



Introduction to the Physics of Gyrotrons

Gregory S. Nusinovich

**Foreword by Victor Granatstein
and Richard Temkin**

Introduction To The Physics Of Gyrotrons

Kalaria, Parth Chandulal



Introduction To The Physics Of Gyrotrons:

Introduction to the Physics of Gyrotrons G. S. Nusinovich, **Introduction to the Physics of Gyrotrons** Gregory S. Nusinovich, 2020-03-03 As unique sources of coherent high power microwave and millimeter wave radiation gyrotrons are an essential part of the hunt for controlled fusion Presently gyrotrons are actively used for electron cyclotron resonance plasma heating and current drive in various controlled fusion reactors These sources have been under development in many countries for more than forty years In spite of their widespread use however there is as yet no single book to introduce non specialists to this vital field Now Gregory S Nusinovich an early pioneer of the gyrotron and widely regarded today as the world s leading authority on the subject explains the fundamental physical principles upon which gyrotrons and related devices operate Nusinovich first sets forth some rules of thumb that allow readers to understand gyrotron operation in simple terms He then explores the fundamentals of the general theory of gyrotrons and offers an overview of the various types of gyro devices including gyromonotrons gyroklystrons gyro traveling wave tubes and gyrotwistrons He explains not only the theory linear and nonlinear but also the practical challenges that users of such devices face This book will be of interest to undergraduate and graduate students as well as to those who develop gyrotrons or who use them in various applications It should also appeal to plasma physicists interested in charged particle dynamics as well as to applied physicists needing to know more about micro and millimeter wave technologies [Time-dependent spectrum analysis of high power gyrotrons](#) Schlaich, Andreas, 2015-08-06 In this work a novel measurement system for the analysis of the gyrotron RF output spectrum was developed It enables unprecedented time dependent measurements within a large bandwidth dynamic range and unambiguous RF indication in the entire D Band 110 170 GHz Special attention was given to the investigation of parasitic RF oscillations and the analysis of the interplay of thermal cavity expansion and ionization based space charge neutralization at the start of long RF pulses **Electron Gun for Gyrotrons** Udaybir Singh, A. K. Sinha, 2022-08-22 This book highlights the emission transmission and launching of an electron beam It presents an overview and recent advances in order to enhance knowledge in the field of gyrotron in general and electron gun in particular The book is presented in seven chapters starting with the introduction and ending with future possible directions in the field of electron beams and gyrotrons [Diffraction and Scattering in Launchers of Quasi-Optical Mode Converters for Gyrotrons](#) Jens Hanspeter Flamm, 2014-06-17 In this work different methods for the calculation of diffraction and scattering in launchers of quasi optical mode converters for gyrotrons are compared ranked and extended The extension gives the opportunity to take a tapered average radius of the waveguide antenna into account The comparison and the extension of the fast field calculation methods for component synthesis opens the possibility to reduce diffraction and stray radiation of reliable and powerful millimeter wave sources *A First 2 MW-Class (136)/170/204 GHz Multi-Frequency Gyrotron Pre-Prototype for DEMO: Design, Construction and Key Components Verification* Ruess, Tobias, 2023-10-26 Ein Gyrotron wird in magnetisch eingeschlossenen Plasmaexperimenten f r Heizung

Stromtrieb Plasmastabilisierung und Plasmadiagnostik verwendet In dieser Arbeit wird der erste Entwurf und Bau eines Mehrfrequenz Mehrzweck Pre Prototyp Gyrotrons in koaxialer Technologie vorgestellt das bei 136 170 204 GHz mit einer Ausgangsleistung von 2 MW arbeitet Dies ist der erste Schritt zum Betrieb bei Frequenzen bis zu 240 GHz unter Verwendung der Koaxialhohlraum Gyrotrontechnologie A gyrotron is used in magnetically confined plasma experiments for heating current drive plasma stabilization and plasma diagnostics This work presents the first design and construction of a multi frequency multi purpose coaxial cavity pre prototype gyrotron operating at 136 170 204 GHz with an output power of 2 MW It is the first step towards operating frequencies up to 240 GHz using the coaxial cavity gyrotron technology

Gyrotrons Machavaram V. Kartikeyan, Edith Borie, Manfred Thumm, 2013-03-14 Gyrotron oscillators gyrotrons are capable of providing hundreds of kilo watts of power at microwave and millimetric wavelengths From their conception in the late fifties until their successful development for various applications gyrotrons have come a long way technologically and made an irreversible impact on both users and developers The possible applications of high power millimeter and sub millimeter waves from gyrotrons and their variants gyro devices span a wide range of technologies The plasma physics community has already taken advantage of the recent advances of gyrotrons in the areas of RF plasma production heating non inductive current drive plasma stabilization and active plasma diagnostics for magnetic confinement thermonuclear fusion research such as lower hybrid current drive LHCD 8 G Hz electron cyclotron resonance heating ECRH 28 170 G Hz electron cyclotron current drive ECCD collective Thomson scattering CTS and heat wave propagation experiments Other important applications of gyrotrons are electron cyclotron resonance ECR discharges for the generation of multi charged ions and soft X rays as well as industrial materials processing and plasma chemistry Submillimeter wave gyrotrons are employed in high frequency broadband electron paramagnetic resonance EPR spectroscopy Additional future applications await the development of novel high power gyro amplifiers and devices for high resolution radar ranging and imaging in atmospheric and planetary science as well as deep space and specialized satellite communications and RF drivers for next generation high gradient linear accelerators supercolliders

Millimeter-Wave Gyrotron Traveling-Wave Tube Amplifiers Chao-Hai Du, Pu-Kun Liu, 2014-05-29 A gyrotron traveling wave amplifier gyro TWT with the high power and broad band capabilities is considered as a turn on key for next generation high resolution radar The book presents the most advanced theory methods and physics in a gyro TWT The most challenging problem of instability competition has been for the first time addressed in a focused and systematic way and reported via concise states and vivid pictures The book is likely to meet the interest of researchers and engineers in radar and microwave technology who would like to study the gyro TWTs and to promote its application in millimeter wave radars Chao Hai Du and Pu Kun Liu are both professors at Peking University

Investigations of After Cavity Interaction in Gyrotrons Including the Effect of Non-uniform Magnetic Field Roy Choudhury, Amitavo, 2014-02-05 Dynamic after cavity interaction ACI in megawatt class gyrotrons is

investigated that could lead to lower output mode purity and increased level of internal stray radiation The self consistent KIT IHM multi mode code SELFT has been modified to extend the simulation domain into the radius up taper section of the gyrotron cavity where the probability of ACI exists Studies on four different gyrotron configurations confirm that undesired interactions in the up taper region can result in additional parasitic oscillations with relative power in the 1% range

Feasibility and Operational Limits for a 236 GHz Hollow-Cavity Gyrotron for DEMO Kalaria, Parth

Chandulal, 2017-11-08 The DEMOnstration fusion power plant DEMO will be the first fusion reactor which is intended to generate net electrical power For successful operation of DEMO high power gyrotrons with operating frequencies up to 240 GHz are required for plasma heating and stabilization In this work a systematic feasibility study and tolerance analysis are performed for the conventional type hollow cavity DEMO gyrotrons The various approaches are also suggested to identify its operational limits

Microwave and Millimeter-Wave Vacuum Electron Devices: Inductive Output Tubes, Klystrons, Traveling-Wave Tubes, Magnetrons, Crossed-Field Amplifiers, and Gyrotrons A.S. Gilmour, Jr., 2020-04-30 Written by an internationally recognized as an expert on the subject of microwave MW tubes this book presents and describes the many types of microwave tubes and despite competition from solid state devices those using GaN SiC et cetera which continue to be used widely and find new applications in defense communications medical and industrial drying Helix traveling wave tubes TWTs as well as coupled cavity TWTs are covered Klystrons and how they work are described along with the physics behind it and examples of devices and their uses Vacuum electron devices are explained in detail and examines the harsh environment that must exist in tubes if they are to operate properly The secondary emission process and its role in the operation of crossed field devices is also discussed The design of collectors for linear beam tubes including power dissipation and power recovery are explored Discussions of important noise sources and techniques that can be used to minimize their effects are also included Presented in full color this book contains a balance of practical and theoretical material so that those new to microwave tubes as well as experienced microwave tube technicians engineers and managers can benefit from its use

State-of-the-Art of High-Power Gyro-Devices. Update of Experimental Results 2021. (KIT Scientific Reports ; 7761) Thumm, Manfred, 2021-10-28 This report presents an update of the experimental achievements published in the review State of the Art of High Power Gyro Devices and Free Electron Masers Journal of Infrared Millimeter and Terahertz Waves 41 No 1 pp 1 140 2020 related to the development of gyro devices Tables 2 34 Emphasis is on high power gyrotron oscillators for long pulse or continuous wave CW operation and pulsed gyrotrons for any applications

Automated Mode Recovery and Electronic Stability Control for Wendelstein 7-X Gyrotrons Wilde,

Fabian, 2024-08-07 Magnetic confinement fusion relies on plasma heating and plasma control using gyrotron oscillators providing at megawatt power levels The operational reliability decreases when operating at the performance limits due to increasing parasitic mode activity This work demonstrates for the first time the automated fast recovery of nominal gyrotron

operation during a pulse by exploiting the hysteretic gyrotron behaviour after a mode switch being in use at the Wendelstein 7 X ECRH facility

Design and Experimental Investigation of a Second Harmonic 20 kW Class 28 GHz Gyrotron for Evaluation of New Emitter Technologies Malygin, Anton, 2016-12-16 Gyrotrons are high power mm wave tubes Here the design construction and experimental investigation of a 20 kW 28 GHz gyrotron 2nd harmonic are reported This tube was designed to evaluate new emitters for future highly efficient and reliable fusion gyrotrons and for material processing applications Following experimental results have been achieved in CW operation 22.5 kW output power at 23.4 kV electron beam voltage and 2.23 A beam current with the world record efficiency of 43 %

Guide to State-of-the-Art Electron Devices Joachim N. Burghartz, 2013-03-19 Winner 2013 PROSE Award Engineering and Technology Concise high quality and comparative overview of state of the art electron device development manufacturing technologies and applications Guide to State of the Art Electron Devices marks the 60th anniversary of the IRE electron devices committee and the 35th anniversary of the IEEE Electron Devices Society as such it defines the state of the art of electron devices as well as future directions across the entire field Spans full range of electron device types such as photovoltaic devices semiconductor manufacturing and VLSI technology and circuits covered by IEEE Electron and Devices Society Contributed by internationally respected members of the electron devices community A timely desk reference with fully integrated colour and a unique lay out with sidebars to highlight the key terms Discusses the historical developments and speculates on future trends to give a more rounded picture of the topics covered A valuable resource R engineers in the semiconductor industry applied scientists circuit designers Masters students in power electronics and members of the IEEE Electron Device Society

Advances in Terahertz Source Technologies Gun-Sik Park, Masahiko Tani, Jae-Sung Rieh, Sang Yoon Park, 2024-04-16 During the past several decades tremendous progress has been made in terahertz THz science and technology There is a continuing need to have terahertz waves ready for practical applications Terahertz photonic and electronic devices are being readied to be employed in application systems such as communication links satellite communications radar surveillance hard soft material heating biomedical treatment and biomedical diagnostics This book focuses on the advances in terahertz source technologies both from photonics and electronics solid state and vacuum state points of view Written in a noncomplicated language the book will be useful for a broad spectrum of readers including advanced undergraduate and graduate level students in electronics and photonics researchers in various disciplines in physics chemistry biology astronomy and electrical engineering system engineers in various industrial sectors general readers and those who are interested in the interaction between electromagnetic waves and matters and in the effects of electromagnetic waves on matters

Yale Scientific, 2003

High Power Microwaves James Benford, John A. Swegle, Edl Schamiloglu, 2015-11-04 Following in the footsteps of its popular predecessors High Power Microwaves Third Edition continues to provide a wide angle integrated view of the field of high power microwaves HPMs This third edition includes significant updates in every chapter as well as a new chapter on

beamless systems that covers nonlinear transmission lines Written by State-of-the-Art of High Power Gyro-Devices and Free Electron Masers. Update 2015 (KIT Scientific Reports ; 7717) Thumm, Manfred, 2016-08-29 **Electron Beams and Microwave Vacuum Electronics** Shulim E. Tsimring, 2006-11-10 This book focuses on a fundamental feature of vacuum electronics the strong interaction of the physics of electron beams and vacuum microwave electronics including millimeter wave electronics The author guides readers from the roots of classical vacuum electronics to the most recent achievements in the field Special attention is devoted to the physics and theory of relativistic beams and microwave devices as well as the theory and applications of specific devices

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