

RFID, Microwave Circuit, and Wireless Power Transfer Enabling 5/6G Communication

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Description:

The development of future 5G and 6G technologies is critical to meeting the increasing demand for faster, more reliable wireless communication as global connectivity expands. By addressing challenges like low data rates and high latency, these advancements will enable seamless integration of smart cities, autonomous vehicles, and immersive virtual experiences. As the number of connected devices grows exponentially, next-generation networks will play a pivotal role in supporting innovations across healthcare, education, and industry. The evolution of wireless communication not only enhances efficiency but also drives economic growth and societal progress by enabling new digital ecosystems. However, the push for faster networks underscores the need for ongoing research and collaboration to overcome technical and infrastructural barriers.

RFID, Microwave Circuit, and Wireless Power Transfer Enabling 5/6G

Communication explores how advancements in RFID, microwave circuit design, and wireless power transfer are shaping the development of 5G and 6G communication networks. It delves into the practical applications of these technologies, highlighting their transformative impact across industries like healthcare, logistics, and security. Covering topics such as artificial intelligence (AI), network architecture, and vehicle communication, this book is an excellent resource for academicians, researchers, engineers, policymakers, students, and more.

Coverage:

The many academic areas covered in this publication include, but are not limited to:

- 5/6G Communication
- Antennas
- Artificial Intelligence (AI)
- Electric Vehicles (EVs)
- Green Communication

- Intelligent Infrastructure
- Microwave Circuits
- Multisensor Data Fusion
- Network Architecture
- Optical Security Monitoring
- Public Safety
- Spatial Modulation
- Ubiquitous Connectivity
- Vehicle Communication
- Wireless Charging
- Wireless Communication Systems
- Wireless Power Transfer

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Please note that this book is currently in development and this table of contents is tentative. Chapter authors can make adjustments to their individual submissions in the eEditorial Discovery® system if they notice any discrepancies.

Chapter 1

Wireless Power Transfer Techniques for 6G Communication

Tushar N. A., Nandita Pradhan, Pooja Jaiswal

This chapter examines robust beamforming to increase power economy and reliability in magnetic-based wireless power transfer with many transmitters and receivers while accounting for MII imperfection. Transfer learning saves energy and improves efficiency in wireless communications by learning from prior tasks using correlation and similarity information. Since CSI procurement takes energy, its benefits gradually drop as power driven gadgets increase, yet spread. With system stability, channel state information techniques expand power insurance. ISWPT's integrated operation decreases system size, hardware cost, power consumption, and spectrum, enabling 6G wireless networks. Reconfigurable intelligent surfaces in wireless power transfer systems and designs can optimize energy efficiency by addressing multi-user circumstances and power distribution. Using simultaneous lightwave information and power transfer to combine EH and data transmission is fascinating and matures efficiency.

Chapter 2

RFID-Enabled Wireless Charging System for Electric Vehicles

Sarthak Bisht, Tia Mittal, Karan Bhambhani, Naga Malleswari T. Y. J.

The RFID-Enabled Wireless Charging System for Electric Vehicles (EVs) represents a significant advancement in sustainable transportation infrastructure. By integrating Radio Frequency Identification (RFID) technology with wireless charging capabilities, the system not only enhances user experience but also promotes environmental sustainability. One key feature of the system is its security and efficiency. Charging is initiated only when a valid RFID card is swiped, ensuring that only authorized users can access the charging facility. This helps prevent unauthorized usage and ensures that the system operates smoothly and efficiently. The system allows EV batteries to be charged using solar panels, tapping into renewable energy sources and reducing reliance on non-renewable energy. This not only reduces the carbon footprint of EV charging but also promotes the use of clean energy in transportation. The wireless charging capability of the system is facilitated by two copper coils one on the charging pad and the other integrated into the EV.

Chapter 3

Investigating Single- to Dual-Band Bandpass Filter Transformation for Wireless Communication Systems

Anup Raju Vasistha, Chandramouli H. Mahadevaswamy, Solomon H. Ebenuwa, Augustine O. Nwajana

A simple technique for transforming a single-band bandpass filter (BPF) into a dual-band BPF is presented in this chapter. The method starts with a 2nd-order single-band BPF design, giving rise to a 4th-order dual-band BPF after the proposed transformation. Both filters are implemented using compact U-shaped microstrip resonator for improved device miniaturization. The proposed work features a centre frequency of 1.4 GHz for the single-band BPF, with a 3.4% fractional bandwidth. The dual-band BPF operates at 1.35 and 1.45 GHz for the first and second bands, respectively. The design implementation employs the commercially available Rogers RT/Duroid 6010LM substrate, having a dissipation factor of 0.0023, dielectric constant of 10.7, and thickness of 1.27 mm. The practical responses of the prototype dual-band BPF indicate a good return loss of better than 18 dB across both bands, and an insertion loss of better than 0.1 dB. The design prototype achieved physical size of $0.23 \times 0.18 \lambda_g$. λ_g is the guided wavelength for the microstrip line impedance at the centre frequency of the filter.

Chapter 4

Microwave Circuits Enabling 5G/6G Communication

Smrity Dwivedi

There is growing demand for 5G as well as 6G technologies as per user's requirements and enhanced applications. As low latency and high data rates are key findings of 5G, in same way more improved bandwidth, maximum data enabled rate, and many new applications are basic achievable things from 6G systems. There are several types of microwave circuits used for such high frequency. RF/microwave circuits include antennas, filters, power amplifiers, phase shifters, power dividers, mixers, and multiplexers. Here, microwave antennas have been discussed under the microwave circuits. In the last few years, as per economic and social development which is greatly influenced by the advancements in mobile communication and technology, 5G technology has emerged as an important of the future 2020 generation which is already in use.

Chapter 5

The Role of Artificial Intelligence in 6G Networks, Architecture, Protocol, Transmission, and Applications

Aldrin Pandian W., Palak Mangal, Lakshmi D., Jasmine Jeya I.

The 6G wireless communication technology is the successor to the 5G cellular-based technique. It is aimed at the increased bandwidth and higher dimensions of data transmission with the measurement of less than one microsecond of latency communication. Artificial Intelligence (AI) is pivotal in establishing computational and intelligence infrastructure, data storing, transmission, and decision-making. With the increased frequencies of 6G, sampling rates will surge beyond those achievable with 5G (Fifth Generation). Access points will gain the capacity to serve multiple clients through orthogonal frequency-division multiple access concurrently. The expected spectrum of communication using 6G is up to terahertz (THz). Artificial Intelligence (AI) guides Quality of Service (QoS) in 6G communication. This chapter covers a high-level overview of the role of AI in 6G, architecture, protocols, transmission technologies, and applications.

Chapter 6

Enhancing Public Safety in Developing Countries Using a Mobile Application Solution: Nigeria as a Case Study

Moyinoluwalogo Mayowa, Richard I. Otuka, Nemitari Ajenka, Augustine O. Nwajana

In today's world, the escalating global insecurity poses significant challenges for both developed and undeveloped countries. The high crime rates and shortcomings in reporting crimes are pressing issues, emphasizing just how crucial it is to ensure the safety of citizens. While law enforcement agencies play a vital role, relying solely on them is insufficient. Embracing modern technology and fostering active citizen

participation are essential to address these concerns effectively. This research adopts an agile methodology to tackle the above concerns. The result of this approach is the development of a user-friendly mobile application that leverages cutting-edge technology. The primary objective of this application is to effectively map incidents of crime and provide real-time alerts, thereby significantly enhancing citizen security. With this, users are empowered to report criminal incidents directly from their smartphones, eliminating the need to physically approach law enforcement authorities.

Chapter 7

Millimetre-Wave Communication for 5G/B5G Applications

Rahul Koshti

Emerging millimeter wave (mm Wave) wireless communication systems reflect the culmination of more than a century of advancement in modern communications. Millimeter wave (mm Wave) communications have recently piqued the interest of researchers due to the enormous available bandwidth, which has the potential to result in rates of multiple Gbps (gigabit per second) per user. The novelty in the chapter is to suggest a modern antenna design for mm wave application and link budget analysis so as to achieve flaw less communication with reduced call drop rate. In this chapter we are focusing on introduction and background. The chapter further will focus on mm wave in cellular mobile communication along with the applications in 5G/B5G wireless communication networks. The chapter will also deal with system architecture of 5G communication employing mm wave and antenna in mm wave communication will be discussed.

Chapter 8

The Role of 6G in Empowering Smart Cities Enabling Ubiquitous Connectivity and Intelligent Infrastructure

Hitesh Mohapatra

Wireless communication is advancing, leading to 6G networks. These networks will reshape society with unprecedented connectivity and intelligence. 6G is key for future smart cities, integrating terahertz communication, ultra-low latency, and AI-driven networks. This will create hyper-connected cities where real-time data supports systems like autonomous vehicles, energy management, and public safety. 6G research shows its potential for ultra-reliable communication, immersive experiences like extended reality, and widespread sensing, crucial for smart city applications. However, challenges like technical issues, data privacy, and regulations need addressing. This chapter proposes a 6G-enabled smart city model using IoT, AI, and edge computing to improve urban operations. It explores dynamic network slicing, intelligent resource allocation, and edge AI processing to meet latency and bandwidth needs. The chapter

concludes by emphasizing collaboration and strategic planning to overcome challenges, ensuring 6G technologies foster sustainable urban growth.

Chapter 9

Multisensor Data Fusion and Its Application

Gregory Omozuhomwen Egbe, Stella Ndidi Arinze, Emenike Raymond Obi, Augustine O. Nwajana

Smart industrial processes are impossible without the use of machinery. Majority of these machines comprise rotating machines. As supporting tools for developing maintenance strategies, a Data-driven approach for multifault diagnosis of Rotating Machines is currently used in smart industry. This Chapter presents Multisensor Data Fusion and its application in Predictive maintenance methodology for multifault diagnosis of Industrial Rotating Machines. The main objective of Multisensor Data Fusion, rather than the different sensors being applied independently, are optimally fused to take advantage of their respective strengths, by combine data from multiple sensors and related information to achieve specific inferences than could be achieved by a single sensor. This chapter presents a methodology using data extraction features domain parameters for multifault diagnosis of Rotating Machines. The analysis shows that Root Mean Square Amplitude increases as fault develops, Crest Factor is more for healthy bearing and less for faulty bearing, these can provide early warning of faults

Chapter 10

Circular Fractal Array Antenna for C and S-Band Applications

Gnanalakshmi Venkatachalam, Heman M., Sumesh S.

In this article, a circular fractal array antenna is proposed for C-band and S-band applications. The antenna uses circular fractal geometry to achieve high gain across the S and C bands frequency spectrum. The antenna is fabricated using an FR-4 substrate and tested in anechoic chamber. The antenna design holds potential for multi-functional wireless systems and S and C band applications. The measurement results reveal that the designed antenna has two resonant frequencies at 3.5 GHz and 5.8 GHz and gain of around 3.1dB is noted. The size of proposed antenna is 28mm×28mm×1.6mm.

Chapter 11

An ITS-G5 Antenna for Vehicle Communication

Eugene Ogbodo, Azunka Ukala, Rahman Saifur

Intelligent Transportation Systems (ITS) represent a revolutionary integration of advanced information and communication technologies into transportation

infrastructure and vehicles. This integration aims to significantly enhance the safety, efficiency, and sustainability of transportation networks across the globe. ITS is transformative, moving beyond mere enhancements of existing frameworks to leverage a broad spectrum of cutting-edge technologies, including real-time traffic monitoring, adaptive signal control, sophisticated vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication systems, alongside advanced public transit solutions. This chapter offers an extensive overview of ITS, encapsulating its diverse technologies, widespread applications, and profound impact on global transportation systems. It introduces a paradigm shift in the conceptualization and management of transportation systems, addressing pressing urban challenges such as congestion, safety, and sustainability.

Chapter 12

Energy-Efficient SWIPT-Aided NOMA With Spatial Modulation for Green Communication in Beyond 5G/6G Networks

Srikamu C., Jayabharathy R., Sujanth Narayan K. G., Karthikeyan S.

This chapter introduces an energy-efficient system combining Simultaneous Wireless Information and Power Transfer (SWIPT), Cooperative Non-Orthogonal Multiple Access (CNOMA), and Spatial Modulation (SM) for beyond 5G and 6G networks. Designed for high data rates and low power use, it supports applications like smart cities, mMTC, vehicular networks. Non-Orthogonal Multiple Access (NOMA) enhances spectral efficiency by allowing multiple users to share frequency and time resources via power domain multiplexing. SWIPT enables near users to harvest RF energy to relay information to distant users, reducing infrastructure needs. Spatial Modulation (SM) minimizes hardware demands by activating one antenna per transmission, lowering power use while maintaining data rates. This SM SWIPT NOMA framework is optimized for power-limited, spectrum-constrained settings, aligning with 5G and 6G sustainability goals. Simulations demonstrate its efficiency: at 20 dBm, it achieves 135.12 joules of energy harvesting compared to 67.56 joules in SM SWIPT OMA, making it suitable for beyond 5G applications.

Chapter 13

Advancements in Edible Antennas: Design, Development, and Future Prospects in Biomedical and 5G/6G Applications

Kavitha K., Karthika K., Rajkumar S.

This chapter presents a comprehensive survey of edible antennas, focusing on their design, development, and applications in biomedical monitoring, healthcare, and environmental sensing. Made from biocompatible, biodegradable materials, edible antennas are ideal for scenarios where traditional antennas are unsuitable, especially

when ingestion or close human contact is required. The chapter reviews the state-of-the-art in edible antenna technology, discussing fabrication methods, materials, and key performance metrics like gain, efficiency, and bandwidth. It also addresses challenges such as miniaturization, impedance matching, and SAR compliance. Integration with 5G/6G networks is explored, highlighting benefits like enhanced data rates, low latency, and reliable connectivity for real-time applications. The role of advanced materials such as metamaterials in improving performance is examined, along with future research directions and challenges, and potential impact of edible antennas on personalized medicine, smart healthcare, and IoMT are provided.

Chapter 14

Li-Fi for Next Generation Wireless Communication: Technical Insights and Innovations

Dipti Chauhan, Jay Jain

Li-Fi technology uses Visible Light Communication for data transmission have the potential to transform wireless communication. The benefits offered by this technology, it has the potential to transform many industries and improve connectivity in both indoor and outdoor settings. It also provides significantly faster speeds and better security than standard Wi-Fi. This paper discusses significant developments in Li-Fi, such as its compatibility with 5G networks, support IoT, and how it improves the system of current wireless communication. In this chapter, we have presented an in-depth analysis of Li-Fi, including its potential benefits and drawbacks, as well as its range limitations, interoperability issues, and cost implications. The study aims to provide a comprehensive overview and contribute to the understanding and advancement of the technology by examining the basic ideas, technological advances, and issues of Li-Fi. The goal of this chapter is to improve our understanding and ability to use Li-Fi as a next generation technology in wireless communications.

Chapter 15

Intelligent and Optical Security Monitoring for 6G Communications

Sindhumitha Kulandaivel, Madhumitha Kulandaivel, Keerthana N. V.

The infrastructure of communication technologies in recent years has grown more complex and autonomous to meet societal requirements. Advanced technologies such as optical communication due to their enormous bandwidth and less latency capabilities have become the most sought-after candidates for 6G communications. The optical networks provide an agile and secure platform for effective data transmission. Thus, it is important to include cognitive and intelligent security monitoring for autonomous optical network management to improve reliability. Machine learning is a great tool that provides advancements in security monitoring in terms of

accuracy and cost-effectiveness for optical network diagnosis and management. This chapter discusses the vulnerability of optical networks to various security threats in the physical layer along with countermeasures for network survivability. Several monitoring techniques using various performance parameters are also discussed for effective attack identification and localization to ensure robust optical network performance for 6G communications.

Editor/Author Biographies

Augustine O. Nwajana (Senior Member, IEEE) received the M.Sc. (distinction) and the Ph.D. degrees in electrical and electronic engineering from the University of East London, U.K., in 2010 and 2017, respectively. He also received the research CPD certificate in Practical Antenna Design from the University of Oxford, U.K., in 2019. He was with Siemens AG as telecommunications engineer from 2005 to 2009, where his experience spanned many countries, including the U.S.A., U.K., United Arab Emirates, Germany, South Africa, Ghana, and Nigeria. He was also with Coventry University (as associate lecturer) and with the University of East London (as part-time lecturer). He is currently a senior lecturer (assistant professor) at the University of Greenwich where his current research interests include radio frequency (RF) energy harvesting/scavenging, battery-less RF/microwave systems, passive RF/microwave devices, and more. He has authored/co-authored five books, several journal articles, book chapters, and conference papers. He has served as keynote speaker and TPC member to several conferences and is currently the Editor-in-Chief for the International Journal of Electronics, Communications, and Measurement Engineering (IJECME) published by IGI Global, USA. He is a fellow of the Higher Education Academy.

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