High Voltage, Fast Rise Nanosecond Pulsers

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EAGLE HARBOR TECHNOLOGIES

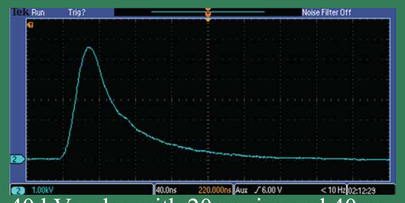
Introduction

Eagle Harbor Technologies, Inc. (EHT) has developed a series of high voltage nanosecond pulsers that allow the user to independently adjust the output voltage, pulse width, and pulse repetition frequency. Recent results demonstrate the ability to produce 80 kV pulses with rise times down to 18 ns and a full width half maximum (FWHM) pulse width down to 20 ns. Additionally, versions of these pulsers have the capability to drive low impedance loads (25 Ω) with 11 ns rise time. These pulsers have been used for non-equilibrium plasma production for surface sterilization, surface modification, nonlinear transmission driving for high power microwave production, as well as other aerospace and biomedical applications.

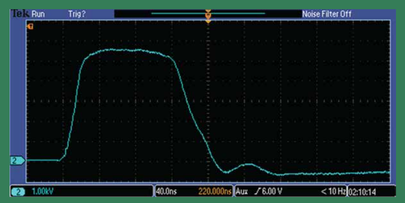
EHT Nanosecond Pulser

EHT produces off-the-shelf nanosecond pulsers with independently adjustable voltage (0-20 kV), pulse width (20 - 260 ns), and pulse repetition frequency (0-100 kHz). To generate 40 kV output pulses, EHT modified the transformer of an off-the-shelf unit. The board was tested outside the metal enclosure due to high voltage tracking constraints.

EHT off-the-shelf nanosecond pulser NSP-120-20-F



40 kV pulse with 20 ns rise and 40 ns FWHM (minimum).

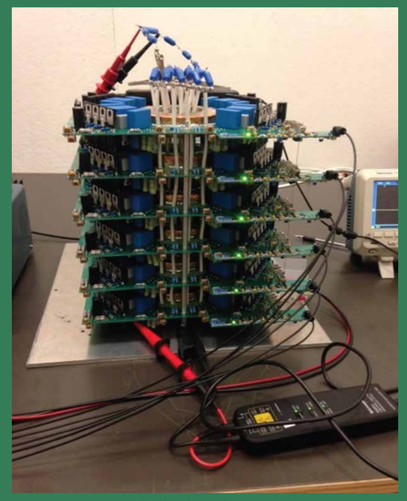


40 kV pulse with 20 ns rise and 130 ns FWHM.

The pulser could generate 40 kV pulses with 20 ns rise times into 7 kΩ. While this is impressive performance for the small package, many applications require lower impedance driving and/or faster rise times. To accomplish this, an inductive adder was required.

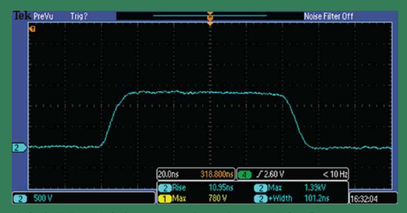
Low Impedance Driving Inductive Adder

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 low impedance loads (25-50 Ω) with fast rise times (sub-10 ns). EHT has built a six-board stack that can operate at 10 kV, with adjustable pulse width, fast rise time, and PRF. This inductive adder was testing into resistive loads at various pulse widths. The rise time into 25 Ω and 50 Ω was 11 ns and 6.6 ns respectively. Pulse flat-top was measured to be within 5%, which was limited by the accuracy of our high voltage probe at this voltage.

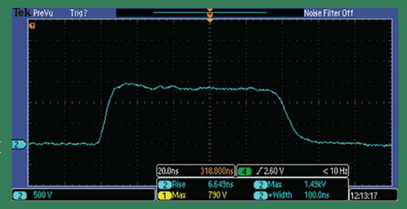


10 kV inductive adder.

This circuit topology can be easily scaled operate at higher voltage and still drive these low impedance loads at with fast rise times. This can be accomplished with either adding more boards to the stack and/or adding an output transformer.



10 kV - 100 ns pulse into 50 Ω resistive load with 6.6 ns rise time.



10 kV - 100 ns pulse into 25 Ω resistive load with 11 ns rise time.

Acknowledgment

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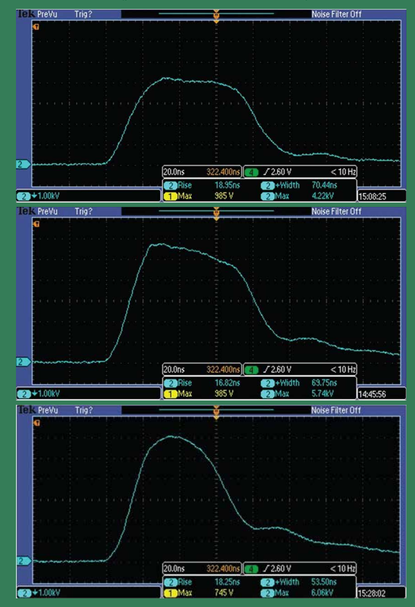
80 kV Pulse Demonstration

EHT utilized a six-board inductive adder with a custom pulse transformer to produce 66 - 80 kV pulses into 3 to 6 kΩ resistive loads with very fast rise time (17 to 19 ns).



Output voltage pulses at 66 (top), 74 (middle), and 80 kV (bottom).

Conclusion

EHT has constructed three different high voltage pulsers:

1. Increased turns ratio of NSP product series - 40 kV pulse into high impedance loads with 20 ns rise time.
2. Low impedance driving inductive adder - 10 kV pulses into 50 Ω with 6.6 ns rise time.
3. Inductive adder with pulse transformer - 80 kV pulses into high impedance loads with sub-20 ns rise time.

All three designs have different strengths and weaknesses. The exact choice of pulser design depends on the requirements of a given application.

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