Smith Charts and More

[Sponsored by the Chelsea Amateur Radio Club (WD8IEL)](#).

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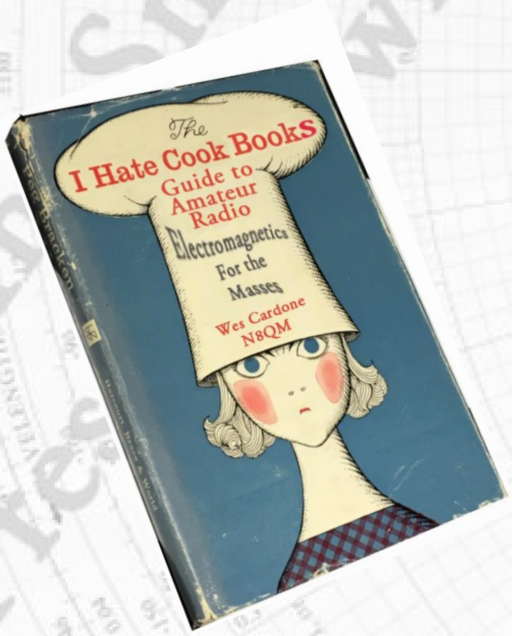


Strategic Overall Class Objectives

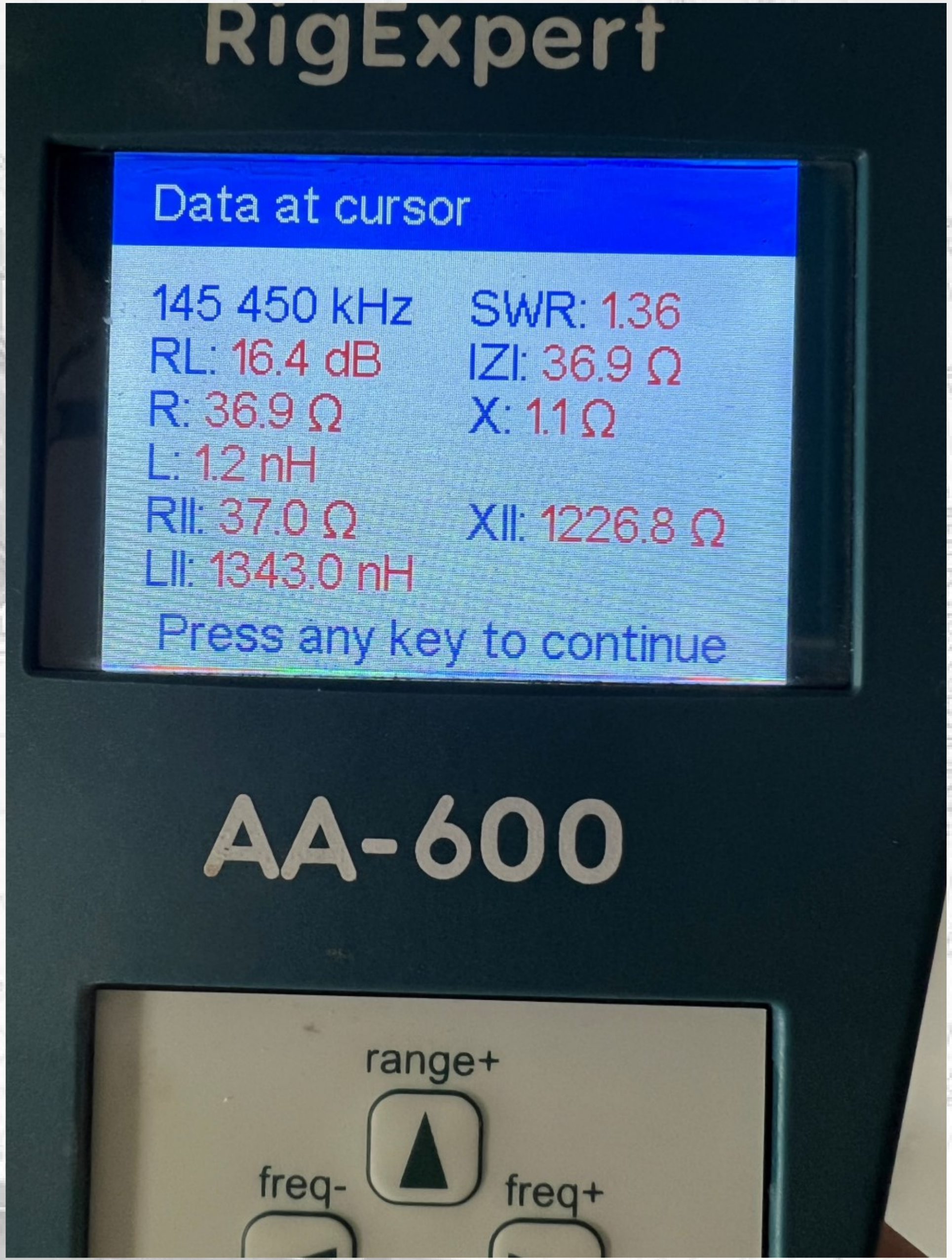
- Prepare for the FCC upgrade license exams efficiently.
- Have fun learning what you thought was a stumbling block.
- Use SimSmith—A Practical Example
- Center lessons on explicit FCC pool questions.

Tonight…

- We will fully review what was covered last week.
- We want to look at polar coordinates.
- But first we need to back up a little.
- We will review what impedance is all about using the Chelsea repeater as an example.
- Then examine impedance via
  - Rectangular coordinates
  - The Smith Chart
- Eventually we will tie this all back to the Smith Chart and you will then recognize the massive value the Smith Chart adds to simplicity.

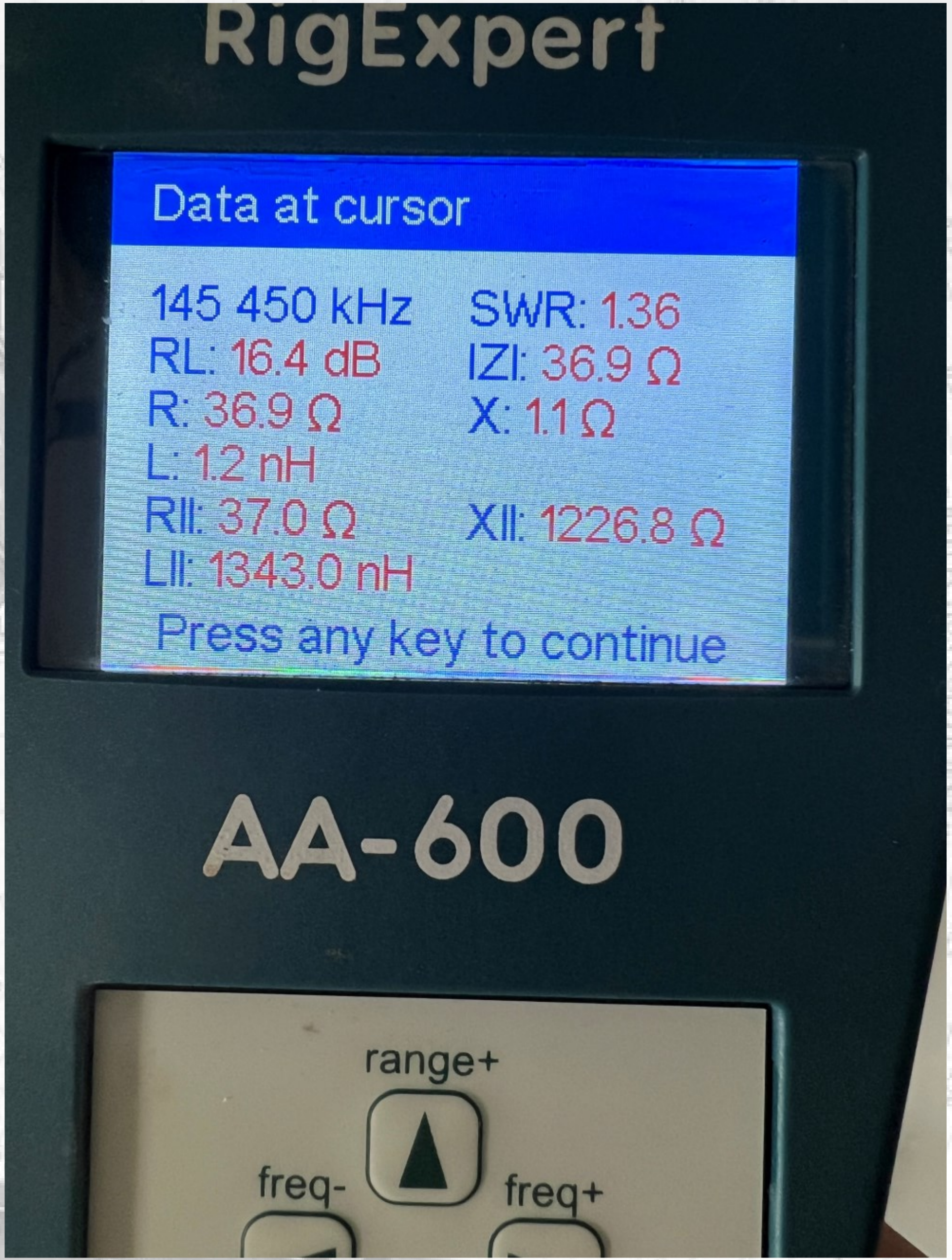
The Chelsea Repeater

- On June of 2022 we measured a vector impedance that the transmitter was looking into at 145.450 MHz of
  - f = 145.45 MHz
  - R = 36.9 Ω
  - X = 1.10 Ω
  - Z = 36.9 Ω



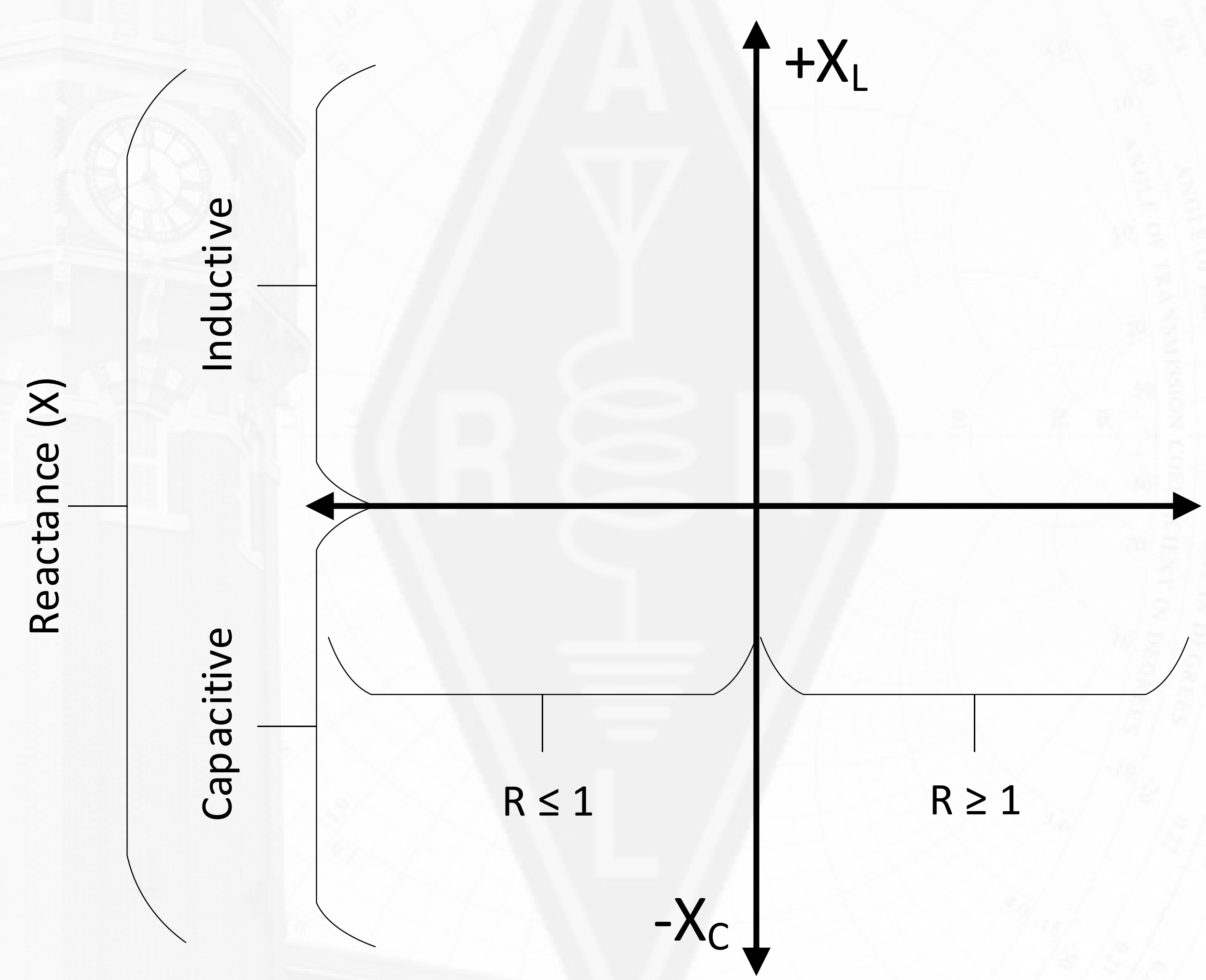
The Chelsea Repeater

- What do R, X and Z mean at f?
  - Frequency (f) = 145.450 MHz
  - Resistance (R) has no polarity and is independent of f.
  - Reactance (X) has a polarity
    - Minus (-) is CAPACITIVE reactance
    - Plus (+) is INDUCTIVE reactance-(+1.10 Ω)
  - X together with f defines a capacitance or inductance because X depends on f.
    - $\mathrm{L} = {}^{X}/_{2\pi f} = {}^{1.1\Omega}/_{2\,\pi\,145.45MHz} = 1.20nH$
  - Magnitude Impedance (Z) is



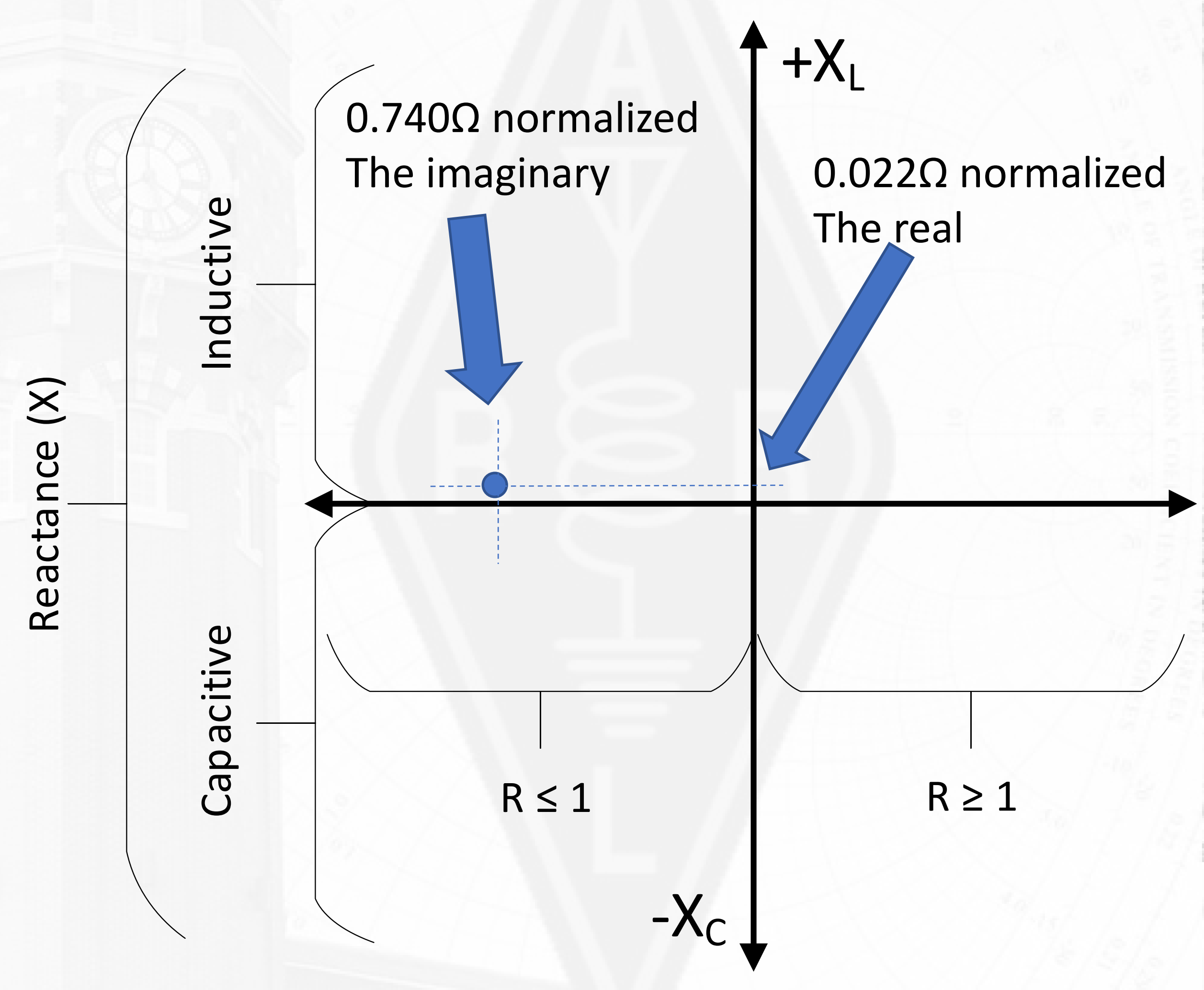
Impedance Represented Rectangular

- Horizontal is Resistance
  - All values positive
  - To the right of X is greater than unity (i.e. 1.01, 10.345, etc.)
  - To the left of X is less than unity (i.e. 0.99, 0.12, etc.)
- Vertical is Reactance
  - Plus is inductive
  - Minus is capacitive
- Special Observation: Where is the equivalent of the Smith Chart's "home plate?"



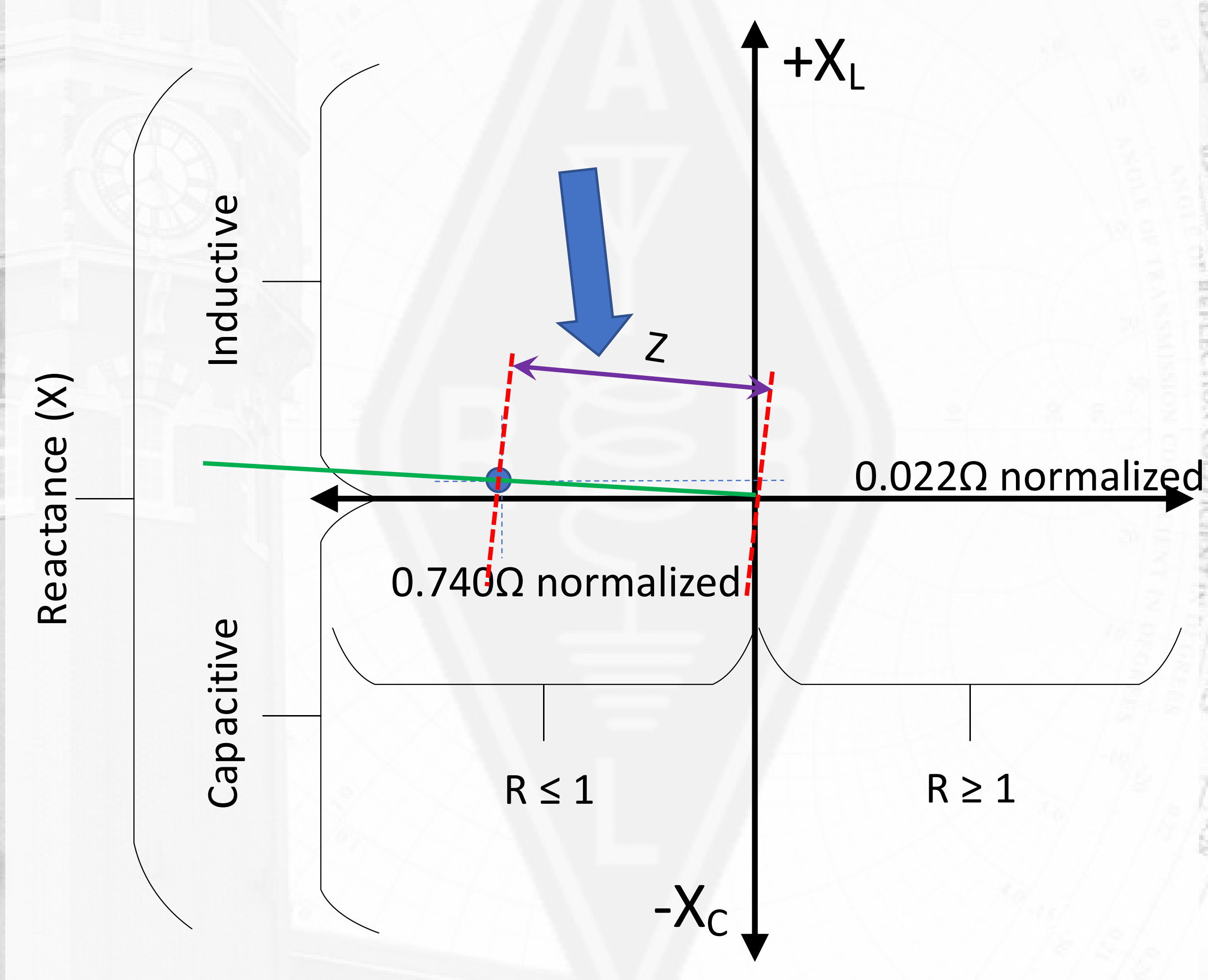
Impedance Represented Rectangular

- The illustration is not necessarily to scale.
- Has two (2) components
  - Real
  - imaginary
- First, normalize measurement
  - 36.9/50 = 0.74
  - 1.1/50 = 0.022
- 0.74 Ohms is less than unity
- 0.022 Ohms is positive



Z—Magnitude Impedance

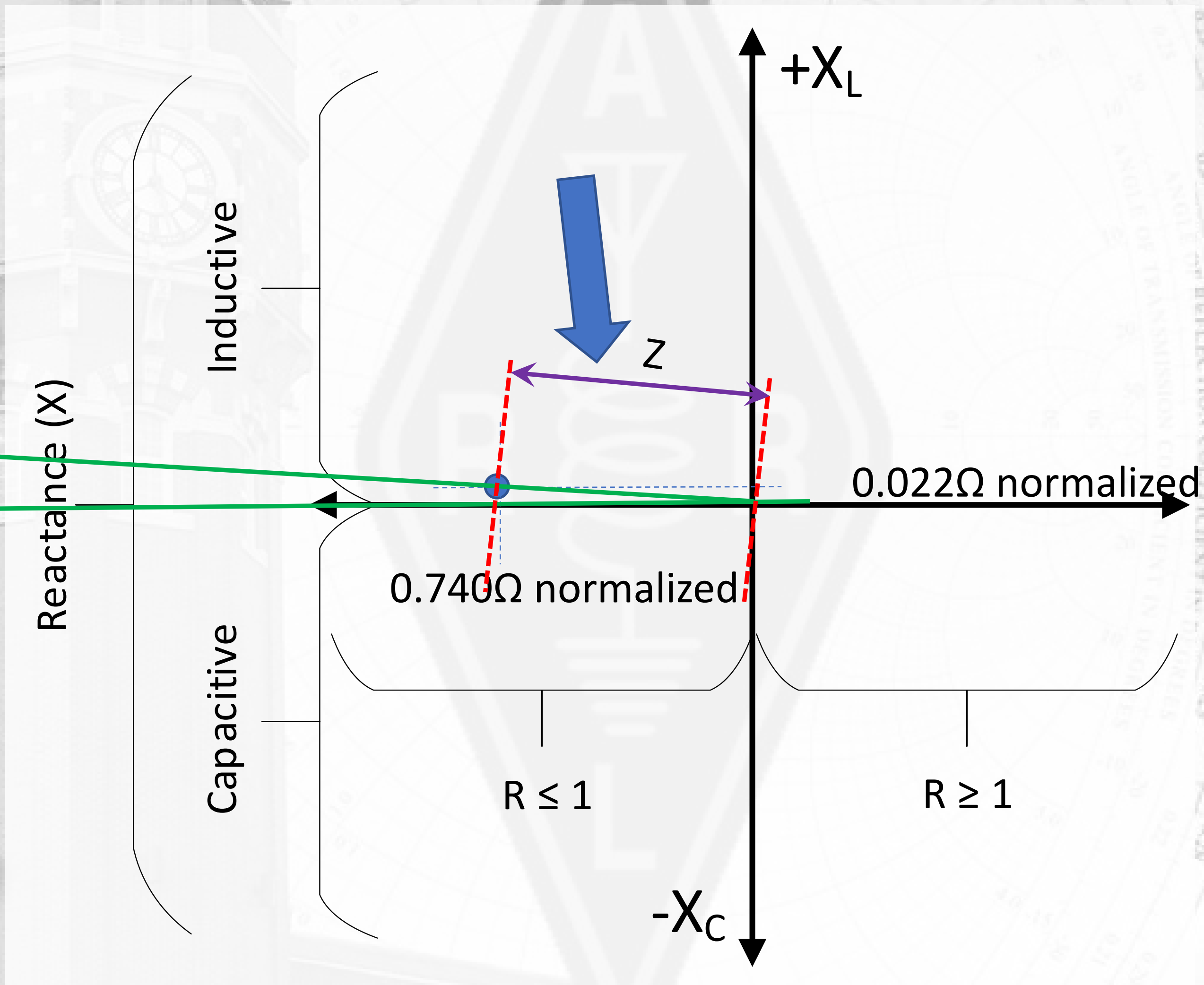
- The magnitude impedance (Z) is something like "…the distance as the crow flies."
- $Z = \sqrt{R^2 + X^2}$
- $Z = \sqrt{0.740^2 + 0.022^2}$
- $Z = 0.738\ Ohms$



Now···a peak at the angle

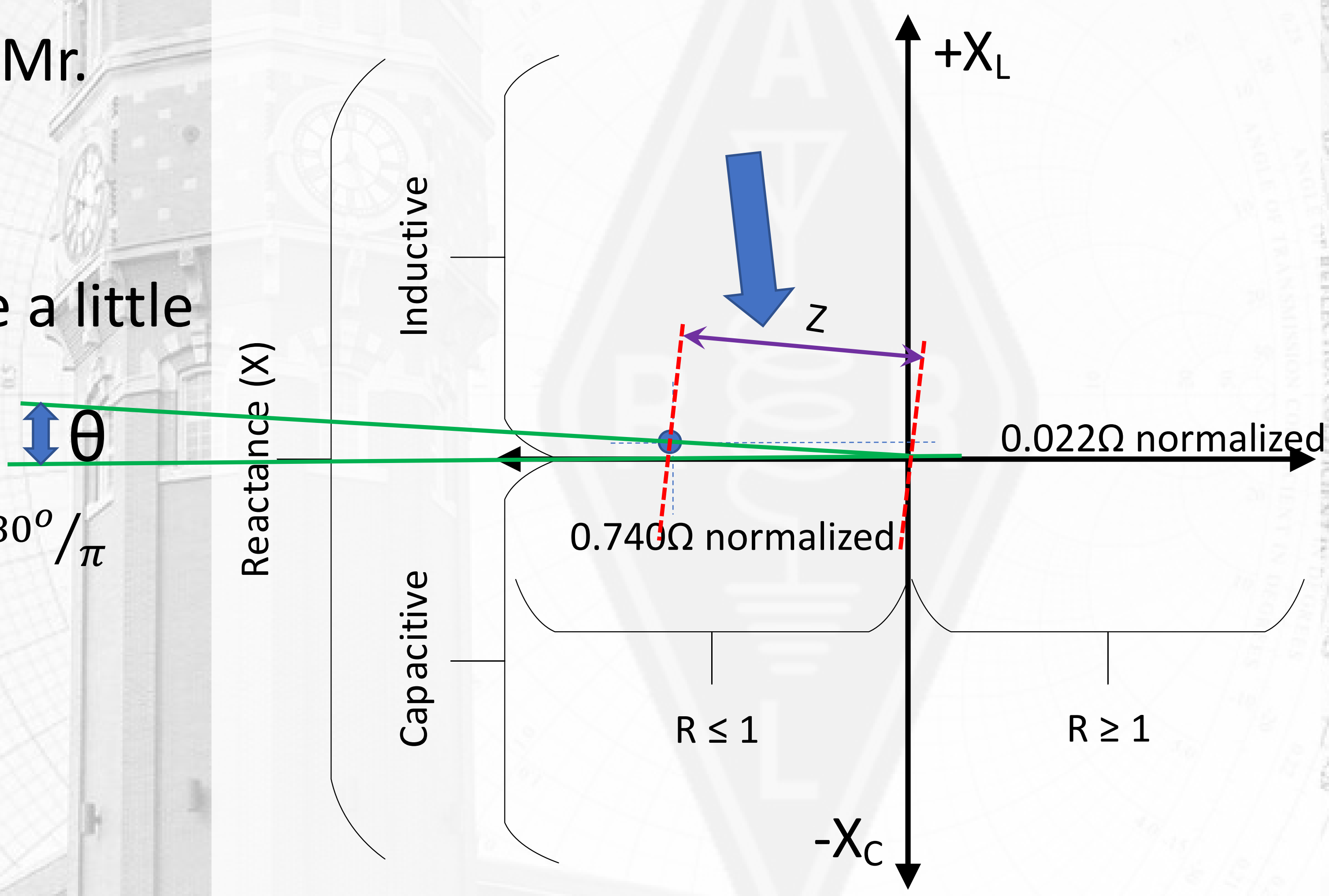
- This is another way of saying the same thing but useful for some applications.
- We looked at the vector components
  - 0.022 real (normalized)
  - 0.740 imaginary (normalized)
- Because we have a vector component…
  - There is a Z, the distance as the crow flies for a “magnitude.”
  - That magnitude has an angle from the real.

θ



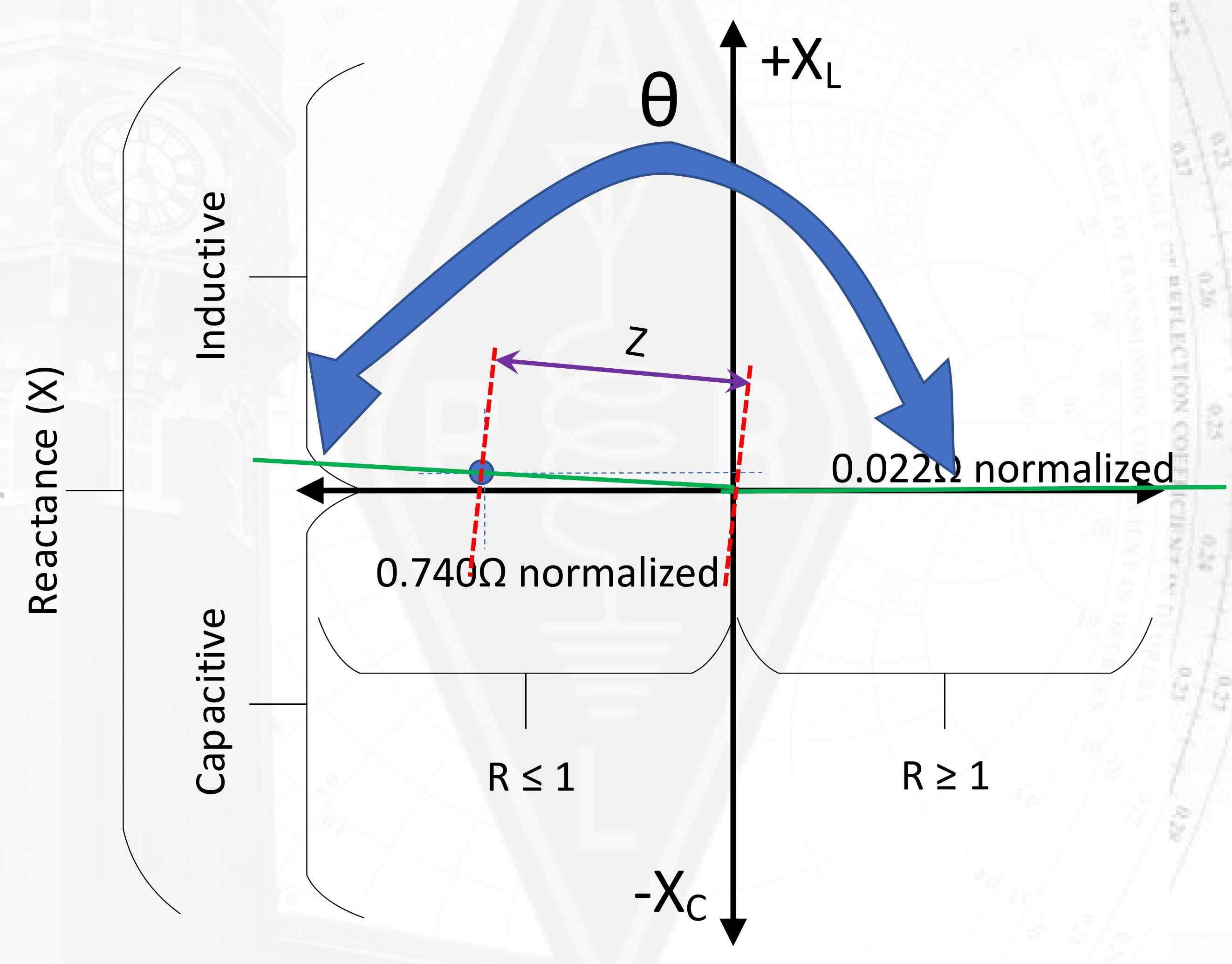
The Hard Way…

- Invoke our good friend Mr. Pythagoras.
  - $Z = \sqrt{R^2 + X^2}$
- For the phase angle use a little of your old high school trig.
  - $\theta = \tan^{-1}\left(\frac{imag}{real}\right)_{rad} \;\; {}^{180^o}/_{\pi}$
  - $\theta = 1.7^o$



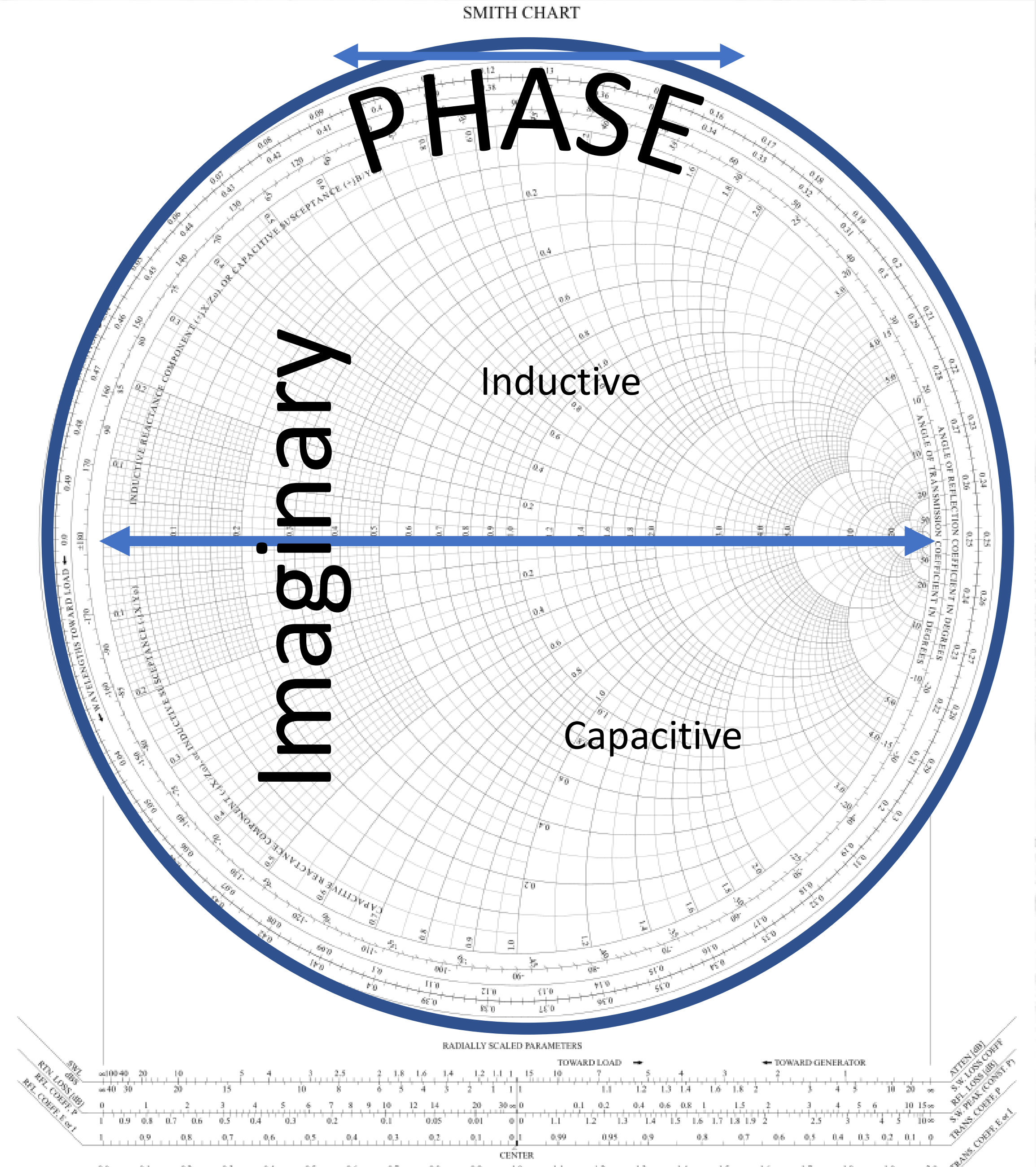
Another Way to say the same…

- Invoke our good friend Mr. Pythagoras doesn't change.
  - $Z = \sqrt{R^2 + X^2}$
- Let's skip the trig on this one.
- It gets even more complicated so I think the Smith Chart is our best bet.



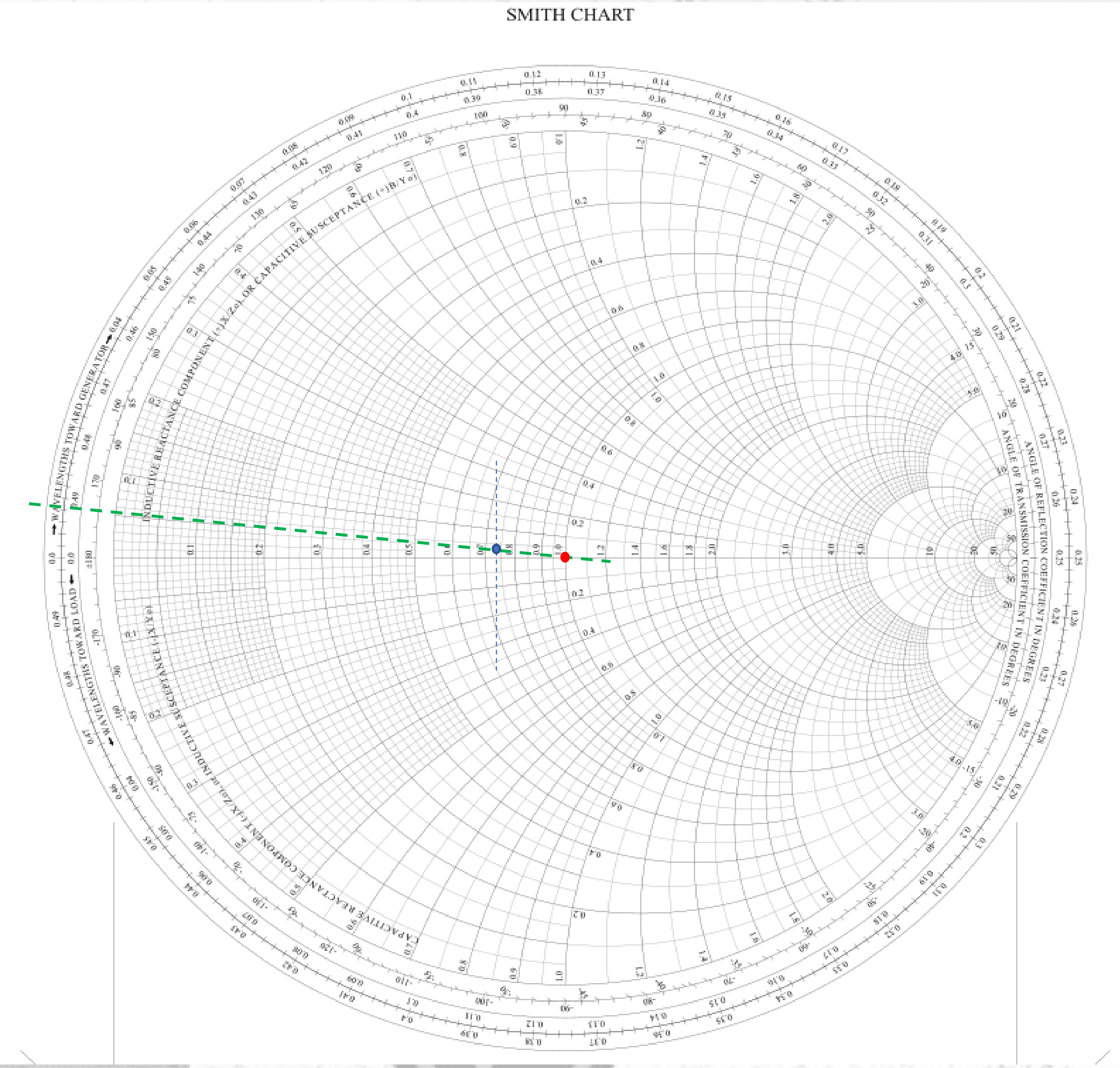
Smith Chart Review

- Hemispherical Reactances
  - Inductive are in the northern hemisphere
  - Capacitive in the southern
- Points directly on the equator are real with zero value reactances.
- The circle
  - Where the circle appears is irrelevant in theory.
  - 360° represents a half-wave

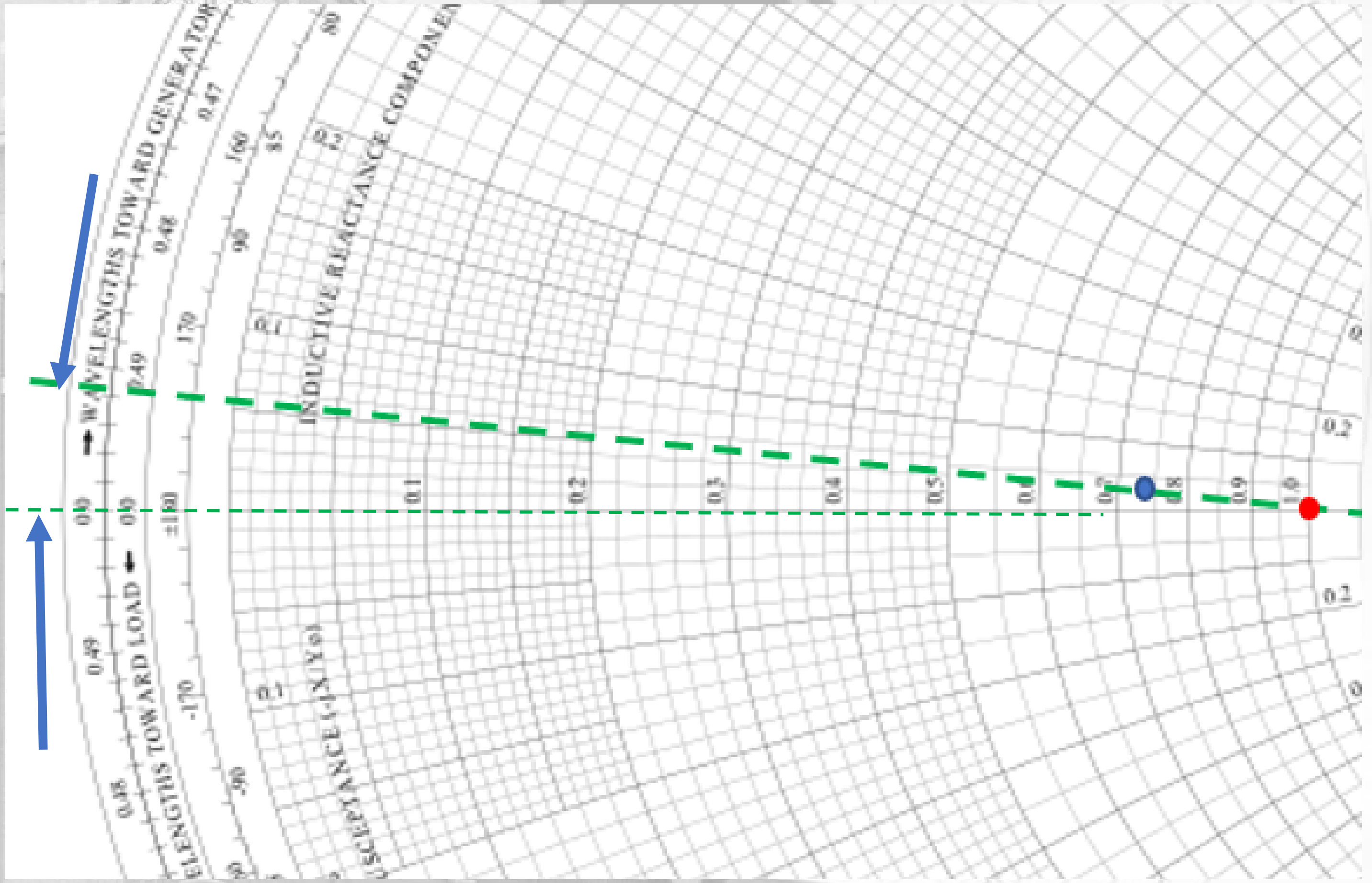


Polar on Smith

- Similar to rectangular
- But new information gained.



- The angle can be from
  - The outside or
  - From the inside
- The same angle but from different perspectives.



FCC Pool Question E5A02

- What is resonance in an LC or RLC circuit
  - The highest frequency that will pass current
  - The lowest frequency that will pass current
  - The frequency at which the capacitive reactance equals the inductive reactance.
  - The frequency at which the reactive impedance equals the resistive impedance.
- This is a critical element of antenna analysis
  - The antenna is resonant when the reactance is neutral
    - The capacitive reactance equals the inductive reactance.

FCC Pool Question E5A03

- What is the magnitude of the impedance of a series RLC circuit at resonance?
  - High, as compared to the circuit resistance
  - Approximately equal to capacitive reactance
  - Approximately equal to the inductive reactance
  - ~~Approximately~~ equal to the circuit resistance
- Why?
- At resonance reactance
  - Is neutral
  - Capacitive and Inductive reactances cancel each other
  - Therefore, there is no travel along the vertical axis and
  - There is only resistive impedance

FCC Pool Question E5A04

- What is the magnitude of the impedance of a parallel RLC circuit at resonance?
  - ~~Approximately~~ equal to the circuit resistance
  - Approximately equal to the inductive reactance
  - Low compared to the circuit resistance
  - High compared to the circuit resistance
- No matter whether series of parallel, at resonance, reactance is neutral, capacitive and inductive canceling each other.
- Only a resistive component is left.

FCC Pool Question E5B12

- What is admittance
  - The inverse of impedance
  - The term for the gain of a field effect transistor
  - The turns ratio of a transformer
  - The inverse of Q factor
- Hints to use if you don’t remember while taking the test
  - You are going to have to remember that admittance has something to do with or is related to impedances.
  - Therefore
    - A field effector transistor answer is out of the question leaving 1, 3 & 4.
    - A transformer is disqualified leaving only 1 & 4.
    - You will likely recall that admittance is the inverse of something making the last elimination tough. You will have to remember that Q is not an impedance thing.

FCC Pool Question E5C01

- Which of the following represents capacitive reactance in rectangular notation
  - -jX
  - +jX
  - Delta
  - Omega
- Rule out 3 & 4, those are gibberish answers leaving only 1 & 2.
- Nos 1 & 2 are both viable answers as far as relevance is concerned.
- Is easy to forget which is which
- Recall that +X (northern hemisphere) is inductive
- Therefore, -X is capacitive reactance.

FCC Pool Question E5C03

- What coordinate system is often used to display the resistive, inductive, and/or capacitive reactance components of impedance?
  - Maidenhead grid
  - Faraday grid
  - Elliptical coordinates
  - Rectangular coordinates
- A Maidenhead grid is for a global grid square locator map eliminating No 1 and Faraday grid is just plain gibberish eliminating No 2.
- Elliptical coordinates are unheard of so eliminate No 3…
- …leaving No 4.

FCC Pool Question E5C06

- What does the impedance 50 – j25 represent?
  - 50 Ohms resistance in series with 25 Ohms inductive reactance
  - 50 Ohms resistance in series with 25 Ohms capacitive reactance
  - 25 Ohms resistance in series with 50 Ohms inductive reactance
  - 25 Ohms resistance in series with 50 Ohms capacitive reactance
- There are no non-sense answers here to eliminate
- You should immediately recognize the R +/- jX convention cluing you in to eliminating Nos 3 & 4 leaving only 1 & 2.
- You need to remember that minus (-) reactance is capacitive leaving you with No 2.

Questions