EE 481/581 Microwave Engineering
Quiz #3 (Fall 2025)

Name KEY A

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

A lossless transmission line (80 Ω, 2.42×10^8 m/s) of length 18.235 cm has a measured input impedance of $128 + j\,144$ Ω at 2.2 GHz. Then, using a Smith chart, find the input admittance & reflection coefficient, load impedance & reflection coefficient, standing wave ratio (SWR), and return loss (RL). **Show** and **clearly label** all work on the Smith chart (this will be graded).

- Normalize $z_{\text{in}} = Z_{\text{in}} / Z_0 = (128 + j\,144)/80 \Rightarrow$ $\mathbf{z_{in} = 1.6 + j\,1.8}$ **Ω/Ω**.
- Plot z_{in} on Smith chart by finding intersection of $r = 1.6$ circle with $x = 1.8$ arc.
- Set compass to distance from center of Smith chart to z_{in} point. Draw circle, centered on Smith Chart, through z_{in} point.
- Use compass to make marks on 'RFL COEFF, E or I', 'SWR', and 'RTN LOSS (dB)' scales. Read off **|Γ| = 0.6**, **SWR = 4**, and **RL = 4.4 dB**.
- Use straightedge to draw radial line from center of Smith chart to outer rings. Use "ANGLE OF REFLECTION COEFFICIENT IN DEGREES" scale to read $\angle\Gamma_{\text{in}} = 36.9°$. Put the magnitude and angle together to get the input reflection coefficient $\Gamma_{\text{in}} = 0.6\angle 36.9°$.
- Use straightedge to extend radial line across Smith chart. Read normalized input admittance $\mathbf{y_{in} = 0.275 - j\,0.31}$ **S/S** where radial line intersects circle of constant |Γ| opposite to z_{in} (i.e., 180°). Unnormalize to get $Y_{\text{in}} = y_{\text{in}}/Z_0 = (0.275 - j\,0.31)/80$ $\Rightarrow$ $Y_{\text{in}} = 0.00344 - j\,0.00388 \text{ S} = 3.44 - j\,3.88 \text{ mS}$.
- Calculate wavelength to be $\lambda = v_p / f = 2.42 \times 10^8 / 2.2 \times 10^9 = 0.11$ m = 11 cm. The TL length in wavelengths is $\ell/\lambda = 18.235 / 11 = 1.6577$. Subtract $3(0.5) = 1.5$ (i.e., remove integer multiples of $n\lambda/2$) to get $\boldsymbol{\ell/\lambda = 0.1577}$.
- Move $\boldsymbol{\ell/\lambda = 0.1577}$ in the "WAVELENTHS TOWARD LOAD" direction on arc of constant |Γ| from input point (0.3012) to load point (0.3012+0.1577 = 0.4589) and draw radial line from center of Smith chart.
- At load point, read $\angle\Gamma_L = 150.4°$ on "ANGLE OF REFLECTION COEFFICIENT IN DEGREES" scale and $z_L = 0.27 + j\,0.244$ **Ω/Ω**. The load reflection coefficient is then $\Gamma_L = 0.6\angle 150.4°$ and load impedance is $Z_L = z_L Z_0 = (0.27 + j\,0.244)\,80 \Rightarrow$ $Z_L = 21.6 + j\,19.52$ **Ω**.

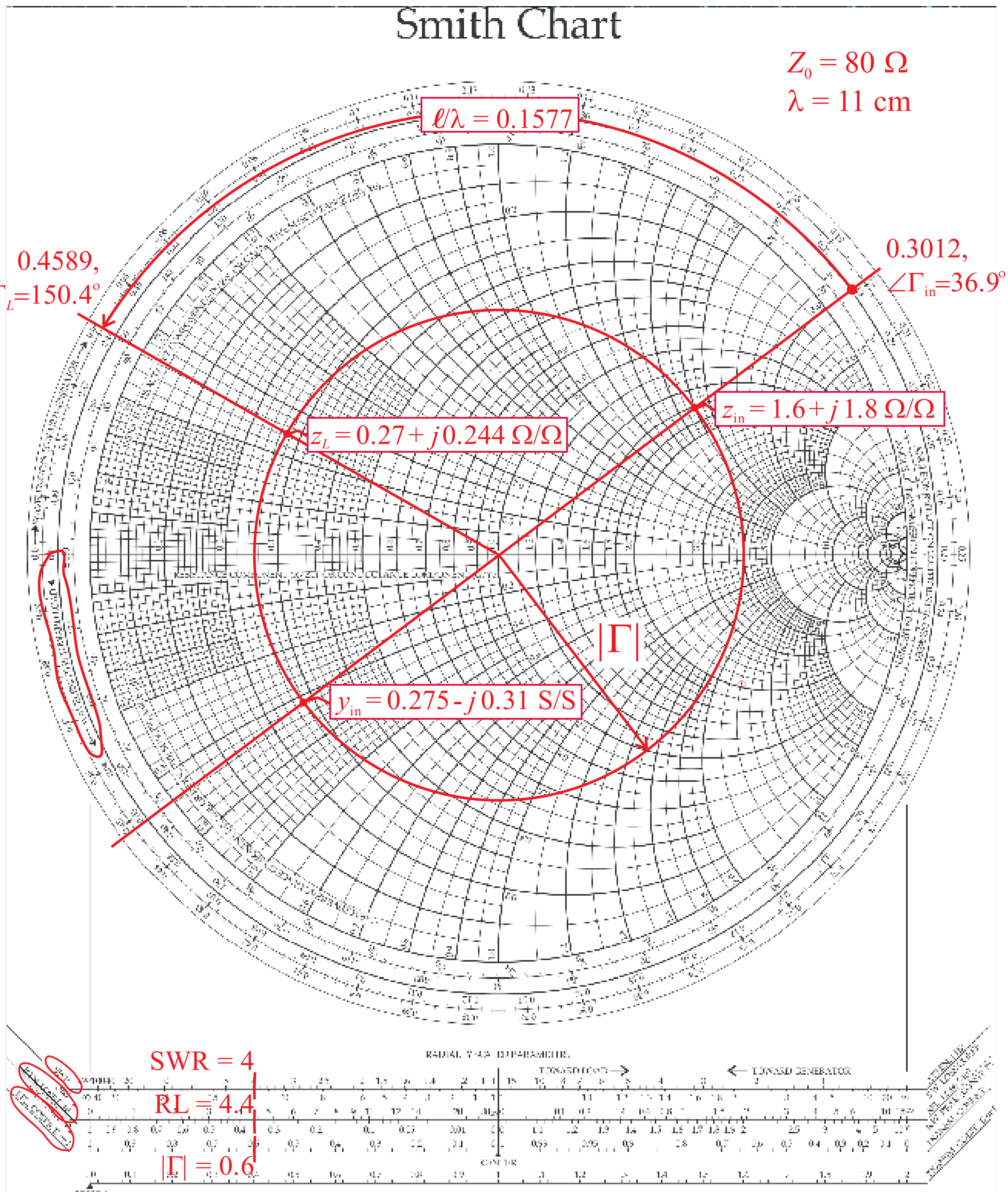
SWR = **4** Y_{in} = $3.44 - j\,3.88$ **mS** input refl. coeff. = $\Gamma_{\text{in}} = 0.6\angle 36.9°$

RL = **4.4 dB** load refl. coeff. = $\Gamma_L = 0.6\angle 150.4°$ Z_L = $21.6 + j\,19.52$ **Ω**

Exact answers-

SWR = **4** Y_{in} = **3.45 - *j* 3.88 mS** input refl. coeff. = **Γ_{in} = 0.6∠36.87°**

RL = **4.44 dB** load refl. coeff. = **Γ_L = 0.6∠150.43°** Z_L = **21.3 + *j* 19.71 Ω**



EE 481/581 Microwave Engineering
Quiz #3 (Fall 2025)

Name __**KEY B**__

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

A lossless transmission line (120 Ω, 2.208×10^8 m/s) of length 24.99 cm has a measured input impedance of 72 - j 96 Ω at 2.4 GHz. Then, using a Smith chart, find the input admittance & reflection coefficient, load impedance & reflection coefficient, standing wave ratio (SWR), and return loss (RL). **Show** and **clearly label** all work on the Smith chart (this will be graded).

- Normalize $z_{in} = Z_{in} / Z_0 = (72 - j\,96) / 120 \Rightarrow$ $\boldsymbol{z_{in} = 0.6 - j\,0.8}$ **Ω/Ω**.
- Plot z_{in} on Smith chart by finding intersection of $r = 0.6$ circle with $x = -0.8$ arc.
- Set compass to distance from center of Smith chart to z_{in} point. Draw circle, centered on Smith Chart, through z_{in} point.
- Use compass to make marks on 'RFL COEFF, E or I', 'SWR', and 'RTN LOSS (dB)' scales. Read off **$|\Gamma| = 0.5$**, **SWR = 3**, and **RL = 6 dB**.
- Use straightedge to draw radial line from center of Smith chart to outer rings. Use "ANGLE OF REFLECTION COEFFICIENT IN DEGREES" scale to read **$\angle\Gamma_{in} = -90°$**. Put the magnitude and angle together to get the input reflection coefficient **$\Gamma_{in} = 0.5\angle -90°$.**
- Use straightedge to extend radial line across Smith chart. Read normalized input admittance $\boldsymbol{y_{in} = 0.6 + j\,0.8}$ **S/S** where radial line intersects circle of constant $|\Gamma|$ opposite to z_{in} (i.e., 180°). Unnormalize to get $Y_{in} = y_{in} / Z_0 = (0.6 + j\,0.8)/120 \Rightarrow$ **$Y_{in} = 0.005 + j\,0.00667$ S = $5 + j\,6.67$ mS**.
- Calculate wavelength to be $\lambda = v_p / f = 2.208 \times 10^8 / 2.4 \times 10^9 = 0.092$ m = 9.2 cm. The TL length in wavelengths is $\ell/\lambda = 24.99 / 9.2 = 2.7163$. Subtract $5(0.5) = 2.5$ (i.e., remove integer multiples of $n\lambda/2$) to get $\boldsymbol{\ell/\lambda = 0.2163}$.
- Move $\boldsymbol{\ell/\lambda = 0.2163}$ in the "WAVELENTHS TOWARD LOAD" direction on arc of constant $|\Gamma|$ from input point (0.125) to load point (0.125+0.2163 = 0.3413) and draw radial line from center of Smith chart.
- At load point, read **$\angle\Gamma_L = 65.8°$** on "ANGLE OF REFLECTION COEFFICIENT IN DEGREES" scale and **$z_L = 0.9 + j\,1.09$ Ω/Ω**. The load reflection coefficient is then **$\Gamma_L = 0.5\angle 65.8°$** and load impedance is $Z_L = z_L Z_0 = (0.9 + j\,1.09)\,120 \Rightarrow$ **$Z_L = 108 + j\,130.8$ Ω**.

SWR = __**3**__ Y_{in} = **$5 + j\,6.67$ mS** input refl. coeff. = **$\Gamma_{in} = 0.5\angle -90°$**

RL = __**6 dB**__ load refl. coeff. = **$\Gamma_L = 0.5\angle 65.8°$** Z_L = **$108 + j\,130.8$ Ω**

Exact answers-

SWR = __**3**__ Y_{in} = **5 + *j* 6.67 mS** input refl. coeff. = **$\Gamma_{in} = 0.5\angle{-90°}$**

RL = _**6.02 dB**_ load refl. coeff. = **$\Gamma_L = 0.5\angle 65.74°$** Z_L = **107.26 + *j* 130.379 Ω**