The figure shows a CB/CE amplifier. For each transistor, $r_x = 100 \, \Omega$, \( \beta = 99 \), \( \alpha = 0.99 \), \( I_E = 1 \, \text{mA} \), \( r_{ic} = 100 \, \text{k}\Omega \), and \( V_T = 25 \, \text{mV} \). The circuit element values are \( R_S = 82 \, \Omega \), \( R_{C1} = 12 \, \text{k}\Omega \), \( R_{E2} = 50 \, \Omega \), and \( R_{C2} = 16 \, \text{k}\Omega \). Reference equations: \( g_m = I_C/V_T \), \( r_n = V_T/I_B \), \( r_e = V_T/I_E \), \( i'_e = g_m v_n = \beta i_b = \alpha i'_e \), \( r'_x = r_x + r_n + (1 + \beta) R_{te} \), \( r'_e = (R_{tb} + r_x) / (1 + \beta) + r_e \). First express your answers in symbolic form. Then evaluate them numerically. Draw a box around your answers.

\[
\begin{align*}
    r_e &= \frac{V_T}{I_E} = 25 \, \Omega \\
    r'_e &= \frac{r_x}{1 + \beta} + r_e = 26 \, \Omega \\
    R_{tb2} &= R_{C1} || r_{ic1} = 10.71 \, \text{k}\Omega \\
    r'_e &= \frac{R_{tb2} + r_x}{1 + \beta} + r_e = 133.143 \, \Omega
\end{align*}
\]

The following solutions are based on the simplified T model.

(a) Solve for \( i'_{c1} / v_s \).

\[
\begin{align*}
    i'_{c1} &= \alpha i'_e = \alpha \frac{-v_s}{R_S + r'_e} = -9.167 \times 10^{-3} v_s \\
\end{align*}
\]

\[\implies \frac{i'_{c1}}{v_s} = -9.167 \times 10^{-3}\]

(b) Solve for \( v_{tb2} / i'_{c1} \).

\[
\begin{align*}
    v_{tb2} &= -i'_{c1} R_{C1} || r_{ic1} = -10.71 \times 10^3 i'_e \\
\end{align*}
\]

\[\implies \frac{v_{tb2}}{i'_{c1}} = -10.71 \times 10^3\]

(c) Solve for \( i'_{c2} / v_{tb2} \).

\[
\begin{align*}
    i'_{c2} &= \alpha i'_e = \alpha \frac{v_{tb2}}{R_{E2} + r'_e} = 5.406 \times 10^{-3} v_{tb2} \\
\end{align*}
\]

\[\implies \frac{i'_{c2}}{v_{tb2}} = 5.406 \times 10^{-3}\]
(d) Solve for \(v_o/i'_{c2}\).

\[ v_o = -i'_{c2}R_c || r_{ic2} = -13.79 \times 10^3 i'_{c2} \quad \implies \quad \frac{v_o}{i'_{c2}} = -13.79 \times 10^3 \]

(e) Combine the above answers to solve for \(v_o/v_s\).

\[
\frac{v_o}{v_s} = \frac{i'_{c1}}{v_s} \times \frac{v_{tb2}}{i'_{c1}} \times \frac{i'_{c2}}{v_{tb2}} \times \frac{v_o}{i'_{c2}} = -7323
\]