ENGR-2300

Electronic Instrumentation

Quiz 3

Spring 2013

Name _____

Section ___

Question I (25 points) _____

Question II (25 points) _____

Question III (25 points) _____

Question IV (25 points) _____

Total (100 points) _____


Optional: Replacement for Quiz 2 Question

Question V (25 points) _____

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBChSTITUTE VALUES <u>AND UNITS</u>. No credit will be given for numbers that appear without justification. Read the entire quiz before answering any questions. Also it may be easier to answer parts of questions out of order.

Some Additional Background
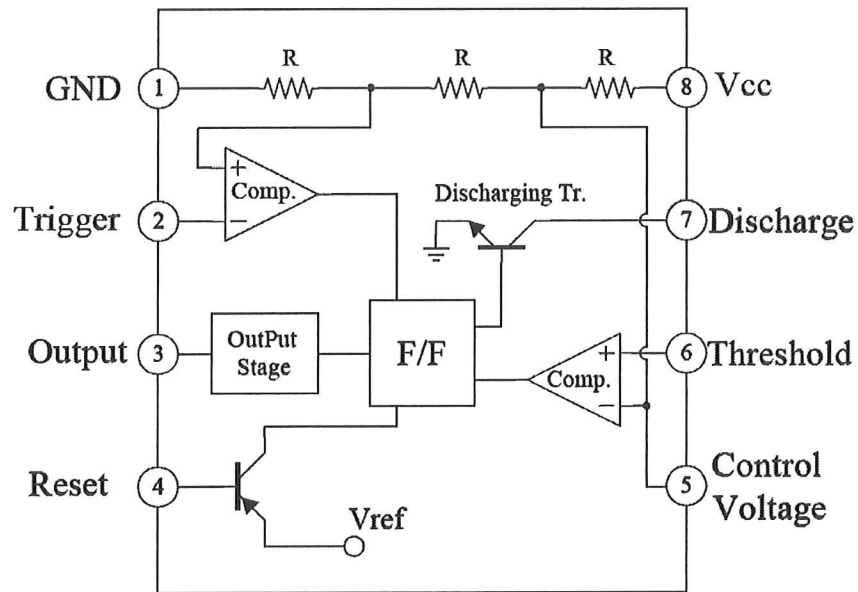
17 April
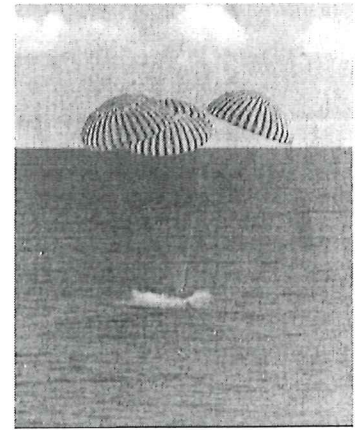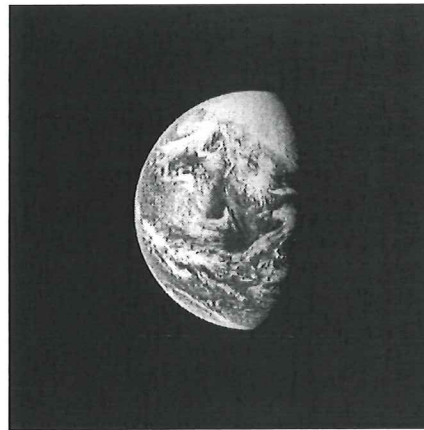
Apollo 13 was the seventh manned mission in the American Apollo space program and the third intended to land on the Moon. The craft was launched on April 11, 1970, at 13:13 CST from the Kennedy Space Center, Florida, but the lunar landing was aborted after an oxygen tank exploded two days later, crippling the service module upon which the Command Module depended. Despite great hardship caused by limited power, loss of cabin heat, shortage of potable water, and the critical need to jury-rig the carbon dioxide removal system, the crew returned safely to Earth on April 17. Shown above are a photo of the earth taken on the craft and a photo of the splashdown in the Pacific.

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**Question 1 (25 Points) Astable Multivibrator (An iconic 555 timer application)**
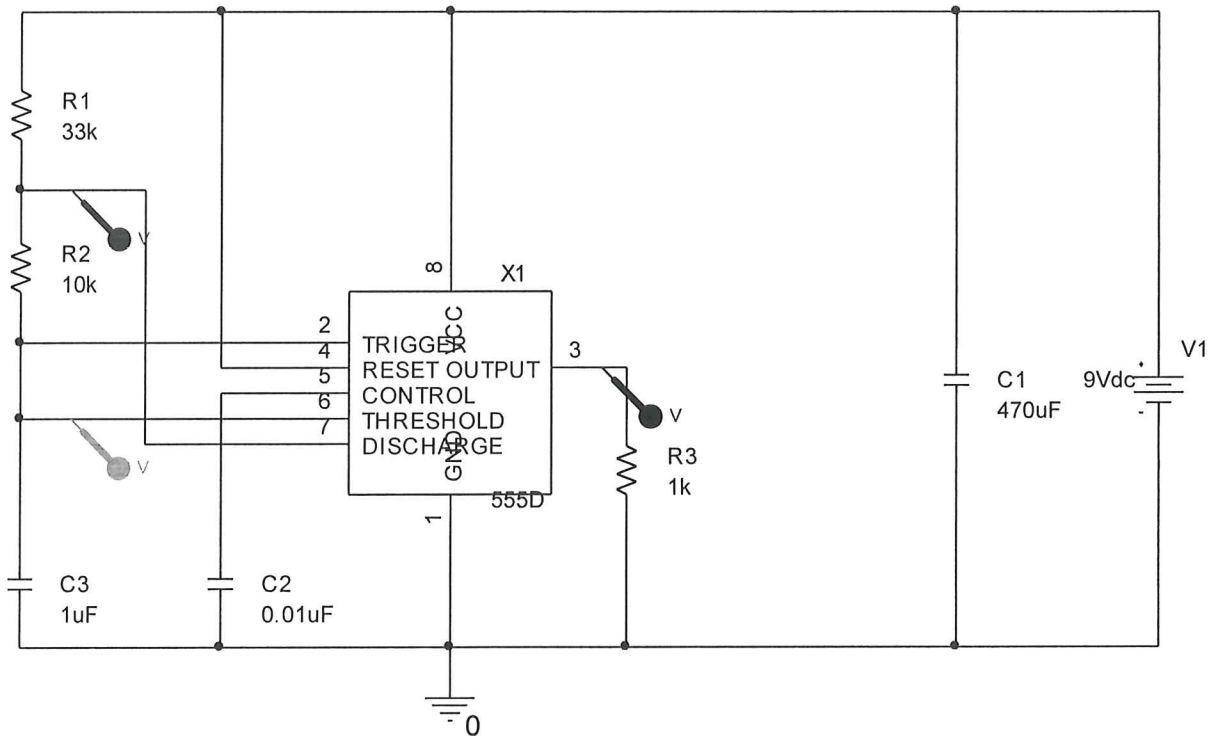
a. A 555 timer, astable multivibrator is built as shown above. Determine the on time (T1) and the off time (T2) for this circuit. (6 points)

$$T1 = .693 (R1 + R2) C3 = 30 \text{ ms}$$

$$T2 = .693 (R2) C3 = 7 \text{ ms}$$

b. Plot the output voltage below, showing two full cycles, starting with the output voltage at its maximum. Label the horizontal and vertical scales. (6 points) Should be near Vcc
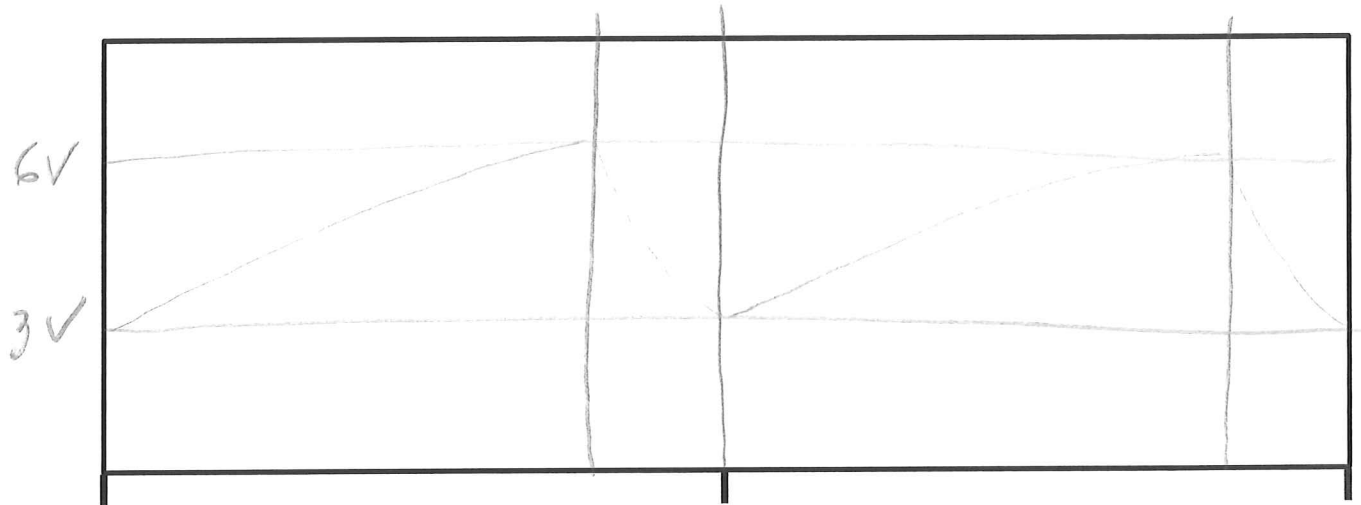
Not possible to determine exactly

V_{out}

9V

30 ms   7 ms

37 ms   74 ms

E I

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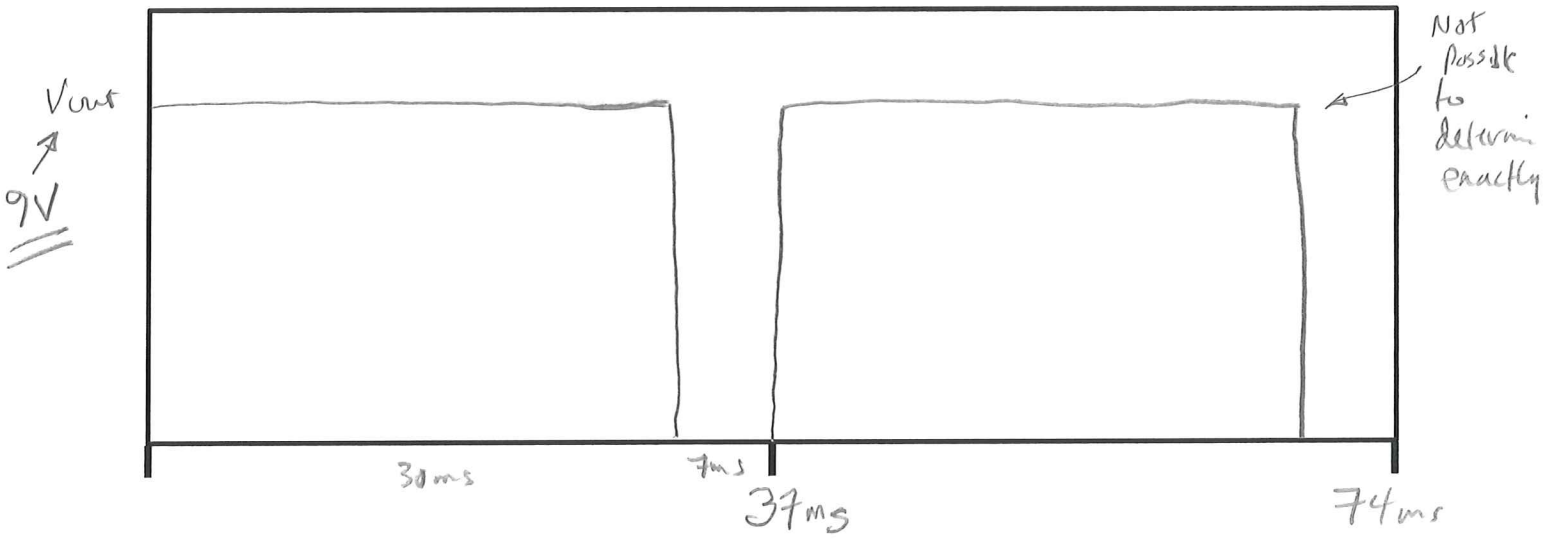
c. Determine the maximum and minimum voltages at pins 6 and 7. Assume that the circuit is in steady state. (6 points)

Pin 6　　　3V & 6V　　　$\left(\frac{2}{3}V_{cc} \doteq \frac{1}{3}V_{cc}\right)$

Pin 7　Min is zero but it also goes from

V_{min} to V_{max}

d. Plot two cycles of the voltage at pin 6. Label the vertical and horizontal scales. (6 points)
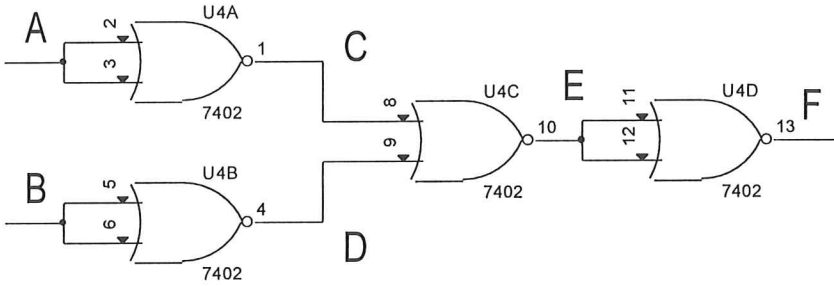
6V

3V

Cont for pin 7　　　$V_{min} = \frac{V_{cc}}{3} + \frac{2}{3}V_{cc}\left(\frac{10}{43}\right)$

$= 3 + \frac{20}{86}6 = 4.4$

$V_{max} = \frac{2V_{cc}}{3} + \frac{1}{3}V_{cc}\left(\frac{10}{43}\right)$

$= 6 + \frac{10}{43}3 = 6.7$

EI　　　　　　　　　　　　　　　　　　　　　　K. A. Connor

Question 2 (25 Points) Combinational Logic Circuits

    a. The following circuit is configured using only NOR gates. Fill in the truth table for this circuit. (8 points)


| A	B	C	D	E	F
0	0	1	1	0	1
0	1	1	0	0	1
1	0	0	1	0	1
1	1	0	0	1	0

    b. This circuit produces the same result as a standard logic device. What device is it? Draw the symbol for the device and provide its truth table. (7 points)

NAND Gate

c. A new circuit is built, based on the circuit above, again only using NOR gates. Fill in the truth table below. *Hint: you may want to label some or all other nodes in the circuit and determine them. Which nodes you choose to determine are up to you, but being as complete as possible will permit more opportunities for partial credit. Be sure to label things clearly. Whatever approach you use, be sure to show all work including any additional diagrams you generate.* (10 points)


3 NANDS
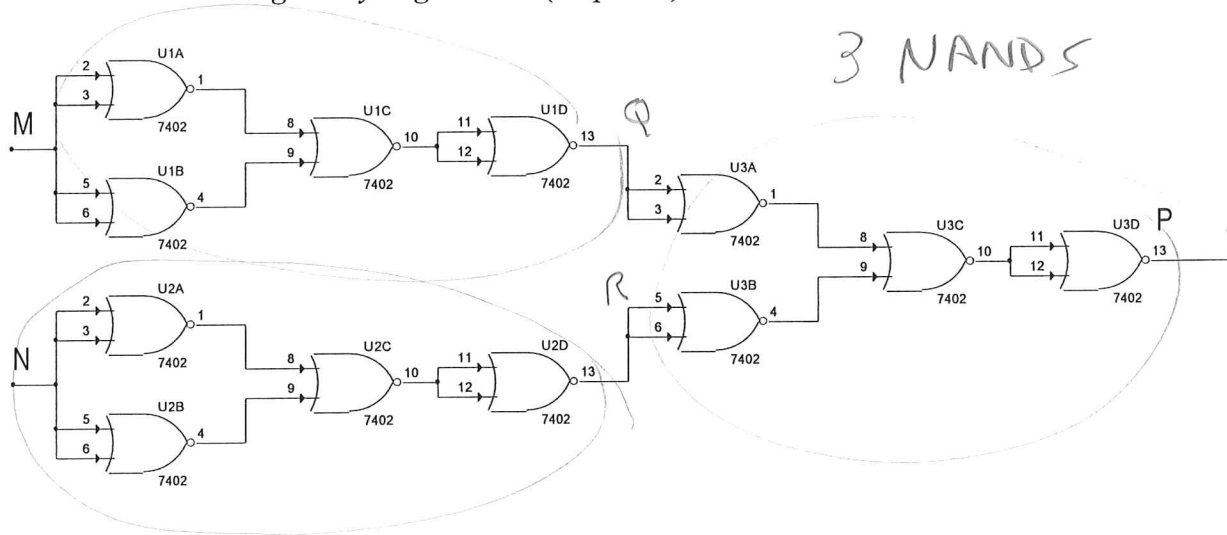
M	N	P	Q	R										
0	0	0	1	1										
0	1	1	1	0										
1	0	1	0	1										
1	1	1	0	0										

NAND

NAND

NAND
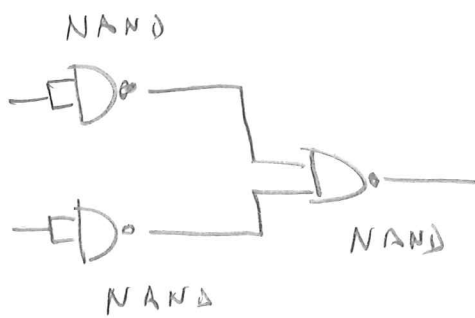
Question 3 (25 Points) Combinational Logic

The following circuit is configured using a variety of logic components. Complete the two timing diagrams below. The signals observed at A and E are given. The first is for the first counter, nodes A1-D1. (8 points) The second includes all components, but you only need to plot nodes B, C, D & F. (8 points) *All devices respond on the trailing edge of the pulses. The time scale goes from 0 to 150 ms.*
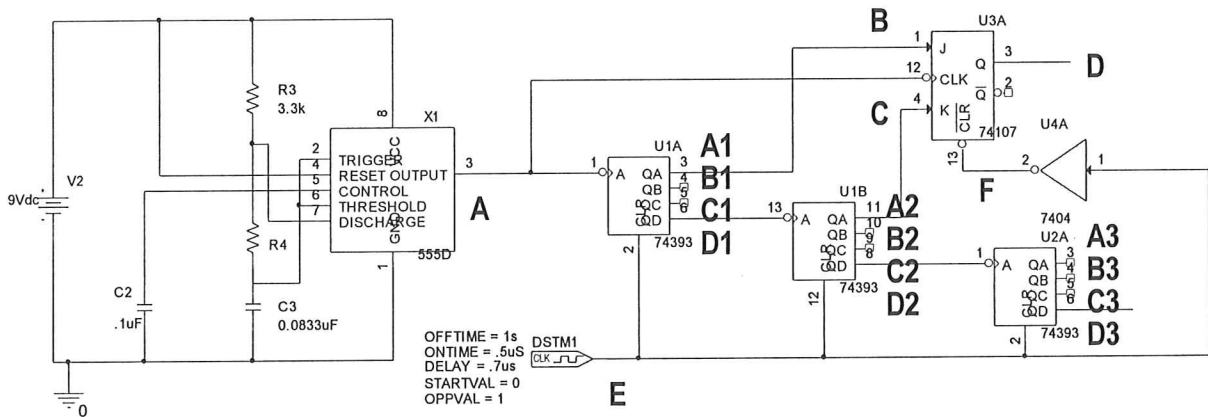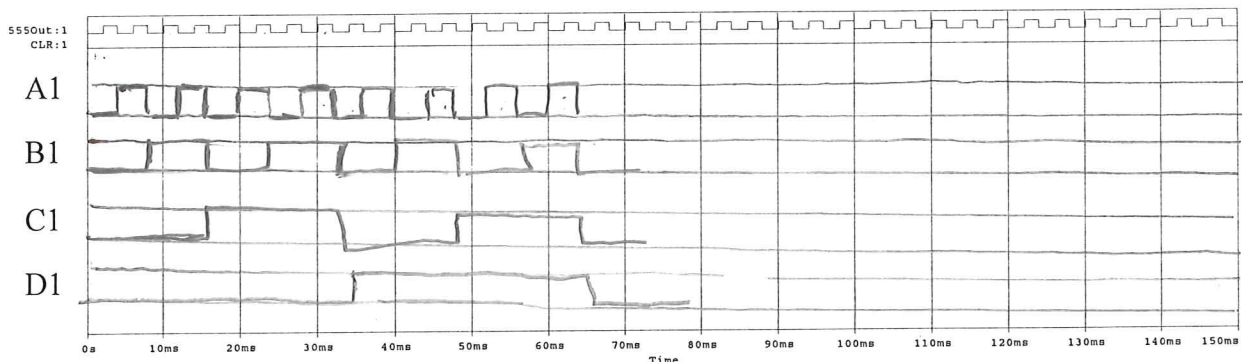

a. Note that a 555 timer circuit is used to produce the clock signal. From the plot below, determine the period of the timer output pulses and from the period determine the value of the resistor R4. (4 points)

$$T = T1 + T2 = \frac{10ms}{2.5} = 4ms$$

$$.693 \left(R_3 + 2R_4 \right) C_3 = .004$$

with $R_3 = 3.3k$ and $C_3 = 0.0833\mu F$

$$\Rightarrow R_4 = 3.3k$$
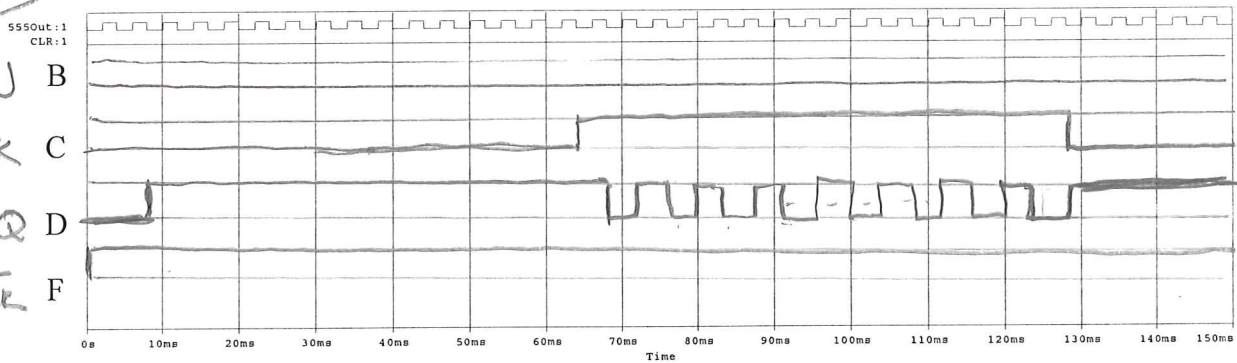
b. First Counter Alone – Label the given signals at A & E and plot the other four. (8 points)

See PSpice Plot.

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c. Entire Circuit – Label the given signals at A & E and plot the other four. (8 points)

Save as A1

555Out:1
CLR:1
J B
K C
Q D
$\overline{CLR}$ F

0s 10ms 20ms 30ms 40ms 50ms 60ms 70ms 80ms 90ms 100ms 110ms 120ms 130ms 140ms 150ms

Time

d. What is the maximum number that the combination of counters can count to? Give your answer in both binary and decimal forms. (4 points)

$|\,|\,|\,|\,|\,|\,|\,|\,|\,|\,|\,|$

32 16 8 4 2 1
64
128
256
512
1024
2048

4095

For the given clock signal, approximately how long will it take for the counters to reach the maximum number? *Your answer should be correct to within 10%.* (1 point)

4ms × 4095 ≈ 16 sec or so.

(Work Space)

Question 4 (25 Points) Schmitt Trigger

A combination of two very low frequency sine waves is passed through a homemade Schmitt Trigger, as shown below along with a plot of the resulting input signal vs. time.
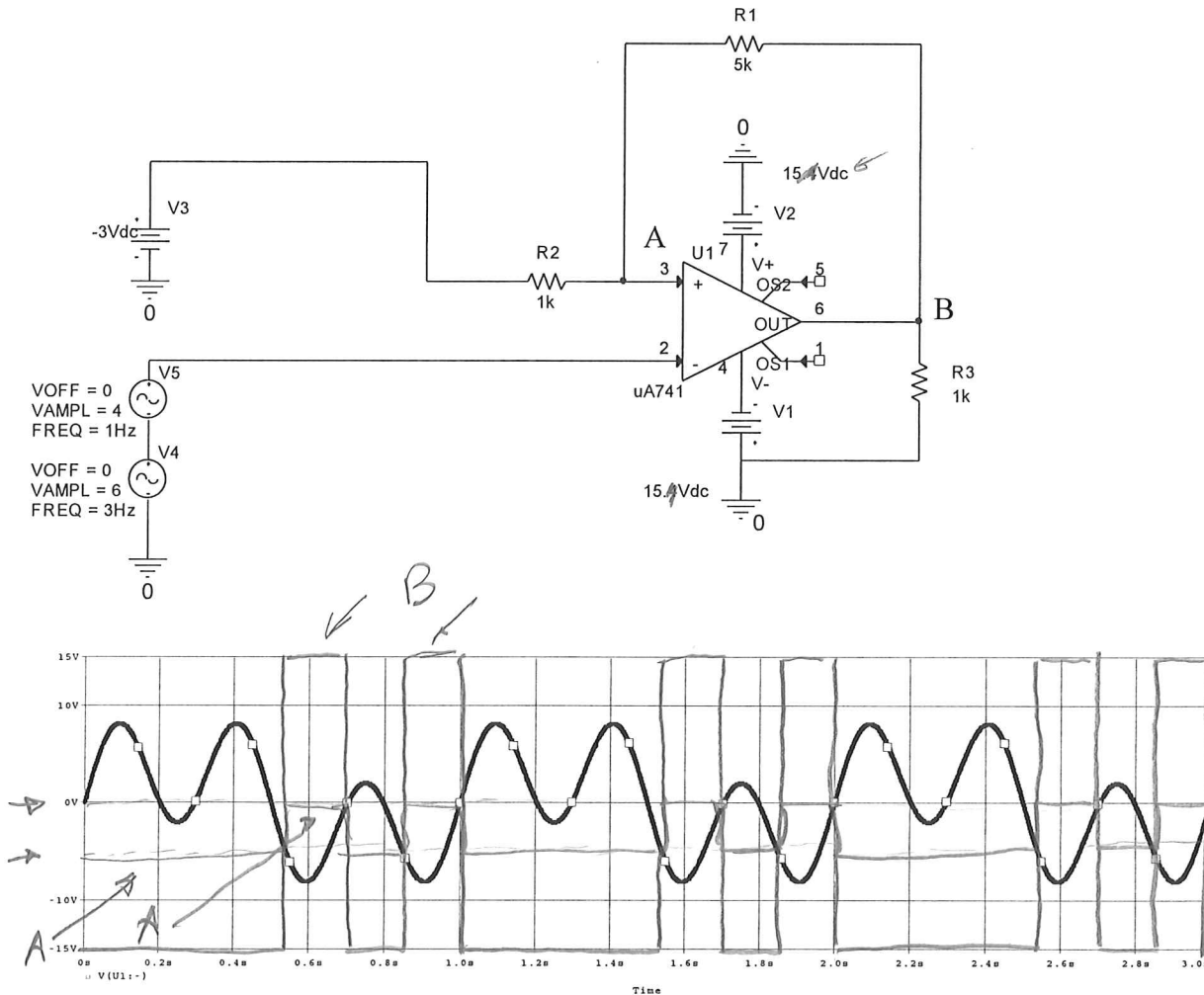
a. Assume ideal conditions, what are the two threshold voltages for the Schmitt Trigger? (8 Points)
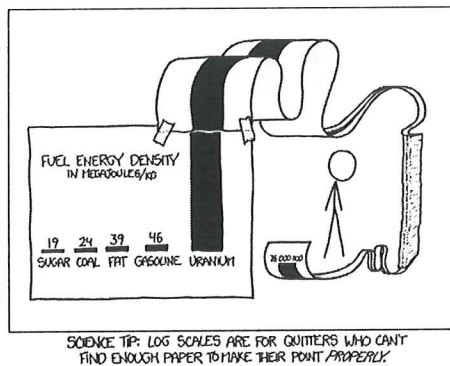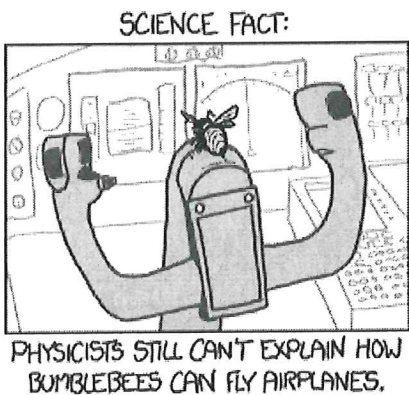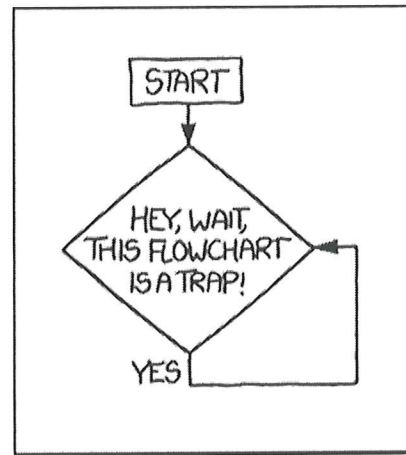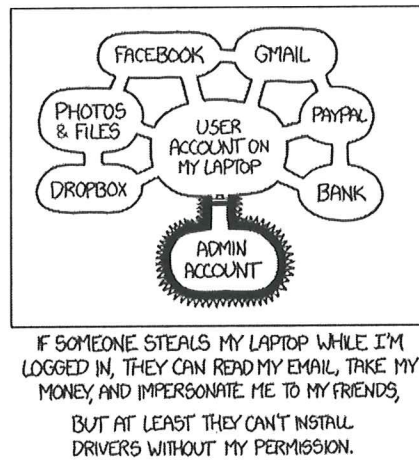
$$V+ = V_{ref} + \frac{R_2}{R_1 + R_2}(V_{out} - V_{ref})$$

$$= -3 + \frac{1}{6}(15 + 3) = 0$$

$$= -3 + \frac{1}{6}(-15 + 3) = -5$$

b. Plot the voltages at points A and B vs. time on the plot above. (8 Points) Be sure to clearly label the two voltages.

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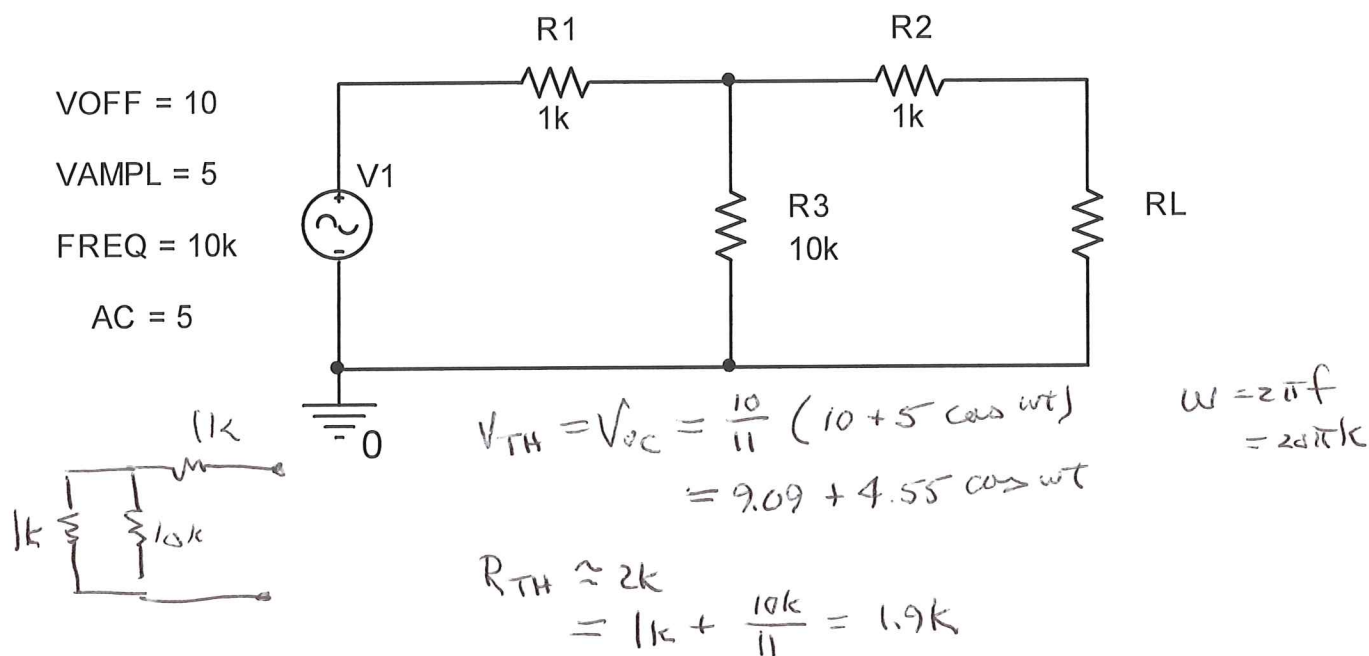c. If you are using this as a counter, how many positive pulses does it count per second? (5 Points)

②

d. What is the source of the cartoons below? Circle the correct answer. (4 points)
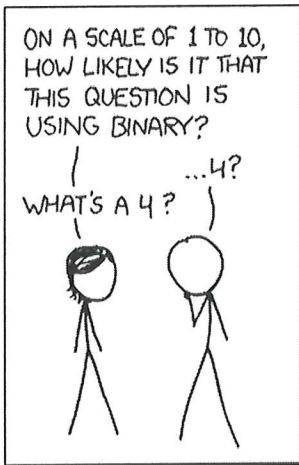
a. (xkcd) or
b. xkcd or
c. xkcd or
d. (xkcd)

Question V (25 Points) Thevenin Equivalent Source *Extra Problem for Quiz 2*

a. (10 Points) Determine the Thevenin Voltage and Resistance for the following circuit.

$$V_{TH} = V_{oc} = \frac{10}{11}(10 + 5\cos \omega t)$$

$$= 9.09 + 4.55 \cos \omega t$$

$$\omega = 2\pi f = 2\pi 10k$$

$$R_{TH} \approx 2k$$

$$= 1k + \frac{10k}{11} = 1.9k$$

b. (6 Points) Determine the Thevenin Voltage and Resistance for the following circuit.

Neglect all of the 100k Resistors **except**

$$V_{TH} \approx \frac{150}{5} = 30 V$$
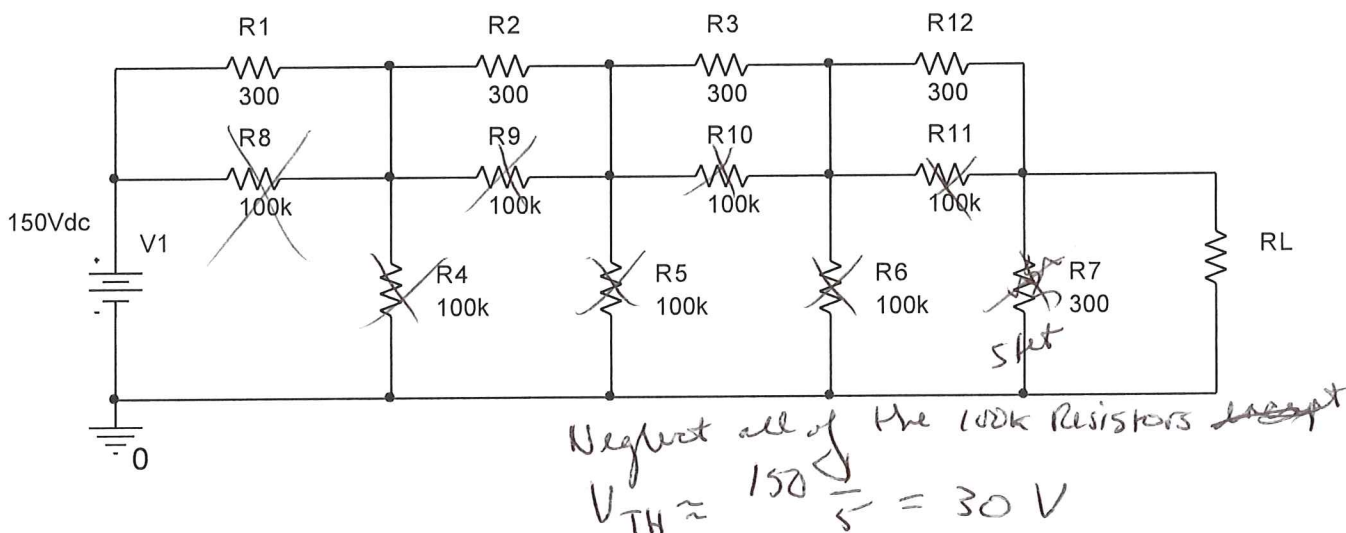
Circle the <u>closest</u> answers below.

$$R_{TH} \approx 300 \| 1200 = 240 \, \Omega$$

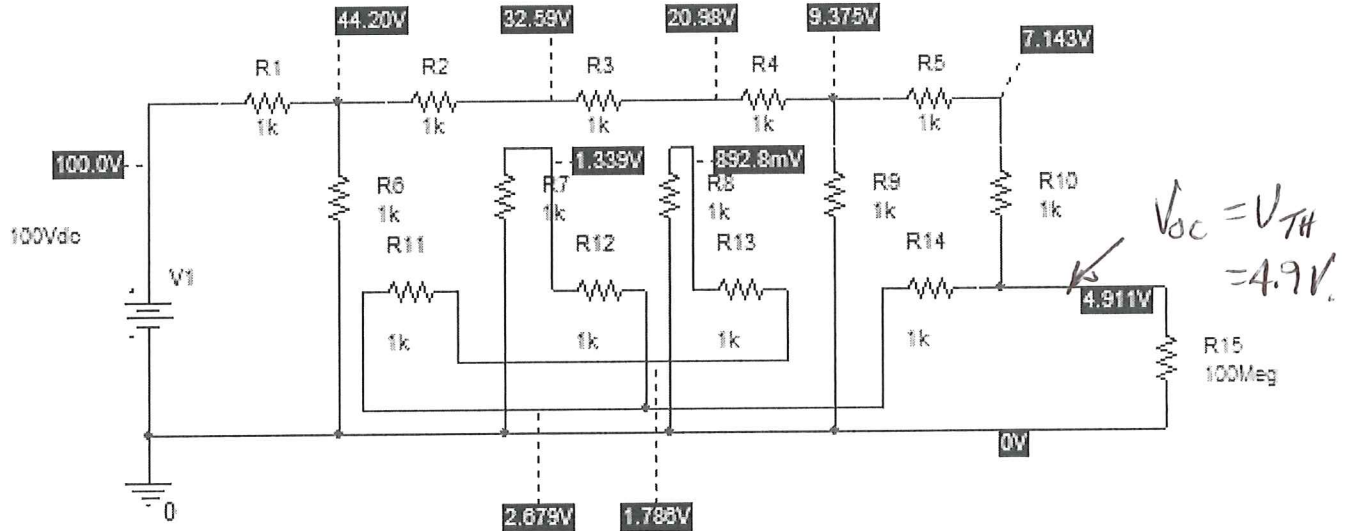V_{TH}

150V, 140V, 130V, 120V, 110V, 100V, 90V, 80V, 70V, 60V, 50V, 40V, (30V,) 20V, 10V, 0V
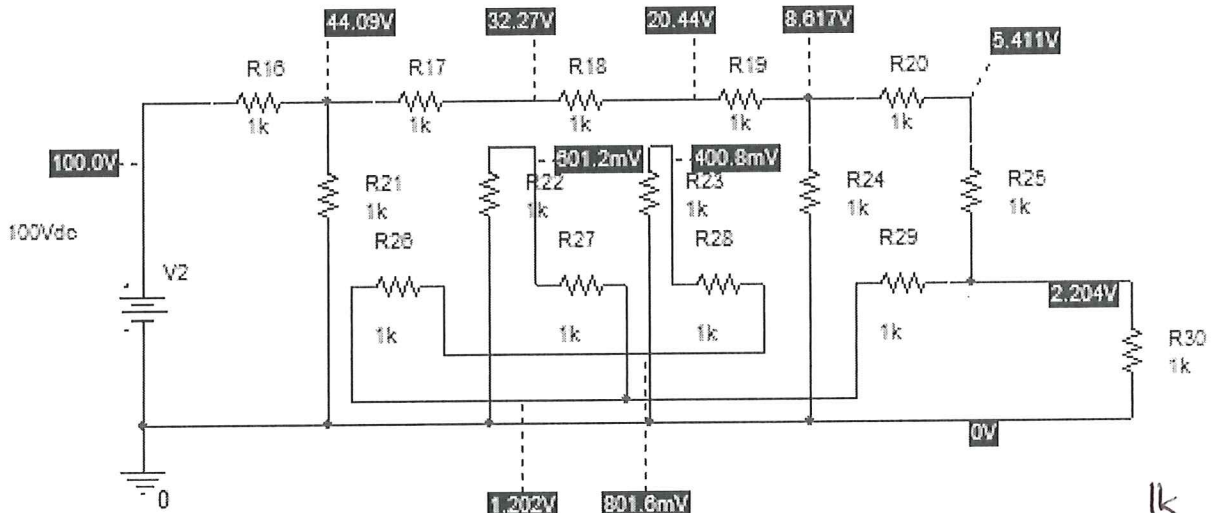
R_{TH}

1.2kΩ, 960Ω, 840Ω, 770Ω, 600Ω, 540Ω, 470Ω, 390Ω, 300Ω, (240Ω,) 180Ω, 120Ω, 90Ω, 30Ω

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c. (9 Points) Determine the Thevenin Voltage and Resistance for the circuit below. The circuit was analyzed using PSpice with two different loads, 100MΩ and 1kΩ. Use the information given in the two cases to find your answers.
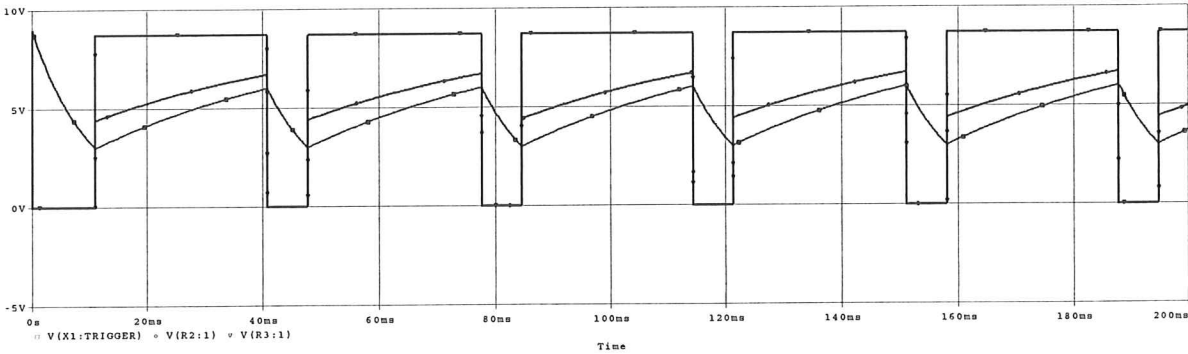

$V_{OC} = U_{TH} = 4.9V.$
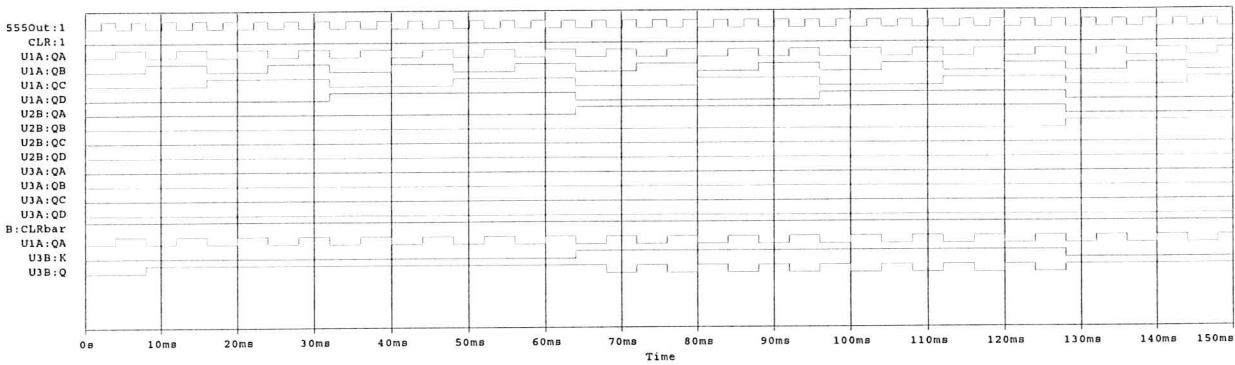
$R_{TH} \leftarrow 2.2$

$\dfrac{2.2}{R_{TH}+1k} = \dfrac{4.9}{2.2} \dfrac{1k}{R_{TH}+1k}$

$R_{TH}+1k = \dfrac{4.9}{2.2} \cdot 1k$

$R_{TH} = 1.2k$

Problem 1:

V(X1:TRIGGER)   V(R2:1)   V(R3:1)

Time

Problem 3

555Out:1
CLR:1
U1A:QA
U1A:QB
U1A:QC
U1A:QD
U2B:QA
U2B:QB
U2B:QC
U2B:QD
U3A:QA
U3A:QB
U3A:QC
U3A:QD
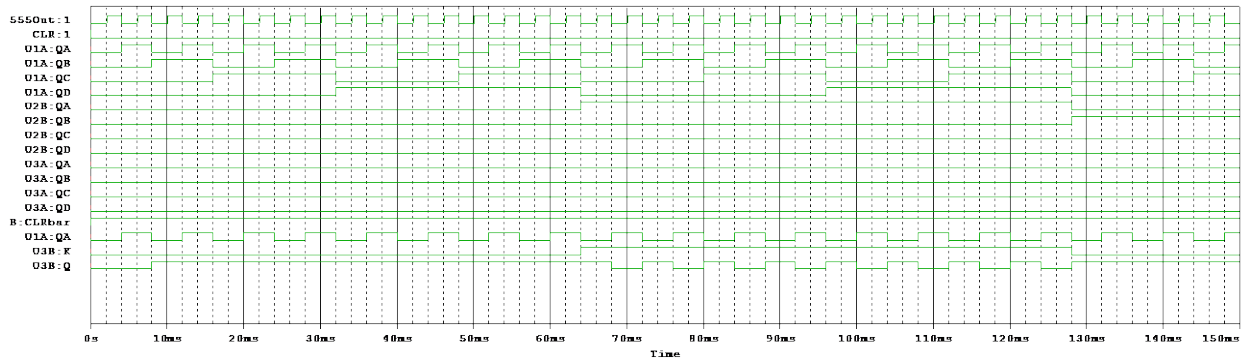B:CLRbar
U1A:QA
U3B:K
U3B:Q

Time

Problem 4

V(U1:-)   V(R1:2)   V(R2:2)

Time

Problem 1:

Problem 3

Problem 4