Review

25% Signals

Given $f(t) = 5 + \cos t + 3 \sin 3t$

What is the fundamental frequency, f_0 (Hz)?

$\omega_0 t = 2\pi f_0 t = t \Rightarrow f_0 = \frac{1}{2\pi} = 0.16$ Hz

What is the fundamental angular frequency, ω_0 (rad/s)

$\omega_0 t = t \Rightarrow \omega_0 = 1$ rad/s

What is the peak-to-peak amplitude of the 2nd harmonic?

0, there is no 2nd harmonic

What is the rms amplitude in dBV of the fundamental $V_{rms} = \frac{1}{\sqrt{2}} = 0.707$

$= 20 \log_{10} 0.707 = -3$ dBV

For signal in → $F(\omega)$ → signal out

What is signal out in time domain if

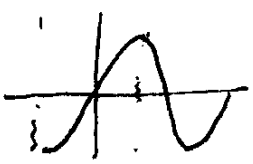
$F(\omega) = 0 \quad 0 < \omega < \frac{\pi}{2}$

$F(\omega) = 1 \angle -90, \ \frac{\pi}{2} \leq \omega$

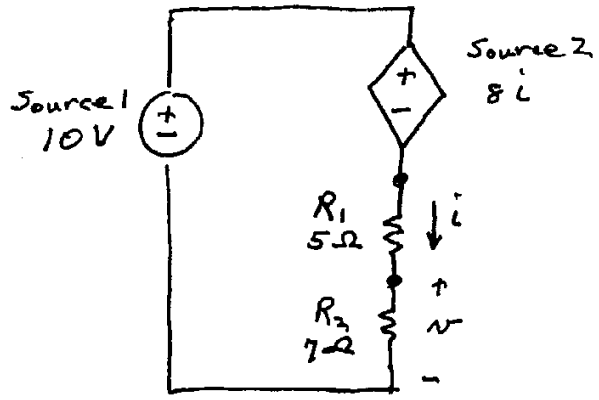
} high pass filter

$f_{out}(t) = 3 \sin(3t - 90^\circ)$

$= -3 \cos(3t)$



75% Circuits



find v

find power generated (−) or dissipated (+) in each element

Simplify → not obvious

Superposition → doesn't help with only 1 independent source

nodal-voltage analysis – $m = 4 - 1 - 1 = 2$ equations

mesh-current analysis – $m = 1$ equation

Try mesh:

Label i_1 with $i = i$

Write mesh equation $10 - 8i - 5i - 7i = 0$

$20i = 10$; $i = 0.5$ A

$\therefore$ $v = R_2 i = 7 \times 0.5 = 3.5$ A

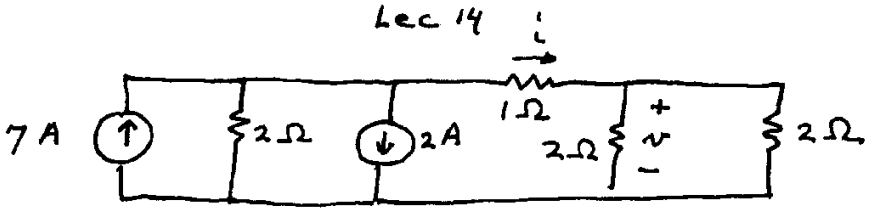
$P_{S1} = (-10)(0.5) = -5$ W

$P_{S2} = (8 \times 0.5)(0.5) = 2$ W

$P_{R1} = i^2 R_1 = (0.5)^2 \times 5 = 1.25$

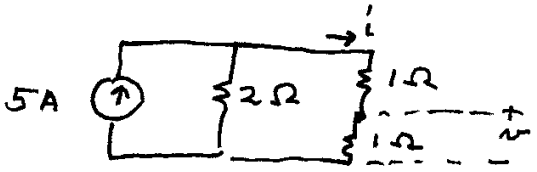
$P_{R2} = i^2 R_2 = (0.5)^2 \times 7 = 1.75$

note: $\sum P_x = 0$ as required



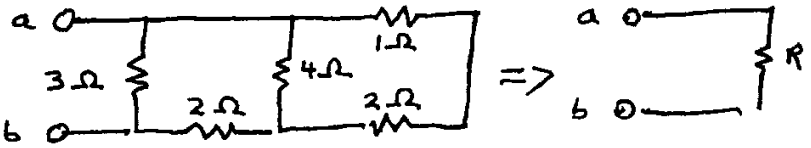
find v and i using simplification

Combine 2 Ω resistors & 2 current sources



find i? current divider $i = 5\frac{\frac{1}{2}}{\frac{1}{2}+\frac{1}{2}} = \underline{2.5\ A}$

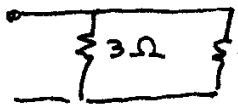
v? $v = 1\Omega \times i = 1 \times 2.5 = \underline{2.5\ V}$



find R

Patience

$R_1 = 4 \| 3 = \frac{12}{7}\ \Omega$

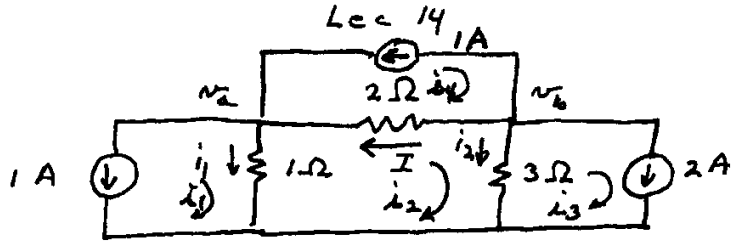


$R_2 = 2 + \frac{12}{7} = \frac{26}{7}$

$R_3 = 3 \| \frac{26}{7} = \frac{3 \times \frac{26}{7}}{3 + \frac{26}{7}} = \frac{3 \times 26}{21 + 26} = \underline{\frac{78}{47}\ \Omega}$

leave as ratio

don't insist upon "nice" numbers



a) Write necessary node-voltage equations ; $n = 3-1 = 2$

a) $-1 - i_1 + 1 + I = 0 \Rightarrow -1 - \frac{v_a}{1} + 1 + \frac{v_b - v_a}{2} = 0$

b) $-I - 1 - i_2 - 2 = 0 \Rightarrow -\left(\frac{v_b - v_a}{2}\right) - 1 - \frac{v_b}{3} - 2 = 0$

Simplify

$$3v_a - v_b = 0$$

$$-3v_a + 5v_b = -18$$

b) Find I by solving node-voltage equations need both v_a and v_b $\Rightarrow$

$$v_a = \frac{\begin{vmatrix} 0 & -1 \\ -18 & 5 \end{vmatrix}}{\begin{vmatrix} 3 & -1 \\ -3 & 5 \end{vmatrix}} = \frac{-18}{15-3} = -\frac{18}{12} = -\frac{3}{2}\ V$$

$$v_b = \frac{\begin{vmatrix} 3 & 0 \\ -3 & -18 \end{vmatrix}}{12} = \frac{-54}{12} = -\frac{9}{2}\ V$$

$$I = \frac{v_b - v_a}{2} = \frac{-\frac{9}{2} + \frac{3}{2}}{2} = -\frac{3}{2}\ A$$

c) Write necessary mesh-current equations $m = 4-3 = 1$

Label, equation $-1(i_2 - i_1) - 2(i_2 - i_4) - 3(i_2 - i_3) = 0$

but $i_1 = -1$, $i_4 = -1$, $i_3 = 2$

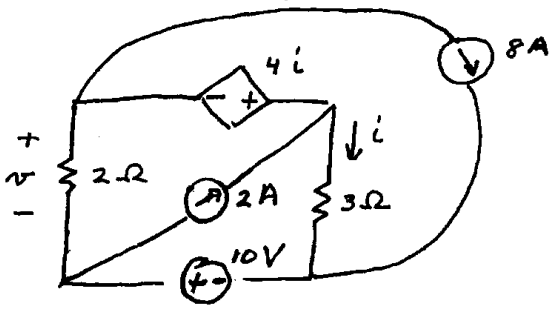
$\therefore$ $-1(i_2 + 1) - 2(i_2 + 1) - 3(i_2 - 2) = 0$

or $-6i_2 = 3$ or $i_2 = 0.5\ A$

$I = -i_2 + i_4 = -0.5 + i_4 = -0.5 - 1.0$

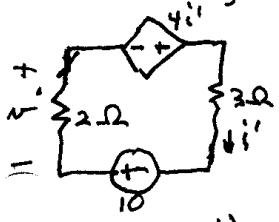
$= -\frac{3}{2}\ A$

d) Find I by solving mesh-current equations



Find v using superposition

a) v_1 from 10V source



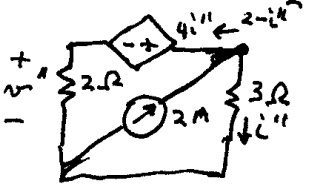
If we know i', we have it, KVL

$$-2i' + 4i' - 3i' + 10 = 0$$

$$i' = 10 \text{ A}$$

$$\Rightarrow \quad v' = 2(-i') = -2 \times 10 = -20\text{V}$$

b) v_2 from 2A source



KVL around outer loop

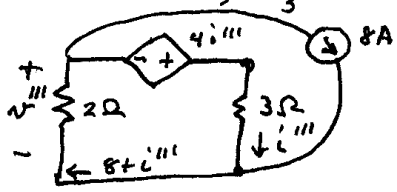
$$-2(-(2-i'')) + 4i'' - 3i'' = 0$$

$$4 - 2i'' + 4i'' - 3i'' = 0$$

$$i'' = 4\text{A}$$

$$v'' = 2(2-i'') = 2(2-4) = -4\text{V}$$

c) v_3 from 8A source



KVL around loop

$$-2(8+i''') + 4i''' - 3i''' = 0$$

$$-16 - 2i''' + 4i''' - 3i''' = 0$$

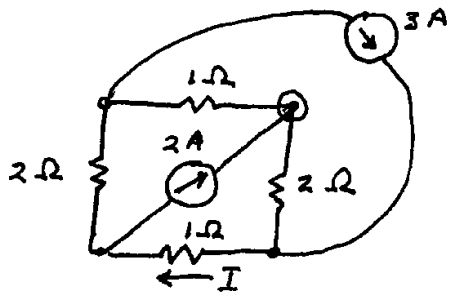
$$i''' = -16\text{ A}$$

$$\therefore \quad v''' = 2(-(8+i''')) = 2(-(8-16))$$

$$= 16\text{V}$$

d) $v =$

$$\therefore \quad v = -20\text{V} - 4\text{V} + 16\text{V} = -8\text{V}$$

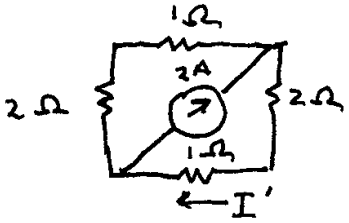


Find I any way you want

node-voltage $m = 4 - 1 - 0 = 3$ equations

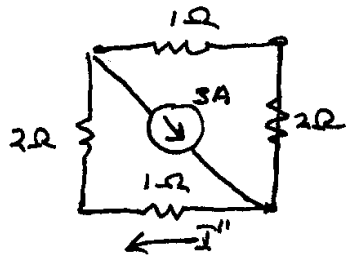
mesh-current $m = 3 - 2 = 1$ but 2A source is shared

I would use superposition



what do we have => current divider

$$I' = 2 \frac{1/3}{1/3 + 1/3} = 1\ A$$



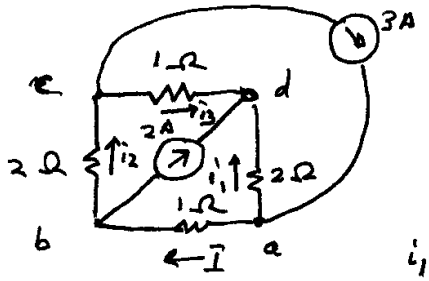
again current divider

$$I'' = 3 \times \frac{1}{2} = 1.5A$$

$$\Rightarrow I = I' + I'' = 2.5A$$

(over)

Node-voltage method



set d as reference (arbitrary)

Label

$i_1 = \frac{v_a}{2}$; $I = \frac{v_a - v_b}{1}$; $i_2 = \frac{v_b - v_c}{2}$

$i_3 = \frac{v_c}{1}$

a) $-I - i_1 + 3 = 0$

$-\left(\frac{v_a - v_b}{1}\right) - \frac{v_a}{2} + 3 = 0 \Rightarrow 3v_a - 2v_b + 0v_c = 6$

b) $-i_2 - 2 + I = 0$

$-\left(\frac{v_b - v_c}{2}\right) - 2 + \frac{v_a - v_b}{1} \Rightarrow -2v_a + 3v_b - v_c = -4$

c) $i_2 - i_3 - 3 = 0$

$+\left(\frac{v_b - v_c}{2}\right) - \frac{v_c}{1} - 3 = 0 \Rightarrow 0v_a - v_b + 3v_c = -6$

or

$$\begin{bmatrix} 3 & -2 & 0 \\ -2 & 3 & -1 \\ 0 & -1 & 3 \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} 6 \\ -4 \\ -6 \end{bmatrix}$$

need v_a and v_b