

electromagnetic band gap structures in antenna engineering

Electromagnetic Band Gap Structures in Antenna Engineering: Enhancing Performance and Efficiency

electromagnetic band gap structures in antenna engineering have become a pivotal topic of discussion among researchers and practitioners aiming to improve antenna performance. These structures, often abbreviated as EBGs, are engineered materials that manipulate electromagnetic waves in unique ways, offering promising solutions to some of the longstanding challenges in antenna design. Whether it's reducing surface wave losses, enhancing gain, or improving radiation patterns, electromagnetic band gap structures are reshaping how antennas are conceived and optimized.

Understanding Electromagnetic Band Gap Structures

Before diving into their applications in antenna engineering, it's helpful to grasp what electromagnetic band gap structures are. Essentially, EBGs are periodic arrangements of materials that prohibit the propagation of electromagnetic waves within certain frequency ranges, known as band gaps. This behavior is somewhat analogous to how electronic band gaps prevent electron flow in semiconductors. By carefully designing these periodic patterns, engineers can control wave propagation, reflection, and transmission in ways that traditional antenna materials cannot.

The Physics Behind EBGs

At the heart of electromagnetic band gap structures is the concept of periodicity. When electromagnetic waves travel through a medium that has a repeating structure, constructive and destructive interference occurs. This interference creates frequency bands where wave propagation is significantly suppressed—these are the electromagnetic band gaps. In antenna applications, this property can be harnessed to suppress unwanted surface waves, which often degrade the antenna's radiation efficiency and cause signal interference.

Common Types of EBG Structures

Several types of electromagnetic band gap structures are prevalent in antenna design, including:

- **1D EBGs:** Consist of periodic structures in one direction, often used in waveguides.
- **2D EBGs:** Have periodicity in two dimensions and are commonly used as substrate layers beneath antennas.
- **3D EBGs:** More complex structures with periodicity in three directions, less common but useful for specialized applications.
- **Mushroom-Type EBGs:** These consist of patch arrays connected to the ground plane via vias, forming a high-impedance surface favorable for antenna performance.

Each type offers unique advantages and can be tailored to specific antenna parameters like frequency, bandwidth, and radiation characteristics.

Applications of Electromagnetic Band Gap Structures in Antenna Engineering

Electromagnetic band gap structures have found diverse applications within antenna engineering, addressing some of the most critical challenges designers face. Let's explore several key applications where EBGs are making a significant impact.

Suppressing Surface Waves to Enhance Radiation Efficiency

One of the most valuable features of EBGs in antenna design is their ability to suppress surface waves. Surface waves are modes that travel along the substrate-air interface and can cause energy to be trapped near the antenna, reducing overall radiation efficiency and creating unwanted interference patterns.

By integrating EBG structures into the substrate or ground plane, these surface waves can be blocked within the band gap frequencies, allowing more energy to radiate into free space. This leads to antennas with higher gain and cleaner radiation patterns, which is especially beneficial in compact and microstrip antenna designs.

Improving Antenna Isolation and Reducing Mutual

Coupling

In antenna arrays, mutual coupling between adjacent elements can severely impact performance, causing distortion in beamforming and reducing array efficiency. Electromagnetic band gap structures can be introduced between array elements to act as isolation barriers.

These EBG-based isolation techniques create stop bands that prevent electromagnetic energy from coupling between elements, thereby improving the overall array performance without increasing its physical size. This approach is particularly useful in MIMO (Multiple-Input Multiple-Output) systems, where multiple antennas operate in close proximity.

Enhancing Bandwidth and Frequency Selectivity

Antenna bandwidth is often limited by the physical and material properties of the antenna structure. By utilizing EBGs, engineers can design antennas that exhibit enhanced bandwidth properties. The periodic nature of EBGs can create multiple resonant modes or modify the antenna's impedance characteristics to widen the operational frequency range.

Moreover, EBGs can be designed to function as frequency selective surfaces (FSS), allowing antennas to operate efficiently within specific frequency bands while suppressing others. This capability is crucial in environments crowded with multiple communication standards and signals.

Design Considerations for Integrating EBG Structures in Antennas

While electromagnetic band gap structures offer numerous benefits, their integration into antenna systems requires careful design and optimization.

Material Selection and Fabrication Techniques

The choice of substrate materials and fabrication methods plays a significant role in the effectiveness of EBGs. Low-loss dielectric materials are preferred to minimize signal attenuation. Additionally, precise manufacturing processes such as photolithography or PCB etching are essential to achieve the fine periodic patterns that define the band gaps.

Emerging fabrication technologies like 3D printing are also being explored to create complex 3D EBG structures with greater design freedom.

Dimensioning and Periodicity

The geometric parameters of the EBG unit cells—such as size, shape, and periodic spacing—directly impact the frequency range of the band gap. Designers must carefully calculate these dimensions based on the target operating frequency of the antenna.

Simulation tools like CST Microwave Studio, HFSS, or COMSOL Multiphysics are invaluable for modeling the electromagnetic behavior and iterating designs before physical prototyping.

Integration with Antenna Elements

EBG structures can be placed in various locations relative to the antenna element, including beneath the patch, around the perimeter, or between array elements. The positioning influences the antenna's impedance matching, radiation pattern, and mutual coupling effects.

Practical designs often involve trade-offs: for example, placing EBGs too close can detune the antenna, while too far might reduce their effectiveness. Experimental validation remains a critical step to fine-tune these parameters.

Emerging Trends and Future Directions

The field of electromagnetic band gap structures in antenna engineering continues to evolve rapidly, fueled by advancements in materials science, computational electromagnetics, and communication technology demands.

Reconfigurable and Tunable EBGs

Recent research explores the creation of reconfigurable EBGs using varactors, MEMS switches, or liquid crystals. These dynamic structures can alter their band gap properties on demand, enabling antennas that adapt their performance to changing environments or frequency requirements.

This tunability opens exciting possibilities for cognitive radio systems and multi-band antennas that can seamlessly switch between communication standards.

Integration with Metamaterials and Plasmonics

EBGs share conceptual similarities with metamaterials, and hybrid structures that combine both are being investigated. By leveraging plasmonic effects and negative refractive indices, such advanced materials could further enhance antenna miniaturization, directivity, and near-field control.

Applications in 5G and Beyond

As wireless communication moves into millimeter-wave frequencies with 5G and future 6G technologies, antenna design faces new challenges related to propagation losses and compactness. Electromagnetic band gap structures offer a pathway to overcome these by enabling antennas that are both high-performance and physically small enough to integrate into mobile devices and base stations.

Practical Tips for Antenna Designers Working with EBGs

For engineers interested in leveraging electromagnetic band gap structures, here are some insights to keep in mind:

- **Start with Simulation:** Given the complexity of EBG behavior, rely heavily on full-wave electromagnetic simulation tools before prototyping.
- **Focus on Loss Minimization:** Use substrates with low dielectric loss tangent to preserve antenna efficiency.
- **Consider Manufacturing Tolerances:** Small variations in the periodic patterns can shift the band gap frequencies; ensure fabrication precision.
- **Balance Size and Performance:** While EBGs can improve radiation characteristics, their addition can increase antenna size; optimize for your specific application.
- **Experiment with Placement:** Test different configurations of EBG placement relative to the antenna element to find the best performance trade-off.

Electromagnetic band gap structures are more than just theoretical curiosities; they are practical tools that can elevate antenna designs to new levels of efficiency, selectivity, and adaptability. As technology continues to push the boundaries of wireless communication, the role of EBGs in antenna engineering will undoubtedly grow, inviting innovation and creative

engineering solutions.

Frequently Asked Questions

What are electromagnetic band gap (EBG) structures in antenna engineering?

Electromagnetic band gap (EBG) structures are periodic materials or surfaces designed to prohibit the propagation of electromagnetic waves within certain frequency bands. In antenna engineering, they are used to suppress surface waves, reduce mutual coupling, and improve antenna performance such as gain, efficiency, and bandwidth.

How do EBG structures improve antenna performance?

EBG structures improve antenna performance by suppressing surface waves that cause unwanted coupling and radiation losses. This leads to enhanced antenna gain, reduced back radiation, improved impedance matching, and better isolation between antenna elements in arrays, resulting in overall improved efficiency and radiation characteristics.

What types of EBG structures are commonly used in antenna design?

Common types of EBG structures include mushroom-type (patch with vias), uniplanar EBG, and periodic arrangements of dielectric or metallic elements. These structures can be implemented as 2D periodic surfaces or 3D volumetric configurations, depending on the application and frequency range.

Can EBG structures be integrated with wearable and flexible antennas?

Yes, EBG structures can be integrated with wearable and flexible antennas by using flexible substrates and conformal designs. This integration helps to reduce electromagnetic interference from the human body, improve antenna efficiency, and maintain performance despite bending or movement.

What are the challenges in designing EBG structures for antenna applications?

Key challenges in designing EBG structures include achieving the desired bandgap at specific frequencies while maintaining compact size, ensuring manufacturability, minimizing losses, and integrating them without significantly increasing antenna complexity or weight. Additionally, tuning and optimization for broadband or multi-band applications can be complex.

Additional Resources

****Electromagnetic Band Gap Structures in Antenna Engineering: Enhancing Performance and Efficiency****

electromagnetic band gap structures in antenna engineering have emerged as a critical area of research and development over the past few decades. These structures, often abbreviated as EBG, represent a class of artificial materials designed to control the propagation of electromagnetic waves. Their integration into antenna systems has opened new avenues for improving antenna performance, addressing longstanding challenges such as surface wave suppression, mutual coupling reduction, and bandwidth enhancement. This article delves into the fundamental principles, applications, and recent advancements of electromagnetic band gap structures within antenna engineering, providing a comprehensive overview for professionals and researchers in the field.

Understanding Electromagnetic Band Gap Structures

Electromagnetic band gap structures are engineered periodic arrangements of dielectric or metallic materials that prohibit the propagation of electromagnetic waves within certain frequency ranges, known as band gaps. These band gaps arise from the constructive and destructive interference effects within the periodic lattice, akin to photonic crystals in optics. In the context of antenna engineering, EBG structures serve as a powerful tool to manipulate electromagnetic fields, enabling designers to tailor antenna characteristics with greater precision.

At their core, EBGs can be considered as frequency-selective surfaces that exhibit unique dispersion properties. Their ability to forbid surface waves within the band gap frequencies significantly improves antenna radiation efficiency by preventing energy leakage along the substrate. This characteristic makes EBGs indispensable for high-frequency antenna designs where surface wave losses are particularly problematic.

Types of Electromagnetic Band Gap Structures

The classification of EBG structures is primarily based on their dimensionality and the nature of periodicity:

- **1D EBG Structures:** These consist of periodic variations in one dimension, often used in waveguide designs to suppress undesired modes.
- **2D EBG Structures:** Featuring periodicity in two dimensions, 2D EBGs are

commonly implemented as planar structures for antenna substrates, enabling surface wave control and improved radiation patterns.

- **3D EBG Structures:** More complex and challenging to fabricate, 3D EBGs offer complete electromagnetic band gaps in all directions and are explored for advanced antenna applications.

Among these, 2D EBGs have gained the most traction in practical antenna engineering due to their compatibility with planar manufacturing technologies.

Applications of Electromagnetic Band Gap Structures in Antenna Engineering

The practical integration of electromagnetic band gap structures in antenna systems has addressed several critical design challenges. Below are some key applications illustrating their versatility and impact.

Surface Wave Suppression

Surface waves, which travel along the antenna substrate, often degrade antenna performance by reducing radiation efficiency and causing undesired coupling between antenna elements. EBG structures act as an effective barrier to these waves within their band gap frequencies. By embedding periodic EBG patterns beneath or around the antenna, engineers can significantly reduce surface wave propagation, thereby enhancing the antenna's gain and directivity.

For example, in microstrip patch antennas, the inclusion of mushroom-type EBG structures—comprised of metal patches connected to the ground plane via vias—has demonstrated up to 3 dB improvement in gain and notable side-lobe level reduction. This improvement is particularly advantageous for applications in wireless communications where signal clarity and strength are paramount.

Mutual Coupling Reduction in Antenna Arrays

In phased array antennas and multiple-input multiple-output (MIMO) systems, mutual coupling between closely spaced elements can deteriorate system performance by affecting impedance matching and radiation patterns. Electromagnetic band gap structures provide an effective solution by acting as electromagnetic shields, isolating antenna elements from each other within the band gap frequencies.

Studies have shown that integrating EBG structures between array elements can reduce mutual coupling by more than 10 dB. This reduction translates to enhanced isolation and improved overall system capacity, particularly in dense antenna array configurations used in modern radar and 5G communication systems.

Bandwidth Enhancement and Miniaturization

While EBG structures are primarily recognized for their wave suppression capabilities, they also contribute to bandwidth enhancement. By modifying the electromagnetic environment around an antenna element, EBGs can alter the antenna's resonant modes and facilitate wider impedance bandwidths.

Additionally, EBGs support antenna miniaturization by enabling compact designs without compromising performance. The periodic nature of EBGs allows for effective electromagnetic control in smaller footprints, which is crucial for portable and embedded antenna applications in IoT devices and wearable technology.

Design Considerations and Challenges

Despite their promising benefits, the design and implementation of electromagnetic band gap structures in antenna engineering involve several challenges.

Fabrication Complexity

The intricate periodic patterns required for effective EBG behavior often demand precise fabrication processes. Mushroom-type EBGs, for example, involve vertical vias that connect patches to the ground plane, increasing manufacturing complexity and cost. For large-scale or flexible substrates, maintaining pattern fidelity can be difficult, potentially affecting the consistency of antenna performance.

Frequency Band Limitations

EBG structures are inherently frequency selective, operating effectively only within specific band gap ranges. This limitation means that they must be carefully tailored to the intended operational frequencies. For broadband antennas, designing EBGs that cover wide frequency ranges without compromising their band gap properties remains a technical hurdle.

Integration and Size Constraints

The addition of EBG structures can increase the overall size and thickness of the antenna system, especially when multiple layers or vias are involved. This factor is critical in compact devices where space and weight restrictions are stringent. Balancing the trade-offs between performance improvements and physical constraints is a key aspect of EBG antenna design.

Case Studies and Comparative Insights

Comparative analyses between conventional antennas and their EBG-enhanced counterparts provide valuable insights into the practical impact of electromagnetic band gap structures.

- **Microstrip Patch Antennas:** Integrating mushroom-type EBGs beneath patch antennas has consistently shown improved gain, reduced back lobe radiation, and narrower beamwidths, beneficial for directional communication systems.
- **Array Antennas:** Incorporating EBG slabs between elements in linear and planar arrays has demonstrated significant mutual coupling reduction, enhancing array efficiency and enabling higher element densities.
- **Wearable Antennas:** EBG structures have been used to minimize human body absorption effects and improve antenna safety by suppressing unwanted surface waves, thereby maintaining consistent performance in proximity to the body.

Each case underscores how electromagnetic band gap structures can be customized to meet specific antenna design goals, reinforcing their role as a versatile component in modern antenna engineering.

Emerging Trends and Future Directions

Recent research trends emphasize the integration of reconfigurable and tunable EBG structures, enabling dynamic control over band gap properties. Utilizing materials such as liquid crystals, varactors, or graphene, these advanced EBGs can adapt to changing operational requirements, paving the way for intelligent antenna systems.

Moreover, the exploration of metamaterial-inspired EBGs is expanding the scope of electromagnetic manipulation beyond traditional designs. These metamaterial EBGs offer compactness, multi-band operation, and improved

polarization control, aligning with the demands of next-generation wireless communication technologies.

The synergy between electromagnetic band gap structures and antenna engineering continues to evolve, promising innovative solutions to longstanding challenges and fostering enhanced system performance across diverse applications.

Electromagnetic band gap structures represent a transformative approach in antenna engineering, enabling unprecedented control over electromagnetic wave propagation. As fabrication techniques mature and novel materials emerge, the integration of EBGs in antenna design is set to become increasingly sophisticated, driving advancements in wireless communication, radar, and sensing technologies. The ongoing research and development in this domain reflect a broader trend toward engineered electromagnetic environments, where the boundaries of antenna performance are continually being redefined.

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electromagnetic band gap structures in antenna engineering: *Electromagnetic Band Gap Structures in Antenna Engineering* Fan Yang, Yahya Rahmat-Samii, 2009 This book is a detailed account of electromagnetic band gap (EBG) theory, analysis and applications, ideal for researchers and engineers.

electromagnetic band gap structures in antenna engineering: Information and Communication Technologies Vinu V Das, R. Vijaykumar, 2010-09-03 This book constitutes the proceedings of the International Conference on Information and Communication Technologies held in Kochi, Kerala, India in September 2010.

electromagnetic band gap structures in antenna engineering: *Electromagnetic Bandgap (EBG) Structures* Antonio Orlandi, Bruce Archambeault, Francesco de Paulis, Samuel Connor, 2017-05-31 An essential guide to the background, design, and application of common-mode filtering structures in modern high-speed differential communication links Written by a team of experts in the field, *Electromagnetic Bandgap (EBG) Structures* explores the practical electromagnetic bandgap based common mode filters for power integrity applications and covers the theoretical and practical design approaches for common mode filtering in high-speed printed circuit boards, especially for boards in high data-rate systems. The authors describe the classic applications of electromagnetic bandgap (EBG) structures and the phenomena of common mode generation in high speed digital boards. The text also explores the fundamental electromagnetic mechanisms of the functioning of planar EBGs and considers the impact of planar EBGs on the digital signal propagation of single ended and differential interconnects routed on top or between EBGs. The authors examine the concept, design, and modeling of EBG common mode filters in their two forms: on-board and

removable. They also provide several comparisons between measurement and electromagnetic simulations that validate the proposed EBG filters' design approach. This important resource:

- Presents information on planar EBG based common mode filters for high speed differential digital systems
- Provides systematic analysis of the fundamental mechanisms of planar EBG structures
- Offers detailed design methodology to create EBG filters without the need for repeated full-wave electromagnetic analysis
- Demonstrates techniques for use in practical real-world designs

Electromagnetic Bandgap (EBG) Structures: Common Mode Filters for High Speed Digital Systems offers an introduction to the background, design, and application of common-mode filtering structures in modern high-speed differential communication links, a critical issue in high-speed and high-performance systems.

electromagnetic band gap structures in antenna engineering: Emerging Innovations in Microwave and Antenna Engineering Zbitou, Jamal, Errkik, Ahmed, 2018-10-12 Continuing advancements in electronics creates the possibility of communicating with more people at greater distances. Such an evolution calls for more efficient techniques and designs in radio communications. Emerging Innovations in Microwave and Antenna Engineering provides innovative insights into theoretical studies on propagation and microwave design of passive and active devices. The content within this publication is separated into three sections: the design of antennas, the design of the antennas for the RFID system, and the design of a new structure of microwave amplifier. Highlighting topics including additive manufacturing technology, design application, and performance characteristics, it is designed for engineers, electricians, researchers, students, and professionals, and covers topics centered on modern antenna and microwave circuits design and theory.

electromagnetic band gap structures in antenna engineering: Advanced Engineering Electromagnetics Constantine A. Balanis, 2012-01-24 Balanis' second edition of Advanced Engineering Electromagnetics - a global best-seller for over 20 years - covers the advanced knowledge engineers involved in electromagnetic need to know, particularly as the topic relates to the fast-moving, continually evolving, and rapidly expanding field of wireless communications. The immense interest in wireless communications and the expected increase in wireless communications systems projects (antenna, microwave and wireless communication) points to an increase in the number of engineers needed to specialize in this field. In addition, the Instructor Book Companion Site contains a rich collection of multimedia resources for use with this text. Resources include: Ready-made lecture notes in Power Point format for all the chapters. Forty-nine MATLAB® programs to compute, plot and animate some of the wave phenomena Nearly 600 end-of-chapter problems, that's an average of 40 problems per chapter (200 new problems; 50% more than in the first edition) A thoroughly updated Solutions Manual 2500 slides for Instructors are included.

electromagnetic band gap structures in antenna engineering: Defected Ground Structure (DGS) Based Antennas Debatosh Guha, Chandrakanta Kumar, Sujoy Biswas, 2022-12-28 Defected Ground Structure (DGS) Based Antennas A unique exploration of critical topics in defected ground structures and their applications In Defected Ground Structure (DGS) Based Antennas: Design Physics, Engineering, and Applications, three distinguished authors deliver a comprehensive discussion of key topics related to defected ground structures (DGSs) and their applications to advanced antenna designs, including microstrips, arrays, dielectric resonators, PIFA, and printed monopoles. The book explores major advances in the technology that have occurred since 2006, as well as the fundamentals of the research in the subject. It also presents future possibilities for new researchers to assist in the development of new studies and technologies for practicing engineers and developers. Readers will discover: A thorough introduction to the concept and evolution of defected ground structure-based antennas In-depth examinations of defected ground structures for printed antenna feeds Comprehensive discussions of the use of defected ground structures to control unwanted modes under a microstrip patch for reducing cross-polarized radiation Enlightening descriptions of defected ground structures used to control mutual coupling in arrays and MIMO designs Perfect for students, researchers, and professionals with an interest in

wireless communications, Defected Ground Structure (DGS) Based Antennas: Design Physics, Engineering, and Applications will also earn a place in the libraries of engineers and scientists working in space exploration and defense organizations.

electromagnetic band gap structures in antenna engineering: Surface Electromagnetics

Fan Yang, Yahya Rahmat-Samii, 2019-06-20 Written by the leading experts in the field, this text provides systematic coverage of the theory, physics, functional designs, and engineering applications of advanced engineered electromagnetic surfaces. All the essential topics are included, from the fundamental theorems of surface electromagnetics, to analytical models, general sheet transmission conditions (GSTC), metasurface synthesis, and quasi-periodic analysis. A plethora of examples throughout illustrate the practical applications of surface electromagnetics, including gap waveguides, modulated metasurface antennas, transmit arrays, microwave imaging, cloaking, and orbital angular momentum (OAM) beam generation, allowing readers to develop their own surface electromagnetics-based devices and systems. Enabling a fully comprehensive understanding of surface electromagnetics, this is an invaluable text for researchers, practising engineers and students working in electromagnetics antennas, metasurfaces and optics.

electromagnetic band gap structures in antenna engineering: RF Circuit Design

Techniques for MF-UHF Applications Abdullah Eroglu, 2017-12-19 Magnetic resonance imaging, semiconductor processing, and RFID are some of the critical applications within the medium frequency (MF) to ultrahigh frequency (UHF) range that require RF designers to have a solid understanding of analytical and experimental RF techniques. Designers need to be able to design components and devices cost effectively, and integrate them with high efficiency, minimal loss, and required power. Computer-aided design (CAD) tools also play an important part in helping to reduce costs and improve accuracy through optimization. *RF Circuit Design Techniques for MF-UHF Applications* explains how to design, simulate, and implement RF/microwave components and devices for applications within the medium frequency (MF) to ultrahigh frequency (UHF) range. The book makes RF design simple by expertly blending theory, simulation, and practical application examples. *A Practical Guide to RF Circuit Design in the MF-UHF Range: Theory, Simulation, and Real-World Application Examples* After a review of network parameters used in the analysis of RF components and devices, the book examines MF-UHF design techniques in detail. These include techniques for designing high-power microstrip circuits, directional couplers, transformers, composite and multilayer inductors, filters, combiners/dividers, and RFID systems. For every device, the book gives the required theory and then explains the verification process with CAD tools. In addition, each design is illustrated with real-life implementation examples that use a variety of CAD tools such as MATLAB®, Mathcad, HFSSTM, Ansoft Designer®, Sonnet®, and PSpice®. Design tables, curves, and charts are included to demonstrate an efficient design process. Throughout, the book also offers practical hints to help engineers shorten the design time. *Design MF-UHF Devices More Cost-Effectively* The book reflects the optimum design methodology used in RF engineering, from the application of theory, to simulation for verification, to experimentation. Packed with useful techniques, tips, and examples, it is an invaluable resource for engineers, researchers, and students working in the MF-UHF range.

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electromagnetic band gap structures in antenna engineering: Printed Antennas Binod Kumar Kanaujia, Surendra Kumar Gupta, Jugul Kishor, Deepak Gangwar, 2020-11-22 Printed antennas have become an integral part of next-generation wireless communications and have been found to be commonly used to improve system capacity, data rate, reliability, etc. This book covers theory, design techniques, and the chronological regression of the printed antennas for various applications. This book will provide readers with the basic conceptual knowledge about antennas along with advanced techniques for antenna design. It covers a variety of analytical techniques and their CAD applications and discusses new applications of printed antenna technology such as sensing. The authors also present special reconfigurable antennas such as ME dipole, polarization, feeding, and DGS. The book will be useful to students as an introduction to design and applications of antennas. Additionally, experienced researchers in this field will find this book a ready reference and benefit from the techniques of research in printed antennas included in this book. Following are some of the salient features of this book: Covers a variety of analytical techniques and their CAD applications Discusses new applications of printed antenna technology such as sensing Examines the state of design techniques of printed antenna Presents special reconfigurable antennas such as ME dipole, polarization, feeding, and DGS

electromagnetic band gap structures in antenna engineering: *Broadband Metamaterials in Electromagnetics* Douglas H. Werner, 2017-07-06 The rapid development of technology based on metamaterials coupled with the recent introduction of the transformation optics technique provides an unprecedented ability for device designers to manipulate and control the behavior of electromagnetic wave phenomena. Many of the early metamaterial designs, such as negative index materials and electromagnetic bandgap surfaces, were limited to operation only over a very narrow bandwidth. However, recent groundbreaking work reported by several international research groups on the development of broadband metamaterials has opened up the doors to an exciting frontier in the creation of new devices for applications ranging from radio frequencies to visible wavelengths. This book contains a collection of eight chapters that cover recent cutting-edge contributions to the theoretical, numerical, and experimental aspects of broadband metamaterials.

electromagnetic band gap structures in antenna engineering: Energy Audit and Management L. Ashok Kumar, Gokul Ganesan, 2022-12-30 This book describes the energy management concepts, energy audit principles, resource efficiency, and other energy conservation opportunities involved in different sectors across varied industries. Real-time case studies from various large industrial sectors, like cement, paper and pulp, refineries, manufacturing, garments and textile processing, power plants, and other MSME industrial sectors with cross functional energy conservation opportunities, are included. It also describes the future scope of energy auditing and management including IoT and data analytics. It also helps to gather the energy generated and utilization, energy conservation, and other process related data. Features: Provides entire coverage of energy management and audit concepts Explores energy audit methodologies and energy saving initiatives Incorporates current technologies like machine learning, IoT, data analytics in energy audit for reliability improvement Includes case studies covering detailed energy saving calculation with investment pay back calculations This book is aimed at researchers, professionals, and graduate students in electrical engineering, power systems, energy systems, and renewable energy.

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simulation techniques.

electromagnetic band gap structures in antenna engineering: Band-Notch Characteristics in Ultra-Wideband Antennas Taimoor Khan, Yahia M.M. Antar, 2021-06-08 This book comprehensively reviews ultra-wideband (UWB) and UWB multi-input multi-output (MIMO) antennas with band-notched characteristics, with a focus on interference cancellation functionality. The book is organized into seven chapters that cover single band, dual band, and multi band-notched UWB antennas, followed by band-notched characteristics in UWB (MIMO) antennas. Further, it explains the mechanism of reconfigurability and tunability in band-notched UWB antennas, including advanced applications of UWB systems. Overall, it covers different techniques of canceling the electromagnetic interference in UWB in a concise volume. Features Provides a comprehensive presentation of avoiding interference in UWB systems Reviews state of the art literature related to UWB antennas, filtennas, and various reconfigurable technologies Explains different techniques for producing band-notch characteristics in UWB systems Includes discussion on historical perspectives of UWB technology Consolidates different research activities carried out on the electromagnetic interference cancellation techniques in the UWB communication systems Band-Notch Characteristics in Ultra-Wideband Antennas is aimed at researchers and graduate students in electrical and antenna engineering. Taimoor Khan has been an Assistant Professor at the Department of Electronics and Communication Engineering, National Institute of Technology Silchar since 2014. In addition to this, Dr. Khan has also worked as a Visiting Assistant Professor at Asian Institute of Technology Bangkok, Thailand during September–December, 2016. His active research interests include Printed Microwave Circuits, Electromagnetic Bandgap Structures, Ultra-wideband Antennas, Dielectric Resonator Antennas, Ambient Microwave Energy Harvesting, and Artificial Intelligence Paradigms in Electromagnetics. Dr. Khan has successfully guided three Ph.D. theses, and is supervising six Ph.D. students. He has published over 75 research articles in well-indexed journals and in world-renowned conference proceedings. Currently, he is executing three funded research projects, including two international collaborative SPARC and VAJRA research projects. In September 2020, Dr. Khan has been awarded a prestigious national IETE-Prof SVC Aiya Memorial Award for the year 2020. Yahia M. M. Antar has been a Professor at the Department of Electrical and Computer Engineering, Royal Military College of Canada since 1990. He served as the Chair of CNC, URSI from 1999 to 2008, Commission B from 1993 to 1999, and has a cross appointment at Queen's University in Kingston. He has authored and co-authored over 250 journal papers, several books and chapters in books, over 500 refereed conference papers, holds several patents, has chaired several national and international conferences, and has given plenary talks at many conferences. Dr. Antar is a fellow of the Engineering Institute of Canada, the Electromagnetic Academy, and an International Union of Radio Science (URSI). He was elected by the URSI to the Board as the Vice President in 2008 and in 2014, and to the IEEE AP AdCom in 2009. In 2011, he was appointed as a member of the Canadian Defence Advisory Board (DAB) of the Canadian Department of National Defence. He serves as an Associate Editor for many IEEE and IET Journals, and as an IEEE-APS Distinguished Lecturer. Presently, he is working as President-Elect for IEEE Antenna and Propagation Society for the year 2020.

electromagnetic band gap structures in antenna engineering: Microwave and Millimeter Wave Circuits and Systems Apostolos Georgiadis, Hendrik Rogier, Luca Roselli, Paolo Arcioni, 2012-09-17 Microwave and Millimeter Wave Circuits and Systems: Emerging Design, Technologies and Applications provides a wide spectrum of current trends in the design of microwave and millimeter circuits and systems. In addition, the book identifies the state-of-the art challenges in microwave and millimeter wave circuits systems design such as behavioral modeling of circuit components, software radio and digitally enhanced front-ends, new and promising technologies such as substrate-integrated-waveguide (SIW) and wearable electronic systems, and emerging applications such as tracking of moving targets using ultra-wideband radar, and new generation satellite navigation systems. Each chapter treats a selected problem and challenge within the field of Microwave and Millimeter wave circuits, and contains case studies and examples where

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electromagnetic band gap structures in antenna engineering: Analysis and Design of Transmitarray Antennas Ahmed H. Abdelrahman, Fan Yang, Atef Z. Elsherbeni, Payam Nayeri, 2022-06-01 In recent years, transmitarray antennas have attracted growing interest with many antenna researchers. Transmitarrays combines both optical and antenna array theory, leading to a low profile design with high gain, high radiation efficiency, and versatile radiation performance for many wireless communication systems. In this book, comprehensive analysis, new methodologies, and novel designs of transmitarray antennas are presented. Detailed analysis for the design of planar space-fed array antennas is presented. The basics of aperture field distribution and the analysis of the array elements are described. The radiation performances (directivity and gain) are discussed using array theory approach, and the impacts of element phase errors are demonstrated. The performance of transmitarray design using multilayer frequency selective surfaces (M-FSS) approach is carefully studied, and the transmission phase limit which are generally independent from the selection of a specific element shape is revealed. The maximum transmission phase range is determined based on the number of layers, substrate permittivity, and the separations between layers. In order to reduce the transmitarray design complexity and cost, three different methods have been investigated. As a result, one design is performed using quad-layer cross-slot elements with no dielectric material and another using triple-layer spiral dipole elements. Both designs were fabricated and tested at X-Band for deep space communications. Furthermore, the radiation pattern characteristics were studied under different feed polarization conditions and oblique angles of incident field from the feed. New design methodologies are proposed to improve the bandwidth of transmitarray antennas through the control of the transmission phase range of the elements. These design techniques are validated through the fabrication and testing of two quad-layer transmitarray antennas at Ku-band. A single-feed quad-beam transmitarray antenna with 50 degrees elevation separation between the beams is investigated, designed, fabricated, and tested at Ku-band. In summary, various challenges in the analysis and design of transmitarray antennas are addressed in this book. New methodologies to improve the bandwidth of transmitarray antennas have been demonstrated. Several prototypes have been fabricated and tested, demonstrating the desirable features and potential new applications of transmitarray antennas.

electromagnetic band gap structures in antenna engineering: Contemporary Developments in High-Frequency Photonic Devices Bhattacharyya, Siddhartha, Debnath, Pampa, Deyasi, Arpan, Dey, Nilanjan, 2019-06-14 Microwave photonics and information optics provide high bandwidth and precision along with ultrafast speed at a low cost. In order to reduce noise at the communication trans-receivers, scattering in the devices needs to be decreased, which can be achieved by replacing optoelectronic devices with photonic devices because in the latter only photons propagate electromagnetic waves. Contemporary Developments in High-Frequency Photonic Devices is a crucial research book that examines high-frequency photonics and their applications in communication engineering. Featuring coverage on a wide range of topics such as metamaterials, optoelectronic devices, and plasmonics, this book is excellent for students, researchers, engineers, and professionals.

electromagnetic band gap structures in antenna engineering: Springer Handbook of Global Navigation Satellite Systems Peter Teunissen, Oliver Montenbruck, 2017-06-16 This Handbook presents a complete and rigorous overview of the fundamentals, methods and

applications of the multidisciplinary field of Global Navigation Satellite Systems (GNSS), providing an exhaustive, one-stop reference work and a state-of-the-art description of GNSS as a key technology for science and society at large. All global and regional satellite navigation systems, both those currently in operation and those under development (GPS, GLONASS, Galileo, BeiDou, QZSS, IRNSS/NAVIC, SBAS), are examined in detail. The functional principles of receivers and antennas, as well as the advanced algorithms and models for GNSS parameter estimation, are rigorously discussed. The book covers the broad and diverse range of land, marine, air and space applications, from everyday GNSS to high-precision scientific applications and provides detailed descriptions of the most widely used GNSS format standards, covering receiver formats as well as IGS product and meta-data formats. The full coverage of the field of GNSS is presented in seven parts, from its fundamentals, through the treatment of global and regional navigation satellite systems, of receivers and antennas, and of algorithms and models, up to the broad and diverse range of applications in the areas of positioning and navigation, surveying, geodesy and geodynamics, and remote sensing and timing. Each chapter is written by international experts and amply illustrated with figures and photographs, making the book an invaluable resource for scientists, engineers, students and institutions alike.

electromagnetic band gap structures in antenna engineering: Microwave Devices and Circuits for Advanced Wireless Communication Dilip Kumar Choudhary, Naveen Mishra, Indrasen Singh, Naser Ojaroudi Parchin, Ghanshyam Singh, 2024-08-27 This book offers a comprehensive overview of design and analysis of microwave devices and circuits for 5G and beyond wireless communication systems. It focuses on modern microwave antennas, filters, metamaterials, and MIMO systems. It includes a design approach based on Artificial Intelligence and the practical use of microwave devices and circuits in commercial, medical, and military applications. Microwave Devices and Circuits for Advanced Wireless Communications: Design and Analysis explores the performance of microwave devices and circuits by highlighting the difficulties encountered by researchers and designers such as latency, interoperability, wireless coexistence, data streaming, safety, security, and privacy. The book explores the most important aspects of antenna design, including radiation pattern control, impedance matching with bandwidth improvement, and gain enhancement. It also examines different categories of metasurfaces, including frequency-selective surfaces (FSS) and electromagnetic bandgap (EBG) structures, and their distinct roles in antenna design. Additionally, the book examines concepts such as ultra-wideband (UWB) radar for 5G millimeter wave applications, and advanced techniques such as synthetic aperture radar (SAR), beam-forming, compressed sensing, and diffraction tomography for enabling high-resolution imaging across wider application areas. The authors also present an overview on applying machine learning (ML) techniques to advanced wireless communication for signal-processing tasks such as signal denoising, equalization, and modulation recognition. They then discuss the potential significance of UAV communication systems in achieving seamless connection, quality of service (QoS), as well as the difficulties and potential remedies involved in building dependable networks using UAVs. Throughout the book the authors offer a critical assessment of the strengths and limitations of each topic and approach presented, thus providing valuable guidance for future research in this exciting field. This book will be helpful for graduate students, researchers, and engineers working in the area of design and reliability of circuits for microwave and communication systems.

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