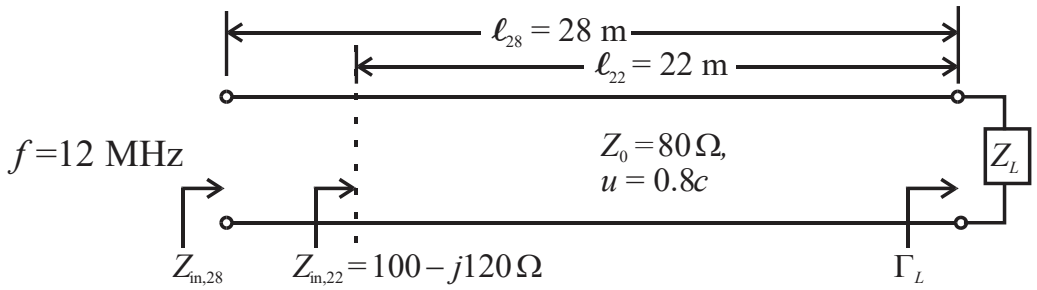
11.49 An 80 Ω transmission line operating at 12 MHz is terminated by a load Z_L. At 22 m from the load, the input impedance is $100 - j120\ \Omega$. If $u = 0.8c$,

(a) Calculate Γ_L, $Z_{in,\,max}$, and $Z_{in,\,min}$.

(b) Find Z_L, s, and the input impedance at 28 m from the load.

(c) How many $Z_{in,\,max}$ and $Z_{in,\,min}$ are there between the load and the $100 - j120\ \Omega$ input impedance?

- Use Smith chart. First, calculate wavelength λ.



➢ Wavelength $\lambda = u/f = 0.8(2.9979\times10^8)/12\times10^6 \Rightarrow$ **$\lambda = 19.986$ m**.

a)

➢ Normalize $Z_{in,22}$ & plot on Smith chart. $z_{in,22} = Z_{in}/Z_0 = (100 - j120)/80 = 1.25 - j1.5\ \Omega/\Omega$.

➢ Set compass to distance between center of Smith chart and $z_{in,22}$. Use compass to draw circle, centered on Smith chart, through $z_{in,22}$.

➢ Next, use compass to mark the "REFL. COEFF. V or I" scale below Smith chart on right side to find $|\Gamma_{in}| = |\Gamma_L| = 0.562$.

➢ Calculate $\ell_{22}/\lambda = 22/19.986 = 1.101$. Move 1.101-2(0.5) = 0.101 on circle of constant $|\Gamma|$ from $z_{in,22}$ point in "WAVELENGTHS TOWARD LOAD" direction from 0.1845 to 0.1845+0.101 = 0.2855. Draw radial line from center of Smith chart.

➢ Use the "ANGLE OF REFLECTION COEFFICIENT IN DEGREES" scale to read $\angle\,\Gamma_L = 25.7°$.

➢ Put magnitude & angle of the load reflection coefficient together **$\Gamma_L = 0.562\angle 25.7°$**.

➢ At intersection of $|\Gamma| = 0.562$ circle w/ real axis to right of origin read, $r_{max} = 3.57$. Calculate maximum input impedance $Z_{in,max} = r_{max} Z_0 = (3.57)80 \Rightarrow$ **$Z_{in,max} = 285.6\ \Omega$**.

➢ At intersection of $|\Gamma| = 0.562$ circle w/ real axis to left of origin read, $r_{min} = 0.28$. Calculate minimum impedance $Z_{in,min} = r_{min} Z_0 = (0.28)80 \Rightarrow$ **$Z_{in,min} = 22.4\ \Omega$**.

b)

➢ At Γ_L point, read off normalized load impedance $z_L = 2.25 + j1.61\ \Omega/\Omega$.

➢ Calculate load impedance $Z_L = z_L Z_0 = (2.25 + j1.61)80 \Rightarrow$ **$Z_{in} = 180 + j128.8\ \Omega$**.

➢ Use compass to mark SWR (VSWR) scale below Smith chart on left side.

➢ Read standing wave ratio to be **$s = SWR = r_{max} = 3.57$**.

- Calculate $\ell_{28}/\lambda = 28/19.986 = 1.401$. Move 1.401-2(0.5) = 0.401 on the circle of constant $|\Gamma|$ in "WAVELENGTHS TOWARD GENERATOR" direction from z_L point, i.e., to 0.401 – 0.2855 = 0.1155. Draw radial line from center of Smith chart.
- Read $z_{\text{in},28} = 0.47 + j0.77\ \Omega/\Omega$. Calculate the input impedance 28 m from load to be $Z_{\text{in},28} = z_{\text{in},28} Z_0 = (0.47 + j0.77)80 \Rightarrow$ **$Z_{\text{in},28} = 37.6 + j61.6\ \Omega$**.

c) Since $\ell_{22}/\lambda = 1.101$ or by looking at Smith chart, we will pass through the $Z_{\text{in,max}}$ (r_{max}) point **3 times** and through the $Z_{\text{in,min}}$ (r_{min}) point **2 times**.