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Simulation and Analysis of Monopole Leaky Wave Antenna

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ABSTRACT- In this article a monopole leaky wave antenna is proposed. This article describe comparative analysis of leaky wave antenna with monopole leaky wave antenna .The configuration of the proposed LWA contains two parts: the conventional open structure LWA, the added monopole connected to the end of the LWA on a reduce ground plane, Because of the open structure of the LWA, the reflected power produces a large back lobe radiated backwardly. By using the method of the added monopole connected to the end of the antenna, the remainder power could radiate through the added monopole without reflecting at the end. This paper uses a monopole antenna which can improve the return loss, reduce the back lobe of proposed antenna. . Above antenna has become interesting due to their simple shape and geometry.This antenna has been simulated on electromagnetic simulator computer simulation technology (CST)Microwave suit software and results are analyzed at frequency 2.76 GHz.

Keywords- Monopole leaky wave antenna.

1. INTRODUCTION

The leaky-wave antenna (LWA) was first constructed by Menzel in 1979 [1], based on exciting the first higher order mode (TE_{01} mode) of the microstrip line to obtain a narrow beam radiation pattern. Progress in the recent years has been obtained on the development of leaky-wave antennas based on the higher order mode of microstip [2, 3]. The LWAs possess the advantages of low-profile, easy matching, fabrications implicitly, and frequency/electrically scanning capability. But in some application especially for point-to-point communication, the main beam variation of LWA should be as low as possible. The MLWA proposed by Menzel [4], in that the length L_{leaky} = 2.23 λ_0 of the micro strip line radiated only about 65% of the power. The remaining power reflects from the open structure end, and produces a large back lobe. To radiate 90% of the power, the length L_{leaky} needs to increase to 4.85λ_0. The length of the LWA typically requires about five wavelengths to suppress back lobes and radiate power efficiently [5].

Recent research findings show that the back lobes can be suppressed by array topology [6] or a taper-loaded antenna end [7]. The array topology in [6] suppresses to 10.5 dB with the length L_{leaky} of about 2 λ_0 . The taper-loaded LWA end in [7] suppresses the back lobe 15 dB with the length L_{leaky} of about 3 λ_0 . Also, in [8], adding parasitic elements beside the MLWA can suppress the back lobe at about 12 dB at 6.9 GHz while the length L_{leaky} is about 2 λ_0. The back lobes suppress 10 dB at 10 GHz and 8 dB at 10.5 GHz by the radiating circuits in [9] and [10] respectively while the length L_{leaky} is 2λ_0. However, the above mentioned designs require a large length (at least 2λ_0) or a complicated structure.

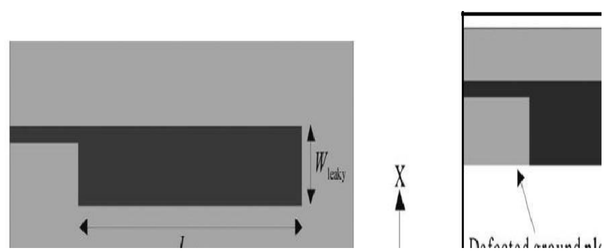

Fig. 1: Configuration of the proposed LWA (a) short length conventional MLWA (b) added monopole to the end of the MLWA

The proposed design in this study can suppress back lobe gain at about 8 dB at 2.765 GHz while the length L_{leak} is only 0.6 λ_0. This work employs an alternative structure with suppressed back lobes and an increased frequency scanning region. Fig. 1 shows the proposed LWA, which has two mechanisms to radiate the power.

In addition to the conventional MLWA which radiates while the travelling wave propagates, an added monopole with length of about λ_0/4 also radiates out the remaining power of the conventional MLWA (see Fig. 1(b)). Consequently, the back lobes reduce due to the dropped reflected power.

2. ANTENNA PARAMETER

The radiation mechanism of higher order modes on micro strip LWA is attributed to a traveling wave instead of the standing wave as in patch antennas, and is characterized by a complex propagation constant k= $\beta - j\alpha$ where β is phase constant of the first higher mode and α is the leakage constant Above the cut frequency, where the phase constant equals the attenuation constant ($\alpha_c = \beta_c$) ,it is possible to observe three different ranges of propagation: leaky wave, surface wave and bound wave, Instead, at low frequency, below the cut of frequency, we have the reactive region (without radiation) due to evanescent property of LWA. When the frequency is such that the phase constant of complex propagation constant, is higher than the free space wave number, we have the Bound mode region. The main-beam radiation angle of LWA can be approximated by:

$$\theta = \cos^{-1}\left(\frac{\beta}{k_0}\right) \qquad \text{………….. (1)}$$

Where θ is angle measured from end fire direction, and k0 is the free space wave number. The radiation leaky region can be defined as the band between the frequency point at which the phase constant equals the attenuation constant ($\beta = \alpha$), and that at which the phase constant equals the free-space wave number ($\beta = k_0$). Where k_0 is free space wave number. The frequency region below the radiation region can be considered as the reactive region owing to its evanescent property. At a frequency above the radiation region the bound mode propagates. The frequency range of leaky- mode radiation indicated in the more usefull way for the design of our antenna [11]

$$\text{Cutoff frequency } fc = \frac{c}{2W_{eff}\sqrt{\varepsilon r}} \qquad \text{…... (2)}$$

$$\text{Radiation region } fc < f < fc\,;\ \frac{\sqrt{\varepsilon r}}{\sqrt{\varepsilon r - 1}} \qquad \text{…...(3)}$$

Here, c is the speed of the light in a vacuum; weff is the effective line width, and $\mathcal{E}r$ is the dielectric constant. These equations show that the radiation bandwidth of a micro strip leaky-wave antenna is governed by the line width after the substrate is selected. According to (2) we can see as the width of antenna decreases, whereas the cutoff frequency increases shift towards higher frequency.

3. SIMULATION

Fig. 1 shows the proposed LWA, consisting of two parts: (a) the short length (only 0.6 λ_0) of the conventional open structure LWA,(b) the added monopole connected to the end of the LWA on a defected ground plane The proposed LWAs were exited simply with an asymmetrical planar feed of 50Ω , because the metal wall down the centerline connecting the conductor strip and ground plane, used to suppress the dominant mode, allows to travel only the higher order mode. The length of LWA was chosen 140mm, The length L leaky is 65 mm, and the width W leaky is 25 mm and one microstrip line with width of 4mm and lengh of 20mm is boolean add with main structure by CST-Microwave suite softwere and $\varepsilon r = 4.4$ in Fig. 1(a). Fig. 1(b) shows the design of the added monopole connected to the end of the LWA. The perfect ground plane has obviously reduced to the reduced (defected) ground plane. The transversal width edge of the reduced ground plane is aligned with the edge of the LWA. The monopole is added by transversely extending a rectangular metal at the end of the LWA. This study chooses the length of Lmonopole and the Wmonopole of the rectangular metal to be 25mmand 5mm respectively. The added monopole is fed directly by the microstrip line, operated in the first higher order mode. The length Lmonopole is about λ0/4 at the operating range. By adding the monopole, the remainder power of the LWA radiates out without reflecting at the end. However, because the monopole radiation pattern is like a donut surrounding the monopole [12], there are still side lobes around the monopole and the back lobe of the short MLWA cannot suppress well.

4. THEORETICAL AND EXPERIMENTAL RESULTS

The normalized complex propagation constant ($\beta/k_0) - j(\alpha/k_0)$ of the first higher order mode in the microstrip line can be found using a rigorous (Wiener-Hopf) solution in [13] and [14], where β/k_0 is thenormalized phase constant and α/k_0 is the normalized attenuation constant. The radiated leaky mode begins from the frequency where α/k_0 is equal to β/k_0 and ends when the β is equal to the free-space wave number. In this region, the power in the MLWA radiates into air. Fig. 2 shows the theoretical β/k_0 and α/k_0 as frequency functions. Moreover, the MLWA scanning angle θ between the broadside direction (the Z axis direction) and the end-fire direction (the Y axis direction) is determined by the equation θ = cos-1 β k0 Hence, the scanning angle of theMLWA is a function of frequency. In the current study of the open structure conventional MLWA as shown in Fig. 1(a), findings show that the measured maximum gain of the back lobe appears at 5.0 GHz, only 2.84 dB lower than the main beam while the length Lleaky is 0.6 λ_0, about 4.6 dB lower at both 4.6 and 4.8 GHz. The design considerations of the added monopole as shown in figure.

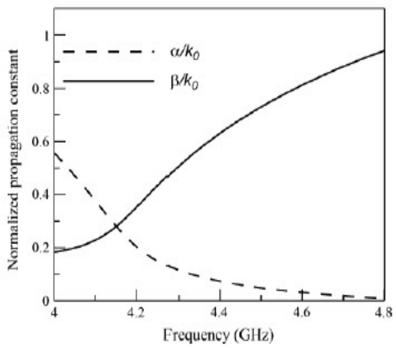

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Fig. 2: Normalized complex propagation constant $\beta/k_0 - j\alpha/k_0$ of the first higher order mode in the microstrip line (W=15 mm, h= 1.6 mm, εr = 4.4)

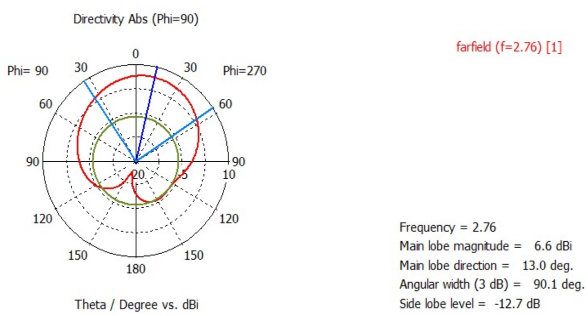

Fig.3: Far field radiation patterns of the conventional MLWA at 2.7 GHz

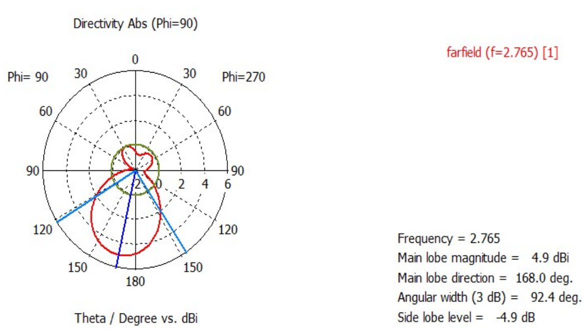

Fig. 4: measured farfield radiation patterns the added monopole connected to the MLWA at 2.7 GHz.

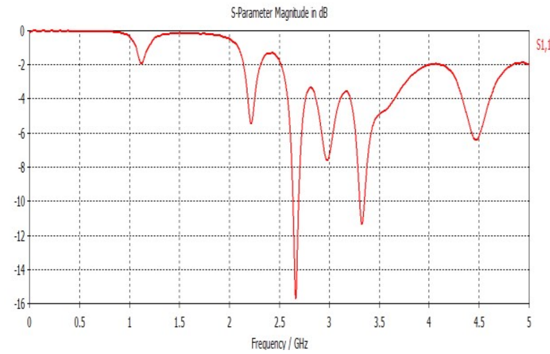

Fig.5 measured return loss of conventional MLWA at 2.7 GHz.

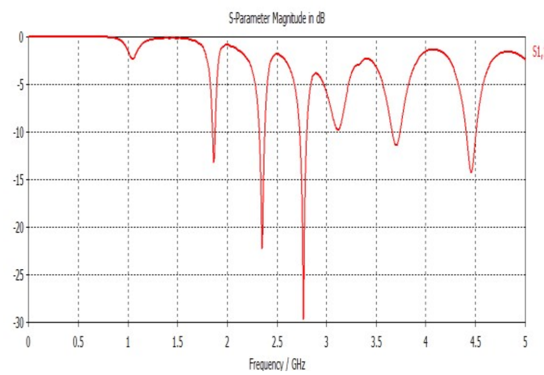

Fig.6 measured return loss of the added monopole connected to the MLWA at 2.7 GHz.

5. CONCLUSION

In this paper, the proposed short LWA design suppresses the back lobes successfully and improve the return loss effectively. The back lobe gain at 2.7 GHz has been suppressed 8 dB and the angular beam width increases while the frequency operated around 2.7 GHz. Return loss improved -16 db to -30 db. This proposed LWA is suitable for the scanning systems such as traffic control, collision avoidance system, radiolocation, etc. and has great potential for application in the future.

6. REFERENCES

[1] W. Menzel, "*A new travelling-wave antenna in microstrip*," *Archiv. Electrnik, Ubertrag Tech.*, pp. 137–140, Apr. 1979.

[2] W. Menzel, "A new traveling-wave antenna in microstrip," Archiv für Elektronik und Ubertragungstechnik, vol. 33, no. 4, pp. 137–140, 1979.

[3] A. A. Oliner, "Leakage from higher modes on microstrip line with application to antennas,"Radio Science, vol. 22, no. 6, pp. 907–912, 1987.

[4] A. A. Oliner and K. S. Lee, "*Microstrip leaky wave strip antennas," in IEEE AP-S Int. Symp. Dig.*, Philadelphia, PA, Jun. 1986, pp. 443–446.

[5] Yi-Lin Chiou, Jin-Wei Wu, Jie-Huang Huang, and Christina F. Jou "*Design of Short Microstrip Leaky-Wave Antenna With Suppressed Back Lobe and Increased Frequency Scanning Region*" IEEE transactions on antennas and propagation, vol.57,no.10,October 2009,pp3329.

[6] C. J. Wang, C. F. Jou, J. J. Wu, and S. T. Peng, "Radiation characteristic of active frequency-scanning leaky-mode antenna arrays," *IEIEC Trans. Electron.*, vol. E82-C, no. 7, pp. 1223–1228, Jul. 1999.

[7] Y. C. Shih, S. K. Chen, C. C. Wu, and C. F. Jou, "Active feedback microstrip leaky wave antenna-synthesizer design with suppressed back lobe radiation," *IEE Electron Lett.*, vol. 35, no. 7, pp. 513–514, Apr. 1999.

[8] Y. X. Li, Q. Xue, E. K.-N. Yung, and Y. Long, "Radiation patterns of microstrip leaky-wave antenna with parasitic elements," *Microw. Opt. Technol. Lett.*, vol. 50, no. 6, pp. 1565–1567, Jun. 2008.

[9] C. J.Wang, H. L. Guan, and C. F. Jou, "A novel method for short leakywave antennas to suppress the reflected wave," *Microw. Opt. Technol. Lett.*, vol. 36, no. 2, pp. 129–131, Jan. 2003.

[10] I. Y. Chen, C. J.Wang, H. L. Guan, and C. F. Jou, "Studies of suppression of the reflected wave and beam-scanning features of the antenna arrays," *IEEE Trans. Antennas Propag.*, vol. 53, no. 7, pp. 2220–2225, Jul. 2005.

[11] O. Losito, "*Design of Conformal Tapered Leaky Wave Antenna*" PIERS online, vol.3, no.8, 2007, pp1316.

[12] W. L. Stutzman and G. A. Thiele*, Antenna Theory and Design*, 2nd ed. New York: Wiley, 1998, ch. 2.