Ex:

The above circuit diagrams show an emitter-follower circuit and its small-signal equivalent circuit. The dependent source effectively multiplies the impedances to the right of it by 100, yielding the following equivalent circuit:

Find $i_{tot}(t)$. 
**Sol’n:** We begin by converting the circuit to the frequency domain. The frequency is \( \omega = 1 \text{M r/s} \) from the voltage source.

\[
\begin{align*}
\frac{1}{j\omega 640 \text{pF}} &= -j \frac{1 \text{M} \cdot 640 \text{p}}{640} \\
&= -j 1 \text{M} \\
\end{align*}
\]

\( j\omega 20 \text{mH} = j 1 \text{M} \cdot 20 \text{m} \Omega = j20 \text{k} \Omega \\

\[
\begin{align*}
\frac{1}{j\omega 300 \text{pF}} &= -j \frac{1 \text{M} \cdot 300 \text{p}}{300} \\
&= -j 1 \text{M} \\
\end{align*}
\]

We obtain the following frequency-domain circuit:

![Circuit Diagram]

The parallel impedance of the \( L \) and \( C \) on the right may be computed using admittances, (i.e., 1/impedance):

\[
\begin{align*}
\frac{1}{j20 \text{k}} + \frac{1}{-j1 \text{M}} &= \frac{-j 20 \text{kHz}}{20 \text{k}} + \frac{-j 1 \text{MHz}}{1 \text{M}} \\
&= \frac{-j 50 \text{k} \Omega}{1 \text{M}} + \frac{j 300 \text{pF}}{1 \text{M}} \\
&= \frac{1}{-j 50 \text{k} \Omega} + \frac{1}{j 300 \text{pF}} \\
\end{align*}
\]

or

\[
\begin{align*}
\frac{1}{j 250 \text{pF}} + \frac{1}{-j 1 \text{M}} &= \frac{1 \text{M}}{j 250 \text{pF}} + \frac{-j 1 \text{M}}{1 \text{M}} \\
&= \frac{-j 4 \text{k} \Omega}{1 \text{M}} \\
\end{align*}
\]

For the entire right-hand branch through which \( I_b \) flows, we have the following impedance:

\[
z_{\text{right}} = (3 - j4) \text{k} \Omega
\]

We compute the parallel impedance of the 5 \( \Omega \) and \( z_{\text{right}} \).
The grand total of all impedance in the circuit is as follows:

\[
z_{\text{tot}} = \frac{-j1M}{640} \Omega + \frac{5}{4} \cdot \frac{3 - j4}{2 - j} = \frac{5(3 - j4)}{5 + 3 - j4} = \frac{5}{4} \cdot \frac{3 - j4}{2 - j}
\]

We continue the calculation by simplifying terms as much as possible before adding.

\[
z_{\text{tot}} = \frac{5}{4} \cdot \left( \frac{-j25}{16} + \frac{10 - j5}{2} + j \right) = \frac{5}{4} \cdot \left( \frac{-j25}{16} + \frac{40}{16} - j20 \right)
\]

or

\[
z_{\text{tot}} = \frac{5}{16} (8 - j9)
\]

The total current is given by the voltage of the source divided by \(z_{\text{tot}}\).

\[
I_{\text{tot}} = \frac{\frac{1}{10} \angle 0^\circ V}{\frac{5}{16} (8 - j9)} = \frac{16}{50(8 - j9)} \text{mA}
\]

or

\[
I_{\text{tot}} = \frac{16}{50 \cdot \sqrt{8^2 + 9^2} \tan^{-1}\left(\frac{-9}{8}\right)} = \frac{16}{50 \cdot \sqrt{145} - 48.4^\circ} \text{mA}
\]

or

\[
I_{\text{tot}} = 26.6 \angle 48.4^\circ \mu A
\]

Taking the inverse phasor gives the final answer.

\[
i_{\text{tot}}(t) = 26.6 \cos(1M\pi + 48.4^\circ) \mu A
\]