A high voltage nanosecond pulser with independently adjustable output voltage, pulse width, and pulse repetition frequency

J. R. Prager; T. M. Ziemba; K. E. Miller; J. G. Carscadden; and I. Slobodov
prager@eagleharbortech.com

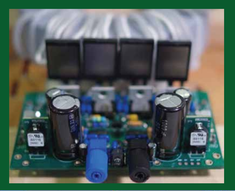
EAGLE HARBOR TECHNOLOGIES

Introduction:

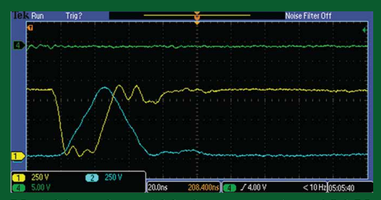
Eagle Harbor Technologies (EHT) is developing a high voltage nanosecond pulser capable of generating non-equilibrium plasmas, including dielectric barrier discharges, pseudospark discharges, and liquid plasma discharges for plasma medicine, material science, enhanced combustion, drag reduction, and other research applications. The EHT nanosecond pulser technology is capable of producing high voltage (up to 60 kV) pulses (width 20 – 500 ns) with fast rise times (< 10 ns) at high pulse repetition frequency (adjustable over 100 kHz) for CW operation. The pulser does not use saturable core magnetics, which allows for the output voltage, pulse width, and pulse repetition frequency (PRF) to be fully adjustable, enabling researchers to explore non-equilibrium plasmas over a wide range of parameters. Recent advances in the EHT nanosecond pulser technology include higher average power (2.6 kW) operation in continuous wave (CW) mode, improved user interface, enhanced thermal management.

Nanosecond Pulser Hardware:

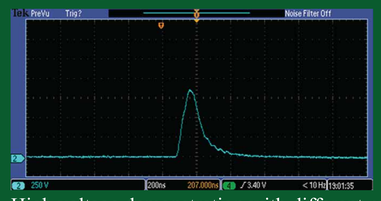
The EHT nanosecond pulser is based on IGBT switching technology that allows for extremely fast IGBT transitions. Two test boards have been constructed. A low power board was designed to enable rapid prototyping and solid-state switch testing (right). A high power version was designed for use in plasma applications that require higher input power and for directly driving lower impedance loads (not shown).



10 kV, 70 ns pulse with 6 ns rise.



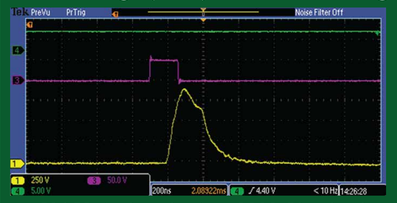
Variable pulse width demonstration: 18 kV pulse with 30 ns (Left, Blue Trace) and 500 ns (Right) pulse width measured at the FWHM.



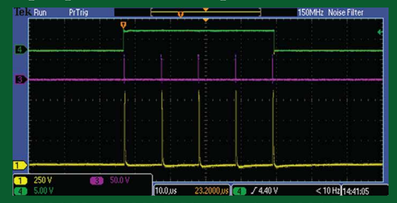
High voltage demonstration with different pulse widths: (Left) 50 kV pulse with 60 ns FWHM. (Right) 60 kV (flat section) 360 ns pulse.

High Pulse Repetition Frequency Testing:

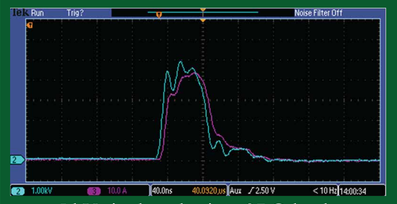
The EHT nanosecond pulser technology is capable of high PRF (tested to 1 MHz). High PRF has been tested in burst mode for high voltage (50 kV) and at lower voltage (5 kV) for 2.6 kW average output power for CW operation.



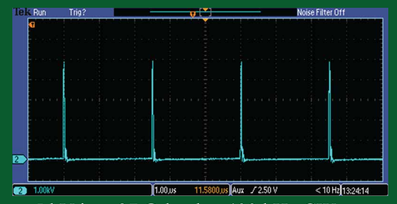
50 kV single pulse into 3000 Ohm load



50 kV into 3000 Ohm load at 100 kHz



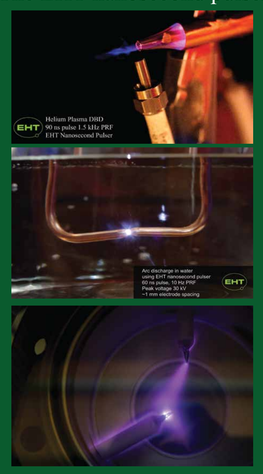
5 kV single pulse into 97 Ω load

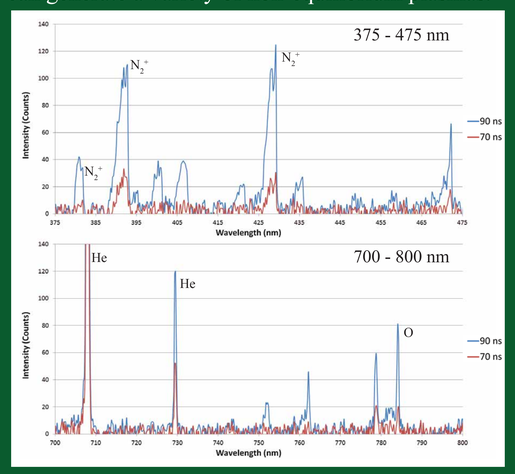


5 kV into 97 Ω load at 400 kHz CW

Plasma Physics Applications:

The EHT nanosecond pulser can generate a variety of non-equilibrium plasmas.





Top Left: DBD-based plasma pencil made with flowing helium gas. Middle Left: Water plasma discharge. Bottom Left: Pseudospark generated in low pressure argon background (~200 mTorr). The pulser produced 30 kV, 80 ns pulses at 200 Hz during CW operation. Right: DBD-based plasma pencil nozzle spectra with flowing helium gas and NSP-1000. The output pulse was 15 kV at 1.5 kHz PRF and 70 ns and 90 ns PW.

Acknowledgments:

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Product Development

EHT has developed a line of customizable, high voltage nanosecond pulsers for a wide range of applications including high power RF source drivers, laser drivers, and non-equilibrium plasma production like pseudosparks and dielectric barrier discharges. Unlike other nanosecond pulsers on the market, the EHT product line gives the user the ability to independently adjust the output voltage, pulse width, and pulse repetition frequency using front panel controls. This capability allows researchers to carefully dial in the pulse parameters needed for a specific application and/or explore a wide range of plasma parameters.

	Micro-second Pulser	Pulse Forming Network	Fast Ionization Dynistor	EHT Nanosecond Technology
High Output Voltage	✓	✓	✓	✓
Adjustable PW				✓
High PRF			✓	✓
Independent Control	✓			✓

NSP-1000

- Variable pulse widths (20 – 500 ns)
- Adjustable, high repetition frequency operation > 20 kHz
- Fast rise times (< 10 ns)
- Adjustable voltage (20 kV)
- High peak power (10s MW)

EHT NSP-1000

NSP-5000

- Variable pulse widths (20 – 100 ns)
- Adjustable, high repetition frequency operation > 100 kHz
- Fast rise times (< 10 ns)
- Adjustable voltage (5 kV)
- High peak power (10s MW)
- CW operation at > 2.6 kW average output power

EHT NSP-5000

Further Information:

For more information on nanosecond pulsers or other switching power supplies please visit our website (http://www.eagleharbortech.com) or email me.