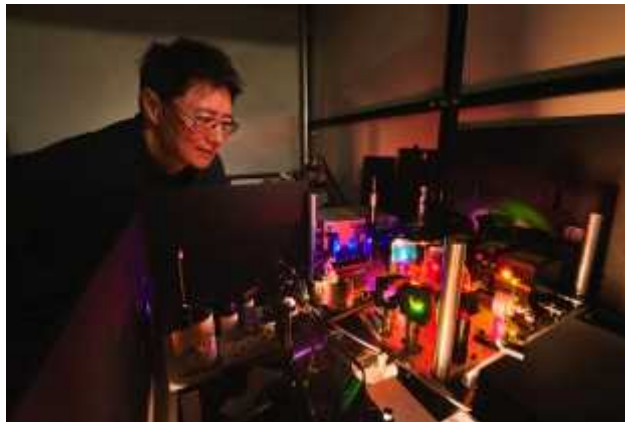
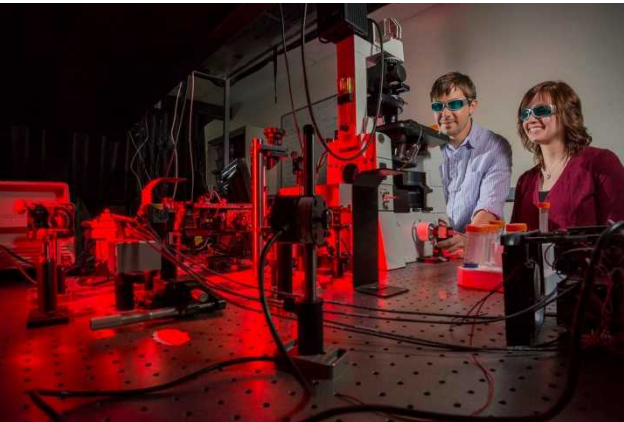


Exceptional service in the national interest



Sandia National Laboratories Tech Talk

F. Murray Fishbeck



U.S. DEPARTMENT OF
ENERGY



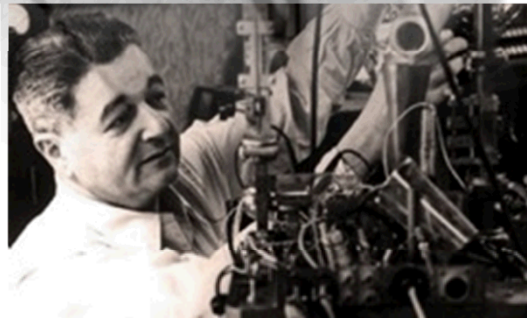
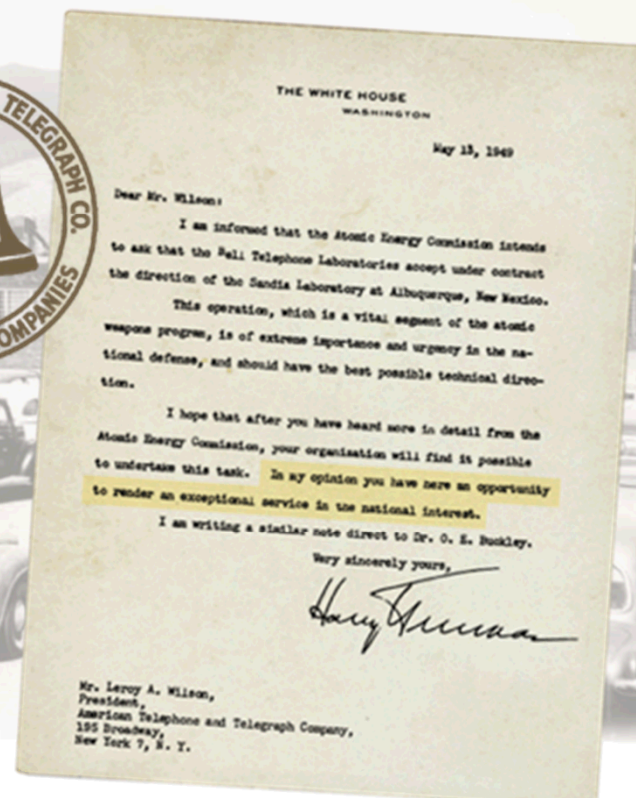
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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

to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.



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 Sites

Albuquerque, New Mexico



Livermore, California



Kauai, Hawaii



*Waste Isolation Pilot Plant,
Carlsbad, New Mexico*



*Pantex Plant,
Amarillo, Texas*



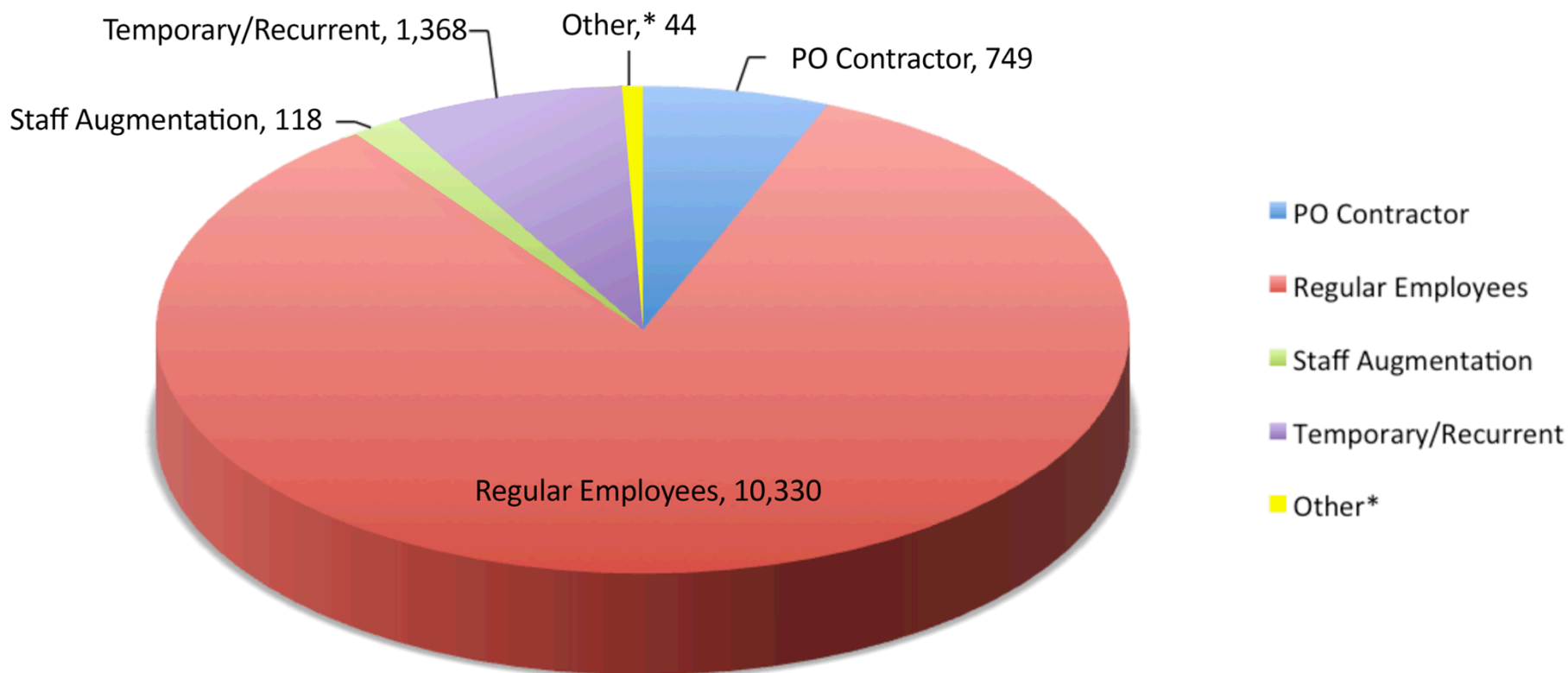
*Tonopah,
Nevada*



Our Workforce

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

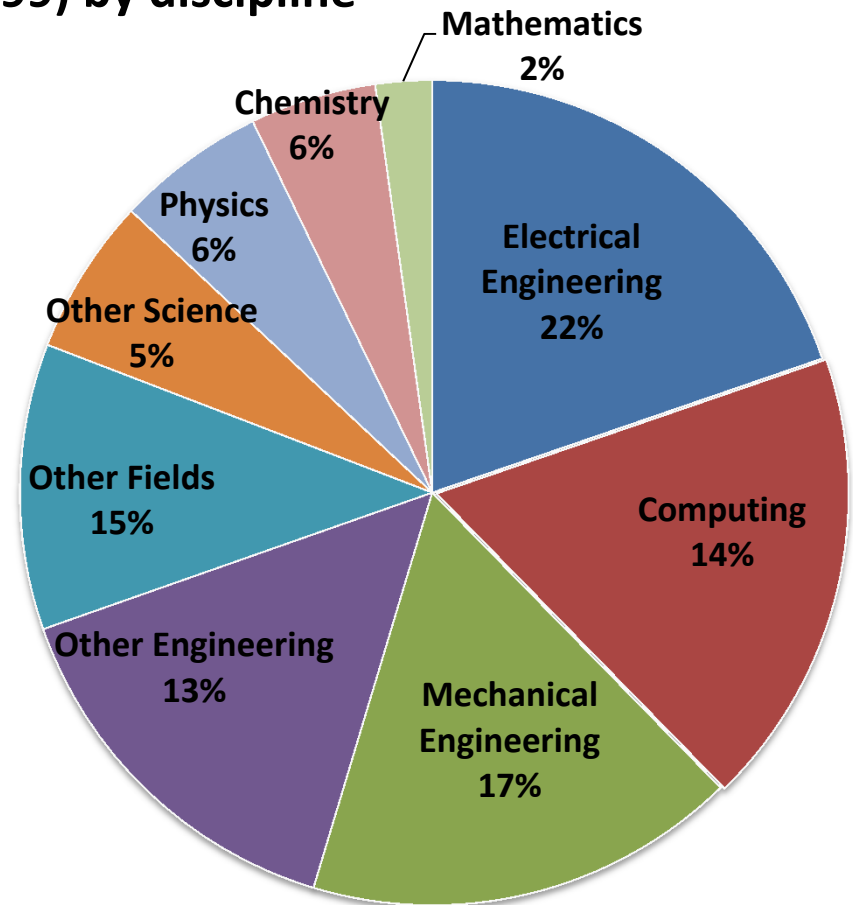
Data as of July 20, 2015



** 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

MICHIGAN STATE UNIVERSITY

College of Engineering

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]

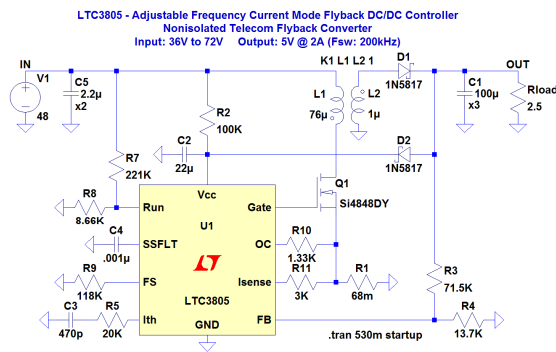


Association Connecting Electronics Industries

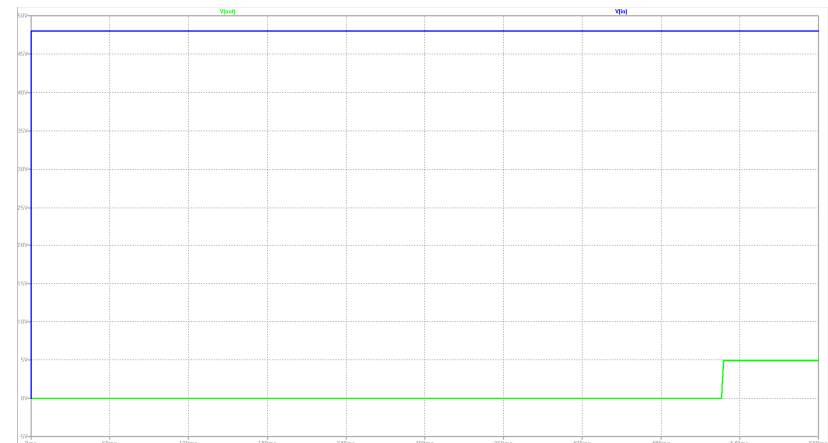


Tools and Software

- 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



Note:
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

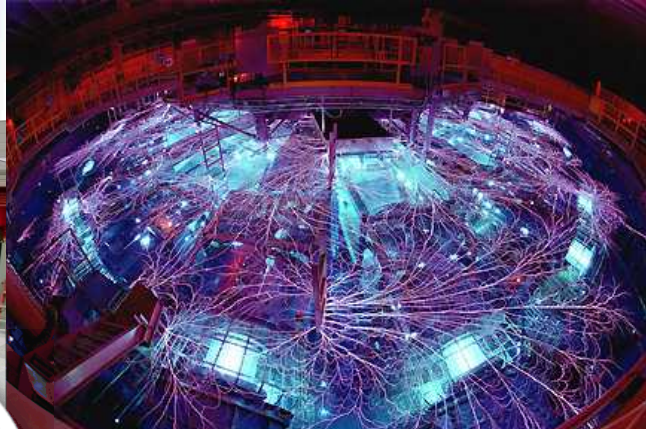
- Our labs have state of the art test equipment
- We have some of the best lab technologist support personal
- Build custom testers to support our design needs
 - LabVIEW, TestStand
- Personnel safety is our highest priority
 - High Voltage Safety



Our Research Framework

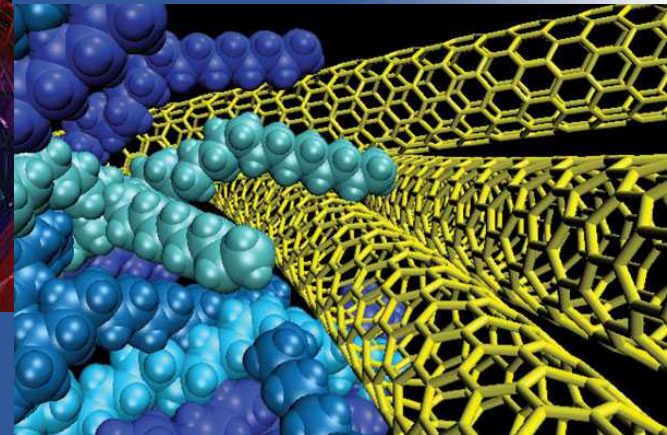
Strong research foundations play a differentiating role in our mission delivery

Computing & Information Sciences

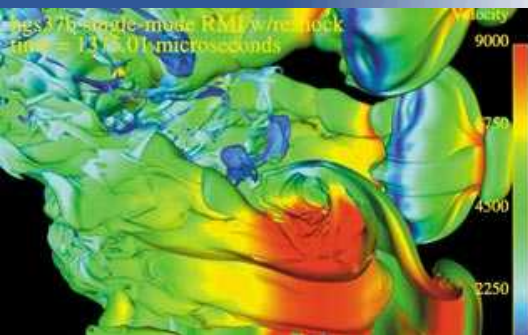


Radiation Effects & High Energy Density Science

Materials Sciences

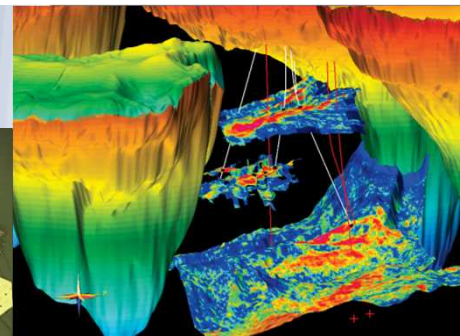
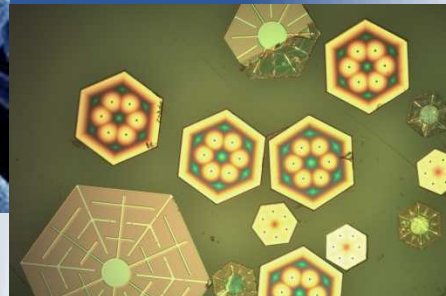


Engineering Sciences



Bioscience

Nanodevices & Microsystems



Geoscience

DC-DC Convert Overview

- Converts one voltage level to another level

- Types

- Non-isolated

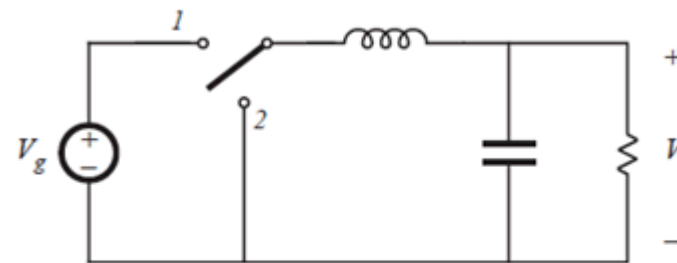
- Buck (Step Down)
- Boost (Step Up)

- Isolated

- Flyback

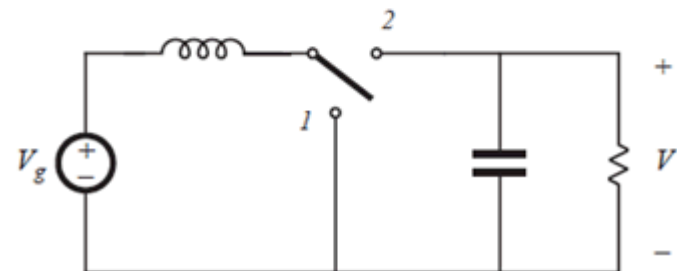
Buck

$$M(D) = D$$



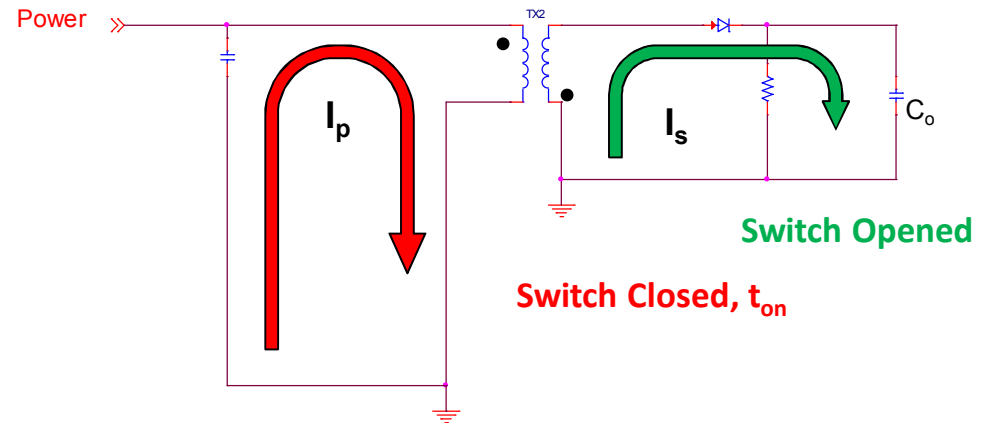
Boost

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



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



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

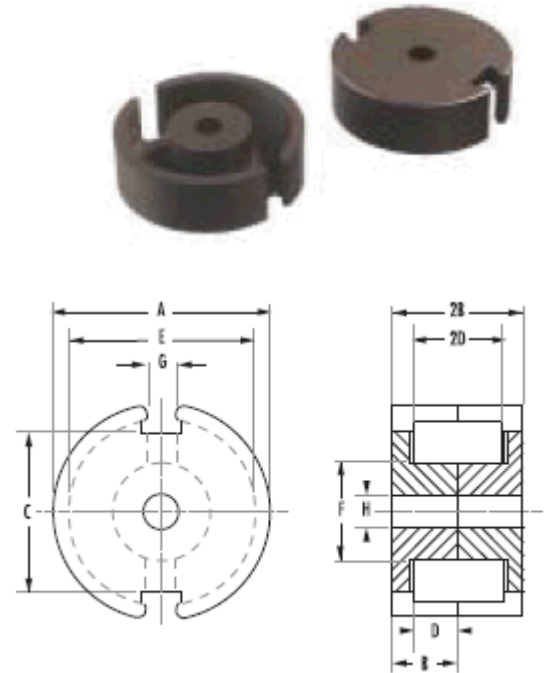
$$\text{Energy per Pulse, } \frac{1}{2} L_p I_p^2 = E_{Lp}$$

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

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

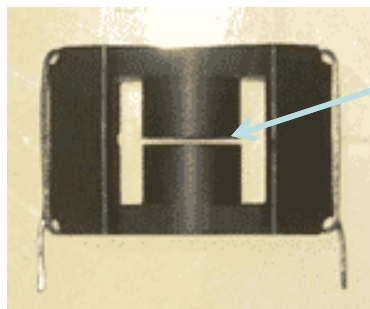
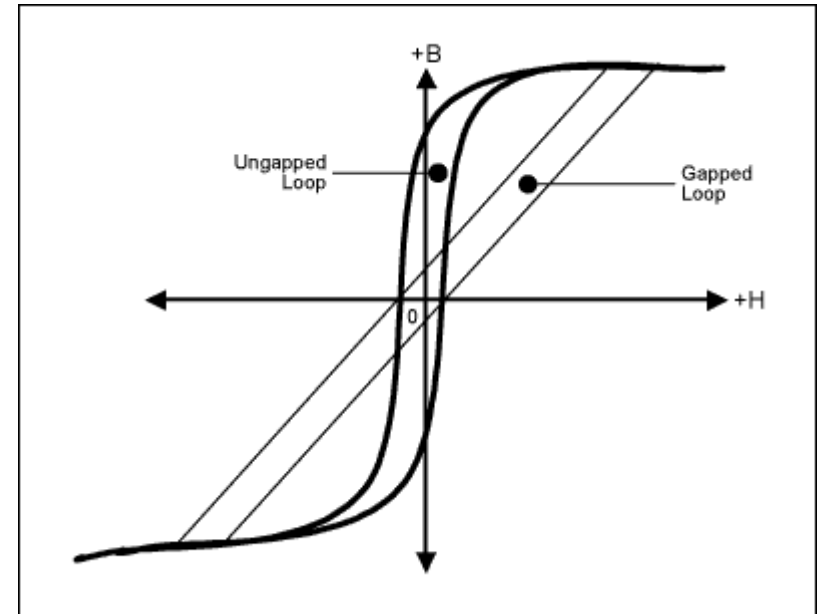
Magnetic Pot Core

- 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



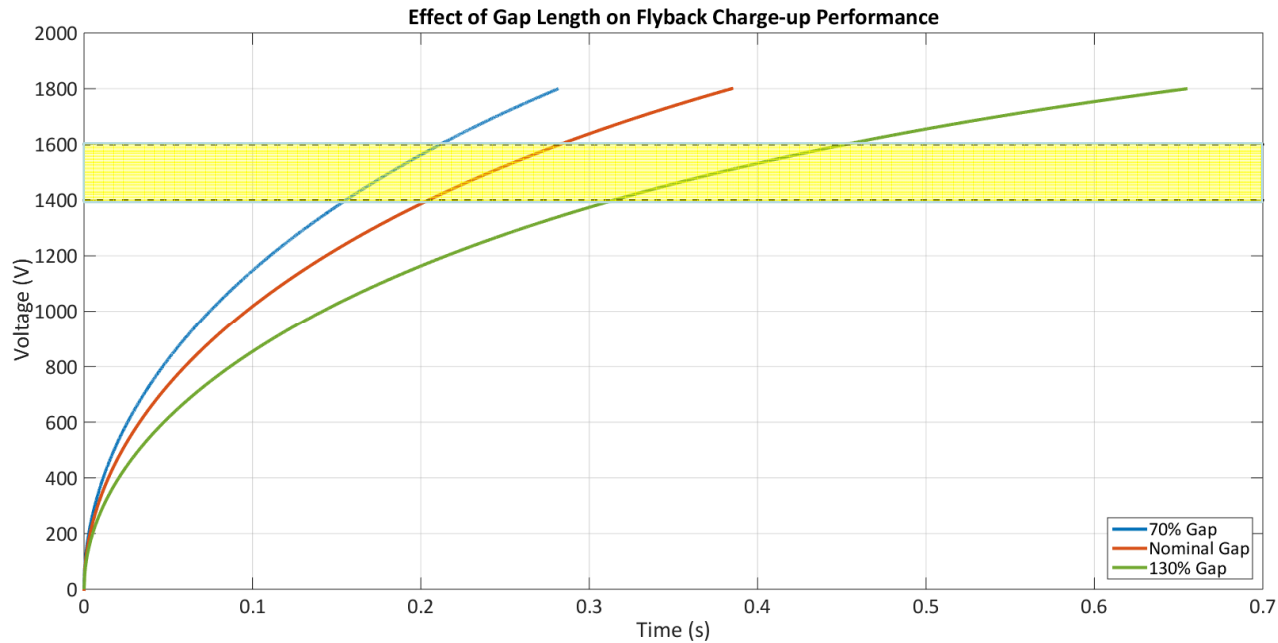
Importance of the Gap

- 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



Gap

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?