Quiz I ECSE 1010 **Spring 2017**

Name ________________________________

Part B (80 Points)

1. (10 Pts) _________
2. (16 Pts) _________
3. (10 Pts) _________
4. (5 Pts) _________
5. (12 Pts) _________
6. (16 Pts) _________
7. (11 Pts) _________

Total __________________

Be sure to simplify circuits into standard forms.

Draw circuit diagrams for all problems, especially re-draw 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. Use the backs of pages if there is not enough room on the front.

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.

Free Points:

Problems 1 and 6 are required. For problems 2, 3, 4, 5 and 7, you can select up to 15 points worth of questions to not be graded. For these questions, you will receive half credit. Circle the letter or number associated with the questions that you would not like to be graded. Note that there are 16 individual question parts in problems 2-5 and 7. If you circle all 15 points, the maximum total grade you can receive for Quiz 1 is 20 + 65 + 7.5 = 92.5

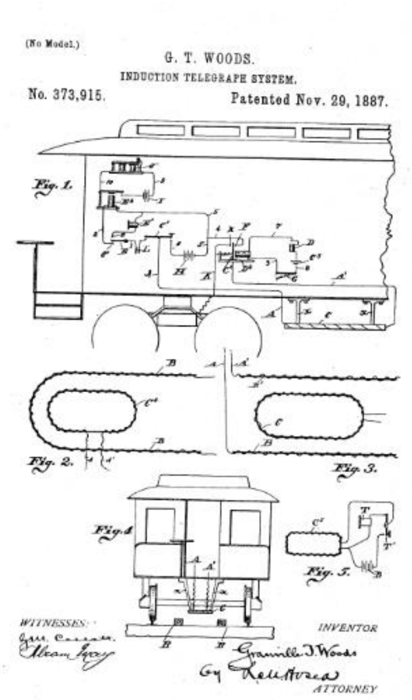
Granville T. Woods (April 23, 1856 – January 30, 1910) The following comes from the Seattle Medium: 'A sound argument can be made that Woods' inventive genius was equal to if not superior to that of both Bell and Edison. During his brief life, Woods … registered over 65 patents for electrical, mechanical, and communications devices which today we take for granted with virtually no awareness of their connection to (him). His inventions ranged from the electrified third rail common to most subway systems worldwide to 12 devices which modernized the railroad to an advanced telephone transmitter.'

'Woods' "advanced telephone transmitter" was so advanced … that Alexander Graham Bell's company purchased the rights to it … because it was superior to what Bell had invented and out of fear that Woods might become a major competitor to the Bell company. Woods called his invention "telegraphony" featuring a combination of the best of the telegraph and the telephone.'

'In 1887, he patented the Synchronous Multiplex Railway Telegraph which for the first time allowed communications between train stations and moving trains. It was this invention that ran him afoul of the powerful Thomas Alva Edison ... Edison sued Woods charging that he (Edison) was the first to invent the multiplex telegraph. After a costly court battle, Woods won the case. But even after losing to Woods, Edison remained so impressed with him that he offered the Black genius a partnership in one of his companies. In order to maintain his independence, Woods rejected the offer.'

As shown in these diagrams, his railroad communication system worked in a manner similar to modern cell phone near field communication. Coils were mounted under the rail car and in the track bed. He was probably the most important inventor for electrified railroads, like subways and even roller coasters.

Granville T Wood's *Synchronous Multiplex Railway Telegraph* allowed for communication between moving trains and train depots, greatly improving railway safety.



Inductance Specs – From Digilent Parts Kit Website

Electrical Specifications (@ 25 °C)

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

Standard Resistor Values (±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

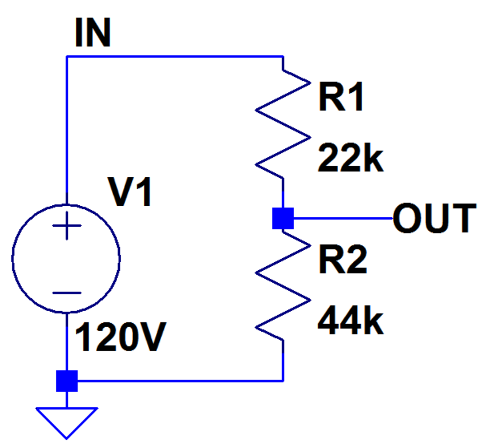
Type	R_{int} (Ω)	V_{oc} (V)	Capacity[a] continuous, to 1V/cell				Size (in)	Weight (gm)	Connec[b]	Comments
			(mAh)	@ (mA)	(mAh)	@ (mA)				
9V "1604"										
Le Clanche	35	9	300	1	160	10	0.65x1x1.9	35	S	
Heavy Duty	35	9	400	1	180	10	"	40	S	
Alkaline	2	9	500	1	470	10	"	55	S	280mAh@100mA
Lithium	18	9	1000	25	950	80	"	38	S	Kodak Li-MnO_2

Capacitance Standard Values

These fixed capacitor values are the most commonly found										
pF	pF	pF	pF	µF	µF	µF	µF	µF	µF	µF
1.0	10	100	1000	0.01	0.1	1.0	10	100	1000	10,000
1.1	11	110	1100							
1.2	12	120	1200							
1.3	13	130	1300							
1.5	15	150	1500	0.015	0.15	1.5	15	150	1500	
1.6	16	160	1600							
1.8	18	180	1800							
2.0	20	200	2000							
2.2	22	220	2200	0.022	0.22	2.2	22	220	2200	
2.4	24	240	2400							
2.7	27	270	2700							
3.0	30	300	3000							
3.3	33	330	3300	0.033	0.33	3.3	33	330	3300	
3.6	36	360	3600							
3.9	39	390	3900							
4.3	43	430	4300							
4.7	47	470	4700	0.047	0.47	4.7	47	470	4700	
5.1	51	510	5100							
5.6	56	560	5600							
6.2	62	620	6200							
6.8	68	680	6800	0.068	0.68	6.8	68	680	6800	
7.5	75	750	7500							
8.2	82	820	8200							
9.1	91	910	9100							

Problem 1 (10 Points) – Basic Voltage Divider

A voltage divider consisting of two resistors and a DC voltage source is configured as shown.



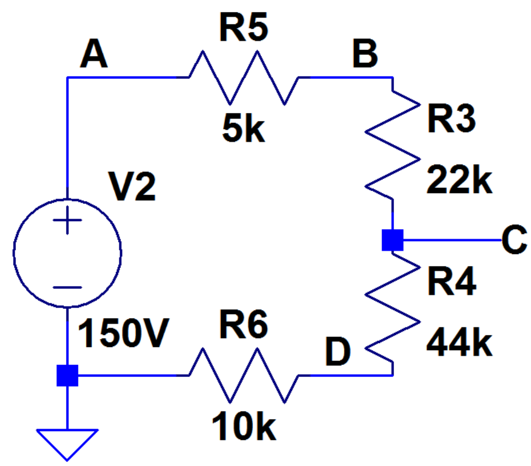
a. Determine the output voltage across R2 (in Volts)

b. Determine the power delivered to the load R2 (in milli-Watts)

Problem 2 (16 Points) – A Bit More Complicated Voltage Divider

A somewhat more complicated voltage divider, consisting of more than the usual two resistors and DC source, is configured as shown.

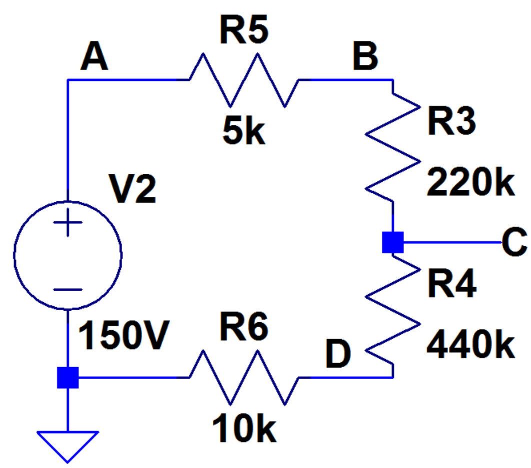
a. (6 pts) Determine the voltages at B, C and D (in Volts)



b. (4 pts) Determine the current through R5 (in milli-Amps)

The circuit is modified by replacing the 22kΩ & 44kΩ resistors R3 and R4 with resistors that are 10X larger.

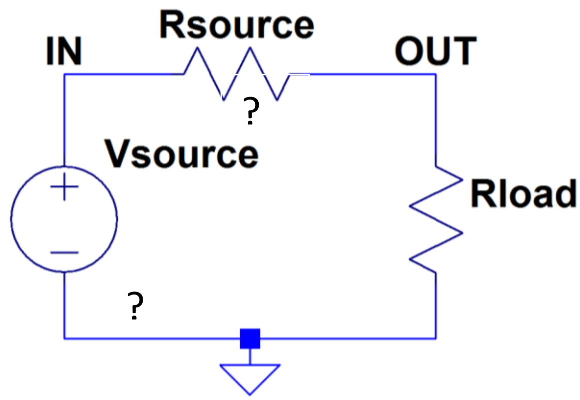
c. (3 pts) Determine the voltage at C (in Volts)



d. (3 pts) Determine the current through R5 (in milli-Amps)

Problem 3 (10 Points) – Source Characterization Using a Voltage Divider

Batteries and other voltage sources can generally be modeled by combining an ideal voltage source and a resistor. The circuit at the right is set up to study some kind of a black box DC voltage source. Six different load resistors are connected and the voltage V(OUT) is measured. The results of the six trials are listed in the table below. *Note that there is more information than you need to find the source voltage and resistance. Note also that the source characteristics may be different than you have seen in class.*



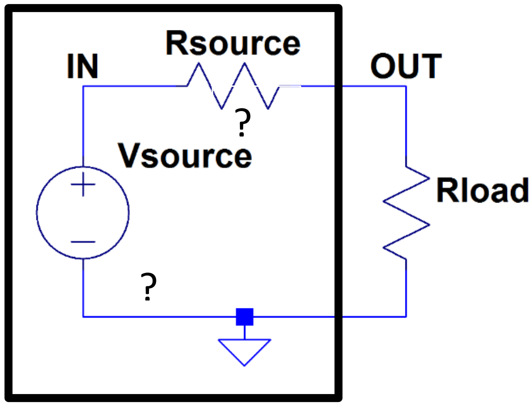
Trial	Rload	V(OUT)
1	1Ω	.1V
2	3Ω	.4V
3	10Ω	1.3V
4	30Ω	3.6V
5	100Ω	10.0V
6	300Ω	20.0V
7	1kΩ	30.8V
8	3kΩ	36.4V
9	10kΩ	38.8V
10	30kΩ	39.6V
11	100kΩ	39.9V
12	300kΩ	40.0V
13	1MΩ	40.0V

a. Determine the source voltage Vsource (in Volts)

b. Determine the source resistance Rsource (in Ohms)

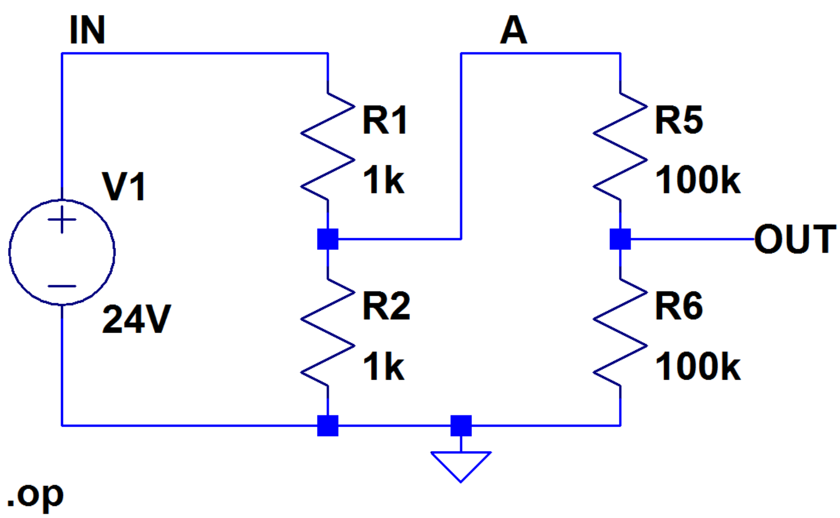
Problem 4 (5 Points) – Measurements

The black box circuit from the previous problem is redrawn at the right (with the box outline shown). What wires from your Analog Discovery board should be connected to this circuit (and where) to obtain the voltage information in the table? List the wires below and show their connection points on the circuit diagram. *There is more than one correct answer.*



Problem 5 (12 Points) – Resistor Ladder Circuit

A more complex circuit is formed by essentially connecting two voltage dividers. The voltage source is 24V DC, so that is the input voltage. The remainder of the circuit is built with resistor values: 1kΩ and 100kΩ.



a. (2 pts) Before beginning the analysis of this circuit, answer the following two general questions:
   a. What is the approximate value for the series combination of two resistors, R_1 and R_2, when $R_1 >> R_2$?

   b. What is the approximate value for the parallel combination of two resistors, R_1 and R_2, when $R_1 >> R_2$?

b. (4 pts) Using the approximations of part a, find the voltages at node A and the output node OUT. This should give you voltages reasonably close to what LT-Spice can find for you.

c. (2 pts) Assume that you replace resistors R5 and R6 with 500Ω resistors. Which of the following will be true?
   a. The voltages at nodes A and OUT will remain the same.
   b. The voltages at nodes A and OUT will both increase.
   c. The voltages at nodes A and OUT will both decrease.
   d. The voltage at node A will increase while the voltage at node OUT will decrease.
   e. The voltage at node A will decrease while the voltage at node OUT will increase.

d. (4 pts) Now we want to see if the general prediction in part c is correct and, again, assume that R1 and R2 are equal to 1kΩ, while R5 and R6 are equal to 500Ω (as in part c), determine the voltages at nodes A and OUT.

Problem 6 (16 Points) – Conceptual Questions

This problem contains some conceptual questions. The following addresses how to approach such questions, provided in the unlikely event that you have not seen such questions before.

A **conceptual question** is designed to help determine whether a student has an accurate working knowledge of a specific set of concepts. For example, from the background quiz you completed on the first day of class:
A 9V battery is connected across a 2kΩ resistor. If the resistor is replaced with a 10kΩ resistor, will the current from the battery

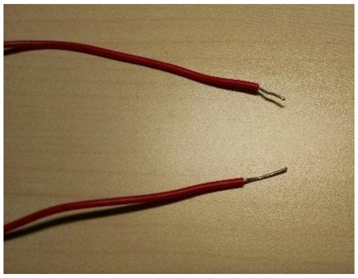
a. Increase
b. Decrease
c. Stay about the same

This question tests conceptual knowledge of Ohm's Law. It can most rigorously be answered by recalling the relationship between voltage, current and resistance (the three parameters mentioned directly or indirectly in the question). $I = \frac{V}{R}$. From this expression a larger R will produce a smaller I for the same voltage (9V in this case). The answer does not depend on the exact values of the two resistances, only that a resistor is replaced with one that is larger. Then the current will be smaller, so the answer is b. Decrease.

Conceptual Questions: The answers for all questions are worth (2 pts) each, except where noted. Remember to briefly explain your answers.

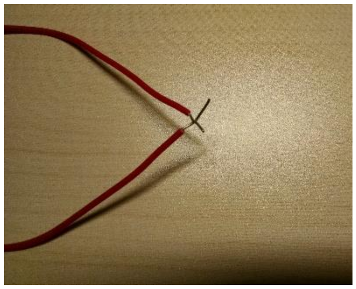
a) Is the image shown at the right

1. A short circuit?
2. An open circuit?



b) Is the image shown at the right

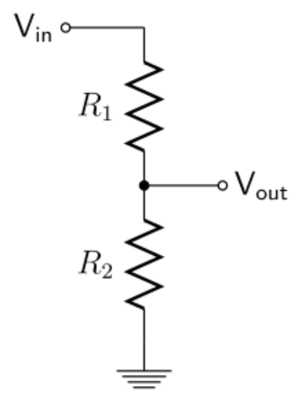
1. A short circuit?
2. An open circuit?



c) For the standard voltage divider configuration shown in part d), which of the following statements is true, for all values of resistance:

1. The voltage across each resistor is the same.
2. The current through each resistor is the same.

d) In the standard voltage divider configuration shown at the right, resistor R_2 is much larger than resistor R_1. Is the power dissipated in R_1

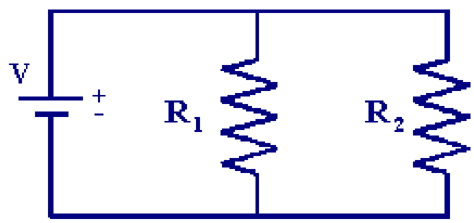


1. Much greater than the power dissipated in R_2
2. Much less than the power dissipated in R_2
3. About the same as the power dissipated in R_2

e) The configuration in part f) is a standard current divider. For this configuration, which of the following statements is true, for all values of resistance:

1. The voltage across each resistor is the same.
2. The current through each resistor is the same.

f) In the circuit at the right, two resistors (R_2 much larger than R_1) are connected in parallel across a voltage source V. Is the power dissipated in R_1



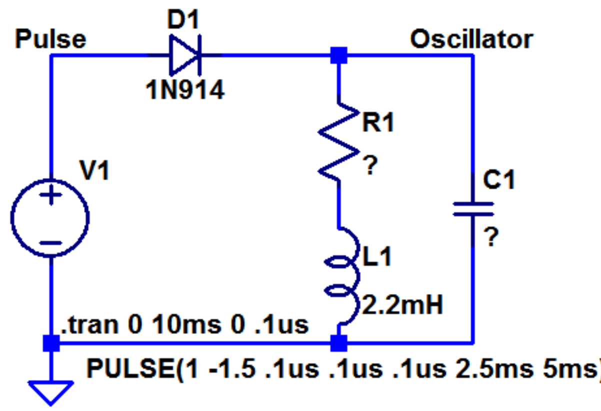
1. Much greater than the power dissipated in R_2
2. Much less than the power dissipated in R_2
3. About the same as the power dissipated in R_2

For the next two questions, we return to the standard voltage divider configuration of part d).

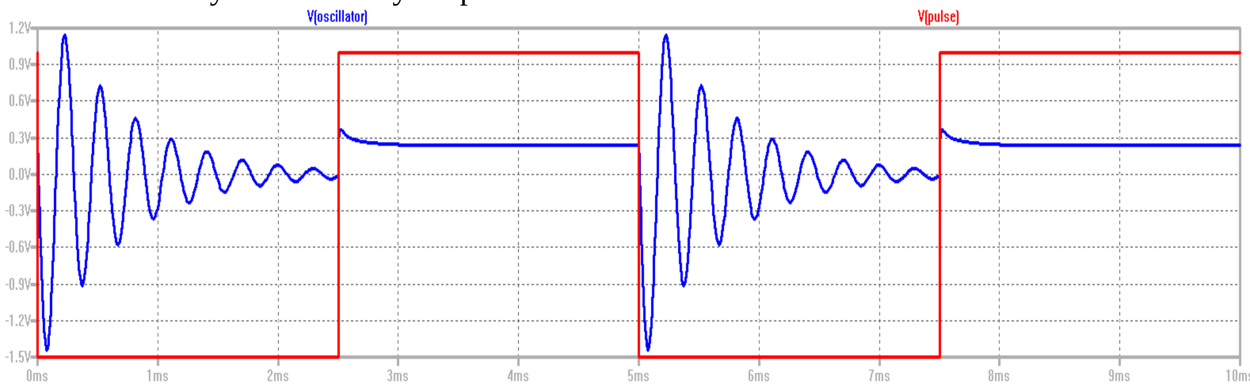
g) For the standard voltage divider configuration, when R_2 is a short circuit, the voltage across R_1 will be (circle the correct answer): 0 or V_{in}

h) For the standard voltage divider configuration, when R_2 is an open circuit, the voltage across R_1 will be (circle the correct answer): 0 or V_{in}

Problem 7 (11 Points) – LC Resonant Circuit Experiment



The circuit at the right is similar to the one we studied in classes 5 and 7. A different inductor (L is given) and a different capacitor (C is unknown) are used. The resistance is also the DC Resistance of the inductor (also not given in the figure). The pulsed source is a square wave that is -1.5V when low and +1V when high. Two complete cycles of the Source and Oscillator voltages are shown below. The time scale is 1ms/Div and the voltage scale is 0.3V/Div. Recall that there are 10 divisions both horizontally and vertically. Express answers below to within 5%.



a. (3 pts) What is the frequency of the Source square wave voltage V(pulse)?

b. (3 pts) What is the frequency of the damped oscillation voltage V(oscillator)? *Hint: Can be found 2 ways, but one approach will be much easier.*

c. (3 pts) What is the value of the capacitance? *Hint: The capacitor value is standard.*

d. (2 pts) What is the value of the resistance? *Hint: The inductor is a standard component.*