Analog Circuits (EE3002/EE5310) : Problem Set 10

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1

For the transistor shown, $\beta = 99$, and V_{BE} is nominally $0.65\,\mathrm{V}$. Find the quiescent V_{CE}, r_i, r_o and the incremental voltage gain. Assume $v_i = (1\,\mathrm{mV})\sin\omega t$. All capacitors are infinite.

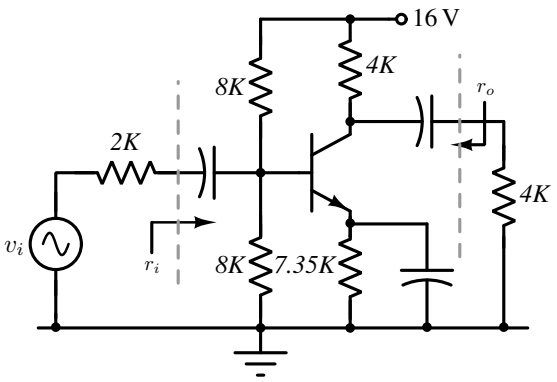

Figure 1: Figure for problem 1.

2

In the circuit shown, use $\alpha = 0.995$, $V_T = 25\,\mathrm{mV}$. The quiescent V_{CE} must be 5 V and r_i - the resistance presented by the circuit to the driving source v_i must be 1.5 K. Use $V_{BE} = 0.7\,\mathrm{V}$ nominally. Calculate V_{cc}, R_1 & R_2 to get a small signal gain of -200.

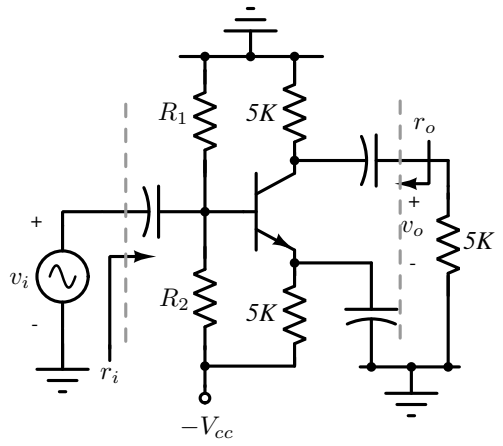

Figure 2: Circuit for problem 2.

3

The signal picture of an amplifier is as shown.

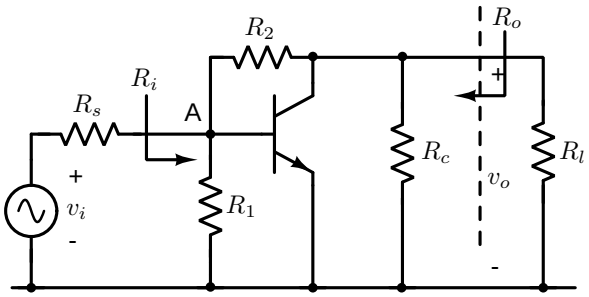

Figure 3: Circuit for problem 3.

Find R_i, R_o and $\frac{v_o}{v_i}$ in terms of g_m, β and r_o (the incremental output resistance of the device). Find their limits when $\beta \to \infty$. The signal is small.

4

Assume in the figure shown that g_m is high enough to make the incremental voltage gain $\frac{v_o}{v_i}$ independent of the device. Assume all capacitors are large. Also assume that $aR \| (1-a)R \ll (1+\beta)R$. Take V_{EB} = 0.7 V nominally; $I_E R_e$ = 4.3 V. A gain of -4 is needed with the circuit being just capable of handling a maximum amplitude of 2 V for the input sinusoid v_i. V_{ee} should be the minimum possible for the specified $I_E R_E$. Calculate R_1, R_e, V_{ee} and a.
Next remove the external load of 12 K. What will the limiting swings possible for v_o on either side now ? To what maximum amplitude will you have to restrict v_s if v_o is to be a full undistorted sine wave ?

5

The input sine wave has $v_i = 2.5\,\mathrm{V}$. To get an undistorted output within swing limits, calculate V_{cc} and R. Take V_{BE} nominal = 0.65 V. Also calculate R_i for small signals given that $\beta = 100$ and V_T = 25 mV.

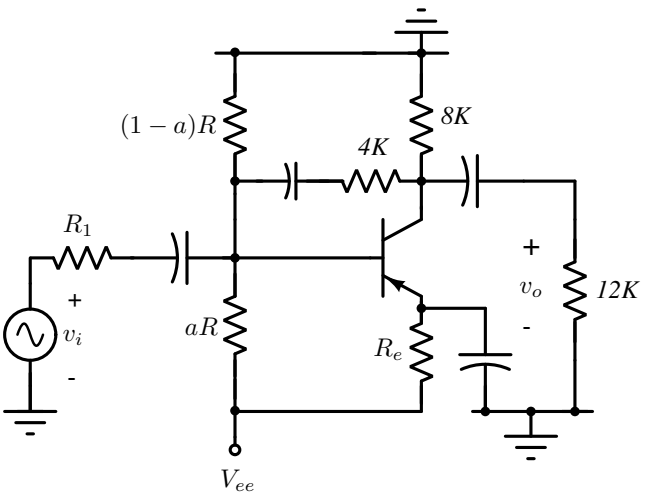

Figure 4: Circuit for problem 4.

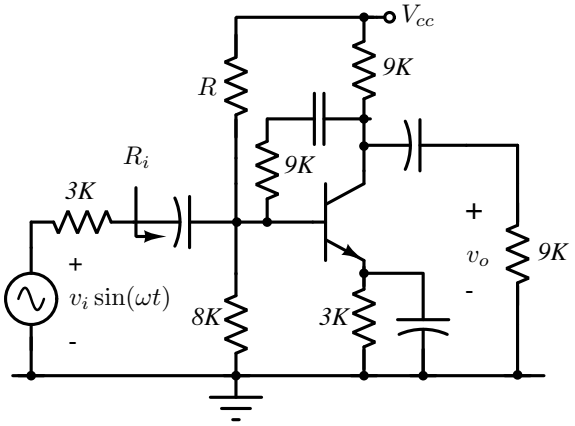

Figure 5: Circuit for problem 5.

6

V_{BE} = 0.65 V nominally. V_T = 25 mV. For small signals, find R_i and $\frac{v_o}{i_s}$. Assume β = 250.

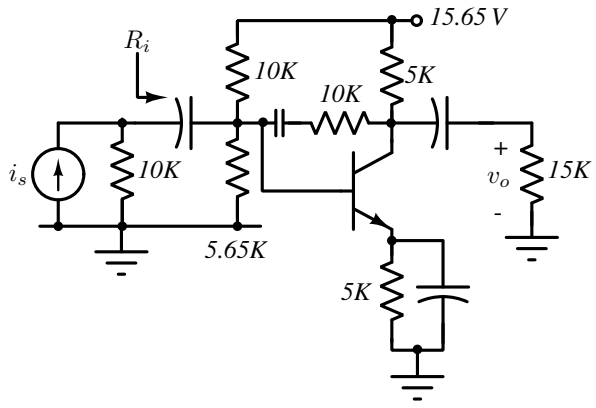

Figure 6: Circuit for problem 6.

7

The capacitances are very large. v_o, the output sinusoid, is to be linked with the input sinusoid by a device independent gain factor of 2, with a limiting amplitude of 8 V before clipping sets in. v_o should just begin to distort at both the extremes.

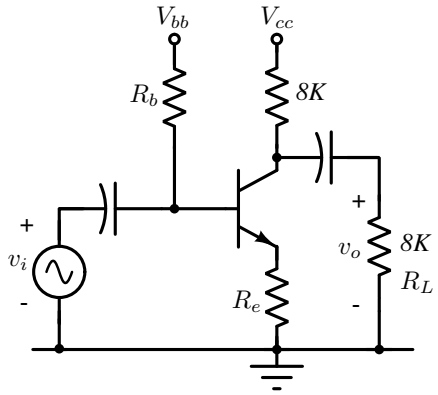

Figure 7: Circuit for problem 7.

Find V_{cc}, V_{bb} and R_e. V_{BE} is 0.7 V, nominally. Given that $R_b \ll (\beta + 1)R_e$, comment on the stability of the transistor operating point - that is, compute the change in emitter current when the nominal V_{BE} changes by ± 0.1 V due to device variability and/or ambient temperature.

Now let $R_L \to \infty$. What are the limiting swings now possible for v_o on the either side? To what value will you restrict the amplitude of v_i to get an undistorted sinusoidal output?

8

The transistor has very high β. With minimum possible V_{bb} and V_{cc}, the circuit should be able to handle the given input of 5 V maximum amplitude. Calculate the values of V_{bb} and V_{cc} required.

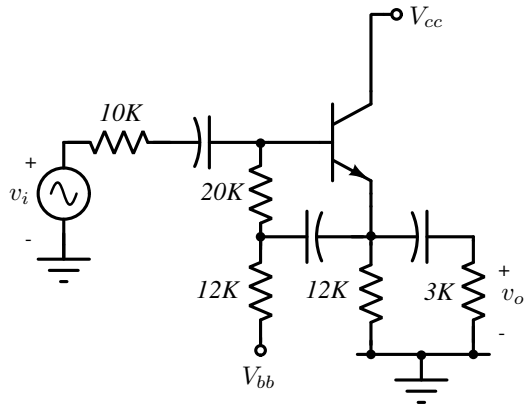

Figure 8: Circuit for problem 8.

When the 3 K lead is removed, determine the swing possible for v_o on either side, and the maximum amplitude to which v_i must now be restricted if v_o is to be a full undistorted sine wave. Take V_{BE} = 0.7 V, nominally. Assume all capacitances are large.

9

All the coupling capacitors are very large in value. Take V_T = 25 mV, α = 0.99. Find for small signals R_i, R_{o1} as seen from the output terminal 1, R_{o2} as seen from output terminal 2, v_{o1}/v_i and v_{o2}/v_i.

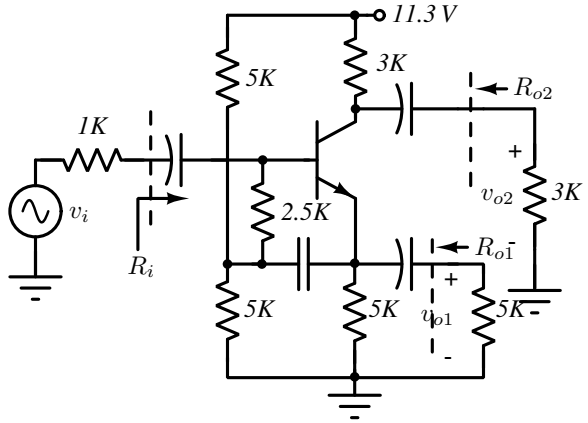

Figure 9: Circuit from problem 9.

10

V_{BE} = 0.65 V nominally. V_T = 25 mV. Calculate R_i for small signals. Also find the positive and negative limits for v_o if it is to be free from distortion. Take β = 200, V_{cc} = 15.65 V.

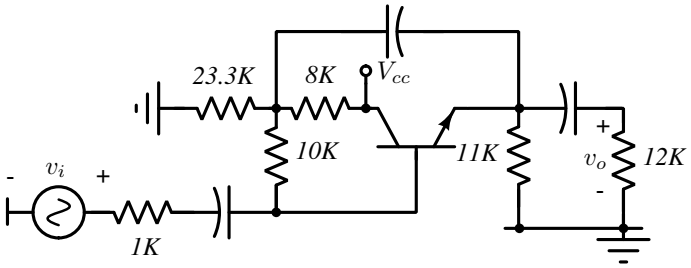

Figure 10: Circuit for problem 10.

11

The input v_i is a sine wave with an amplitude of 3.75 V. To get an undistorted output sine wave within swing limits, calculate V_{cc} and R.

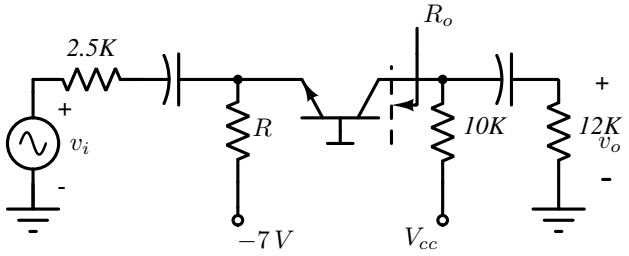

Figure 11: Circuit for problem 11.

If V_T = 25 mV, β = 200, r_o = 40 K, Calculate R_o. Take V_{BE} = 0.65 V nominally.

12

For very small signals, find v_o/v_i with the proper sign. Take V_{BE} = 0.65 V, nominally, V_T = 30 mV, α = 0.995 for all transistors. Also determine which transistor controls the upper limit of swing and which controls the lower one.

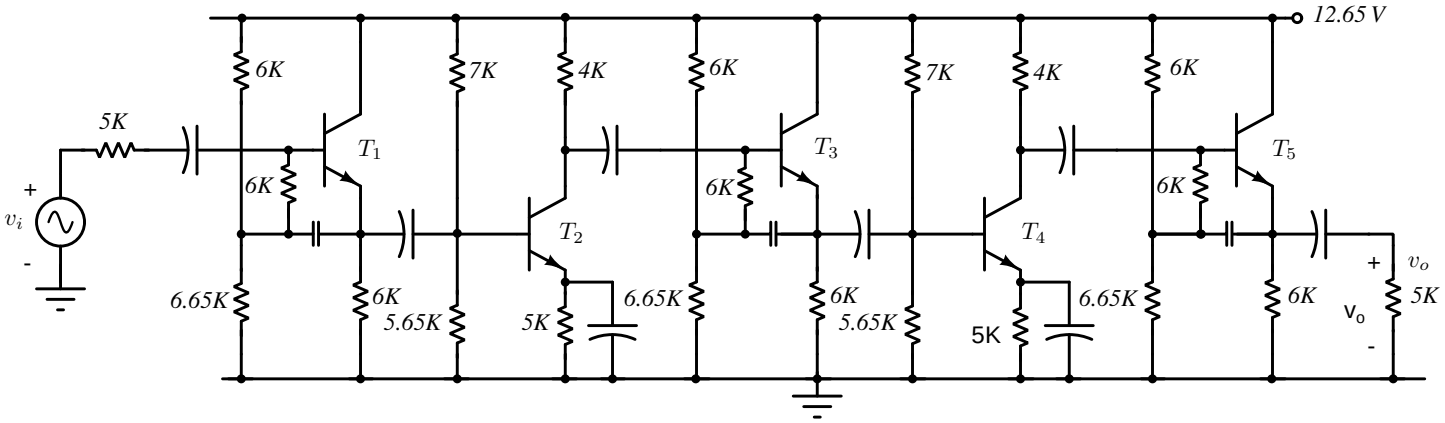

Figure 12: Circuit for problem 12.