Bandpass filters

The RLC bandpass filter in Figure 8. acts as a way to pass a narrow range of frequencies (band) while attenuating or rejecting all other frequencies.
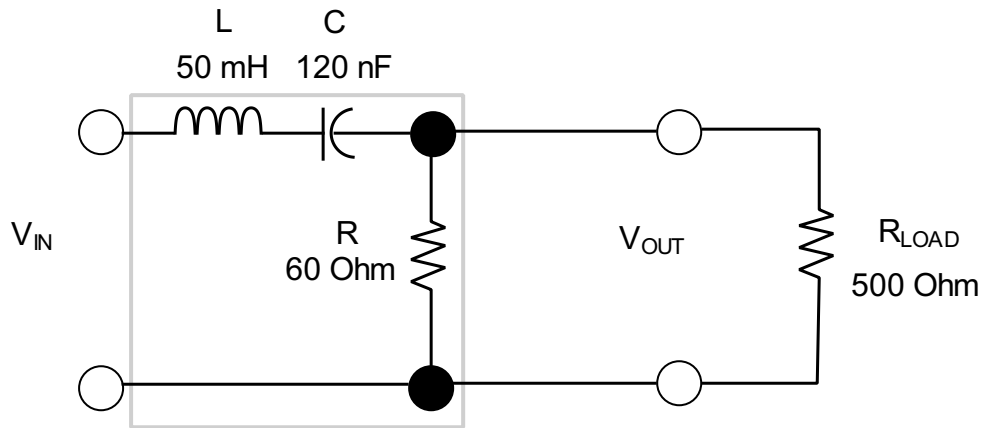

Figure 8.

Example:

To find the transfer function or attenuation of the unloaded RLC circuit, we set up the equations for V_{IN} and V_{OUT}.

$$H = \frac{V_{OUT}}{V_{IN}} = \frac{R}{R + j \cdot \left(\varphi L - \dfrac{1}{\varphi C} \right)}$$

This is the transfer function for an unloaded output. However, now we get more realistic and have a load resistance attached to the output. In this case we must replace R and R_T, which is the parallel resistance of R and R_{LOAD}:

$$R_5 := 500 \text{ Ohm} \qquad R_{LOAD} := 60 \text{ Ohm}$$

$$R_T := \frac{R_5 \ R_{LOAD}}{R_5 + R_{LOAD}}$$

$$R_T = 53.571 \text{ Ohm}$$

Placing in all component values and setting $\varphi = 2\pi f$, we get:

$$\left| H \right| = \left| \frac{V_{out}}{V_{IN}} \right| = \frac{53.5143}{\sqrt[2]{53.5143^2 + \left(0.314\ f - \dfrac{1}{7.54 \cdot 10^{-7} \cdot f} \right)^2}}$$

The attenuation versus frequency graph based on this equation is shown in Fig. 9. (Three other families of curves are provided for loads of 4 Ohm, 100 Ohm, and an infinite resistance load.)

Parallel Bandpass Filter

The parallel bandpass filter shown here yields characteristics similar to those of the previous bandpass filter. However, unlike the previous filter, as you approach the resonant frequency of the tuned circuit, the LC (RL coil) section's impedance gets larger, not allowing current to be diverted away from the load. On either side of the resonance, the impedance goes down, diverting the current away from load.
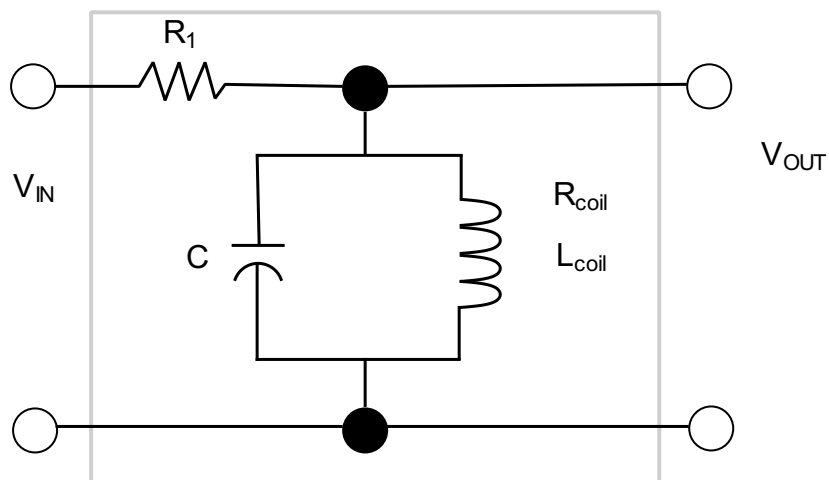

Figure 9.

The resonant frequency, Q, bandwidth, and upper and lower cutoff frequencies are given by:

$$L_1 := 50 \cdot 10^{-3} \cdot H \qquad\qquad C_1 := 120 \cdot 10^{-9} \cdot F$$

$$f_0 := \frac{1}{2\ \pi \cdot \sqrt[2]{L_1\ C_1}}$$

$$f_0 = 2054.681\ H^{-0.5}\ F^{-0.5}$$

$$Q = \frac{X_{LO}}{R_T}$$

$$Q := \frac{2\,\pi \cdot f_0\,L_1}{R_T}$$

$$Q = 12.049\ \text{Ohm}^{-1}\ \text{H}^{0.5}\ \text{F}^{-0.5}$$

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

$$BW = 170.523\ \text{Ohm}\ \text{H}^{-1}$$

$$f1 := f_0 - \frac{BW}{2} \qquad\qquad f2 := f_0 + \frac{BW}{2}$$

$$f_1 = 2054.681\ \text{H}^{-0.5}\ \text{F}^{-0.5} - 85.262\ \text{Ohm}\ \text{H}^{-1} \qquad f_2 = 2054.681\ \text{H}^{-0.5}\ \text{F}^{-0.5} + 85.262\ \text{Ohm}\ \text{H}^{-1}$$