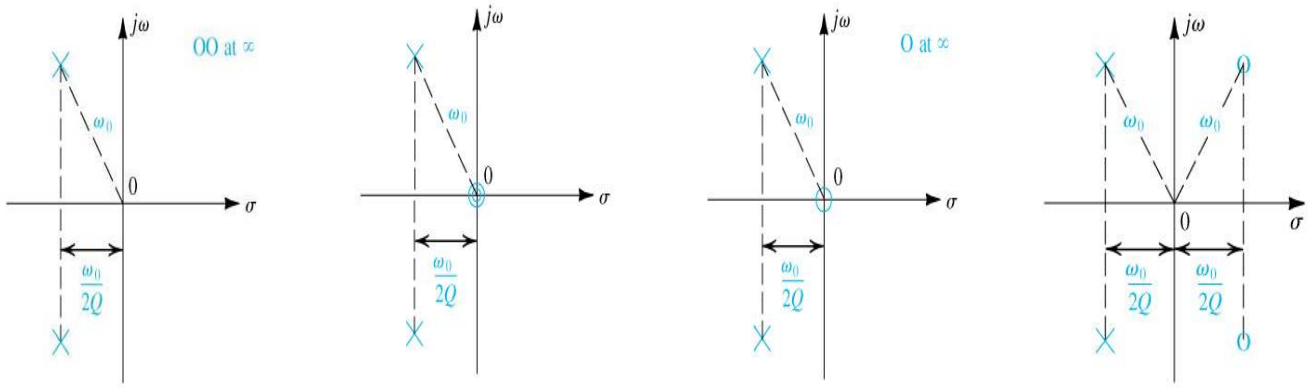
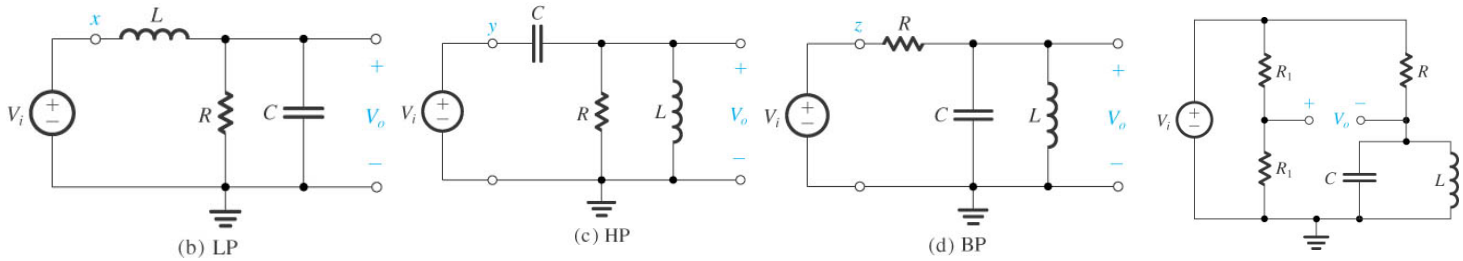
Lect. 19: Second-Order Active Filters (Razavi 14.4)

2nd-order filters



LP HP BP AP

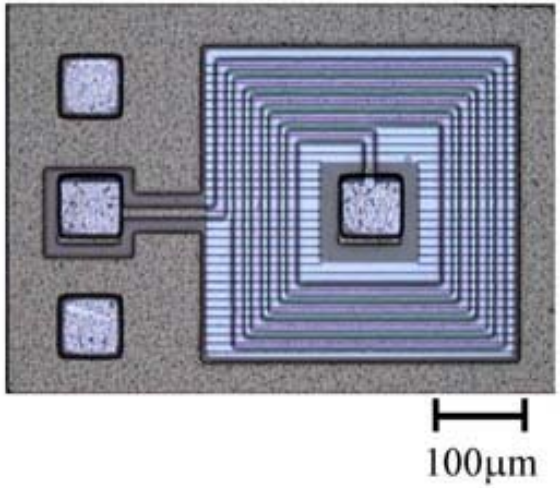
Passive Realization



Lect. 19: Second-Order Active Filters (Razavi 14.4)

Inductor: $v = L\frac{di}{dt}$

Inductor on chip

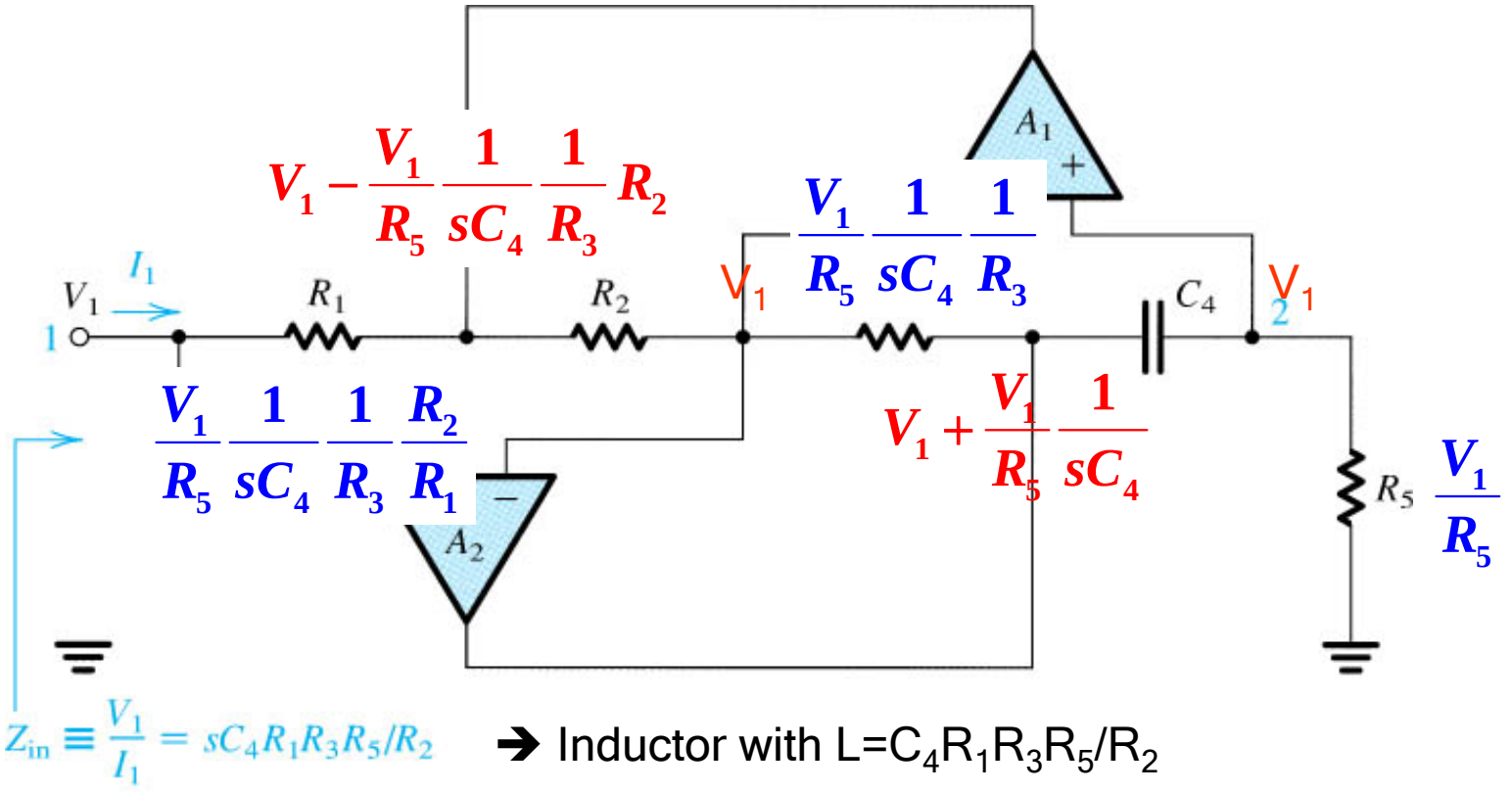


For IC implementation, inductors can be very large

Realization of inductive component by active circuits?

Lect. 19: Second-Order Active Filters

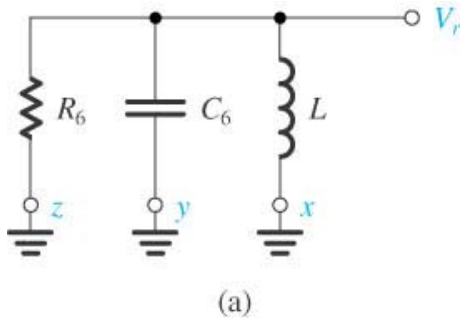
Antoniou Inductance-Simulation Circuit



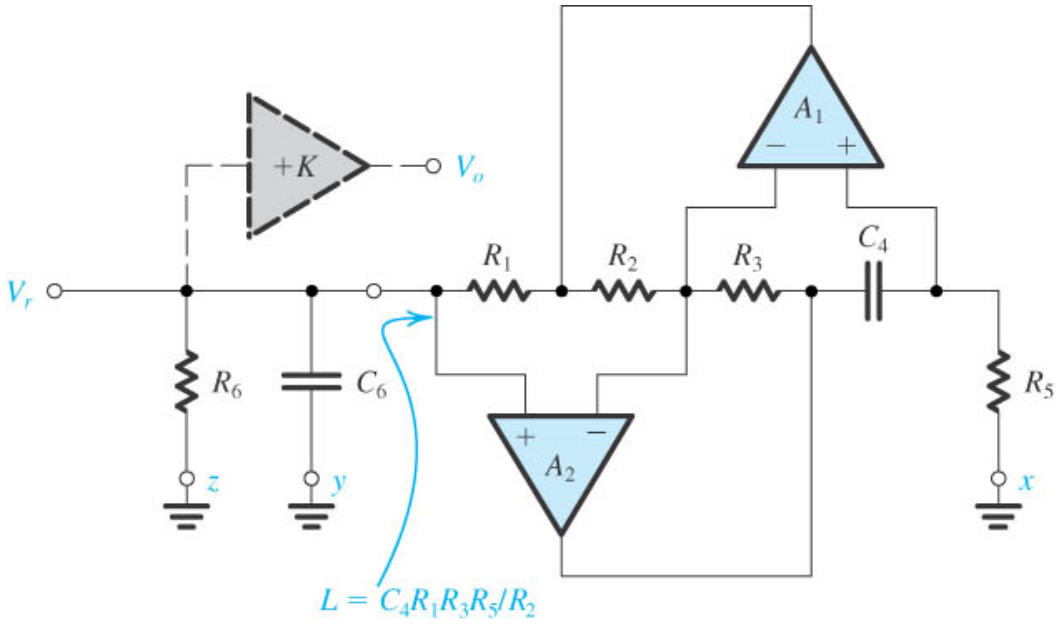
➔ Inductor with $L=C_4R_1R_3R_5/R_2$

(a)

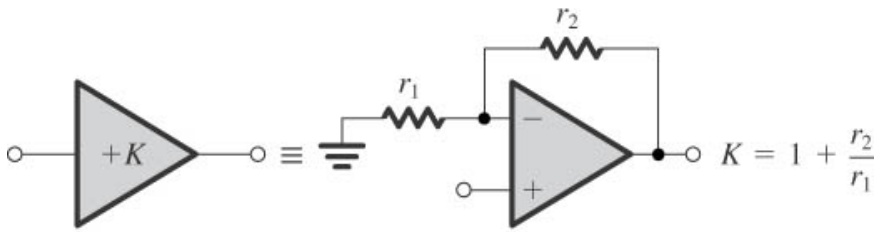
Lect. 19: Second-Order Active Filters



(a)



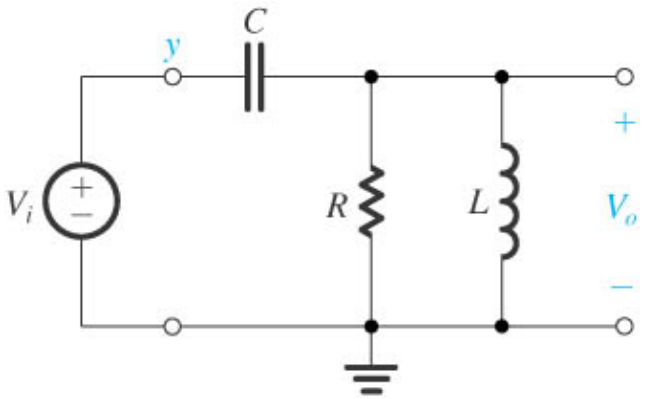
(b)



(c)

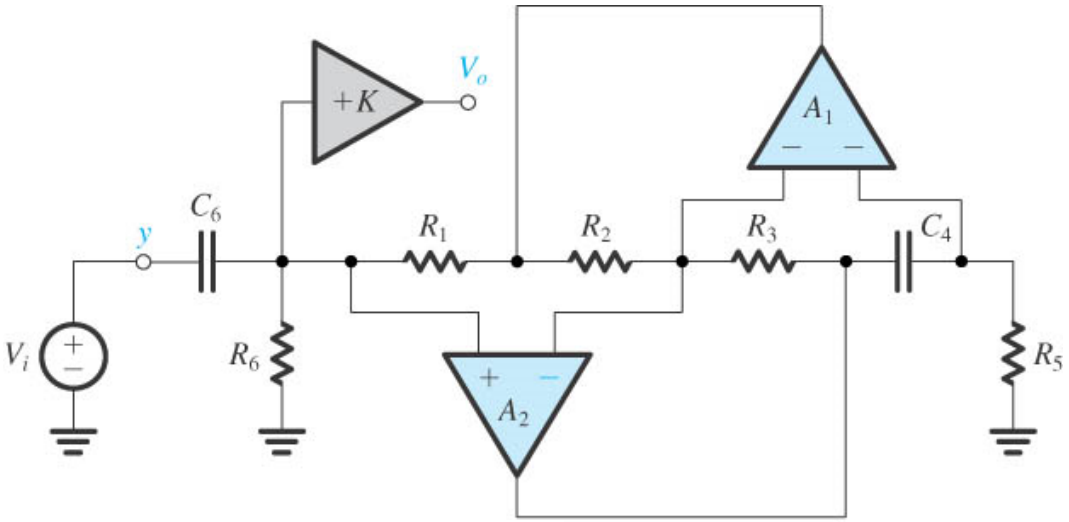
Buffer with Gain K

Lect. 19: Second-Order Active Filters



$$T(s) = \frac{s^2}{s^2 + s(1/RC) + (1/LC)}$$

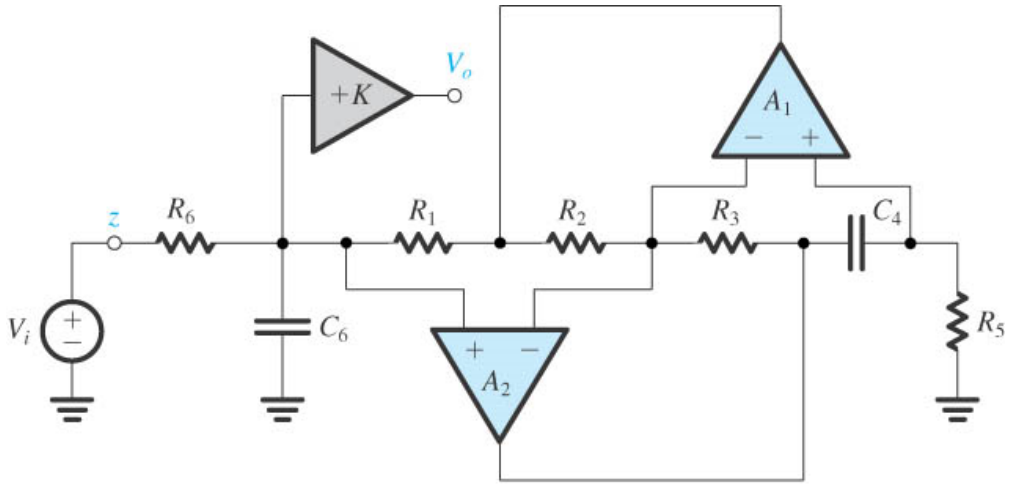
$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad Q = \sqrt{\frac{C}{L}}R$$



➔Replace L with $C_4R_1R_3R_5/R_2$

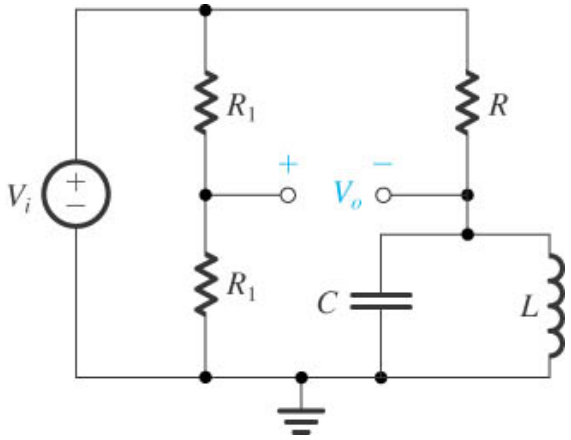
Multiply K

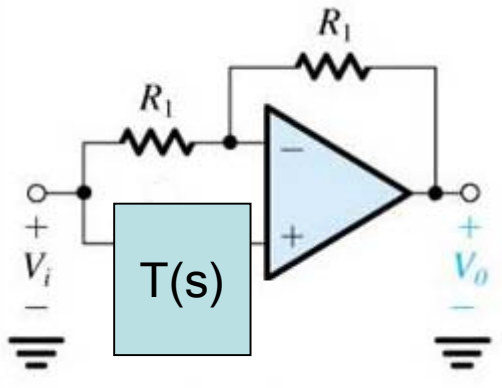
Lect. 19: Second-Order Active Filters



Lect. 19: Second-Order Active Filters

Second-Order All-Pass Filter





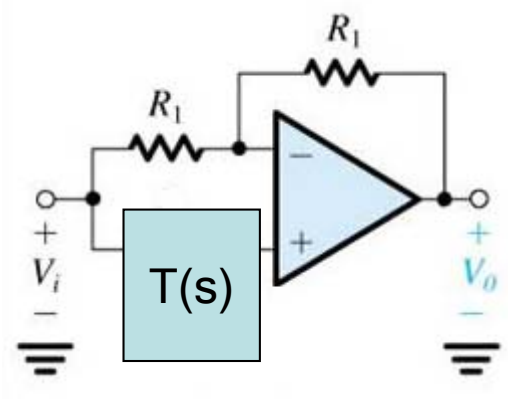
$$T(s) = \frac{s^2 - s(\omega_0 / Q) + \omega_0^2}{s^2 + s(\omega_0 / Q) + \omega_0^2}$$

$$= 1 - \frac{2s(\omega_0 / Q)}{s^2 + s(\omega_0 / Q) + \omega_0^2}$$

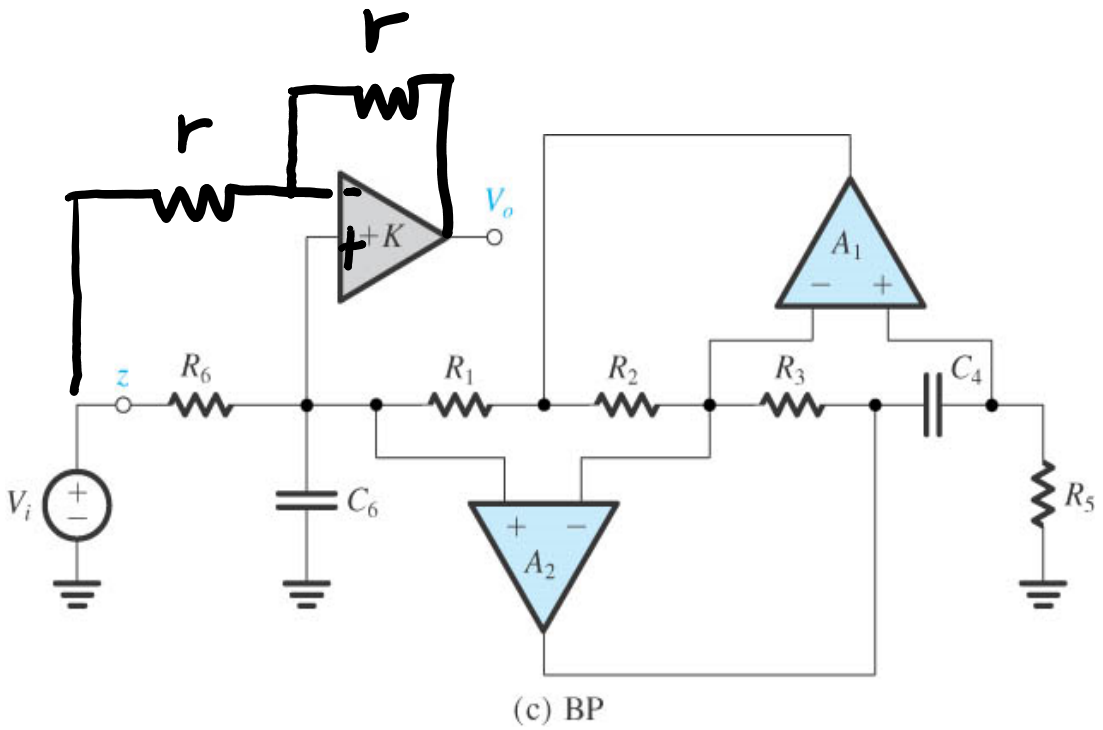
$$= 2\left(\frac{1}{2} - \frac{s(\omega_0 / Q)}{s^2 + s(\omega_0 / Q) + \omega_0^2}\right)$$

T(s): Bandpass Filter

Lect. 19: Second-Order Active Filters



T(s): Bandpass Filter



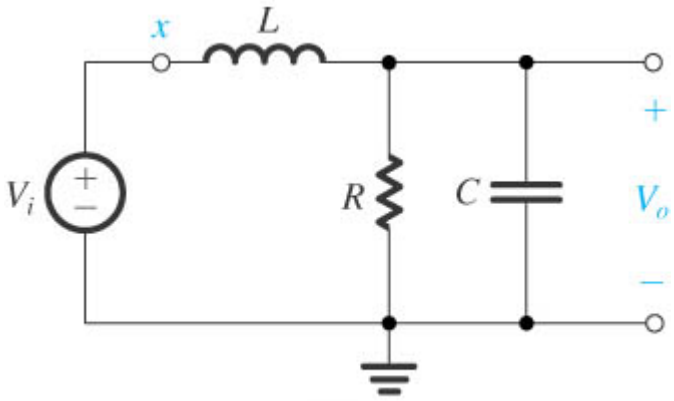
(c) BP

Second-order Bandpass Filter

➔ Second-Order All-Pass Filter

Lect. 19: Second-Order Active Filters

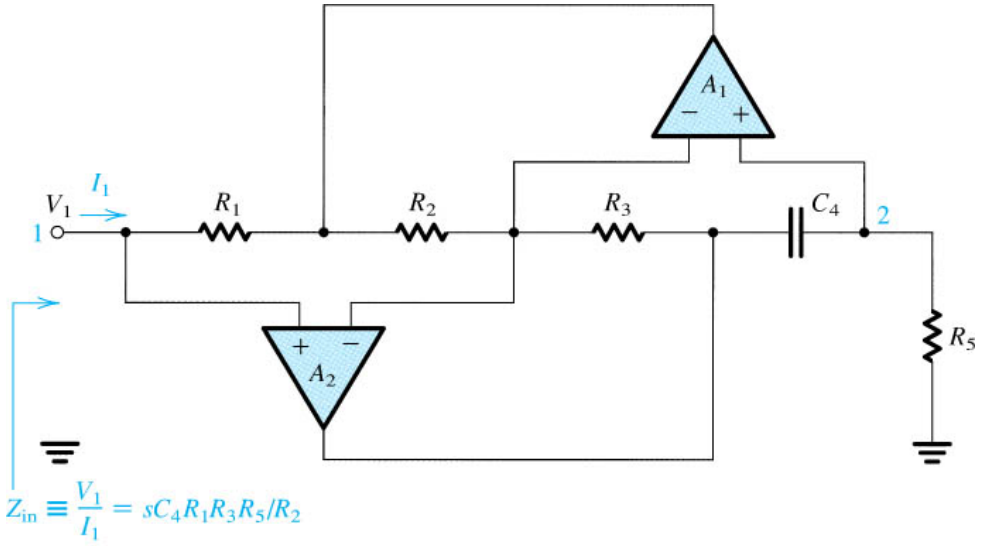
2nd-order LP filter



$$T(s) = \frac{\omega_0^2}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

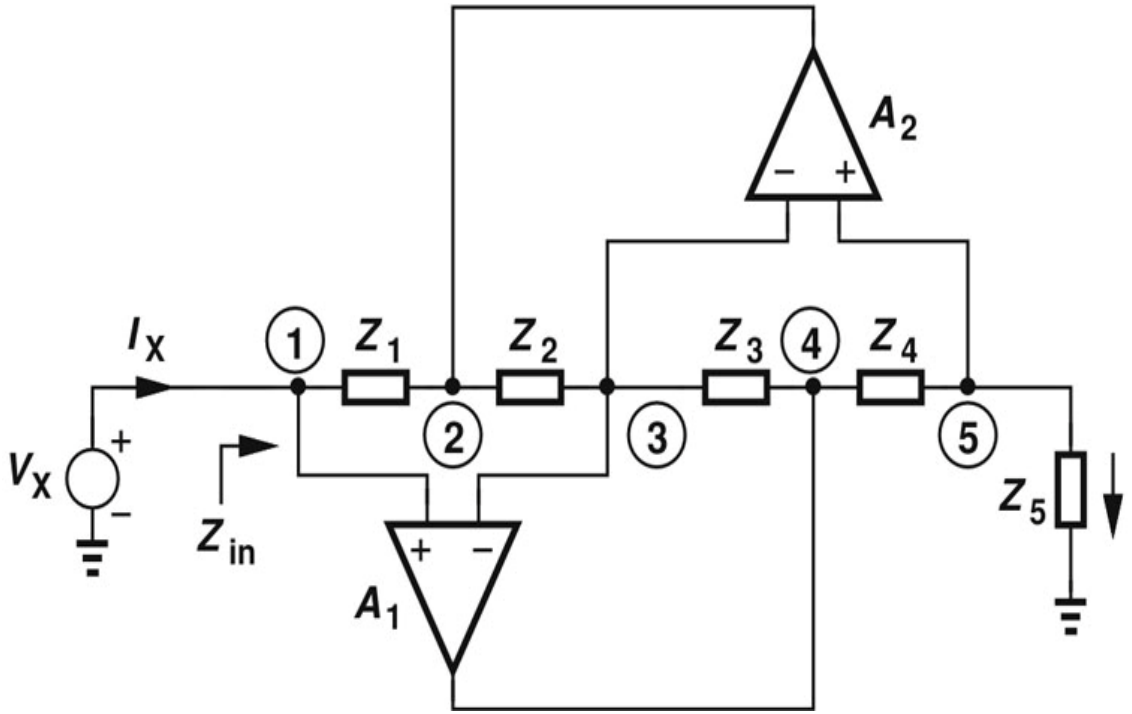
$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad Q = \sqrt{\frac{C}{L}}R$$

Antoniou Inductance-Simulation Circuit



(a)

Lect. 19: Second-Order Active Filters



$$Z_{in} = \frac{Z_1 Z_3}{Z_2 Z_4} Z_5$$ Impedance converter

Lect. 19: Second-Order Active Filters

Homework:

Determine $V_{out}(s)/V_{in}(s)$ for the circuit shown below. What type of filter is this?