Chapter 6 & 7 — Capacitor, Inductor & Source-free RC

Dr. Waleed Al-Hanafy
waleed_alhanafy@yahoo.com
Faculty of Electronic Engineering, Menoufia Univ., Egypt

MSA Summer Course:
Electric Circuit Analysis I (ESE 233) — Lecture no. 9

August 8, 2011

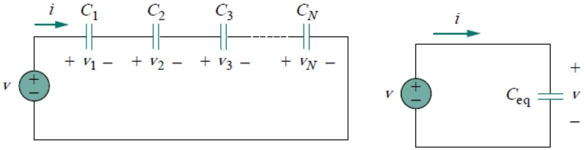
Overview

Reference:

[1] Alexander Sadiku, Fundamentals of Electric Circuits, 4th ed. McGraw-Hill, 2009.

Series Capacitors

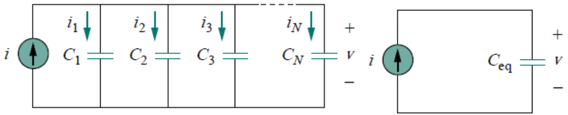
The equivalent capacitance of series-connected capacitors is the reciprocal of the sum of the reciprocals of the individual capacitances.



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}$$

Parallel Capacitors

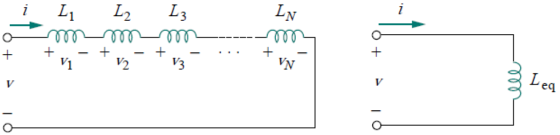
The equivalent capacitance of N parallel-connected capacitors is the sum of the individual capacitances.



$$C_{eq} = C_1 + C_2 + C_3 + \cdots + C_N$$

Series Inductors

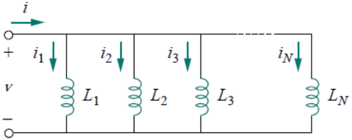
The equivalent inductance of series-connected inductors is the sum of the individual inductances.

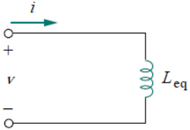


$$L_{eq} = L_1 + L_2 + L_3 + \cdots + L_N$$

Parallel Inductors

The equivalent inductance of parallel-connected inductors is the reciprocal of the sum of the reciprocals of the individual inductances.

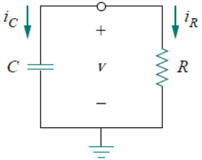


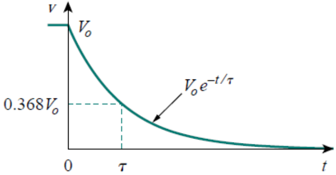


$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$$

Source-free RC

A first-order circuit is characterised by a first-order differential equation. An example is the source-free RC circuit which occurs when its dc source is suddenly disconnected. The energy already stored in the capacitor is released to the resistors.





Source-free RC (cont'd)

Applying KCL at the top node of the circuit shown below,

$$i_C + i_R = 0\,.$$

Since $i_C = Cdv/dt$ and $i_R = v/R$. Thus,

$$C\frac{dv}{dt} + \frac{v}{R} = 0 \qquad \text{or} \qquad \frac{dv}{v} = -\frac{1}{RC}dt$$

Integrating both sides, we get

$$\ln v = -\frac{t}{RC} + \ln A$$

where lnA is the integration constant. Thus,

$$\ln\frac{v}{A} = -\frac{t}{RC} \Rightarrow v(t) = Ae^{-t/RC}$$

But from the initial conditions, $v(0) = A = V_0$. Hence,

$$v(t) = V_0 e^{-t/RC}\,.$$

This equation is illustrated in the figure below, which represents an exponentially decaying function.

Conclusions

Concluding remarks

- Series and parallel capacitor connections is considered
- Series and parallel inductor connections is considered
- A sample first-order circuit is highlighted by a source-free RC circuit