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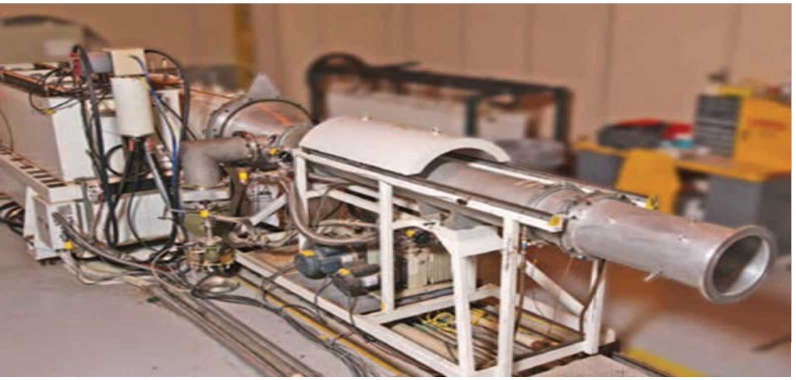

Enhancements to the Short Pulse Nano Second X–radiator (SPHINX) Pulsed Power System

IEEE Pulsed Power Conference 2015

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U.S. DEPARTMENT OF ENERGY

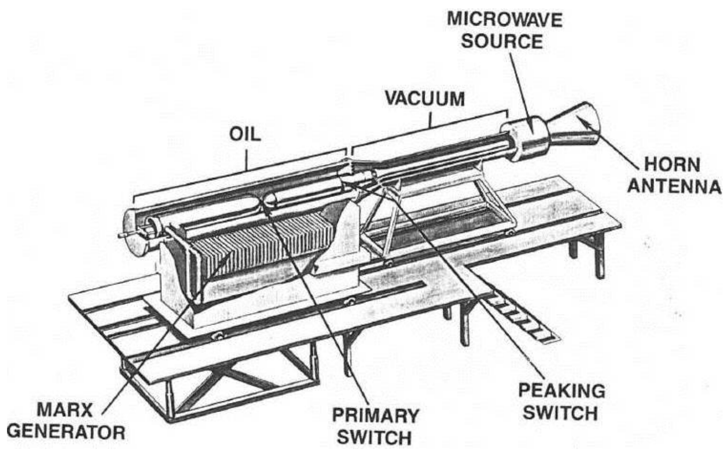
NNSA National Nuclear Security Administration

Acronyms

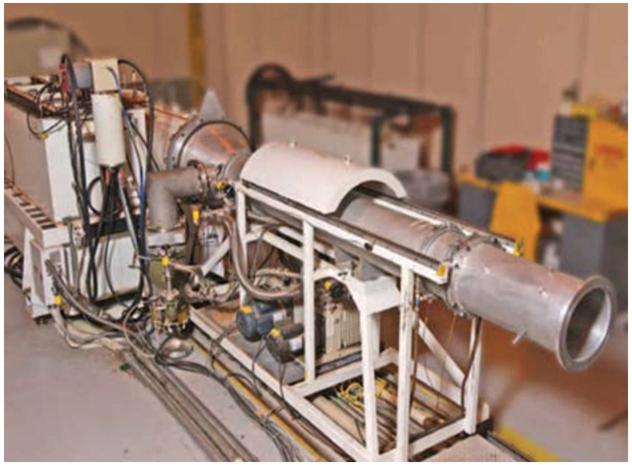
- CVR: Current Viewing Resistor
- MITL: Magnetically Insulated Transmission Line
- PFL: Pulse Forming Line
- SNL: Sandia National Laboratories
- V–dot: Capacitive Voltage Monitor

Introduction

- The Short Pulse High Intensity Nanosecond X–radiator (SPHINX) accelerator is used to study the response of electronics to pulsed x–ray and electron environments. SPHINX was designed and built by Pulse Sciences, Inc. and delivered for use to Sandia National Laboratories in January of 1986. The compact pulsed–power design allows SPHINX to have an adjustable output pulse width from 3 to 10 ns at a 2–MV peak. The original intention of SPHINX was to be a pulsed high–power microwave system. SPHINX is now used as an electron beam and bremsstrahlung accelerator with the capability of producing 12 shots a day.

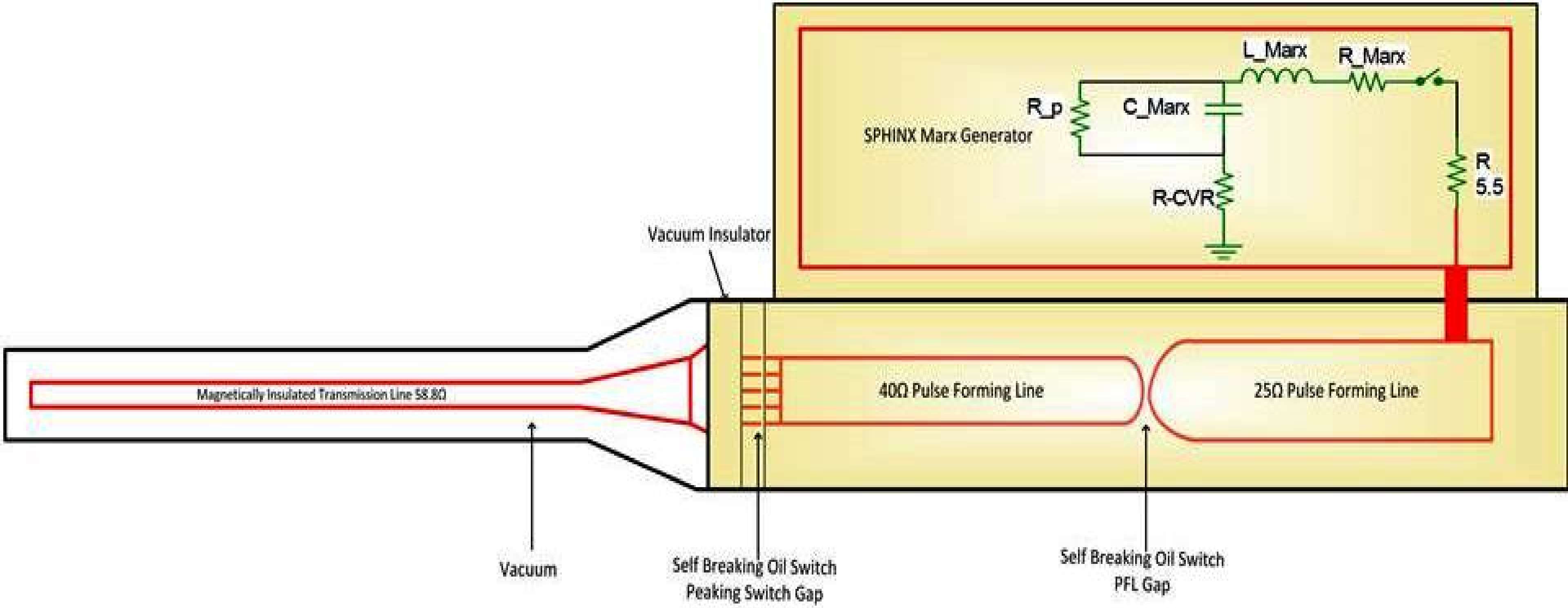


Original Design



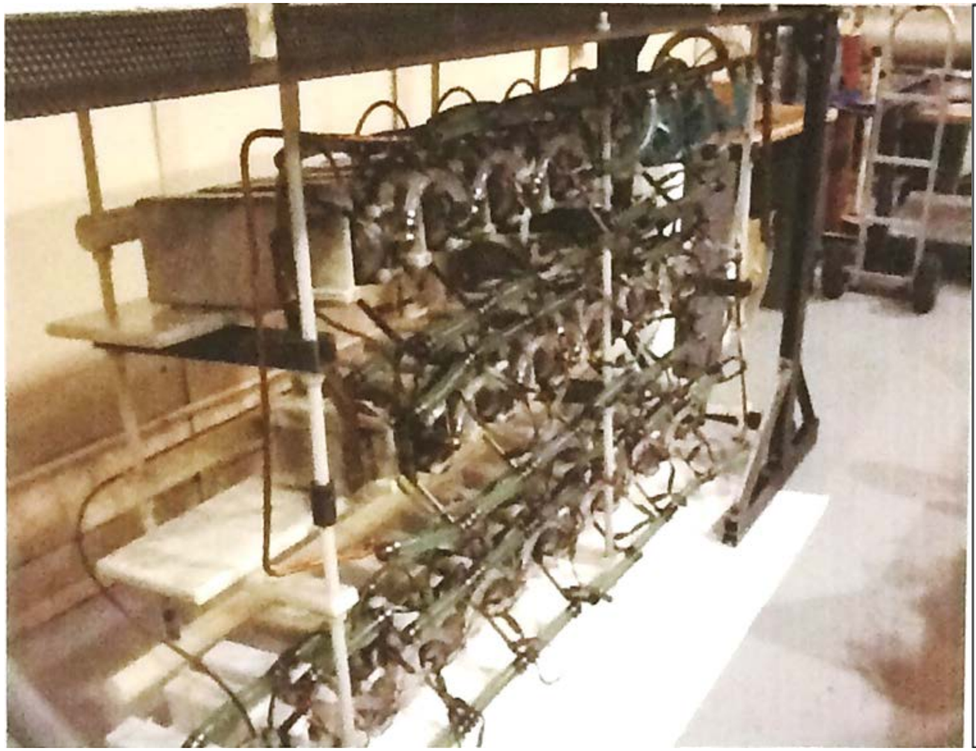
Current Configuration

Pulsed Power Design Cont.

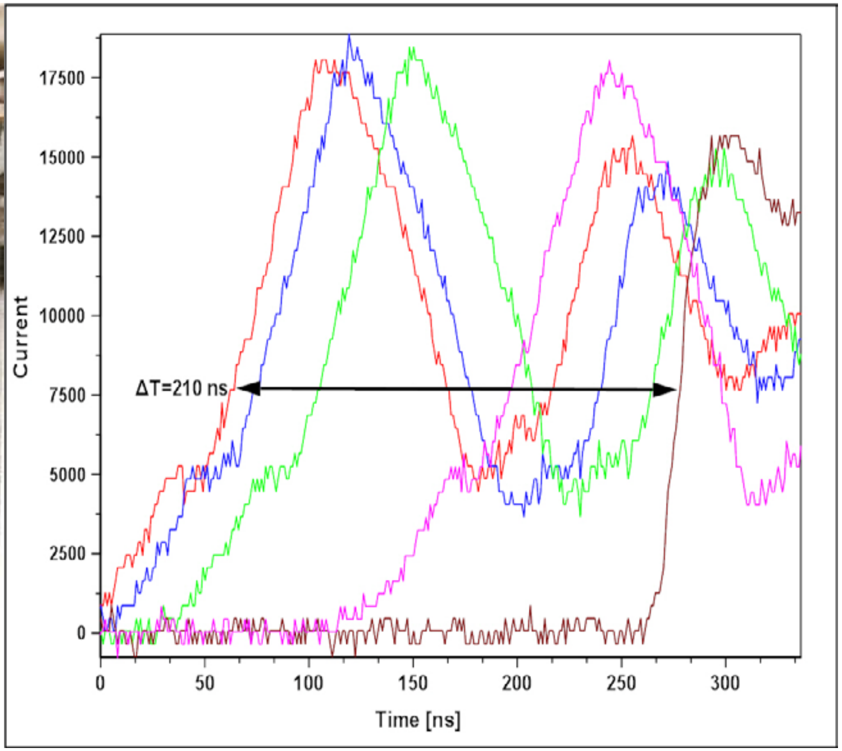


SPHINX Accelerator

Problem Statement Cont.



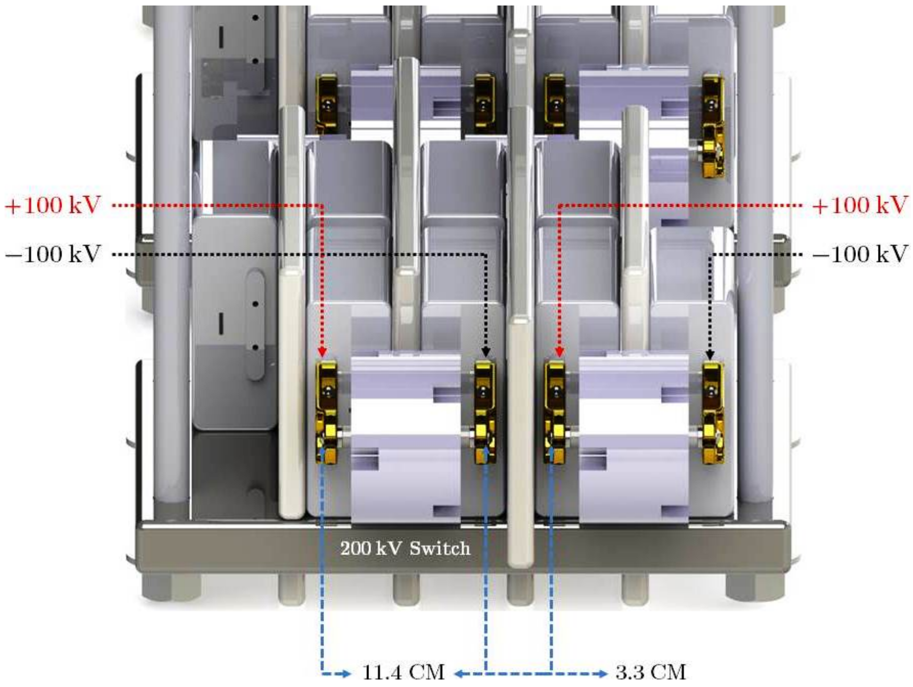
SPHINX Marx



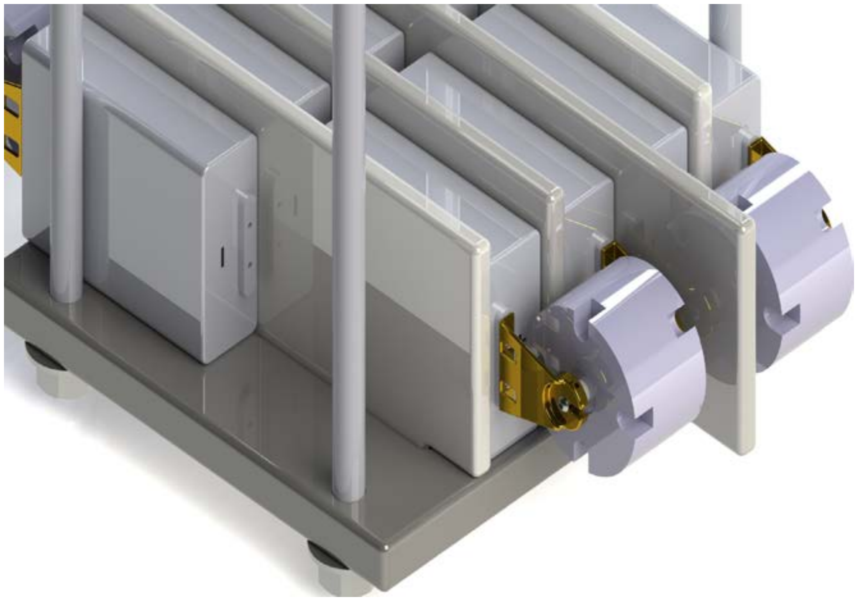
SPHINX Marx Timing Spread

SPHINX Marx (Old System)

Enhancements Cont.

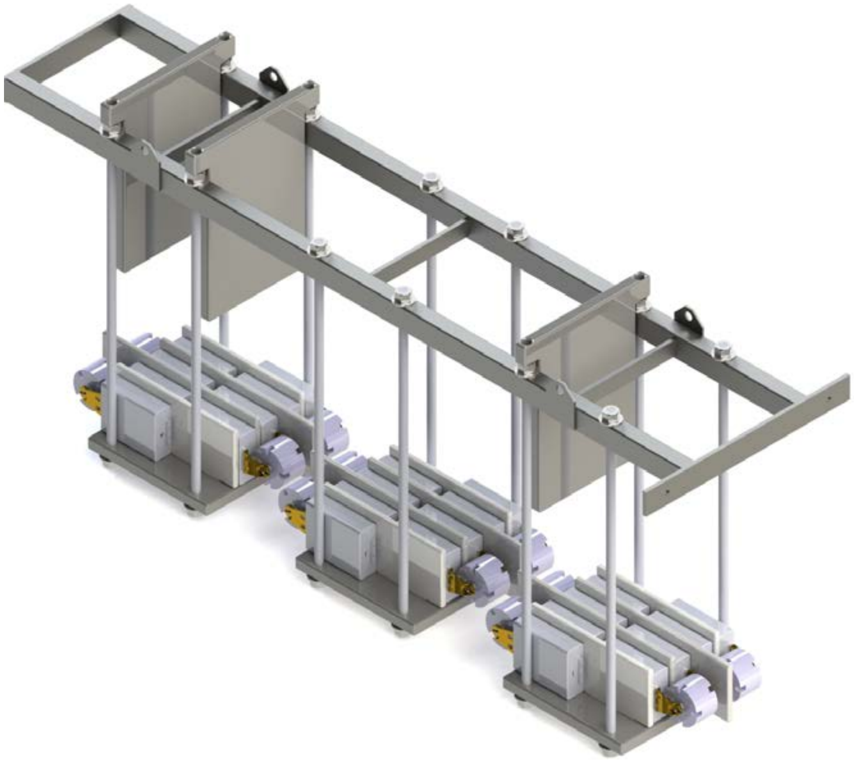


SPHINX Marx Switches (Front View)

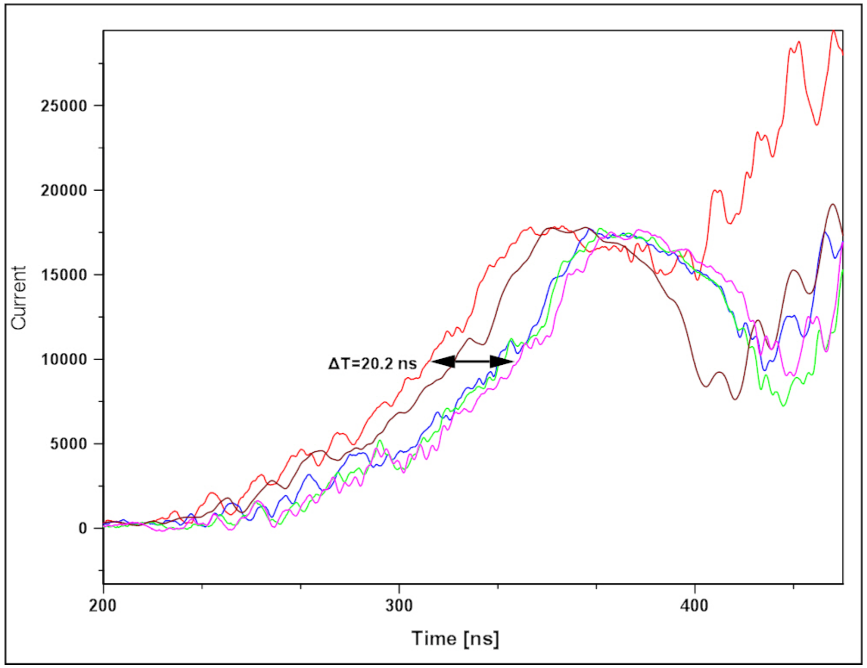


SPHINX Marx Switches (Side View)

Enhancements Cont.



SPHINX Marx

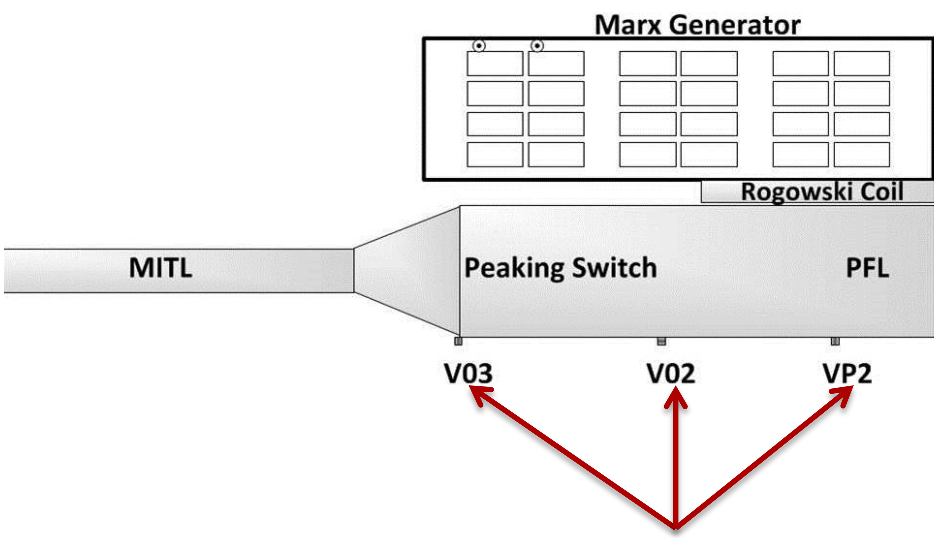


SPHINX Marx Timing Spread

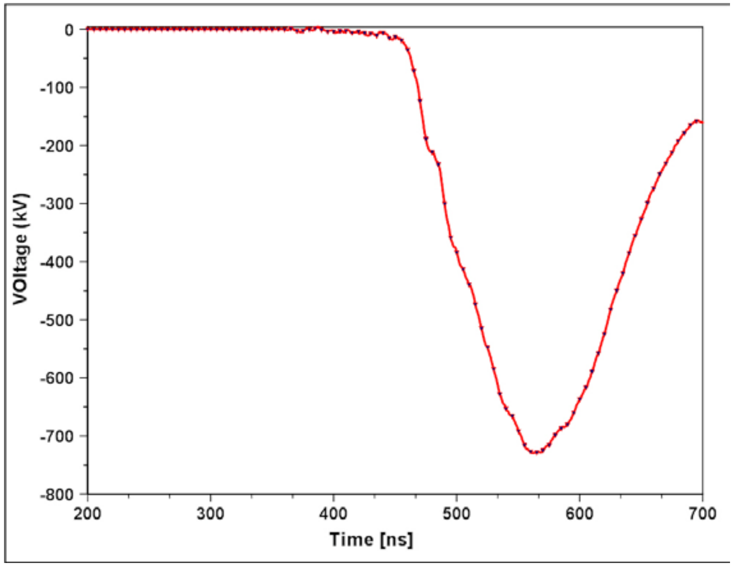
SPHINX Marx (New System)

Characterization Cont.

- SPHINX has three V–dots located on different sections of the PFL

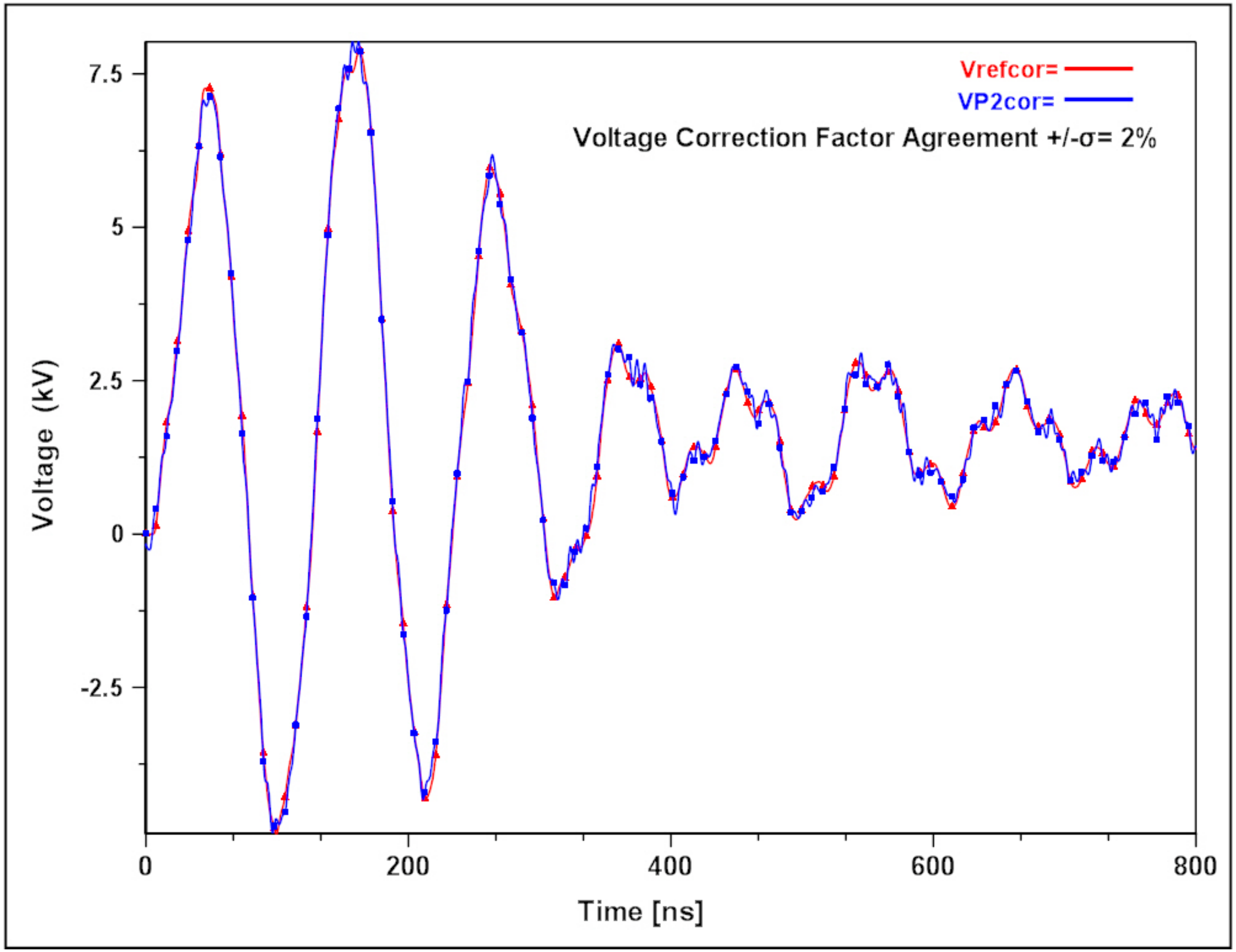


V–dots



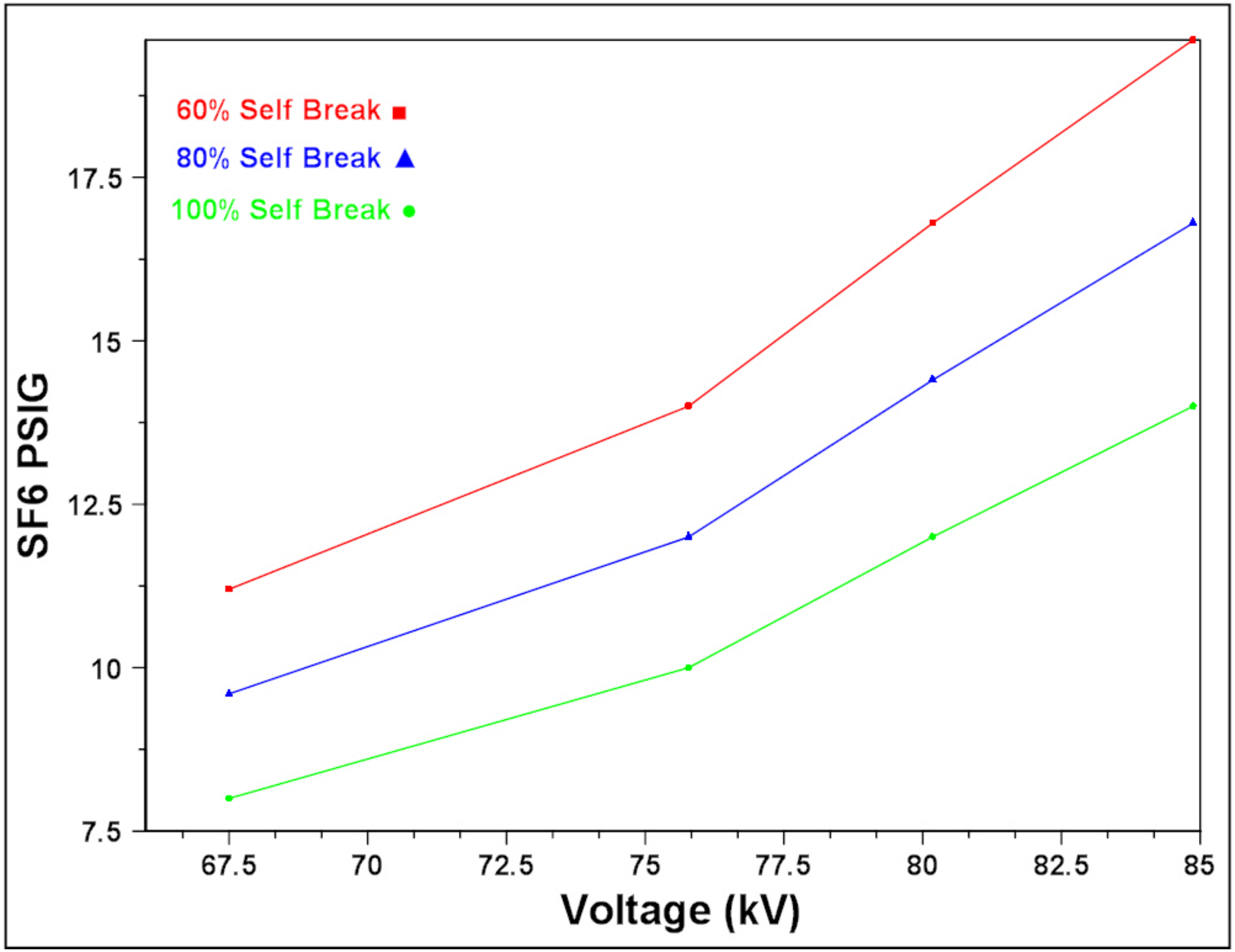
VP2 Wave Form

Characterization Cont.



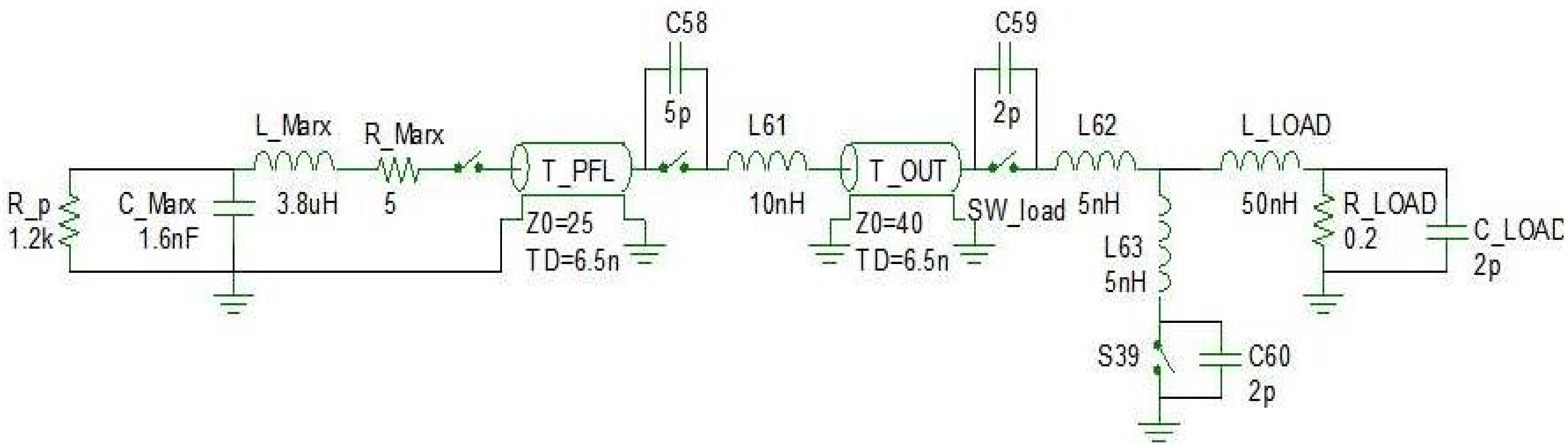
V–dot reference corrected waveform

Characterization Cont.



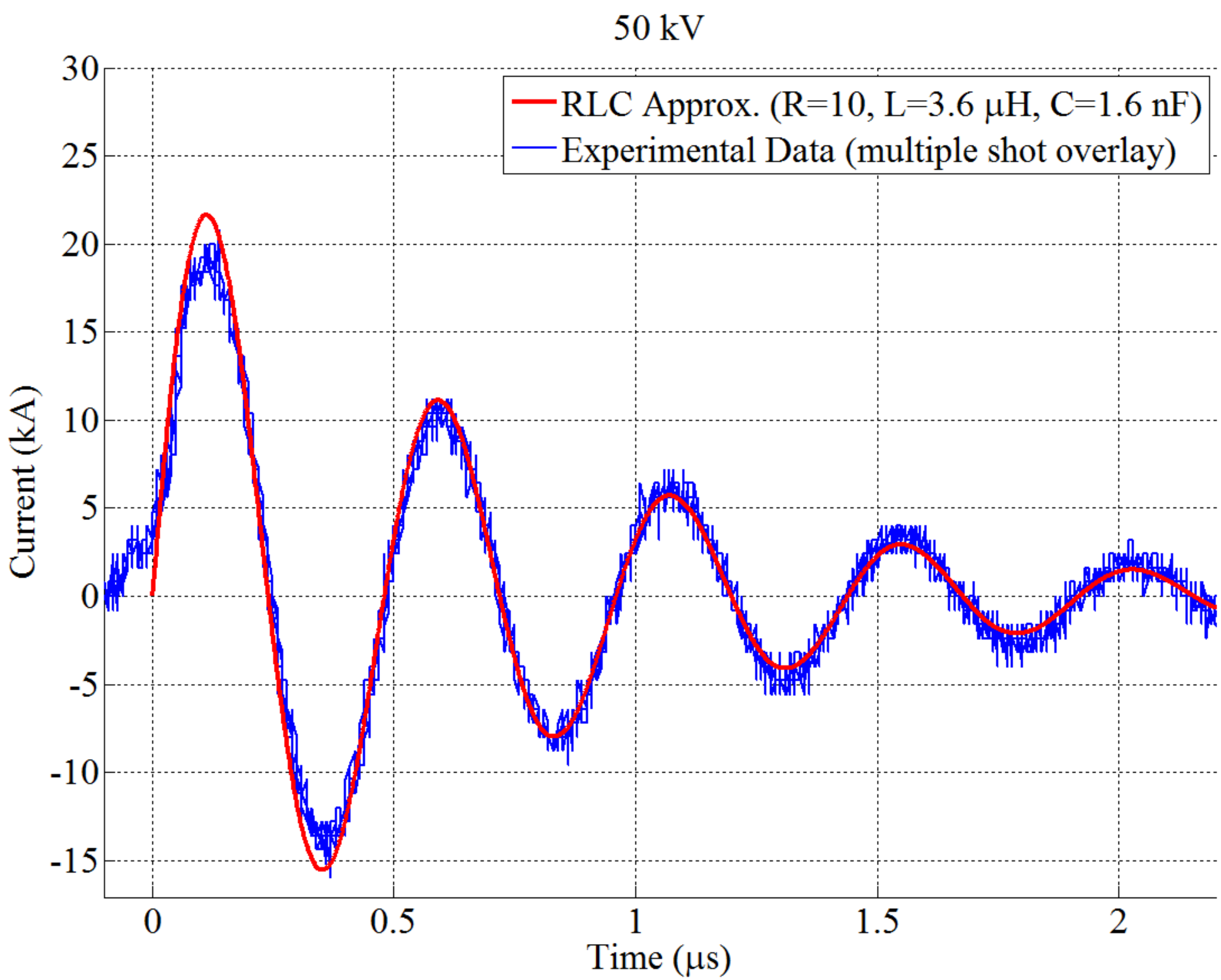
SPHINX Marx Self–Break Curve

Characterization Cont.



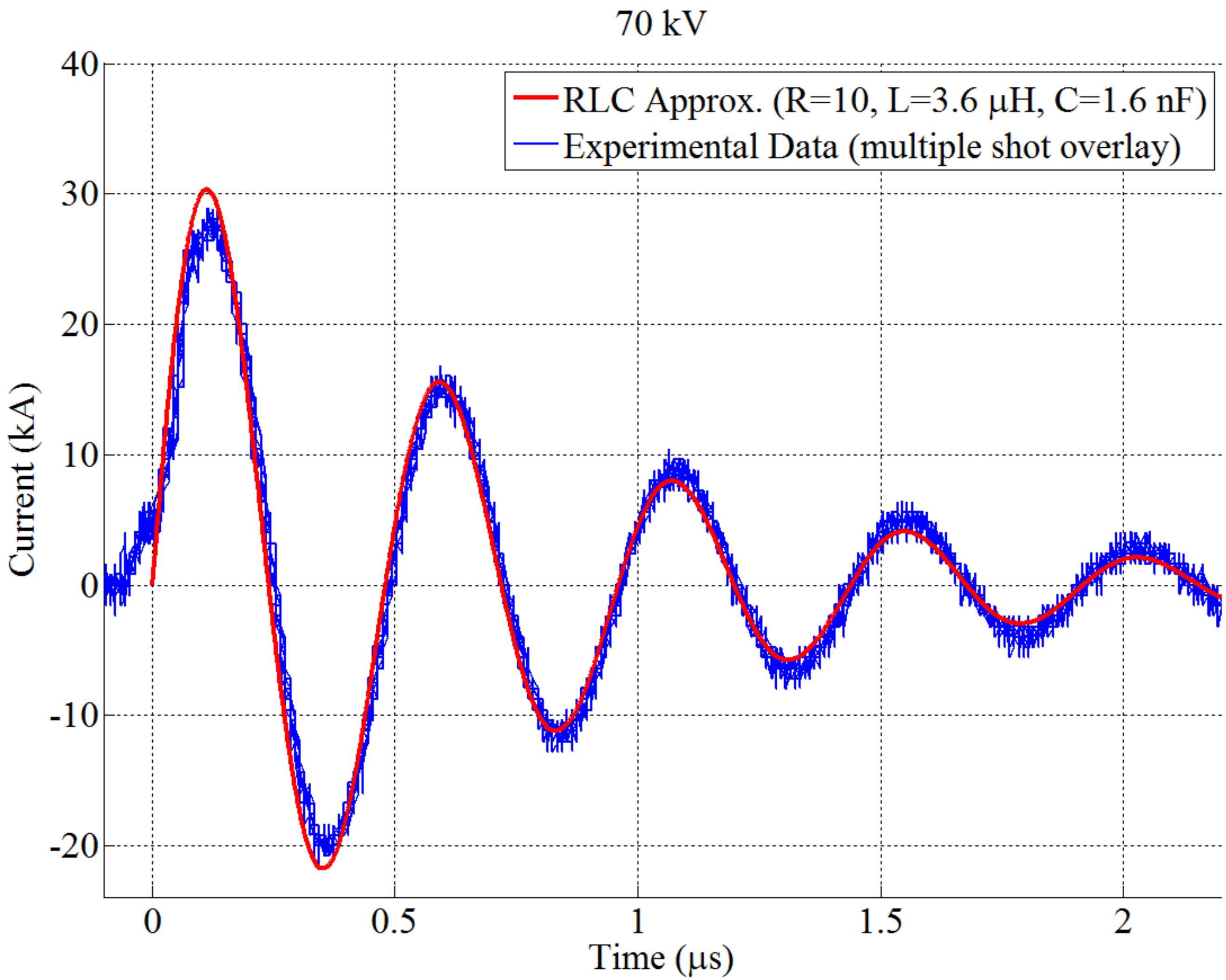
SPHINX Simplified Pulsed−Power Circuit

Characterization Cont.



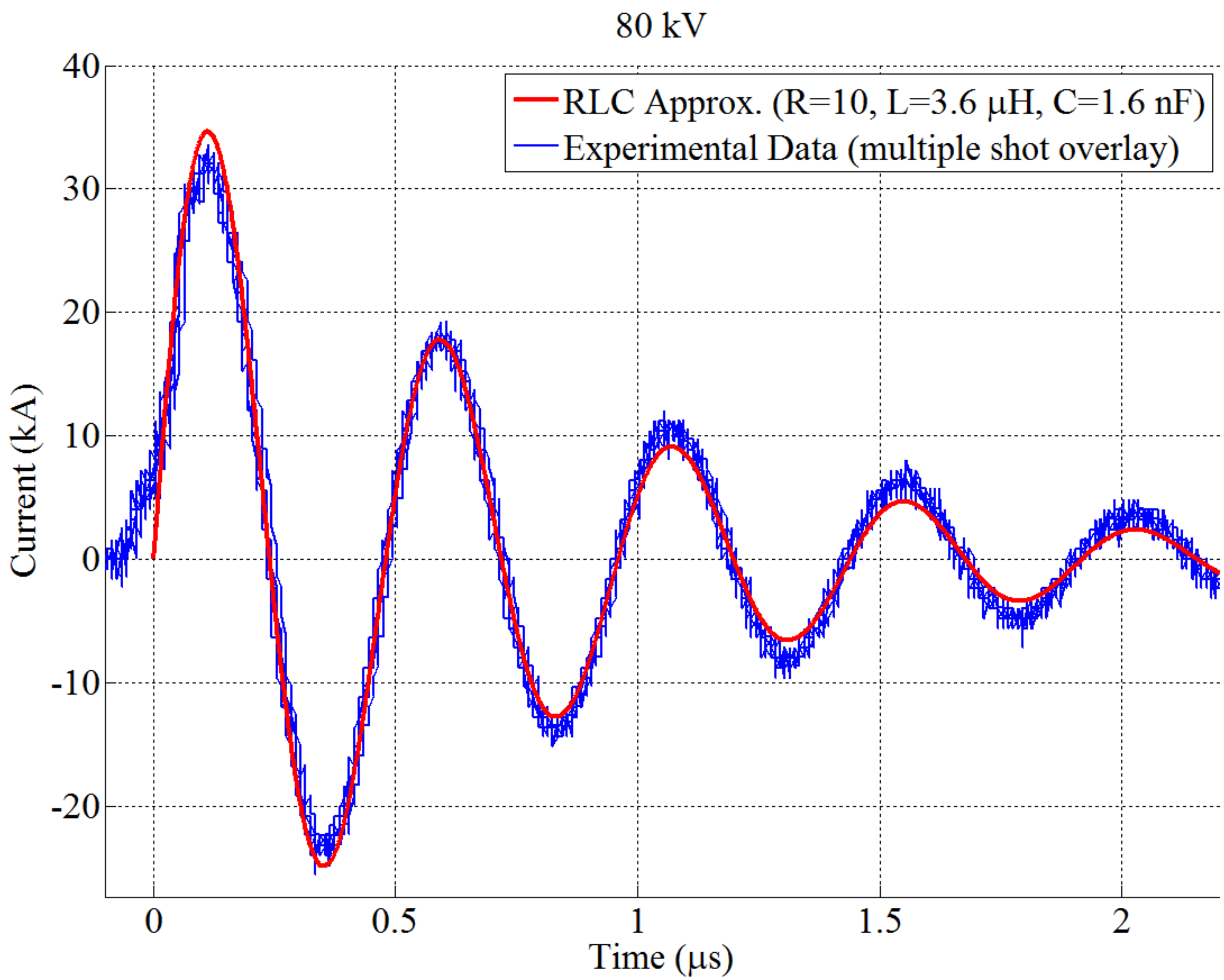
SPHINX Marx CVR Waveform +/– 50 kV

Characterization Cont.



SPHINX Marx CVR Waveform +/− 70 kV

Characterization Cont.



SPHINX Marx CVR Waveform +/– 80 kV

Characterization Cont.

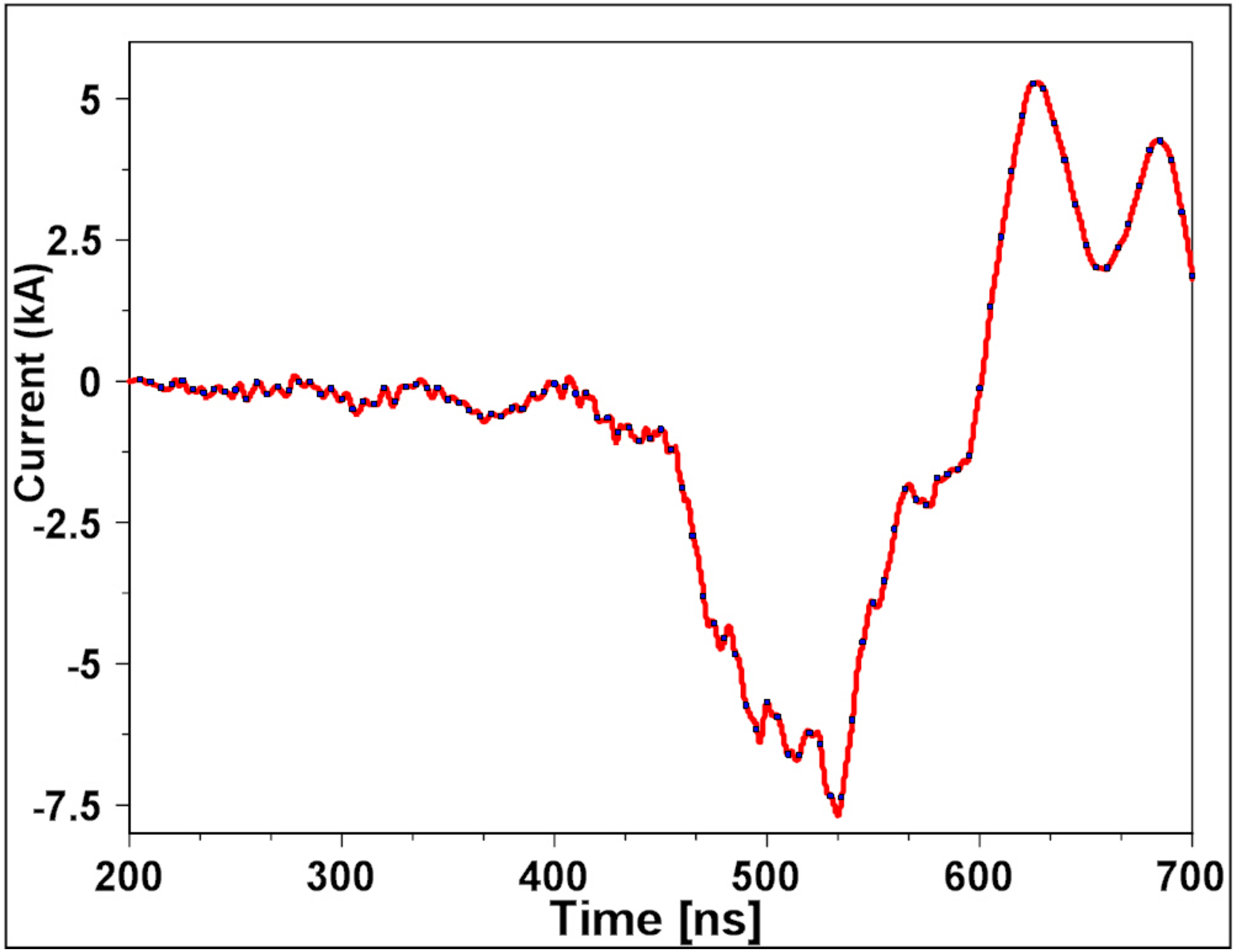
- A ring–over test of the SPHINX PFL was conducted at a Marx charge voltage of +/−32 kV and a SF6 pressure of 5 psi. From the test data, the SPHINX PFL capacitance can be measured.
- Using the Rogowski–coil output current and integrating using Equation (2) the total charge of the SPHINX PFL can be found. With finding peak charge of Rogo(Q) an taking the peak voltage from the VP2 PFL voltage monitor, the total capacitance of the SPHINX PFL can found using Equation (3) and Equation (4).

$$Rogo(Q) = \int_0^t Rogo(I) \qquad (2)$$

$$Q_{\text{PFL}} = C_{\text{PFL}} * VP2_{\text{Peak}} \qquad (3)$$

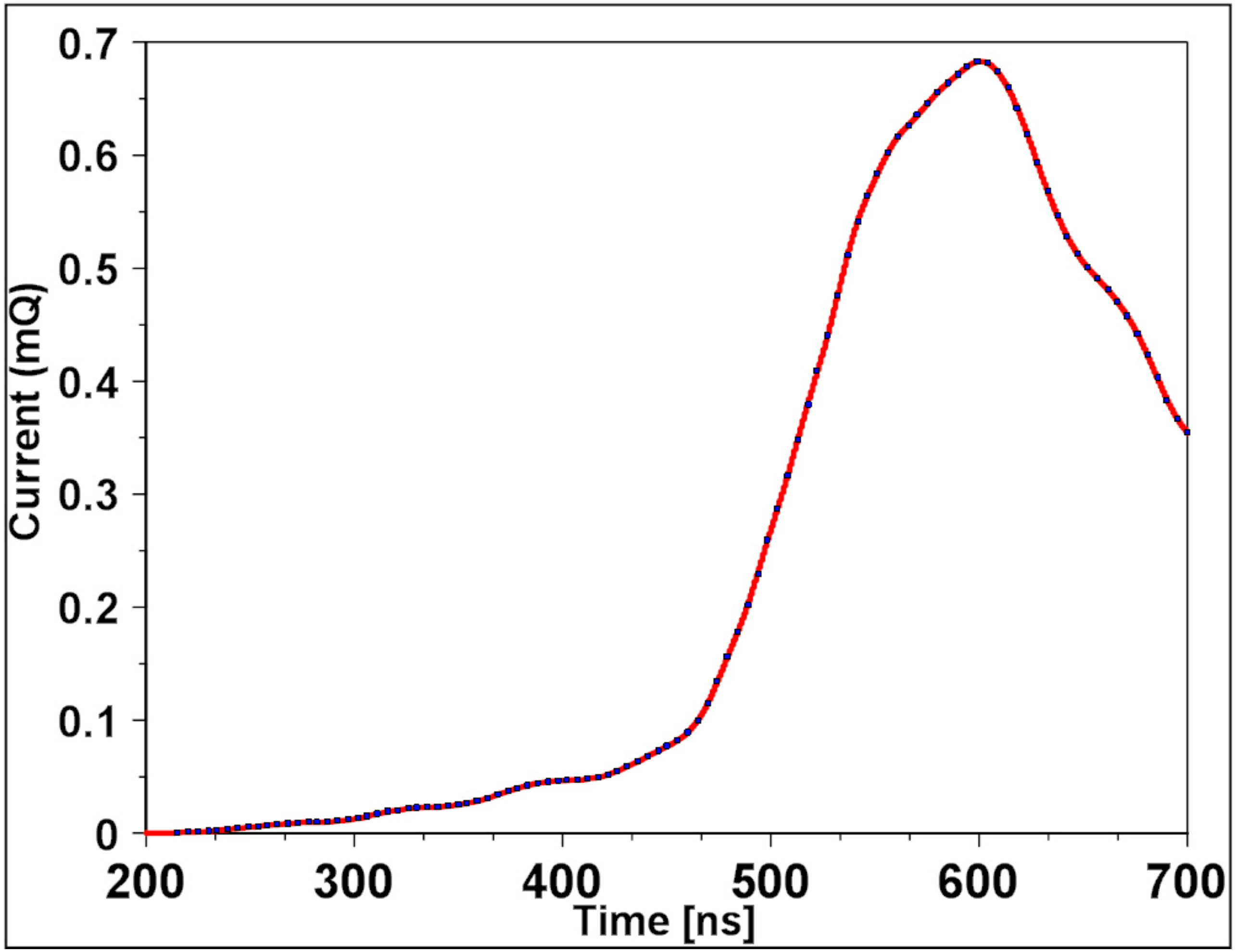
$$C_{\text{PFL}} = Q_{\text{PFL}} / VP2_{\text{Peak}} \qquad (4)$$

Characterization Cont.



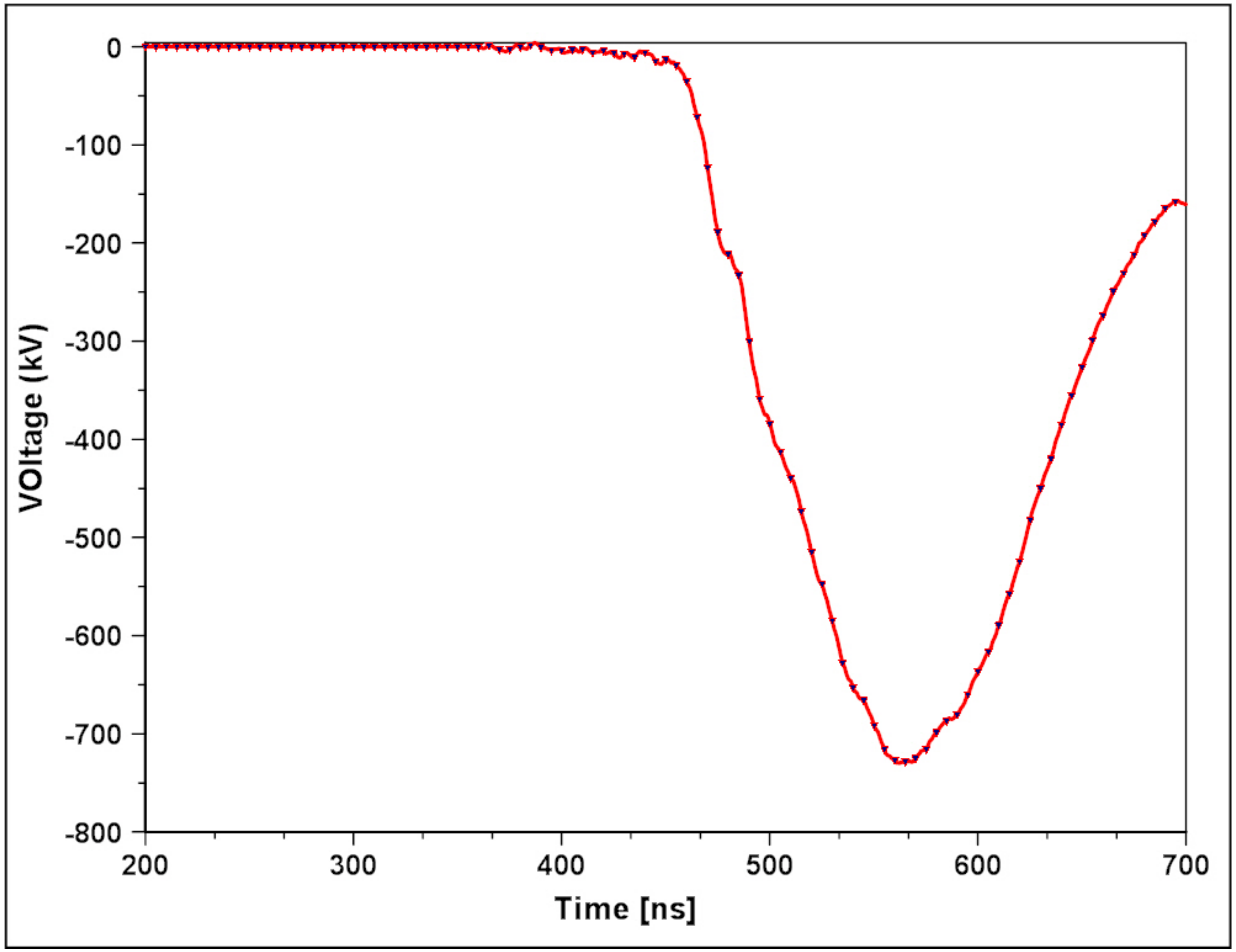
SPHINX Rogowski Coil Current Waveform

Characterization Cont.



SPHINX Rogowski Coil Charge Waveform

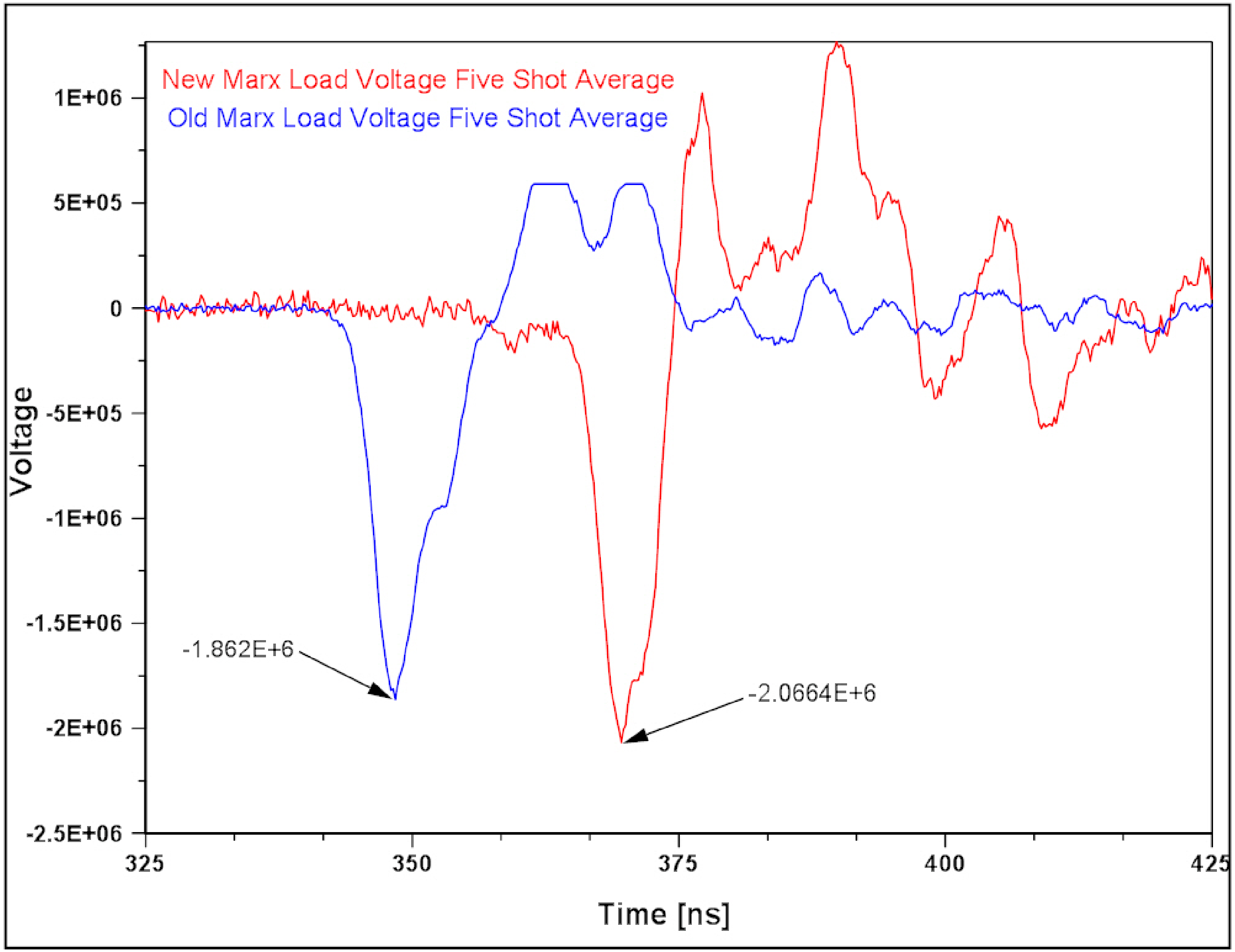
Characterization Cont.



SPHINX V–dot VP2 Waveform

Comparison Cont.

Sandia National Laboratories



SPHINX Marx Output Comparison

Comparison Cont.

TABLE I: SPHINX Marx Values for Comparison Testing

**Relative charge voltage to +/-100 kV*

SPHINX Marx Configuration	Erected Capacitance	Inductance	Charge Voltage
Previous Marx	3.6 nF	7 μH	+/-50 kV*
Redesigned Marx	1.6 nF	3.6 μH	+/- 80 kV

TABLE II: SPHINX Total Output Comparison

SPHINX Marx Configuration	Power Output Jitter +/- σ	Timing Jitter +/- σ
Previous Marx	18.3%	210 ns
Redesigned Marx	0.22%	20.2 ns

SPHINX Marx Design Comparison

References

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