

**DESIGN OF AN O-TYPE METAMATERIAL SLOW WAVE STRUCTURE FOR
HIGH POWER MICROWAVE GENERATION**

by

Sabahattin Cihad Yurt

B.Sc., Electrical & Electronic Engineering, Istanbul University, Turkey, 2009

M.Sc., Electrical Engineering, Istanbul Technical University, Turkey, 2011

Ph.D., Electrical Engineering, University of New Mexico, Albuquerque, USA, 2017

ABSTRACT

The aim of this dissertation is to design a novel metamaterial slow wave structure (MSWS) for high power microwave (HPM) generation which is an efficient and compact new generation O-type device that is comparable to, and even better than conventional devices. There is an increasing interest in using metamaterials for designing HPM sources because of their so-called unique electromagnetic properties that are not found in nature, such as below cutoff propagation, which is the main property that allows for a compact design, and negative refractive index that allows backward wave propagation and reversed Cerenkov radiation.

In this work, we analyzed conventional vacuum electron devices to show the similarity of properties with MSWSs at microwave frequencies and pay more attention to understanding MSWSs for HPM generation. We show that the evolution of wave dispersion in systems of all-metallic periodic structures with increasing corrugation depth have properties similar to MSWSs used in HPM sources. We show that the main properties

of MSWSs, such as the existence of the lowest order wave with negative dispersion, also appear in ordinary metallic periodic systems with deep corrugation.

Our structure in this dissertation is a broadside-coupled split ring resonator (BCSRR) slow wave structure (SWS) that produces backward waves and beam/wave interaction with a TE-like mode at an operating frequency near 1.4 GHz. It is an array of periodically loaded all-metallic split ring resonators (SRRs) in a cylindrical waveguide with an output horn to extract power efficiently. This MSWS allows for high power extraction at the output, up to 310 MW and with 20% beam-to-RF conversion efficiency in a compact design compared to conventional backward wave oscillators (BWOs). We performed cold test experiments on a crudely manufactured MSWS in order to measure the resonant frequency and passband characteristics from the S-parameters using a TE-like mode launcher. Hot test experiments have validated the experimental design of this MSWS.