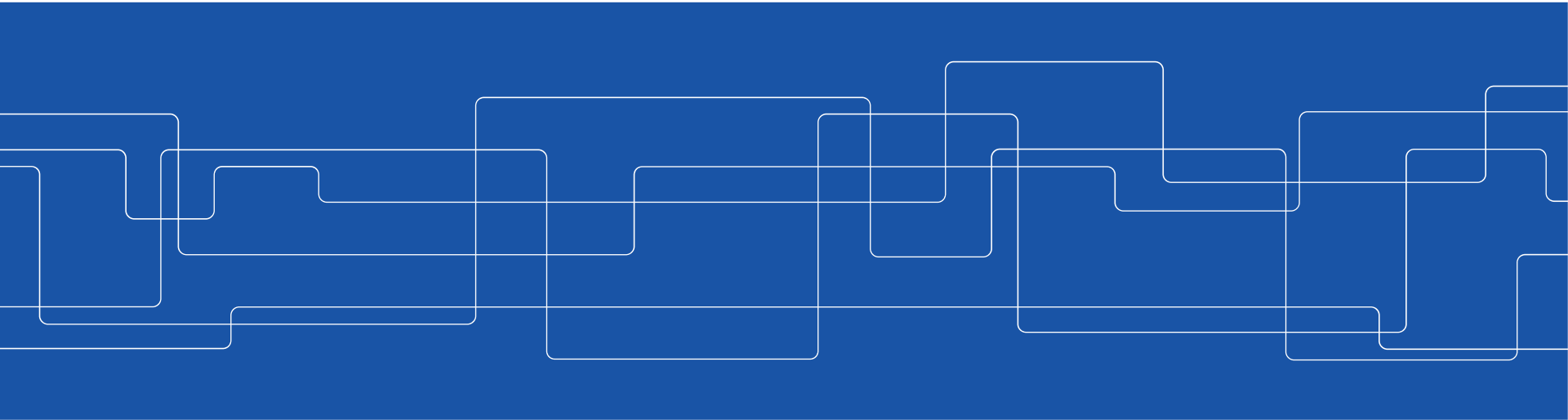




# High-frequency behaviour of electrical Components

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MODULE 3.4





# High-frequency or Non-ideal behavior of components

Conductors [MODULE 3.1]

Capacitors [MODULE 3.2]

Inductors

Resistors

Mechanical switches [MODULE 3.3]

Transformers

**Exercises [MODULE 3.4]**



# 1) Numerical example – performance of resistors with frequency

(same package and construction assumed)

$C_p = 2$  pF      Parasitic capacitance and  
 $L_{we} = 20$  nH      inductance

$$f_o = \frac{1}{2\pi\sqrt{L_{we}C_p}} = 796 \text{ MHz} \quad \text{Resonant frequency}$$

$$R \qquad \frac{1}{2\pi RC}$$

1  $\Omega$                       79.6 GHz     $> f_o$     Resistive  $\rightarrow$  Inductive

100  $\Omega$                     796 MHz     $= f_o$     Resistive  $\rightarrow$  Inductive

1000  $\Omega$                     79.6 MHz     $< f_o$     Resistive  $\rightarrow$  Capacitive  $\rightarrow$  Inductive

For low value resistors the inductive reactance became dominant even before the resonant frequency is reached. For example, at 1 MHz, a 20 nH inductance has an impedance of 0.125  $\Omega$ . If the nominal value of the resistor is 0.1  $\Omega$ , the resistor is behaving mostly as an inductance.



2. Find the resistance and internal inductance of a round wire of radius 0.5 mm made of

- a) Copper ( $\sigma_r = 5.8 \times 10^7 \text{ S/m}$ ,  $\mu_r = 1$ )
- b) Aluminium ( $\sigma_r = 0.6$ ,  $\mu_r = 1$ ), and
- c) Iron ( $\sigma_r = 0.6$ ,  $\mu_r = 500$ )

at frequencies  $\omega = 0, 1, 500, 1 \text{ kHz}, 1 \text{ MHz}$  and  $1 \text{ GHz}$ .

at frequencies 50 Hz, 1 kHz, 1MHz and 1 GHz.

3. Compute the loop inductance of a rectangular loop of dimensions 20 mm x 5 mm (representing typical leads of a component) by calculating self-partial inductances and mutual-partial inductances. Also calculate the inductance assuming it to be a parallel wire transmission line of length 20 mm and find the difference between the two inductance calculations (radius of the wire=0.4 mm).

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4. Suppose ten metal-film resistors of 10 ohm value are connected in parallel to construct a shunt of 1 ohm. The lead inductance and capacitance of each resistor is 3 nH, and 1 pF, respectively. If the current flowing in the circuit was measured by measuring the voltage drop across the shunt, find the error in the current measurement at a frequency of 100 MHz.

**5.** A component is measured and found to have an impedance whose asymptotic frequency response (bode plot) is as shown. Synthesize an equivalent circuit to represent this impedance. Write the values of the circuit elements.

