

Experiment: TIA simple Z2 Z4 ZL

Filter 1

Filter Type: BP

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

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

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

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

$$\text{Bandwidth: } \frac{2}{C_L R_4}$$

Filter 2

Filter Type: BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{C_L R_4 R_L}$$

Filter 3

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

Filter 4

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4 (2C_4 + C_L)}$$

Filter 5

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

Filter 6

Filter Type: BP

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

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

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

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

$$\text{Bandwidth: } \frac{1}{2C_4 R_L}$$

Filter 7

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_4 (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

Filter 8

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{\frac{L_L + 2R_L}{L_L L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

Filter 9

Filter Type: BP

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

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

$$\mathbf{Q}: \frac{2C_4 R_4 R_L \sqrt{\frac{1}{C_L^2 L_L}}}{R_4 + 2R_L}$$

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{2C_4 R_4 R_L}$$

Filter 10

Filter Type: BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L (2C_4 + C_L)}$$

#### Filter 11

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, R_2, \infty, \frac{1}{C_4s + \frac{1}{R_2} + \frac{1}{L_4s}}, \infty, \frac{R_L}{C_L R_L s + 1} \right) \\ H(s) &: \frac{\frac{L_L R_4 R_L s}{2C_4 L_L R_L R_L s^2 + C_L L_L R_4 R_L s + L_L R_4 + 2L_L R_L s + 2R_4 R_L}}{\sqrt{2} R_4 R_L \sqrt{\frac{L_L(2C_4 + C_L)}{R_4 + 2R_L}} (2C_4 + C_L)} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{L_L(2C_4 + C_L)}{R_4 + 2R_L}}}{2} \\ \omega_0 &: \sqrt{2} \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)} \end{aligned}$$

#### Filter 12

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, R_2, \infty, \frac{1}{C_4s + \frac{1}{R_2} + \frac{1}{L_4s}}, \infty, \frac{L_L s}{C_L L_L s^2 + 1} \right) \\ H(s) &: \frac{\frac{L_L R_4 R_L s}{2C_4 L_L R_L R_L s^2 + C_L L_L R_4 R_L s + L_L R_4 + 2L_L R_L s + 2R_4 R_L}}{R_4 \sqrt{\frac{L_L(2C_4 + C_L)}{L_L L_L(2C_4 + C_L)}} (2C_4 + C_L)} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{L_L(2C_4 + C_L)}{L_L L_L(2C_4 + C_L)}}}{2} \\ \omega_0 &: \sqrt{\frac{L_L + 2L_L}{L_L L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{2}{R_4(2C_4 + C_L)} \end{aligned}$$

#### Filter 13

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, R_2, \infty, \frac{1}{C_4s + \frac{1}{R_2} + \frac{1}{L_4s}}, \infty, \frac{1}{C_L s + \frac{1}{R_L} + \frac{1}{L_L s}} \right) \\ H(s) &: \frac{\frac{L_L L_L R_4 R_L s}{2C_4 L_L R_L R_L R_L s^2 + C_L L_L L_L R_4 R_L R_L s^2 + L_L L_L R_4 s + 2L_L L_L R_L s + L_4 R_4 R_L + 2L_L R_4 R_L}}{R_4 R_L \sqrt{\frac{L_L + 2L_L}{L_L L_L(2C_4 + C_L)}} (2C_4 + C_L)} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{L_L + 2L_L}{L_L L_L(2C_4 + C_L)}}}{2} \\ \omega_0 &: \sqrt{\frac{L_L + 2L_L}{L_L L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)} \end{aligned}$$

#### Filter 14

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, R_4, \infty, \frac{L_L s}{C_L L_L s^2 + 1} \right) \\ H(s) &: \frac{\frac{L_L R_4 s}{C_L L_L R_L s^2 + 2L_L s + R_4}}{C_L R_4 \sqrt{\frac{1}{C_L L_L}}} \\ \mathbf{Q} &: \frac{C_L R_4 \sqrt{\frac{1}{C_L L_L}}}{2} \\ \omega_0 &: \sqrt{\frac{1}{C_L L_L}} \\ \text{Bandwidth} &: \frac{2}{C_L R_4} \end{aligned}$$

#### Filter 15

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, R_4, \infty, \frac{1}{C_L s + \frac{1}{R_L} + \frac{1}{L_L s}} \right) \\ H(s) &: \frac{\frac{L_L R_4 R_L s}{C_L L_L R_L R_L s^2 + L_L R_4 s + 2L_L R_L s + R_4 R_L}}{C_L R_4 R_L \sqrt{\frac{1}{C_L L_L}}} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{1}{C_L L_L}}}{2} \\ \omega_0 &: \sqrt{\frac{1}{C_L L_L}} \\ \text{Bandwidth} &: \frac{R_4 + 2R_L}{C_L R_4 R_L} \end{aligned}$$

#### Filter 16

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, \frac{1}{C_4 s}, \infty, \frac{1}{C_L s + \frac{1}{R_L} + \frac{1}{L_L s}} \right) \\ H(s) &: \frac{\frac{L_L R_L}{2C_4 L_L R_L R_L s^2 + C_L L_L R_L s^2 + L_L s + R_L}}{\mathbf{Q} \sqrt{\frac{1}{L_L(2C_4 + C_L)}} (2C_4 + C_L)} \\ \mathbf{Q} &: R_L \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \omega_0 &: \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{1}{R_L(2C_4 + C_L)} \end{aligned}$$

#### Filter 17

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, \frac{R_4}{C_L R_4 s + 1}, \infty, \frac{L_L s}{C_L L_L s^2 + 1} \right) \\ H(s) &: \frac{\frac{L_L R_4}{2C_4 L_L R_L R_L s^2 + C_L L_L R_4 R_L s^2 + 2L_L s + R_4}}{R_4 \sqrt{\frac{L_L(2C_4 + C_L)}{2}} (2C_4 + C_L)} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{L_L(2C_4 + C_L)}{2}}}{2} \\ \omega_0 &: \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{2}{R_4(2C_4 + C_L)} \end{aligned}$$

#### Filter 18

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, \frac{R_4}{C_L R_4 s + 1}, \infty, \frac{1}{C_L s + \frac{1}{R_L} + \frac{1}{L_L s}} \right) \\ H(s) &: \frac{\frac{L_L R_4 R_L s}{2C_4 L_L R_L R_L s^2 + C_L L_L R_4 R_L s^2 + L_L R_4 s + 2L_L R_L s + R_4 R_L}}{R_4 R_L \sqrt{\frac{1}{L_L(2C_4 + C_L)}} (2C_4 + C_L)} \\ \mathbf{Q} &: \frac{R_4 \sqrt{\frac{1}{L_L(2C_4 + C_L)}}}{2} \\ \omega_0 &: \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)} \end{aligned}$$

#### Filter 19

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, \frac{L_4 s}{C_L L_4 s^2 + 1}, \infty, R_L \right) \\ H(s) &: \frac{\frac{L_L R_L s}{2C_4 L_4 R_L s^2 + L_L L_4 R_L s^2 + L_4 s + 2R_L}}{2C_4 R_L \sqrt{\frac{1}{C_L L_4}}} \\ \mathbf{Q} &: 2C_4 R_L \sqrt{\frac{1}{C_L L_4}} \\ \omega_0 &: \sqrt{\frac{1}{C_L L_4}} \\ \text{Bandwidth} &: \frac{1}{2C_4 R_L} \end{aligned}$$

#### Filter 20

**Filter Type:** BP

$$\begin{aligned} Z(s) &: \left( \infty, \frac{1}{C_2 s}, \infty, \frac{L_4 s}{C_L L_4 s^2 + 1}, \infty, \frac{R_L}{C_L R_L s + 1} \right) \\ H(s) &: \frac{\frac{L_L R_L s}{2C_4 L_4 R_L s^2 + L_L L_4 R_L s^2 + L_4 s + 2R_L}}{\mathbf{Q} \sqrt{2} \sqrt{\frac{1}{L_L(2C_4 + C_L)}} (2C_4 + C_L)} \\ \mathbf{Q} &: \sqrt{2} \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \omega_0 &: \sqrt{2} \sqrt{\frac{1}{L_L(2C_4 + C_L)}} \\ \text{Bandwidth} &: \frac{1}{R_L(2C_4 + C_L)} \end{aligned}$$

#### Filter 21

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{L_4s}{C_4L_4s^2+1}, \infty, \frac{1}{C_Ls+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{\frac{L_4L_LR_Ls}{2C_4L_4L_LR_LR_Ls^2+C_LL_4L_LR_Ls^2+L_4L_Ls+L_4R_L+2L_LR_L}}{\frac{L_4L_LR_Ls}{\sqrt{2R_L}\sqrt{L_4(2C_4+C_L)}}(2C_4+C_L)}$$

$$\mathbf{Q}: R_L\sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}(2C_4+C_L)$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L(2C_4+C_L)}$$

#### Filter 22

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, R_L \right)$$

$$H(s): \frac{L_4R_LR_Ls}{2C_4L_4R_LR_LR_Ls^2+L_4R_4s+2L_4R_Ls+2R_LR_L}$$

$$\mathbf{Q}: \frac{2C_4R_LR_L\sqrt{C_4^2L_4}}{R_4+2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4L_4}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{2C_4R_LR_L}$$

#### Filter 23

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{1}{C_Ls} \right)$$

$$H(s): \frac{L_4R_Ls}{2C_4L_4R_4s^2+C_LL_4R_4s^2+2L_4s+2R_4}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

#### Filter 24

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{R_L}{C_LR_Ls+1} \right)$$

$$H(s): \frac{\frac{L_4R_LR_Ls}{\sqrt{2R_L}\sqrt{L_4(2C_4+C_L)}}(2C_4+C_L)}{\frac{L_4R_LR_Ls}{\sqrt{2R_L}\sqrt{L_4(2C_4+C_L)}}(2C_4+C_L)}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{R_4R_L(2C_4+C_L)}$$

#### Filter 25

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{L_4s}{C_LR_Ls+1} \right)$$

$$H(s): \frac{\frac{L_4L_LR_Ls}{2C_4L_4L_LR_LR_Ls^2+C_LL_4L_LR_LR_Ls^2+2L_4L_LR_Ls+L_4R_L+2L_LR_L}}{\frac{L_4L_LR_Ls}{\sqrt{2R_L}\sqrt{L_4(2C_4+C_L)}}(2C_4+C_L)}$$

$$\mathbf{Q}: \frac{R_4\sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}(2C_4+C_L)}{2}$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

#### Filter 26

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{1}{C_LR_Ls+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{\frac{L_4L_LR_LR_Ls}{R_4R_LR_L\sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}(2C_4+C_L)}}{2C_4L_4L_LR_LR_LR_Ls^2+C_LR_LR_LR_LR_LR_Ls^2+L_4L_LR_LR_LR_LR_Ls+2L_4L_LR_LR_LR_LR_Ls+2L_LR_LR_LR_LR_LR_Ls}$$

$$\mathbf{Q}: \frac{R_4R_LR_L\sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}(2C_4+C_L)}{R_4+2R_L}$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{R_4R_L(2C_4+C_L)}$$

#### Filter 27

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2}{C_2R_2s+1}, \infty, R_4, \infty, \frac{L_4s}{C_LR_Ls+1} \right)$$

$$H(s): \frac{\frac{L_4R_4s}{C_LR_LR_LR_LR_Ls^2+2L_LR_Ls+R_4}}{\frac{L_4R_4s}{C_LR_LR_LR_LR_LR_Ls^2+2L_LR_Ls+R_4}}$$

$$\mathbf{Q}: \frac{C_LR_LR_L\sqrt{C_L^2L_L}}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_LR_LR_L}}$$

$$\text{Bandwidth: } \frac{2}{C_LR_LR_L}$$

#### Filter 28

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2}{C_2R_2s+1}, \infty, R_4, \infty, \frac{1}{C_LR_L+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{\frac{L_LR_LR_Ls}{C_LR_LR_LR_LR_LR_Ls^2+L_LR_LR_LR_LR_LR_Ls+2L_LR_LR_LR_LR_LR_Ls+R_LR_LR_LR_LR_LR_Ls}}{\frac{L_LR_LR_LR_LR_LR_Ls}{C_LR_LR_LR_LR_LR_LR_Ls^2+L_LR_LR_LR_LR_LR_LR_Ls+2L_LR_LR_LR_LR_LR_Ls+R_LR_LR_LR_LR_LR_Ls}}$$

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

$$\omega_0: \sqrt{\frac{1}{C_LR_LR_L}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{C_LR_LR_LR_L}$$

#### Filter 29

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2}{C_2R_2s+1}, \infty, \frac{1}{C_4s}, \infty, \frac{1}{C_LR_L+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{\frac{L_LR_LR_Ls}{2C_4L_4R_LR_LR_LR_Ls^2+C_LR_LR_LR_LR_LR_Ls^2+L_LR_LR_LR_LR_LR_Ls}}{\frac{1}{L_L(2C_4+C_L)}}(2C_4+C_L)$$

$$\mathbf{Q}: R_LR_L\sqrt{\frac{1}{L_L(2C_4+C_L)}}(2C_4+C_L)$$

$$\omega_0: \sqrt{\frac{1}{L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_LR_L(2C_4+C_L)}$$

#### Filter 30

**Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2}{C_2R_2s+1}, \infty, \frac{R_4}{C_4R_4s+1}, \infty, \frac{L_4s}{C_LR_Ls+1} \right)$$

$$H(s): \frac{\frac{L_LR_LR_Ls}{2C_4L_4R_LR_LR_LR_Ls^2+C_LR_LR_LR_LR_LR_Ls^2+2L_LR_LR_LR_LR_LR_Ls+R_4}}{\frac{L_LR_LR_LR_LR_LR_Ls}{2C_4L_4R_LR_LR_LR_LR_Ls^2+C_LR_LR_LR_LR_LR_Ls^2+2L_LR_LR_LR_LR_LR_Ls+R_4}}$$

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

$$\omega_0: \sqrt{\frac{1}{L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

#### Filter 31

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

#### Filter 32

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{1}{2C_4 R_L}$$

#### Filter 33

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

#### Filter 34

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

#### Filter 35

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{2C_4 R_4 R_L}$$

#### Filter 36

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L (2C_4 + C_L)}$$

#### Filter 37

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

#### Filter 38

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L (2C_4 + C_L)}$$

#### Filter 39

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

#### Filter 40

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{2}{C_L R_4}$$

#### Filter 41

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_L + 2 R_L}{C_L R_L R_L}$$

#### Filter 42

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 43

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 44

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 45

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{1}{2 C_L R_L}$$

#### Filter 46

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 47

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_L + 2 L_L}{L_L L_L (2 C_L + C_L)}}$$

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

#### Filter 48

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_L + 2 R_L}{2 C_L R_L R_L}$$

#### Filter 49

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 50

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2 C_L + C_L)}}$$

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

#### Filter 51

**Filter Type:** BP

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

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

$$Q: \frac{R_4 \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_L + C_L)}} (2C_L + C_L)}{2}$$

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_L + C_L)}}$$

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

#### Filter 52

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_L + C_L)}}$$

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

#### Filter 53

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{2}{C_L R_4}$$

#### Filter 54

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{C_L R_4 R_L}$$

#### Filter 55

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_L + C_L)}}$$

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

#### Filter 56

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_L + C_L)}}$$

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

#### Filter 57

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_L + C_L)}}$$

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

#### Filter 58

**Filter Type:** BP

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

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

$$Q: 2C_L R_L \sqrt{\frac{1}{C_L L_L}}$$

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

$$\text{Bandwidth: } \frac{1}{2C_L R_L}$$

#### Filter 59

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_L + C_L)}}$$

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

#### Filter 60

**Filter Type:** BP

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

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

$$Q: R_L \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_L + C_L)}} (2C_L + C_L)$$

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_L + C_L)}}$$

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

**Filter 61****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + \frac{1}{C_2s}, \infty, \frac{1}{C_4s + \frac{1}{R_4 + \frac{1}{L_4s}}}, \infty, R_L \right)$$

$$H(s): \frac{L_4R_4R_Ls}{2C_4L_4R_LR_Ls^2 + L_4R_4s + 2L_4R_Ls + 2R_4R_L}$$

$$\mathbf{Q}: \frac{2C_4R_4R_L\sqrt{C_4^2L_4}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4^2L_4}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{2C_4R_4R_L}$$

**Filter 62****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + \frac{1}{C_2s}, \infty, \frac{1}{C_4s + \frac{1}{R_4 + \frac{1}{L_4s}}}, \infty, \frac{1}{C_Ls} \right)$$

$$H(s): \frac{L_4R_4s}{2C_4L_4R_4R_Ls^2 + C_LL_4R_4R_Ls^2 + L_4R_4s + 2L_4s + 2R_4}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

**Filter 63****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + \frac{1}{C_2s}, \infty, \frac{1}{C_4s + \frac{1}{R_4 + \frac{1}{L_4s}}}, \infty, \frac{R_L}{C_LR_Ls + 1} \right)$$

$$H(s): \frac{L_4R_4R_Ls}{2C_4L_4R_4R_LR_Ls^2 + C_LL_4R_4R_Ls^2 + L_4R_4s + 2L_4R_4s + 2R_4R_L}$$

$$\mathbf{Q}: \frac{\sqrt{2}R_4R_L\sqrt{L_4(2C_4+C_L)}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4R_L(2C_4+C_L)}$$

**Filter 64****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + \frac{1}{C_2s}, \infty, \frac{1}{C_4s + \frac{1}{R_4 + \frac{1}{L_4s}}}, \infty, \frac{L_4s}{C_LL_Ls^2 + 1} \right)$$

$$H(s): \frac{L_4L_4R_4s}{2C_4L_4L_4R_4R_Ls^2 + C_LL_4L_4R_4s^2 + L_4L_4s + 2L_4L_4s + L_4R_4 + 2L_4R_4}$$

$$\mathbf{Q}: \frac{R_4\sqrt{\frac{L_4 + 2L_L}{L_4L_4(2C_4+C_L)}}}{2}$$

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

**Filter 65****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + \frac{1}{C_2s}, \infty, \frac{1}{C_4s + \frac{1}{R_4 + \frac{1}{L_4s}}}, \infty, \frac{1}{C_Ls + \frac{1}{R_L + \frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_4L_4R_4R_Ls}{2C_4L_4L_4R_4R_LR_Ls^2 + C_LL_4L_4R_4R_Ls^2 + L_4L_4s + 2L_4L_4s + L_4R_4R_L + 2L_4R_4R_L}$$

$$\mathbf{Q}: \frac{R_4R_L\sqrt{\frac{L_4 + 2L_L}{L_4L_4(2C_4+C_L)}}}{2}$$

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4R_L(2C_4+C_L)}$$

**Filter 66****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, R_4, \infty, \frac{L_4s}{C_LL_Ls^2 + 1} \right)$$

$$H(s): \frac{L_4R_4s}{C_LL_LR_4R_Ls^2 + L_LR_4s + 2L_Ls + R_4}$$

$$\mathbf{Q}: \frac{C_LR_4\sqrt{C_L^2L_L}}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_L^2L_L}}$$

$$\text{Bandwidth: } \frac{2}{C_L^2R_4}$$

**Filter 67****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, R_4, \infty, \frac{1}{C_Ls + \frac{1}{R_L + \frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_4R_4R_Ls}{C_LL_LR_4R_Ls^2 + L_LR_4s + 2L_LR_Ls + R_4R_L}$$

$$\mathbf{Q}: \frac{C_LR_4R_L\sqrt{C_L^2L_L}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_LL_L}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{C_LR_4R_L}$$

**Filter 68****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s}, \infty, \frac{1}{C_Ls + \frac{1}{R_L + \frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_4R_4s}{2C_4L_4R_4R_Ls^2 + C_LL_4R_4s^2 + L_4s + R_L}$$

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

$$\omega_0: \sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L(2C_4+C_L)}$$

**Filter 69****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{R_4}{C_LR_4s + 1}, \infty, \frac{L_4s}{C_LL_Ls^2 + 1} \right)$$

$$H(s): \frac{L_4R_4s}{2C_4L_4R_4R_Ls^2 + C_LL_4R_4s^2 + 2L_Ls + R_4}$$

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

$$\omega_0: \sqrt{\frac{1}{L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

**Filter 70****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{R_4}{C_LR_4s + 1}, \infty, \frac{1}{C_Ls + \frac{1}{R_L + \frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_4R_4R_Ls}{2C_4L_4R_4R_LR_Ls^2 + C_LL_4R_4R_Ls^2 + L_4R_4s + 2L_LR_Ls + R_4R_L}$$

$$\mathbf{Q}: \frac{R_4R_L\sqrt{L_L(2C_4+C_L)}}{R_4 + 2R_L}$$

$$\omega_0: \sqrt{\frac{1}{L_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4R_L(2C_4+C_L)}$$

**Filter 71****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{L_4s}{C_4L_4s^2+1}, \infty, R_L \right)$$

$$H(s): \frac{L_4R_Ls}{2C_4L_4R_Ls^2+L_4s+2R_L}$$

$$\mathbf{Q}: 2C_4R_L\sqrt{\frac{1}{C_4L_4}}$$

$$\omega_0: \sqrt{\frac{1}{C_4L_4}}$$

$$\text{Bandwidth: } \frac{1}{2C_4R_L}$$

**Filter 72****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{L_4s}{C_4L_4s^2+1}, \infty, \frac{R_L}{C_LR_Ls+1} \right)$$

$$H(s): \frac{L_4R_Ls}{2C_4L_4R_Ls^2+C_LL_4R_LR_Ls^2+L_4s+2R_L}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L(2C_4+C_L)}$$

**Filter 73****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{L_4s}{C_4L_4s^2+1}, \infty, \frac{1}{C_Ls+\frac{1}{R_L+\frac{1}{L_L}}} \right)$$

$$H(s): \frac{L_4R_LR_Ls}{2C_4L_4L_LR_Ls^2+C_LL_4R_LR_Ls^2+L_4L_LR_Ls+L_4R_L+2L_LR_L}$$

$$\mathbf{Q}: R_L\sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}(2C_4+C_L)$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L(2C_4+C_L)}$$

**Filter 74****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, R_L \right)$$

$$H(s): \frac{L_4R_LR_Ls}{2C_4L_4R_LR_Ls^2+L_4R_LR_Ls^2+2L_4R_L+2R_LR_L}$$

$$\mathbf{Q}: \frac{2C_4R_LR_L\sqrt{\frac{1}{C_4L_4}}}{R_4+2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_4L_4}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{2C_4R_LR_L}$$

**Filter 75****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{1}{C_Ls} \right)$$

$$H(s): \frac{L_4R_Ls}{2C_4L_4R_Ls^2+C_LL_4R_Ls^2+2L_4s+2R_L}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4(2C_4+C_L)}$$

**Filter 76****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{R_L}{C_LR_Ls+1} \right)$$

$$H(s): \frac{L_4R_LR_Ls}{2C_4L_4R_LR_Ls^2+C_LL_4R_LR_Ls^2+L_4R_L+2L_4R_Ls+2R_LR_L}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{R_LR_L(2C_4+C_L)}$$

**Filter 77****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{L_Ls}{C_LL_Ls^2+1} \right)$$

$$H(s): \frac{L_4L_LR_Ls}{2C_4L_4L_LR_Ls^2+C_LL_4R_LR_Ls^2+2L_4L_LR_Ls+L_4R_L+2L_LR_L}$$

$$\mathbf{Q}: \frac{R_L\sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}(2C_4+C_L)}{2}$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L(2C_4+C_L)}$$

**Filter 78****Filter Type:** BP

$$Z(s): \left( \infty, L_2s + R_2 + \frac{1}{C_2s}, \infty, \frac{1}{C_4s+\frac{1}{R_4+\frac{1}{L_4s}}}, \infty, \frac{1}{C_Ls+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_4L_LR_LR_Ls}{2C_4L_4L_LR_LR_Ls^2+C_LL_4R_LR_LR_Ls^2+L_4L_LR_LR_Ls+2L_4L_LR_Ls+L_4R_LR_L+2L_LR_LR_L}$$

$$\mathbf{Q}: \frac{R_LR_L\sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}(2C_4+C_L)}{R_4+2R_L}$$

$$\omega_0: \sqrt{\frac{L_4+2L_L}{L_4L_LL_L(2C_4+C_L)}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{R_LR_L(2C_4+C_L)}$$

**Filter 79****Filter Type:** BP

$$Z(s): \left( \infty, \frac{L_2s}{C_2L_2s^2+1} + R_2, \infty, R_4, \infty, \frac{L_Ls}{C_LL_Ls^2+1} \right)$$

$$H(s): \frac{L_4R_Ls}{C_LL_LR_Ls^2+2L_Ls+R_4}$$

$$\mathbf{Q}: \frac{C_LR_L\sqrt{\frac{1}{C_LR_L}}}{2}$$

$$\omega_0: \sqrt{\frac{1}{C_LR_L}}$$

$$\text{Bandwidth: } \frac{2}{C_LR_L}$$

**Filter 80****Filter Type:** BP

$$Z(s): \left( \infty, \frac{L_2s}{C_2L_2s^2+1} + R_2, \infty, R_4, \infty, \frac{1}{C_Ls+\frac{1}{R_L+\frac{1}{L_Ls}}} \right)$$

$$H(s): \frac{L_LR_LR_Ls}{C_LL_LR_LR_Ls^2+L_LR_LR_Ls+2L_LR_L+R_LR_L}$$

$$\mathbf{Q}: \frac{C_LR_LR_L\sqrt{\frac{1}{C_LR_L}}}{R_4+2R_L}$$

$$\omega_0: \sqrt{\frac{1}{C_LR_L}}$$

$$\text{Bandwidth: } \frac{R_4+2R_L}{C_LR_LR_L}$$



#### Filter 81

**Filter Type:** BP

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

$$H(s): \frac{L_L R_L R_s}{2C_2 L_L R_L s^2 + C_2^2 L_L R_L s^2 + L_L s + R_L}$$

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

#### Filter 82

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4 (2C_4 + C_L)}$$

#### Filter 83

**Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

#### Filter 84

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{1}{2C_4 R_L}$$

#### Filter 85

**Filter Type:** BP

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

$$H(s): \frac{L_L R_L R_s}{2C_2 L_L R_L s^2 + C_2 L_L R_L s^2 + L_L s + 2R_L}$$

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

#### Filter 86

**Filter Type:** BP

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

$$H(s): \frac{L_L L_L R_L R_s + C_L L_L R_L R_L s^2 + L_4 L_L s + L_4 R_L + 2L_L R_L}{2C_2 L_L L_L R_L s^2 + C_L L_L R_L R_L s^2 + L_4 L_L s + L_4 R_L + 2L_L R_L}$$

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

$$\omega_0: \sqrt{\frac{L_L + 2L_L}{L_L L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

#### Filter 87

**Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{2C_4 R_L R_L}$$

#### Filter 88

**Filter Type:** BP

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

$$H(s): \frac{L_L R_L R_s}{\sqrt{2} R_L \sqrt{\frac{1}{L_L (2C_4 + C_L)}} (2C_4 + C_L)}$$

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L (2C_4 + C_L)}$$

#### Filter 89

**Filter Type:** BP

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

$$H(s): \frac{L_L R_L R_L R_s}{2C_2 L_L R_L R_L s^2 + C_L L_L R_L R_L s^2 + L_4 R_L s + 2L_4 R_L s + 2R_L R_L}$$

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_L + 2R_L}{R_L R_L (2C_4 + C_L)}$$

#### Filter 90

**Filter Type:** BP

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

$$H(s): \frac{L_L L_L R_L R_s}{2C_2 L_L L_L R_L s^2 + C_L L_L R_L R_L s^2 + 2L_4 L_L s + L_4 R_L + 2L_L R_L}$$

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

$$\omega_0: \sqrt{\frac{L_L + 2L_L}{L_L L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_L (2C_4 + C_L)}$$

**Filter 91****Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_4 L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

**Filter 92****Filter Type:** BP

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

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

$$Q: \frac{C_L R_4 \sqrt{\frac{1}{C_L L_L}}}{2}$$

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

$$\text{Bandwidth: } \frac{2}{C_L R_4}$$

**Filter 93****Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{C_L R_4 R_L}$$

**Filter 94****Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2 (L_2 s + \frac{1}{C_2})}{L_2 s + R_2 + \frac{1}{C_2 s}}, \infty, \frac{1}{C_4 s}, \infty, \frac{1}{C_L s + \frac{1}{R_L} + \frac{1}{L_L s}} \right)$$

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

**Filter 95****Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{2}{R_4 (2C_4 + C_L)}$$

**Filter 96****Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{R_4 R_L (2C_4 + C_L)}$$

**Filter 97****Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{1}{2C_4 R_L}$$

**Filter 98****Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{2} \sqrt{\frac{1}{L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

**Filter 99****Filter Type:** BP

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

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

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

$$\omega_0: \sqrt{\frac{L_4 + 2L_L}{L_L L_L (2C_4 + C_L)}}$$

$$\text{Bandwidth: } \frac{1}{R_L (2C_4 + C_L)}$$

**Filter 100****Filter Type:** BP

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

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

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

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

$$\text{Bandwidth: } \frac{R_4 + 2R_L}{2C_4 R_4 R_L}$$

**Filter 101****Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2(L_2s + \frac{1}{C_2^2})}{L_2s + R_2 + \frac{1}{C_2^2s}}, \infty, \frac{1}{C_4s + \frac{1}{R_4} + \frac{1}{L_4s}}, \infty, \frac{1}{C_Ls} \right)$$

$$H(s): \frac{L_4R_4s}{2C_4L_4R_4R_Ls^2 + C_4L_4R_4s^2 + 2L_4s + 2R_4}$$

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

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

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

**Filter 102****Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2(L_2s + \frac{1}{C_2^2})}{L_2s + R_2 + \frac{1}{C_2^2s}}, \infty, \frac{1}{C_4s + \frac{1}{R_4} + \frac{1}{L_4s}}, \infty, \frac{R_R}{C_LR_Ls+1} \right)$$

$$H(s): \frac{L_4R_4R_Ls}{2C_4L_4R_4R_LR_Ls^2 + C_4L_4R_4R_Ls^2 + L_4R_4 + 2L_4R_Ls + 2R_4R_L}$$

$$\mathbf{Q:} \frac{\sqrt{2}R_4R_L\sqrt{\frac{1}{L_4(2C_4+C_L)}}}{R_4+2R_L}(2C_4+C_L)$$

$$\omega_0: \sqrt{2}\sqrt{\frac{1}{L_4(2C_4+C_L)}}$$

$$\mathbf{Bandwidth:} \frac{R_4+2R_L}{R_4R_L(2C_4+C_L)}$$

**Filter 103****Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2(L_2s + \frac{1}{C_2^2})}{L_2s + R_2 + \frac{1}{C_2^2s}}, \infty, \frac{1}{C_4s + \frac{1}{R_4} + \frac{1}{L_4s}}, \infty, \frac{L_Rs}{C_LR_Ls^2+1} \right)$$

$$H(s): \frac{L_4L_LR_4s}{2C_4L_4L_LR_4R_Ls^2 + C_4L_4L_LR_4R_Ls^2 + 2L_4L_Ls + L_4R_4 + 2L_LR_4}$$

$$\mathbf{Q:} \frac{R_4\sqrt{\frac{L_4+2L_R}{L_4L_L(2C_4+C_L)}}}{2}(2C_4+C_L)$$

$$\omega_0: \sqrt{\frac{L_4+2L_R}{L_4L_L(2C_4+C_L)}}$$

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

**Filter 104****Filter Type:** BP

$$Z(s): \left( \infty, \frac{R_2(L_2s + \frac{1}{C_2^2})}{L_2s + R_2 + \frac{1}{C_2^2s}}, \infty, \frac{1}{C_4s + \frac{1}{R_4} + \frac{1}{L_4s}}, \infty, \frac{1}{C_Ls + \frac{1}{R_L} + \frac{1}{L_Ls}} \right)$$

$$H(s): \frac{L_4L_LR_4R_Ls}{2C_4L_4L_LR_4R_Ls^2 + C_4L_4L_LR_4R_Ls^2 + L_4L_LR_4R_Ls^2 + 2L_4L_LR_4s + L_4R_4R_L + 2L_LR_L}$$

$$\mathbf{Q:} \frac{R_4R_L\sqrt{\frac{L_4+2L_R}{L_4L_L(2C_4+C_L)}}}{R_4+2R_L}(2C_4+C_L)$$

$$\omega_0: \sqrt{\frac{L_4+2L_R}{L_4L_L(2C_4+C_L)}}$$

$$\mathbf{Bandwidth:} \frac{R_4+2R_L}{R_4R_L(2C_4+C_L)}$$