

Experiment: TIA simple Z2 Z4 ZL

Filter 1

Filter Type: GE

$$Z(s): \left(\infty, R_2, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_4(C_L L_L s^2 + C_L R_L s + 1)}{2C_L L_L s^2 + C_L R_4 s + 2C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2L_L \sqrt{C_L^2 L_L}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{2L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{\frac{1}{C_L^2 L_L}}}{R_L}$$

Filter 2

Filter Type: GE

$$Z(s): \left(\infty, R_2, \infty, R_4, \infty, \frac{L_L s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_4(C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2C_L L_L R_L s^2 + 2L_L s + R_4 + 2R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{C_L^2 L_L}{2}} (R_4 + 2R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{2}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 3

Filter Type: GE

$$Z(s): \left(\infty, R_2, \infty, L_4 s + R_4 + \frac{1}{C_4 s}, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_4 L_4 s^2 + C_4 R_4 s + 1)}{C_4 L_4 s^2 + C_4 R_4 s + 2C_4 R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{C_4^2 L_4}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{\frac{1}{C_4^2 L_4}}}{R_4}$$

Filter 4

Filter Type: GE

$$Z(s): \left(\infty, R_2, \infty, \frac{L_4 s}{C_4 L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_4 L_4 R_L s^2 + L_4 s + R_4)}{C_4 L_4 R_L s^2 + 2C_4 L_4 R_L s^2 + L_4 s + R_4 + 2R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_4 (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_4 L_4}}$$

Filter 5

Filter Type: GE

$$Z(s): \left(\infty, \frac{1}{C_2 s}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_4(C_L L_L s^2 + C_L R_L s + 1)}{2C_L L_L s^2 + C_L R_4 s + 2C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2L_L \sqrt{\frac{1}{C_L^2 L_L}}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{2L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{\frac{1}{C_L^2 L_L}}}{R_L}$$

Filter 6

Filter Type: GE

$$Z(s): \left(\infty, \frac{1}{C_2 s}, \infty, R_4, \infty, \frac{L_L s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_4(C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2C_L L_L R_L s^2 + 2L_L s + R_4 + 2R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{C_L^2 L_L}{2}} (R_4 + 2R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{2}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 7

Filter Type: GE

$$Z(s): \left(\infty, \frac{1}{C_2 s}, \infty, L_4 s + R_4 + \frac{1}{C_4 s}, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_4 L_4 s^2 + C_4 R_4 s + 1)}{C_4 L_4 s^2 + C_4 R_4 s + 2C_4 R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{C_4^2 L_4}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{\frac{1}{C_4^2 L_4}}}{R_4}$$

Filter 8

Filter Type: GE

$$Z(s): \left(\infty, \frac{1}{C_2 s}, \infty, \frac{L_4 s}{C_L L_L s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_4 L_4 R_L s^2 + L_4 s + R_4)}{C_4 L_4 R_L s^2 + 2C_4 L_4 R_L s^2 + L_4 s + R_4 + 2R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_4 (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_4 L_4}}$$

Filter 9

Filter Type: GE

$$Z(s): \left(\infty, \frac{R_2}{C_2 R_2 s + 1}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_4(C_L L_L s^2 + C_L R_L s + 1)}{2C_L L_L s^2 + C_L R_4 s + 2C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2L_L \sqrt{C_L^2 L_L}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{2L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{\frac{1}{C_L^2 L_L}}}{R_L}$$

Filter 10

Filter Type: GE

$$Z(s): \left(\infty, \frac{R_2}{C_2 R_2 s + 1}, \infty, R_4, \infty, \frac{L_4 s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_L (C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2 C_L L_L R_L s^2 + 2 L_L s + R_L + 2 R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{1}{C_L^2 L_L^2}} (R_L + 2 R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\mathbf{Bandwidth}: \frac{2}{C_L (R_L + 2 R_L)}$$

$$\mathbf{Qz}: C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 11

Filter Type: GE

$$Z(s): \left(\infty, \frac{R_2}{C_2 R_2 s + 1}, \infty, L_4 s + R_4 + \frac{1}{C_4 s}, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 s^2 + C_4 R_4 s + 1)}{C_L L_L s^2 + C_L R_4 s + 2 C_L R_4 s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\mathbf{Bandwidth}: \frac{R_4 + 2 R_L}{L_4}$$

$$\mathbf{Qz}: \frac{L_4 \sqrt{\frac{1}{C_4^2 L_4^2}}}{R_4}$$

Filter 12

Filter Type: GE

$$Z(s): \left(\infty, \frac{R_2}{C_2 R_2 s + 1}, \infty, \frac{L_4 s}{C_4 L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 R_4 s^2 + L_4 s + R_4)}{C_L L_L R_4 s^2 + 2 C_L L_L R_4 s^2 + L_4 s + R_4 + 2 R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2 R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\mathbf{Bandwidth}: \frac{1}{C_4 (R_4 + 2 R_L)}$$

$$\mathbf{Qz}: C_4 R_4 \sqrt{\frac{1}{C_4 L_4}}$$

Filter 13

Filter Type: GE

$$Z(s): \left(\infty, R_2 + \frac{1}{C_2 s}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_L (C_L L_L s^2 + C_L R_L s + 1)}{2 C_L L_L s^2 + C_L R_4 s + 2 C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2 L_L \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\mathbf{Bandwidth}: \frac{R_4 + 2 R_L}{2 L_L}$$

$$\mathbf{Qz}: \frac{L_L \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_L}$$

Filter 14

Filter Type: GE

$$Z(s): \left(\infty, R_2 + \frac{1}{C_2 s}, \infty, R_4, \infty, \frac{L_4 s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_L (C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2 C_L L_L R_L s^2 + 2 L_L s + R_L + 2 R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{1}{C_L^2 L_L^2}} (R_L + 2 R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\mathbf{Bandwidth}: \frac{2}{C_L (R_L + 2 R_L)}$$

$$\mathbf{Qz}: C_L R_L \sqrt{\frac{1}{C_L^2 L_L^2}}$$

Filter 15

Filter Type: GE

$$Z(s): \left(\infty, R_2 + \frac{1}{C_2 s}, \infty, L_4 s + R_4 + \frac{1}{C_4 s}, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 s^2 + C_4 R_4 s + 1)}{C_L L_L s^2 + C_L R_4 s + 2 C_L R_4 s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\mathbf{Bandwidth}: \frac{R_4 + 2 R_L}{L_4}$$

$$\mathbf{Qz}: \frac{L_4 \sqrt{\frac{1}{C_4^2 L_4^2}}}{R_4}$$

Filter 16

Filter Type: GE

$$Z(s): \left(\infty, R_2 + \frac{1}{C_2 s}, \infty, \frac{L_4 s}{C_4 L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 R_4 s^2 + L_4 s + R_4)}{C_L L_L R_4 s^2 + 2 C_L L_L R_4 s^2 + L_4 s + R_4 + 2 R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2 R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\mathbf{Bandwidth}: \frac{1}{C_4 (R_4 + 2 R_L)}$$

$$\mathbf{Qz}: C_4 R_4 \sqrt{\frac{1}{C_4^2 L_4^2}}$$

Filter 17

Filter Type: GE

$$Z(s): \left(\infty, L_2 s + \frac{1}{C_2 s}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_L (C_L L_L s^2 + C_L R_L s + 1)}{2 C_L L_L s^2 + C_L R_4 s + 2 C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2 L_L \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\mathbf{Bandwidth}: \frac{R_4 + 2 R_L}{2 L_L}$$

$$\mathbf{Qz}: \frac{L_L \sqrt{\frac{1}{C_L^2 L_L^2}}}{R_L}$$

Filter 18

Filter Type: GE

$$Z(s): \left(\infty, L_2 s + \frac{1}{C_2 s}, \infty, R_4, \infty, \frac{L_4 s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_L (C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2 C_L L_L R_L s^2 + 2 L_L s + R_L + 2 R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{1}{C_L^2 L_L^2}} (R_L + 2 R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\mathbf{Bandwidth}: \frac{2}{C_L (R_L + 2 R_L)}$$

$$\mathbf{Qz}: C_L R_L \sqrt{\frac{1}{C_L^2 L_L^2}}$$

Filter 19

Filter Type: GE

$$Z(s): \left(\infty, L_2s + \frac{1}{\phi_{2s}^2}, \infty, L_4s + R_4 + \frac{1}{\phi_{4s}}, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_L L_4 s^2 + C_L R_4 s + 1)}{C_L L_4 s^2 + C_L R_4 s + 2C_L R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4}$$

Filter 20

Filter Type: GE

$$Z(s): \left(\infty, L_2s + \frac{1}{\phi_{2s}^2}, \infty, \frac{L_4s}{C_L L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_L L_4 R_4 s^2 + L_4 s + R_4)}{C_L L_4 R_4 s^2 + 2C_L L_4 R_L s^2 + L_4 s + R_4 + 2R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_L L_4}} (R_4 + 2R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_L L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_L L_4}}$$

Filter 21

Filter Type: GE

$$Z(s): \left(\infty, L_2s + R_2 + \frac{1}{\phi_{2s}^2}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_L(C_L L_L s^2 + C_L R_L s + 1)}{2C_L L_L s^2 + C_L R_L s + 2C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2L_L \sqrt{\frac{C_L L_L}{R_L + 2R_L}}}{R_L + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{2L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{\frac{C_L L_L}{R_L + 2R_L}}}{R_L}$$

Filter 22

Filter Type: GE

$$Z(s): \left(\infty, L_2s + R_2 + \frac{1}{\phi_{2s}^2}, \infty, R_4, \infty, \frac{L_L s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_L(C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2C_L L_L R_L s^2 + 2L_L s + R_4 + 2R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{C_L L_L}{C_L L_L (R_4 + 2R_L)}}}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{2}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 23

Filter Type: GE

$$Z(s): \left(\infty, L_2s + R_2 + \frac{1}{\phi_{2s}^2}, \infty, L_4s + R_4 + \frac{1}{\phi_{4s}}, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_L L_4 s^2 + C_L R_4 s + 1)}{C_L L_4 s^2 + C_L R_4 s + 2C_L R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4}$$

Filter 24

Filter Type: GE

$$Z(s): \left(\infty, L_2s + R_2 + \frac{1}{\phi_{2s}^2}, \infty, \frac{L_4s}{C_L L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_L L_4 R_4 s^2 + L_4 s + R_4)}{C_L L_4 R_4 s^2 + 2C_L L_4 R_L s^2 + L_4 s + R_4 + 2R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_L L_4}} (R_4 + 2R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_L L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_L L_4}}$$

Filter 25

Filter Type: GE

$$Z(s): \left(\infty, \frac{L_2s}{C_L L_2 s^2 + 1} + R_2, \infty, R_4, \infty, L_L s + R_L + \frac{1}{\phi_L s} \right)$$

$$H(s): \frac{R_L(C_L L_L s^2 + C_L R_L s + 1)}{2C_L L_L s^2 + C_L R_L s + 2C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2L_L \sqrt{\frac{C_L L_L}{R_L + 2R_L}}}{R_L + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{2L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{\frac{C_L L_L}{R_L + 2R_L}}}{R_L}$$

Filter 26

Filter Type: GE

$$Z(s): \left(\infty, \frac{L_2s}{C_L L_2 s^2 + 1} + R_2, \infty, R_4, \infty, \frac{L_L s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_L(C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_L s^2 + 2C_L L_L R_L s^2 + 2L_L s + R_4 + 2R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{C_L L_L}{C_L L_L (R_4 + 2R_L)}}}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{2}{C_L (R_4 + 2R_L)}$$

$$\mathbf{Qz: } C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 27

Filter Type: GE

$$Z(s): \left(\infty, \frac{L_2s}{C_L L_2 s^2 + 1} + R_2, \infty, L_4s + R_4 + \frac{1}{\phi_{4s}}, \infty, R_L \right)$$

$$H(s): \frac{R_L(C_L L_4 s^2 + C_L R_4 s + 1)}{C_L L_4 s^2 + C_L R_4 s + 2C_L R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{\frac{C_L L_4}{R_4 + 2R_L}}}{R_4}$$

Filter 28**Filter Type:** GE

$$Z(s): \left(\infty, \frac{L_2 s}{C_2 L_2 s^2 + 1} + R_2, \infty, \frac{L_4 s}{C_4 L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_4 (C_4 L_4 R_4 s^2 + L_4 s + R_4)}{C_2 L_4 R_4 s^2 + 2 C_4 L_4 R_L s^2 + L_4 s + R_4 + 2 R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2 R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_4 (R_4 + 2 R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_4 L_4}}$$

Filter 29**Filter Type:** GE

$$Z(s): \left(\infty, \frac{R_2 (L_2 s + \frac{1}{C_2})}{L_2 s + R_2 + \frac{1}{C_2^2}}, \infty, R_4, \infty, L_L s + R_L + \frac{1}{C_L s} \right)$$

$$H(s): \frac{R_4 (C_L L_L s^2 + C_L R_L s + 1)}{2 C_L L_L s^2 + C_L R_4 s + 2 C_L R_L s + 2}$$

$$\mathbf{Q}: \frac{2 L_4 \sqrt{C_L L_L}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2 R_L}{2 L_L}$$

$$\mathbf{Qz: } \frac{L_L \sqrt{C_L L_L}}{R_L}$$

Filter 30**Filter Type:** GE

$$Z(s): \left(\infty, \frac{R_2 (L_2 s + \frac{1}{C_2})}{L_2 s + R_2 + \frac{1}{C_2^2}}, \infty, R_4, \infty, \frac{L_4 s}{C_L L_L s^2 + 1} + R_L \right)$$

$$H(s): \frac{R_4 (C_L L_L R_L s^2 + L_L s + R_L)}{C_L L_L R_4 s^2 + 2 C_L L_L R_L s^2 + 2 L_L s + R_4 + 2 R_L}$$

$$\mathbf{Q}: \frac{C_L \sqrt{\frac{1}{C_L L_L}} (R_4 + 2 R_L)}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L L_L}}$$

$$\textbf{Bandwidth: } \frac{2}{C_L (R_4 + 2 R_L)}$$

$$\mathbf{Qz: } C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

Filter 31**Filter Type:** GE

$$Z(s): \left(\infty, \frac{R_2 (L_2 s + \frac{1}{C_2})}{L_2 s + R_2 + \frac{1}{C_2^2}}, \infty, L_4 s + R_4 + \frac{1}{C_4 s}, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 s^2 + C_4 R_4 s + 1)}{C_4 L_4 s^2 + C_4 R_4 s + 2 C_4 R_L s + 1}$$

$$\mathbf{Q}: \frac{L_4 \sqrt{\frac{1}{C_4 L_4}}}{R_4 + 2 R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{R_4 + 2 R_L}{L_4}$$

$$\mathbf{Qz: } \frac{L_4 \sqrt{C_4 L_4}}{R_4}$$

Filter 32**Filter Type:** GE

$$Z(s): \left(\infty, \frac{R_2 (L_2 s + \frac{1}{C_2})}{L_2 s + R_2 + \frac{1}{C_2^2}}, \infty, \frac{L_4 s}{C_4 L_4 s^2 + 1} + R_4, \infty, R_L \right)$$

$$H(s): \frac{R_L (C_4 L_4 R_4 s^2 + L_4 s + R_4)}{C_4 L_4 R_4 s^2 + 2 C_4 L_4 R_L s^2 + L_4 s + R_4 + 2 R_L}$$

$$\mathbf{Q}: C_4 \sqrt{\frac{1}{C_4 L_4}} (R_4 + 2 R_L)$$

$$\omega_0: \sqrt{\frac{1}{C_4 L_4}}$$

$$\textbf{Bandwidth: } \frac{1}{C_4 (R_4 + 2 R_L)}$$

$$\mathbf{Qz: } C_4 R_4 \sqrt{\frac{1}{C_4 L_4}}$$