A Solid-State High Voltage Trigger for HEDP Application

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Introduction
Thyratron-based generators are used to trigger higher voltage switches at the Z Machine at Sandia National Laboratory. The trigger generator long-term availability, reliability, and lead times are a concern for future projects. Thyratrons need stable, high-current, low-voltage power sources, have long warm-up times, and require conditioning shots to achieve a stable operating point. When measured over short timescales, thyratrons typically have a jitter of a few nanoseconds, but over longer timescales, they can have a much larger drift.

Eagle Harbor Technologies (EHT) Inc. developed a prototype solid-state thyratron replacement to trigger higher voltage spark-gap switches typically used in these HEDP applications to address the needs of Sandia and other pulsed-power laboratories. The first-generation EHT solid-state thyratron replacement can produce 20 kV pulses into 50 Ω with a sub-10 ns rise time and 100 ns e-folding fall time. The unit is designed to be compact and low cost. EHT will present the design tradeoff study, selected topology, and key waveforms results.

Solid-State Thyratron Replacement Requirements
A solid-state thyratron replacement suitable for HEDP applications at Sandia should meet the following specifications:
- Output voltage: 20 kV
- Capable of driving 50 Ω transmission lines
- One-sigma jitter: < 2 ns
- Rise time: < 10 ns
- Fall e-folding time: 120 ns
- Low volume
- Low cost (< $30k)
- Long lifetime

Nonlinear Transmission Line
To reduce the rise time 20 ns to below 10 ns, an NLTL was used. NLTLs have a nonlinear permittivity, ε(ε'), and/or nonlinear permeability μ(μ'). This NLTL is consists of an inner conductor surrounded by ferrite beads, encapsulated by a dielectric surrounded by an outer conducting braid.

Topography Selection
- High Voltage Switch
  - Expensive charging supply
  - Corona issues at DC
  - Needs snubbers for safety
  - Isolation transformer needed
  - More fibers (increases cost)
- Inductive Adder
  - No HV DC
  - No corona
  - More fault tolerant
  - Less complex
  - Modular/scalable
  - Better NLTL integration

Conclusion
Facilities such as Sandia National Labs’ Z Machine would benefit greatly from the increased reliability and decreased jitter and cost offered by modern solid-state switching technology. EHT successfully designed, built, and tested a compact (< 1500 in³) proof-of-concept solid-state HV trigger system that met the waveform specifications outlined for use as a thyratron replacement for spark-gap switch triggering. This HV trigger system utilizes proven inductive adder and NLTL technology developed at EHT to achieve a 20 kV pulse into a 50 Ω load with a sub-10 ns rise time. Future improvements would optimize the pulse-sharpening stage for compactness and reduce the complexity of the high voltage pulse transformer design.

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

Acknowledgment
This work was funded by a DOE SBIR (DE-SC0019852). EHT would also like to thank Sandia National Laboratory for assistance in spec generation.