

C - Circuit Lab - C - Nov 7 Country-wide SO Practice - 11-07-2020

- You have 50 minutes to complete the test
- Each team member may have their own binder/calculator
- Binders must be printed (not digital)
- You may use any form of communication unless prohibited by coaches/schools
- Provide numeric answers using the appropriate metric prefix and round to 3 digits
- Ex: 0.000023456F -> 23.5uF

1. (10.00 pts) An ideal op-amp seeks to maintain what relationship between the inverting and non-inverting inputs?

- A) Inverting > Non-Inverting
- B) Inverting < Non-Inverting
- C) Inverting == Non-Inverting
- D) Inverting != Non-Inverting

2. (5.00 pts) An op-amp with no feedback can be used as a \_\_\_\_\_.

comparator

3. (15.00 pts) What is the Thevenin equivalent resistance of an ideal op-amp's non-inverting input terminal?

- A) Infinite resistance
- B) Zero Ohms
- C) Between 0 Ohms and 10k Ohms
- D) Between 10k Ohms and infinite resistance

4. (20.00 pts) Select the circuits that can be implemented using a single op-amp.

(Mark ALL correct answers)

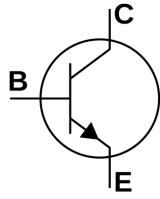
- A) Current Mirror
- B) Non-Inverting Amplifier
- C) Summing Amplifier
- D) Differential Amplifier
- E) Transimpedance Amplifier
- F) Instrumentation Amplifier

5. (25.00 pts) When using an NPN transistor as an amplifier, what parameter is varied to control the output?

- A)  $V_{ce}$
- B)  $V_{be}$
- C)  $I_{ce}$
- D)  $I_{be}$

- E)  $h_{fe}$

6. (5.00 pts)

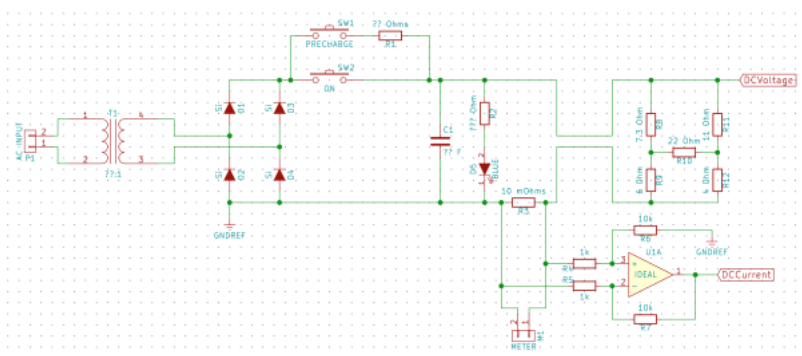


The above image is a PNP transistor.

- True  False

7. (15.00 pts) What parameter, often found on transistor data sheets, is the ratio of collector current to base current when the transistor is used as a common-emitter amplifier?

- A)  $V_{ce(sat)}$   
 B)  $V_{be}$   
 C)  $I_c$   
 D)  $h_{fe}$



In the following section, you will go through most of the design steps for an AC-DC rectifier (Full Bridge). The above schematic is included for reference, however, further questions will only involve specific portions at any given time.

8. (20.00 pts)

To construct the capacitor, C1, you can use two sheets of copper foil, both squares with a side length of 50m. You have the choice between the following two materials as an insulator

- Paper, 0.1mm,  $\epsilon_r = 1.4$
- Polypropylene, 0.05mm,  $\epsilon_r = 2.3$

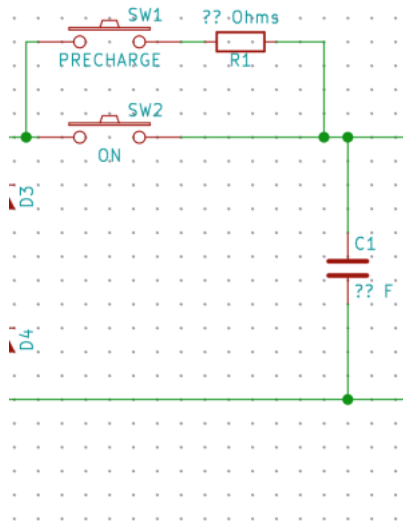
What's the largest value capacitor you can build?

- A) 1.02uF  
 B) 1020uF  
 C) 310uF  
 D) 20.4uF

9. (10.00 pts) The 'AC INPUT' terminals are connected to a standard US outlet (120v). What turns ratio is needed in T1 to achieve 480v across terminals 3 and 4?

- A) 4:1
- B) 1:4
- C) 2:3
- D) 3:8

10. (10.00 pts)



Assume 700Vdc is connected to the left-hand side of the circuit, and the capacitor from the previous question is used for C1. C1 is initially at 0v.

What is the current in the circuit at the instant SW2 is closed?

- A) 5A
- B) 0A
- C) 100A
- D) >750A

11. (15.00 pts)

The input to the rectifier is protected by a fuse that will blow if the current through switch 1 or 2 ever exceeds 150Adc. Determine the minimum resistance of R1 needed to prevent the fuse from blowing when SW1 is closed.

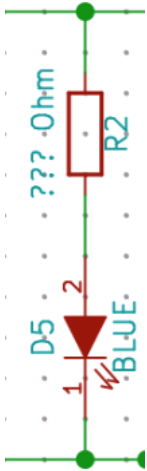
**Expected Answer:** 4.67 Ohms

12. (20.00 pts)

Experimentally, it's been determined that SW2 can be closed when C1 is charged to 690v without causing the fuses to blow. How long will SW1 need to be closed to charge the capacitor before SW2 can be closed?

- A) 20.2 ms
- B) 20.2  $\mu$ s
- C) 202 s
- D) 202 ms

13. (25.00 pts)



Circuits involving high voltages can be a dangerous business. As a safety feature, an LED has been added to indicate when the capacitor is charged to >50Vdc. The blue LED is visible with a forward current as low as 2mA, however, any more than 20mA will destroy the LED.

Approximately what is the forward voltage drop of the diode?

- A) 3.2V
- B) 2.2V
- C) 2V
- D) 0.7V

14. (18.00 pts)

To light the LED when C1 is charged to 50v, R2 should be \_\_\_\_\_ kOhms. With this resistor, the maximum voltage across C1 before the LED is destroyed is \_\_\_\_\_ volts.

23.4

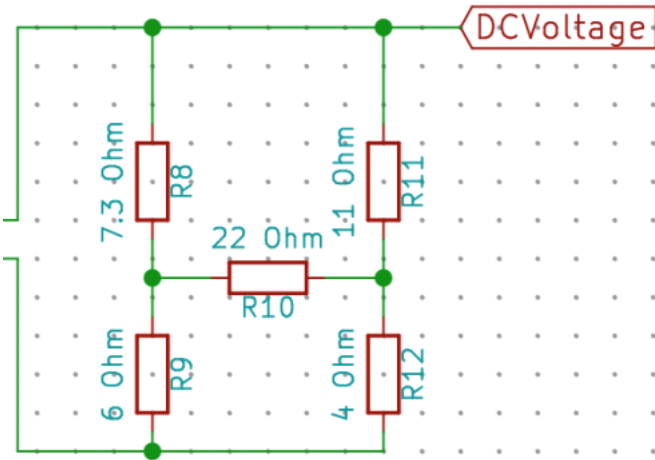
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15. (20.00 pts) Since the LED is a safety feature, what device could be used to regulate the current so it doesn't destroy itself at high DC voltages, but still is visible at 50vDC?

(Mark ALL correct answers)

- A) Current Source
- B) Resistor
- C) Zener Diode
- D) Capacitor

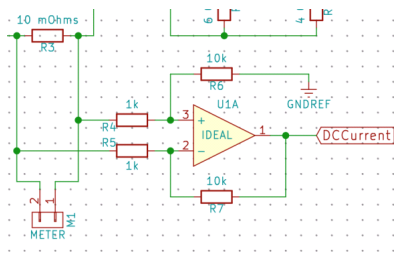
16. (25.00 pts)



Determine the power dissipated by the load when the rectifier is operating at 700Vdc. The voltage is applied across the two terminals on the left hand side.

- A) 50.1 kW
- B) 70 kW
- C) 102 kW
- D) 54.4 W

17. (10.00 pts)



What is the resistor R3 commonly called in this application?

- A) Resistor Bridge
- B) Voltage Divider Resistor
- C) Current Limiting Resistor
- D) Current Shunt Resistor

18. (30.00 pts) What is the voltage present at the 'DCCurrent' terminal when the rectifier is operating at 700Vdc?

Expected Answer: 10v

19. (15.00 pts)

The load resistors are connected to the rest of the circuit using two wires, spaced 1cm apart and 1m long. Compute the magnitude of the force between the two wires (in Newtons) due to their magnetic fields when the current through the load is 200A.

Expected Answer: 0.8 N

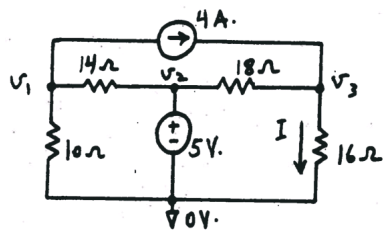
20. (25.00 pts) In which direction does the force cause the wires to move?

- A) Towards each other
- B) Away from each other

21. (18.00 pts) What is the distinction between 'hot' and 'neutral' in AC outlets?

- A) Hot swings positive, while neutral swings negative.
- B) Neutral is connected to the ground by the utility, while hot is not.
- C) Hot carries current flowing towards the outlet, while neutral carries current flowing away.
- D) Hot increases in temperature, while neutral does not.

22. (10.00 pts)



Using the above circuit, solve for the voltage at V2.

- A) -21.3V
- B) 5V
- C) 36.2V
- D) 2.26A

23. (40.00 pts) Solve for the voltage at V3.

- A) -21.3V
- B) 5V
- C) 36.2V
- D) 2.26A

24. (20.00 pts) Does the current source generate or absorb power?

- A) Generate
- B) Absorb

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Congratulations, you made it through the test! Remember, rankings will not be released, but the test, key, and your score will be available at the end of the contest.

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