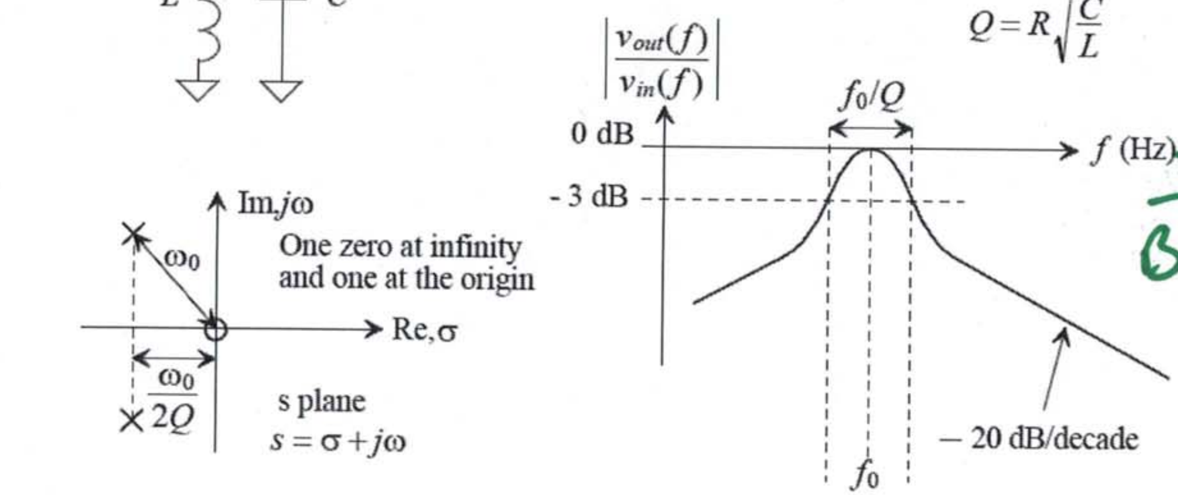
$$\frac{v_{out}}{v_{in}} = \frac{s\frac{1}{RC}}{s^2 + s\frac{1}{RC} + \frac{1}{LC}} \qquad f_0 = \frac{1}{2\pi\sqrt{LC}} \qquad Q = R\sqrt{\frac{C}{L}}$$

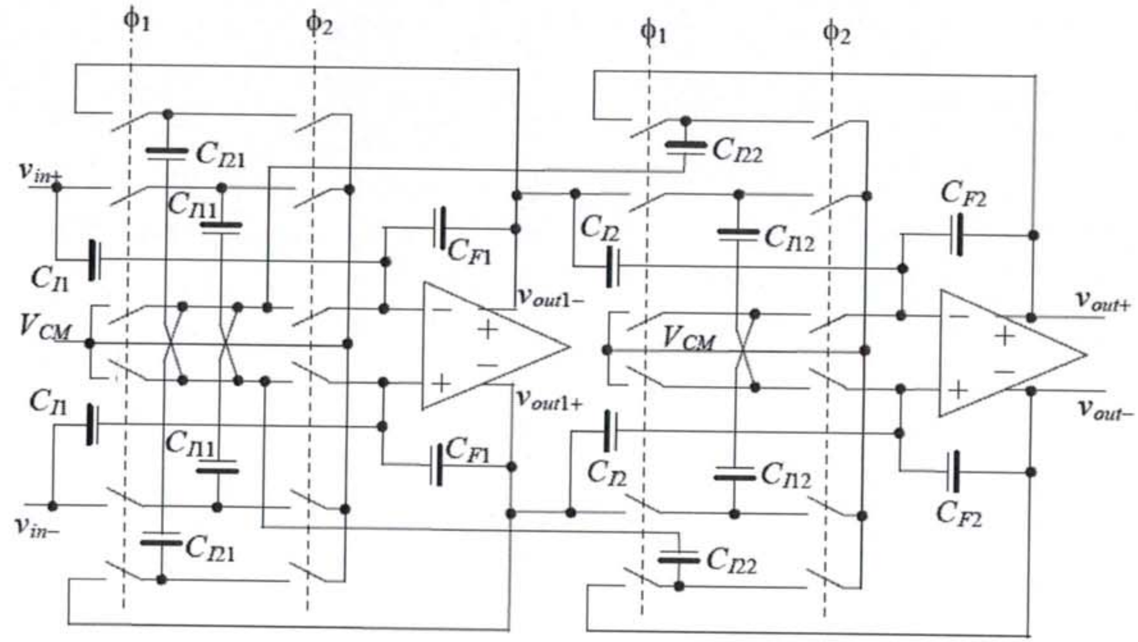


$$\frac{f_0}{BW} = Q$$

Figure 3.39 Second-order bandpass filter.

S.C.

$$\frac{v_{out}}{v_{in}} = \frac{a_1 s + a_0}{s^2 + \left(\frac{2\pi f_0}{Q}\right)s + (2\pi f_0)} = \frac{sG_1G_3G_4 + G_1G_4}{s^2 + G_1G_2 s + G_1G_4G_5}$$



$$G_1 = \frac{C_{I11}}{C_{F1}} \cdot f_s \quad G_2 = \frac{C_{I21}}{C_{I11}} \quad G_3 = \frac{C_{I1}}{C_{I11} \cdot f_s} \quad G_4 = \frac{C_{I12}}{C_{F2}} \cdot f_s \quad G_5 = \frac{C_{I22}}{C_{I11}} \quad G_6 = \frac{C_{I2}}{C_{I12} \cdot f_s}$$ ←

Figure 3.43 Implementing a biquad filter using switched capacitors.

Hi-Q

$Q = \frac{2\pi f_0}{G_1 G_2}$

3.77

$R_{sc} = \frac{1}{fC}$

$Q \propto R_F$

[illegible] $G \propto \frac{1}{R}$

2

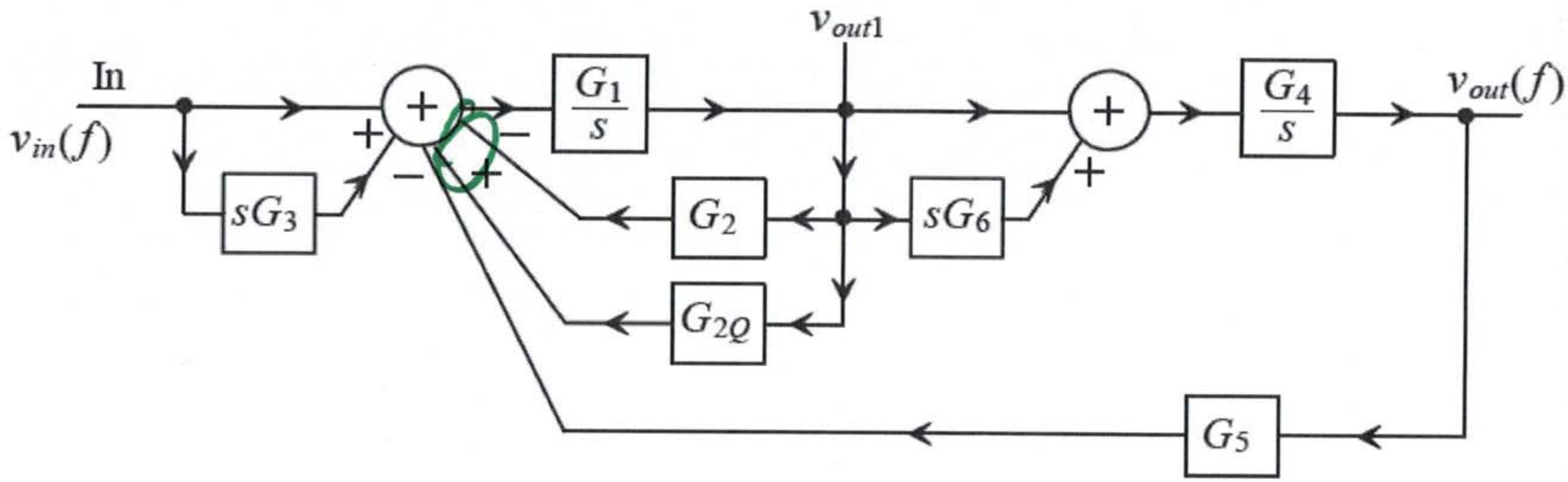


Figure 3.44 Implementation of a "high-Q" biquadratic transfer function.

$v_{out1} \cdot (G_{2Q} - G_2)$

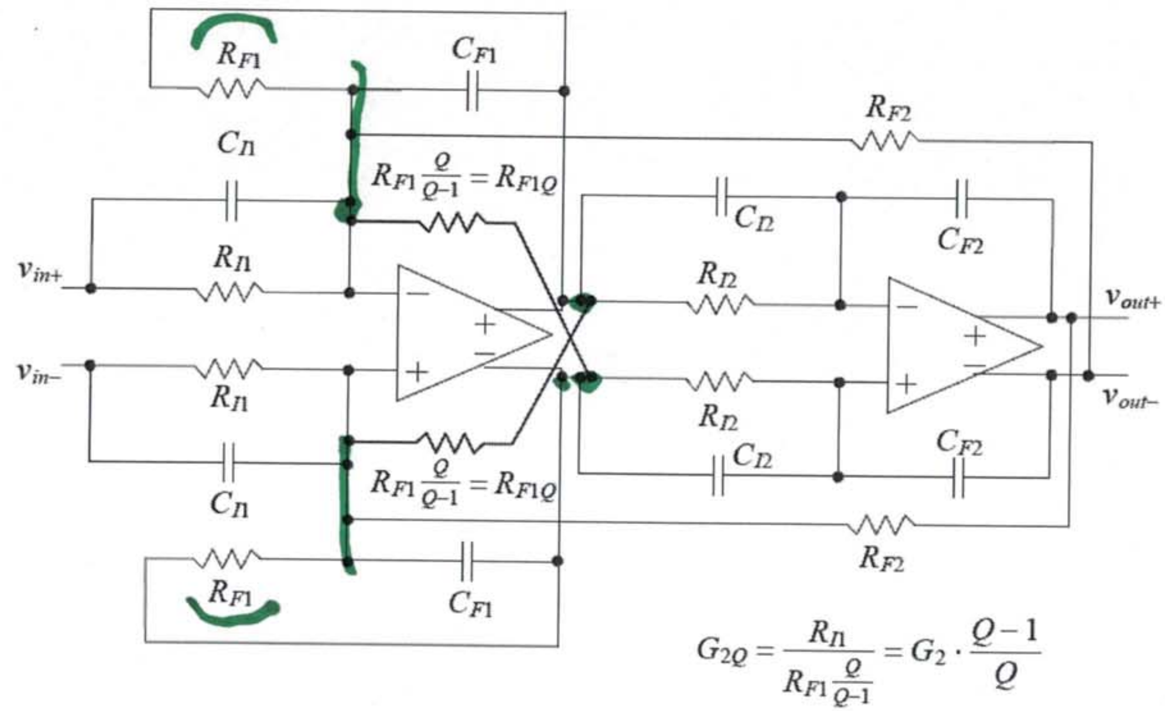


Figure 3.45 Implementation of the "high-Q" active-RC biquadratic transfer function filter. The bold lines indicate the added components.

4)

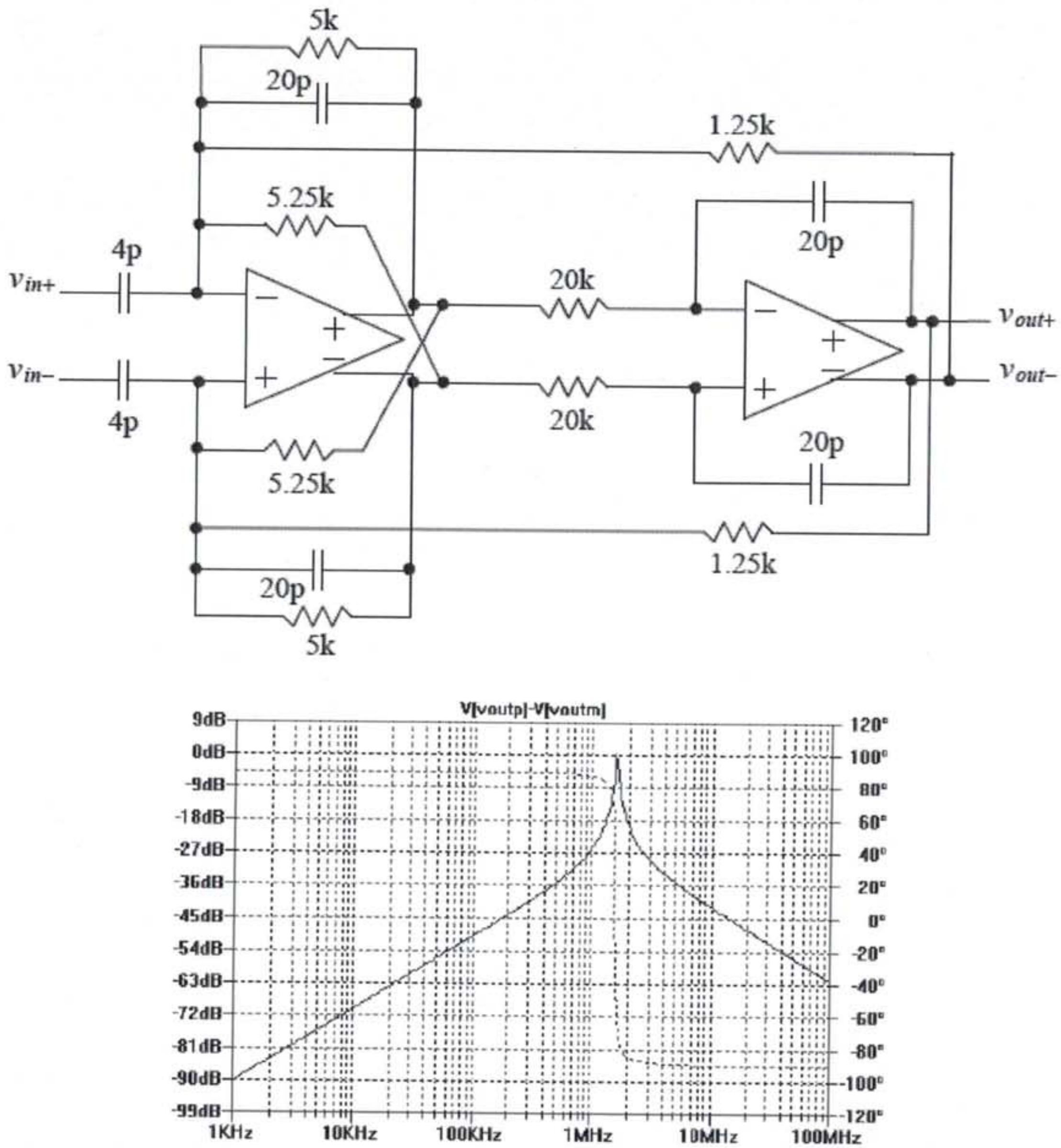


Figure 3.46 Bandpass filter discussed in Ex. 3.13.

5)

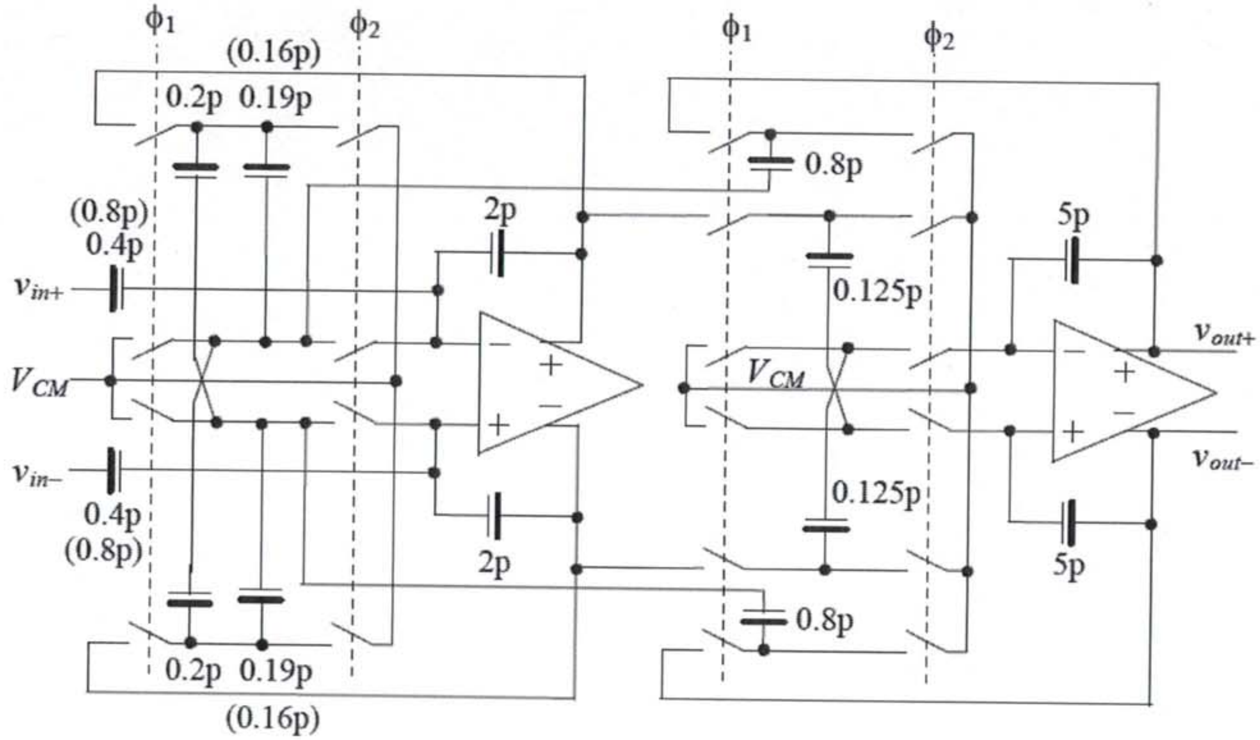


Figure 3.47 Switched-capacitor implementation of a high-Q filter; see Ex. 35.14.

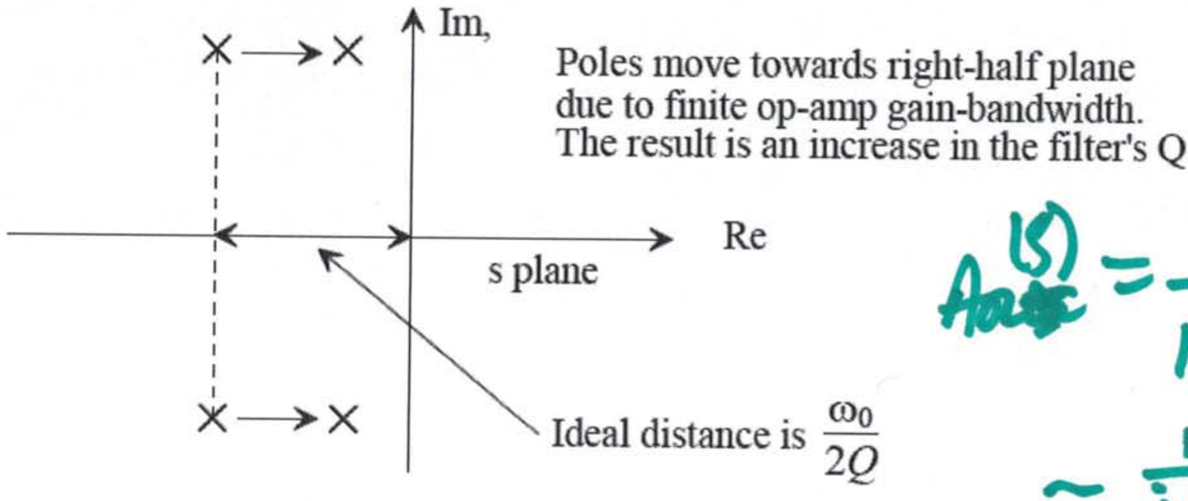


Figure 3.50 Showing Q peaking resulting from the op-amp finite gain bandwidth product.

$$A(s) = \frac{A_{OL}}{1 + j\frac{f}{f_{3dB}}} \approx \frac{1}{j\frac{f}{f_{un}}}$$

Q peaking related to finite BW of op-Amp

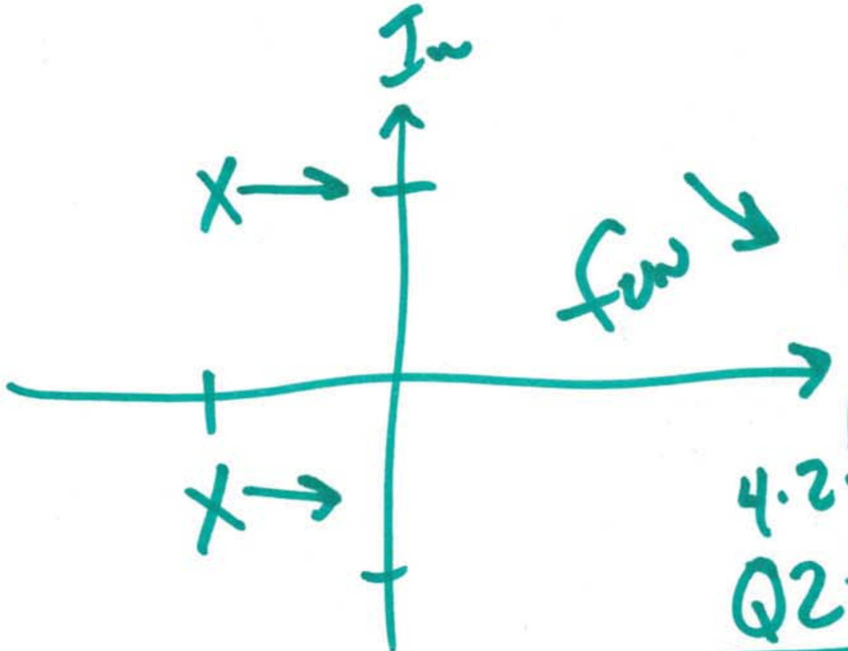
$$f_{un} = f_{3dB} \cdot A_{OL}$$

$$\frac{1}{s} \rightarrow \frac{1}{s\left(1+\frac{s}{2\pi f_{un}}\right)}$$

$$\frac{1}{s\left(1+\frac{s}{2\pi f_{un}}\right)+p_1} \cdot \frac{1}{s\left(1+\frac{s}{2\pi f_{un}}\right)+p_2}$$

$$s\left(1+\frac{s}{2\pi f_{un}}\right)+p_1 = s + p_1 + \frac{s^2}{2\pi f_{un}}$$

$$= s + p_1 + \frac{-(2\pi f)^2}{2\pi f_{un}}$$

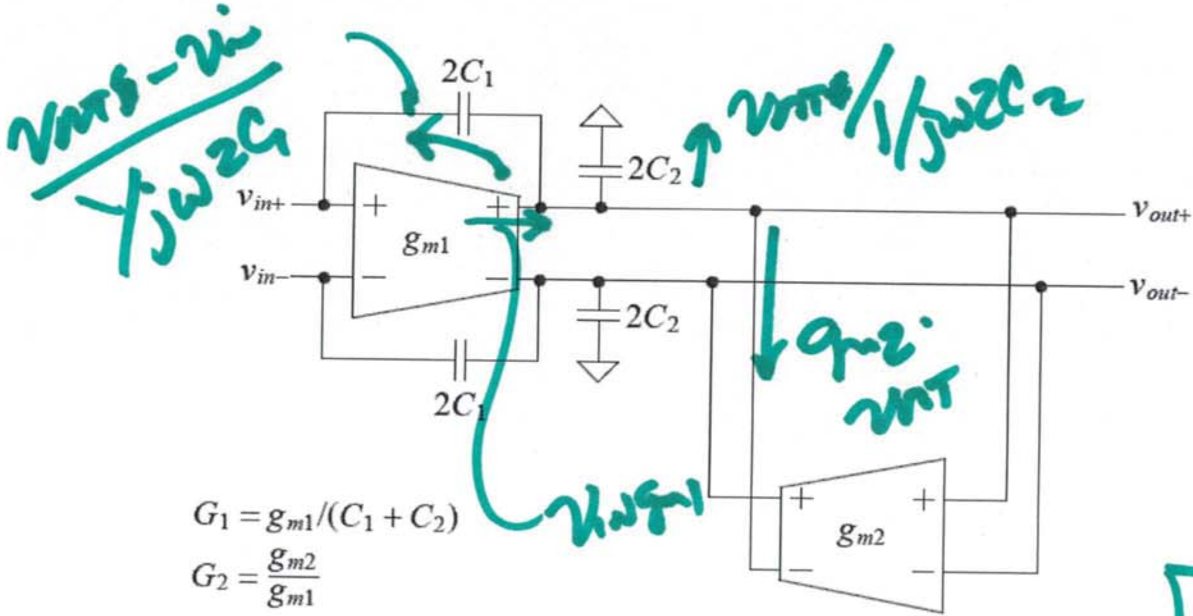


$f_{un} \searrow$ poles move towards RHP

$4 \cdot 2 \cdot 1.59$ MHz

$$\frac{Q 2 f_o}{f_{un}} << 1$$

$\wedge$



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

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

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

Figure 3.52 Redrawing the bilinear filter shown in Fig. 3.31.

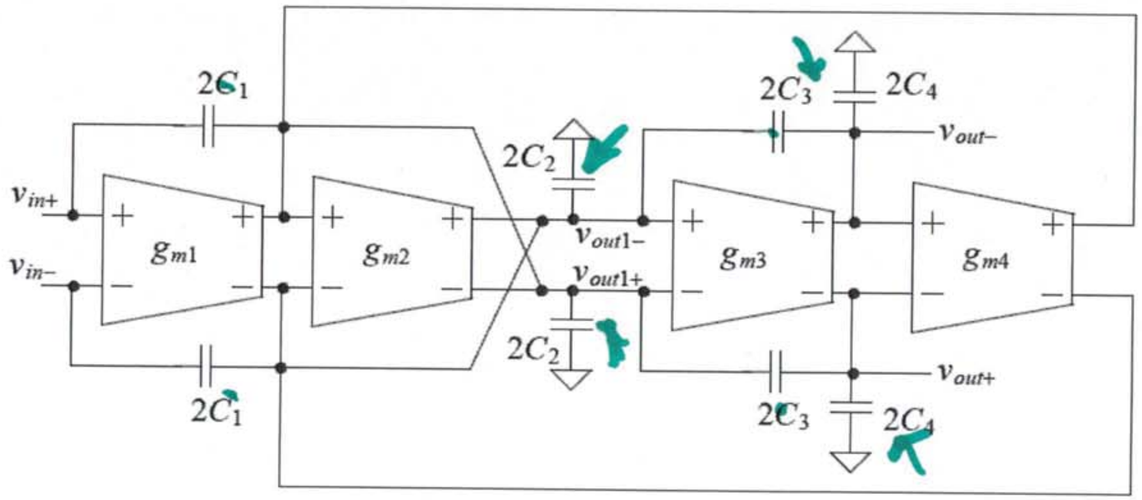
$v_{out+} - v_{out-} = i_+\left(\frac{1}{j\omega C}\right)$ $i_+ = i_-$

$v_{out+} - v_{out-} = i_+ \cdot \frac{1}{j\omega 2C} - i_- \cdot \frac{1}{j\omega C2}$

$i_+ = -i_-$

$2i_+ \cdot \frac{1}{j\omega 2C}$

a)



$G_1 = g_{m1}/(C_1 + C_2)$ $G_2 = \frac{g_{m2}}{g_{m1}}$ $G_3 = \frac{C_1}{g_{m1}}$ $G_4 = g_{m3}/(C_3 + C_4)$ $G_5 = \frac{g_{m4}}{g_{m1}}$ $G_6 = \frac{C_3}{g_{m3}}$

Figure 3.53 Implementing a biquadratic filter using transconductors.

10)