High Frequency 30 kV Pulsed-DC Generator with User-Adjustable Pulse Width

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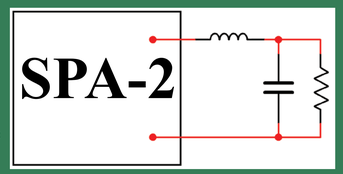
EAGLE HARBOR TECHNOLOGIES

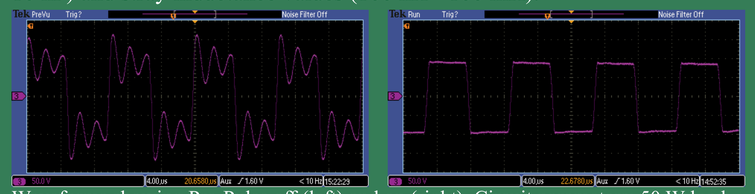
Introduction

Investigation of atmospheric, liquid, and vacuum plasma discharges requires a flexible pulse generator that can operate of a wide range of parameters. Eagle Harbor Technologies, Inc. (EHT) had developed a new pulse generator to drive dielectric barrier discharges as well as other plasma loads, Using a series resonant circuit, coupled with a customized transformer, this high voltage pulse generator can produce square wave pulses up to 30 kV with pulse widths from 2 - 100 µs and a pulse repetition frequency up to 1 kHz. Into 20 pF capacitive loads, the pulse have 4.5 µs rise time to 30 kV.

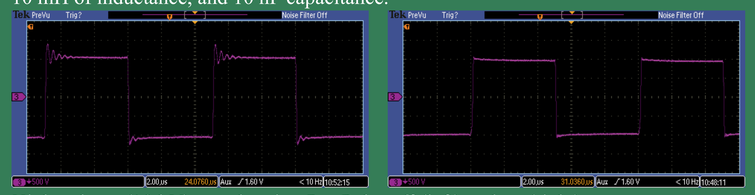
Pre-Pulse Technology

Many loads, even those considered pure resistive loads, have stray inductance and capacitance. These stray elements can cause ringing on the output waveform. EHT has developed a precision gate drive technique (patent pending) that can be used to significantly reduce or eliminate the ringing on the waveforms. EHT tested this technique over a wide range of stray capacitance values (100 pF - 10 nF) and stray inductance values (100 nH - 100 mH).





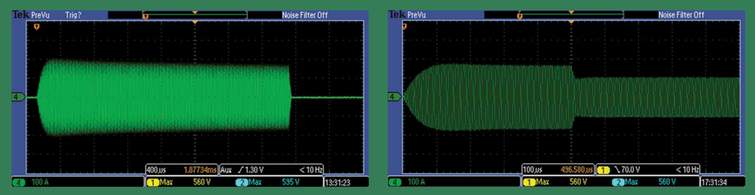
Waveforms showing Pre-Pulse off (left) and on (right). Circuit parameters: 50 W load, 10 mH of inductance, and 10 nF capacitance.



High voltage (10 kV) test showing Pre-Pulse off (left) and on (right).

Resonant Circuit Driving

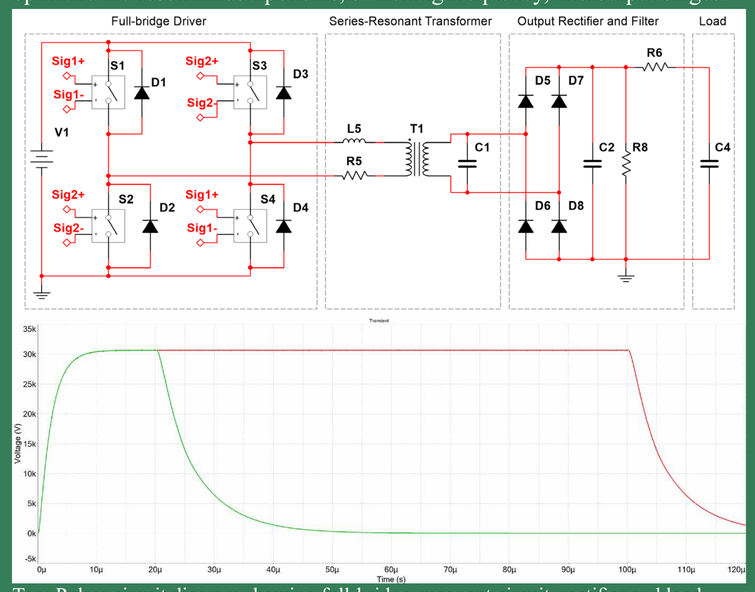
EHT has previously demonstrated a SiC MOSFET-based full bridge that can pulse width modulate resonant circuits at high frequency and high voltage.



Resonant circuit: 85 µH, 5 nF, and 1.25 Ω (f_{res} = 250 kHz) Left: 200 A for 3 ms. Right: 500 µs at 200 A and 500 µs at 100 A. Both with 500 V drive.

Circuit Modeling

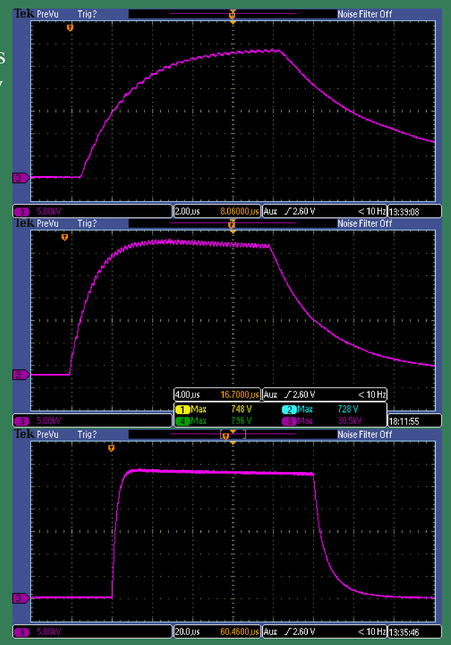
The pulser was initially modeled using National Instruments Multisim to optimize the resonant components, switching frequency, and output stages.



Top: Pulser circuit diagram showing full-bridge, resonant circuit, rectifier and load. Bottom: Voltage across the load (C4) for 20 and 100 µs pulses.

Output Waveforms

Oscilloscope traces showing typical output waveforms. This pulser was tested into a variety of resistive and capacitive loads. The waveforms here were generated with a 20 pF capacitor used to simulate at dielectric barrier discharge-like load at the end of three foot long output cables. The charge voltage was 600 V and the output voltage produced was 30 kV. Single output pulses are shown for 10, 20, and 100 µs. The rise time for these pulses was 4.6 µs. The output voltage can be directly measured with a high voltage probe. At EHT, we use the Tektronix P6015A 40kV probes.

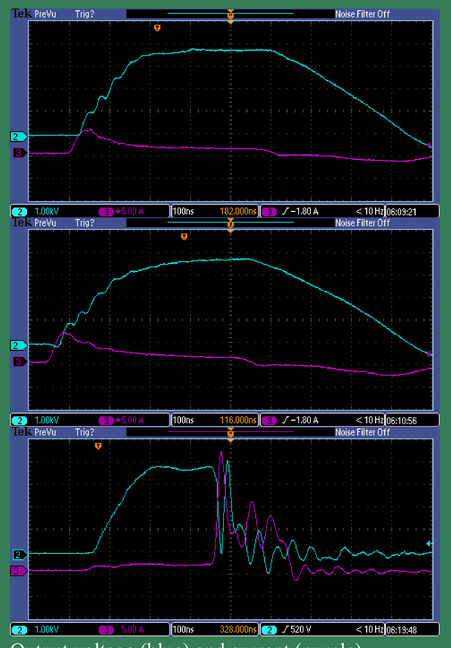


Single pulse waveforms: 30 kV with pulse widths of 10 µs (top), 20 µs (middle), 100 µs (bottom).

30 kV Nanosecond Pulser

In addition to the microsecond pulser, EHT has also developed a pulser for operation in the tens to hundreds of nanosecond regime. The 30 kV nanosecond pulser features user adjustable output voltage, pulse width, and pulse repetition frequency.

The pulser has been tested into a wide variety of plasma loads including dielectric barrier discharges and arcs. The pulser output shown here was optimized to be capable of producing 500 ns pulses, which increases the rise time due to larger stray capacitances which much be charged on each cycle.



Output voltage (blue) and current (purple) waveforms for a 13 pF DBD (top), 35 pF DBD (middle), and arc (bottom).

Conclusion

EHT has developed a 30 kV microsecond pulser with adjustable pulse width (20-100 µs) for driving plasma loads like dielectric barrier discharges. The pulser can operate at high pulse repetition frequencies up to 1 kHz. Into 20 pF capacitive loads, the output pulse has a rise time of 4.5 µs.

EHT has also developed a 30 kV nanosecond pulser with user adjustable pulse width and pulse repetition frequency. This pulser has been used to drive a variety of plasma loads.

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