is not long enough for the travelling wave to radiate out at the end.

The efficiency of the LWA hinges on its feeding structure and only appropriate feeding structures can facilitate the demonstration of the intrinsic properties of the leaky mode. Unsymmetrical microstrip line [3], microstrip-to-slotline transition [4], and CPW-to-slotline transition [5] were developed to excite the microstrip line first higher order leaky mode. These feeding structures, however, use either transformer or transition circuits as matching networks that would limit the bandwidth or affect the radiation fields. Also, these feeding structures cause the main beam of the antenna to be away from the broadside direction. In this Letter, we use the aperture-coupled microstrip [6] to excite the microstrip first higher order leaky mode. Besides the advantage of avoiding interference between feeding networks and antenna radiation, no complicated matching networks or transition circuits are required. Furthermore, the position of the slot can be adjusted to achieve the desired scanning angle range, which is restricted by the inherent property of the LWA. As in the patterns described below, the application of the broadside LWA can be used in long rectangular areas such as corridors, tunnels, trains, traffic and toll management systems, wireless communications in buildings, etc.

Fig. 1 Centre-fed aperture-coupled microstrip LWA

w = 8.5mm, L = 90mm, w1 = 1.58mm, l1 = 3.9mm, w2 = 0.2mm, l2 = 10mm, e1 = 2.2, e2 = 2.2, h1 = 1.57mm, h2 = 0.508mm

Fig. 2 Normalised phase and attenuation constants for leaky mode of microstrip, and measured return losses of LWA and PA

Specification of PA: w = 8.9mm, 2L = 8.6mm, w2 = 1.58mm, l1 = 3.5mm, w2 = 0.8mm, l2 = 5mm, e1 = 2.2, e2 = 2.2, h1 = 1.57mm, h2 = 0.508mm

The slot between the two layers acts like a transformer port that couples the energy between the two layers. The size of slot determines the equivalent turns ratio, which is tuned to match the real part of the input impedance of the LWA on the top layer. A 50Ω
open microstrip line on the other side of the ground plane is used to excite the slot. The length of the open stub \( L_o \) is selected to be one-quarter of the guided-wavelength of the feeding microstrip line, to obtain the maximum power coupling to the slot.

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Experiment results: The measured return loss of the LWA compared with the aperture-coupled patch antenna (PA) is also shown in Fig. 2. They are fabricated on RT-Duroid 5880 substrate with 0.5oz copper cladding. This shows the typical difference between the LWA and conventional resonant type antenna; the former possesses a wider bandwidth (23% for VSWR < 2:1, 9.3-11.8GHz) which is in agreement with the predicted space-wave leakage region mentioned above, while the latter has a much narrower bandwidth (8.4% for VSWR < 2:1, 9.1-9.9GHz).

The measured H-plane (\( x-z \) plane) and E-plane (\( y-z \) plane) power gain patterns are shown in Figs. 3 and 4. The dominant polarisation is \( E_y \), where \( \phi \) is the azimuth angle on the \( y-z \) plane. At 9.5GHz, the pattern of the LWA is similar to that of the PA, except that it has a slightly narrower beamwidth in the H-plane. Because the pattern caused by half of the LWA inclines toward the end-fire as the frequency increases, the sum pattern of the radiation field of the total strip results in the field spreading in the H-plane at 11.5GHz, as shown in Fig. 3. This characteristic can be applied to the specified broadside pattern contour of a long rectangular zone.

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References

Compact low noise receiving antenna

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The authors report a novel active integrated receiving antenna providing between 12 and 24dB gain when referred to a passive equivalent at 1.355GHz. The antenna is of a compact coplanar form, integrating DC and RF requirements to obtain both high gain and low noise.

Introduction: The development of active antennas that provide higher gain and low noise has been reported; examples include a half wave microstrip active antenna [1] and a printed dipole antenna [2]. These gave an increase of 8.6dB at 1.547GHz and 8.3dB at 5.8GHz above a passive equivalent with noise figures of 1.8 and 1.4dB, respectively. To our knowledge, a highly integrated compact solution in a coplanar form has not previously been achieved. A short circuit patch was chosen since the short can be used to allow the FET source leads to be easily grounded, within a quarter wave compact antenna shape. To improve the noise, it is often desirable to introduce some negative feedback [3]. In an FET-based amplifier, this is achieved by adding some inductance to the source leads [4]. This antenna topology is carefully designed so that some source inductance may be introduced onto the source leads. Thus DC, RF and low noise criteria have been satisfied in the same topology with a much more compact and coplanar shape than any previous design. Hence, this antenna may be described as having a compact structure.