Converter Analysis Using Discrete Time State-Space Modeling

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Background and motivation:
- Discrete time, state-space modeling shows merits for general, 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

Technical approach:
- Solve directly for the steady-state of switching converter
\[ X_{ss} = \left[ I - \prod_{i=1}^{m} e^{A_i t_i} \right]^{-1} \times \sum_{i=1}^{m} \left[ \left( \prod_{k=i+1}^{m} e^{A_k t_k} \right) A_i^{-1} \left[ e^{A_i t_i} - I \right] B_i u_i \right] \]
- Develop of a framework to correct state dependent switching

Conclusions:
- Proposed method is general to switching converters and can give fast insight to converter performance
- Utilize the eigenvalues of the converter to potential correct single frequency errors in passive switching

Fig 1. Detailed flow diagram of broad electrical domain design of a synchronous buck converter
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- Time intervals must be known before directly solving steady state
- State dependent switching must be solved for after finding the initial steady state solution

Fig 2. Synchronous Buck Converter

Fig 3. Synchronous Buck Converter Deadtime Waveforms

### TABLE I

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State Dependent Switching Error Causes Invalid Diode Voltage
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- Developed an algorithm to correct for constant slope and high frequency errors
- Results showed faster steady state convergence time compared to other simulation methods and accuracy to experimental results

![Converter Simulation and Experimental Results](image)

**Fig 4. Flyback Converter Simulation and Experimental Results**

![Flow diagram to find steady-state](image)

**Fig 5. Flow diagram to find steady-state**
Acknowledgements

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