



Capstone Senior Design Project Abstract

Project Title: Modelling of dc-dc Power Electronics Converters (buck and boost) with parasitic elements

Sponsor: SPANIO

Team Members: Daniel Poorak, Nathan Nobles, Harrison Iles

Faculty Mentor: Dr. Mehmet Kurum

Motivation:

Our team's motivation for this project stems from the need to address the discrepancies between theoretical and real-world performance in buck and boost converters. Parasitic elements such as stray inductances and resistances significantly influence the converter's efficiency and reliability, yet these factors often go overlooked in standard designs. By developing various models of converters that explicitly account for parasitic components, we aim to advance power electronics research and produce a more accurate, stable, and efficient power conversion solution. Potential applications span electric vehicles, renewable energy systems, and portable electronic devices—areas where reliable, high-efficiency power is critical.

Design:

Our design approach is divided into six distinct models, each capturing a different aspect of converter behavior. By analyzing buck and boost topologies individually, we can derive a holistic understanding of parasitic effects and overall system performance. These models, listed below (which each include both a buck and boost design), cover both theoretical and practical design considerations:

Equivalent Circuit Models:

Provides a simplified representation of the buck topology, focusing on key components such as the MOSFETs, inductor, and capacitors. Highlights how parasitic resistances and inductances influence current flow and switching transitions.

State-Space Models:

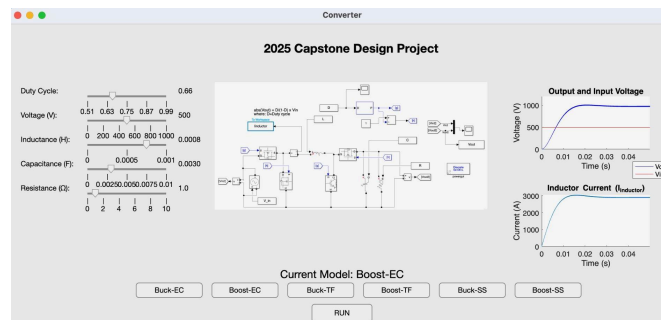
Uses system equations to capture the continuous-time dynamics of the buck converter. Enables precise analysis of inductor current ripple, output voltage response, and controller stability when parasitic elements are introduced.

Transfer Function Models:

Converts the buck state-space representations into frequency-domain transfer functions. Supports control loop design and stability analysis, allowing for optimization of feedback gains while factoring in parasitic effects.

By systematically developing these six models, our team can evaluate performance trade-offs and refine component choices. This methodology ensures that our final implementation effectively addresses both the theoretical design principles and the real-world challenges posed by parasitic elements.

Prototype:



Prototype of GUI with models integrated