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## ACKNOWLEDGEMENTS

Foremost, I thank The Almighty for giving me the strength and showering his blessings to bring my research investigations to a logical end successfully. I would like to express my immense gratitude to my supervisor Dr. M. Thottappan for his excellent guidance and motivation. The completion of this research work is truly an outcome of their constant untiring support, valuable ideas and suggestions during my research work. The insightful discussions with them always provided me great enthusiasm. I could not have imagined having better advisors and mentors for my research work.

I wish to extend my sincere gratitude towards my research performance evaluation committee (RPEC) members, Dr. Smrity Dwivedi and Dr. B. Biswas for their encouragement and insightful comments. I also thank Prof. B. N. Basu, Dr. Somak Bhattacharyya, and other faculty members for their kind cooperation and encouragement during this journey. I am indebted to Prof. M. V. Kartikeyan, and Dr. Anirban Bera for their constant help during my one-week visit to Ceeri Pilani, Rajasthan and IIT Roorkee, Uttarakhand respectively.

My special thanks to Dr. M. S. Chauhan, Dr. M. V. Swati, Dr. Anshu Sharan Singh, Dr. Rajan Agrahari, Dr. Vikram Kumar, and Dr. A. P. Singh for their valuable assistance from personal to the technical level. I am very much thankful to many research scholars of the CRMT laboratory for providing a stimulating and friendly environment. My thanks go to Mr. Prabhakar Tripathi, Mr. R. K. Singh, Mr. Arjun Kumar, Mr. M. A. Ansari, Mr. Vineet Singh, Mr. S. G. Yadav, Mr. Sambit, Mr. Diptiranjana, Mr. Nilotpall, Mr. Soumjit, Mr. V. V. Reddy, Mr. V. Veera Babu, Mr. G. Venkatesh, Mrs. Kritika, and Ms. Pratibha. I also thank my colleagues, Mr. Amit Kumar Singh, Mr. Deepak Jarwal, Dr. Aman Sikri, and Mr. Smriti Ratan, for providing a fun-filled environment.

My most profound appreciation towards my wife (Roma Rani), my sisters (Akansha Rani and Ayushi) and brother (Paras Kumar) for their continuous support and encouragement. They are the source of strength for me and remain an invaluable asset to me. Finally, last but not the least I owe my special gratitude to my father Shri Sunil Kumar, and mother Smt. Ram Dulari for their love, prayers, blessings, and sacrifices to educate and prepare me for my future.

*Date:*

**(Akash)**





*Dedicated*  
*To*  
*My Family*



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## LIST OF ABBREVIATIONS

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<b>ABBREVIATION</b>	<b>FULL FORM</b>
<b>BWO</b>	Backward Wave Oscillator
<b>BeO-SiC</b>	Beryllium Oxide-Silicon Carbide
<b>CRM</b>	Cyclotron Resonance Maser
<b>TWT</b>	Travelling Wave Tube
<b>EM</b>	Electromagnetic
<b>FIT</b>	Finite Integration Technique
<b>FDTD</b>	Finite-difference Time-domain
<b>GHz</b>	Giga-hertz
<b>Gyro-TWT</b>	Gyrotron Travelling Wave Tube
<b>Gyro-BWO</b>	Gyrotron Backward Wave Oscillator
<b>TM</b>	Transverse Magnetic
<b>TE</b>	Transverse Electric
<b>ESR</b>	Electron Spin Resonance
<b>NMR</b>	Nuclear Magnetic Resonance
<b>PIC</b>	Particle-In-Cell
<b>PDL</b>	Periodic Dielectric Loading
<b>UDL</b>	Uniform Dielectric Loading
<b>MIG</b>	Magnetron Injection gun
<b>OFHC</b>	Oxygen Free High Conductivity
<b>VEDs</b>	Vacuum Electron Devices
<b>CST</b>	Computer Simulation Technologies





## LIST OF SYMBOLS

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Symbol	Details
$\alpha$	Velocity ratio
$r_w$	Radius of the interaction waveguide
$r_b$	Electron beam radius
$r_g$	Guiding center radius
$r_L$	Larmor radius
$v_t$	Transverse electron velocity
$v_z$	Longitudinal electron velocity
$\epsilon_0$	Permittivity of free space
$\Delta r$	Lossy layer thickness
$\epsilon_r$	Relative permittivity of the dielectric material
$\delta$	Skin depth
$\rho_{Cu}$	Resistivity of copper
$\mu_0$	Permeability of free space
$\omega_c$	Cutoff angular frequency of the waveguide
$\Omega$	Cyclotron frequency
$f$	Frequency
$K_0$	Beam-wave coupling impedance
$H_{sm}$	Beam-wave coupling coefficient
$G_{mn}$	Geometry factor
$m_e$	Mass of an electron
$s$	Cyclotron harmonic number
$B_0$	Static magnetic field
$v_p$	Phase velocity of RF wave
$v_g$	Group velocity of RF wave
$\beta_t$	Transverse normalized velocity
$\beta_z$	Longitudinal normalized velocity
$E$	Electric field

$H$	Magnetic Field
$\varphi, r, z$	Azimuthal, radial, and axial cylindrical coordinates
$c$	Speed of light
$L_{dB}$	Total loss of the circuit in $dB$
$V_0$	Beam voltage
$I_0$	Beam current
$\eta_e$	Electronic efficiency of gyro-TWT amplifier
$\eta_0$	Efficiency of gyro-TWT with RF losses
$\eta_{col}$	Collector efficiency
$\eta_{Total}$	Total efficiency of gyro-TWT after recovery of spent beam energy
$P_{RF}$	Generated output power
$P_{DC}$	DC electron beam power
$k_z$	Axial wavenumber
$k_c$	Cut-off wavenumber
$m$	Azimuthal wavenumber
$n$	Radial wavenumber
$\chi'_{mn}$	The $n^{th}$ zero of Bessel function
$J_m(\chi'_{mn})$	$m^{th}$ order ordinary Bessel function of first kind
$\lambda_g$	Wavelength inside the disk medium
$F_m$	Compression ratio
$l_s$	Slant length
$r_c$	Emitter radius
$\Delta v_z / v_z$	Axial velocity spread
$\Delta v_t / v_t$	Transverse velocity spread
$m_B$	Number of folds
$k_B$	Bragg's periodicity vector
$r_1$	Corrugation amplitude
$d$	Corrugation period

## PREFACE

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The gyrotron traveling wave tube (gyro-TWT) amplifiers offers a unique opportunity to fill a long-standing gap in the generation of high-power coherent millimeter and sub millimeter wave radiation with its promise of broadband amplification. The gyro-TWT amplifier has emerged out as an efficient and stable high power, wide band amplifier which develops CW as well as pulse power that could not be done by the conventional microwave tubes or quantum mechanical devices. In recent years, there is renewed interest toward research and development of the gyro-TWT amplifier due to its requirement in the systems for the applications, such as high-resolution radar, high information density communication, satellite communication, material processing, weaponry, remote sensing, industrial heating, hyperthermia, linear accelerators, waste remediation, *etc.* Another major area of development is the possibility of exploiting the world leading gyro-TWT amplifier to be used in Electron Paramagnetic Resonance (EPR) and Dynamic Nuclear Polarization (DNP) spectroscopy which is currently hampered by the lack of high-power sources and especially broadband amplifiers of terahertz radiation.

Author is fascinated by various applications of high-frequency high-power gyrotron amplifiers. However, the inherent instability problem of gyro-TWT due to various source of oscillations limits the output power gain and efficiency. The existing single mode analysis fails to give the mutual effect of operating and oscillating modes on the performance of the device. These issues have motivated the author to investigate the multimode nonlinear beam-wave interaction of lossy dielectric loaded gyro-TWT using nonlinear analytical equation and numerical simulation tool by considering more than

one mode in the operation. The lossy dielectric loading effectively suppresses the potential oscillations by providing them attenuation.

The other issues such as sensitivity to beam velocity spread, high-magnetic field requirement are also limiting the performance of the gyro-TWT to meet the practical application requirement. The author has also studied the design and simulation of low velocity spread diode and triode magnetron injection gun to improve the electronic efficiency. The design and simulation study of other subassemblies of gyro-TWT such as input coupler, output window and beam collector has been described. The author has investigated the second harmonic higher order mode operation to reduce the requirement of high magnetic field by a factor of 2.

The author has reported the present work in different parts at national and international conferences as well as in referred journals, namely, IEEE Transaction on Electronic Devices and IEEE transaction on Plasma Science.

The author will consider his modest effort as a success if it would be useful to the community of microwave tube designers and researchers.