[ECDL3-Unit3] Series RLC Band-pass Filter and Parallel RLC Band-rejection Filter

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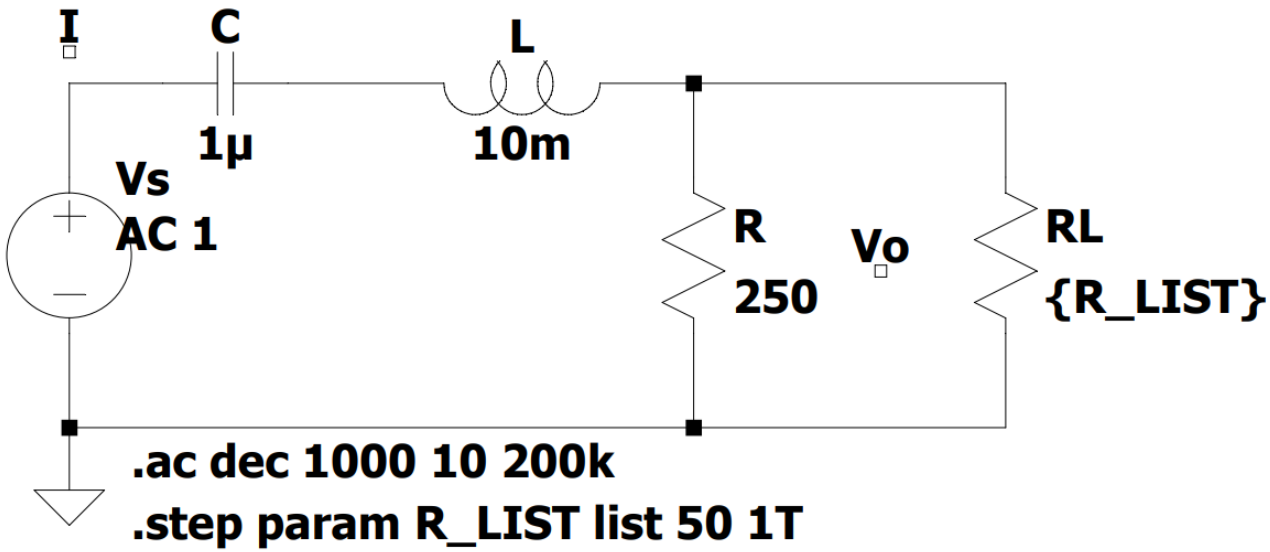
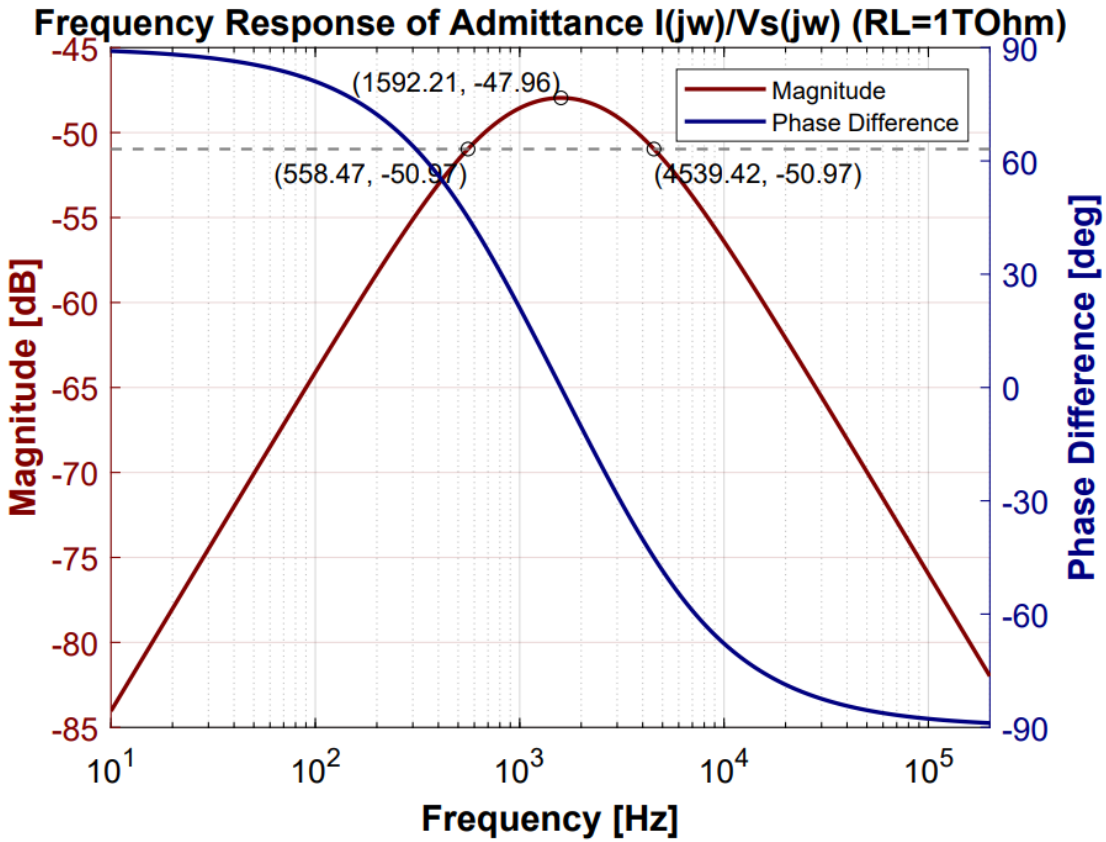
Series RLC Band-pass Filter (a)



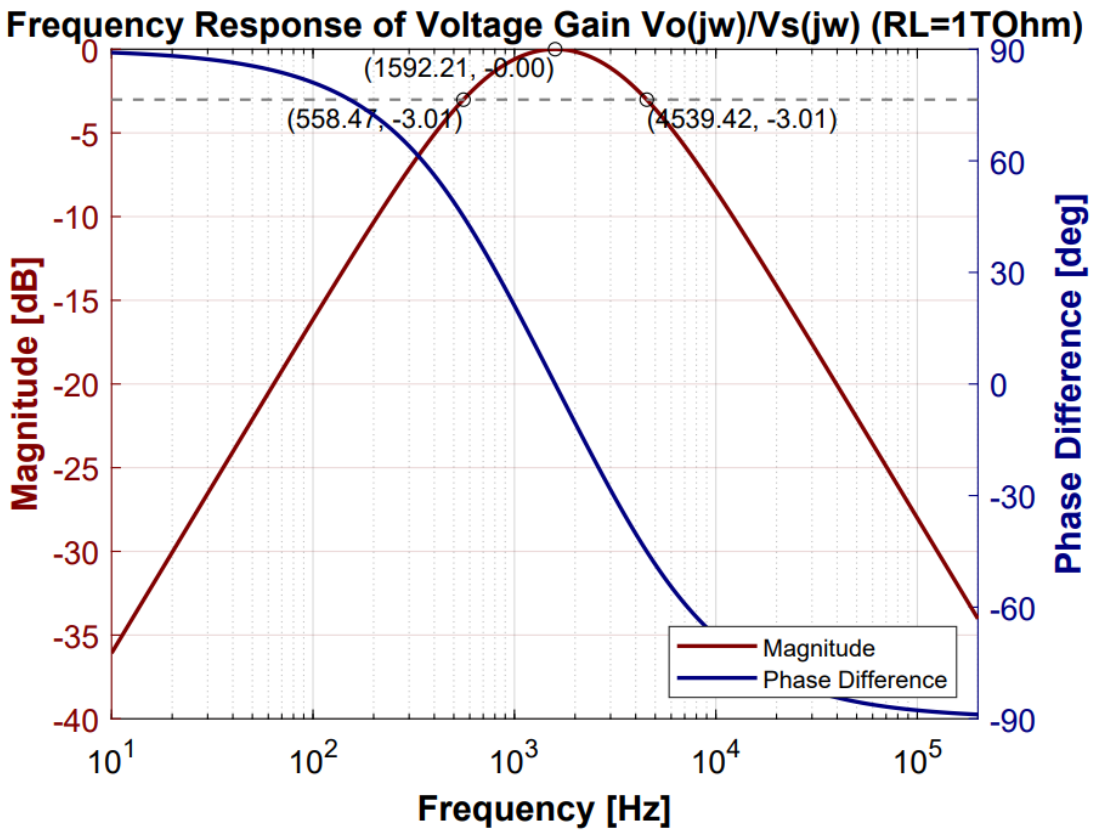
- $Q = 0.4,\ f_0 = 5000/\pi (= 1591.55)$ Hz (RL $= \infty$)
- $Q = \frac{1}{R}\sqrt{\frac{L}{C}},\ w_0 := \frac{1}{\sqrt{LC}} \rightarrow \mathbf{R = 250\Omega},\ \mathbf{C = 1\mu F}$ (series RLC circuit)

Series RLC Band-pass Filter (b)



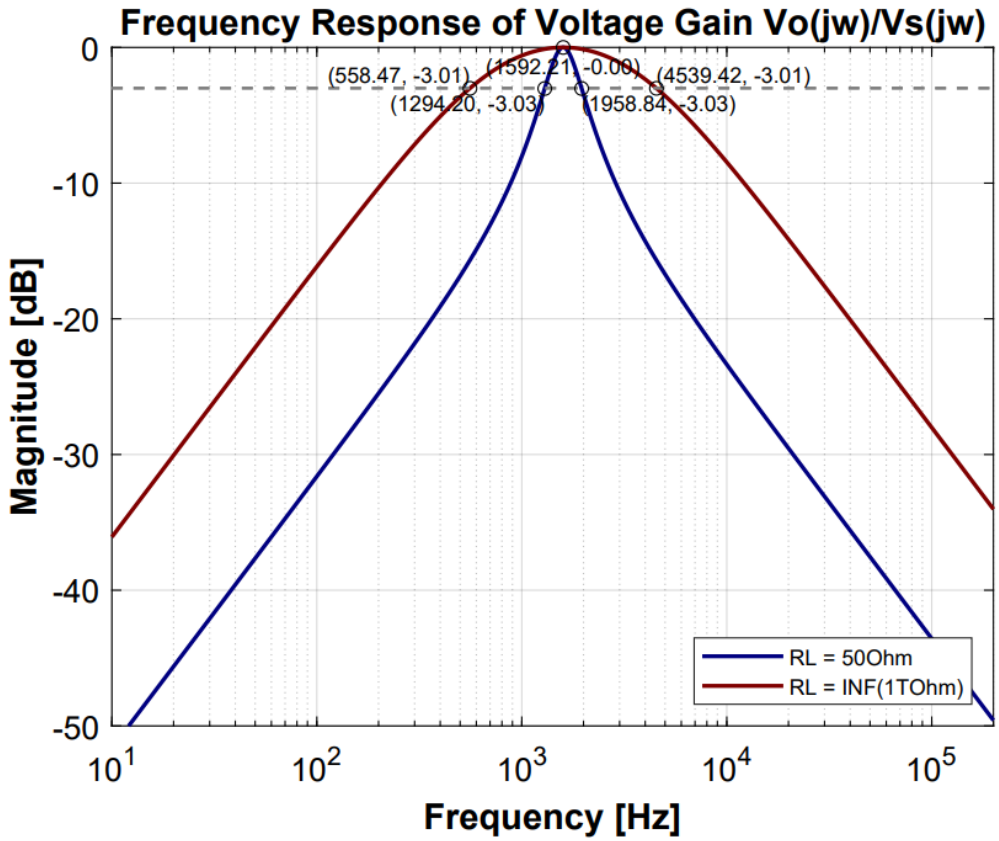
- $20\log(10^{-47.96/20}/\sqrt{2}) = -50.97$ dB

Series RLC Band-pass Filter (c)



- I/V_s and V_o/V_s have the same resonance frequency and the same cutoff frequencies.
- I/V_s and V_o/V_s have consistent phase shifts with frequency.
- $20\log(1/\sqrt{2}) = -3.01$ dB

Series RLC Band-pass Filter (d)



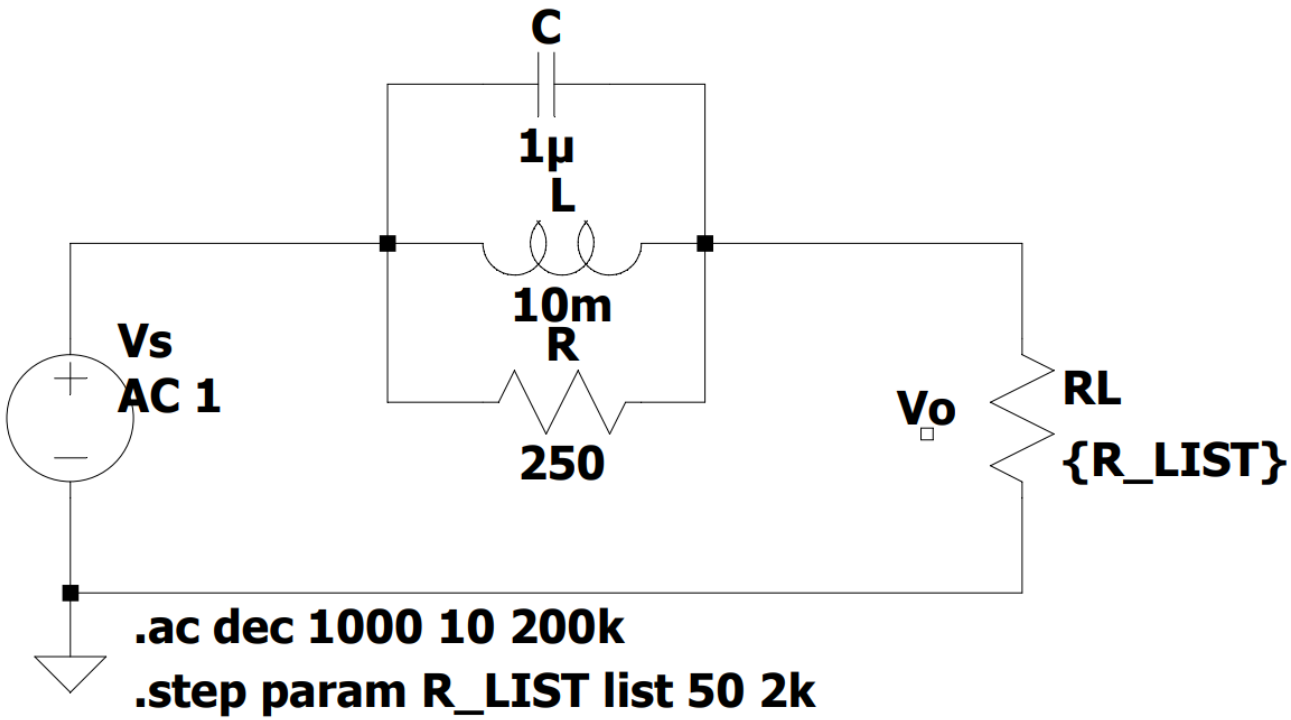
- As the load resistance RL increases, the bandwidth increases.

Series RLC Band-pass Filter (e)

RL [Ω]	50		INF (1T)	
Cutoff frequency [Hz]	1294.2	1958.84	558.47	4539.42
Bandwidth [Hz]	664.64		3980.95	
Central frequency [Hz]	1592.21		1592.21	
Quality factor	2.40		0.40	

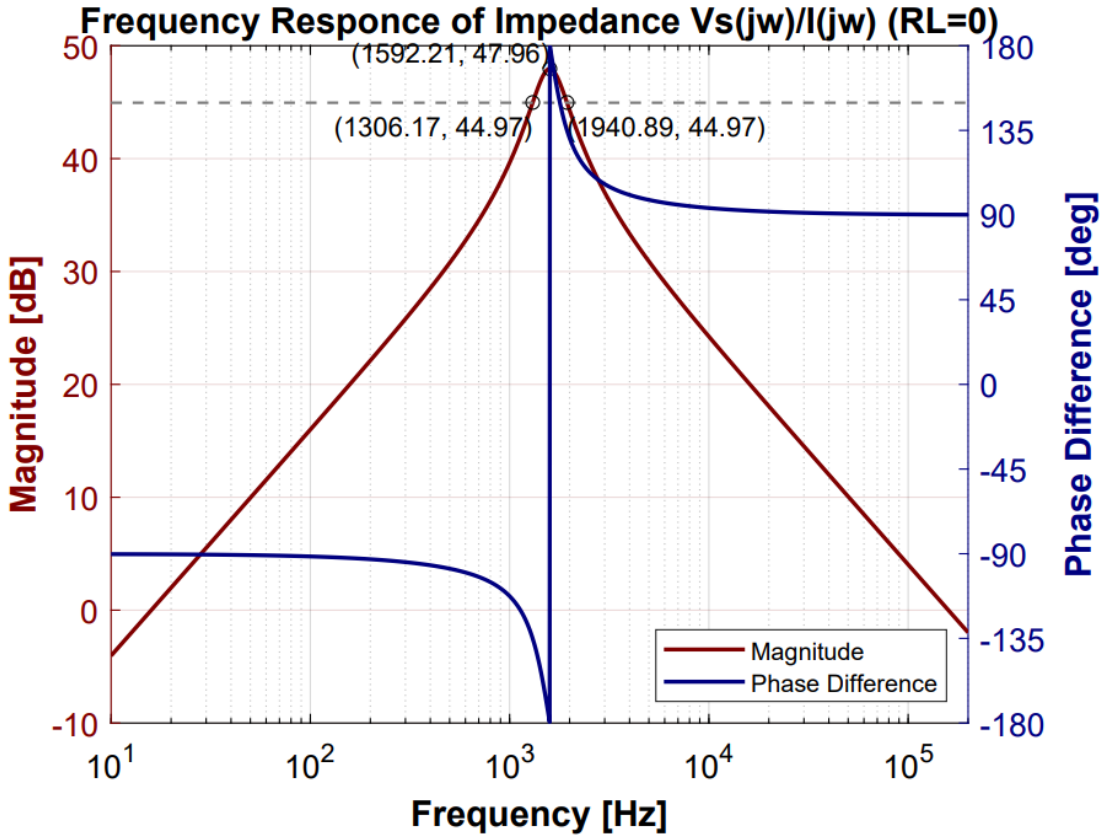
- As the load resistance RL increases, the quality factor decreases.
  $R_{eq} = \frac{R \cdot R_L}{R + R_L} = R - \frac{R^2}{R + R_L}$, $Q = \frac{1}{R_{eq}} \sqrt{\frac{L}{C}}$ (series RLC circuit)
- The simulated resonant frequency (1592.21 Hz) matches the theoretical resonant frequency (1591.55 Hz) within 0.04%.
- That simulated quality factor (0.4) matches correctly with the theoretical quality factor (0.4) when RL = INF(1TOhm).
- $Q := \frac{\text{(Central frequency)}}{\text{(Bandwidth)}} = \frac{\sqrt{\omega_{LO}\omega_{HI}}}{\omega_{HI} - \omega_{LO}}$

Parallel RLC Band-rejection Filter (a)



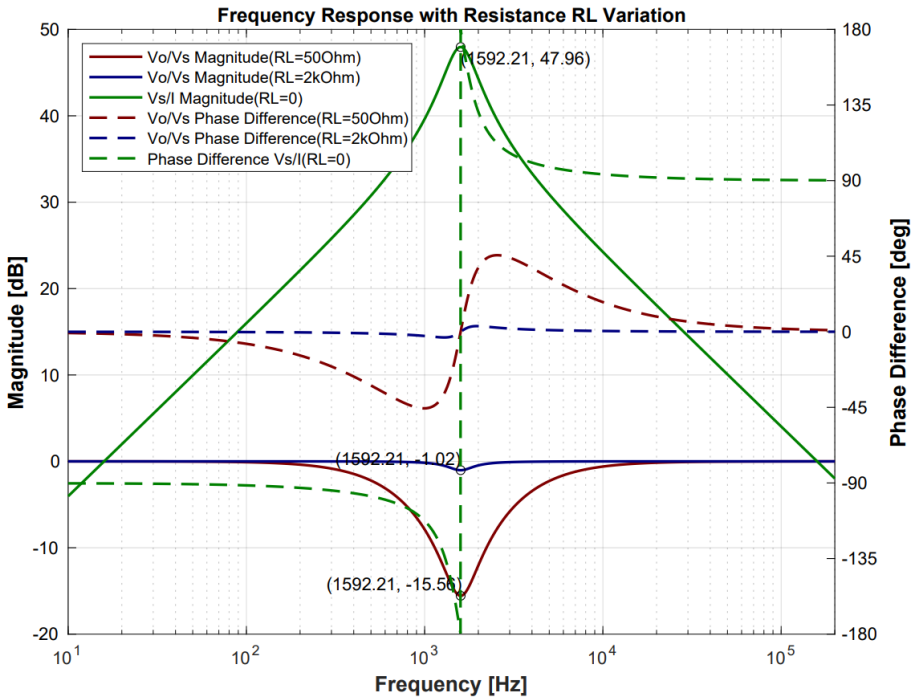
- Quality factor $Q = R\sqrt{\frac{C}{L}} = 2.5$ (Parallel RLC circuit)
- Resonance frequency $f_0 = \frac{1}{2\pi\sqrt{LC}} = 1591.55$ Hz (RL = 0)

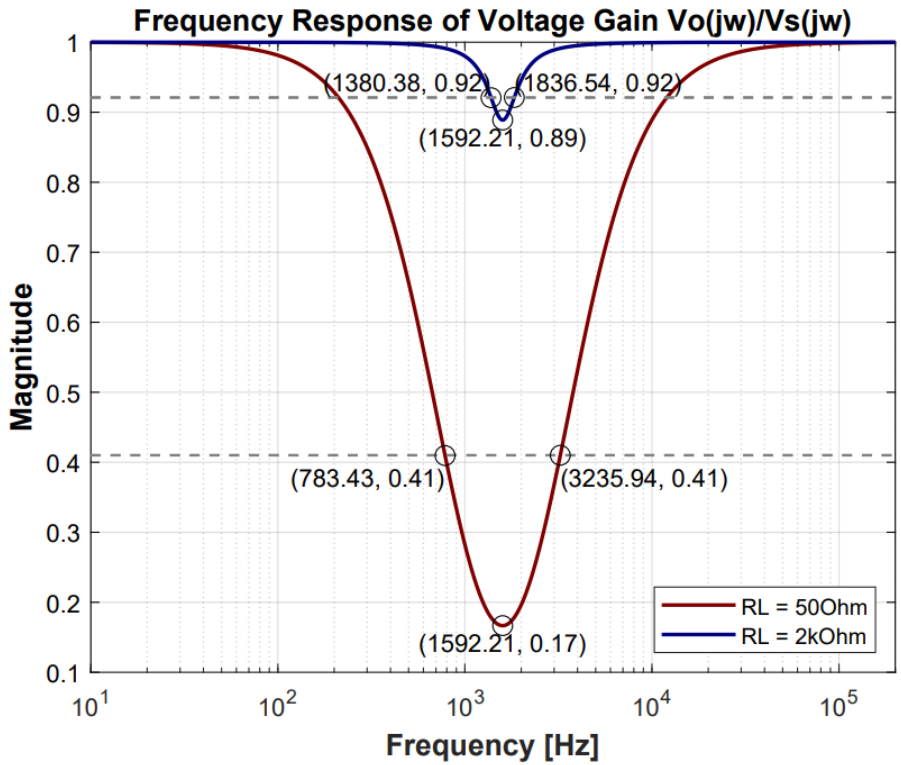
Parallel RLC Band-rejection Filter (b)



- The simulated resonant frequency (1592.21 Hz) matches the theoretical resonant frequency (1591.55 Hz) within 0.04% when RL = 0
- That simulated quality factor (2.51) matches correctly with the theoretical quality factor (2.5) when RL = 0.

Parallel RLC Band-rejection Filter (c)





- As the load resistance RL increases, the bandwidth decreases and the minimum value increases.
- V_s/I and V_o/V_s have the same resonance frequency regardless of RL and different phase shifts with frequency.
- $1-(1-0.17)/\sqrt{2}=0.41$, $1-(1-0.89)/\sqrt{2}=0.92$

Parallel RLC Band-rejection Filter (d)

RL [Ω]	50		2000	
Cutoff frequency [Hz]	783.43	3235.94	1380.38	1836.54
Bandwidth [Hz]	2452.51		456.16	
Central frequency [Hz]	1592.21		1592.21	
Quality factor	0.65		3.49	

- As the load resistance RL increases, the quality factor increases.
- The simulated resonant frequency (1592.21 Hz) matches the theoretical resonant frequency (1591.55 Hz) within 0.04% regardless of RL

Mistakes

- The cutoff frequency is the frequency where the maximum value is divided by the square root of 2 in the band-rejection filter also.