R. Ludwig and G. Bogdanov
"RF Circuit Design: Theory and Applications"
2^{nd} edition

Figures for Chapter 1

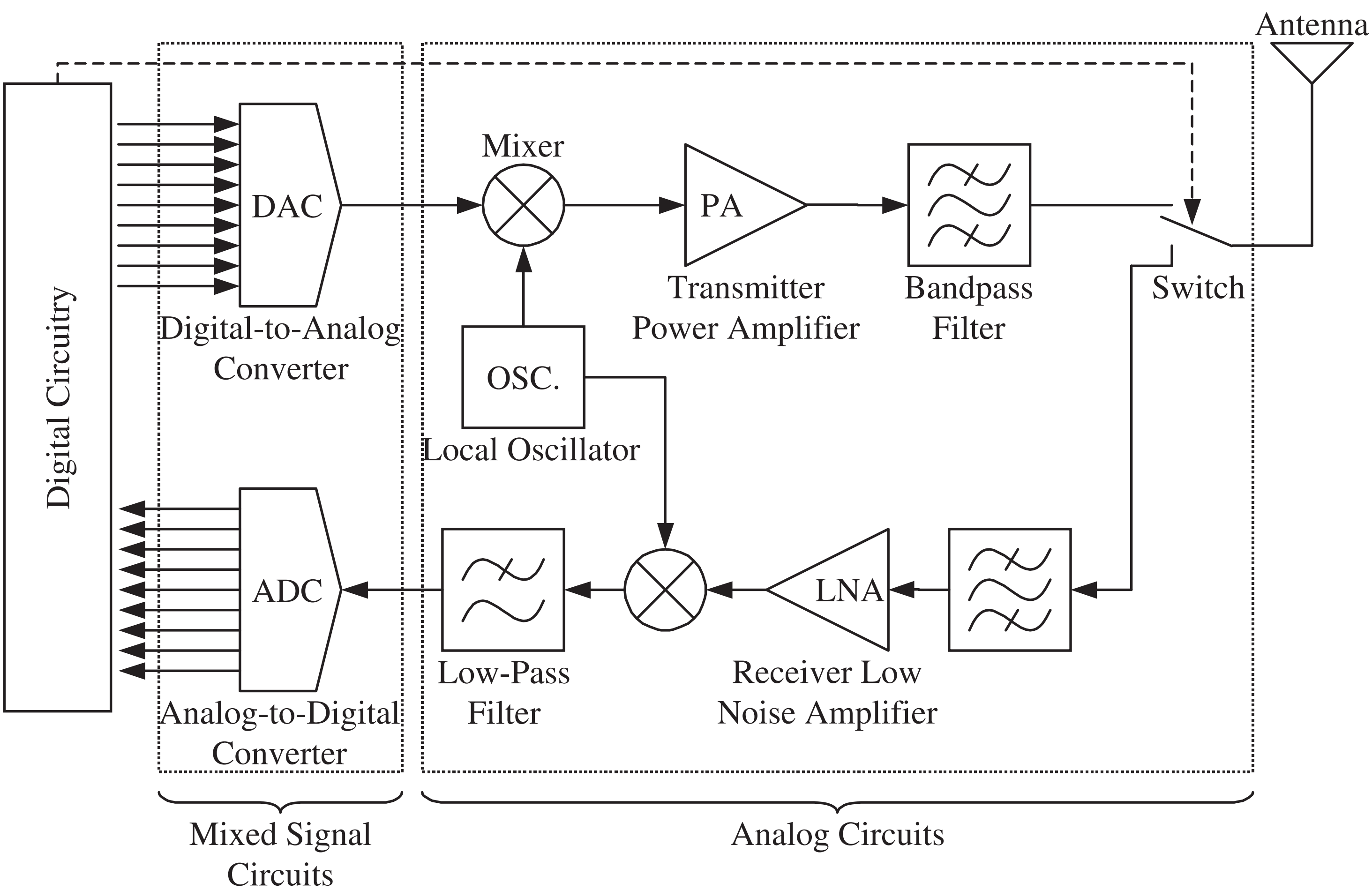

Figure 1-1 Block diagram of a generic RF system.

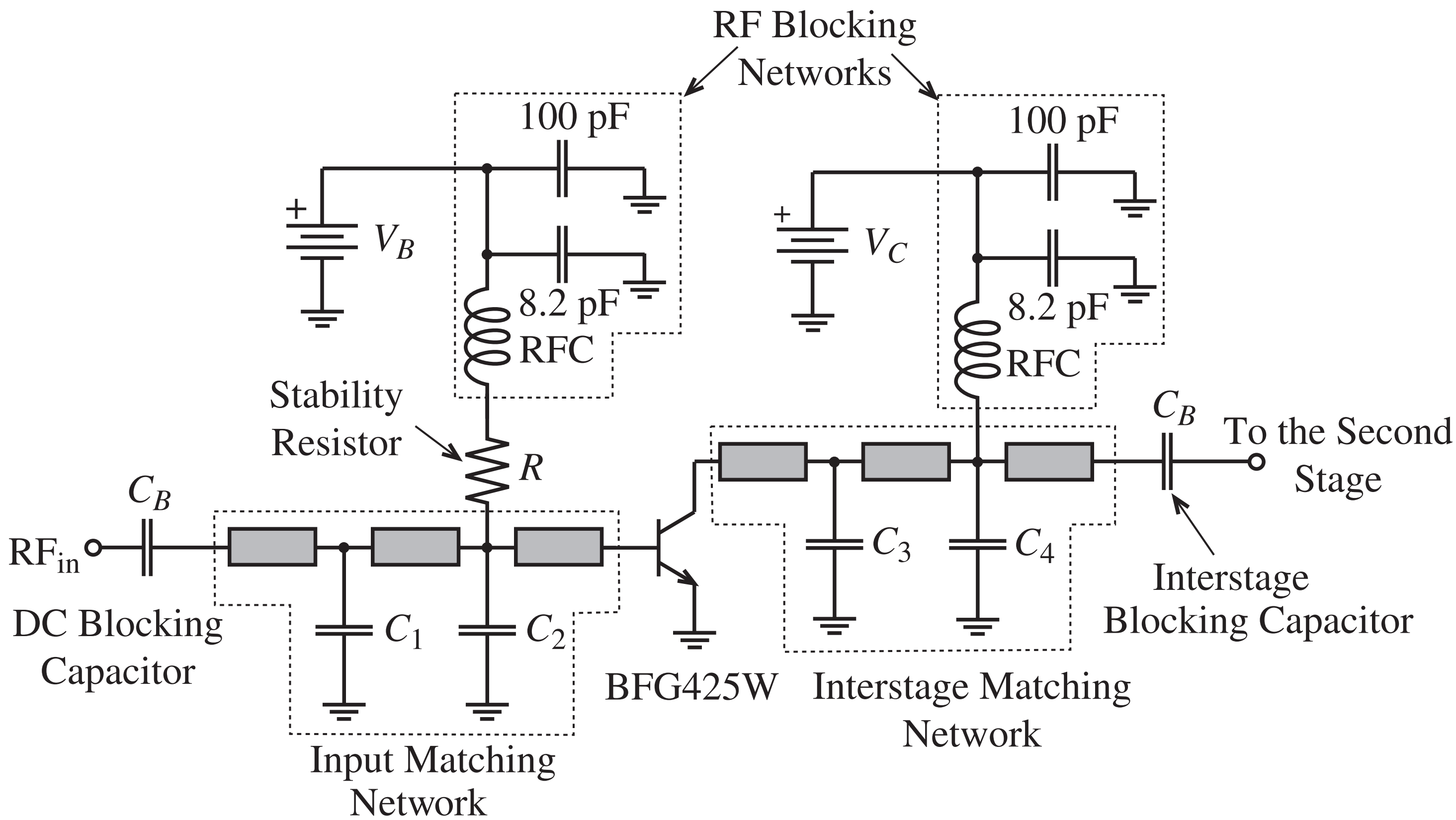

Figure 1-2(a) Simplified circuit diagram of the first stage of a 2 GHz power amplifier for a mobile phone.

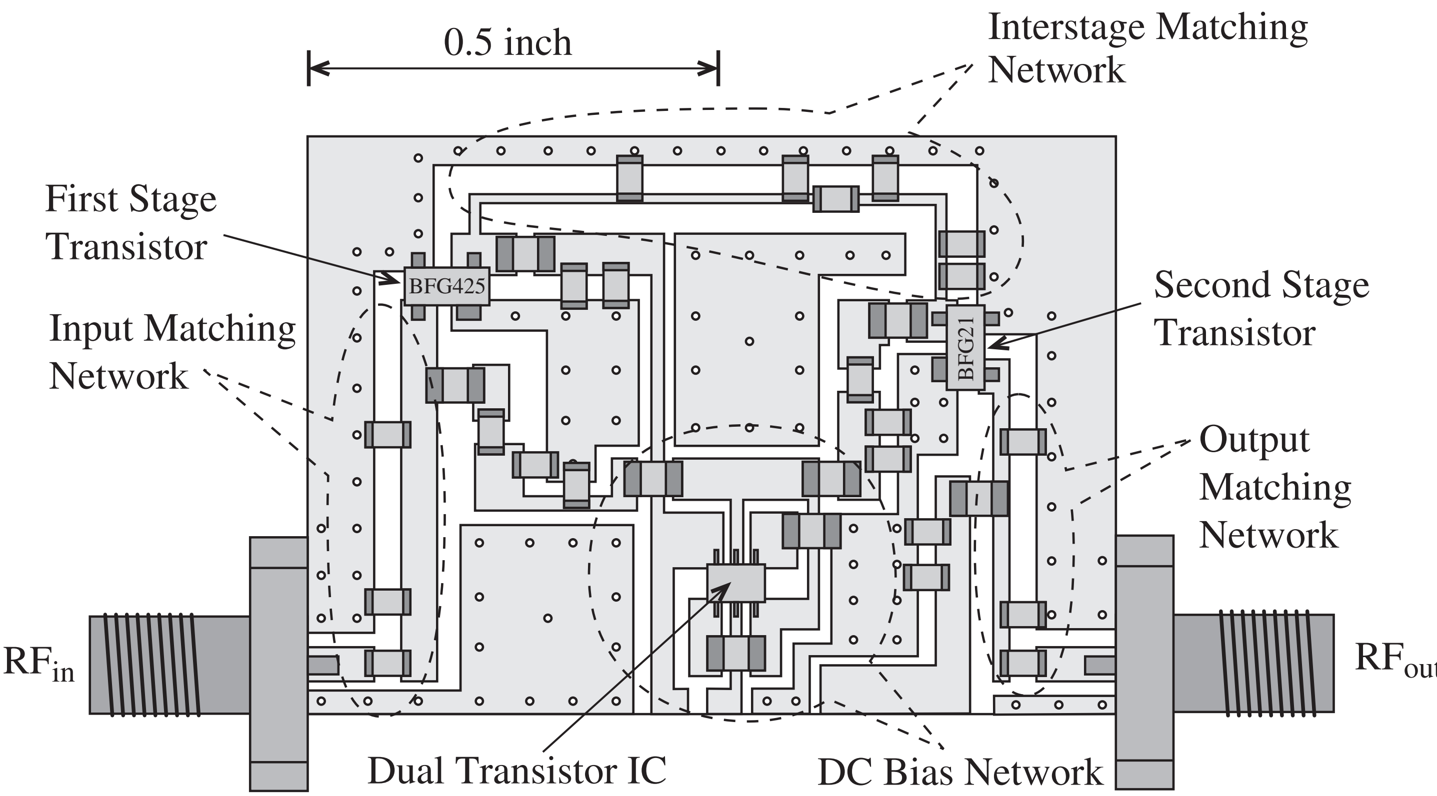

Figure 1-2(b) Printed circuit board layout of the power amplifier.

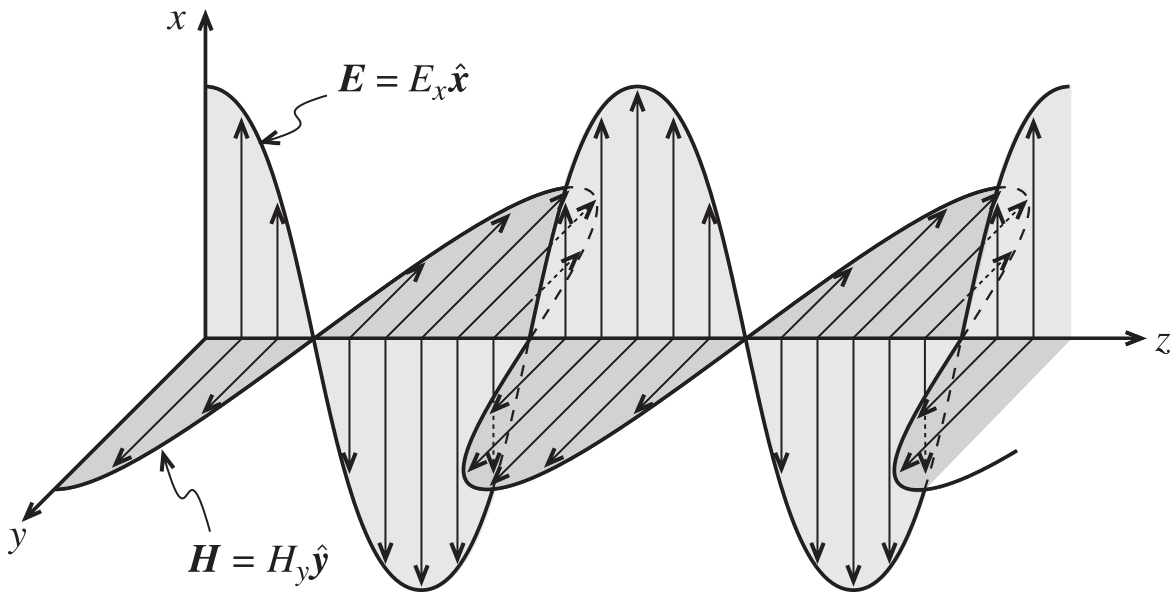

Figure 1-3 Electromagnetic wave propagation in free space. The electric and magnetic fields are shown at a fixed instance in time as a function of space ($\hat{\boldsymbol{x}}$, $\hat{\boldsymbol{y}}$ are unit vectors in *x*- and *y*-direction).

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Table 1-1 Frequency bands and their applications

Frequency Band	Frequency	Typical Application
VHF (Very High Frequency)	88 – 108 MHz	FM broadcasting
UHF (Ultrahigh Frequency)	824 – 894 MHz 810 – 956 MHz	CDMA mobile phone service GSM mobile phone service
UHF (Ultrahigh Frequency)	2,400 MHz	WLAN
SHF (Superhigh Frequency)	5,000 – 5,850 MHz	Unlicensed National Information Infrastructure
SHF (Superhigh Frequency)	6,425 – 6,523 MHz	Cable Television Relay
SHF (Superhigh Frequency)	3,700 – 4,200 MHz	Geostationary fixed satellite service
X Band	8 – 12.5 GHz	Marine and airborne radar
Ku Band	12.5 – 18 GHz	Remote sensing radar
K Band	18 – 26.5 GHz	Radar
Ka Band	26.5 – 40 GHz	Remote sensing radar

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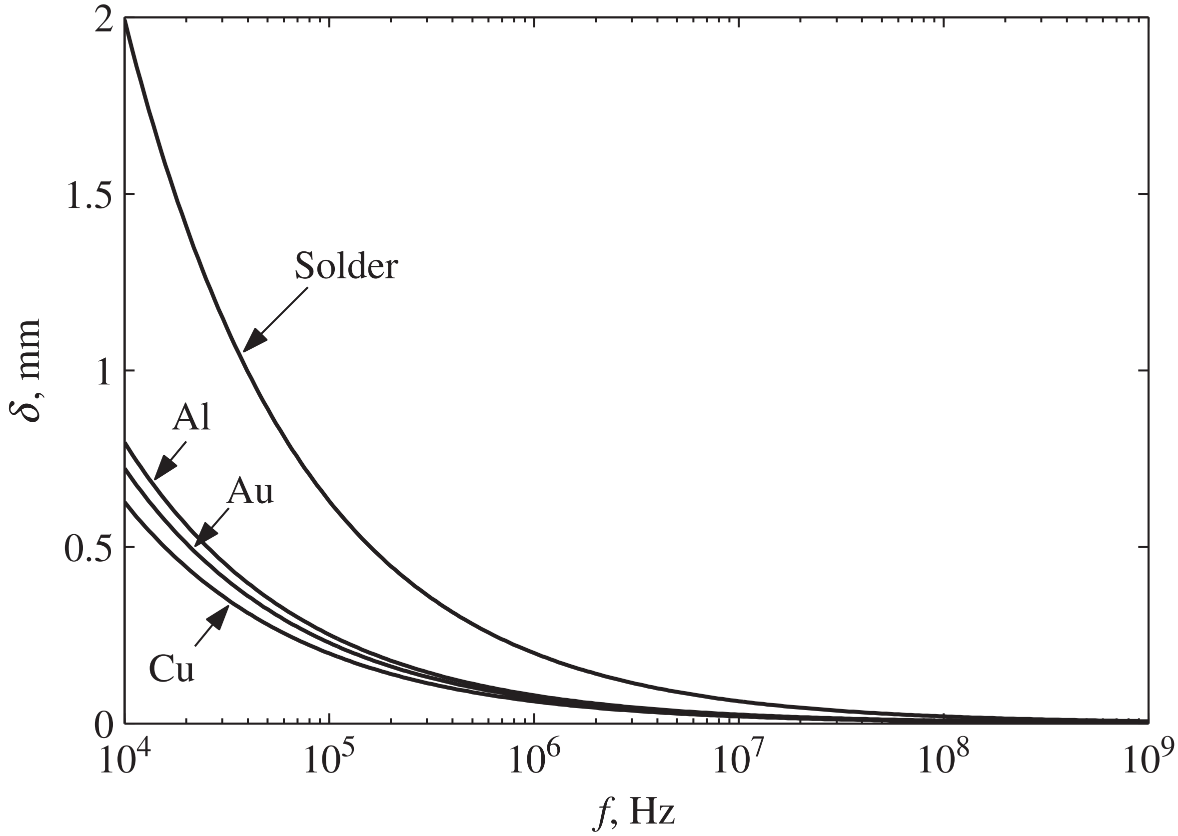


Figure 1-4 Skin depth behavior of copper $\sigma_{Cu} = 64.5 \times 10^6$ S/m, aluminum $\sigma_{Al} = 40.0 \times 10^6$ S/m, gold $\sigma_{Au} = 48.5 \times 10^6$ S/m, and typical solder $\sigma_{solder} = 6.38 \times 10^6$ S/m.

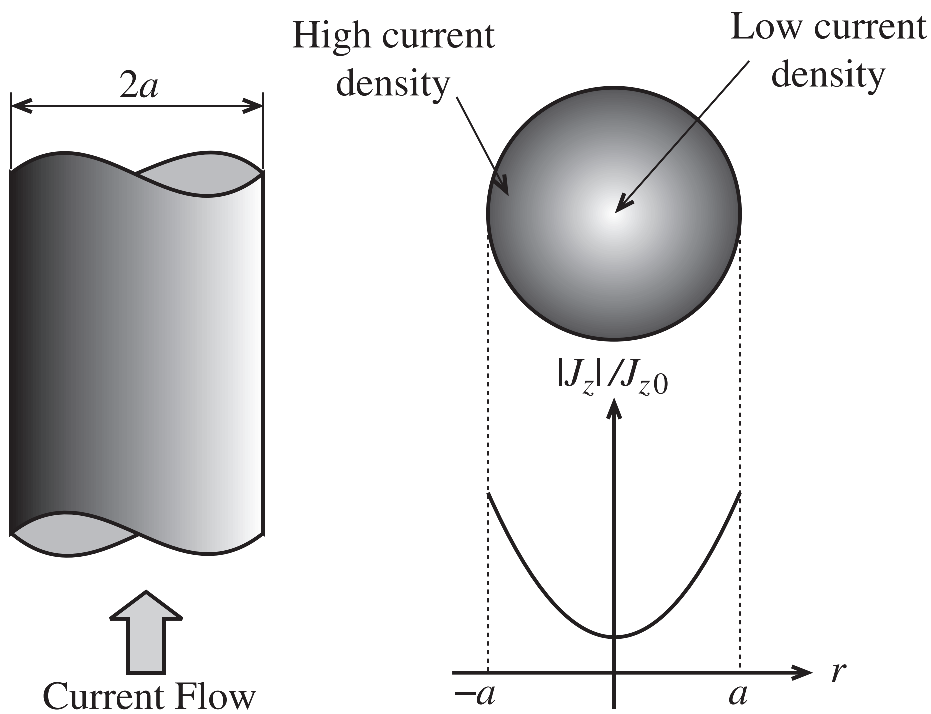


Figure 1-5(a) Schematic cross-sectional AC current density representation normalized to DC current density.

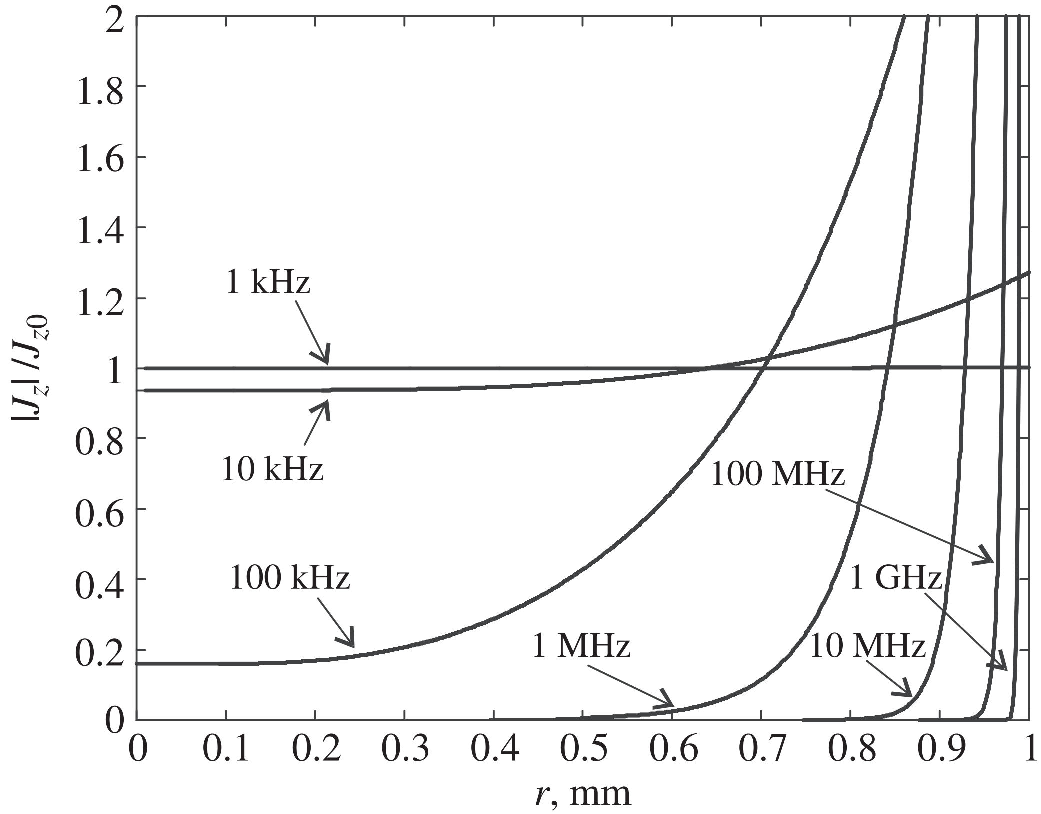


Figure 1-5(b) Frequency behavior of normalized AC current density for a copper wire of radius a = 1 mm.

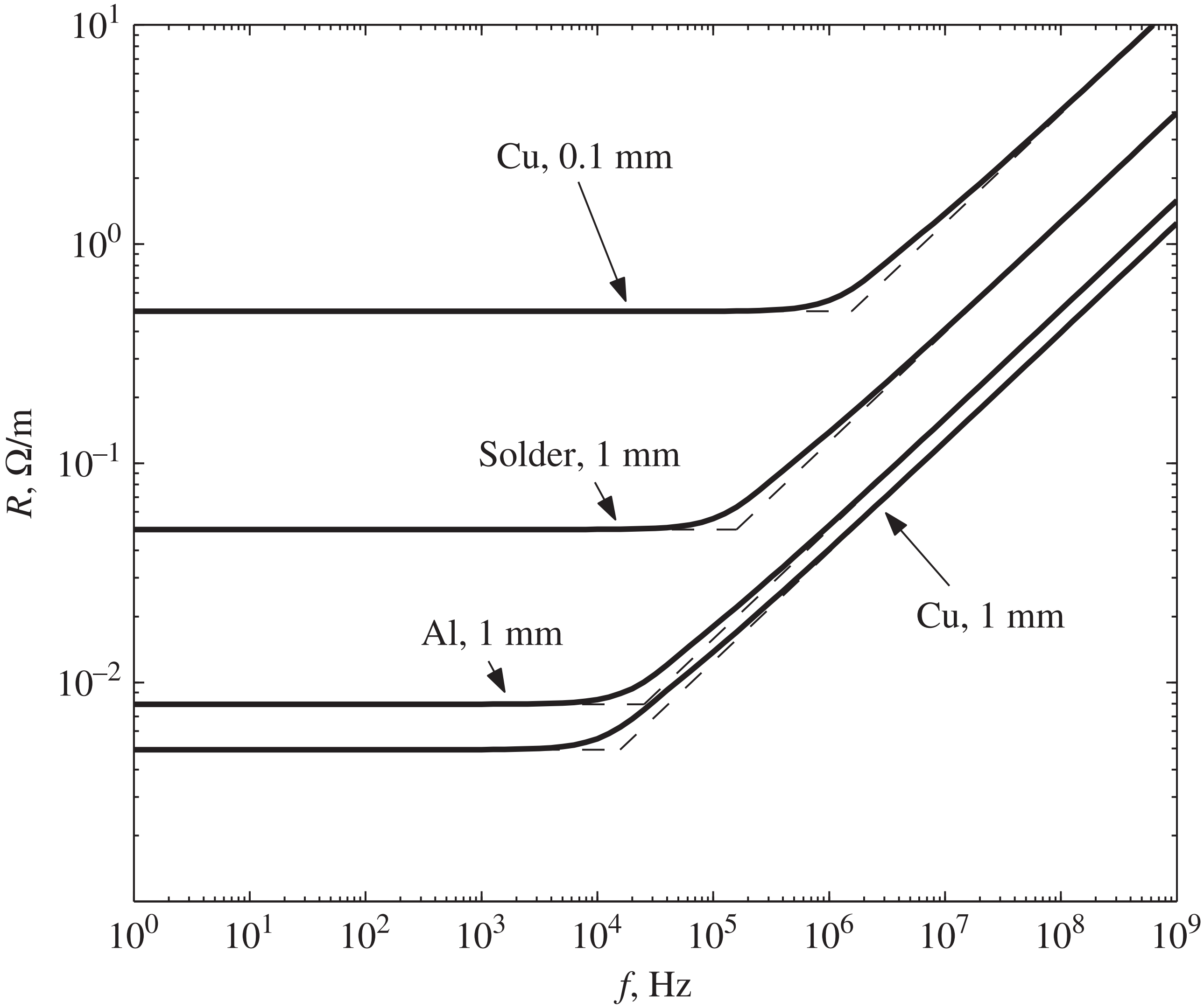


Figure 1-6 The exact theoretical per-unit-length resistance as a function of frequency for round wires of varying materials and radii. The dashed lines represent the DC and skin depth based resistance approximations.

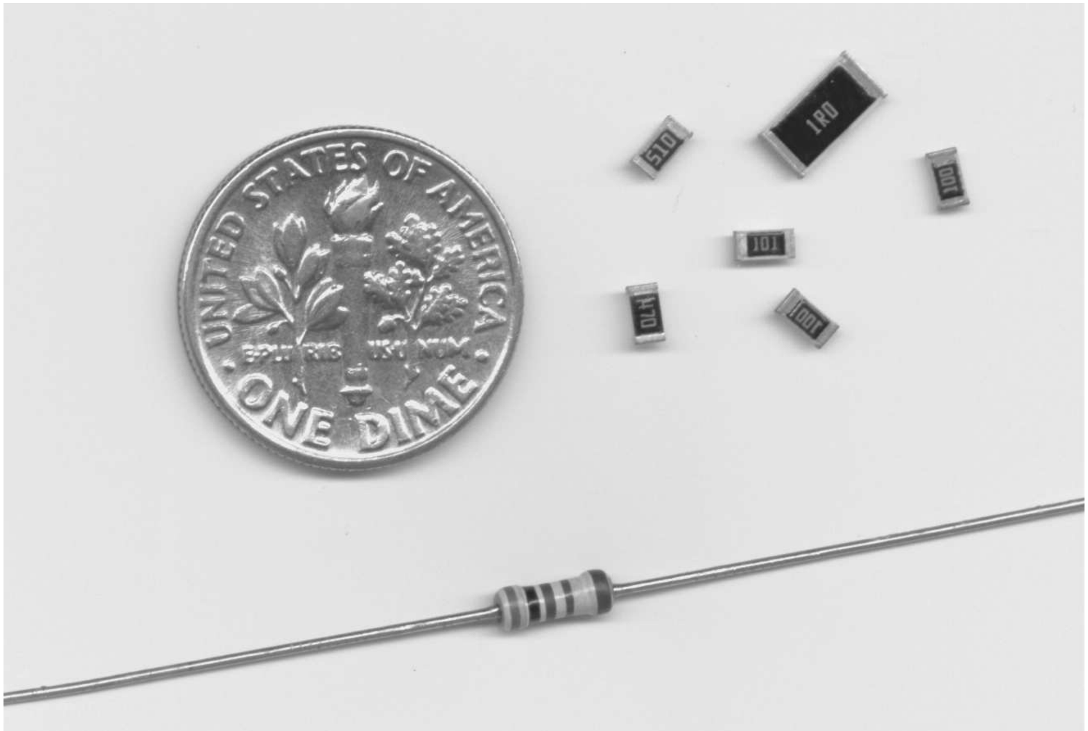


Figure 1-7 One- and quarter-watt thin-film chip resistors in comparison with a conventional quarter-watt resistor.

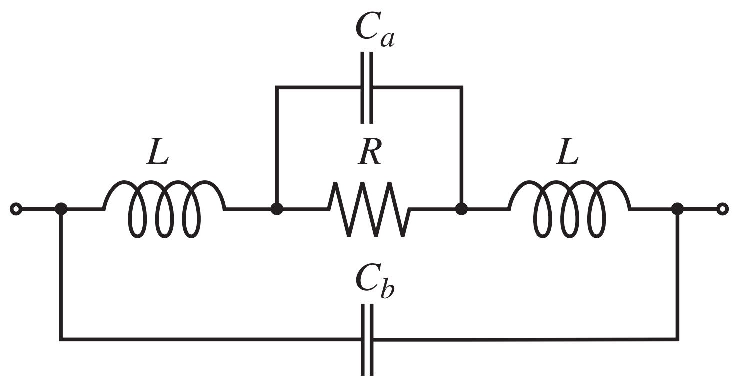


Figure 1-8 Electric equivalent circuit representation of a high frequency resistor.

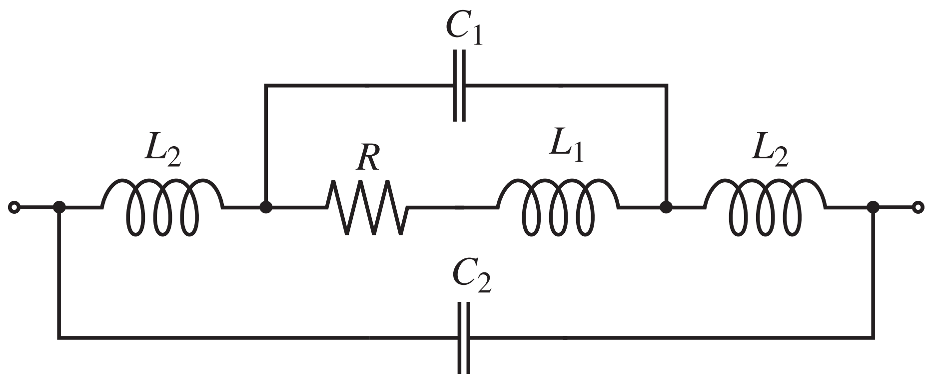


Figure 1-9 Electric equivalent circuit representation of a wire-wound resistor at high frequency.

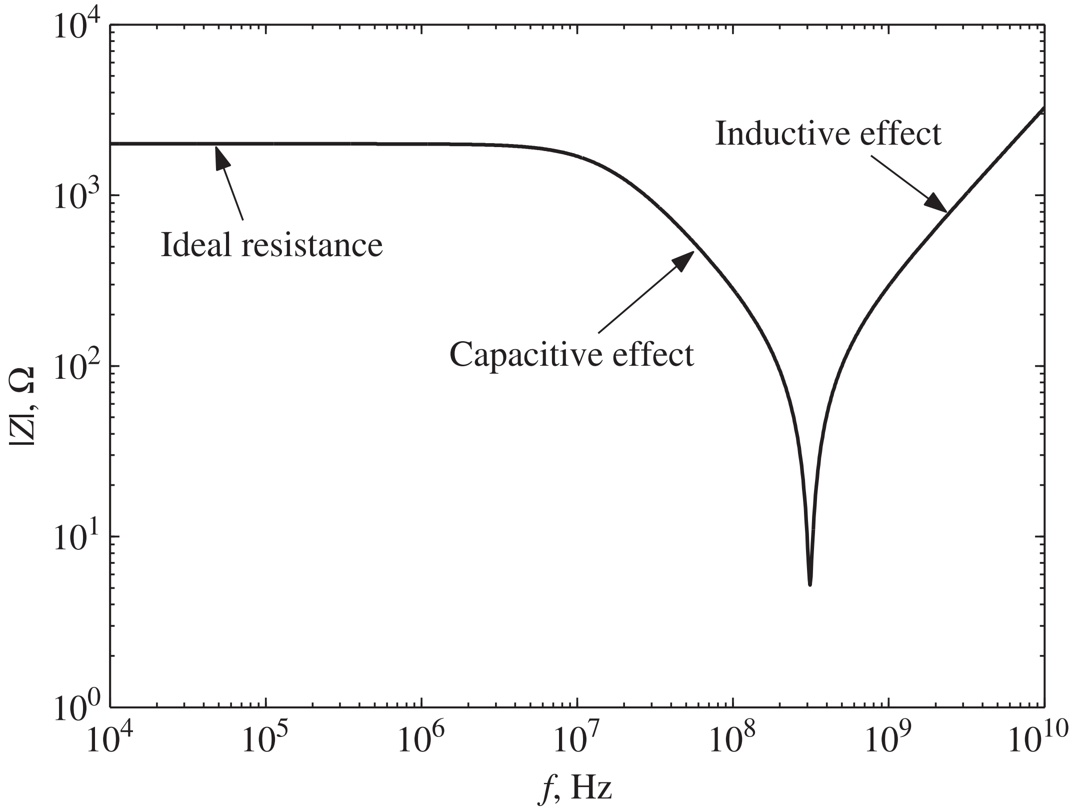


Figure 1-10 Absolute impedance value of a 2000-Ω thin-film resistor as a function of frequency.

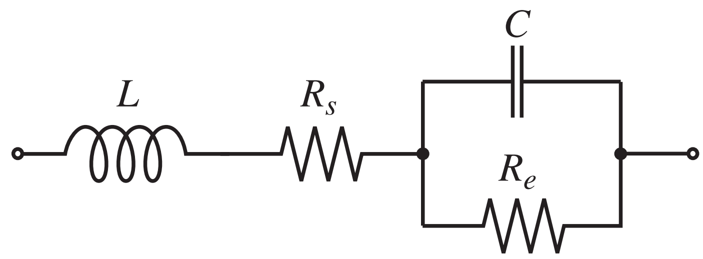


Figure 1-11 Electric equivalent circuit of a capacitor at high frequency.

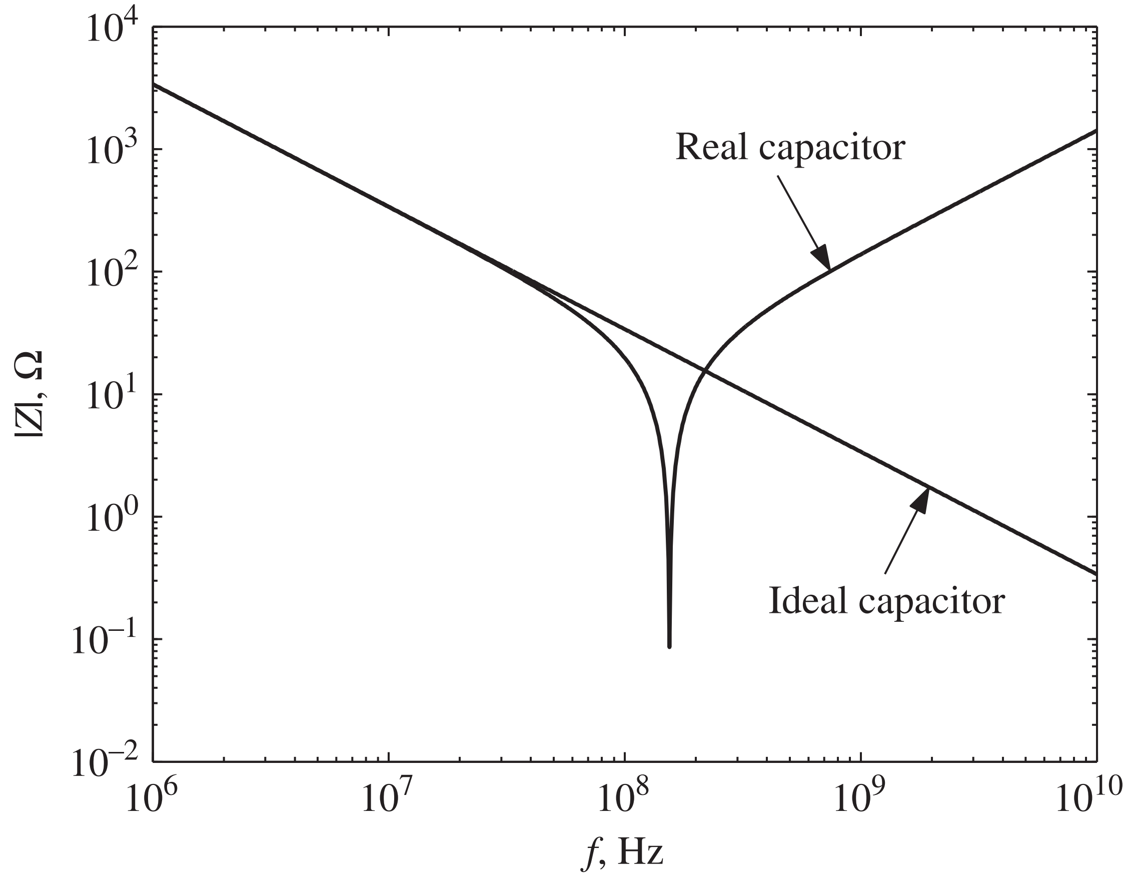


Figure 1-12 Absolute value of the capacitor impedance as a function of frequency.

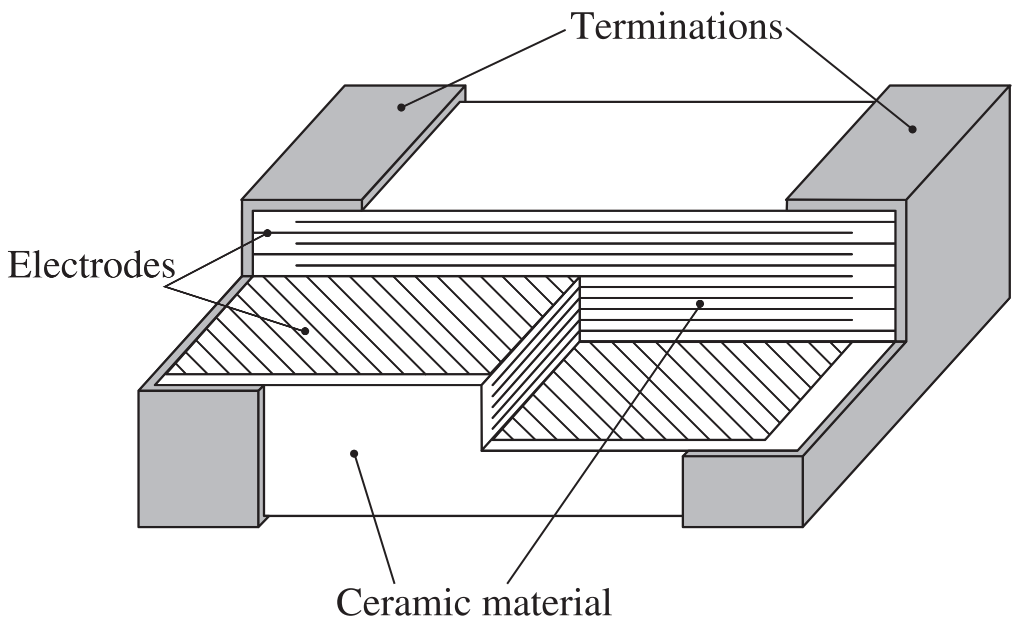


Figure 1-13 Actual construction of a surface-mounted ceramic multilayer capacitor.

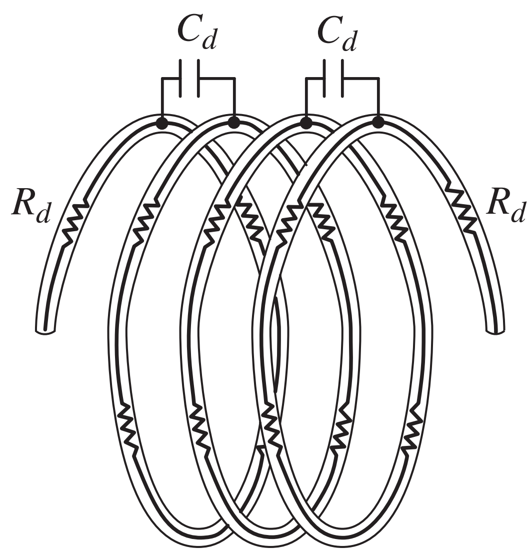


Figure 1-14 Distributed capacitance and series resistance in the inductor coil.

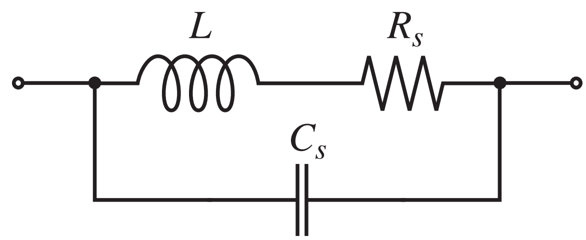


Figure 1-15 Equivalent circuit of the high-frequency inductor.

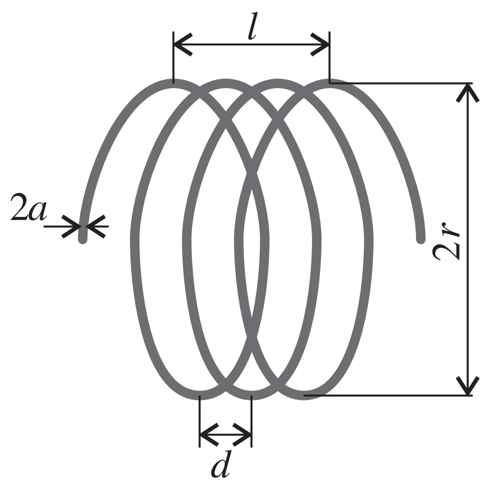


Figure 1-16　Inductor dimensions of an air-core coil.

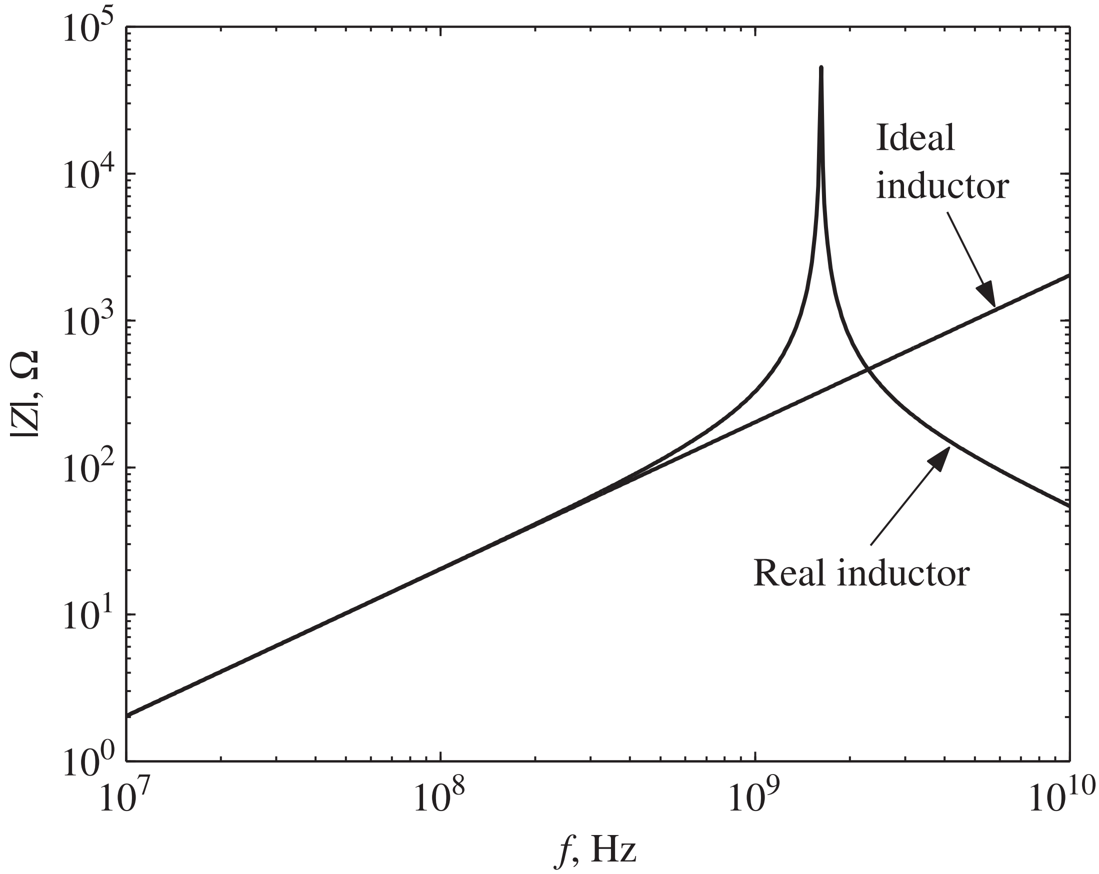
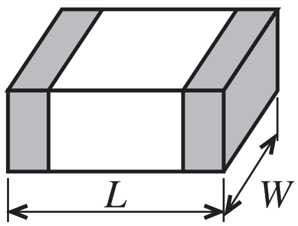


Figure 1-17 Frequency response of the impedance of an RFC.

Table 1-2 Standard sizes of chip resistors

Geometry	**Size Code**	**Length *L*, mils**	**Width *W*, mils**
	0402	40	20
	0603	60	30
	0805	80	50
	1206	120	60
	1812	120	180

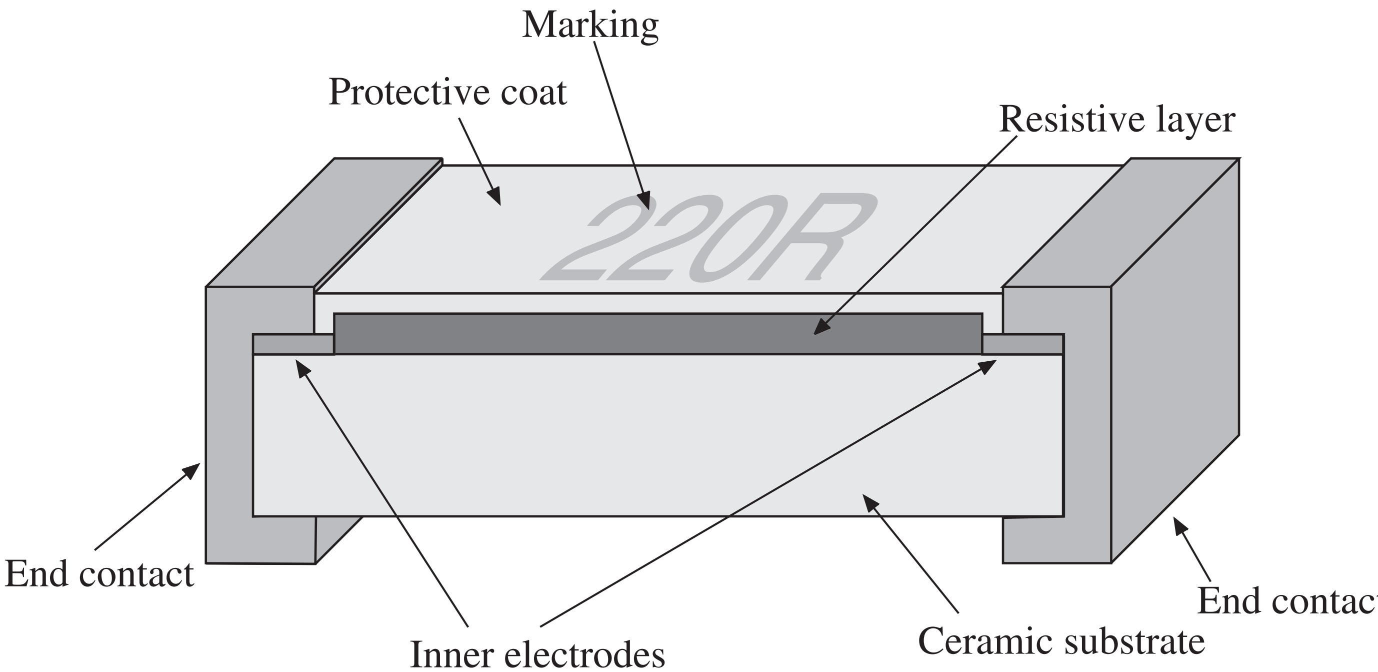


Figure 1-18 Cross-sectional view of a typical chip resistor.

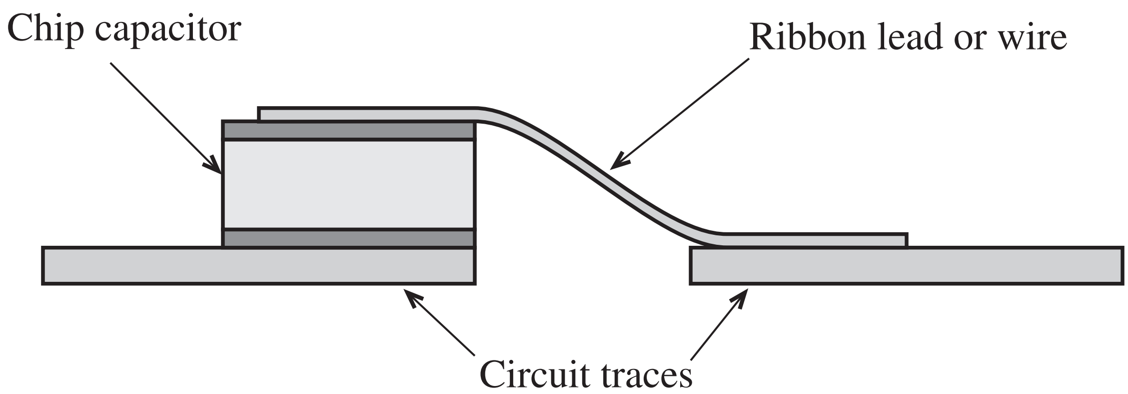


Figure 1-19 Cross section of a typical single-plate capacitor connected to the board.

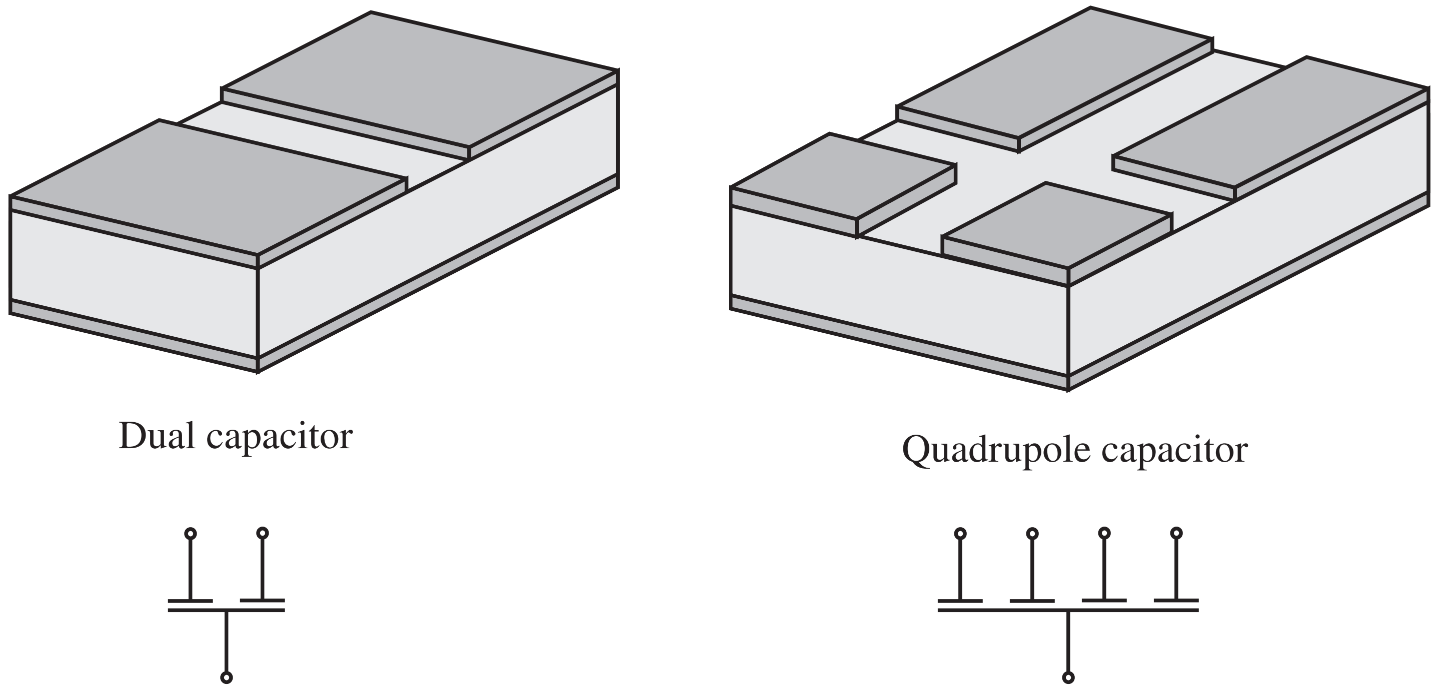


Figure 1-20 Clusters of single-plate capacitors sharing a common dielectric material.

Figure 1-21   Typical size of an RF wire-wound air-core inductor (courtesy of Coilcraft, Inc.).

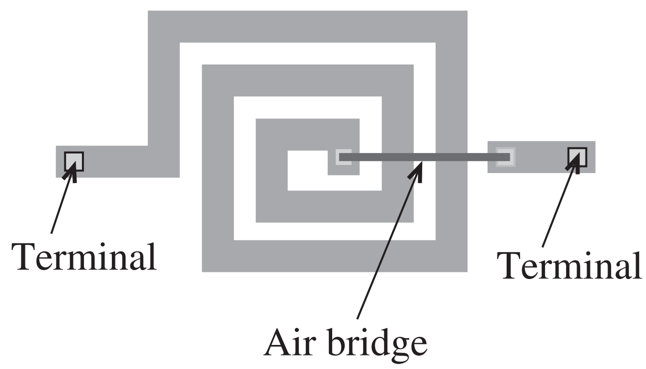


Figure 1-22 Flat coil configuration. An air bridge is made by using either a wire or a conductive ribbon.

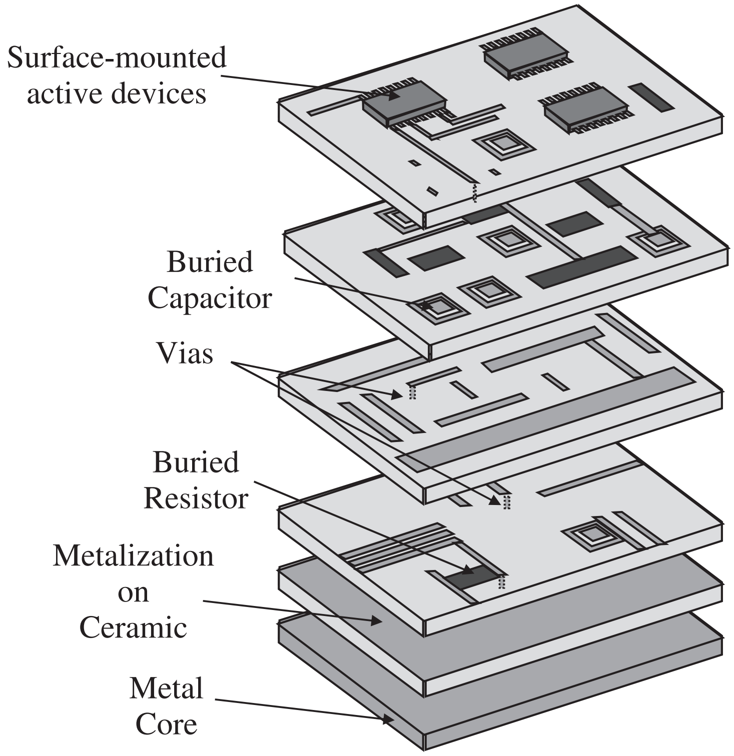


Figure 1-23 Construction of a three-dimensional LTCC/HTCC module made out of individual layers of ceramic tape that are collated, stacked, and fired (courtesy of Lamina Ceramics Inc.).

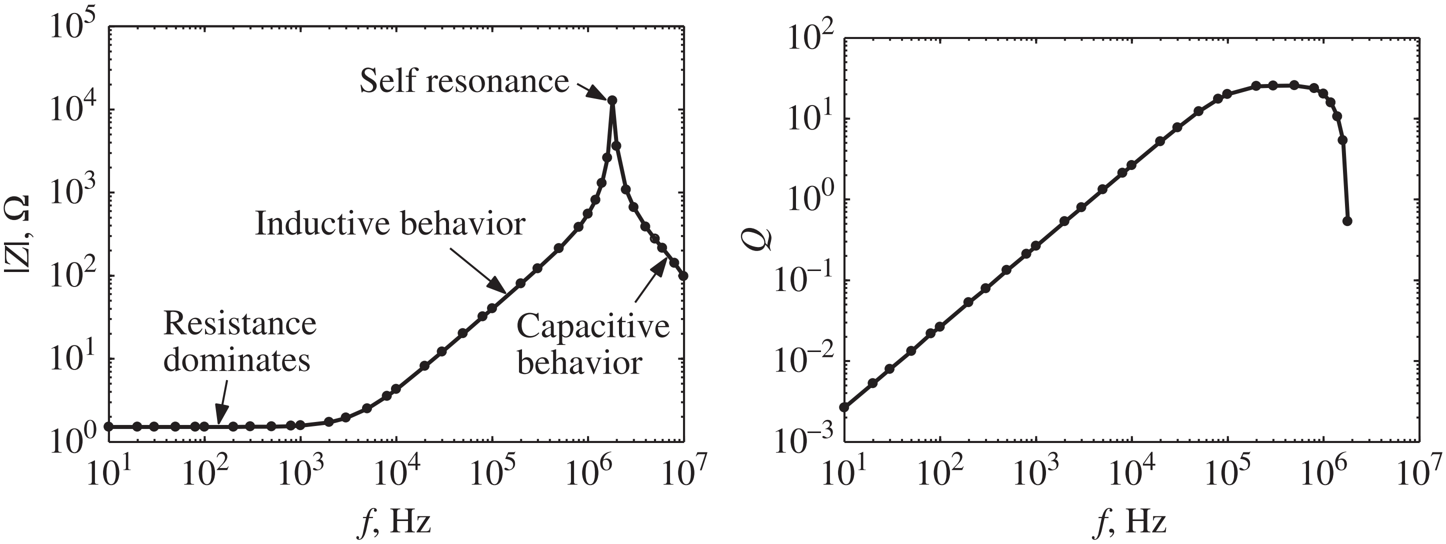


Figure 1-24 Impedance and quality factor behavior of a real, non-magnetic core inductor as measured by the HP 4192A LCR meter.

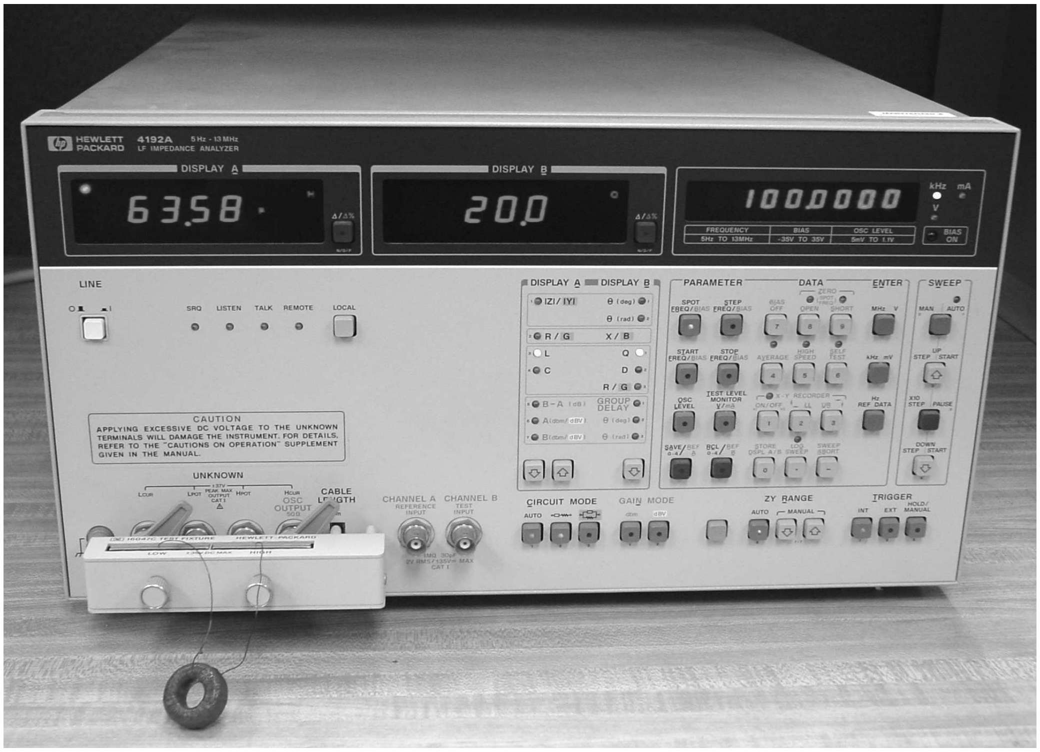


Figure 1-25 LCR meter with a plastic core torroidal inductor connected to the test fixture and a measurement taken at 100 kHz.