Matlab Code to Design A Slotted Waveguide Array Antenna

Aritra Roy

Lab-STICC, Universite de Bretagne Occidentale
Brest, France
aritra.roy@univ-brest.fr

Abstract

This article presents a MATLAB script used to design slotted waveguide array (SWA) antennas. A brief theory of the antenna is discussed to understand the scope and requirement of this code. A numerical comparison is also presented to design a SWA of 25 GHz to validate the proposed script.

I. INTRODUCTION

Slotted waveguide array antenna is known for its high power radiation and is often employed in space applications. It possesses a significantly high antenna gain by exploiting the radiations through multiple slots placed at half wavelength distances. The effects of slots on waveguide is throughly discussed in [1] which inspired the design of SWA as discussed in [2], [3], [5]. The slot placement on the waveguide plays a critical role to optimize the antenna radiation at a given frequency. In this article a MATLAB script is presented which is inspired by the analytical discussion presented in [3]–[6]. A brief theory of SWA is discussed in Sec. II which is followed by the Matlab script in Sec. III, numerical validation in Sec. IV and conclusion in Sec. V.
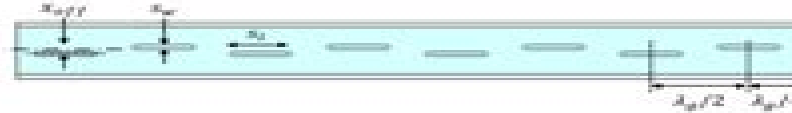
II. THEORY

Fig. 1. Schematic of a SWA indicating the slot length s_l, slot width s_w and slot offset from the longitudinal axis x_{off}. λ_g is the guided wavelength at the operating frequency considering the waveguide dimensions.

Schematic of a conventional SWA is shown in Fig. 1. It consists of a rectangular wavelength terminated at one end with multiple slots on one of its broad wall. The slots are placed longitudinally in a tandem orientation by maintaining a distance of the multiple of the guided wavelength (λ_g). It increases the interaction of slots with the standing wave inside the terminated waveguide to increases the antenna radiation. The total radiated electric field ($E_r(\theta)$) can be approximated using array theory by considering the radiation from individual slots

$$E_r(\theta) = f(\theta) \sum_{n=1}^{N} \alpha_n e^{jnk\frac{\lambda_g}{2}\cos\theta} \tag{1}$$

where, $f(\theta)$ the is radiated electric field of a slot, α_n is the magnitude of excitation coefficient of the nth slot, k is the free space wave number at the operating frequency and θ is the angle of observation. Since the slot-field is a function its placement about the waveguide axis, the conductance of the nth slot can be calculated from the excitation coefficients as

$$g_n = \frac{\alpha_n^2}{\sum_{n=1}^{N} \alpha_n^2} \tag{2}$$

It can also be expressed in terms of the design parameters of the SWA as

$$g_n = 2.09 \frac{\lambda_g}{\lambda_0} \frac{a}{b} \cos^2\left(\frac{\pi\lambda_0}{2\lambda_g}\right) \sin^2\left(\frac{\pi x_{off}}{a}\right) \tag{3}$$

where, a and b are the inner dimensions of the corresponding waveguide. These equations are used to design the SWAs at the operating frequency as will be explained in the following section.

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Electromagnetic and Photonic Simulation for the Beginner: Finite-Difference Frequency-Domain in MATLAB® Raymond C. Rumpf,2022-01-31 This book teaches the finite difference frequency domain FDFD method from the simplest concepts to advanced three dimensional simulations It uses plain language and high quality graphics to help the complete beginner grasp all the concepts quickly and visually This single resource includes everything needed to simulate a wide variety of different electromagnetic and photonic devices The book is filled with helpful guidance and computational wisdom that will help the reader easily simulate their own devices and more easily learn and implement other methods in computational electromagnetics Special techniques in MATLAB are presented that will allow the reader to write their own FDFD programs Key concepts in electromagnetics are reviewed so the reader can fully understand the calculations happening in FDFD A powerful method for implementing the finite difference method is taught that will enable the reader to solve entirely new differential equations and sets of differential equations in mere minutes Separate chapters are included that describe how

Maxwell s equations are approximated using finite differences and how outgoing waves can be absorbed using a perfectly matched layer absorbing boundary With this background a chapter describes how to calculate guided modes in waveguides and transmission lines The effective index method is taught as way to model many three dimensional devices in just two dimensions Another chapter describes how to calculate photonic band diagrams and isofrequency contours to quickly estimate the properties of periodic structures like photonic crystals Next a chapter presents how to analyze diffraction gratings and calculate the power coupled into each diffraction order This book shows that many devices can be simulated in the context of a diffraction grating including guided mode resonance filters photonic crystals polarizers metamaterials frequency selective surfaces and metasurfaces Plane wave sources Gaussian beam sources and guided mode sources are all described in detail allowing devices to be simulated in multiple ways An optical integrated circuit is simulated using the effective index method to build a two dimensional model of the 3D device and then launch a guided mode source into the circuit A chapter is included to describe how the code can be modified to easily perform parameter sweeps such as plotting reflection and transmission as a function of frequency wavelength angle of incidence or a dimension of the device The last chapter is advanced and teaches FDFD for three dimensional devices composed of anisotropic materials It includes simulations of a crossed grating a doubly periodic guided mode resonance filter a frequency selective surface and an invisibility cloak The chapter also includes a parameter retrieval from a left handed metamaterial The book includes all the MATLAB codes and detailed explanations of all programs This will allow the reader to easily modify the codes to simulate their own ideas and devices The author has created a website where the MATLAB codes can be downloaded errata can be seen and other learning resources can be accessed This is an ideal book for both an undergraduate elective course as well as a graduate course in computational electromagnetics because it covers the background material so well and includes examples of many different types of devices that will be of interest to a very wide audience **Full Matlab Code for Synthesis and Optimization of Bragg Gratings** Fethallah Karim,2018-11-07 This book presents a theoretical description of fiber Bragg gratings focusing on channels densification and the tunability of Bragg filters It also includes a full Matlab code for the synthesis and optimization of several kinds of fiber Bragg gratings by using the directed tabu search the simulated annealing method and the genetic algorithm Physical and optical parameters of uniform chirped and sampled fiber Bragg gratings are then reconstructed with these algorithms **Magnetics, Dielectrics, and Wave Propagation with MATLAB® Codes** Carmine Vittoria,2023-11-15 Future microwave wireless communication systems computer chip designs and sensor systems will require miniature fabrication processes in the order of nanometers or less as well as the fusion of various material technologies to produce composites consisting of many different materials This requires distinctly multidisciplinary collaborations implying that specialized approaches will not be able to address future world markets in communication computer and electronic miniaturized products Anticipating that many students lack specialized simultaneous

training in magnetism and magnetics as well as in other material technologies Magnetics Dielectrics and Wave Propagation with MATLABR Codes avoids application specific descriptions opting for a general point of view of materials per se Specifically this book develops a general theory to show how a magnetic system of spins is coupled to acoustic motions magnetoelectric systems and superconductors Phenomenological approaches are connected to atomic scale formulations that reduce complex calculations to essential forms and address basic interactions at any scale of dimensionalities With simple and clear coverage of everything from first principles to calculation tools the book revisits fundamentals that govern magnetic acoustic superconducting and magnetoelectric motions at the atomic and macroscopic scales including superlattices Constitutive equations in Maxwell s equations are introduced via general free energy expressions which include magnetic parameters as well as acoustic magnetoelectric semiconductor and superconducting parameters derived from first principles More importantly this book facilitates the derivation of these parameters as the dimensionality of materials is reduced toward the microscopic scale thus introducing new concepts The deposition of ferrite films at the atomic scale complements the approach toward the understanding of the physics of miniaturized composites Thus a systematic formalism of deriving the permeability or the magnetoelectric coupling tensors from first principles rather than from an ad hoc approach bridges the gap between microscopic and macroscopic principles as applied to wave propagation and other applications   Photonic Crystals Igor A. Sukhoivanov,Igor V. Guryev,2009-09-21 The great interest in photonic crystals and their applications in the last 15 years is being expressed in the publishing of a large number of monographs collections textbooks and tutorials where existing knowledge concerning eration principles of photonic crystal devices and microstructured bers their mathematicaldescription well knownandnovelapplicationsofsuchtechno gies in photonics and optical communications are presented They challenges authors of new books to cover the gaps still existing in the literature and highlight and popularize of already known material in a new and original manner Authorsofthisbookbelievethatthenextsteptowardswideapplicationof photoniccrystalsisthesolutionofmanypracticalproblemsofdesignandc putation of the speci c photonic crystal based devices aimed at the speci c technicalapplication Inordertomakethisstep itisnecessarytoincreasethe number of practitioners who can solve such problems independently The aim of this book is to extend the group of researchers developers and students who could practically use the knowledge on the physics of photonic crystals together with the knowledge and skills of independent calculation of basic characteristics of photonic crystals and modeling of various elements of tegrated circuits and optical communication systems created on the basis of photonic crystals The book is intended for quali ed readers specialists in the eld of optics and photonics students of higher courses master degree students and PhD students As an introduction to the snopest the book contains the basics of wave optics and radiation propagation in simple guiding media such as planar waveguides and step index bers   **Millimeter-Wave Waveguides** Dmitri Lioubtchenko,Sergei

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microelectronics and VLSI design communication systems and networks and image and signal processing The contents of this book will be useful to researchers and professionals alike **Optical Communications from a Fourier Perspective** Palle Jeppesen,Bjarne Tromborg,2023-11-17 Optical Communications from a Fourier Perspective Fourier Theory and Optical Fiber Devices and Systems covers a broad range of subjects spanning Fourier theory and signal analysis over photonic components including time lenses in optical communication Some of the theory is more generally applicable beyond optical communication and is of relevance also for communications engineering The Fourier theory dimension of the book presents the relationship between Fourier series and Fourier integrals and also the related Laplace transform The book covers wave propagation in optical waveguides based on Maxwell equations and the nonlinear Schr dinger equation Various modulation formats are addressed along with coherent detection and required bandwidth Optical Fourier transform in the form of time lens is covered for example in modulation format conversion and spectrum magnification and couplers and their use for optical discrete Fourier transformation are also discussed Other important subjects such as noise linewidth and coherence are discussed in relation to semiconductor lasers Detailed derivations and a deeper background for the chapters are provided in appendices where appropriate Introduces Fourier theory and signal analysis tailored to applications in optical communications devices and systems Provides a strong theoretical background and a ready resource for researchers and advanced students in optical communication and optical signal processing Starts from basic theory and then develops descriptions of useful applications *Computational Electromagnetics for RF and Microwave Engineering* David B. Davidson,2010-10-28 This hands on introduction to computational electromagnetics CEM links theoretical coverage of the three key methods the FDTD MoM and FEM to open source MATLAB codes freely available online in 1D 2D and 3D together with many practical hints and tips gleaned from the author s 25 years of experience in the field Updated and extensively revised this second edition includes a new chapter on 1D FEM analysis and extended 3D treatments of the FDTD MoM and FEM with entirely new 3D MATLAB codes Coverage of higher order finite elements in 1D 2D and 3D is also provided with supporting code in addition to a detailed 1D example of the FDTD from a FEM perspective With running examples through the book and end of chapter problems to aid understanding this is ideal for professional engineers and senior undergraduate graduate students who need to master CEM and avoid common pitfalls in writing code and using existing software

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