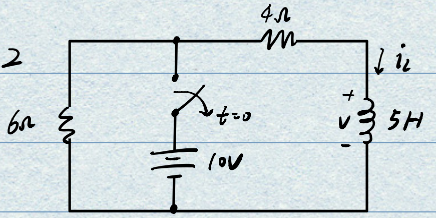
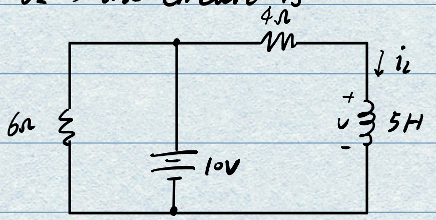
8.2



For t≤0, the circuit is



Apply KVL to the circuit,

$$-V + 4i_L + 5\frac{di_L}{dt} = 0$$

Substituting $i_L = -\frac{V}{6}$,

$$\frac{5}{6}\frac{dv}{dt} + \left(\frac{4}{6}+1\right)V = 0$$

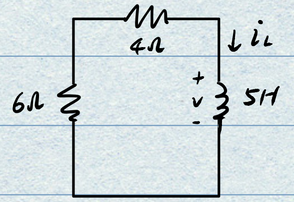
$$\frac{dv}{dt} + 2V = 0$$

From the circuit, we can find that

$$V(0) = 10\text{ V}$$

$$i_L = \frac{10}{4} = 2.5\text{ A}$$

For t≥0, the circuit is



Thus $i(t) = i_L(0)e^{-\frac{R_{eq}t}{L}}$

$$R_{eq} = 6+4 = 10\,\Omega$$

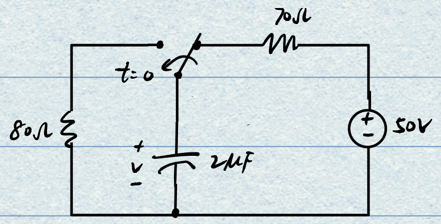
$$i(t) = 2.5e^{-2t}$$

$$v(t) = L\frac{di}{dt}$$

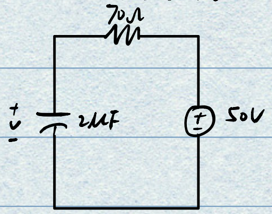
$$= 5\,\frac{d}{dt}(2.5e^{-2t})$$

$$= -25e^{-2t}\text{ V}$$

8.4



For t≤0, the circuit is



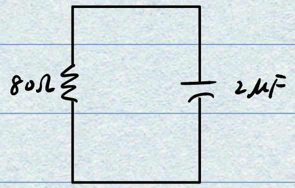
$$V(0) = 50\text{ V}$$

$$\tau_1 = R_1C = (70)(2\times10^{-6}) = 140\times10^{-6}\text{ s}$$

$$V(t) = V(0)e^{-\frac{t}{RC}} = 50e^{-\frac{t}{140\times10^{-6}}}$$

At t=0, $V(t) = 50\,e^{0} = 50\text{ V}$

For t≥0, the circuit is



$$\tau_2 = R_2C = (80)(2\times10^{-6}) = 160\times10^{-6}\text{ s}$$

$$V(t) = V(0)e^{-\frac{t}{R_2C}} = 50\,e^{-\frac{t}{160\times10^{-6}}}$$

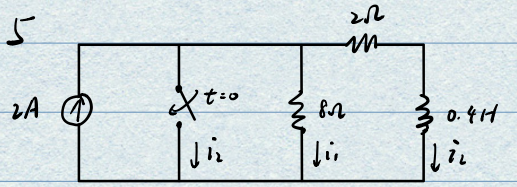
At t=160 μs,

$$V(t) = 50\,e^{-\frac{160\times10^{-6}}{160\times10^{-6}}} = \frac{50}{e} \approx 18.39\text{V}$$

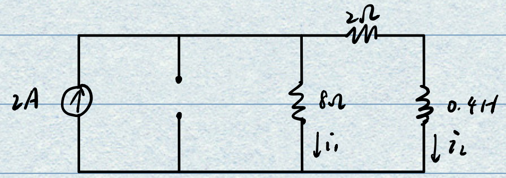
Thus V(t) = 50V when t=0

V(t) = 18.39V when t=160μs

8.5



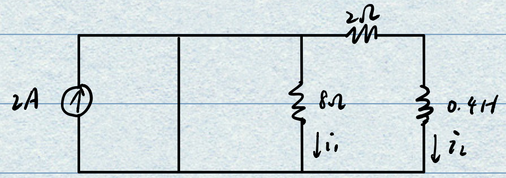
For $t<0$, the circuit is



$i_L(0^-) = 2\times\frac{2}{8+2} = 1.6A$

$i_L(0^+) = i_L(0^-) = i_L(0) = 1.6A$

For $t>0$, the circuit is



$R_{eq} = (0||8)+2 = 2\Omega$

$\tau = \frac{L}{R_{eq}} = \frac{0.4}{2} = 0.2s$

$i_L(t) = i_L(0)e^{-\frac{t}{\tau}}$

$= 1.6e^{-5t}A$

when $t=0.15$, $i_L = 1.6e^{-5\times0.15} \approx 0.756A$

$V_L(t) = L\frac{di_L(t)}{dt} = 0.4\frac{d}{dt}(1.6e^{-5t})$

$= -3.2e^{-5t}V$

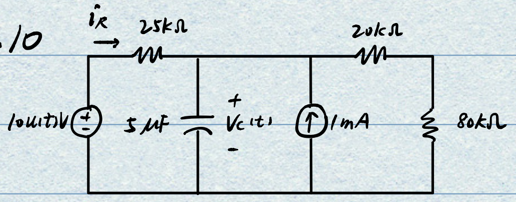
$i_1 = \frac{i_L(t)R_2+V_L(t)}{R_1} = \frac{3.2e^{-5t}-3.2e^{-5t}}{8} = 0A$

$i_2 = 2 - i_1 - i_L = 2-0-0.756 = 1.244A$

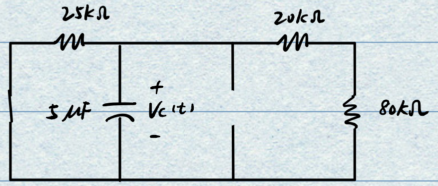
Therefore, when $t=0.15s$,

$i_L = 0.75A$, $i_1 = 0A$, $i_2 = 1.244A$

8.10



Replace all the independent sources by short circuit or open circuit.



$R_{eq} = 25k\Omega \,||\, (20k\Omega + 80k\Omega)$

$= \frac{25\times10^3\times100\times10^3}{25\times10^3+100\times10^3}$

$= 20\times10^3\Omega$

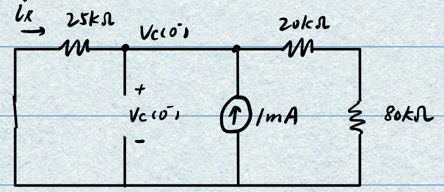
$\tau = R_{eq}C = 20\times10^3\times5\times10^{-6}$

$= 0.1s$

Since $u(t) = \begin{cases}1, & t>0\\0, & t<0\end{cases}$

$V = 10u(t)V$,

(a) for $t<0$, the voltage source can be replaced by short circuit. Viewing C as an open circuit.



Apply KCL to node $V_C(0^-)$,

$\frac{V_C(0^-)}{25\times10^3}+\frac{V_C(0^-)}{20\times10^3+80\times10^3} = 1\times10^{-3}$

$V_C(0^-) = 20V$

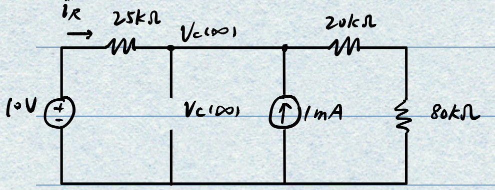
(b)

Since capacitor does not allow sudden changes in the voltage,

$V_C(0^+) = V_C(0^-) = 20\text{ V}$

For $t>0$, the voltage source is 10V.

(c) Viewing C as an open circuit.



Apply KCL to node $V_C(\infty)$,

$$\frac{V_C(\infty)-10}{25\times10^3} + \frac{V_C(\infty)}{20\times10^3+80\times10^3} = 1\times10^{-3}$$

$V_C(\infty) = 28\text{ V}$

(d) $V_C(t) = V_f + V_n$

$= V_C(\infty) + V_n$

$= 28 + Ae^{-\frac{t}{\tau}}$

$= 28 + Ae^{-10t}$

$\because V_C(0) = 28 + A = 20$

$\therefore A = -8$

$\therefore V_C(t) = 28 - 8e^{-10t}$

When $t=0.08$, $V_C(0.08) = 28 - 8e^{-10\times0.08}$

$= 24.4\text{V}$.

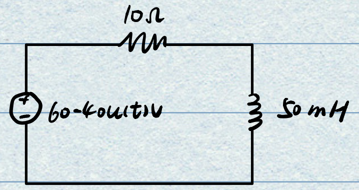
Therefore, $V_C(0^-) = 20\text{V}$,

$V_C(0^+) = 20\text{V}$,

$V_C(\infty) = 28\text{V}$,

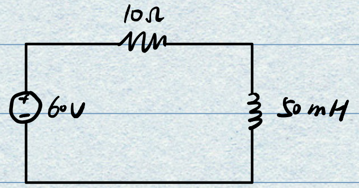
$V_C(0.08) = 24.4\text{V}$.

8.12



Since $u(t) = \begin{cases} 0, & t<0 \\ 1, & t>0 \end{cases}$

(a) For $t<0$, the circuit is

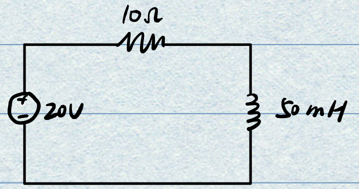


Viewing L as a short circuit.

$V_L(0^-) = 0\text{ V}$

$i_L(0^-) = \frac{60}{10} = 6\text{A}$

(b) For $t>0$, the circuit is



$i_L(0^+) = i_L(0^-) = 6\text{ A}$

Apply KVL to the mesh.

$V_L(0^+) = 20 - V_R$

$= 20 - 10\times6$

$= -40\text{ V}$

Therefore the magnitude of $V_L(0^+)$ is 40V.

(c) when $t\to\infty$, viewing L as a short circuit,

$V_L(\infty) = 0\text{ V}$

$i_L(\infty) = \frac{20}{10} = 2A$

(d) $\tau = \frac{L}{R} = \frac{50\times10^{-3}}{10} = 5\times10^{-3}s$

$i_L(t) = i_f + i_n$

$= i_L(\infty) + i_n$

$= 2 + Ae^{-\frac{t}{\tau}}$

$= 2 + Ae^{-\frac{t}{5\times10^{-3}}}$

$\because i_L(0) = 2 + A = 6$

$\therefore A = 4$

$\therefore i_L(t) = 2 + 4e^{-\frac{t}{5\times10^{-3}}}$

when $t = 3\times10^{-3}$,

$i_L(3\times10^{-3}) = 2 + 4e^{-\frac{3}{5}} \approx 4.2A$

Apply KVL to the mesh,

$V_L(3\times10^{-3}) = 20 - 4.2\times10 = -22V$

Therefore the magnitude of V_L is 22V.

So when $t = 0^-$, $|i_L| = 6A$, $|V_L| = 0V$,

$t = 0^+$, $|i_L| = 6A$, $|V_L| = 40V$,

$t = \infty$, $|i_L| = 2A$, $|V_L| = 0V$,

$t = 3ms$, $|i_L| = 4.2A$, $|V_L| = 22V$.

10.2

$40\cos(100t - 40^\circ) - 20\sin(100t + 170^\circ)$

$= 40\cos100t\cos40^\circ + 40\sin100t\sin40^\circ -$

$20\sin100t\cos170^\circ - 20\cos100t\sin170^\circ$

$= (40\cos40^\circ - 20\sin170^\circ)\cos100t +$

$(40\sin170^\circ - 20\cos170^\circ)\sin100t$

$\approx 27.2\cos100t + 45.2\sin100t$

$= A\cos100t + B\sin100t$

Therefore $A = 27.2$, $B = 45.2$

$A\cos100t + B\sin100t$

$= \sqrt{A^2+B^2}\left(\frac{A}{\sqrt{A^2+B^2}}\cos100t + \frac{B}{\sqrt{A^2+B^2}}\sin100t\right)$

$= \sqrt{A^2+B^2}(\cos\theta\cos100t + \sin\theta\sin100t)$

$= \sqrt{A^2+B^2}\cos(100t - \theta)$

$= \sqrt{A^2+B^2}\cos[100t - \tan^{-1}(\frac{B}{A})]$

$= \sqrt{27.2^2 + 45.2^2}\cos[100t - \tan^{-1}(\frac{45.2}{27.2})]$

$\approx 52.9\cos(100t - 59.1^\circ)$

$= C\cos(100t + \phi)$

Therefore $C = 52.9$, $\phi = -59.1^\circ$

10.4

(a) By using polar to rectangular form transformation.

$2\angle 30^\circ = 2(\cos 30^\circ + j\sin 30^\circ)$

$= 2(\frac{\sqrt{3}}{2} + j\frac{1}{2})$

$= \sqrt{3} + j \approx 1.732 + j$

$5\angle -110^\circ = 5(\cos(-110^\circ) + j\sin(-110^\circ))$

$\approx -1.7101 - j4.698$

Therefore, $[(2\angle 30^\circ) \times (5\angle -110^\circ)](1+j2)$

$= (1.732 + j)(-1.7101 - j4.698)(1+j2)$

$\approx (1.7358 - j9.847)(1+j2)$

$\approx 21.4 - j6.38$

(b) By using polar to rectangular form transformation.

$5\angle -200^\circ = 5(\cos(-200^\circ) + j\sin(-200^\circ))$

$\approx -4.6985 + j1.7101$

$4\angle 20^\circ = 4(\cos 20^\circ + j\sin 20^\circ)$

$\approx 3.7588 + j1.3681$

Therefore $5\angle -200^\circ + 4\angle 20^\circ$

$= -4.6985 + j1.7101 + 3.7588 + j1.3681$

$\approx -0.940 + j3.08$

(c) $\frac{2-j7}{3-j} = \frac{2-j7}{3-j} \times \frac{3+j}{3+j}$

$= \frac{(2-j7)(3+j)}{3^2 - j^2}$

$= \frac{6 - j21 + j2 - 7j^2}{3^2 - j^2}$

$= 1.3 - j1.9$

Convert the rectangular for into polar form $r\angle\theta$.

$1.3 - j1.9$

$= \sqrt{1.3^2 + (-1.9)^2} \angle \tan^{-1}(\frac{-1.9}{1.3})$

$\approx 2.30\angle -55.6^\circ$

(d) $\frac{5\angle 80^\circ}{2\angle 20^\circ} = \frac{5}{2}\angle 80^\circ - 20^\circ$

$= 2.5\angle 60^\circ$

$= 2.5(\cos 60^\circ + j\sin 60^\circ)$

$\approx 1.25 + j2.165$

$8 - j4 + (\frac{5\angle 80^\circ}{2\angle 20^\circ})$

$= 8 - j4 + 1.25 + j2.165$

$= 9.25 - j1.835$

Convert the rectangular for into polar form $r\angle\theta$.

$9.25 - j1.835$

$= \sqrt{9.25^2 + (-1.835)^2} \angle \tan^{-1}(\frac{-1.835}{9.25})$

$\approx 9.43\angle -11.22^\circ$

10.7

(a) $-5\sin(580t-110^\circ)$

$= 5\cos(580t-20^\circ)$

$I = 5\angle -20^\circ$

(b) $3\cos 600t - 5\sin(600t+110^\circ)$

$= 3\cos 600t - 5\cos(600t+20^\circ)$

$I = 3\angle 0^\circ - 5\angle 20^\circ$

$5\angle 20^\circ = 5\cos 20^\circ + j\sin 20^\circ$

$\approx 4.698 + j1.7101$

$3\angle 0^\circ - 5\angle 20^\circ = -1.6985 - j1.7101$

Convert the rectangular for into polar form $r\angle\theta$.

$-1.6985 - j1.7101$

$= \sqrt{(-1.6985)^2+(-1.7101)^2} \angle \left[\tan^{-1}\left(\frac{1.7101}{1.6985}\right) + 180^\circ\right]$

$= 2.41 \angle (45.2^\circ + 180^\circ)$

$= 2.41 \angle 225.2^\circ$

$= 2.41 \angle (225.2^\circ - 360^\circ)$

$= 2.41 \angle -134.8^\circ$

(c) $8\cos(4t-30^\circ) + 4\sin(4t-100^\circ)$

$= 8\cos(4t-30^\circ) - 4\cos(4t-10^\circ)$

$= 8\angle -30^\circ - 4\angle -10^\circ$

$8\angle -30^\circ = 8[\cos(-30^\circ) + j\sin(-30^\circ)]$

$\approx 6.9282 - j4$

$4\angle -10^\circ = 4[\cos(-10^\circ) + j\sin(-10^\circ)]$

$\approx 3.9392 - j0.6946$

$8\angle -30^\circ - 4\angle -10^\circ$

$= 2.989 - j3.3054$

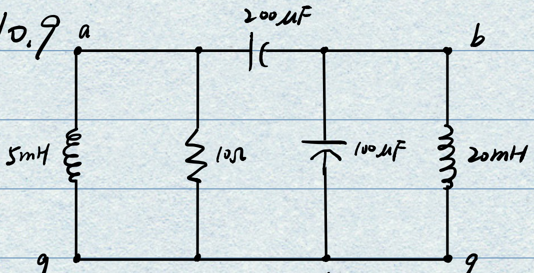
Convert the rectangular for into polar form $r\angle\theta$.

$2.989 - j3.3054$

$= \sqrt{2.989^2+(-3.3054)^2} \angle \tan^{-1}\left(\frac{-3.3054}{2.989}\right)$

$\approx 4.46 \angle -47.9^\circ$

10.9



$\omega = 1000$ rad/s

Since $\omega = 1000$ rad/s,

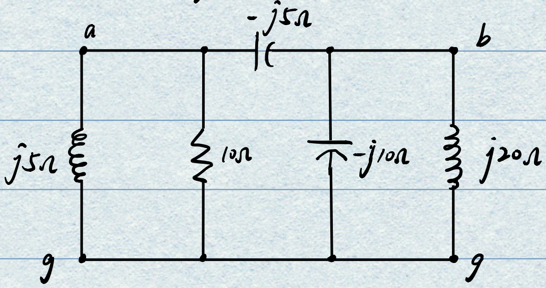
$$Z_{200\mu F} = \frac{1}{j\omega C} = \frac{1}{j\times1000\times200\times10^{-6}} = -j5\,\Omega$$

$$Z_{5mH} = j\omega L = j\times1000\times5\times10^{-3} = j5\,\Omega$$

$$Z_{100\mu F} = \frac{1}{j\omega C} = \frac{1}{j\times1000\times100\times10^{-6}} = -j10\,\Omega$$

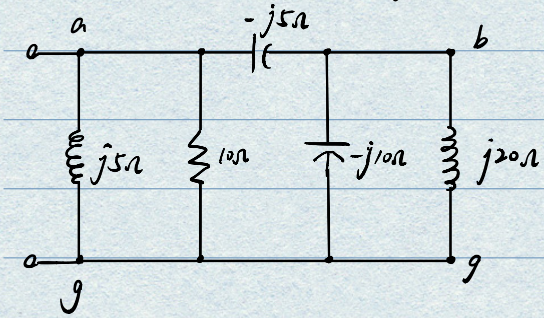
$$Z_{20mH} = j\omega L = j\times1000\times20\times10^{-3} = j20\,\Omega$$

Thus the equivalent circuit is



(a) For input impedance across a and g terminal.

Rewrite the circuit diagram.



Since $j20\Omega$ is in parallel with $-j20\Omega$,

$$Z_1 = j20\Omega \,||\, -j10\Omega = \frac{j20\cdot(-j10)}{j20 - j10} = -j20\,\Omega$$

Since Z_1 is in series with $-j5\Omega$,

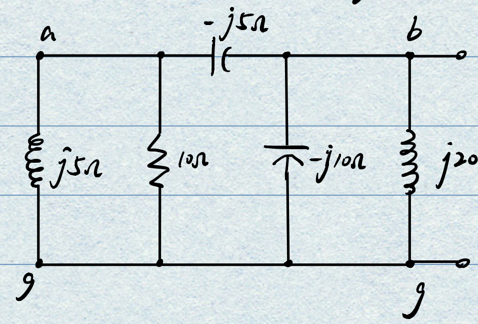
$$Z_2 = -j20\Omega - j5\Omega = -j25\Omega$$

Since Z_2, 10Ω, $j5\Omega$ are in parallel,

$$Z_{in} = -j25\Omega \,||\, 10\Omega \,||\, j5\Omega$$
$$= (8.6207 - j3.4483) \,||\, j5\Omega$$
$$= \frac{17.241 + j43.103}{8.6207 + j1.55\Omega}$$
$$\approx 2.81 + j4.49\,\Omega$$

(b) For input impedance across b and g terminal.

Rewrite the circuit diagram.



Since $j5\Omega$ is in parallel with 10Ω.

$$Z_3 = j5\Omega \,||\, 10\Omega = \frac{10\times j5\Omega}{10+j5}$$
$$= 2+j4\,\Omega$$

Since Z_3 is in series with $-j5\Omega$,

$Z_4 = 2+j4 - j5 = 2 - j\,\Omega$

Since Z_4, $-j10\Omega$, $j20\Omega$ are in parall,

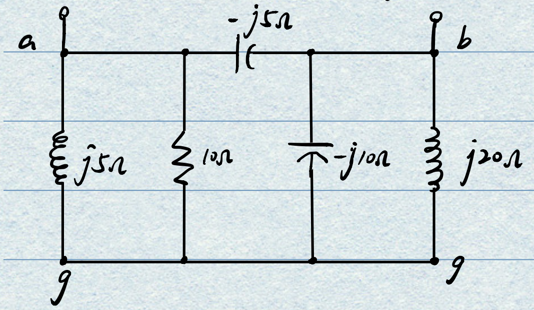
$Z_{in} = 2-j\Omega \,\|\, -j10\Omega \,\|\, j20\Omega$

$= (1.6 - j1.2) \,\|\, j20\,\Omega$

$= \dfrac{24+j32}{1.6+j18.8} \approx 1.798 - j1.125\,\Omega$

(c) For input impedance across a and b terminal.

Rewrite the circuit diagram.



Since $j5\Omega$ is in parallel with 10Ω.

$Z_5 = j5\Omega \,\|\, 10\Omega$

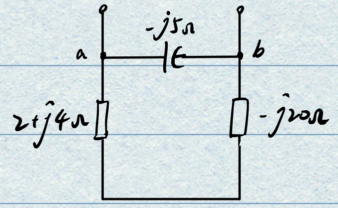
$= 2+j4\,\Omega$

Since $-j10\Omega$ is in parallel with $j20\Omega$,

$Z_6 = -j10\Omega \,\|\, j20\Omega$

$= -j20\,\Omega$

Rewrite the circuit diagram.



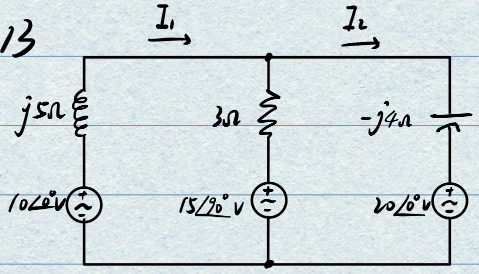
$Z_{in} = (Z_5 - Z_6) \,\|\, -j5\Omega$

$= 2 - j16\Omega \,\|\, -j5\Omega$

$= \dfrac{-80 - j10}{2 - j21}$

$\approx 0.1124 - j3.82\,\Omega$

10.13



Apply KVL to mesh 1,

$-10\angle 0° + j5I_1 + 3(I_1 - I_2) + 15\angle 90° = 0$

$-10 + (3+j5)I_1 - 3I_2 + j15 = 0$

$(3+j5)I_1 - 3I_2 = 10 - j15$ —①

Apply KVL to mesh 2,

$-15\angle 90° + 3(I_2 - I_1) - j4I_2 + 20\angle 0° = 0$

$-j15 - 3I_1 + (3-j4)I_2 + 20 = 0$

$-3I_1 + (3-j4)I_2 = -20 + j15$ —②

By ① $\times \dfrac{3-j4}{3}$ + ②,

$I_1 = \dfrac{-90-j40}{20+j3}$

$= \dfrac{98.488\angle -156.04°}{20.224\angle 8.531°}$

$= 4.87\angle -164.6°$ A

$I_2 = \dfrac{-105 - j100}{20+j3}$

$= \dfrac{145\angle -136.4°}{20.224\angle 8.531°}$

$= 7.17\angle -144.9°$ A