

Active feedback microstrip leaky wave antenna-synthesiser design with suppressed back lobe radiation

Ying-Chou Shih, Shing-Kwang Chen, Cheng-Chi Hu and C.F. Jou

The design of an active leaky-wave antenna which integrates the antenna with a feedback synthesiser is introduced. The measurement result shows that the antenna has very low back lobe radiation compared with that of traditional single-terminal feeding leaky-wave antennas. Single frequency measurement shows that the radiated power difference between the main beam and back lobe is > 15dB at 8.2GHz. For the designed feedback synthesiser antenna, the measured radiated power difference between the main beam and back lobe is > 15dB at 9.25GHz, and the scanning angle is ~5° as the synthesiser frequency sweeps from 9.25 to 9.37GHz.

Introduction: Active antennas have the advantages of small size, simple structure, and ease of fabrication, and allow for the incorporation of more functions within the same substrate. Active leaky-wave antennas have also been intensively investigated in [1, 2]. Although the active leaky-wave antenna has many advantages, the large reflected back lobe radiation caused by the open-ended structure can be problematical. In [3], it was mentioned that with a strip of 10.0cm (2.23λ₀), the leaky-wave antenna can radiate ~65% of the power, with the remaining 35% being largely reflected from the open end producing a large back lobe at the same angle from broadside. However, it was proposed in [3], that if the antenna strip length is increased to 21.7cm (4.85λ₀), 90% of the power can be radiated. In this Letter, an alternative method is introduced to suppress back lobe radiation. An active leaky-wave antenna integrated with a feedback amplifier and with a feedback synthesiser is demonstrated. With an antenna length of ~9cm (2.46λ₀), the back lobe radiation level can be suppressed to 15dB below the main beam. Measurement results for both of these two types of circuits show that the back lobe of the leaky-wave antenna is effectively suppressed.

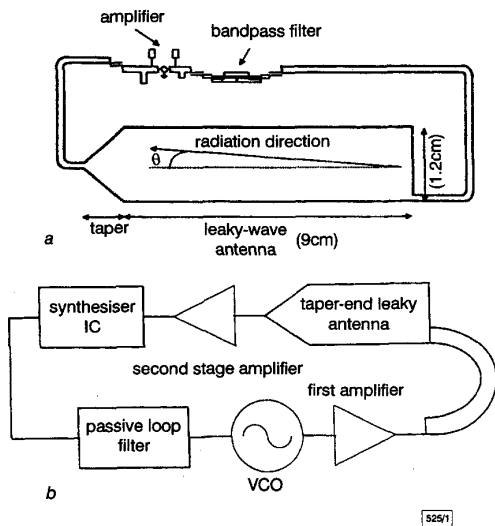


Fig. 1 Configurations of integrated active leaky-wave antenna with feedback amplifier and integrated active leaky-wave antenna with feedback synthesiser

a Configuration with feedback amplifier
b Configuration with feedback synthesiser

Design and measurement results:

(i) *Active leaky-wave antenna with feedback amplifier structure:* Fig. 1a shows the active leaky-wave antenna with a feedback amplifier structure. The circuit consists of three parts: amplifier, bandpass filter, and leaky-wave antenna. The entire circuit is fabricated on RT/Duroid substrate with a dielectric constant of 2.2 and thickness of 20mils. Fig. 2 shows the power dissipation of the microstrip leaky-wave antenna. From the result of Fig. 2 and [4], we know that the first high order mode is successfully excited by

asymmetrical feeding. The taper is added behind the end of the antenna to reduce the discontinuities which could cause reflected waves and the generation of undesired modes. This antenna with a taper has a transmission loss of 9.2dB (due to the radiation of the leaky-wave antenna), and it is placed in the path of the amplifier feedback loop. An NEC42484 low noise HEMT is used as the amplifier, and the drain is biased at 2.0V with a drain current of 10mA. The amplifier with bandpass filter can provide ~10dB small-signal gain within the bandwidth (centred: 8.2GHz, span: 500MHz). The amplifier is placed in the loop in order to satisfy the gain requirements for oscillation. To satisfy the Barkhausen criterion, the electrical length of the feedback loop is adjusted to be a multiple of 360°. The active antenna is designed to oscillate

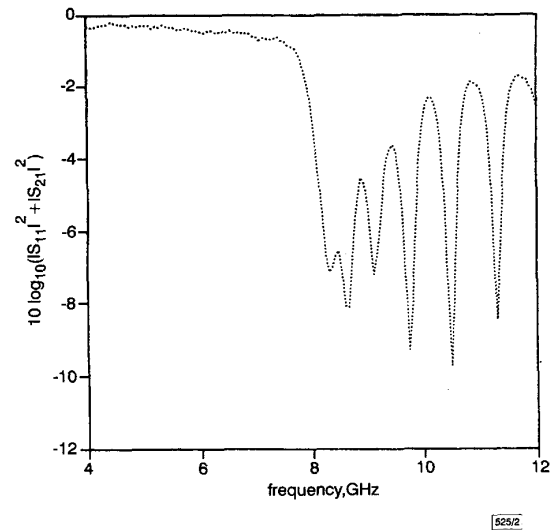


Fig. 2 Measured power dissipation of leaky-wave antenna

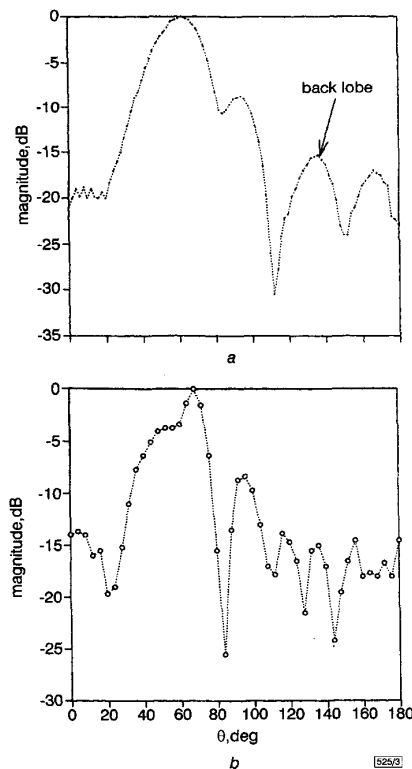


Fig. 3 H-plane pattern measurements of integrated active leaky-wave antenna with feedback amplifier and with feedback synthesiser

a H-plane pattern measurements with feedback amplifier
b H-plane pattern measurements with feedback synthesiser
--○-- f = 9.25621 GHz

at a frequency of 8.2GHz. Fig. 3a shows the radiation patterns of the H-plane. The power between the main beam and back lobe is > 15dB and the effective isotropic radiated power (EIRP) is 19.5dBm.

(ii) *Active leaky-wave antenna with synthesiser structure*: Fig. 1b shows the active leaky-wave antenna with a synthesiser structure. The circuit consists three parts: synthesiser, amplifier, and leaky-wave antenna. Two NEC42484 low noise HEMTs are used as the first and second stage amplifiers, respectively, the drain is biased at 2.0V with a drain current is 10mA. The synthesiser is composed of a VCO, a synthesiser IC and a passive loop filter. The synthesiser itself has ~300MHz operation bandwidth, from 9.1 to 9.4GHz. When the circuit forms a closed loop with the feedback synthesiser and the leaky-wave antenna, in the closed loop the active antenna scanning frequency is 9.25–9.37GHz. Fig. 3b shows the radiation patterns of the H-plane at 9.25GHz. The power difference between the main beam and back lobe is > 15dB. The scanning angle is ~5° as the frequency is swept from 9.25 to 9.37GHz.

Conclusion: In this Letter, by using a 'taper-end' feedback structure we have successfully demonstrated a method which can effectively reduce the back lobe radiation of a leaky-wave antenna without increasing the strip length of the antenna. This active leaky-wave antenna has the advantages of a narrow main beam and very low back lobe radiation level, with a shorter antenna length. Such an active integrated antenna is suitable for power combining applications and active antenna arrays for communications and radar systems.

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Bow-tie slot antenna fed by CPW

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A bow-tie slot antenna fed by CPW is introduced. It is designed to work in the Ku-band around 15.5GHz. The proposed antenna is analysed both theoretically and experimentally. The presented results include the return loss and the radiation patterns. Two different geometries of the bow-tie antenna are presented and compared. The proposed antenna has several advantages such as a very large bandwidth, good control of its input impedance, and ease of fabrication. The proposed antenna has a dipole like radiation pattern which makes it suitable for mobile communication systems designed to work in the Ku-band.

Introduction: Integrated circuit antennas are becoming increasingly popular owing to their advantages in terms of size, cost, and possible direct integration with communication system electronics.

They are divided into two main classes, microstrip and slot types. A representative sample from the first type is the microstrip patch antenna which has been studied extensively over the past two decades [1]. Slot antennas have several appealing advantages over microstrip antennas: they provide wider bandwidth, good impedance matching, and the possibility of obtaining bidirectional [2] and unidirectional [3] radiation patterns. Slot antennas are usually fed by coplanar waveguide (CPW). Coplanar waveguides are preferable to microstrip lines for several reasons, such as their low dispersion, the ability to effectively control their characteristic impedance, and their ease of integration with active devices. In this Letter, a bow-tie slot antenna fed by CPW is introduced. The analysis is carried out both theoretically and experimentally. In the following Section, the return loss and the radiation patterns of the proposed antenna are presented and briefly discussed. The effect of the antenna geometry on the results is also investigated.

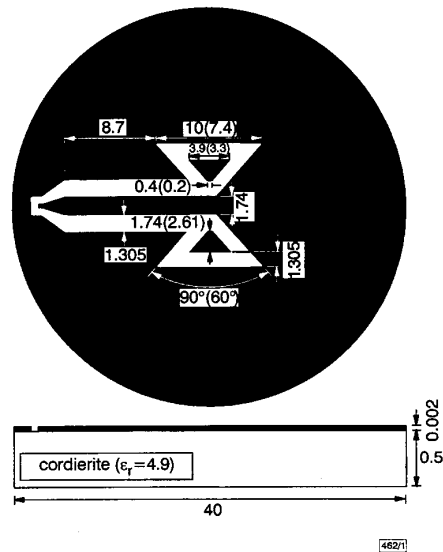


Fig. 1 Geometry of proposed bow-tie antenna with flare angle of 90 and 60°

All dimensions are in millimetres, dimensions between braces correspond to case of 60°

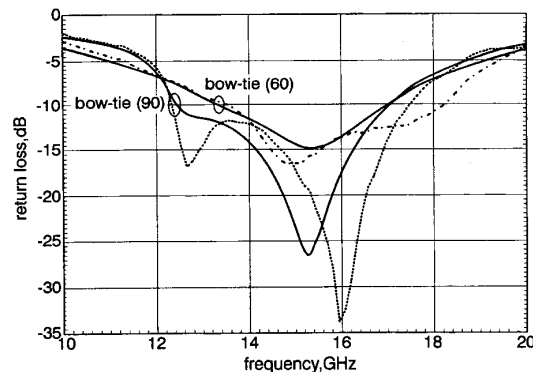


Fig. 2 Measured and calculated return loss against frequency for bow-tie(90) and bow-tie(60)

— simulation
 --- measurements
 --- measurements

Results and discussions: The geometry of the proposed bow-tie antenna is shown in Fig. 1. Two bow-ties with approximately the same physical aperture sizes and different flare angles are implemented and compared. Fig. 1 shows the geometry of the bow-tie antenna with flare angles of 90° and 60°; the dimensions in the braces correspond to a bow-tie antenna with a flare angle of 60°. These antennas will be referred to as bow-tie(90) and bow-tie(60). Both of them are realised on a 500µm thick Cordierite [4]