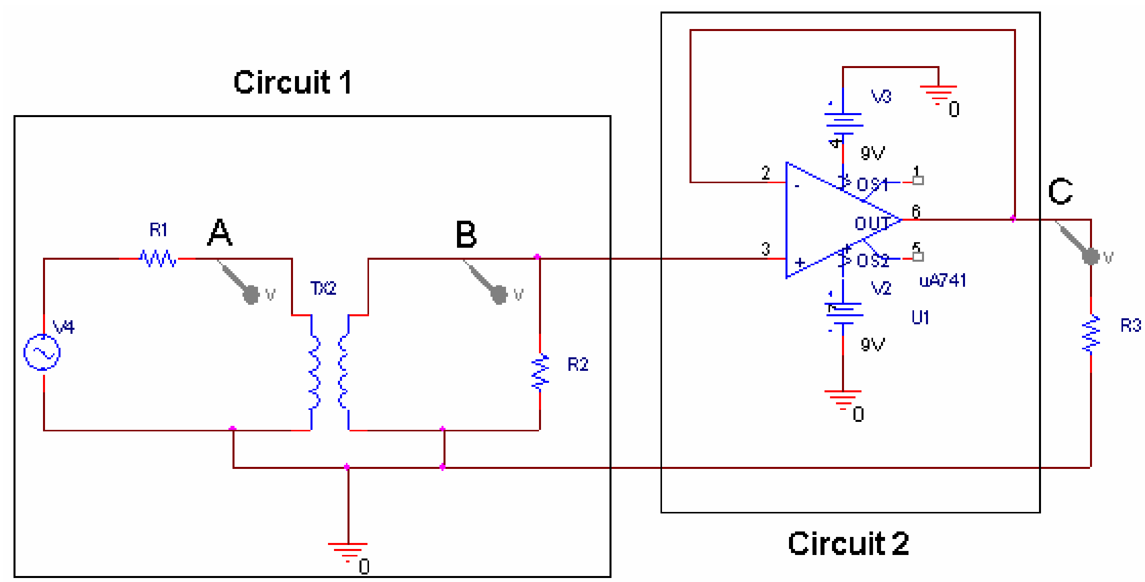
Questions about Circuit Functionality

Fall 2004
Question 5 -- Transformers *(15 points)*

Below is a circuit containing a transformer and an op-amp circuit you should recognize from the homework and experiment 8. Assume R1 = 50 ohms, R2 = 5K ohms, and R3 = 200 ohms.



a) What is circuit 2 called and what does it do? *(3 points)*

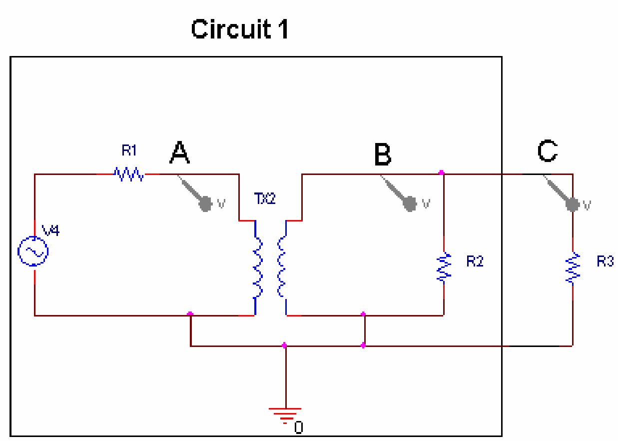
b) Given that the imput impedance of the transformer, TX2, is 4mH and the output impedance is 400mH, determine the value of the constant "a" for the transformer. *(2 points)*

c) Given the amplitude of the voltage at point A is 50mV and transformer has perfect coupling, what is the amplitude of the voltage at point B? *(2 points)*

d) For the same signal as described in part c, what is the amplitude of the voltage at point C? *(2 points)*

e) For the same signal in parts c and d, find the amplitude of the current through the load resistor, R3. *(3 points)*

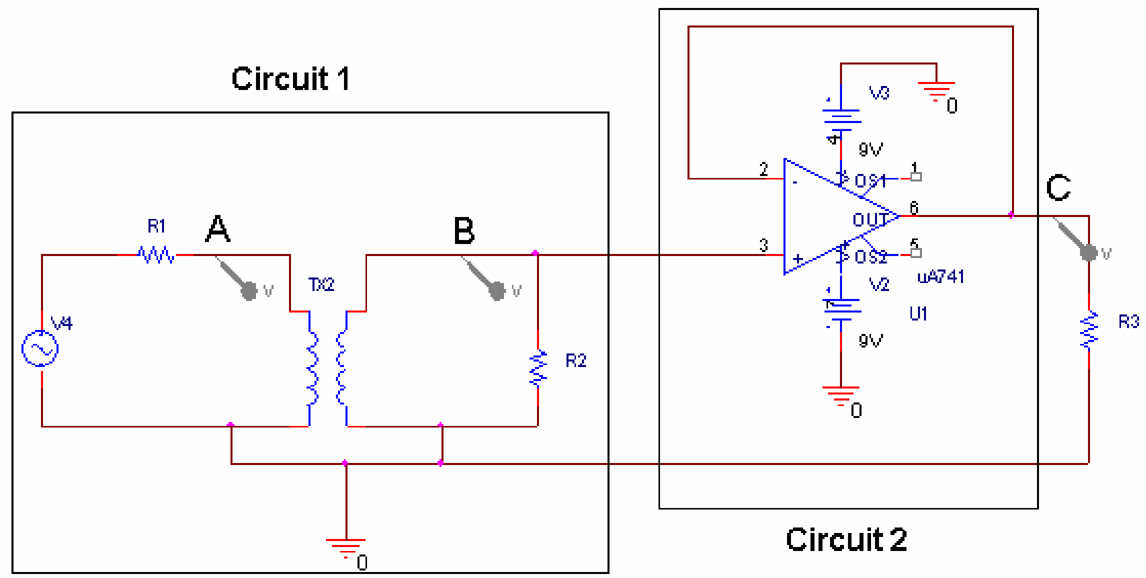
f) If we remove circuit 2 and connect the load resistor, R3, directly to point B (as shown below), would the new value of the voltage at point B be greater than, less than, or equal to the value you determined in part c?   Why? *(3 points)*



Fall 2004 Solution

Question 5 -- Transformers *(15 points)*

Below is a circuit containing a transformer and an op-amp circuit you should recognize from the homework and experiment 8. Assume R1 = 50 ohms, R2 = 5K ohms, and R3 = 200 ohms.



a) What is circuit 2 called and what does it do? *(3 points)*
Circuit 2 is a voltage follower (or buffer). It isolates the input from the output so the circuits on either side do not influence each other.

b) Given that the input inductance of the transformer, TX2, is 4mH and the output inductance is 400mH, determine the value of the constant "a" for the transformer. *(2 points)*

$a = \sqrt{(L2/L1)} = \sqrt{(400m/4m)} = 10$

c) Given the amplitude of the voltage at point A is 50mV and the transformer has perfect coupling, what is the amplitude of the voltage at point B? *(2 points)*

$V2/V1 = V_B/50m = 10 \quad V_B = 500mV$

d) For the same signal as described in part c, what is the amplitude of the voltage at point C? *(2 points)*

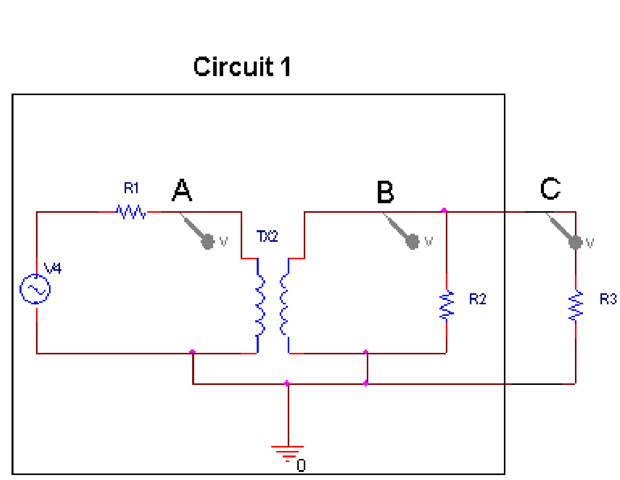
$V_C = 500mV$

e) For the same signal in parts c and d, find the amplitude of the current through the load resistor, R3. *(3 points)*

$I = V/R = 500mV/200 = 2.5mA$

f) If we remove circuit 2 and connect the load resistor, R3, directly to point B (as shown below), would the new value of the voltage at point B be greater than, less than, or equal to the value you determined in part c?   Why? *(3 points)*

*The voltage at point B would be less than the original circuit. The two resistors, R2 and R3 are now in parallel. The combined resistance is 192 ohms, (200*5K)/(200+5K). This is significantly smaller than the value of R2 alone, 5K. This would result in a much smaller voltage at point B.*

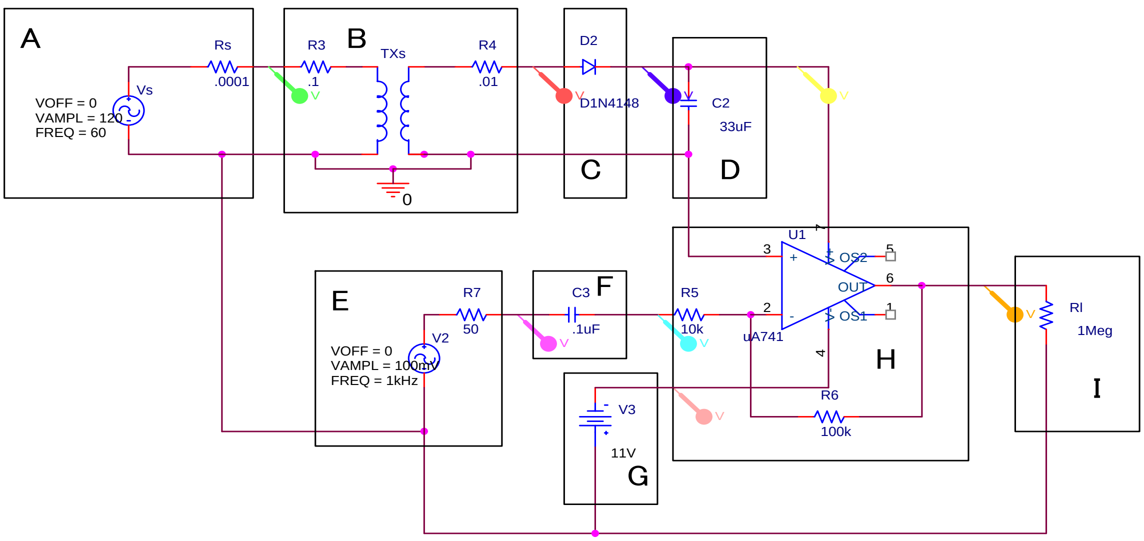


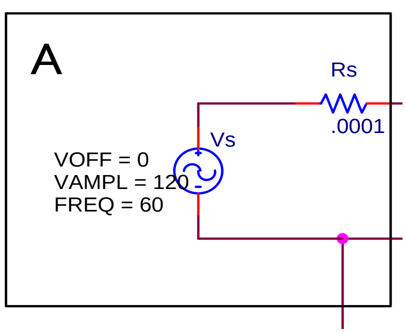
If we want to consider the transformer in the answer (this is not required), the argument is as follows:

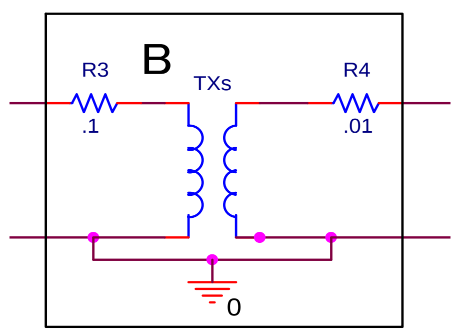
Zin = $R2/a^2$. Therefore, if R2 decreases, then Zin decreases. If Zin decreases, then V_A will also decrease. (V_A is determined by a voltage divider between R1 and Zin. Less impedance at Zin, means less voltage at A.) You cannot argue that the voltage at point B will not change because of the transformer. R2//R3 is much too close to the 50 ohm resistance of R1 to have no effect.

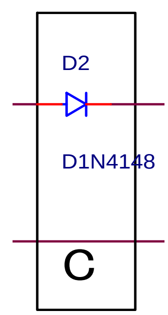
Fall 2003
Question 5 -- Circuit functionality and transformers *(20 points)*

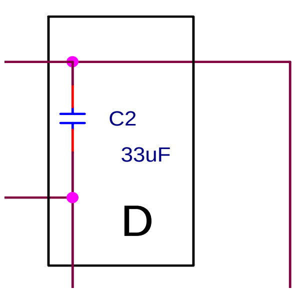
The following circuit was constructed to test two DC power supplies. One is a battery and one is a wall wart (connects to a normal 120V outlet). The boxes surrounding each part of the circuit identify the functional blocks (each has a specific purpose). Each of the boxes is also shown expanded for clarity.

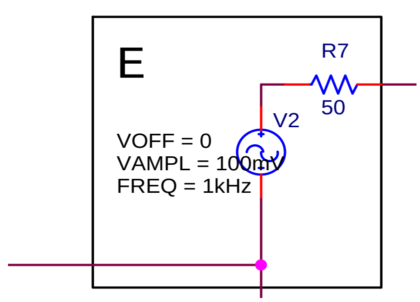


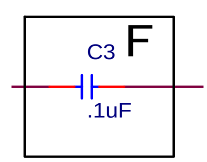


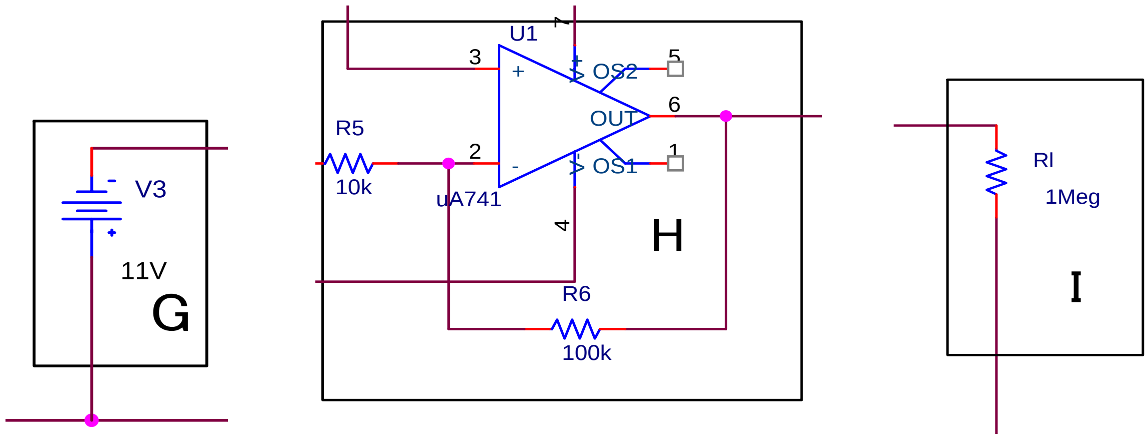












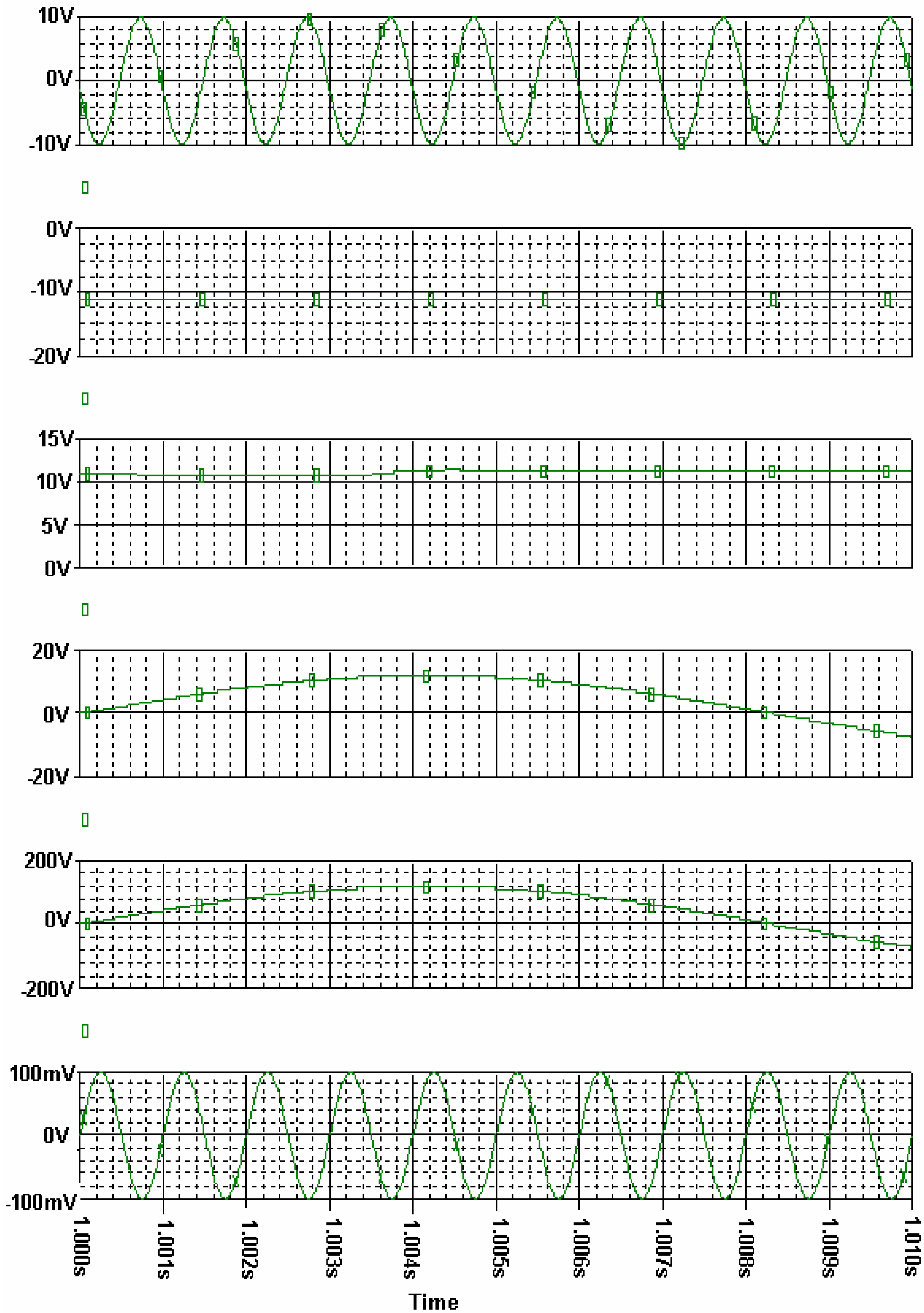
a. Identify the function of each of the nine blocks. (Draw a line to connect the letter of the block to its function). *(9 points)*

A	1. Measure output voltage
B	2. Rectify AC voltage
C	3. Input signal voltage
D	4. Block DC voltage while passing AC voltage
E	5. Smooth ripples to improve DC output voltage
F	6. Step AC voltage down from 120V to 12V
G	7. Provide AC power for DC supply
H	8. Amplify signal voltage
I	9. –12V power supply

b. On the next page are plotted six voltages measured at various points in the circuit. Identify each of the voltages by indicating the block for which this is the output voltage. Note that there are only six voltages but there are eight output points for the blocks. *(6 points)*

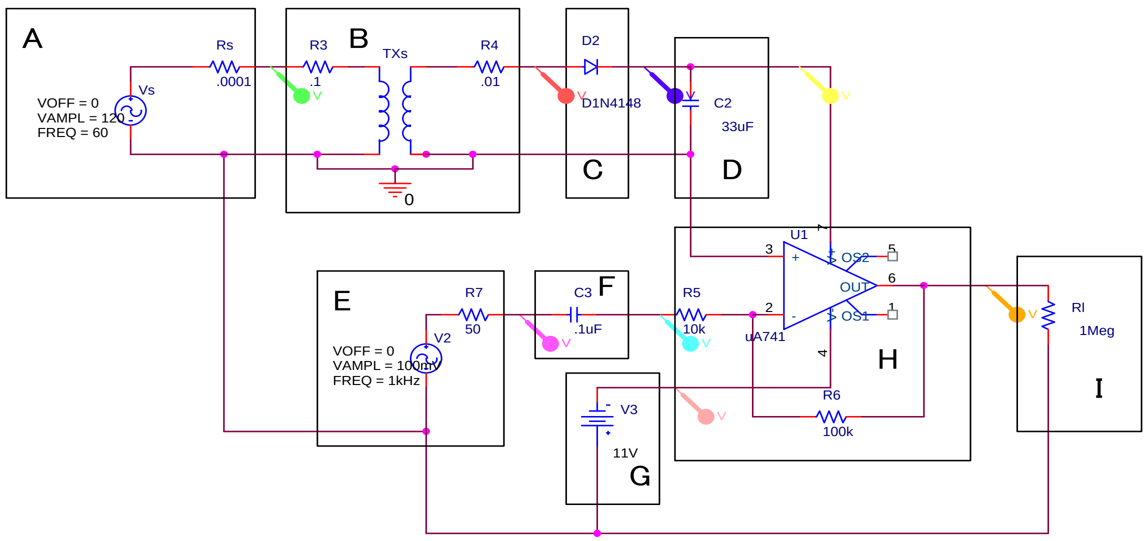
c. Based on the voltages you have just identified, what is the ratio of the input voltage to the output voltage of the transformer? Note that a real transformer is modeled here so that it has finite resistance in its windings. However, you can neglect these small resistances in the rest of this problem. *(3 points)*

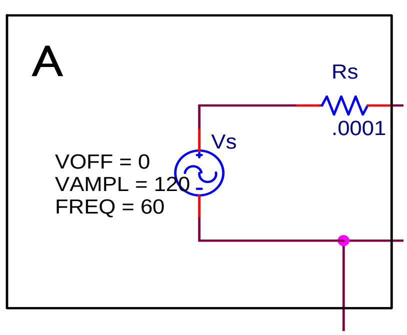
d. If the primary winding of the transformer has 10000 turns, how many turns does the secondary winding have to produce this change in voltage? (2 points)

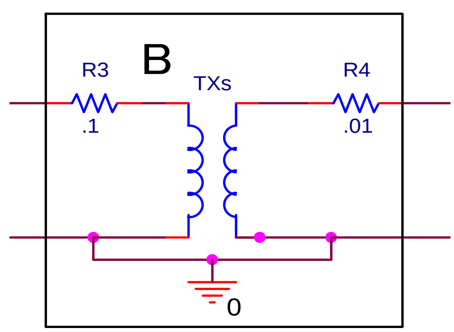

10V
0V
-10V
0V
-10V
-20V
15V
10V
5V
0V
20V
0V
-20V
200V
0V
-200V
100mV
0V
-100mV
1.000s
1.001s
1.002s
1.003s
1.004s
1.005s
1.006s
1.007s
1.008s
1.009s
1.010s
Time

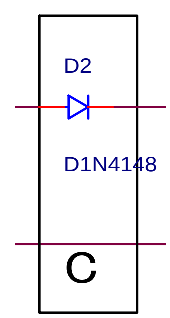
Fall 2003 Solution
Question 5 -- Circuit functionality and transformers *(20 points)*

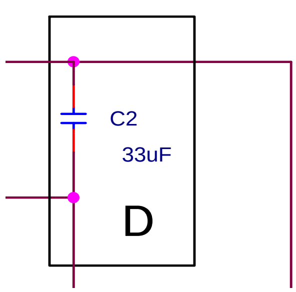
The following circuit was constructed to test two DC power supplies. One is a battery and one is a wall wart (connects to a normal 120V outlet). The boxes surrounding each part of the circuit identify the functional blocks (each has a specific purpose). Each of the boxes is also shown expanded for clarity.

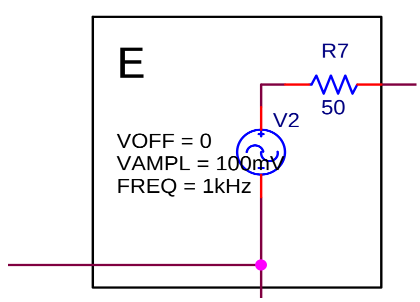


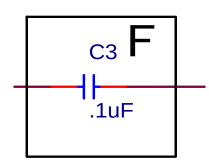


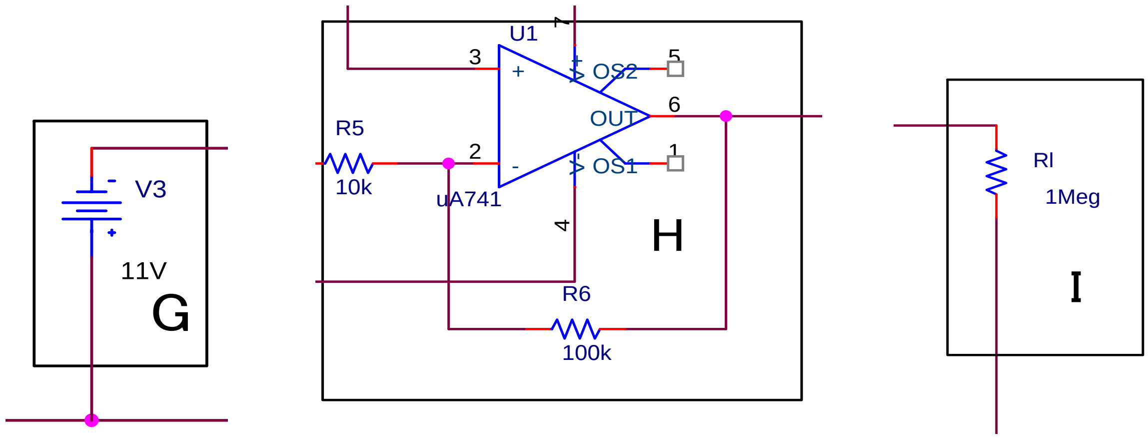












a. Identify the function of each of the nine blocks. (Draw a line to connect the letter of the block to its function). *(9 points)*

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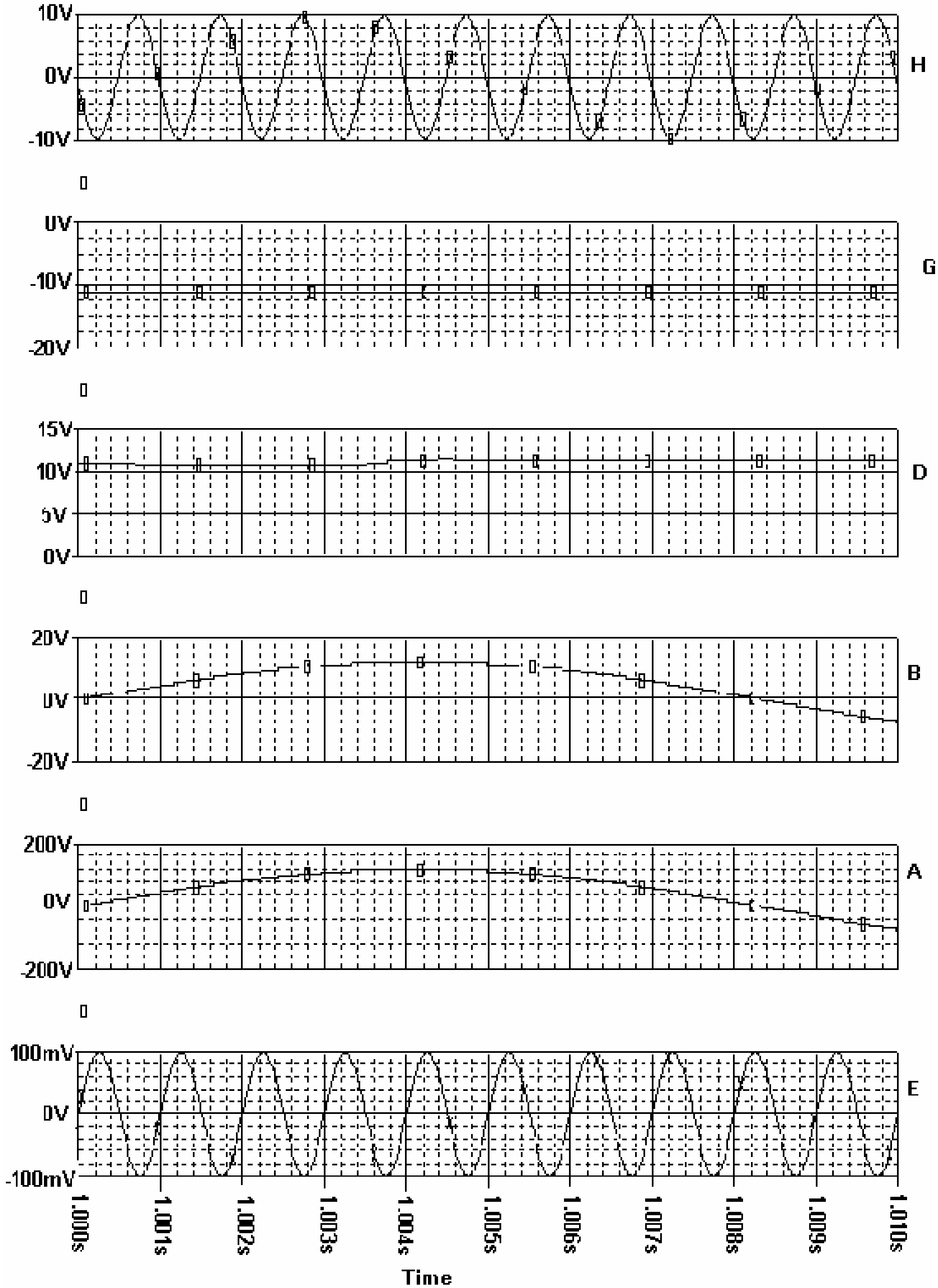
c. Based on the voltages you have just identified, what is the ratio of the input voltage to the output voltage of the transformer? Note that a real transformer is modeled here so that it has finite resistance in its windings. However, you can neglect these small resistances in the rest of this problem. *(3 points)*

120V : 12V = ***10 : 1***

d. If the primary winding of the transformer has 10000 turns, how many turns does the secondary winding have to produce this change in voltage? (2 points)

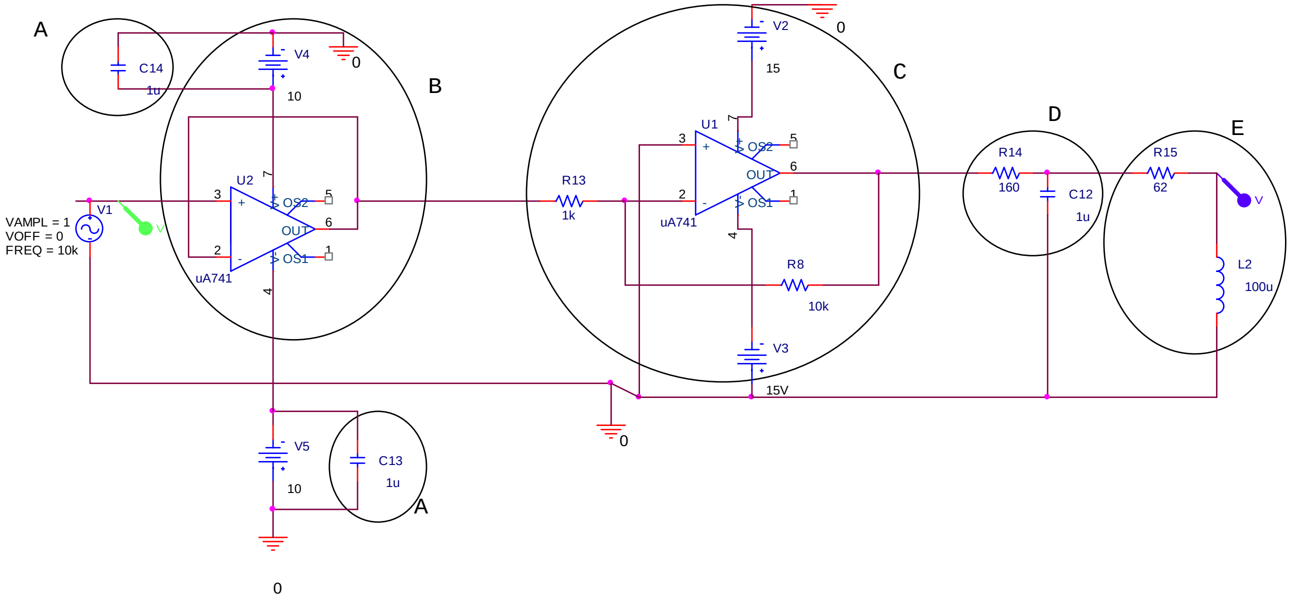
Test A: N2/10000 = 1/10 **N2 = 1000 turns**

Test B: N2/20000 = 1/10 **N2 = 2000 turns**

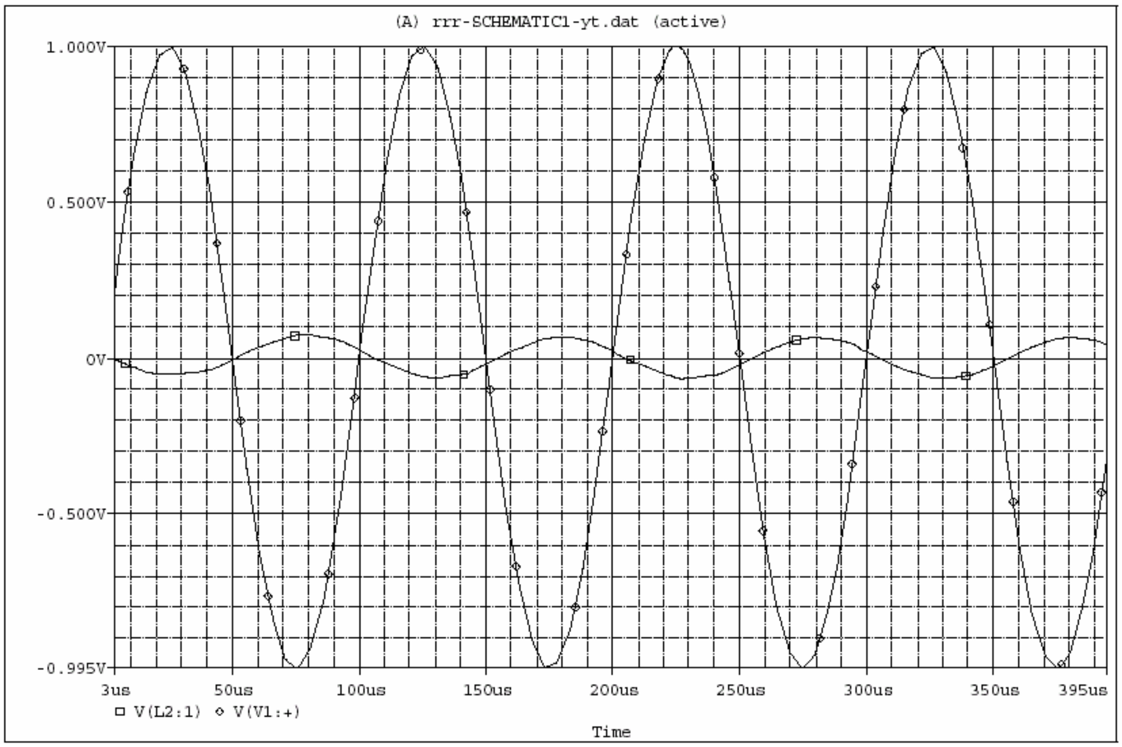


10V
0V
-10V
H
0V
-10V
-20V
G
15V
10V
5V
0V
D
20V
0V
-20V
B
200V
0V
-200V
A
100mV
0V
-100mV
E
1.000s
1.001s
1.002s
1.003s
1.004s
1.005s
1.006s
1.007s
1.008s
1.009s
1.010s
Time

Spring 2002
5) Circuit Functionality (20 pts)



Below is a graph of the input and output, just to give you some reference of what the circuit will do. The source is 1V at 10KHz.



List the functionality of each block, A,B,C,D and E. (4 pt each

Spring 2002 solution
5) Circuit Functionality (20 pts)

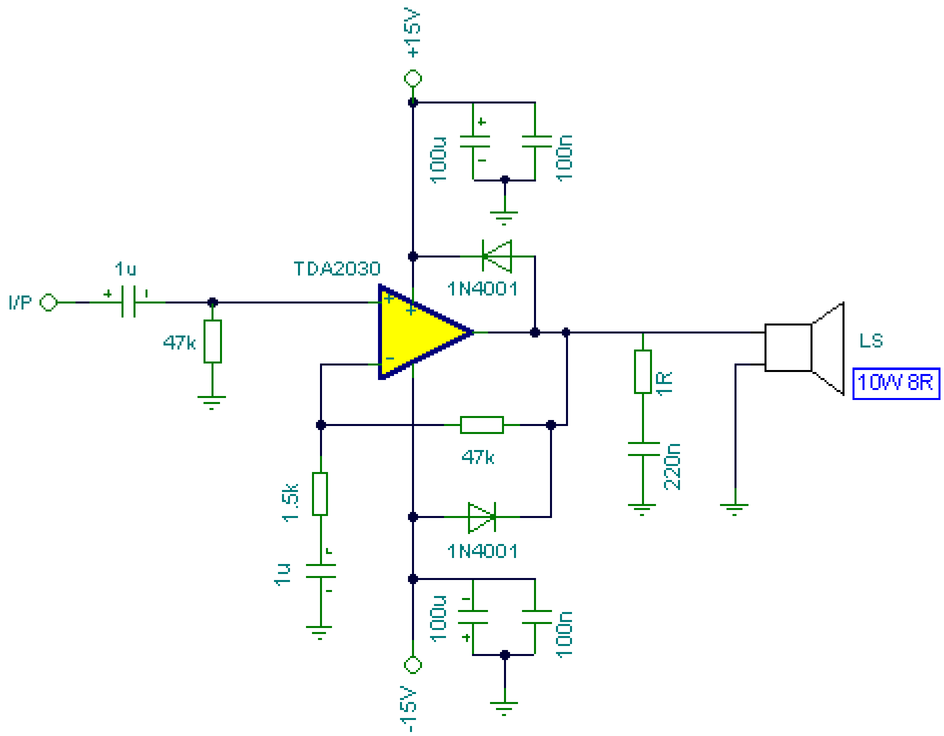
List the functionality of each block, A,B,C,D and E. (4 pt each)

A = bypass capacitors (filter out high frequency noise from power supply)
B = buffer or voltage follower
C= inverting amplifier
D = approximate integrator or low pass filter
(capacitor is open at low frequencies and short at high frequencies)
E = high pass filter
(inductor is short at low frequencies and open at high frequencies)

Fall 2000

5. Circuit Functionality

Shown below is an audio amplifier circuit.



Indicate on the circuit diagram where each of the following sub-circuits is found. Also, answer any questions asked.

Bypass Capacitors

Standard Amplifier (Is it an inverting or a non-inverting amplifier?)

Speaker

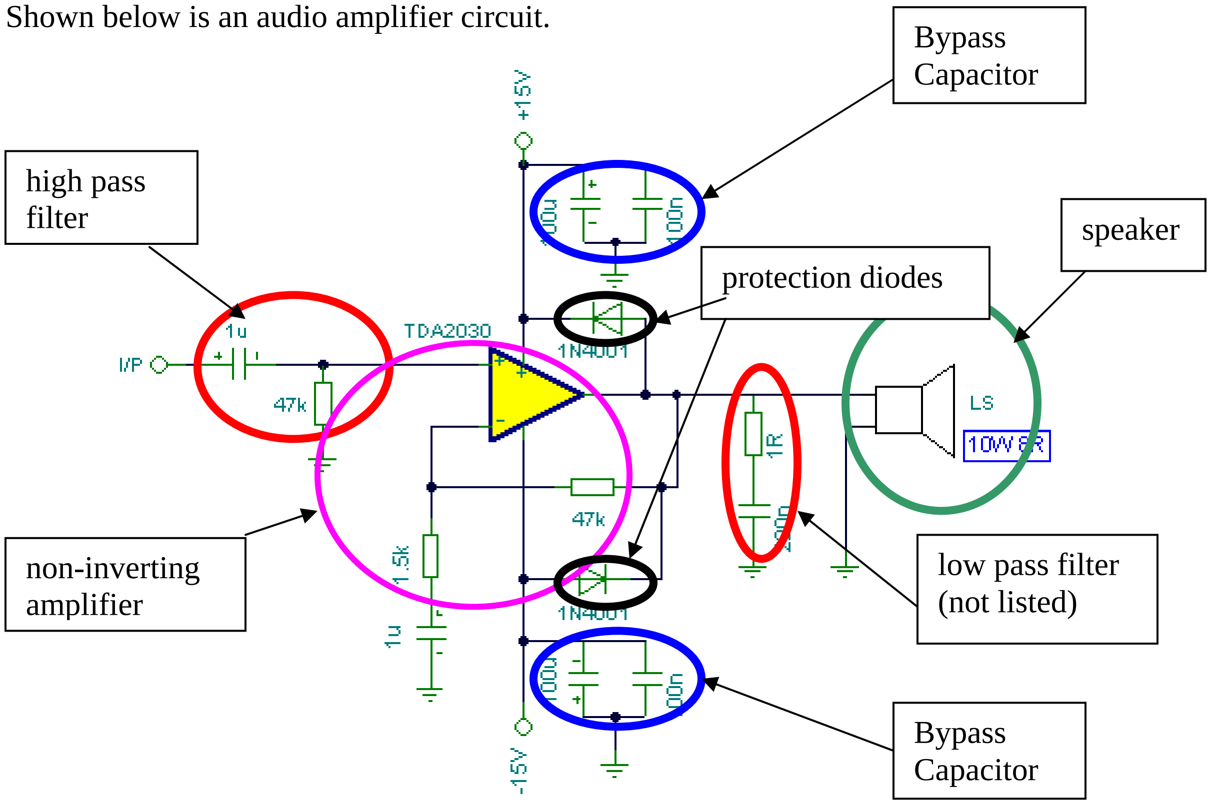
Protection Diodes

High Pass Filter (Give an example of a frequency that is blocked and a frequency that is passed)

Fall 2000 Solution

5. Circuit Functionality

Shown below is an audio amplifier circuit.



Indicate on the circuit diagram where each of the following sub-circuits is found. Also, answer any questions asked.

Bypass Capacitors

Standard Amplifier (Is it an inverting or a non-inverting amplifier?)

Speaker

Protection Diodes

High Pass Filter (Give an example of a frequency that is blocked and a frequency that is passed)

R=47K C=1μF fc=(1/2πRC) = 1/[(2)(π)(47K)(1μ)] = 3.4 Hertz

Frequency blocked = 1Hz (anything less than about 2 Hertz)
Frequency passed = 1K Hz (anything more than about 10 Hertz)