High Power Microwave Production with a Nanosecond Pulser and Nonlinear Transmission Line

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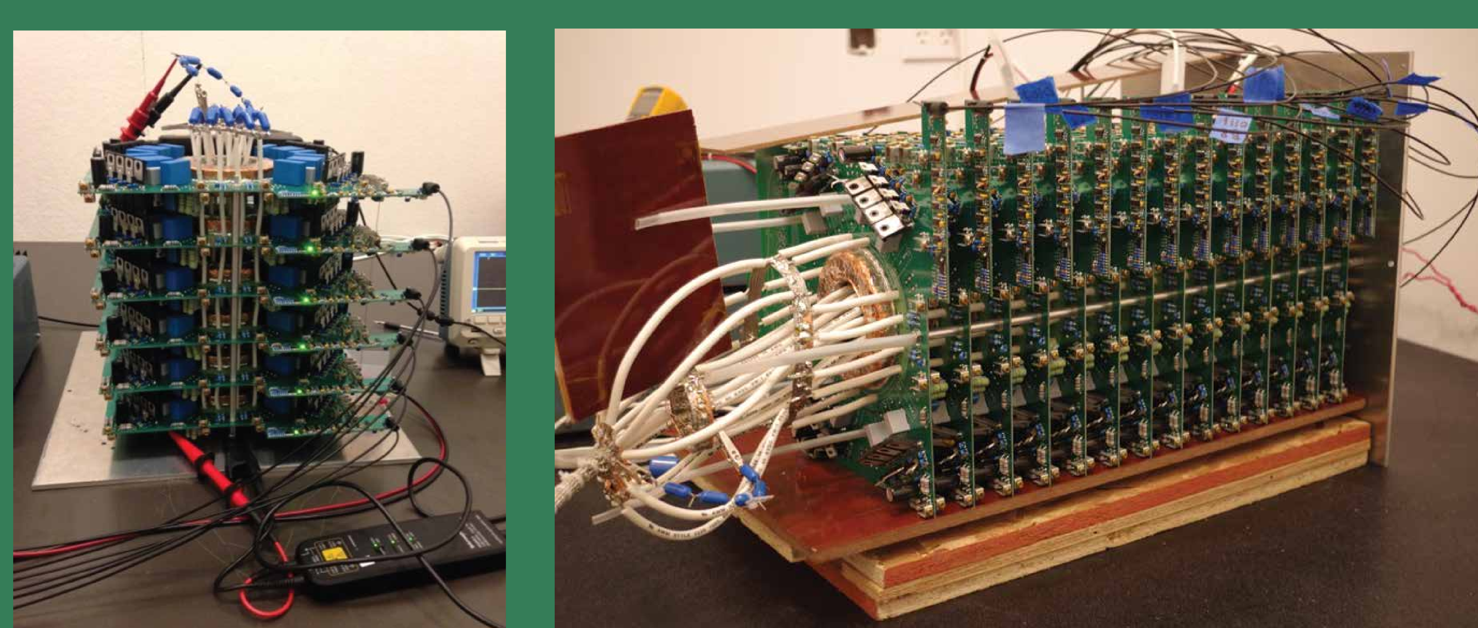
EAGLE HARBOR TECHNOLOGIES

Introduction

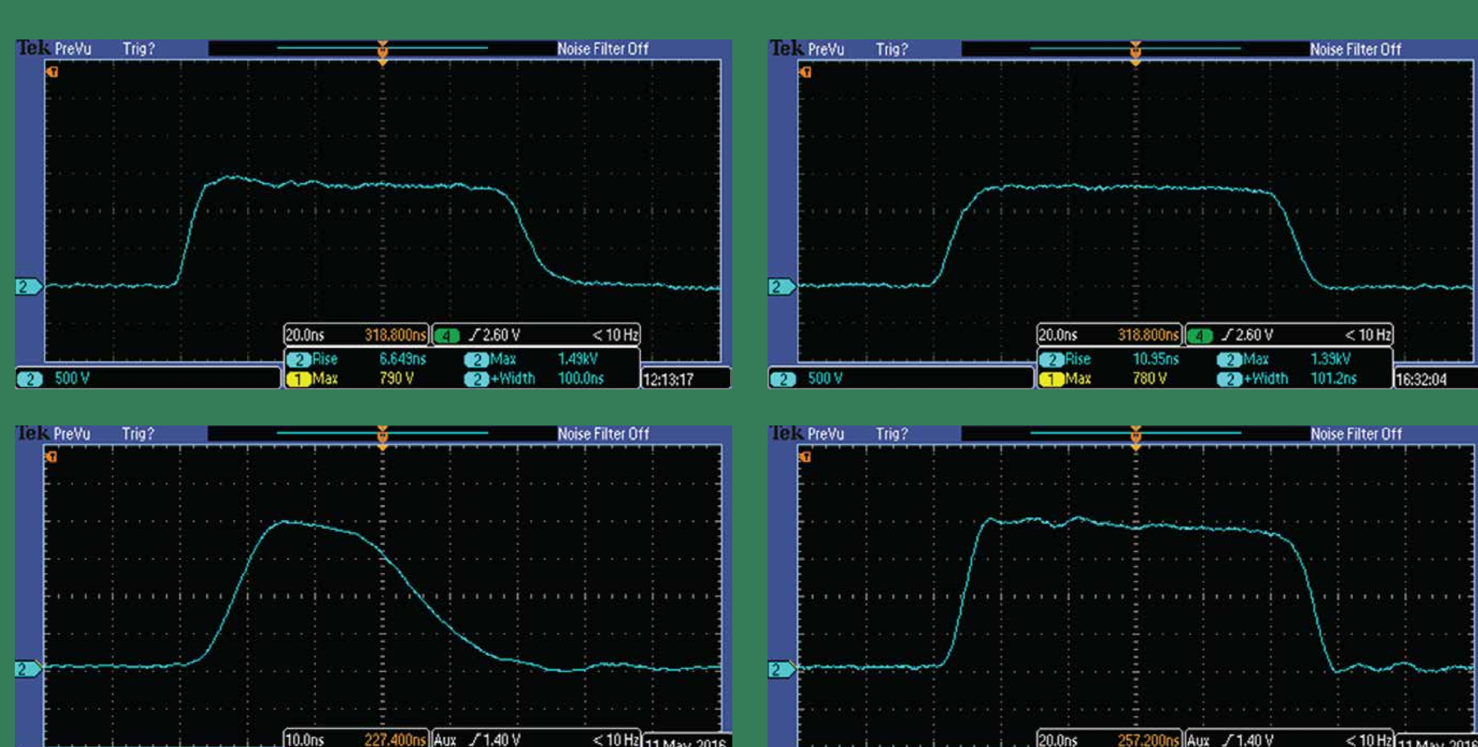
Eagle Harbor Technologies, Inc. (EHT) is utilizing the previously developed EHT Nanosecond Pulser (NSP) to drive a nonlinear transmission line (NLTL) for high power microwave production. The EHT NSP provides independent control of the output voltage (20 kV), pulse width (20 – 200 ns), and pulse repetition frequency (up to 100 kHz). EHT is using this pulser to investigate RF production with a gyromagnetic NLTL and lumped-element NLTL based on nonlinear effects in Schottky diodes. The gyromagnetic NLTL has a frequency around 2 GHz, while the diode-based NLTL's frequency is lower. EHT will present experimental, including RF measurements with D-dot probes. Additionally, modeling results will be presented for the diode-based NLTL and compared with experiment.

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.



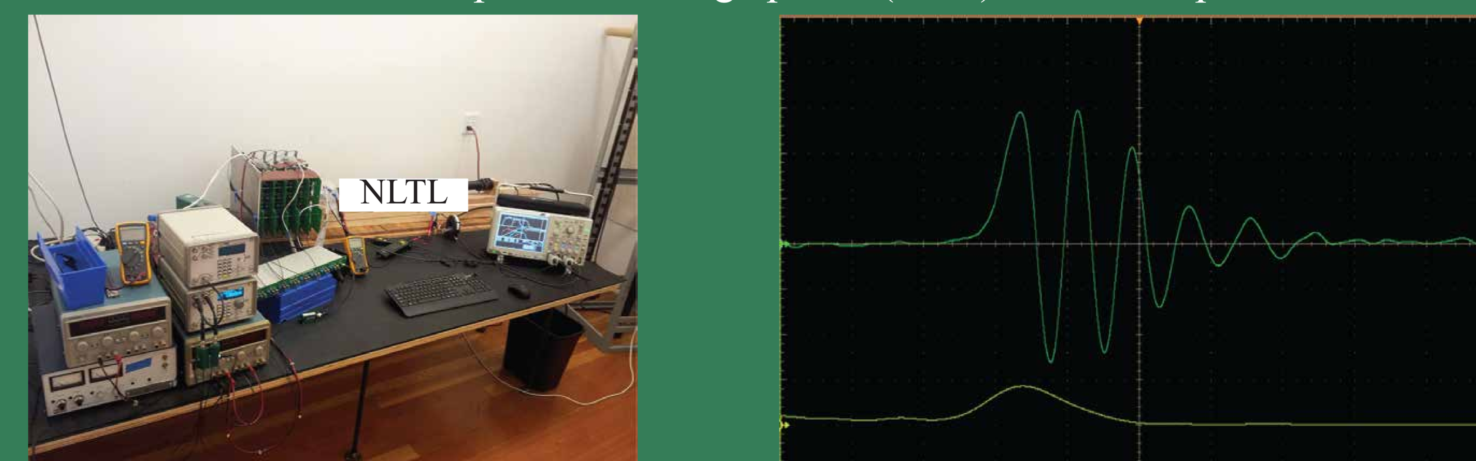
Left: 10 kV inductive adder. Right: 20 kV inductive adder.



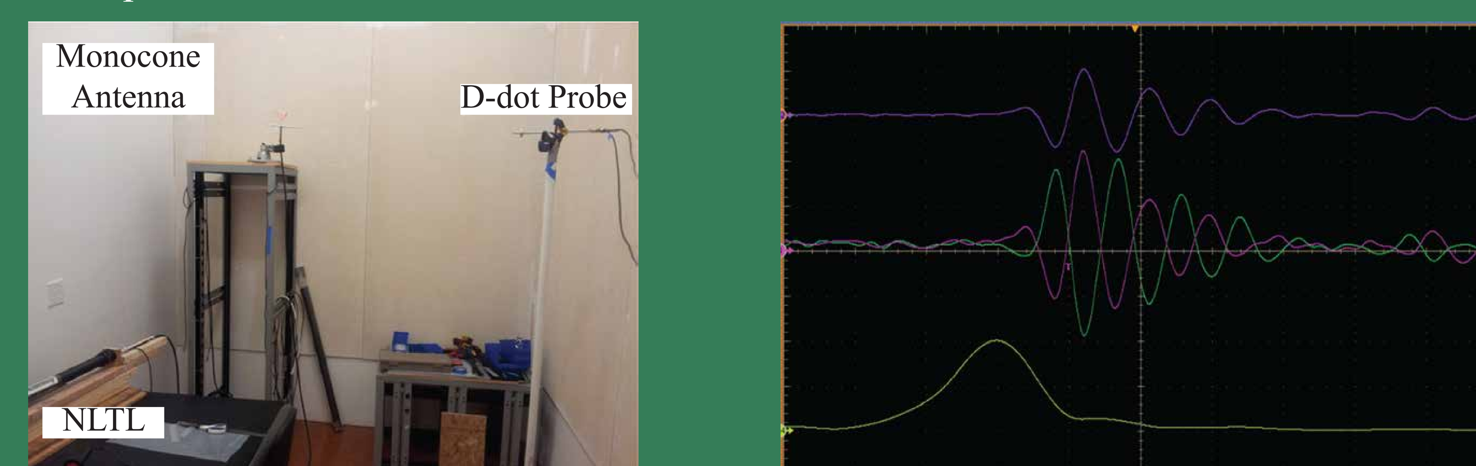
Top Left: 10 kV - 100 ns pulse into 50 Ω load with 6.6 ns rise time. Top Right: 10 kV - 100 ns pulse into 25 Ω load with 11 ns rise time. Bottom: 20 kV, 51 ns (left) and 110 ns pulse widths into 50 Ω load with 8.4 ns rise.

RF Production with NLTL

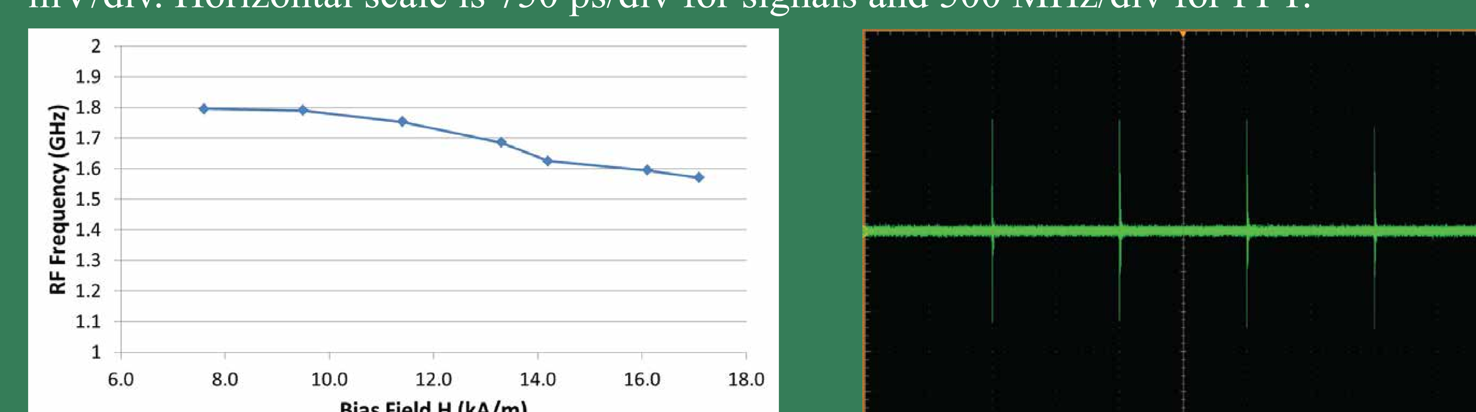
EHT measured the RF output of the gyromagnetic NLTL driven by a 10 kV inductive adder with a capacitive voltage probe (CVP) and D-dot probe.



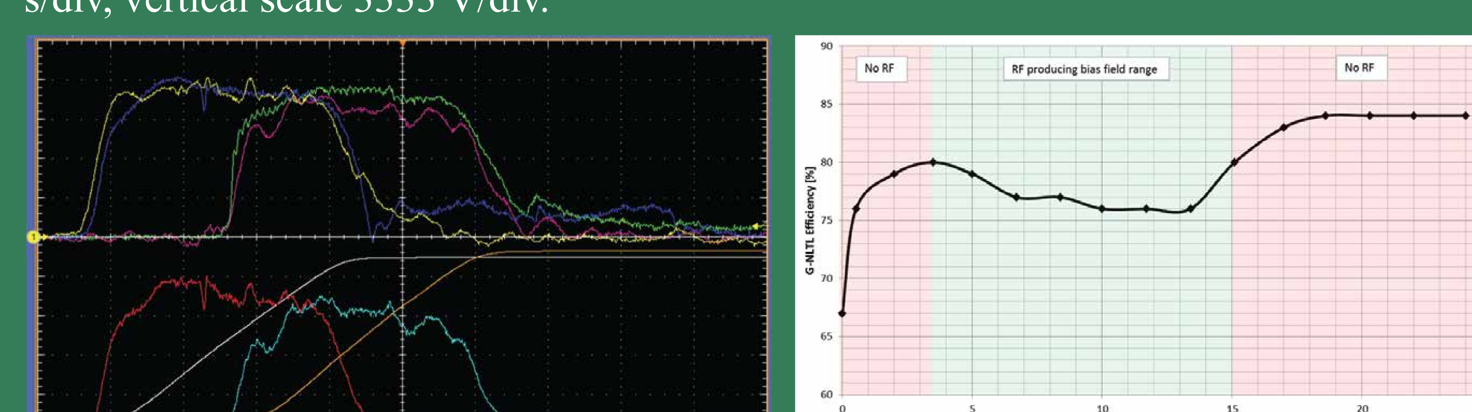
Left: Experimental setup showing the 50 Ohm pulse driver, the NLTL, and the CVP at the output of the NLTL. Right: CVP output (green) with 12.6 [kA/m] bias field. Horizontal scale 740 ps/div, vertical scale 3333 V/div. An FFT of the signal (yellow) has a peak at ~ 1.7 GHz. FFT scale is 25 mV/div vertical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



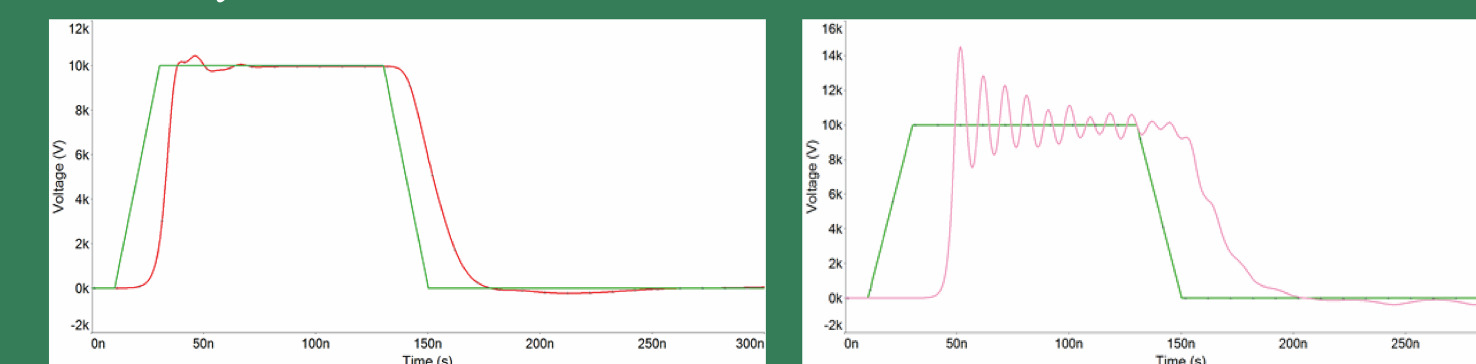
Left: NLTL RF output frequency as a function of magnetic bias field. Right: CVP output with 12.6 [kA/m] bias field. Burst of 4 pulses at 100 kHz. Horizontal scale 5 μ s/div, vertical scale 3333 V/div.



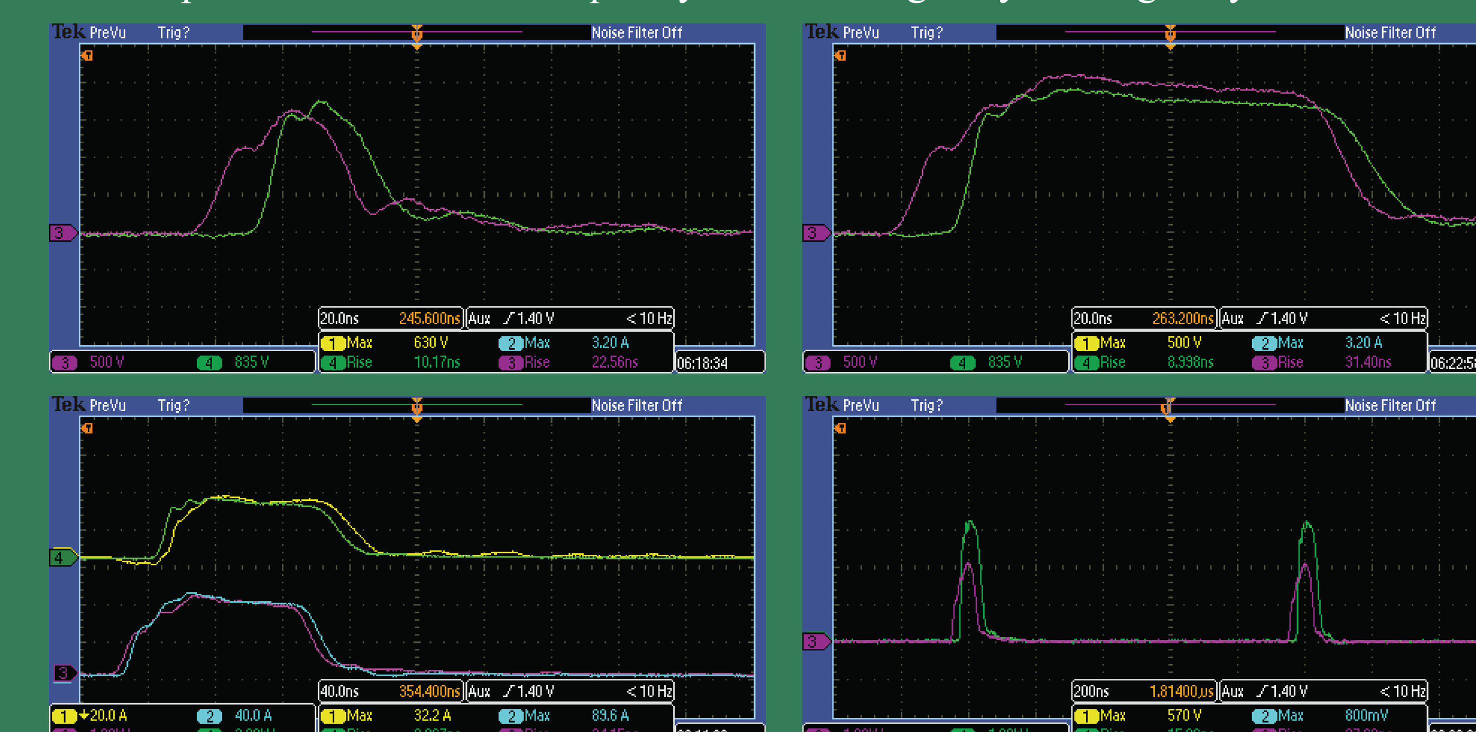
Left: Signals for G-NLTL single shot efficiency driving 52 Ω load at a bias field of ≈ 17 kA/m. Input voltage (yellow), input current (blue), load voltage (purple), load current (green), instantaneous input power (red), instantaneous output power (cyan), total input energy (white), and total energy delivered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

Lumped-element NLTL

To improve pulser rise time, EHT is investigating lumped-element NLTLs with off-the-shelf components. Spice modeling showed that the pulse rise time could be improved to below 10 ns. A 10 kV NLTL with 20 elements was built and tested, which produced sub-10 ns rise time at 82-86% efficiency.



Spice model showing pulse sharpening from 16 ns to 8.4 ns (left). 100 MHz RF with lumped-element NLTL. Frequency can be changed by altering stray inductance.



NLTL input and output for 40 ns (top right) and 120 ns pulse (top left). Measurement of efficiency (bottom left). High frequency burst at 1 MHz (bottom right). Input voltage (pink), input current (blue), output voltage (green), and output current (yellow).

Conclusion

EHT has constructed a 10 kV inductive adder that has adjustable pulse width and PRF and has tested it into resistive loads. This 10 kV inductive adder has been used to drive a gyromagnetic NLTL to produce RF near 2 GHz over a range of parameters.

EHT is in the process of testing a 20 kV inductive adder into resistive loads. Future work will focus on RF production with

EHT has modeled, built, and tested a lumped- element NLTL and demonstrated efficient rise time reduction.

For more info: http://www.eagleharbortech.com/

Acknowledgment

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Further Information

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