PREFACE

The work of the present thesis focuses on the beam-wave interaction studies and thermal studies of the high power gyrotron oscillators. In addition, the beam wave interaction studies of low power tunable gyrotron device are presented. The thesis aims to develop RF and thermo mechanical studies on the fixed frequency, high power gyro-vacuum electron device, i.e. gyrotron oscillators to create a solid theoretical background for future experimental studies. Historical developments of gyrotrons, in addition to VEDs, is scrutinised to bring out the research gap and problems. A series of works have been done on the gyrotron oscillator, and the part of these works has been published in reputed Journals. Further, the aim, introduction and scope of the thesis are briefly discussed below.

As compared to solid state devices, Vacuum electron devices (VEDs) generate high RF power to serve the various applications from space exploration to nuclear researches. At higher frequencies, the fabrication difficulties and operational limitation of conventional microwave tubes, push the research and development activities towards Gyrotron devices. Gyrotron devices not only overcome the limitation of transverse dimension limitation for high harmonic but also allow the beam wave interaction at a half radius from the wall for fundamental harmonic. With high power generation/ amplification and handling capabilities, gyrotron devices find applications in plasma heating, ceramic sintering, RADAR and particle accelerator application. Gyrotron oscillator finds application in plasma heating in popularly known thermonuclear fusion reactors while its amplifier counterparts are found suitable for RADAR and particle accelerator applications.

For the medium and high power levels, due to the finite conductive nature of interaction cavity walls, in the process of beam wave interaction, the generated RF power results ohmic losses in the structure and thereby thermal effects comes into the picture and leads mechanical deformations. Since, the device is very sensitive to the geometrical perturbations; a proper incorporation of thermal system for optimized RF performance is needed. As well under practical considerations, the misalignments and spreads in the beam limit the geometrical tolerances of the structure. Taking this, the operation of the 95GHz, 100kW gyrotron in a relative high order mode is investigated and its pros and cons are discussed. In addition, the beam wave interaction studies with the inclusion of the nonlinear taper regions which are derived by inspecting the axial mode field profiles, using the time dependent multimode theory are performed. As well the necessary modifications to the multimode theory for the study of beam wave interaction behaviour under the practical beam conditions i.e., axial beam shift and tilt are incorporated and compared with the PIC simulations. Considering the importance of the efficiency, the design and analysis of internal quasi optical mode launchers has been presented using a self-developed numerical code based on the coupled mode theory instead of using Commercial Tools like LOT and SURF3D. As well the design studies of low power tunable source for DNP NMR spectroscopy applications are discussed