SC Converters

- Fixed conversion ratio
  - No regulation (except linear)
- Not lossless, even with ideal elements
- Can be very small, fully integrated
  - Driscoll caps can be small and efficient in many applications
  - Integrated on-chip caps much better than on-chip inductors
- **Resonant** versions can reduce loss
- **Hybrid** versions can allow regulation

\[ \frac{V}{V_{	ext{in}}} = \frac{1}{2} = \eta \]
Capacitor Charging: Voltage Source

\[ \Delta E_c = \frac{1}{2} C V_z^2 - \frac{1}{2} C V_i^2 \]

\[ \Delta E_v = \frac{1}{2} C \left( V_z^2 - V_i^2 \right) \]

\[ \Delta E_v = C V_z (V_z - V_i) \]

\[ \Delta E_v = C V_z \]

\[ E_{loss} = \Delta E_v - \Delta E_c = CV_z (V_z - V_i) - \frac{1}{2} C (V_z^2 - V_i^2) \]

\[ = CV_z^2 - CV_z V_i - \frac{1}{2} CV_z^2 + \frac{1}{2} CV_i^2 \]

\[ = \frac{1}{2} CV_z^2 + \frac{1}{2} V_i^2 - CV_z V_i = \frac{1}{2} C \left[ V_z^2 + V_i^2 - 2V_z V_i \right] \]

\[ E_{loss} = \frac{1}{2} C (V_z - V_i)^2 = \frac{1}{2} C (\Delta V_c)^2 \]

\[ \eta = \frac{\Delta E_c}{\Delta E_v} = \frac{\frac{1}{2} C (V_z^2 - V_i^2)}{C V_z (V_z - V_i)} = \frac{1}{2} \frac{V_z^2 - (V_z - \Delta V_c)^2}{V_z (V_z - (V_z - \Delta V_c))} \]

\[ \eta = \frac{1}{2} \frac{2V_z \Delta V_c - (\Delta V_c)^2}{V_z \Delta V_c} \]

\[ = \frac{1}{2} \left( 2 - \frac{\Delta V_c}{V_z} \right) \]

\[ \eta = 1 - \frac{\Delta V_c}{2V_z} \]

No dependence on \( R \) except \( t_e \gg RC \)

Slow-switching limit (SSL)
Capacitor Charging: Current Source

\[ v_c(t_0) = V_1 \]

\[ v_c(t) \]

\[ i(t) \]

\[ t_c \]