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The Power of Connected Models at NGES

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Power Conversion Technology Department

Outline

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- Typical Power System using Saber Circuit Simulator by Synopsys
- ModelCenter® Wrappers
- Saber Wrapper Requirements
- Implementation
- Example Circuit: Parametric Sweeps and Optimization
- Cost, Size, Weight and Schedule Implications
- Trades and Analysis
- Summary

Saber Circuit Simulator Used For Power System Design/Analysis

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A Typical Power System…

Electrical Circuit Simulator

SYNOPSYS Saber

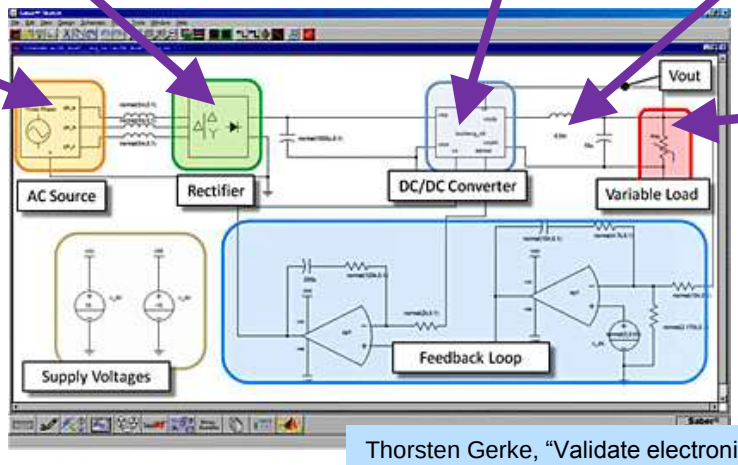
Source

AC-DC Converter

DC-DC Power Supply

Distribution

Load



Thorsten Gerke, “Validate electronics robustness: Part 2-Find the worst case” EE Times, 11/19/2010

ModelCenter® Out-of-Box "Wrappers"

Link Together & Add **Functionality**

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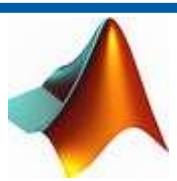
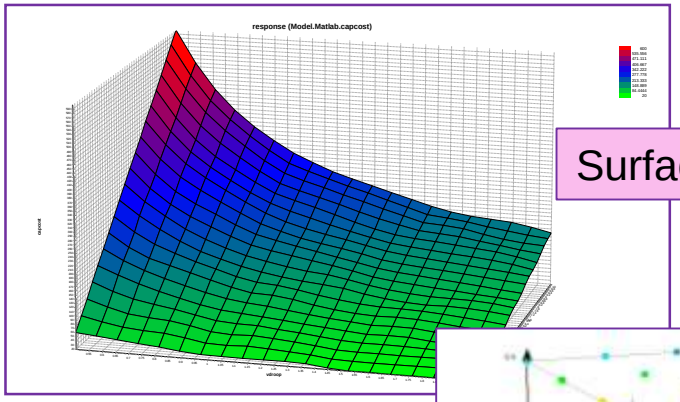
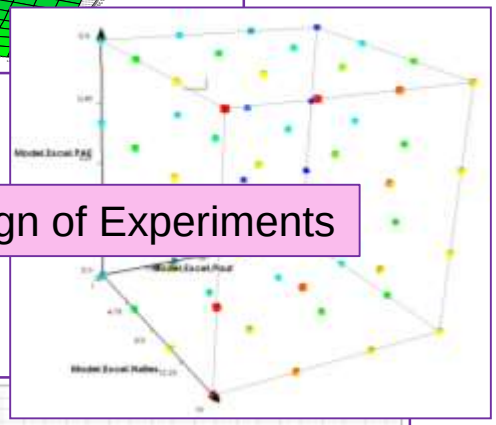


PHOENIX INTEGRATION

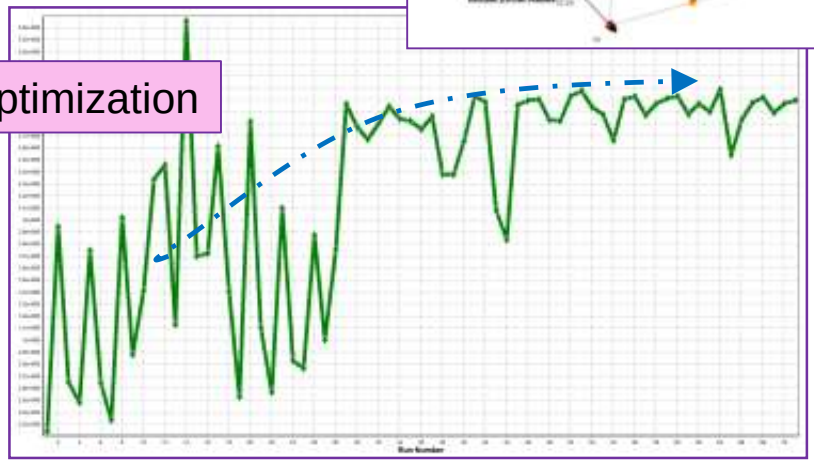
phx ModelCenter®



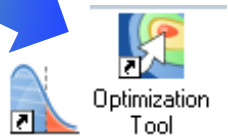
Surface Plots



Design of Experiments



Optimization



Probabilistic...

Optimization Tool

QuickWrap

Numerous Others

Mathcad

MSCNastran

ANSYS

NX

The “QuickWrap” Function

Creates **Connection** to Saber Circuit Simulator

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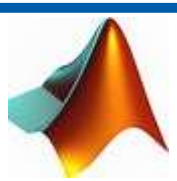


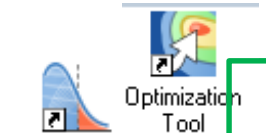
Gain the capabilities of the detailed circuit simulator

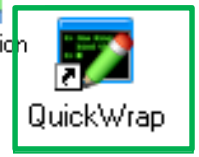
PHOENIX INTEGRATION

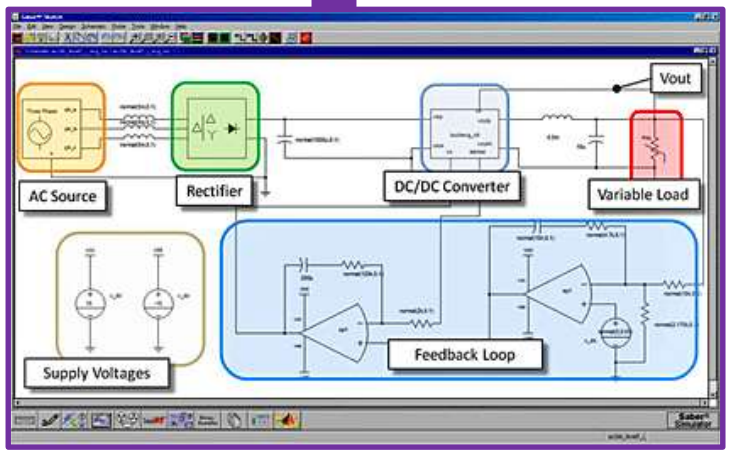
phx ModelCenter

QuickWrap

SYNOPSYS Saber







Mathcad

MSCNastran

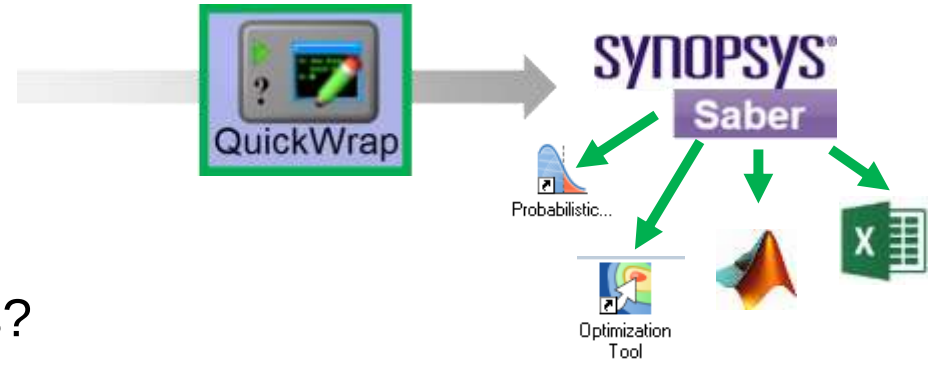
Numerous Others

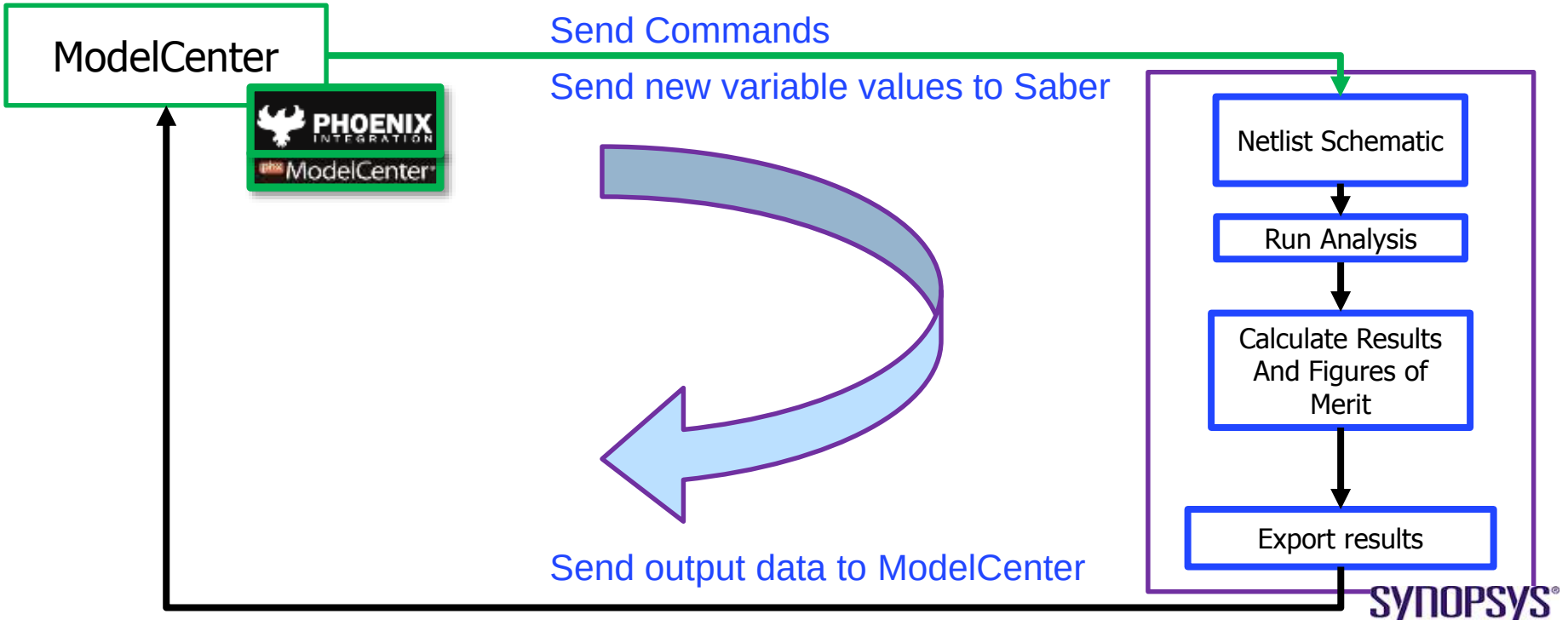
ANSYS

NX

“Wrapping” Saber with ModelCenter

- What is the added **functionality**?
- What are the **manual steps**?
- How can we **automate** this process?





Wrapping Saber Process Overview

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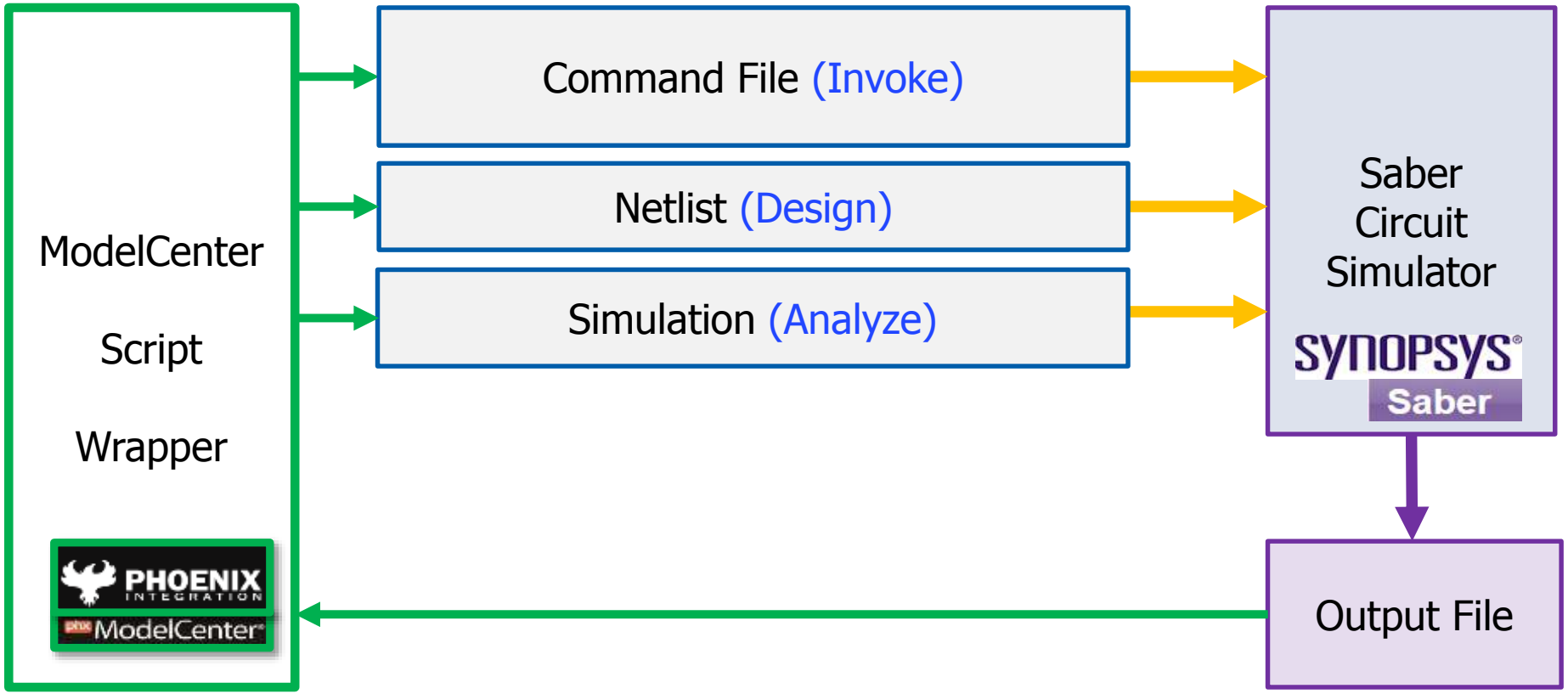

Example Saber Schematic

7th Order Chebyshev Filter

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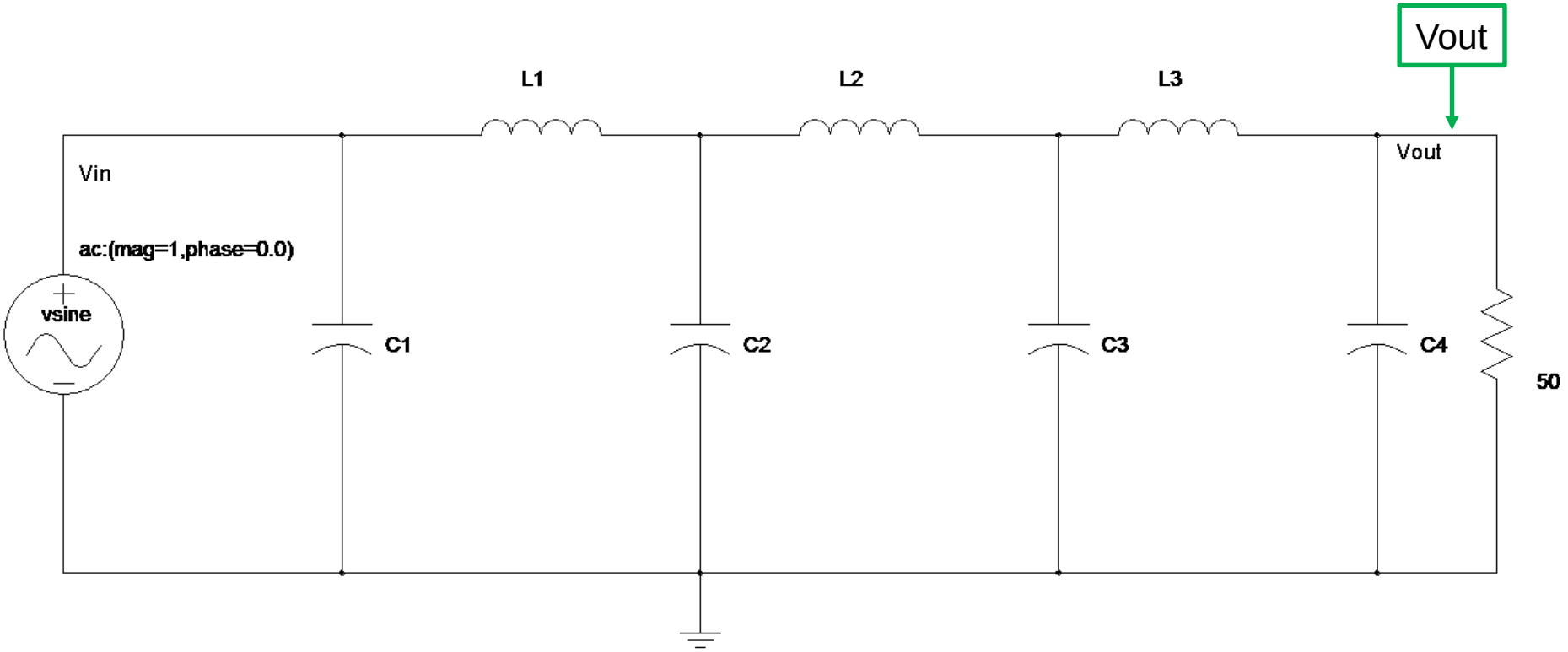

SYNOPSYS®
Saber

Example Filter Response

-20 dB Threshold Point Defined as Figure of Merit

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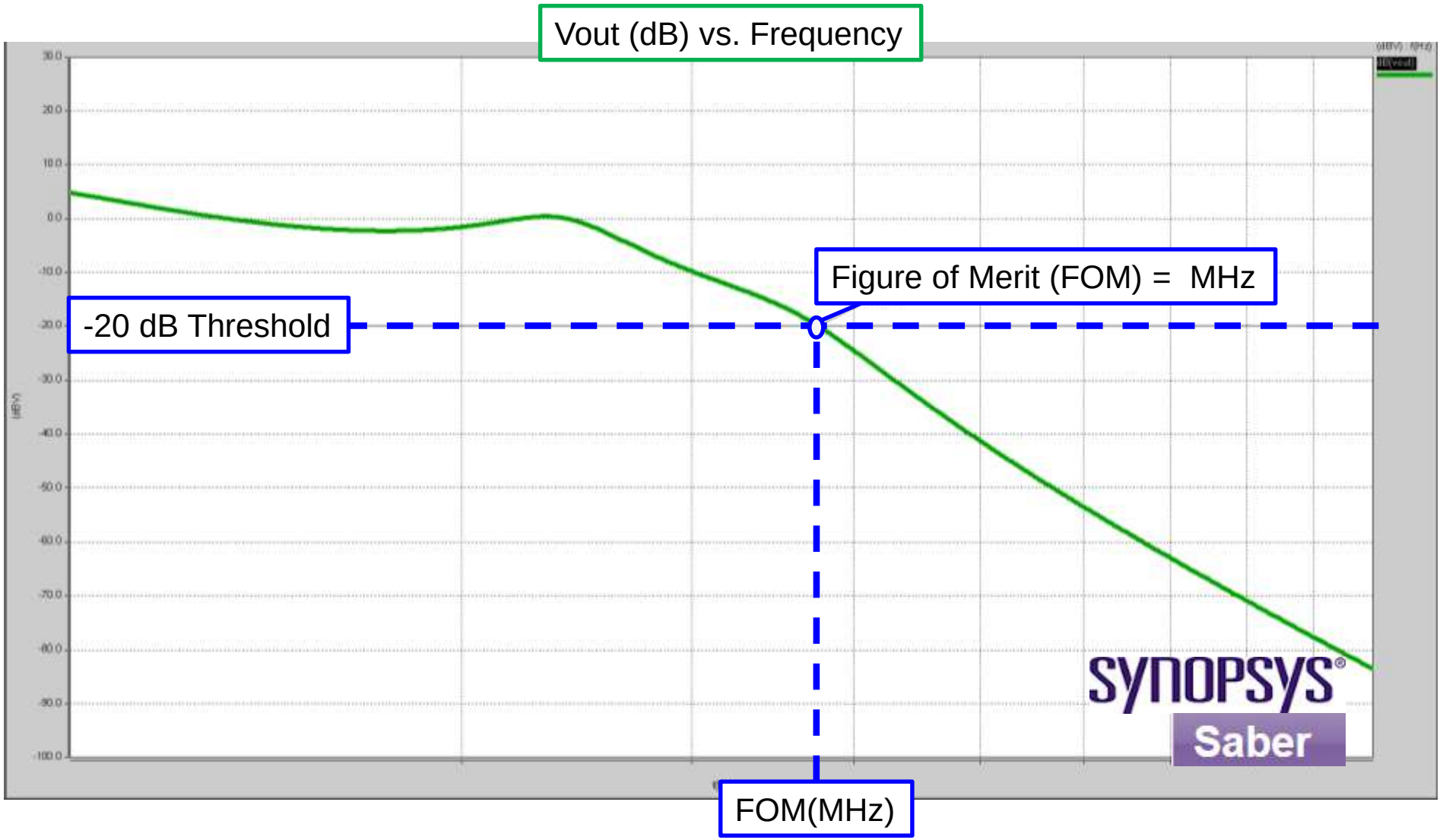

QuickWrap Created to “Wrap” Saber

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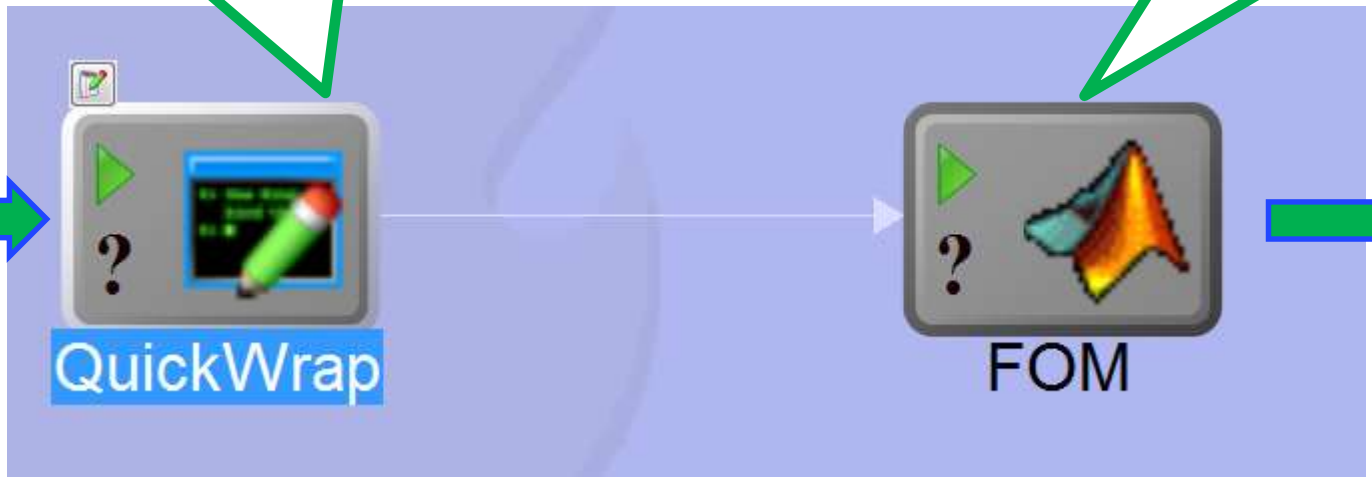
QuickWrap Invokes Saber:
-Vary Parameter Sets
-Run an analysis/simulation
-Export the results when done

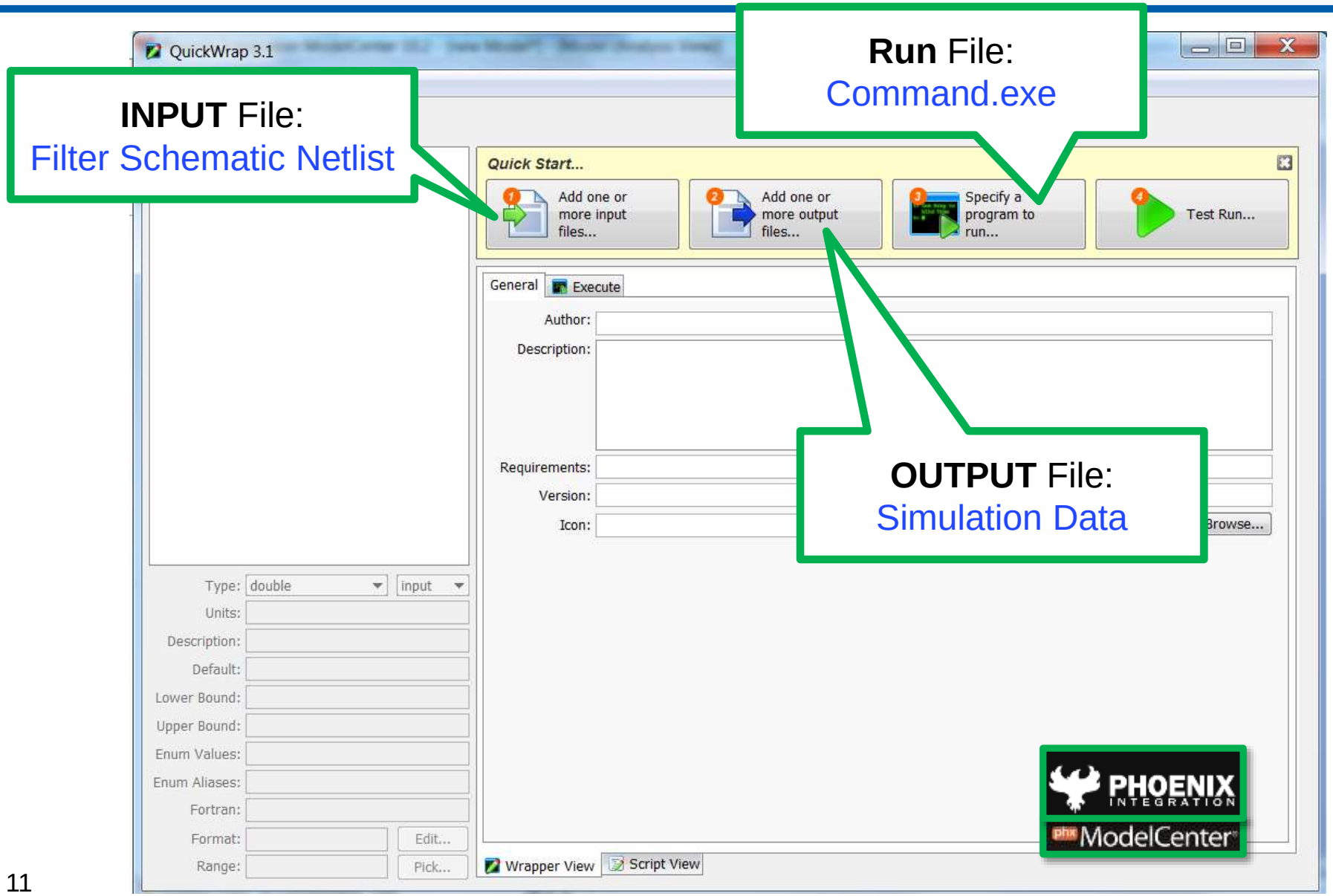
Matlab used for unit conversion and post processing of results



Inputs

Outputs (FOM)

QuickWrap Interface Window



Parameter Sweep (L1) w/ ModelCenter + Saber

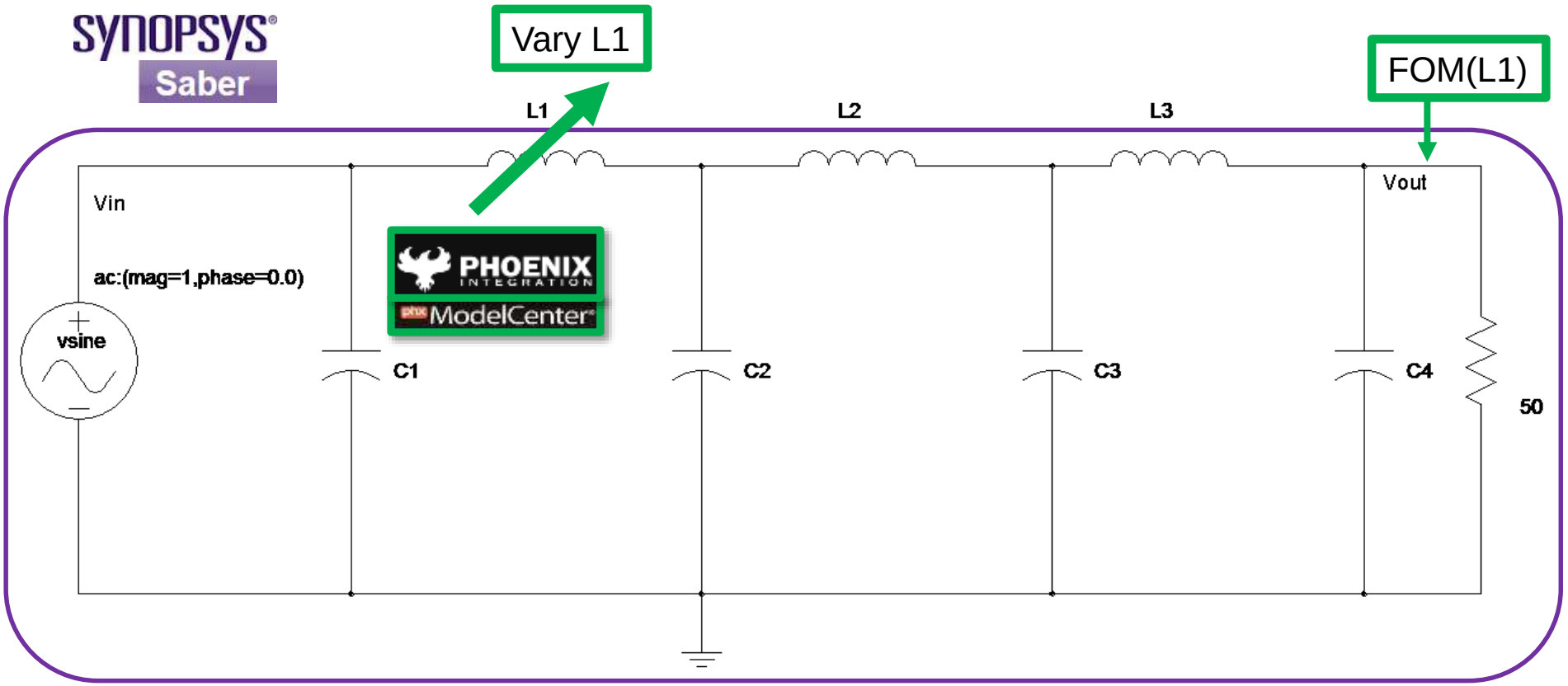
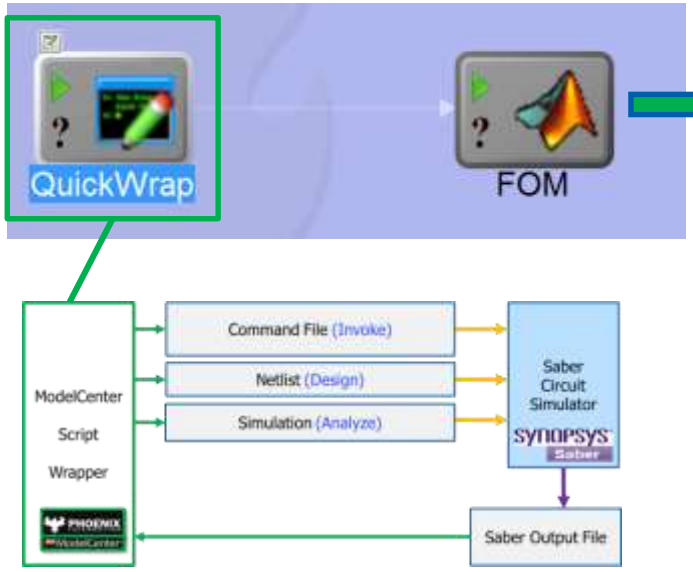
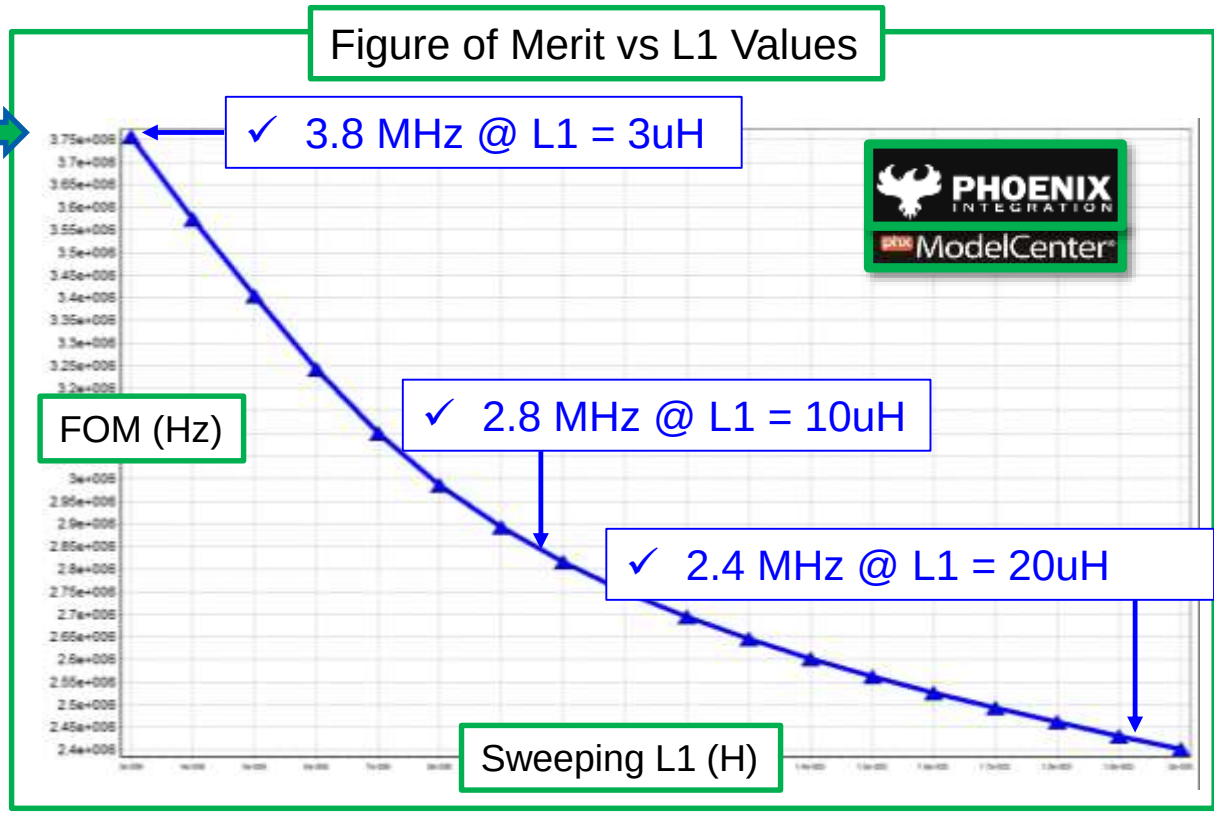


Figure of Merit (FOM) measurement when Vout(dB) = -20 dB point MHz

ModelCenter Parameter Sweeps

Matches Saber





Notes:

ModelCenter accurately creates parameter sweep curves and values

Optimization Problem for Filter Design

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Objective:

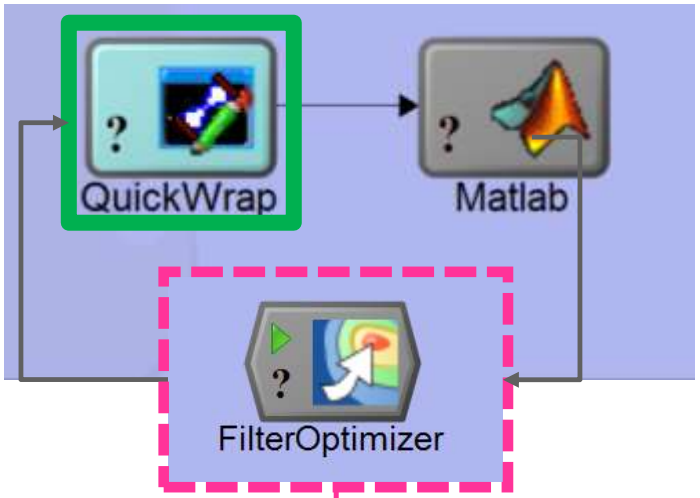
Design filter s.t. -20 dB pt equal 5 MHz

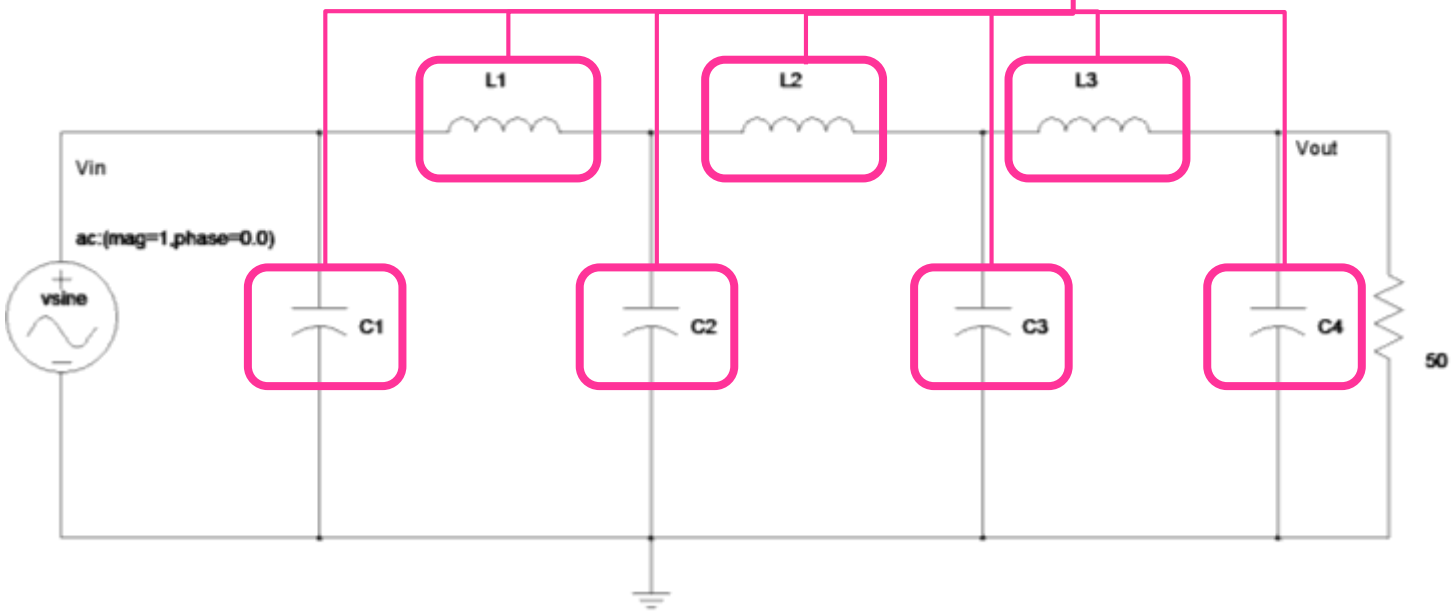
$$\mathrm{FOM}_{-20dB\_pt}(L_1, L_2, L_3, C_1, C_2, C_3) = X \ MHz$$

Constraints:

$$A < L_1, L_2, L_3 < B$$

$$C < C_1, C_2, C_3 < D$$





QuickWrap Allows Parametric Sweeps and FOM Optimization

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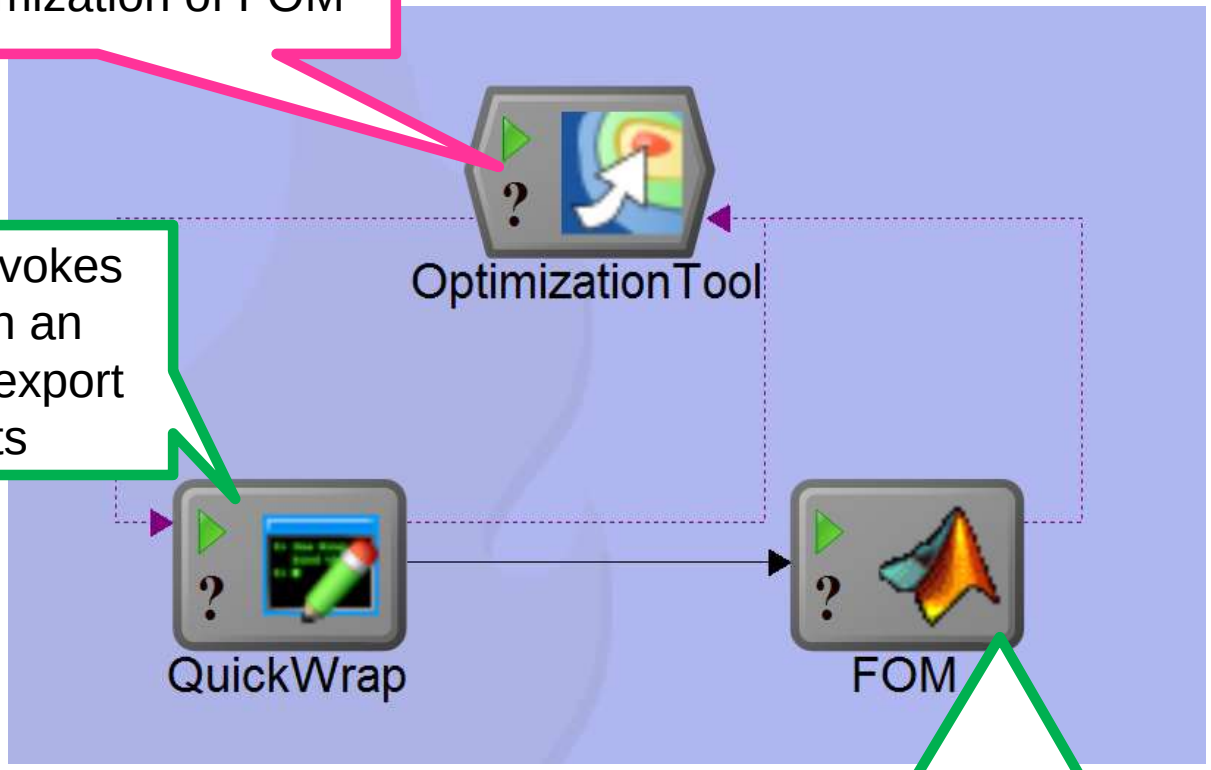
Optimizer tool used for circuit element optimization of FOM



QuickWrap invokes Saber to run an analysis and export the results

Matlab used for unit conversion and post processing

ModelCenter + Saber + Matlab Optimized Solution

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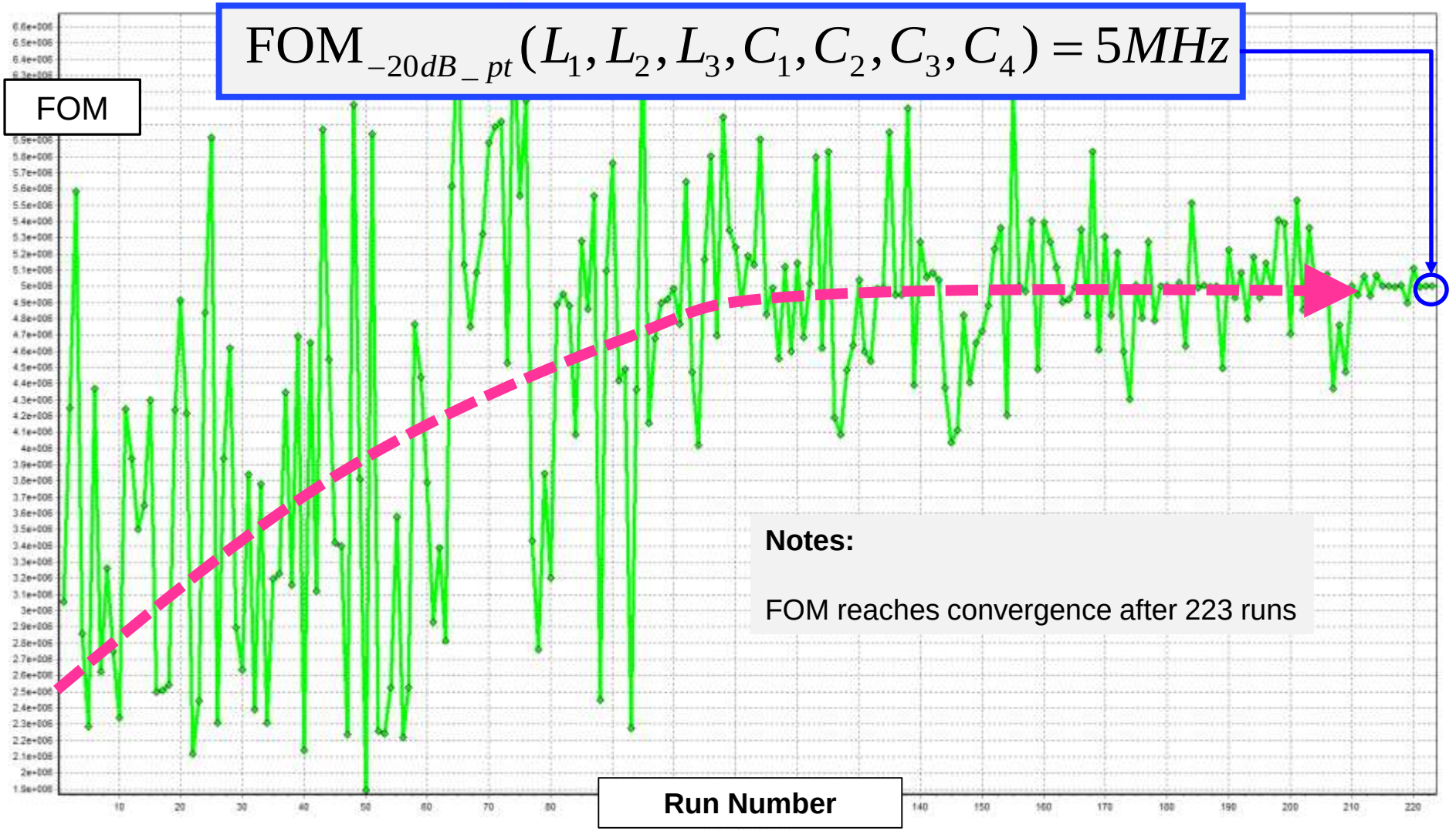
Optimized Run Solution Found at N=233 runs, FOM = 5 MHz



Including Disparate Models

Cost and Weight Spreadsheet

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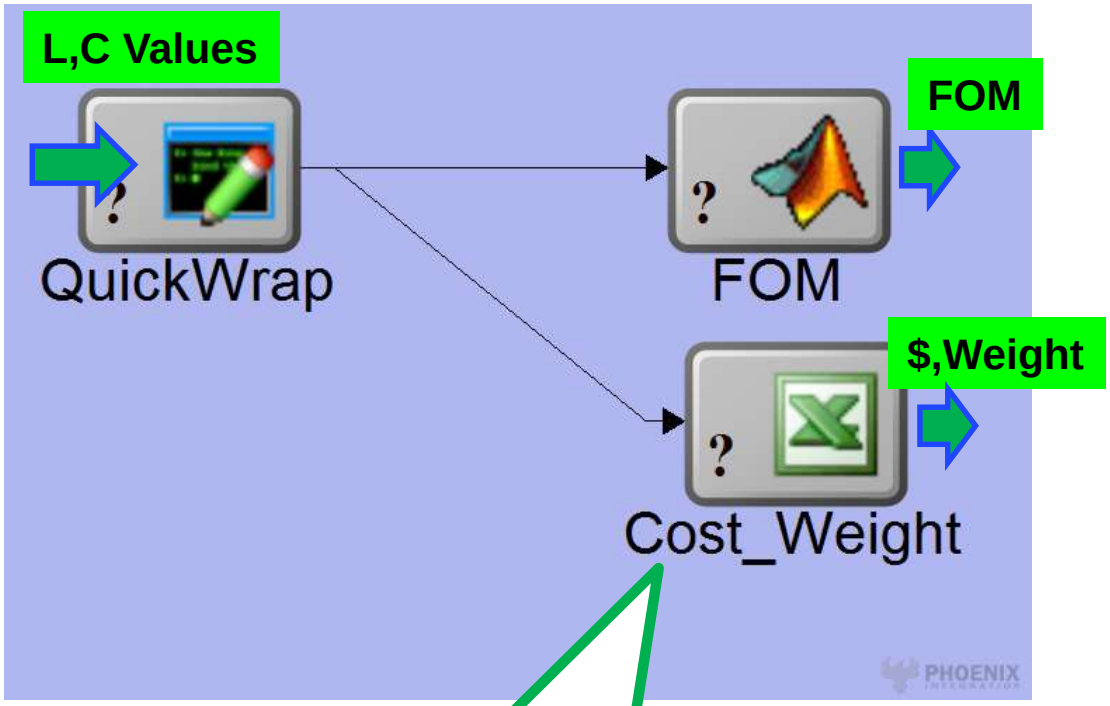
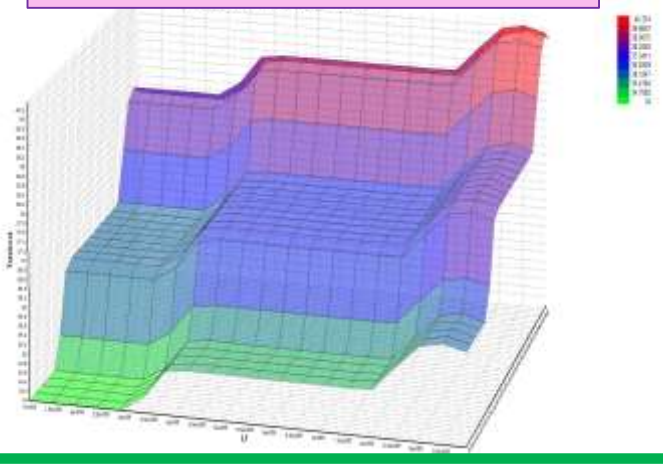
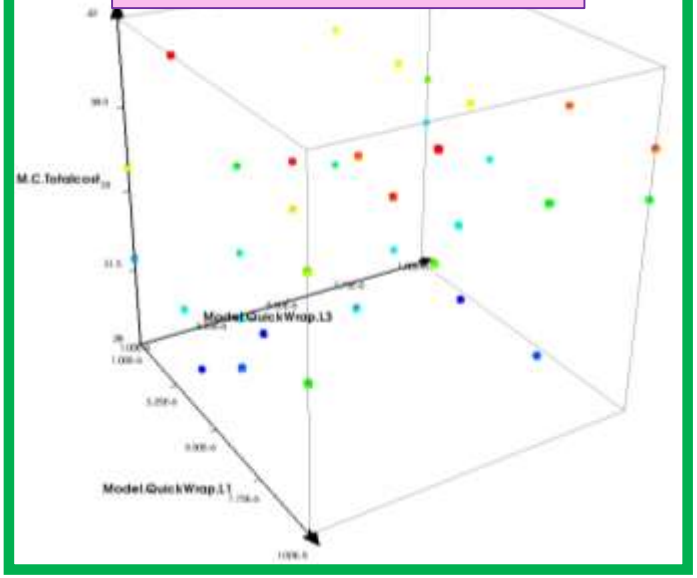


Excel Database
of Inductor Costs and Weight

Cost, Weight vs L, C Values



DOE of All Parameters



Optimized Solution Achieved

FOM = 5 MHz, Minimized Cost and Weight

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Objective:

Design filter s.t. -20 dB pt equal 5 MHz

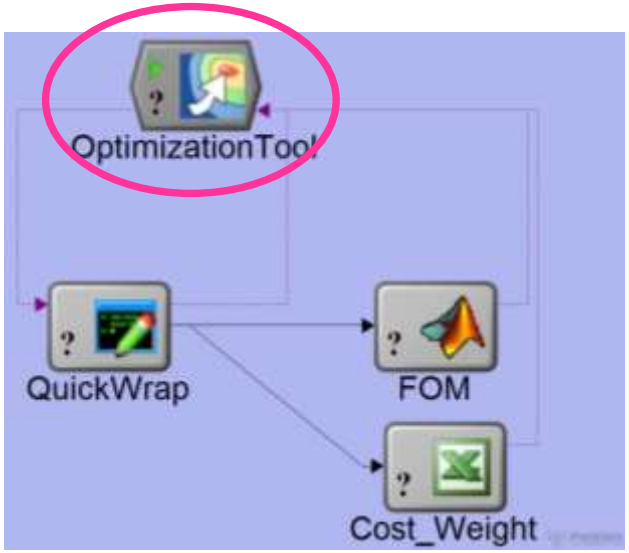
$$\mathrm{FOM}_{-20dB\_pt}(L_1, L_2, L_3, C_1, C_2, C_3) = 5\ MHz$$

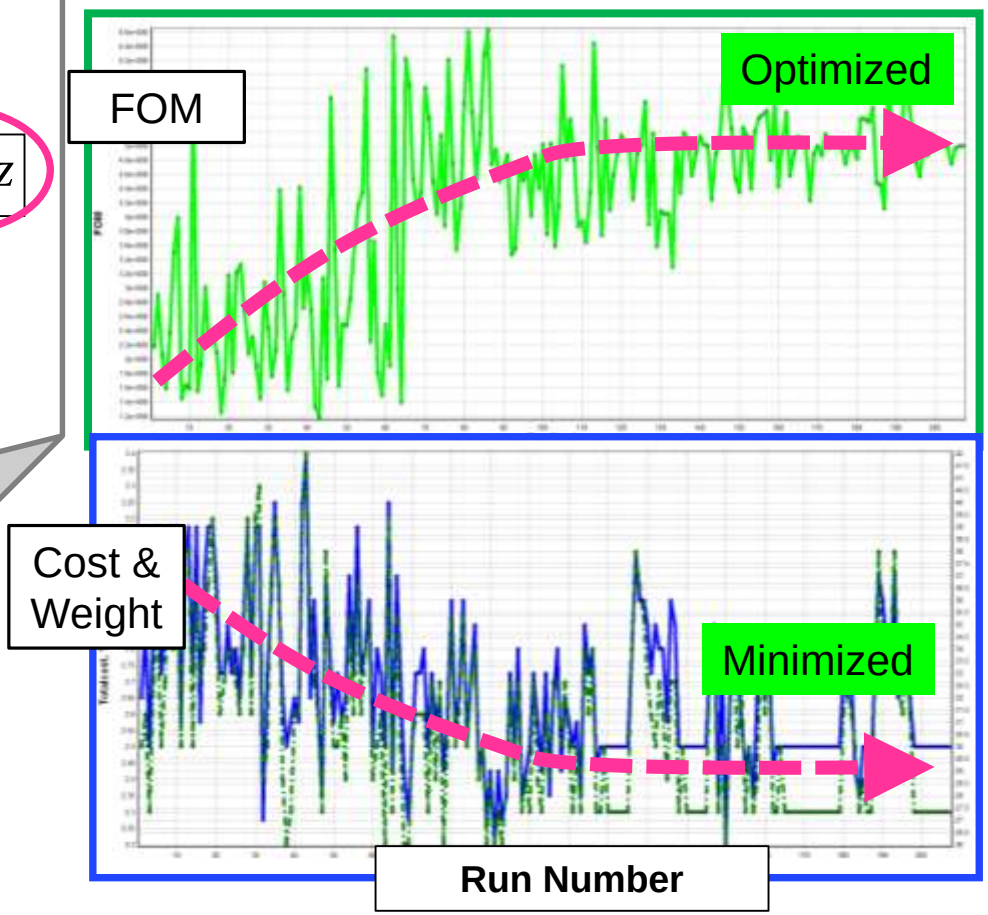
Constraints:

$$A < L_1, L_2, L_3 < B$$

$$C < C_1, C_2, C_3 < D$$

$$\min(\$, Weight)$$





Summary

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- We demonstrate the following using ModelCenter + Saber
  - To **modify** Saber netlist values and **analyze** a Chebyshev filter design
  - Calculate a **figure of merit** for the filter response
  - **Parameter** sweep the design and generate parameter curves
  - **Optimize** the design given a problem statement and constraints
  - Introduced **cost and weigh**t into the model based design

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Author Biography

Kerron Duncan received his B.S. and M.S degree in Electrical Engineering from Morgan State University in 2000 and 2003, respectively. He joined Northrop Grumman ES in 2001 and is currently manager of Power Systems & Control group in the Power Conversion Technology Department. He is also pursuing a PhD at Johns Hopkins University in the area of wireless biotelemetry trade space modeling and simulation and is interested in system architecture models which include “push factors” for various subsystems such that their interdependences (size, weight, cost, power) with respect to performance that can be used in model based engineering efforts.