

Dickson Output Resistance

$$R_{O,SSL} = \sum_{i \in caps} \frac{(aci)^2}{C_i f_s}$$

Assume all $C_i = C_{fH}$

$$R_{O,SSL} = 5 \cdot \frac{(\frac{1}{6})^2}{C_{fH} f_s} = \boxed{\frac{5}{36} \cdot \frac{1}{C_{fH} f_s} = R_{O,SSL}}$$

fSL output resistance

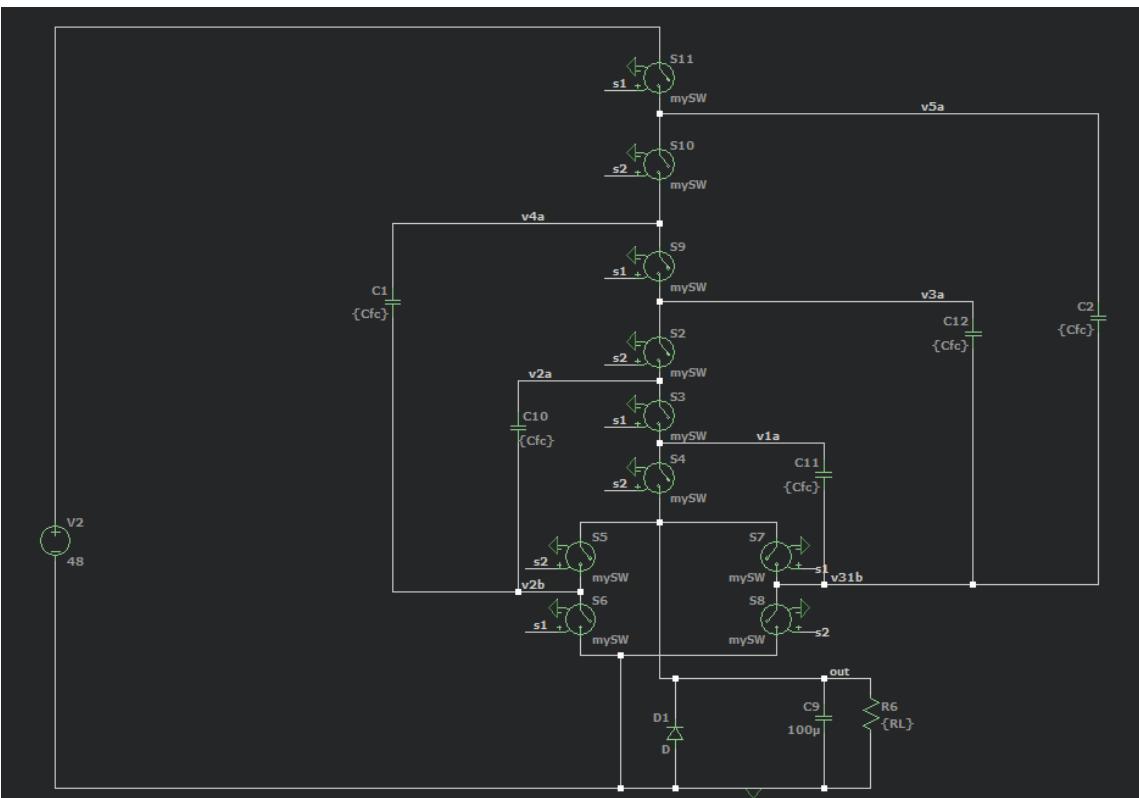
$$\bar{a}_r = [\frac{1}{6} \quad \frac{1}{6} \quad \frac{1}{6} \quad \frac{1}{6} \quad \frac{1}{6} \quad \frac{1}{6} \quad \frac{1}{2} \quad \frac{1}{2} \quad \frac{1}{3} \quad \frac{1}{3}] \\ Q_1 \quad Q_2 \quad Q_3 \quad Q_4 \quad Q_5 \quad Q_6 \quad Q_7 \quad Q_8 \quad Q_9 \quad Q_{10}$$

If all $R_{on,i} = R_{on}$
(same FETs)

$$R_{O,FSL} = \sum_{i \in FETs} (a_{ri})^2 \cdot 2 \cdot R_{on,i} \\ = \left[6 \cdot \left(\frac{1}{6}\right)^2 + 2\left(\frac{1}{2}\right)^2 + 2\left(\frac{1}{3}\right)^2 \right] \cdot 2 \cdot R_{on} \\ = \left[\frac{6}{36} + \frac{19}{36} + \frac{16}{36} \right] \cdot 2 \cdot R_{on} = \frac{64}{36} R_{on} = \frac{16}{9} R_{on} \\ R_{O,FSL} = \boxed{\frac{16}{9} R_{on}}$$

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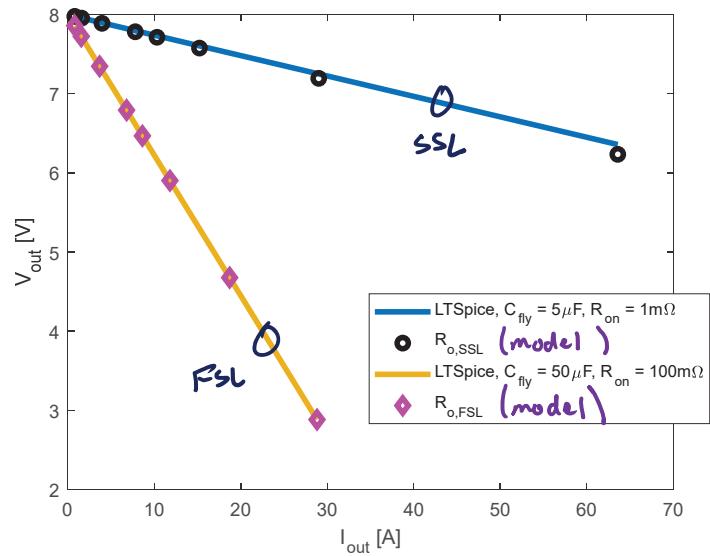
6:1 Dickson Converter Simulation



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Simulation Comparison to Model

fixed $f_s = 1\text{MHz}$

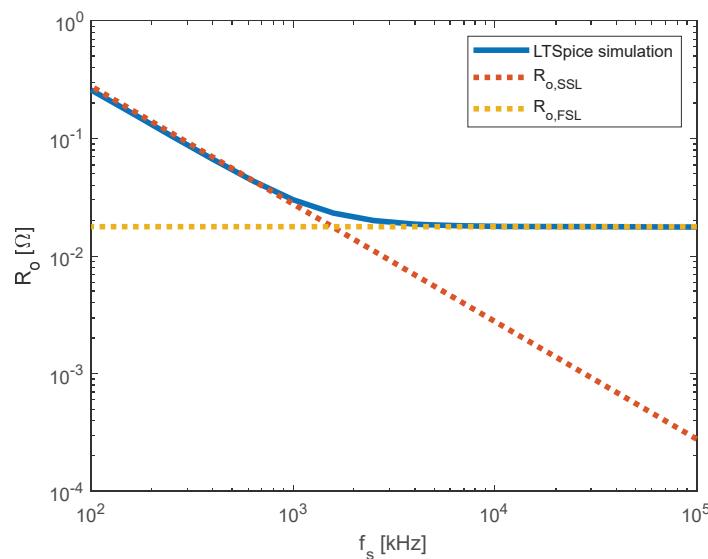


R_o vs Switching Frequency

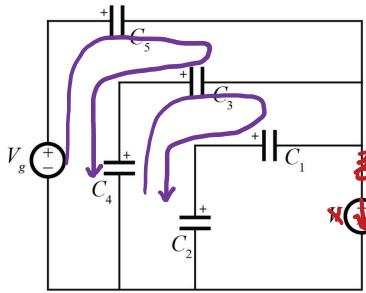
fixed $R_{on} = 10\text{m}\Omega$, $C_{fly} = 5\mu\text{F}$

combined model:

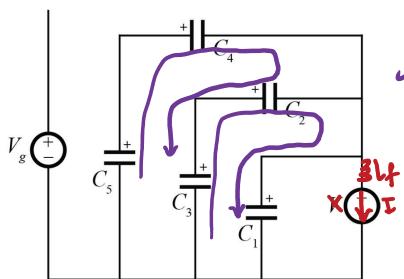
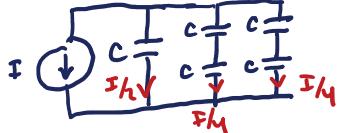
$$R_o \approx \sqrt{R_{o,SSL} + R_{o,FSL}}$$



Hybrid Dickson converter



In either subinterval, DC solution is



However, there are also pure V-C loops. If any current flows in the V-C loops, there will still be charge-sharing loss.

Assume current is only I_{out} DC solution:

$$\bar{\alpha}^I = \begin{bmatrix} \frac{1}{4} & \frac{1}{8} & \frac{-1}{8} & \frac{1}{8} & \frac{-1}{8} & \frac{1}{4} & \frac{1}{2} \end{bmatrix} \begin{matrix} I_{out} T_3 \\ I_{out} T_3 \end{matrix}$$

in C_1 C_2 C_3 C_4 C_5 out

$$\bar{\alpha}^{II} = \begin{bmatrix} \emptyset & \frac{-1}{4} & \frac{1}{8} & \frac{-1}{8} & \frac{1}{8} & \frac{-1}{8} & \frac{1}{2} \end{bmatrix}$$