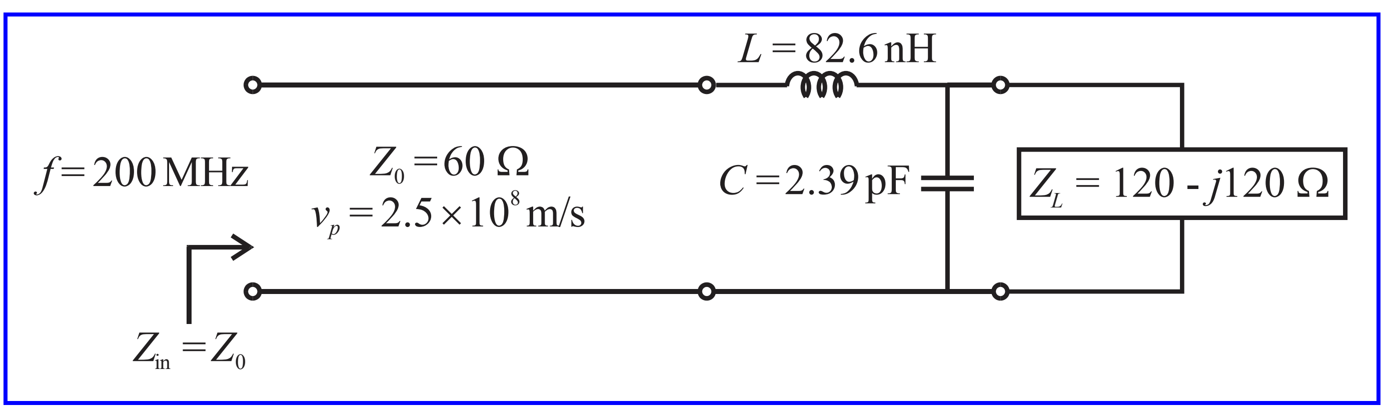
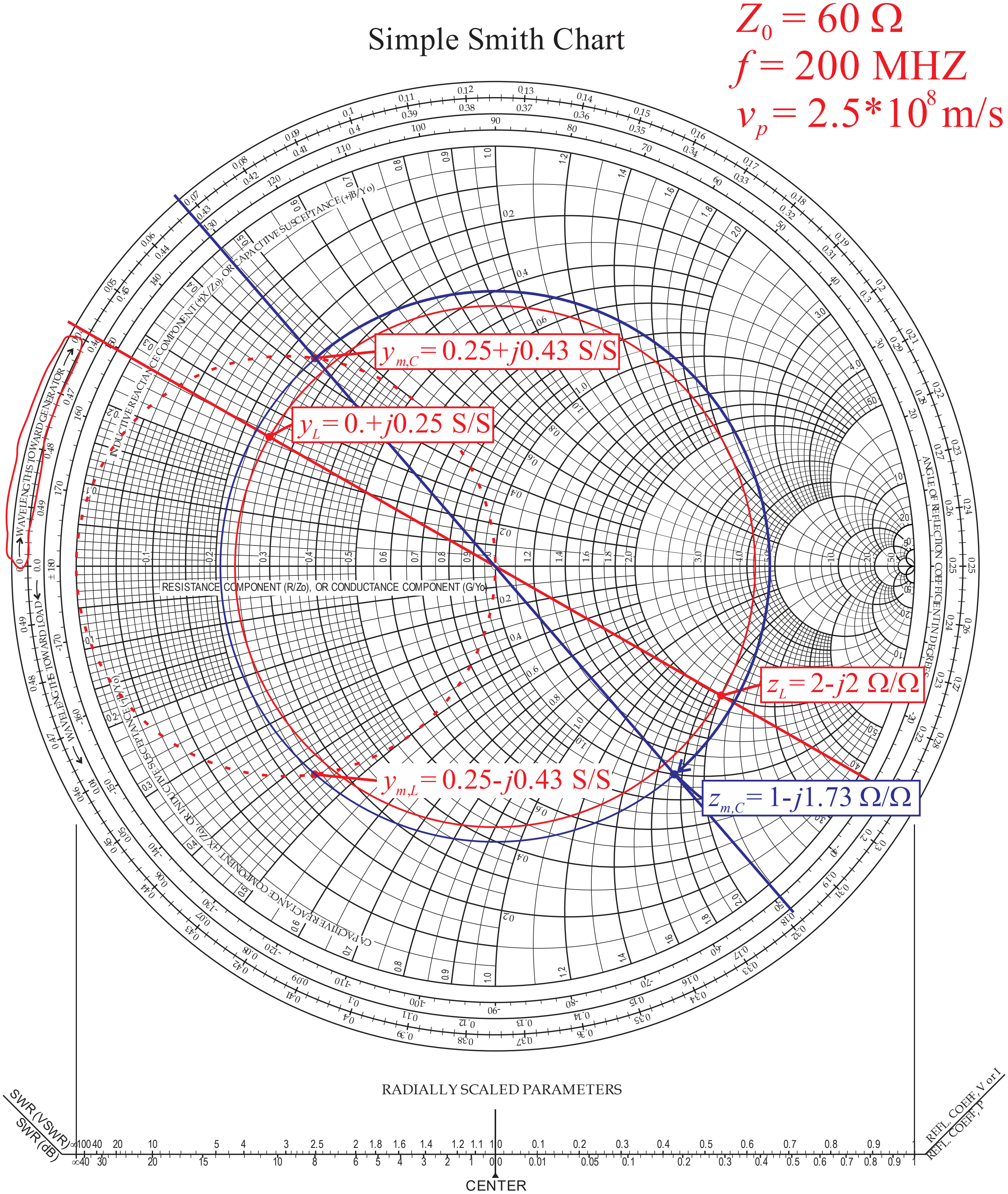
For a circuit operating at 200 MHz, design and sketch a lossless *L*-network using a parallel capacitor to match a load $Z_L = 120 - j120\,\Omega$ to a lossless transmission line (60 Ω, 2.5 × 10^8 m/s). Use Smith chart solution method and give component values to 3 significant figures. Confirm component values using analytic equations.

- Note that $R_L = 120\ \Omega > Z_0 = 60\ \Omega \Rightarrow$ *L*-network has parallel capacitor first, then series element.
- Calculate the normalized load impedance $z_L = Z_L / Z_0 = (120 - j120) / 60$ $\Rightarrow$ **$z_L = 2 - j2\ \Omega/\Omega$**. Plot z_L on Smith chart.
- Use compass to draw a circle through z_L, centered on Smith chart. Use a straight edge to draw line through center of Smith chart & z_L to outer rings of Smith chart.
- Move 180° around circle of constant $|\Gamma|$ from z_L point to **$y_L = 0.25 + j0.25$ S/S**.
- Draw rotated $r = 1$ circle.
- Follow the $g_L = 0.25$ S/S circle from y_L to where it intersects the rotated $r = 1$ circle at $y_{m,L} = 0.25 - j0.43$ S/S and **$y_{m,C} = 0.25 + j0.43$ S/S.** Choose $y_{m,C}$ as it requires a parallel capacitor.
- Calculate $b_{cap} = b_{m,C} - b_L = 0.43 - 0.25 = 0.18$ S/S. Then, calculate $C = b_{cap} / \omega Z_0 = 0.18/[(2\pi)200 \times 10^6 (60)] \Rightarrow$ **$C = 2.3873\times10^{-12}$ F = 2.39 pF**.
- Draw a circle through $y_{m,C}$, centered on Smith chart. Use a straight edge to draw line through center of Smith chart & $y_{m,C}$ to outer rings of Smith chart.
- Move 180° around this circle of constant $|\Gamma|$ from $y_{m,C}$ point to **$z_{m,c} = 1 - j1.73\ \Omega/\Omega$**.
- To match, add a series normalized inductive reactance of 1.74 Ω/Ω. The inductor required is $L = x_{ind} Z_0 / \omega = 1.73(60)/[(2\pi)200 \times 10^6] \Rightarrow$ **$L = 8.260\times10^{-8}$ H = 82.6 nH**.



$Z_0 = 60\ \Omega$
$f = 200$ MHZ
$v_p = 2.5*10^8$ m/s



Verify using analytic equations-

First, use (5.3a)

$$B = \frac{X_L \pm \sqrt{R_L / Z_0}\,\sqrt{R_L^2 + X_L^2 - Z_0 R_L}}{R_L^2 + X_L^2}$$

$$= \frac{-120 \pm \sqrt{120/60}\,\sqrt{(120)^2 + (-120)^2 - 60(120)}}{(120)^2 + (-120)^2}$$

$$= \frac{-120 \pm 207.8460969}{28800}$$

$\Rightarrow$ ***B* = 0.0030502 S (capacitive)** or B = -0.01138545 S.

Next, use (5.3b)

$$X = \frac{1}{B} + \frac{X_L Z_0}{R_L} - \frac{Z_0}{B R_L} = \frac{1}{0.0030502} + \frac{-120(60)}{120} - \frac{60}{0.0030502(120)}$$

$\Rightarrow$ ***X* = 103.923677 Ω (inductive)**

Parallel capacitor value

$$C = B/\omega = 0.0030502/[(2\pi)200 \times 10^6] \quad \Rightarrow \quad \boxed{C = 2.4273 \times 10^{-12}\text{ F} = 2.43\text{ pF}}.$$

This is a touch higher than the 2.39 pF value found using Smith chart.

Series inductor value

$$L = X/\omega = 103.923677/[(2\pi)200 \times 10^6] \quad \Rightarrow \quad \boxed{L = 8.1904 \times 10^{-8}\text{ H} = 81.9\text{ nH}}.$$

This is a bit lower than the 82.6 nH value found using Smith chart.