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Editorial

Editorial on "Design, Analysis, and Measurement of Antennas"

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The area of modern wireless communication systems has experienced rapid growth, leading to a rising demand for multifunctional devices capable of providing various wireless services. For these devices, the antennas need to possess key characteristics: compactness, multifunctionality, and consistent high performance across different environments. A critical aspect in communication systems is ensuring the correct orientation between transmitters and receiver systems [1]. Circular/dual-polarized antennas offer effective solutions to address this challenge. These antennas enable reliable and efficient signal transmission and reception. In addition, reconfigurable and switchable antennas have garnered significant interest in diverse applications, such as cognitive radio. By incorporating active elements, these antennas can operate across multiple bands and generate different radiation patterns, providing versatility and adaptability in their functions [2]. Employing MIMO and phased array systems with several smart antenna elements can significantly increase the system capacity. As a result, these technologies hold considerable promise for meeting the requirements of future 5G networks, where higher data rates and seamless connectivity are essential. However, implementing MIMO antenna systems in a limited space presents urgent challenges, particularly in reducing mutual couplings from adjacent elements. In today's context, miniaturization of wireless and handheld devices has become a necessity [3]. Miniaturized antennas with the integration of metamaterial cells, Electromagnetic Band Gap (EBG) structures, and Frequency Selective Surfaces (FSS) are gaining importance. These advanced materials and structures allow for efficient antenna designs, making them indispensable components in modern wireless technologies. Furthermore, the quest for small, low-cost antennas remains high on the agenda. These antennas are highly desirable for various applications, including Radio Frequency Identification (RFID) and Ultra-Wideband (UWB) systems [4]. As wireless communication continues to evolve, addressing these challenges and incorporating innovative antenna technologies will pave the way for more efficient, versatile, and reliable wireless devices and systems, meeting the ever-increasing demands of the modern world. Therefore, antennas play a pivotal role in modern wireless communication systems and, as technology continues to evolve, the demand for more efficient, compact, and multifunctional antennas becomes ever more apparent.

The scope of this Special Issue is to provide a comprehensive overview of the latest developments and innovative methodologies in the design, analysis, and measurement of antennas. It comprises a collection of 11 papers that explore various aspects of antenna design, analysis, and measurement for emerging wireless communication systems. Each paper delves into specific topics and advancements within the field, contributing to the overall objective of shedding light on novel approaches and encouraging further research into this exciting area. The brief explanations of these papers are as follows:

Yang et al. [5] introduce a low-profile Wi-Fi antenna designed to deliver optimized radiations for Uncrewed Aerial Vehicle (UAV) applications. Specifically engineered for mounting on small UAVs, on the non-metallic wing's outermost side, this antenna exhibits impressive impedance bandwidths across two frequency ranges: 2.11 to 2.58 GHz and 5.06 to 7.5 GHz. The antenna's radiation patterns have been carefully optimized at 5.8 and

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2.4 GHz, ensuring enhanced antenna gain as the small UAV operates at greater distances in urban and open environments, respectively. Moreover, it demonstrates excellent vertically polarized radiation, making it well-suited for long-distance communication applications.

Hussain et al. [6] investigate the development and verification of an antenna tailored for Ka-band 5G networks. The resulting antenna demonstrates remarkable performance across a broad frequency range, spanning from 26.5 GHz to 43.7 GHz. The proposed design incorporates stubs with loaded rectangular patches, strategically integrated to enhance impedance bandwidth and achieve ultra-wideband characteristics. To further enhance functionality, a MIMO antenna is created by combining multiple elements. The hardware prototypes of both the individual antenna element and its MIMO configuration are fabricated and tested. The measured results closely align with the simulated outcomes.

Rizvi et al. [7] present a new CPW-fed antenna specifically designed for UWB applications with a WLAN band notch. The antenna boasts a simple geometry, featuring a rectangular radiation element integrated with a Y-shaped resonator, which effectively enhances the impedance bandwidth over the frequency range of 3–14.55 GHz. To achieve rejection at 4.59–5.82 GHz, an additional stub is incorporated into the antenna's design. This feature enables the antenna to maintain constant radiations with a gain exceeding 2 dBi within the pass-band, while demonstrating a minimum gain of −3.9 dB in the notch band. The antenna's measurement results exhibit excellent agreement with the simulations, confirming the accuracy and effectiveness of the proposed design.

Fernandez et al. [8] propose a modified patch antenna with a notable design simplified by using air as the dielectric and a straightforward patch shape. Ensuring that the feeding pin rod connects to the patch to the microstrip line is critical, ensuring excellent impedance matching for maximum radiation at the resonance frequency. Operating at 2.4 GHz, the antenna achieves impressive performance metrics, including a 9.63 dBi gain and a 93.08% total efficiency. The antenna's advantages lie in its easy design and manufacturing process, absence of a dielectric, through-wire feeding technique, robustness, error tolerance, and the ability to achieve superior performance across all metrics simultaneously.

Hu et al. [9] analyze and discuss the fundamental properties, as well as signal propagation curves, of a single-tower umbrella antenna, which can be a suitable choice for enhancing Loran transmission. Detailed analysis and comparison of the radiation characteristics of the transmitting antenna along with simulations in the complex geographical environment of Tibet, China are discussed. The results demonstrate the advantages of using the single-tower antenna in Tibet, and led to the design of the transmitting antenna's structure and electrical parameters, resulting in the capability to extend the enhanced Loran signal transmission to 1000 km or even further.

Qashlan et al. [10] employ a microwave breast imaging model using nine identical Vivaldi antennas to detect cancer tumors in a multilayer model. The array's configuration involved one antenna as a transmitter, and the remaining eight as receivers, in order to measure the backscattering signal of the breast phantom. This process was repeated with each antenna taking turns as the transmitter. Various tumor sizes and locations were tested and, remarkably, the locations could be accurately determined regardless of the tumor size. The Vivaldi element used in the study features a compact size of 25×20 mm^2, and a unique geometry. This antenna was fabricated and demonstrated excellent agreement between its simulated and measured performance.

Ahmed et al. [11] propose a straightforward and efficient design for an ultra-wideband (UWB) antenna, which takes the form of a jug shape with a handle on the right side of the radiator. This UWB antenna is printed on a cost-effective FR-4 substrate, making it suitable for wireless communication systems. The antenna's dimensions are 25 mm × 22 mm × 1.6 mm. The performance of the antenna is impressive, with a maximum gain of 4.1 dB, covering the entire UWB spectrum from 3 GHz to 11 GHz. The antenna's performances are investigated through simulations and measurements. This design is particularly well-suited for wireless communication systems and portable devices, due to its compact size and excellent performance across the UWB frequency range.

Rahamim et al. [12] present an innovative concept for a tunable reflector metasurface (MS) that enables beam steering at 28 GHz. This has been achieved by using varactor diodes as the tunability component in unit cells of the metasurface. This new concept, called the "stripes configuration", leads to remarkable enhancements in beam steering capabilities. The results demonstrated a 3 dB improvement in reflectance gain, depending on the scanning angle, compared to a uniform metasurface with just one stripe. Moreover, the stripes configuration showcased an impressive enhancement of 50% in the steering accuracy of the angle for various frequencies.

Umair et al. [13] offer a high-gain and compact antenna that offers both low backscattering and improved gain characteristics. The antenna's construction involves a cavity formed by combining an absorptive Frequency Selective Surface (FSS) with a double-sided Partially Reflective Surface (PRS), placed above a patch resonator. This configuration achieves a wideband Radar Cross Section (RCS) reduction in incident waves, including in-band frequencies. The results demonstrate a wideband RCS reduction from 4 to 16 GHz, with an average RCS reduction of approximately 8.5 dB compared to a reference patch antenna. Additionally, the antenna achieves off-broadside peak radiation at an angle of -38°, with a gain approaching around 9.4 dB.

Niu et al. [14] explore a novel multi-node inverse Finite Element Method (iFEM) for sensing the shape of flexible structures using strain sensors. In accordance with the Mindlin plate theory, a weighted-least-squares function is minimized by considering all strain measures. This approach enables accurate approximation for large inverse finite elements, providing the advantage of simultaneous extrapolation and interpolation calculations for elements. By substantially expanding the size of elements, the proposed method decreases the number of sensors required while improving the accuracy of the reconstruction process. This innovation holds promise for enhancing shape-sensing capabilities in flexible structures, and can lead to more efficient and accurate strain measurement systems.

Liu et al. [15] introduce a novel method for generating multiple pseudo-Bessel beams, with precise control over their propagation directions using a reflective metasurface. In this technique, the reflective metasurface's miniaturized unit cell modulates the electromagnetic waves, generating pseudo-Bessel beams that are propagated in various directions off-axis. This metasurface is capable of generating dual pseudo-Bessel beams, and their propagation directions can be accurately controlled. The efficiency of these beams is measured at 59.2% when propagated at 400 mm. Overall, the method showcases the promising potential for producing high-efficiency multiple beams with precise control, which could find applications in various fields.

We would like to sincerely express our gratitude and appreciation to all the esteemed authors whose exceptional contributions have enriched this journal. Their valuable research has significantly advanced the field of design, analysis, and measurement of antennas. Our heartfelt thanks go out to the diligent reviewers whose insightful comments and feedback have played a crucial role in enhancing the quality of these articles. Their expertise and dedication have been instrumental in ensuring the rigor and accuracy of the published works. We also extend our acknowledgment to the dedicated editorial board and the supportive editorial office of MDPI's *Applied Sciences* journal. Their guidance and assistance throughout the publication process have been invaluable in bringing this collection to fruition. We are confident that the readers will find these articles informative and enlightening, offering valuable insights into the world of antenna design, analysis, and measurement. We look forward to continued collaboration and contributions from researchers in the field, as we strive to further advance and explore new frontiers in antenna technology. Thank you all for your remarkable efforts and dedication.

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References

1. Zhang, Z. *Antenna Design for Mobile Devices*; Wiley-IEEE Press: Hoboken, NJ, USA, 2017.
2. Ojaroudi Parchin, N.; See, C.H.; Abd-Alhameed, R.A. Editorial: A Planar Dual-Polarized Phased Array with Broad Bandwidth and Quasi-Endfire Radiation for 5G Mobile Handsets. *IEEE Trans. Antennas Propag.* **2021**, *69*, 6410–6419. [CrossRef]
3. Ojaroudi Parchin, N.; See, C.H.; Abd-Alhameed, R.A. Editorial: Special Issue "Antenna Design for 5G and Beyond". *Sensors* **2021**, *21*, 7745. [CrossRef] [PubMed]
4. Ojaroudi Parchin, N.; Jahanbakhsh Basherlou, H.; Al-Yasir, Y.I.A.; Abdulkhaleq, A.M.; Abd-Alhameed, R.A. Ultra-Wideband Diversity MIMO Antenna System for Future Mobile Handsets. *Sensors* **2020**, *20*, 2371. [CrossRef] [PubMed]
5. Yang, Y.-L.; Lin, D.-B. A Compact Planar Wi-Fi Antenna with Optimized Radiation Patterns for Small UAV Applications. *Appl. Sci.* **2023**, *13*, 7470. [CrossRef]
6. Hussain, S.A.; Taher, F.; Alzaidi, M.S.; Hussain, I.; Ghoniem, R.M.; Sree, M.F.A.; Lalbakhsh, A. Wideband, High-Gain, and Compact Four-Port MIMO Antenna for Future 5G Devices Operating over Ka-Band Spectrum. *Appl. Sci.* **2023**, *13*, 4380. [CrossRef]
7. Rizvi, S.N.R.; Awan, W.A.; Choi, D.; Hussain, N.; Park, S.G.; Kim, N. A Compact Size Antenna for Extended UWB with WLAN Notch Band Stub. *Appl. Sci.* **2023**, *13*, 4271. [CrossRef]
8. Fernandez, M.D.; Herraiz, D.; Herraiz, D.; Alomainy, A.; Belenguer, A. Design of a Wide-Bandwidth, High-Gain and Easy-to-Manufacture 2.4 GHz Floating Patch Antenna Fed with the Through-Wire Technique. *Appl. Sci.* **2022**, *12*, 12925. [CrossRef]
9. Hu, Z.; Dong, M.; Li, S.; Yang, C. Simulation-Based Selection of Transmitting Antenna Type for Enhanced Loran System in Selected Location. *Appl. Sci.* **2022**, *12*, 6031. [CrossRef]
10. Qashlan, A.M.; Aldhaheri, R.W.; Alharbi, K.H. A Modified Compact Flexible Vivaldi Antenna Array Design for Microwave Breast Cancer Detection. *Appl. Sci.* **2022**, *12*, 4908. [CrossRef]
11. Ahmad, S.; Ijaz, U.; Naseer, S.; Ghaffar, A.; Qasim, M.A.; Abrar, F.; Parchin, N.O.; See, C.H.; Abd-Alhameed, R. A Jug-Shaped CPW-Fed Ultra-Wideband Printed Monopole Antenna for Wireless Communications Networks. *Appl. Sci.* **2022**, *12*, 821. [CrossRef]
12. Rahamim, E.; Rotshild, D.; Abramovich, A. Performance Enhancement of Reconfigurable Metamaterial Reflector Antenna by Decreasing the Absorption of the Reflected Beam. *Appl. Sci.* **2021**, *11*, 8999. [CrossRef]
13. Umair, H.; Latef, T.B.A.; Yamada, Y.; Hassan, T.; Mahadi, W.N.L.B.W.; Othman, M.; Kamardin, K.; Hussein, M.I. Quarter Wavelength Fabry–Perot Cavity Antenna with Wideband Low Monostatic Radar Cross Section and Off-Broadside Peak Radiation. *Appl. Sci.* **2021**, *11*, 1053. [CrossRef]
14. Niu, S.; Li, K.; Liu, J.; Bao, H. A Refined Shape Sensing Method for Skin Antenna Structure Based on Inverse Finite Element Method. *Appl. Sci.* **2020**, *10*, 7620. [CrossRef]
15. Liu, H.; Xue, H.; Liu, Y.; Li, L. Generation of Multiple Pseudo Bessel Beams with Accurately Controllable Propagation Directions and High Efficiency Using a Reflective Metasurface. *Appl. Sci.* **2020**, *10*, 7219. [CrossRef]