Broad-Scale Converter Optimization Utilizing Discrete Time State-Space Modeling

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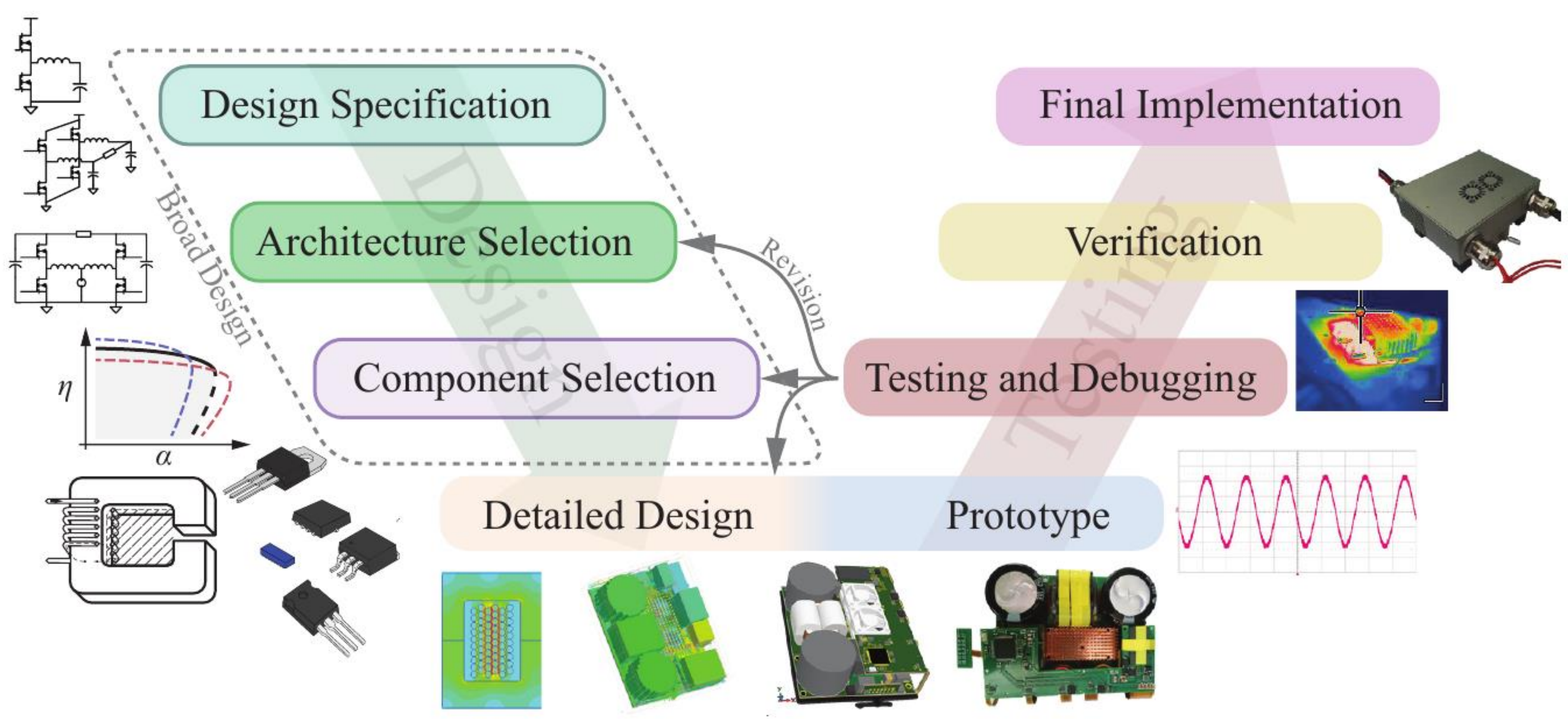
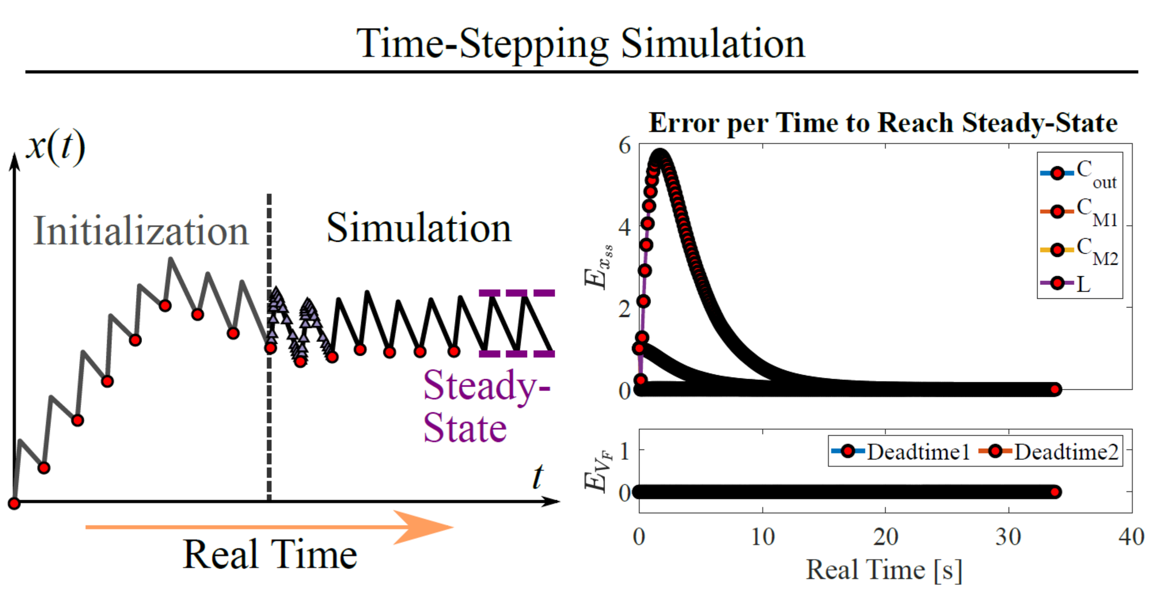
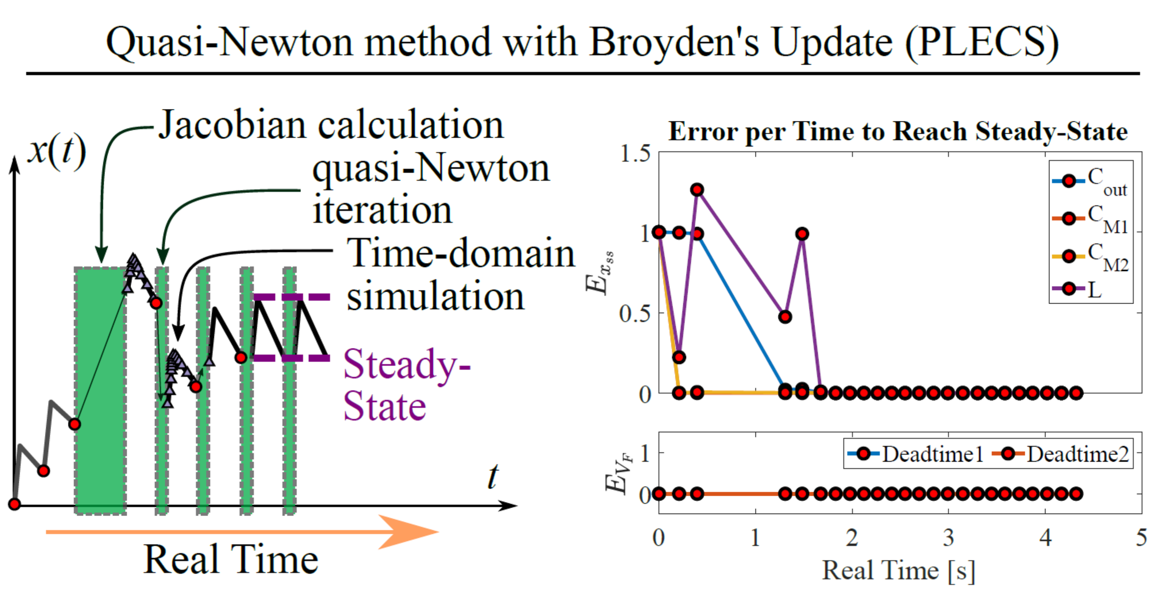
MOTIVATION

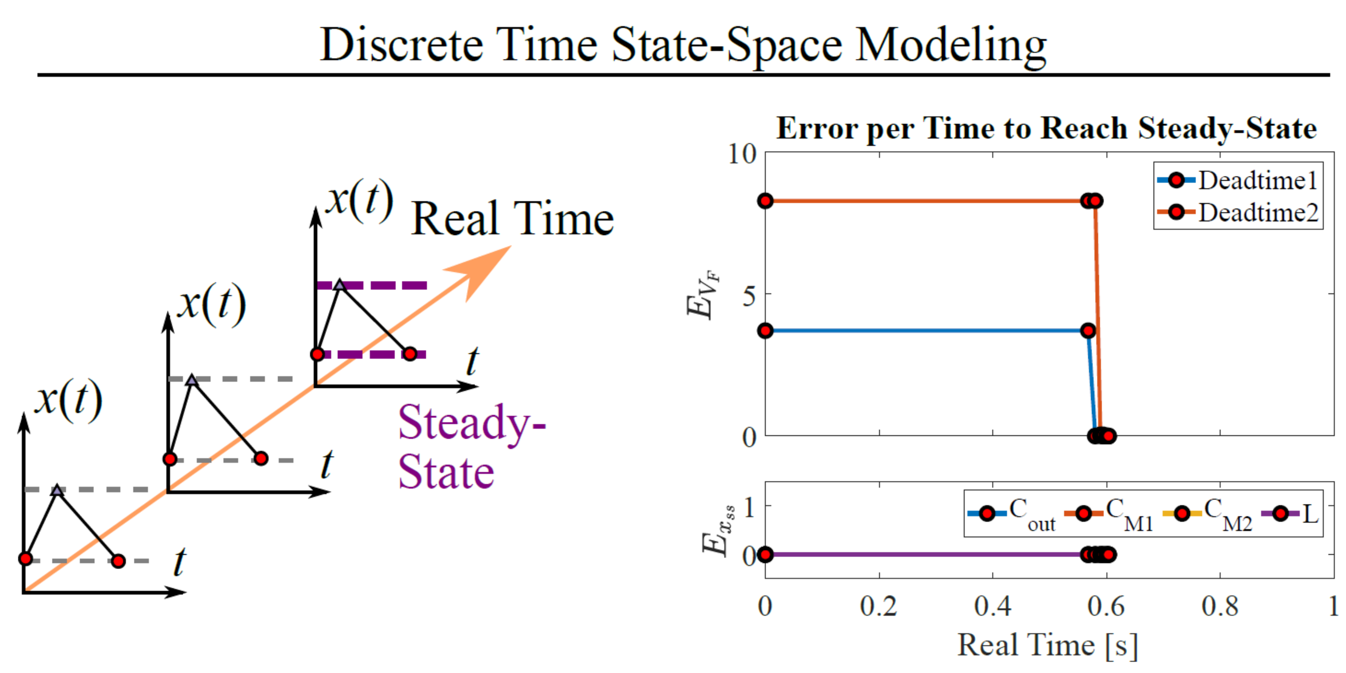
- Discrete time, state-space modeling has shown merits for generality and rapid analysis of switching converters but has issues incorporating nonlinear elements
- Broaden the capabilities of incorporating nonlinear elements into a generalized discrete time, state-space modeling framework
- Utilize framework to optimize power converters and quickly make design comparisons

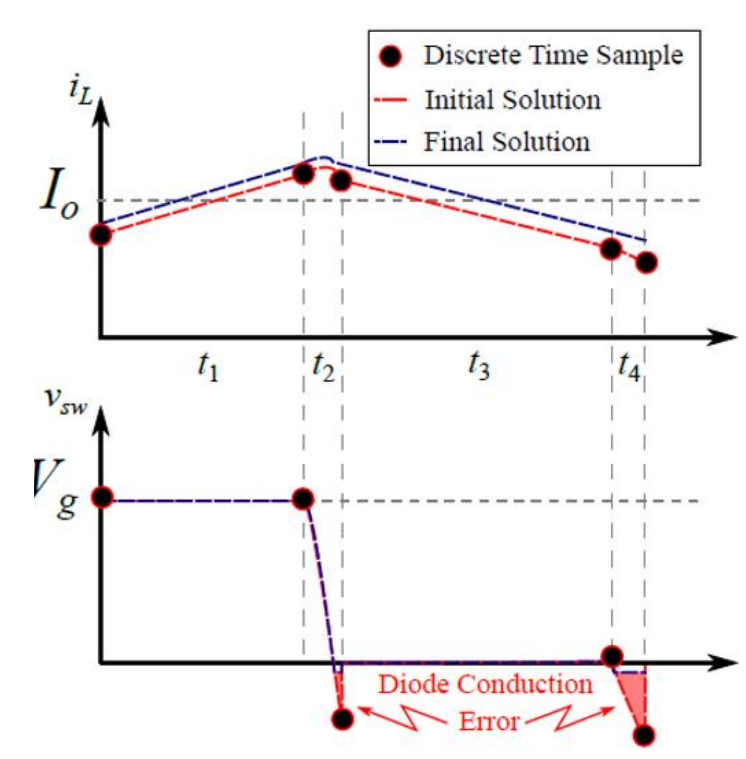


STATE-SPACE MODELING COMPARISON







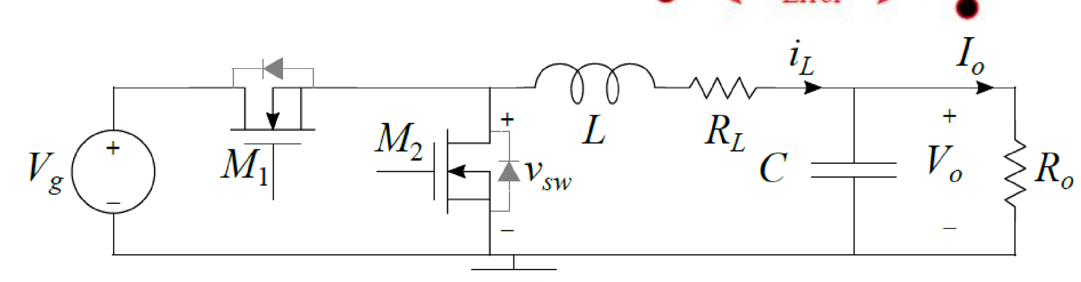


Inital Solution

Time Interval	t_1	t_2	t_3	t_4
Circuit Model	A_1	A_2	A_3	A_4
Conducting Devices	M_1	—	M_2	—

Final Solution

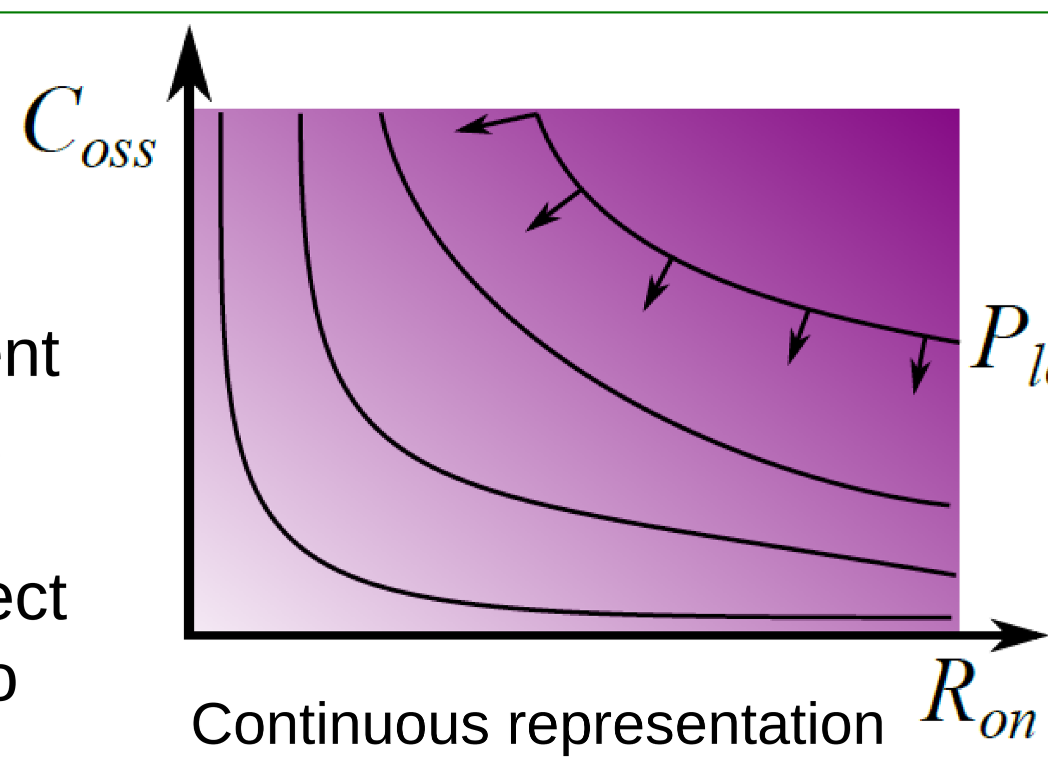
Time Interval	t_1		t_2	t_3		t_4
Circuit Model	A_1	A_2	A_2^*	A_3	A_4	A_4^*
Conducting Devices	M_1	—	$M_{2,BD}$	M_2	—	$M_{2,BD}$



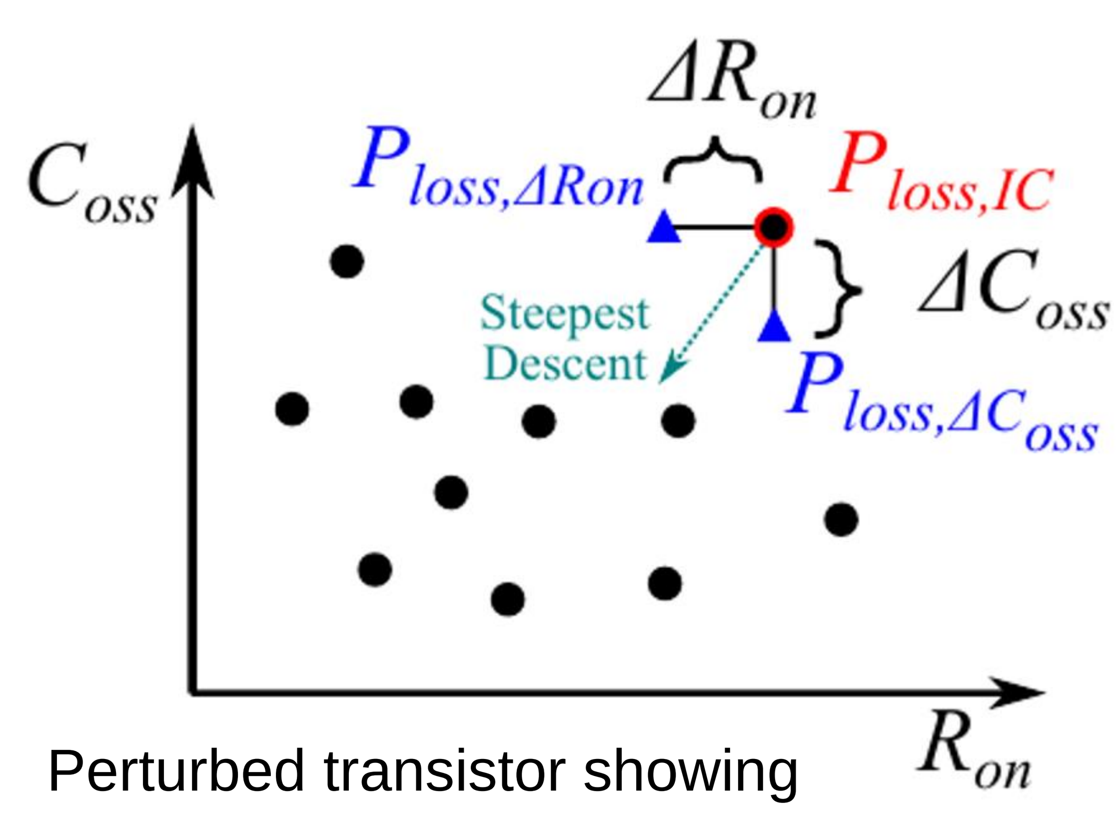
$$\boldsymbol{X}_{ss} = \left[\mathbf{I} - \prod_{i=m}^{1} e^{\boldsymbol{A}_i t_i}\right]^{-1} \cdot \sum_{i=1}^{m}\left[\left(\prod_{k=m}^{i+1} e^{\boldsymbol{A}_k t_k}\right)\boldsymbol{A}_i^{-1}\left[e^{\boldsymbol{A}_i t_i} - \mathbf{I}\right]\boldsymbol{B}_i \boldsymbol{u}_i\right]$$

OPTIMIZED COMPONENT SELECTION

- Some discrete components such as transistors can be optimized via gradient methods since they be arranged into a pseudo-ordered multivariable space
- Perturb initial discrete device and project power loss on other discrete devices to find lower power loss

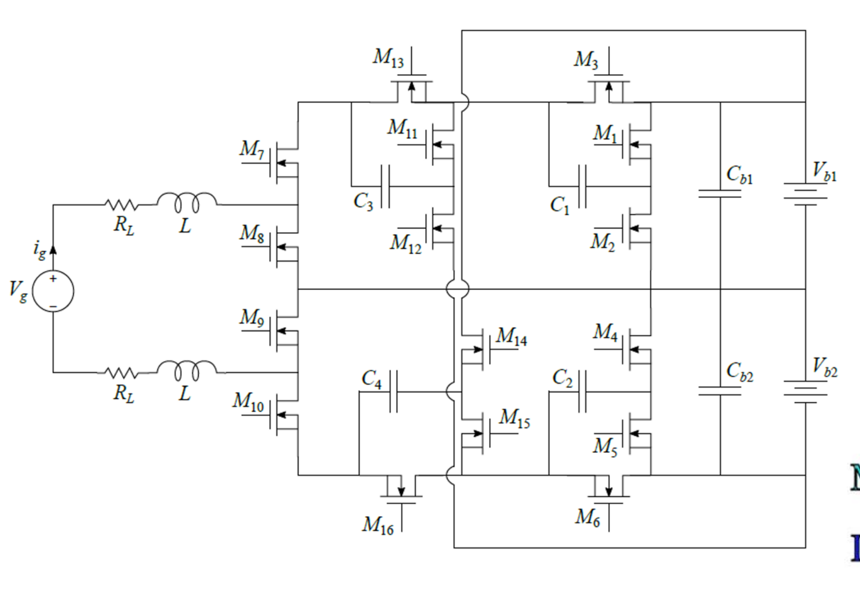


Continuous representation of transistor power loss



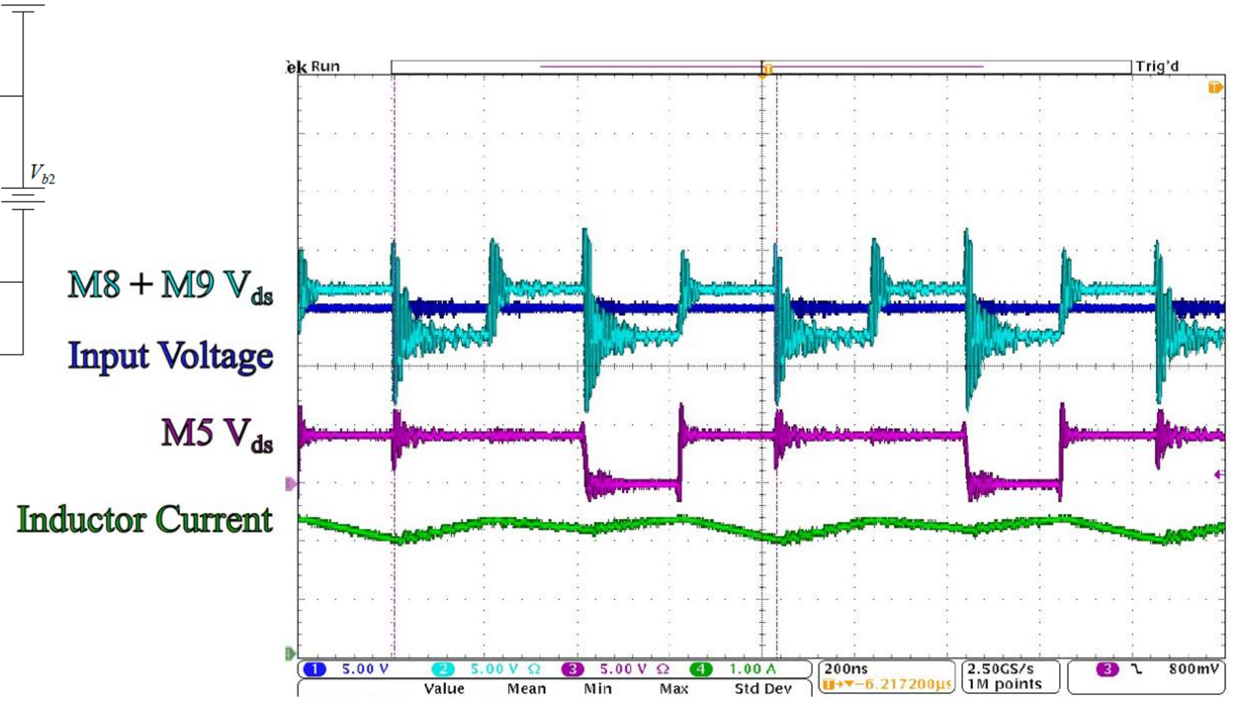
Perturbed transistor showing direction of decreasing power loss

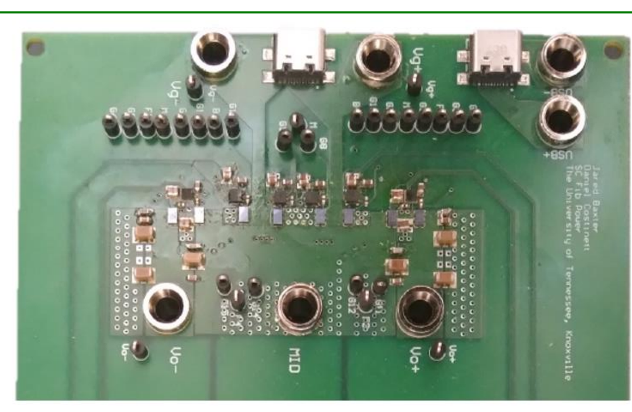
EXPERIMNETAL & SIMULATION RESULTS

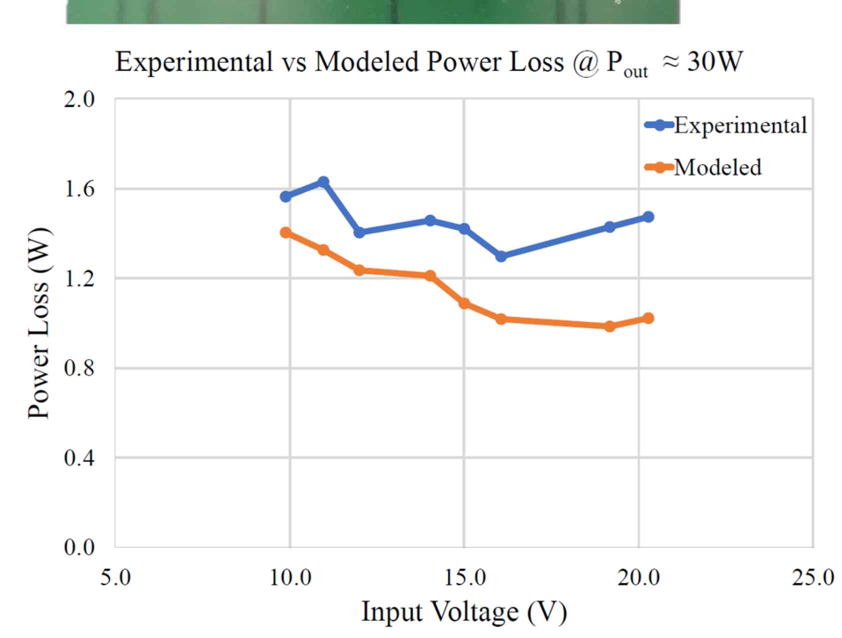


Switched Capacitor Fibonacci Sequence Converter

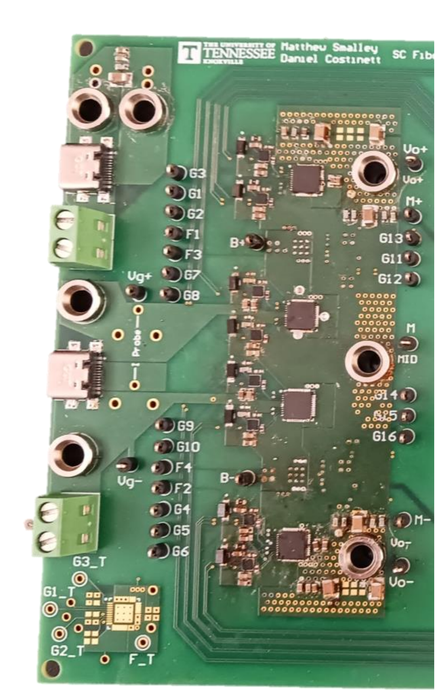
Discrete Transistor Prototype Experimental Results







Future Work



Integrated Circuit Prototype