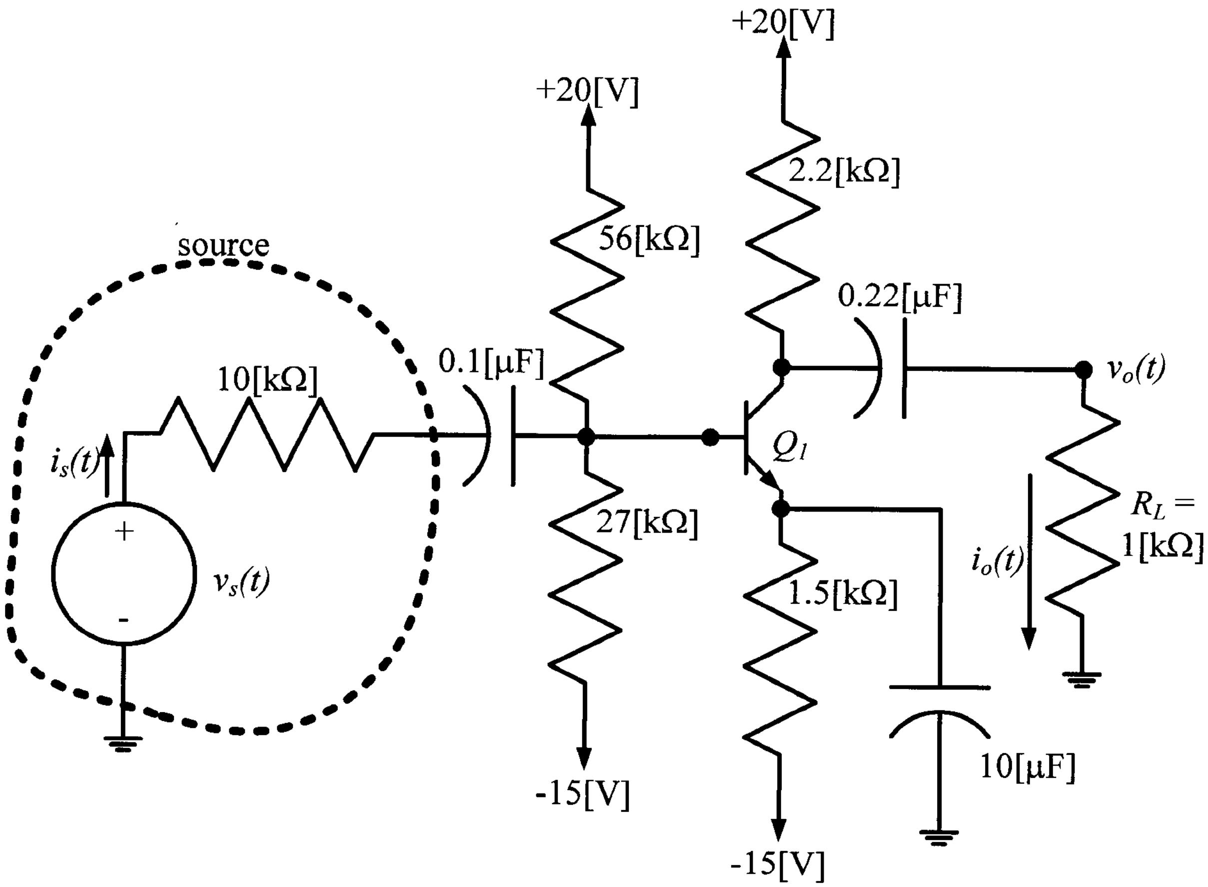
In the circuit shown, the transistor has $\beta = 150$, and operates at room temperature. The source $v_s(t)$ is a signal source with frequencies in the passband for this amplifier.

a) Find the voltage gain v_o/v_s for this amplifier.
b) Find the current gain, i_o/i_s, for this amplifier, in dB.
c) Find the output resistance seen by the load R_L for these frequencies.
d) Find the input resistance seen by the source for these frequencies.



We start with dc analysis. For dc, all capacitors act as an open circuit. Before guessing a region, we choose to find the Thevenin equivalent of the "voltage divider" at the base.

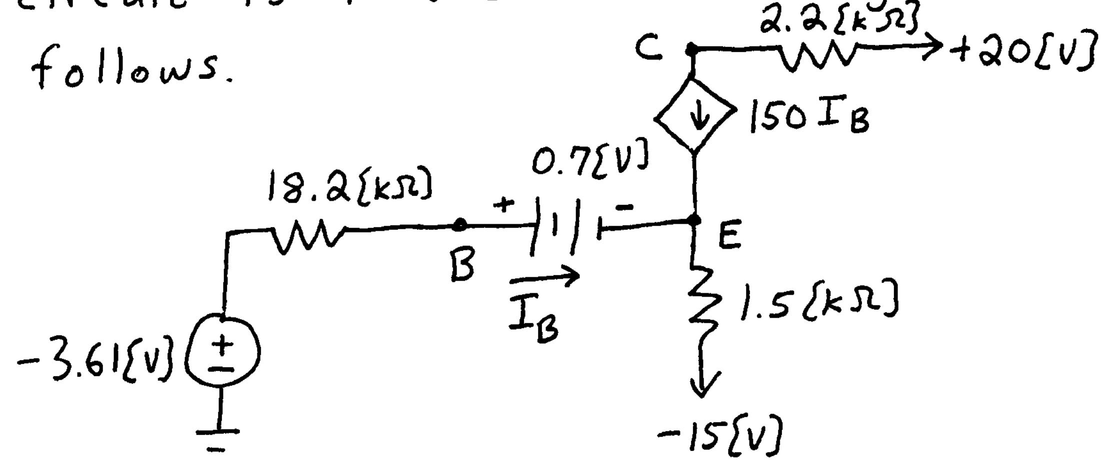
$$V_{TH} = (20[V] - (-15[V]))\left(\frac{27}{27+56}\right) - 15[V] = -3.61[V]$$

$$R_{TH} = 27[k\Omega] \| 56[k\Omega] = 18.2[k\Omega]$$

see next page

With this information, we will

Guess the transistor is biased into the linear, or active, region. The dc equivalent circuit is inserted in the diagram that follows.



KVL around the BE loop gives us

$$3.61\{V\} + I_B(18.2\{k\Omega\}) + 0.7\{V\} + (151\, I_B)(1.5\{k\Omega\}) - 15\{V\} = 0$$

Solving: $I_B = 43.7\{\mu A\}$

$$V_C = 20\{V\} - (150\, I_B)(2.2\{k\Omega\}) = 5.58\{V\}$$

$$V_E = -15\{V\} + (151\, I_B)(1.5\{k\Omega\}) = -5.10\{V\}$$

$$V_{CE} = 5.58\{V\} - (-5.10\{V\}) = 10.7\{V\}$$

Tests: Is $I_B > 0$? Yes.

Is $V_{CE} > 0.2\{V\}$? Yes.

Good guess.

Now, we can draw the ac equivalent, using the room temperature value $V_T = 25\{mV\}$.

$$r_\pi = \frac{V_T}{I_B} = \frac{25\{mV\}}{43.7\{\mu A\}} = 572\{\Omega\}$$

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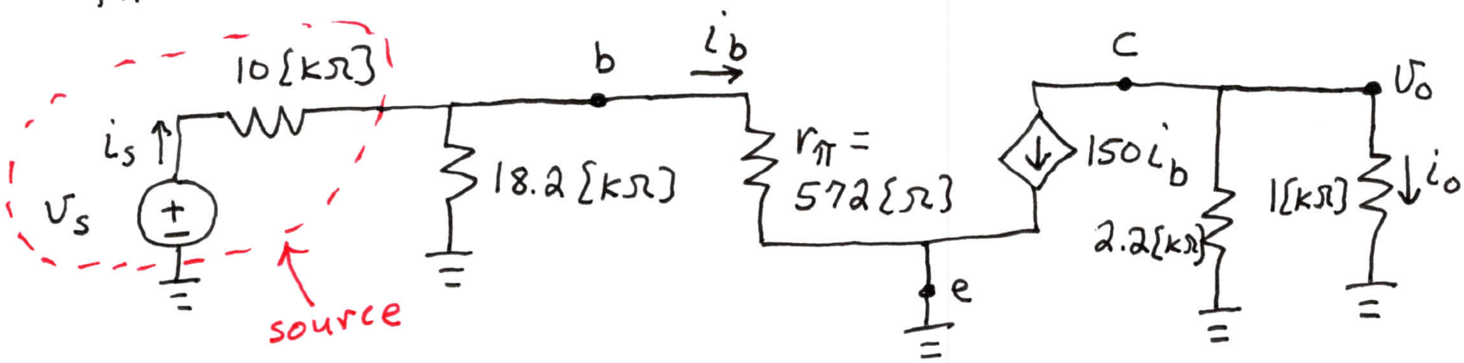
Remember that for the ac equivalent circuit we set all dc sources equal to zero. Each capacitor here will be a short-circuit in the passband, because that maximizes the gain in this circuit.



We can write the equations

$$v_o = -150\, i_b \left(1\{k\Omega\} \| 2.2\{k\Omega\}\right) = -103.1\{k\Omega\}\, i_b$$

$$i_b = \frac{v_b}{572\{\Omega\}}$$

$$v_b = v_s \frac{(572 \| 18{,}200)}{(572 \| 18{,}200) + 10{,}000} = 52.5 \times 10^{-3}\, v_s$$

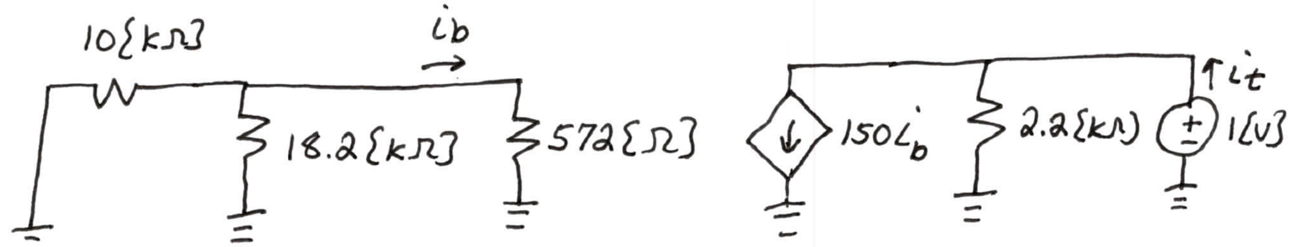
So, $\boxed{\dfrac{v_o}{v_s} = -9.47}$

b) $i_o = \dfrac{v_o}{1\{k\Omega\}}$

$$i_s = \frac{v_s}{10\{k\Omega\} + (572\{\Omega\} \| 18.2\{k\Omega\})} = \frac{v_s}{10.6\{k\Omega\}}$$

$$\frac{i_o}{i_s} = \frac{v_o}{v_s} \times \frac{10.6\{k\Omega\}}{1\{k\Omega\}} = -100.33, \text{ so } 20\log_{10}\left|\frac{i_o}{i_s}\right| = \boxed{40.0\{dB\}}$$

c) To get the output resistance seen by the load, we remove the load, and set the independent source, v_S, equal to zero. We have a dependent source, so we apply a test source.

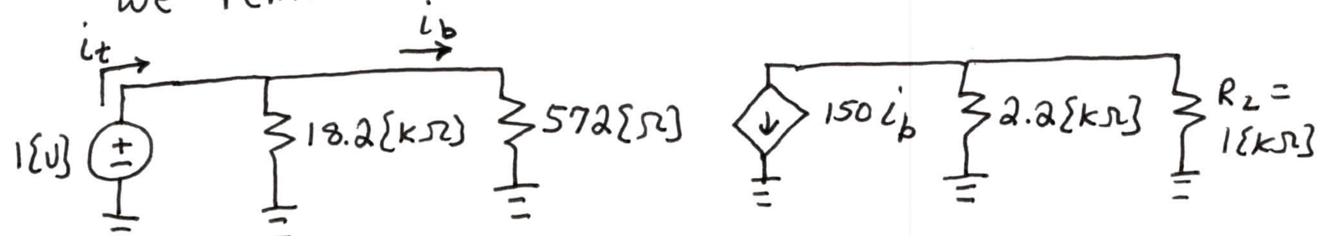


$i_b = 0$, so $150 i_b = 0$.

$$i_t = \frac{1\{V\}}{2.2\{k\Omega\}}$$

$$R_{out} = \frac{1\{V\}}{i_t} = \boxed{2.2\{k\Omega\}}$$

d) To get the input resistance seen by the source, we remove the source, and apply a test source.



$$i_t = \frac{1\{V\}}{18.2\{k\Omega\}} + \frac{1\{V\}}{572\{\Omega\}} = 1.803\{mA\}$$

$$R_{in} = \frac{1\{V\}}{i_t} = \boxed{555\{\Omega\}}$$