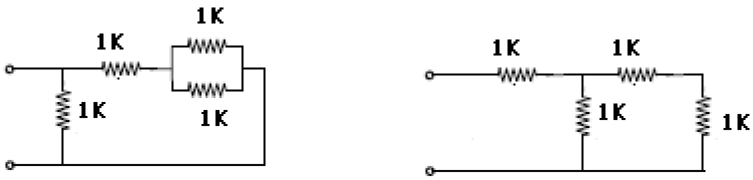
JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY
Electronics and Communication Engineering

Electrical Science-1 (15B11EC111)
TUTORIAL 1: Solution

Q1. Using minimum number of 1K resistors only, synthesize a resistor of value 3/5 K and 5/3 K.

Sol. 3/5 K and 5/3 K.



Q2. Find the effective resistance between terminals A and B for the networks given in Fig. 1.1. [**Ans.** (*a*) 12 Ω; (*b*) 5 Ω; (*c*) 10*R*/3 (d) 3 Ω (e) 4 Ω]

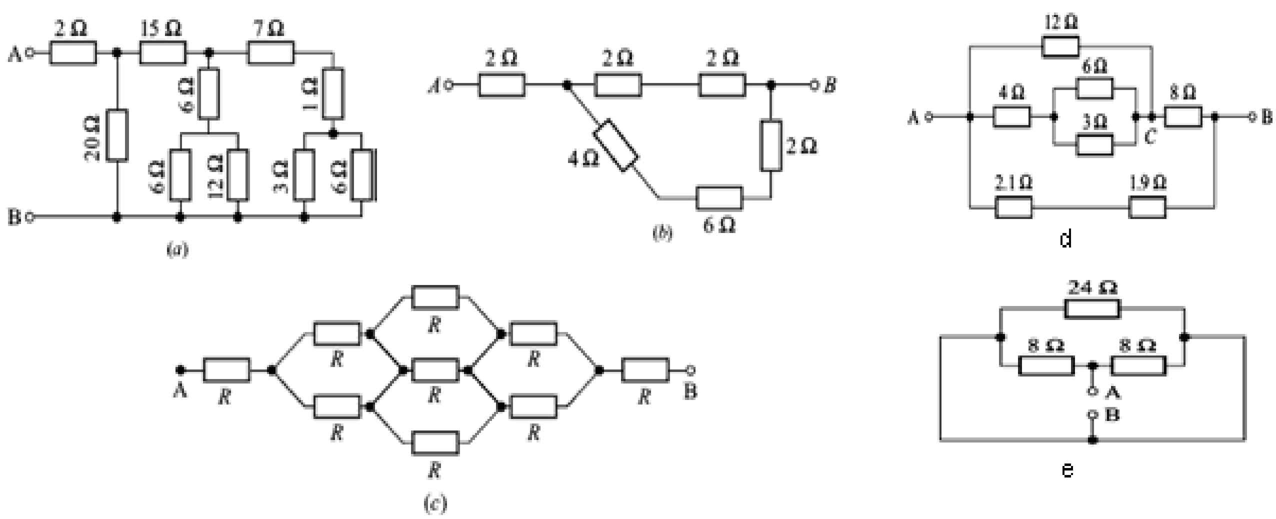


Fig. 1.1

Sol. **(a)** The resistance of the last branch is $R_4 = 8 + (3 \| 6) = 10\ \Omega$. The resistance of the second branch is $R_3 = 6 + (6 \| 12) = 10\ \Omega$. These two are connected in parallel, to give a resistance of 10/2 = 5 Ω. Now, (15 + 5) || 20 = 10 Ω. Therefore, $R_{AB} = 2 + 10 = \mathbf{12\Omega}$.

(b) $R_{AB} = 2 + [(2+2) \| (4+6+2)] = 2 + [4 \| 12] = \mathbf{5\Omega}$.

(c) $R_{AB} = R + R/2 + R/3 + R/2 + R = 10R/3$.

(d) $R_{AC} = 12 \| [4 + (6 \| 3)] = 4\Omega$; $R_{AB} = (4+8) \| (2.1+1.9) = \mathbf{3\ \Omega}$

(e) The 24-ohm resistance is shorted. Thus, 8-ohm and 8-ohm resistances are in parallel.

Q3. The resistance of two coils is 25 ohms when connected in series, and 6 ohms when connected in parallel. Determine the individual resistances of the two coils.
[**Ans.** 15 Ω, 10 Ω]

Sol. $R_1 + R_2 = 25$ and $\dfrac{R_1 R_2}{R_1 + R_2} = 6 \quad \Rightarrow \quad R_1 = 15\ \Omega$ and $R_2 = 10\ \Omega$

Q4. Calculate the current drawn from a 12-V supply with internal resistance 0.5 Ω by the infinite ladder network, each resistance being 1 ohm, in Fig. 1.4. [**Ans.** 3.71 A]

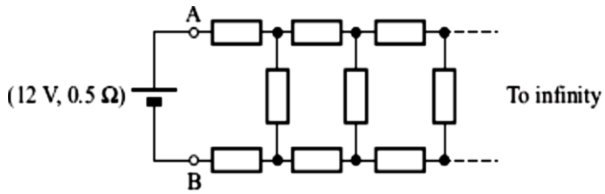


Fig. 1.4

Sol. Removing the first three resistances of the infinite ladder, the remaining ladder network has an equivalent resistance that is equal to that to the original ladder. Removing one rung of an infinite ladder does not change its resistance R_x. Hence,

$$R_x = 1 + (1 \| R_x) + 1 \quad \text{or} \quad R_x = 2 + \frac{1 \times R_x}{1 + R_x} \quad \text{or} \quad R_x^2 - 2R_x - 2 = 0 \quad R_x = 2.73\Omega;\ I = \frac{12}{0.5 + 2.73} = \mathbf{3.71\ A}$$

Q5. A 4 mF capacitor has the current waveform shown in Fig. 1.5. Assuming that v(0)=10 V, sketch the voltage waveform v(t).

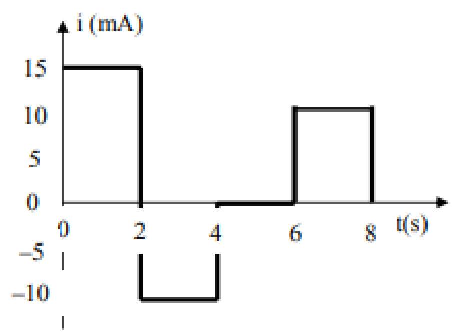


Fig. 1.5

Sol. $$v = \frac{1}{C}\int_0^t i dt + v(0) = 10 + \frac{1}{4\text{x}10^{-3}}\int_0^t i(t) dt$$

For0<t<2 , i(t)=15 mA, $V(t) = 10 + \frac{10^{-3}}{4\times 10^{-3}}\int_0^t 15dt = 10 + 3.75t$

v(2) = 10+7.5 =17.5

For 2 < t <4, i(t) = –10 mA

$$v(t) = \frac{1}{4x10^{-3}}\int_2^t i(t)dt + v(2) = -\frac{10x10^{-3}}{4x10^{-3}}\int_2^t dt + 17.5 = 22.5 + 2.5t$$

v(4)=22.5-2.5x4 =12.5

For 4<t<6, i(t) = 0, $v(t) = \frac{1}{4x10^{-3}}\int_2^t 0dt + v(4) = 12.5$

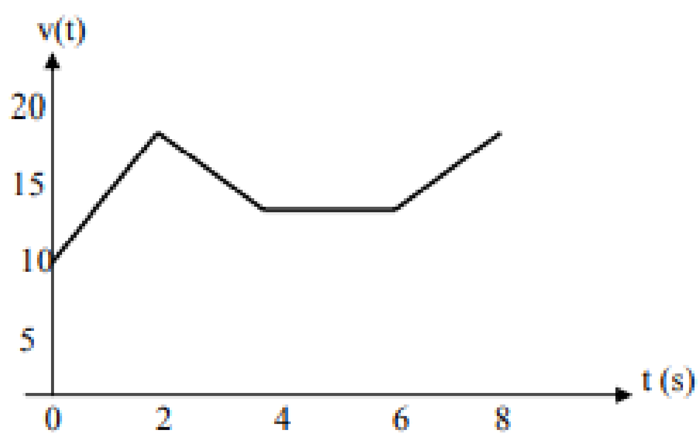
For 6<t<8, i(t) = 10 mA

$$v(t) = \frac{10x10^{3}}{4x10^{-3}}\int_4^t dt + v(6) = 2.5(t-6) + 12.5 = 2.5t - 2.5$$

Hence,

$$v(t) = \begin{cases} 10 + 3.75t\,V, & 0 < t < 2s \\ 22.5 - 2.5t\,V, & 2 < t < 4s \\ 12.5\,V, & 4 < t < 6s \\ 2.5t - 2.5\,V, & 6 < t < 8s \end{cases}$$

which is sketched below.



Q6. The current i(t) in a 2H inductor connected in a telephone circuit changes according to

$$i(t) = \begin{cases} 0 & t \le 0 \\ 4t & 0 < t \le 2 \\ -4t + 16 & 2 < t \le 4 \end{cases}$$

Where unit of time is second and the unit of current is mA. Determine the power p(t) absorbed by the inductor and energy w(t) stored in the inductor.

Sol.

Given $i(t) = \begin{cases} 0 & t \leq 0 \\ 4t & 0 < t \leq 2 \\ -4t + 16 & 2 < t \leq 4 \end{cases}$ and L=2H

Voltage across inductor is

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

$$v(t) = \begin{cases} 0 & t \leq 0 \\ 8mV & 0 \leq t \leq 1 \\ -8mV & t \geq 1 \end{cases}$$

1)Power

$$p = v(t).i(t)$$

So

$$p(t) = \begin{cases} 0 & t \leq 0 \\ 32t\mu\text{W} & 0 < t \leq 2 \\ (32t - 128)\mu\text{W} & 2 < t \leq 4 \end{cases}$$

2)Energy

$$w = \int pdt$$

$$w(t) = \begin{cases} 0 & t \leq 0 \\ 16t^2\mu\text{J} & 0 < t \leq 2 \\ (16t^2 - 128t)\mu\text{J} & 2 < t \leq 4 \end{cases}$$

Q7. Consider the circuit shown in Fig. 1.4 with $v(t) = 12e^{-8t}V$ and $i(t) = 5e^{-8t}A$ for $t \geq 0$. Both v(t) and i(t) are zero for t < 0. Find the power supplied by this element and the energy supplied by the element over the first 100 ms of operation.

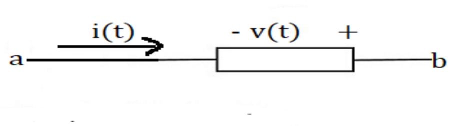


Fig. 1.4

Sol. The power p(t) = v(i) i(t) =$(12e^{-8t}) * (5e^{-8t}) = 60e^{-16t}\ W$

is the power supplied by the element because v(t) and i(t) do not adhere to the passive convention.This element is supplying power to the charge flowing through it.

The energy supplied during the first 100 ms= 0.1 seconds is

$$w(0.1) = \int_{0}^{0.1} p dt = \int_{0}^{0.1} 60e^{-16t} dt$$

$$= 60 \frac{e^{-16t}}{-16} \Big|_{0}^{0.1} = -\frac{60}{16}(e^{-1.6} - 1) = 3.75(1 - e^{-1.6}) = 2.99\, J$$