Radiofrequency Circuits and Systems - Useful expressions

Input impedance and propagation constant of an infinite-length transmission line	$Z_0 = \sqrt{\frac{Z}{Y}}, \quad \gamma = \sqrt{ZY}$
Low-loss transmission line	$Z_0 = \sqrt{\frac{L}{C}}, \quad \gamma = \alpha + \frac{s}{V_p}, \quad V_P = \frac{1}{\sqrt{LC}}$
T-paremeter matrix of a transmission line of length l and $\theta = \gamma l$	$\mathbf{T} = \begin{bmatrix} \cosh\theta & Z_0 \sinh\theta \\ \frac{1}{Z_0}\sinh\theta & \cosh\theta \end{bmatrix}$
Lossy transmission line	$\theta = \gamma l = \alpha l + \tau s, \quad \tau = \frac{l}{V_p}$
Lossless (ideal) transmission line	$\theta = \gamma l = \tau s$
Wavelenth in the sinusoidal steady state	$\lambda = \frac{V_p}{f}$
Reflection coefficient	$\rho = \frac{Z - Z_0}{Z + Z_0}, \quad Z = Z_0\ \frac{1+\rho}{1-\rho}$
Evolution of ρ along the line	$\rho = \rho_L\ e^{-2\theta}$
Voltage wave incident on the load in the general problem	$V_{iL} = \frac{1}{2}\ (1 - \rho_G)\ \frac{e^{-\theta}}{1 - \rho_G\ \rho_L\ e^{-2\theta}}\ V_G$
Voltage at a distance l from the load	$V = V_{iL}\ (e^{\theta} + \rho_L\ e^{-\theta})$
Current (towards the load) at a distance l from the load	$I = \frac{V_{iL}}{Z_0}\ (e^{\theta} - \rho_L\ e^{-\theta})$
Voltage standing wave ratio	$VSWR = ROE = \frac{1 + \|\rho\|}{1 - \|\rho\|}$
Attenuation	$A(\mathrm{dB/m}) = \alpha\ 20 \log_{10} e$
Power transferred to the load	$P_L = \frac{\|\overline{V}_{iL}\|^2}{2Z_0}\ (1 - \|\rho_L\|^2)$
Power delivered by the generator	$P_G = \frac{\|\overline{V}_{iL}\|^2}{2Z_0}\ (e^{2\alpha l} - \|\rho_L\|^2\ e^{-2\alpha l})$
Input reflection coefficient at port 1 of a two-port network loaded with ρ_L at port 2	$\rho_{in} = S_{11} + \frac{S_{12}S_{21}\rho_L}{1 - S_{22}\rho_L}$
Rectangular wave guide	$a = \frac{\lambda}{2\cos\theta}$

Power density at coordinates (r, θ, φ) with respect to the transmitter	$\mathscr{P} = \frac{P_T}{4\pi r^2}\ G_T(\theta, \varphi)$
Effective area	$A = \frac{\lambda^2}{4\pi}\ G$
Friis transmission equation	$P_R = P_T\ G_T\ G_R\ (\frac{\lambda}{4\pi r})^2$
Gain of a $\lambda/2$ dipole (arm length $= \lambda/4$)	$G = 1.64\ \left(\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\right)^2$
Array of two antennas with phase shift	$FA = [1 + e^{j\alpha}e^{jkd\cos\Phi}]$