High Voltage Nanosecond Pulser Operating at 100 kHz Pulse Repetition Frequency

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EAGLE HARBOR TECHNOLOGIES

Introduction

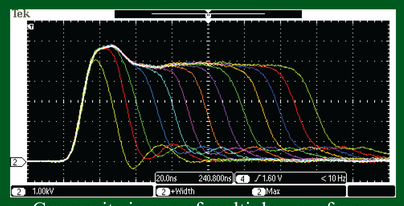
Eagle Harbor Technologies, Inc. (EHT) is developing high voltage nanosecond pulsers with independently adjustable output voltage, pulse width, pulse repetition frequency (PRF). EHT nanosecond pulsers with voltages up to 20 kV are now commercially available and used to drive a wide range on nonequilibrium plasmas for aerospace, combustion, biomedical, and material science applications. These pulser can generate pulses with widths between 20 - 250 ns and operate at PRF up to 100 kHz CW and can be burst to frequencies up to 1 MHz.

EHT is continuing to advance the capabilities of these pulsers. Higher voltages (over 50 kV) are of interest for driving nonlinear transmission lines for high power microwave applications. EHT has recently demonstrated high voltage pulses operating at 100 kHz while maintaining the capability of pulse width adjustability. Additional research is being conducted to control the pulse shape, decrease the pulse risetime, and drive low impedance loads, while maintaining the 100 kHz PRF and adjustable pulse width capabilities.

NSP-5000

EHT has developed a 5 kW nanosecond pulser that produces 5 kV output pulses into a 100 Ω load with adjustable pulse width (20 - 105 ns) that can operate at 100 kHz CW or be burst to higher frequency. In order to test this pulser, EHT developed a custom low inductance resistor array capable of dissapating 5 kW. This pulser is currently being used a prime contractor for aerospace research.

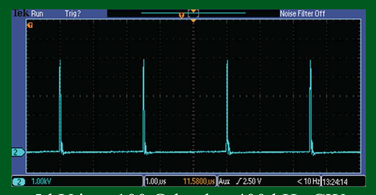
Below are waveforms showing the variable pulse width, a single pulse into 100 Ω load, and a burst at 400 kHz, as well as the pulser on the table. The next generation pulser will produce 20 kV pulses at 100 kHz. The intital waveforms are shown in the Dielectric Barrier Discharges Waveforms.



Composite image of multiple waveforms showing adjustable pulse width at 5 kV.

NSP-5000: 5 kW output with fully integrated front panel control.

5 kV single pulse into 100 Ω load

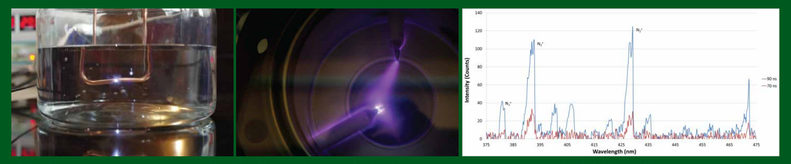


5 kV into 100 Ω load at 400 kHz CW

Nanosecond Pulser Driving Nonequilibrium Plasma

EHT and EHT customers have used the EHT Nanosecond Puslers to drive nonequilbrium plasmas including dielectric barrier discharges, pseudosparks, capilary discharges, and atmospheric pressure plasma jets (APPJ).

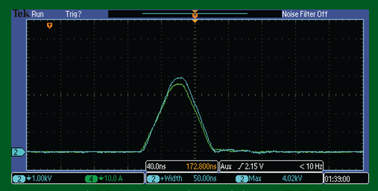
Dielectric barrier discharge jet into low pressure background (left). large area APPJ - 3 cm diameter (middle) and small APPJ 0.625 cm diamter (right)



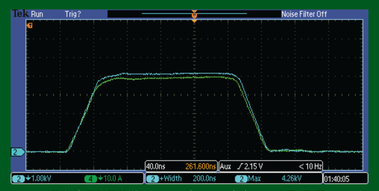
Underwater discharge (left). Pseudospark in low pressure xenon (middle). Spectrum of the plasma plume of a APPJ demonstrating the effect of varying the pulse width (right)

Dielectric Barrier Discharge Waveforms

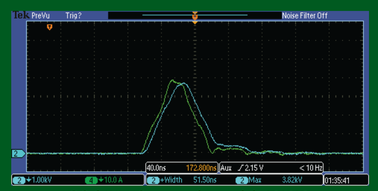
Many DBD applications require voltages up to 20 kV. An ideal pulser would produce an output that would not change significantly in the presence of a DBD. The traces below show the output voltage (blue) and output current (green) with and without a DBD at two different pulse widths. The load resistor was 550 Ω and the DBD was 12 pF. At this higher voltage, the pulser can still operate at 100 kHz CW and be burst to higher frequency.



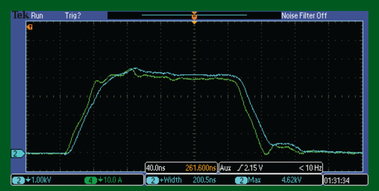
20 kV 50 ns pulse without DBD



20 kV 200 ns pulse without DBD



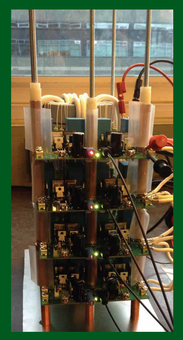
20 kV 50 ns pulse with DBD



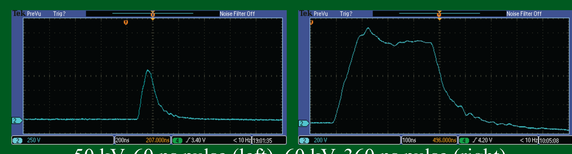
20 kV 200 ns pulse with DBD

High Voltage and High PRF Research

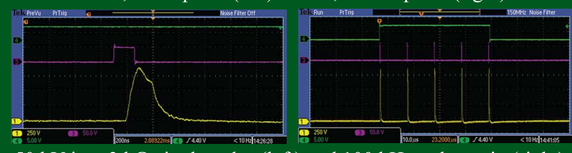
EHT has developed a nanosecond pulser test stand to demonstrate high voltage pulses (50 kV) at high PRF for driving nonlinear transmision lines.



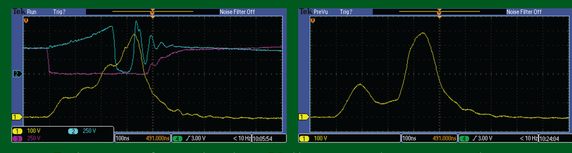
High voltage nanosecond pulser test setup to demonstrate high voltage 100 kHz frequency



50 kV, 60 ns pulse (left). 60 kV, 360 ns pulse (right).



50 kV into 3 kΩ single pulse (left) and 100 kHz pulse train (right).



Pulse waveform shaping: Yellow trace is output voltage.

Conclusions

EHT is developing a range of high voltage nanosecond pulsers than can operate with at PRF up to 100 kHz CW and be burst even higher. These pulsers can drive a wide range of nonequilibirum plasma sources for aerospace, combustion, biomedical and material science applications. The pulsers have the following characteristics:

- Independently adjustable voltage (0 - 20 kV), pulse width (20 - 250 ns), and pulse repetition frequency (up to 100 kHz CW and 1 MHz burst).
- Output waveform does not change in the presence of a DBD
- Fully integrated front panel pulse control
- Turnkey system that includes DC power supply
- Pulse shaping output stage is available
- Available in a range of powers: 30 W - 5 kW

Ongoing research at EHT is extending these capabilities to include higher voltage (over 50 kV), faster rise times, and the ability to drive low impedance loads as well as waveform shape control. The next generation pulsers will be used for driving nonlinear transmission lines for high power microwave production.

Acknowledgments:

This work was supported by the U.S. Navy SBIR (N00014-14-P-1055) and U.S. Air Force STTR (FA9550-14-C-006).

Further Information:

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