**Initial Development of a High-Voltage Pulse Generator for High-Energy Beam Kickers**

James Prager, Kenneth E. Miller, Zach Mulalley, Alex Henson

*prager@eagleharbortech.com*

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**EAGLE HARBOR TECHNOLOGIES**

**Introduction**

The future Electron Ion Collider, to be located at Brookhaven National Laboratory (BNL), will require a 150 MeV energy recovery LINAC, which requires a new short-pulse stripline kicker. The kicker power system must deliver ±50 kV pulses with pulse widths of less than 28 ns into a 50 Ω load and with low jitter. The power system must be highly reliable and robust to potential faults. Eagle Harbor Technologies (EHT), Inc. is leveraging our previous experience developing inductive adders to produce a pulsed-power system that can meet the needs of the BNL kickers. In this program, EHT designed a single inductive adder stage that was used to demonstrate the pulse characteristics including fast rise and fall times, low jitter, and flat-top stability while operating at the full current (1 kA). EHT will present the development status and output waveforms.

**Inductive Adder**

- Limits the presence of high voltage to the transformer.
- Ground-referenced switches increase robustness, simplifies gate drive design, and reduces jitter.
- Solid-state switches like MOSFETs and IGBTs allow for user-adjustable pulse widths.
- Off-the-shelf components are used within manufacturer specifications.
- Single stage failure does not fail the entire power system.
- The output can be modulated to improve the flattop with the addition of a modulation stage.

**Modeling Purdue IA**

- Stray component values calculated from analytic analysis.
- Switch model is proprietary and ideal switch doesn’t match behavior.
- Developed R(t) “switch” to mimic IV behavior.
- Manufacturers’ C/V curves used for diode and switch capacitance.

**Switch Testing**

To reduce risk, the new switches were tested on a small PCB to demonstrate fast rise times. Current sharing was also tested by monitoring the device temperature while operating at 1 kHz CW.

**Modeling Kicker IA**

Purdue model used as a starting point to optimize IA design for BNL kicker.

- Reduce PCB plane capacitance
- Custom PCB stackup with lower dielectric than FR4
- Change plane geometry on PCB
- Change switches
- Smaller footprint – reduces $C_{plane}$
- Lower switch capacitance
- Add tailbiter circuit
- Decrease output inductance
- Use $S_{F}$
- Allows smaller distance between transformer and primary

**Inductive Adder PCBs**

Comparison of Purdue PCB (left) and BNL Kicker PCB with tailbiters (right).

**HV Testing of Switching PCB**

The switching PCB is currently being tested into a low-ductance test load. The test load resistance was designed so that at 1.56 kV out the unit will be switching 1 kA, which is required for the 50 kV system into a 50 Ω load. Preliminary waveforms are shown below.

**Scaling to 50 kV**

EHT used the SPICE model of a single module and stacked them into a full 50 kV inductive adder configuration. The preliminary modeling results indicate that this will scale to 50 kV.

**Conclusion**

The stripline kickers at BNL EIC will require a high voltage pulse generator that is capable of producing 50 kV pulses with fast rise (<6 ns) and fall times (<12 ns) with a flat top ripple below 2%. EHT redesigned our inductive adder PCB to improve the flat top stability and decrease the fall time compared with our previously designed inductive adders.

EHT conducted switch testing and demonstrated that these lower capacitance devices could produce fast rise times and share current well. EHT has started testing the PCB and showed that the tailbiter improves the fall time to 12 ns and the stability is better than 2%.

For more information: [http://www.eagleharbortech.com/](http://www.eagleharbortech.com/)

**Acknowledgment**

This work was funded by a DOE SBIR (DE-SC0021470). EHT would also like to thank BNL for assistance in spec generation.

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