

Isolated, High Voltage Arbitrary Pulse Generator

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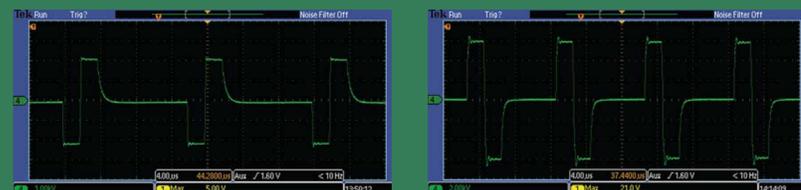
EAGLE HARBOR TECHNOLOGIES

Introduction

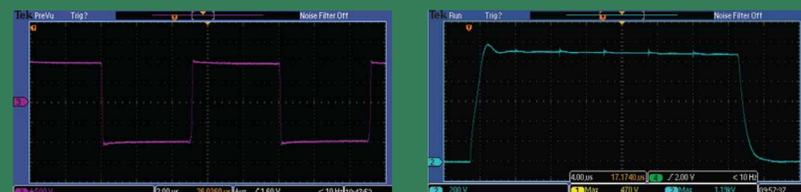
Eagle Harbor Technologies, Inc. has developed an Arbitrary Pulse Generator (APG) with isolated high voltage output. The EHT APG can produce output pulses with voltages up to 10 kV and fast rise time (100 ns) at high pulse repetition frequency (up to 100 kHz) with a user-adjustable duty cycle from 0 – 100%. The isolated output allows the pulse generator to be connected to loads that need to be biased. These pulser generators utilize modern silicon carbide (SiC) MOSFETs, which offer lower switching and conduction losses while allowing for higher switching frequency capabilities compared to IGBTs. This pulse generator has applications for RF plasma heating; inductive and arc plasma sources; magnetron driving; and generation of arbitrary pulses at high voltage, high current, and high pulse repetition frequency in the semiconductor processing, non-equilibrium plasma source, and material processing communities.

Arbitrary Pulse Generator

The EHT APG can be operated in a unipolar configuration, which can output pulses from single shot to hundreds of kilohertz with adjustable duty cycle. In the bipolar configuration, the pulser is limited to pulse widths of tens of microseconds, but can both source and sink current.



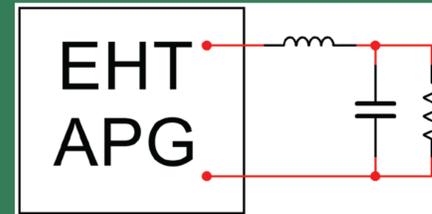
Bipolar, floating output. Left: 2 kV into 6 kΩ resistive load, 2 μs pulses at 70 kHz. Right: 6 kV into 2.5 kΩ resistive load, 2 μs pulses at 100 kHz.



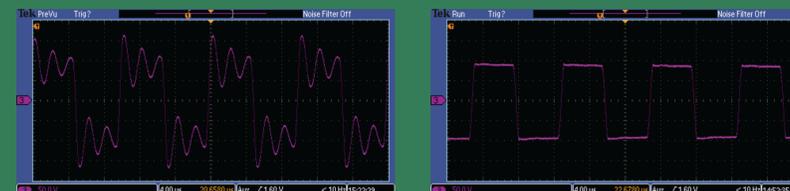
The floating, unipolar configuration allows for very long pulses and a very wide range of parameters from a single pulser. Left: 1 kV into 6 kΩ resistive load, 5 μs pulses at 100 kHz. Right: 1.1 kV into 250 Ω resistive load, 30 μs pulses at 100 kHz.

Pre-Pulse Technology

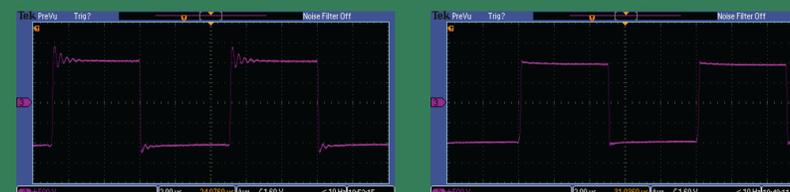
Many loads, even those generally considered pure resistive loads, have stray inductance and capacitance. These stray elements can cause ringing on the output waveform. EHT has developed a precision gate drive technique (patent pending) that can be used to significantly reduce or eliminate the ringing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



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

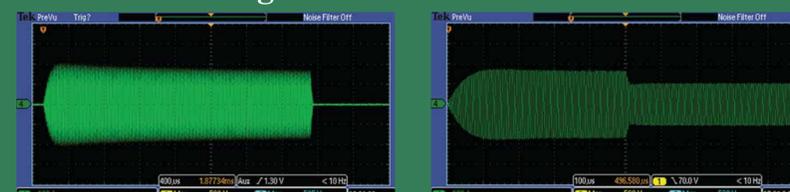


High voltage (10 kV) test showing Pre-Pulse off (left) and on (right).



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

Resonant Testing



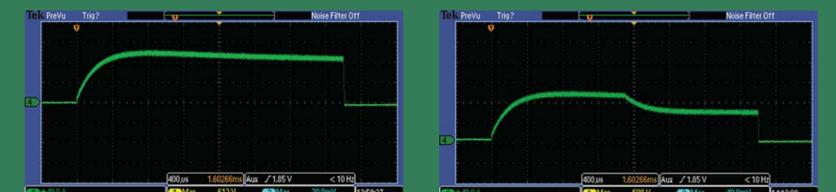
Resonant circuit: 85 μH, 5 nF, and 1.25 Ω Left: 200 A for 3 ms. Right: 500 μs at 200 A and 500 μs at 100 A.

Acknowledgment

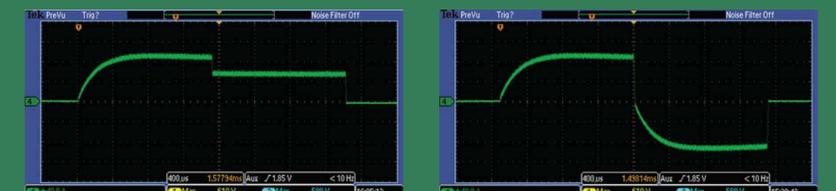
Supported by the Department of Energy (DE-SC0011907).

Fast Magnet PWM Control

EHT tested the APG for fast magnet driving. The pulser, operating at 250 kHz drove a magnet coil with an inductance of 85 μH. The pulse width was fixed during the initial current rise, but this could easily be changed for a faster rise.



Left: 2.15 μs pulse width at 250 kHz produced 100 A for 3 ms. Right: The pulse width started at 2.15 μs and was decreased to 2.09 μs to produce 100 A for 1.5 ms followed by 60 A for 1.5 ms.



Left: Same as above right with a single negative going pulse at the transition for 7.8 μs. Right: 2.15 μs pulse width for 100 A for 1.5 ms followed by -100 A for 1.5 ms.

Conclusion

EHT has developed a high voltage, floating Arbitrary Pulse Generator.

- Floating/galvanically isolated output can be biased with respect to the load
- Standard output voltages: 1, 2.5, 5, 10 kV
- Arbitrary square wave generation, DC - 100 kHz, 0 - 100% duty cycle
- Clean square wave output with ~100 ns rise/fall time (load dependent)
- Integrated full front panel control with remote interface options
- Requires DC supply, 0 - 600 V input (100, 500, 1000, 5000 W)
- Wide variety of loads, including plasma discharges

For more info: <http://www.eagleharbortech.com/>