Analysis of Phase Timings for a Zero-Voltage Switching, Split-Phase Hybrid Dickson Converter

Motivation and Application

- Dickson-based converters are popular for hybrid switched capacitor (SC) solutions due to the reduced switch stress as compared to other topologies [1]
- Applications: high-conversion ratio systems
  - 48 V bus architectures for data centers and automotive powertrains
- Transistor switching losses can be significant share of overall losses, especially with trends towards faster switching frequencies
- Soft-switching techniques, such as zero-current and zero-voltage switching (ZCS and ZVS) can be used to reduce these losses

Challenges

- Phase-timings become non-trivial to determine
- ZVS timings are also non-trivial
  - Non-linear switch output capacitance
  - Multiple switches with different blocking voltages

Hardware

48 V-to-6 V prototype

- Per-phase analysis of an equivalent LC network to determine phase-timings
- Equivalent capacitance $C_{eq}$:
  - Main phases: A network of the flying capacitors $C_1$-$C_7$
  - ZVS sub-phases: A network of linearized transistor output capacitances [2]

Experimental Verification

- Exemplary phase-timings and waveforms of a resonant Dickson converter achieving ZVS on all switches
- Measured drain-source voltages showing ZVS for all switches

References: