Metamatieral-Inspired Magnetic EZ Antenna for High Power Microwave Applications

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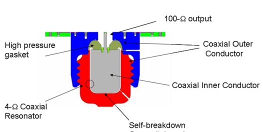
***Abstract*—Metamaterial-inspired antennas leverage techniques that can make an electrically small antenna (ESA), that would typically be an inefficient radiator, achieve radiation efficiencies of greater than 90%. Driving one of these antennas with a high power microwave (HPM) source, such as a quarter-wave, coaxial standing-wave oscillator (SWO), one can create a HPM system that has a very low profile above the source due to the ESA. In this paper we will discuss results from CST simulations of one of these HPM systems using a magnetic EZ antenna as the radiating element.**

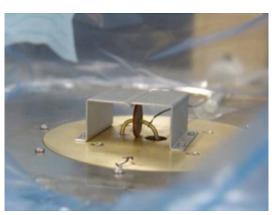
***Index Terms*—high power microwave, MATRIX, metamaterial, electrically small antenna.**

I. Background and Introduction

The source works by charging the low-impedance transmission line to a high potential and then discharging it through a self-breakdown switch on axis. This sets up a standing wave that delivers a small amount of microwave energy to the high-impedance load, which in this case is the antenna. The nearly-open circuit at the load and and the nearly-short circuit at the switch end result in a resonance that has a period that is four-times the round-trip transit time of the oscillator [1].



(a)



(b)

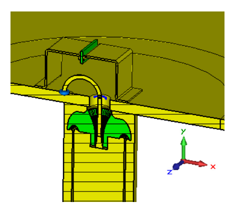
Figure 1: (a) Cross section diagram of the SWO and (b) the built prototype of the EZ antenna

The EZ antenna, which is pictured in Fig. 1b, is an electrically small, magnetic dipole antenna. The EZ antenna consists of an electrically small semi-loop antenna over a ground plane. This driven element is then surrounded by a capacitively loaded loop (CLL) element that is located in the near-field of the semi-loop antenna. This near-field element acts as a resonant parasitic element, which is conjugate matched to the impedance of the semi-loop antenna that causes their respective reactances to cancel and gives the antenna a purely real input impedance at the resonant frequency [2], [3]. In Fig. 1b there is a solid disk capacitor at the top of the semi-loop antenna, this is necessary to electrically isolate the SWO from the ground plane during the charging phase.

II. Simulation Results

In CST we simulated the performance of the EZ antenna and the SWO separately at first to tune their individual resonances. With the EZ antenna being driven by a $100\,\Omega$ coaxial cable the antenna was tuned to minimize the $|S_{11}|$ near $500\,MHz$. This tells us the antenna has an input impedance of near $100\,\Omega$, which will lead to the SWO having $Q \cong 20$.

Once the systems were individually tuned they were coupled together, as seen in Fig. 2a. The electric field of this combination was monitored $1\,m$ from the antenna in the broadside direction and the spectrum is shown in Fig. 2b for a charge voltage of $10\,kV$ of the SWO. The peak electric field value is near $500\,MHz$ as expected. In addition to these simulated CST results high power test data from a prototype system will be presented.



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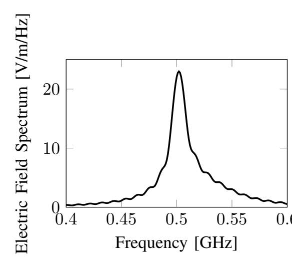

(b)

Figure 2: (a) CST model of the SWO coupled to the EZ antenna and (b) the electric field spectrum measure $1\,m$ from the antenna in the broadside direction

References

[1] C. E. Baum, "Switched oscillators," Circuit and Electromagnetic System Design Notes, Air Force Research Laboratory, Tech. Rep. 45, 2000.

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[3] A. Erentok and R. W. Ziolkowski, "Metamatrieral-inspired efficient electrically small antennas," *IEEE Trans. Antennas Propag.*, vol. 56, no. 3, pp. 691–707, March 2008.