DTG2D3

ELEKTRONIKA TELEKOMUNIKASI

INSTITUT TEKNOLOGI TELKOM

RF COMPONENT

By : Dwi Andi Nurmantris

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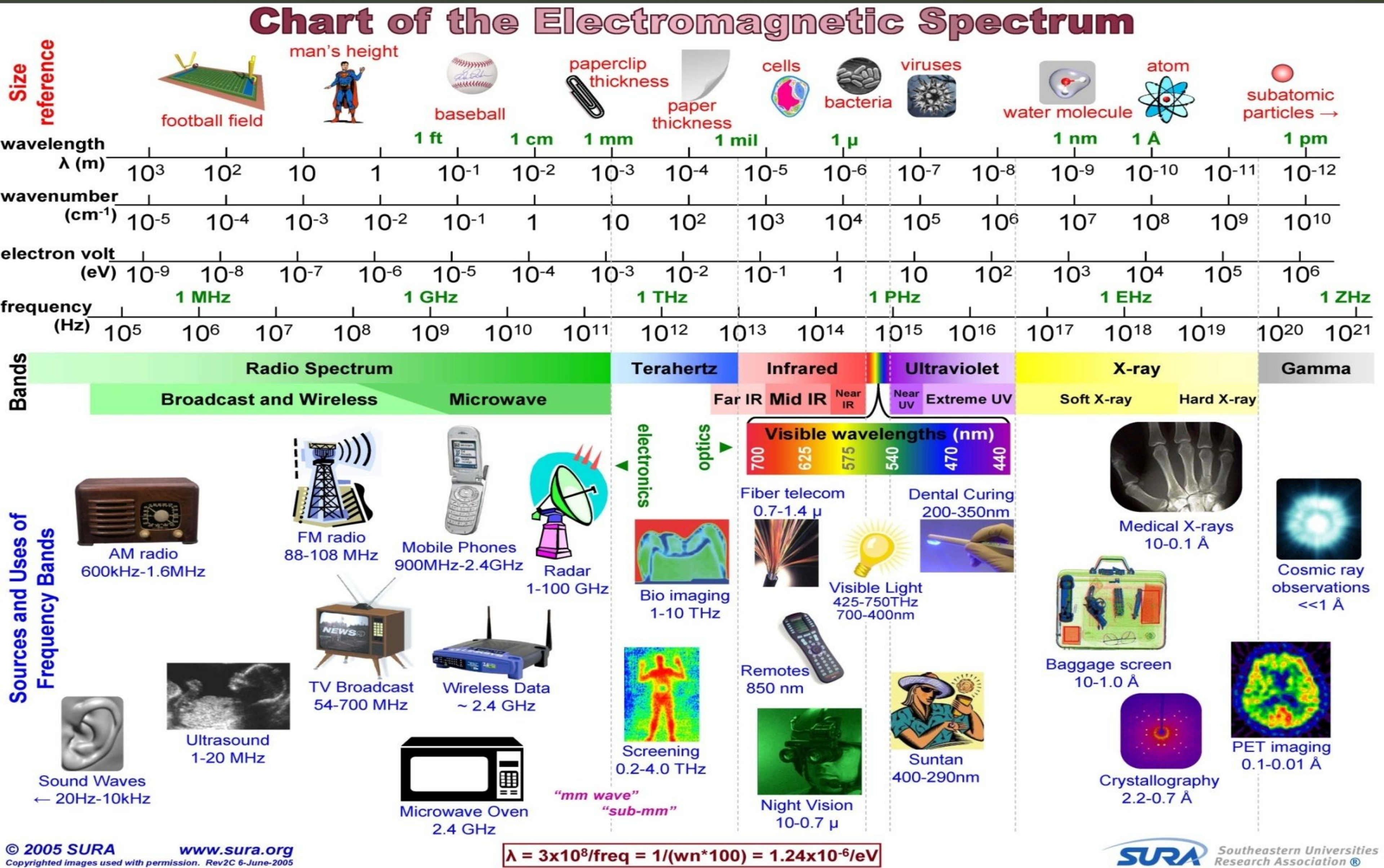
What is Radio Frequency????



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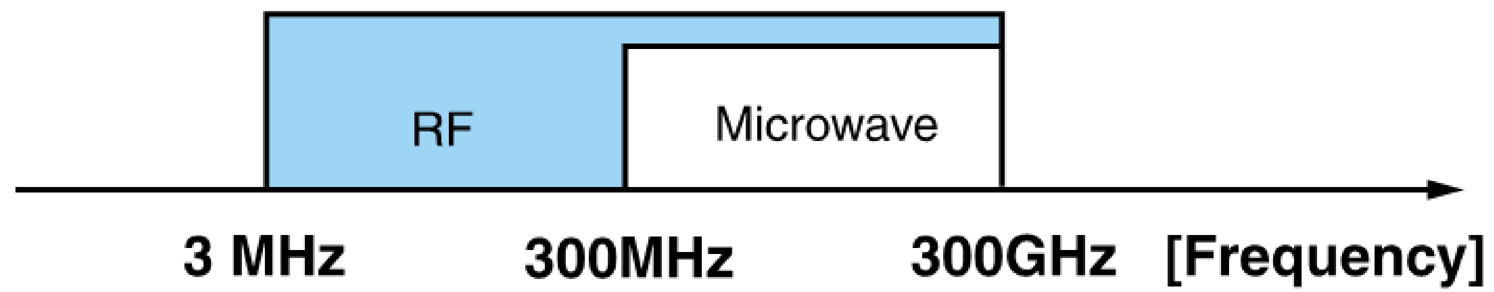
What is Radio Frequency???



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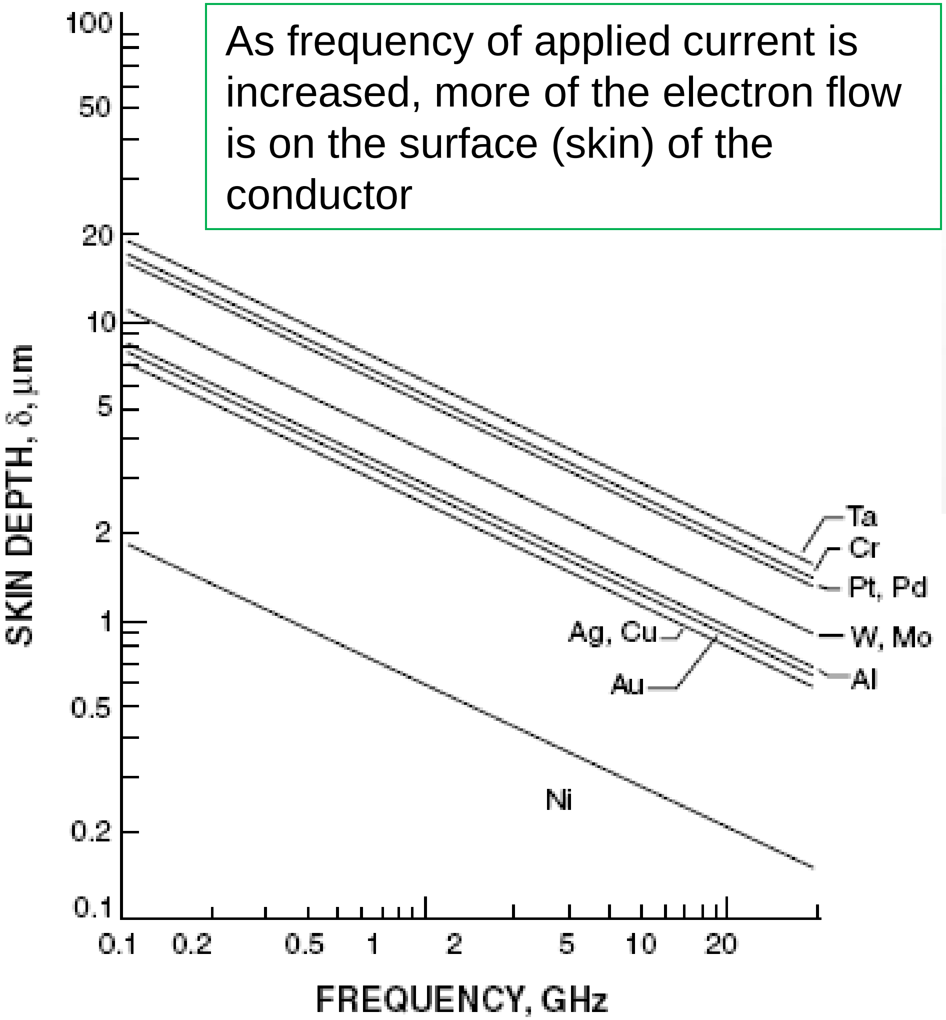
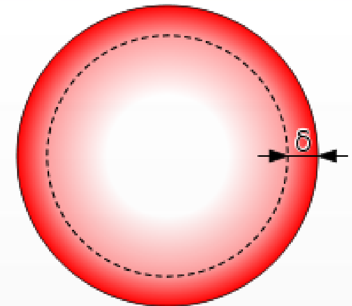
Skin Effect



As frequency of applied current is increased, more of the electron flow is on the surface (skin) of the conductor

$$\delta = \sqrt{\frac{2}{\omega\sigma\mu}}$$



σ = Conductivity of the metal (S/m)

f = frequency (Hz)

μ = permeability of metal (H/m)

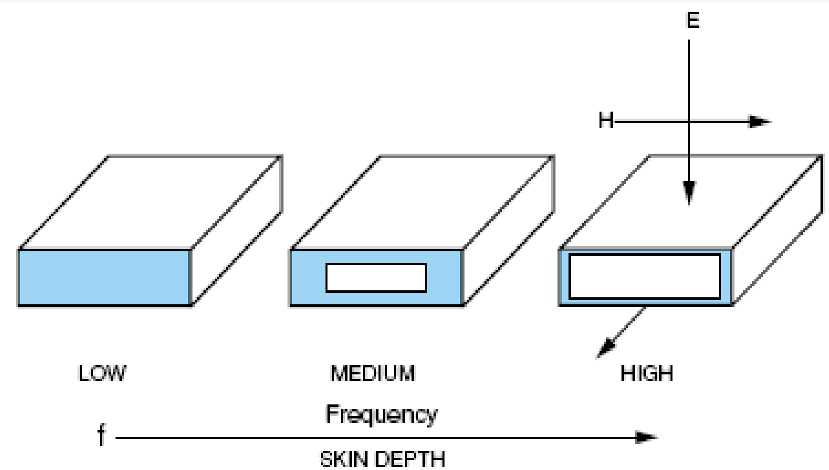


FIGURE 13.19 Effect of frequency on conductor cross section.

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Wire

In the medium surrounding any current-carrying conductor, there exists a magnetic field. If the current in the conductor is an alternating current, this magnetic field is alternately expanding and contracting and, thus, producing a voltage on the wire which opposes any change in current flow. This opposition to change is called self-inductance

$$L = 0.002l\left[2.3\log\left(\frac{4l}{d} - 0.75\right)\right]\ \mu H$$

where,

L = the inductance in μH,
l = the length of the wire in cm,
d = the diameter of the wire in cm.

Straight-wire inductance might seem trivial, but the higher we go in frequency, the more important it becomes.

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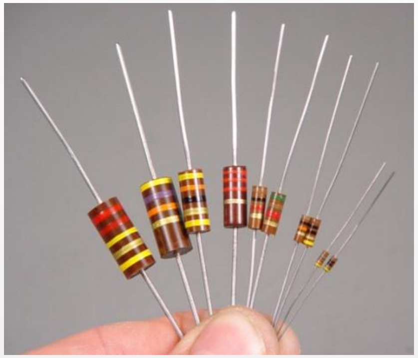
Resistor

Resistance is the property of a material that determines the rate at which electrical energy is converted into heat energy for a given electric current

Carbon Composition Resistor

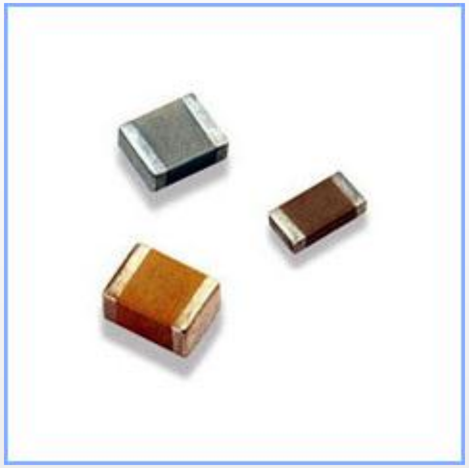


Wire Wound Resistor

Metal Film Resistor

Carbon Film Resistor

Thin-Film Chip Resistor



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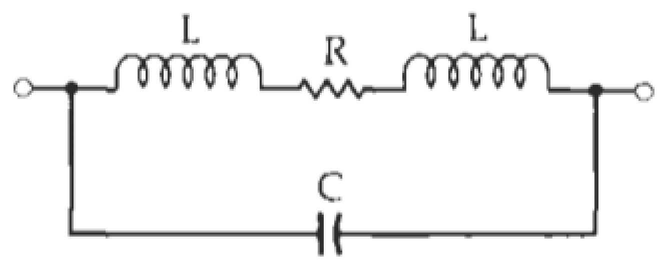
Resistor at Radio Frequency

Resistor Equivalent Circuit



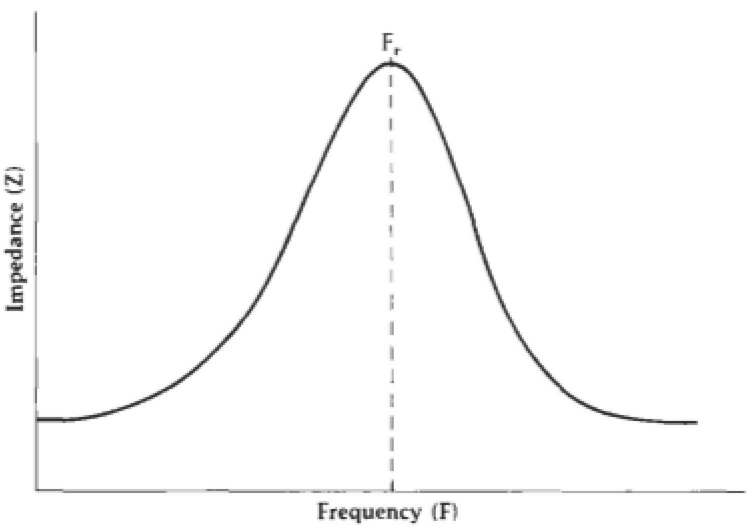


Fig. 1-3. Impedance characteristic of a wirewound resistor.

R is the resistor value itself,
L is the lead inductance, and
C is a combination of parasitic capacitances which varies from resistor to resistor depending on the resistor's structure

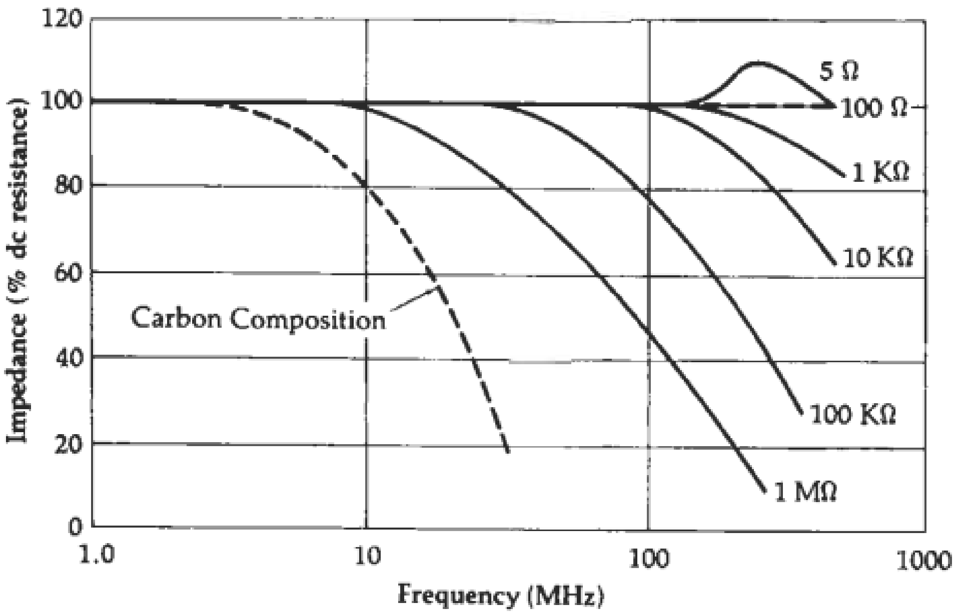


Fig. 1-4. Frequency characteristics of metal-film vs. carbon-composition resistors. (Adapted from *Handbook of Components for Electronics*, McGraw-Hill).

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Resistor at Radio Frequency

EXAMPLE 1-3

In Fig. 1-2, the lead lengths on the metal-film resistor are 1.27 cm (0.5 inch), and are made up of No. 14 wire. The total stray shunt capacitance (C) is 0.3 pF. If the resistor value is 10,000 ohms, what is its equivalent rf impedance at 200 MHz?

Solution

From Table 1-1, the diameter of No. 14 AWG wire is 64.1 mils (0.1628 cm). Therefore, using Equation 1-1:

$$L = 0.002(1.27)\left[2.3 \log\left(\frac{4(1.27)}{0.1628} - 0.75\right)\right]$$

$$= 8.7 \text{ nanohenries}$$

This presents an equivalent reactance at 200 MHz of:

$$X_L = \omega L$$
$$= 2\pi(200 \times 10^6)(8.7 \times 10^{-9})$$
$$= 10.93 \text{ ohms}$$

The capacitor (C) presents an equivalent reactance of:

$$X_c = \frac{1}{\omega C}$$
$$= \frac{1}{2\pi(200 \times 10^6)(0.3 \times 10^{-12})}$$
$$= 2653 \text{ ohms}$$

The combined equivalent circuit for this resistor, at 200 MHz, is shown in Fig. 1-5. From this sketch, we can see that, in this case, the lead inductance is insignificant when compared with the 10K series resistance and it may be

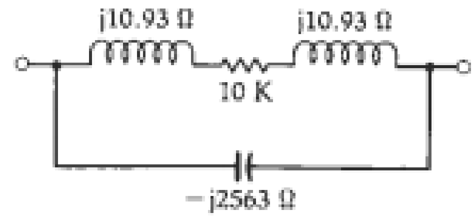

Fig. 1-5. Equivalent circuit values for Example 1-3.

neglected. The parasitic capacitance, on the other hand, cannot be neglected. What we now have, in effect, is a 2563-ohm reactance in parallel with a 10,000-ohm resistance. The magnitude of the combined impedance is:

$$Z = \frac{RX_c}{\sqrt{R^2 + X_c^2}}$$
$$= \frac{(10K)(2563)}{\sqrt{(10K)^2 + (2563)^2}}$$
$$= 1890.5 \text{ ohms}$$

Thus, our 10K resistor looks like 1890 ohms at 200 MHz.

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Capacitor

A capacitor is any device which consists of two conducting surfaces separated by an insulating material or dielectric. The dielectric is usually ceramic, air, paper, mica, plastic, film, glass, or oil

The capacitance of a capacitor is that property which permits the storage of a charge when a potential difference exists between the conductors

Ceramic Capacitor

Mica Capacitor

Metalized-Film Capacitor

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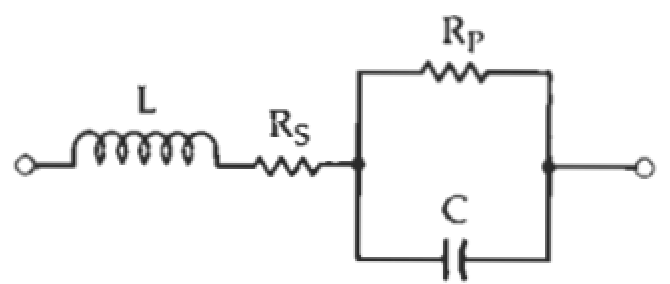
Capacitor at Radio Frequency

Capacitor Equivalent Circuit



C equals the capacitance,
Rs, is the heat-dissipation loss
Rp, is the insulation resistance, and
L is the inductance of the leads and plates

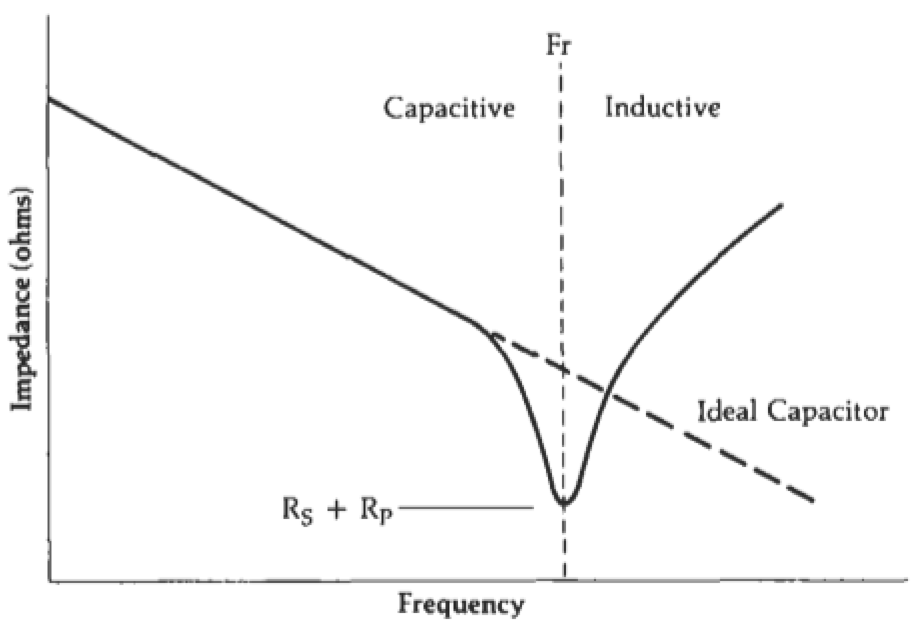


Fig. 1-9. Impedance characteristic vs. frequency.

as the frequency of operation increases, the lead inductance becomes important. Finally, at Fr, the inductance becomes series resonant with the capacitor. Then, above Fr, the capacitor acts like an inductor.

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Inductor

An **inductor** is nothing more than a wire wound or coiled in such a manner as to increase the magnetic flux linkage between the turns of the coil

Single Layer Air Core Inductor

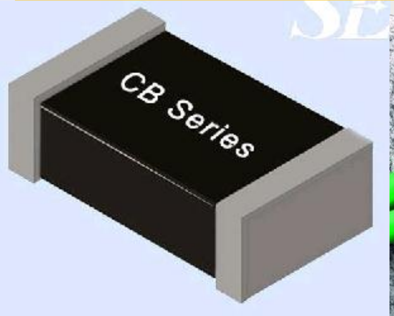
Magnetic-Core Materials Inductor

Toroid

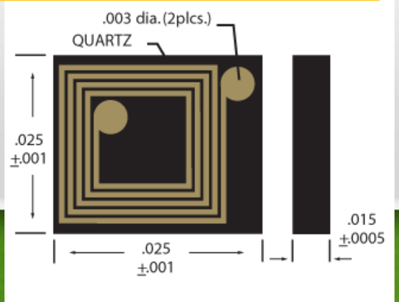
Ferrite Material

Iron-Powder Material

microminiature fixed-chip inductors

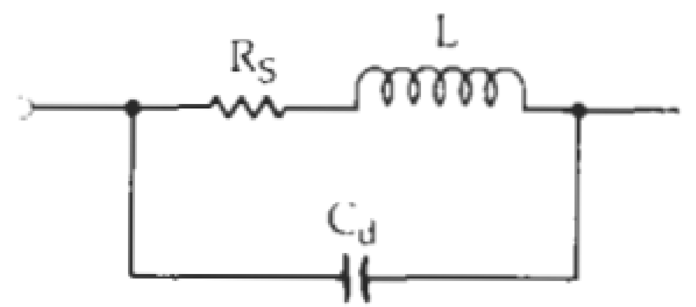


Planar Chip Conductor



Inductor at Radio Frequency

Inductor Equivalent Circuit



L is Inductance,
Rs, is the heat-dissipation loss
Cd is an aggregate of the individual parasitic distributed capacitances of the coil

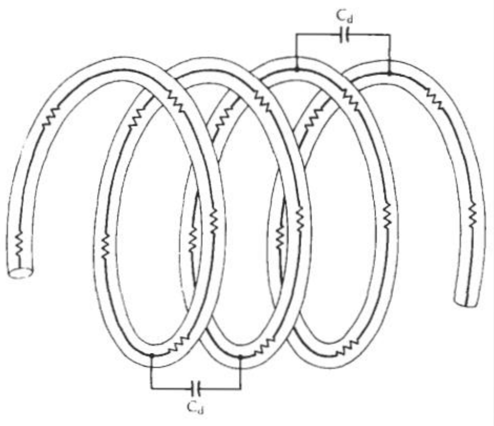


Fig. 1-14. Distributed capacitance and series resistance in an inductor.

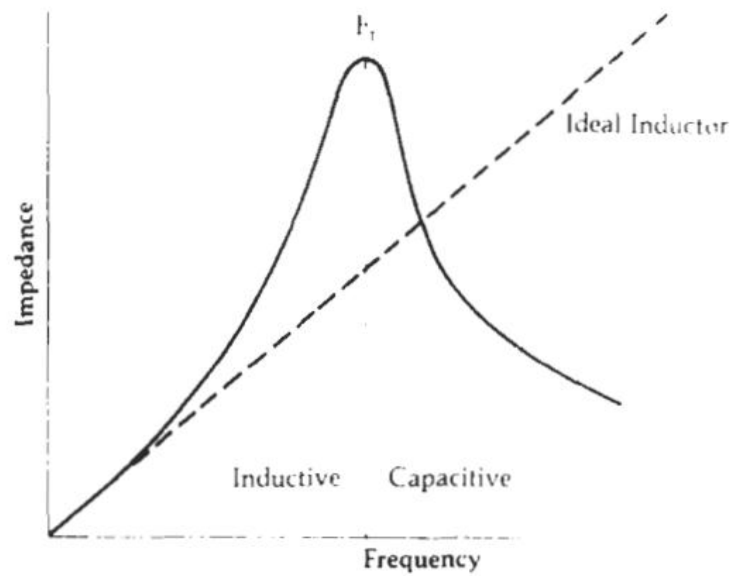


Fig. 1-16. Impedance characteristic vs. frequency for a practical and an ideal inductor.

at lower frequencies, the inductor's reactance parallels that of an ideal inductor. Soon, however, its reactance departs from the ideal curve and increases at a much faster rate until it reaches a peak at the inductor's parallel resonant frequency (Fr) , **Above Fr,** the inductor's reactance begins to decrease with frequency and, thus, the inductor begins to look like a capacitor


THANK
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