Design and Experimental Evaluation of a Printed Monopole Antenna for GPR Applications

Abderrezak Khalfallaoui[1,*], Abdelhalim Chaabane[1], and Abdesselam Babouri[2]
[1] Laboratoire des Télécommunications-LT, Université 8 Mai 1945 Guelma, BP 401, Guelma 24000, Algeria
[2] Laboratoire de Génie Électrique de Guelma-LGEG, Université 8 Mai 1945 Guelma, BP 401, Guelma 24000, Algeria
Email: khalfallaoui.abderrezak@univ-guelma.dz (A.K.), abdelhalim.chaabane@univ-guelma.dz (A.C.), babouri.abdesselam@univ-guelma.dz (A.B.)

***Abstract*—In this paper, a printed monopole antenna is designed and experimentally evaluated for Ground Penetrating Radar (GPR) applications. The antenna resonates at two narrow frequency bands centered at 0.5 GHz and 2 GHz. Four stages are used to achieve the final model, which is based on a rectangular patch, a simple microstrip feed line, and a reduced ground plane. The proposed antenna consists of a simple patch with notches and a quarter-wavelength feed line. The introduced notches help to reduce the conductor losses and decrease the weight of the design. The antenna prototype is fabricated on a low-cost FR-4 epoxy substrate with dimensions of 17.55 cm^3, using the LPKF S103 laser printer, and then measured with the R&S®ZNB Vector Network Analyzer. The experimental results demonstrate that the operating bands range between 0.48–0.52 GHz (8%) and 1.94–2.04 GHz (5.02%). The antenna exhibits good radiation patterns with a reasonable gain of 1.5/2.6 dBi and a high radiation efficiency of 97/78% at the two resonating frequencies 0.5/2 GHz, respectively. To validate the usefulness of the designed antenna for GPR applications, a penetrability test is conducted through a concrete separator wall. The electric field probe HZ551 is used to receive the electromagnetic waves behind the obstacle, and the power received by the probe is measured with the GSP-730 spectrum analyzer. The obtained results confirm that the proposed model performs well in the UHF band at 0.5 GHz and 2 GHz, with a high level of penetrability.**

***Index Terms*—Printed monopole antenna, narrow frequency bands, dual band, Ground Penetrating Radar (GPR)**

I. INTRODUCTION

The antenna is one of the most important devices in wireless communication systems. Numerous printed antennas have been proposed in the literature for various applications, including millimeter-wave and terahertz integrated circuits and systems [1–4], communication systems and microwave devices [5–8], and radio transceivers [9]. Ground penetrating radar (GPR), which focuses on detecting hidden objects, has attracted significant attention from researchers. To meet the diverse applications and requirements of GPR systems, various antenna systems have been proposed. However, these systems need to be adapted to the evolving technology of GPR. Antenna types such as Bow tie [10], Vivaldi [11], Quasi-Yagi [12], Tapered slot [13], and Dipole [14] have been suggested for GPR applications. Unfortunately, many of these antennas suffer from drawbacks such as large size, high cost, and complexity, limiting their practicality. Therefore, it is crucial to develop new antenna models that are simple, affordable, and offer improved performance.

Planar patch antennas, in comparison to traditional microwave antennas, have the advantages of being compact, lightweight, inexpensive, and easily integrated into different systems [15]. However, most of these antennas are Ultra-wideband (UWB) [16, 17], wideband [18], or processes only a single resonating band [19]. The investigation of multi-band antennas for GPR application is a significant research area that aims to provide greater flexibility in the detection process with different degrees of penetration.

Until now, only a limited number of studies have been conducted on multi-band microstrip antennas for GPR applications such as those presented in [20–22]. The penetration capability through different surfaces and obstacles primarily relies on the frequency of the signal emitted by the antenna, with lower frequencies generally enabling deeper penetration [23]. Consequently, the selection of the appropriate frequency is crucial and should align with the specific requirements of each application. For instance, low frequency waves have the ability to penetrate multiple surfaces with substantial thickness [24]. Thus, it is of a great importance to develop antennas that can operate effectively at low frequencies while also processing steady radiation characteristics, and compact size.

In order to beat the over mentioned challenges, a novel dual-band monopole patch antenna suitable for GPR applications has been designed, fabricated, and experimentally evaluated. The antenna operates in the UHF band at frequencies of 0.5 GHz and 2 GHz. The design process utilized CST Microwave Studio™ software and the physical prototype was fabricated using LPKF S103 laser printer. The experimental evaluation of the antenna's performance was conducted using the R&S®ZNB Vector Network Analyzer, the HZ551 electric field probe, and the GSP-730 spectrum analyzer.

Manuscript received May 12, 2023; revised July 6, 2023; accepted July 24, 2023.
*Corresponding author

doi: 10.18178/ijeetc.12.6.405-410

This work presents additional contributions, including 1) experimental evaluation of a novel, low-cost dual-band monopole patch antenna designed specifically for GPR applications 2) the proposed antenna exhibits dual resonating frequencies and reduced size compared to existing antennas operating at similar frequencies, 3) a new experimental penetration test is conducted through a concrete wall using the electric field probe HZ551 and the spectrum analyzer GSP-730, 4) the usefulness of the fabricated antenna prototype for GPR applications is demonstrated through experimental validation, showcasing a high level of penetrability.

This paper is structured as follows: Section II provides a detailed description of the design process employed to develop the final antenna design. Section III presents the measured results and compares them with the simulated ones. In Section IV, an experimental evaluation of the antenna's the penetration capability is performed to affirm its suitability for GPR applications. Finally, the paper concludes with a summary and concluding remarks.

II. Antenna Geometry

The configuration and dimensions of the proposed model are depicted in Fig. 1. Four stages were implemented to obtain the final design of the antenna, as illustrated in Fig. 2. In the first stage (antenna 1), which is inspired from [25], a standard printed monopole antenna formed by a rectangular radiating element with a simple microstrip feed line and a reduced ground plane (less than 10% of the total ground plane) was considered. In the second stage (antenna 2), the conventional rectangular patch was transformed into a new shape by cutting rectangular slots and inserting splits into the patch. In the third stage (antenna 3), a quarter-wavelength feed line was introduced. In the last stage (antenna 4), two additional rectangular strips were added along the feed line on the lower edge of the patch. The proposed model was optimized to enhance its performance at specific frequencies. The optimized dimensions are given in Table I.

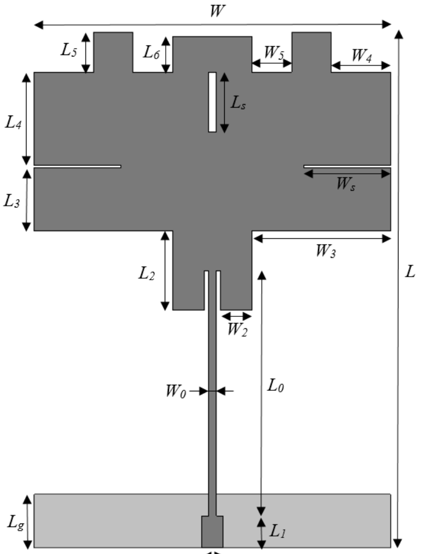


Fig. 1. Structure of the proposed model.

TABLE I: Optimized Geometrical Parameters of the Designed Model

Parameters	Dimensions (cm)	Parameters	Dimensions (cm)
W	9	L	13
W_0	0.2	L_0	6.2
W_1	0.54	L_1	0.8
W_2	0.8	L_2	2
W_3	3.5	L_3	1.6
W_4	1.5	L_4	2.35
W_5	1	L_5	1
W_s	2.2	L_s	1.5
L_6	0.9	L_g	1.35

The proposed antenna was fabricated using a double-sided FR-4 epoxy substrate with a relative permittivity of 4.4 and a loss tangent of 0.025. The substrate has a thickness of 1.5 mm. The overall dimensions of the substrate are 13 cm × 9 cm × 0.15 cm, which is smaller compared to other commercially available GPR antennas operating at the same frequency bands.

III. Results and Discussion

The reflection coefficients of the antennas presented in Fig. 2 are compared in Fig. 3. The initial antenna (Antenna 1), which has a reduced ground plane, resonates at two fundamental frequencies of 0.55 and 2.13 GHz. It is evident that the modifications introduced in the second stage (antenna 2) allow for tuning the higher operating frequency to 2.04 GHz and improving the resonance level in this range to –34 dB. As mentioned in [26], the inclusion of cuts and notches in a printed antenna can help reduce its weight and minimize conductor losses. Besides, the use of a half quarter-wavelength feed line in antenna 3 effects both operating bands. Finally, the introduction of a notch in antenna 4 ensures that the lower band is centered at 0.5 and the upper band at 2 GHz with good impedance matching. The designed model was adapted by exploiting different techniques including a quarter-wavelength, notches, and strips.

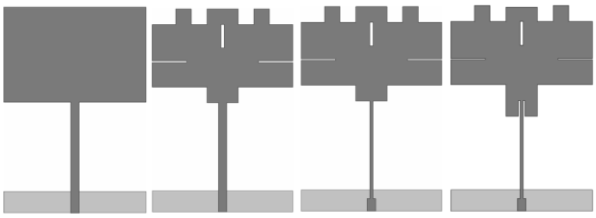


Fig. 2. Design stages of the designed model.

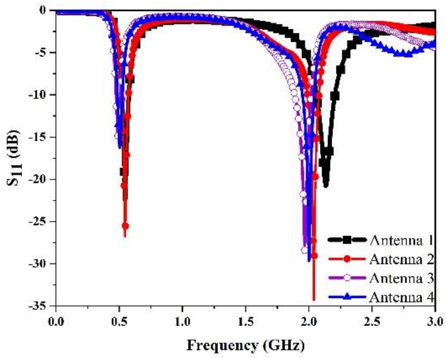
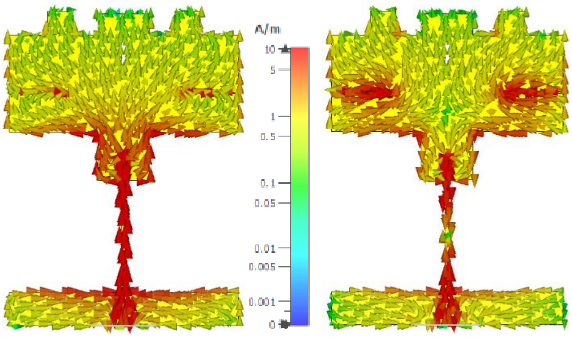
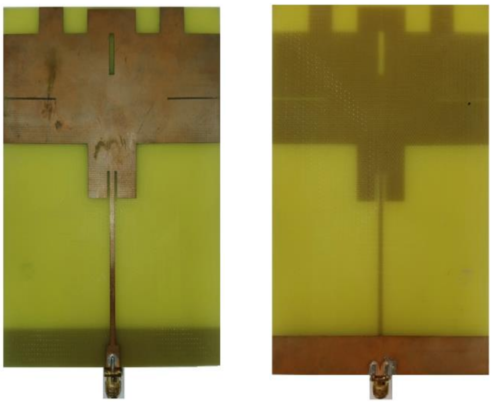


Fig. 3. Reflection coefficient curve in each design stage.



(a) (b)

Fig.4. Surface current distributions at (a) 0.5 GHz, (b) 2 GHz.



(a) (b)

Fig. 5. Front and back view of the fabricated antenna.

Fig. 4 reveals the distribution of surface current density at the two resonating frequencies of 0.5/2 GHz. It can be observed that the surface current flows along the feed line at both operating frequencies. At the lower resonating frequency of 0.5 GHz, a significant current is present on the lower part of the radiating element, while at the upper resonating frequency of 2 GHz, the current is concentrated on the two horizontal slits. This suggests that the lower band is heavily influenced by the dimensions of the lower part of the patch, whereas the second resonating frequency is primarily affected by the presence of the two horizontal slits. Additionally, there is a minimal current flow on the upper part of the patch, indicating its limited impact on the resonating frequencies. Thus, the rectangular notches introduced on the upper side of the patch help reduce conductor losses and decrease the overall weight of the design.

As mentioned above, the antenna prototype is fabricated by using the LPKF S103 laser printer. Fig. 5(a) and Fig. 5(b) respectively illustrate the front and back views of this prototype. It occupies an area of 13 cm × 9 cm × 0.15 cm.

The reflection coefficient response of the fabricated antenna prototype was obtained using the R&S®ZNB Vector Network Analyzer. Fig. 6 illustrates the reflection coefficients (S_{11} (dB)) plotted against frequency, showing a good agreement between the measured and simulated results. It can be observed that the antenna exhibits good impedance matching at the two resonating frequencies, with $|S_{11}|$ values of 16 dB at 0.5 GHz and 30 dB at 2 GHz. The simulated and measured results confirm that the fabricated antenna prototype operates in two frequency bands, the lower band ranging from 0.48 to 0.52 GHz (8%) and the upper band ranging from 1.94 to 2.04 GHz (5.02%).

Fig. 7 showcases the simulated and measured far-field radiation patterns in the *xoz* plane (E-plane) and *xoy* plane (H-plane) at the two resonating frequencies 0.5/2 GHz. The measured patterns closely align with the simulated ones, indicating that the fabricated antenna prototype exhibits omnidirectional patterns in the *xoy* plane and bidirectional patterns in the *xoz* plane, which are typical for this type of antenna. As indicated in Fig. 8, the gain at the two frequencies is simulated to be 1.5 dBi and 2.6 dBi, respectively, furthermore, the radiation efficiency is calculated to be 97% at 0.5 GHz and 78% at 2 GHz.

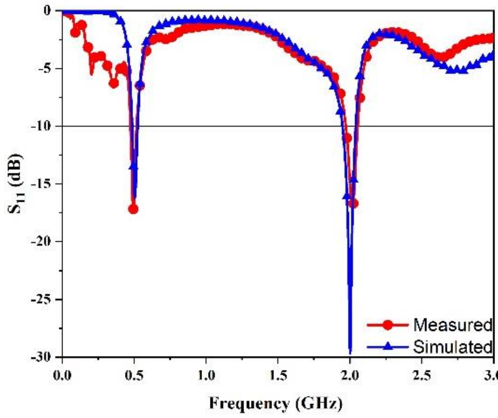
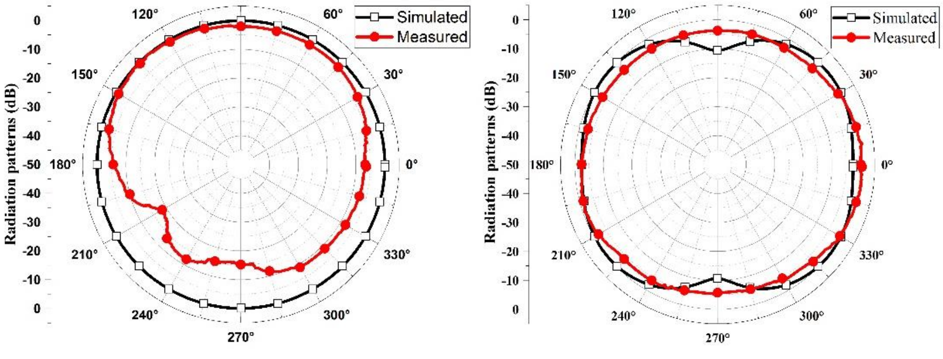
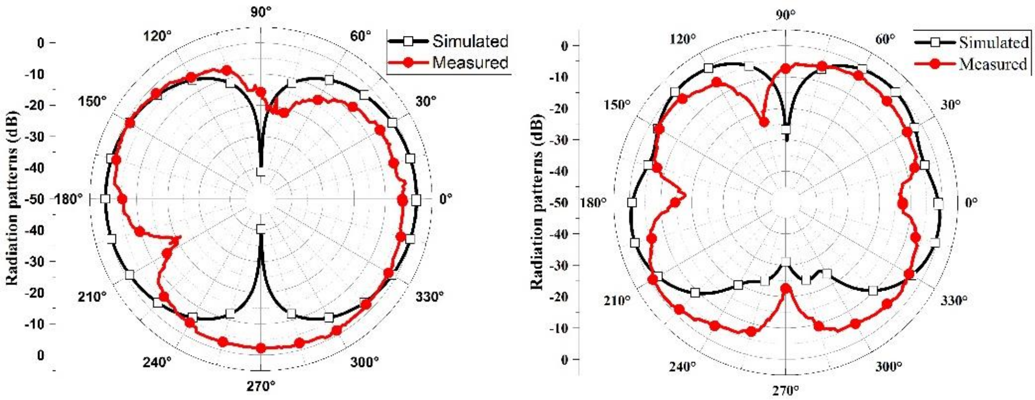


Fig. 6. Comparison of the measured and simulated reflection coefficients.



(a) (b)



(c) (d)

Fig. 7. Radiation patterns of the designed antenna: (a) E-plane @ 0.5 GHz, (b) H-plane @ 0.5 GHz, (c) E-plane @ 2 GHz, and (d) H-plane @ 2 GHz.

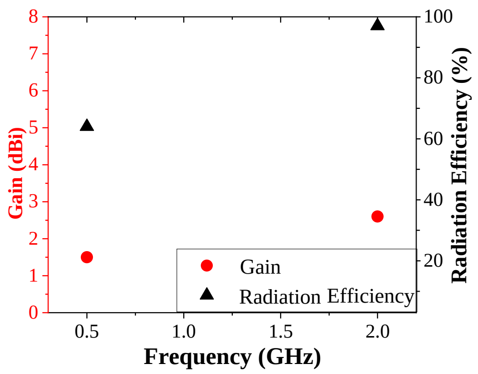
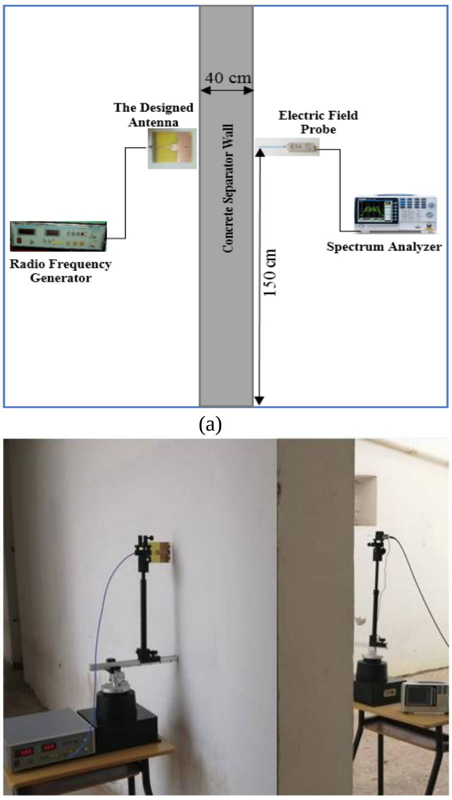


Fig. 8. Gain and radiation efficiency at the two resonating frequencies of the proposed antenna.



(a)

(b)

Fig. 9. GPR measurement setup **(a)** Schematic diagram and **(b)** Illustration by photography.

IV. Ground Penetration Test

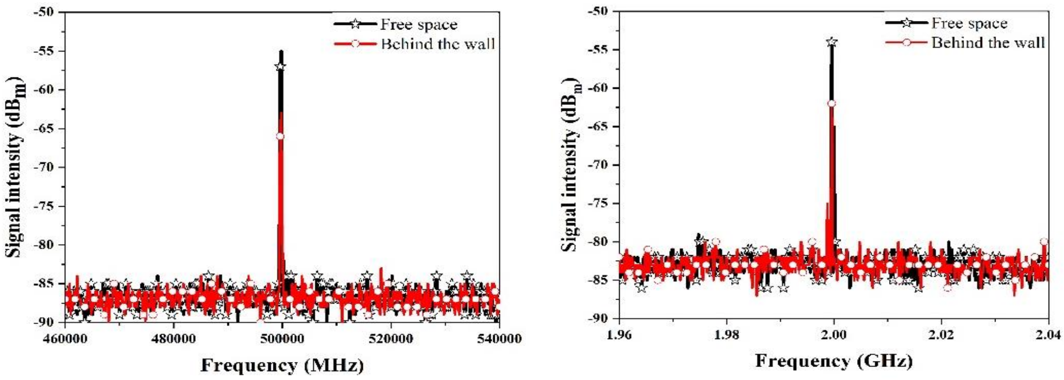
In this section, an experiment was conducted to validate the level of penetrability of the proposed model. As revealed in Fig. 9(a), the fabricated antenna prototype was positioned near a concrete separator wall with a width 40 cm. Throughout the measurement process, a distance of approximately 5 cm was maintained between the antenna and the obstacle. The antenna was connected to a radio frequency generator ED-3200A, which operates at fixed frequencies including 0.5 and 2 GHz. An electric field probe HZ551 was placed behind the obstacle to serve as a receiver. A photograph of the measurement setup is shown in Fig. 9(b). The power received by the probe and the resonating peaks behind the concrete wall were measured using the spectrum analyzer GSP-730.

The measured results, obtained using the spectrum analyzer, are shown in Fig. 10. The results demonstrates that the signals emitted by the antenna at 0.5 GHz and 2 GHz, and received by the probe behind the concrete wall, exhibit acceptable power levels of approximately −63 dBm and −62 dBm, respectively. In addition, it is noteworthy that the signal remains detectable by the probe even when the probe's location behind the wall is altered. A summary of the obtained results is provided in Table II.

TABLE II: Summaries of the Test Results

Frequency (GHz)	Signal intensity (dBm)			
	Free space (40 cm)	Wall (40 cm)	Wall+Free space (80 cm)	Wall+Free space (120 cm)
0.5	−55	−63	−66	−72
2	−54	−62	−67	−74

This test confirms that the electromagnetic waves transmitted by the proposed antenna are able to penetrate the studied obstacle effectively, indicating a strong penetration capability of the antenna. Consequently, the measured results provide evidence that our proposed antenna is highly suitable for GPR applications. To further demonstrate the convenience of the fabricated antenna, its parameters are compared with those of some existing GPR models in Table III. As it can be seen, the proposed antenna offers double resonating frequencies and a smaller size compared to the other existing antennas.



(a) (b)

Fig. 10. Power received by the probe at (a) 0.5 GHz, (b) 2 GHz.

TABLE III: COMPARISON OF THE PROPOSED ANTENNA WITH SOME OTHER EXISTING GPR ANTENNAS

Ref.	Sizes (cm^3)	BW (GHz)	Average Gain/ Efficiency	Ant. type	Test of penetrability/ Surfaces	Design complexity
[27]	43.37	3–14.64	7 dBi 83%	UWB	Yes/Sand	Complex
[28]	1980	0.6–4.6	4.5 dBi/ Not studied	Wideband	Yes/Sandy soil	Complex
[29]	103.5	0.5–5.5	3.13 dBi/ Not studied	Wideband	Yes/wooden Table	Easy
[30]	7497	0.4–2.53	6.7 dBi/ Not studied	Wideband	No	Complex
This work	17.55	0.48–0.52 1.94–2.04	1.5/2.6 dBi/ 97/78%	Multiband	Yes/Concrete Wall	Easy

V. CONCLUSION

A novel printed monopole antenna that resonates at two narrow bands has been designed, fabricated, and experimentally measured for GPR applications. The antenna prototype was fabricated on an FR-4 epoxy substrate with a size of 17.55 cm^3. Excellent agreement is shown between the measured results and the simulated ones. The measured impedance bandwidths extend from 0.48 GHz to 0.52 GHz and from 1.94 GHz to 2.04 GHz. Moreover, the radiation patterns at the center of these two resonating ranges are good. A penetration test of the fabricated antenna through a concrete wall is conducted to verify its ability to function as a GPR antenna. The HZ551 electric field probe is used to receive the electromagnetic waves behind the wall. Satisfactory results are obtained by the probe and measured using the GSP-730 spectrum analyzer, confirming that the proposed antenna is well-suited for GPR applications.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Abderrezak Khalfallaoui: simulating and measuring the antenna, collecting and presenting the results, writing and editing the paper; Abdelhalim Chaabane: supervising and validating the results, methodology, and reviewing/editing; Abdesselam Babouri: providing advice on measurement methods and reviewing/editing. All authors had approved the final version.

ACKNOWLEDGMENT

The present study was supported by the Ministry of Higher Education and Scientific Research of Algeria, as part of research project (PRFU N, A01L07UN2401201 90001). The authors would like to thank Dr. Fayçal Boulsina, Université 8 Mai 1945 Guelma, Algeria, for his diligent review of this paper.

REFERENCES

[1] R. N. Tiwari, V. Kaim, P. Singh, T. Khan, and B. K. Kanaujia, “Semi-flexible diversified circularly polarized millimeter-wave MIMO antenna for wearable biotechnologies,” *IEEE Trans. on Antennas and Propagation*, vol. 71, no. 5, pp. 3968–3982, 2023.

[2] M. Alibakhshikenari, E. M. Ali, M. Soruri, M. Dalarsson, M. N.-Mohandas, B. S. Virdee, C Stefanovic, A. P. Dabrowska, S. Koziel, S. Szczepanski, and E. Limiti, “A comprehensive survey on antennas on-chip based on metamaterial, metasurface, and substrate integrated waveguide principles for millimeter-waves and terahertz integrated circuits and systems,” *IEEE Access*, vol. 10, pp. 3668–3692, 2022.

[3] N. K. Maurya and M. J. Ammann, “Printed-dipole end-fire array for mm-wave applications,” in *Proc. IEEE European Conference on Antennas and Propagation (EuCAP),* Florence, Italy, 2023, doi: 10.23919/EuCAP57121.2023.10133366.

[4] J. Xu, K.-M. Luk, and W. Hong, “Low-profile wideband circularly polarized complementary antenna and arrays for millimeter-wave communications,” *IEEE Trans. on Antennas and Propagation*, vol. 71, no. 3, pp. 2052–2063, 2023.

[5] M. Alibakhshikenari, A. Andujar and J. Anguera, “New compact printed leaky-wave antenna with beam steering,” *Microwave and Optical Technology Letters*, vol. 58, no. 1, pp. 215–217, 2016.

[6] W. Zhang, Y. Li, K. Wei, and Z. Zhang, “A dual-band MIMO antenna system for 2.4/5 GHz WLAN applications,” *IEEE Trans. on Antennas and Propagation*, vol. 71, no. 7, pp. 5749–5758, 2023.

[7] H. Zhang, M. Li, F. Yang, S. Xu, H. Zhou, Y. Yang, and L. Chen, “A low-profile compact dual-band l-shape monopole antenna for microwave thorax monitoring,” *IEEE Antennas Wirel.. Propag. Lett*., vol. 19, no. 3, pp. 448–452, 2020.

[8] S. Gao, L. Chang, A. Zhang, Y. Li, and Z. Zhang, “Small-volume microstrip patch antennas exactly covering Wi-Fi 6 bands of 2.4–2.5 GHz and 5.15–5.85 GHz,” *IEEE Trans. on Antennas and Propagation*, vol. 71, no. 7, pp. 5739–5748, 2023.

[9] M. Alibakhshikenari, M. Naser-Moghadasi, and R. A. Sadeghzadeh, “Composite right–left-handed-based antenna with wide applications in very-high frequency–ultra-high frequency bands for radio transceivers,” *IET Microwaves, Antennas & Propagation*, vol. 9, no. 15, pp. 1713-1726, 2015.

[10] H. S. Senapati, P. Chongder, K. K. Ajith, and S. Maiti, “Design of UWB bow tie antenna for GPR object detection,” in *Proc. Advanced Communication Technologies and Signal Processing*, Rourkela, India, 2021, doi: 10.1109/ACTS53447.2021.9708073.

[11] D. N. Elsheakh and E. A. Abdallah, “Compact ultra-wideband Vivaldi antenna for ground-penetrating radar detection application,” *Microwave and Optical Technology Letters*, vol. 61, no. 5, pp. 1268–1277, 2019.

[12] D. N. Elsheakh and E. A. Abdallah, “Ultra wide band planar printed quasi-Yagi antenna with size reduction for water detection in the Egyptian desert,” *Microw. Opt. Technol. Lett*, vol. 57, no. 1, pp. 226–233, 2015.

[13] J. Shao, G. Fang, Y. Ji, K. Tan, and H. Yin, “A novel compact tapered-slot antenna for GPR applications,” *IEEE Antennas and Wireless Propagation Letters*, vol. 12, pp. 972–975, 2013.

[14] J. Tong, Y. Guo, C. Ji, X. Chai and Q. Zhao, “A compact wideband semi-elliptical dipole antenna for boat-borne GPR,” *IEEE Trans. on Antennas and Propagation*, vol. 70, no. 12, pp. 11496–11504 2022.

[15] W. Cao, B. Zhang, A. Liu, T. Yu, D. Guo, and K. Pan, “A reconfigurable microstrip antenna with radiation pattern selectivity and polarization diversity,” *IEEE Antennas Wirel. Propag. Lett*., vol. 11, pp. 453–456, 2012.

[16] M. Guerroui, A. Chaabane, S. Ikni, A. Boualleg, N. Guebgoub, and O. Mahri, “A printed U-shaped coplanar waveguide fed UWB antenna for GPR applications,” *Advanced Electromagnetics*, vol. 11, no. 4, pp. 51–59, 2022.

[17] A. Chaabane and M. Guerroui, “Circularly polarized ultra wideband antenna with question mark-shaped patch for ground penetrating radar applications,” *Journal of Applied Research and Technology*, vol. 20, no. 3, pp. 274–283, 2022.

[18] A. Raza, W. Lin, Y. Liu, A. B. Sharif, Y. Chen, and C. Ma, “A magnetic-loop based monopole antenna for GPR applications,” *Microwave and Optical Technology Letters*, vol. 61, no. 4, pp. 1052–1057, 2018.

[19] A. H. Rambe, A. M. Setiawan, Suherman *et al*., “Design and simulation of a rectangular microstrip patch antenna with single stub for GPR applications at 500 MHz,” *IOP Conf. Ser.: Mater. Sci. Eng*., vol. 1122, #012040, 2021.

[20] A. Chaabane and A. Babouri, “Dual band notched UWB MIMO antenna for surfaces penetrating application,” *Advanced Electromagnetics*, vol. 8, no. 3, pp. 6–15, 2019.

[21] K. Saeid, H. Ahmet, D. Fatih, and K. Oğuz, “Double band fractal bow tie antenna design for GPR application,” *International Journal of Electronics, Mechanical and Mechatronics Engineering*, vol. 7, no. 4, pp. 1499–1503, 2017.

[22] Surajit Kundu, “Gain augmentation of a triple notched ultra-wideband antenna using compact uniplanar frequency selective surface for ground penetrating radar,” *IETE Journal of Research*, vol. 69, no. 2, pp. 813–824, 2020.

[23] S. Warathe, R. K. Tanti, and N. Anveshkumar, “Compact Vivaldi antenna design at 500MHz for GPR applications,” in *Proc. IEEE Indian Conf. on Antennas and Propogation*, 2019, pp. 1–5.

[24] A. Cacciatori, D. Modotto, S. Boscolo *et al*., “Broadband printed directional bow-tie antenna for the 500–1600-MHz band,” *Microw. Opt. Technol. Lett.*, vol. 55, no. 10, pp. 2329–2333, 2013.

[25] A. Mohamed, I. M. Rafiqul, S. Yasmin, and K. Badron, “Design of a quintuple band microstrip patch antenna using multiple L-slots,” in *Proc. International Conf. on Computer and Communication Engineering*, Kuala Lumpur, Malaysia, 2016, pp. 30-35.

[26] A. Chaabane, O. Mahri, D. Aissaoui, and N. Guebgoub, “Multiband stepped antenna for wireless communication applications,” *Inform. Midem.*, vol. 50, no. 4, pp. 275–283, 2020.

[27] S. Kundu, A. Chatterjee, S. K. Jana, and S. K. Parui, “Gain enhancement of a printed leaf shaped UWB antenna using dual FSS layers and experimental study for ground coupling GPR applications,” *Microwave Opt. Technol. Lett*., vol. 60, no. 6, pp. 1417–1423, 2018.

[28] A. Raza, W. Lin, M. K. Ishfaq, M. Inam, F. Masud, and M. H. Dahri, “A wideband reflector-backed antenna for applications in GPR,” *International Journal of Antenna and Propagation, Hindawi*, #3531019, 2021.

[29] K. K. Ajith and A. Bhattacharya, “Improving the GPR detectability using a novel loop bowtie antenna,” *Journal of Telecommunications and Information Technology*, vol. 2017, no. 3, pp. 9–16, 2017.

[30] H.-H. Sun, Y. H. Lee, A. C. Yücel, G. Ow, and M. L. M. Yusof, “Compact dual-polarized vivaldi antenna for ground penetrating radar (GPR) application,” in *Proc. IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting*, Montreal, Canada, 2020, doi: 10.1109/IEEECONF35879.2020.9329581.

Abderrezak Khalfallaoui received the Ph.D. degree in electronics from the University of Littoral Côte d’Opale, France, in 2010 at the Laboratory of Materials and Components for Electronics (LEMCEL). In 2011, he joined the Laboratory of Telecommunication at the University 8 Mai 1945 of Guelma, where he is currently an Assistant Professor. His research interests include the design and processing of radio-frequency integrated circuits, tunable ferroelectric devices, and their applications in microwaves. Since 2020, he has been focused his research on antennas, multiband antennas, and ground-penetrating radar antennas.

Abdelhalim Chaabane received his Ph.D. degree in electronics in 2017 and completed his habilitation in 2020. He currently holds the position of associate professor and serves as the director of the Telecommunications Laboratory at the University 8 Mai 1945 Guelma, Algeria. His current research areas of interest encompass fractal antennas, MIMO antenna systems, reconfigurable antennas, millimeter-wave high-gain and wide-band antennas, UWB applications and radar, as well as biomedical engineering.

Abdesselam Babouri is full professor and the head of the Department of Electrical and Automatic Engineering in the Department of Electrical Engineering at the University of Guelma, Algeria. He received his Ph.D. degree in Electronics from the University of Nancy, France in 2007. He is a member and Team Leader of Electromagnetic compatibility and biomedical systems at the LGEG Laboratory. With over 70 papers published in international journals and conference proceedings, his research focuses on sensor networks and biomedical application, VLC, clinical evaluation of pacemaker systems and arrhythmia problems.