TABLE 11.1 Distributed Line Parameters at High Frequencies*

Parameters	Coaxial Line	Two-Wire Line	Planar Line
R (Ω/m)	$\frac{1}{2\pi\delta\sigma_c}\left[\frac{1}{a}+\frac{1}{b}\right]$ $(\delta \ll a, c-b)$	$\frac{1}{\pi a\delta\sigma_c}$ $(\delta \ll a)$	$\frac{2}{w\delta\sigma_c}$ $(\delta \ll t)$
L (H/m)	$\frac{\mu}{2\pi}\ln\frac{b}{a}$	$\frac{\mu}{\pi}\cosh^{-1}\frac{d}{2a}$	$\frac{\mu d}{w}$
G (S/m)	$\frac{2\pi\sigma}{\ln\frac{b}{a}}$	$\frac{\pi\sigma}{\cosh^{-1}\frac{d}{2a}}$	$\frac{\sigma w}{d}$
C (F/m)	$\frac{2\pi\varepsilon}{\ln\frac{b}{a}}$	$\frac{\pi\varepsilon}{\cosh^{-1}\frac{d}{2a}}$	$\frac{\varepsilon w}{d}$ $(w \gg d)$

*$\delta = \frac{1}{\sqrt{\pi f\mu_c\sigma_c}}$ = skin depth of the conductor; $\cosh^{-1}\frac{d}{2a} \simeq \ln\frac{d}{a}$ if $\left[\frac{d}{2a}\right]^2 \gg 1$.

Notes:

1) The material parameters μ, ε, and σ are for the transmission line (TL) **insulation**.
2) The material parameters μ_c, ε_c, and σ_c are for the TL **conductors**.
3) $L \approx L_{ext}$. At high frequencies, the current is essentially on the surface of the TL conductors due to the skin depth effect (see Chapter 10). Therefore, $L_{int} \approx 0$.
4) The electric permittivity ε is typically expressed in terms of the relative permittivity ε_r (see Appendix B), i.e., $\varepsilon = \varepsilon_r\,\varepsilon_0$ where $\varepsilon_0 = 8.8541878 \times 10^{-12}$ F/m is the permittivity of free space.
5) The magnetic permeability μ is typically expressed in terms of the relative permeability μ_r (see Appendix B), i.e., $\mu = \mu_r\,\mu_0$ where $\mu_0 = 4\pi\times10^{-7}$ H/m is the permeability of free space.

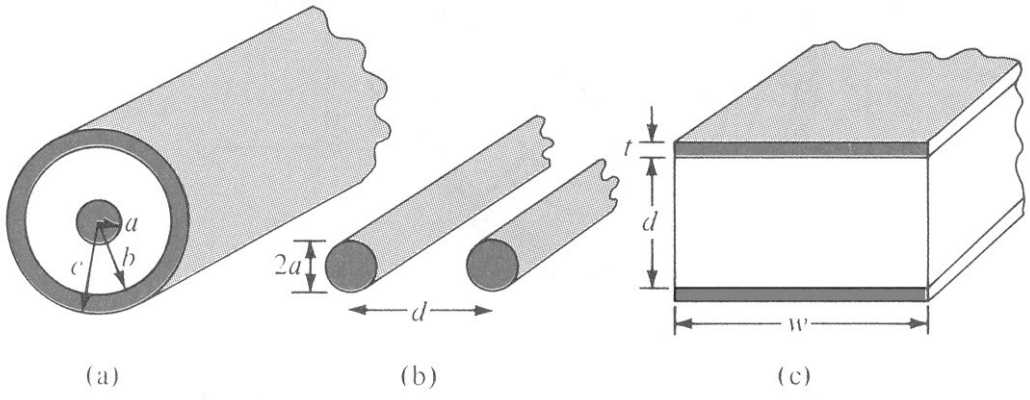

Figure 11.2 Common transmission lines: **(a)** coaxial line, **(b)** two-wire line, **(c)** planar line.