

Diversified Technologies, Inc.

Daresbury Laboratory Short Pulse Klystron Modulators

Chris Chipman, Dr. Marcel P.J. Gaudreau, PE, Luan Jashari,
John Kinross-Wright, Michael Kempkes, Rebecca Simpson
Diversified Technologies, Inc., USA

Alan Wheelhouse, Stephen Griffiths
STFC - Science & Technology Facilities Council, UK

Rebecca Simpson
Technical Marketing Manager
IPMHVC 5 June 2018

Diversified Technologies, Inc., Bedford, MA USA

Diversified Technologies, Inc.

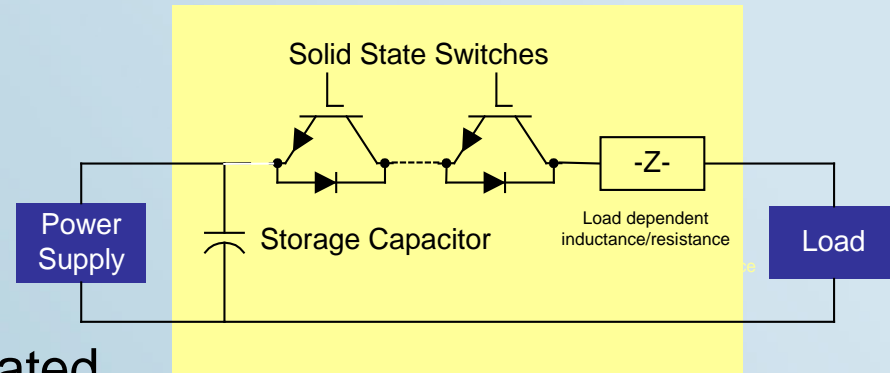
- Founded 1987 by Dr. Marcel Gaudreau (MIT PSFC)
 - Located Outside of Boston
 - 60 Employees, 6 PhDs
 - Diverse Technical Background (EE, Physics, Aero)
- Core Technology: High Power Solid-State Switching Systems
 - Solid State Modulators, Power Supplies
 - RF Transmitters
 - HV Pulsed Electric Field (PEF) Systems
- Major Market Applications
 - Radar Systems
 - Particle Accelerators
 - Power Conversion
 - DC Power Distribution
 - PEF / Food / Biomass Processing



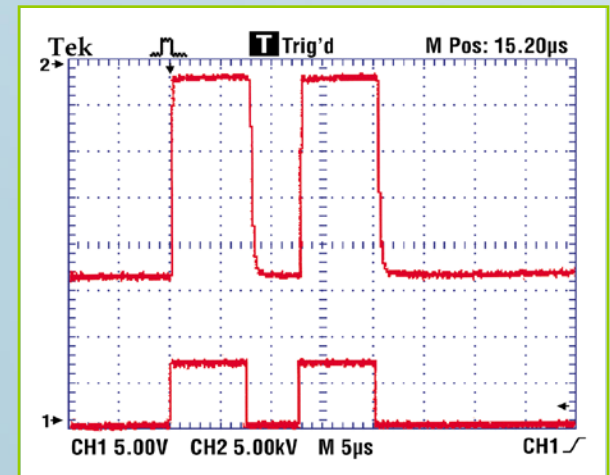
DTI 33,000 ft² Corporate
Headquarters in Bedford, MA

Solid-State Switching

- Series String of Transistors
 - All Operate Synchronously
 - Patented Design
- Very High Voltage & Current Demonstrated
 - Up to 500 kV (500,000 Volts)
 - Up to 20 kA (20,000 Amperes)
- Extremely Uniform & Reliable Pulses
 - Sub-Microsecond Switching
 - Arbitrary Pulsewidth & Frequency
 - 1 ns – CW; > 300 kHz Continuous



DTI's PowerMod™ Model



DTI's Core Technology

Product Examples



Project Overview

- Three Klystron Modulators for the CLARA Project at Daresbury Laboratory, UK
 - Based on previous units delivered to Daresbury and Lawrence Berkeley National Lab in 2014
 - Similarities in design allow for complete, replicable package
 - Pulse voltage flatness and stability crucial to LINAC operation
 - Good pulse fidelity over all conditions, optimized near nominal peak power of preferred klystron

System Specifications



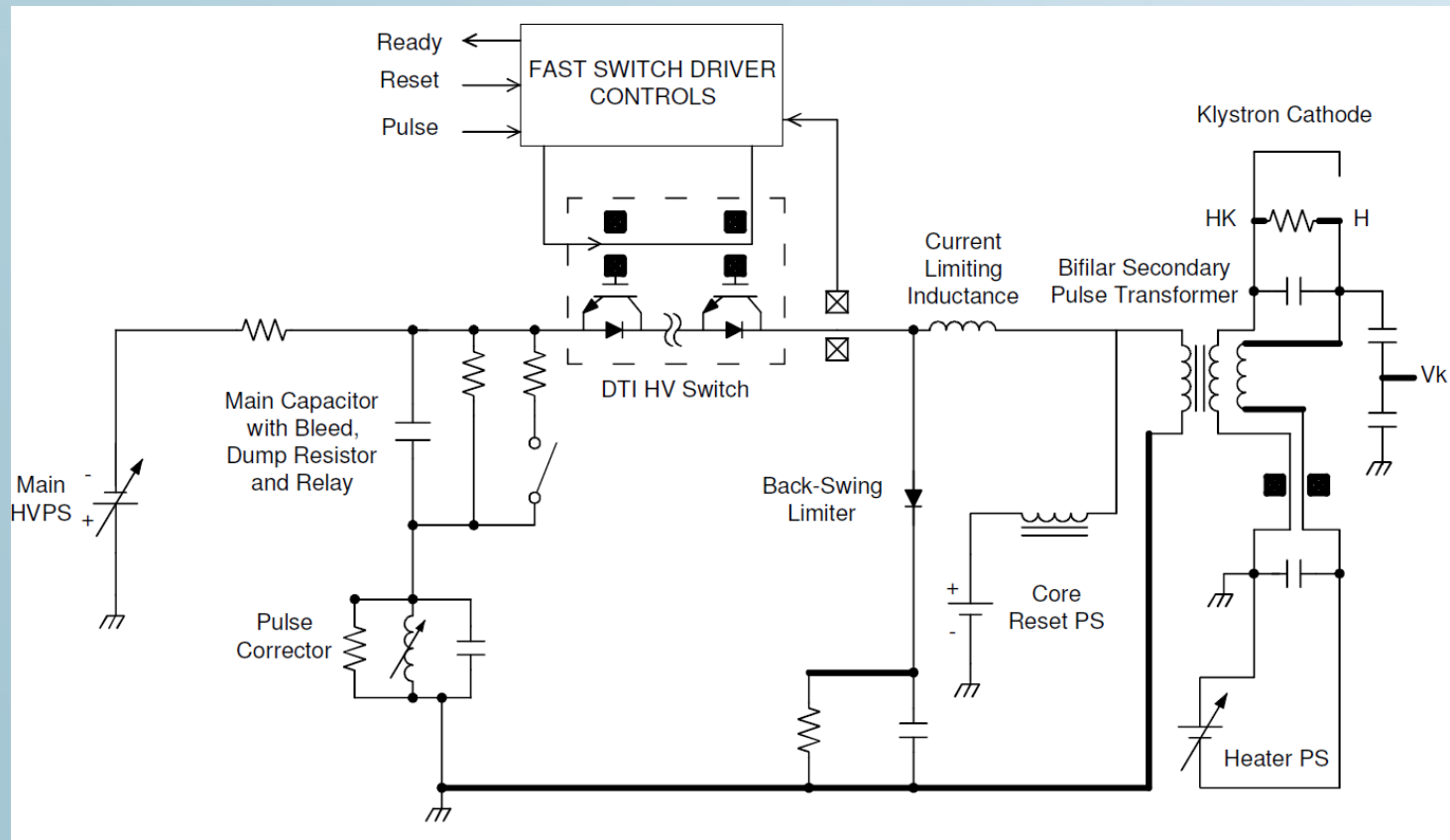
Specifications	CLARA 2018 (3x)	CLARA 2014 (1x)	LBNL 2014 (1x)	Unit
Peak RF Power	80	45	25	MW
Modulator Avg Power	250*	20	2.5	kW
Cathode Voltage	40-450	350	270	kV
Beam Current	50-545	375	250	A
Pulse Width	0.25-3.0	3	10	μs
Repetition Rate	400*	400	10	Hz
Voltage Flatness	< ± 0.02	0.1	1	%
Voltage Reproducibility	< ± 0.05%	0.25%	0.10%	Of Vmax
Pulse-to-Pulse Jitter	< ± 1	4	0.5	ns

*System is upgradeable to 500 kW / 1 kHz with addition of another 250 kW DTI HVPS

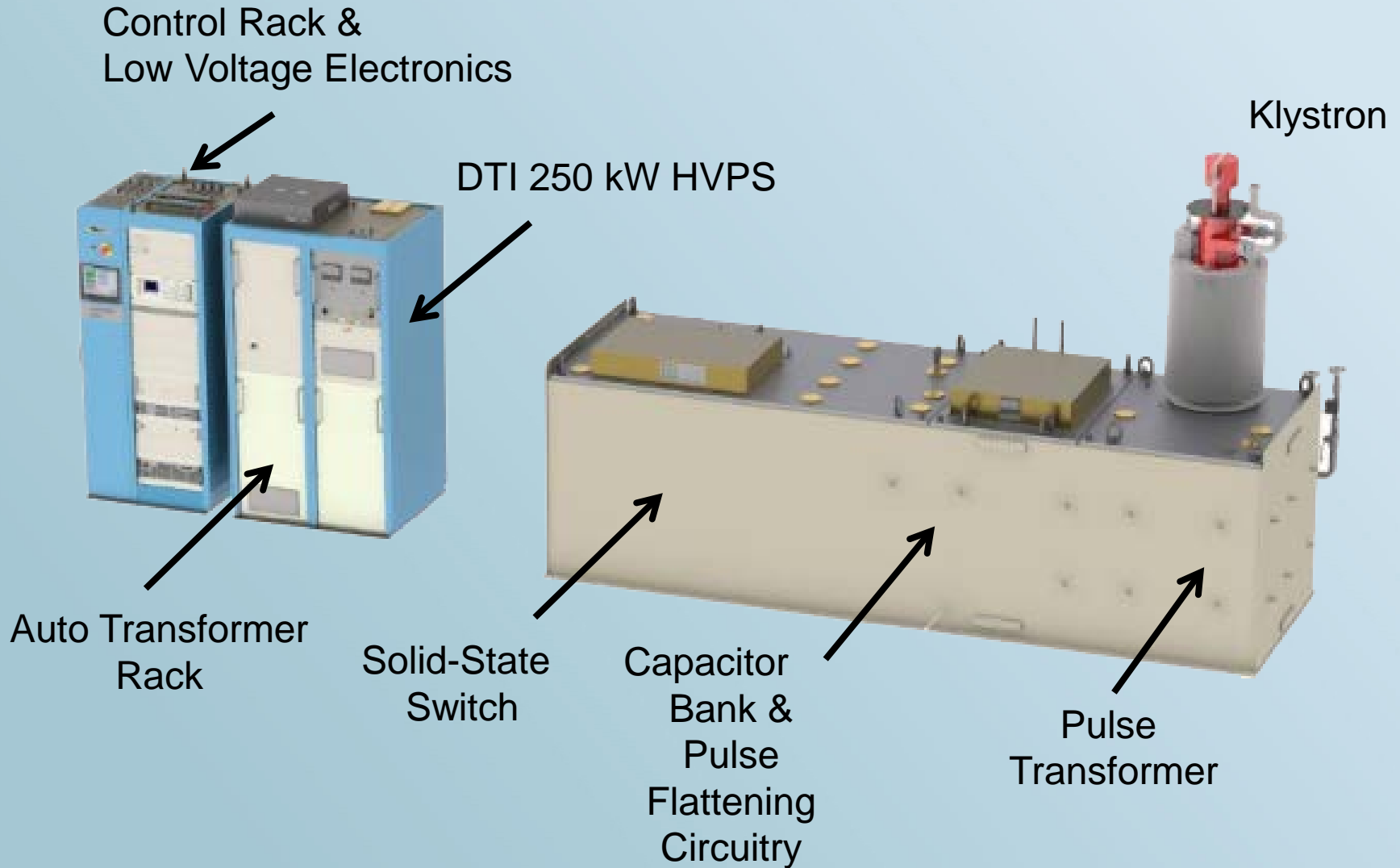
Modulator Design

- Topology: Solid-State Switch-Driven Pulse Transformer
- Components Include:
 - High Voltage Power Supply
 - Storage Capacitor
 - High Voltage Series Switch
 - Step-up Pulse Transformer
- Benefits
 - Small Footprint (Moderately Sized Storage Capacitor)
 - Direct Switching = Low Losses, Fast Rise and Fall Times
 - Klystron Protection
 - Inherent Redundancy

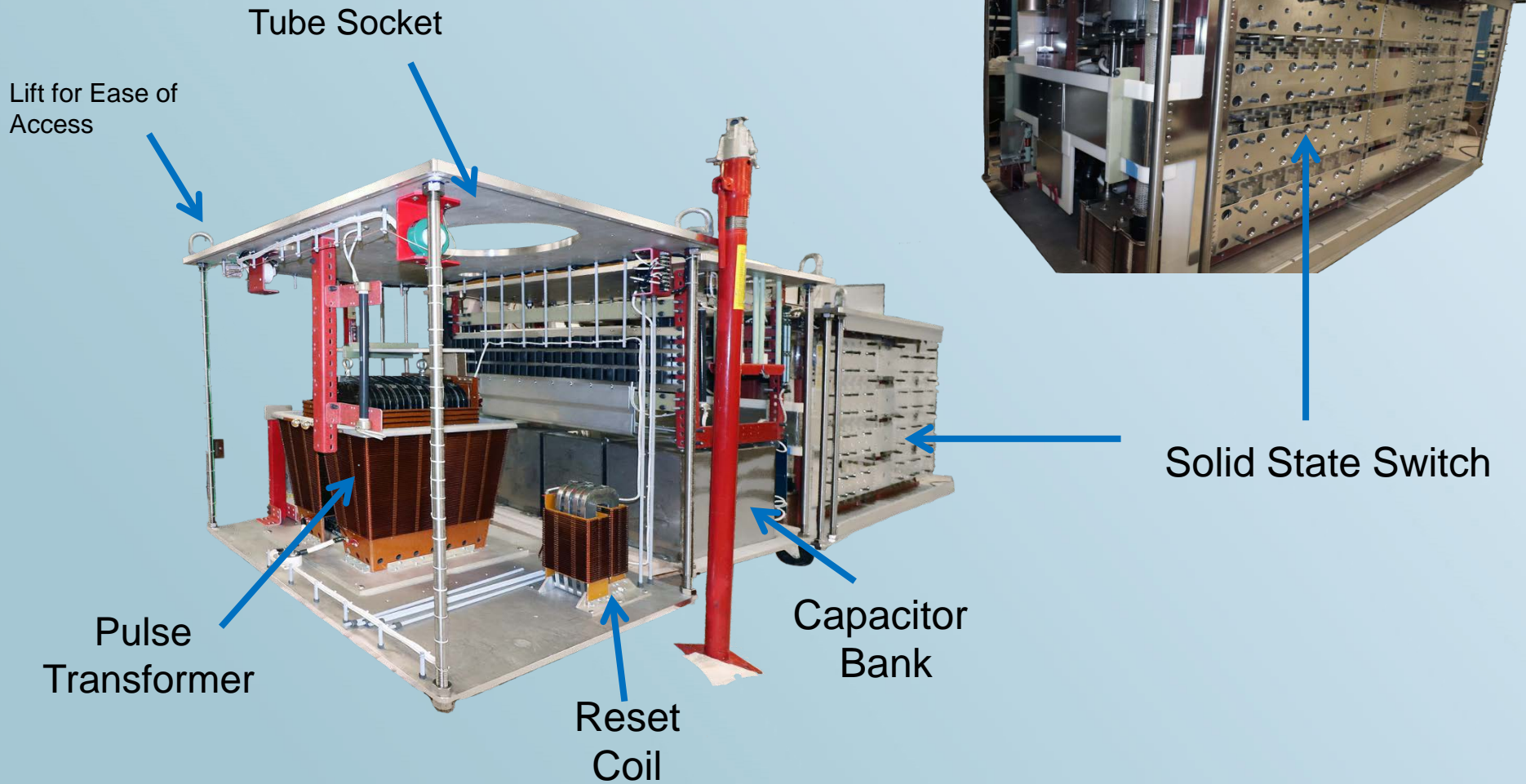
Modulator Schematic



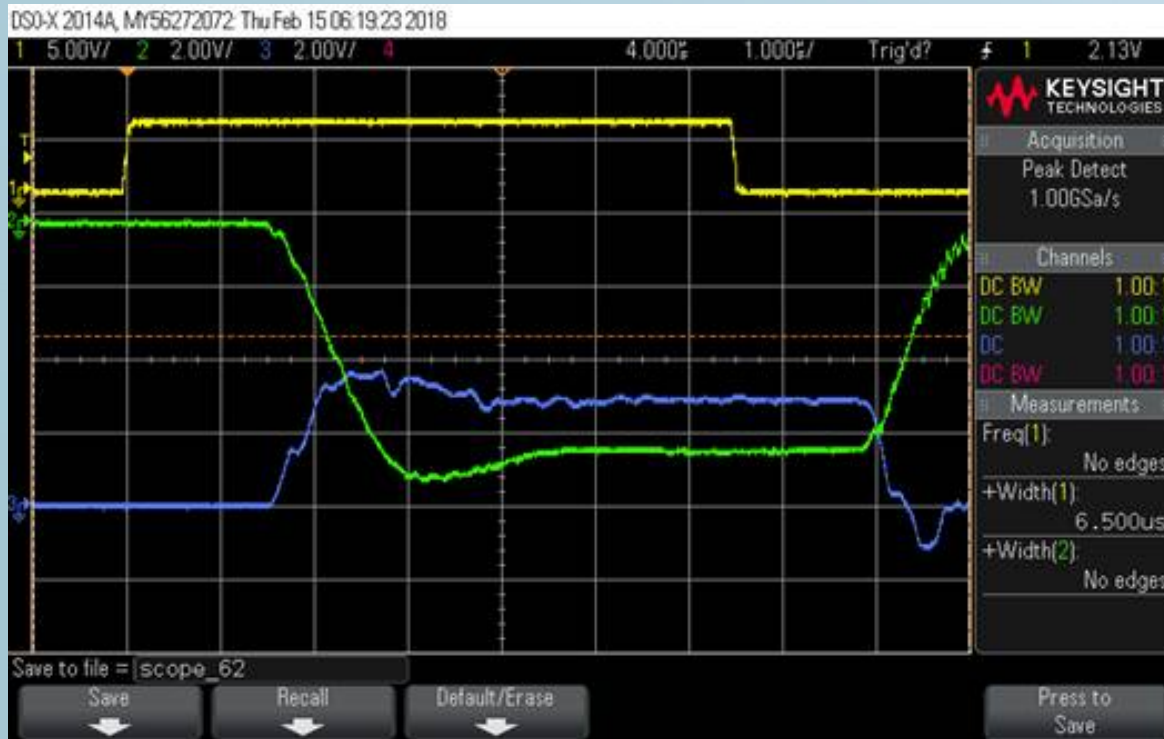
System Packaging



Tank Details



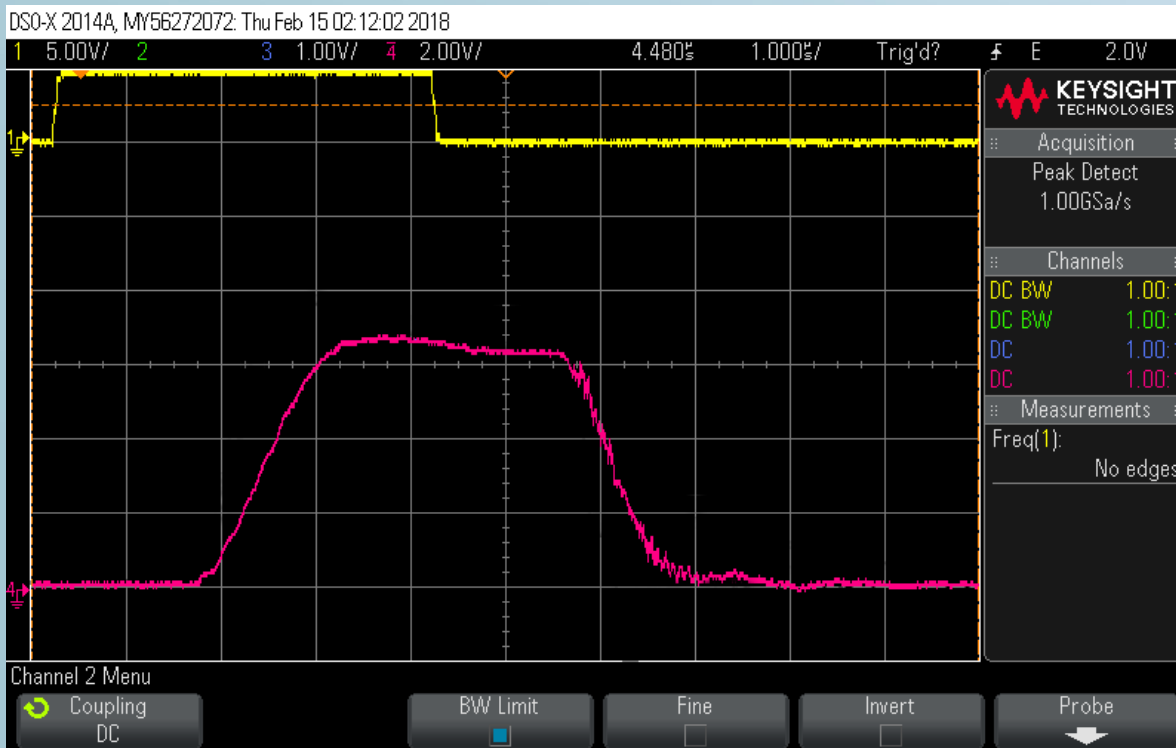
Pulse Performance



350 kV, 300 A, 6.5 μ s Pulse into resistive load, no bouncer

Yellow – Pulse Command
Green – Current
Blue – Cathode Voltage

Pulse Performance



420 kV, 400 A, 4 μ s Pulse, into resistive load, no bouncer

Yellow – Pulse Command
Pink – Cathode Voltage

Conclusion & Project Status

- System 1
 - Factory Acceptance Test Complete
 - Unit Shipped
 - Installation May 2018
- Systems 2 & 3
 - Factory Acceptance Test to be Complete June 2018
 - Installation Summer 2018

Thank You

Diversified Technologies, Inc.
35 Wiggins Avenue
Bedford, MA 01730
(781)-275-9444

www.divtecs.com