PREFACE

Several potential applications of High power microwave (HPM) sources in various domains, such as defense (directed-energy weapon, jammer, imaging, high power radar, a study of the effect of HPM on the survivability/ vulnerability of electronic component or devices), civilian (food irradiation, material processing, cargo inspection), scientific and medical, support the demand for more research studies on conventional microwave tubes in the relativistic regime as well as dedicated HPM sources. Due to advances in cathode technology, the initial velocity of the cathode-borne electron beam has become approximately equal to the speed of light, also known as the rapid relative electron beam (IREB). The various conventional microwave tubes have been transformed into their HPM variants using this IREB approach such as klystron to relativistic klystron, magnetron to the relativistic magnetron, backward wave oscillator to relativistic backward wave oscillator, and others. Apart from all these conventional tubes, there are many dedicated HPM sources such as the Virtual Cathode Oscillator (VIRCATOR) and Magnetically Insulated Line Oscillator (MILO) are compact and capable to generate RF output power at the gigawatt level. But the main constraint associated with both types of sources is that they suffer from pulse shortening problems therefore such devices have single-shot or low pulse repetition rate (PRR). In addition, they also require an additional mode converter to couple the RF output power to the external antenna.

Many research studies have been reported on high-peak-power or single-shot or low-repetition microwave sources, however, there is a huge research gap in the high-average-power or high-energy, high-repetition-based sources. The latest grid-less reltron in HPM sources has been investigated due to its various attractive features such as high efficiency, compact, multiple frequency operation, frequency stability, frequency tunability, and long pulse operation with high repetition rate (PRR).

In this thesis, the author calculates the magnetic coupling factor in terms of the structural parameters of the side-coupled cavity (SCC) and also proposes an empirical expression for calculating the frequency associated with the fundamental resonance mode of the structure, in which the effect of magnetic-coupling depth has been also included. The behavior of SCC in the presence of an electron beam has also been investigated, and the effect of various beam parameters on RF growth rates has also been estimated. The author presents a brief description of the device, design methodology, and working principle. The effect of the various structural parameters of the SCC on the resonating frequency of the SCC has been assessed with the help of the CST's eigenmode solver, and simultaneously validated the device's design methodology through the CST's PIC solver. Also, the RF performance of the device has been estimated for different electrical specifications with the help of a PIC solver. Finally, a new variant of reltron (i.e. explosive emission-based grid-less reltron) for high RF power, long pulse-width, and high pulse repetition rate has been proposed. The simulation studies show that the proposed variant generates 10 times more RF peak power than the grid-less reltron and the width of the generated RF pulse is 5 times higher than the gridded reltron. Since this variant uses a grid-less configuration, therefore, this device has a high PRR value.

The author has reported the present work part-wise at national and international conferences as well as in reputed journals, namely, IEEE Transactions on Plasma Science, and Journal of Electromagnetic and Wave Applications.

The authors would consider their modest effort successful if it was useful for both the understanding as well as the design and development of the SCC and high average power grid-less reltron HPM oscillators.