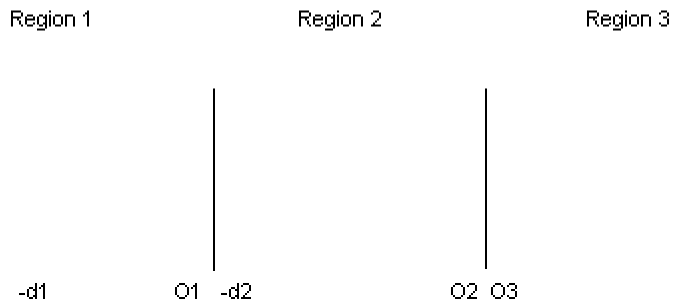
ECE 3300 Plane Wave in Lossy Media Reflection Using a Smith Chart



Region 1: $\mu = \mu_o$ $\varepsilon = 9\varepsilon_o$ $\sigma = 0$, F=90 MHz
Region 2: $\mu = \mu_o$ $\varepsilon = 20\varepsilon_o$ $\sigma = 20$ S/m d2 = λ_2 /25
Region 3: Perfect Electric Conductor
Find characteristic impedances:
η_1 = sqrt(μ_1 / ε_1)=125.67 Ω;

$$|\eta_2| = \frac{\sqrt{\frac{\mu_2}{\varepsilon_o \varepsilon_2}}}{\left(1+\left(\frac{\sigma_2}{\omega\varepsilon_o\varepsilon_2}\right)\right)^{1/4}} = 5.96; \quad \theta_2 = \frac{1}{2}\arctan\left(\frac{\sigma_2}{\omega\varepsilon_o\varepsilon_2}\right) = -.7829; \quad \eta_2 = 4.225 + j4.204\Omega$$

α_2 = 84.03; β_2 = 84.45; $\lambda_2 = 2\pi/\beta_2$ = .0744m
η_3 = sqrt(μ_3 / ε_3)=0 Ω

Step 1: (going from O_3 to O_2)
$Z_3(O_3) = \eta_3 = 0$ Ω OR $\Gamma_2(O_2) = -1.0$
At an interface, the characteristic impedance η is equal, so:
$Z_2(O_2) = Z_3(O_3) = 0$ Ω
Normalize Z_2 :
$Z_{2n}(O_2) = Z_2(O_2) / \eta_2 = 0$
Plot $Z_{2n}(O_2)$ on the Smith Chart

Step 2: (Rotating from O_2 to $-d_2$)
Rotate 3/8 λ_2 towards the generator (TWG)
Read $|\Gamma_2(-d_2)_{lossless}| = 1.0$
Attenuation changes the magnitude of the reflection coefficient:
$|\Gamma_2(-d_2)|$ (lossy) = $|\Gamma_2(-d_2)_{lossless}|\, e^{-2(\alpha 2)(d2)} = (1.0)\, e^{-2(84.03)(.0744/25)} = 0.606$
Plot this new magnitude.
Read $Z_{2n}(-d_2) = 0.26 + j\,0.24$
Denormalize: $Z_2(-d_2) = [Z_{2n}(-d_2)][\eta_2] = 0.09 + j\,2.1$ Ω

Step 3: (going from $-d_2$ to O_1)
At an interface, the characteristic impedance η is equal, so:
$Z_1(O_1) = Z_2(-d_2) = 0.09 + j\,2.1$ Ω
If later values are needed: Normalize Z_1 :
$Z_{1n}(O_1) = Z_1(O_1) / \eta_1 = 0 + j\,0.017$
Plot $Z_{1n}(O_1)$ on the Smith Chart

Example 2

The Complete Smith Chart

Black Magic Design