Parametric Characterization of Electromagnetic Energy Production From Over-Voltaged Spark Gaps*

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Abstract— **Spark gap based high power microwave sources have been actively developed as possible high power microwave (HPM) sources for directed energy applications for over two decades. These sources rely on the fast rising time varying current and as such are dependent on the geometry and the overall LCR characteristics of the source and input pulse. Due to the geometric considerations of an over-voltaged spark gaps the resultant spectral output is generally in the broadband regime [1]. This paper presents our preliminary work on developing a test bed for spark gap based HPM sources, initial field measurements characterising this test bed and preliminary particle in cell and time and frequency domain models that attempt to capture the physics of these spark gaps with respect to electromagnetic energy production.**

Keywords-high power microwaves, spark gap sources, pulsed power

I. Introduction

The high power microwave, plasma and beam physics group at the University of New Mexico, Electrical and Computer Engineering Department is actively pursuing a physics based approach to understanding the generation of electromagnetic energy for directed energy applications. As part of these efforts a modular spark gap test bed is being developed to facilitate the measurement of plasma streamers and their characteristics and the concomitant production of electromagnetic energy.

II. Test Bed and Field Measurements

Our Spark gap based test bed is a modular system comprised of a variable separation between electrodes and the capability to vary the electrode shape. The main housing is made up a dielectric with a low attenuation coefficient in the 300-900 nm range. It is designed to hold relatively high pressures using N_2 as the inter-electrode dielectric. The optical transmission of the housing is needed as future work will include time resolved spectral and density measurements of the breakdown which in turn will be tied to the net electromagnetic radiation production.

The pulsed power driver, which is capable of delivering up to 50 kV in single stage mode will described along with its spice model. The pulsed driver is also of modular design, incorporating a pulse forming network (PFN) as part of the main circuit. This PFN is of type E design with parallel LC discrete components.

Preliminary data for the angular distribution of electromagnetic energy production, in absolute units will be presented. The Electric fields will be measured directly using a D-dot and Balun combination from Prodyn Corp. Additional UNM built D-dots, and calibrated to the Prodyn sensor, will be fielded to measure the angular fields. The fields spectral content dependence on the LCR circuit, voltage and resultant dI/dT of the test bed, which also includes the spark gap shape will be shown.

III. Numerical Modeling

Preliminary particle in cell numerical model is presently being designed. A parametric scan of various electrode geometries and AK gaps will be conducted and its results fed back into the experimental parts of this work. Future work will include not just the geometric and pulsed power dependence of the generated RF but additional work will focus on the atomic physics of the spark channels to gain further understanding of the spark gap process and how this affects the electromagnetic energy production.

Due to the varying needs of directed energy applications a narrowband or mesoband bandwidth may be needed. This has been the motivation to conduct time domain and frequency domain numerical modeling of geometric structures to produce this narrowband content.

References

[1] F. Sabbath, D.V. Giri, *Ultra-Wideband, Short Pulse Electromagnetics* Vols 1-10 (Springer).

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