

(17-16) First error voltage:

$$V_{1err} = (R_{B1} - R_{B2}) I_{in(bias)}$$

(17-17) Second error voltage:

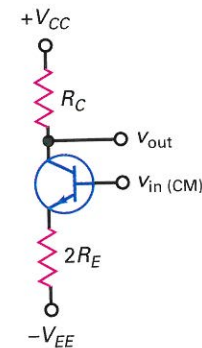
$$V_{2err} = (R_{B1} + R_{B2}) \frac{I_{in(off)}}{2}$$

(17-18) Third error voltage:

$$V_{3err} = V_{in(off)}$$

(17-19) Total output error voltage:

$$V_{error} = A_v(V_{1err} + V_{2err} + V_{3err})$$



(17-20) Common-mode voltage gain:

$$A_{v(CM)} = \frac{R_C}{2R_E}$$

## Student Assignments

### 1. Monolithic ICs are

- Forms of discrete circuits
- On a single chip
- Combinations of thin-film and thick-film circuits
- Also called hybrid ICs

### 2. The op amp can amplify

- AC signals only
- DC signals only
- Both ac and dc signals
- Neither ac nor dc signals

### 3. Components are soldered together in

- Discrete circuits
- Integrated circuits
- SSI
- Monolithic ICs

### 4. The tail current of a diff amp is

- Half of either collector current
- Equal to either collector current
- Two times either collector current
- Equal to the difference in base currents

### 5. The node voltage at the top of the tail resistor is closest to

- Collector supply voltage
- Zero
- Emitter supply voltage
- Tail current times base resistance

### 6. The input offset current equals the

- Difference between the two base currents
- Average of the two base currents

- Collector current divided by current gain
- Difference between the two base-emitter voltages

### 7. The tail current equals the

- Difference between the two emitter currents
- Sum of the two emitter currents
- Collector current divided by current gain
- Collector voltage divided by collector resistance

### 8. The voltage gain of a diff amp with an unloaded differential output is equal to $R_C$ divided by

- $r'_e$
- $r'_e/2$
- $2r'_e$
- $R_E$

### 9. The input impedance of a diff amp equals $r'_e$ times

- 0
- $R_C$
- $R_E$
- $2\beta$

### 10. A dc signal has a frequency of

- 0 Hz
- 60 Hz
- 0 to more than 1 MHz
- 1 MHz

### 11. When the two input terminals of a diff amp are grounded,

- The base currents are equal
- The collector currents are equal

- An output error voltage usually exists
- The ac output voltage is zero

### 12. One source of output error voltage is

- Input bias current
- Difference in collector resistors
- Tail current
- Common-mode voltage gain

### 13. A common-mode signal is applied to

- The noninverting input
- The inverting input
- Both inputs
- The top of the tail resistor

### 14. The common-mode voltage gain is

- Smaller than the voltage gain
- Equal to the voltage gain
- Greater than the voltage gain
- None of the above

### 15. The input stage of an op amp is usually a

- Diff amp
- Class B push-pull amplifier
- CE amplifier
- Swamped amplifier

### 16. The tail of a diff amp acts like a

- Battery
- Current source
- Transistor
- Diode

### 17. The common-mode voltage gain of a diff amp is equal to $R_C$ divided by

- $r'_e$
- $r'_e/2$
- $2r'_e$
- $2R_E$

### 18. When the two bases are grounded in a diff amp, the voltage across each emitter diode is

- Zero
- 0.7 V
- The same
- High

### 19. The common-mode rejection ratio is

- Very low
- Often expressed in decibels

- Equal to the voltage gain
- Equal to the common-mode voltage gain

### 20. The typical input stage of an op amp has a

- Single-ended input and single-ended output
- Single-ended input and differential output
- Differential input and single-ended output
- Differential input and differential output

### 21. The input offset current is usually

- Less than the input bias current
- Equal to zero
- Less than the input offset voltage
- Unimportant when a base resistor is used

### 22. With both bases grounded, the only offset that produces an error is the

- Input offset current
- Input bias current
- Input offset voltage
- $\beta$

### 23. The voltage gain of a loaded diff amp is

- Larger than the unloaded voltage gain
- Equal to  $\frac{R_C}{r'_e}$
- Smaller than the unloaded voltage gain
- Impossible to determine

## Problems

### SEC. 17-2 DC ANALYSIS OF A DIFF AMP

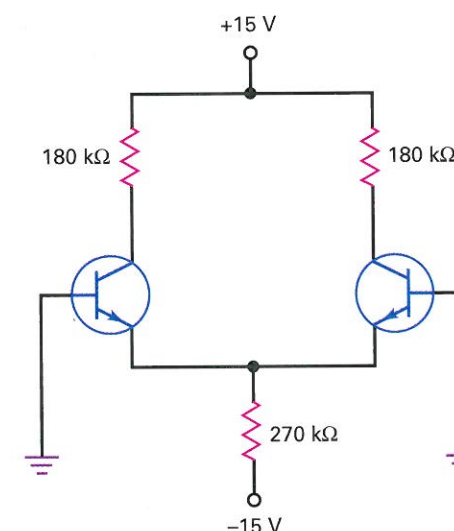
17-1 What are the ideal currents and voltages in Fig. 17-33?

17-2 **MultiSim** Repeat Prob. 17-1 using the second approximation.

17-3 What are the ideal currents and voltages in Fig. 17-34?

17-4 **MultiSim** Repeat Prob. 17-3 using the second approximation.

Figure 17-33



### SEC. 17-3 AC ANALYSIS OF A DIFF AMP

17-5 In Fig. 17-35, what is the ac output voltage? If  $\beta = 275$ , what is the input impedance of the diff amp? Use the ideal approximation to get the tail current.

17-6 Repeat Prob. 17-5 using the second approximation.

17-7 Repeat Prob. 17-5 by grounding the noninverting input and using an input of  $v_2 = 1$  mV.

### SEC. 17-4 INPUT CHARACTERISTICS OF AN OP AMP

17-8 The diff amp of Fig. 17-36 has  $A_v = 360$ ,  $I_{in(bias)} = 600$  nA,  $I_{in(off)} = 100$  nA, and  $V_{in(off)} = 1$  mV. What is the output error voltage? If a matching base resistor is used, what is the output error voltage?

17-9 The diff amp of Fig. 17-36 has  $A_v = 250$ ,  $I_{in(bias)} = 1$   $\mu$ A,  $I_{in(off)} = 200$  nA, and  $V_{in(off)} = 5$  mV. What is the output error voltage? If a matching base resistor is used, what is the output error voltage?

### SEC. 17-5 COMMON-MODE GAIN

17-10 What is the common-mode voltage gain of Fig. 17-37? If a common-mode voltage of  $20$   $\mu$ V exists on both bases, what is the common-mode output voltage?

17-11 In Fig. 17-37,  $v_{in} = 2$  mV and  $v_{in(CM)} = 5$  mV. What is the ac output voltage?

17-12 A 741C is an op amp with  $A_v = 100,000$  and a minimum  $CMRR_{dB} = 70$  dB. What is the common-mode voltage gain? If a desired and common-mode signal each has a value of  $5$   $\mu$ V, what is the output voltage?

17-13 If the supply voltages are reduced to  $+10$  V and  $-10$  V, what is the common-mode rejection ratio of Fig. 17-37? Express the answer in decibels.

17-14 The data sheet of an op amp gives  $A_v = 150,000$  and  $CMRR = 85$  dB. What is the common-mode voltage gain?

### SEC. 17-8 THE LOADED DIFF AMP

17-15 A load resistance of  $27$  k $\Omega$  is connected across the differential output of Fig. 17-36. What is the load voltage?

17-16 What is the load current in Fig. 17-36 if an ammeter is across the output?