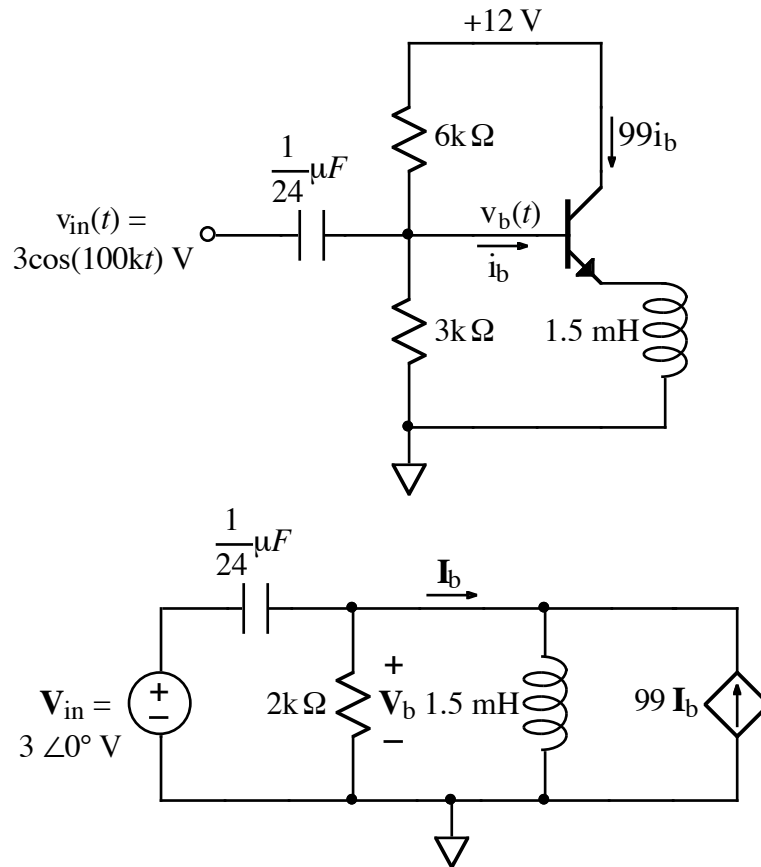


Ex:

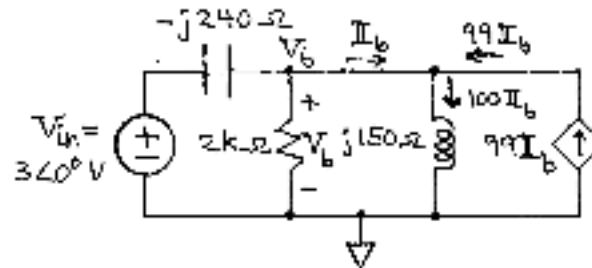


The above circuit diagrams show an emitter-follower amplifier and its high-frequency equivalent circuit. Find  $v_b(t)$ .

sol'n: The bottom diagram uses a mixed notation in that the C and L values are shown instead of  $z_c$  and  $z_L$ . We first compute  $z_c$  and  $z_L$  using  $\omega = 100k$  from the top circuit.

$$z_c = \frac{1}{j\omega C} = \frac{-j}{\omega C} = \frac{-j \Omega}{100k \cdot \frac{1}{24} \mu} = -j 240 \Omega$$

$$\mathbb{Z}_L = j\omega L = j 100k \cdot 1.5 \text{ mH} = j150 \Omega$$



A straight-forward solution approach is to use the node-voltage method with  $V_b$  on the top rail.

$$\frac{V_b - V_{in}}{-j240 \Omega} + \frac{V_b}{2k \Omega} + \frac{V_b}{j150 \Omega} - \frac{1}{100} = 0 \text{ A}$$

$$\text{or } V_b \left( \frac{1}{-j240 \Omega} + \frac{1}{2k \Omega} + \frac{1}{j150 \Omega} \right) = \frac{V_{in}}{-j240 \Omega}$$

$$\text{or } V_b = \frac{V_{in}}{-j240 \Omega} \cdot -j240 \Omega \parallel 2k \Omega \parallel j150 \Omega$$

$$\text{or } V_b = V_{in} \cdot 1 \parallel \frac{2k}{-j240} \parallel \frac{-15k}{240}$$

$$\text{Now } 1 \parallel \frac{-15k}{240} = \frac{1 \left( \frac{-15k}{240} \right)}{1 + \frac{-15k}{240}} = \frac{-15k}{240 - 15k}$$

$$= \frac{15k}{14.76k} = \frac{15}{14.76}$$

$$V_b = V_{in} \cdot \frac{15}{14.76} \parallel \frac{2k}{-j240}$$

$$= V_{in} \cdot \frac{15}{14.76} \parallel \frac{j25}{3}$$

$$= 3 \angle 0^\circ V \cdot \frac{15 \cdot j \frac{25}{3}}{14.76 \left( \frac{15}{14.76} + j \frac{25}{3} \right)}$$

$$= 3 \angle 0^\circ V \cdot \frac{j(15)(25)}{3(15) + j25(14.76)}$$

$$= 3 \angle 0^\circ V \cdot \frac{j3(25)}{3 \cdot 3 + j5(14.76)}$$

$$= 3 \angle 0^\circ V \cdot \frac{j75}{9 + j73.8}$$

$$= \frac{225 \angle 90^\circ V}{\sqrt{9^2 + 73.8^2} \angle \tan^{-1} \frac{73.8}{9}}$$

$$= \frac{225 \angle 90^\circ V}{74.3 \angle 83.0^\circ}$$

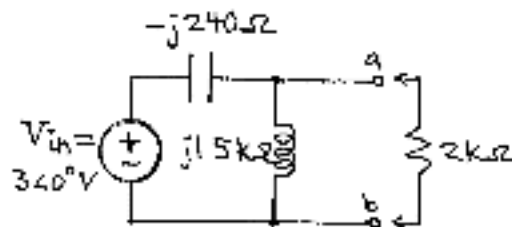
$$\approx 3.02 \angle 90^\circ - 83.0^\circ V$$

$$V_b \hat{=} 3 \angle 7^\circ V$$

$$\therefore v_b(t) \hat{=} 3 \cos(100kt + 7^\circ) V$$

An alternate approach begins with the observation that the L and the dependent source may be replaced by  $j\omega L \cdot 100$ . This concept is called "impedance multiplication".

Then we remove the  $2k\Omega$  resistor and find the Thevenin equivalent of the circuit with respect to the terminals where the  $2k\Omega$  resistor is attached.



$$V_{Th} = V_{a,b} \text{ no load}$$

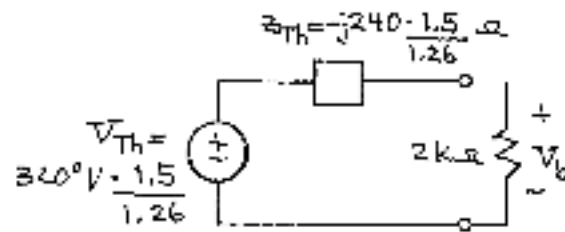
$$= V_{in} \cdot \frac{j15k\Omega}{j15k\Omega - j240\Omega}$$

$$V_{Th} = 340^\circ V \cdot \frac{15}{14.76}$$

$z_{Th} = z$  seen looking into a,b with  $V_{in}$  off (= wire)

$$z_{Th} = -j240 \parallel j15k\Omega$$

$$z_{Th} = \frac{240(15k)}{j(15k - 240)} \Omega = -j240 \cdot \frac{15}{14.76} \Omega$$



$$V_b = V_{Th} \cdot \frac{2k\Omega}{2k\Omega + Z_{Th}}$$

$$= 3\angle 0^\circ V \cdot \frac{1.5}{14.76} \cdot \frac{2k\Omega}{2k\Omega - j\frac{240 \cdot 1.5}{14.76} \Omega}$$

$$= 3\angle 0^\circ V \cdot \frac{1.5(2k\Omega)}{14.76(2k\Omega) - j240(1.5)\Omega}$$

$$= 3\angle 0^\circ V \cdot \frac{30k}{29.52k - j36k}$$

$$= 3\angle 0^\circ V \cdot \frac{30}{29.52 - j3.6}$$

$$= 3\angle 0^\circ V \cdot \frac{1}{0.984 - j0.12}$$

$$= \frac{3\angle 0^\circ V}{0.99\angle -6.95^\circ}$$

$$V_b \hat{=} 3\angle 7^\circ V$$

$$\therefore v_b(t) = 3 \cos(100kt + 7^\circ) V$$