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Research Article

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A 80 GHz Microstrip Leaky-Wave Antenna with Degraded Ground Plane Design

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AbstractThis article describes the design of a leaky-wave antenna in microstrip technology with defected ground plane, operating at 80 GHz. The analysis of its reflection losses and radiation patterns results obtained from simulations with HFSS software shows that the antenna keeps its performances with a none defected ground that permits to reduce the antenna weight while keeping unchanged its performances.

Keywords Leaky wave, Antenna, microstrip, damaged ground plane

Introduction

Reducing the time and the cost of the conception and the manufacturing of electronic devices is a key point of industrial process nowadays. One can also add strong constraints of weight and clutters for embarked equipments. The design of high performance electric equipments satisfies the overall constraints leans thus on advanced design approaches at a time in the rapidity and the precision.

To this effect, numerous electromagnetic techniques of modelling have been developed during these recent years to achieve miniaturized antennas [1-8]. The research activity is enormously concentrated on the survey of planar structures to the number of which, the leaky-wave antennas can be quoted and that constitutes essential components in the more part of the signal transmission equipments.

Several studies are led on the reduction of their weight while maintaining their performances. Thus, several solutions are envisaged amongst other things, to carry out slots on their ground plane as in the microstrip filters with degraded ground plane [9-10]. In this article, we put forward a leaky-wave antenna with a defected ground plane for W-band applications.

Antenna Design

Figure 1 presents the structure of microstrip leaky-wave antenna with a defected ground plane, constituted of a dielectric substrate ε_r, width B, and thickness h with a ground plane perfectly conductor on which are carried out circular slots of radius r. Metallic patches of width w along with length b, with a periodicity l following (Oz), are printed on the top face of the substrate. Ghomi [11], T.N. Trinh and al [12] and F. Schwering and al [13] showed that the parameters of a microstrip leaky-wave antenna obey the following conditions:

$$\begin{cases} \dfrac{\lambda_o}{\beta/k_o + 1} \le l \le \dfrac{\lambda_o}{\beta/k_o - 1} & \text{for} \quad \beta/k_o > 3 \\ \dfrac{\lambda_o}{\beta/k_o + 1} \le l \le \dfrac{2\lambda_o}{\beta/k_o + 1} & \text{for} \quad \beta/k_o < 3 \end{cases} \tag{1}$$

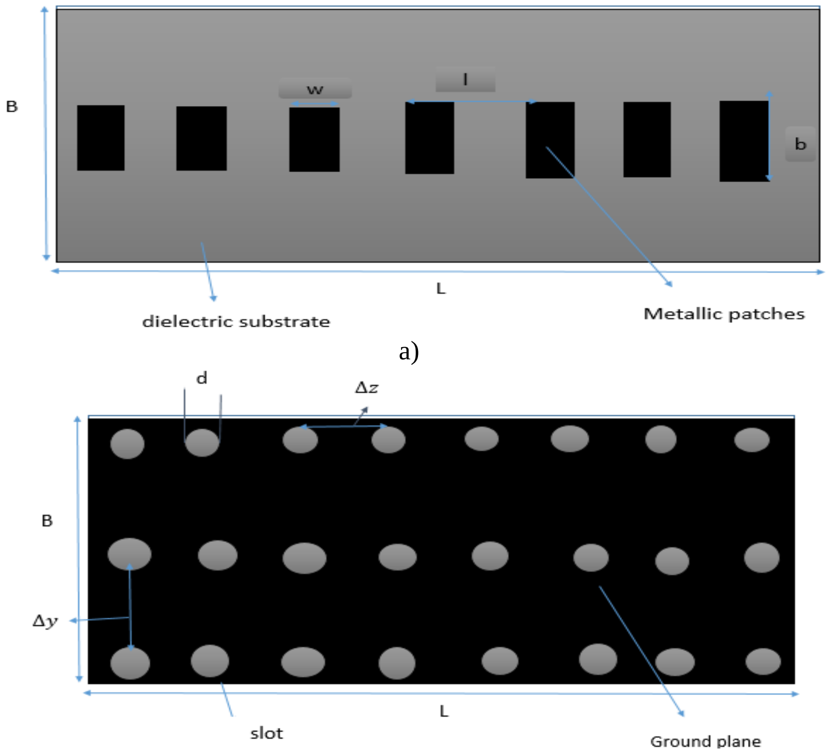
$$0.2\lambda_O \leq w \leq 0.5\lambda_O \quad (2)$$

$$b < \frac{\lambda_O}{(\varepsilon_{eff} - 1)^2} \quad (3)$$

where λ_o is the free-space wavelength, $\beta$the phase constant, $k_o = \frac{2\pi}{\lambda_O}$, the free-space wave number, and ε_{eff}, effective dielectric constant of the structure, with regard to the L length of the antenna, it is fixed to 40.5 mm. The dimensions of the antenna calculated from formulas (1), (2) and (3) at the working frequency of 80 GHz are consigned in the table 1, λ_o being in (mm).

Table 1: Antenna dimensions

Dimensions (mm)	w	l	b	B
Values	$0.3387\lambda_o$	2.5	$0.8\lambda_o$	30



a)

b)

Figure 1: A defected ground plane microstrip leaky-wave antenna a) Top view; b) Bottom view (defected ground plane)

Results and Discussions

We present the results of simulation of the microstrip leaky-wave antenna that we developed. The system has been designed and simulated using High Frequency Structure Simulator (HFSS) software. The estimated parameters are: S-Parameters, directivity and radiation patterns.

a. Reflection Coefficient

Figure 2 presents the behavior of the reflection coefficient versus frequency of miniaturized antenna with defected ground plane investigated, for different values of the slots radius r. Simulations have been made for four values of r (r=0; 0.25; 0.5; 1) mm. One obtains a resonance frequency of 80.045 GHz for r=0. One observes a slight shift of the resonance frequency and a reduction of the reflection coefficient when r increases. However, for $0 \leq r \leq 0.5$, the resonance frequency remains unaltered:

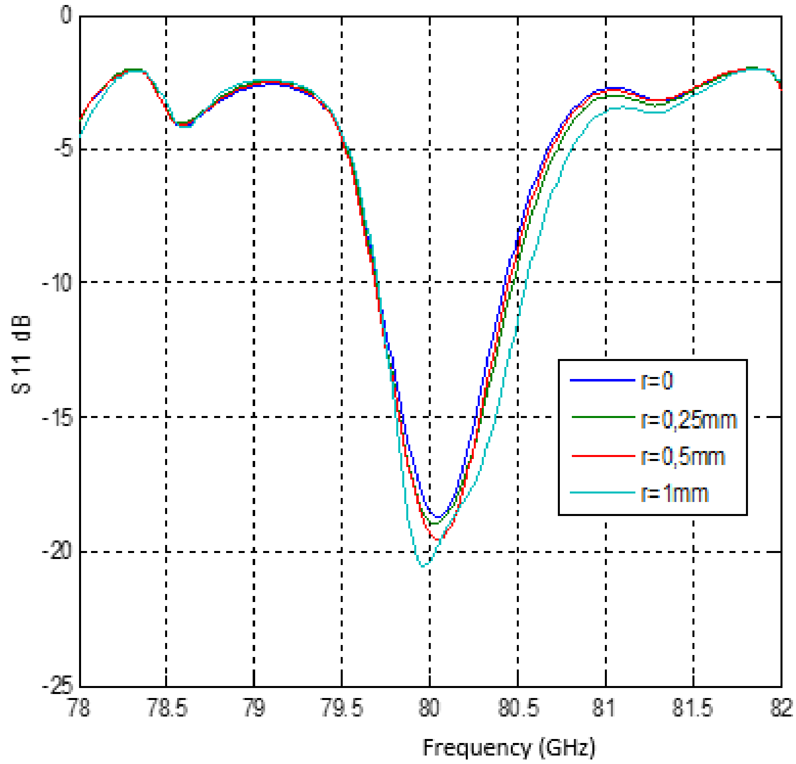


Figure 2: Reflection coefficient of a defected ground plane microstrip leaky-wave antenna $b=0.8\lambda_o$ *; N=11 ; l=2.5mm ;* $w=0.3387\lambda_o$ *;* $B=8\lambda_o$ *;* $\Delta y = \Delta z = 1.0667\lambda_o$

b. Directivity

On figure 3, we represent the antenna directivity variation versus frequency for different values of r. We can note that the directivity increases when the radius of slots decreases. But, as for the reflection coefficient, one can note that the directivity remains unaltered that the radius of the slots r ≤ 0.5 (mm).

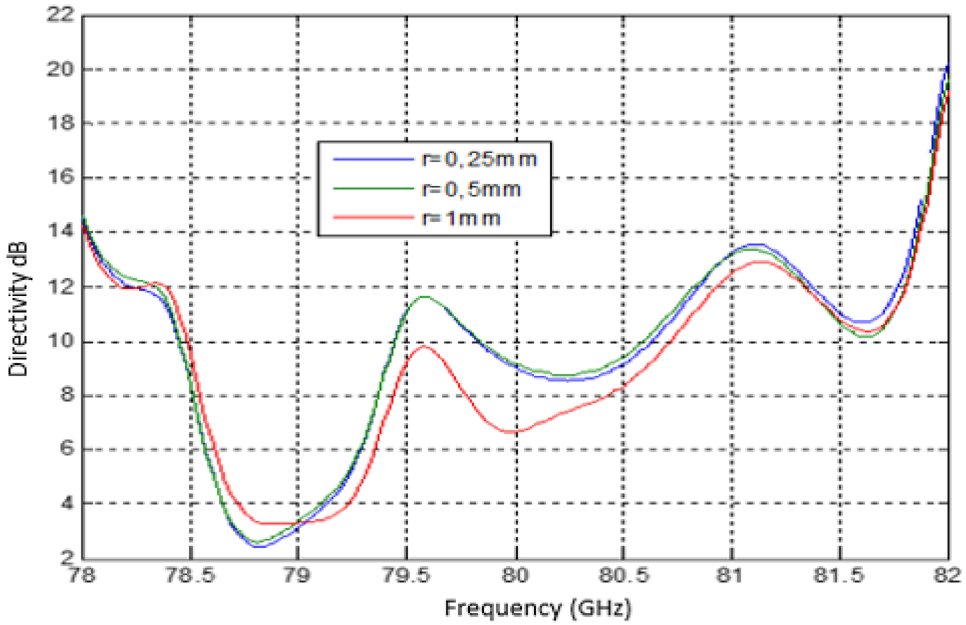


Figure 3: Directivity of the defected ground plane microstrip leaky-wave antenna $b=0.8\lambda_o$ *; l=2.5mm ;* $w=0.3387\lambda_o$ *;* $B=8\lambda_o$ *;* $\Delta y = \Delta z = 1.0667\lambda_o$*; N=11*

c. Radiation patterns

In figures (4) and (5) we present the radiation patterns on field in the E-plane for the value of θ ranging between -90° and 90° and for different values of r. The radiation pattern in the E-plane of the antenna is shown in the figure (4). We note that the defected ground plane doesn't nearly influence the radiation patterns. We also note a very remarkable asymmetry of these radiation patterns. In fact, the levels of minor's lobes are lower on the right than those of on the left of the scanning angle that is approximately equal -1°. Indeed, all the energy radiated is concentrated in the main lobes limiting radiation losses.

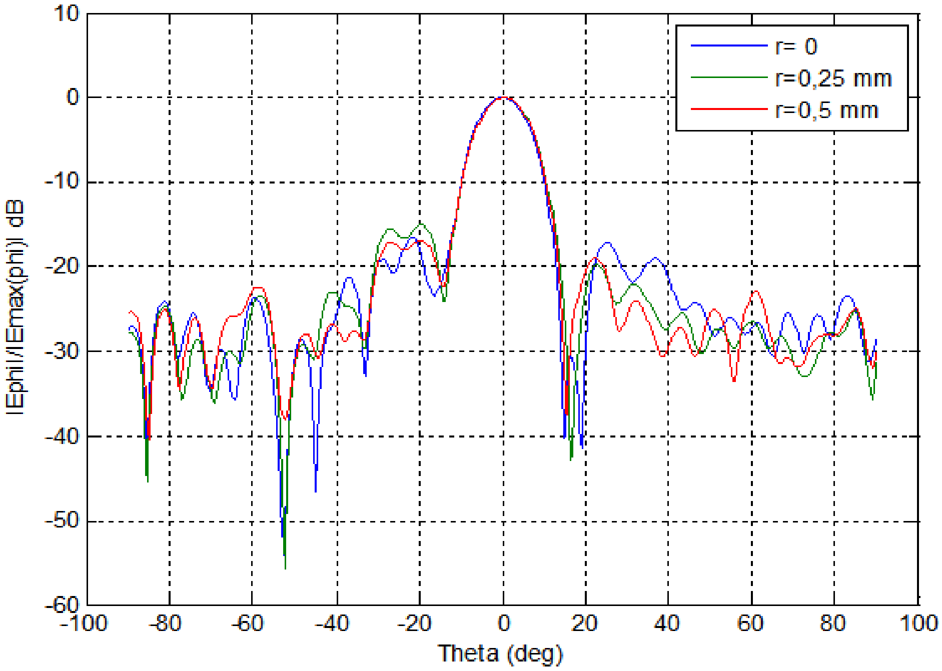


Figure 4: Radiation patterns of the E-plane at F=80 GHz, b=0.8λ_o ; l=2.5 mm; w=0.3387λ_o ; B=8λ_o ; $\Delta y = \Delta z$=1.0667λ_o ; 6 range of 7 slots.

The figure (5) illustrates the radiation patterns of the defected ground microstrip leaky-wave antenna for steps Δy and Δz different. As previously, the scanning angle is always equal to -1°. However, the number of the slots doesn't seem to affect meaning fully the radiation patterns.

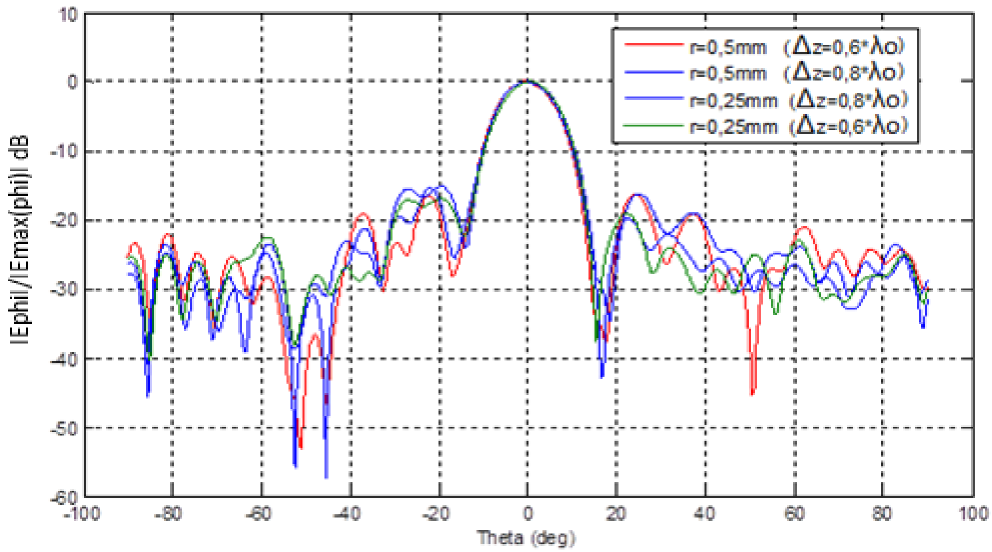


Figure 5: Radiation patterns of the E-plane at F=80 GHz, b=0.8λ_o ; l=2.5 mm ; w=0.3387λ_o ; B=8λ_o ; Δy=1.0667λ_o

Conclusion

Through this study, we have showed the advantage of using a defected ground plane on the microstrip leaky-wave antenna, which gives the opportunity of sizing down the antenna design. That advantage of reducing the constraints related to their weights while preserving almost their performances has a real advantage to be used in embarked system domains, facilitate the integration of other components or devices in telecommunication through new application developments.

References

[1]. Juhua Liu, Jackson D. R. and Yunliang. (2012). Substrate Integrated Waveguide Leaky-Wave Antenna with Transverse Slots. IEEE Transactions on Antennas and Wireless Propagation, vol. 60(1), pp. 20-29.

[2]. Juhua Liu, Xihui Tang et al. (2012). Substrate Integrated Waveguide Leaky-Wave Antenna With H-Shaped Slot. IEEE Transactions on Antennas & Propagation, vol. 60(8): pp.3962-3967

[3]. Souad Doucha, Mehadji Abri et al. (2015). Leaky Wave Antenna Design based on SIW Technology for Millimeter Wave Applications. WSEAS Transactions on Communications, vol. 14: pp2224-2864.

[4]. Sajad Mohammad-Ali et al. (2015). Periodic Ridged Leaky-wave Antenna Design based on SIW Technology. IEEE Antennas and Wireless Propagation Letters, vol.14: pp354-357.

[5]. SolofoRazafimahatratra, Theodoros Mavridis et al. Antenne cornet SIW pour Réseaux de Capteurs Corporels à 60 GHz. XIX^{ème}JournéesNationalesMicroondes 3-4-5 Juin 2015 - Bordeaux, France.

[6]. Feng Xu, Ke Wu and Xiupu Zhang. (2010). Periodic Leaky-Wave Antenna for Millimeter Wave Applications Based on Substrate Integrated Waveguide. vol. 58(2): pp340-347.

[7]. SwetaKumari, SINEE Kumari et al. (2017). Leaky-Wave Antenna using SIW with Transverse slot. Int. J. of Res. in Eng., Tech. and Science, vol. 7(Special Issue).

[8]. AlirezaMallahzadeh et al. (2014). Long Slot Ridged SIW Leaky Wave Antenna Design Using Transverse Equivalent Technique. IEEE Transactions on Antennas and Propagation, vol. 62(11): pp5445-5452.

[9]. Ch. G. L Nkouka Moukengue and DésiréLilonga-Boyenga. (2017) Effect of Defected Ground Plane on the Bandwidth of Parallel Line-coupled Bandpass Filter at 3.3 GHz. Int. J. of Eng. & Tech. vol. 6(3): 62-64.

[10]. VesnaRadisic, Yongxi Qian et al. (1998). Novel 2-D Photonic Bandgap Structure for Microstrip Lines. IEEE Microwave and Guided Wave Letters. vol 8(2): pp. 69-71.

[11]. Ghomi M. Contribution à l'Etude des antennes micro-rubans à ondes de fuite. Thèse de Doctorat INP Toulouse 1992.

[12]. T. N. Trinh, R. Mittra, et al. (1981). Horn Image-guide Leaky-wave Antenna. IEEE Trans. Microwave Theory and Tech. vol. 29: 1310-1314.

[13]. Schwering F. Oliner A.A. et al. (1988). Millimeter-wave antennas, ch.17, Antenna Hand book, New York: