Formulas for Some Printed Lines

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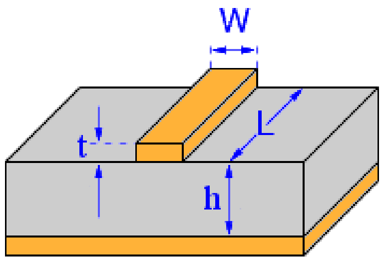
October 8, 2012

Microstrip Line



1. Effective dielectric constant

$$\epsilon_{r,eff} = \begin{cases} \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[\frac{1}{\sqrt{1+12\frac{h}{W}}} + 0.04\left(1.0-\frac{W}{h}\right)^2\right] & W/h \leq 1.0 \\ \\ \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2\sqrt{1+12\frac{h}{W}}} & W/h \geq 1.0 \end{cases}$$

2. Characteristic impedance

$$Z_0 = \begin{cases} \frac{60}{\sqrt{\epsilon_{r,eff}}}\ln\left(\frac{8h}{W}+\frac{W}{4h}\right) & \frac{W}{h} \leq 1 \\ \frac{120\pi}{\sqrt{\epsilon_{r,eff}}[W/h+1.393+0.667\ln(W/h+1.444)]} & \frac{W}{h} \geq 1 \end{cases}$$

3. Design W to obtain a given characteristic impedance Z_0

$$\frac{W}{h} = \begin{cases} \frac{8e^A}{e^{2A}-2} & \frac{W}{h} < 2 \\ \frac{2}{\pi}\left[B-1-\ln(2B-1)+\frac{\epsilon_r-1}{2\epsilon_r}\left(\ln(B-1)+0.39-\frac{0.61}{\epsilon_r}\right)\right] & \frac{W}{h} > 2 \end{cases}$$

where

$$A = \frac{Z_0}{60}\sqrt{\frac{\epsilon_r+1}{2}} + \frac{\epsilon_r-1}{\epsilon_r+1}\left(0.23+\frac{0.11}{\epsilon_r}\right)$$

$$B = \frac{377\pi}{2Z_0\sqrt{\epsilon_r}}$$

4. Excess length (fringing capacitance for an open-ended microstrip)

$$\frac{\Delta L}{h} = 0.412\frac{\epsilon_{r,eff}+0.3}{\epsilon_{r,eff}-0.258}\cdot\frac{W/h+0.264}{W/h+0.8}$$

5. Width correction due to finite metallization thickness

$$\frac{\Delta W}{t} = \frac{1.0}{\pi}\ln\left[\frac{4e}{\sqrt{\left(\frac{t}{h}\right)^2+\left(\frac{1/\pi}{W/t+1.1}\right)^2}}\right]$$

6. Conduction loss constant

$$\alpha_c(\mathrm{Np/m}) = \begin{cases} \frac{R_s}{2\pi}\frac{\left(\frac{8.0h}{W}-\frac{W}{4h}\right)\left(1.0+\frac{h}{W}\left(1+\frac{\partial W}{\partial t}\right)\right)}{hZ_0 e^{\frac{Z_0}{60}}} & W/h \leq 1.0 \\ \\ \frac{Z_0 R_s}{14400\pi^2 h}\left[1.0+\left(\frac{h}{W}\right)^2\left(0.44+6.0\left(1.0-\frac{h}{W}\right)^5\right)\right]\left(1.0+\frac{W}{h}+\frac{\partial W}{\partial t}\right) & W/h \geq 1.0 \end{cases}$$

where

$\frac{\partial W}{\partial t} = \begin{cases} \frac{1.0}{\pi} \ln \frac{4.0\pi W}{t} & \frac{W}{h} \leq \frac{1}{2\pi} \\ \frac{1.0}{\pi} \ln \frac{2.0h}{t} & \frac{W}{h} \geq \frac{1}{2\pi} \end{cases}$

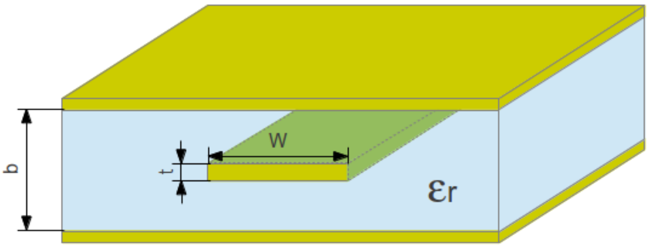
7. dielectric loss constant

   $\alpha_d(\mathrm{Np/m}) = \pi \frac{q \tan\delta}{\lambda_0/\sqrt{\epsilon_{r,eff}}}$

   where q is the "filling factor":

   $q = \frac{\epsilon_{r,eff}-1}{\epsilon_r - 1}$

1 Stripline



1. Characteristic Impedance:

$$Z_0 = \frac{\eta_0}{2.0\pi\sqrt{\epsilon_r}} \ln\left\{1.0 + 0.5\frac{8b}{\pi w'}\left[\frac{8b}{\pi w'} + \sqrt{\left(\frac{8b}{\pi w'}\right)^2 + 6.27}\right]\right\} \tag{1}$$

$$w' = w + \frac{\Delta w}{t} t \tag{2}$$

$$\frac{\Delta w}{t} = \frac{1.0}{\pi}\left\{1.0 - 0.5 \ln\left[\left(\frac{1.0}{2.0b/t + 1.0}\right)^2 + \left(\frac{1.0/(4\pi)}{w/t + 1.1}\right)^m\right]\right\} \tag{3}$$

$$m = \frac{6.0}{3.0 + \frac{2.0t}{b}} \tag{4}$$

References

[1] B. C. Wadell, *Transmission Line Design Handbook.* Artech House, 1991.

[2] D. M. Pozar, *Microwave Engineering.* John Wiley & sons, 1998.