Filtering topologies

$v_{in}\left(\cancel{\ } + sG_3\right) - G_2 v_{out}$ $\cdot \frac{G_1}{s} = v_{out}$

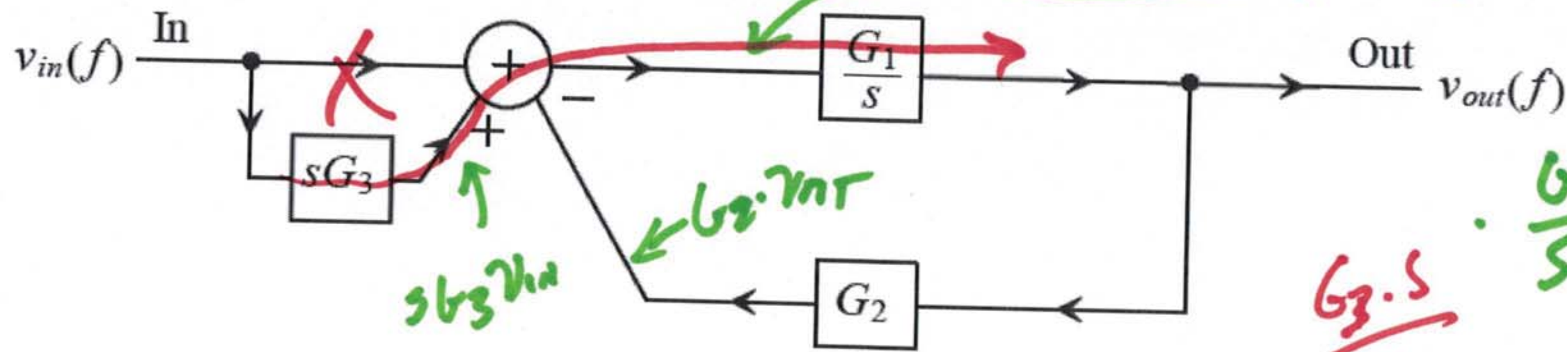
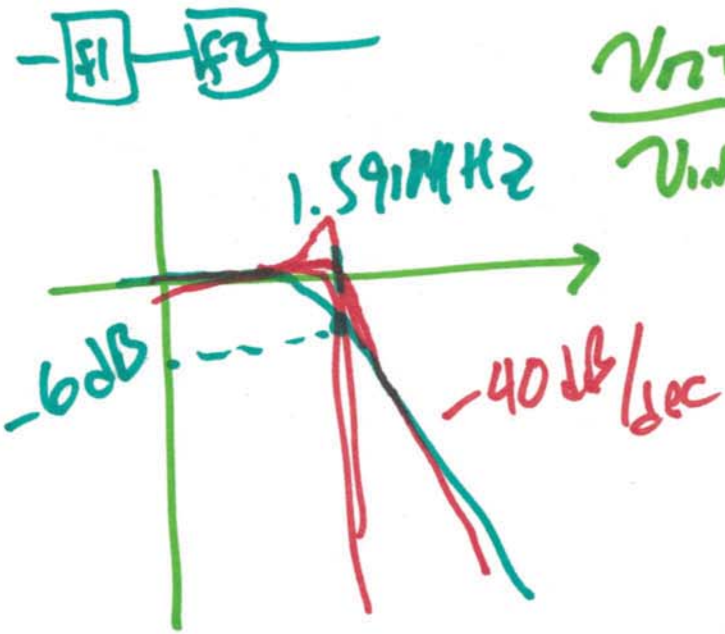
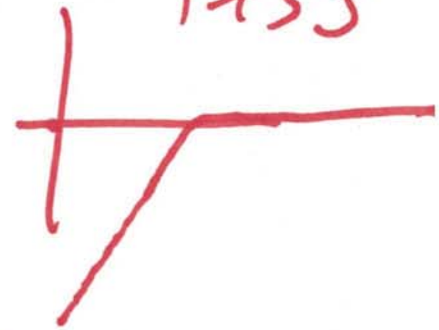


Figure 3.29 Implementation of a bilinear transfer function using an integrator.

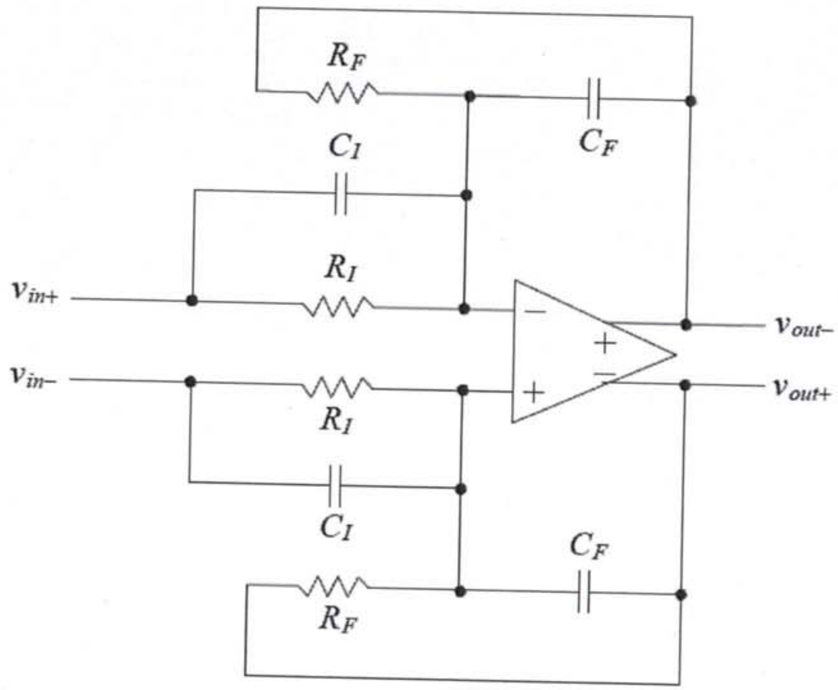
$$\frac{\frac{G_3 \cdot s}{G_2}}{1+s/G_1G_2} \qquad \frac{sK}{1+s\tau}$$



$$\frac{v_{out}}{v_{in}} = \frac{1}{G_2} \cdot \frac{\cancel{1}\ \frac{s}{1/G_3}}{1+ s/G_1G_2}$$



Bilinear transfer function
ratio of two
linear equations



$$G_1 = \frac{1}{R_I C_F}$$

$$G_2 = \frac{R_I}{R_F}$$

$$G_3 = R_I C_I$$

Figure 3.30 Implementation of an active-RC bilinear transfer function filter.

$$\frac{v_{OUT}}{v_{in}} = \frac{1}{G_2} \cdot \frac{1 + s/G_3}{1 + \frac{s}{G_1 G_2}}$$

$R_I \to \infty$

$G_1 \to 0$

$G_2 \to \infty$

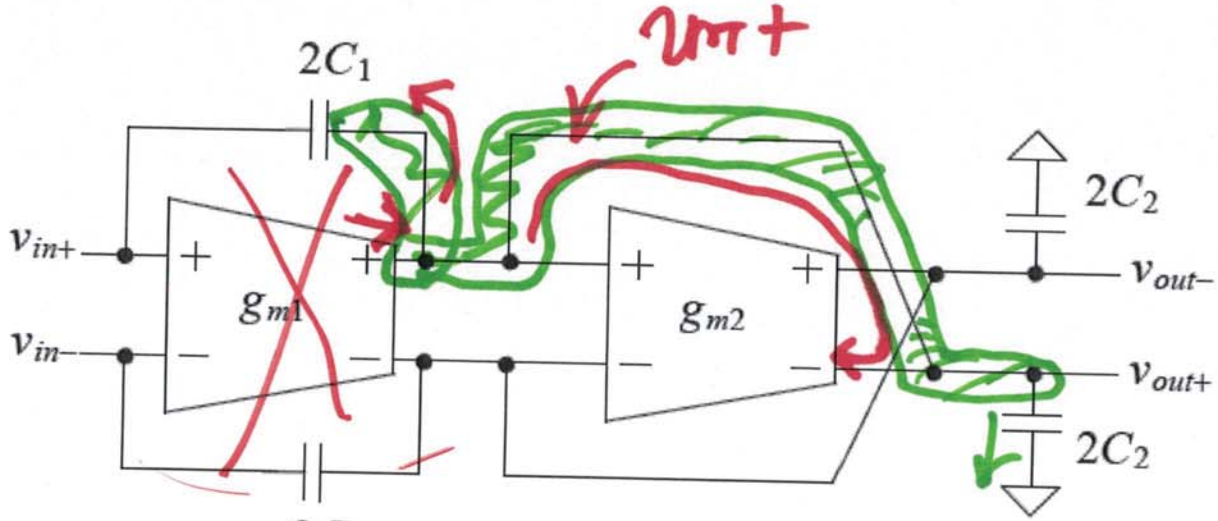
$G_3 \to \infty$

$$\frac{R_F}{R_I} \cdot \frac{1 + s R_I \cdot C_I}{1 + s R_F C_F}$$

$R_I \to \infty$

$$\frac{\cancel{R_F/R_I} + s R_F C_I}{1 + s R_F \cdot C_F}$$

2)



$$G_1 = g_{m1}/(C_1 + C_2)$$

$$G_2 = \frac{g_{m2}}{g_{m1}}$$

$$G_3 = \frac{C_1}{g_{m1}}$$

$g_1 \to 0$ (remove)

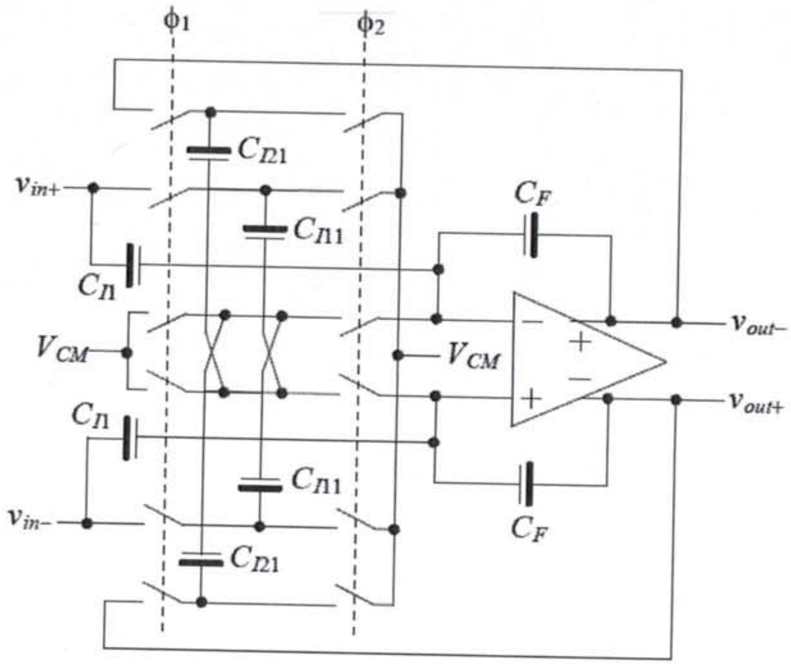
$G_1 \to 0$

$G_2 \to \infty$

$G_3 \to \infty$

Figure 3.31 Implemention of a bilinear filter using transconductors.

$$g_{m1}(V_{in}) = \frac{V_{oT} - V_{in}}{1/j\omega C_1 \cdot 2} + V_{oT} \cdot g_{m2} + \frac{V_{oT}}{1/j\omega 2C_2}$$



$$G_1 = \frac{C_{f11}}{C_F} \cdot f_s$$

$$G_2 = \frac{C_{f21}}{C_{f11}}$$

$$G_3 = \frac{C_{f1}}{C_{f11} \cdot f_s}$$

$$\frac{v_{out}(f)}{v_{in}(f)} = \frac{1}{G_2} \cdot \frac{1 + \frac{s}{1/G_3}}{1 + \frac{s}{G_1 G_2}}$$

Figure 3.32 Implemention of a bilinear filter using switched capacitors.

4)

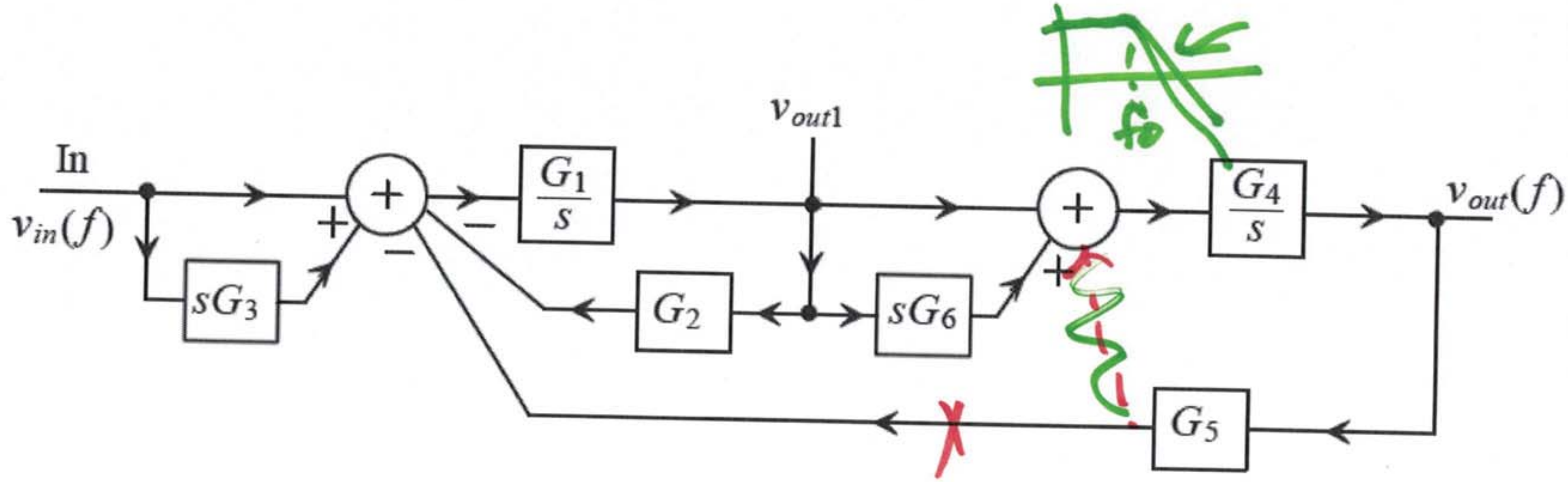


Figure 3.33 Implementation of a biquadratic transfer function using two integrators.

$$\frac{V_{OUT}}{V_{in}} = \frac{a_2 s^2 + a_1 s + a_0}{s^2 + \left(\frac{2\pi f_0}{Q}\right)s + (2\pi f_0)^2}$$

Biquad

$\omega_N = 2\pi f_0$ ← NATURAL

overdamp

Q → $\dfrac{\text{Energy stored}}{\text{Energy lost}}$

1MHz

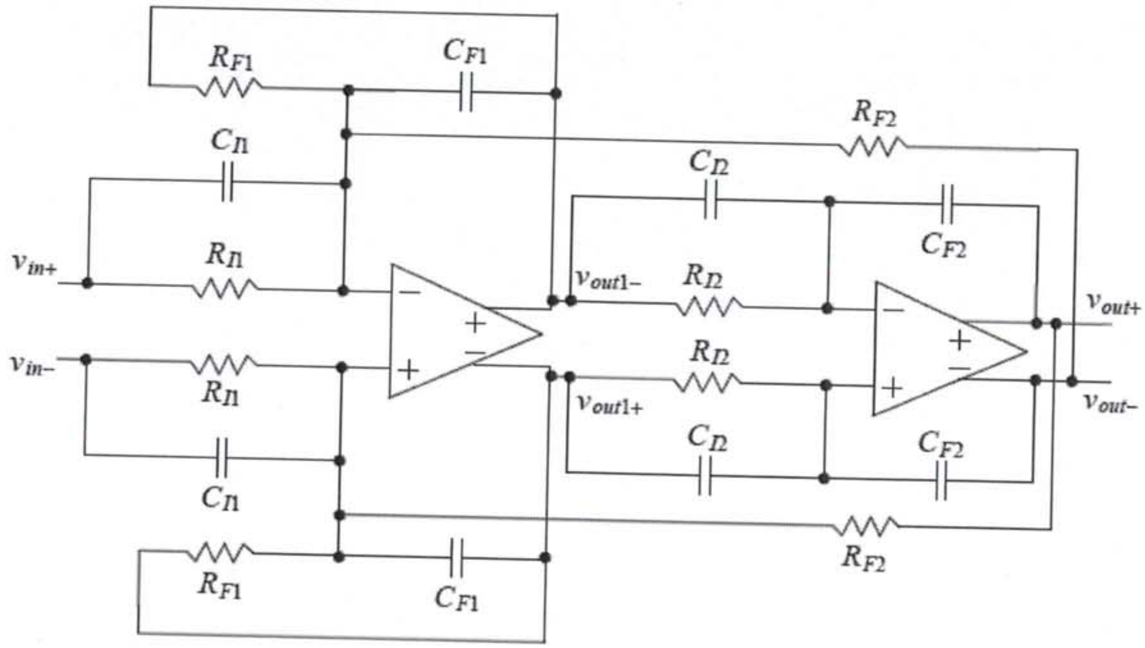
3dB 900K

3dB 1.1MHz

fcenter

$Q = \dfrac{f_0}{BW} = \dfrac{1\text{MHz}}{200K} = 5$

5)



$$G_1 = \frac{1}{R_{I1}C_{F1}} \quad G_2 = \frac{R_{I1}}{R_{F1}} \quad G_3 = R_{I1}C_{I1} \quad G_4 = \frac{1}{R_{I2}C_{F2}} \quad G_5 = \frac{R_{I1}}{R_{F2}} \quad G_6 = R_{I2}C_{I2}$$

$$a_2 = \frac{C_{I1}C_{I2}}{C_{F1}C_{F2}} \qquad a_1 = \frac{C_{I1}}{R_{I2}C_{F1}C_{F2}} + \frac{C_{I2}}{R_{I1}C_{F1}C_{F2}} \qquad a_0 = \frac{1}{R_{I1}C_{F1}R_{I2}C_{F2}}$$

$$\frac{\omega_0}{Q} = \frac{2\pi f_0}{Q} = \frac{1}{R_{F1}C_{F1}} + \frac{C_{I2}}{C_{F1}R_{F2}C_{F2}} \qquad f_0 = \frac{1}{2\pi}\cdot\sqrt{\frac{1}{C_{F1}R_{I2}C_{F2}R_{F2}}}$$

Figure 3.34 Implementation of the active-RC biquadratic transfer function filter.

6)

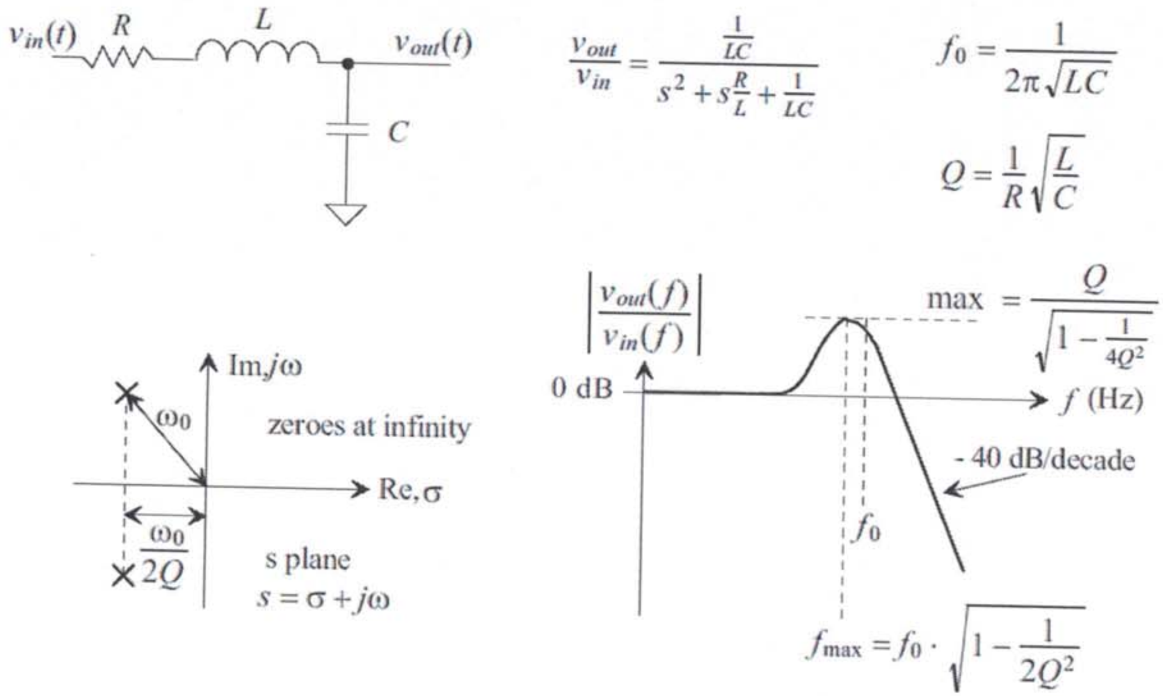


Figure 3.35 Second-order lowpass filter.

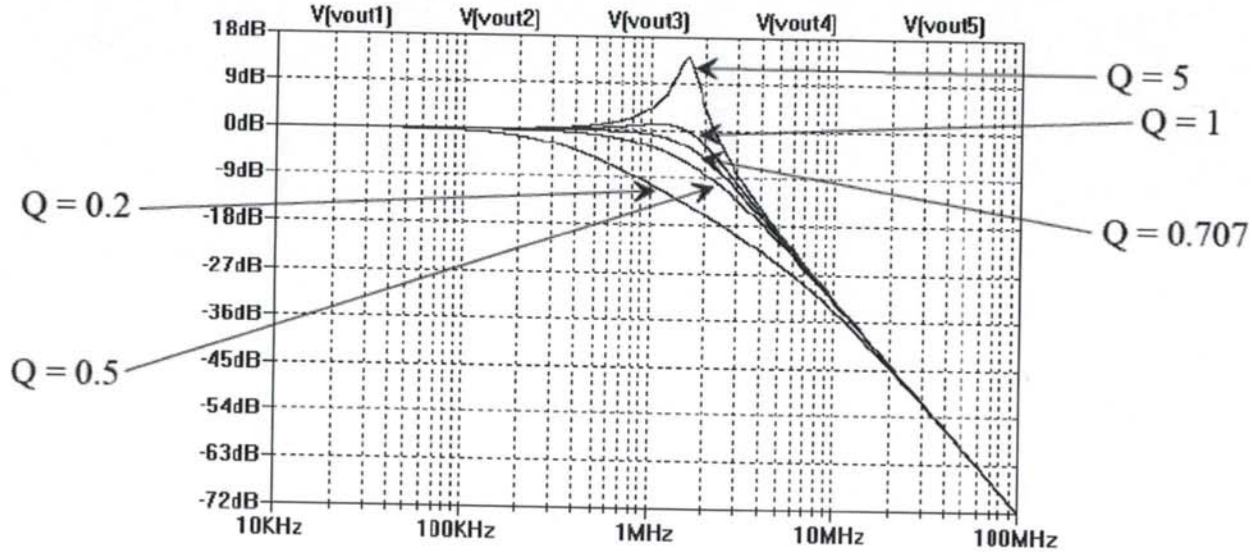


Figure 3.37 The effect of Q on the frequency response of a second-order lowpass filter.

SAW

8)