2:1 Converter Charge Vector Analysis
Dickson Charge Vector Analysis

Charge Vector Analysis in FSL
DISCRETE TIME MODELING

Converter Analysis

- Sinusoidal Analysis
- State Plane (QSW & QR Converters, Resonant SC)
- Multilevel
- Averaging (waveform, switch, state space)
- Z-source, matrix, others

Converter Types:
- PWM (small ripple)
- Resonant (AC-DC link)
- Switched Capacitor
- Hybrid Switched Capacitor
Model a switched system as an averaged, time-invariant system with

\[ \dot{x}(t) = Ax(t) + Bu(t) \]

where

\[ A = DA_1 + D'A_2 \]
\[ B = DB_1 + D'B_2 \]
Large Signal Modeling of SMPS: Averaging

Linear Circuit Modeling Using State Space
Switching Signal

Converting to Linear System
Approximate Steady State Waveforms

\[ x(nT_s) = 1 \]

\[ x(t) \]

\[ x(0) \]

\[ x(T_s) \]

\[ (n)T_s \]

\[ (n+1)T_s \]

\[ t \]

\[ \langle x(t) \rangle = \frac{1}{T_s} \int_0^{T_s} x(t) dt \]
Approximate Steady State Waveforms

The Averaging Approximation
The Averaged System

Buck State Space Averaging

\[ V_g \]
Buck Averaged Model