ENGR-4300

Electronic Instrumentation

Quiz 1

Fall 2010

Name _____________________________

Section ___

Question I (20 points) _____________

Question II (20 points) _____________

Question III (20 points) _____________

Question IV (20 points) _____________

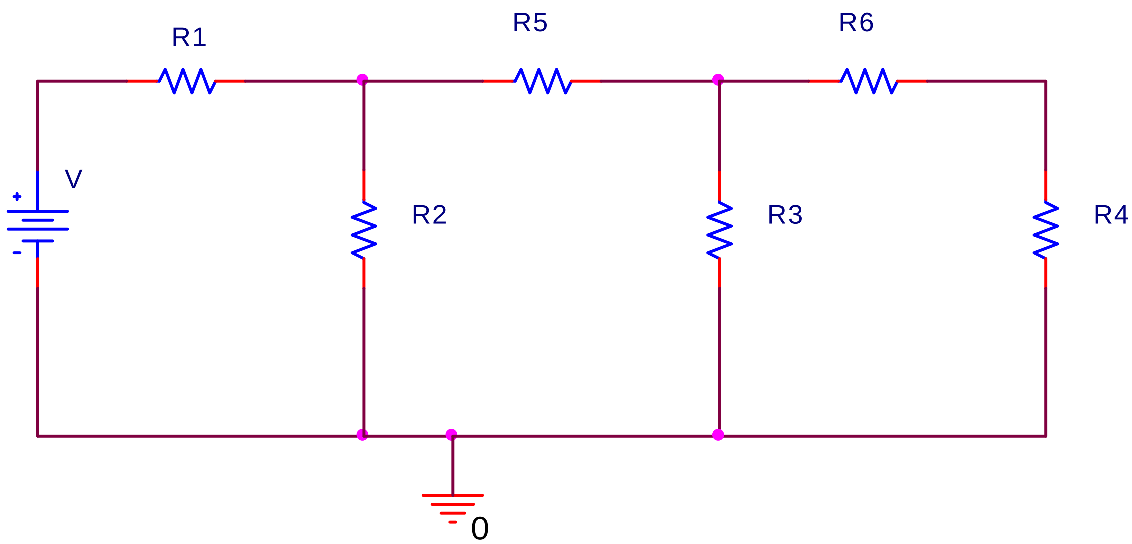
Question V (20 points) _____________

Total (100 points) _________________

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES <u>AND UNITS</u>. No credit will be given for numbers that appear without justification.

Question I. Resistive circuits (20 points)

V=40V, R1=R4=R5=R6=1kΩ, R2=R3=2kΩ



1) Find the total resistance of the circuit, seen from the voltage source. (6 pts)

Ra=R6+R4=2k, Rb=Ra||R3=1k, Rc=Rb+R5=2k, Rd=R2||Rc=1k, <u>Rtotal=Rd+R1=2k</u>

Across R2: VR2=40x0.5=20V; Across R3: VR3=20x0.5=10V; Across R4: VR4=10x0.5=5V

2) Find the voltages across R1 and R4. (8 pts)

VR1=40-VR2=20V

VR4=5V

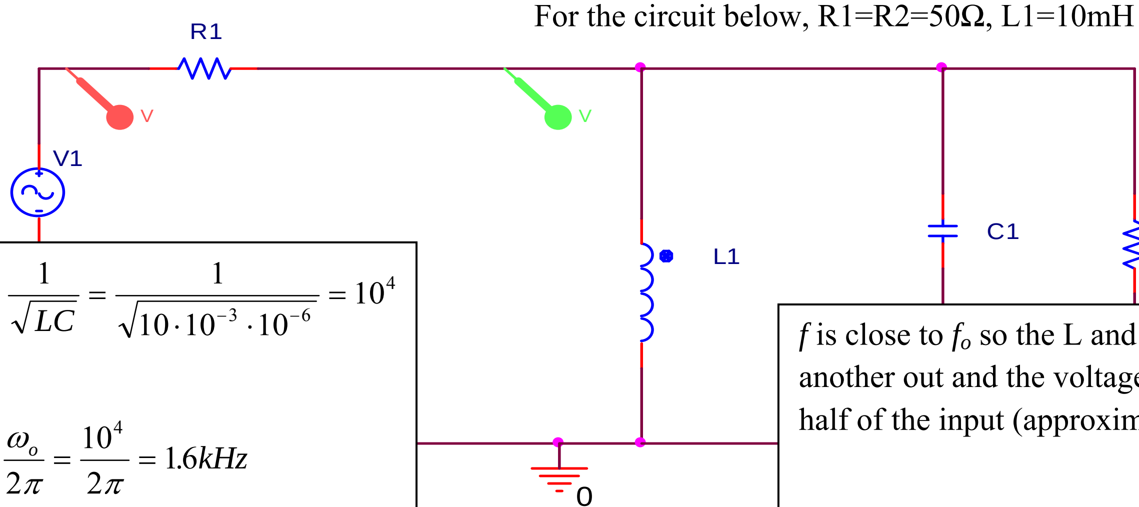
3) Find the currents through R2 and R3. (6 pts)

IR2=VR2/R2=20/2000=10mA

IR3=VR3/R3=10/2000=5mA

Question II. Filters (20 points)

For the circuit below, R1=R2=50Ω, L1=10mH and C1=1μF.

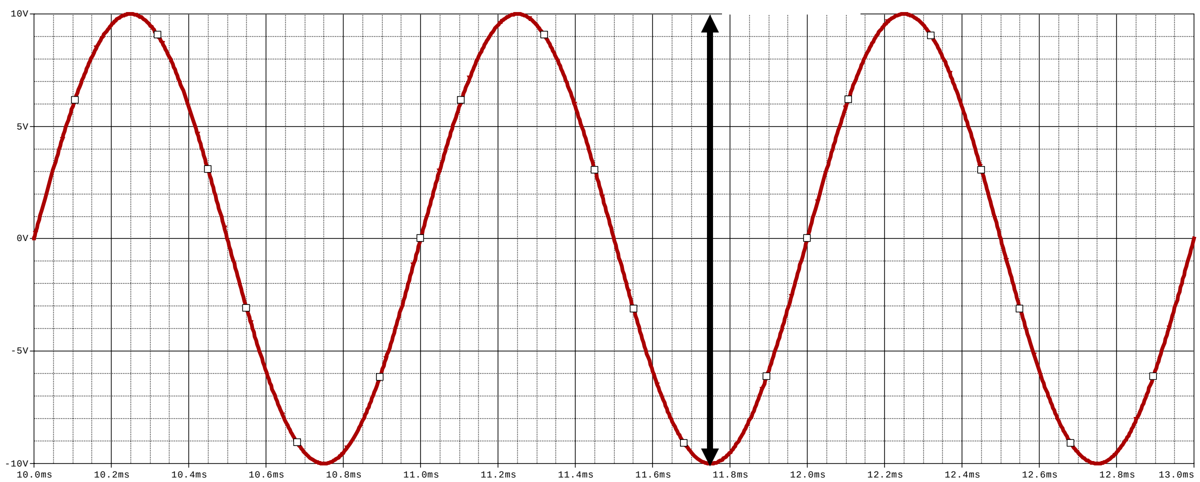


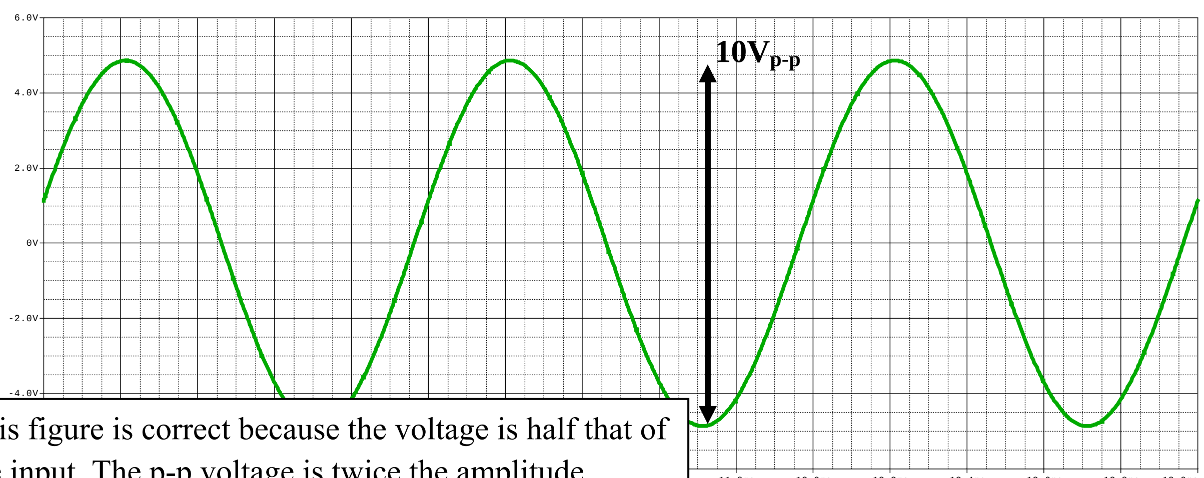
$$\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10 \cdot 10^{-3} \cdot 10^{-6}}} = 10^4$$

$$f_o = \frac{\omega_o}{2\pi} = \frac{10^4}{2\pi} = 1.6kHz$$

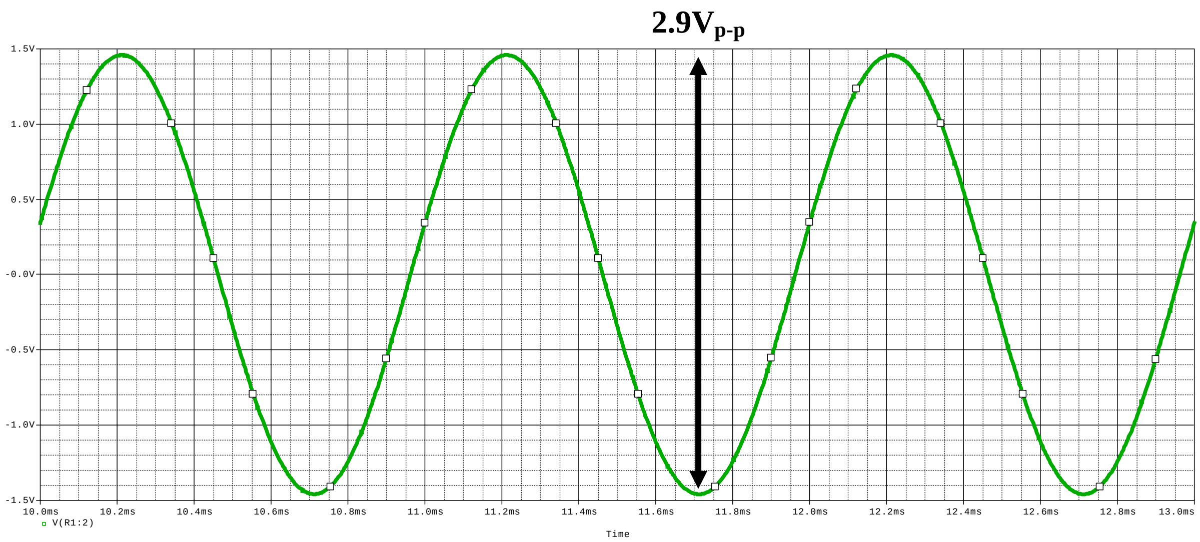
f is close to f_o so the L and C cancel one another out and the voltage across R2 is half of the input (approximately)

1) Which of the 3 graphs below would best represent the output seen across resistor R2; where Vin = 10V cos(2πft), with **f = 1kHz**? (8 pts)





This figure is correct because the voltage is half that of the input. The p-p voltage is twice the amplitude.



2) What kind of filter response would best represent this circuit? (Please circle one.) (4 pts)

a) Low Pass

b) Band Pass – because the L and C short out the output at low and high frequencies, respectively. See next page for output plot.

c) High Pass

d) Band Reject

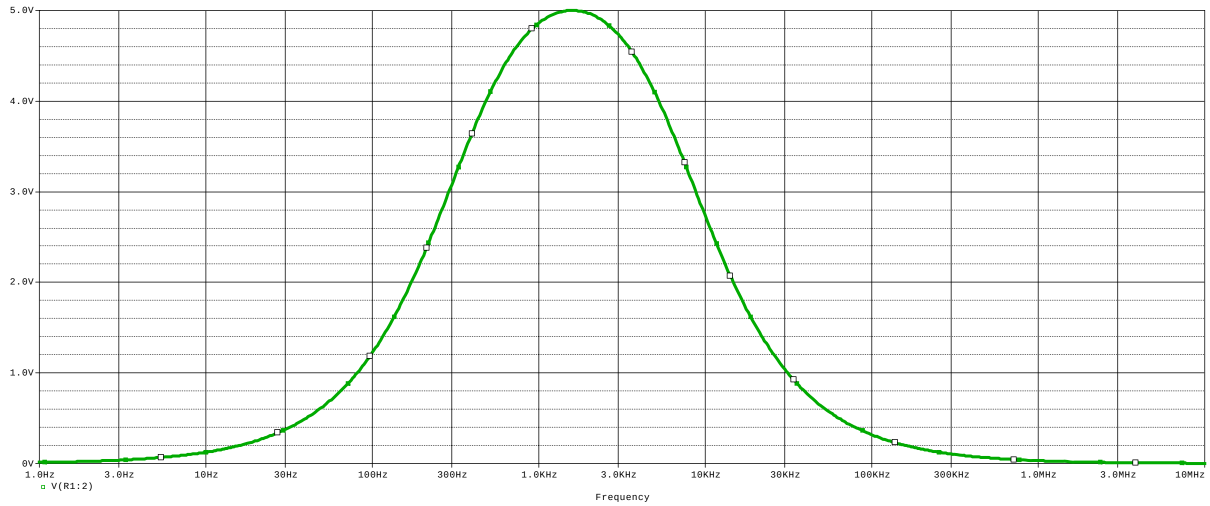
3) What kind of filter response would best represent this circuit if the inductor were removed, leaving the capacitor and two resistors? (Please circle one.) (4 pts) *Hint: Sketch the new circuit diagram.*

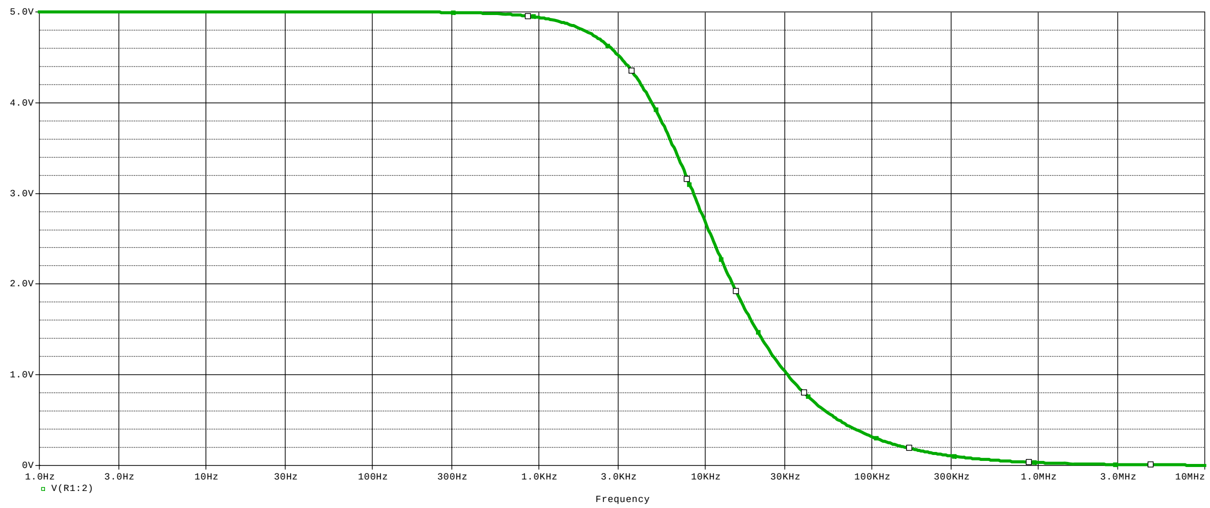
a) Low Pass– because the C shorts out high frequencies and is open at low frequencies. See next page for output plot.

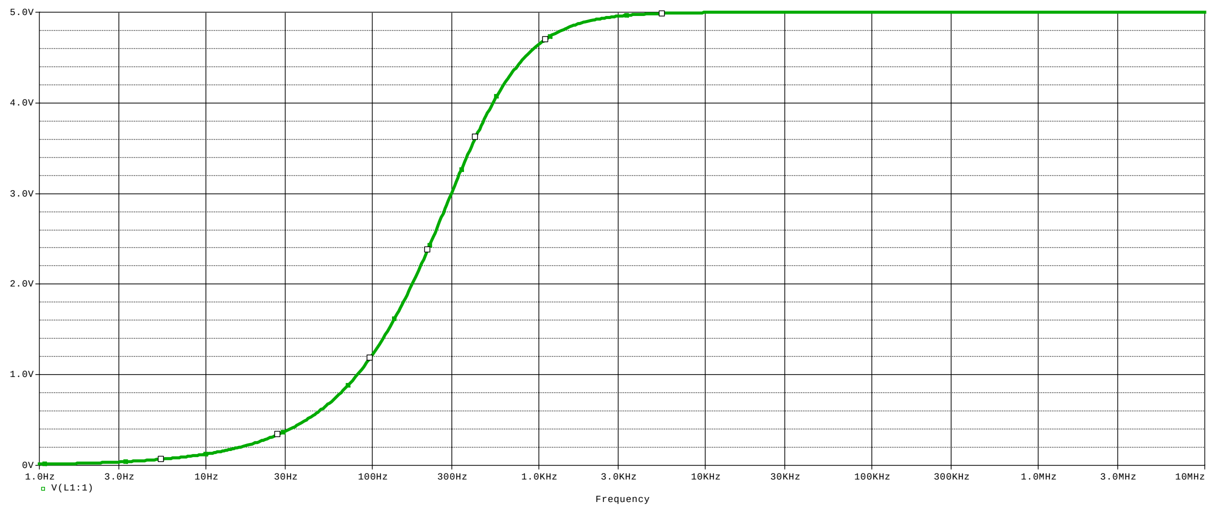
b) Band Pass

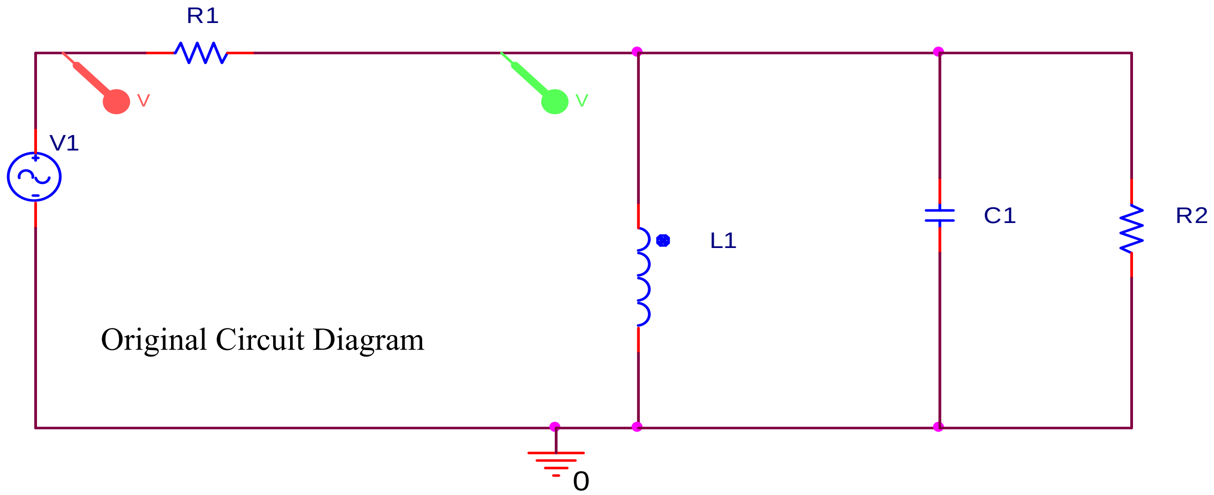
c) High Pass

d) Band Reject


5.0V
4.0V
3.0V
2.0V
1.0V
0V
1.0Hz 3.0Hz 10Hz 30Hz 100Hz 300Hz 1.0KHz 3.0KHz 10KHz 30KHz 100KHz 300KHz 1.0MHz 3.0MHz 10MHz
V(R1:2)
Frequency


5.0V
4.0V
3.0V
2.0V
1.0V
0V
1.0Hz 3.0Hz 10Hz 30Hz 100Hz 300Hz 1.0KHz 3.0KHz 10KHz 30KHz 100KHz 300KHz 1.0MHz 3.0MHz 10MHz
V(R1:2)
Frequency


5.0V
4.0V
3.0V
2.0V
1.0V
0V
1.0Hz 3.0Hz 10Hz 30Hz 100Hz 300Hz 1.0KHz 3.0KHz 10KHz 30KHz 100KHz 300KHz 1.0MHz 3.0MHz 10MHz
V(L1:1)
Frequency



4) What kind of filter response would best represent the original circuit if the capacitor were removed leaving the inductor and two resistors? (Please circle one.) (4 pts) *Hint: Sketch the new circuit diagram.*

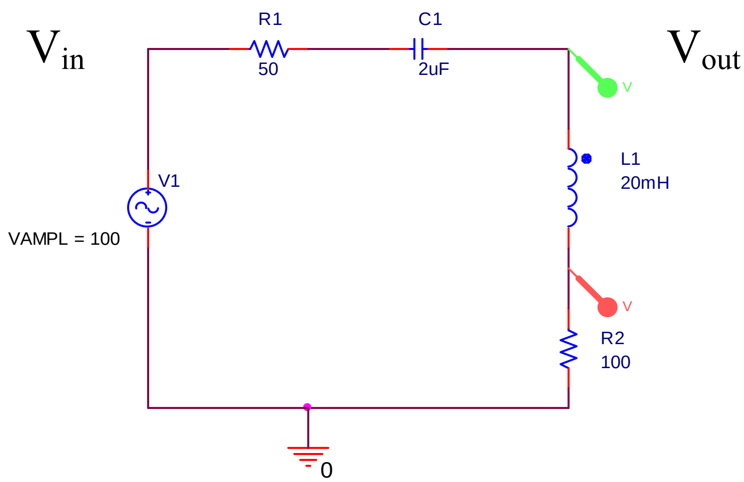
a) Low Pass

b) Band Pass

c) High Pass – because L shorts out low frequencies and is open at high frequencies. See previous page for output plot.

d) Band Reject

Question III – Transfer Functions (20 points)



For this circuit, V_{in} is the voltage source and V_{out} is the voltage across the series combination of the inductor and resistor.

1) What is the transfer function (V_{out}/V_{in}) for the circuit in terms of R1, R2, L, & C? (6 pts)

$$\frac{V_{out}}{V_{in}} = \frac{R2 + j\omega L1}{R1 + R2 + j\omega L1 + \dfrac{1}{j\omega C1}}$$

2) What is the simplified transfer function of the circuit at low frequencies? (3 pts)

$$\frac{V_{out}}{V_{in}} = \frac{R2}{R1 + R2 + \dfrac{1}{j\omega C1}} = j\omega R2C1$$

3) What is the simplified transfer function of the circuit at high frequencies? (3 pts)

$$\frac{V_{out}}{V_{in}} = \frac{j\omega L1}{j\omega L1} = 1$$

Resonance

4) Find the frequency ω_0 (in terms of L & C) where the impedance of the inductor and capacitor (Z_L & Z_C) have the same magnitude (but opposite signs) and cancel each other. (2 pts)

$\omega_o L1 = \frac{1}{\omega_o C1}$ so that $\omega_o = \frac{1}{\sqrt{L1C1}}$

5) How does the frequency in 4) compare to the circuit's resonant frequency? (2 pts)

$\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20 \cdot 10^{-3} \cdot 2 \cdot 10^{-6}}} = \frac{10^4}{2} = 5x10^3$ so the frequencies are the same.

$f_o = \frac{\omega_o}{2\pi} = \frac{10^4}{4\pi} = 0.8kHz$ {This was not asked for in this problem, but is provided for completeness.}

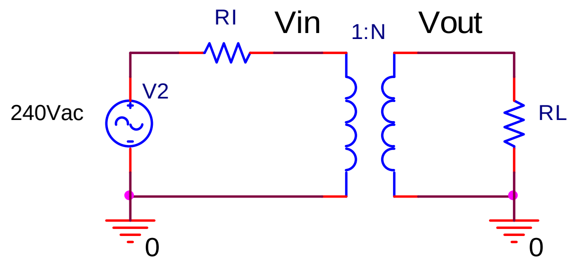
6) What is the value of the transfer function $\frac{V_{R2}(j\omega_0)}{Vin(j\omega_0)}$ at this frequency ω_0? (2 pts)

$$\frac{V_{R2}}{V_{in}} = \frac{R2}{R1 + R2 + j\omega L1 + \frac{1}{j\omega C1}} = \frac{R2}{R1 + R2} = \frac{2}{3}$$

7) For Vin(t) = 300sin(ω_0t + π/2) where ω_0 is the frequency found in 4), what is V_{R2}(t)? (2 pts)

$V_{R2} = \frac{2}{3} V_{in} = 200 \sin(\omega_o t + \frac{\pi}{2})$ because it is just 2/3 of the input.

Question IV – Signals, Transformers and Inductors (20 points)



1) Given the circuit above, assume an ideal transformer with full coupling. With RI = RL = 100Ω and N=1, find Vin, Vout, and the power in RL. (6 pts)

$$\frac{V_{out}}{V_{in}} = 1 \quad \frac{I_{out}}{I_{in}} = 1 \quad Z_{in} = RL$$

$$V_{in} = V_{out} = 120V \qquad P_{RL} = \frac{V_{out}^{\ 2}}{RL} = \frac{120^2}{100} = 144W$$

2) If RL is changed to 25Ω (everything else remains as in 1), what are the new values for Vin, Vout, and the power in RL? (6 pts)

$$V_{in} = V_{out} = 48V \qquad P_{RL} = \frac{V_{out}^{\ 2}}{RL} = \frac{48^2}{100} = 92W$$

3) Find the value for N that allows the circuit in 2) to see the same load on the primary (source) side of the transformer as in 1). (4 pts)

$Z_{in} = \frac{RL}{N^2} = 4RL$ so that $N=1/2$

4) Knowing that a real transformer's behavior deviates from that of an ideal, what would be an appropriate minimum value for the inductance on the primary of the transformer in 1), given the source's frequency of 60Hz? (4 pts)

a) 0.003mH

b) 0.3mH

c) 30mH

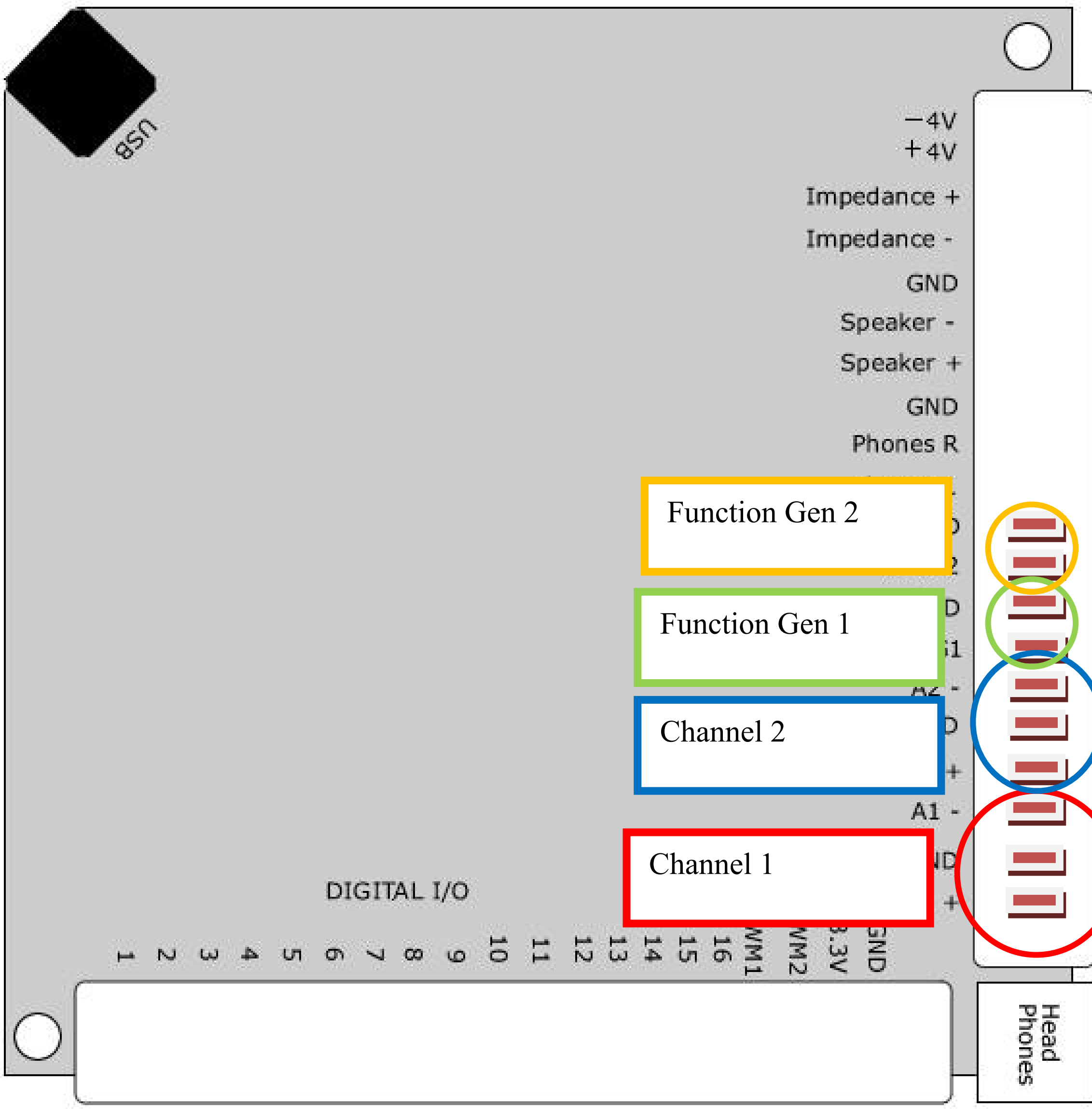
d) 3H

$\omega L >> R1, R2$

$L >> \frac{100}{120\pi} = .265H$

So the answer has to be d)3H

Question V – Instrumentation, PSpice and components (20 points)



Shown above is the pinout diagram for the Mobile Studio. Shown also at the right are the 10 input/output connections we have used so far in the course.

1) Which three connections are used to input signals to channel 1 of the oscilloscope? Circle and label your answer. (1pt)

2) Which three connections are used to input signals to channel 2 of the oscilloscope? Circle and label your answer. (1pt)

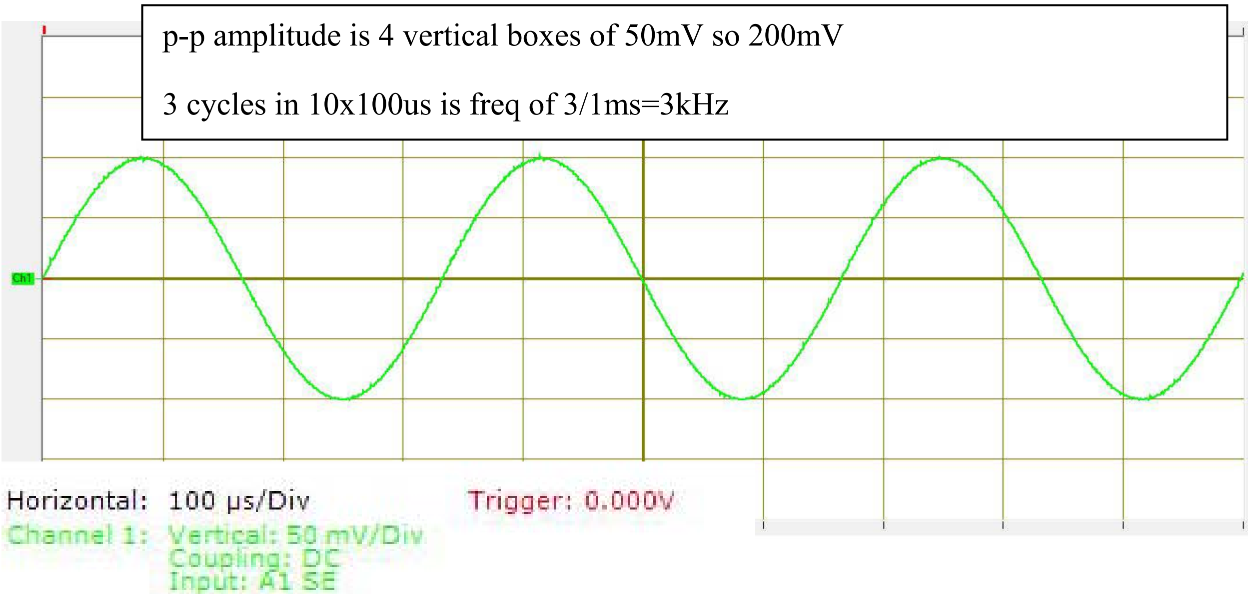
3) Which two connections are used to output sine, triangular and square waves from Function Generator 1? Circle and label your answer. (1pt)

4) Which two connections are used to output sine, triangular and square waves from Function Generator 2? Circle and label your answer. (1pt)

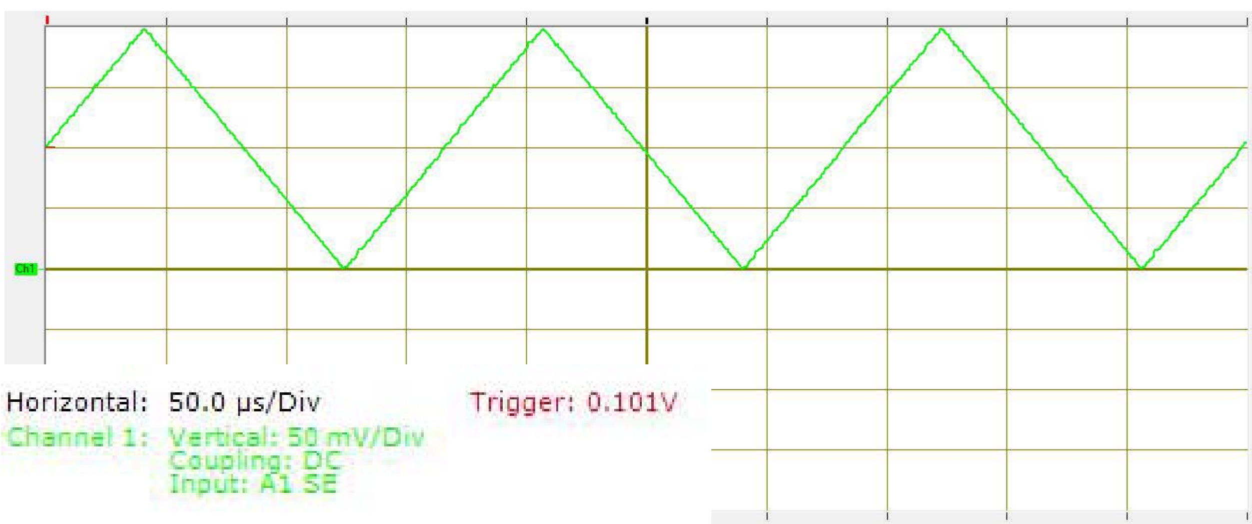
5) Assume that Function Generator 1 is used to generate a 3kHz sine wave with peak-to-peak amplitude of 0.2V and it is connected to Channel 1 of the Oscilloscope. Which of the following three signals will be observed on Channel 1? Explain your choice. (6pts)

p-p amplitude is 4 vertical boxes of 50mV so 200mV

3 cycles in 10x100us is freq of 3/1ms=3kHz



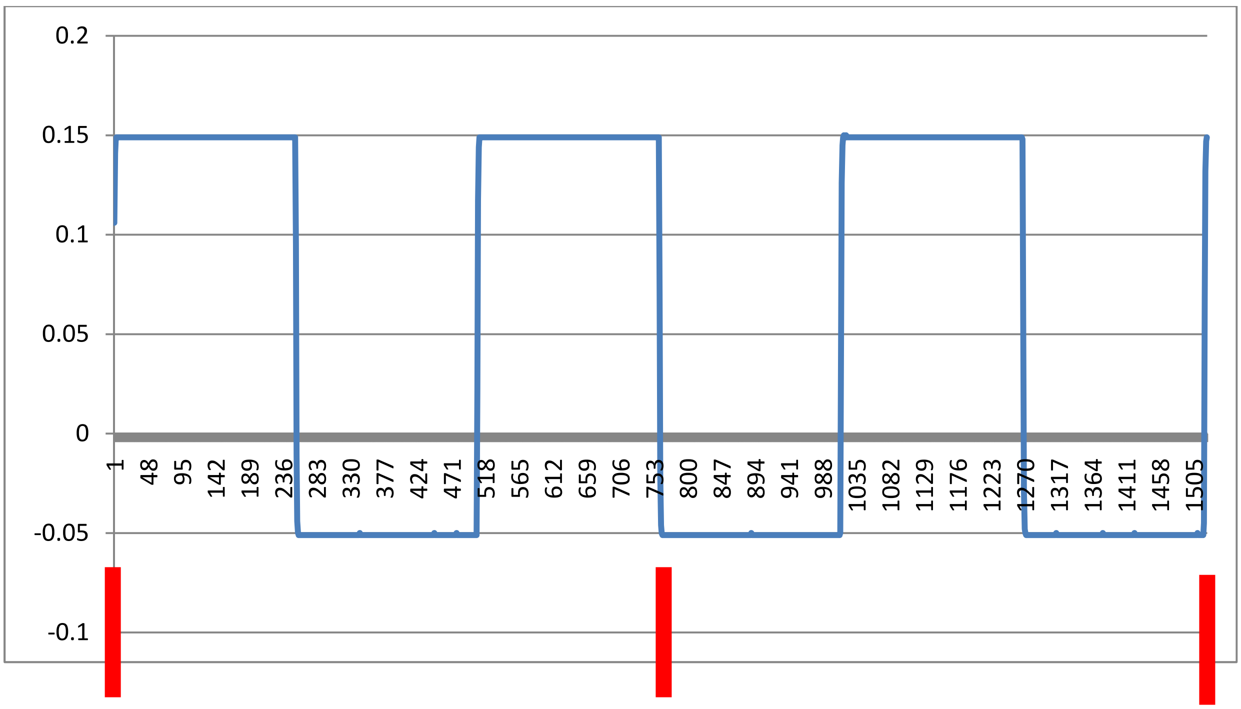
6) Function Generator 1 is modified so that it outputs the triangle wave shown below as it is observed on oscilloscope channel 1. What are the frequency, the period, the peak-to-peak amplitude and the offset voltage for this wave? (8pts)



3 cycles in 10x50us so the frequency is 3/0.5ms=6kHz, the period is 0.5ms/3=1.67ms

p-p amplitude is 4x50mV or 200mV or 0.2V, offset is 2x50mV or 100mV or 0.1V

7) Function Generator 1 is modified so that it outputs the square wave shown below as it is observed on oscilloscope channel 1, saved as a comma separated file, then displayed in Excel. The frequency of this wave is 3kHz. The horizontal scale shown in the Excel plot is just the number of points so it does not really tell us anything about the wave. Label the plot with the correct time scale, assuming that t = 0sec occurs at the left end of the plot. (2pts)



For a frequency of 3kHz, the period is 0.33ms or 3 cycles is 1ms

0ms 0.5ms 1ms