Reflections on the Smith Chart

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- Key talk concepts
  - Magnitude and Phase relationship of 2 sine waves.
  - Incident and Reflected Waves (one example of relating 2 sine waves)
  - Complex Reflection Coefficient (Greek letter Gamma, or G here)
    - Math: vectors, complex numbers, complex functions, Cartesian (x, y) vs polar (rho, theta) coordinate systems. We will try to stay with concepts and pictures instead.
    - From the magnitude of Gamma alone (Greek letter rho, or p here, a number from 0 to 1) we can derive SWR = "Standing Wave Ratio", Return Loss, Transmission Loss, and more.
    - From the magnitude *and phase* of Gamma we can derive the all-important "complex load impedance" = Zl, resistance and reactance.
  * The Smith Chart does the conversion from Gamma to load impedance (or vice versa) graphically instead of requiring this complex math:

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Zl/Z0 = (1 + G)/(1 - G)          <<< G to Zl, all complex numbers
  G   = (Zl/Z0 - 1)/(Zl/Z0 + 1)  <<< Zl to G, all complex numbers
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- Insight to Reflection (www.fourier-series.com/rf-concepts/reflection.html)
  \# Web audio: next to Gamma; near load resistor; to right of % power.
  - Visualize magnitude and phase of reflected wave relative to incident. Notice particularly the *phase* relationship of the two *at the load*.
    - A short: R=0, X=0, Gamma = (1, 180 deg). Total V at load = 0.
    - An open: R or X = infinity, Gamma = (1, 0 deg). Total V at load = Vsource = V(open circuit). 1/4 wavelength back = short.
    - An inductor with Xl = 2*pi*f*L = Z0 (50 ohms), Gamma = (1, +90 deg).
    - A capacitor with Xc = 1/(2*pi*f*C) = Z0, Gamma = (1, -90 deg).
    - A resistor equal to Z0 (Magnitude of Gamma = 0. USUALLY THE GOAL.)
    - A resistor larger than Z0 (phase of Gamma = 0 deg).
    - A resistor smaller than Z0 (phase of Gamma = 180 deg).
  * Knowing Zl we can "match" it, for example with an antenna tuner, so the resulting Z is Z0. (This is key to many engineering problems.)
  \# Page 2, listen to audio. Standing Wave Ratio!

- Smith Chart (http://www.fourier-series.com/rf-concepts/smithchart.html)
  - Page 1, resistive load and resulting Reflection Coefficient.
    - Review what we've already done using the Gamma Chart (a polar coordinate system).
  - Page 2, impedance (resistance and reactance) and resulting Gamma.

- Further topics and references
  - Single frequency versus swept frequency measurements/analysis.
  - http://www.printfreegraphpaper.com (printable PDF Smith Chart, more)
  - http://en.wikipedia.org/wiki/Reflection_coefficient
  - http://en.wikipedia.org/wiki/Smith_chart
    - Checking "Practical examples" with an HP-32SII calculator:

ZL/Z0	==> Gamma (r, deg)
0.80 + j1.40	0.620, 60.3
0.20 + j0.50	0.726, 125
0.50 - j0.50	0.447, -117

Smith Chart

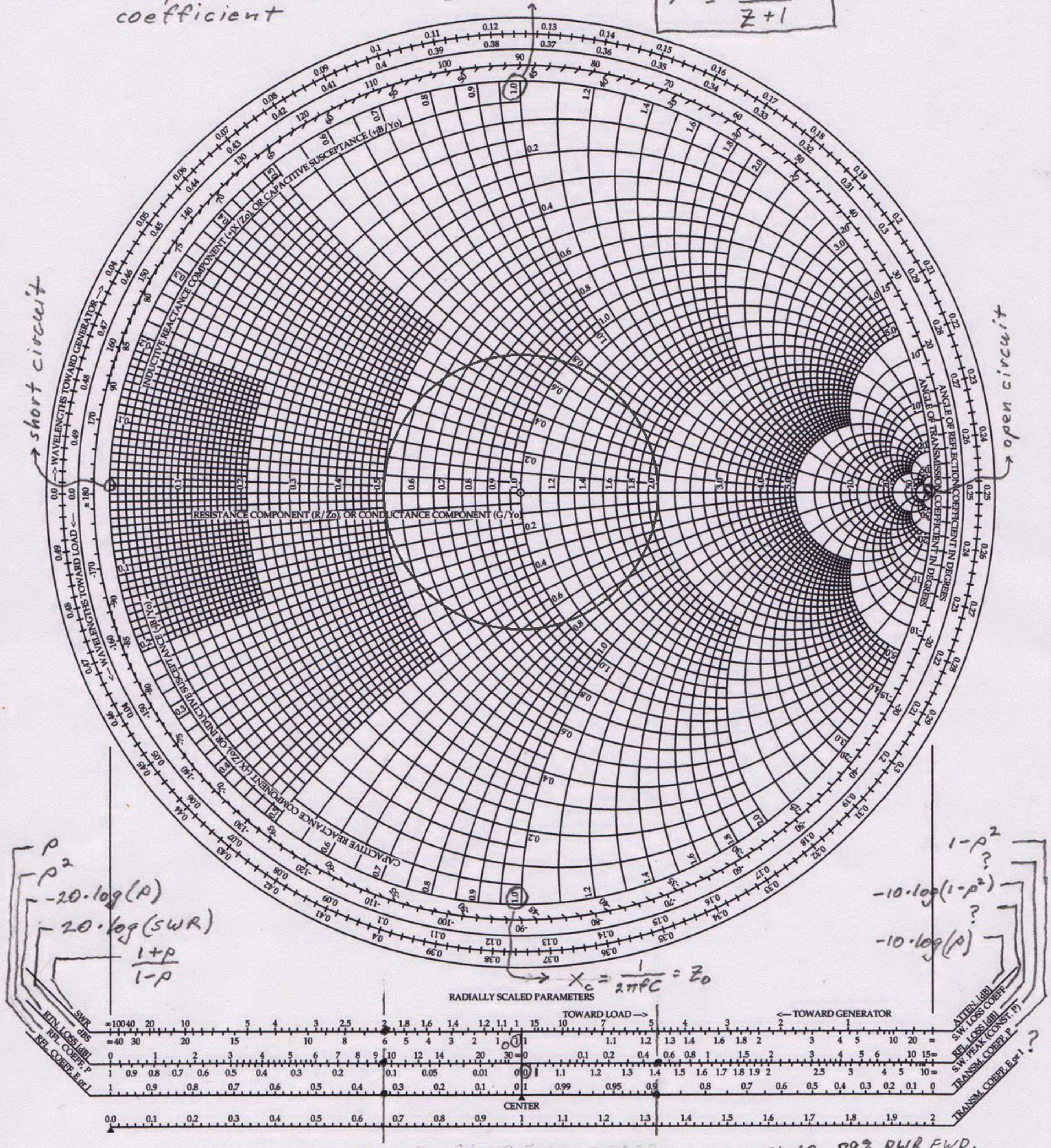
$z = \frac{Z_L}{Z_0}$ = normalized impedance

Γ = complex reflection coefficient

$z = \frac{1+\Gamma}{1-\Gamma}$

$\Gamma = \frac{z-1}{z+1}$

$X_L = 2\pi f L = Z_0$



SWR = 2, RTN LOSS = 9.5 dB, ρ = 0.333, REFL. LOSS = 0.51 dB, 89% PWR FWD, 11% PWR BACK

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