

Executive Summary

This project presents the Fall 25 - Spring 26 development of a compact Solid-State Linear Transformer Driver (SSLTD), a pulsed power generator that utilizes MOSFET-based modules arranged radially around a magnetic core. Fall 2025 work focused on literature review, component selection, and simulation. Research was conducted using multiple sources, including IEEE publications, and previous team reports. Circuit simulations were performed using LTspice, PSpice, and NI Multisim. In Spring 2026, the focus shifted to hardware implementation, including gate driver selection, and PCB design. The system was assembled and tested, resulting in a functional single module capable of generating fast and stable pulses. Gate drivers LM5134 and NCP81074 are demonstrating superior performance. Oscilloscope measurements confirmed reliable operation over a wide frequency range, from 100 ns pulse widths up to 1 MHz, when driving a 50 Ω load. The validated module provides a scalable foundation for future expansion into semi-stage and full-stage SSLTD systems.

Background

A Solid-State Linear Transformer Driver (SSLTD) is a modern pulsed power system designed to generate extremely fast, high-current, high-voltage pulses using modular units called "modules," each containing capacitors, gate drivers, solid-state switches, and magnetic cores that shape and combine the pulses.

Unlike a traditional Marx Generator, which charges capacitors in parallel and discharges them in series using spark gaps, resulting in slower rise times, larger size, and less reliable, noisier switching the SSLTD uses solid-state devices to achieve much faster, cleaner, and highly repeatable pulses in a compact, scalable form. The magnetic cores in an SSLTD prevent reverse current and sharpen the pulse, allowing multiple modules to work together to create a single powerful, precisely timed output.



Figure 1. Sandia Labs LTD

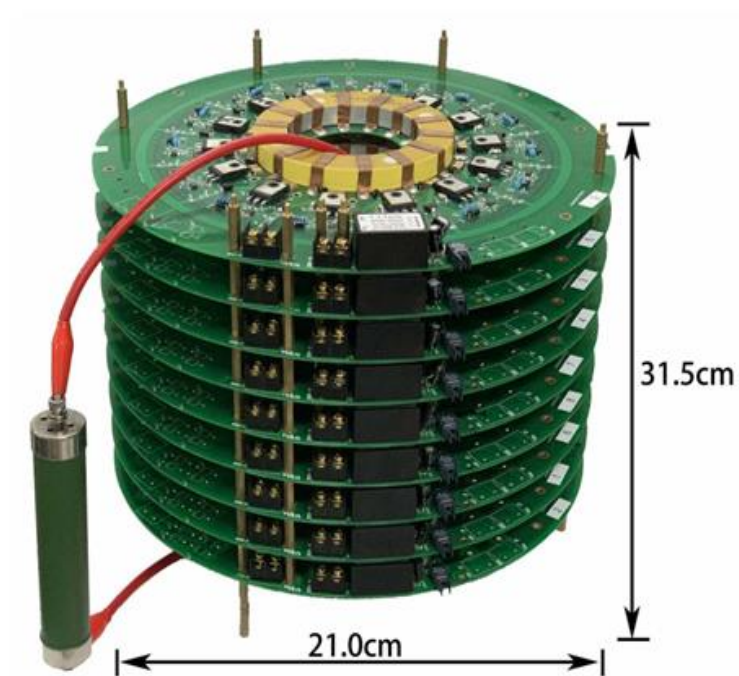


Figure 2. SSLTD

Experimental Setup

This semester, the experimental setup was developed through iterative PCB design, assembly, and testing from Week 1 to Week 9. Three PCB modules with identical MOSFET topology and different gate drivers (MCP14A1201-E/MS, and NCP81074, LM5134) were fabricated to evaluate switching performance. Testing was conducted using a function generator, DC supply ($\approx 12\text{--}30\text{ V}$), and oscilloscope, with measurements across a 50 Ω load. Pulse behavior was evaluated under multiple conditions (no trigger, single-shot, double-shot) over 10 ns to 200 ns intervals. Initial limitations due to PCB parasitic were resolved through layout improvements. Final results confirmed stable high-speed switching, enabling scaling to a semi-stage (~ 5 modules).

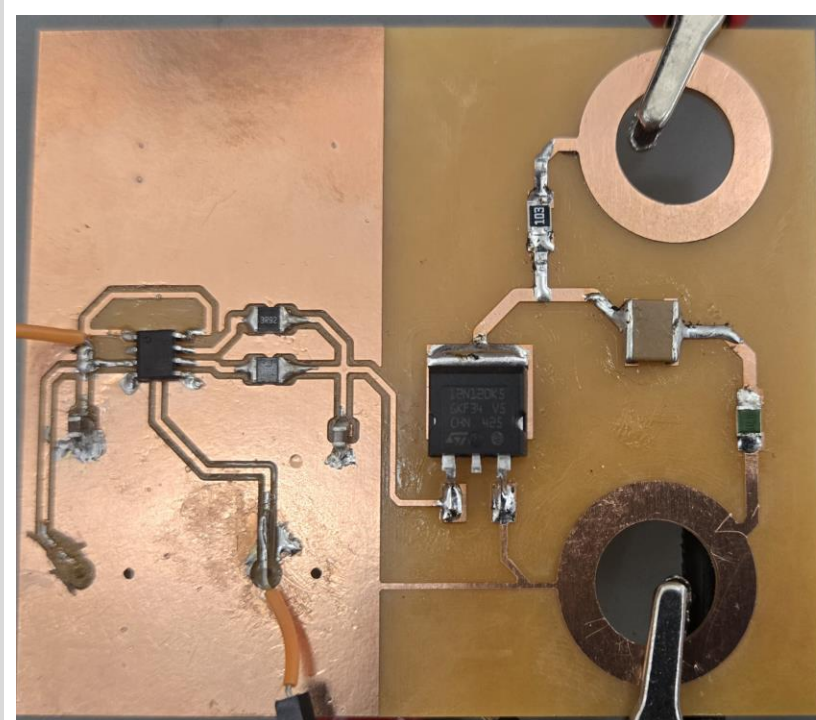


Figure 3. GD MCP14A1201-E/MS Single Module

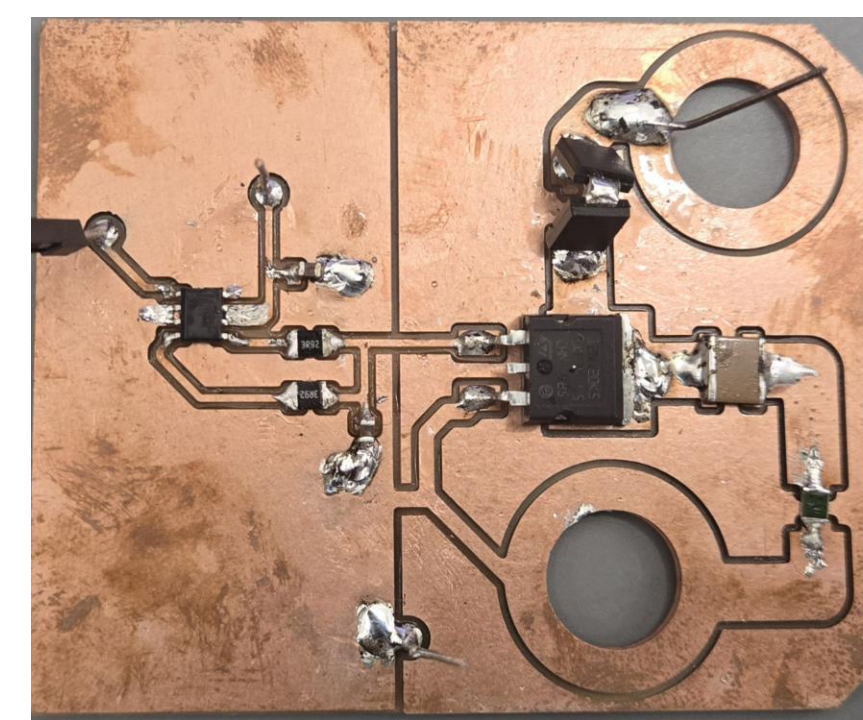


Figure 4. GD NCP81074 Single Module

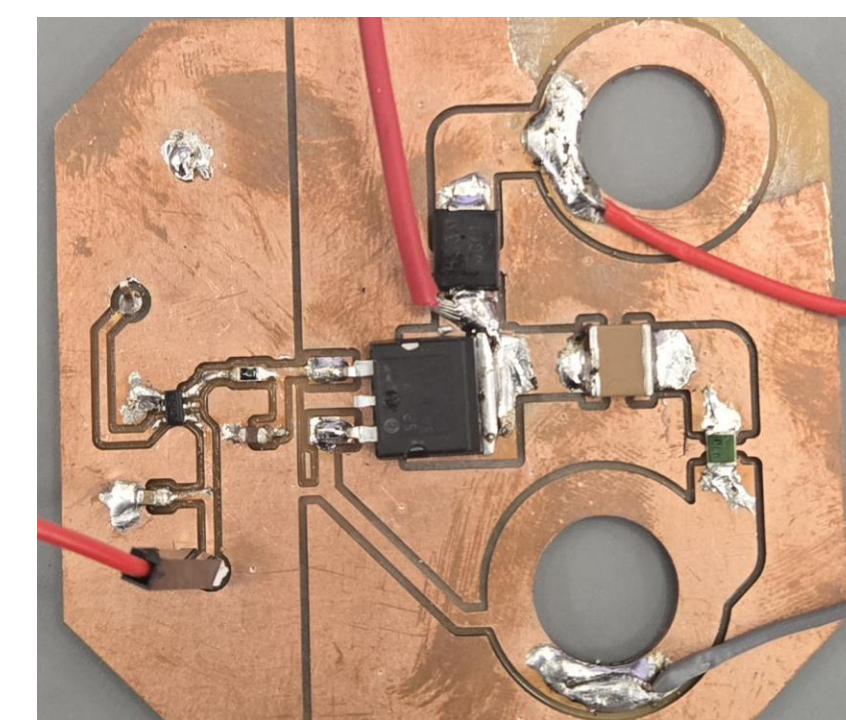


Figure 5. GD LM5134 Single Module

Experiment Test Plan

- Simulations have confirmed desired application of gate drivers and modules. Real world testing of a single module are undergoing.
- Testing includes various charging levels to measure current through MOSFET/discharge pathway by applying Ohm's Law with a known resistance. Scaling up to semi-stage is next, with an Altium design completed and ready to be sent out for milling.
- Block Diagram (Fig. 8) shows Ross Relay change to MOSFET driven by the low side of GD to prevent shorting during the discharge cycle.

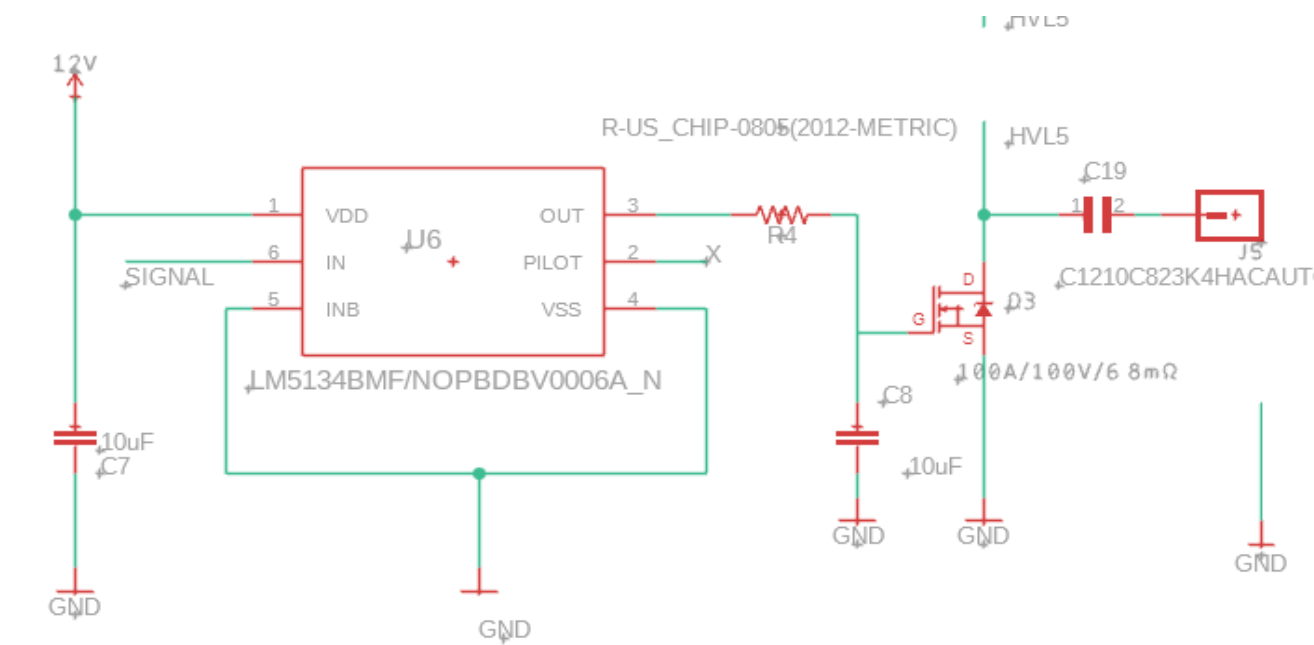


Figure 6. Module Circuit

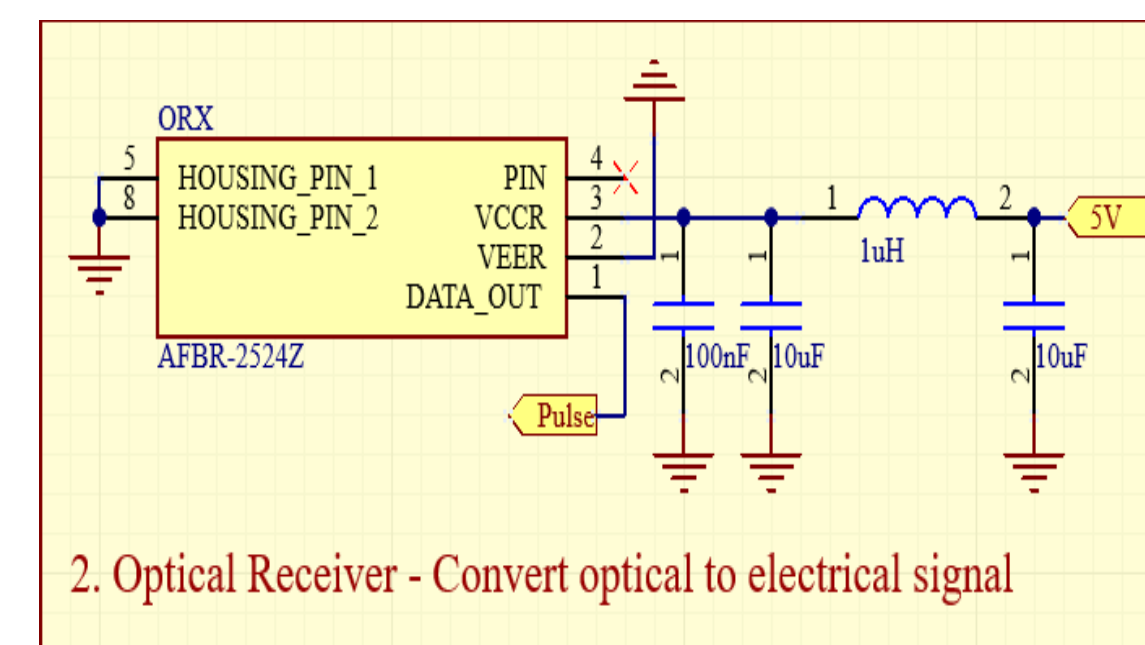


Figure 7. Optical Receiver Circuit

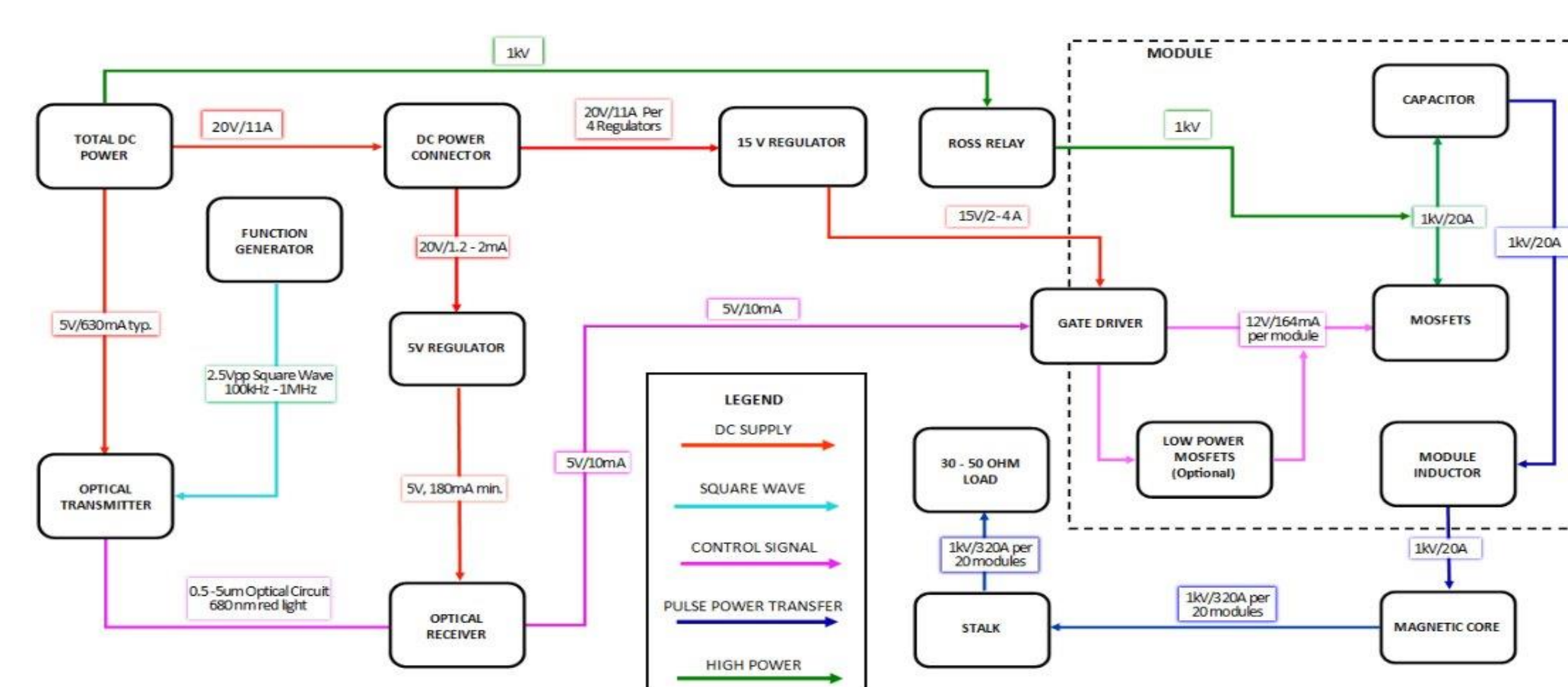


Figure 8. SSLTD Block Diagram

Experimental Results

- Voltage regulator tested and operating as expected: 15V Gate Driver Side and 30V High Voltage (Fig. 9).
- LM5134 Gate driver (GD) input signal propagation (Yellow), and Output signal Pulse (Blue) during the Module testing (Fig. 10). Test is successful with approximately 100 ns delay. Scaling to semi-stage is the next step to verify proper signal propagation.
- Fig. 11 shows a single module charge at 40 ns. Further testing required to smooth output and ensure MOSFET operating in saturation region. Charging at higher ratings should provide more realistic performance.



Figure 9. Voltage Regulator Output



Figure 10: Oscilloscope showed fast switching behavior at 100 ns rise and fall time.

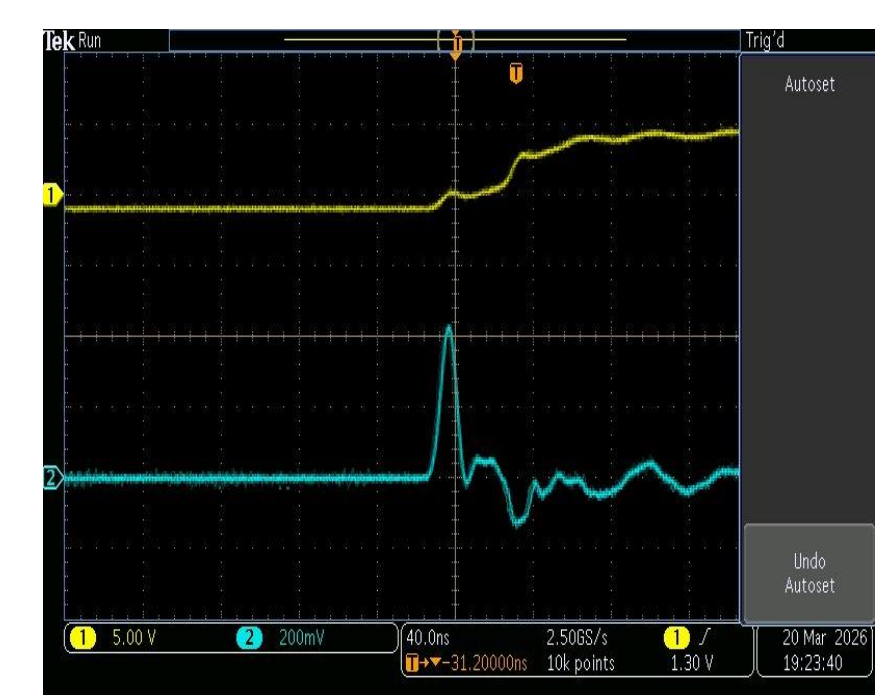


Figure 11: Module charging time behavior at 40 ns rise time.

Conclusions

- Current simulations suggest module capable of outputting $\sim 25\text{A}$ at 1000V, which would result in full stage output of $\sim 500\text{A}$.
- Module design done on PCB and works well with minimum noise and parasitics. Semi stage will be milled professionally, and optimization.
- Current semi-stage is on the way for PCB production and full stage design loosely follow previous semesters.
- Energy Transfer Testing using Metglas core



Figure 12. Semi-Stage w/ 5 Modules from Fall 2025

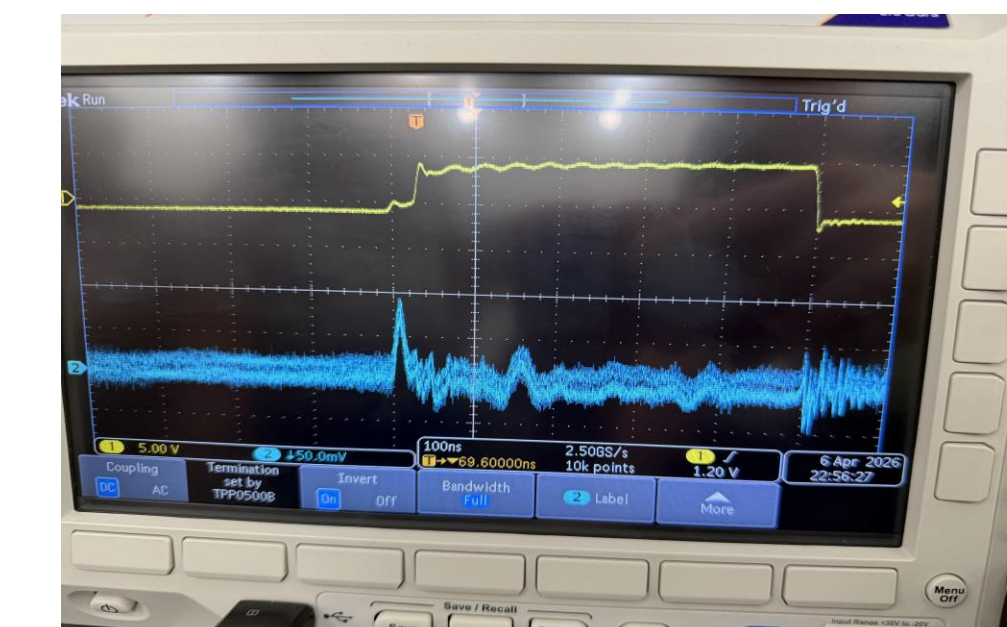


Figure 13. Oscilloscope Reading w/ Metglas Core

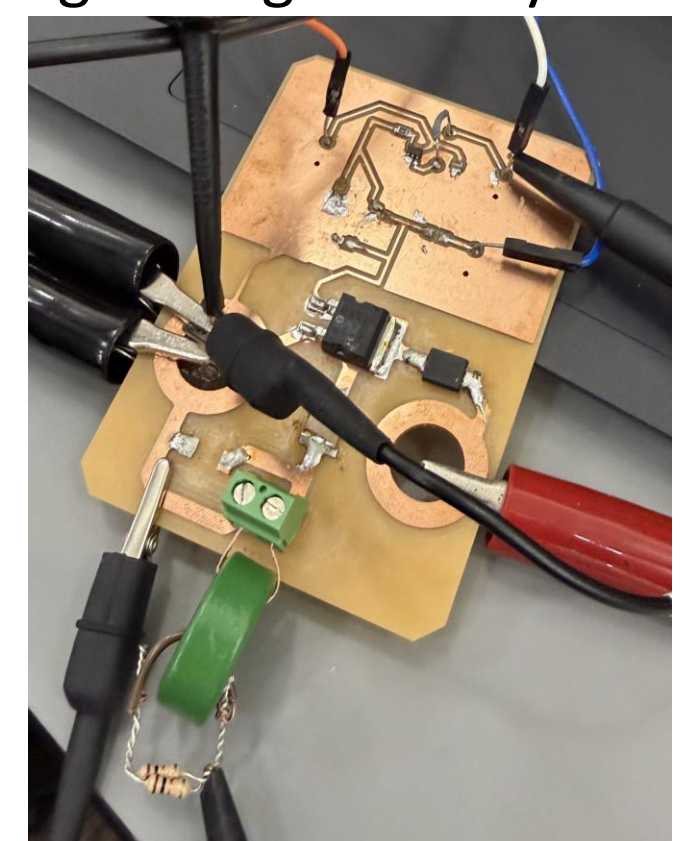


Figure 14. Module w/ Metglas Core

References

- [1] J. Leckbee et al., "Linear Transformer Driver (LTD) research for radiographic applications," 2011 IEEE Pulsed Power Conference, Chicago, IL, USA, 2011, pp. 614-618, doi: 10.1109/PPC.2011.6191550.
- [2] Jiang, W. (2018). Review of solid-state linear transformer driver technology. *Matter and Radiation at Extremes*, 3(4), 159-164. <https://doi.org/10.1016/j.mre.2018.02.001>
- [3] M. D. Sherburne, "Design of a 15MW Solid-State Linear Transformer Driver for Gas Switch Triggering Applications," Virginia Tech Works, <https://techworks.lib.vt.edu/server/api/core/bitstreams/c39902fd-993e-4191-94be-b186938f9f25/content> (accessed Oct. 25, 2024).
- [4] 2ED1324S12P 1200 V half-bridge gate driver IC. (2023, March 16). <https://www.infineon.com/cms/en/product/power/gate-driver-ics/2ed1324s12p/>
- [5] STMicroelectronics STH12N120K5-2. (n.d.). Mouser Electronics. <https://www.mouser.com/ProductDetail/STMicroelectronics/STH12N120K5-2?qs=DqCdCwOw4%2F4mlacx3Ymy8Q%3D%3D&srltId=AfmBOorVfIsHFCQwFEB7hkp8ZcWCse4MsX7qzWF6eAei9yhZbAhObZ8A>
- [6] LTspice, Analog Devices, version