# PRACTICE REVIEW PROBLEMS

## SOLUTIONS (CORRECTIONS IN RED)



① If $f = 2.3\,MHz$, what is the wavelength?

$$\lambda = \frac{3 \times 10^8}{2.3\,MHz\ (2.3 \times 10^6)} = \boxed{130.4\,M}$$

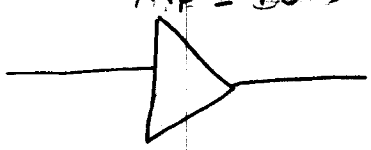
② If a signal has a wavelength of 2 km, what is its frequency?

$$f = \frac{3 \times 10^8}{2\,km} = \boxed{150\,KHz}$$

③ Given;

$A_V = 200$

$A_P = 46\,dB$



Ⓐ If the input signal is 14 mV, what is the output voltage?

Since $A_V = \frac{V_{OUT}}{V_{in}}$ ; $V_{OUT} = (14\,mV)(200) =$ ~~280 mV~~ $\boxed{2.8\,V}$

Ⓑ If the input power is $-3\,dB$, what is output power?

Since we are using dB, $dB_{OUT} = dB_{in} + dB_{GAIN}$

$$P_{OUT} = -3\,dB + 46\,dB = \boxed{43\,dB}$$

Ⓒ What is your answer from Ⓐ in dB?

$dB = 20 \log 280\,mV =$ ~~−11.1 dB~~ $8.94\,dB$

ⓓ What is your answer from Ⓑ in watts?

$$P = 10^{\frac{43}{10}} = 10^{4.3} = \boxed{19.95\,KW}$$

ⓔ What is $A_P$ in ratio form?

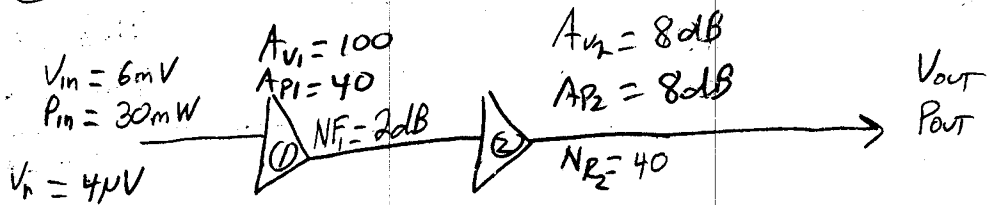
Since $A_{P_{dB}} = 10 \log A_P$ ; $A_P = 10^{\frac{46}{10}} = 10^{4.6} = \boxed{39810}$

ⓕ If the noise at the input is $2\,\mu V$, what is SNR in both ratio and dB?

$SNR = \frac{14\,mV}{2\,\mu V} = \boxed{7000}$ $= 20 \log SNR = \boxed{76.9}$

④ Given:






Ⓐ What is the total voltage gain?

$A_{V_{TOTAL}} = ~~100 + A_{V2}~~ \; (100)(2.51)$ ; $A_{V_2} = 10^{\frac{8}{20}} = 2.51$

$= ~~102.51~~ \quad \boxed{251}$

Ⓑ What is $V_{OUT}$?

$V_{OUT} = (V_{in})(A_{V_{TOTAL}}) = (6mV)(~~102.51~~ \; 251) = ~~615.1mV~~ \quad \boxed{1.506V}$

Ⓒ What is the total power gain?

$A_{P_{TOTAL}} = ~~40 + A_{P2}~~ \; (40)(6.31) = ~~46.31~~ \quad \boxed{252.4}$ ; $A_{P_2} = 10^{\frac{8}{10}} = 6.31$

ⓓ What is $P_{OUT}$?

$P_{OUT} = (30mW)(~~46.31~~ \; 252.4) = ~~1.39W~~ \quad \boxed{7.57W}$

ⓔ What is the total noise ratio ($NR_T$)?

$NR_T = NR_1 + \frac{N_{R2}-1}{A_{P1}} = 1.59 + \frac{39}{40} = \boxed{2.56}$ ; $NR_1 = 10^{\frac{2}{10}} = 1.59$

ⓕ What is the total noise figure ($NF_T$)?

$NF_T = 10\log NR = \boxed{4.08dB}$

ⓖ What is the SNR at the input in both ratio and dB?

$SNR = \frac{6mV}{4\mu V} = 1500$ ; $20\log SNR = \boxed{63.5dB}$

ⓗ What is the SNR at the output in both ratio and dB? (Ratio in both power and volts)

$SNR_{OUT} = SNR_{in} - NF$

$= 63.5dB - 4.08dB$

$\boxed{= 59.42dB}$

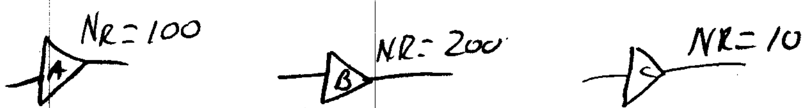
Also ratio $= 10^{\frac{59.42}{10}} = 875 \times 10^3 \rightarrow$ Power ratio

$= 10^{\frac{59.42}{20}} = 935.4 \rightarrow$ Voltage ratio

(5) If Signal has a power of 4mW and a Noise Level of 24pW, what is its SNR in dB?

$$SNR = 10\log\frac{4mW}{24pW} = \boxed{82.2dB}$$

(6) If you have 3 stages as shown below, which one should come first from a Noise perspective and why?




Stage C, Frii's formula states the Largest contributor to Noise comes from the 1st stage, so it should have the Lowest NR.

(7) If a Resistor is operating in a circuit whose Bandwidth is 1KHz and the Temperature is 75°C, what is the magnitude of its Noise?

$$V_n = \sqrt{4KTBR} \qquad K = 1.38\times10^{-23}$$

$$= \sqrt{4(1.38\times10^{-23})(273+75)(1KHz)(10K)} = \boxed{438.3nV}$$

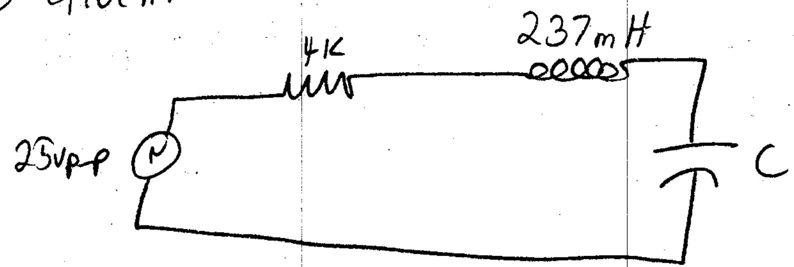
(8) What is the Equation for the reactance of a capacitor? What does its reactance do as frequency increases?

$X_c = \frac{1}{2\pi fC}$ $X_c \downarrow$ as $f\uparrow$, thus $V_c$ ~~↑~~ $\downarrow$

(9) Same Question as #8, but for an inductor.

$X_L = 2\pi fL$, $X_L \uparrow$ as $f\uparrow$, thus $V_L \uparrow$

(10) Given:




(A) If we want the resonant frequency to be 85 KHz, what is C?

$f_R = \frac{1}{2\pi\sqrt{LC}}$ ; $(f_R)^2 = \frac{1}{4\pi^2 LC}$

Also called center frequency

$C = \frac{1}{4\pi^2(85KHz)^2(237mH)} =$ **14.8 pF**

(B) What is Q for this circuit?

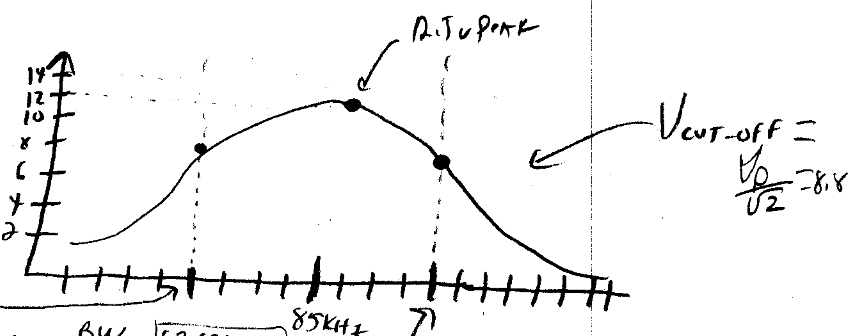
$Q = \frac{2\pi f_r L}{R} = \frac{2\pi(85KHz)(237mH)}{4K} = 31.64$

(C) What is the bandwidth of this circuit?

$BW = \frac{f_r}{Q} = 2.69\ KHz$

(d) Draw the frequency response and label the upper and lower cut-off frequencies, the voltage at the peak, and voltage at the cut-offs

$25v_{pp} = 12.5\ v$ peak!!!




$f_{LCO} = f_R - \frac{BW}{2} =$ **83.66 KHz**

$f_{UCO} = f_R + \frac{BW}{2} =$ **86.35 KHz**

(e) If the input voltage is $25\ V_{p-p}$, how much power is dissipated in the resistor at the lower cut-off frequency? What is the dB difference between the dB at the peak and the dB @ the cut-off?

$P_R$ @ cut-off $= \frac{(\frac{V_p}{\sqrt{2}})^2}{R} = \frac{(8.8)^2}{4K} =$ **19.4 mW** ~~-3dB!!!~~ **-17.09dB**

(f) How much power is dissipated in the resistor @ the resonant frequency?

$P_{@\ res.} = \frac{(V_p)^2}{R} = \frac{(12.5)^2}{4K} =$ **39.1 mW** (-14.08dB) — -3dB difference!!

(g) What is $\left|\frac{V_R}{V_S}\right|$ @ resonance? What is that in dB?

@ Res $\frac{V_R}{V_S} = \frac{12.5}{12.5} = 1$, $= 20\log 1 =$ **0!**

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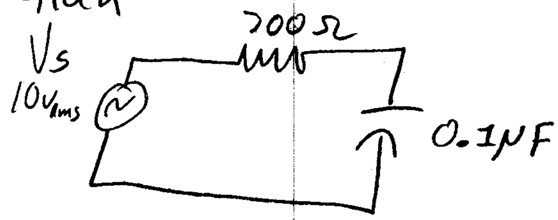
(11) Tell me the 3 things the cut-off frequency means.

1/2 power point

$\frac{V_p}{\sqrt{2}}$

−3dB down

(12) Given




(A) What is the cut-off frequency for this circuit?

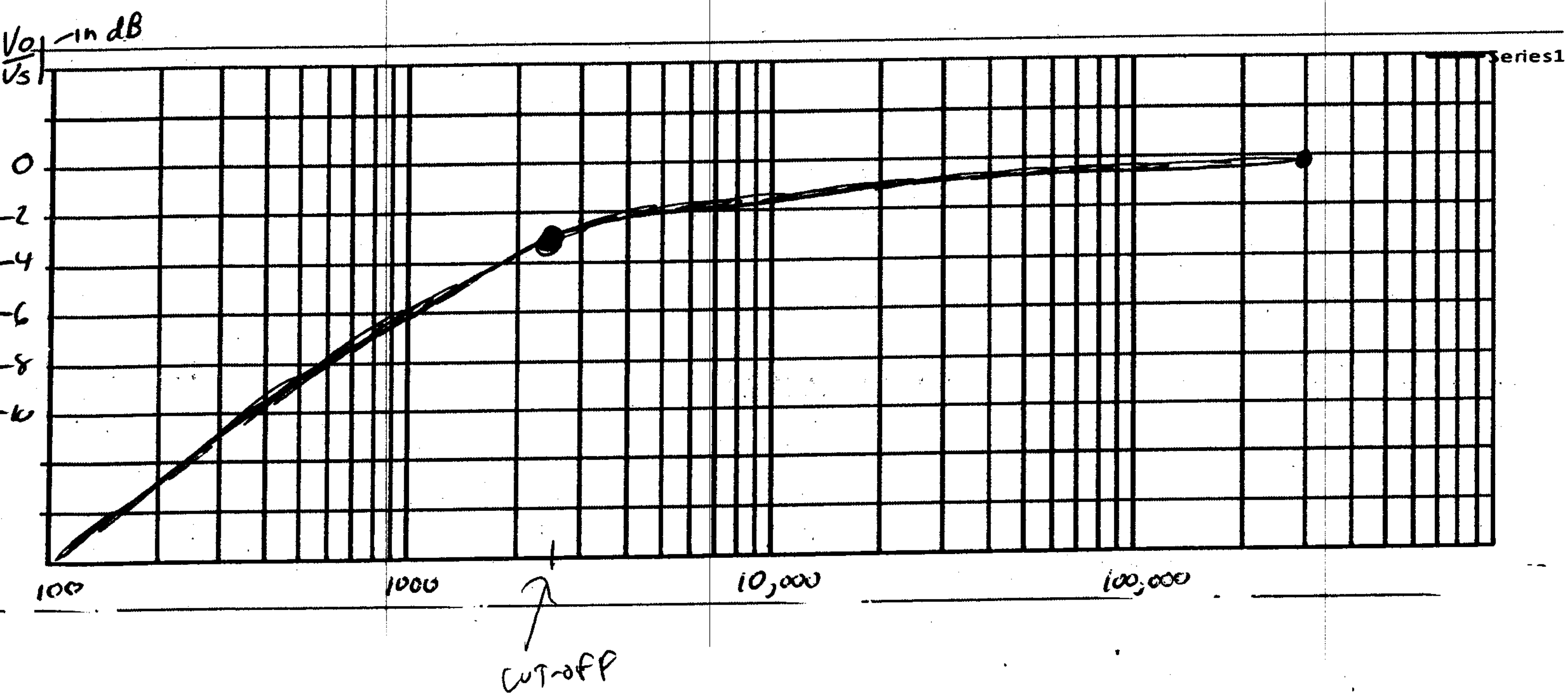
$f_{co} = \frac{1}{2\pi RC} = 2.27\ \text{KHz}$

(B) If I want to use this as a high-pass circuit, what component do I take the voltage across? Why?

Resistor. Because the cap's $X_c$ drops as $f\uparrow$ (and so does $V_c\downarrow$) and thus based on KVL if $V_c\downarrow$ w/ $f\uparrow$, $V_R\uparrow$ w/ $f\uparrow$.

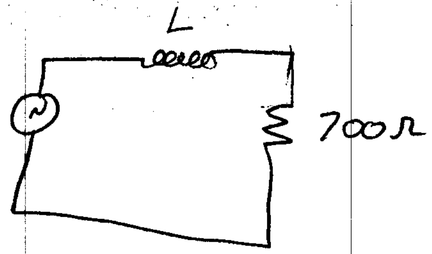
(C) Plot the frequency response for this HP filter

At high f, $\left|\frac{V_o}{V_s}\right| \simeq \left|\frac{10}{10}\right| = 1$, $20\log 1 = 0$



(13)

Given: $V_s$ 25v P-P → 12.5 peak




(A) What is L if we want a cut-off frequency of 5KHz?

$f_{co} = \frac{R}{2\pi L}$, $L = \frac{R}{2\pi f_{co}} = \frac{700}{(2\pi)(5KHz)} =$ **22.28 mH**

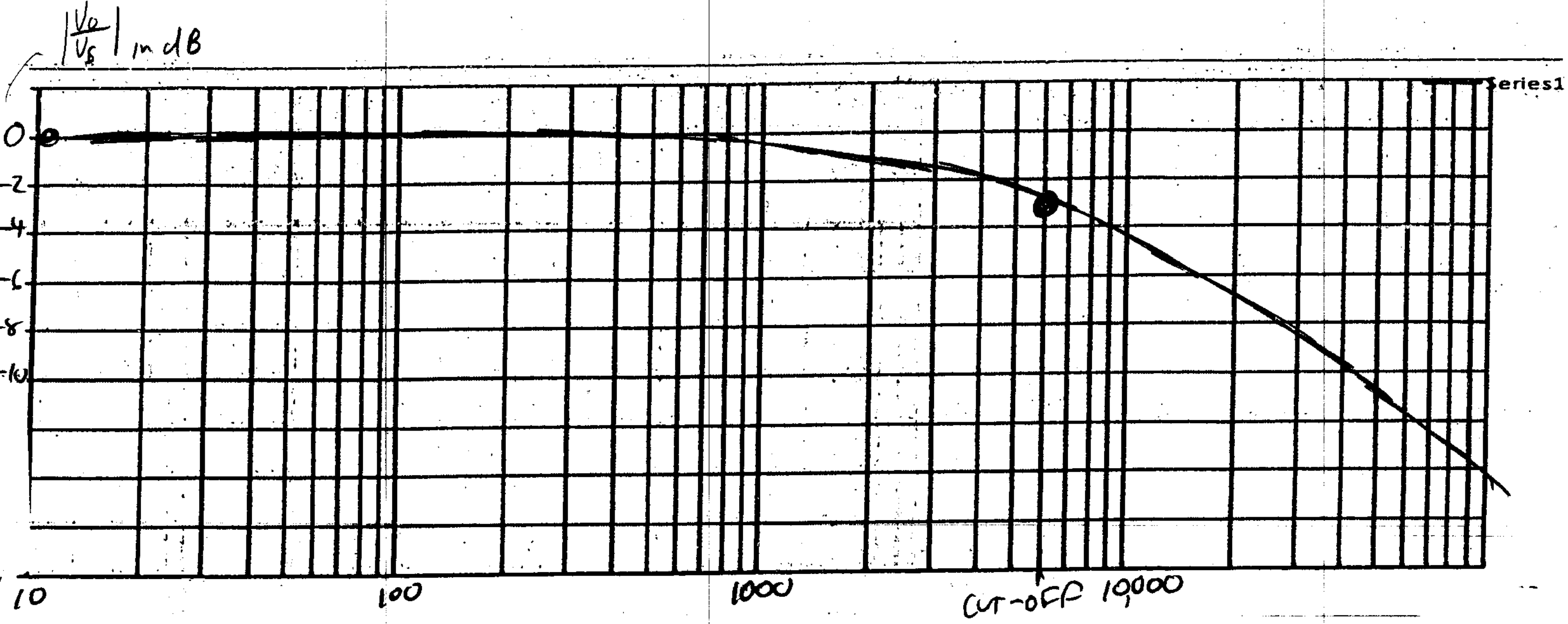
(B) If we want to use this as a low pass filter, what component do we take the voltage across and why?

Resistor. Because $X_L \uparrow$ as $f \uparrow$, so based on KVL, $V_R \downarrow$ as $f \uparrow$

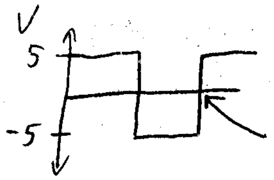
(C) What is the voltage across the component selected in B at the cut-off frequency?

$V_R$ @ cut-off $= \frac{V_P}{\sqrt{2}} = V_P(.707) = 8.8v$

(d) Plot the frequency response $\left|\frac{V_o}{V_s}\right| \approx \left|\frac{12.5}{12.5}\right| = 1$, $20\log 1 = 0$ @ very low frequency!



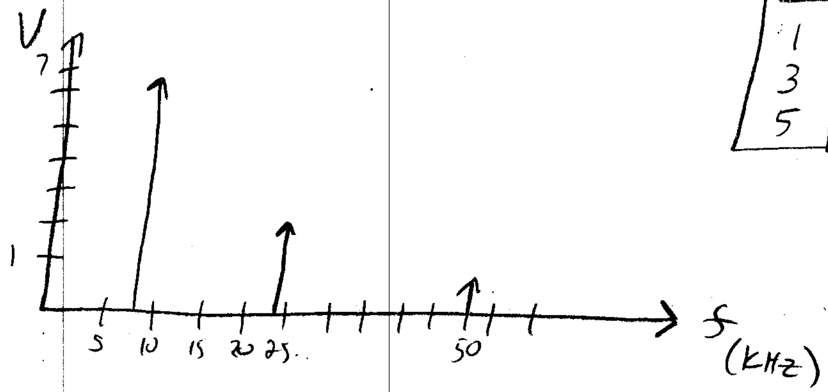
(14) Given:




125μS = T   f = 8KHz

(A) What is the frequency spectrum using

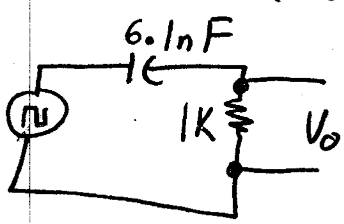
$$f(t) = \frac{4V}{\pi}\left[\sin 2\pi\left(\frac{1}{T}\right)t + \frac{1}{3}\sin 2\pi\left(\frac{3}{T}\right)t + \frac{1}{5}\sin 2\pi\left(\frac{5}{T}\right)t \ldots\right]$$




| N | f | V |
|---|---|---|
| 1 | 8KHz | 6.37 |
| 3 | 24K | 2.12 |
| 5 | 50K | 1.27 |

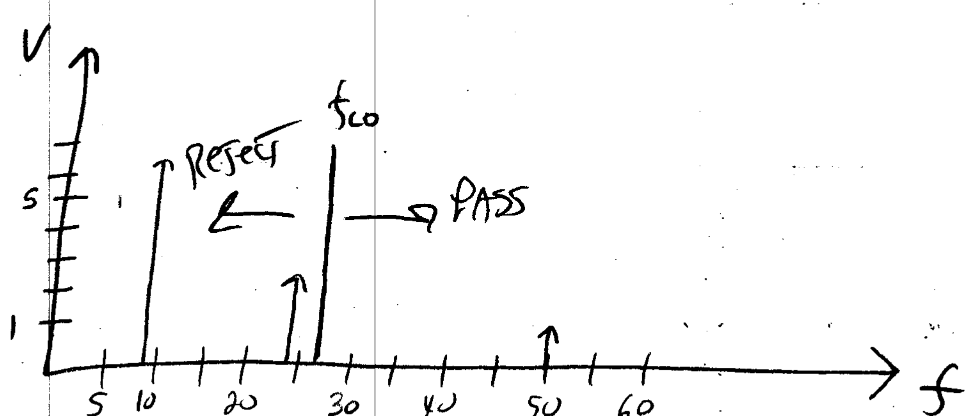
$\frac{4V}{\pi} = \frac{20}{\pi} = 6.37$

(B) If the above waveform was source of the below circuit, what would the resulting frequency spectrum look like?




$f_{co} = \frac{1}{2\pi RC} = 26\ KHz$

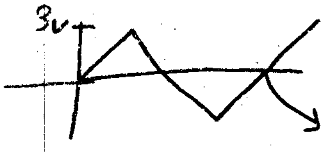
This is a High Pass Filter




(C) What would the time domain equation be? [Hint: look @ A]

$$f(t) = \left(\frac{4V}{\pi}\right)\left(\frac{1}{5}\right)\sin 2\pi\left(\frac{5}{T}\right)t$$

(15) Given:




$\rightarrow$ 400 μs = T, f = 2.5 kHz

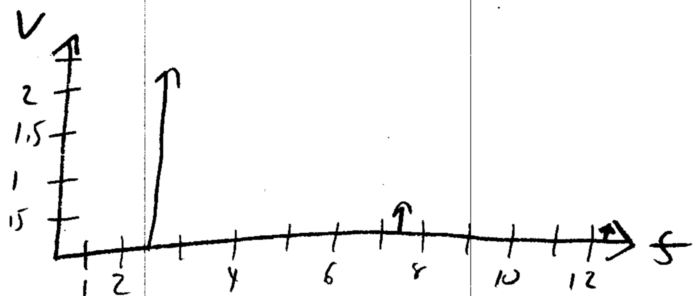


$$f(t) = \frac{8V}{\pi^2}\left[\cos 2\pi\left(\frac{1}{T}\right)t + \frac{1}{9}\cos 2\pi\left(\frac{3}{T}\right)t + \frac{1}{25}\cos 2\pi\left(\frac{5}{T}\right)t \ldots\right]$$

$$\frac{8(3)}{\pi^2} = 2.43$$

(A) What is the frequency spectrum?

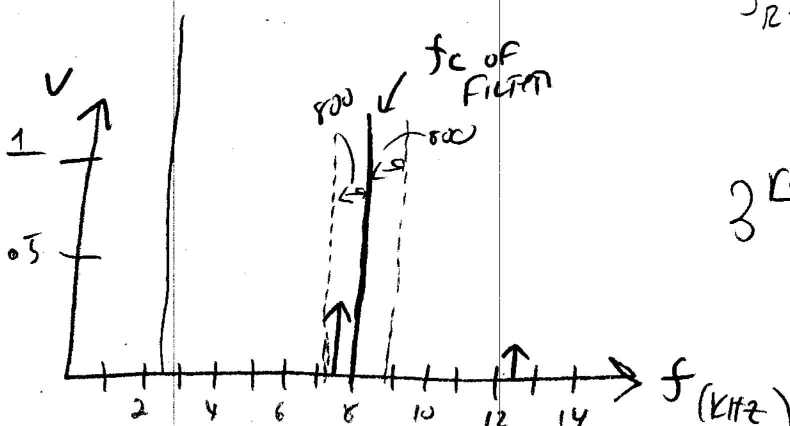
| N | f (kHz) | V |
|---|---|---|
| 1 | 2.5 | 2.43 |
| 3 | 7.5 | 0.27 |
| 5 | 12.5 | 0.097 |




(B) If the above was passed thru a bandpass filter w/ Q = 5 and a resonant frequency of 8 kHz, what does the resultant frequency spectrum look like?

$f_R = f_c = 8\text{ kHz}$

$BW = \frac{8\text{ kHz}}{5} = 1.6\text{ kHz}$

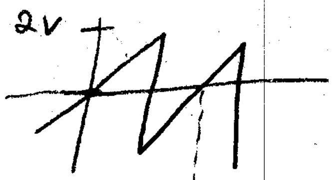



3rd harm. only passes

(C) What would the time domain equation be? [Hint: look @ A]

$$f(t) = \frac{2.43}{9}\cos 2\pi\left(\frac{3}{T}\right)t$$

Given:

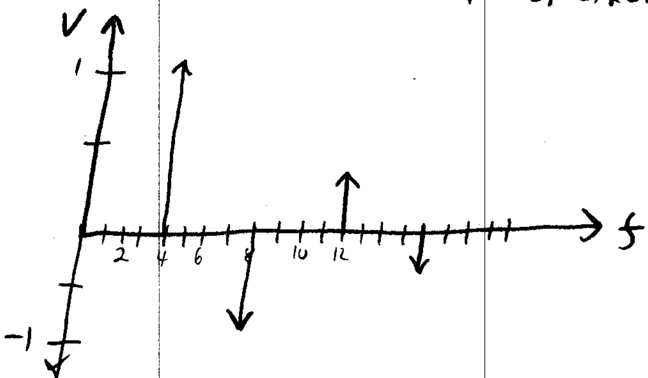



250μS = T , f = 4KHz

$$f(t) = \frac{2V}{\pi}\left[\sin 2\pi\left(\frac{1}{T}\right)t - \frac{1}{2}\sin 2\pi\left(\frac{2}{T}\right)t + \frac{1}{3}\sin 2\pi\left(\frac{3}{T}\right)t - \frac{1}{4}\sin 2\pi\left(\frac{4}{T}\right)t \ldots\right.$$

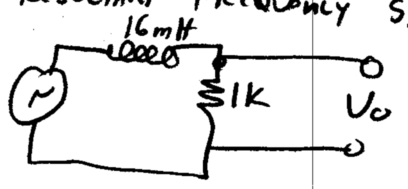
$$\frac{4}{\pi} = 1.27$$

(A) What is the frequency spectrum?



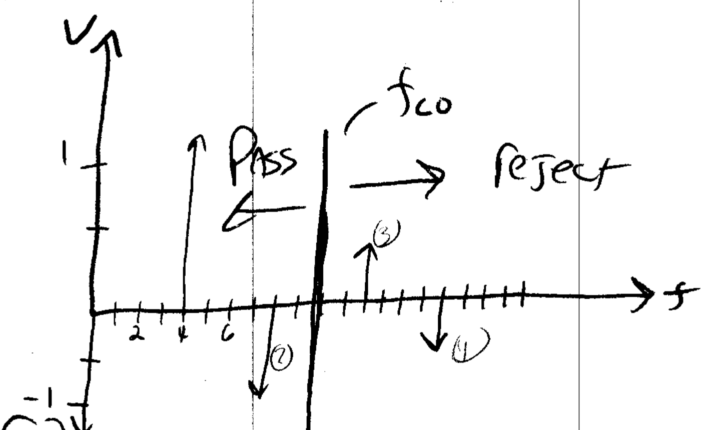

| N | f | V |
|---|---|---|
| 1 | 4 KHz | 1.27 |
| 2 | 8 KHz | −0.637 |
| 3 | 12 KHz | 0.424 |
| 4 | 16 KHz | −0.318 |

(B) Assume this wave is the source of the circuit below, what would the resultant frequency spectrum look like?




LOW PASS

$$f_{CO} = \frac{R}{2\pi L} = 9.95\ \text{KHz}$$

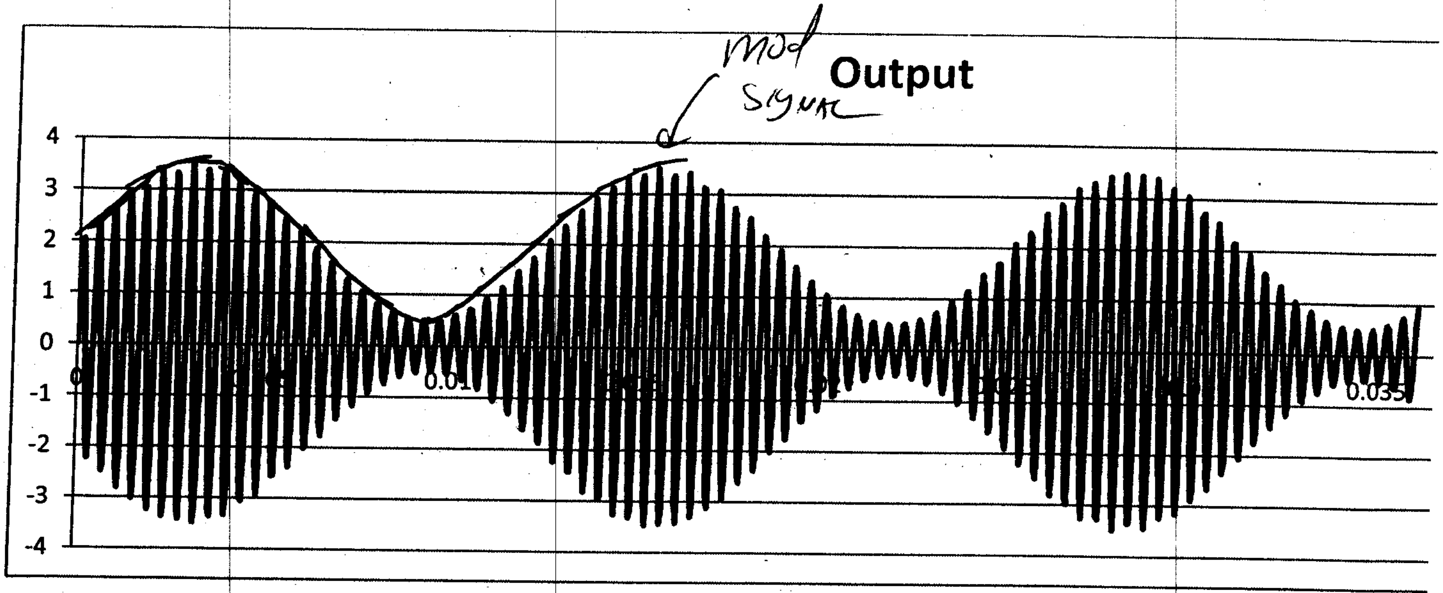



(C) Suppose we wanted a band pass filter to pass only the 2, 3, and 4th harmonics, what would the resonant frequency need to be and what would the BW need to be?

2 − 4 is 8KHz, so 1/2 is 4KHz, adding that to the 2nd harm

$f_c = f_R = 12$ KHz, BW ≥ 8KHz (9 would be better)

(17) (10)




(A) DRAW IN WHAT WOULD BE THE MODULATING FREQUENCY

See graph

(B) WHAT IS $V_{MAX}$?

3.5

(C) WHAT IS $V_{MIN}$?

0.5

(d) WHAT COULD YOU CALCULATE GIVEN THESE 2 VALUES? [HINT: LAB 5!!]

$$m = \frac{V_{MAX} - V_{MIN}}{V_{MAX} + V_{MIN}} = \frac{3}{4} = 0.75, \quad 75\%$$

$$V_c = \frac{V_{MAX} + V_{MIN}}{2} = 2$$

$$V_m = \frac{V_{MAX} - V_{MIN}}{2} = 1.5$$

$$m = \frac{V_m}{V_c} = \frac{1.5}{2} = 0.75 \,!!$$

(18) Given:

An AM signal

$V_c = 10$

$V_m = 6.5$

$f_c = 500\ KHz$

$f_m = 6\ KHz$

$I_c$ (unmodulated) = 25A

$R_{ANTENNA} = 75\Omega$

(A) What is the modulation index?

$m = \frac{6.5}{10} = 0.65$ , 65%

(B) What is the Bandwidth?

$BW = 2 \times 6KHz = 12KHz$

(C) How much power is in the carrier?

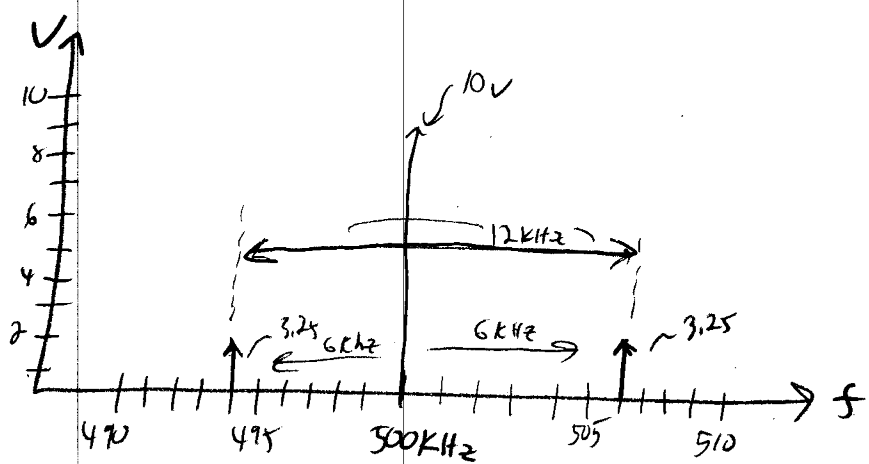
$P_c = I_c^2 \cdot R = 46.88\ KW$

(D) how much power is in each sideband?

$P_T = P_c(1 + \frac{m^2}{2})$ ; $P_T = 46.88KW(1 + \frac{(.65)^2}{2}) = 56.78KW$

So, Power in SB = 56.78 − 46.88 = 9.98KW, so in Each SB = $\frac{9.98KW}{2}$ = 4.99KW

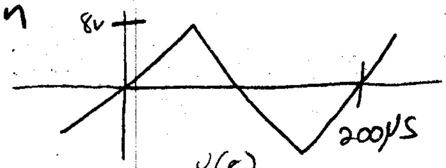
(e) Draw the Frequency spectrum for this AM signal.




(f) Use the above graph to verify B.

12KHz

(119) Given



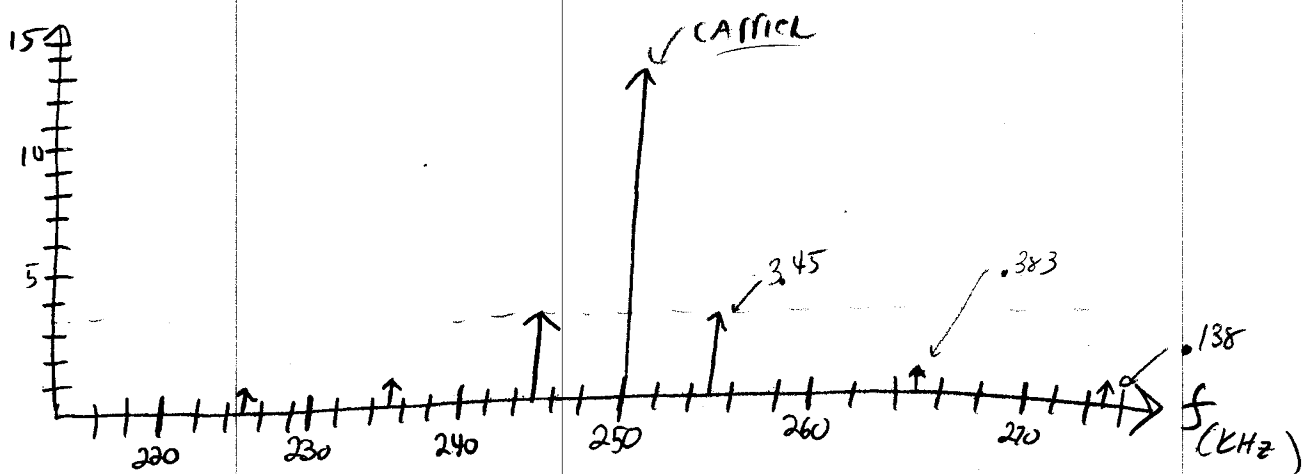

$\frac{8(8)}{\pi^2} = 6.89v$

$v(t) = \frac{8V}{\pi^2}\left[\cos 2\pi\left(\frac{1}{T}\right)t + \frac{1}{9}\cos 2\pi\left(\frac{3}{T}\right)t + \frac{1}{25}\cos 2\pi\left(\frac{5}{T}\right)t\right]$

| N | f | V |
|---|---|---|
| 1 | 5KHz | 6.89 |
| 3 | 15KHz | 0.766 |
| 5 | 25KHz | 0.276 |

If we modulate this signal with a carrier of 250 KHz and magnitude of 15V:

(A) What does the resultant frequency spectrum look like?




(B) If the antenna has a resistance 75Ω and the unmodulated current is 1.5 A, what is total power, power in the carrier, and the power in each sideband?

$P_C = (1.5)^2(75) = 168.8W$

$P_T = 168.8\left(1 + \frac{(.459)^2}{2} + \frac{(.051)^2}{2} + \frac{(.018)^2}{2}\right)$

$= 168.8(1.107)$

$= \boxed{186.8W}$

In side bands

$P_{SB} = P_T - P_C$

$= 18.03$

**9.01W in each side band**

(C) What is m for each harmonic in this AM signal?

$m_1 = \frac{6.89}{15} = 0.459$

$m_2 = \frac{.766}{15} = 0.051$

$m_3 = \frac{.276}{15} = 0.018$