Fast Rise Time and High Voltage Nanosecond Pulses at High Pulse Repetition Frequency

EAGLE HARBOR TECHNOLOGIES

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Introduction
Eagle Harbor Technologies (EHT), Inc. is conducting research to decrease the rise time and increase the output voltage of the EHT Nanosecond Pulser product line, which allows for independently, user-adjustable output voltage (0 – 20 kV), pulse width (20 – 500 ns), and pulse repetition frequency (0 – 100 kHz). The goals are to develop higher voltage pulses (50 – 60 kV), decrease the rise time from 20 to below 10 ns, and maintain the high pulse repetition capabilities. These new capabilities have applications to pseudospark generation, corona production, liquid discharges, and nonlinear transmission line driving for micro-wave production.

High Voltage
EHT has developed a prototype board to demonstrate techniques of reducing stray inductance and capacitance to improve the pulse rise time. The 40 kV output voltage was measured with 7 kΩ resistive load with a 1:7 voltage division ratio. The rise times are defined as 10% - 90% of the peak output voltage across the load. The next goal will be to produce similar pulses into lower impedance loads.

Previous work has focused on higher voltage (50 - 60 kV) at high pulse repetition frequency (100 kHz). This technique also allowed for unique waveform shapes.

Dielectric Barrier Discharge Waveform
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.

Nanosecond Pulser Driving Non-equilibrium Plasma
EHT has used the EHT Nanosecond Pulser to drive non-equilibrium plasmas including dielectric barrier discharges, pseudosparks, capillary discharges, and atmospheric pressure plasma jets (APPJ).

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

Rise Time Improvements
The goal of this test was to evaluate the output of the upgraded nanosecond pulser to identify the shortest rise time. The output voltage was 20 kV into a floating 1.7 kΩ load. The 10% - 90% (of waveform flat top) rise time ≈ 9 ns.

Conclusion
Eagle Harbor Technologies, Inc. has developed a customizable, high voltage nanosecond pulser specifically designed to produce non-equilibrium plasmas like pseudosparks, dielectric barrier discharges, atmospheric pressure plasma jets, and other cold atmospheric plasmas. Unlike other nanosecond pulsers on the market, EHT pulsers give the user the ability to independently adjust the output voltage, pulse width, and pulse repetition frequency using front panel controls. With this control researchers can carefully optimize the specific plasma parameters needed for their application.

- Output voltage: 0 - 20 kV
- Pulse width: 20 - 500 ns
- Pulse repetition frequency:
  - CW: Single Pulse - 100 kHz
  - Burst: Up to 1 MHz
- Rise time: 20 ns (load dependent)
- Power: 30 W - 5 kW
- Integrated front panel control
- DC power supply included

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Further Information
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