



# MIDWIN & OLIFSON

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## EQUATIONS

### Transmission Line Relationships

$$Z_{in} = Z_o \frac{Z_l + jZ_o \tan \theta}{Z_o + jZ_l \tan \theta}$$

Where:  $Z_o$  = characteristic impedance  
 $Z_l$  = load impedance

$$\lambda_{(inches)} = \frac{11.803}{frequency(GHz)}$$

Where:  $\lambda$  = wavelength

$$\lambda_g = \frac{\lambda_o}{\sqrt{1 - (\lambda_o / 2a)^2}}$$

Where:  $\lambda_g$  = guide wavelength  
 $\lambda_o$  = free space wavelength  
 $a$  = width of waveguide

### For a coaxial line:

$$Z_o = \frac{59.96}{\sqrt{\epsilon_r}} \cdot \ln \frac{b}{a}$$

Where:  $b$  = outer diameter  
 $a$  = inner diameter  
 $\epsilon_r$  = relative dielectric constant

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

Where:  $|\Gamma|$  = magnitude of voltage reflection coefficient

$$|\Gamma| = \frac{Z_l - Z_o}{Z_l + Z_o}$$

Where:  $P_i$  = incident power  
 $P_r$  = reflected power  
 $P_t$  = transmitted power

$$\frac{P_r}{P_i} = |\Gamma|^2 = \left( \frac{VSWR - 1}{VSWR + 1} \right)^2$$

$$\frac{P_t}{P_i} = 1 - |\Gamma|^2 = \frac{4VSWR}{(VSWR + 1)^2}$$



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## EQUATIONS

### 2nd Stage Noise Figure Contribution

$$f_t = f_1 + \frac{f_2 - 1}{g_1}$$

Where:  $f_t$  = total noise figure  
 $f_1$  = first stage noise figure  
 $f_2$  = second stage noise figure  
 $g_1$  = first stage gain

### Rise Time

$$T_r = 2.2T = \frac{.35}{BW}$$

Where:  $T_r$  = risetime  
 $T$  = time constant  
 $BW$  = 3dB bandwidth

### Price Learning Curve

$$\frac{P_2}{P_1} = \left[ \frac{\% Learning Curve}{100} \right]^{\frac{\ln(Q_2/Q_1)}{\ln 2}}$$

Where:  $\ln$  = natural log  
 $P_1$  = price at lower quantity  
 $P_2$  = price at higher quantity  
 $Q_1$  = lower quantity  
 $Q_2$  = higher quantity