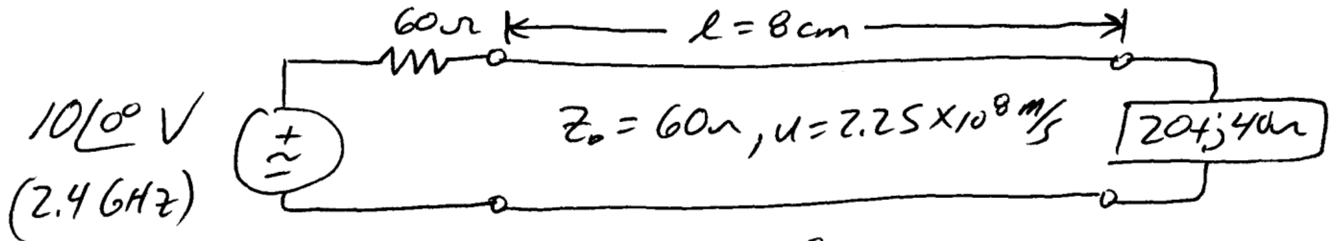
Match a load of $Z_L = 20 + j\,40\ \Omega$ connected to a $60\,\Omega$, $10\angle 0^\circ$ V, 2.4 GHz, sinusoidal generator with an 8 cm long, lossless transmission line ($Z_0 = 60\,\Omega$, $u = 2.25 \times 10^8$ m/s) and a **short circuit** single-stub tuner. Find and sketch both possible solutions. How much power is delivered to the load before matching? How much power is delivered to the load after matching? Use the $60\,\Omega$ transmission line for everything.



→ Calculate $\lambda = \frac{u}{f} = \frac{2.25\times10^8}{2.4\times10^9} \Rightarrow \underline{\lambda = 9.375\text{ cm}}$

→ Normalize load impedance $z_L = \frac{Z_L}{Z_0} = \frac{20+j40}{60}$

and plot $z_L = 0.\overline{33} + j\,0.\overline{66}$ Ω/Ω on Smith Chart

and $y_L = \frac{1}{z_L} = 0.6 - j1.2$ S/S (on circle thru z_L 180° around)

<u>No Match</u>

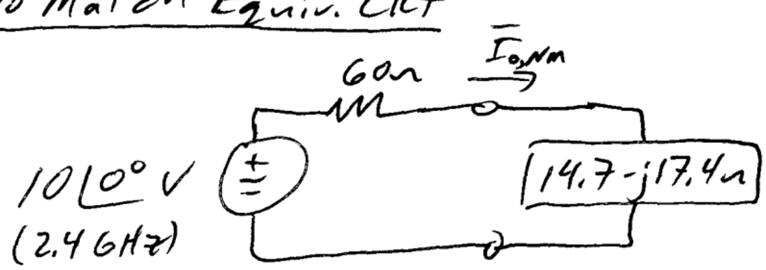
→ Move $\ell/\lambda = \frac{8\text{cm}}{9.375\text{cm}} = 0.85\overline{33} \rightarrow 0.3533\lambda$

"WAVELENGTHS TOWARD GENERATOR" from z_L to

$z_{in,NM} = 0.245 - j\,0.29$ Ω/Ω

→ $Z_{in,NM} = Z_0\, z_{in,NM} = 60(0.245 - j0.29) \Rightarrow \underline{Z_{in,NM} = 14.7 - j17.4\,\Omega}$

<u>No Match Equiv. Ckt</u>



$\bar{I}_{0,NM} = \frac{10\angle 0^\circ}{60 + (14.7 - j17.4)} = 0.13038\angle 13.11^\circ$ A

$P_{in,NM} = P_{L,NM} = \frac{1}{2}|\bar{I}_{0,NM}|^2(14.7) = \frac{1}{2}(0.1304)^2(14.7) \Rightarrow \underline{\underline{P_{L,NM} = 0.125\text{ W}}}$

Matching

→ On circle of constant $|\Gamma| = 0.63$, find two match points $\underline{y_{m1} = 1 + j\,1.63 \text{ S/S}}$ @ $\underline{\underline{d_1 = 0.25 + 0.08 = 0.33\lambda}}$

$\underline{y_{m2} = 1 - j\,1.63 \text{ S/S}}$ @ $\underline{\underline{d_2 = 0.25 + 0.221 = 0.471\lambda}}$

→ Convert d_1 & d_2 into units of distance

$$d_1 = 0.33(9.375\text{cm}) = \underline{\underline{3.094\text{cm}}}$$

$$d_2 = 0.471(9.375\text{cm}) = \underline{4.416\text{ cm}}$$

→ Find length of short circuit stubs required to achieve $y_{STUB1} = -j\,1.63 \text{ S/S}$ and $y_{STUB2} = +j\,1.63 \text{ S/S}$ by starting @ $y_{SC} = \infty$ point and moving toward generator on perimeter of Smith chart

$$\ell_1 = (0.3375 - 0.25)\lambda \Rightarrow \underline{\underline{\ell_1 = 0.0875\lambda = 0.820\text{ cm}}}$$

$$\ell_2 = (0.25 + 0.1625)\lambda \Rightarrow \underline{\underline{\ell_2 = 0.4125\lambda = 3.867\text{ cm}}}$$

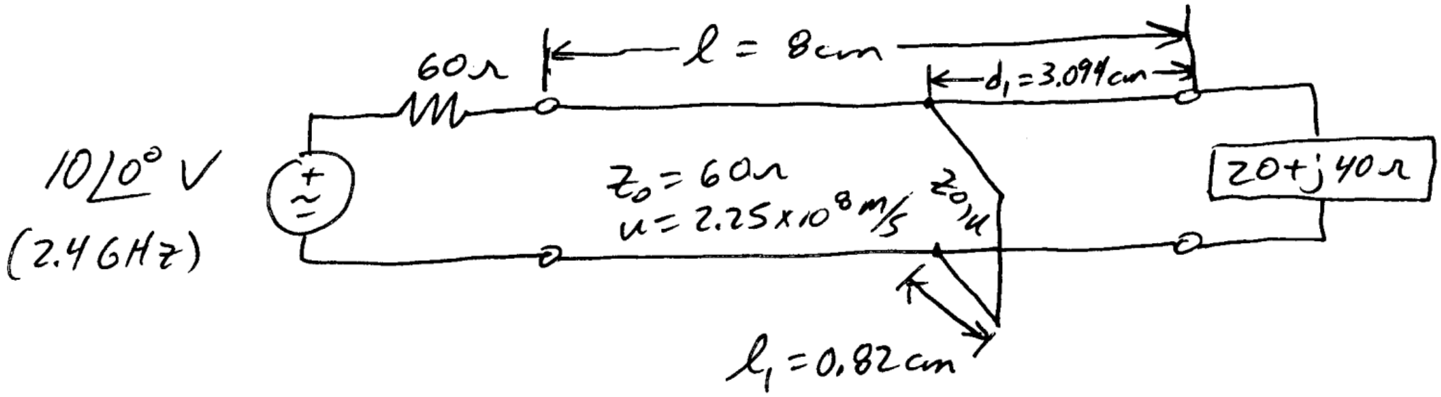
Matched Equiv. Ckt.

$$\bar{I}_{o,m} = \frac{10\angle 0^\circ}{60+60} = 0.08\bar{3}\angle 0^\circ \text{ A}$$

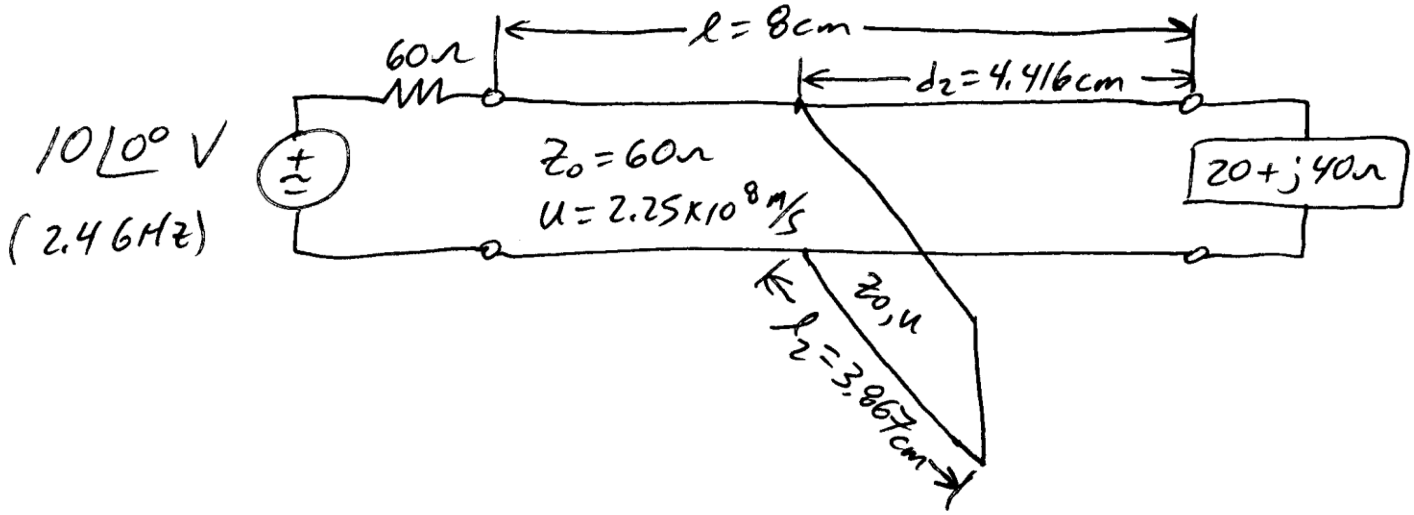
$$P_{in,m} = P_{L,m} = \tfrac{1}{2}|\bar{I}_{o,m}|^2 60 = \tfrac{1}{2}(0.08\bar{3})^2 60$$

$$\underline{\underline{P_{L,m} = 0.208\bar{3}\text{ W}}} \quad (166.\bar{6}\,\%\text{ of } P_{L,NM})$$

Match #1 (use $y_{m1} = 1 + j1.63$ S/S match point)



Match #2 (use $y_{m2} = 1 - j1.63$ S/S match point)



Simple Smith Chart

$Z_0 = 60\Omega$

$u = 2.25 \times 10^8$ m/s

$f = 2.4$ GHz