ENGR-2300

Electronic Instrumentation

Quiz 3

Fall 2022

Print Name ________________ RIN ________________

Section ____

I have read, understood, and abided by the Collaboration and Academic Dishonesty statement in the course syllabus. The work presented here was solely performed by me.

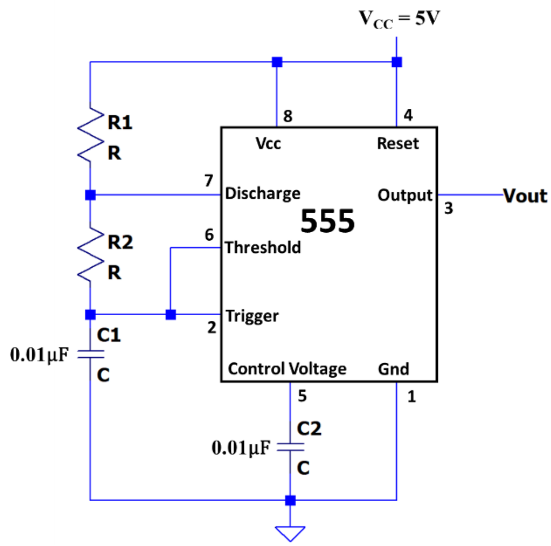
Signature: ______________________________

Date: ________

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. Unless otherwise stated in a problem, provide 3 significant digits in answers. Read the entire quiz before answering any questions. Also it may be easier to answer parts of questions out of order.

I. The 555 Timer in Astable Multivibrator Configuration (20 points)

Shown below is a 555-Timer configured as an astable multivibrator, which generates a train of voltage pulses.



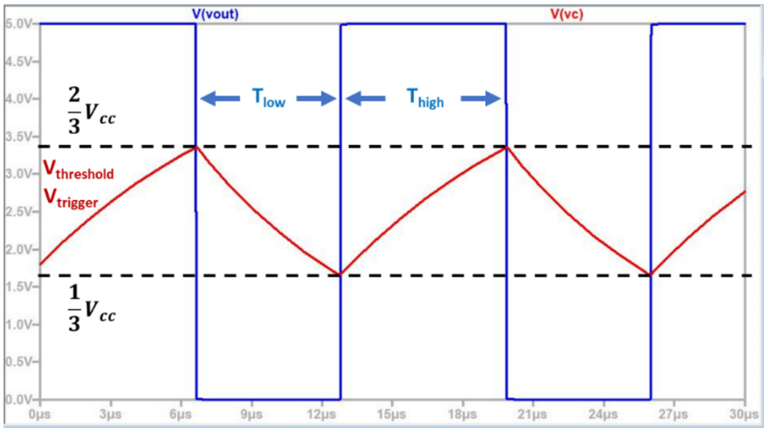
1. (4 pts) You are tasked with using the 555-Timer to generate a train of voltage pulses with a frequency of f = 100 kHz and a duty cycle of 75%. Calculate the total period of one cycle of pulses (T), the amount of time per cycle that the voltage output is high (T_{high}) and the amount of time per cycle that the voltage output is low (T_{low}).

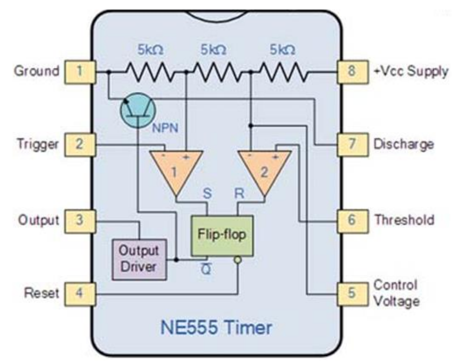
2. (6 pts) Sketch at least 3 cycles of the output voltage from the 555-Timer vs. time. Label all relevant voltages, the total period (T), the time per cycle that the output voltage is high (T_{high}) and the time per cycle that the output voltage is low (T_{low}).

3. (4 pts) Calculate values for R_1 and R_2 to the nearest Ohm that will generate the output voltage you sketched in part 2.

4. (4 pts) If you were to use this output signal to drive an LED via pulse-width modulation (PWM), what is the average voltage that is delivered to the LED over time?

5. (2 pts) The astable multivibrator configuration of the 555 timer switches its output from high to low when $V_{threshold}$ crosses $2/3V_{cc}$ and from low to high when $V_{trigger}$ crosses $1/3V_{cc}$, as shown below:



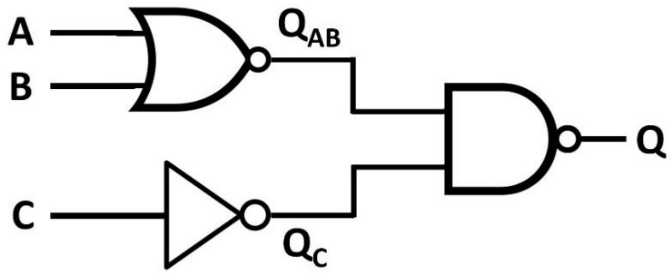


https://commons.wikimedia.org/wiki/File:Ne555.gi

Why is T_{high} determined by $(R_1+R_2)C_1$, but T_{low} is determined by R_2C_1?

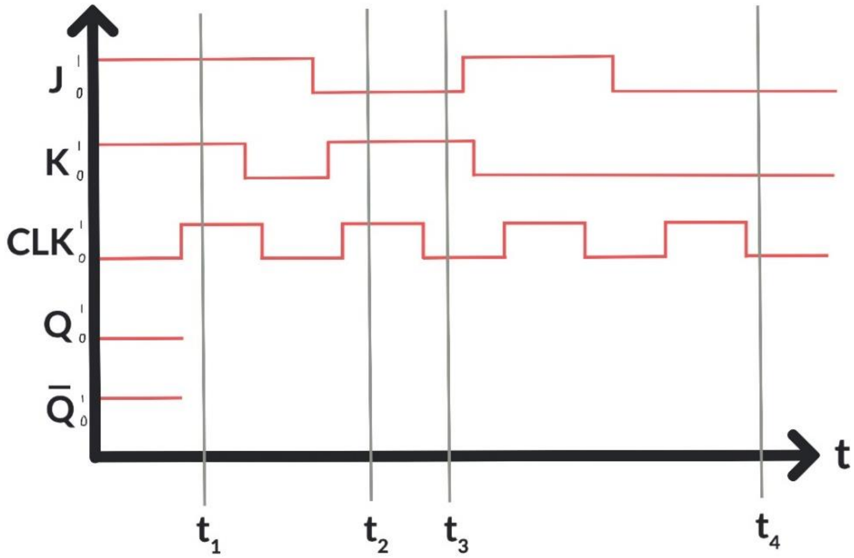
II. Combinational and Sequential Digital Logic (20 points)

1. (6 pts) Write the truth table for the following logic circuit, including entries for Q_{AB}, Q_C and Q.



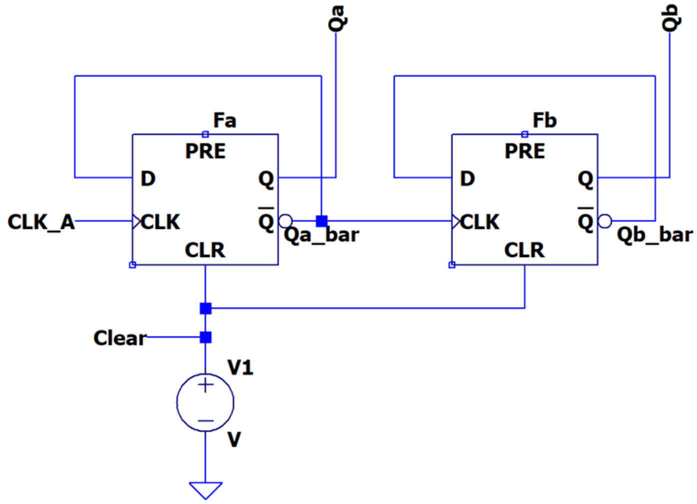
2. (2 pts) Which fundamental 3-input logic gate is the circuit in part 1 equivalent to? Explain your reasoning in one sentence.

3. (6 pts) JK Flip Flop: below is the timing diagram for a JK flip-flop with the inputs **CLK**, **J** and **K** already given. Sketch $\boldsymbol{Q}$ and $\overline{\boldsymbol{Q}}$ vs. time and fill out the table for $\boldsymbol{Q}$ and $\overline{\boldsymbol{Q}}$ at the given times.



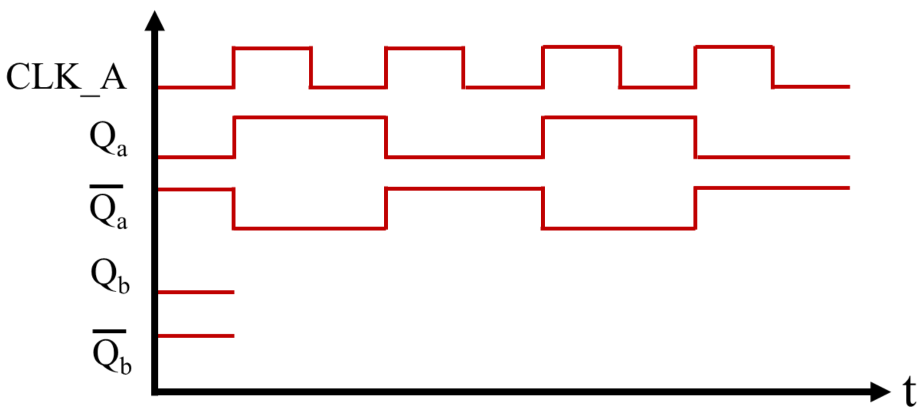
Time	J	K	Q	$\overline{Q}$
t_1				
t_2				
t_3				
t_4				

4. (4 pts) Counter: The counter circuit below consists of two D flip-flops (**Fa** and **Fb**), with a clock input **CLK_A** and two outputs **Qa** and **Qb**. The D flip-flop is a *rising edge device* with the following truth table:

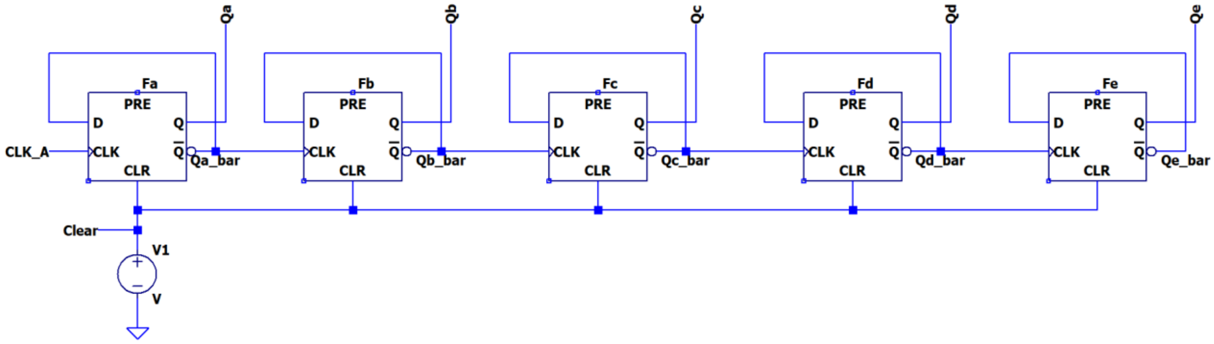


D	CLK	Q	$\overline{Q}$
0	Rising edge	0	1
1	Rising edge	1	0

Complete the timing diagram below by sketching the outputs Q_b and $\overline{Q_b}$ **(Qb_bar)**.

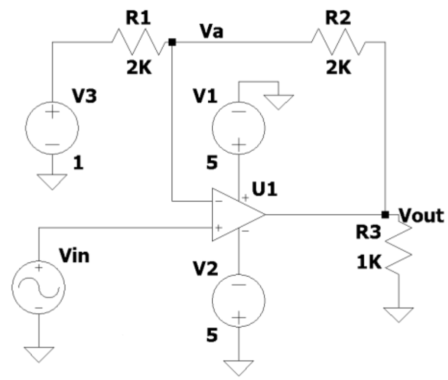


5. (2 pts) If a 3rd, 4th, and 5th D flip-flop (**Fc**, **Fd** and **Fe**) were to be added to the counter circuit in part 4 beyond **Fb** to provide additional outputs $\mathbf{Q_c}$, $\mathbf{Q_d}$ and $\mathbf{Q_e}$ to the circuit as shown below, what is the highest number this counter could represent? Give your answer in both binary (base 2) and decimal (base 10) representations.



III. Comparators and Schmitt Triggers (20 points)

The circuit shown is used for this problem. V1, V2 and V3 are DC voltage sources with the values shown. **V1=5V, V2=5V (resulting in -5V at the V- input) and V3=1V.** Assume the output of the op-amp is capable of reaching the power supply voltages; hence it is what is called a **rail-to-rail op amp**.



1. (2 pts) What are the two possible values of Vout?

2. (4 pts) What are the two possible values of Va, the voltage at the inverting node of the op amp?

3. (8 pts) Plot Vin vs Vout on the graph shown. Label critical voltages.

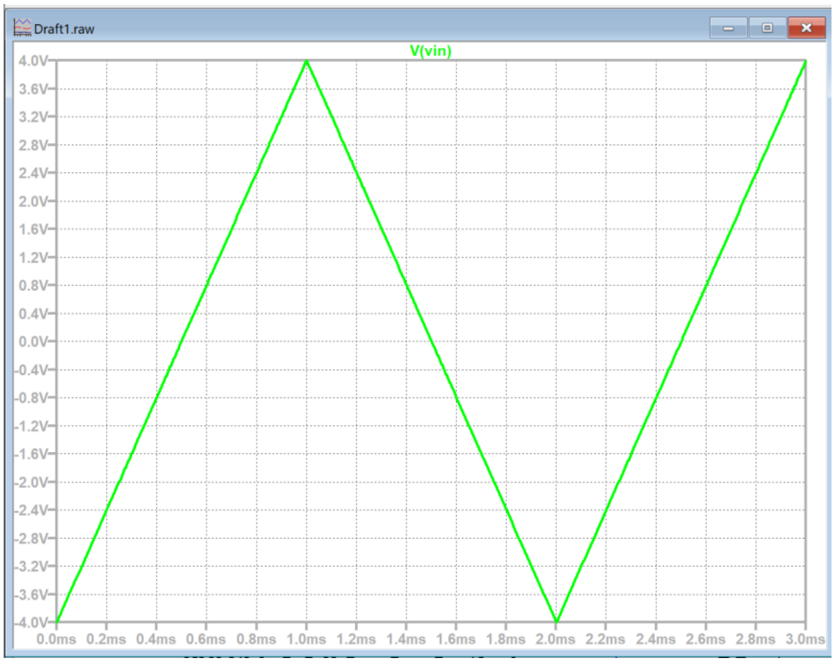
4. (2 pts) Explain how a Schmitt trigger circuit is different from a comparator circuit. (This should be a structural description, not a description of the inputs/outputs)

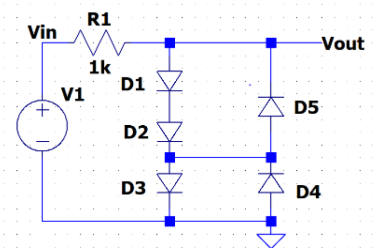
5. (2 pts) Describe in your own words exactly how a Schmitt trigger circuit eliminates noise from an input signal.

6. (2 pts) Can you increase the noise reduction capability of the circuit shown on the previous page by changing the value of one or more of the resistors? If so, state which resistor or resistors you would change and whether you would increase or decrease their resistance.

IV. Diodes (20 points)

1. (4 pts) The graph shows V1(t) for the circuit shown. Draw Vout(t) on the graph using the V_{on} Model with V_{on}=0.5V. **Label important voltages.**

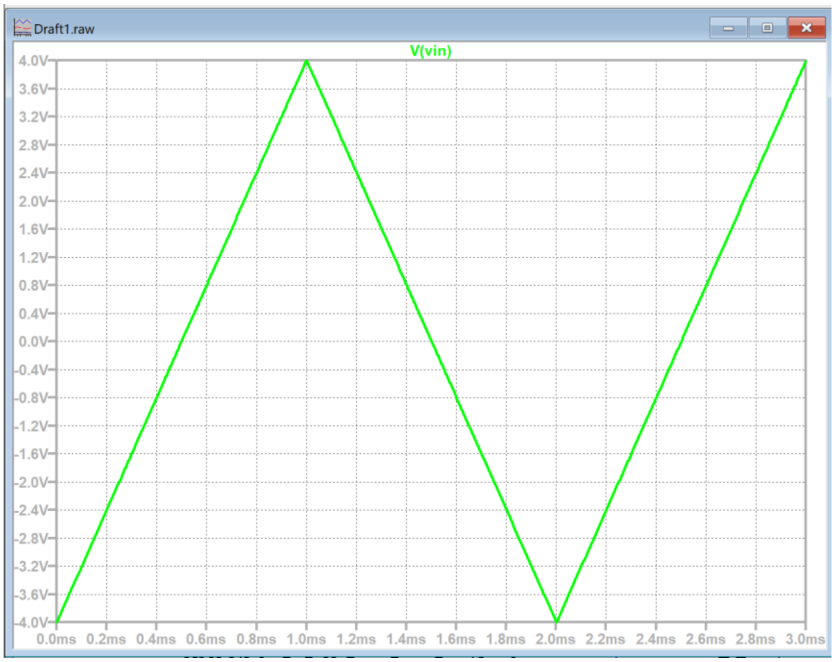


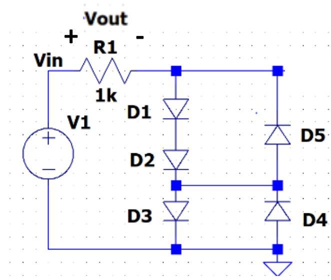


2. (2 pts) A diode is found to have $I_S=4\text{x}10^{-11}$A. Find V_D, the diode voltage when I_D=200mA at room temperature and if n=1. Use the diode equation. Hint: assume that the -1 term is insignificant when solving for V_D but then go back and show if it was appropriate to make that assumption about the "-1" term.

3. (2 pts) Calculate the power flowing through the diode in part 2.

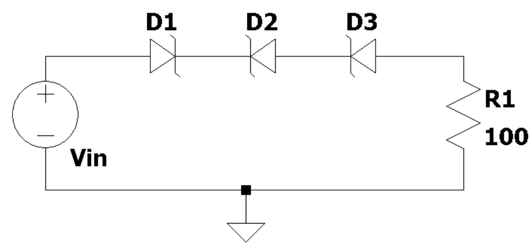
4. (3 pts) Rectifier diodes: For the circuit shown, R1 is the load and the voltage across R1 is Vout. Use the Von diode model with Vd=0.5V. Sketch Vout. V1 is already plotted.



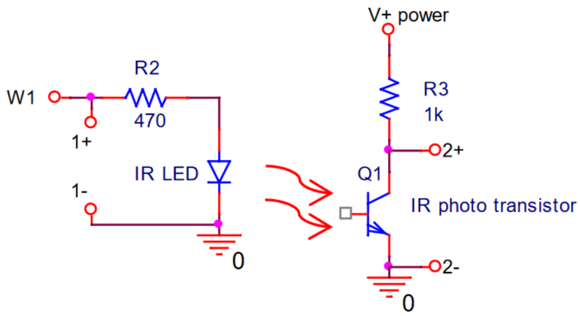


5. (2 pts) Describe in your own words how the behavior of Zener diodes is different from that of other diodes.

6. (3 pts) In the diagram at right, is there some voltage Vin that will cause current to flow in R1? Explain why or why not.



7. (2 pts) Suppose that another student has built the following circuit from Experiment 8.



The student shows you an input and output waveform and claims that the output waveform represents the phototransistor responding to the IR LED. Describe one way you can verify that this is true without modifying the circuit.

8. (2 pts) In addition to being used to generate light, can light-emitting diodes also be used to build rectifier circuits? Explain why or why not.