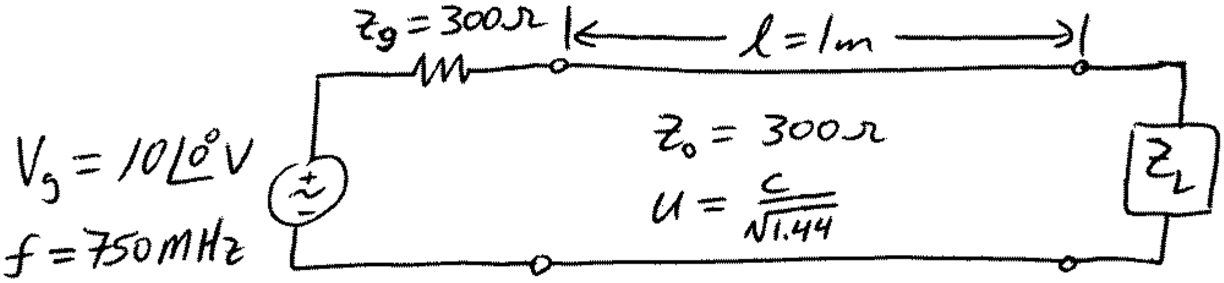
Matching load using a discrete parallel capacitor



Using a discrete capacitor placed in parallel w/ the transmission line, match the load $Z_L = 150 - j600\Omega$ to the transmission line and generator. Place the capacitor as close to the load as possible. How much power is delivered to the load?

$$z_L = \frac{Z_L}{Z_0} = \frac{150 - j600}{300} = 0.5 - j2 \ \Omega/\Omega$$

→ plot z_L on Smith Chart

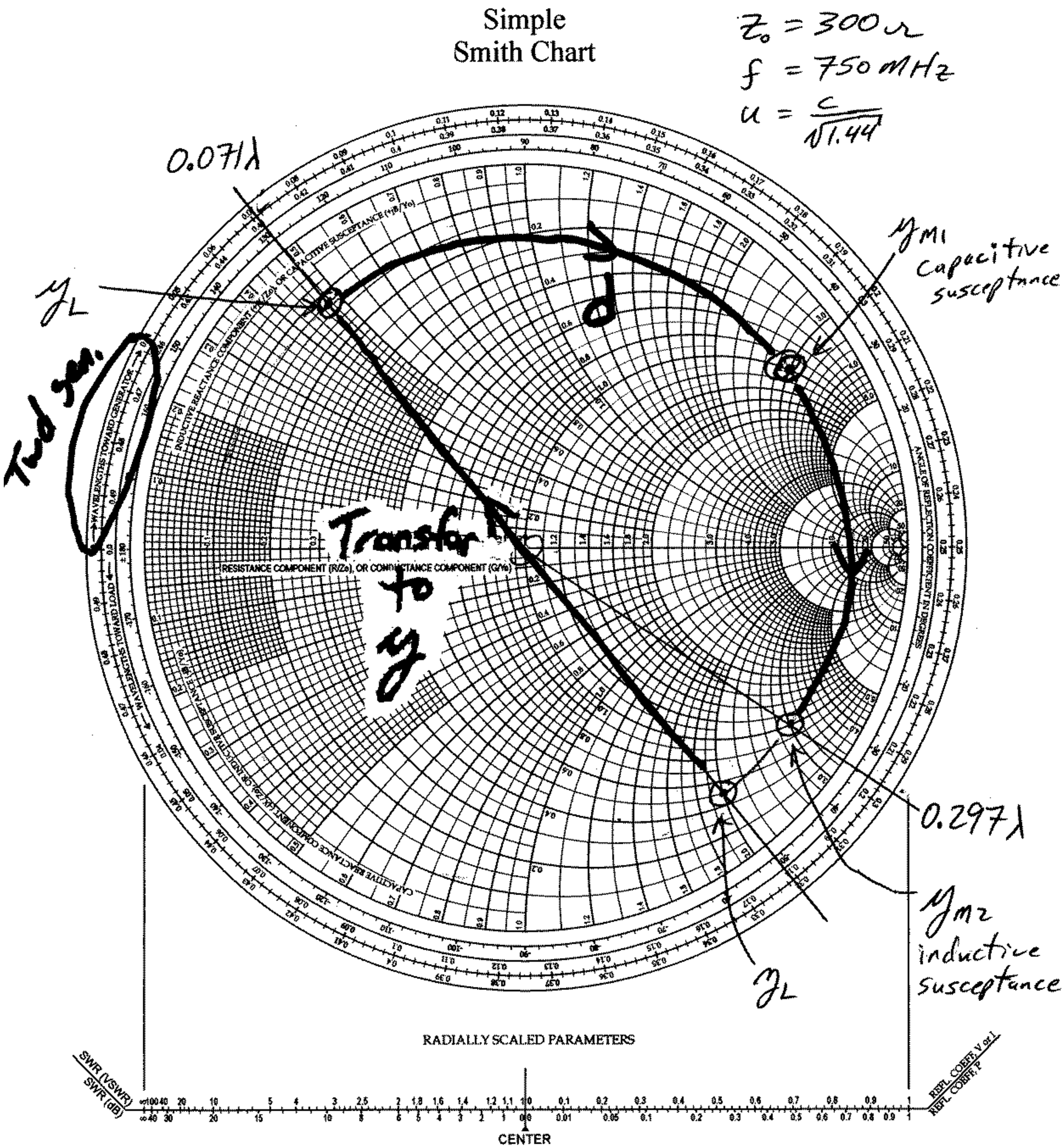
→ draw circle, centered on Smith Chart, thru z_L

→ rotate ½ from z_L to $y_L = 0.11765 + j0.4706$ S/S

→ Note location of match points (points where $|\Gamma|$ circle intersects $g = 1$ S/S circle).

$y_{m1} = 1 + j3$ S/S ← capacitive susceptance

$y_{m2} = 1 - j3$ S/S ← inductive susceptance


Simple
Smith Chart
Zo = 300 Ω
f = 750 MHz
u = c / √1.44
0.071λ
yL
Twd gen.
Transform to y
d
yM1
capacitive
susceptance
0.297λ
yM2
inductive
susceptance
zL
RADIALLY SCALED PARAMETERS
CENTER

Normalized capacitive susceptance $y_{cap} = (j\omega C) Z_o$

To use a discrete capacitor for matching, select match point #2 and require

$$y_{m2} + y_{cap} = 1$$

$$(1 - j3) + j(2\pi)(750 \times 10^6)C(300) = 1$$

$$\hookrightarrow \quad C = \frac{3}{2\pi(750 \times 10^6)(300)}$$

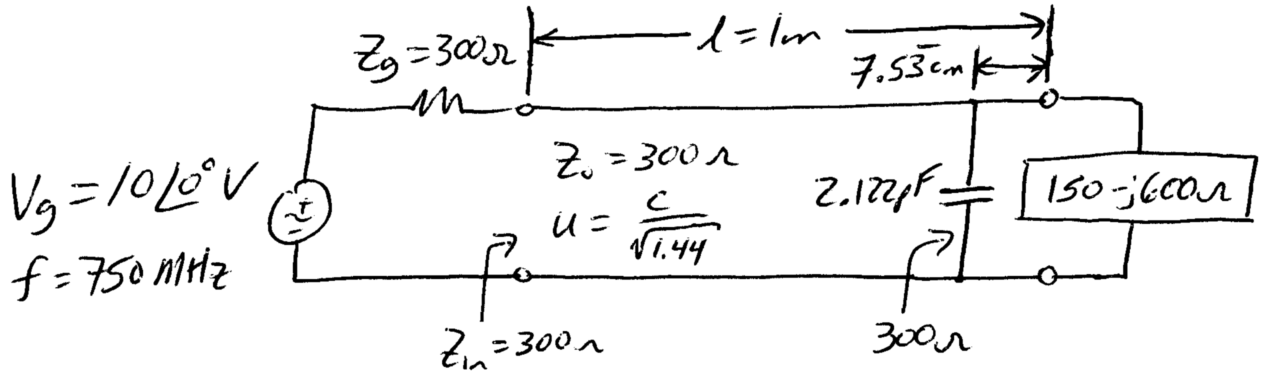
$$\underline{\underline{C = 2.122\,pF}}$$

Distance from load to y_{m2} location closest to load? ↙ from "Toward Generator" scale

$$d = 0.297\lambda - 0.071\lambda = \underline{\underline{0.226\lambda}}$$

$$d = 0.226\left(\frac{3\times10^8/\sqrt{1.44}}{750\times10^6}\right) = 0.075\bar{3}\,m$$

$$\underline{\underline{d = 7.5\bar{3}\,cm}}$$



$$I(0) = \frac{V_g}{Z_g + Z_{in}} = \frac{10\angle 0°}{300 + 300} = \frac{1}{60}\angle 0° \ A$$

$$P_{in} = \frac{1}{2}\left|I(0)\right|^2 R_{in} = \frac{1}{2}\left(\frac{1}{60}\right)^2 300 = \frac{|V_g|^2}{8R_g}$$

$$\underline{P_{in} = 41.\bar{6}\ mW}$$

Since capacitors do not absorb <u>real</u> power and the transmission line is lossless,

$$\underline{P_L = P_{in} = 41.\bar{6}\ mW} \quad \text{w/ matching capacitor}$$

For comparison, w/out matching capacitor,

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{(150 - j600) - 300}{(150 - j600) + 300} = 0.8246\angle -50.9°$$

$$\Gamma_{in} = \Gamma_L e^{-j2\beta l} = (0.8246\angle -50.9°)\, e^{-j2\frac{2\pi(750\times 10^6)}{c/\sqrt{1.44}}(1)} = 0.8246\angle -52.42°$$

$$Z_{in} = Z_0 \frac{1+\Gamma_{in}}{1-\Gamma_{in}} = 300\ \frac{1 + 0.825\angle -52.4°}{1 - 0.825\angle -52.4°} = 142.4 - j581.62\ \Omega$$

$$I_0 = \frac{V_g}{Z_{in} + Z_g} = \frac{10\angle 0°\ V}{142.4 - j581.6 + 300} = 0.01368455\angle 52.74°\ A$$

$$P_{in,noc} = P_{L,noc} = \frac{1}{2}(0.01368)^2\, 142.4 = \underline{13.\bar{3}\ mW} \quad \approx 32\% \text{ of matched } P_L$$