Filtering of capacitors:

C parallel with load

[accept low f, reject high f]

$f = 0$ $\quad\quad$ $f = \infty$

$X_C = \infty$ $\uparrow Z \uparrow$ $\quad\quad$ $X_C = 0$ $\quad Z \Rightarrow$ it depend

$I = 0$ $\quad\quad$ $I = max$

Filtering of inductors:

L series with load

(accept low f, reject high f)

$F < 0$ $\quad\quad$ $F >$ (high)

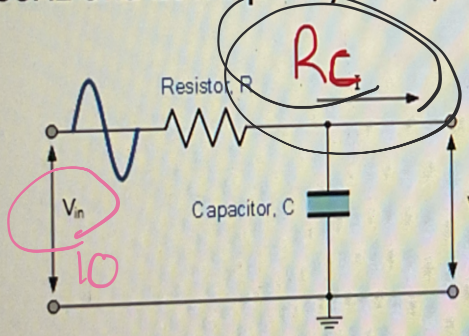
$X_L < 0$ $\quad\quad$ $X_L >$ (high)

Low pass filter examples :o

Low Pass Filter

Example:

A low pass filter circuit consisting of a resistor of 4.7kΩ in series with a capacitor of 47nF is connected across a 10v sinusoidal supply. Calculate the output voltage (V_{OUT}) at a frequency of 100Hz and at frequency of 10,000Hz or 10kHz.



Voltage Output at a Frequency of 100Hz and 10KHz:

$$X_C = \frac{1}{2\pi f C}$$

$$V_{OUT} = V_{IN} \times \frac{X_C}{\sqrt{R^2 + X_C^2}}$$

$F_1 = 100Hz$ $F_2 = 10,000 Hz$

$R = 4.7k\Omega$ or $4.7 \times 10^3 \Omega$

$C = 47nF$ or $47 \times 10^{-9} F$

$V = 10V \Rightarrow V_{in}$

Voutput = ??

$f_1 = 100 HZ$

$f_2 = 10,000 Hz$ or $10 kHZ$

extra

Fcutoff = ??

[1]

$X_C = \frac{1}{2\pi F C}$

$= \frac{1}{6.28 \times 100 \times 47 \times 10^{-9}}$

$= 33879.9 \Omega$

$X_C = \frac{1}{6.28 \times 10,000 \times 47 \times 10^{-9}}$

$= 338.8 \Omega$

[2] Voutput for both $F_1 = 100 Hz$ and $F_2 = 10,000 HZ$

$V_{out} = V_{in} \frac{X_C}{\sqrt{R^2 + X_C^2}}$

$= 10 \times \frac{33879.9}{\sqrt{(4.7 \times 10^3)^2 + (33879.9)^2}}$

$= 9.9 V$

$V_{out} = V_{in} \frac{X_C}{\sqrt{R^2 + X_C^2}}$

$= 10 \times \frac{338.8}{\sqrt{(4.7 \times 10^3)^2 + (338.8)^2}}$

$= 0.72 V$

[3] $f_{cutoff} = \frac{1}{2\pi RC}$

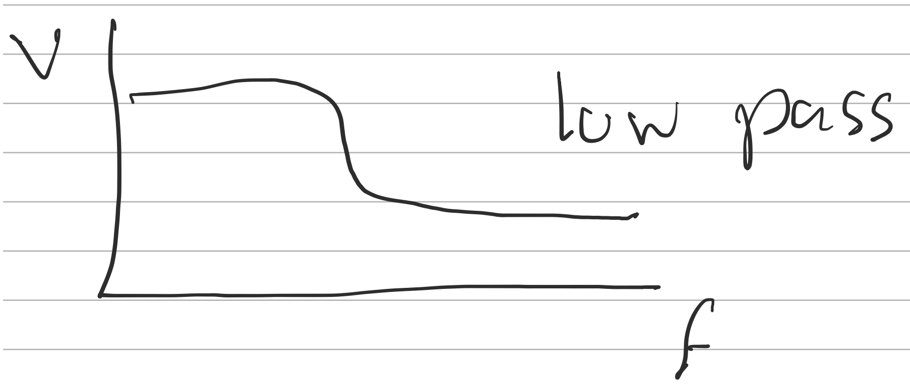
Because it's capacitor

$= \frac{1}{6.28 \times 4.7 \times 10^3 \times 47 \times 10^{-9}}$

$= 720.8$ HZ

how to knew if it is low or high pass check the circuit above?

if the capacitor parallel with load so it is low means, accept low frequency and reject high frequency.



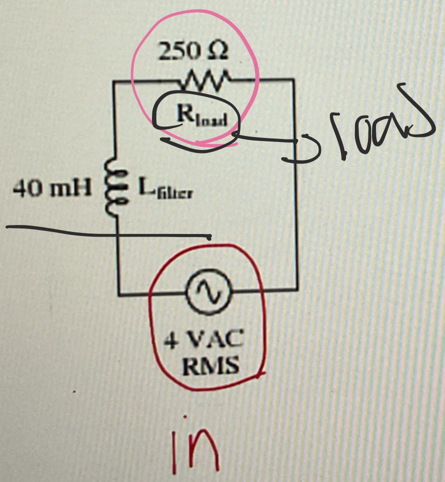
Filters

Low Pass Filter

Example:

$R_L =$

Identify the cut-off frequency of below circuit and calculate the output voltage at this frequency.



low pass

$R = 250\ \Omega$

$L = 40\ mH$
or
$40 \times 10^{-3}\ H$

$V = 4V \Rightarrow$ input V_{in} in RMS

$f_{cutoff} = ??$ ✓✓

$V_{output} = ??$ ✓✓

[1] $f_{cutoff} = \dfrac{R}{2\pi L}$

$= \dfrac{250}{6.28 \times 40 \times 10^{-3}}$

$= 995.2\ Hz$

[2] $V_{out} = V_{in} \dfrac{R}{\sqrt{R^2 + X_L^2}}$ $\Rightarrow$??

$R = X_L$

$X_L = 2\pi F L$

$= 6.28 \times 995.2 \times 40 \times 10^{-3}$

$= 249.9 \approx 250\ \Omega$

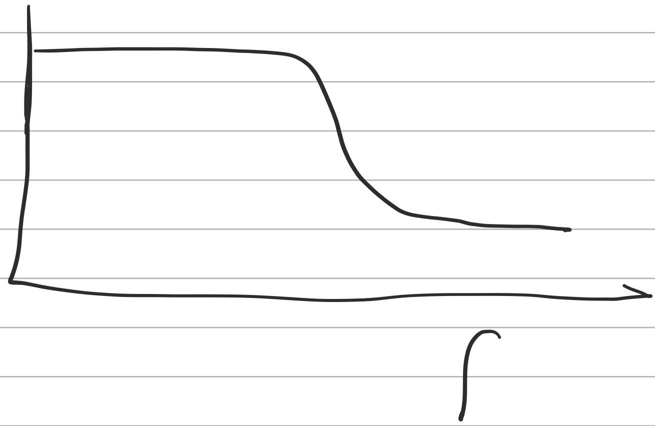
$V_{out} = V_{in} \dfrac{R}{\sqrt{R^2 + X_L^2}}$

250

$4 \times \sqrt{250^2 + 250^2}$

$= 2.8\ V$

* low pass because the inductor is in series with the load



High pass filter examples:

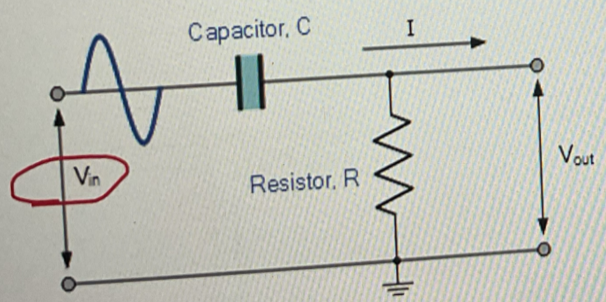
High Pass Filter

Vin = 10

Example:

a) Calculate the cut-off or "breakpoint" frequency (f_c) for a simple passive high pass filter consisting of an 82pF capacitor connected in series with a 240kΩ resistor.

RC



$F_{cutoff} = ??$

$C = 82\ pF$ or $82 \times 10^{-12}\ F$

$R = 240\ k\Omega$ or 240×10^3

$$F_{cutoff} = \frac{1}{2\pi RC}$$

$$= \frac{1}{6.28 \times 240 \times 10^3 \times 82 \times 10^{-12}}$$

$= 8091.2\ Hz$

$V_{in} = 10$

extra question find V_{out} ??

$$V_{out} = V_{in} \frac{R}{\sqrt{R^2 + X_C^2}}$$

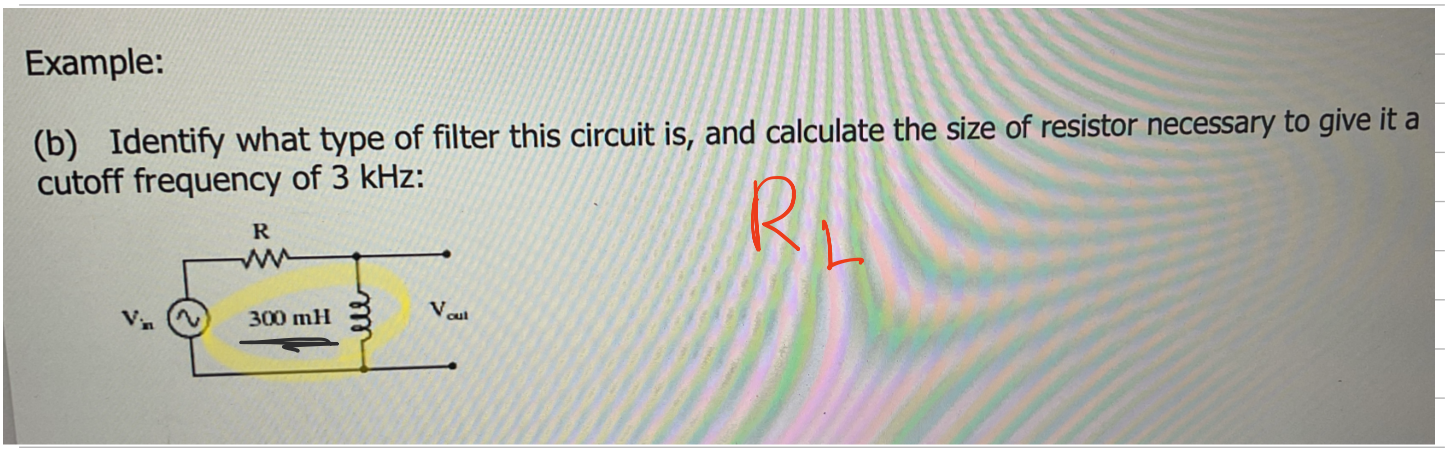
$$X_C = \frac{1}{2\pi F C}$$

$$= \frac{1}{6.28 \times 8091.2 \times 82 \times 10^{-12}}$$

$$= 240001.3\ \Omega$$

$$V_{out} = 10 \times \frac{240 \times 10^3}{\sqrt{(240 \times 10^3)^2 + (240001.3)^2}}$$

$$= 7.07\ V$$



Example:

(b) Identify what type of filter this circuit is, and calculate the size of resistor necessary to give it a cutoff frequency of 3 kHz:

$R = ??$

$F_{cutoff} = 3\ kHz$

or

$3 \times 10^3\ Hz$

$L = 300\ mH$ or

$300 \times 10^{-3}\ H$

$$F_{cutoff} = \frac{R}{2\pi L}$$

$$3 \times 10^3 = \frac{R}{6.28 \times 300 \times 10^{-3}}$$

$$(3 \times 10^3) \times (6.28 \times 300 \times 10^{-3}) = R$$

$$5652 = R$$

This is high pass filter because the inductor is parallel to the load.

extra practices

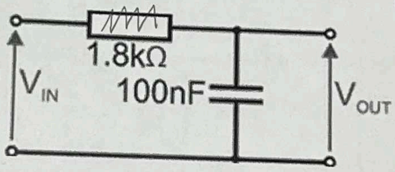
AVT 2113 AC Electrical Fundamental
Assignment
AC Filters Calculations
Total Marks: 100

Name: Nouf Ahmed
HCT's ID #: H00532259

The following electrical assignment covers calculating various values for alternating current circuits.

1. For the filter shown in the diagram, V_{IN} = 10 V, identify the type of filter.
   Calculate the:
   ✓ (a) reactance of capacitor at 10 Hz, 1 kHz, and 100 kHz.
   ✓ (b) output voltage at each of these frequencies
   ✓ (c) cutoff frequency of the circuit
   (d) output voltage at cutoff frequency

RC — low



$V_{in} = 10V$

$f_1 = 10\ Hz$

$f_2 = 1\ kHz \Rightarrow 1 \times 10^3$

$f_3 = 100\ kHz \Rightarrow 100 \times 10^3$

$f_{cutoff} = ??$

$V_{out} = ??$

$R = 1.8\ k\Omega \quad 1.8 \times 10^3$

$X_C = ??$

$C = 100nF \quad 100 \times 10^{-9}$

a

1) $f_1 = 10\ Hz$

$X_C = \frac{1}{2\pi f c}$

$= \frac{1}{2\pi \times 10 \times 100 \times 10^{-9}}$

$= 159235.7\ \Omega$

2) $f_2 = 1 \times 10^3$

$X_C = \frac{1}{2\pi f c}$

$= \frac{1}{2\pi \times 1 \times 10^3 \times 100 \times 10^{-9}}$ (6.28 ←)

$= 1592.4\ \Omega$

3) $f_3 = 100 \times 10^3$

$X_C = \frac{1}{2\pi \times 100 \times 10^3 \times 100 \times 10^{-9}}$

$= 15.9\ \Omega$

b

1) $V_{out} = V_{in} \frac{R}{\sqrt{R^2 + X_C^2}}$

$10 \times \frac{1.8 \times 10^3}{\sqrt{(1.8 \times 10^3)^2 + (159235.7)^2}}$

$V_{out} = 0.11\ V$

2) $V_{out} = V_{in} \frac{R}{\sqrt{R^2 + X_C^2}}$

$10 \times \frac{1.8 \times 10^3}{\sqrt{(1.8 \times 10^3)^2 + (1592.4)^2}}$

$V_{out} = 7.48V$

3) $V_{out} = 10 \times \frac{1.8 \times 10^3}{\sqrt{(1.8 \times 10^3)^2 + (15.9)^2}}$

$V_{out} = 9.99\ V$

c

$f_{cutoff} = \frac{1}{2\pi RC}$

$= \frac{1}{6.28 \times 1.8 \times 10^3 \times 100 \times 10^{-9}}$

$= 884.6\ HZ$

d

$X_C = \frac{1}{6.28 \times 884.6 \times 100 \times 10^{-9}}$

$= 1800\ \Omega$

$V_{out} = 10 \times \frac{1.8 \times 10^3}{\sqrt{(1.8 \times 10^3)^2 + (1800)^2}}$

$= 7.07V$

cutoff

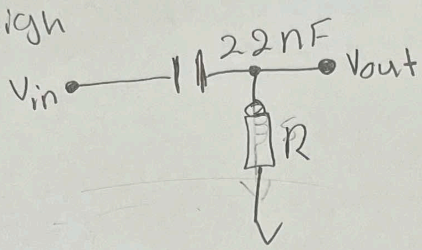
2. Design and draw two high-pass filter circuits with a break frequency of 2kHz which uses a 22 nF capacitor and the other uses a 50mH inductor.

$f = 2kHz$

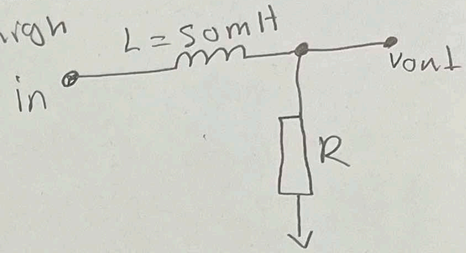
$C = 22\,nF$

$L = 50\,mH$

high



high



$$f_{cutoff} = \frac{1}{2\pi RC}$$

$$2\times10^3 = \frac{1}{6.28\times R\times 22\times10^{-9}}$$

$$\boxed{R = 3590.3\,\Omega}$$

$$f_{cutoff} = \frac{R}{2\pi L}$$

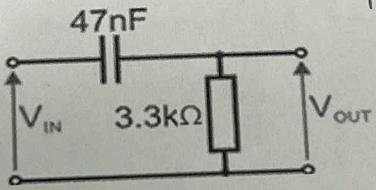
$$2\times10^3 = \frac{R}{6.28\times 50\times10^{-3}}$$

$$\boxed{R = 628\,\Omega}$$

3. Find the voltage gain of the filter circuit below, $f = 100Hz$

high

(high)



$$f = \frac{1}{2\pi RC}$$

$$X_C = \frac{1}{6.28\times 100\times 47\times10^{-9}}$$

$$\boxed{= 33879.9\,\Omega}$$

$C = 47\times10^{-9}F$

$R = 3.3\times10^3\,\Omega$

$V_{in} = ??$

$V_{out} = ??$

$$\frac{V_{out}}{V_{in}} = \frac{R}{\sqrt{R^2 + X_C^2}}$$

$$= \frac{3.3\times10^3}{\sqrt{(3.3\times10^3)^2 + (33879.9)^2}}$$

$$= 0.096$$