LABORATORY 5

ASSIGNED: 4/11/17

OBJECTIVE: The purpose of this lab is to evaluate the transient and steady-state circuit response of first order and second order circuits.

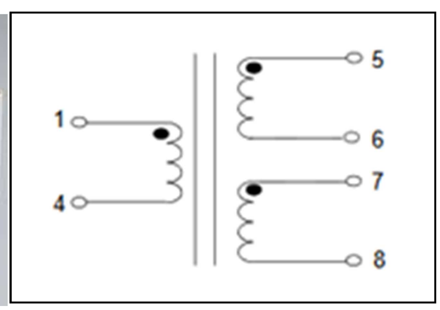
MINIMUM EQUIPMENT LIST: You will need the following supplies to complete this lab, at a minimum:

1. Function generator
2. Two-channel oscilloscope
3. BNC cables with clip leads
4. Two oscilloscope probes
5. Breadboard
6. Electronic Components: Capacitors, inductors and resistors

TRANSFORMERS

The magnetically coupled transformer shown below is manufactured by Triad Magnetics (PN: F16-070-C2) and is designed to transform an AC signal on its primary windings into an AC signal on its secondary windings with the same frequency, but altered voltage and current magnitudes.

You may notice by examining the leads and looking at the equivalent schematic symbol that the primary windings have two leads while the secondary side has four leads. Though very simple transformers classically have two leads for the primary windings and another two leads for the secondary windings, both the simple transformer and the one shown below have the same functionality, with the exception that the secondary side is broken into two isolated branches, both of which are magnetically coupled to the primary side. This is useful if you need isolated sections or would like to provide a DC offset the secondary side.



Configure the function generator to output a 100Hz sine wave with a 10V amplitude [V = 10sin(wt)] and place 100-ohm resistors across [PIN5 + 6 and PIN7 + 8]. Place the function generator on the primary side of the transformer and answer the corresponding questions. Note that it may be useful to solder wires on all the transformer leads in order to use the breadboard.

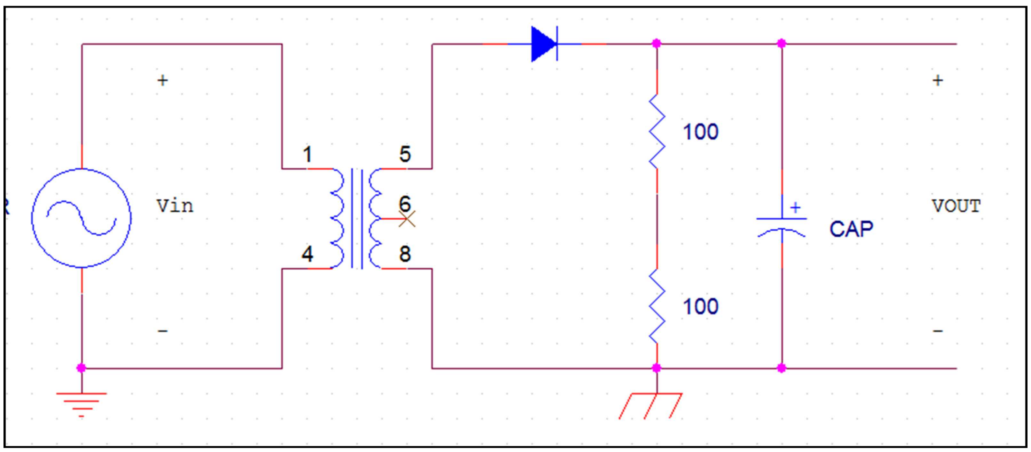
QUESTIONS

1. Determine the amplitude and phase of the signal across PIN5 + 6
2. Determine the amplitude and phase of the signal across PIN7 + 8
3. What is the transformation ratio from [PIN1 + 2 to PIN 5 + 6] and [PIN1 + 2 to PIN 7 + 8]
4. Shorting PIN6 + 7
    a. Measure the amplitude and phase of the signal across PIN5 + 8
    b. What is the transformation ratio from [PIN1 + 2 to PIN 5 + 8]

TRANSFORMER POWER SUPPLY

Transformers are widely used in AC-DC power supplies because the transformer steps down the voltage from high amplitudes to lower amplitudes, where a simple filter circuit can be added on the secondary windings to rectify and smooth the amplitude variation. The circuit shown below is a half-wave rectified AC-DC converter. Please configure the circuit shown and answer the corresponding questions noting that the diode is a Shottky.

A side note, transformers like the one used in this lab electrically isolate the primary windings from the secondary windings. This provides ground isolation between the input and output terminals which can help reduce ground noise from leaking between the two sides of the device. From a measurement perspective, you will need to be careful to ensure the ground terminal of your oscilloscope probe is on the correct ground connection, depending on which side of the transformer you are measuring.



QUESTIONS:

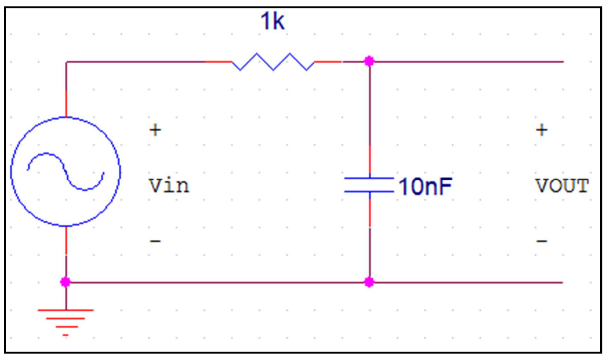
1. Without the capacitor installed, take a screenshot of the input and output voltage waveforms measuring "Vin" and "Vout"
    a. What observations can you make about the different waveforms?
2. Place a capacitor [100uF to 330uF] across the output terminals and take a screenshot of the input and output voltage waveforms
    a. What observations can you make about the different waveforms?
    b. What is the voltage ripple on the output terminals?
3. Repeat (2) with a load resistance of 1k:
    a. Describe the change in the signal response?
    b. How much capacitance do you need to achieve the same ripple as seen with the 200-ohm load resistance?

FILTERS

Filters are widely used in electronic systems. In some cases, specific filter responses are specifically designed into the circuit to achieve a desired response. In other cases, the parasitics associated with the components or device technologies used in the design provide unwanted filtering response that often must be compensated for.

LOWPASS FILTER (LPF)

Consider the basic (RC) low-pass filter shown below and answer the corresponding questions:

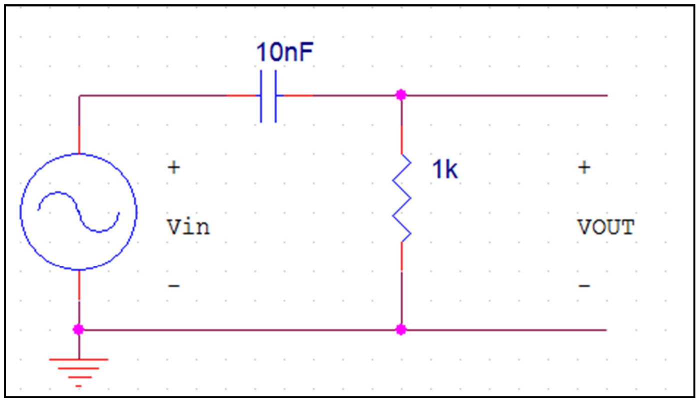


QUESTIONS

1. Starting at 10Hz and increasing the frequency in decade steps (multiples of x10), measure the amplitude and phase of the output signal relative to the input signal
2. A point of metric for most filters is the cutoff frequency. This is the frequency where the amplitude has dropped 3dB (half-power), and the phase has changed by 45-degrees for each pole.
    a. Given that the circuit shown above is a voltage divider, determine the frequency that the voltage has dropped to 25% and measure the amplitude and phase of the output signal at that frequency
    b. Measure the actual frequency where the amplitude has dropped by 25% and determine the percent difference between the measured and calculated cutoff frequency
    c. Describe sources of error that could cause larger than desired differences
3. Sketch the amplitude and phase response as a function of frequency based using your measurements on a logarithmic scale (X-Axis = Frequency, Y-Axis = Amplitude)

HIGHPASS FILTER (HPF)

Consider the basic (RC) high-pass filter shown below and answer the corresponding questions:

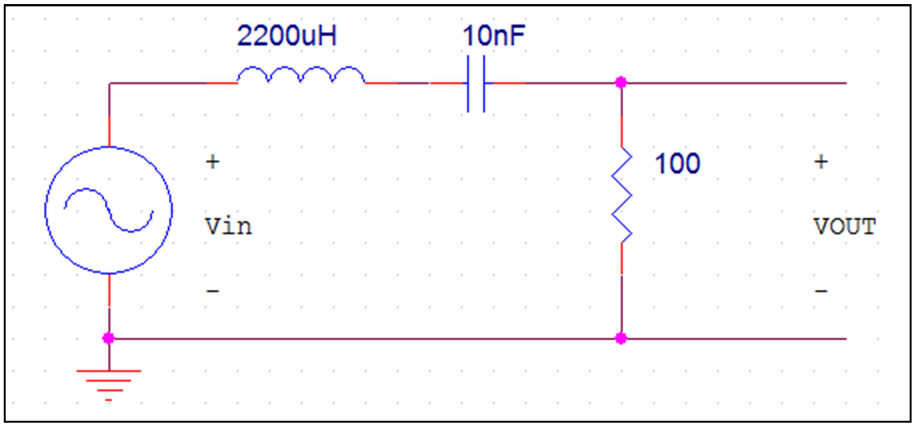


QUESTIONS

1. Starting at 10Hz and increasing the frequency in decade steps (multiples of x10), measure the amplitude and phase of the output signal relative to the input signal
2. A point of metric for most filters is the cutoff frequency. This is the frequency where the amplitude has dropped 3dB (half-power), and the phase has changed by 45-degrees for each pole.
    a. Given that the circuit shown above is a voltage divider, determine the frequency that the voltage has dropped to 25% and measure the amplitude and phase of the output signal at that frequency
    b. Measure the actual frequency where the amplitude has dropped by 25% and determine the percent difference between the measured and calculated cutoff frequency
    c. Describe sources of error that could cause larger than desired differences
3. Sketch the amplitude and phase response as a function of frequency based using your measurements on a logarithmic scale (X-Axis = Frequency, Y-Axis = Amplitude)

BANDPASS FILTER (BPF)

Consider the basic (RLC) band-pass filter shown below and answer the corresponding questions:



QUESTIONS

1. Starting at 10Hz and increasing the frequency in decade steps (multiples of x10), measure the amplitude and phase of the output signal relative to the input signal
2. A point of metric for most filters is the cutoff frequency. This is the frequency where the amplitude has dropped 3dB (half-power), and the phase has changed by 45-degrees for each pole. In the case of a BPF, there are two cutoff frequencies that define the pass-band frequency range.
    a. Given that the circuit shown above is a voltage divider, determine the frequencies that the voltage has dropped to 25% and measure the amplitude and phase of the output signal at those frequencies
    b. Measure the actual frequencies where the amplitude has dropped by 25% and determine the percent difference between the measured and calculated cutoff frequencies
    c. Describe sources of error that could cause larger than desired differences
3. Sketch the amplitude and phase response as a function of frequency based using your measurements on a logarithmic scale (X-Axis = Frequency, Y-Axis = Amplitude)