QUESTIONS

1. After reading the Career Tasks section, describe the type of career in the area of solid-state devices that would be most attractive to you.
2. What is the approximate value of the R/CM^3 in the material used in practical solid-state devices?
3. How many crystals are used in the forming of a PN junction?
4. Describe forward bias as applicable to a diode.
5. Describe reverse bias as applicable to a diode.
6. Explain the zener effect.
7. Describe the relationship between V_Z and I_{ZT}.
8. How many PN junctions are used in forming a transistor?
9. Name the three terminals of a transistor.
10. What are the main operation regions of a transistor?
11. Most transistors today are fabricated with what material and what process?
12. What are the three transistor-circuit configurations?
13. What are the three key terms used to describe transistor switches?
14. What is the symbol and name for the current that flows when a transistor is in cutoff?
15. For a transistor not quite in saturation, the collector current is a product of what two terms?
16. Name and define the two components of a transistor's turn-on transition.
17. Name and define the two components of a transistor's turn-off transition.
18. What factor has the most influence on the switching times of a transistor?
19. Describe how transistors are connected in the darling configuration.
20. Name two advantages and two disadvantages of a soli state relay compared to an electromechanical relay.
21. Describe transistor biasing.
22. What are three rules of thumb in calculating the resisto in the four-resistor bias scheme?
23. Describe the operation of a transistor regulator.
24. Describe the purpose of the zener diode in a series an shunt voltage regulator.
25. Differentiate between a series regulator and a shunt reg ulator.
26. Describe the operation of a transistor inverter.
27. What is the function of a DC-to-DC converter?
28. What are the advantages of a switching power supply over a linear power supply?
29. In a full-bridge DC-to-DC converter, what happens to the waveform at the secondary AC of the transformer?
30. Describe how the depletion region in a JFET affects its operation.
31. Define the pinch-off voltage of the JFET.
32. Compare the three terminals of a BJT to the three termi nals of a MOSFET.
33. Describe the differences between the depletion-mode and the enhancement-mode MOSFET relative to doping and biasing.
34. What is the advantage of CMOS over bipolar technology?

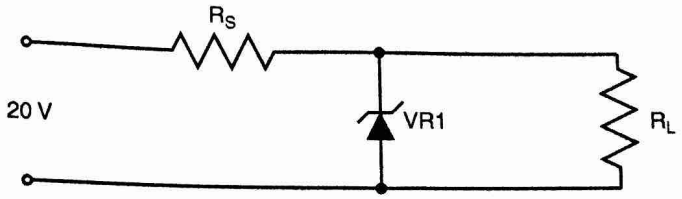
DATA SHEET QUESTIONS

1. Where is the polarity band located on the 1N4001 series rectifiers?
2. At room temperature, what is the maximum reverse current of a 1N4001?
3. What is the nominal zener voltage range for the 1N5333B series zeners?
4. What is the derating factor for the power dissipation of the 1N5333B series zeners when the temperature is above 75°C?
5. What is the maximum surge current of a 1N5334B?
6. What is the nominal zener voltage for a 1N5338B?
7. What is the maximum operating junction temperature of the P2N2222A?
8. What is terminal 2 of the P2N2222A called?
9. What is the maximum collector cutoff current of the P2N2222A at room temperature?
10. What is the minimum DC current gain of the P2N2222A in saturation with a collector current of 10 mA?
11. What is the minimum DC current gain of the P2N2222A op erating in the active region with a collector current of 1 mA?
12. What is the maximum storage time of the P2N2222A when it is used as a switch?

PROBLEMS

1. Calculate the value of R_S in Figure 3-48.
2. Calculate the collector current of a transistor in Figure 3-49 with a gain of 75 when (a) it's not quite in saturation (using the base current shown), and (b) it's in saturation with a saturation voltage of 0.2 volt.
3. Redraw Figures 3-16(a) and (b) using the transistor data in Figure 3-13 when the input pulse is 1 microsecond wide.
4. What is the base current necessary to saturate the darling ton configuration in Figure 3-17 when each transistor has a current gain of 75 and the load resistor is 330 ohms?

FIGURE 3-48 Problem 1



VR1 is an IN5349B.

FIGURE 3-49 Problem 2

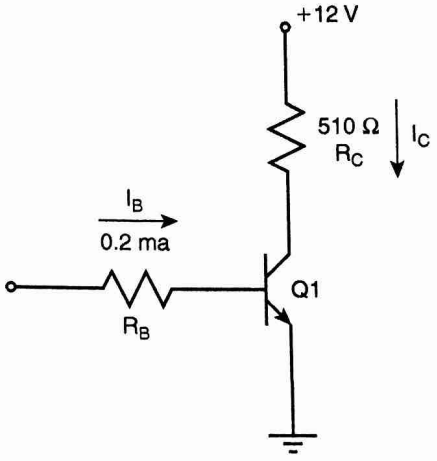
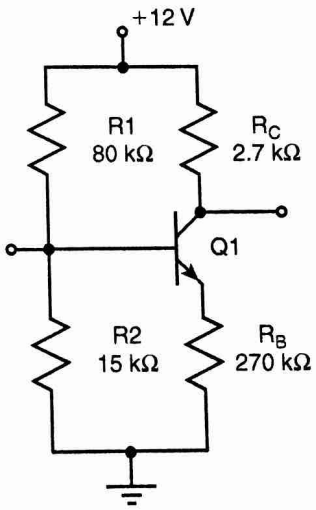


FIGURE 3-50 Problem 5



$h_{FE(MIN)} = 100$

5. Analyze the four-resistor biased BJT amplifier in Figure 3-50 and determine the following: I_C, I_B, I_E, V_C, and V_E.
6. Design a BJT common-emitter amplifier with a four-resistor biasing configuration. The circuit has an AC gain of 20 for an input voltage of less than 0.3 vpp, an input resistance greater than 5 kΩ, an output resistance less than 2.5 kΩ, a +24-V DC power supply for V_{CC}, and an h_{FE} of 100.
7. The amplifier designed in Problem 5 used a transistor with an h_{FE} of 100. The batch of transistors used to manufacture the design has an h_{FE} of 150. Calculate the new operating point V_C for the transistors with the higher h_{FE}.
8. Determine the minimum h_{FE} for Q2 in Figure 3-51 so that Q2 will turn completely on and activate the relay K1, whose coil needs 500 mA to energize with an h_{FE} for Q1 of 175.
9. How much voltage is dropped across Q1 in Figure 3-27 with a 5.1-V zener and a 10-V unregulated DC input?
10. How much voltage is dropped across R2 in Figure 3-28 with a 5.1-V zener and a 10-V unregulated DC input?

- Monolithic devices provide the complete instrumentation amplifier function, fully specified, usually factory trimmed, and often to a higher DC precision than discrete designs can.

4-14 Current-Differencing Amplifiers

- The current-differencing amplifier (CDA), or Norton amplifier, responds to a differential current.

4-15 Troubleshooting Op-Amp

- Malfunctions can be categorized as no output signal, low output signal, or distorted output signal.
- The first step in troubleshooting op-amps is to verify that the circuit is wired correctly.

QUESTIONS

1. After reading the Career Tasks section, describe the type of career in the area of operational amplifiers that would be most attractive to you.
2. What were two problems with the first manufactured solid-state monolithic operational amplifier?
3. Define the input offset current of an op-amp.
4. Define the output short-circuit current of an op-amp.
5. Define the slew rate of an op-amp.
6. Describe crosstalk.
7. What is a DIP?
8. Why is using the op-amp in the open-loop mode impractical in industrial applications?
9. What is negative feedback?
10. In industry, how are the power inputs of an op-amp handled on design schematics?
11. Describe when the output of an op-amp becomes clipped.
12. In an inverting op-amp, what input is a virtual ground?
13. How can an inverting op-amp's output offset be partially eliminated?
14. Compare and contrast the formulas for the gain of an inverting op-amp and the gain of a noninverting op-amp.
15. What is a summing amplifier?
16. What is a differential amplifier?
17. Compare and contrast a voltage-to-current converter with a current-to-voltage converter.
18. What op-amp configuration's output is proportional to the length of time that the input is present?
19. What op-amp configuration functions as a switch?
20. Describe the term *window* as it is used in a window detector.
21. What is an electronic filter?
22. What are the rules for determining the frequency range of low- and high-pass filters?
23. What are the rules for selecting components and op-amps in active filter design?
24. Define the cutoff frequency of a filter.
25. Define the roll-off of a filter.
26. What are the roll-off characteristics of a second-order filter?
27. What filter design would you use if a very flat frequency response within the pass-band is needed?
28. Describe a Bode plot.
29. Describe a bandpass filter.
30. How would you construct a bandpass filter?
31. What is the formula for Q of a bandpass filter?
32. In general, what is the Q for a wideband filter?
33. Compare a band-elimination filter to a notch filter.
34. How would you construct a band-elimination filter?
35. What is the purpose of an instrumentation amplifier?
36. How is the gain set on an instrumentation amplifier?
37. Describe mirror current as it applies to a CDA.
38. Explain the relationship between the reactance of the coupling capacitor and the resistance of the input resistor in a CDA circuit.
39. Describe the relationship between the DC and AC outputs of an inverting CDA circuit.
40. Explain why it is important to verify circuit connections first when troubleshooting an op-amp circuit failure.

DATA SHEET QUESTIONS

1. What is the typical input offset voltage of the MC34071A op-amp?
2. What is the minimum slew rate of the MC34071A op-amp?
3. What is the typical channel separation level of the MC34071A op-amp?
4. What is the maximum input voltage range of the MC34071A op-amp?
5. What is the maximum output saturation voltage of the LM119 comparator at temperatures less than 0°C?
6. What is the typical response time of the LM119 comparator?
7. What is the characteristic that distinguishes the LM119 from the LM219 comparator?
8. What instrumentation amplifier would you select if a gain of 1 was needed and the power supply is 15 V?

9. What is the part number of a dual INA322 instrumentation amplifier?
10. What is the typical slew rate for a unity gain LM359 CDA?
11. What would be the maximum output voltage swing for an LM359 CDA?
12. What is the purpose of the $I_{SET(IN)}$ and $I_{SET(OUT)}$ terminals on an LM359 CDA?

PROBLEMS

1. Calculate the closed-loop gain and output voltage of the inverting op-amp circuit in Figure 4-45.
2. Using the gain in Problem 1, what is the maximum input voltage swing needed to avoid a clipped output?
3. Calculate R_B in Figure 4-45.
4. Calculate the closed-loop gain and output voltage of the noninverting op-amp circuit in Figure 4-46.
5. Calculate the output voltage of the summing amplifier circuit in Figure 4-47 with $V_1 = -1.2$ V, $V_2 = +0.5$ V, and $V_3 = -2.8$ V.
6. Refer to Problem 5. If V_1 and V_3 remain the same, what is the value of V_2 to have an output voltage of +1.5 V?
7. Calculate the value of the feedback resistor for an output voltage of −7.5 V for the differential amplifier in Figure 4-12 when all other resistors are equal to 10 kΩ, and $V_1 = 1.9$ V and $V_2 = 2.4$ V.
8. Refer to Figure 4-15(a). Calculate the maximum value of V_{OUT} for a V_{IN} that is a 2-kHz square wave with a ±1.8-V amplitude.
9. Draw the input and output waveforms for Problem 8.
10. Calculate V_{OUT} in Figure 4-17 if R1 = 1.5 kΩ and C1 = 0.0047 μF, and if V_{IN} is a ramp input that goes from −5 V to +5 V in 100 μs.
11. Calculate the response time of an LM119 comparator in V/μs. Contrast it with the typical slew rate of an MC34071A op-amp.
12. For the CDA inverting amplifier in Figure 4-48, calculate the bias current and the AC gain.
13. Using the results of Problem 12, calculate the DC and the AC output voltage.

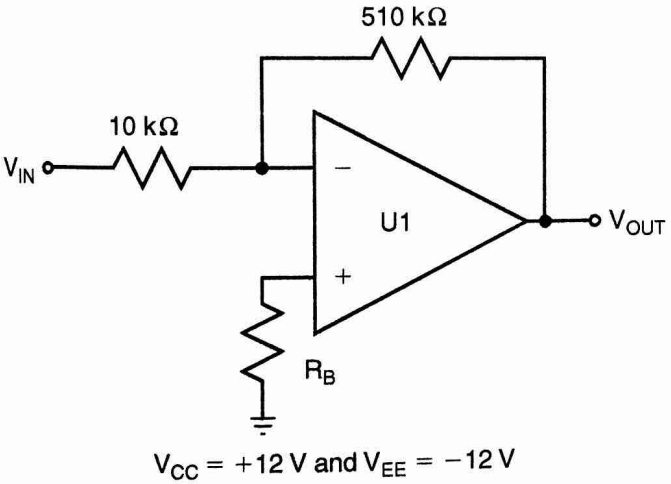


FIGURE 4-45 Op-amp circuit for Problems 1–3

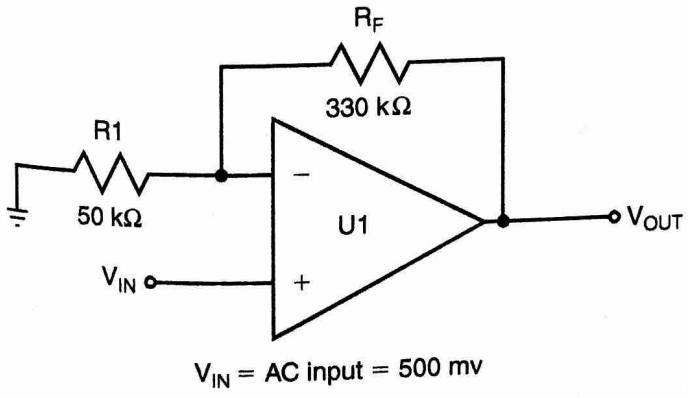


FIGURE 4-46 Op-amp circuit for Problem 4

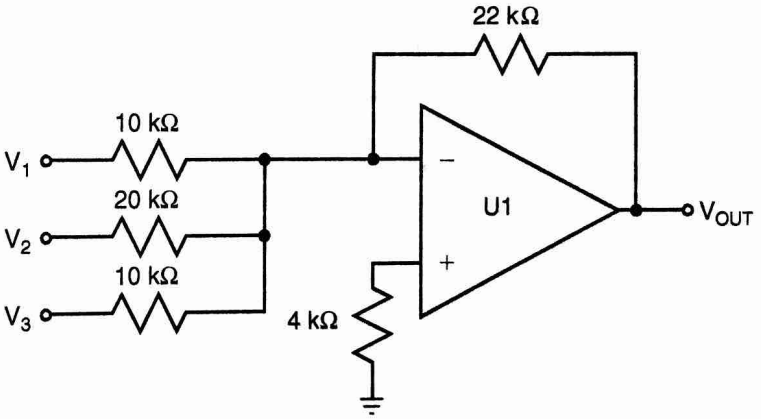


FIGURE 4-47 Op-amp circuit for Problems 5 and 6

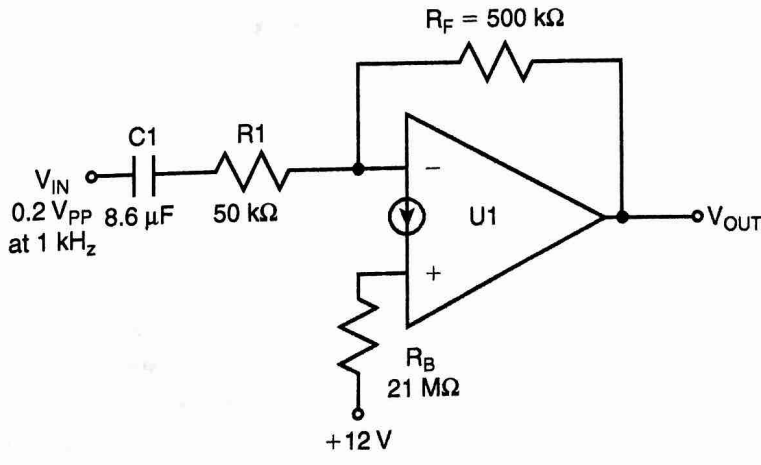


FIGURE 4-48 CDA circuit for Problems 12 and 13