A load of $Z_L = 420 + j\,600\ \Omega$ is connected to a 300 Ω, 12 V_{RMS}, 500 MHz, sinusoidal generator by a 1 m long, lossless ($u = 2.1 \times 10^8$ m/s, $Z_0 = 300\ \Omega$) twin-lead, transmission line. With no matching, how much power is delivered to the load? Match the load to the generator by placing a single discrete capacitor in parallel with the transmission line as close to the load as possible. Sketch the resulting circuit with all relevant values. How much power is delivered to the load after matching?

$$\lambda = \frac{u}{f} = \frac{2.1\times10^8}{500\times10^6} = \underline{0.42\,m}$$

$$\rightarrow z_L = \frac{Z_L}{Z_0} = \frac{420+j600\,\Omega}{300\,\Omega} = 1.4 + j2\ \Omega/\Omega$$ & plot on Smith Chart

No Match

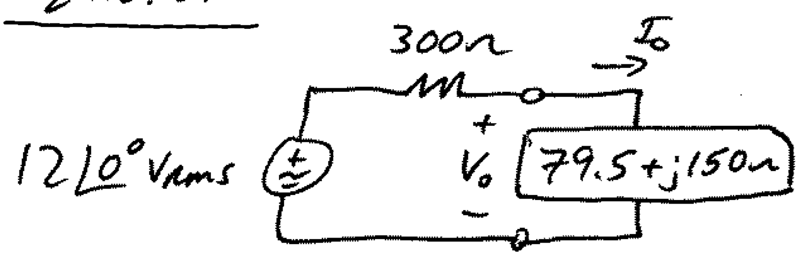
$$\rightarrow \ell/\lambda = \frac{1m}{0.42m} = 2.38095 \rightarrow 0.38095$$

→ move ℓ/λ from z_L to $z_{in,NM}$ (toward generator)
↖ No Match

$$\rightarrow \text{read } z_{in,NM} = 0.265 + j0.5\ \Omega/\Omega$$

$$Z_{in,NM} = z_{in,NM} Z_0 = 79.5 + j150\ \Omega$$

Equiv. Ckt.



$$I_0 = \frac{12\angle 0^\circ}{300 + (79.5 + j150)}$$

$$= 0.0294068 \angle -21.57^\circ\ A_{RMS}$$

$$V_0 = 12\angle 0^\circ \frac{79.5 + j150}{300 + (79.5 + j150)}$$

$$= 4.99225 \angle 40.50966^\circ\ V_{RMS}$$

No Match cont.

No factor of ½ ↙

$$P_{in,NM} = P_{L,NM} = \mathrm{Re}\{V_0 I_0^*\}$$

$$= \mathrm{Re}\{(4.992\angle 40.51^\circ)(0.02941\angle +21.57^\circ)\}$$

$$P_{in,NM} = 0.06874\ \text{W} = 68.741\ \text{mW}$$

Matching

→ Move $l_{M2} = 0.3184\lambda + 0.054\lambda = 0.3724\lambda$ toward the generator ($0.1564\ \text{m}$)

from $y_L = \frac{1}{z_L} = 0.235 - j0.336\ \text{S/S}$ to

$y_{m2} = 1 - j1.72\ \text{S/S}$ (Inductive Susceptance)

→ For $y_{in} = y_{m2} + y_{cap} = 1$

$$y_{cap} = +j1.72\ \text{S/S} \rightarrow Y_{cap} = \frac{y_{cap}}{Z_0}$$

$$j\omega C_{cap} = +j5.7\bar{3}\ \text{mS}$$

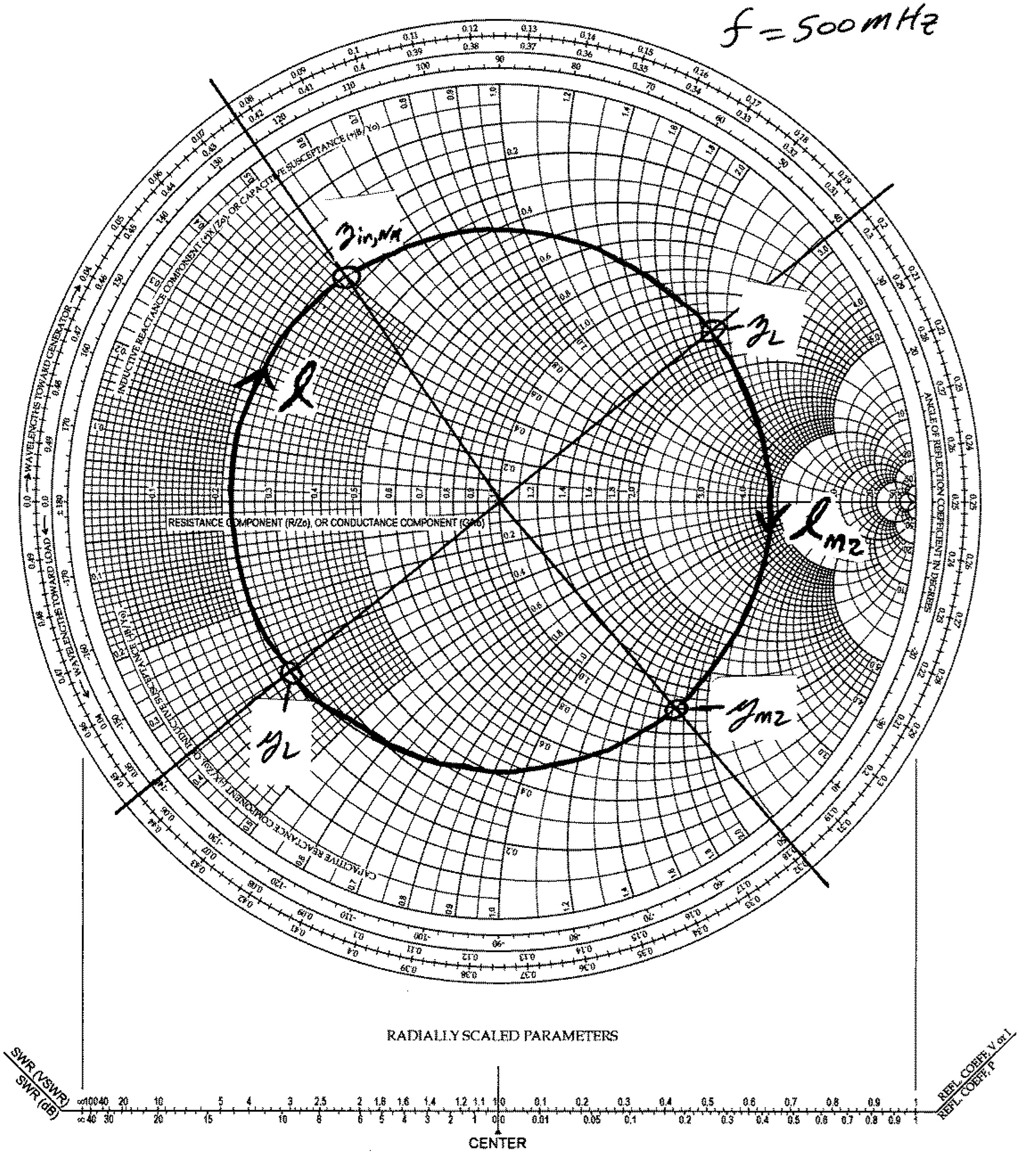
$$C_{cap} = \frac{5.7\bar{3}\times 10^{-3}}{2\pi(500\times 10^6)} = 1.825\ \text{pF}$$

Simple Smith Chart

$Z_o = 300\Omega$

$u = 2.1\times10^{8}\ m/s$

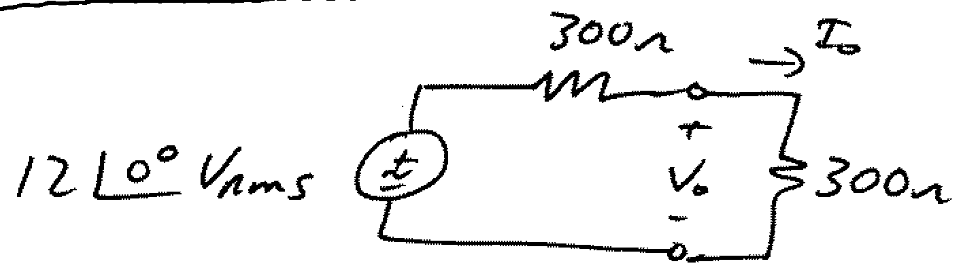
$f = 500\ MHz$



Matching Cont.

w/ matching $Z_{in} = Z_0 = 300\Omega$

Equiv. Ckt



$$I_0 = \frac{12\angle 0^\circ}{300+300} = 0.02\angle 0^\circ \text{ Arms}$$

$$V_0 = 12\angle 0^\circ \frac{300}{300+300} = 6\angle 0^\circ \text{ Vrms}$$

$$P_{in,m} = \text{Re}\{V_0 I_0^*\} = 6(0.02) = 0.12W$$

$$P_{in,m} = 120 \text{ mW}$$

Nearly twice the power delivered to load!