University of Portland
School of Engineering

EE 301
Spring 2014
A.Inan

Introduction to Smith Chart—Practice Problems

(Monday, March 24, 2014)

1. **Impedance points on the Smith chart.** Given the impedance values $Z_A = 500\ \Omega$, $Z_B = 20-j75\ \Omega$, $Z_C = 80+j50\ \Omega$, $Z_D = -j13\ \Omega$, and $Z_E = 10+j100\ \Omega$, enter each one of them on the Smith chart. (Use the Smith chart as an impedance chart and assume $Z_0 = 50\ \Omega$.)

2. **Open- and short-circuit points on the Smith chart.** Show the open- and short-circuit points on the Smith chart if the Smith chart is used as an (a) impedance chart, and (b) admittance chart.

3. **Standing-wave-ratio circles on the Smith chart.** Draw the three constant standing-wave ratio circles with values $S = 2$, 4 and 10 on the Smith chart. Then, use the reflection coefficient scale provided at the left bottom of the Smith chart to read the approximate value of each reflection coefficient magnitude corresponding to each one of these constant S-circles.

4. **Input impedance of a quarter-wavelength long (quarter-wave) transmission line.** Consider a quarter-wavelength long 100-Ω transmission line terminated with a load impedance of $Z_L = 60\ \Omega$.

   (a) Use the Smith chart to find the approximate value of the input impedance of this line.

   (b) Assume the source wavelength is changed by a factor of 2/3, i.e., $\lambda_{new} = 2\lambda_{old}/3$. Again, use the Smith chart to find the approximate value of the input impedance of the same line. (Assume the Z_0 and Z_L values to stay the same.)

5. **Converting impedance to admittance on the Smith chart.** Use the Smith chart to find the approximate value of the admittance corresponding to the impedance given by $Z = 120+j40\ \Omega$. (Use $Z_0 = 100\ \Omega$.)

6. **Input admittance of a transmission line.** Consider a 6.5-m long, 50-Ω coaxial line terminated with a load impedance of 150 Ω.

   (a) What is the standing-wave-ratio on this line? (Use the Smith chart to read this value.)
   (b) Using the Smith chart, find the approximate value of the input admittance Y_{in} of this line at a frequency of $f = 250$ MHz. Assume the velocity factor of the coax to be $v_p/c = 2/3$.

7. **What nearest positions Z_{in} is purely resistive?** Consider a 50-Ω transmission line terminated with a load impedance of $Z_L = 50 - j50$ Ω.

   (a) Use the Smith chart to find the electrical position (i.e., l/λ) on the line which is nearest to the load where the input impedance is purely resistive.
   (b) What is the approximate value of Z_{in} at this position?
   (c) Find the second nearest position on the line where again Z_{in} is purely real and its value at that position.

8. **What nearest positions $Z_{in} = Z_0 + j\,X_{in}$?** Consider a 50-Ω transmission line terminated with a load impedance of $Z_L = 10 - j25$ Ω. Using the Smith chart, find the two nearest electrical positions away from the load where the real part of the input impedance is equal to Z_0. Provide the approximate value of Z_{in} at each one of these positions.

9. **Standing-wave-ratio.** Consider a 75-Ω transmission line terminated by a load impedance given by $Z_L = j270$ Ω. Use the Smith chart to find the standing-wave ratio S on this line. Provide some explanation for your S value.

10. **Unknown load impedance.** The input impedance of a 0.375λ long 50-Ω transmission line terminated with an unknown load is approximately measured to be $Z_{in} \approx 20$ Ω. Use the Smith chart to find the approximate value of the unknown load impedance Z_L.

11. **A transmission line terminated with a complex load.** Consider a 1.625λ long 90-Ω transmission line terminated with a load having an impedance of value $Z_L = 72 - j270$ Ω. Use the Smith chart to find the approximate values of the following:
    (a) The standing-wave-ratio value on the line.
    (b) The input impedance and the input admittance of the line.

12. **Region on the Smith chart.** Shade the region of the Smith chart where the real and imaginary parts of the impedance $Z = R + jX$ satisfy $Z_0/2 < R < 2Z_0$ and $Z_0/2 < |X| < 2Z_0$ simultaneously.

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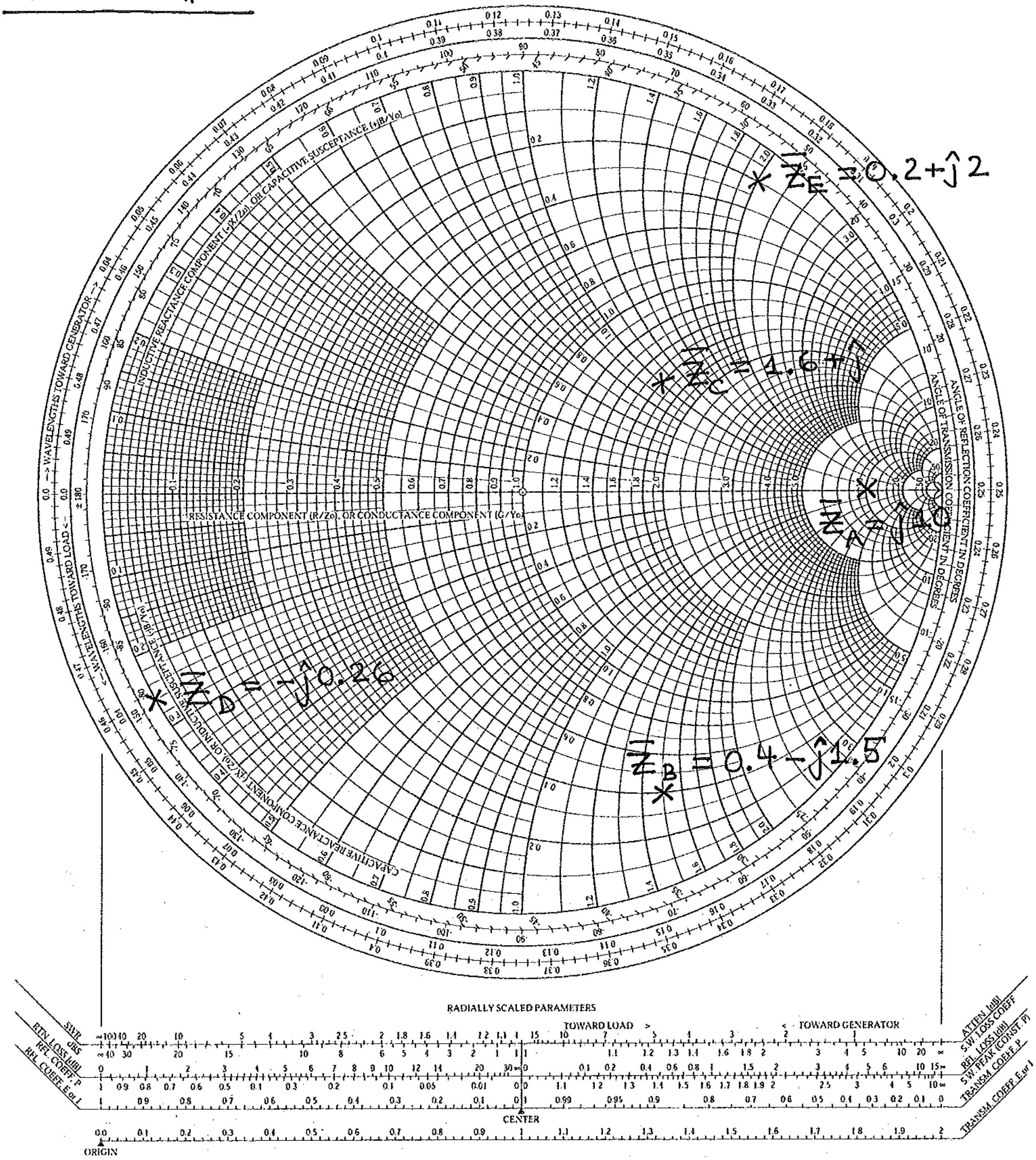
Introduction to Smith Chart – Practice Problems

The Complete Smith Chart

Black Magic Design

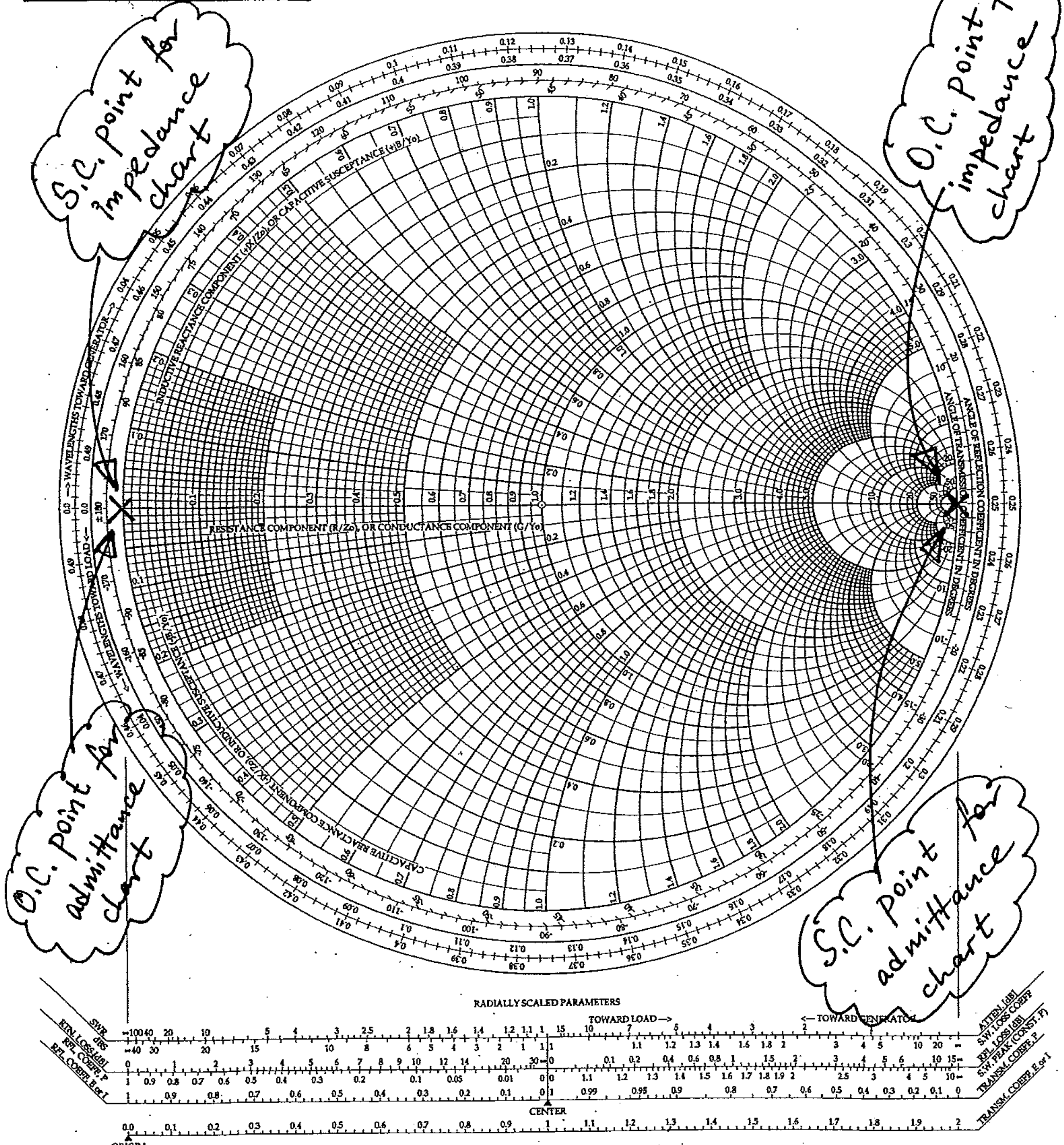
Problem # 1



Problem#2

The Complete Smith Chart

Black Magic Design



Problem#3

The Complete Smith Chart

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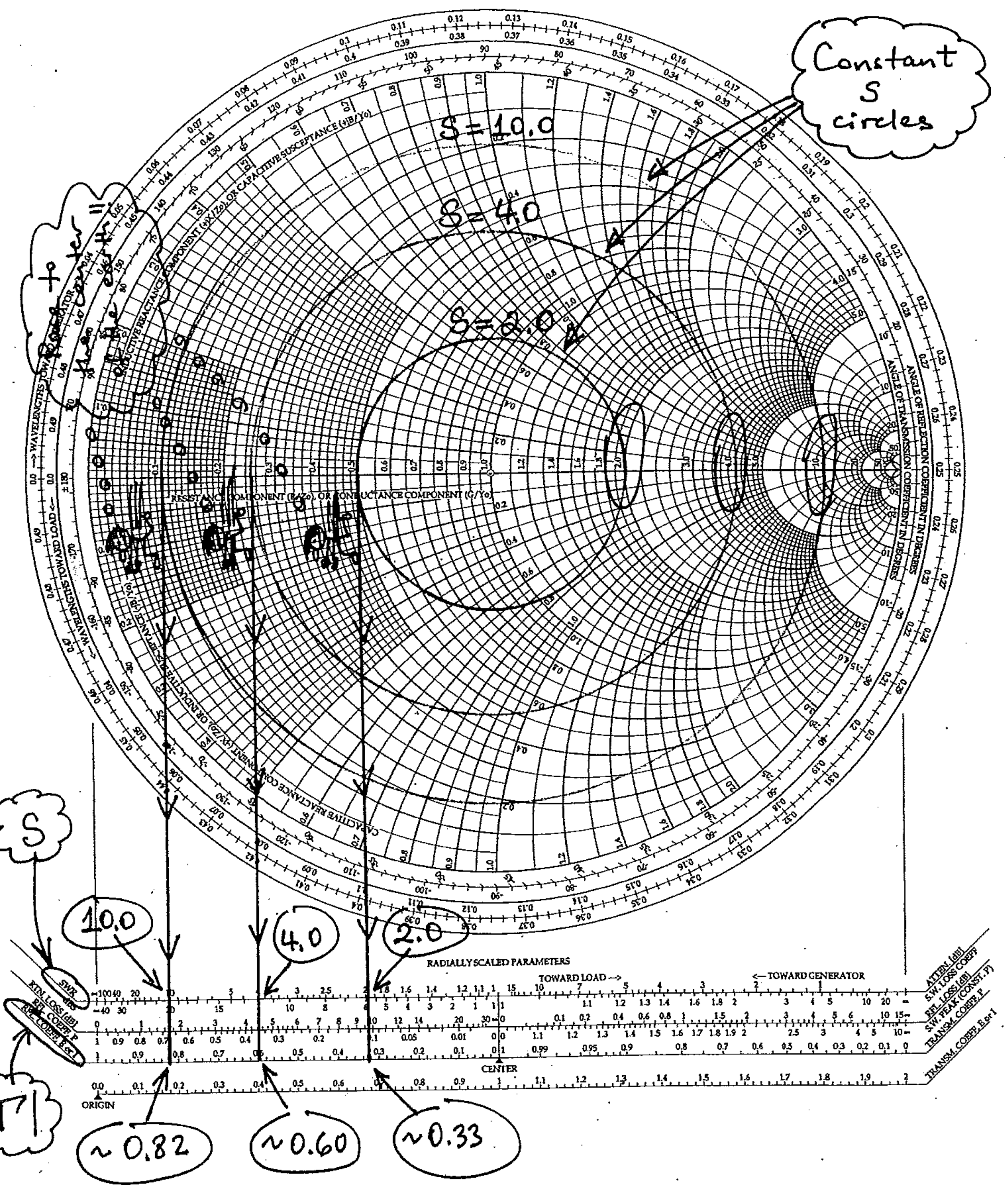

The Complete Smith Chart

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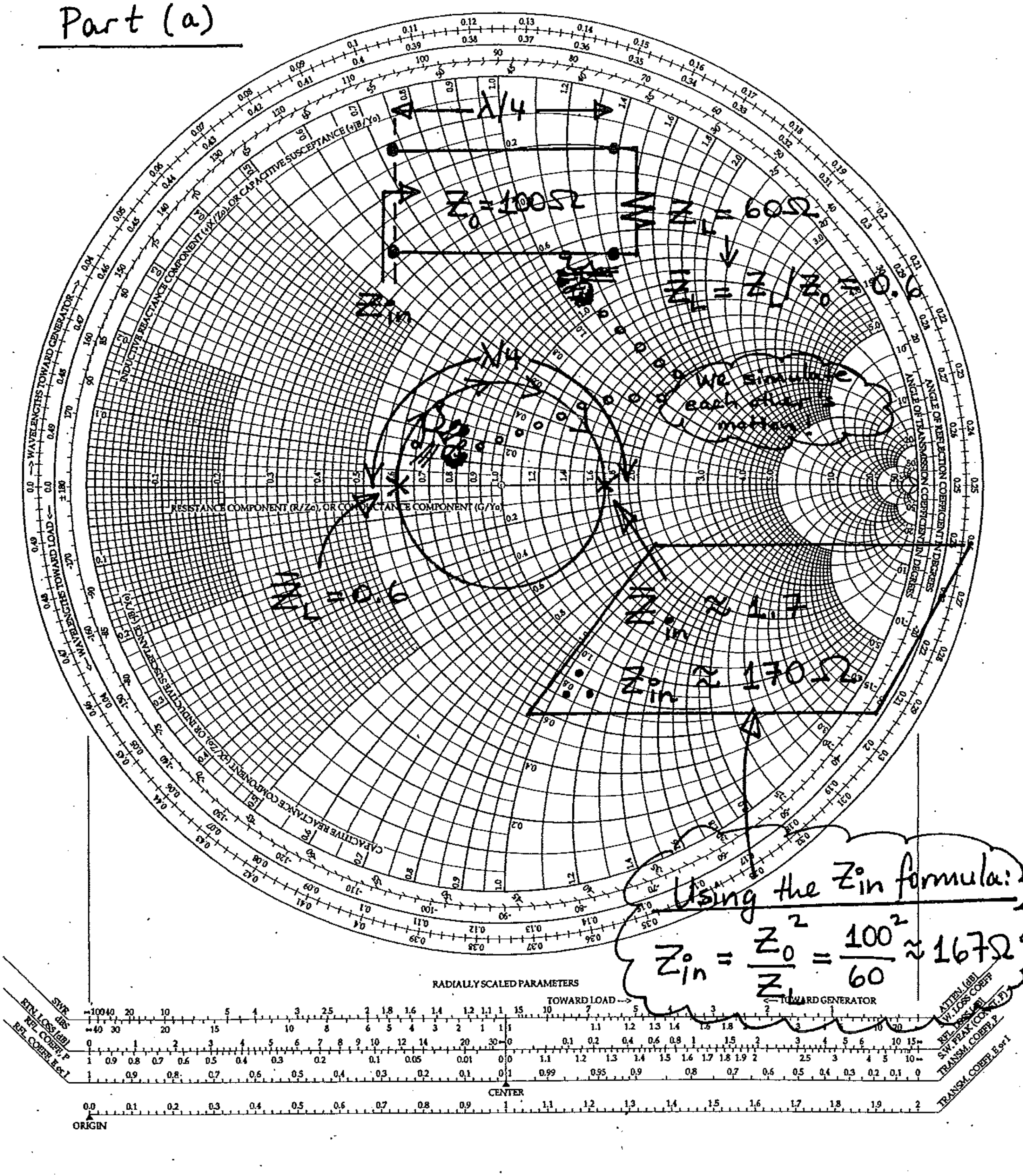
Problem#4

Part (a)



Using the Z_{in} formula:

$$Z_{in} = \frac{Z_0^2}{Z_L} = \frac{100^2}{60} \approx 167\Omega$$

The Complete Smith Chart

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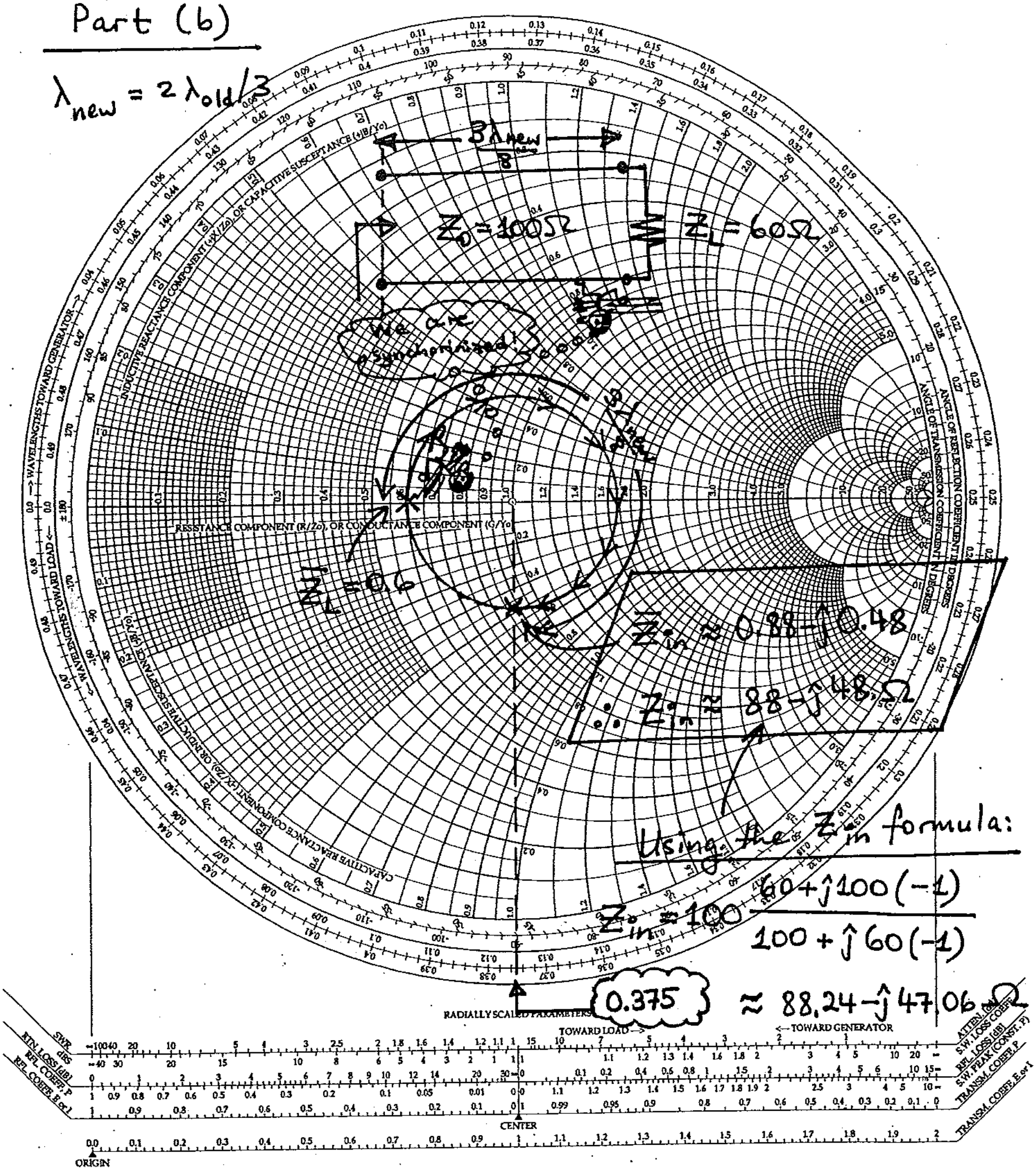
Problem #4

Part (b)

$\lambda_{new} = 2\lambda_{old}/3$



Using the Z_{in} formula:

$$Z_{in} = 100\,\frac{60 + j100(-1)}{100 + j60(-1)} \approx 88.24 - j47.06\ \Omega$$

Problem#5

The Complete Smith Chart

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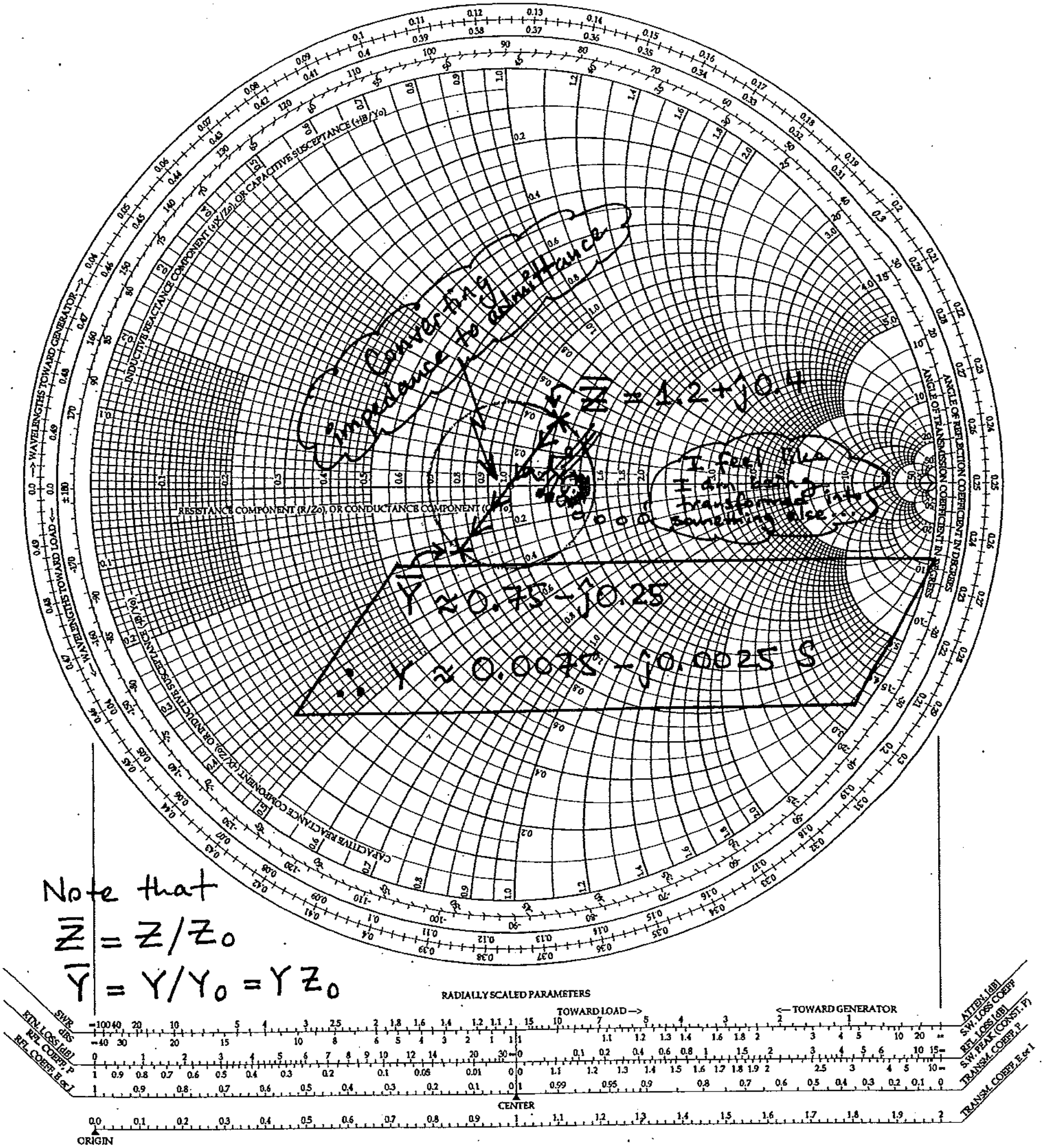

Note that

$\overline{Z} = Z/Z_0$

$\overline{Y} = Y/Y_0 = Y Z_0$

The Complete Smith Chart

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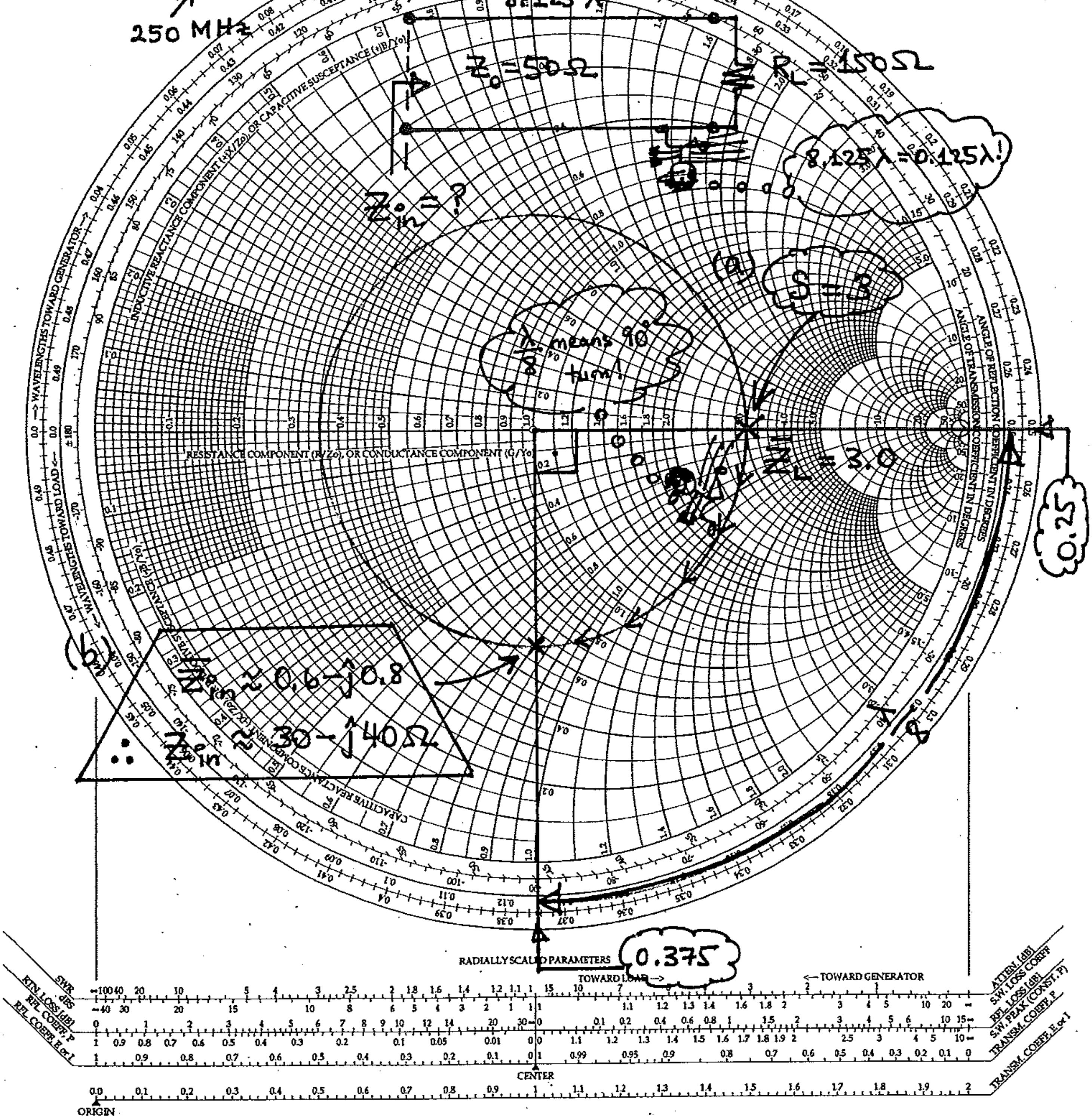
Problem#6

$$\lambda = \frac{v_p}{f} = \frac{(2c/3)}{f} \approx 0.8\,m$$

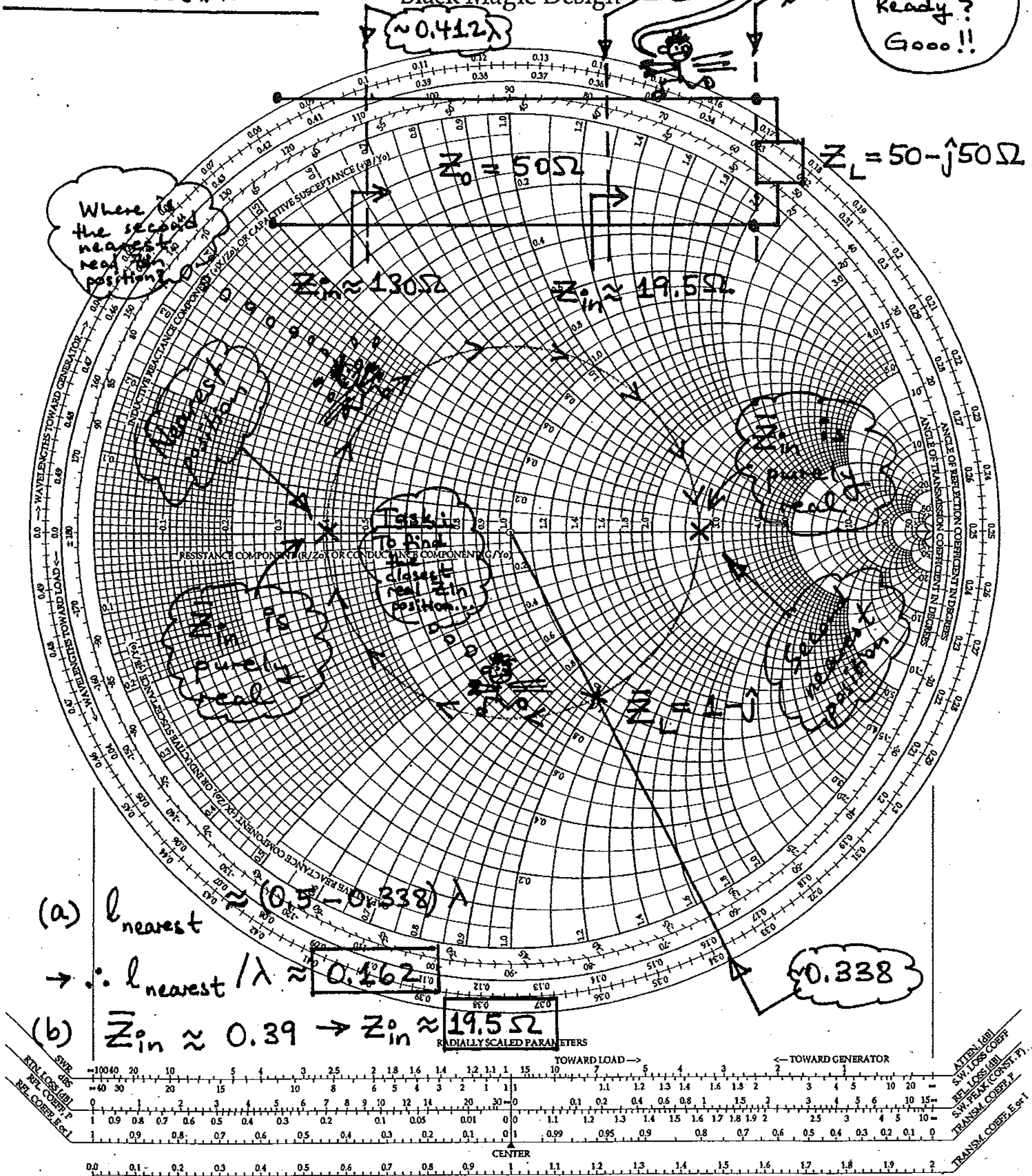
250 MHz



The Complete Smith Chart

Black Magic Design

Problem #7



(a) $l_{nearest} \approx (0.5 - 0.338)\lambda$

$\rightarrow \therefore l_{nearest}/\lambda \approx \boxed{0.162}$

(b) $\bar{Z}_{in} \approx 0.39 \rightarrow Z_{in} \approx \boxed{19.5\,\Omega}$

(c) $l_{\substack{second\\nearest}} \approx (0.162 + 0.25)\lambda \rightarrow \therefore l_{\substack{second\\nearest}}/\lambda \approx \boxed{0.412}$

$\bar{Z}_{in} \approx 2.6 \rightarrow Z_{in} \approx \boxed{130\,\Omega}$

Problem #8

The Complete Smith Chart

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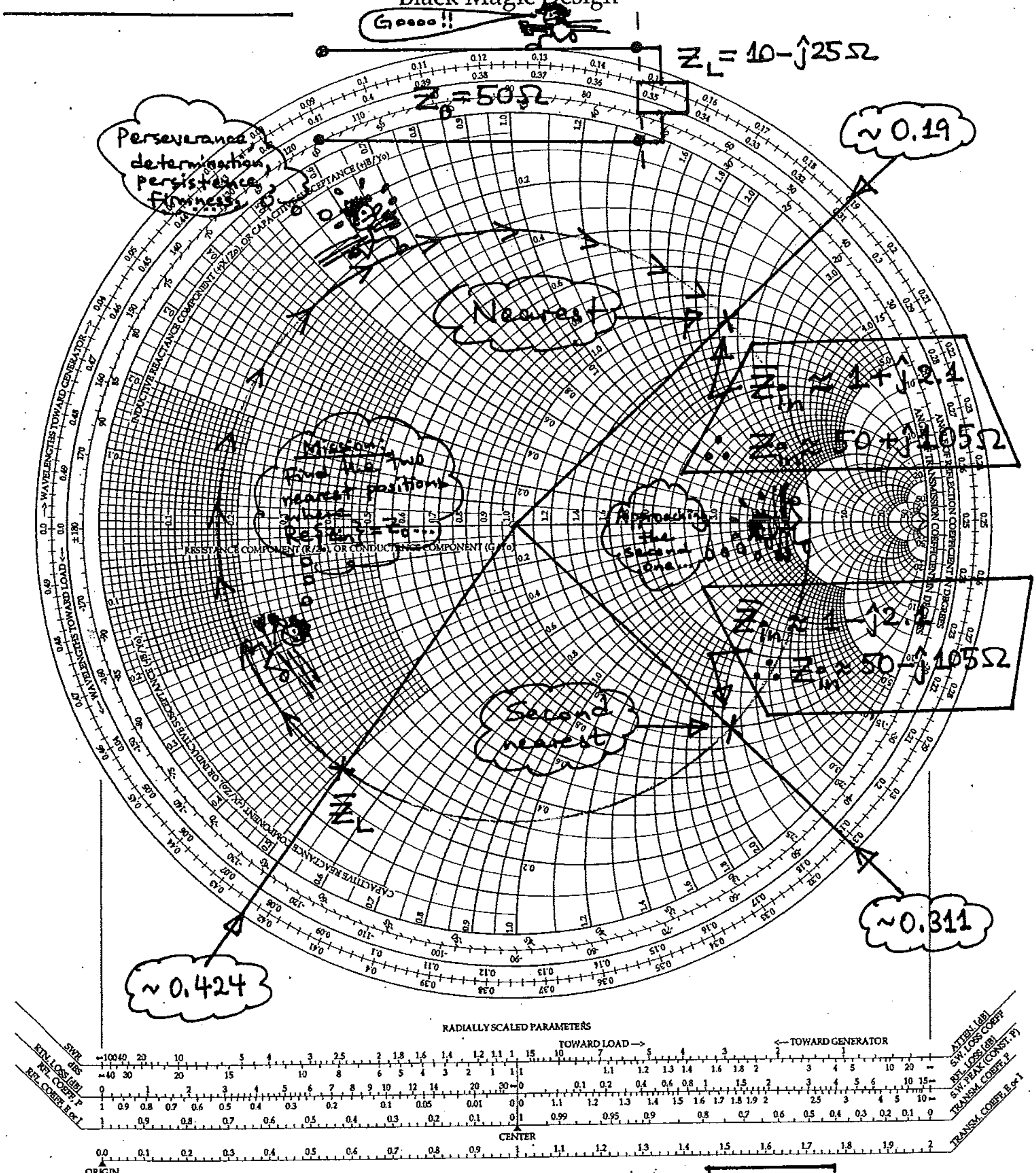

Nearest → $l_1/\lambda \approx (0.5-0.424) + 0.19 = \boxed{0.266}$

Second nearest → $l_2/\lambda \approx (0.5-0.424) + 0.311 = \boxed{0.387}$

Problem#9

The Complete Smith Chart

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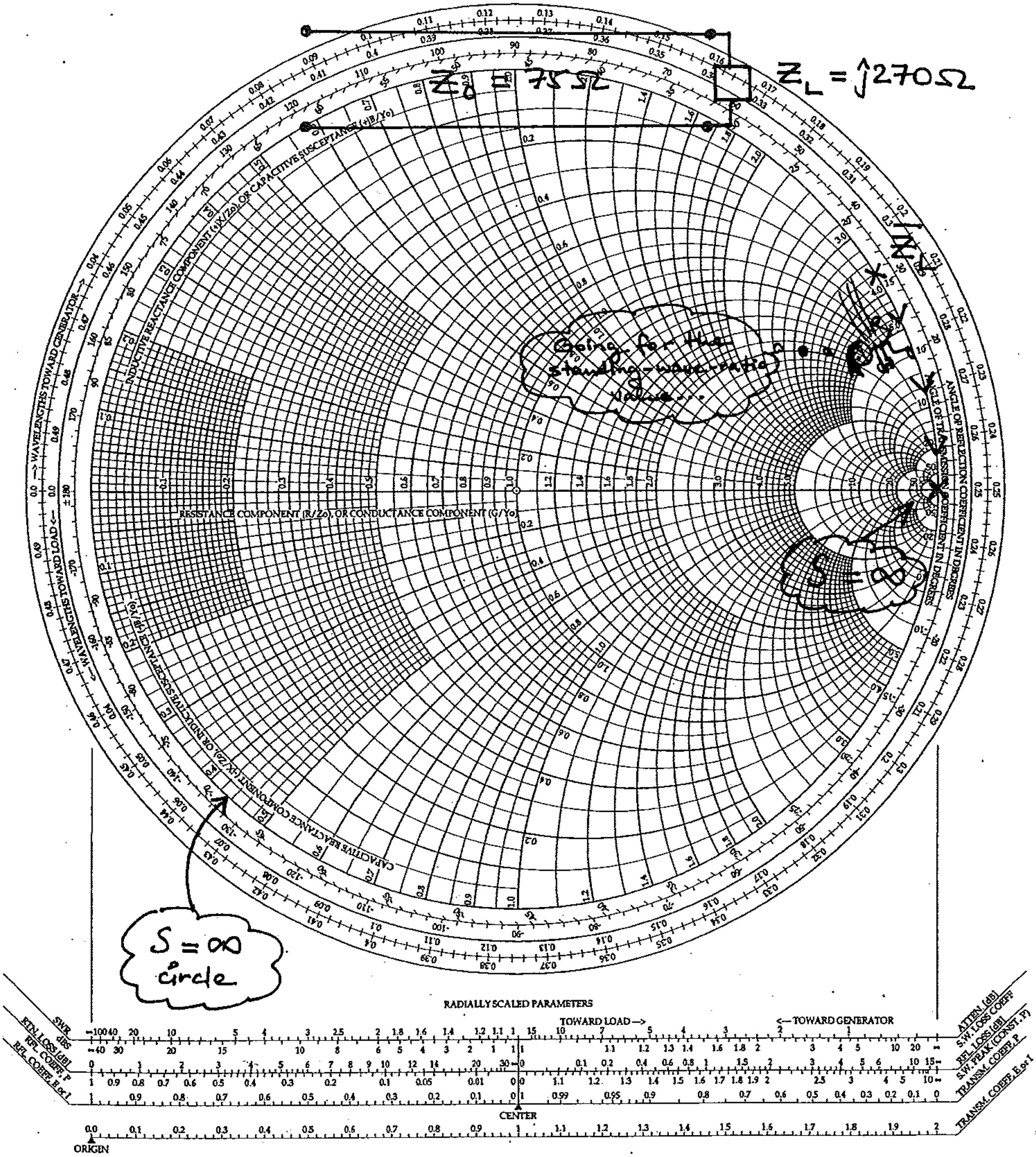

Problem#10

The Complete Smith Chart

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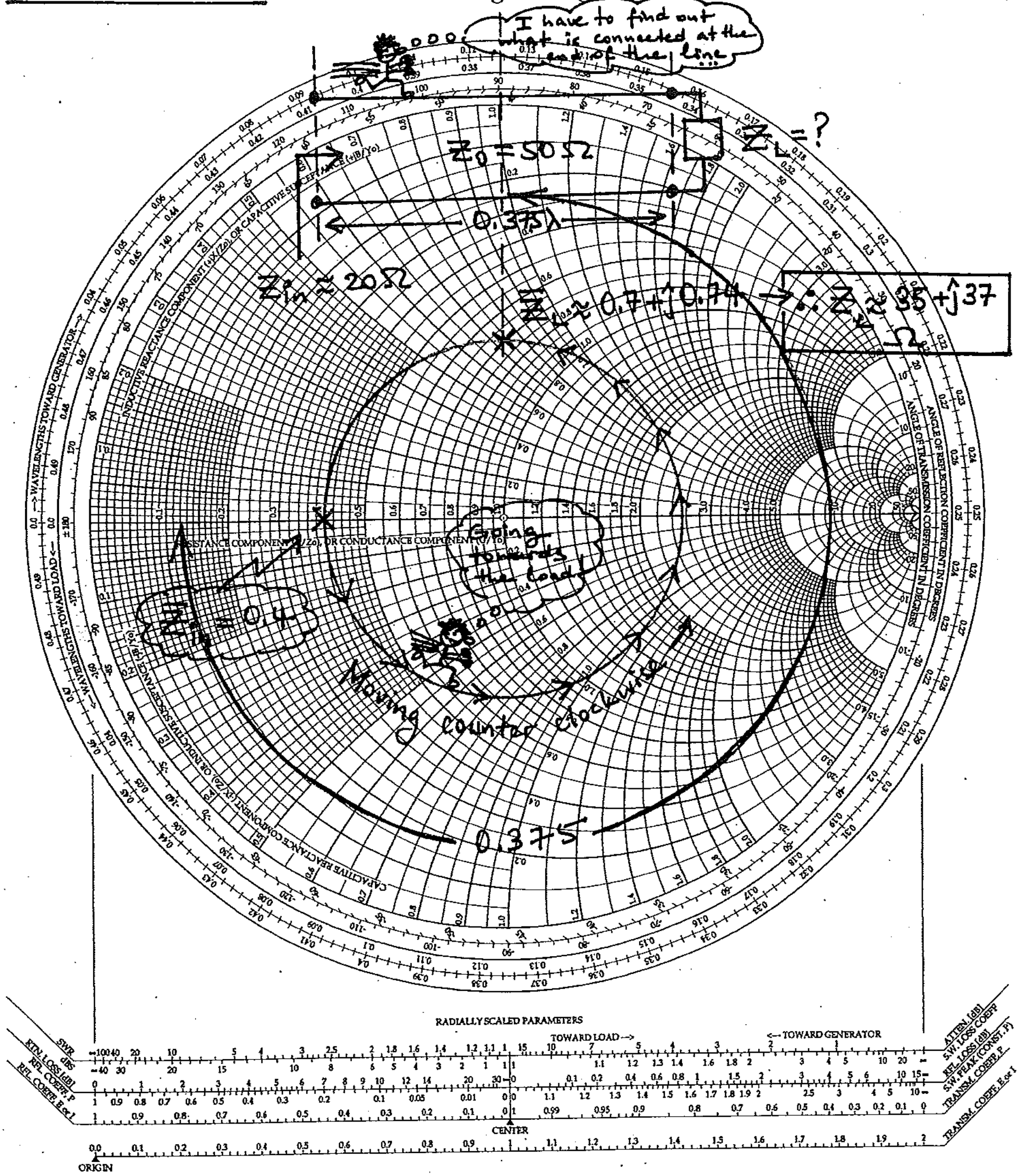

The Complete Smith Chart

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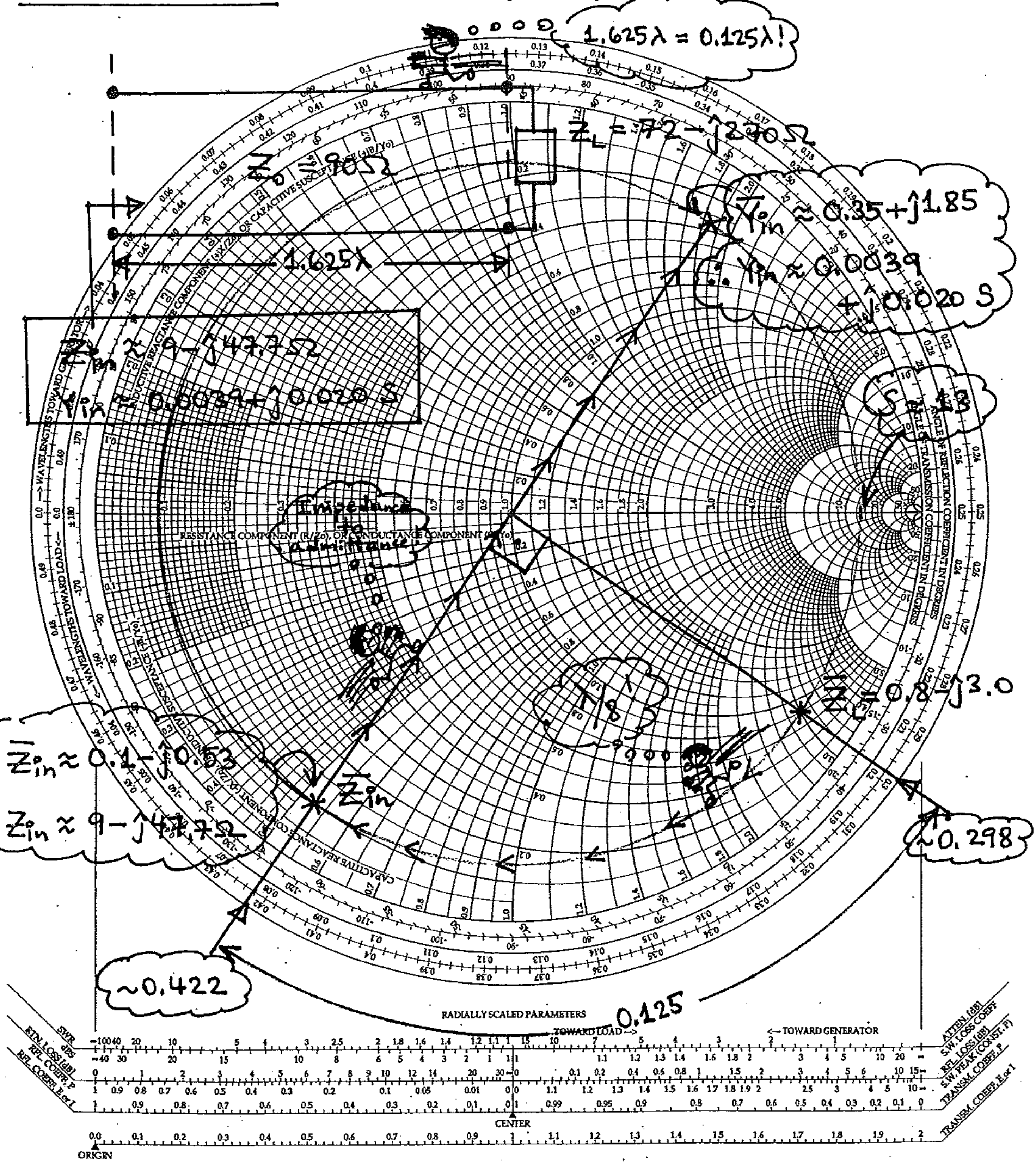
Problem#11



Problem # 12

The Complete Smith Chart

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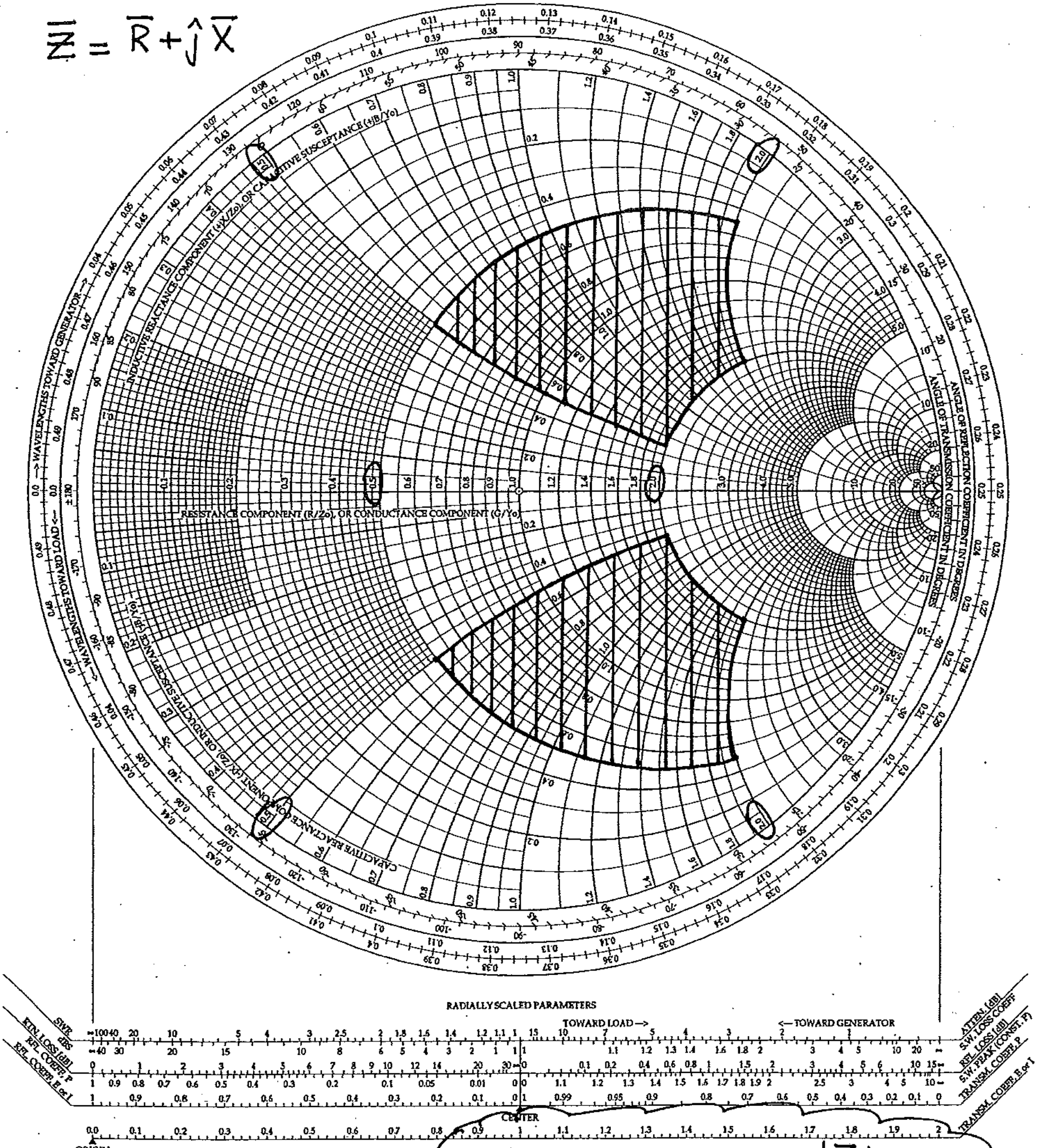
$\overline{Z} = \overline{R} + \hat{j}\,\overline{X}$



shaded region → $0.5 < \overline{R} < 2.0$ & $0.5 < |\overline{X}| < 2.0$