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8.6 The Unit Step Source

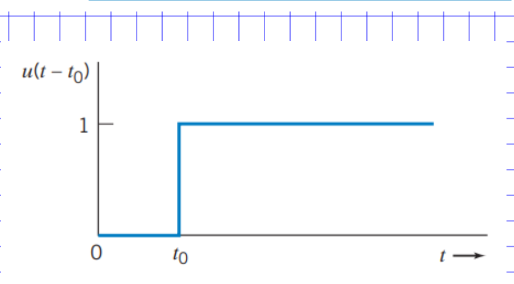


FIGURE 8.6-1 Unit step forcing function, $u(t - t_0)$.

$$u(t - t_0) = \begin{cases} 0 & t < t_0 \\ 1 & t > t_0 \end{cases} \quad (8.6\text{-}1)$$

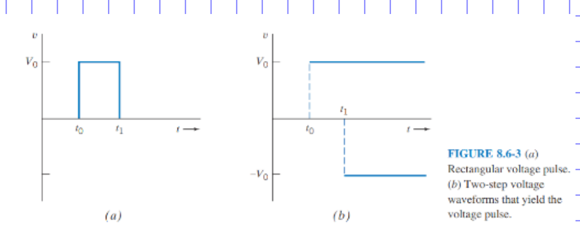


FIGURE 8.6-3 (a) Rectangular voltage pulse. (b) Two-step voltage waveforms that yield the voltage pulse.

Let us consider the pulse source

$$v(t) = \begin{cases} 0 & t < t_0 \\ V_0 & t_0 < t < t_1 \\ 0 & t_1 < t \end{cases}$$

A **pulse signal** has a constant nonzero value for a time duration of $\Delta_t = t_1 - t_0$.

P 8.6-3 The input to the circuit shown in Figure P 8.6-3 is the voltage of the voltage source, $v_s(t)$. The output is the current in the inductor, $i_o(t)$. Determine the output of this circuit when the input is $v_s(t) = -7 + 13\,u(t)$ V.

1) $i_o(t) = ?$

$V_s(t) = -7 + 13\,u(t)$ V

Sol:

0)

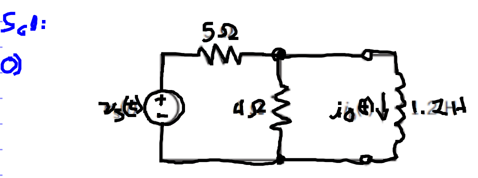
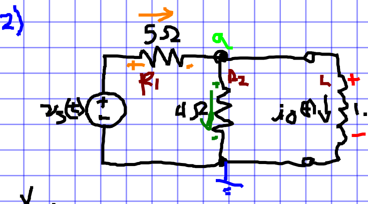
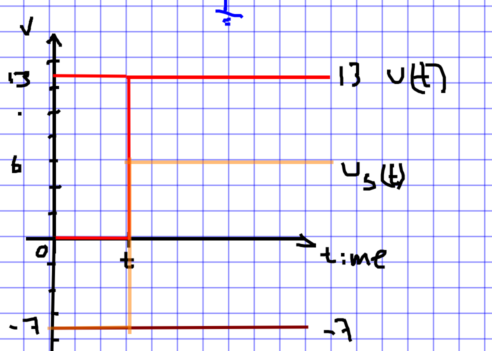


Figure P 8.6-3

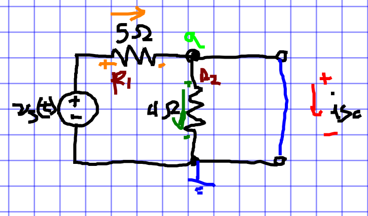
2)



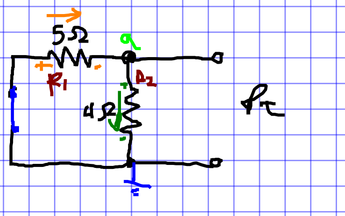


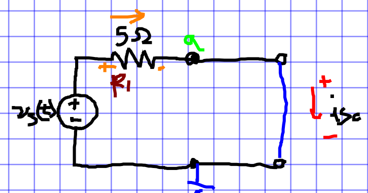
3) Req

3.1) $i_{sc} = ?$



$R_t = R_{th} = ?$

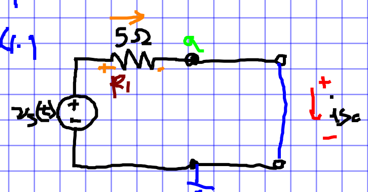




$R_t = 2.22\,\Omega$

4

4.1)



$i_{sc} = \frac{V_{s_1}}{R_1} = \frac{-7}{5\Omega} = -1.4\,A$

time < t

$i(t) = i_{sc} + [\,i(0) - i_{sc}\,]e^{-t/\tau}$ A

$i(0) = i_{sc}$

$[\ ] = 0$

$\tau = \frac{L}{R_t} = \frac{1.2H}{2.22\,\Omega} = 0.54\ s$

$1/\tau = \frac{R_t}{L} = \frac{2.22\,\Omega}{1.2\,H} = 1.83$

$i(t) = -1.4 + [\quad 0 \quad]e^{-1.83t}$ A

$i(t) = -1.4\ A$

4.2)

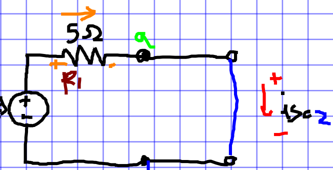
time > t

$i(t) = i_{sc} + [\,i(0) - i_{sc}\,]e^{-t/\tau}$ A

$i(0) = -1.4\,A$

$i_{sc} =$

$i_{sc_2} = \frac{V_{s_2}}{R_1} = \frac{-7+13}{5\Omega} = \frac{6V}{5\Omega} = 1.2\,A$

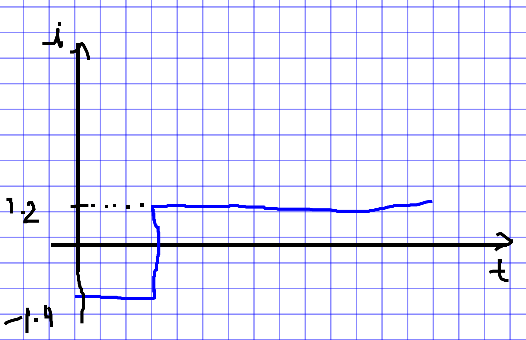


$1/\tau = \frac{R_t}{L} = \frac{2.22\,\Omega}{1.2\,H} = 1.83$

$i(t) = 1.2 + [-1.4 + 1.2]\,e^{-1.83t}$ A

$= 1.2 - 0.2\,e^{-1.83t}$ A

$i(t) \begin{cases} -1.4\,A & t: me < t \\ 1.2 - 0.2e^{-1.83t} & t: me \geq t \end{cases}$



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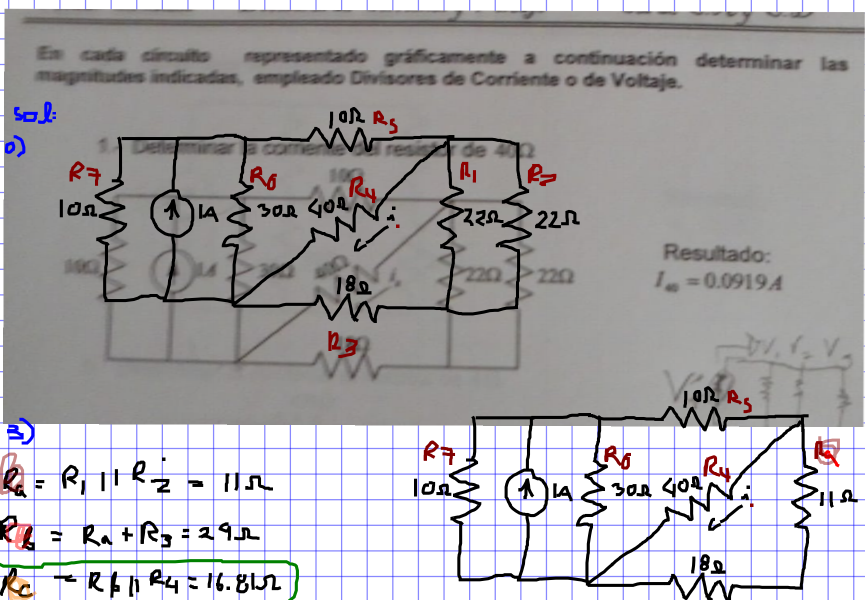
Current Division



sol

0)

2)

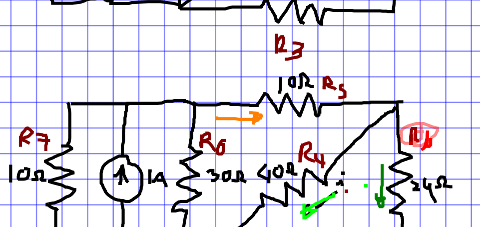
$R_c = R_1 \| R_2 = 11\,\Omega$

$R_b = R_a + R_3 = 29\,\Omega$

$R_c = R_b \| R_4 = 16.81\,\Omega$

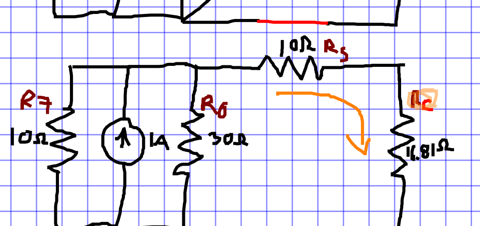
$R_d = R_c + R_5 = 26.81\,\Omega$

$R_e = R_T = R_6 \| R_d \| R_7 = 5.86\,\Omega$



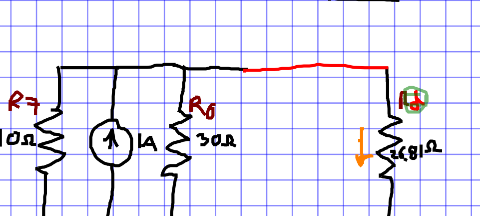
2

4) Laws,



3

$\boxed{i_{Rx} = \frac{R_P}{R_x}\, i_P}$ Current Division



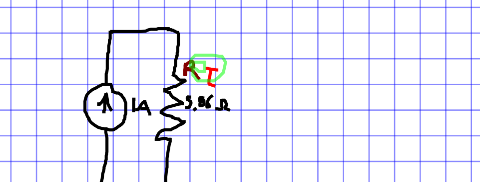
4

Current Division Circuit 6 to 5

$i_{Rd} = \frac{R_T}{R_d}\, i_T$

$= \frac{5.86\,\Omega}{26.81\,\Omega}\, 1A$

$= 218.57\,mA$

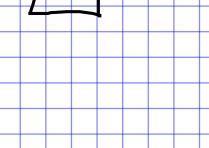


5

Current Division Circuit 4 to 3

$i_{R4} = \frac{R_c}{R_4}\, i_{Rd}$

$= \frac{16.81\,\Omega}{40\,\Omega}\, 218.57\,mA$



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$i_{R4} = 91.85\,mA$