(a) -1 V/V
(b) -10 V/V
(c) -20 V/V
(d) -0.5 V/V

D 2.14 Design an inverting op-amp circuit for which the gain is -5 V/V and the total resistance used is 6 kΩ.

D 2.15 Using the circuit of Fig. 2.5 and assuming an ideal op amp, design an inverting amplifier with a gain of 26 dB having the largest possible input resistance under the constraint of having to use resistors no larger than 100 kΩ. What is the input resistance of your design?

VE 2.1

2.16 An ideal op amp is connected as shown in Fig. 2.5 with $R_1 = 2$ kΩ and $R_2 = 8$ kΩ. A symmetrical square-wave signal with levels of 0 V and 1 V is applied at the input. Sketch and clearly label the waveform of the resulting output voltage. What is its average value? What is its highest value? What is its lowest value? Also sketch the current waveform through R_1, labeling its maximum, minimum, and average.

2.17 For the circuit in Fig. P2.17, assuming an ideal op amp, find the currents through all branches and the voltages at all nodes. Find the power dissipated in each resistor, and the total power dissipated in all resistors. How much power is delivered by the -1-V input source? Where does the rest of the power come from?

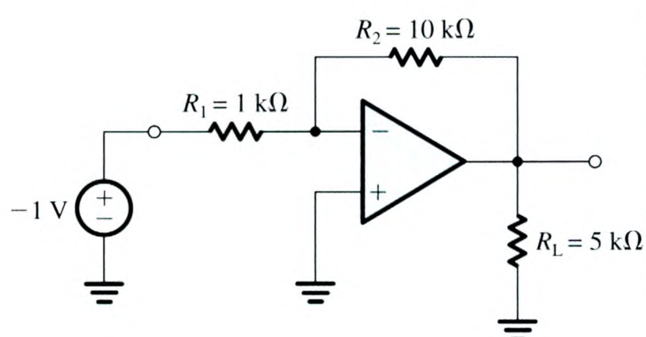

Figure P2.17

2.18 In the circuit of Fig. P2.17, what is the current flowing through the output of the ideal op amp? If we wish to use a practical op amp that has a specified maximum output current of 2.5 mA, how may the values of the resistors R_1 and R_2 be changed so that the gain remains the same?

2.19 An inverting op-amp circuit is fabricated with the resistors R_1 and R_2 having $x\%$ tolerance (i.e., the value of each resistance can deviate from the nominal value by as much as $\pm x\%$). What is the tolerance on the realized closed-loop gain? Assume the op amp to be ideal. If the nominal closed-loop gain is -100 V/V and $x = 1$, what is the range of gain values expected from such a circuit?

2.20 An ideal op amp with 5-kΩ and 10-kΩ resistors is used to create a $+2.5$-V supply from a -5-V reference. Sketch the circuit. What are the voltages at the ends of the 5-kΩ resistor? If these resistors are so-called 1% resistors, whose actual values are the range bounded by the nominal value $\pm 1\%$, what are the limits of the output voltage produced? If the -5-V supply can also vary by $\pm 1\%$, what is the range of the output voltages that might be found?

D 2.21 An inverting op-amp circuit for which the required gain is -50 V/V uses an op amp whose open-loop gain is only 200 V/V. If the larger resistor used is 100 kΩ, to what must the smaller be adjusted? With what resistor must a 2-kΩ resistor connected to the input be shunted to achieve this goal? (Note that a resistor R_a is said to be shunted by resistor R_b when R_b is placed in parallel with R_a.)

D 2.22 (a) Design an inverting amplifier with a closed-loop gain of -200 V/V and an input resistance of 1 kΩ.
(b) If the op amp is known to have an open-loop gain of 5000 V/V, what do you expect the closed-loop gain of your circuit to be (assuming the resistors have precise values)?
(c) Give the value of a resistor you can place in parallel (shunt) with R_1 to restore the closed-loop gain to its nominal value. Use the closest standard 1% resistor value (see Appendix J).
(d) Alternatively, give the closest standard resistor value that may be connected in series with R_2 to restore the closed-loop gain to its ideal value.

2.23 An op amp with an open-loop gain of 5000 V/V is used in the inverting configuration so that its output voltage ranges from -10 V to $+10$ V. What is the maximum voltage by which the "virtual ground node" departs from its ideal value?

2.24 The circuit in Fig. P2.24 is frequently used to provide an output voltage v_o proportional to an input signal current i_i.