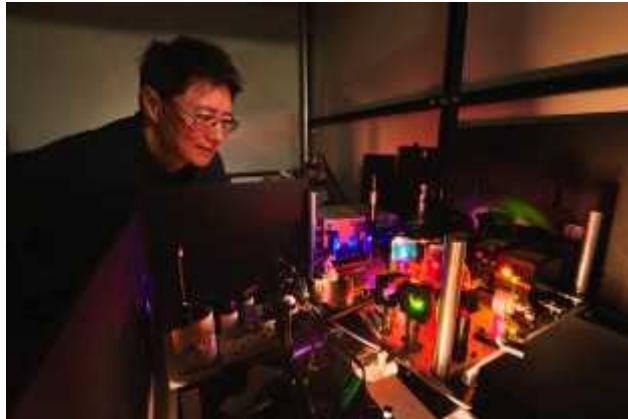
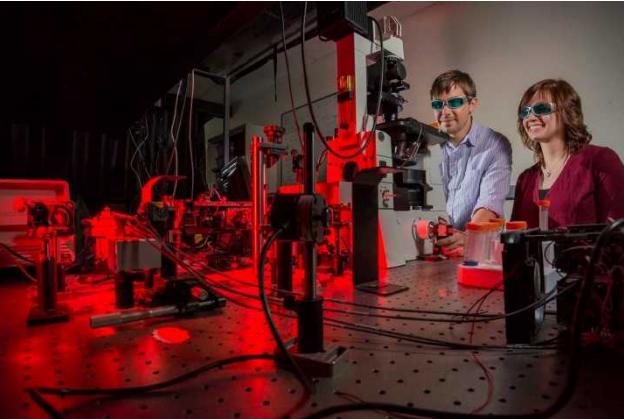


*Exceptional service in the national interest*



# Sandia National Laboratories Tech Talk

F. Murray Fishbeck

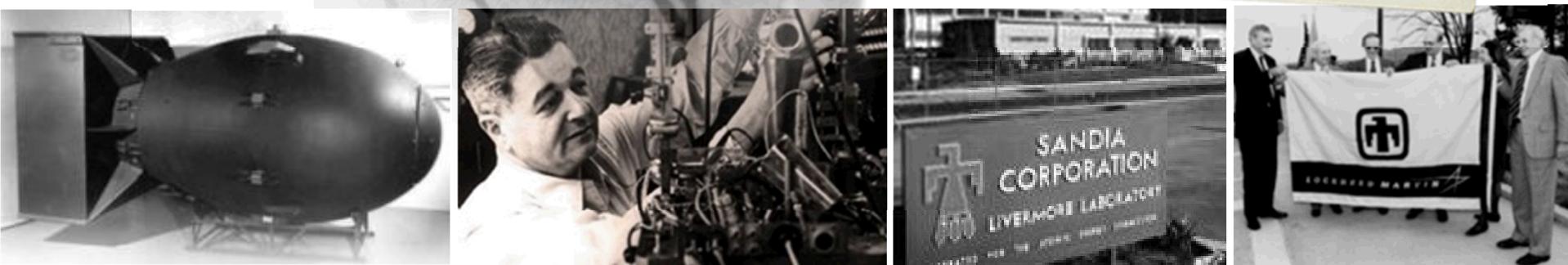
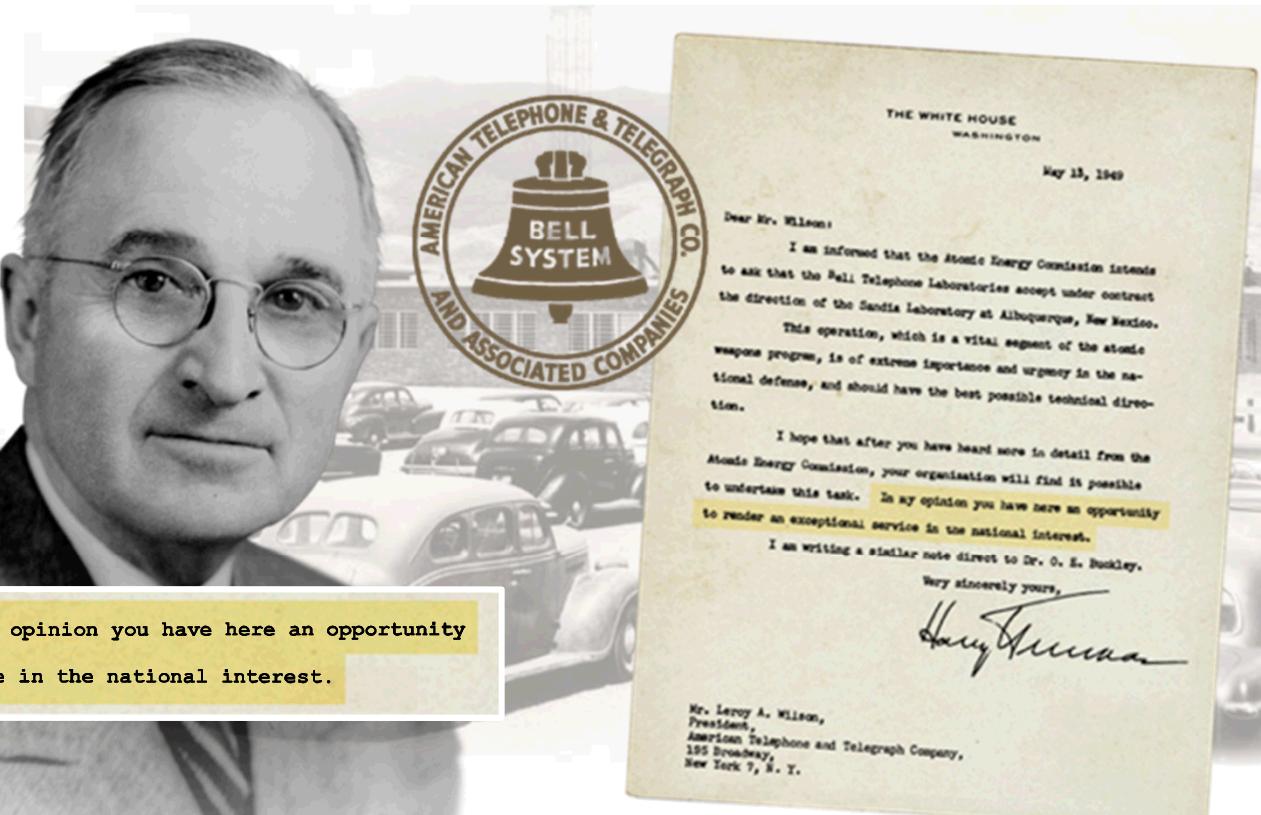


Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# Sandia's History

*Exceptional service in the national interest*

- July 1945: Los Alamos creates Z Division
- Nonnuclear component engineering
- November 1, 1949: Sandia Laboratory established



# Governance of Sandia Laboratories

## Sandia Corporation

- AT&T: 1949–1993
- Martin Marietta: 1993–1995
- Lockheed Martin: 1995–present
- Existing contract expires: April 30, 2017, with a one-year contract extension option
- Government owned, contractor operated



Federally funded  
research and development center

Sandia  
National  
Laboratories

Managed for DOE by Sandia Corporation  
A Lockheed Martin Company

United States  
Department of Energy

National Nuclear  
Security Administration



# Sandia Sites

*Albuquerque, New Mexico*



*Livermore, California*

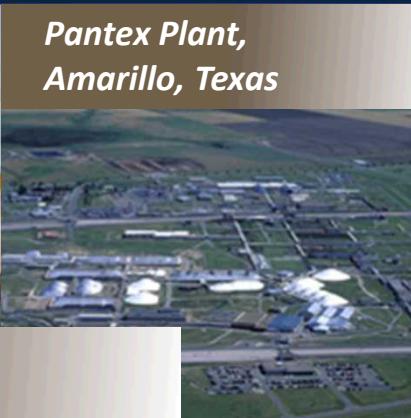


*Kauai, Hawaii*



*Waste Isolation Pilot Plant,  
Carlsbad, New Mexico*

*Pantex Plant,  
Amarillo, Texas*



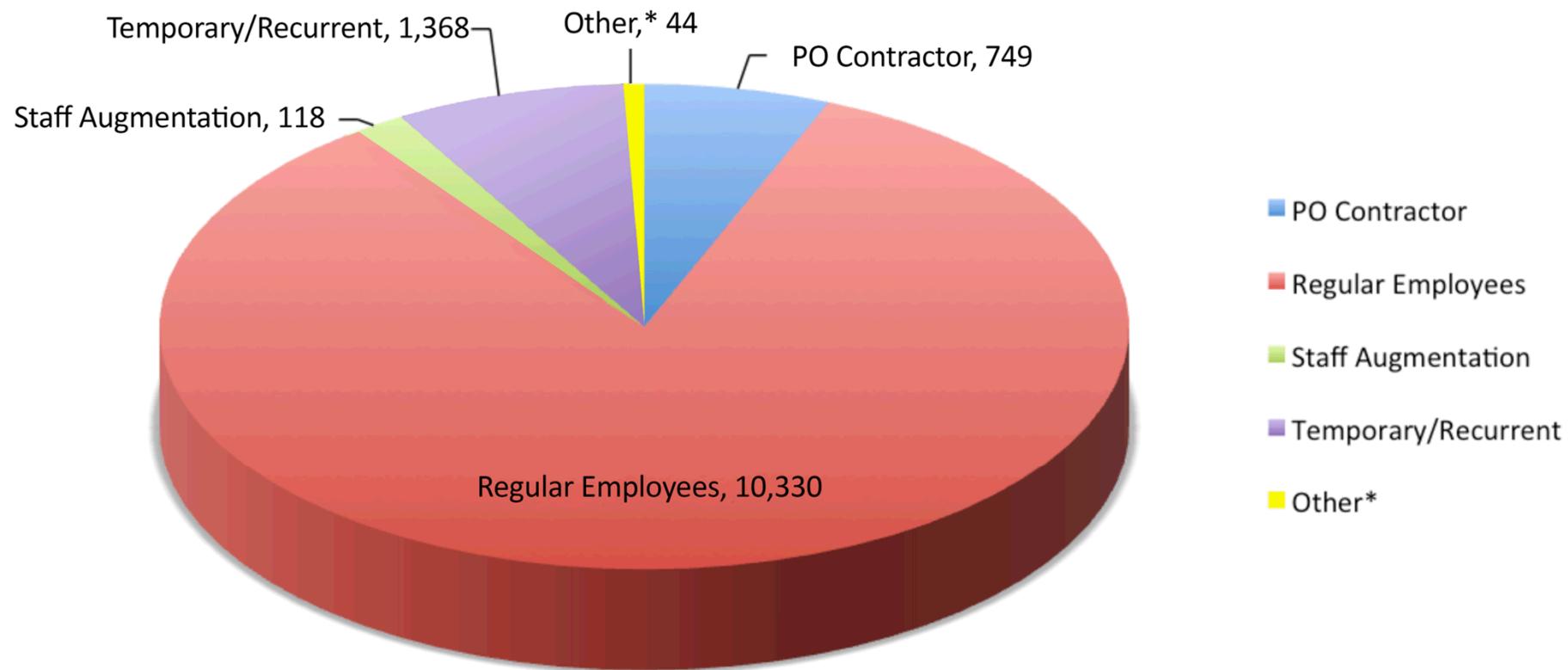
*Tonopah,  
Nevada*



# Our Workforce

- Total Sandia workforce: 12,609
- Regular employees: 10,330
- Advanced degrees: 5,790 (56%)

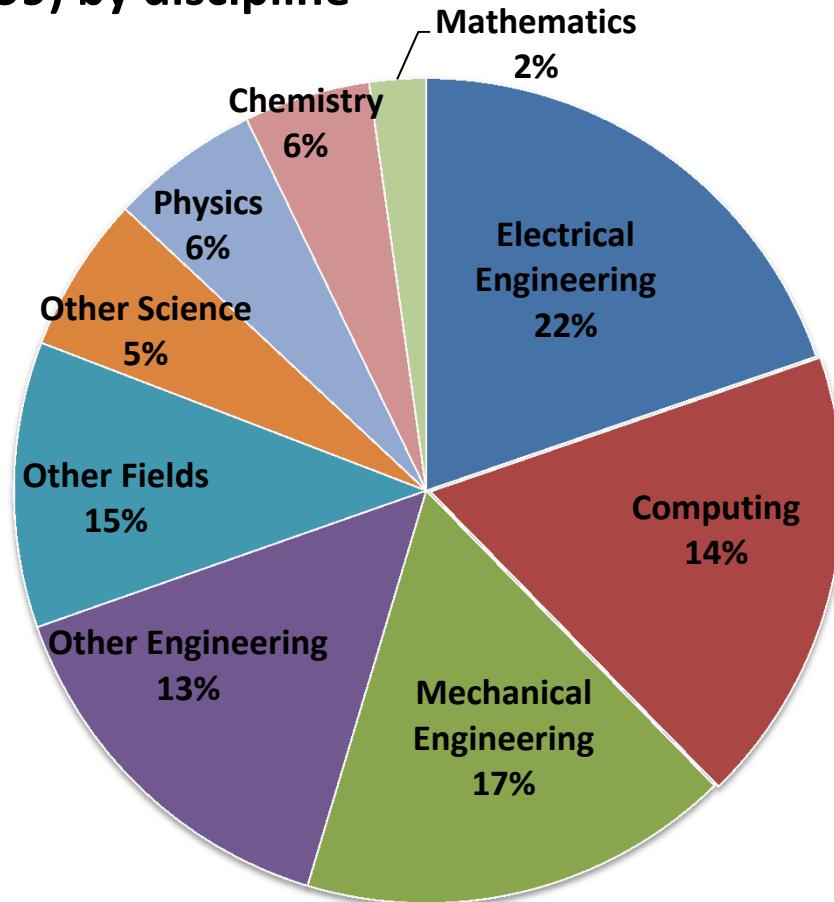
*Data as of July 20, 2015*



\* Other badged personnel

# Research and Development Staff

R&D staff (4,799) by discipline



*Data as of April 12, 2013*

# About Me

- Graduated from Carnegie Mellon University in December 2010 with my Master's of Science in Electrical Engineering
  - Focused on controls and signal processing
    - Linear Systems 18-771, Network Control Systems 18-879S, Advanced Digital Signal Processing 18-792, Machine Learning for Signal Processing 18-797
  - Teaching Assistant for Computer Control Engineering 18-879A



- Graduated from Michigan State University with my Bachelor's of Science in Electrical Engineering with a minor in Mathematics

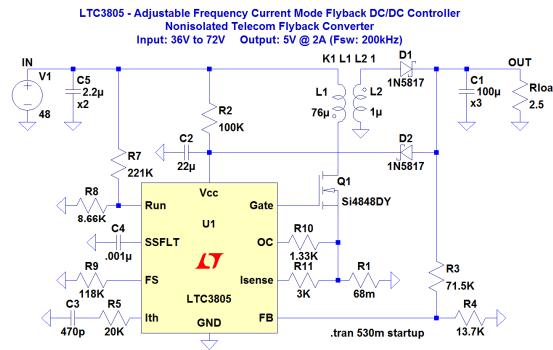
# Transition to Sandia

- Transitioned to circuit design
  - DC-DC converts, DC-AC converts, analog circuits
  - Circuit modeling, schematic capture, Printed Circuit Board (PCB) layout, board population, circuit testing
- Culture of continued learning
  - J-STD-001, Requirements for Soldered Electrical and Electronic Assemblies
  - Project Management Professional (PMP)
- Don't have to be an expert at everything
- Very collaborative environment [team oriented]

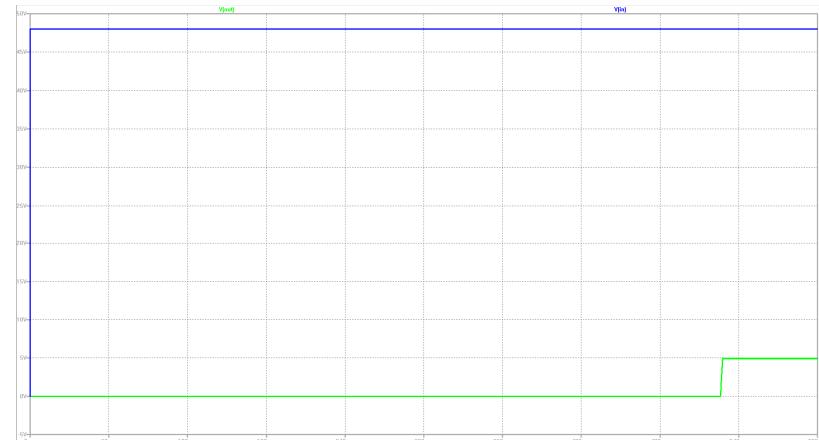


# Tools and Software

- Ability to pick and use software that suites you best
  - MATLAB, MATHCAD, NI Multisim, PSpice, LTspice, Tanner Spice
  - Sandia covers software training classes to improve your efficiency with the tool
- The design process is very iterative
  - Model the circuit to get expected performance
  - Built and test the circuit to utilize data to update and improve the model



**Notes:**  
 To reduce simulation time a smaller value for the SS capacitor has been used; please refer to the datasheet for typical values.  
 If the simulation model is not found, please update with the "Sync Release" command from the "Tools" menu.  
 It remains the customer's responsibility to verify proper and reliable operation in the actual application.  
 Component substitution and printed circuit board layout may significantly affect circuit performance or reliability.  
 Contact your local sales representative for assistance. This circuit is distributed to customers only for use with LTC parts.  
 Copyright © 2012 Linear Technology Inc. All rights reserved.



# Labs and Test Equipment

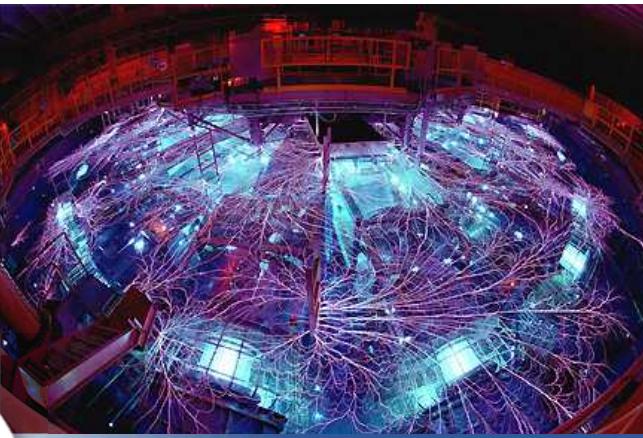
- Our labs have state of the art test equipment
- We have some of the best lab technologist support personal
- Build custom testers to support our design needs
  - LabVIEW, TestStand
- Personnel safety is our highest priority
  - High Voltage Safety



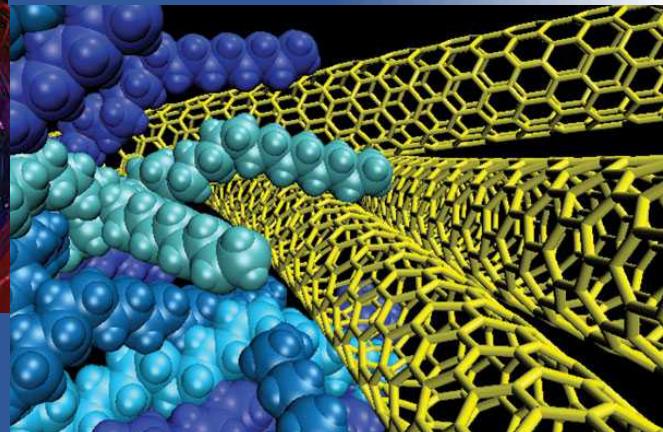
# Our Research Framework

*Strong research foundations play a differentiating role in our mission delivery*

## Computing & Information Sciences

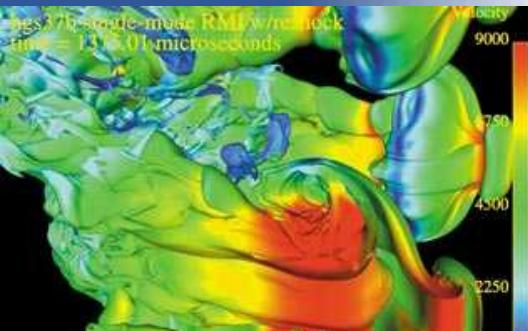


## Materials Sciences



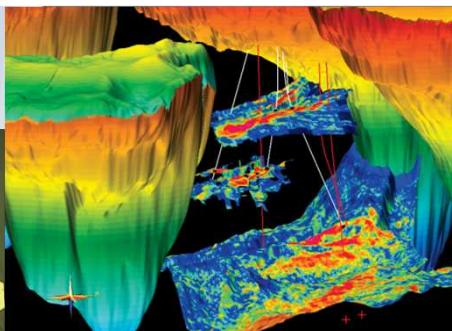
## Radiation Effects & High Energy Density Science

## Engineering Sciences



## Bioscience

## Nanodevices & Microsystems



## Geoscience

# DC-DC Convert Overview

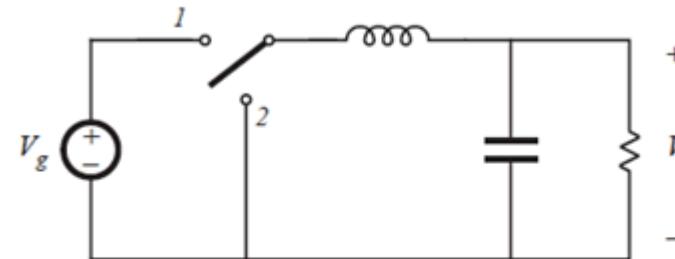
- Converts one voltage level to another level

- Types

- Non-isolated
    - Buck (Step Down)
    - Boost (Step Up)
  - Isolated
    - Flyback

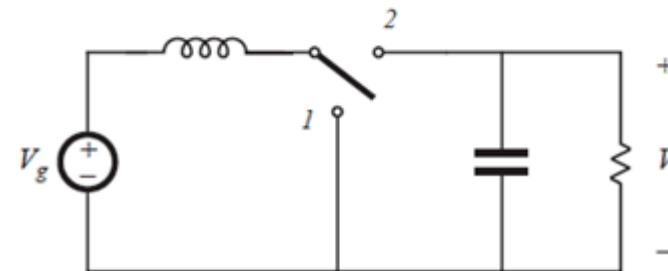
*Buck*

$$M(D) = D$$



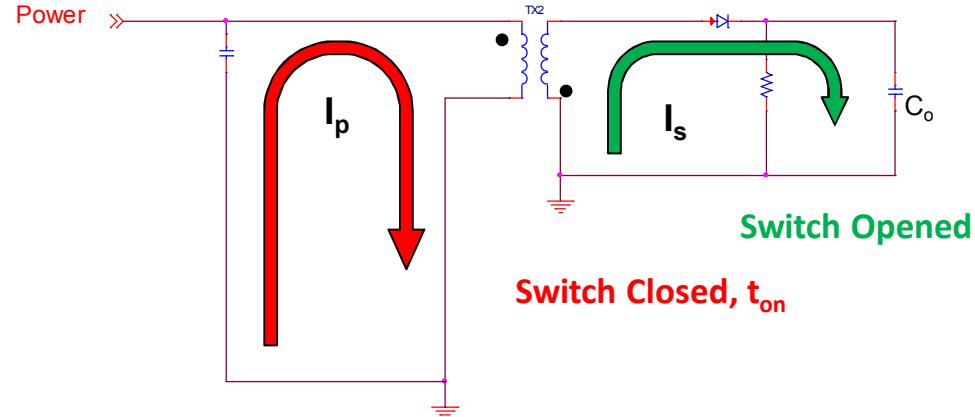
*Boost*

$$M(D) = \frac{1}{1 - D}$$



# Flyback Basics

- Flyback transformer is basically an inductor coupled to another isolated inductor
- During input current application, energy is stored in the system. When input current removed, stored energy coupled to the output winding
- Current does NOT flow from primary to secondary at the same time



$$\text{Peak Inductor Current, } \frac{1}{L_p} \int_0^{t_{on}} V_s \, dt = I_p$$

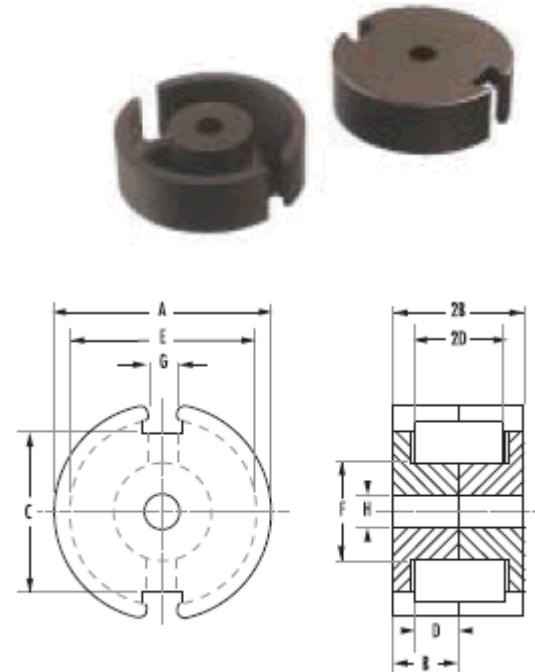
$$\text{Energy per Pulse, } \frac{1}{2} L_p I_p^2 = E_{Lp}$$

$$\text{Time to Charge up, } t_{ch} = \frac{TC_o V_o^2}{2E_{Lp}} \quad T = \text{Period}$$

$$\text{Maximum Output, } V_o = I_p \sqrt{\frac{L_p}{C_s}} \quad \begin{matrix} C_s = \text{Transformer} \\ \text{Secondary Capacitance} \end{matrix}$$

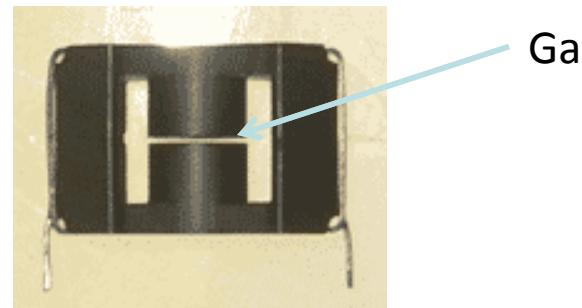
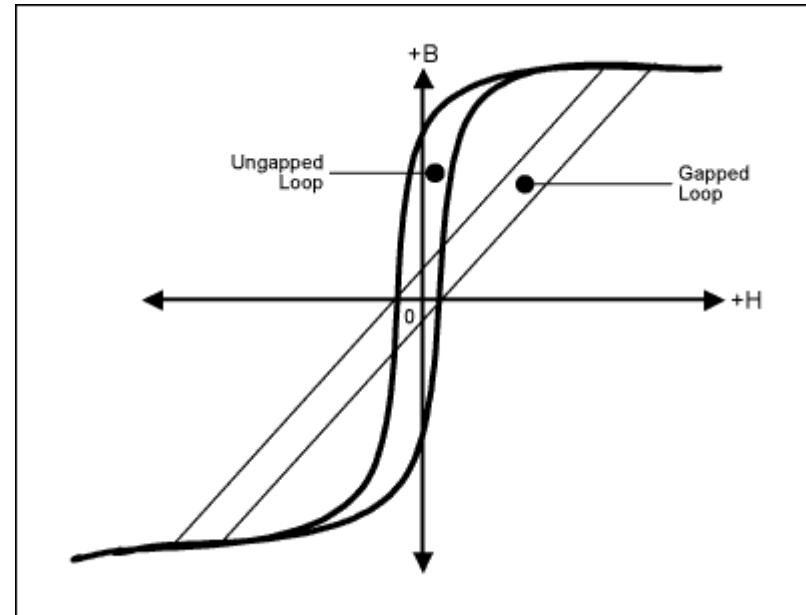
# Magnetic Pot Core

- Path for magnetic flux generated by input current
- Gap in center leg
  - Increase onset of saturation with input current (not saturation point)
    - Energy goes up as  $I^2$  and  $L$
  - Temperature stability
- Geometry allows for some measure of EMI shielding since windings are enclosed by core
- Simple assembly

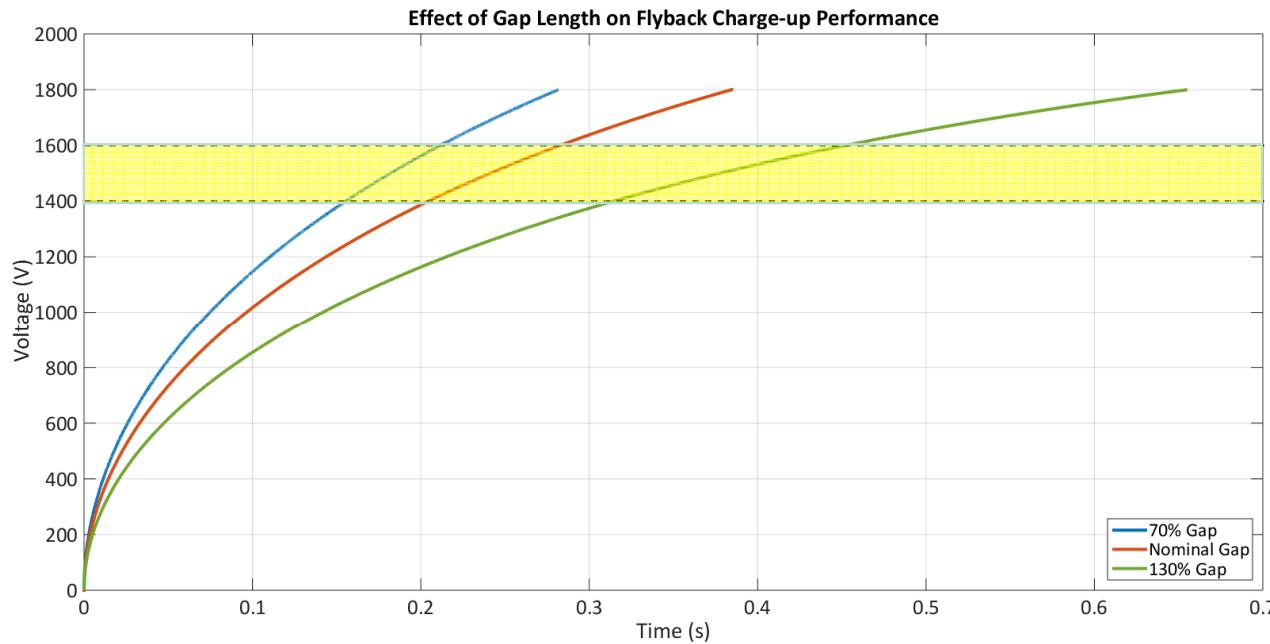


# Importance of the Gap

- Linearizes the BH loop
  - Less sensitive to current and temperature
- Increases field (current) to reach saturation
- Decreases inductance
- Increases allowable energy stored in the system as  $I^2$  vs L



# Calculated Flyback Charging



- Gap calculation takes into account tolerance on inductance target due to manufacturing
- At worst case parameters (input voltage, load capacitance, current, efficiency)

# Summary

- It was a smooth transition from Graduate school to working at Sandia
- Culture of continue learning
- Don't have to be an expert at everything
- Very collaborative environment [team oriented]
- Video - Sandia Labs: Who We Are



# Questions?