HW8_EE341_Fall2019

10 points for each problem except for Spice problem that is 60 points (total 200 points)

6.1 The terminal voltages of various *npn* transistors are measured during operation in their respective circuits with the following results:

Case	E	B	C	Mode
1	0	0.7	0.7	
2	0	0.8	0.1	
3	−0.7	0	1.0	
4	−0.7	0	−0.6	
5	1.3	2.0	5.0	
6	0	0	5.0	

In this table, where the entries are in volts, 0 indicates the reference terminal to which the black (negative) probe of the voltmeter is connected. For each case, identify the mode of operation of the transistor.

6.7 Consider an *npn* transistor whose base–emitter drop is 0.76 V at a collector current of 5 mA. What current will it conduct at $v_{BE} = 0.70$ V? What is its base–emitter voltage for $i_C = 5\ \mu A$?

Assume "active"

6.16 When operated in the active mode, a particular *npn* BJT conducts a collector current of 1 mA and has $v_{BE} = 0.70$ V and $i_B = 10\ \mu A$. Use these data to create specific transistor models of the form shown in Fig. 6.5(a) to (d).

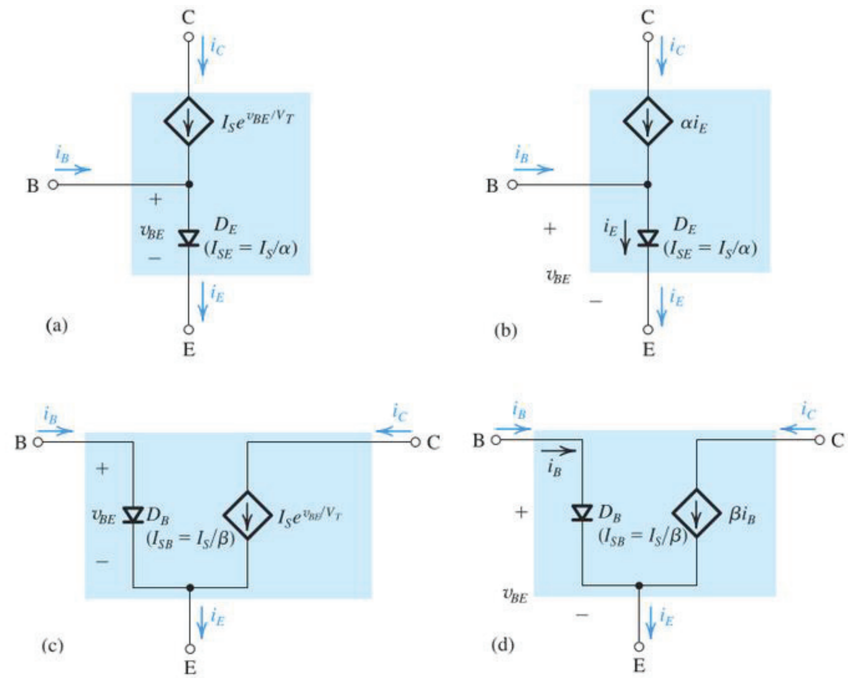


Figure 6.5 Large-signal equivalent-circuit models of the *npn* BJT operating in the forward active mode.

6.28 For the circuits in Fig. P6.28, assume that the transistors have very large β. Some measurements have been made on these circuits, with the results indicated in the figure. Find the values of the other labeled voltages and currents.

only (a) and (d)

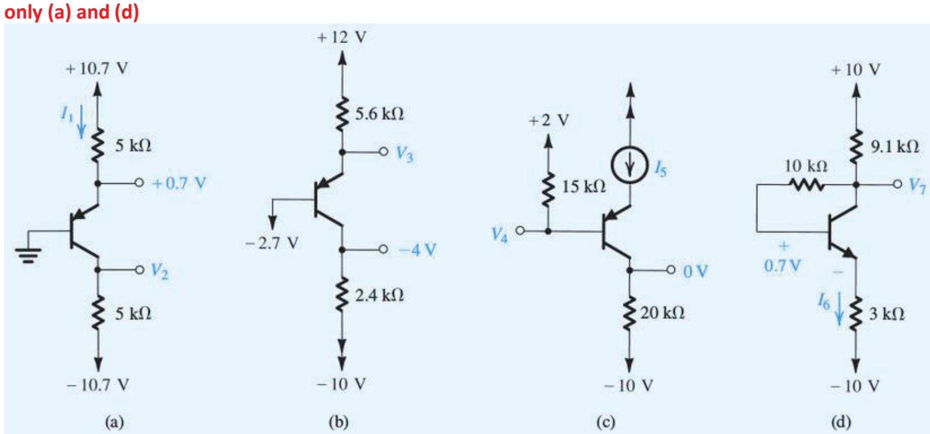


Figure P6.28

6.35 For each of the circuits shown in Fig. P6.35, find the emitter, base, and collector voltages and currents. Use $\beta = 50$, but assume $|V_{BE}| = 0.8$ V independent of current level.

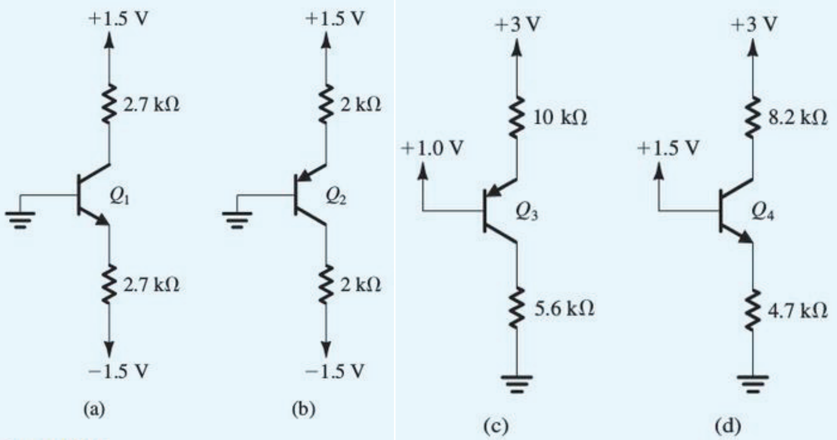


Figure P6.35

6.59 In the circuit shown in Fig. P6.58, the transistor has $\beta = 50$. Find the values of V_B, V_E, and V_C, and verify that the transistor is operating in the active mode. What is the largest value that R_C can have while the transistor remains in the active mode?

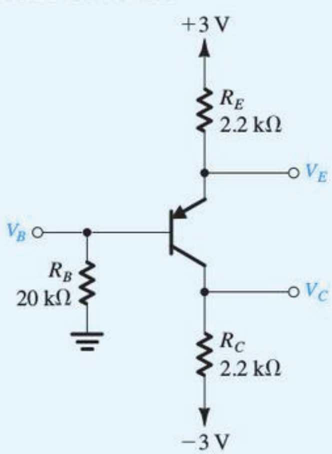


Fig. P6.58

***6.66** For the circuit shown in Fig. P6.66, find the labeled node voltages for:

(a) $\beta = \infty$

(b) $\beta = 100$

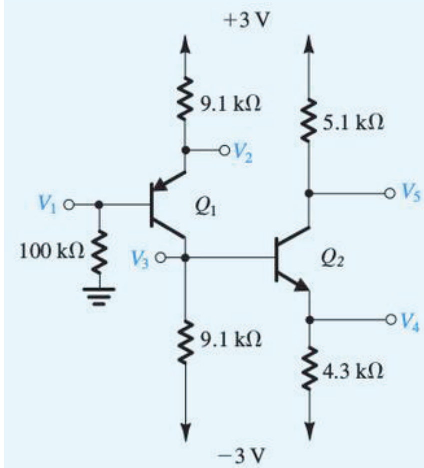


Fig. P6.66

7.51 Figure P7.51 shows a transistor with the collector connected to the base. The bias arrangement is not shown. Since a zero v_{BC} implies operation in the active mode, the BJT can be replaced by one of the small-signal models of Figs. 7.24 and 7.26. Use the model of Fig. 7.26(b) and show that the resulting two-terminal device, known as a diode-connected transistor, has a small-signal resistance r equal to r_e.

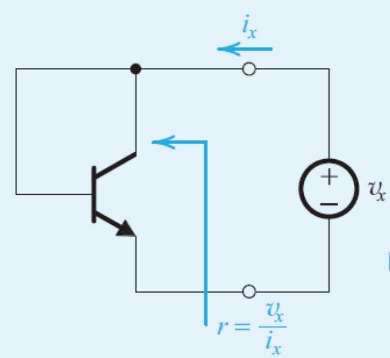


Figure P7.51

7.54 In the circuit shown in Fig. P7.54, the transistor has a β of 200. What is the dc voltage at the collector? Replacing the BJT with one of the hybrid-π models (neglecting r_o), draw the equivalent circuit of the amplifier. Find the input resistances R_{ib} and R_{in} and the overall voltage gain (v_o/v_{sig}). For an output signal of ± 0.4 V, what values of v_{sig} and v_b are required?

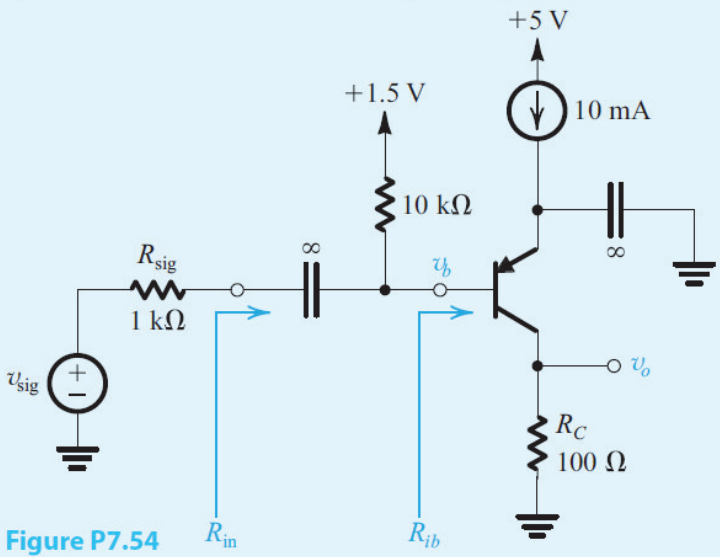


Figure P7.54

8.49 Transistor Q_1 in the circuit of Fig. P8.49 is operating as a CE amplifier with an active load provided by transistor Q_2, which is the output transistor in a current mirror formed by Q_2 and Q_3. (Note that the biasing arrangement for Q_1 is *not* shown.)

(a) Neglecting the finite base currents of Q_2 and Q_3 and assuming that their $V_{BE} \simeq 0.7$ V and that Q_2 has five times the area of Q_3, find the value of I.

(b) If Q_1 and Q_2 are specified to have $|V_A| = 30$ V, find r_{o1} and r_{o2} and hence the total resistance at the collector of Q_1.

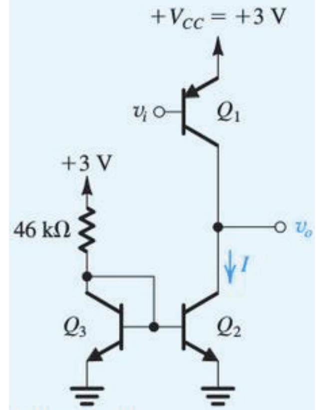


Figure P8.49

(c) Find $r_{\pi 1}$ and g_{m1} assuming that $\beta_1 = 50$.

(d) Find R_{in}, A_v, and R_o.

D 8.85 (a) The circuit in Fig. P8.85 is a modified version of the Wilson current mirror. Here the output transistor is "split" into two matched transistors, Q_3 and Q_4. Find I_{O1} and I_{O2} in terms of I_{REF}. Assume all transistors to be matched with current gain β.

(b) Use this idea to design a circuit that generates currents of 0.1 mA, 0.2 mA, and 0.4 mA, using a reference current source of 0.7 mA. What are the actual values of the currents generated for $\beta = 50$?

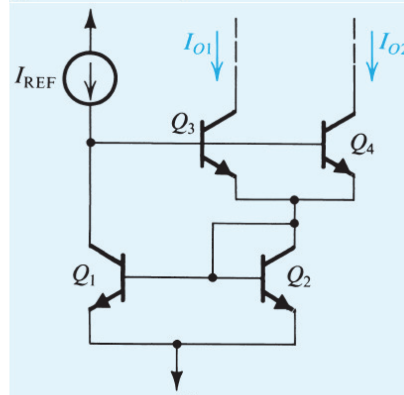


Figure P8.85

8.96 The transistors in the circuit of Fig. P8.96 have $\beta = 100$ and $V_A = 50$ V.

(a) Find R_{in} and the overall voltage gain.
(b) What is the effect of increasing the bias currents by a factor of 10 on R_{in}, G_v, and the power dissipation?

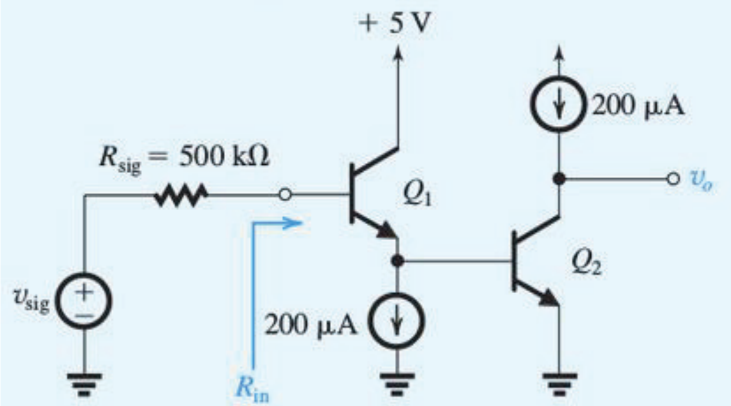


Figure P8.96

8.98 The BJTs in the Darlington follower of Fig. P8.98 have $\beta = 100$. If the follower is fed with a source having a 100-kΩ resistance and is loaded with 1 kΩ, find the input resistance and the output resistance (excluding the load). Also find the overall voltage gain, both open-circuited and with load. Neglect the Early effect.

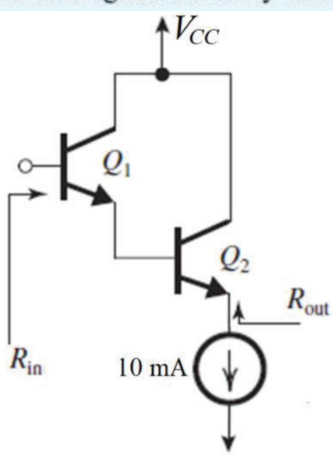


Fig. P9.98

****8.101** In each of the six circuits in Fig. P8.101, let $\beta = 100$, and neglect r_o. Calculate the overall voltage gain.

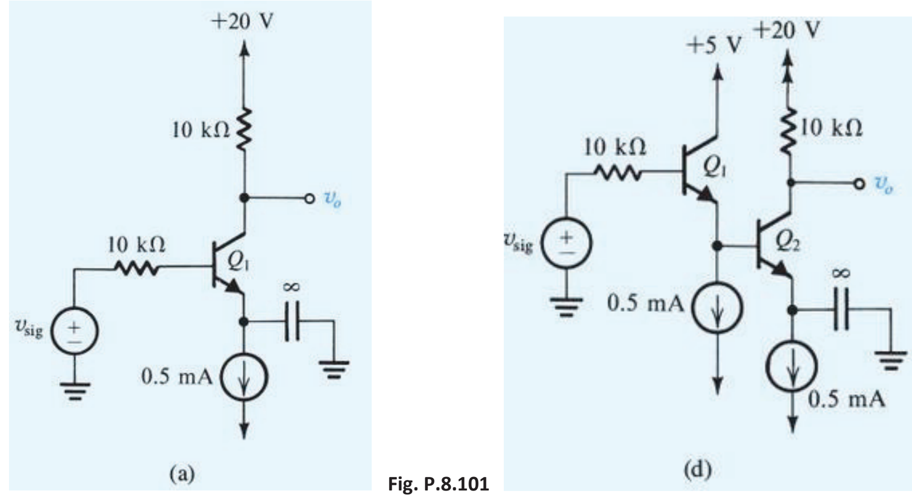


Fig. P.8.101

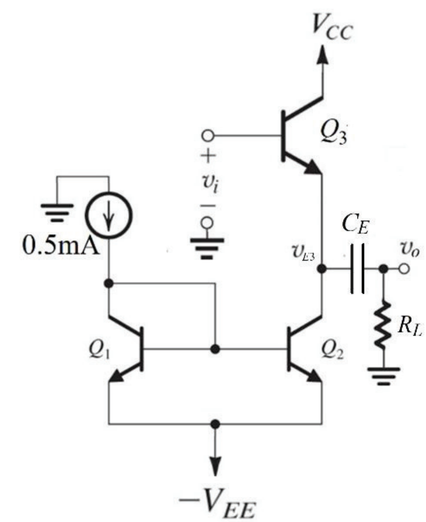
Spice Problem (60%)

Q1-Q3 are all identical with a BJT model whose Spice parameters are given below

IS=1fA, NF=1.1, NR = 1.5, BF=50, BR = 10, VAF=20V, VAR =10V, CJE=0.3nf, CJC=0.2nf, CJS=0.5nf, TR=1ns and TF = 1ns

where the ideality factors for BE and BC junctions are NF and NR, Early voltage V_A = VAF, the common emitter current gain $\beta \approx$ BF

$V_{CC} = V_{EE}$ = 3.5V, R_L = 10kΩ and C_E = 1uF



1. Perform Spice simulation with an ac input and use .ac to sweep the frequency from 10Hz to 100MHz (**100meg** in Spice). Plot v_o/v_i. Answer the following questions
   (a) Theoretically calculate the voltage gain compared to the midband gain observed in Spice simulation, where in the midband the gain is nearly constant and the phase difference between v_o and v_i is nearly 0°.

(b) Change C_E to 10uF and plot v_o/v_i using the same scale/division as that in (a) on the vertical and horizontal axes. Discuss why these 2 Bode plots are different in the low frequency? Use the $R_{eq}C_E$ time constant to estimate the lower corner frequency f_{3dB} compared with the observed value in Spice, $R_{eq}C_E = \omega_{3dB} \approx 2\pi f_{3dB}$ for a single pole circuit.

2. Perform Spice simulation with C_E = 1uF and input voltage $v_i(t) = 2V sin(\omega t)$ at 10kHz. Plot v_i, v_C and v_o. Answer the following questions
   (a) Explain how this follower works. Why doesn't v_C follows v_i? Theoretically find the relation between v_C follows v_i, compared with the observation in Spice.
   (b) Change C_E to 0.01uF and observe the change(s). explain your findings qualitatively.

SPICE information on BJTs

- The BJT element statement in SPICE:
  q*xxx* *C B E modelname*
  q*xxx* is the BJT device name that must start with q. *xxx* could be any character or number. *modelname* is the name of the BJT model that appears in the model statement. *C, B, E* are the node numbers for the collector, base, and emitter, respectively
- The npn BJT model statement
  .model *modelname* npn *values of parameters*
- The pnp BJT model statement
  .model *modelname* pnp *values of parameters*
  modelname is the name of the BJT model that also appears in the BJT element statement. Many transistors may use the same model name, meaning these BJT are identical