1. Find the transfer function V_o/V_s of the circuit in Fig.1. shown that the circuit is a low pass filter.

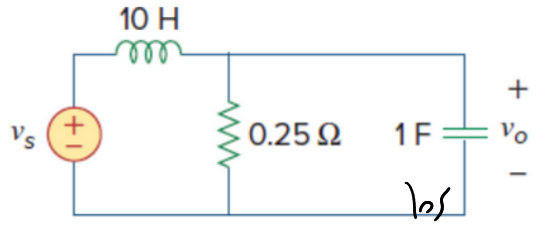
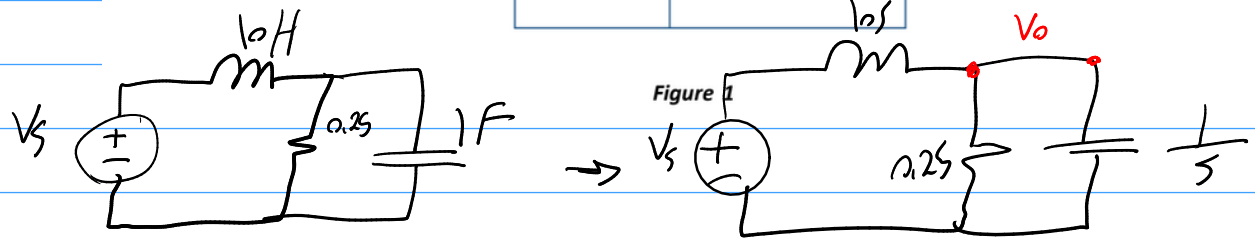


Figure 1



$$\frac{V_o - V_s}{10s} + \frac{V_o}{0.25} + V_o s = 0$$

$$V_o\left(\frac{1}{10s} + \frac{1}{0.25} + s\right) = \frac{V_s}{10s} \Rightarrow$$

$$\frac{V_o}{V_s} = \frac{1}{10s^2 + 4s + 1}$$

$$V_o(10s^2 + 4s + 1) = V_s$$

2. Design a passive RC high pass filter as shown in Fig. 2. With a cutoff frequency of 500 Hz using a 220 pF capacitor.
   a) What is the cutoff frequency in rad/s?
   b) What is the value of the resistor?
   c) Draw your circuit, labeling the component values and output voltage.
   d) What is the transfer function of the filter in part (c)?
   e) If the filter in part (c) is loaded with a resistor whose value is the same as the resistor in (b), what is the transfer function of this loaded filter?
   f) What is the cutoff frequency of the loaded filter from part (e)?
   g) What is the gain in the pass band of the loaded filter from part (e)?

$f_c = 500\,Hz$
$C = 220\,pF$
$= 6283.18$ rad/s
$= 1$

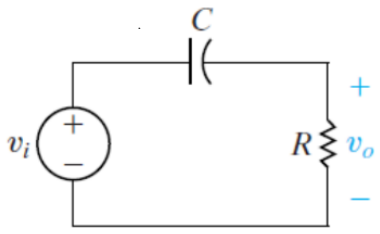
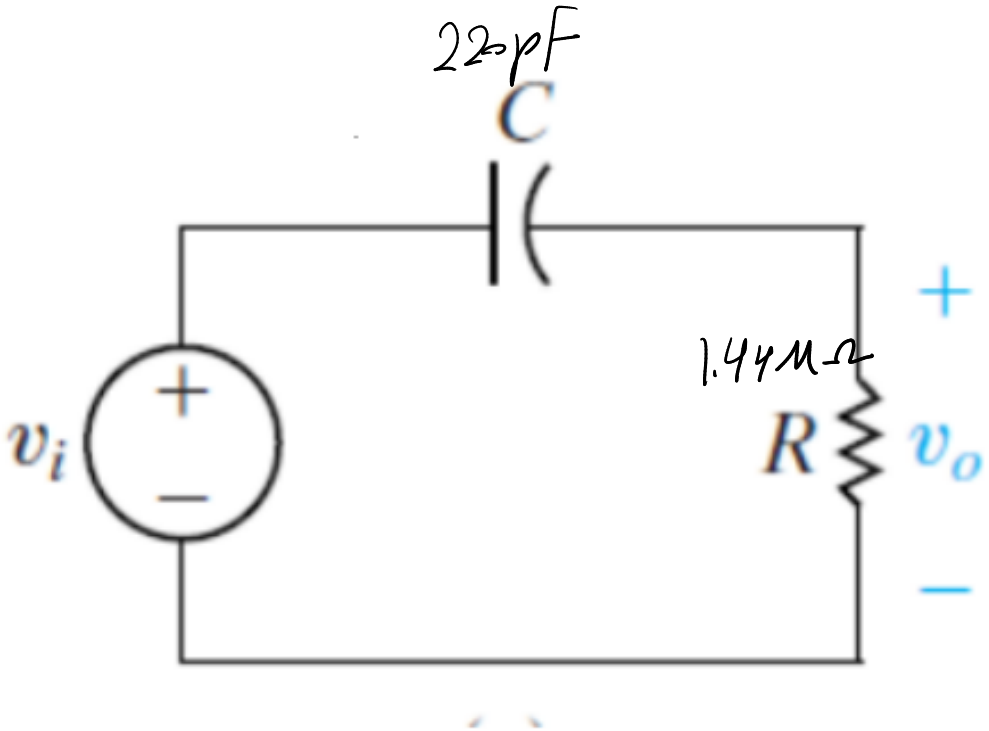


Figure 2

a) $\omega_c = 2\pi f_c = 10^3\pi \approx$ **3140 rad/s.**

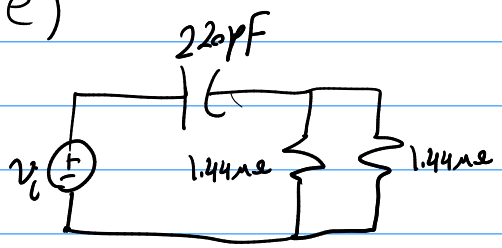
b) $\omega_c = \frac{1}{RC} \Rightarrow R = \frac{1}{C\omega_c} = \frac{1}{220p \cdot 3140} =$ **1.44 MΩ**

c)



d) $H(s) = \frac{sRC}{1+sRC} = \frac{s(22p \times 1.44M)}{1+s(22p \times 1.44M)} = \frac{3.17\times10^{-4}s}{1+3.17\times10^{-4}s}$

e)



$H(\omega) = \frac{R\,j\omega C}{R\,j\omega C + 2}$

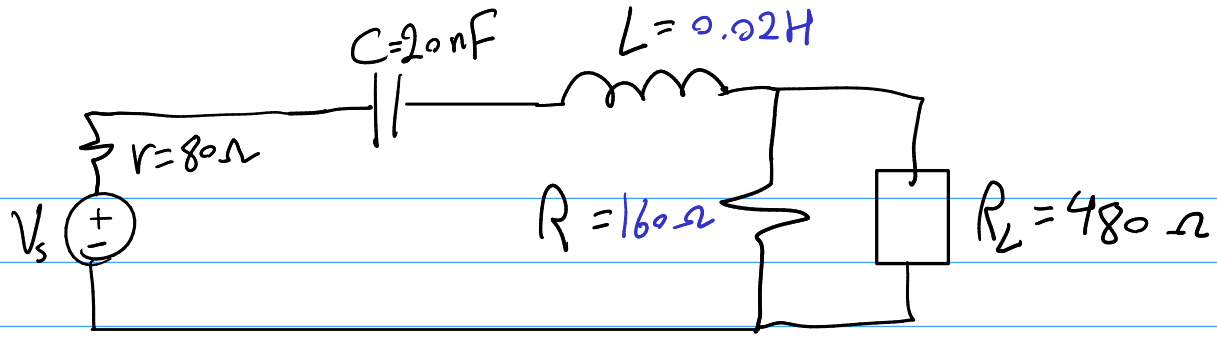
3. A block diagram of a system consisting of a sinusoidal voltage source, an RLC series bandpass filter, and a load is shown in Fig. 3. The internal impedance of the sinusoidal source is 80+j0 Ω, and the impedance of the load is 480 +j0 Ω.

The RLC series bandpass filter has a 20 nF capacitor, a center frequency of 50 Krad/s, and a quality factor of 6.25.

a) Draw a circuit diagram of the system.
b) Specify the numerical values of L and R for the filter section of the system.
c) What is the quality factor of the interconnected system?
d) What is the bandwidth (in hertz) of the interconnected system?

Figure 3

a)



b) $\omega_o = 1/\sqrt{LC} \Rightarrow L = 1/C\omega_o^2 =$ **0.02 H**

$Q = \omega_o L/R \Rightarrow R = \omega_o L/Q =$ **160 Ω**

c) $Q = \omega_o L / R_{eq}$; $R_{eq} = 1/(160+80)^{-1} + 480^{-1} = 160$

$= 6.25$

d) $B = \dfrac{\omega_o}{Q} =$ **8K rad/s**

4. For the bandreject filter in Fig. 4, calculate a) ω_o; b) f_o; c) Q; d) ω_{c1}; e) f_{c1}; f) ω_{c2}; g) f_{c2} and h) β in kilohertz.

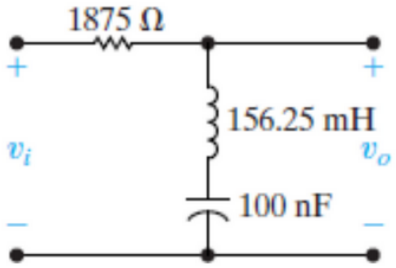


Figure 4

a) $\omega_o = 1/\sqrt{LC} =$ **8K rad/s** b) $f_o = \omega_o/2\pi =$ **1273 Hz**

c) $Q = \omega_o L/R =$ **0.667** d) $\omega_1 =$ **4K rad/s** e) $f_1 =$ **616 Hz**

f) $\omega_2 =$ **16K rad/s** g) $f_2 =$ **2546 Hz** h) $B =$ **1.91 kHz**