High Power Microwave Generation with Solid-State System

T. M. Ziemba*; J.R. Prager;
*ziemba@eagleharbortech.com

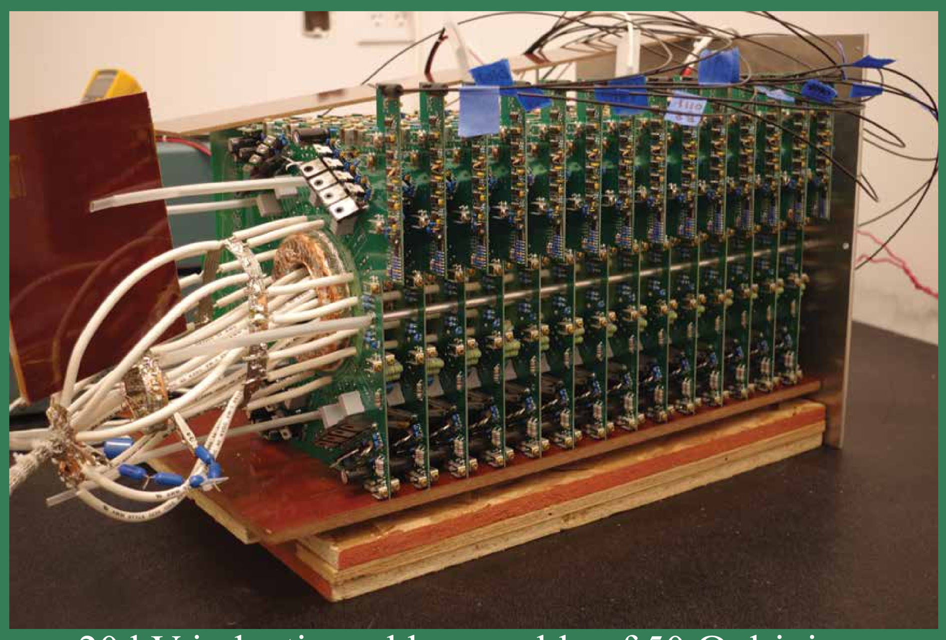
EAGLE HARBOR TECHNOLOGIES

Introduction

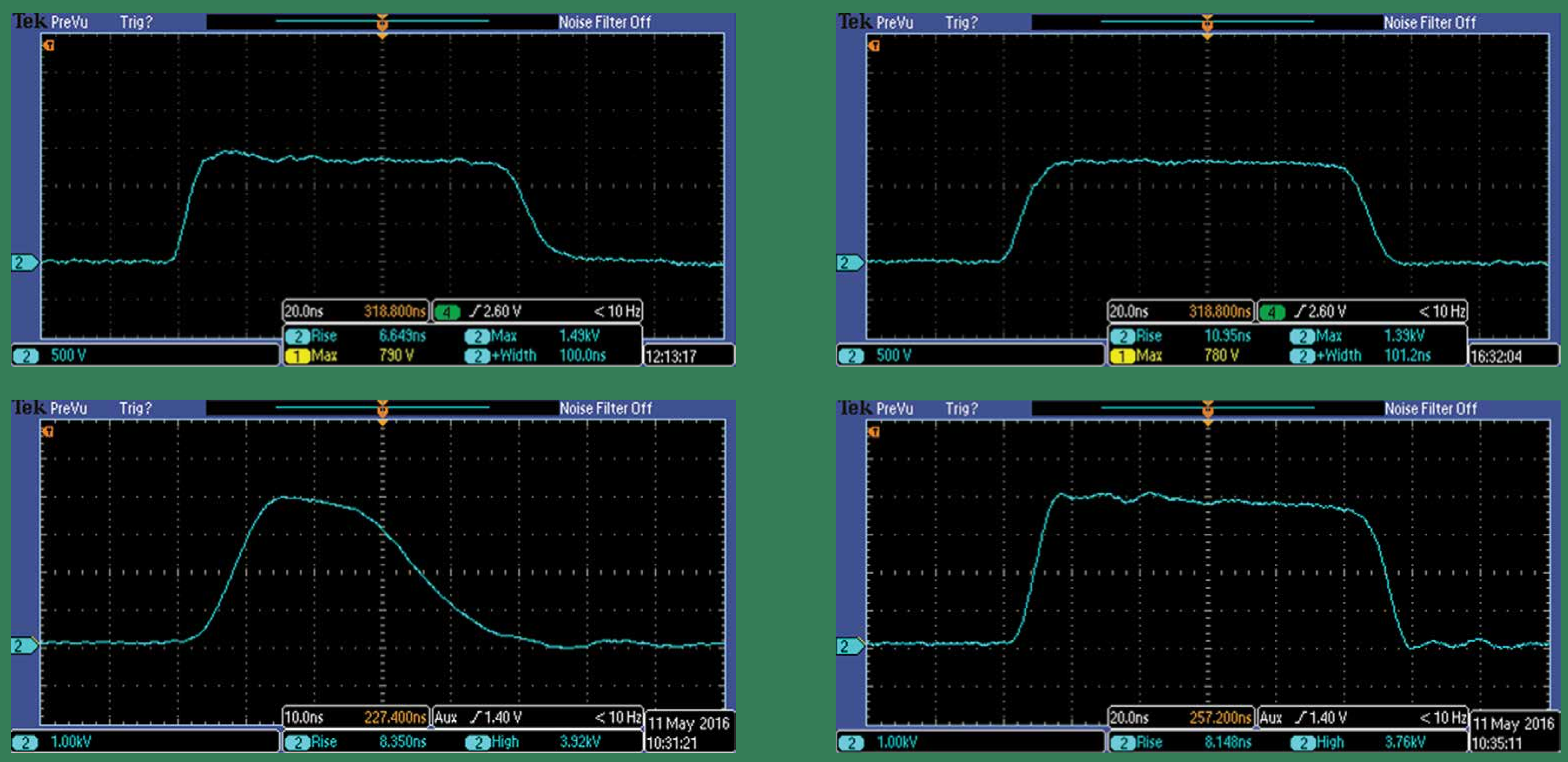
There is interest in the development of an all solid-state, high power microwave (HPM) system that can be deployed on small mobile platforms including trucks, small boats, and small aircraft for remotely destroying enemy electronic systems from a variety of sources. An all solid-state system could allow for a more cost effective and robust solution compared to HPM tube-based systems. To date there are no solid-state solutions for producing high power microwaves that are available for deployment, which limits directed energy weapons to larger platforms. One of the key components is the HPM source driver. Eagle Harbor Technologies, Inc. (EHT) is developing a novel, solid-state, high voltage, nanosecond pulser with fast rise-time and adjustable pulse width that can operate at very high pulse repetition rates for driving nonlinear transmission lines for HPM generation. The pulser is based on technology EHT previously developed for medical devices and aerospace applications. This poster will show detailed capabilities including microwave generation. The ultimate goal is to commercialize this technology and integrate it into military platforms as part of a complete directed energy system, which would likely be accomplished by prime contractors.

EHT Inductive Adder

Most gyromagnetic NLTLs are designed with 25-50 Ω impedance that must be driven with sub-10 ns rise time. EHT is leveraging nanosecond pulser components, which can operate at high pulse repetition frequency (PRF), to build an inductive adder that is capable of driving these low impedance loads with fast rise times. EHT has built a six and twelve board stack that can operate at 10 kV and 20 kV, with adjustable pulse width, fast rise time, and PRF.



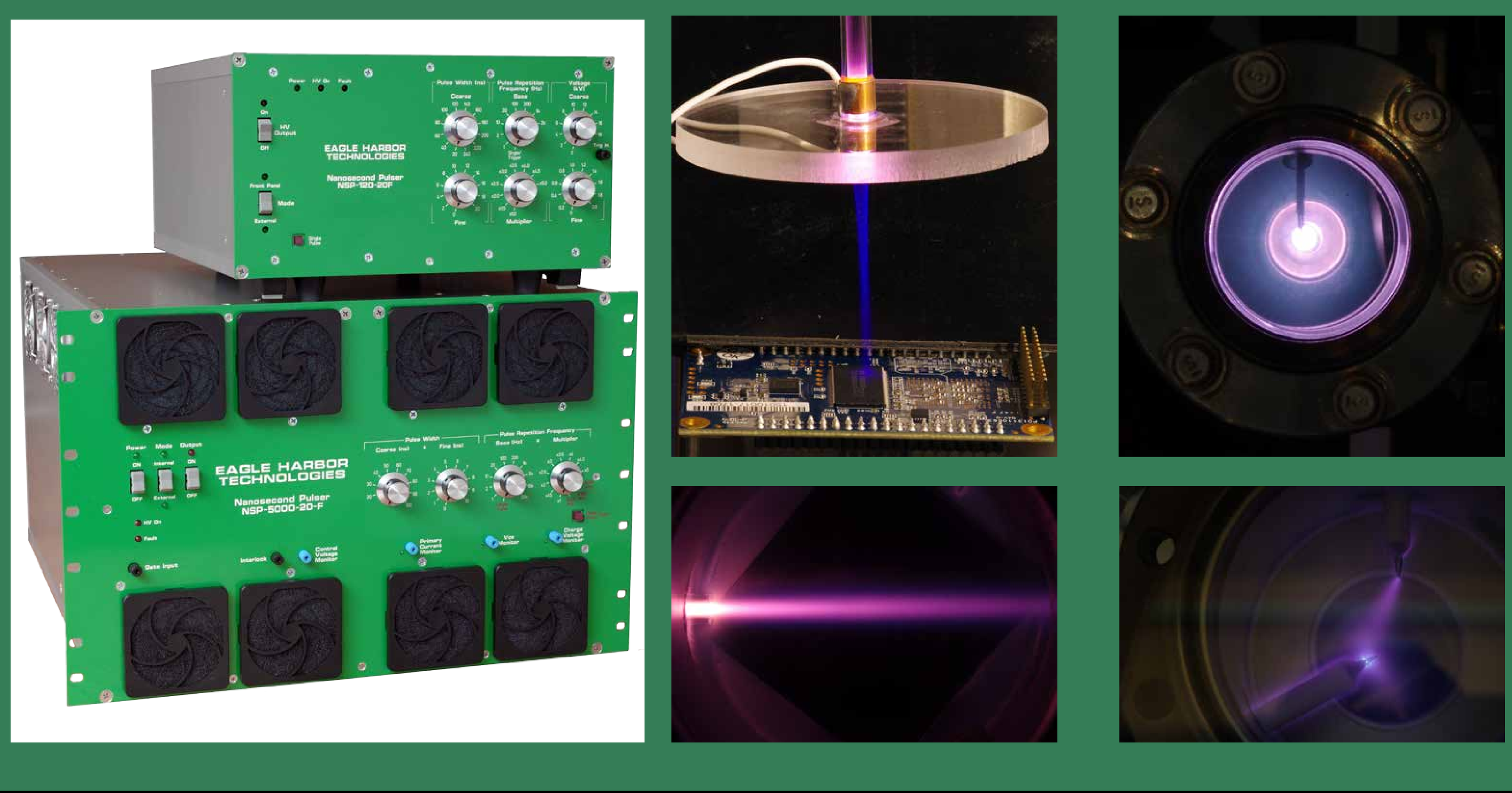
20 kV inductive adder capable of 50 Ω driving.



Top Left: 10 kV - 100 ns pulse into 50 Ω with 6.6 ns rise time. Top Right: 10 kV - 100 ns pulse into 25 Ω with 11 ns rise time. Bottom: 20 kV, 51 ns (left) and 110 ns (right) pulse widths into 50 Ω with 8.4 ns rise.

Other Nanosecond Pulser Applications

EHT has commercialized a low-power nanosecond pulser used for rapid capacitor charging and generating nonequilibrium plasma. These have applicaions in pulsed-power, materials processing, surface modification, medical devices, water treatment, surface sterilization, and efficient combustion.

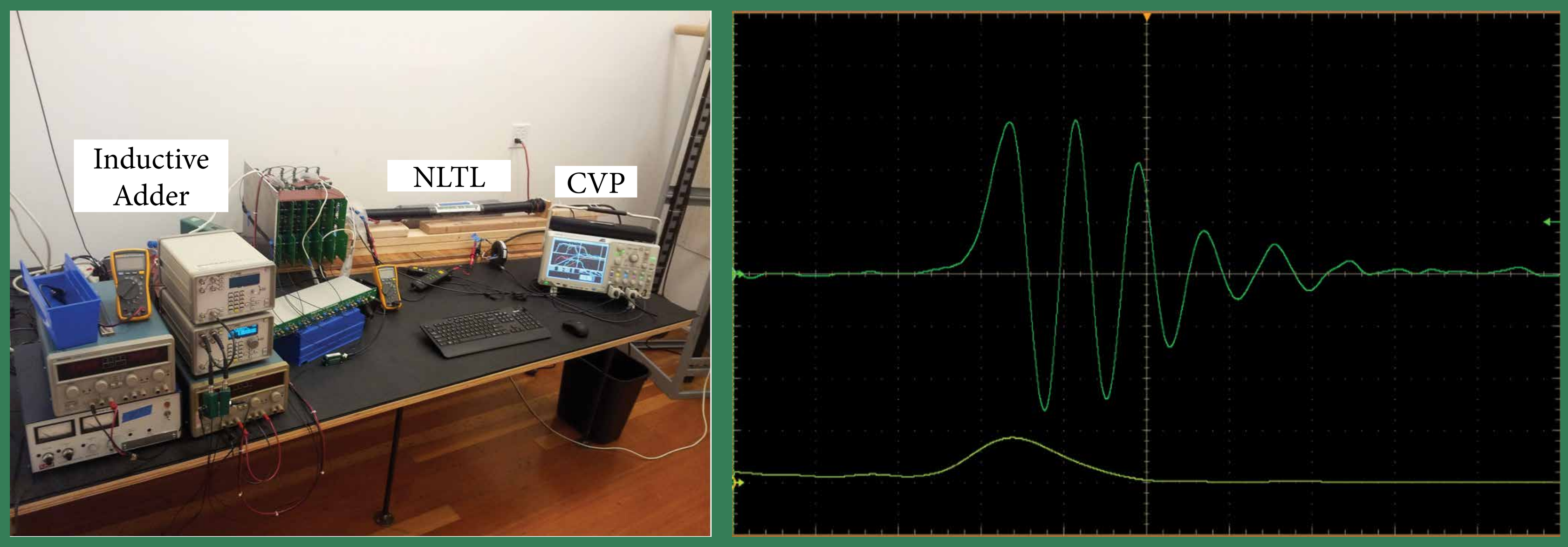


Military Applications

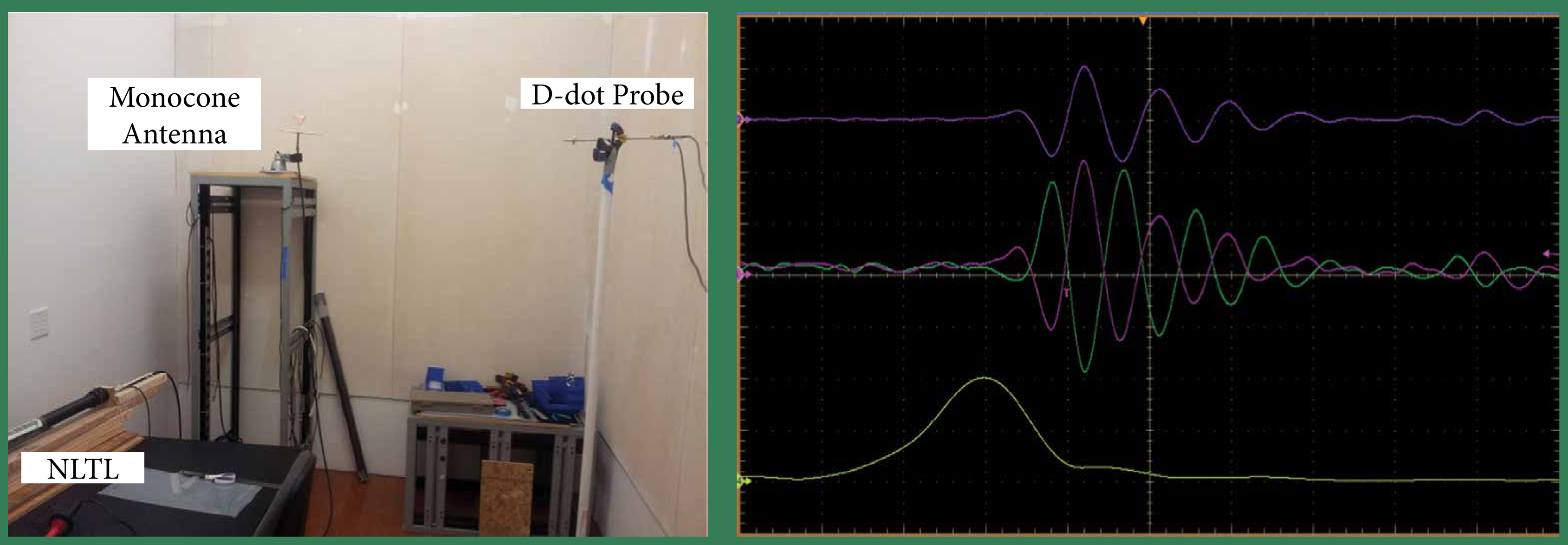
This ultra-wideband high power microwave system can be used for defeating drone electronics; pulsed radar systems; and underground detection. The solid-state nature reduces size, weight, and complexity while increasing robustness over tube-based designs. Additionally, the nanosecond pulser technology can also be used for rapid capacitor charging and non-thermal plasma generation.

RF Production with NLTL

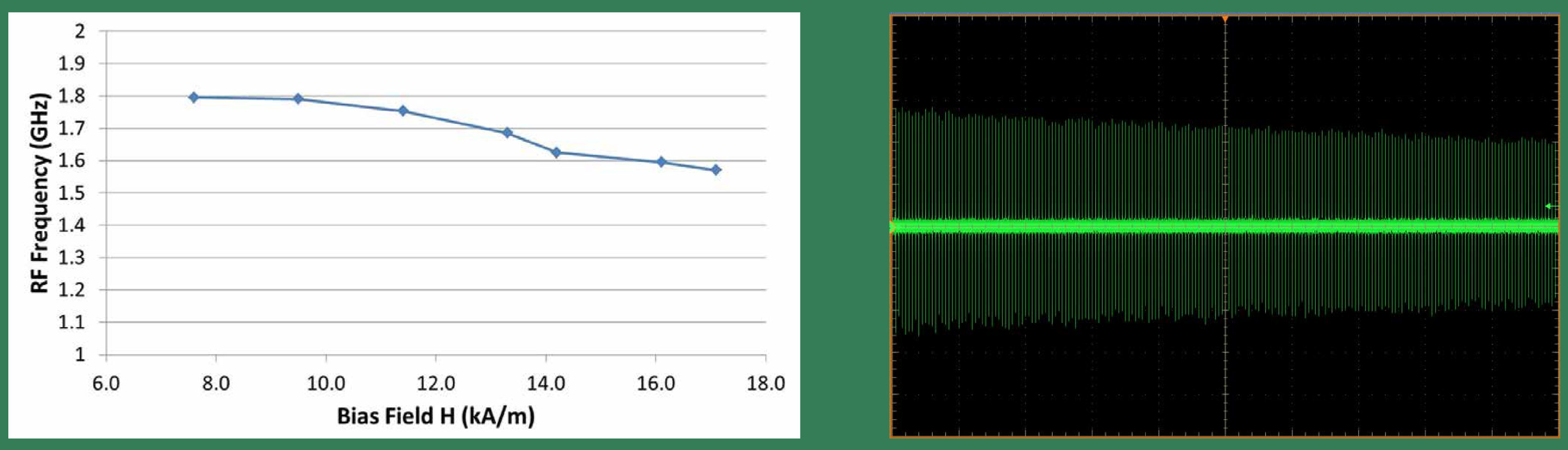
EHT measured the RF output of the gyromagnetic NLTL driven by a 10 kV inductive adder with a capacitive voltage probe (CVP) and D-dot probe.



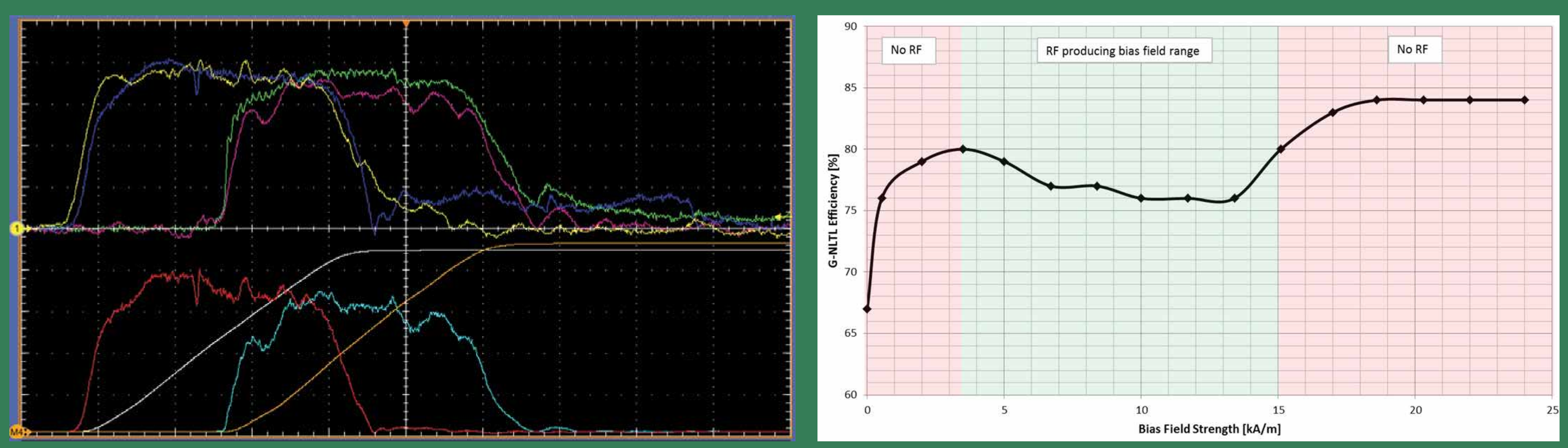
Left: Experimental setup showing the 50 Ohm pulse driver, the NLTL, and the CVP at the output of the NLTL. Right: CVP output (green) with 12.6 [kA/m] bias field. Horizontal scale 740 ps/div, vertical scale 3333 V/div. An FFT of the signal (yellow) has a peak at ~ 1.7 GHz. FFT scale is 25 mV/div vertical and 500 MHz/div horizontal.



Left: Experimental setup with D-dot in far-field of monocone antenna. Right: From top to bottom: Math 2, Ch3 (purple), Ch4 (green), Math4. Math2 = Ch3 – Ch4, Math4 = FFT(Math2). Vertical scale: Math2 = 2V/div, Math4 = 100mV/div, Ch3&Ch4 = 500 mV/div. Horizontal scale is 750 ps/div for signals and 500 MHz/div for FFT.



Left: NLTL RF output frequency as a function of bias field. Right: CVP output with 12.6 [kA/m] bias field. Burst of 200 pulses at 100 kHz. Horizontal scale 5 µs/div, vertical scale 3333 V/div.



Left: Signals for G-NLTL single shot efficiency driving 52 Ω load at a bias field of ≈ 17 kA/m. Input voltage (yellow), input current (blue), load voltage (purple), load current (green), instantaneous input power (red), instantaneous output power (cyan), total input energy (white), and total energy delivered to the load (orange). Efficiency is ≈ 83 %. Right: Coaxial NLTL broadband efficiency vs bias field strength.

Conclusion

EHT has developed an inductive adder capable of generating high voltage, fast rise time pulses. This has been used to drive NLTLs for high power microwave production. EHT is seeking partners and funding for developing a ultra-wideband solid-state RF system for other applications including pulsed radar and underground detection.

More information:
http://www.eagleharbortech.com/