EE 483/583 Antennas for Wireless Communications Quiz #8 (Spring 2024)

Name KEY

Instructions: Open book and notes. Place answers in indicated spaces and **show & explain all work** for credit.

Match a Yagi-Uda antenna ($Z_A = 12.5 + j37.5\ \Omega$) operating at 600 MHz to a 75 Ω feeding transmission line ($u = 2.4 \times 10^8$ m/s) using a discrete inductor connected in **parallel** and placed as close to the antenna as possible. As part of the solution process, find the normalized antenna admittance y_A and impedance z_A, normalized match point admittances (circle match point used), wavelength λ on transmission line, distance d from the antenna to the match point (x.xxx λ & cm), inductor admittance Y_L (not normalized), and inductor value L. **Fully label** the Smith chart and draw a fully-labeled sketch of the final design in box provided [**all** dimensions in **cm**].

- The wavelength is $\lambda = u/f = 2.4 \times 10^8/600 \times 10^6 = 0.4$ m $\Rightarrow$ **λ = 40 cm**.

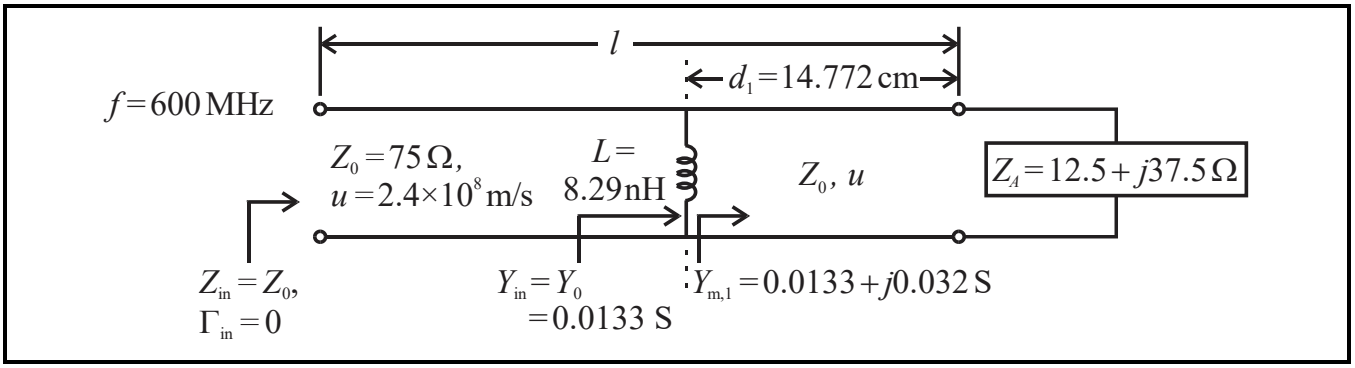
Steps

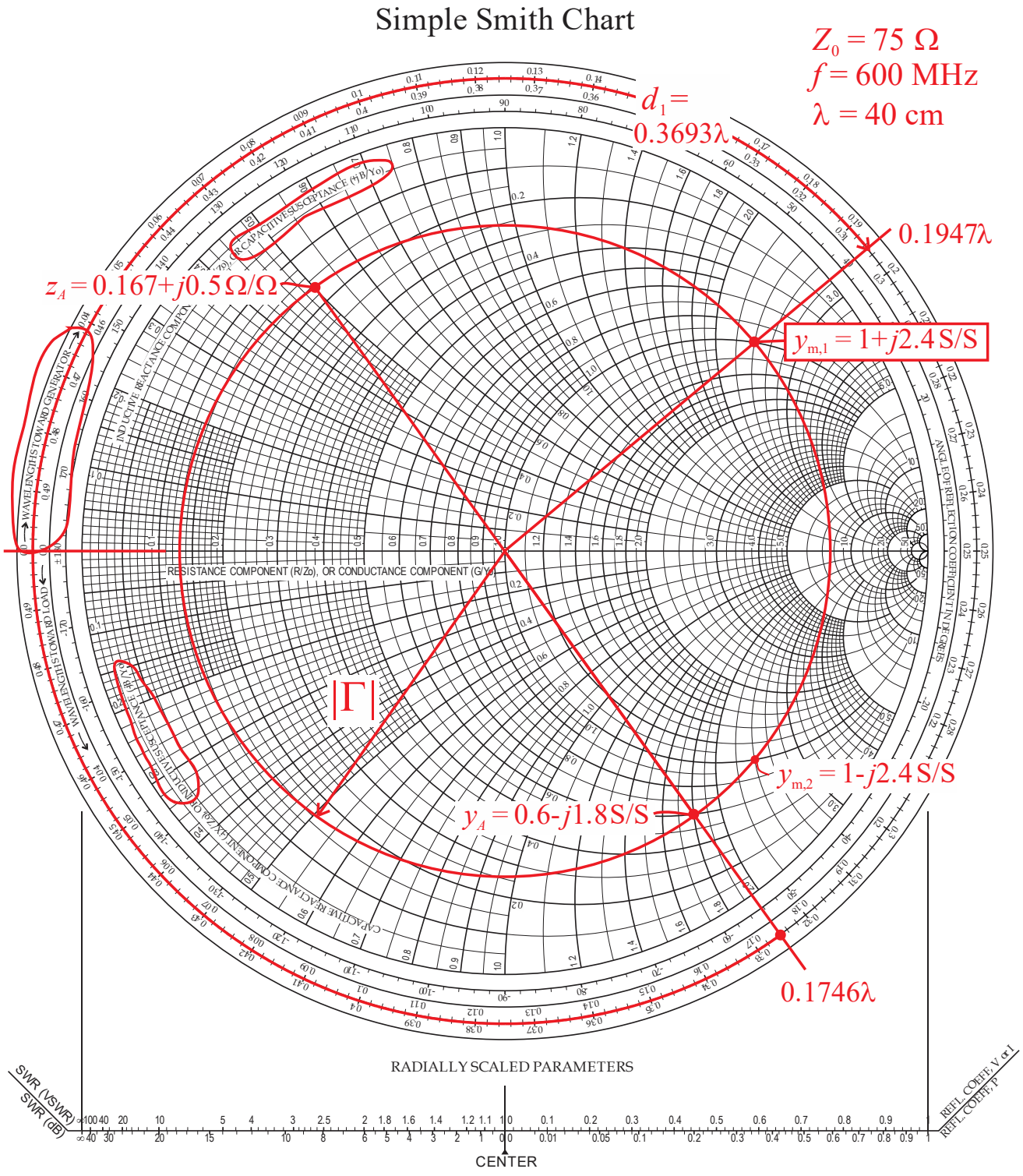
1) Calculate normalized impedance $z_A = Z_A/Z_0 = (12.5 + j37.5)/75 \Rightarrow$ **$z_A = 0.167 + j\,0.5\ \Omega/\Omega$** and plot on **Smith chart**.
2) Draw circle, centered on Smith chart, through z_A point. This circle of constant |Γ| includes the locus of all possible z_{in} (and y_{in}) along the transmission line with this load.
3) Go λ/4 (180°) around the circle of constant |Γ| from z_A point to $y_A = 1/z_A = 1/(0.167 + j\,0.5)$ point and plot $\Rightarrow$ **$y_A = 0.6 - j\,1.8$ S/S**.
4) Note, the two match points are **$y_{m,i} = 1 \pm j2.4$ S/S**. In order to use a discrete inductor for matching, select **$y_{m1} = 1 + j2.4$ S/S** as it has a capacitive susceptance. Note, $Y_{m1} = y_{m1}/Z_0 = (1 + j2.4)/75 = 0.01333 + j0.032$ S.
5) Find distance d_1 from y_A to y_{m1} using scales on Smith chart, **$d_1/\lambda = 0.1746 + 0.1947 = 0.3693$** or, in centimeters, $d_1 = 0.3693(40) \Rightarrow$ **$d_1 = 14.772$ cm**.
6) At d_1, add a discrete inductor in parallel with susceptance **$Y_L = -j0.032$ S** $= -j/\omega L$. Solving for L yields $L = 1/[2\pi\,600 \times 10^6(0.032)] = 8.28932 \times 10^{-9}$ H $\Rightarrow$ **$L = 8.29$ nH**.
7) As shown on circuit, everywhere toward the source from the location of L will be matched, i.e., $Z_{in} = Z_0 = 75\ \Omega$.

$z_A =$ **$0.167 + j\,0.5\ \Omega/\Omega$** $y_A =$ **$0.6 - j\,1.8$ S/S**

$y_{m1} =$ **$1 + j2.4$ S/S** $y_{m2} =$ **$1 - j2.4$ S/S** $\lambda =$ **40 cm**

$d =$ **$d_1 = 0.3693\lambda = 14.772$ cm** $Y_L =$ **$-j0.032$ S** $L =$ **8.29 nH**


l
$d_1 = 14.772\,\text{cm}$
$f = 600\,\text{MHz}$
$Z_0 = 75\,\Omega,$
$u = 2.4\times10^8\,\text{m/s}$
$L =$
$8.29\,\text{nH}$
$Z_0,\ u$
$Z_A = 12.5 + j37.5\,\Omega$
$Z_{in} = Z_0,$
$\Gamma_{in} = 0$
$Y_{in} = Y_0$
$= 0.0133\ \text{S}$
$Y_{m,1} = 0.0133 + j0.032\,\text{S}$


Simple Smith Chart
$Z_0 = 75\ \Omega$
$f = 600\ \text{MHz}$
$\lambda = 40\ \text{cm}$
$d_1 =$
0.3693λ
0.1947λ
$z_A = 0.167 + j0.5\,\Omega/\Omega$
$y_{m,1} = 1 + j2.4\,\text{S/S}$
$y_{m,2} = 1 - j2.4\,\text{S/S}$
$y_A = 0.6 - j1.8\,\text{S/S}$
0.1746λ
$|\Gamma|$
RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
RADIALLY SCALED PARAMETERS
CENTER