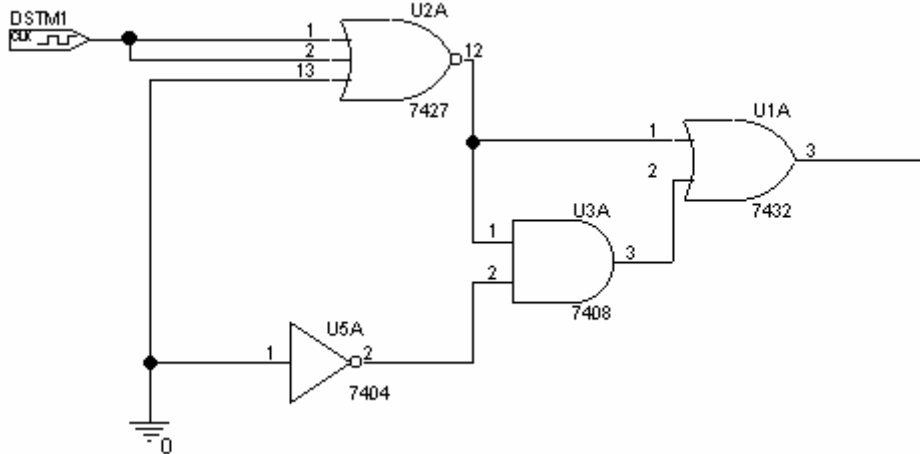


1) Logic Gates (20 points)

You should recognize the digital gates in the following circuit as the ones introduced in the lab and/or in class.



a) What kind of gate is U2A? (2 points)

Answer: U2A is a three input NOR gate

b) What is the truth table for gate U2A? (6 points)

Answer:

A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

c) Indicate which of the three plots on the following page represents the output of the circuit. Show any work below for partial credit. (12 points)

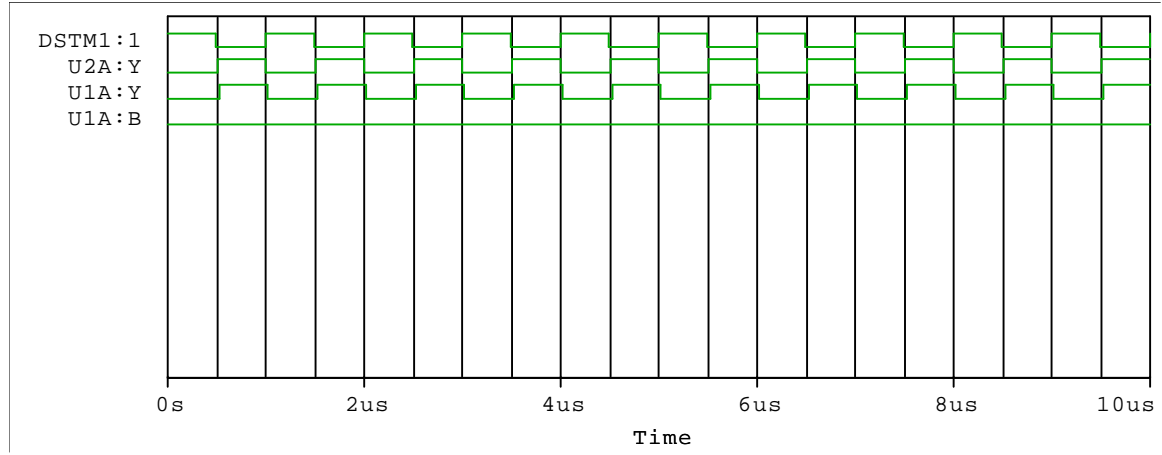
work:

DSTM1	U2A:Y	U5A:Y	U3A:Y	U1A:Y
0	1	1	1	1
1	0	1	0	0

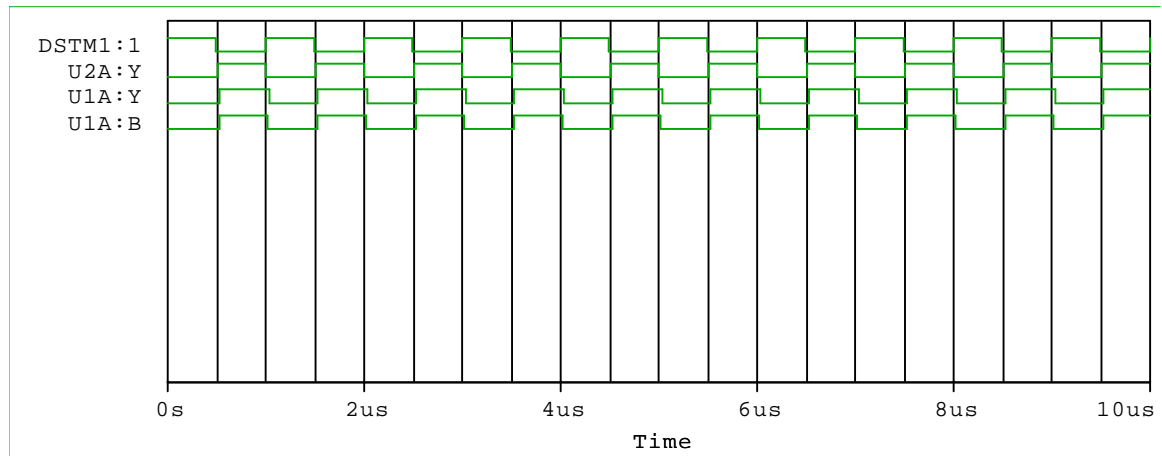
Note: U1A:B is the same as U3A:Y

Circuits for question 1 part c).

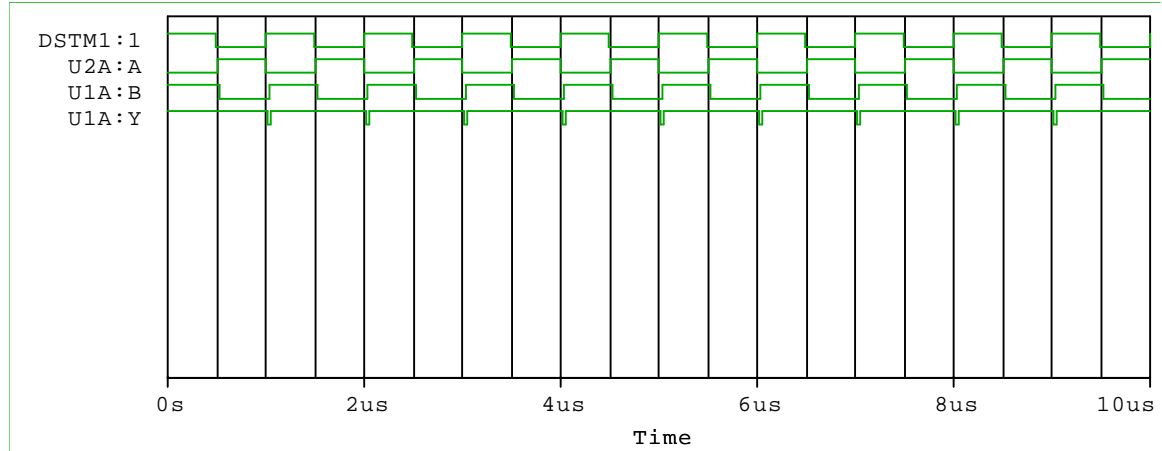
A.



B. Answer: *This one is CORRECT.*

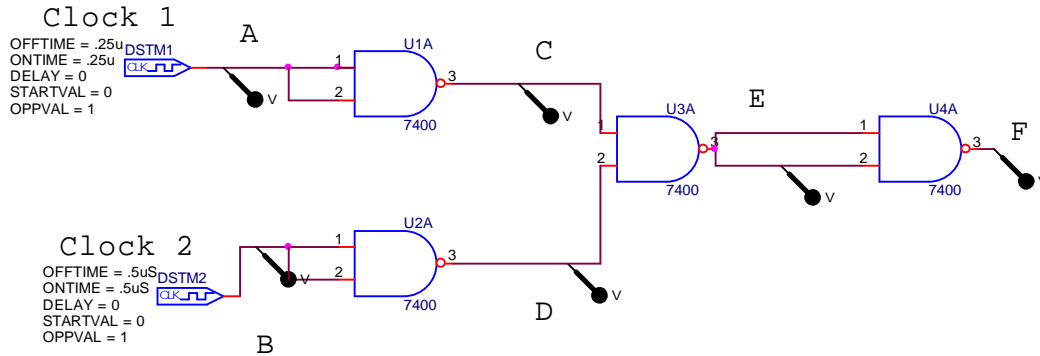


C.

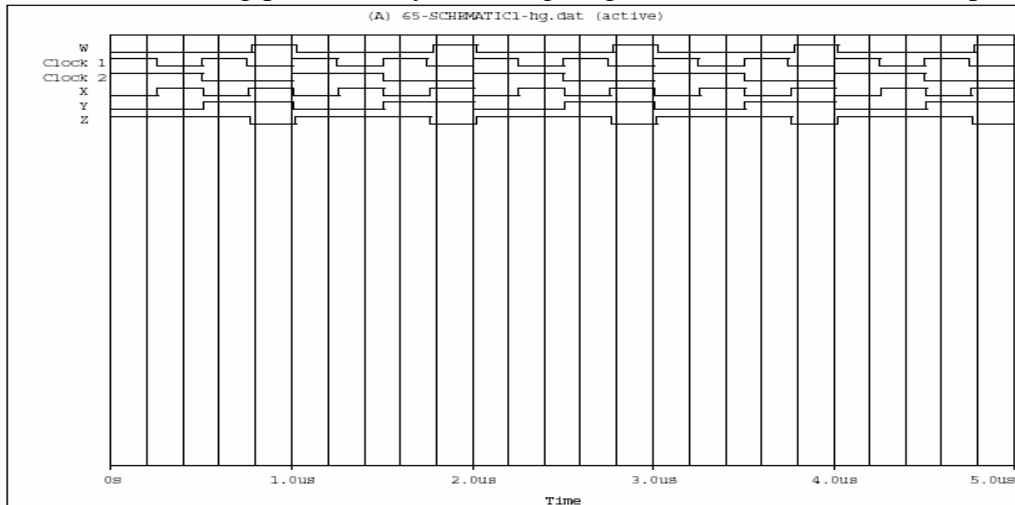


2) NAND Gate Circuits (20 points)

It is possible to configure all standard gates using just NAND gates. The figure below show one such combination of NANDS.



a. On the following plot, identify which signal goes with which location (6 points).



Answer: order from top to bottom: F,A,B,C,D,E

b. Draw a truth table for the circuit, showing the inputs, the output and as many steps in between as you need to determine how it works (10 points).

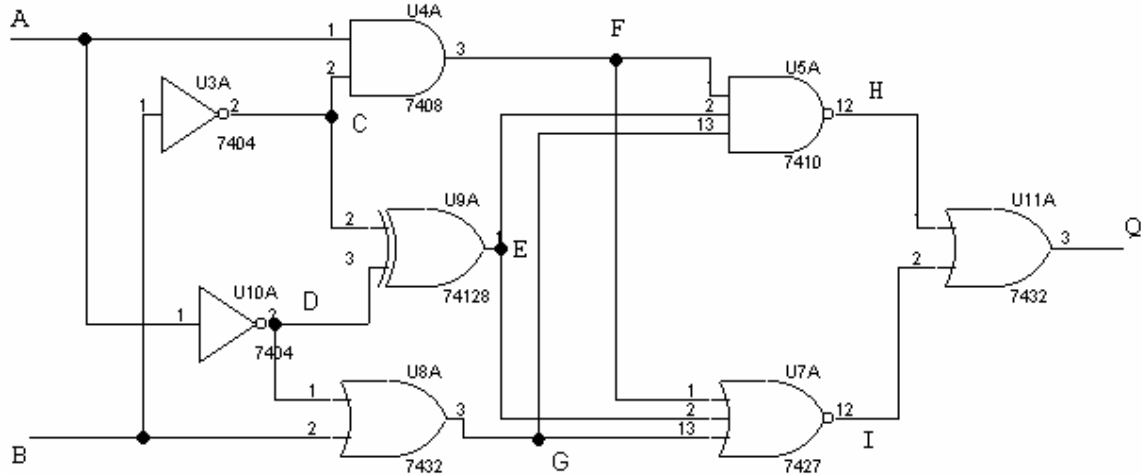
Answer:

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

c. Which single type of gate is this circuit equivalent to (4 points)?

Answer: two input NOR gate

3) Combinational Logic (20 points)



Draw the truth table for the circuit above:

Answer:

A	B	C	D	E	F	G	H	I	Q
0	0	1	1	0	0	1	1	0	1
0	1	0	1	1	0	1	1	0	1
1	0	1	0	1	1	0	1	0	1
1	1	0	0	0	0	1	1	0	1

4) Digital-to-Analog Converter (20 points)

- a) In figure below, $R5 = 20K\Omega$, $R6 = 1K\Omega$ and $R7 = 5K\Omega$. This configuration of op-amps and resistors can produce an analog output voltage equal to the binary word ABCD input at the left. Assume that you are working with TTL devices, so the voltage levels for ones and zeros are TTL levels (0V and 5V). Select values for $R1$, $R2$, $R3$, and $R4$ so that the output voltage will be the decimal equivalent of ABCD. For example if $ABCD=1010$, or equivalently $V_A=V_C=5V$, $V_B=V_D=0V$, $V_{out} = 10V$. The circuit should work for **all** possible ABCD combinations. (12 points)

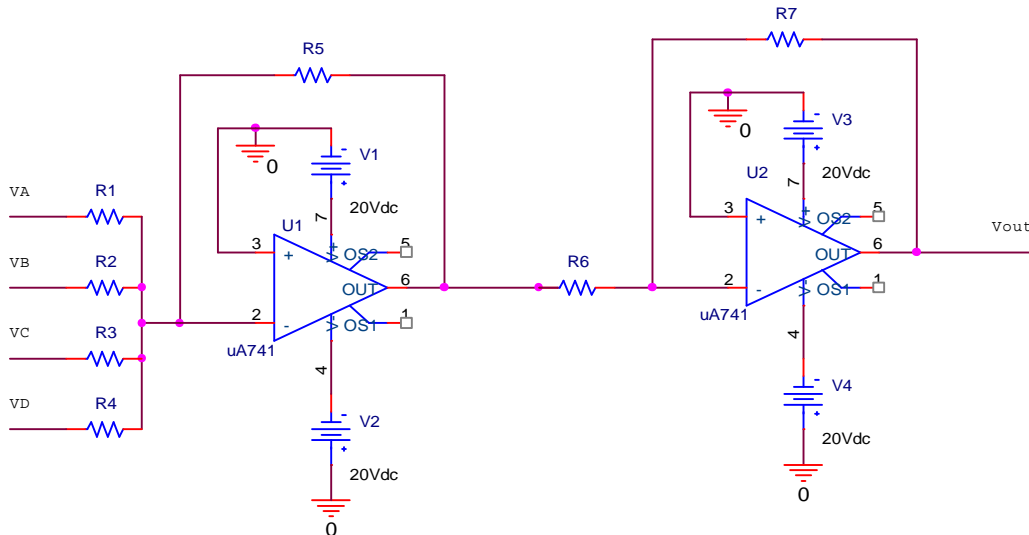
$R1 =$

$R2 =$

$R3 =$

$R4 =$

- b) Your choices of resistors should work for any number, but specifically show that your values work for the two binary numbers $ABCD = 0010$ and $ABCD = 1011$. (8 points)



a) Answer:

$$V_{out} = -R5 \times [V_A/R1 + V_B/R2 + V_C/R3 + V_D/R4] \times -(R7/R6)$$

$$V_{out} = [V_A/R1 + V_B/R2 + V_C/R3 + V_D/R4] \times [(R7 \times R5)/R6]$$

$$(R7 \times R5)/R6 = (5K \times 20K)/1K = 100K$$

input	bit	V_{out}	V_A	V_B	V_C	V_D	Equation	R
0001	1	1V	0	0	0	5V	$V_{out} = 100K \times V_D/R4$	$R4 = 500K$
0010	2	2V	0	0	5V	0	$V_{out} = 100K \times V_C/R3$	$R3 = 250K$
0100	3	4V	0	5V	0	0	$V_{out} = 100K \times V_B/R2$	$R2 = 125K$
1000	3	8V	5V	0	0	0	$V_{out} = 100K \times V_A/R1$	$R1 = 62.5K$

Therefore, $R1 = 62.5K$ ohms, $R2 = 125K$ ohms, $R3 = 250K$ ohms, $R4 = 500K$ ohms.

(Show your work here for question 4.)

b) *Answer:*

$$ABCD = 0010 \text{ (binary)} = 2 \text{ (decimal)}$$

$$V_{out} = 2V = ? [VA/R1 + VB/R2 + VC/R3 + VD/R4] * (R6 * R5) / R7$$

$$2V = ? [5/250K] * 100K = 2V \text{ (checks)}$$

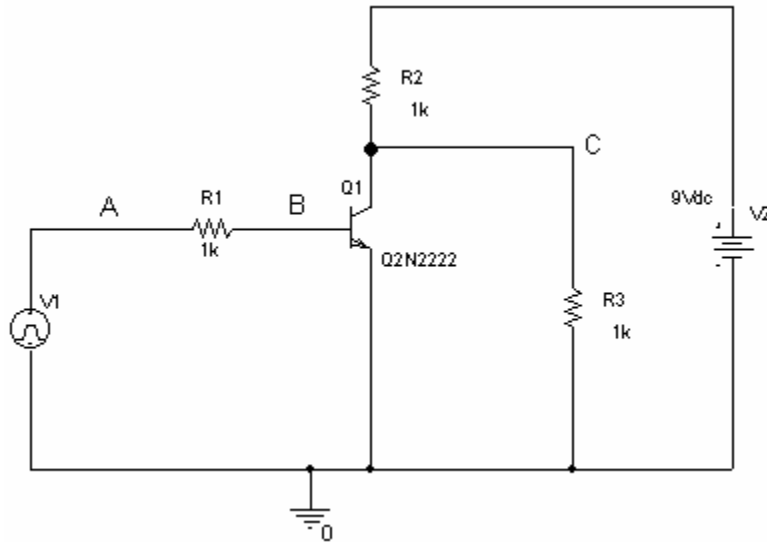
$$ABCD = 1101 \text{ (binary)} = 11 \text{ (decimal)}$$

$$V_{out} = 11V = ? [VA/R1 + VB/R2 + VC/R3 + VD/R4] * (R6 * R5) / R7$$

$$11V = ? [5/62.5K + 5/250K + 5/500K] * 100K$$

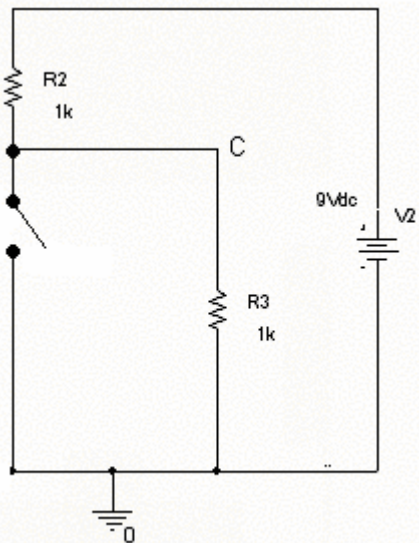
$$11V = ? [.08 + .02 + .01] * 100 = 11V \text{ (checks)}$$

5) Transistor Circuit (20 points)



a) Redraw the circuit when the diode in the transistor is “off”. Show the transistor as a switch in the appropriate position. What is the value of the voltage at point C? (6 points)

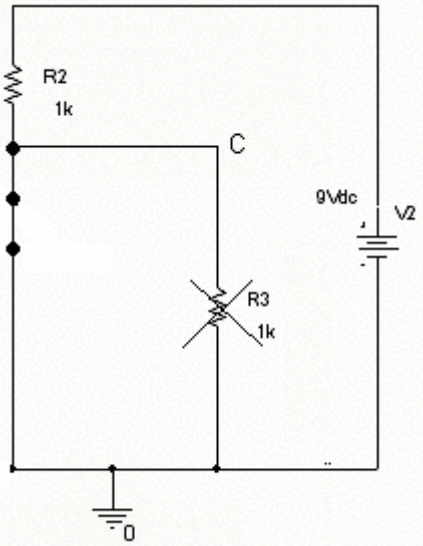
Answer:



$$V_C = \frac{R_3}{R_2 + R_3} V_2 = \frac{1K}{1K + 1K} 9 = 4.5V$$

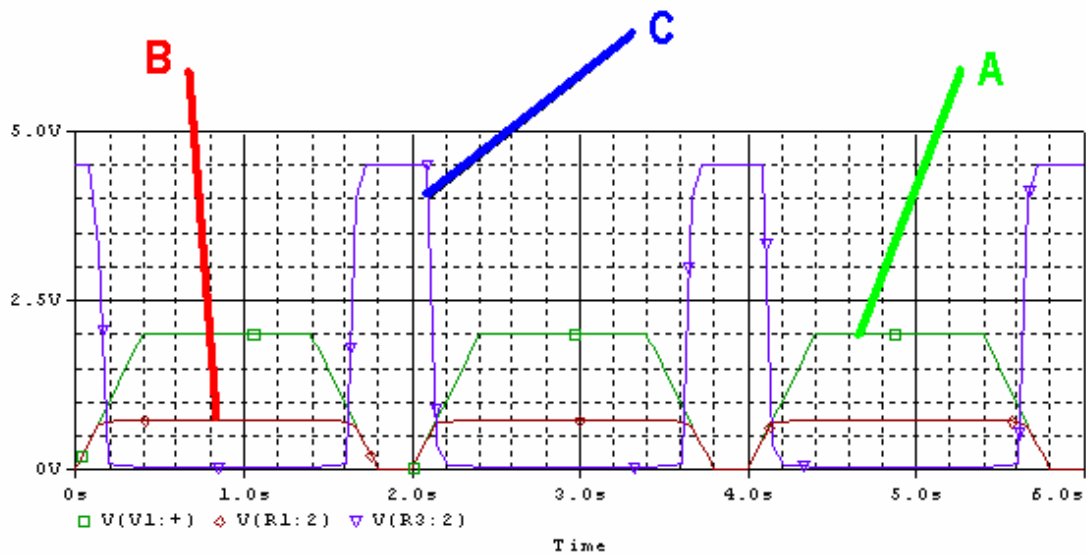
b) Redraw the circuit when the diode in the transistor is “on”. Show the transistor as a switch in the appropriate position. What is the value of the voltage at point C? (6 points)

Answer:



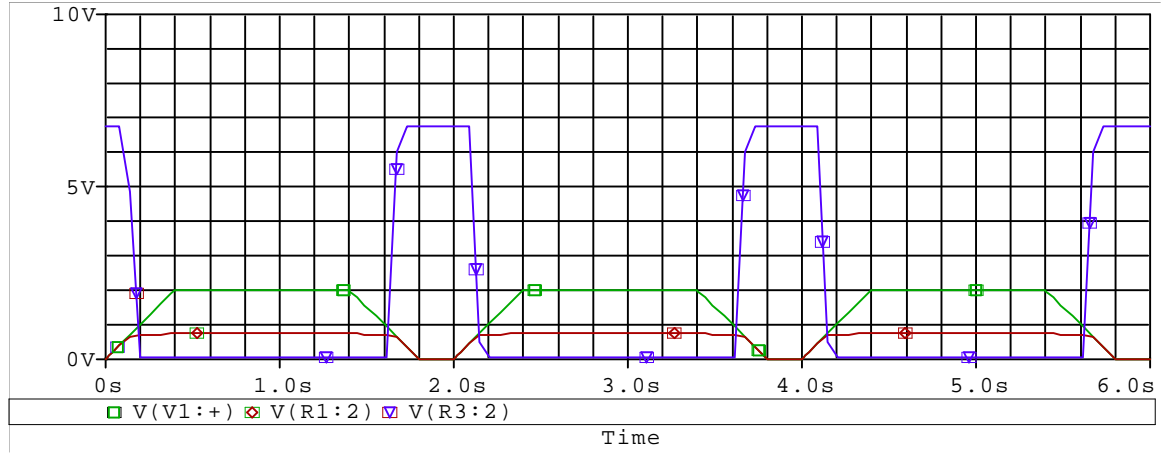
$V_C = 0V$ (attached to ground)

c) Indicate which of the three plots on the following page corresponds to the circuit above AND indicate on the chosen plot, which signal corresponds to which of the above points (A, B, C, D) on the circuit. (8 points)

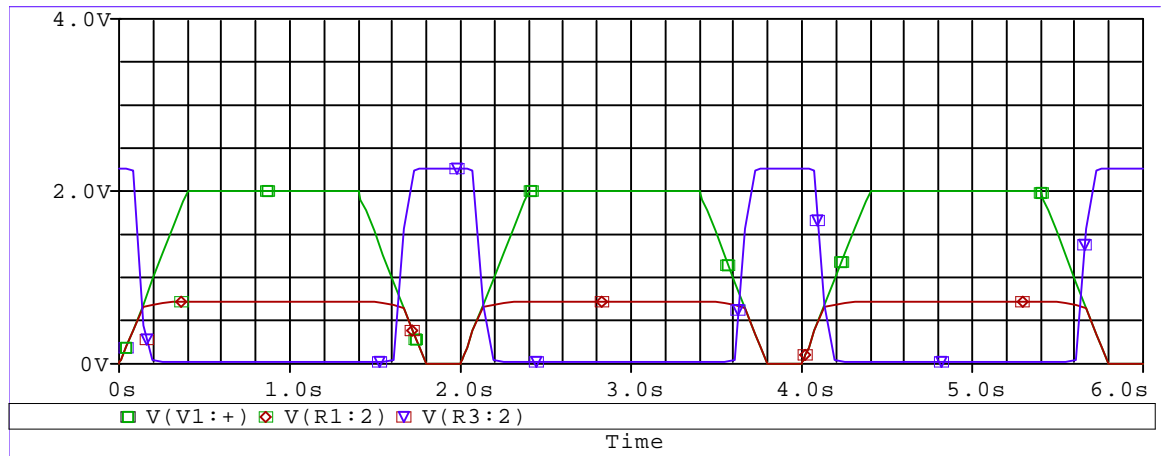


Plots for question 5.

A



B.



C. Answer: This one is correct – see previous page for identification of traces.

