

Name \_\_\_\_\_  
Section 2 (4 – 5:50PM, Monday and Thursday)

**Part B (80 Points)**

- 1. (10 Pts) \_\_\_\_\_
- 2. (10 Pts) \_\_\_\_\_
- 3. (10 Pts) \_\_\_\_\_
- 4. (30 Pts) \_\_\_\_\_
- 5. (10 Pts) \_\_\_\_\_
- 6. (10 Pts) \_\_\_\_\_

Total \_\_\_\_\_

Draw circuit diagrams for all problems, especially as you simplify the circuits.

Be sure to fully annotate plots, even when the problem does not ask you to do this.

Show all of your work

Almost all problems can be solved using more than one method. Check your answers by using a second method.

At least skim through the entire quiz before you begin and then start with the problems you know best.

The proctor will only answer clarification questions where wording is unclear or where there may be errors/typos. No other questions will be responded to.

### First Radio Broadcast of Election Results – 7 November 1916

Radio station 2XG, also known as the "Highbridge station" after its location at 1391 Sedgewick Ave. in the Bronx, was an experimental station licensed to the De Forest Radio Telephone and Telegraph Company from 1915-1917 & 1920-1924. It was the first radio station employing a vacuum-tube transmitter to make news and entertainment broadcasts on a regular schedule.

On the night of the November 7, 1916 Wilson-Hughes presidential election, **2XG**, in conjunction with the *New York American*, broadcast election returns that for the first time were in full audio instead of Morse code. This program featured telephoned bulletins supplied by the newspaper—which hailed the effort as "the first time the wireless telephone has been demonstrated as a practical, serviceable carrier of election news and comment"—and read over the air by "unassuming chap" Walter Schare. Also featured were Columbia recordings that included "'The Star Spangled Banner,' 'Columbia, the Gem of the Ocean,' 'Dixie,' 'America' and other airs long loved by Americans." Just before shutting down at 11:00 PM, the station incorrectly announced that Charles Evans Hughes had won, however the next day it was learned that late totals from California had tilted the election in Woodrow Wilson's favor. It was estimated that 7,000 persons received the broadcast.

The concerts continued, with listeners reported as far away at Cape Hatteras, North Carolina. A "radio dance" held in Morristown, New Jersey at the end of the year received widespread publicity. However, with the entry of the United States into World War One on April 6, 1917, all civilian radio stations were ordered shut down, and **2XG** was silenced for the duration of the conflict. The broadcast location is now part of the I-87 on-ramp near the Yankee Stadium Howard Johnson Motel.



### First Woman Elected to Congress – 7 November 1916

Jeannette Pickering Rankin (June 11, 1880 – May 18, 1973) was the first woman to hold federal office in the United States when, in 1916, she was elected to the U.S. House of Representatives by the state of Montana. She won a second House term 24 years later, in 1940. Each of Rankin's Congressional terms coincided with initiation of U.S. military intervention in each of the World Wars. A lifelong pacifist, she was one of 50 House members (total of 56 in both chambers) who opposed the war declaration of 1917, and the only member of Congress to vote against declaring war on Japan after the attack on Pearl Harbor in 1941. Rankin was also instrumental in initiating the legislation that eventually became the 19th Constitutional Amendment, granting unrestricted voting rights to women; and she championed the causes of gender equality and civil rights throughout a career that spanned more than six decades.



**Source: Wikipedia**

## Inductance Specs – From Digilent Parts Kit Website

## Electrical Specifications (@ 25 °C)

Part Number	Inductance ( $\mu$ H)	Tol.	Q (Min.)	Test Frequency		SRF (MHz) Typ.	DCR ( $\Omega$ ) Max.	I dc (A)
				L	Q			
RL622-1R0K-RC	1.0	$\pm 10\%$	20	7.96 MHz	7.96 MHz	150	0.013	10
RL622-1R5K-RC	1.5	$\pm 10\%$	20	7.96 MHz	7.96 MHz	130	0.016	8.5
RL622-2R2K-RC	2.2	$\pm 10\%$	20	7.96 MHz	7.96 MHz	100	0.021	6.5
RL622-3R3K-RC	3.3	$\pm 10\%$	20	7.96 MHz	7.96 MHz	79	0.025	5.5
RL622-4R7K-RC	4.7	$\pm 10\%$	20	7.96 MHz	7.96 MHz	51	0.030	4.3
RL622-6R8K-RC	6.8	$\pm 10\%$	20	7.96 MHz	7.96 MHz	29	0.035	3.7
RL622-100K-RC	10	$\pm 10\%$	50	2.52 MHz	2.52 MHz	14	0.045	3.0
RL622-120K-RC	12	$\pm 10\%$	50	2.52 MHz	2.52 MHz	13	0.050	2.7
RL622-150K-RC	15	$\pm 10\%$	40	2.52 MHz	2.52 MHz	12	0.056	2.3
RL622-180K-RC	18	$\pm 10\%$	40	2.52 MHz	2.52 MHz	11	0.061	2.2
RL622-220K-RC	22	$\pm 10\%$	40	2.52 MHz	2.52 MHz	9.2	0.070	2.0
RL622-270K-RC	27	$\pm 10\%$	30	2.52 MHz	2.52 MHz	8.5	0.080	1.7
RL622-330K-RC	33	$\pm 10\%$	30	2.52 MHz	2.52 MHz	7.8	0.090	1.6
RL622-390K-RC	39	$\pm 10\%$	30	2.52 MHz	2.52 MHz	6.9	0.10	1.5
RL622-470K-RC	47	$\pm 10\%$	30	2.52 MHz	2.52 MHz	6.5	0.16	1.4
RL622-560K-RC	56	$\pm 10\%$	30	2.52 MHz	2.52 MHz	5.4	0.18	1.3
RL622-680K-RC	68	$\pm 10\%$	30	2.52 MHz	2.52 MHz	4.9	0.21	1.2
RL622-820K-RC	82	$\pm 10\%$	30	2.52 MHz	2.52 MHz	4.1	0.23	1.1
RL622-101K-RC	100	$\pm 10\%$	20	796 KHz	796 KHz	3.7	0.28	0.91
RL622-121K-RC	120	$\pm 10\%$	20	796 KHz	796 KHz	3.4	0.32	0.84
RL622-151K-RC	150	$\pm 10\%$	20	796 KHz	796 KHz	3.2	0.37	0.75
RL622-181K-RC	180	$\pm 10\%$	20	796 KHz	796 KHz	2.8	0.58	0.69
RL622-221K-RC	220	$\pm 10\%$	20	796 KHz	796 KHz	2.7	0.65	0.64
RL622-271K-RC	270	$\pm 10\%$	20	796 KHz	796 KHz	2.4	0.75	0.57
RL622-331K-RC	330	$\pm 10\%$	20	796 KHz	796 KHz	2.3	0.85	0.54
RL622-391K-RC	390	$\pm 10\%$	20	796 KHz	796 KHz	2.1	1.0	0.48
RL622-471K-RC	470	$\pm 10\%$	20	796 KHz	796 KHz	1.9	1.1	0.46
RL622-561K-RC	560	$\pm 10\%$	20	796 KHz	796 KHz	1.8	1.4	0.41
RL622-681K-RC	680	$\pm 10\%$	20	796 KHz	796 KHz	1.6	1.6	0.38
RL622-821K-RC	820	$\pm 10\%$	20	796 KHz	796 KHz	1.5	1.8	0.38
RL622-102K-RC	1000	$\pm 10\%$	50	252 KHz	252 KHz	1.3	2.9	0.29
RL622-122K-RC	1200	$\pm 10\%$	50	252 KHz	252 KHz	1.1	4.0	0.13
RL622-152K-RC	1500	$\pm 10\%$	20	252 KHz	252 KHz	1.0	6.1	0.08
RL622-182K-RC	1800	$\pm 10\%$	20	252 KHz	252 KHz	1.0	6.4	0.08
RL622-222K-RC	2200	$\pm 10\%$	20	252 KHz	252 KHz	0.9	6.8	0.08
RL622-272K-RC	2700	$\pm 10\%$	20	252 KHz	252 KHz	0.9	7.7	0.08
RL622-332K-RC	3300	$\pm 10\%$	20	252 KHz	252 KHz	0.7	9.0	0.08
RL622-392K-RC	3900	$\pm 10\%$	20	252 KHz	252 KHz	0.6	14	0.08
RL622-472K-RC	4700	$\pm 10\%$	20	252 KHz	252 KHz	0.5	16	0.05
RL622-562K-RC	5600	$\pm 10\%$	20	252 KHz	252 KHz	0.4	18	0.05
RL622-682K-RC	6800	$\pm 10\%$	20	252 KHz	252 KHz	0.4	19	0.05
RL622-822K-RC	8200	$\pm 10\%$	20	252 KHz	252 KHz	0.3	21	0.05
RL622-103K-RC	10,000	$\pm 10\%$	40	79.6 KHz	79.6 KHz	0.3	25	0.05

Standard Resistor Values ( $\pm 5\%$ )						
1.0	10	100	1.0K	10K	100K	1.0M
1.1	11	110	1.1K	11K	110K	1.1M
1.2	12	120	1.2K	12K	120K	1.2M
1.3	13	130	1.3K	13K	130K	1.3M
1.5	15	150	1.5K	15K	150K	1.5M
1.6	16	160	1.6K	16K	160K	1.6M
1.8	18	180	1.8K	18K	180K	1.8M
2.0	20	200	2.0K	20K	200K	2.0M
2.2	22	220	2.2K	22K	220K	2.2M
2.4	24	240	2.4K	24K	240K	2.4M
2.7	27	270	2.7K	27K	270K	2.7M
3.0	30	300	3.0K	30K	300K	3.0M
3.3	33	330	3.3K	33K	330K	3.3M
3.6	36	360	3.6K	36K	360K	3.6M
3.9	39	390	3.9K	39K	390K	3.9M
4.3	43	430	4.3K	43K	430K	4.3M
4.7	47	470	4.7K	47K	470K	4.7M
5.1	51	510	5.1K	51K	510K	5.1M
5.6	56	560	5.6K	56K	560K	5.6M
6.2	62	620	6.2K	62K	620K	6.2M
6.8	68	680	6.8K	68K	680K	6.8M
7.5	75	750	7.5K	75K	750K	7.5M
8.2	82	820	8.2K	82K	820K	8.2M
9.1	91	910	9.1K	91K	910K	9.1M

Type	$R_{int}$ ( $\Omega$ )	$V_{oc}$ (V)	Capacity <sup>a</sup> continuous, to 1V/cell				Size (in)	Weight (gm)	Connec <sup>b</sup>	Comments
			(mAh)	@ (mA)	(mAh)	@ (mA)				
<b>9V "1604"</b>										
Le Clanche	35	9	300	1	160	10	0.65x1x1.9	35	S	
Heavy Duty	35	9	400	1	180	10	"	40	S	
Alkaline	2	9	500	1	470	10	"	55	S	280mAh@100mA
Lithium	18	9	1000	25	950	80	"	38	S	Kodak Li-MnO <sub>2</sub>

## Standard Capacitor Values

**STANDARD CAPACITOR VALUES**

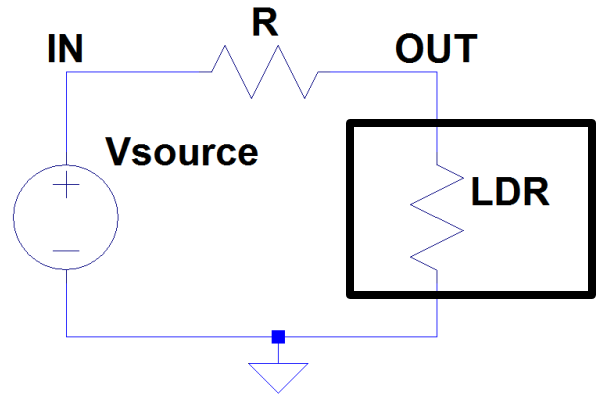
These are the EIA standard capacitor values. These are the values available from most vendors. Non-polarized run from 1pF to 1uF, while electrolytics are available from 0.1uF and higher (not all electrolytic values listed here).

1.0pF	10pF	100pF	.001uF	.01uF	.1uF	1.0uF	10uF
1.2pF	12pF	120pF	.0012uF	.012uF	.12uF	1.2uF	12uF
1.5pF	15pF	150pF	.0015uF	.015uF	.15uF	1.5uF	15uF
1.8pF	18pF	180pF	.0018uF	.018uF	.18uF	1.8uF	18uF
2.2pF	22pF	220pF	.0022uF	.022uF	.22uF	2.2uF	22uF
2.7pF	27pF	270pF	.0027uF	.027uF	.27uF	2.7uF	27uF
3.3pF	33pF	330pF	.0033uF	.033uF	.33uF	3.3uF	33uF
3.9pF	39pF	390pF	.0039uF	.039uF	.39uF	3.9uF	39uF
4.7pF	47pF	470pF	.0047uF	.047uF	.47uF	4.7uF	47uF
5.6pF	56pF	560pF	.0056uF	.056uF	.56uF	5.6uF	56uF
6.8pF	68pF	680pF	.0068uF	.068uF	.68uF	6.8uF	68uF



**Problem 1 (10 Pts) – Experimentally Determining an Input Impedance**

Nearly all loads can be characterized by some kind of simple input impedance. For example, the two analog input channels on the Analog Discovery board have an input resistance of  $1M\Omega$  and an input capacitance of  $24pF$ . The circuit at the right is set up to determine the resistance of a Photocell (aka Light Dependent Resistor or LDR) under two lighting conditions. The source voltage  $V_{source}$  is  $9V$  and the known resistor  $R$  is  $8.2k$ . We plan to use the photocell to control a nightlight so we need to measure its nominal resistance when the room is brightly lit (nightlight should be off) and dark (night light should be fully on). The data for these two conditions are given below.

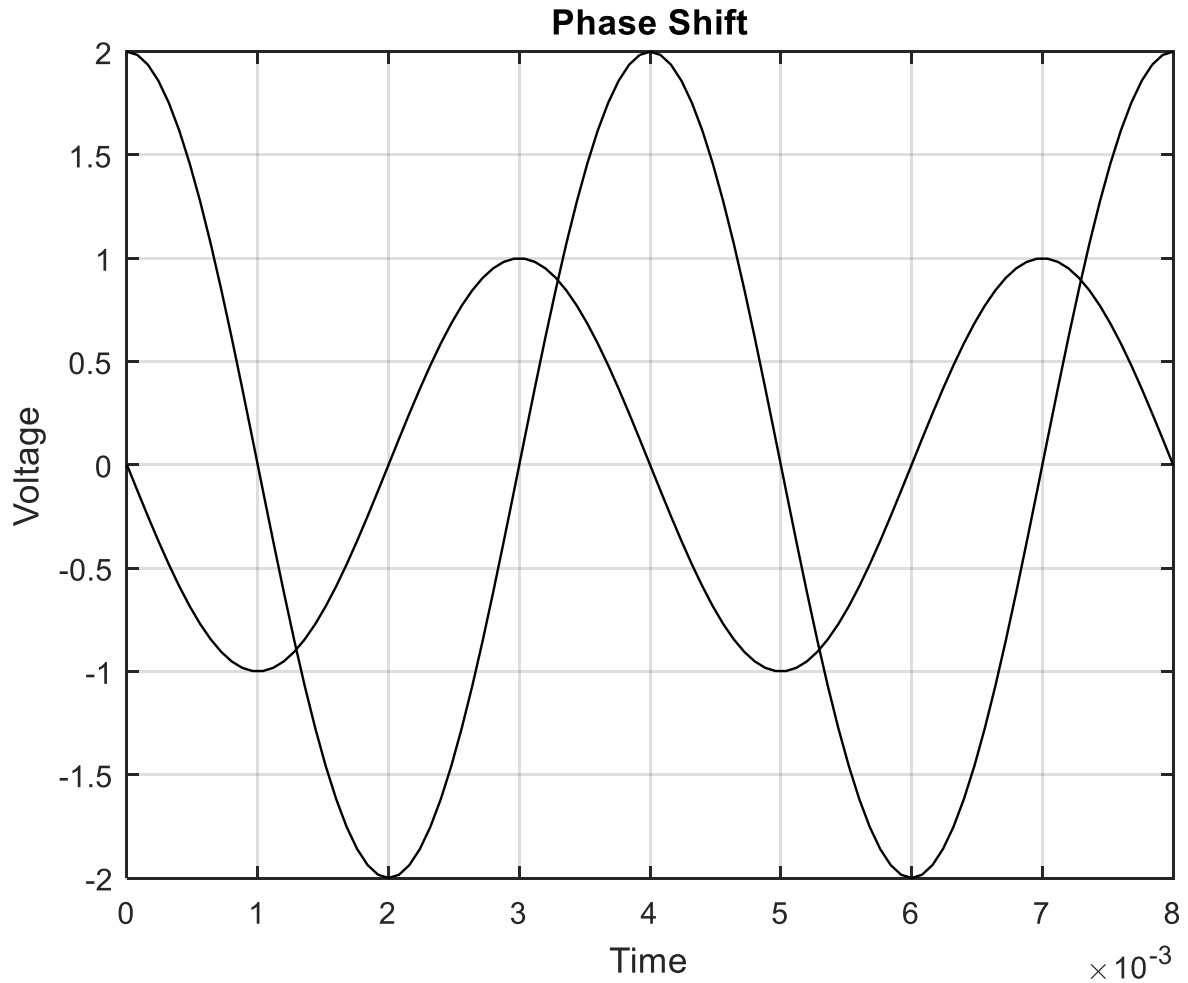


Trial	Light Level	V(OUT)
1	Low	7.5V
2	High	2.4V

- a. (5 Pts) Determine the unknown resistance LDR for low light conditions.
  
- b. (5 Pts) Determine the unknown resistance LDR for high light conditions

**Problem 2 (10 Points) – Phase**

In the Matlab generated plot below, two cosinusoidal voltages are shown vs time.  $V(t) = \cos(\omega t)$  and  $U(t) = \cos(\omega t + \theta)$ . The magnitudes of the two voltages are not the same. The vertical scale is 0.5V/Div and the horizontal scale is 0.5ms/Div

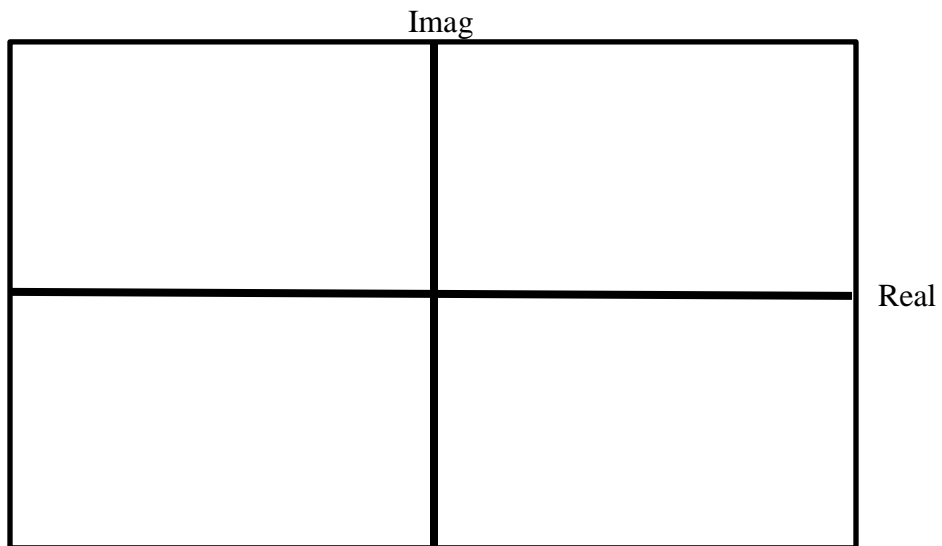


- a. (2 Pts) Determine the frequency  $f$  in Hertz and  $\omega$  in Radians.
  
- b. (2 Pts) Determine the phase of  $U$  in degrees. *Be sure to specify its sign and remember it can have any value from -360 degrees to +360 degrees.*

c. (2 Pts) What is the amplitude of U in Volts?

d. (2 Pts) What is the phasor form of  $\tilde{U} = ?$

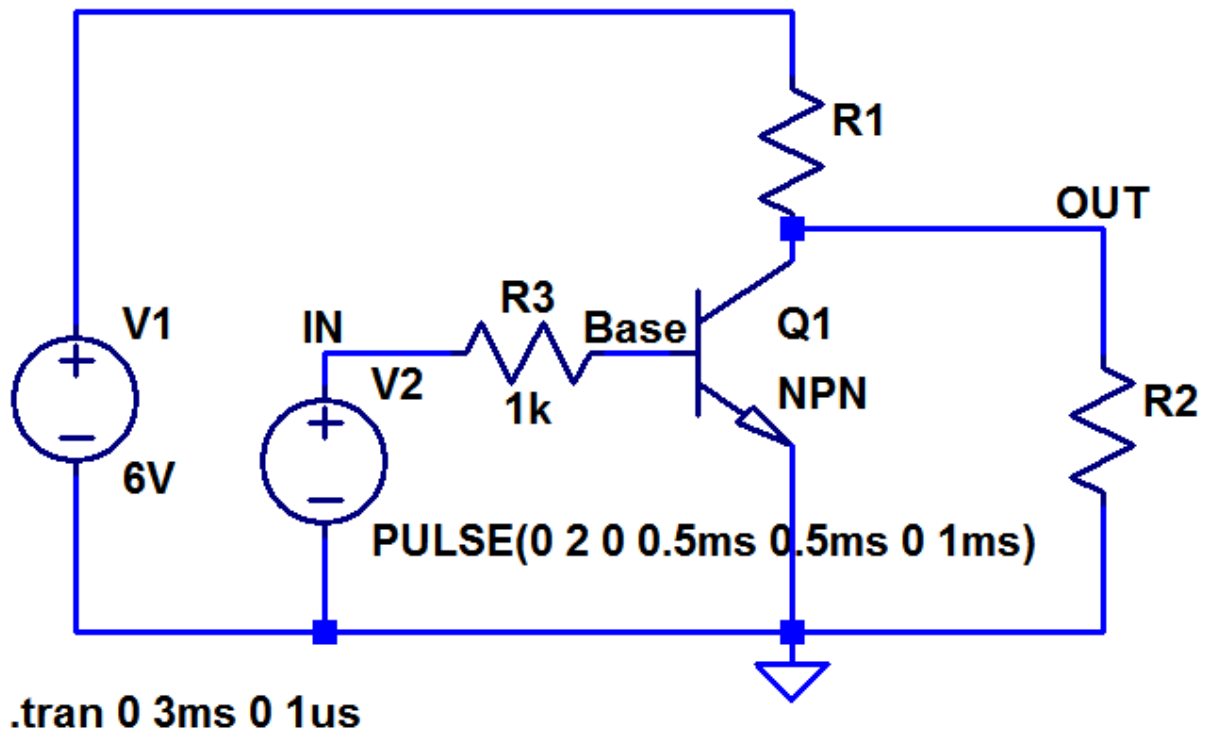
e. (2 Pts) Plot the point for the phasor voltage on the complex plane. *Plot the point that represents its value as a complex number. Be sure to fully label the plot.*





**Problem 3 (10 Pts) – Transistor as a Switch**

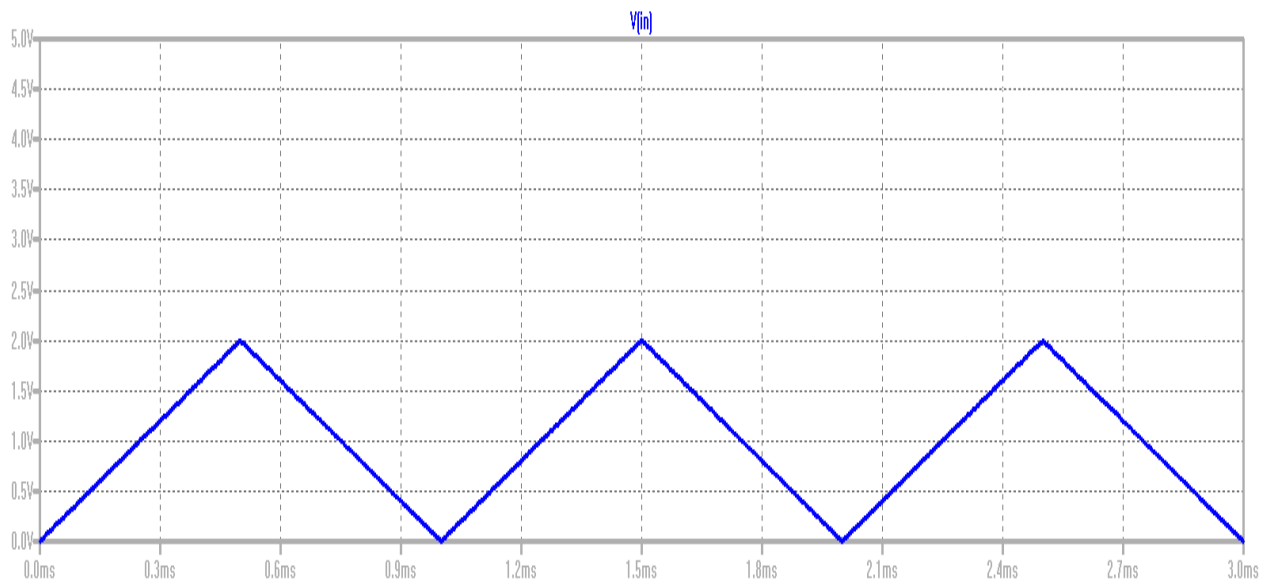
In the circuit below, the 2N2222 NPN transistor is being used as a switch. The pulsed source produces a triangular voltage wave with a 1V amplitude and a 1V offset.  $R_1 = 2k\Omega$  and  $R_2 = 10k\Omega$ .



- (3 Pts) Determine the voltage across resistor  $R_2$  when the source voltage  $V_{source}$  ( $V_2$ ) is at or near its maximum value. Is the switch ON or OFF?
- (3 Pts) Determine the voltage across the resistor  $R_2$  when the source voltage  $V_{source}$  ( $V_2$ ) is at or near its minimum value. Is the switch ON or OFF?

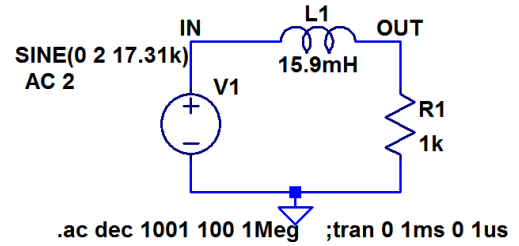
- c. (2 Pts) Which of the following is true?
- a. The transistor is ON more than half the time
  - b. The transistor is OFF more than half the time
  - c. The transistor is ON half the time and OFF half the time
  - d. There is not enough information to select an answer from the choices above

- d. (2 Pts) A plot of the input voltage  $V(IN)$  is shown below. Sketch and label the Base voltage  $V(Base)$  and the output voltage  $V(OUT)$  as functions of time on the same plot. The vertical scale is 0.5V/div and the horizontal scale is 0.3ms/div.



**Problem 4 (30 Points) – Phasor Analysis of Filters**

A simple filter is configured with an inductor and a resistor, as shown. For parts a-d of this problem, you are asked for the general functional form of expressions (i.e. in terms of  $\omega$ , R, L, V1, V(OUT), V(IN)). **Do not plug in numbers until you are asked to do so.**

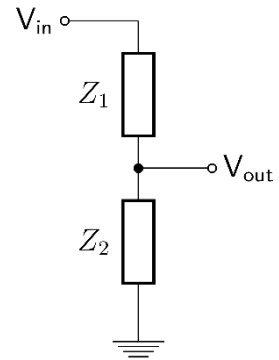


- a. (2 Pts) Is this a high pass or a low pass filter?
- b. (2 Pts) What are the general forms for the impedances of an inductor and a resistor as functions of frequency?

$$Z_R =$$

$$Z_L =$$

- c. (3 Pts) This circuit is of the general form shown at the right which is a voltage divider built with two general impedances rather than resistors. Write the general expression for  $V_{out}$  in terms of  $V_{in}$ ,  $Z_1$  and  $Z_2$ .



- d. (3 Pts) Find the general form of the filter transfer function

$$H(j\omega) = \frac{\tilde{V}_{OUT}}{\tilde{V}_{IN}} = ?$$

For the remainder of this problem, plug in actual numbers for components, voltages, etc.

- e. (4 Pts) Evaluate your expression from part d for the given frequency (17.31kHz) and component values. *Your answer should be complex, but you do not need to simplify it yet.*

- f. (4 pts) Find the real and imaginary parts of your answer to part e.

$$\operatorname{Re}\{H(j\omega)\} = ?$$

$$\operatorname{Im}\{H(j\omega)\} = ?$$

- g. (4 Pts) Using your answers to part f, write the transfer function in polar form. That is find the magnitude and phase (in radians and degrees). *Hint: The phase should be near  $\pi/n$  where  $n$  is some integer from 1 to 12.*

$$H(j\omega) = |H(j\omega)|e^{j\theta_H} = ?$$

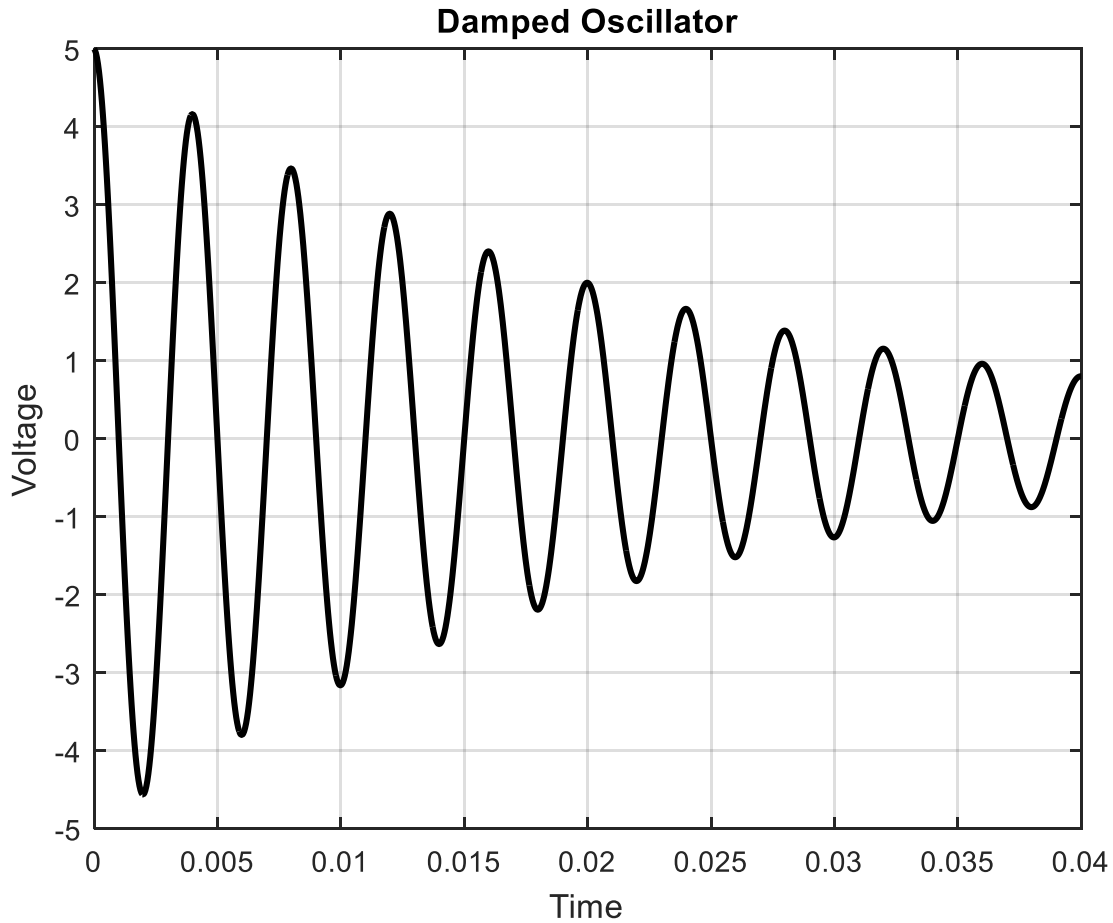
- h. (2 Pts) The input voltage is given as  $V_{IN}(t) = 2\cos\omega t$ . That is, it has a magnitude of 2V, no phase and is at the given frequency. Write the input voltage in phasor form  $\tilde{V}_{IN} = ?$

- i. (3 Pts) Solve for the output voltage in phasor form  $\tilde{V}_{OUT} = ?$ .

- j. (3 Pts) Convert the output voltage back to time varying form  $V_{OUT}(t) = ?$

**Problem 5 (10 Pts) – Damped Harmonic Oscillator**

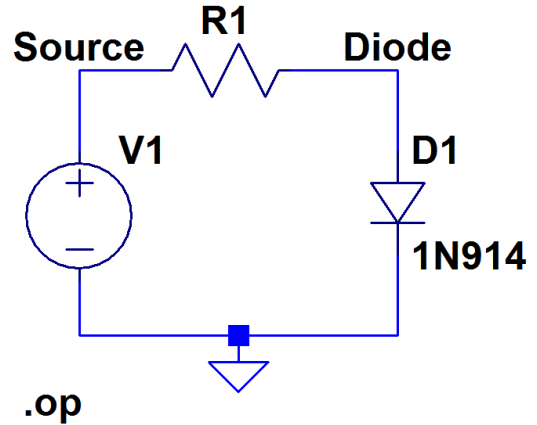
The voltage shown below is for a typical damped harmonic oscillator. The vertical scale is 1.0V/Div and the horizontal scale is 0.005s/Div.



- a. (3 Pts) Determine the frequency of the oscillation  $f$ .
  
- b. (3 Pts) Determine the damping constant of the oscillation  $\alpha = \frac{1}{\tau}$
  
- c. (4 Pts) Write the mathematical expression for the voltage as a function of time in the form  $V(t) = V_o e^{-\alpha t} \cos \omega t$ .

**Problem 6 (10 Pts) – Diodes, Current, Voltage and Power**

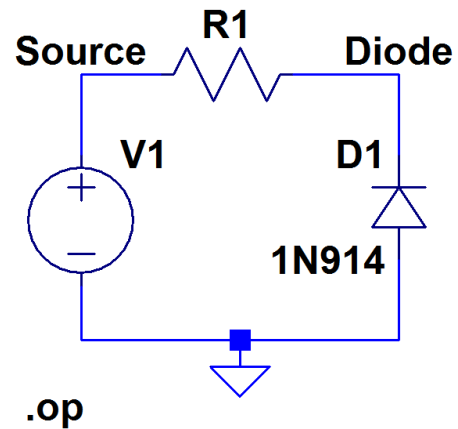
In the diode circuit shown, a 1N914 high speed signal diode is used. The voltage source is DC and equal to 6V. The resistor R1 is 500Ω. Note that you are not given the load line for this diode, so you must assume standard diode parameters. *Explain all answers and indicate any assumptions.*



- a. (1 Pt) Is the diode ON or OFF in this circuit with the given values for V1 and R1?
  
- b. (2 Pts) Given your answer to part a, what is the voltage across the diode?
  
- c. (2 Pts) What is the current through the diode? *Hint: It is the current through the resistor.*

The diode orientation is now reversed, as shown.

- d. (1 Pt) Is the diode ON or OFF in this circuit, with the given values for V1 and R1?
  
- e. (2 Pts) Given your answer to part a, what is the voltage across the diode?



- f. (2 Pts) What is the current through the diode? *Hint: It is the current through the resistor.*