Universidade do Vale do Itajaí
Computer Engineering
Basic Electronics

Final Assignment for Basic Electronics

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Teacher Advisor: Walter Antonio Gontijo

December
2021

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Final Assignment, including test simulations for Basic Electronics presented for the class of the Tenth of December, 2021.

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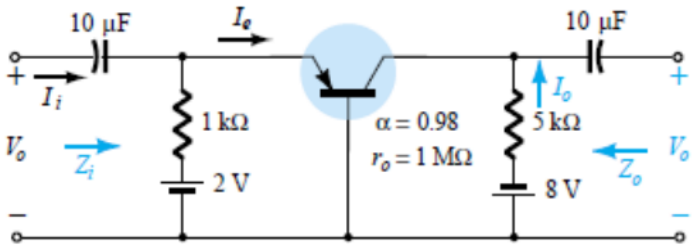
Contents

1 Objective

AC Analysis of circuits containing *NPN* and *PNP* transistors and their simulations, along with the final test simulations.

2 BC Amplifier

This circuit was also seen in the final test.



$$r_e = \frac{26mV}{I_E}$$

2.1 DC analysis

To ensure that the transistor is in an active state, otherwise it would be pointless to perform an AC analysis, the DC analysis must return the voltages for the transistor's nodes.

The I_E current will simply be the current going the *emitter's* resistor minus the transistor *emitter to base* drop and the extra voltage supply.

$$I_E = \frac{2V - 0.7V}{1k} = 1.3mA$$

Since the *hFe* is below 100,

$$\beta = \frac{\alpha}{1-\alpha} = 49$$

The *emitter* current is different from the *collector* current.

$$I_C = \alpha I_E = 98 \times 1.3m = 1.27mA$$

Since we know some of the voltages already,

$$V_B = 0V, V_E = 0.7V$$

the only remaining voltage to confirm the transistor is active is V_C.

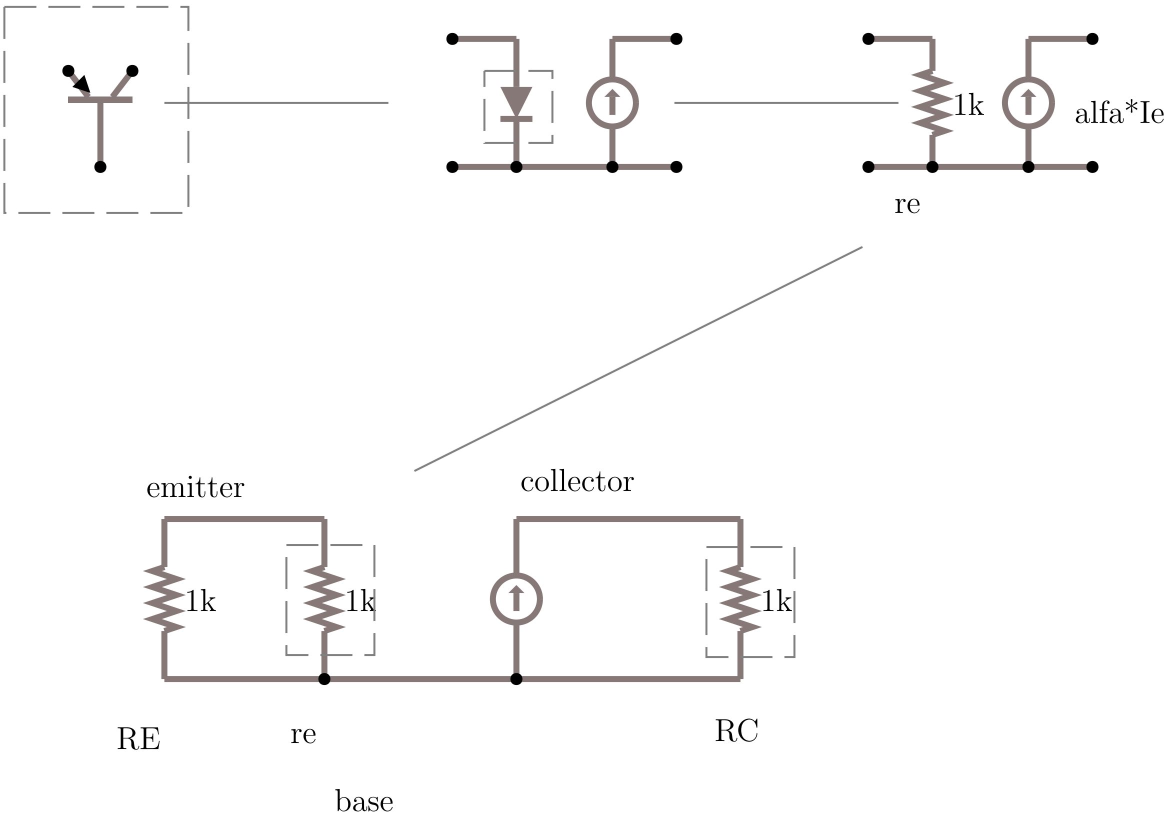
$$V_C = -8V + 1.27mA \times 5k\Omega = -1.63V$$

Since V_B and V_E are polarized appropriately but V_B and V_C are reverse, the transistor is active and the AC analysis can be performed.

If the transistor was either inactive or saturated however, there would be no output or a constant output respectively.

2.2 AC analysis

The AC analysis requires a change in the circuit for a simpler one that can be calculated accordingly.



Av(AC gain) = alfaRC/re

The equations are as such for the impedance's and AC gain of this specific circuit.

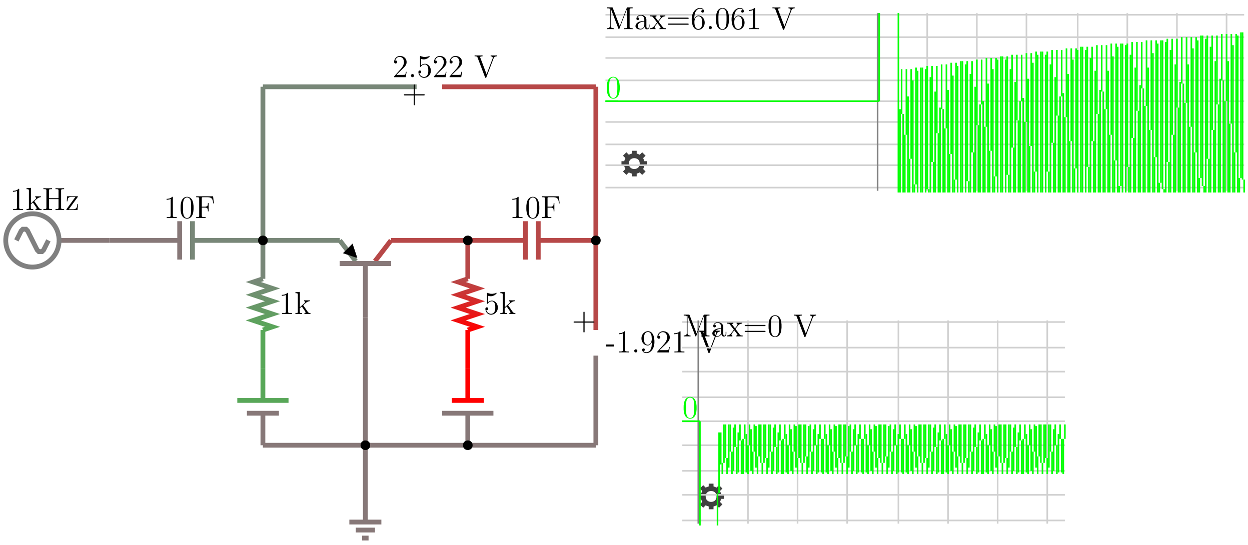
$$Z_o(AC output Impedance) = R_C$$
$$Z_i(AC input Impedance) = R_E//re$$
$$Av(AC gain) = \frac{R_C}{re}$$

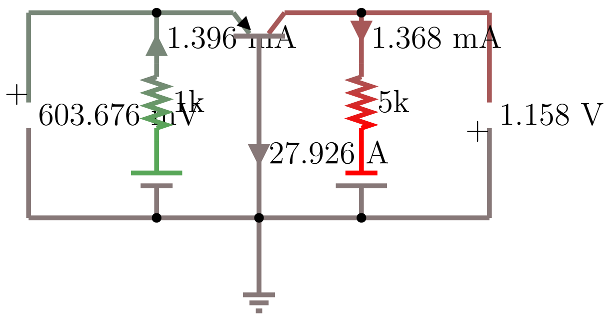
Which when calculated are as follows.

$$Z_o = 5k\Omega$$

$$Z_i = \frac{1k \times 20}{1k + 20} = 19.6\Omega$$

$$Av = \frac{5k}{20} = 250$$





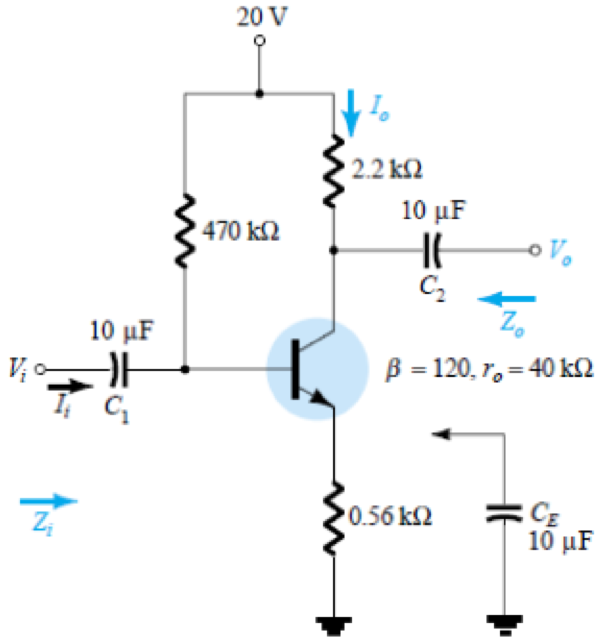
$V_{AC} = 5mV$

The figure before is the AC and DC components of the circuits, mind that the simulator takes into account multiple other variables that are not calculated here, which is why the values are a bit skewed.

Mind also that the graphs shown are AC coupled, they do have a DC component from the supplies.

3 Emitter Polarization Circuit

The following circuit will be analysed.



3.1 DC analysis

Since this type of circuit has been analysed before and this paper intends to explain AC analysis, the values for the currents and voltages will be show, but not their formulas.

$$I_B = 36uA$$

$$I_C = 4.3mA$$

$$I_E = 4.35mA$$

$$V_B = 3V$$

$$V_C = 10.5V$$

$$V_E = 2.45V$$

The DC analysis works with C_E attached to the circuit, as a capacitor does not affect a DC signal.

3.2 AC analysis

The equations are as follows.
Without the capacitor.

$$Z_i = R_B // Z_b$$

$$Z_b \approx \beta \left(r_e + R_E \right)$$

$$Z_o = R_C$$

$$A_v = \frac{\beta R_C}{Z_b}$$

$$r_e = \frac{26}{I_E}$$

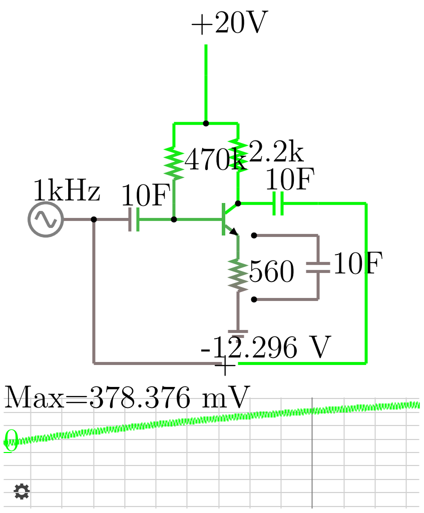
With the capacitor, mid the fact that the capacitor nullifies the resistor, being a short circuit in an AC analysis.

$$Z_i = R_B // \beta r_e$$

$$Z_o = R_C$$

$$A_v = -\frac{R_C}{r_e}$$

3.3 AC without the capacitor



$V_{AC} = 5mV \;\; AC \; coupled$

$$r_e = \frac{26}{I_E} = \frac{26}{4.35mA} = 7761.19\Omega$$

$$Z_b \approx \beta \left(r_e + R_E\right) = 120 \left(7761.19 + 560\right) = 998542.9 \approx 100k\Omega$$

$$Z_i = R_B // Z_b = 82456.14$$

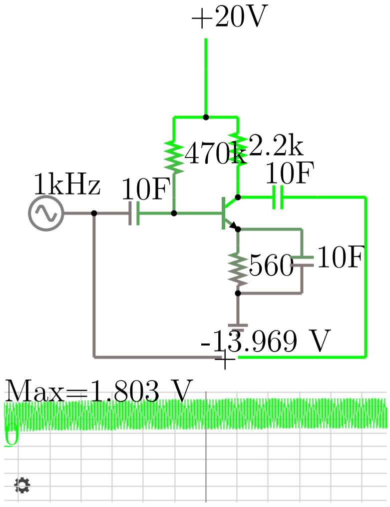
$$Z_o = R_C = 2.2k$$

$$A_v = \frac{\beta R_C}{Z_b} = 2.64$$

3.4 AC with the capacitor

4 Emitter Voltage Divider

The following circuit present in the test is this.



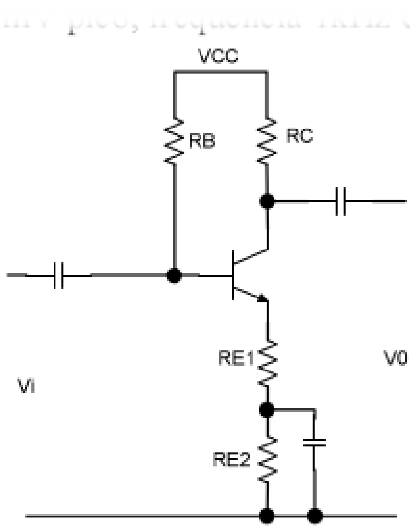
$V_{AC} = 5mV \;\; AC \; coupled$

$$r_e = \frac{26}{I_E} = \frac{26}{4.35mA} = 7761.19\Omega$$

$$Z_i = R_B//Z_b = 82456.14\Omega$$

$$Z_o = R_C = 2.2k\Omega$$

$$A_v = -\frac{R_C}{r_e} = 0.022$$



$$V_E = 0.2V_{CC} = 2V$$
$$V_C = 0.5V_{CC} = 5V$$
$$Z_i >= 10k\Omega$$
$$V_{CC} = 10V$$
$$I_E = 1mA$$
$$\beta = 99$$

4.1 DC analysis

$$V_B = V_E + 0.7V = 2.7V$$

$$R_E = \frac{2V}{1mA} = 2k\Omega$$
$$I_B = \frac{1mA}{99} = 1.01e^{-5}$$
$$R_B = \frac{V + CC - V_B}{I_B} = 722.2k\Omega$$
$$R_C = \frac{V + CC - V_C}{I_C} = 5k\Omega$$
$$R_{E1} = R_{E2} = 2.5k\Omega$$

4.2 AC analysis

$$r_e = \frac{26}{I_E} = \frac{26}{1mA} = 26k\Omega$$

$$Z_i = R_B // \beta r_e = \frac{722.2k \times 26k}{722.2k + 26k} = 25.1k$$

$$Z_o = R_C = 5k$$

$$Z_b \approx \beta \left(r_e + R_E \right) = 3360k\Omega$$

$$A_v = -\frac{\beta R_C}{Z_b} = -0.178$$

4.3 Simulation