# ADAPTATION OF THE ISIS INDUCTION-CELL DRIVER TO A LOW IMPEDANCE *X*-PINCH DRIVER

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## ABSTRACT

*We summarize the work done to design a system to non-destructively convert the Idaho State Induction System (ISIS) induction cell driver (ICD) to a low impedance pulse power driver for x-pinch applications. The simulation results show that such a driver can supply about 300-kA peak current with about 70-ns rise time (10-90%). However, simulations also show that the negative reflective wave is formed, which can cause the destruction of the ISIS ICD's pulse forming line (PFL). Particular attention was taken to simulate the effect of misfire of one of the PFLs. To reduce the amplitude of this destructive wave, high power damping resistors should be placed after the output of each PFL. This would result in the maximum current achievable by this driver to be limited to about 200-kA peak value.*

## I. IDAHO STATE INDUCTION SYSTEM (ISIS )

ISIS is a high-intensity, pulsed-power electron accelerator able to supply about 80 GW of power in a 35-nanosecond pulse [1]. It was donated to the Idaho State University by Titan Pulse Sciences, Inc. in 2002, and its primary purpose has been to serve as a radiation source for radiation effect testing in biological and semiconductor systems [2].

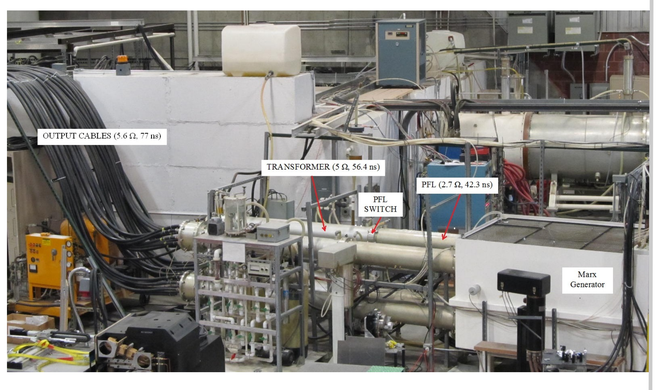


Figure 1: ISIS power supply.

**REFERENCES:**

[1] Titan Pulse Science Division, San Leandro, CA, "ISIS Manual," (October 9 2004).
[2] V.I. Dimitrov, et. al., "The ISIS Pulsed Power Accelerator Facility at ISU," 24 Annual HEART Conference, Santa Clara CA, March 2006.
[3] P. Corcoran, et al., "Experimental Test of the Power Supply and Prototype Cell for the 1.5 MeV SLIA Accelerator Unit," *1991 IEEE Particle Accelerator Conference*.
[4] V.I. Dimitrov "Progress Report for Grant DTRA1-11-1-0036," period May 19, 2011 – Sep. 1, 2012.
[5] LTspice IV Getting Started Guide, 2011 Linear Technology.
[6] R.V. Shapovalov "Design of a compact, portable plasma-radiation-source generator at the Idaho Accelerator Center," (to be published, 2013).
[7] Private communication with Dr. Vesselin I. Dimitrov. "The PFL switch is designed to hold the high-voltage positive pulse. The high-voltage negative reflective pulse will probably destroy this switch," Fall 2012.

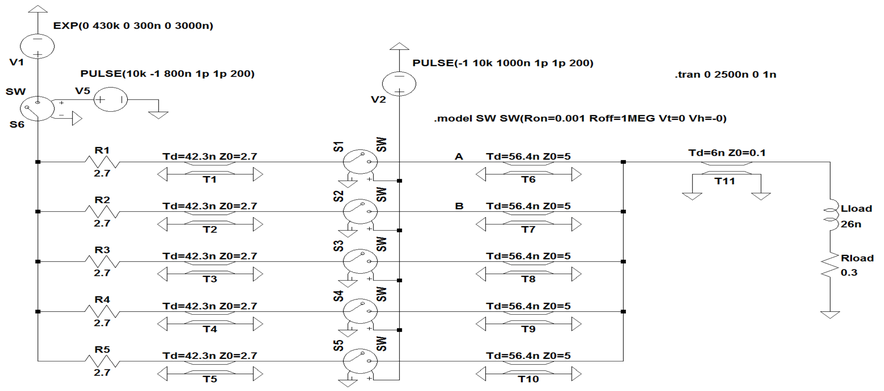


Figure 2: Electrical circuit of an ISIS-based *x*-pinch driver.

## II. LTSPICE SIMULATIONS: 300 KA *X*-PINCH DRIVER

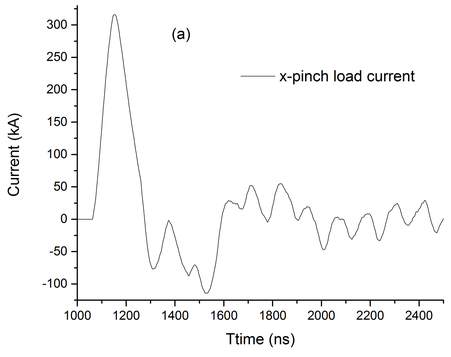


Figure 3a: current measured at the *x*-pinch load

- The impedance transformer is directly attached to the output of each PFL.
- The total inductance of the *x* pinch and all connection lines is 26 nH.
- After optimization of the impedance transformer, such a driver can supply about 320-kA peak current with 70-ns rise time.
- A reflective negative wave is formed traveling back to the PFL switch.
- This reflective wave will become even worse, if one or more PFL switches are not fired.
- Such a driver will probably not survive for a large number of shots due to possible damage to the PFL switches.

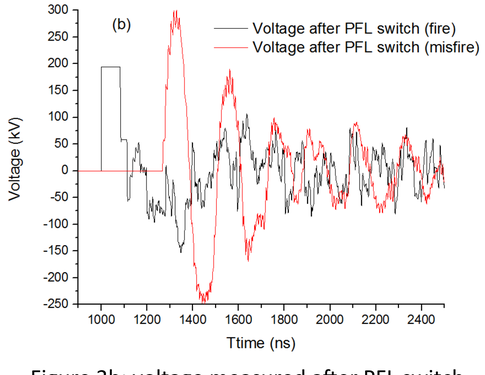


Figure 3b: voltage measured after PFL switch.

## III. LTSPICE SIMULATIONS: 200 KA *X*-PINCH DRIVER WITH DAMPING RESISTORS

To reduce the amplitude of this destructive negative wave, high-power damping resistors (4.7 Ω) are placed after each PFL before the impedance transformer. This will reduce the amplitude of the reflective negative wave at the PFL switch location to the appropriate value, so the *x*-pinch driver can be safely operated.

- High-power damping resistors (4.7 Ω) are placed after each PFL before the impedance transformer.
- A modified *x*-pinch driver can supply about 200-kA peak current with 60-ns rise time.

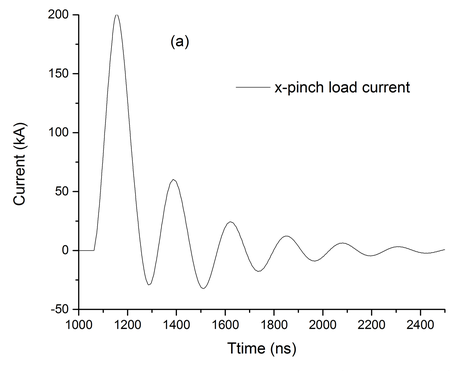


Figure 4a: current measured at the *x*-pinch load

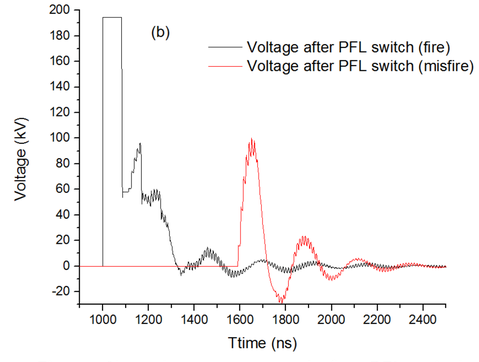


Figure 4b: voltage measured after PFL switch.

- Fire: the amplitude of the negative reflective wave is almost reduced to the zero value
- Misfire: the amplitude of the negative reflective wave is 25 kV, total duration of this wave is only 100 ns.
- This small negative reflective wave will probably not damage the PFL switches.

## IV. CONCLUSION

Taking into account these results and other considerations (time, effort and cost-needed to switch between the *x*-pinch operation mode and the normal operation mode of ISIS), the decision was made to design a new stand-alone, compact and portable pulse-power *x*-pinch generator [6].

**ACKNOWLEDGMENTS:**

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