Second Order Parallel LCR Resonator

\[
\frac{V_o}{I} = \frac{1}{Y} = \frac{1}{(1/sL) + sC + (1/R)} = \frac{s/C}{s^2 + s(1/CR) + (1/LC)}
\]

\[\omega_0^2 = 1/LC; \quad \omega_0 = 1/\sqrt{LC}; \quad Q = \omega_0 CR\]
Second Order Filter

\[ T(s) = \frac{V_0(s)}{V_i(s)} = \frac{Z_2(s)}{Z_1(s) + Z_2(s)} \]

(a) General structure
Low Pass Filter

\[ T(s) = \frac{1/\,LC}{s^2 + s(1/\,CR) + (1/\,LC)} \]
High Pass Filter
Band Pass Filter

\[ T(s) = \frac{s(1/CR)}{s^2 + s(1/CR) + (1/LC)} \]
Notch at $\omega_0$

$$T(s) = \frac{s^2 + (1/L_1C)}{s^2 + s(1/CR) + [1/(L_1 \parallel L_2)C]}$$
Second Order Filters Based on Inductor Replacement

\[ L = \frac{C_4 R_1 R_3 R_5}{R_2} \]
An op-amp RC resonator obtained by replacing L in the LCR circuit

\[ K = 1 + \frac{r_2}{r_1} \]
Low Pass Filter
High Pass Filter
Band Pass Filter
(d) Notch at $\omega_n$

(e) LPN, $\omega_n \leq \omega_0$

(f) HPN, $\omega_n \geq \omega_0$

(g) All-pass