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A Quarter-Wavelength Open Circuited Microstripline Slot Array

($\lambda g/4$ 開放 마이크로스트립 線路 스로트의 配列)

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要 約

X−밴드 周波數에서 $\lambda_g/4$ 開放 마이크로스트립 線路 給電형 스로트 配列을 具現하였다. 最適 給電點은 實驗的으로 決定하였고 스로트 配列의 여러 周波數에서 入力 임피던스와 輻射 패턴을 測定하였으며 다소 다른 길이의 16개 素子와 本 論文에서 提示한 給電 線路를 사용하여 周波數 帶域을 증가시켜 보았다.

Abstract

A quarter-wavelength open circuited microstripline slot array is realized at X-band frequency. The optimal feeding point is experimentally determined. The input impedance of the slot array for various frequencies and its radiation pattern are measured. The bandwidth of the slot array is increased by using the 4x4 elements which are slightly different in length and feeding network which is suggested in this papers.

I. Introduction

Microstrip slot array appears to be quite useful in various fields of application. The several types of microstripline slot antenna have been reported by several authors. Slot antennas utilizing the microstrip conductor which is short-circuited through the dielectric substrate with the slot longer side have been reported by Yoshimura (1). Slot antennas utilizing triplate striplines have also been reported by Sommers (2). In this papers, slot array utilizing a quarter-wavelength open circuited microstriplines is investigated. The advantages of this feeding method are quite obvious from the standpoints of light weight, compactness, economy of construction and minimization of the matching network.

II. A Single Slot

A single slot utilizing quarter-wavelength open circuited microstripline is shown in Fig. 1. It is fabricated by conventional photoetching techniques on the epoxy fiberglass substrate. The relative dielectric constant of the substrate is nominally 4.2 at the operating frequency.

The slot is fed with a 100-ohm microstripline which terminate in an open circuit at the distance of $\lambda g/4$ from the slot center of the shorter side; λg is the guided wavelength on the dielectric substrste. The feed point

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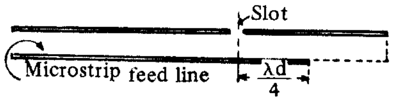
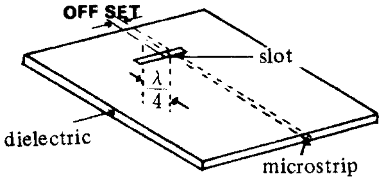


(a) Side view



(b) Front view

Fig. 1. Configulation of a single slot.

is dislocated from the slot center of the longer side. As a result the feeding network does not need any matching network and it also causes to increase its band-width. The E-plane radiation pattern of the slot, though it is not depicted in this paper, is much distorted than the H-plane pattern. As a result of experiments the larger the size of the ground plane is, the more the E-plane pattern is improved When the slot width is small compared to the free space wavelength that is $Ws \ll \lambda o$, to a first order approximation, the electric field across the slot may be assumed to be constant.

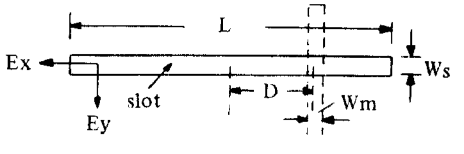


Fig. 2. A microstripline slot.

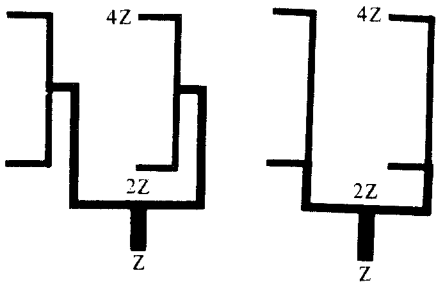
If Ex=0 and Ey=Eo in Fig. 2, the radiation patterns[3] may be written as

$$E\theta = \frac{jK_o E_o LW_s}{4\pi} \cdot \frac{e^{-jKor}}{r} \cdot \frac{\sin(\frac{K_o L}{2} \sin\theta \cos\phi)}{(\frac{K_o L}{2} \sin\theta \cos\phi)} \sin\phi \qquad (1)$$

$$E\phi = \frac{jK_o E_o LW_s}{4\pi} \cdot \frac{e^{-jK_o r}}{r} \cdot \frac{\sin(\frac{K_o L}{2} \sin\theta \cos\phi)}{(\frac{K_o L}{2} \sin\theta \cos\phi)} \cos\phi \cos\theta \qquad (2)$$

III. Slot Array

The elements of the array used in experiments are 15mm long and 0.6mm in width. The thickness of the dielectric substrate and the size of the ground plane are 1.5mm and 135x100mm^2 respectively. An X-band broadside array with 4x4 elements is designed and fabricated. The principal objective in this papers is the development of a broadside array with in phase signals of equal power fed to each slot. The selected optimal feeding networks are shown in Fig. 3. In Fig. 3, the power divider is a junction at which a microstripline of characteristic impedance (Zo) divides into two parallel microstriplines each having a characteristic impedance of 2Zo.



(a) Symmetrical feed (b) Asymmetrical feed

Fig. 3. Feeding network of a broadside array.

If each unit element of the array is arranged one-wavelength apart in the dielectric substrate, it is possible to supply power in phase with minimum feeding network. But in an ideal case, optimum broadside signal would have its slots spaced half-wavelength in free space. These two conflicting condutions can be settled by using the substrate which has the relative dielectric constant of 4. Because the guided wavelength varies as the square root of the dielectric constant. This can be explained by the fact that the width of substrate is very small compared to the free space wavelength; therefore the far field is hardly influenced by existence of the dielectric substrate. Fig. 4 shows the feeding network of the microstripline slot array.

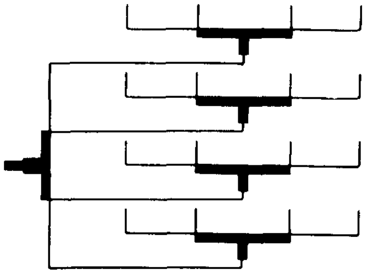


Fig. 4. The feeding network.

Fig. 5. The overall view of the microstripline slot array.

The overall view of the microstripline slot array is also shown in Fig. 5.

Considering that the array pattern is generated by an element pattern times an array factor; the radiation pattern of 4 element broadside array with spacing $d = \frac{\lambda g}{2}$ can be written

$$R_4\ (\theta) = E(\theta) \cdot AF(\theta) = E(\theta) \cdot \frac{\sin(2\pi \cos\theta)}{\sin(\frac{\pi}{2}\cos\theta)}$$

where θ is the angle measured from broadside: "AF(θ)" is array factor for broadside array; E(θ) is a single slot element pattern which can be obtained from equation (1) and (2). The pattern of 4x4 element broadside array with the same spacing can be written as

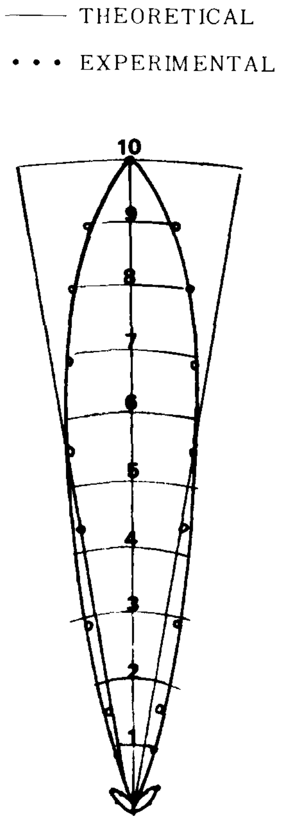


Fig. 6. Radiation pattern of the slot array.

$$R_{4x4}\ (\theta) = E(\theta)\ \left[\frac{\sin(2\pi \cos\theta)}{\sin(\frac{\pi}{2}\cos\theta)}\right]^2 \qquad (4)$$

The radiation pattern of the 4x4 slot array is shown in Fig. 6.

Gain, beam width and first null point are compared with those of an usual Pyramidal horn (pm 7320) in table 1. Fig. 7 illustrates the measured data of the terminal impedance of the 4x4 slot array according to the frequency. The impedance is a function of the length and width of the slot and feed point of the microstripline.

IV. Conclusion

A uniform broadside slot array is designed

Table 1. Characteristics of the tested array and horn.

	Grain	Beam Width	1st Null Point
Tested array	13.9 db	12° x 2	30°
Horn	15.1 db	30° x 2	40°

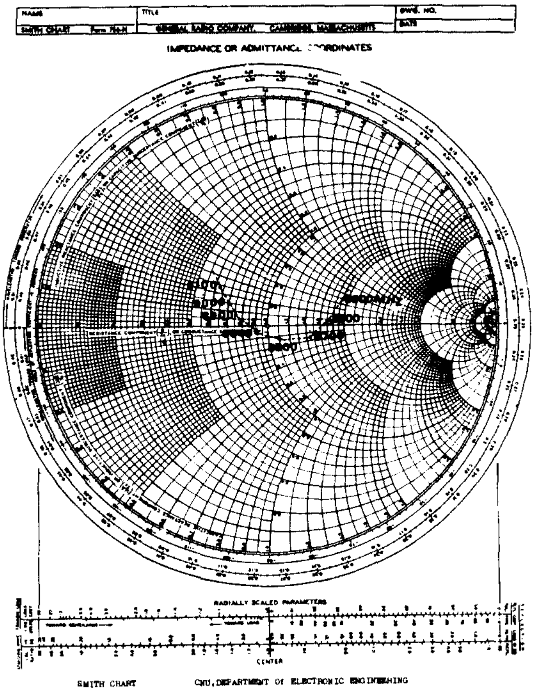


Fig. 7. Terminal impedance of the slot line.

and fabricated as an application of an open-circuited microstripline feed. Experimental result shows that the radiation pattern of the tested antenna nearly coincides with the theoretical expectation. About 450MHz broadband pencile beam of 7.8 solid angle could be obtained. But the tested array has a fall-off in gain though directivity is more improved than that of pyramidal horn as shown in Table 1. This can be explained by the fact that the tangent loss and ohmic loss of epoxy fiber glass substrate are significant problem though it is convenient to minimize feeding network. It is advisable to use this slot array as an element of scanning antenna.

Reference

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