Inductor Design: Geometric Optimization

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Introduction

- Inductors are energy storage components critical to power electronics. They are the fundamental electromagnetic building blocks for power electronic systems.
- **Goal**: Improve overall system power efficiency by improving power efficiency of power inductors
- **Objective**: Design inductor to decrease power loss and utilize benefits of air gap
- **Power Loss Area of Concern**: Fringing effect around air gap
- **Idea:** Develop improved geometric shape of inductor bobbin to:
  - Decrease Fringing Effect
  - Increase Power Efficiency

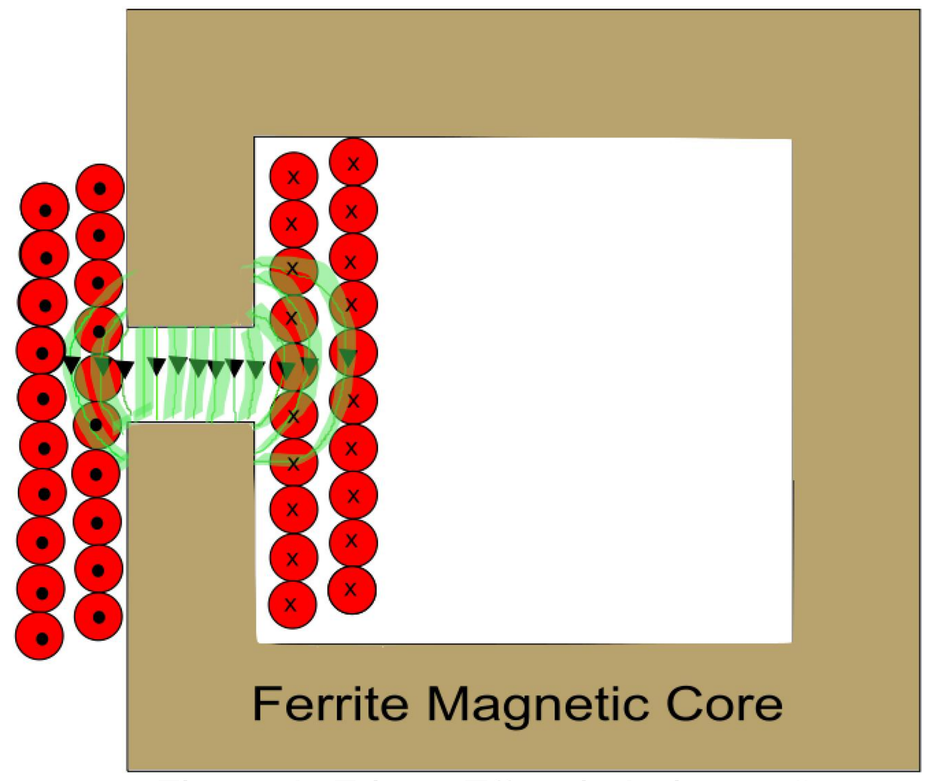

Figure 1: Fringe Effect in Inductor Core

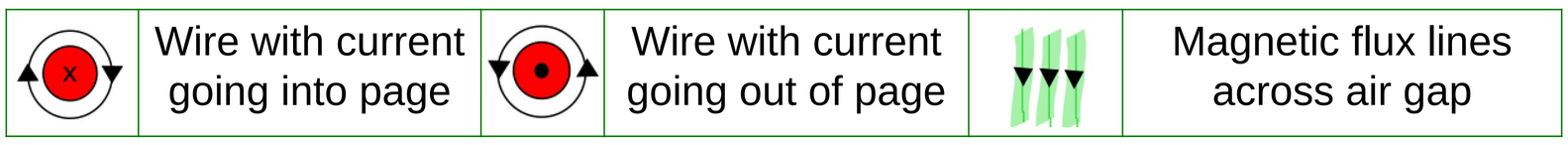

Figure 2: Symbol Key

Electromagnetic Theory

- Flux Φ: Measure of total Magnetic Field in given area
- Air Gap: Increases total reluctance of magnetic circuit

Increased Reluctance → Saturation Current Increases → Controlled Inductance

- Φ through air gap opposes the current induced magnetic fields of each wire
- Lenz's Law: Current induced by a changing magnetic field creates a Φ to Oppose the same field.
- The direction of Φ for the wires and fringing is represented by the black arrows in Fig. 3. This opposition leads to a Decrease in wire current and leads to Power Loss.

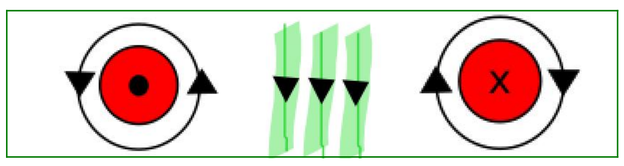

Figure 3: Opposing Magnetic Flux Φ

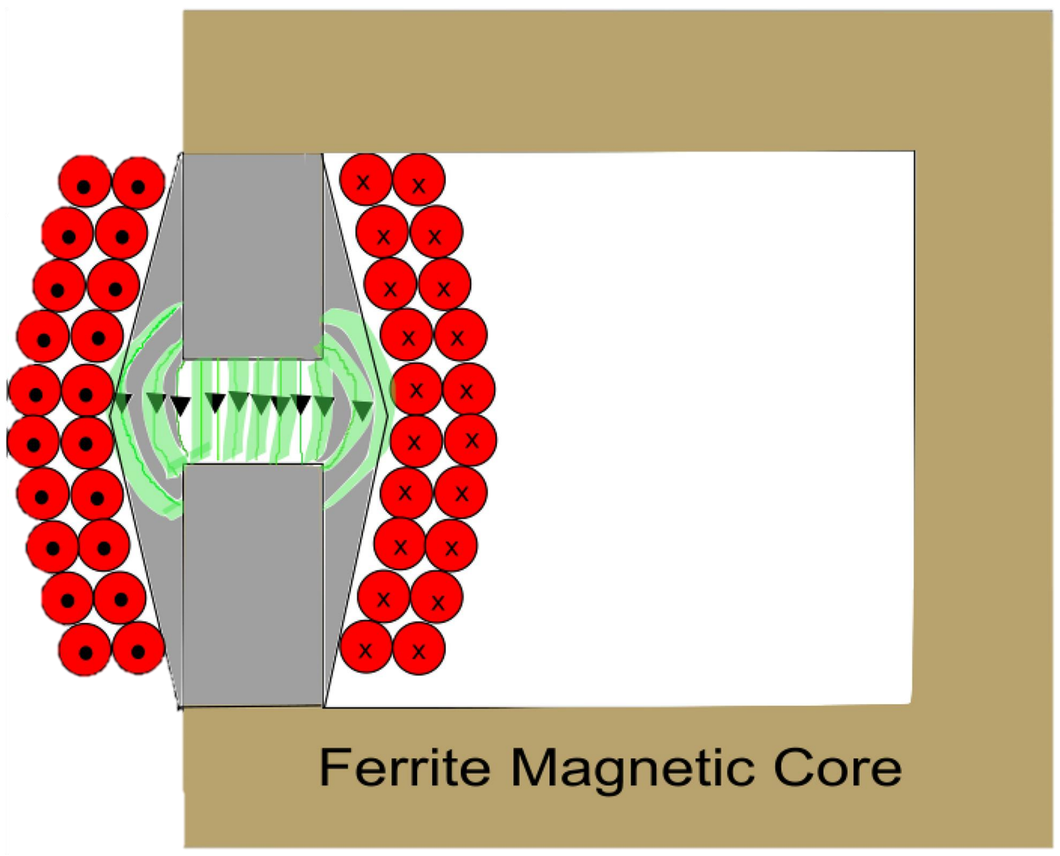

Figure 4: Inductor With Bobbin (Bobbin Shown in Gray)

- The bobbin has Central Bulge to move wire windings farther from the gap
  - Added Bobbin can also allow larger air gaps.
- If the inductor becomes more efficient, the systems that utilize inductors will be as well (Fig. 6).

Buck Converter Design

- Steps-Down voltage (Output to Input)
- Chosen device to test with new inductor.
- Desired Converter Parameters
  - 0.85 Duty Cycle
  - V_{input} = 50 V, V_{output} = 42.5 V
  - Peak Current of 2.6 A
  - Inductance of 50μH

Inductor Design

- Core Material: 3F35
- Core Shape: ETD29
- See Example Fig. 5

Figure 5: Designed Inductor with Proposed Bobbin

Future Work

- Design buck converter for Power Efficiency test.
- Identify and control variables causal to power loss
- 3D print inductor bobbins of a variety of designs
- Test buck converter using inductors
- Compare Power Loss

Figure 6: Energy Flow Within a Generic Power Electronic System