Development of Standing Wave Oscillator-Fed Antenna Array for Compact HPEM Applications

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Abstract—We are developing the capability to produce compact HPEM source systems for the generation and radiation of mesoband pulses in the UHF and low microwave frequencies. Our system is based on a compact standing wave oscillator (SWO) microwave source that feeds a linear array of electrically small antennas (ESAs). We have studied the performance of the system as a function of switching parameters in the SWO and are working on the development of methods to design and implement dense arrays of ESAs for power sharing.

Keywords-HPEM Sources, antenna arrays

I. INTRODUCTION

Mesoband HPEM sources operate with moderate bandwidths, typically in frequencies from around 100 MHz to 10 GHz. These sources are generally composed of a capacitive energy storate, a weakly resonant pulse forming network (PFN), and a radiating system. Often more than one of these sub-components are integrated into a single structure. For example, our system uses a standing wave oscillator where a quarter-wave section of coxial transmission line is used as the energy store, and this element also serves as the PFN by operating as a quarter-wave transmission line oscillator that is shorted at one end in a spark gap and feeds a high impedance antenna at the other end. A schematic of our system is shown in Figure 1, and a representative system has been reported on previously [1].

II. Performance of SWO

The SWO operates by charging the center conductor of a low-impedance (~4 Ω) coaxial line to high voltage. The high voltage initiates a self-breakdown, and this breakdown induces a damped sinusoidal oscillation at the center frequency with period that corresponds to twice the round trip time of the coaxial section. Some energy couples out at each reflection from the load end, resulting in a damped sinusoidal waveform with bandwidth typically on the order of 3 – 15%, depending on the nature of the antenna and the loss in the switch [2].

Because the discharge is initiated by the random event of switch closure, the radiated waveform depends on several factors including the precise location of the spark, the exact charge voltage, the conductive-phase rise time of the spark, and the on-state resistance. Usually it is impossible to measure any of these directly. Here we use a computational model to show how varying these parameters affects the bandwidth, duration, and magnitude of the radiated field. We attempt to use this model to estimate the SWO parameters for real shots measured from an experimental system.

III. Antenna Array Design

We are currently working on strategies to improve our ability to control the coupling of energy from the corporate waveguide feed onto the individual elements of a coaxial array of ESAs. Our current work is focusing on the use of a Huygens-like probe that has both an electric and magnetic dipole moment, allowing the excitation of waves traveling in only one direction [3] and providing precise control of the coupling cross section.

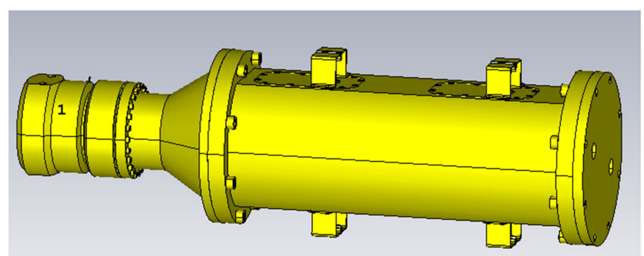

Figure 1. Solid model of an SWO-fed, 4-element coaxial array of ESAs from [1].

REFERENCES

[1] Z. Esmati, *et al*, "Development of an Equivalent Circuit Model for the Design of Arrays of Electrically Small Antennas," in *IEEE Trans. Antennas and Propagation*, doi: 10.1109/TAP.2022.3161326. (Article pre-print service)

[2] M. M. H. Armanious, *et al.,* "Interaction between geometric parameters and output waveforms in high-power quarter-wave oscillator," *IEEE Trans. Plasma Sci*., **38**, 1124 – 1131, 2010.

[3] D. Yi, *et al.,* "Regulating the Direction That Power Flows in Microwave Transmission Line Systems With Huygens Sources," *IEEE Trans. Antennas and Propagation*, **69** 594-599 (2021)