# PREFACE

The desire to bridge the millimeter-wave and submillimeter-wave technology gap in the high-power regime, where numerous civilian and military applications exist, has led to significant research and development in fast-wave gyro sources and amplifiers. Although one such gyro-source, the gyrotron, is now commercially available for applications such as plasma heating and material processing, gyro-amplifiers such as the gyro-klystron and the gyro-TWT have emerged as successful amplifiers for millimetre radar systems, they each have their own set of drawbacks. To mitigate the issues and combine the advantages of both devices, a hybrid device known as a gyro-twystron is introduced.

The gyro-twystron amplifier is created from the gyroklystron and gyrotron travelling wave tube (gyro-TWT) amplifier. This hybrid amplifier integrates the merits of both amplifiers, resulting in a high power-bandwidth product and a gain-bandwidth product. Despite these aspects, the gyro-twystron is the gyrotron family's most undiscovered device. These benefits and uses have sparked the curiosity of research to improve the potential capabilities of a gyro-twystron for applications such as high-resolution radar and high-information-density communication systems in the millimeter-wave frequency band.

The author, in the present thesis, has investigated the different configurations of millimeter wave gyro-twystron, using various techniques to improve the performance of gyro-twystron for various radar applications. For the high power operation, the stability of gyro-twystron is an issue as the output waveguide section is vulnerable to parasitic instabilities and backward wave oscillations. A nonlinear multimode analysis has been used to investigate the growth of operating as well as competing modes in RF

interaction structure of *Ka*-band gyro-twystron and predicted the unwanted spurious oscillating modes cause instability in operation. To suppress spurious oscillating modes, a short periodic dielectric loading in the output waveguide section was made, and multimode analysis was carried out to investigate the behaviour of multiple modes in PDL gyro-twystron, which predicted that spurious oscillating modes was well suppressed. Further, a stability analysis of the PDL gyro-twystron was performed. An intermediate cavity was introduced to single cavity PDL gyro-twystron to improve the performance metrics of the hybrid gyro amplifier. Furthermore a three-cavity *Ka*-band stagger-tuned gyro-twystron was designed to improve the bandwidth, and its beam-wave interaction behaviour was explored. The author has also studied the design and simulation of low-velocity spread diode and triode magnetron injection guns to improve electronic efficiency. The design and simulation study of other subassemblies of gyro-twystron, such as input coupler, output window, undepressed, and depressed collector, has been described.

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, Journal of Electromagnetic Waves and Applications.

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