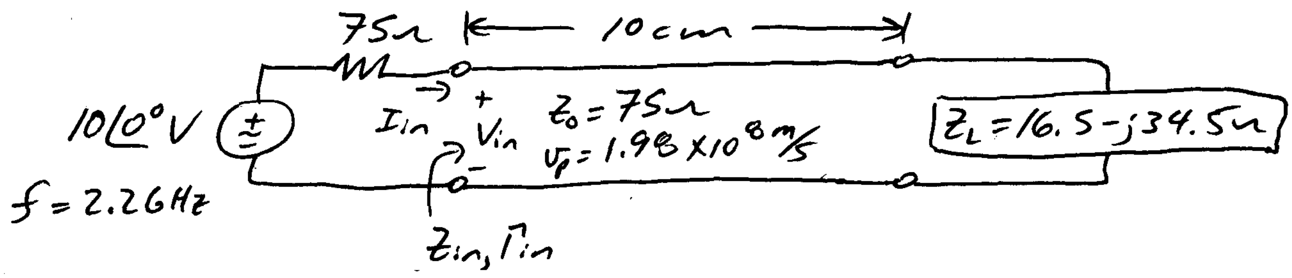
A lossless transmission line (75 Ω, 1.98 × 10^8 m/s) of length 10 cm connects a load of 16.5 – j34.5 Ω to a matched 10 V generator operating at 2.2 GHz. <u>Using a Smith chart</u>, find the unmatched input impedance and load power. Then, design and sketch a shunt single-stub tuning network with short circuit termination. Place the stub as close as possible to the load and make the stub as short as possible. Find the matched input impedance and load power.



$$\lambda = v_p/f = \frac{1.98\times10^8}{2.2\times10^9} = 0.09\,\text{m} = 9\,\text{cm}$$

$$\ell/\lambda = \frac{10}{9} = 1.\overline{111}$$

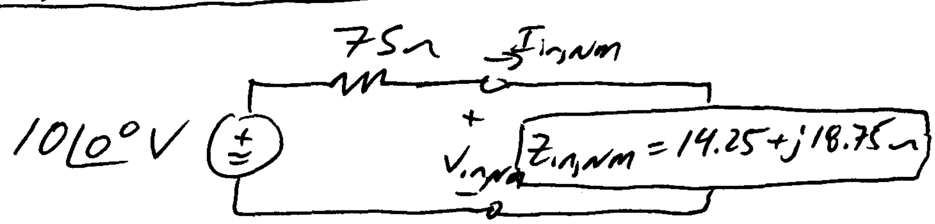
→ Calculate $z_L = \frac{Z_L}{Z_0} = \frac{16.5 - j34.5}{75} = 0.22 - j0.46\ \Omega/\Omega$ and plot on Smith Chart.

→ Move $1.\overline{111}\lambda - 1\lambda = 0.1111\lambda$ WTG to unmatched

$$z_{in,NM} = 0.19 + j0.25\ \Omega/\Omega$$

→ $Z_{in,NM} = z_{in,NM} Z_0 = (0.19 + j0.25)75 = \underline{\underline{14.25 + j18.75\,\Omega}}$

<u>Input Equiv Circuit (un-matched)</u>



$$I_{in,NM} = \frac{10\angle 0^\circ}{75 + 14.25 + j18.75} = 0.1096512\,\angle{-11.864^\circ}\ \text{A}$$

$$P_{L,NM} = P_{in,NM} = \tfrac{1}{2}|I_{in,NM}|^2 R_{in,NM} = 0.5(0.10965)^2 14.25 = \underline{\underline{85.67\,\text{mW}}}$$

Matching w/ short ckt shunt stub

→ go λ/4 around Smith chart to $y_L = 0.85 + j1.77$ S/S

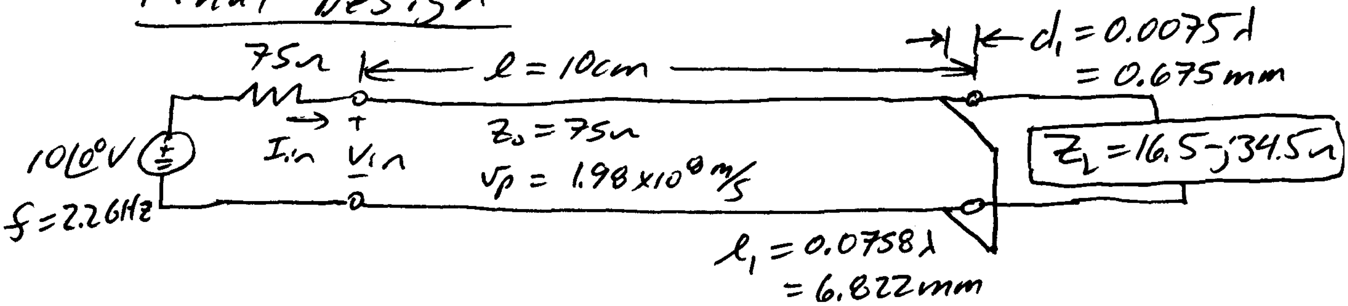
→ Move WTG $d_1 = 0.1855\lambda - 0.178\lambda = \underline{0.0075\lambda}$

to $y_{m1} = 1 + j1.94$ S/S $= 0.0075(9) = \underline{0.0675\text{ cm}}$

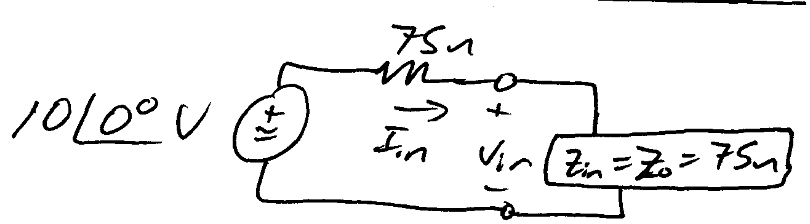
→ Find length ℓ_1 of short circuit stub to yield $y_{stub} = -j1.94$ S/S. Start @ $y_{sc} = \infty$ and move WTG $\ell_1 = 0.3258\lambda - 0.25\lambda = \underline{0.0758\lambda}$

$= 0.0758(9\text{cm}) = \underline{0.6822\text{ cm}}$

Final Design



Matched Input Equiv Ckt



$$I_{in,m} = \frac{10\angle 0^\circ}{75+75} = 0.0\bar{6}\angle 0^\circ \text{ A}$$

$$P_{in,m} = \tfrac{1}{2}|I_{in,m}|^2 Z_0 = \tfrac{1}{2}(0.0\bar{6})^2\, 75$$

$$\underline{P_{in,m} = 166.\bar{6}\text{ mW} = P_{L,m}}$$

~ 195% more power to load!

Simple Smith Chart

$Z_0 = 75\Omega$

$v_p = 1.98 \times 10^8$ m/s

$f = 2.2$ GHz