X/Ku 頻帶高效率頻寬主動積體天線陣列研製

Research of X/Ku band High-Efficiency Wideband Active-Integrate Antenna Arrays

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I.中文摘要

在本計畫中我們完成非對稱雙波束主動掃描是洩漏波天線,在此應用分別使用了兩種不同形式的昇頻器,一種為單端電阻性昇頻器,另一種為主動性昇頻器.在非對稱雙波束主動掃描是洩漏波天線中,我們使用雙端饋入洩漏波天線,一個 X-Band 的訊號經由一功率分配企分成兩路輸入這個雙端天線的饋入端,並在其中的一個饋入端點前加上一昇頻器,故有加昇頻器的這端變形成了一可掃描是的波束,而吳昇頻器的這端形成一定位式的波束.在使用電阻式昇頻器的非對稱雙波束天線中,我們得到約 20 度的單波束掃描角度,而在使用主動式昇頻器的非對稱雙波束天線中.我們得到約 22 度的單波束掃描角度.

最後針對之前所提出的發射器,我們由孔隙饋入式洩漏波天線,發展出一可以兼具發射和接收的天線.觀察其發射與接收的輻射場型,可得知掃描角度分別為 22 度和 16 到 18 度.

關鍵詞: 非對稱雙波束掃描,洩漏波天線,波束掃描

Abstract

In this project, an active asymmetrically dual-beam scanning leaky-wave antenna integrating with an upconverter to con-trol the scanning beam is presented. Two kinds of upconverters are studied, which are a resistive HEMT up convert-er and an active HEMT upconverter. The resistive HEMT upconverter has conver-sion loss. The active HEMT upconverter has conversion gain.

The resistive asymmetrically dual-beam scanning leaky-wave antenna can provide a fixed beam and a scanning beam. The measured scanning beam provides a 20° scanning angle in H-plane from 10.2GHz to 11GHz.

The active asymmetrically dual-beam scanning leaky-wave antenna also gas a fixed beam and a scanning beam. The measured scanning beam provides a 22° scanning angle in H-plane from 10.2GHz to 11.5GHz.

At last, we developed a transceiver/ receiver antenna. It utilized the aperture-fed leaky-wave antenna to develop a multi-beam antenna. The transmitting signal fed into center aperture, and the feeding signal coupled to the leaky-wave antenna,and scanning dual-beam pattern was obtained The receiving signal obtained from the

end-side of the aperture-coupled antenna. Its transmitting and receiving radiation patterns are observed,their scanning angles as 22° and 16° ~18° ,respectively.This antenna gas the potential to be used in the transmit/receive modules such as smart antenna systems because both modules can use only one antenna.

Keywords: asymmetrically dual-beam scanning, leaky-wave antenna, beam scanning

II. INTRODUCTION

MICROSTRIP leaky-wave antennas [1]–[4] have the advantages of narrow beamwidth, small size, easy fabrication, easy matching, frequency scanning, and can be easily integrated with other useful circuits (such as an amplifier [1], a VCO [2], a switch circuit [3]) on the same substrate to be used in communication systems. Recently, some researches have successfully achieved dual-beam symmetrically scanning capability [2]–[4]. However, in many physical applications such as position calibration systems, one beam is fixed at some angle, and the other beam needs to be steered to locate a specified object with relative position to the observer. Traditional dual-beam scanning antennas fail to meet the requirement in these applications. This paper details the design of a two-terminal leaky-wave antenna [2] integrated with a HEMT resistive upconverter (see Fig. 1). If the IF port has no injection, the proposed topology can perform the conventional dual-beam symmetrically scanning function just by changing the LO frequency. In addition, fixing the LO frequency and varying the IF frequency, we can derive the dual-beam asymmetrically scanning radiation patterns.

III-1. DESIGN

Fig. 1 shows the configuration of the X-band dual-beam asymmetrically scanning leaky-wave antenna. The circuit consists of a T-type power divider, a HEMT upconverter and a microstrip leaky-wave antenna with a two-terminal feeding structure. All components mentioned above are fabricated on a RT/Duroid substrate with the thickness of 0.508 mm and the dielectric constant of ε_r =2.2 . A NEC NE42484C low-noise HEMT serves as a frequency-mixing device of the upconverter. The HEMT device is chosen for the consideration of lower noise performance and better conversion gain in comparison with a diode [5]. Additionally, the device also has the advantages of low cost and well integration with monolithic IC (MIC) in the future. To excite the first higher order mode, the leaky-wave antenna is fed asymmetrically. The geometry and coordinate system for the microstrip LWA are shown in Fig. 2. Both of the RF and LO signals radiate the same field as a magnetic dipole with the magnetic current density $M_s = -n \times E$. In order to realize the radiation characteristics of the microstrip LWA, we analyzed its normalized complex propagation constant of $\beta / k_0 - j\alpha / k_0$ the first higher order mode in the radiation region, where β / k_0 is the normalized phase constant and α / k_0 is the normalized attenuation constant. Fig. 3 shows the normalized complex propagation constant as a function of frequency, which was obtained by employing the rigorous (Wiener-Hopf) solutions mentioned in [6]. When $\beta / k_0 < 1$, the power of the input signal will leak in the form of the space wave in addition to the surface wave.

III-2.THEORETICAL AND EXPERIMENTAL RESULTS

The resistive HEMT upconverter includes three ports (LO,IF, RF), where LO and IF are the input ports and RF is the output port. The LO frequency was set at 9.5 GHz (the X band). The IF frequency was varied from 0.7 GHz to 2 GHz (the UHF band). The RF output signal was obtained at the drain via the band-pass filter. The RF frequency range was from 10.2 GHz to 11.5 GHz (the X band). Fig. 4 showed the RF output power as a function of the bias voltage when the frequencies at the IF and the LO ports were 1.0 GHz and 9.5 GHz, respectively. The power of the IF and the LO was approximately 12 dBm and 0 dBm. The maximum output power at the RF port was close to -5.17dBm when the gate voltage was biased at the range from -0.4V to-0.3 V. The bandpass filter was used to extract the RF signal and also excluded the spurious frequencies of (LO and IF). Fig. 5 showed the RF power as a function of IF frequency when the LO power was at 0 dBm and the IF power was at 12 dBm. Fig. 6 showed the conversion loss of the HEMT upconverter when the LO power was 0 dBm at 9.5 GHz and the IF frequency was at 1 GHz. The 1dB compression point was approximately 12 dBm. Figs. 7-9 illustrated the simulated and measured dual-beam asymmetrically scanning radiation patterns as the LO frequency was fixed at 9.5 GHz and the RF signal was varied at the three frequencies of 10.2 GHz, 10.5 GHz and 11.0 GHz. The theoretical radiation patterns for this dual-beam asymmetrically scanning leaky-wave antenna were determined by taking the data in Fig. 4 into the electrical field in [2, eq. (1)]. The calculated angle for the right beam at the LO frequency (9.5 GHz) was 47.5 , and those for the left beam were 137 , 144 , and 156 at three frequencies of 10.2 GHz, 10.5 GHz and 11.0 GHz for the RF signal, respectively. The maximum effective isotropic radiated power (EIRP) was close to 18.96 dBm for the right beam at 9.5 GHz and 19.96 dBm for the left beam at 10.5 GHz. The angle of the right beam was measured of 48 controlled by the operating frequency at the LO port. The left beam should scan from broadside to end-fire as the RF frequency varied from 10.2 GHz to 11.0 GHz. The scanning angles of left beams were measured of 136 , 144 and 158 (the total angle of 22), respectively, in accordance with the increment of the RF frequency. Good agreement between the theoretical predictions and the measured results for the proposed LWA performance was obtained.

IV. CONCLUSION

A novel dual-beam asymmetrically scanning leaky-wave antenna is illustrated in this paper. Experimental result reveals that the radiation patterns agree well with the expected patterns. The left beam scans around 22 while the right beam is fixed. The topology can provide multifunction of dual-beam symmetrically/ asymmetrically scanning patterns and is suitable for automobile radar systems and satellite comm.-unication systems. We also can utilize the function of this structure to achieve calibration in wireless communication systems.

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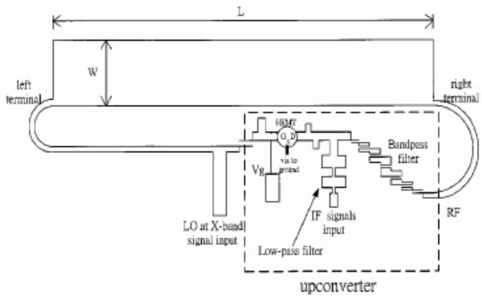

Fig. 1. Configuration of a two-terminal feeding leaky-wave antenna integrated with a resistive HEMT upconverter.

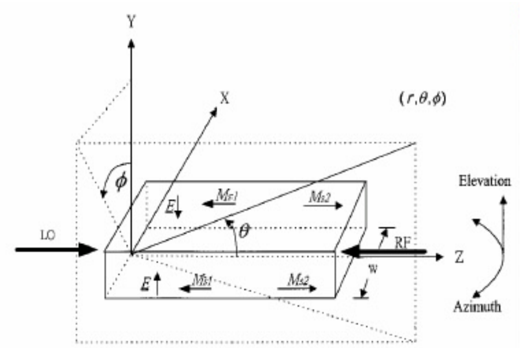

Fig. 2. Geometry and coordinate system for the microstrip LWA.

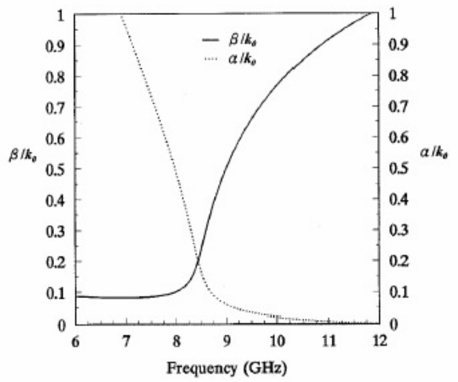

Fig. 3. Normalized complex propagation constants varied as a function of frequency.

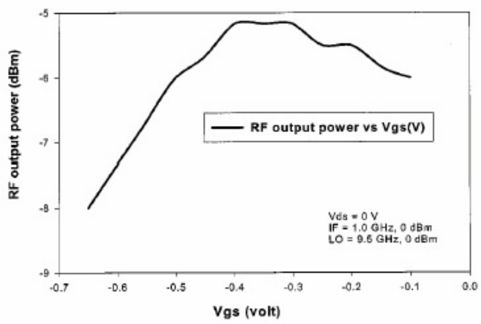

Fig. 4. Measured RF output power as a function of reverse gate bias.

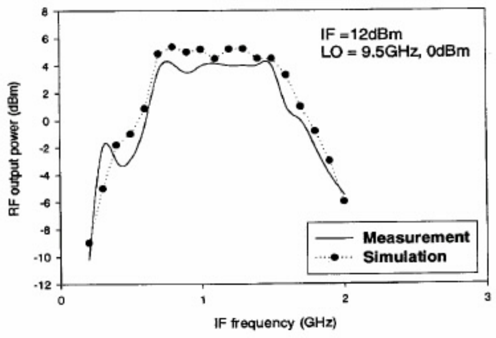

Fig. 5. Measured and simulation RF output power as a function of IF frequency.

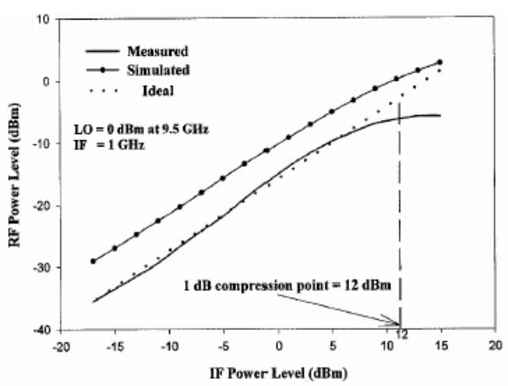

Fig. 6. Conversion loss of the HEMT upconverter.

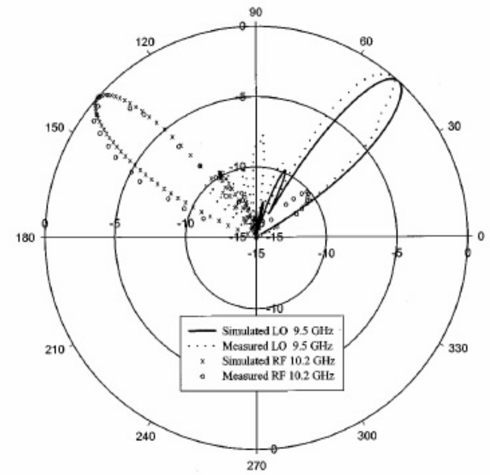

Fig. 7. Dual-beam asymmetrically scanning radiation patterns for the RF signal at 10.2 GHz when the LO signal is fixed at 9.5 GHz.

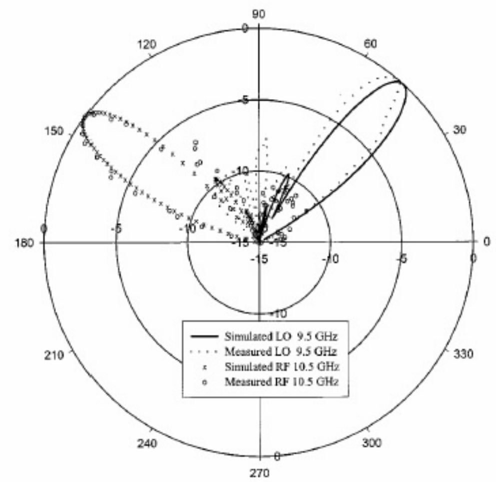

Fig. 8. Dual-beam asymmetrically scanning radiation patterns for the RF signal at 10.5 GHz when the LO signal is fixed at 9.5 GHz.

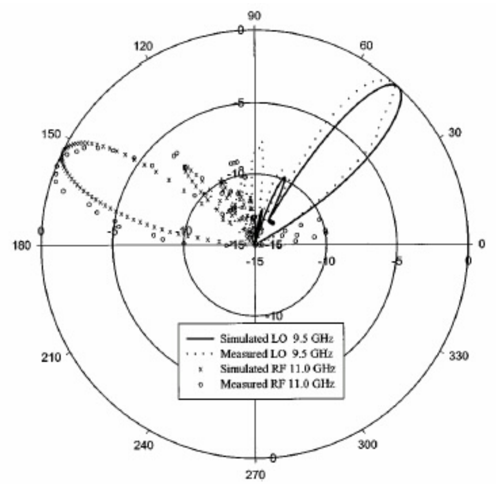

Fig. 9. Dual-beam asymmetrically scanning radiation patterns for the RF signal at 11.0 GHz when the LO signal is fixed at 9.5 GHz.