ENGR-4300

Electronic Instrumentation

Quiz 1

Spring 2011

Name ___________________________

Section ___

Question I (20 points) ____________

Question II (20 points) ____________

Question III (20 points) ____________

Question IV (20 points) ____________

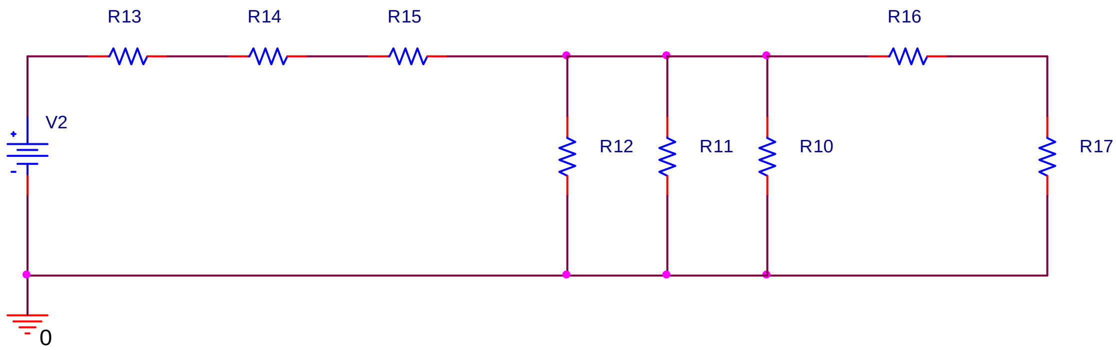
Question V (20 points) ____________

Total (100 points) _______________

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

Question I. Resistive circuits (20 points)

V2=12V, R10=R11=R12=6kΩ, R13=R14=R15=R16=R17=1kΩ



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

The three resistances in parallel will add up to 2k which then will be in series with the 2k for the last two resistors at the right. Then the two sets of 2k resistors add in parallel to 1k. This then adds to the 3k in series to obtain 4k total.

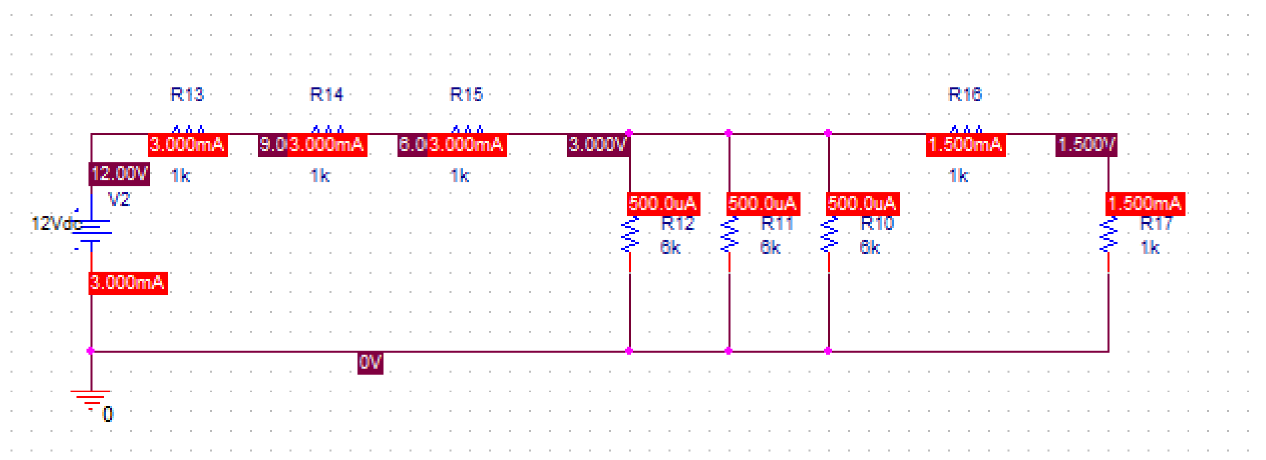
2) Find the voltages across R12 and R17. (8 pts)

The total resistance across the terminals of R2 is 1k so the voltage is (1/4)12=3V
The voltage across R17 will be half of this or 1.5V

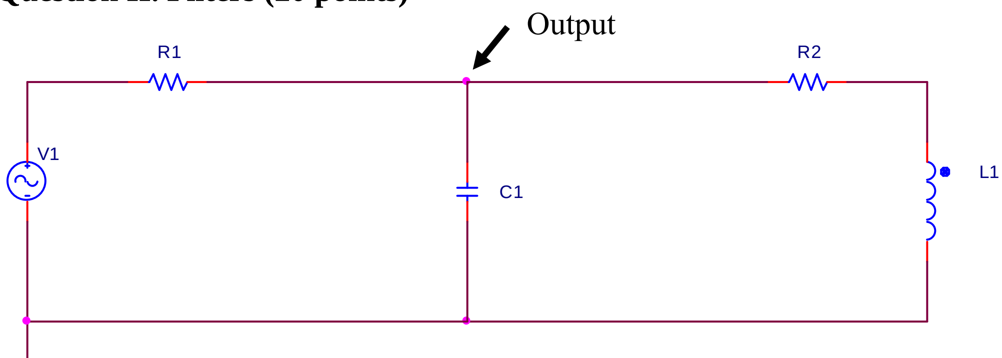
3) Find the currents through R13 and R11. (6 pts)

The current through R13 is 12/4k or 3mA

Half of this current goes through the three 6k resistors in parallel or a third through each one of the resistors or 0.5mA

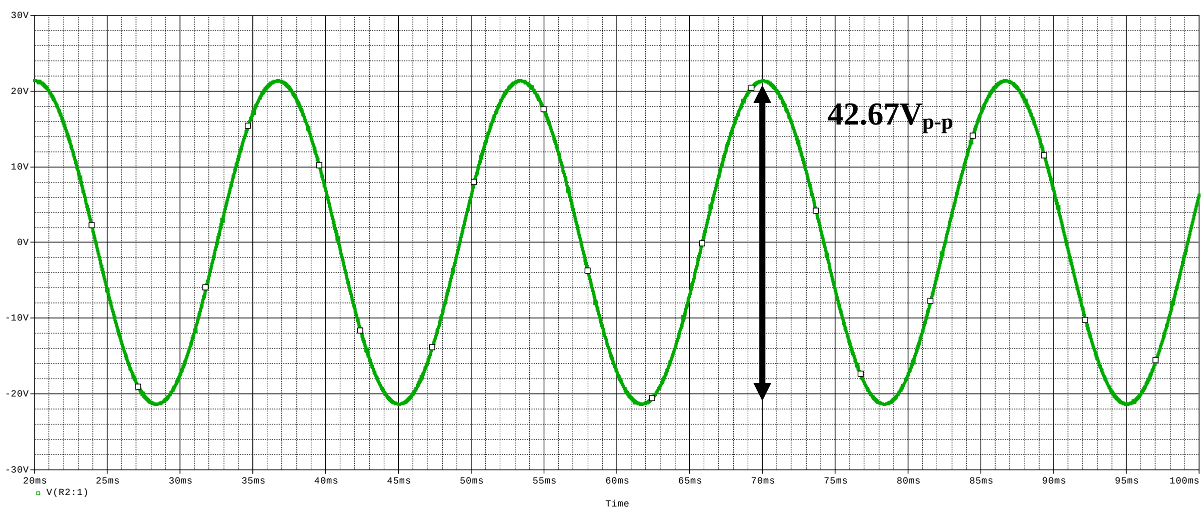


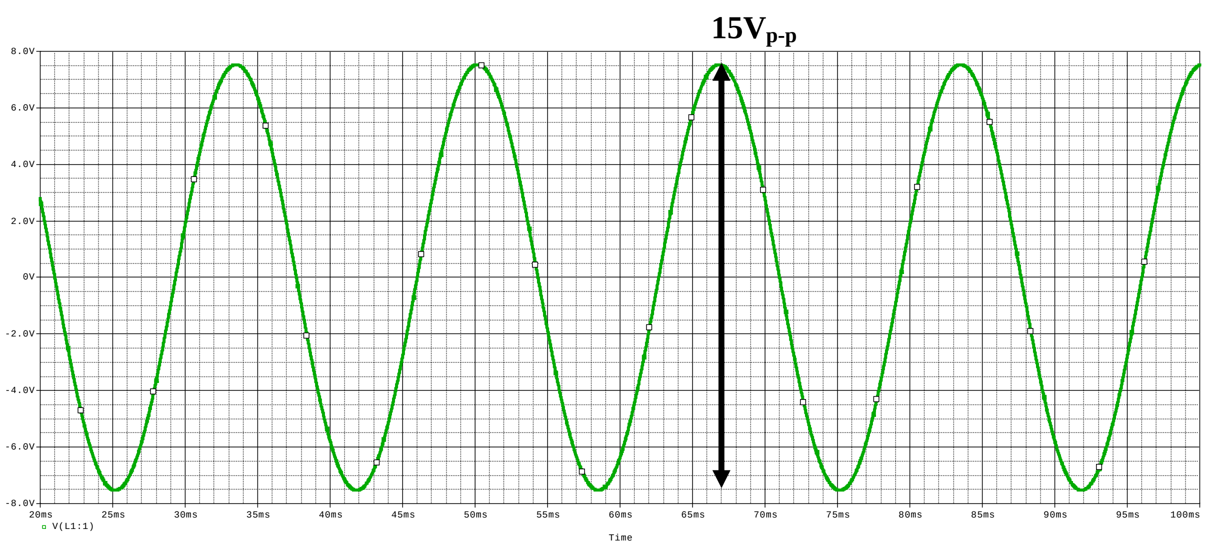
Question II. Filters (20 points)



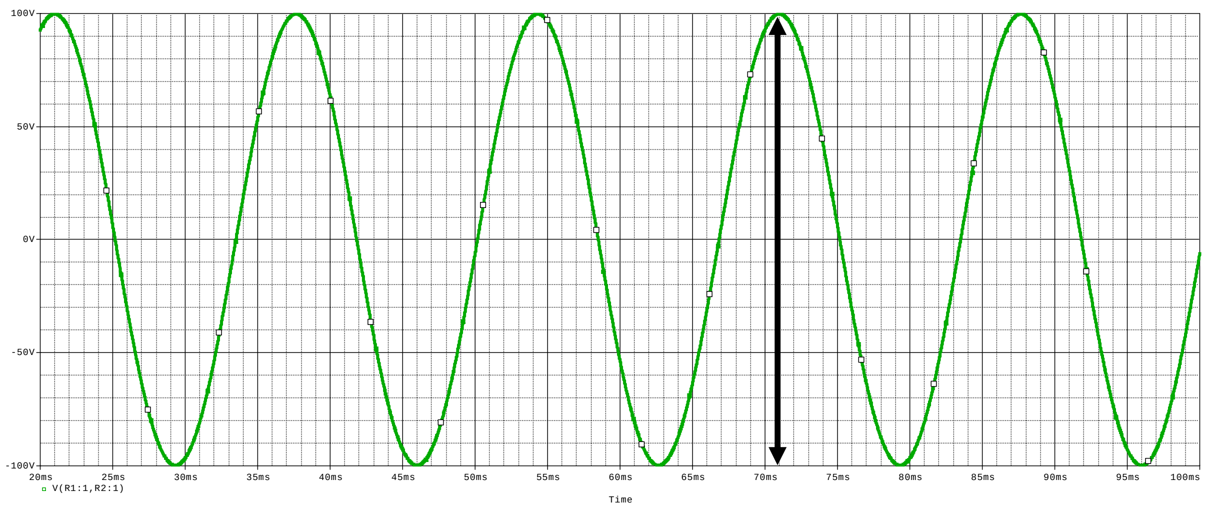
For the circuit above, R1=50Ω, R2=10 Ω, L1=10mH and C1=0.63μF.

1) Which of the 3 graphs below would best represent the output seen across capacitor C1; where Vin = 120V cos(2πft), with **f = 60Hz**? (8 pts)

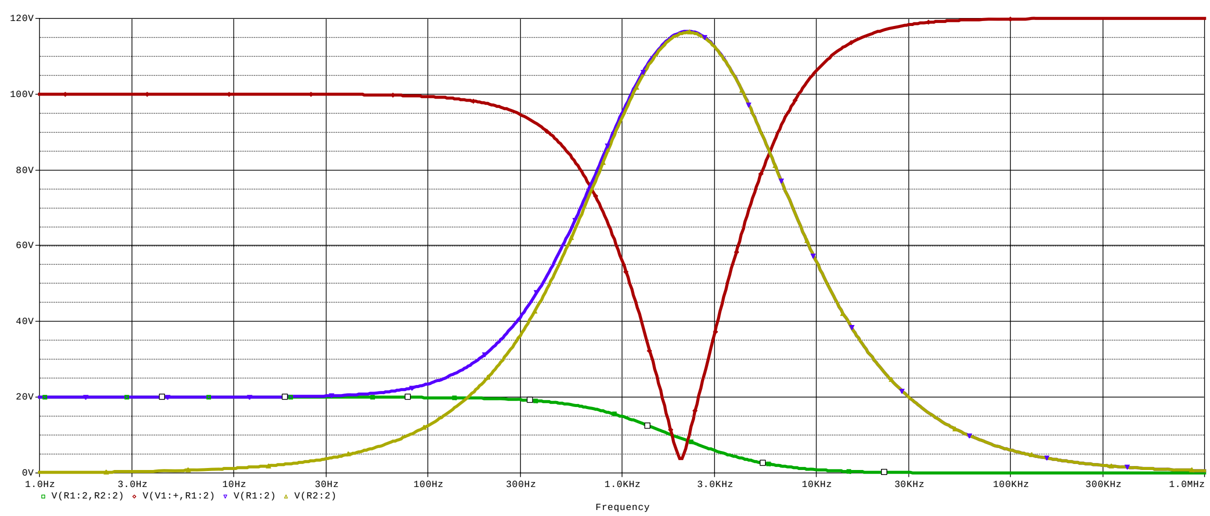




$200V_{p\text{-}p}$



Doing an AC sweep, we can see that the four voltages are quite different. The first one shown on the previous page is across the capacitor.



To do this problem, evaluate the impedance of the capacitor and inductor at 60Hz

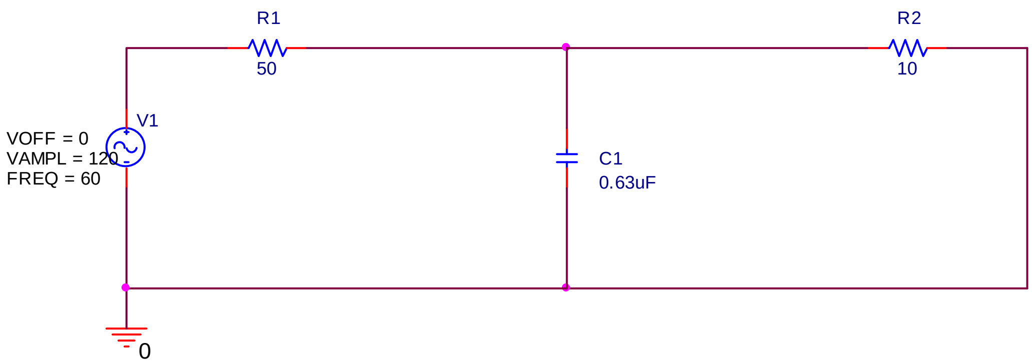
$Z = \frac{1}{j\omega C} = \frac{1}{j(2\pi 60)(0.63\mu F)} = \frac{1}{j}4210$ *and* $Z = j\omega L = j2\pi 60(0.01) = j3.8$ *so that the magnitude of the capacitive impedance is large so can be treated as an open circuit. The impedance of the inductance is smaller than the two resistors in series, so the circuit is mostly resistive. If we neglect the inductive impedance then the p-p voltage across the capacitor will be about 1/6 of the source or about two times 20V. The first plot is the closest one to this (not exactly because the inductance is still relatively large)*

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

b) Band Pass *at very low freq, C is open and L is a short so the load is across the second R so some signal will pass, but it will be smaller. At high freq. C is a short, so nothing will pass. This does operate like a low pass to some extent, because some signal will pass attenuated, so 2 points for that answer.*

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 *The capacitor is open at low freq and a short a high freq so it is a low pass filter.*

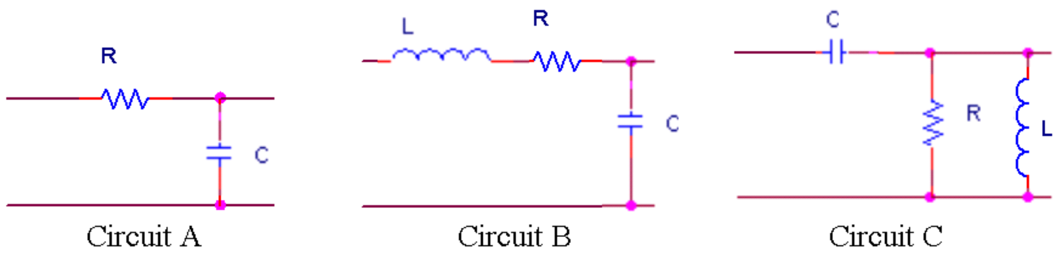


4) What kind of filter response would best represent the original circuit if the capacitor were removed leaving the inductor and two resistors, with the output measured across R2? (Please circle one.) (4 pts) *Hint: Sketch the new circuit diagram. There are two possible answers, if an explanation is provided.*

a) Low Pass *The inductor is open at high frequencies so no current flows through R2 or R1 and there is no voltage across R2. At low freq the inductor is a short so current flows through the resistors and the signal appears (attenuated some) across R2.*

c) High Pass *If the output is measured between R1 and R2, as it was in the other parts of this problem, then the full voltage will appear at high frequencies. Full credit for this answer too.*

Question 3 – Transfer Functions (20 points)



A. Transfer Functions

1) What is the transfer function for circuit A? You must simplify. (2 points)

$$H_A(j\omega) = \frac{1/j\omega C}{R + 1/j\omega C} = \frac{1}{j\omega RC + 1}$$

2) What is the transfer function for circuit B? You must simplify. (2 points)

$$H_B(j\omega) = \frac{1/j\omega C}{j\omega L + R + 1/j\omega C} = \frac{1}{-\omega^2 LC + j\omega RC + 1}$$

3) What is the transfer function for circuit C? You must simplify. (3 points)

$$H_C(j\omega) = \frac{\dfrac{j\omega L \times R}{j\omega L + R}}{1/j\omega C + \dfrac{j\omega L \times R}{j\omega L + R}} = \frac{-\omega^2 RLC}{j\omega L + R - \omega^2 RLC}$$

B. We want to determine what type of filter circuit B is

1) What are the simplified transfer function, the magnitude, and the phase of circuit B at low frequencies? (3 points)

$H_{BLO}(j\omega) = \frac{1}{1} = 1$

$|H_{BLO}|$ = ***1***

$\angle H_{BLO}$ = ***0***

2) What are the simplified transfer function, the magnitude, and the phase of circuit B at high frequencies? (3 points)

$H_{BHI}(j\omega) = \frac{1}{-\omega^2 LC}$

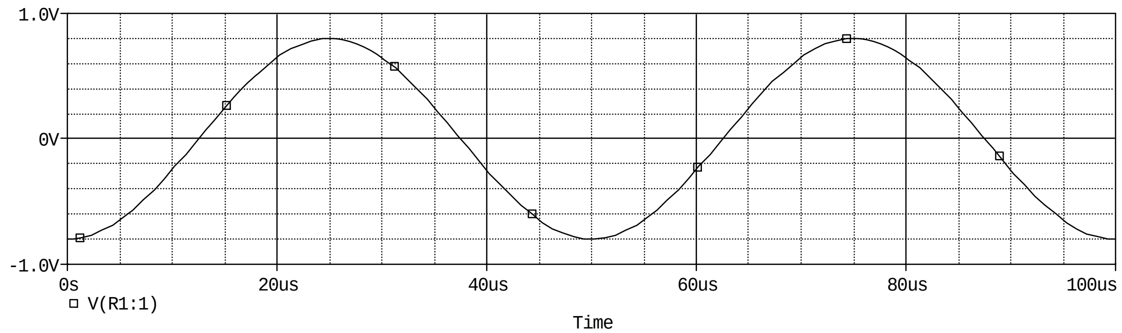
$|H_{BHI}|$ = ***0***

$\angle H_{BHI}$ = $\boldsymbol{\pi}$ **or** $\boldsymbol{-\pi}$

3) What type of filter is circuit B? (1 point)

Low Pass Filter

C. We want to know what the output of circuit A will look like for the input shown below



1) Write an equation in the form $V_{in}(t) = A_{in}\sin(\omega t + \phi_{in})$ which describes the input signal shown. (2 points)

$V_{in}(t) = 800mV \sin(40K\pi t - \pi/2)$

2) If C=0.01μF and R=10K, what are the magnitude and phase of the transfer function of circuit A? (2 points)

$|H_A|$ = ***0.079***

$$|H_A| = \left|\frac{1}{j\omega RC+1}\right| = \left|\frac{1}{j(40k\pi)(10k)(0.01\mu)+1}\right| = \left|\frac{1}{j(12.57)+1}\right|$$

$$|H_A| = \frac{1}{\sqrt{12.57^2+1^2}} = 0.079$$

$\angle H_A$ = ***-1.49 radians***

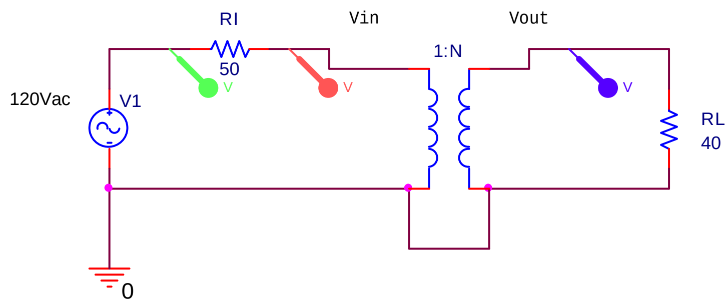
$\angle(1) - \angle(1+j(12.57)) = 0 - \tan^{-1}(12.57) = 0 - 1.49 = -1.49$

3) What are the amplitude and phase of the output of circuit A, when the input signal from part C-1 is applied to the circuit? (2 points)

A_{out} = (0.079)(800m) = ***63.2mV***

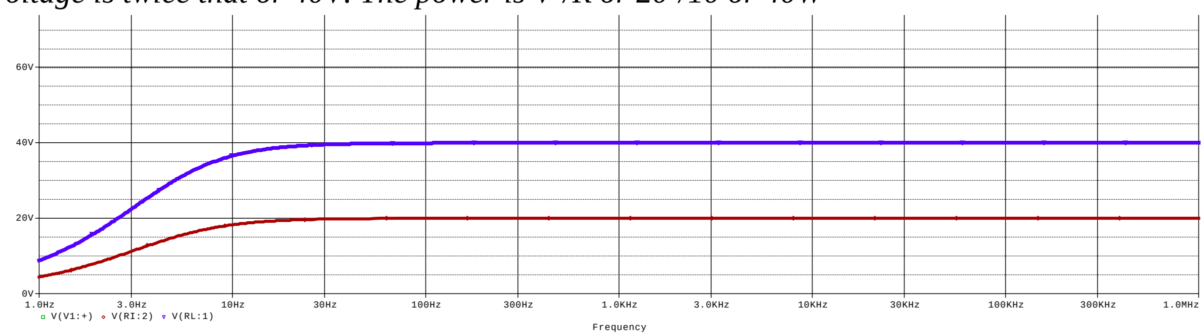
ϕ_{out} = -1.571 – 1.49 = ***-3.06 radians***

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



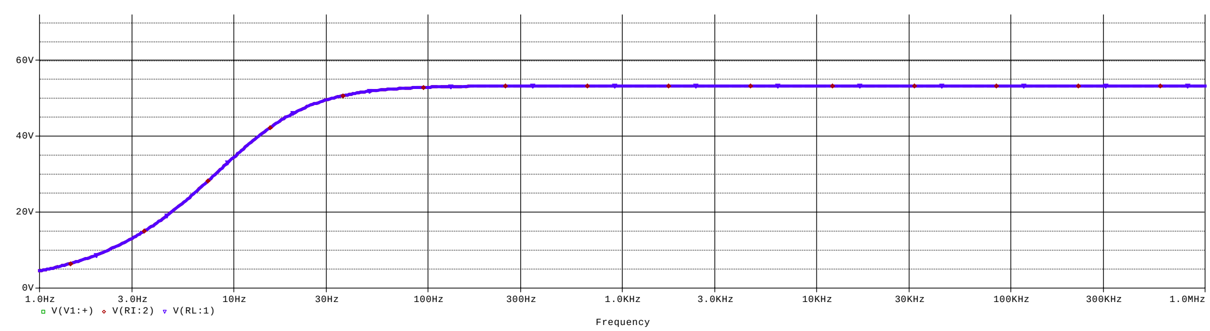
1) Given the circuit above, assume an ideal transformer with full coupling. With RI = 50Ω and RL = 40Ω and N=2, find Vin, Vout, and the power in RL. (6 pts)

For the turns ratio of 1:2 we see that the input voltage is 20V across 10Ω while the output voltage is twice that or 40V. The power is V^2/R or $20^2/10$ or 40W



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

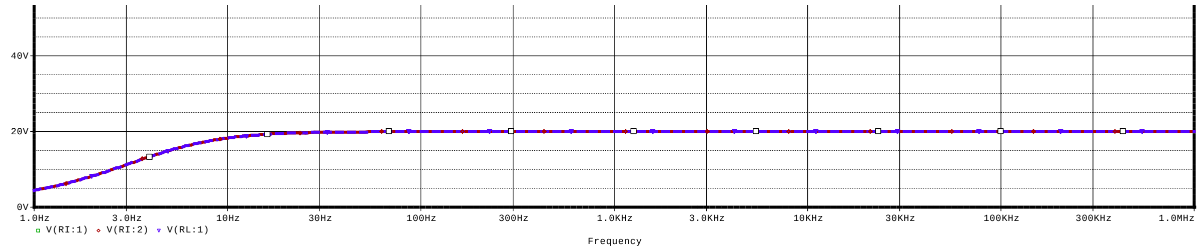
The input and output voltages are the same with N=1 so the input and load impedance are the same. The voltage divider now gives (4/9)120 or about 53V The power is this voltage squared over 40 or about 71W



Note that we are not showing the input voltage on these plots to save space. It is a flat line at 120V.

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

The load has to go down by a factor of 4 to 10Ω



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

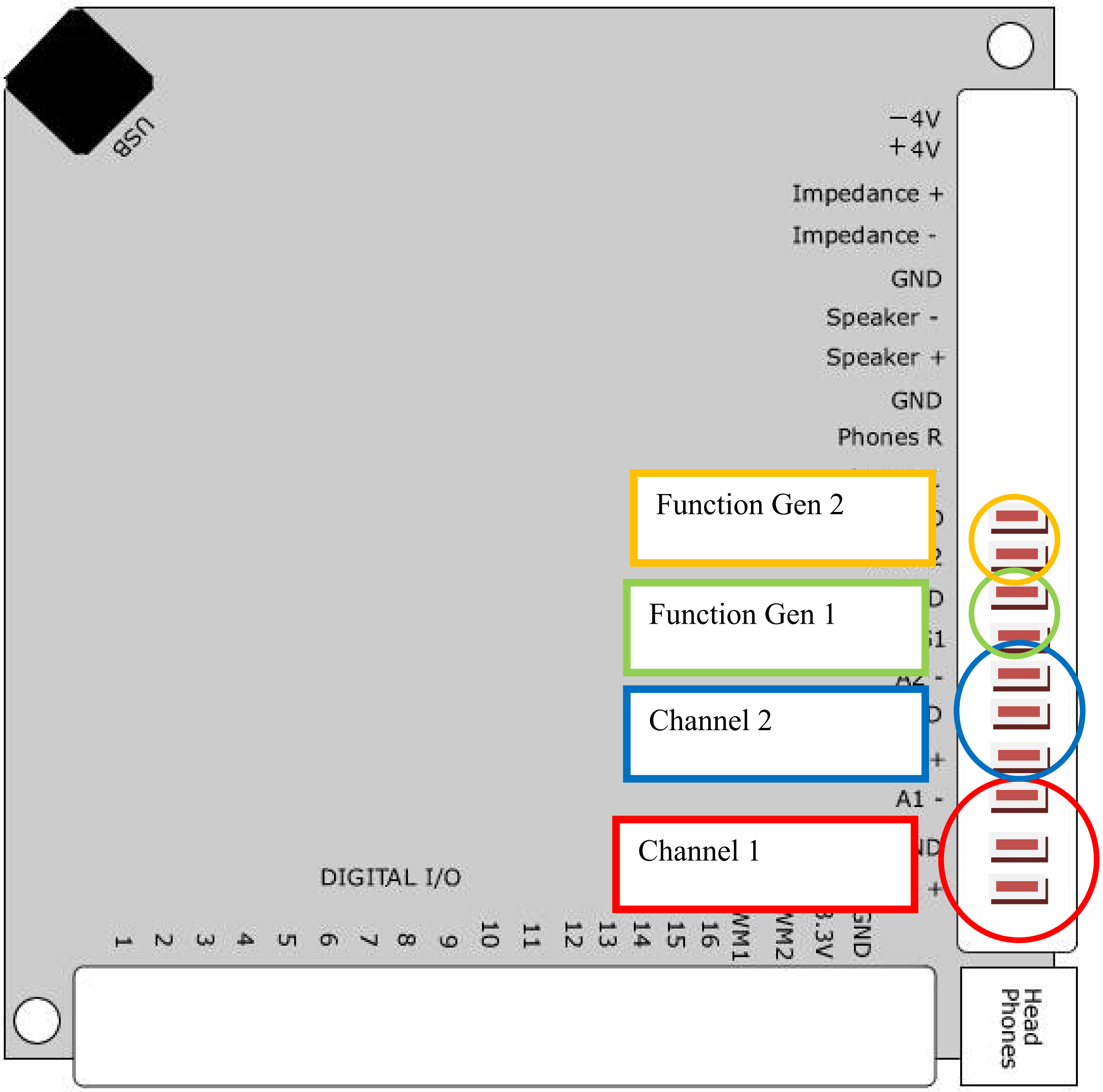
b) 0.3mH

c) 30mH

d) 300mH

This question is basically a gift because the largest inductance will be the best choice to assure that the inductive impedance dominates.

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)

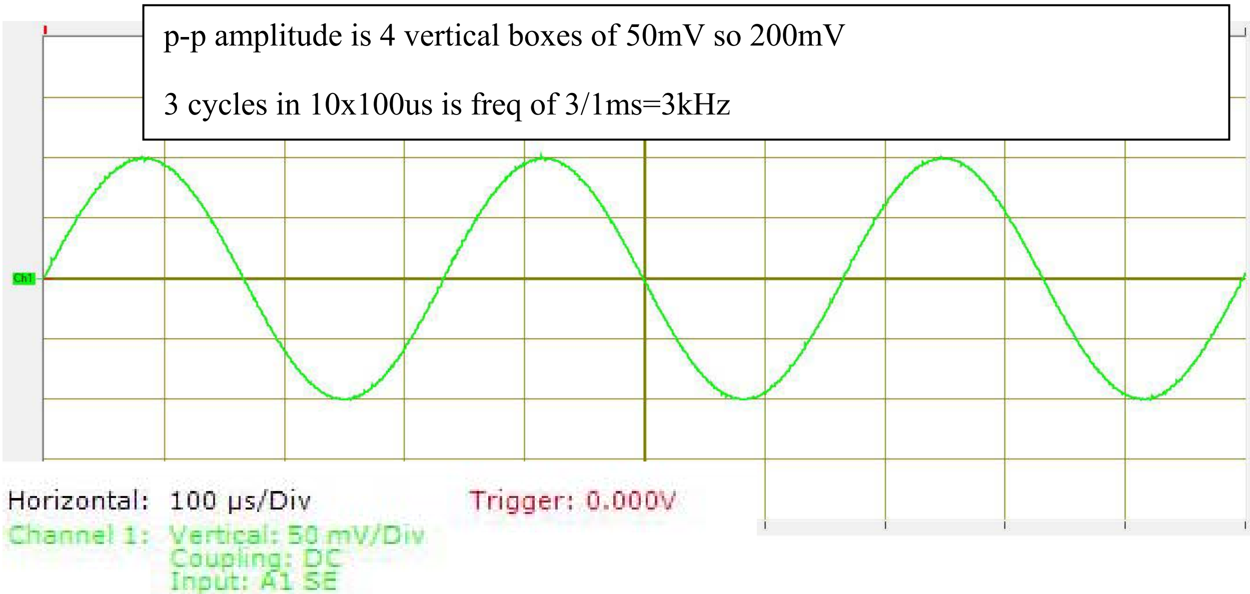
3) Which two connections are used to output sine, triangular and square waves from Function Generator 1? Circle and label your answer. (1pt)

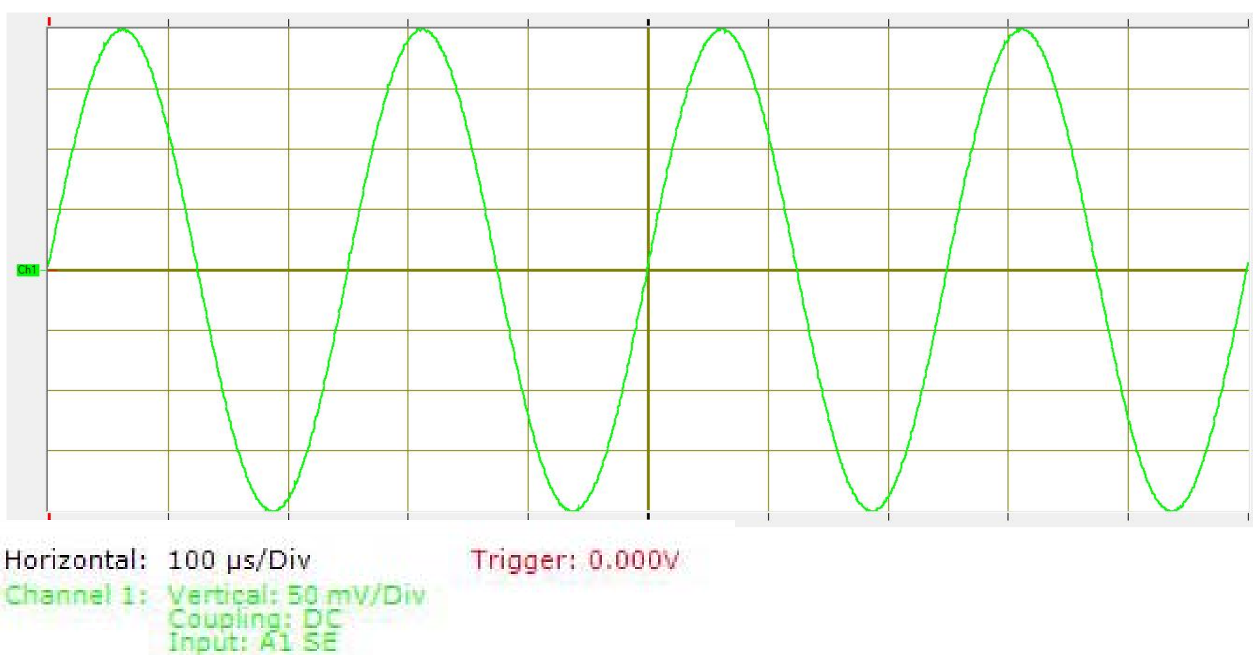
4) Which two connections are used to output sine, triangular and square waves from Function Generator 2? Circle and label your answer. (1pt)

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)

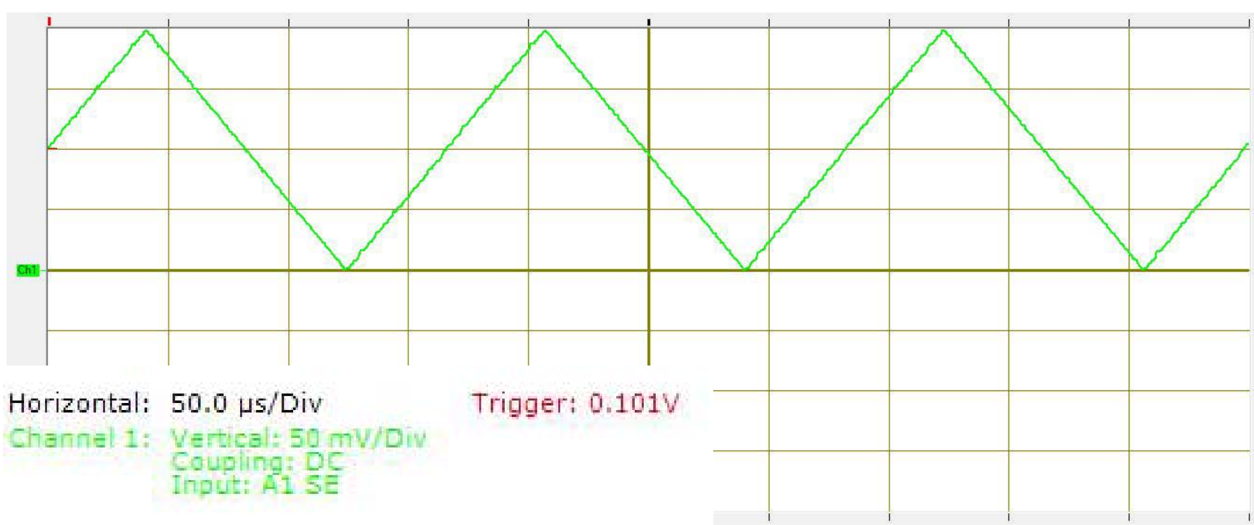
p-p amplitude is 4 vertical boxes of 50mV so 200mV

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





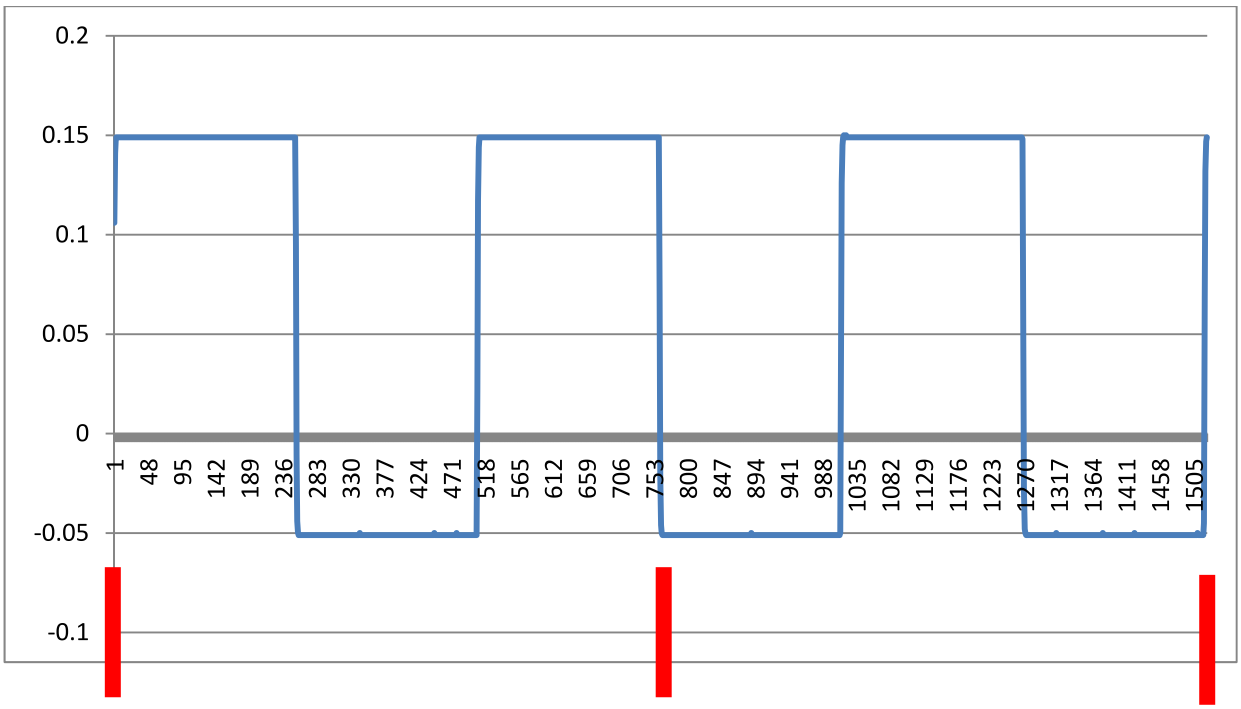
6) Function Generator 1 is modified so that it outputs the triangle wave shown below as it is observed on oscilloscope channel 1. What are the frequency, the period, the peak-to-peak amplitude and the offset voltage for this wave? (8pts)



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