Journal of Physics:
Conference Series

PAPER • OPEN ACCESS

79GHz Substrate Integrated Waveguide antenna for short-range radar applications

To cite this article: G Santhakumar *et al* 2021 *J. Phys.: Conf. Ser.* **1916** 012025

J. Phys.: Conf. Ser. **1916** (2021) 012265 https://doi.org/10.1088/1742-6596/1916/1/012265

Retraction

Retraction: 79GHz Substrate Integrated Waveguide antenna for short-range radar applications (*J. Phys.: Conf. Ser.* 1916 012025)

Published 23 February 2022

This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

Retraction published: 23 February 2022

79GHz Substrate Integrated Waveguide antenna for short-range radar applications

G Santhakumar[1], R Vadivelu[1], M Revathy Lakshmi[1], G J Saranya[1], R Subasini[1]

[1]Department of ECE, Sri Krishna College of Technology, Kovaipudur, 641042, Tamilnadu, India.
g.santhakumar@skct.edu.in

Abstract. It is evident that radar sensing is robust technology compared to camera or LiDAR in the case of autonomous vehicles. Since, they are capable of working even under harsh weather conditions like thick fog, glaring sun, etc. The 77-81GHz frequency band for short range radar provides a global framework for automotive radar by preventing collisions, reducing traffic accidents and thus improvingvehicular safety. The proposed antenna resonates at 79GHz. Below -10dB, return loss characteristic greater than -35dB is obtained in the band of 77.5GHz to 80.4GHz (i.e., impedance bandwidth of 2.86GHz) and gain of above 8dB is achieved. Rectangular vias and complementary concentric square loops of the metamaterial structure are introduced to suppress the surface waves and to achieve the desired frequency of resonance. The feed line and the metamaterial structure are positionedaccordinglyto provide a better impedance matching. VSWR obtained is 1.04 and the antenna is linearly polarized and has a low profile. The total dimension of the antenna is 1.96×2.26×0.127mm^3. The antenna structure can be used in an array for automotive radar applications.

1. Introduction

In conformity with the ITU and the European Union (2017), the 79GHz band (77 to 81 GHz) is allocated for vehicular radars which is ultimately beneficial for the advanced driver assistance systems (ADAS). In the spectrum of millimeter waves, 77 - 81 GHz is utilized for vehicular radars and communications, so the entire 4 GHz bandwidth is available. To make efficient use of the available bandwidth, various innovations have been made in the approaches of antenna designing. Such as introducing arrays, substrate integrated waveguides, use of metamaterial structures, superstrate layers, artificial magnetic conductors (AMC), EBG structures, etc. In the perspective of radar systems, antennas are sensors, which are introduced in vehicles to make an efficient and safe traffic system which enables us to detect information as well as danger swiftly. Achieving the desired operating frequency and reduced size of antenna are two-mile stones in antenna designing. Appropriate, suitable position for the placement of the antenna in the vehicle is also blatantly a significant factor.

In this paper we are proposing a substrate integrated waveguide cavity antenna operating at 79 GHzwith desirable results of gain above 8dB, VSWR of 1.04 and of low-profile. A compact size of length 1.96mm, width 2.26mm and thickness 0.127mm is achieved. The sole target parameter of this project is the frequency, gain and size. This is achieved by using the SIW concept of bringing in the rectangular vias and the complementary concentric square loops on the patch, a type of metamaterial structure, which helps in shifting to the desired frequency of operation.

2. Design

The structure of the antenna is shown in figure1. Seemingly, the structure of the antenna might look like a typical microstrip patch antenna. The radiating sides of any microstrip patch antenna are either edges of the patch, which are perpendicular to the feed line. To suppress the surface waves which is certain at this high frequency, rectangular vias are introduced to short the edges of the patch except for the edge that is connected to the feed line [1]. Rectangular vias are through the substrate, touching the ground plane and the patch. The substrate material used is RT duroid 5880 whose relative permittivity (εr) is 2.2, thickness, t is 0.127mm and loss tangent is 0.0009. Ro5880 is selected, as it is befitting for high- frequency applications [2]. The feed line connecting the patch is slightly moved leftwards from the center of the patch, to provide good impedance matching [3].

The effect of placement of the metamaterial structure plays a major role in getting the desired frequency of resonance [4]. The complementary square loop structures, loaded on the patch act as a combination of inductors and capacitors; i.e., the width of the loop itself acts as an inductor and the distance between the outer and inner loop act as a capacitor [5-10]. The concentric square loop structure (see figure 2), is also shifted from the center of the patch to get the desired resonance at 79GHz. The square shape was selected to shift the frequency forward as well as to obtain higher gain.

Ansys's High-Frequency Structure Simulator (HFSS) software was used for design and simulation.

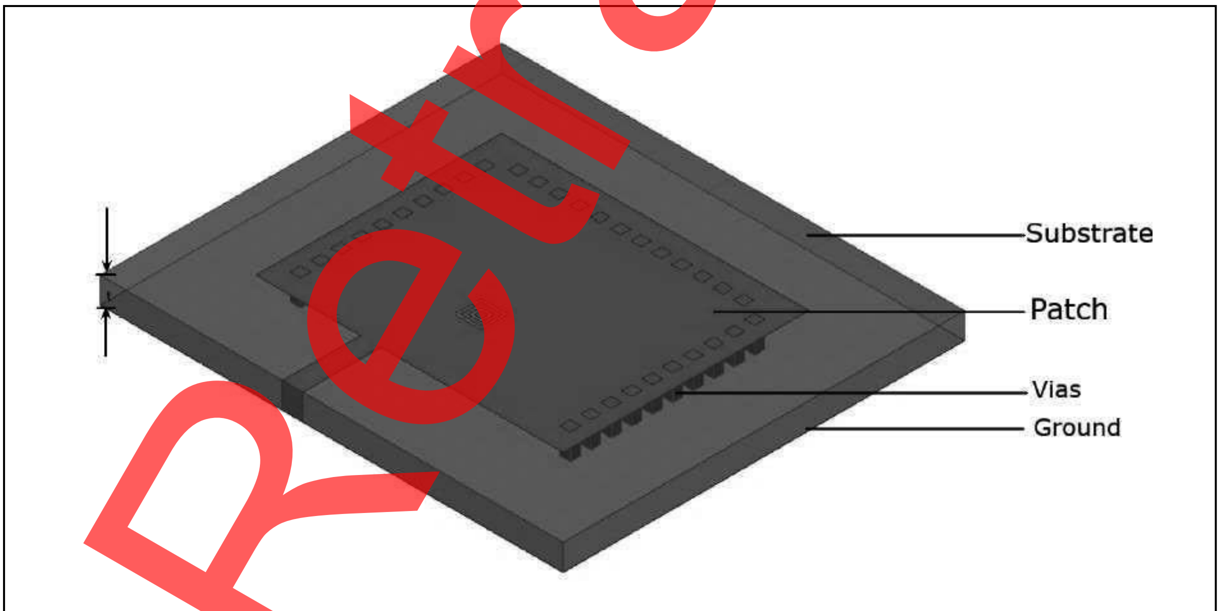

Figure 1. The proposed antenna

2.1. Dimensions of the antenna

The dimensions of the antenna are calculated from the equations below. The antenna's size and shape are the factors that are crucial in order to get the desired output. So, approaching the design in a proper way helps in getting the results required. The width and length of the patch is calculated from equations (1) and (2),

$$W_p = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

$$L_p = L_{eff} - 2\,\Delta L \quad (2)$$

where, c is the velocity of light; f = 79GHz;
ε_r = 2.20 (permittivity of the substrate, RT duroid 5880); and

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{eff}}}$$

$$\Delta L = 0.412t\,\frac{(\varepsilon_{eff} + 0.3) + \left(\frac{W_p}{t} + 0.264\right)}{(\varepsilon_{eff} + 0.258) + \left(\frac{W_p}{t} + 0.8\right)}$$

The dimensions of the ground and substrate is calculated from the equations below,

$$W_s = 6t + W_p \quad (3)$$

$$L_s = 6t + L_p \quad (4)$$

The calculated dimensions from the above equations are, (refer Figure 2) patch's width and length; W_p = 1.5mm, L_p = 1.2mm, ground and substrate's width and length; W_s = 2.26mm, L_s = 1.96mm, the feed length and width; L_b = 0.38mm, W_g = 0.1mm and W_b = 0.51mm and t = 0.127mm, which is the height (or thickness) of the substrate.

1.2. Feed Line and the metamaterial structure

The feed line is slightly moved left from the center of symmetry of the antenna, for efficient impedance matching. Here, the three edges of the patch except for the one which is connected to the feed line is shorted to the ground plane using rectangular vias. The dimension of the vias is d1=d2= 0.05mm. The structures at the center of the patch are complementary concentric square loops of the metamaterial structure, also slightly shifted from the center of the patch. And R1=0.06mm, R2=0.13mm and width of the square loop, Rd = 0.0125mm. The dimension of the patch and the square loops loaded on the patch is given in figure 2. The frequency of resonance was achieved by positioning the square loops slightly below from the center of the patch.

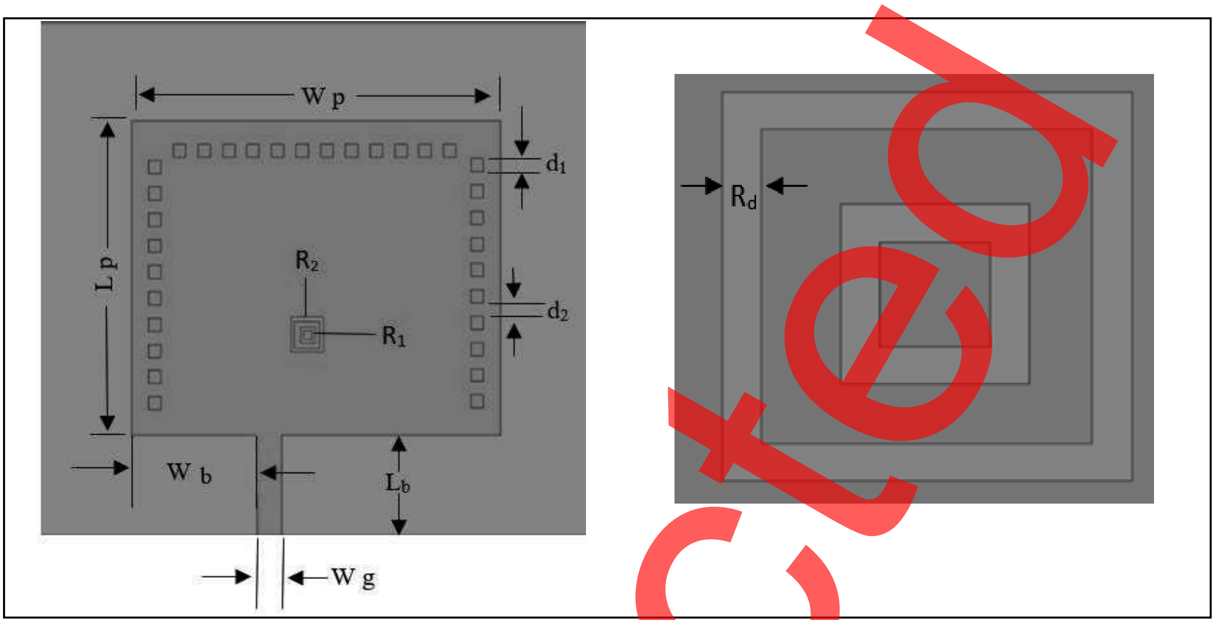

Figure 2. Top view of the antenna and the complementary concentric square loops loaded on the patch

3. Results and Discussion

The simulation results are shown in the figures below. The return loss (shown in figure 3) is achieved at 79GHz as -36.37dB for an impedance bandwidth of approximately 2.9GHz in the band of 77.5 to 80.4GHz. The gain at 79GHz is obtained as 8.1dB. The gain graph is shown and the 3D view of the same is also shown in figure 4. Figure 5 shows the Voltage Standing Wave Ratio and the E-plane beamwidth of the proposed antenna. The E-plane beamwidth is obtained for frequency=79GHz and phi=0degree. A wide beamwidth of 73.21 is achieved. The VSWR is obtained as 1.03 at 79GHz, which is almost the ideal case (see figure5). The E plane and H plane radiation patterns are shown in figure 6.

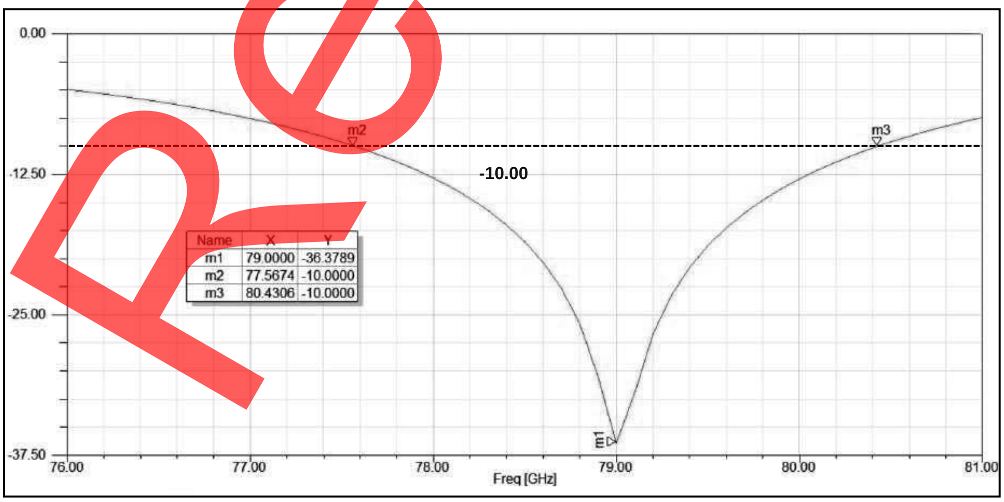

Figure 3. Return loss graph of the proposed antenna (Vertical: S11 (dB))

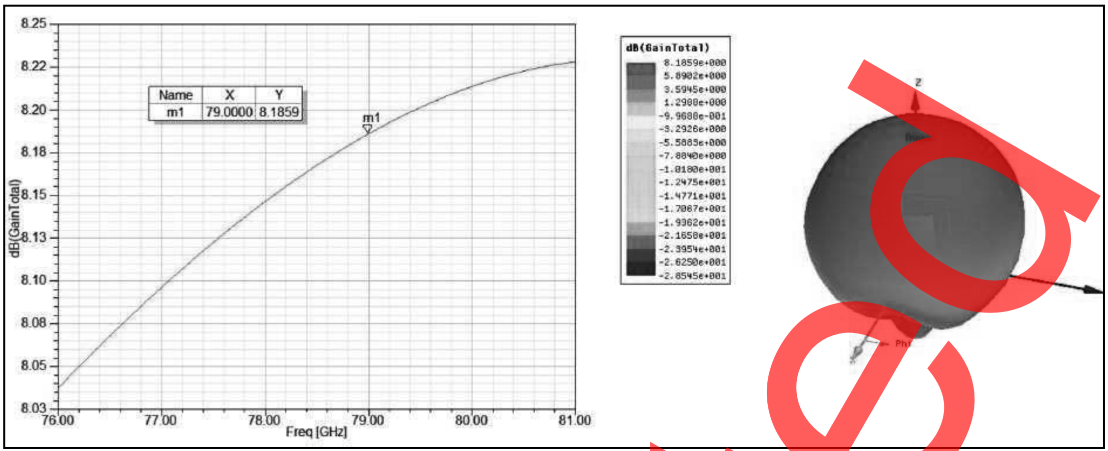

Figure 4. Gain vs. frequency and Gain in 3D view

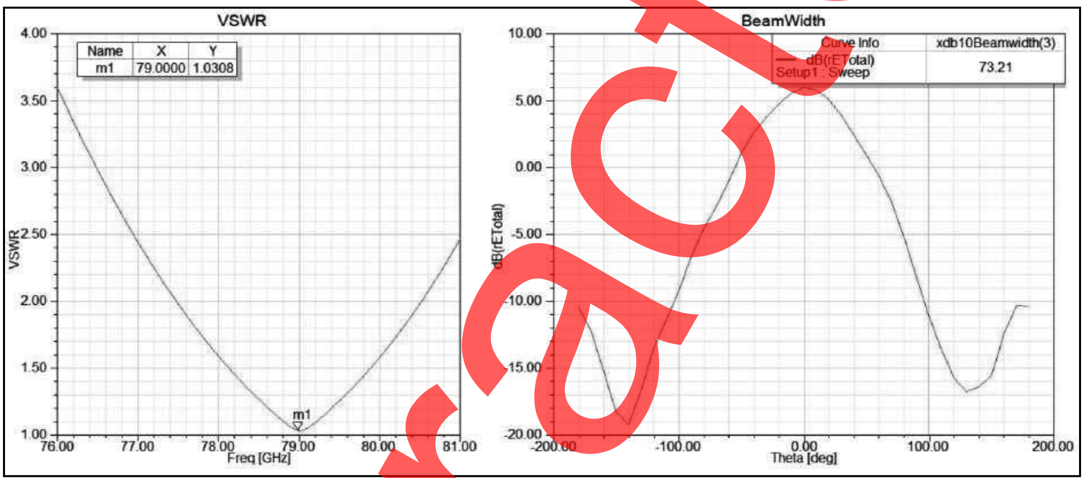

Figure 5. Voltage Standing Wave Ratio(left) and E-plane Beamwidth(right)

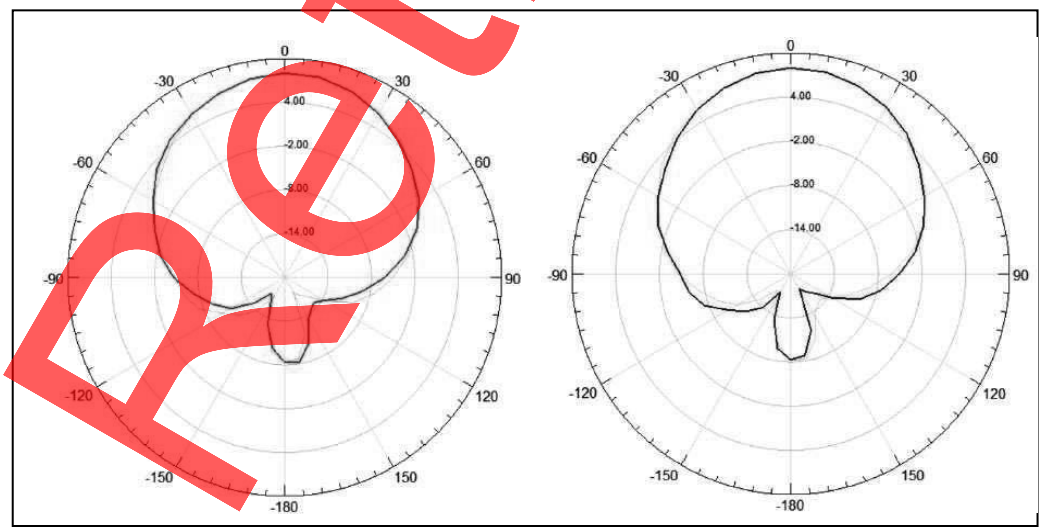

Figure 6. E- plane(red) H-plane(purple) radiation pattern

Polarization is one of the significant parameters when it comes to radars. In the near future there will a number of autonomous cars operating simultaneously; so, there is a high chance of interference among these cars. In that case, one of the suggestions is the polarization of each radar sensor could be configured differently. In the three types of polarization (Linear, Circular, and Elliptical), elliptical polarization is known to provide greater security to the signal. Figure 7 shows the axial ratio characteristics of the proposed antenna.

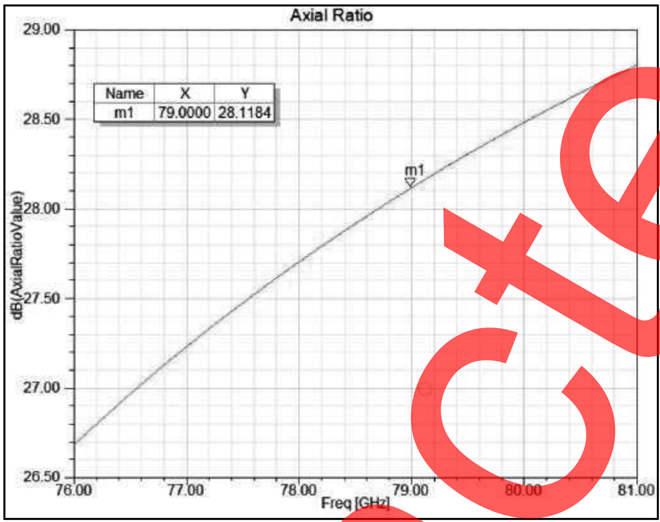

Figure 7. Axial Ratio

The axial ratio is obtained as 28.1dB. And hence the polarization of the proposed antenna is linear.

4. Conclusion

A linear Polarized low-profile microstrip patch antenna has been proposed for automotive Short-Range Radar (SRR) applications at the operating frequency of 79 GHz. The patch is provided with complementary concentric square loops to achieve a frequency of resonance and to maintain a compact size. A beamwidth of 73.21° and a gain of 8.1 dB is achieved at 79 GHz. This antenna structure has multiple rectangular vias at three edges of the radiating patch. And, to achieve efficient impedance matching, the feed line and the metamaterial structure are positioned accordingly. The substrate RT duroid 5880 which has a low electrical loss and is well established for high-frequency applications is used. This antenna could be used for automotive radar applications.

References

[1] Q. Li, W. Li, B. Ren, L. Zhang and B. Zhang, *A Silicon-based On-chip Antenna Operating at 77GHz*, 2019 Photonics & Electromagnetics Research Symposium - Fall (PIERS - Fall), Xiamen, China, 2019, pp. 2848-2852, doi: 10.1109/PIERS-Fall48861.2019.9021682.
[2] C. A. Balanis, *Antenna Theory Analysis and Design*, John Wiley, IncNew Jersey, 2016.
[3] RT/duroid® 5880 Laminates - Rogers Corporation, 2021
[4] H. Nornikman, B. H. Ahmad, M. Z. A. Abd Aziz and A. R. Othman, *Effect of single complementary split ring resonator structure on microstrip patch antenna design*, 2012 IEEE Symposium on Wireless Technology and Applications (ISWTA), Bandung, Indonesia, 2012, pp. 239-244, doi: 10.1109/ISWTA.2012.6373852.
[5] Kavitha, D., & Seyatha, K. (2019). *Metamaterial Superstrate Antenna Design with Gain*

Enhancement.
[6] M. Suganya and H. Anandakumar, Handover based spectrum allocation in cognitive radio networks, 2013 International Conference on Green Computing, Communication and Conservation of Energy (ICGCE), Dec. 2013.doi:10.1109/icgce.2013.6823431. doi:10.4018/978-1-5225-5246-8.ch012
[7] Haldorai and A. Ramu, An Intelligent-Based Wavelet Classifier for Accurate Prediction of Breast Cancer, Intelligent Multidimensional Data and Image Processing, pp. 306–319.
[8] P. Debnath and S. Chatterjee, *Substrate integrated waveguide antennas and arrays*, 2017 1st International Conference on Electronics, Materials Engineering and Nano-Technology (IEMENTech), Kolkata, 2017, pp. 1-6, doi: 10.1109/IEMENTECH.2017.8076933.
[9] R. C. Hadarig, M. E. de Cos, F. Las-Heras, *Microstrip Patch Antenna Bandwidth Enhancement Using AMC/EBG Structures*, International Journal of Antennas and Propagation, vol. 2012, Article ID 843754, 6 pages, 2012. https://doi.org/10.1155/2012/843754
[10] Wojciech Jan Krzysztofik and Thanh Nghia Cao. *Metamaterials in Application to Improve Antenna Parameters*, *Metamaterials and Metasurfaces*, Josep Canet-Ferrer, IntechOpen, DOI: 10.5772/intechopen.80636, November 5th 2018