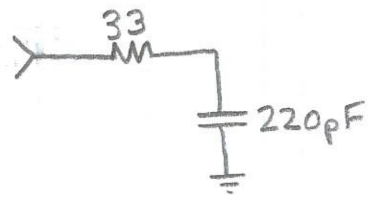
W2AEW

SMITH CHART EXAMPLE

- IMPEDANCE
- REFLECTION COEFFICIENT
- VSWR, RETURN LOSS
- TRANSMISSION LINE EFFECTS

GIVEN A LOAD: $Z_{LOAD} \rightarrow$



... OPERATING AT 14.2 MHz ...

$$Z_{LOAD} = R + jX$$

$$R = 33\Omega$$

$$X_C = -\frac{1}{2\pi f C}$$ (NEGATIVE BECAUSE CAPACITIVE)

$$Z_{LOAD} = 33 - j51$$

TO PLOT ON THE SMITH CHART: NORMALIZE TO Z_0

(Z_0 IS OUR SYSTEM IMPEDANCE = 50Ω)

$$Z_L = \frac{Z_{LOAD}}{Z_0}$$

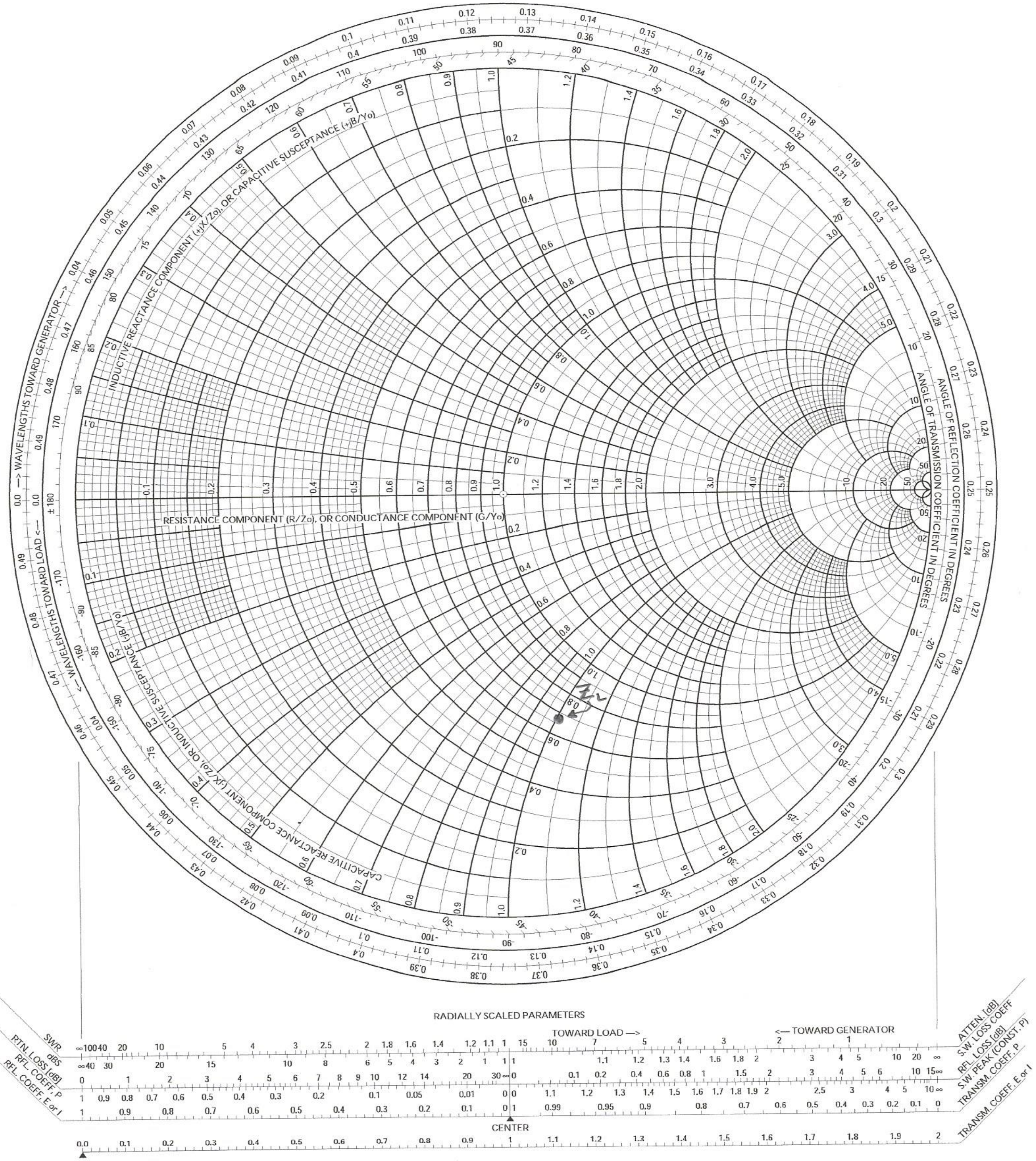
$$Z_L = \frac{33 - j51}{50}$$

$$\boxed{Z_L = 0.66 - j1.02}$$

PLOT THIS!

$Z_L = 0.66 - j1.02$

Smith Chart



ONCE WE KNOW Z_{LOAD} (33 - j51)...

... WE "COULD" CALCULATE :

- <u>COMPLEX REFLECTION COEFFICIENT</u> (VOLTAGE OR CURRENT)

$$\Gamma = \frac{Z_{LOAD} - Z_0}{Z_{LOAD} + Z_0}$$

NOTE: Z + Γ ARE COMPLEX VALUES

- <u>REFLECTION COEFFICIENT</u> (MAGNITUDE)

$$\rho = |\Gamma|$$

- <u>VOLTAGE STANDING WAVE RATIO</u>

$$VSWR = \frac{1 + \rho}{1 - \rho}$$

- <u>POWER REFLECTION COEFFICIENT</u>

$$\Gamma_{PWR} = |\Gamma|^2$$

- <u>RETURN LOSS</u>

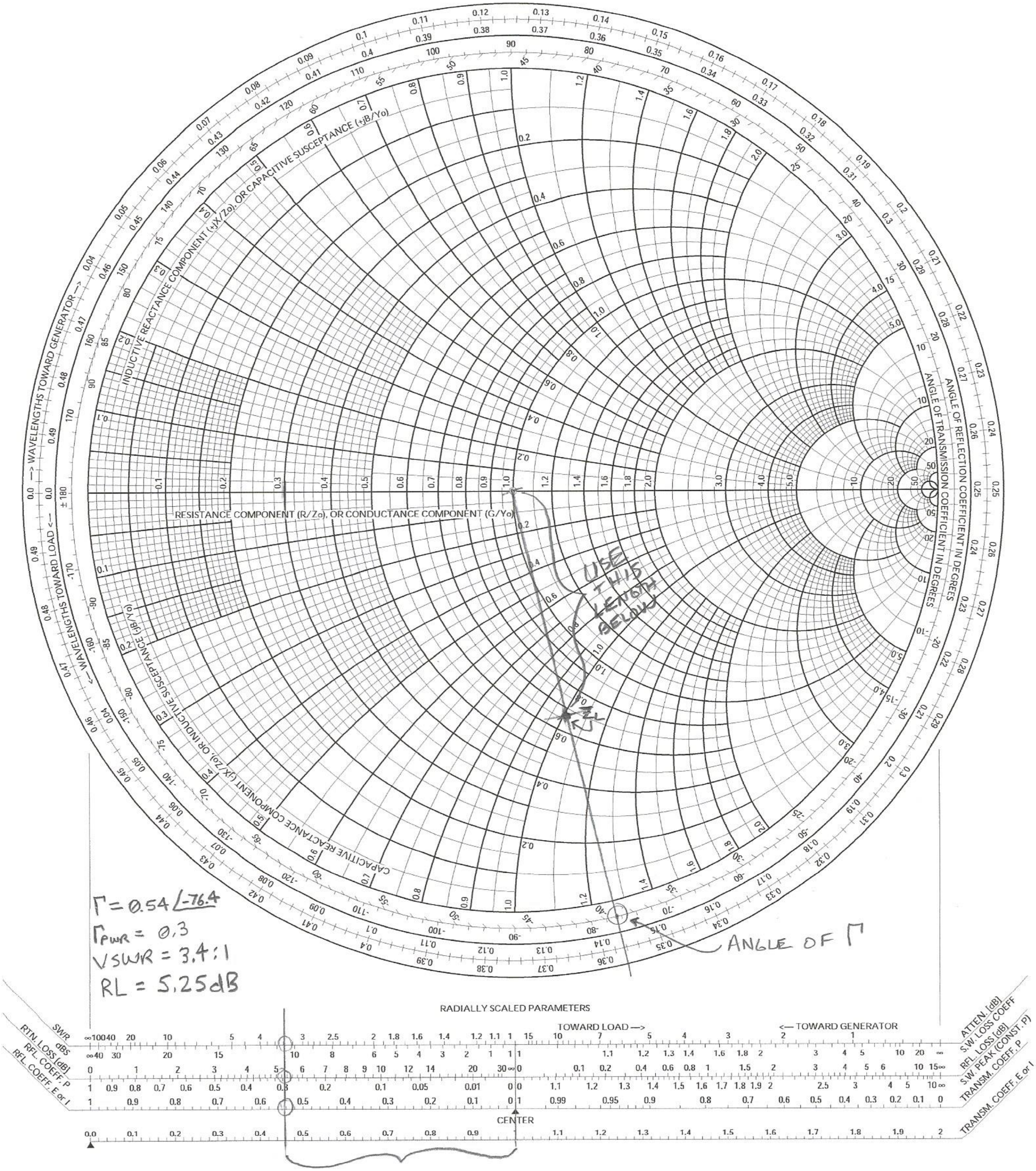
$$RL = 20 \log_{10} \left(\frac{VSWR + 1}{VSWR - 1} \right)$$

$$= 10 \log_{10} \left(\Gamma_{PWR} \right)$$

OR, SIMPLY <u>READ</u> THEM OFF THE <u>SMITH CHART</u> !

$Z_L = 0.66 - j1.02$

Smith Chart



$\Gamma = 0.54\angle{-76.4}$

$\Gamma_{PWR} = 0.3$

$VSWR = 3.4:1$

$RL = 5.25\,dB$

Transmission Line Effects

- When you add a Z_0 transmission line between the source (generator) and the load...
  - The VSWR seen by the source is CONSTANT* *(ignoring losses)
  - The IMPEDANCE seen by the source CHANGES

    [EXAMPLE: Z_{LOAD} of 25Ω or 100Ω both result in VSWR = 2.0:1]

    - Same holds true for complex Z...
    - Calculation of Z_{INPUT} is ugly...

    ... so we use the MAGIC of SMITHCHART!

Transmission Line Length on the Smith Chart

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- Rotating around chart represents adding/subtracting line length
- Complete trip around chart = 1/2 wavelength (λ)

  ∴ $Z_{INPUT} = Z_{LOAD}$ when length is multiple of $\lambda/2$ (regardless of Z_0 & Z_{LOAD})
- Halfway around chart = $\lambda/4$ (quarter wavelength)
  - $\frac{\lambda}{4}$ line that is OPEN AT END looks like a SHORT
  - $\frac{\lambda}{4}$ line that is SHORTED AT END look like OPEN
- For any Z, draw circle thru Z to show how Z_{IN} varies w/ line length

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Smith Chart

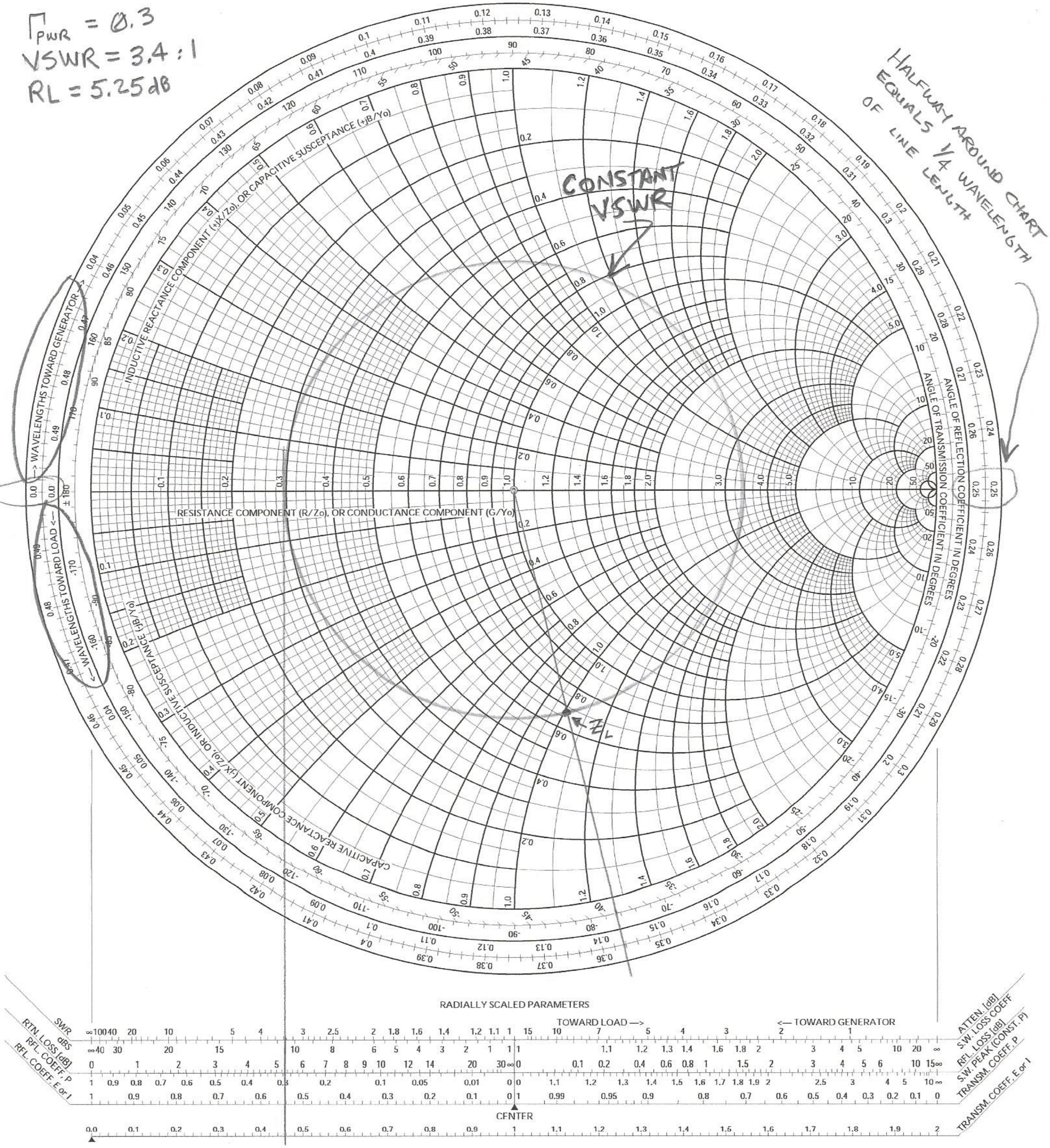
$Z_L = 0.66 - j1.02$

$\Gamma = 0.54 \angle -76.4^\circ$

$\Gamma_{PWR} = 0.3$

VSWR = 3.4 : 1

RL = 5.25 dB



TRANSMISSION LINE EXAMPLE

$f = 14.2\ \text{MHz}$

COAX VELOCITY FACTOR = 0.66

COAX LENGTH = 1 METER

$$\lambda_{\text{FREE SPACE}} = \frac{300}{14.2} = 21.13\text{m}$$

$$\lambda_{\text{COAX}} = \text{V.F.} * \lambda_{\text{FREE SPACE}}$$

$$= 0.66 * 21.13\text{m}$$

$$\lambda_{\text{COAX}} = 13.95\text{m}$$

$\therefore$ 1 METER OF COAX IS $\frac{1}{13.95} = \underline{0.0717\lambda}$

...LETS GO TO THE SMITH CHART...

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COMMON USE CASE

- MEASURE Z_{INPUT} AT THE TRANSMITTER
- KNOWING LINE LENGTH, ROTATE "TOWARD LOAD" TO GET Z_{LOAD}
- DESIGN MATCHING NETWORK TO PLACE AT ANTENNA FEEDPOINT

  (KEEPS VSWR ON THE LINE NEAR 1:1 TO MINIMIZE LOSS)

Smith Chart

$Z_L = 0.66 - j1.02$

$\Gamma = 0.54 \angle 76.4°$

$\Gamma_{PWR} = 0.3$

VSWR = 3.4 : 1

RL = 5.25dB