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I, Rajanish Kumar Singh, certify that the work embodied in this thesis is my own bonafide work and carried out by me under the supervision of Dr. M. Thottappan from "21/07/2015" to "03/08/2020", at the Department of Electronics Engineering, Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not will fully copied any other's work, paragraphs, text, data, results, *etc*., reported in journals, books, magazines, reports, dissertations, theses, *etc*., or available at websites and have not included them in this thesis and have not cited as my own work.

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Date: **(Rajanish Kumar Singh)**

Dedicated
To
My Father
(Late S. N. Singh)
&
Father-In Law
(Late P. N. Singh)

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ABBREVIATIONS

Abbreviation	Details
A	Ampere
ADI	Alternate Direction Implicit
BWOs	Backward Wave Oscillations
CAD	Computer Aided Design
CARM	Cyclotron Auto-Resonance Maser
CPI	Communication and Power Industries
CRM	Cyclotron Resonance Maser
CRPP	Centre de Recherches en Physique des Plasmas
CST	Computer Simulation Technologies
CW	Continuous Wave
DC	Direct Current
DNP	Dynamic Nuclear Polarization
ECRM	Electron Cyclotron Resonance Maser
EM	Electromagnetic
EPFL	Ecole Polytechnique Fédérale de Lausanne
FD	Finite Differences
FDTD	Finite-Difference Time-Domain
FEM	Finite-Element Method
FFT	Fast Fourier Transform
FIR-FU	Far-Infrared Region- University of Fukui
FIT	Finite Integration Technique
GHz	Gigahertz
MW	Megawatt
Gyro-amplifier	Gyrotron Amplifier
Gyro-BWO	Gyrotron Backward Wave Oscillator
Gyro-TWT	Gyrotron Travelling Wave Tube
HPM	High Power Microwaves
IAP	Institute of Applied Physics

keV	Kilo Electron Volt
kV	Kilovolt
kW	Kilowatt
MHz	Megahertz
MIG	Magnetron Injection Gun
MIT	Massachusetts Institute of Technology
MW	Megawatt
NMR	Nuclear Magnetic Resonance
NRL	Naval Research Laboratory
OFHC	Oxygen free High conductivity
PBA	Perfect Boundary Approximation
PBG	Photonic Band Gap
PIC	Particle-in-Cell
PML	Perfect Matched Layer
RF	Radio Frequency
RAS	Russian Academy of Sciences
SOC	Start Oscillation Current
SSDs	Solid State Devices
SWSs	Slow wave Structures
TE	Transverse Electric
TM	Transverse Magnetic
THz	Terahertz
TWTs	Travelling Wave Tubes
VEDs	Vacuum Electronic Devices

LIST OF SYMBOLS

Symbol	Details
A_n ()	Amplitude function of EM field
a	Lattice constant
a_n	Amplitude of n^{th} mode
B	Magnetic field
B_0	Static magnetic field
b	Lattice constant in wave vector space
β	Normalized velocity
β_t	Transverse normalized velocity
β_z	Longitudinal normalized velocity
c	Velocity of light in free space
C_{mn}	Coupling coefficient
Δ	Detuning parameter
e	Electronic charge
E	Electric field
ε_0	Free-space permittivity
ξ	Electron energy
δ	Angle of the electron momentum vector about the gyro-center
ς	Axial position variable
ε	Efficiency
ε_{el}	Electronic efficiency
$\eta_\perp$	Transverse efficiency
F	Normalized field amplitude
$f(z)$	A function with axial dependence
φ, r, z	Azimuthal, radial, and axial cylindrical coordinates
ϕ	Angle of electron in gyrocenter coordinate system (r,ϕ)
γ	Relativistic factor
G	Geometrical factor
$h(z)$	Axial profile of the field along the cavity
I_b	Beam current
I_L	Limiting current
I_{st}	Starting current
J_t	Transverse AC current density
$Jm()$	Bessel function of the ordinary type
k	Wave number

k_x	x-component of wave number
k_y	y-component of wave number
L	Effective cavity interaction length
Λ	slow-time scale phase variable
λ	Wavelength
m, n, q	Azimuthal, radial, and axial mode indices
m_e	Mass of electron
μ	Normalized cavity interaction length
N	Number of modes
v_{mn}	The n^{th} zero of J (Bessel function)
p	Electron momentum
P	Power dissipated
Q	Cavity quality factor
Q_D	Diffractive Q
Q_{ohm}	Ohmic Q
Q_T	Total Q
R_1& R_2	Reflectivity at the input end and output end of the tapered cavity
r	Rod radius
R_b	Electron beam radius
r_L	Larmor radius
R_o	Cavity wall radius
s	Harmonic number
ψ	Phase of electron
t	Time
τ	Width of Gaussian pulse
Θ_0	Beamlets phase in cavity centered coordinate system
ζ	Electron angle in cavity centered coordinate system
u	Normalized energy
U	Total stored energy
v	Electron velocity
v_{t0}	Transverse electron velocity
v_{z0}	Longitudinal electron velocity
V_b	Beam voltage
V_{dep}	Space charge voltage depression
w	Relative energy variable
ω	Wave frequency
ω_c	Cyclotron frequency