BE1M13VES

Manufacturing of Electrical Components

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Overview

TOPIC

Scattering vs Discrete

Discrete:

- The description of the system is given by a specific count of discrete parts (components), that are connected via ideal conductors.
- There are only slow changes of the signals. Therefore the time of signal propagation in the system is negligible. The signal level depends only on the time (time is only variable).

Scattering:

- The description of the system is given by scattering parameters.
- There are fast changes of the signals. The signal propagation depends on time and also on position coordinates in the system.

Linear vs Nonlinear

Linear
- The system dependency is described only by linear equations.
- The superposition can be used.

Nonlinear
- The system dependency is described by nonlinear equations.
- They creates other harmonic frequencies for harmonic signals. The superposition cannot be used.

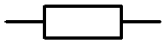
Passive component vs Active component

Passive
- It only dissipates or cumulates the electric energy in electrostatic or magnetic field: resistors, capacitors, inductors, ...

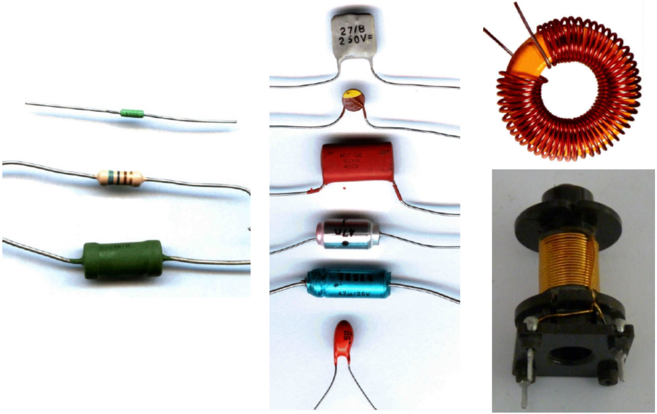
Active
- It contains sources of energy: transistors, amplifiers, sources, ...

TOPIC

Most Common Circuit Components

Component	Symbol	Units	Type
Voltage source		Volts (V)	Active
Current source		Ampers (A)	Active
Resistor		Ohms (Ω)	Passive
Kapacitor		Farads (F)	Passive
Inductor		Henry (H)	Passive

Passive Components



a) *b)* *c)*

a) Resistors, *b)* Capacitors, *c)* Inductors

Resistor

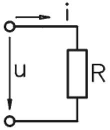
Basic parameters:	electric resistivity (R), dissipated power (P_{max})
Energy:	electrical energy $\Rightarrow$ heat $P = u \cdot i = u^2/R = R \cdot i^2$ u... instantaneous voltage i... instantaneous current

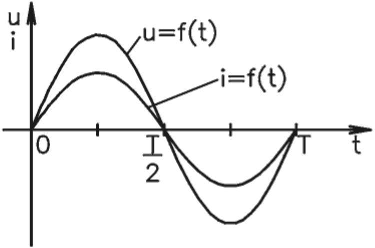
Connection:

$R_{total} = \sum R$ serial	$1/R_{total} = \sum 1/R$ shunt

Ideal Resistor in a Circuit

Ohms law: $u\left(t\right) = R \cdot i\left(t\right)$





Phasor: $Im\left\{\hat{U} \cdot e^{j\omega t}\right\} = R \cdot Im\left\{\hat{I} \cdot e^{j\omega t}\right\}$

$\hat{U} = R \cdot \hat{I}$... $\hat{U}$, $\hat{I}$ no difference in phase

Capacitor

Basic parameters: capacitance (C), nominal voltage (U)

Energy: electrical energy $\Rightarrow$ electrical field

$q = C \cdot u$

$E = C \cdot u^2/2 = q \cdot u/2$

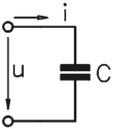
u... instantaneous voltage
q... instantaneous charge

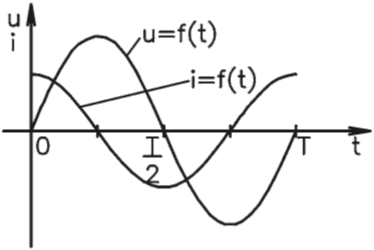
Connection:

$1/C_{total} = \sum 1/C$	$C_{total} = \sum C$
serial	shunt

Ideal Capacitor in a Circuit

Current equation: $i\,(t) = C \cdot \frac{\partial u(t)}{\partial t}$





Phasor:

$$Im\left\{\hat{I} \cdot e^{j\omega t}\right\} = C \cdot \frac{\partial Im\{\hat{U} \cdot e^{j\omega t}\}}{\partial t}$$

$\hat{I} = j\omega C \cdot \hat{I}$... $\hat{U}$ is delayed for 90° after $\hat{I}$

Inductor

Basic parameters: inductance (L), nominal current (I)

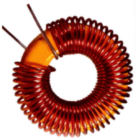
Energy: electrical energy $\Rightarrow$ magnetic field

$\phi = L \cdot i$

$E = L \cdot i^2/2 = \phi \cdot i/2$

i... instantaneous current

ϕ... instantaneous flux



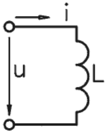
Connection:

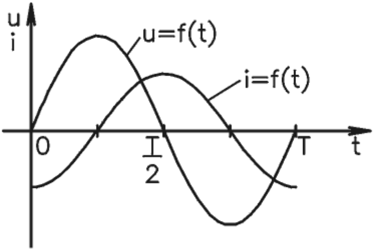
$L_{total} = \sum L$ serial

$1/L_{total} = \sum 1/L$ shunt

Ideal Inductor in a Circuit

Induced voltage: $u\left(t\right) = L \cdot \frac{\partial i(t)}{\partial t}$





Phasor: $Im\left\{\hat{U} \cdot e^{j\omega t}\right\} = L \cdot \frac{\partial Im\left\{\hat{I} \cdot e^{j\omega t}\right\}}{\partial t}$

$\hat{U} = j\omega L \cdot \hat{U}$... $\hat{U}$ is ahead of $\hat{I}$ for 90°

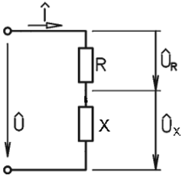
TOPIC

Serial Connection of Components

2nd Kirchhoff's law:

$$\sum_k U_k = 0$$

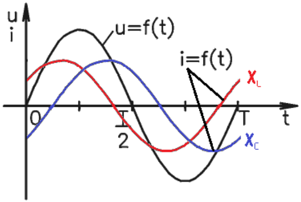
$$\hat{U} = \hat{U}_R + \hat{U}_X$$



Complex Impedance:

$$\hat{Z} = R + j\omega L$$

$$\hat{Z} = R - j/\omega C$$

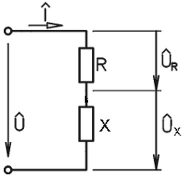


Parallel Connection of Components

1st Kirchhoff's law:

$$\sum_k I_k = 0$$

$$\hat{I} = \hat{I}_G + \hat{I}_B$$



Complex Admittance:

$$\hat{Y} = G - j/\omega L$$

$$\hat{Y} = G + j\omega C$$

Complex Impedance:

$$\hat{Z} = \frac{R \cdot j\omega L}{R + j\omega L}$$

$$\hat{Z} = \frac{R}{1 + j\omega RC}$$

TOPIC

Definition

- It is a non-periodic event as a reaction of the circuit to a sudden change in circuit parameters (variables).
- It is always related to components that are able to cumulate energy: **Capacitor, Inductor**

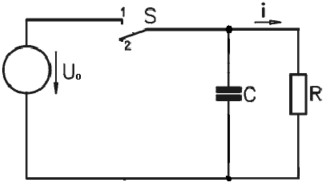
Appearance:

- Step change of the source power (change of the current or voltage),
- sudden change of the circuit component value (R, L, C),
- sudden change in circuit topology $\Rightarrow$ switches.

RC Circuit

Initial Conditions:

- Switch S was in the position 1 for a long time,
- $t \longrightarrow 0-$,
- $u_C = U_0$,
- $i = i_R = U_0/R$.



Switch in the position 2:

- $t \longrightarrow 0+$,
- U_0 source disappear.

$$C \cdot \frac{\partial u_C}{\partial t} + \frac{u_C}{R} = 0$$

$$u_C = -\frac{1}{RC} \cdot \frac{\partial u_C}{\partial t}$$

RC Circuit Solution

After Integration:

$$u_C = K \cdot e^{-t/RC} = K \cdot e^{-t/\tau}$$

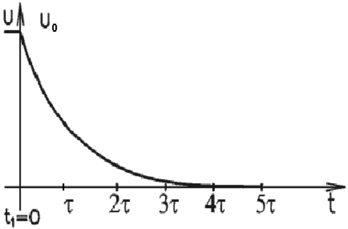
$$\tau = RC$$

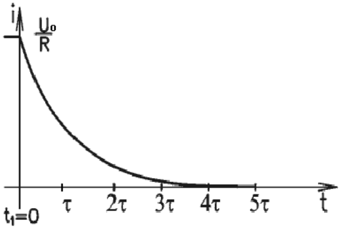
Considering the Initial Conditions:

$$U_0 = K \cdot e^{0/\tau}$$

$$K = U_0$$

RC Circuit Plots





$$u_C = U_0 \cdot e^{-t/\tau}$$

$$i = \frac{U_0}{R} \cdot e^{-t/\tau}$$

Time constant:

- $\tau_{RC} = R \cdot C$,
- $\tau_{RL} = L/R$.

- It is equal to a time of the current or voltage change from 100% to 37.5%,

1^{st} order transient

End of the event:	■ $t = 3\tau$... error less than 5%, ■ $t = 5\tau$... error less than 1%.
Short time event:	■ $t < \tau/10$... beginning of the transient, ■ can be used for integration of the input signal.
Long time event:	■ $t < 10 \cdot \tau$... much longer than the transient, ■ can be used for differentiation of the input signal.

Integrator vs Differentiator