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Dedicated
To
My Gurus

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
BWO	Backward Wave Oscillator
BeO-SiC	Beryllium Oxide-Silicon Carbide
CST	Computer Simulation Technologies
CPI	Communication and Power Industries
CRM	Cyclotron Resonance Maser
DC	Direct Current
ECRM	Electron Cyclotron Resonance Maser
EM	Electromagnetic
FEM	Finite Element Method
FIT	Finite Integration Technique
FDTD	Finite-difference Time-domain
GHz	Giga-hertz
Gyro- Amplifier	Gyrotron Amplifier
Gyro-TWT	Gyrotron Travelling Wave Tube
Gyro-BWO	Gyrotron Backward Wave Oscillator
IAP	Institute of Applied Physics
MIG	Magnetron Injection gun
MHz	Megahertz
MoM	Method of Moments
NRL	Naval Research Laboratory
OFHC	Oxygen Free High Conductivity
PDL	Periodic Dielectric Loading
PIC	Particle In Cell

RF	Radio Frequency
SOC	Start Oscillation Current
SOL	Start Oscillation Length
TM	Transverse Magnetic
TE	Transverse Electric
TWT	Travelling Wave Tube
UDL	Uniform Dielectric Loading
VEDs	Vacuum Electron Devices

LIST OF SYMBOLS

Symbol	Details
ω	Wave angular frequency
$k_{\parallel}$	Axial wave number
$k_{\perp}$	Transverse wave number
Ω_c	Electron cyclotron frequency
$v_{\parallel}$	Axial electron velocity
B_o	DC magnetic field
$v_{\perp}$	Transvers electron velocity
m_e	Effective mass of electron
V	Beam voltage
I_b	Beam current
ω_c	Non relativistic angular frequency
ω_{cut}	Cut off angular frequency
r_{cav}	Cavity radius
x_{mn}	Eigen value of TEmn mode
f_r	Resonating frequency
μ_r	Relative permittivity
ε_r	Relative Permeability
l_{cav}	Cavity length
X	Isolation factor
r_{dt}	Drift tube length
r_b	Gyrating beam radius
r_w	Waveguide radius
v_p	Phase velocity of RF wave
v_g	Group velocity of RF wave
β_t	Normalized transverse velocity
β_z	Normalized axial velocity
N	Beam density parameter

I_A	Alfven current
C_i	Coupling coefficient
c	Speed of light
ψ	Normalized energy
p	Normalized momentum
ζ	Normalize axial length
η_e	Electronic efficiency
η_{col}	Collector efficiency
η_{Total}	Total efficiency after recovery of spent beam energy
F_n	Normalized field amplitude
θ_d	Electron phase at the end of drift tube
F_m	Field amplitude at mth cavity
F_n	Normalized field amplitude
χ_m	Susceptibility
δ_m	Frequency detuning parameter
∇	Stagger tuning parameter
P_d	Drive power
Q_e	External quality factor
λ_g	Wavelength inside the disk medium
G	Gain
ϕ	Normalized gain bandwidth product
BW_∇	Stagger tuned bandwidth
$E_\parallel$	Axial electric field
$B_\parallel$	Axial magnetic field
τ	Radial propagation constant
δ	Skin depth
T	Thickness factor
F_m	Compression ratio
E_c	Electric field at cathode
r_c	Cathode radius
θ_c	Cathode angle

d_{ca}	Cathode anode distance
V_{dep}	Depressed voltage
Γ	Reflection coefficient
$F_{g,h}$	Field amplitude in h cavity of g cluster
$\delta_{g,h}$	Frequency detuning between operating frequency and resonating frequency of h cavity of g cluster

PREFACE

The eagerness to seal the millimetre-wave technology gap in the high-power regime, where there are numerous civilian and military applications, has resulted in extensive research and development activities in fast-wave gyro-sources and amplifiers. Although different gyro-source, namely, the gyro klystron and gyro – TWT are available for radar applications such as asteroid tracking, weather monitoring, space debris detection, the gyro-amplifiers like the gyro-twystron is required that unite the merits of gyro-klystron and gyro-TWT, i.e., high power with wider band width.

The gyro-twystron, employs a resonant cavity in conjunction with a waveguide to support propagating waves, combines the high power merits of the gyro-klystron with the wider bandwidth advantage of the gyro-TWT. Despite this aspect, the gyro-twystron is the most unexplored device in gyrotron family. These advantages and applications have aroused considerable research interest in widening the bandwidth of a gyro-twystron for applications such as in high-resolution radar and high information density communication systems in the millimetre-wave frequency band.

The author, in the present thesis, has explored the different mechanism i.e., stagger tuning (chapter 2 and chapter 3) and cluster cavity (chapter 5), for the bandwidth widening of the gyro-twystron for the various radar application. The periodic dielectric loading (PDL) technique is used to detect and suppress oscillations while increasing output power (chapter 4). A simple field matching technique is used for the analysis of a dielectric loading, for dispersion control and hence wideband coalescence between the beam-mode and waveguide-mode dispersion characteristics of a gyro-twystron. The complete gyro-twystron is designed and simulated in commercially available CST environment and the beam wave interaction behaviour of the gyro-twystron based on Particle In Cell (PIC) is also investigayed.

The ability of the gyro-twystron to deliver the desired outputs is constrained by the design and performance of the various sub-assemblies, such as the electron beam source, spent beam collector, and RF output window. The author has designed, simulation and optimized the magnetron injection gun (MIG), undepressed and single stage depressed collector, single and double disc RF window to improve the amplifier's performance.

The author, from time to time, has reported the present work part-wise at national and international conferences as well as in professional journals, namely, IEEE Transaction on Electron Devices.

The author will consider his small effort a success if this work helps the vacuum electron device community to develop the wideband gyro-twystron, which has a lot of potential but hasn't been looked into much.