Switch Mode Power Supply Small Signal Design Development Tool

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

ON Semiconductor
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ON SEMICONDUCTOR is continuing their support of the Program they initiated last year
https://web.uri.edu/elecomp-capstone/project-details-by-team/on-semiconductor/

Company Overview:

ON Semiconductor (Nasdaq: ON) is driving energy efficient innovations, empowering customers to reduce global energy use. The company is a leading supplier of semiconductor-based solutions, offering a comprehensive portfolio of energy efficient power management, analog, sensors, logic, timing, connectivity, discrete, SoC and custom devices. The company's products help engineers solve their unique design challenges in automotive, communications, computing, consumer, industrial, medical, aerospace and defense applications. ON Semiconductor operates a responsive, reliable, world-class supply chain and quality program, a robust compliance and ethics program, and a network of manufacturing facilities, sales offices and design centers in key markets throughout North America, Europe and the Asia Pacific regions.

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Project Motivation :

Successful design of a switch mode power supply requires the engineer to satisfy the DC and transient load requirements as well as the small signal system stability requirements of the application. The choices that are made for inductors, capacitors and switching frequency to be successful in the large signal domain will impact small signal gain and phase shift and ultimately stability. Many of our customers are not power supply development experts but require development of supplies for their systems. They often encounter difficulties when trying to find a solution that satisfies both performance and stability requirements. To aid their design activity, we have previously provided design aids in the form of Excel or Mathcad files which help them perform the necessary calculations. From these calculations, they can test out the recommended circuit component values by performing a SPICE simulation or building up an evaluation board. Both of these are often a difficult and time consuming step for the customer, but they need to verify the transient performance and stability of the supply that they are designing. It would be more efficient for our customers to have access to an executable file that can import the power supply system requirements which are known to our customer and calculate the circuit and compensation component values that are necessary for their design. The tool should provide bode plots and link the user to cloud based simulation for small-signal and transient verification.

Anticipated Best Outcome:

A configurable tool suite, for ON Semi DC/DC converters, would be developed using Matlab or similar tool that can be used to perform the necessary system calculations, evaluate the system transfer function, provide bode plots, and help for external component selection. This tool should be paired with *System Vision Cloud* product models and test benches that can receive the component values from the calculation tool and enable simulation of the customer's application. The tool should be downloadable from our product webpage.

Project Details:

Several deliverables will be developed prior to putting the tool suite together. Once these are completed, they will be incorporated into a single executable program that will be downloadable from our product webpage. This program will also launch the appropriate cloud based simulation bench when run.

a) Develop a configurable input interface for customer system specification values of buck, boost and other supplies which will calculate the large-signal component values required in the system.
b) Develop transfer functions for current mode buck and boost converters (and potentially other topologies) in both continuous and discontinuous conduction mode.
c) Using a tool, incorporate both the large signal component values and the transfer functions to optimize the compensation network and provide those values and bode plots.
d) Estimate the max junction temperature of the part in worst cases.
e) Develop VHDL-AMS small signal switch models for cloud based simulation.
f) Generate cloud based test benches for a boost and buck product which utilize the VHDL-AMS models and calibrate them to expected results.
g) Wrap the functions into an executable file that when run will also launch the associated cloud based test bench.

Composition of Team:

1 Electrical Engineer & 1 Computer Engineer

Skills Required:

Electrical Engineering Skills Required:

- Analog Circuit Fundamentals, Signals and Systems,
- Familiarity with simulation environments (e.g. PSpice, LabView)

Computer Engineering / Math Skills Preferred:

- Visual Basic and/or Matlab and/or Python
    - Object Oriented Programming, Mathematics Libraries
- Linear Algebra, Complex Math, Pole/Zero Calculations, Transforms
- Computer based solving of matrices

(Not all of these are required but should be helpful in the successful completion of this project.)

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

The Switch Mode Power Supply Design tool will enable customers to more easily design and simulate buck and boost regulator topologies by performing the optimization of large and small-signal design elements for them. This will create a faster design process with both domains tied together and results interactively displayed. A full and rich design and simulation environment will be launched from the tool which will enable tunable simulations of the design as well as the option to perform unique design modifications and simulations that are based on our tool's outputs. This will improve customer support during the design-in process, so that our application engineers will infrequently need to be involved early in the product selection and proof of concept phase of our customer's designs. The improved design experience that results from this tool should increase the number of design-ins on new customer product lines.

Broader Implications of the Best Outcome on the Company's Industry:

There are already a lot of "home-grown" and proprietary power supply design tools in the industry. Most of these tools are really product selection tools and permit some "design synthesis." The tools do not provide a large degree of specification entry and typically optimized based on only a handful of parameters. This tool should incorporate more detail and better optimization including the ability to tailor the small signal stability – transient response trade off. Once this optimization is complete, the user will be placed into a cloud based simulation environment with full design capability, which is not available elsewhere in the industry. This design system will be best in class for our industry and unlike our competitors will not require any special software installations or licensing for the design and simulation process.