Smith Charts and More

Sponsored by the Chelsea Amateur Radio Club (WD8IEL).

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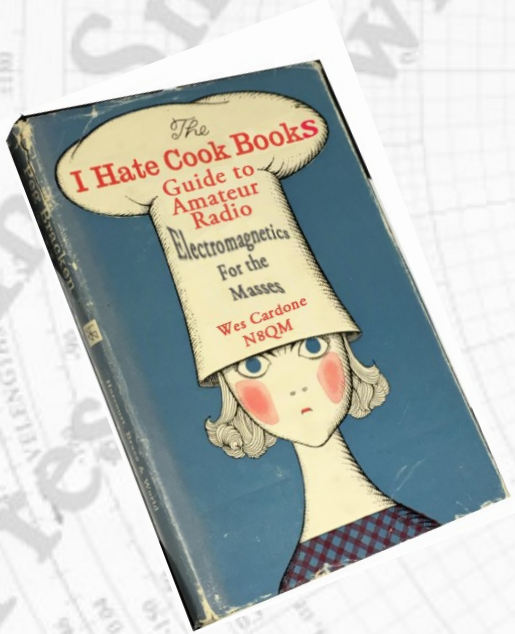


Strategic Overall Class Objectives

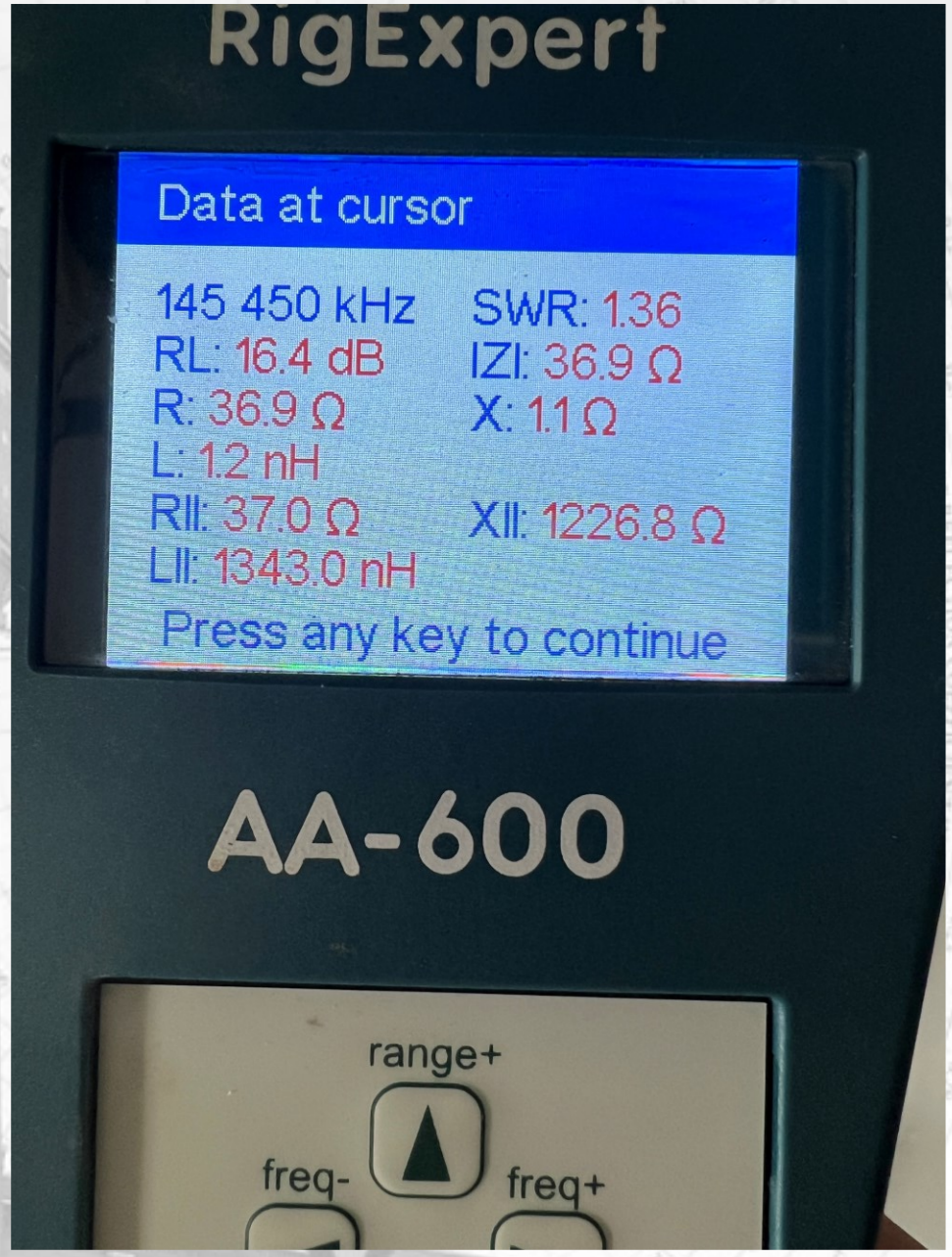
- Prepare for the FCC upgrade license exams efficiently.
- Have fun learning what you thought was a stumbling block.
- Use SimSmith—A Practical Example
- Center lessons on explicit FCC pool questions.

Tonight…

- We will fully review what was covered last week.
- Changing a transmission line length changes the antenna's vector impedance.
- We will use the Smith Chart to understand why.

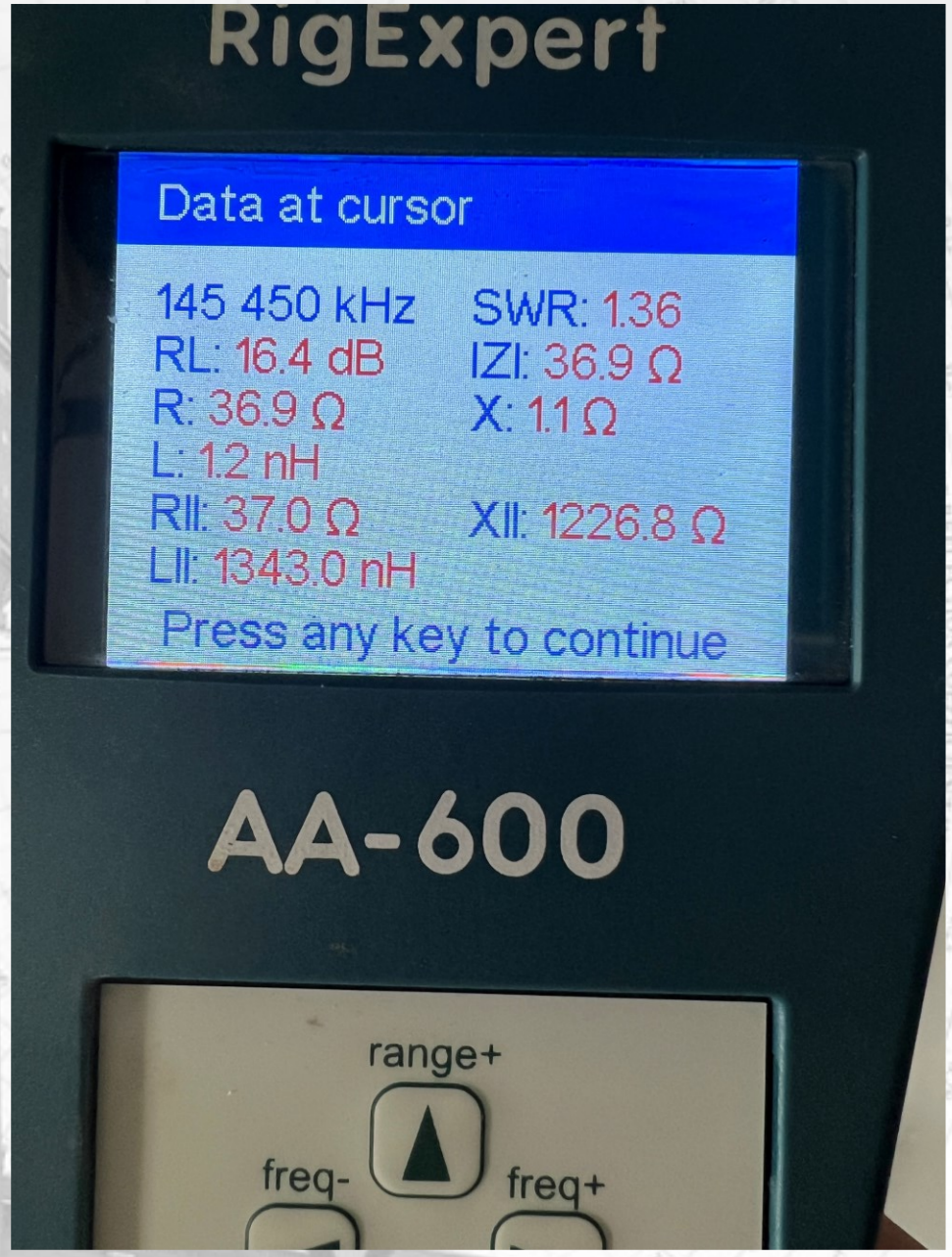
The Chelsea Repeater

- 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
- Z is the one all amateurs recognize. This is the one we want to be 50 Ohms.



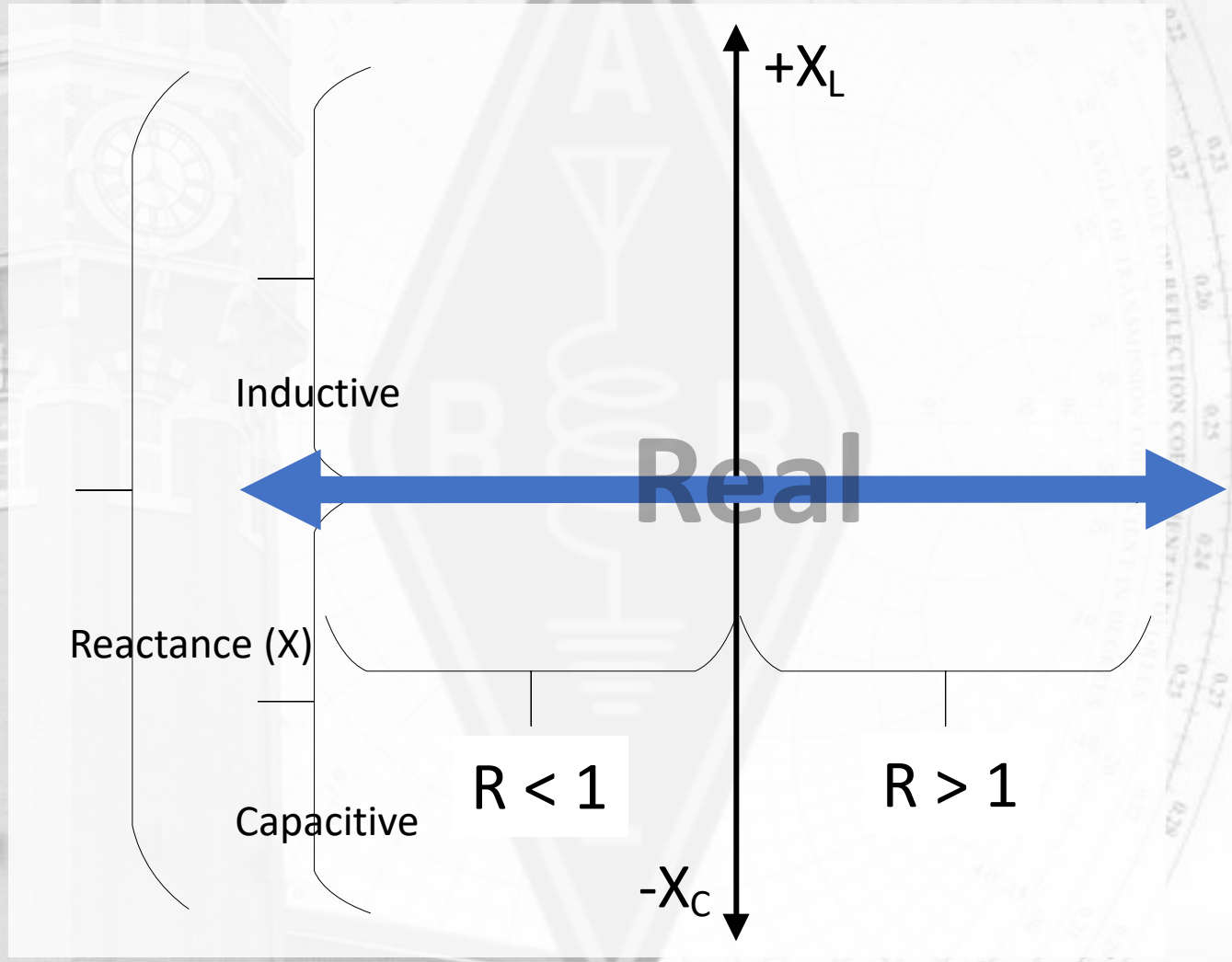
The Chelsea Repeater

- 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)
  - In a perfect world we would want
    - R = 50
    - X = 0 (neutral reactance)



Impedance Represented Rectangular

- Horizontal plane 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.)



Impedance Represented Rectangular

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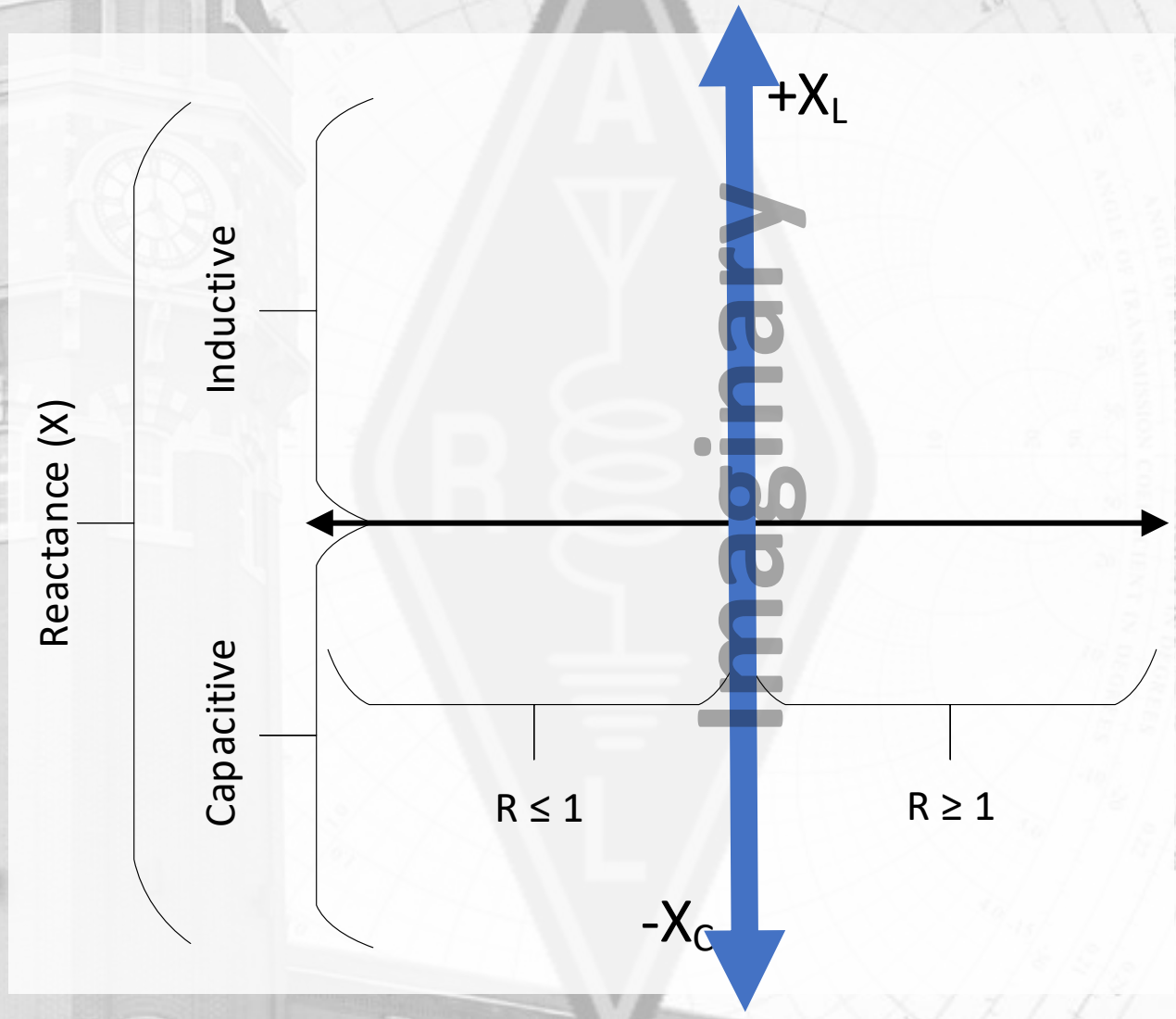
  - To the right of X is greater than unity (i.e. 1.01, 10.345, etc.)
  - To the left of X is less than unity (i.e. 0.99, 0.12, etc.)
- Vertical is Reactance
  - Plus is inductive
  - Minus is capacitive
- Special Observation: Where is the equivalent of the Smith Chart's "home plate?"



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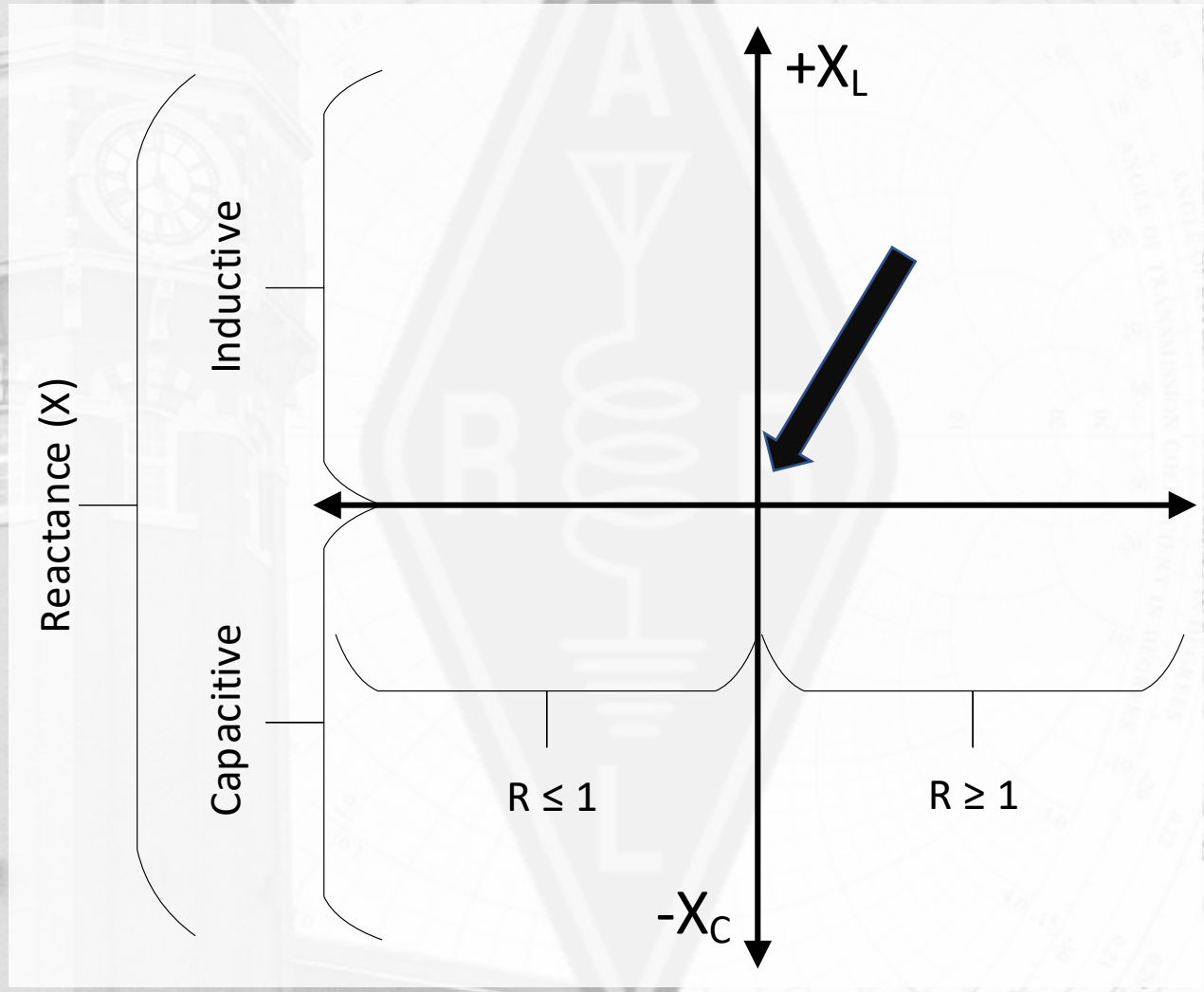
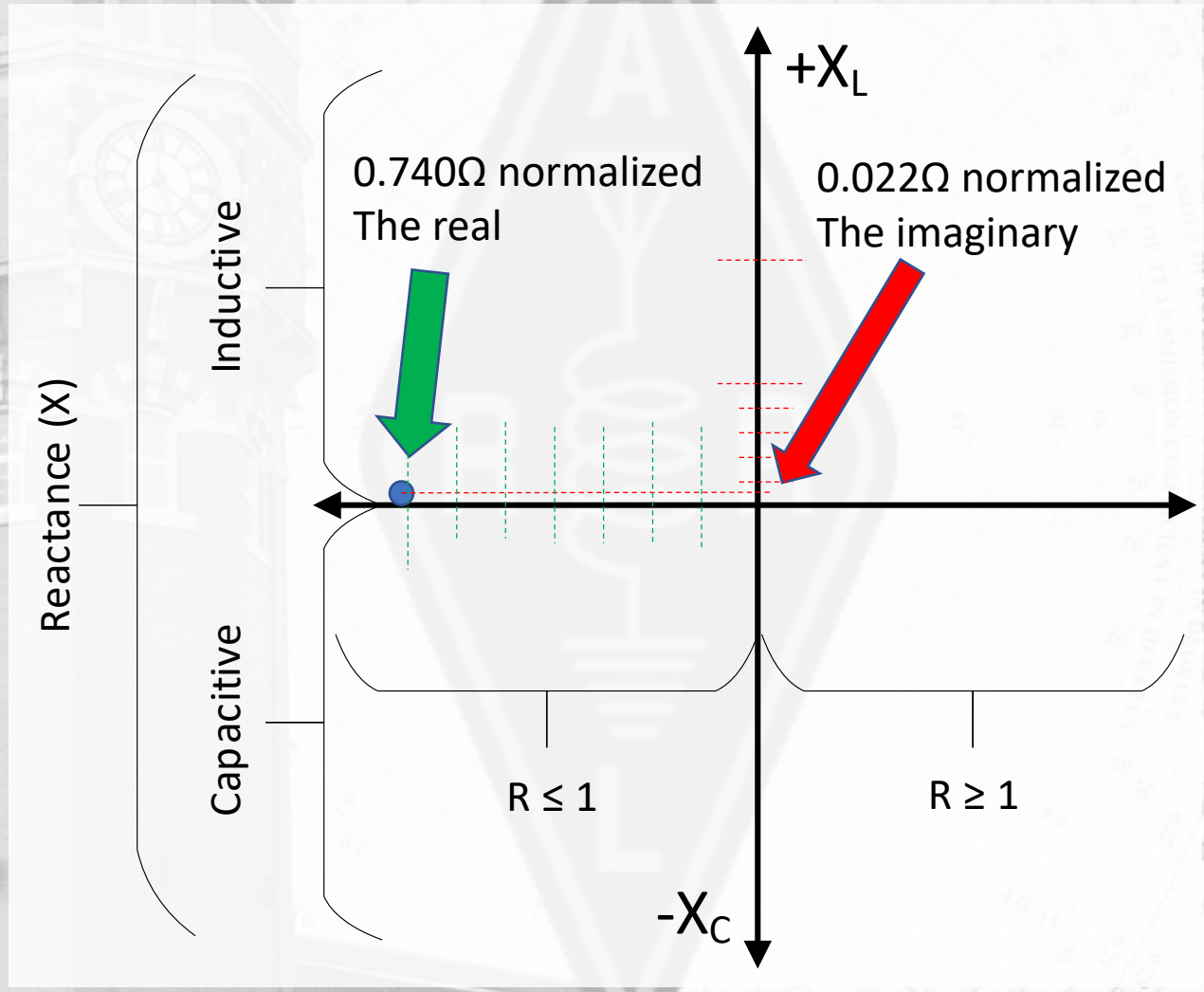


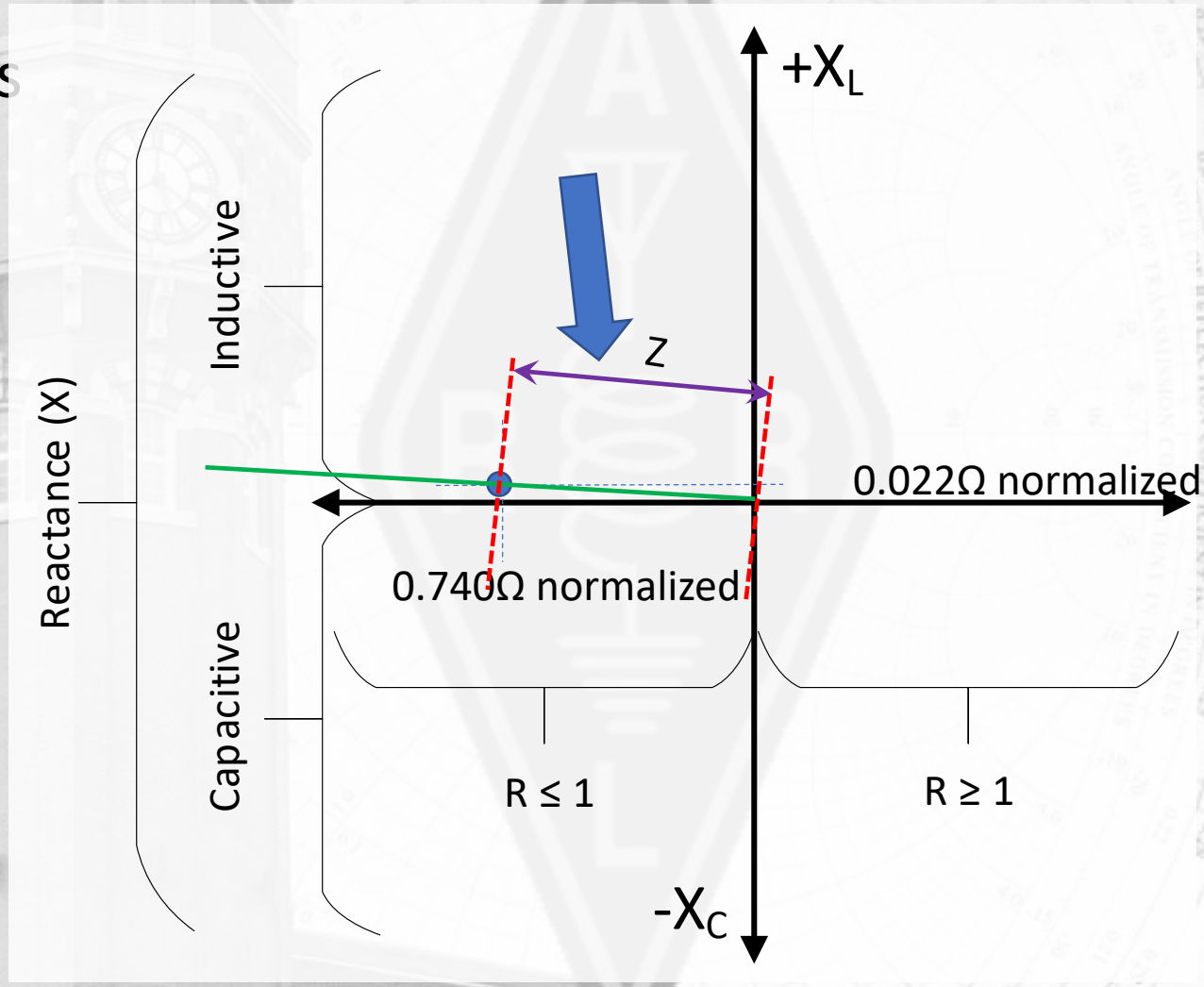
Impedance Represented Rectangular

- 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



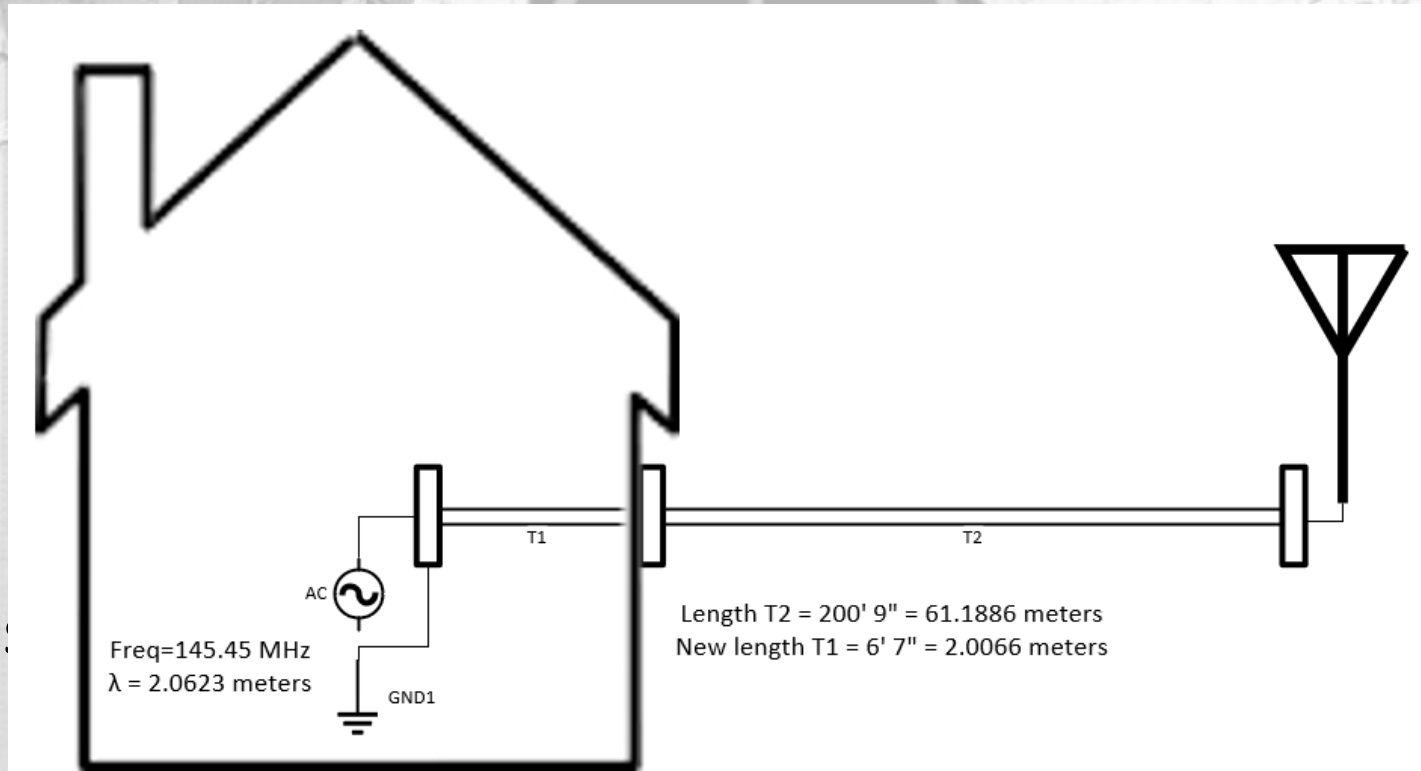
Z—Magnitude Impedance

- There is another way to express this same information
  - Polar form
- The magnitude impedance (Z) is something like "…the distance as the crow flies."
- $Z = \sqrt{R^2 + X^2}$
- $Z = \sqrt{0.740^2 + 0.022^2}$
- $Z = 0.738\ Ohms$



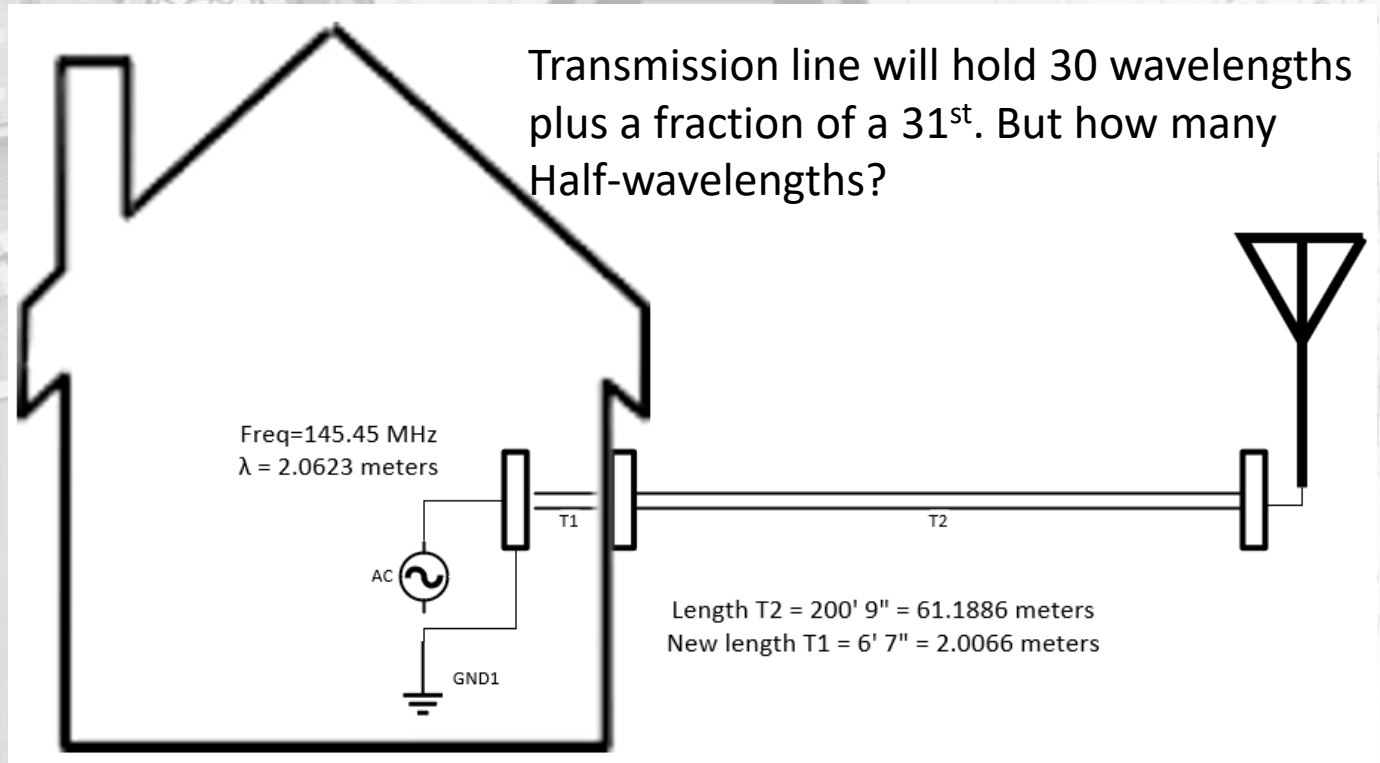
Transmission Lines

- The transmitter frequency is 145.450 MHz
- 1 wavelength (λ) is 2.062 meters
- T_1 is 2.0066 meters in length.
  - How many wavelengths can T_1 hold?
  - 2.0066/2.062 = 0.9731 λ
- T2 is 61.1886 meters
  - How many wavelengths can T_2 hold?
  - 61.1886/2.0623 = 29.670 λ
- Total λ=30.6432 wavelengths



Looks Like…

- 30 complete waves plus a fraction of a 31st fit on the transmission path.
- 63.195 m / 2.062 m = 30.647
- Today's big question:
  - How many half-wavelengths are 30.647 wavelengths?
- This may seem trivial but you must understand what is going on here.
- 0.647 – 0.500 = 0.147

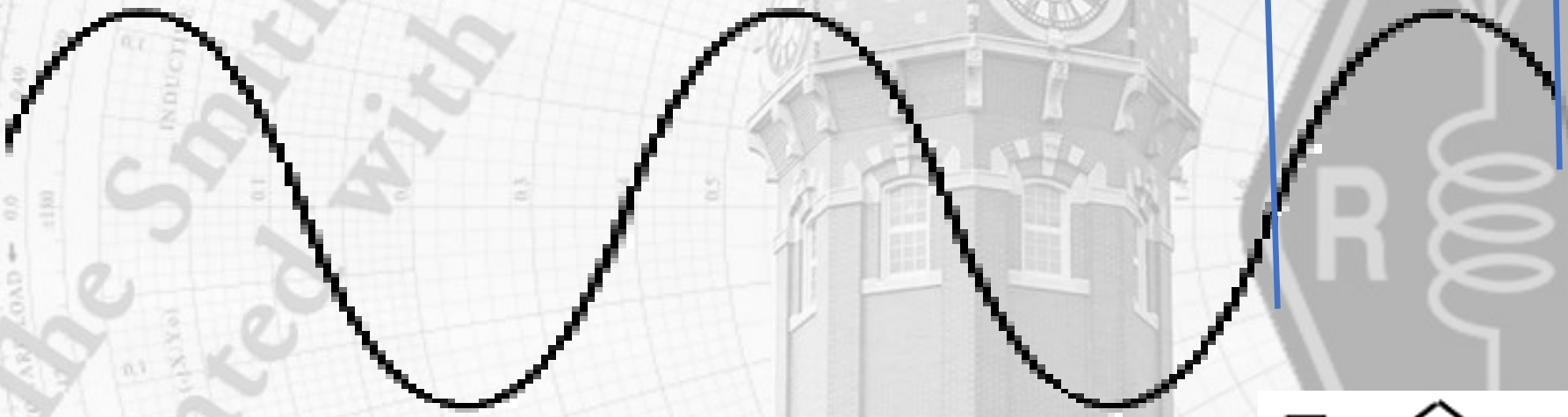


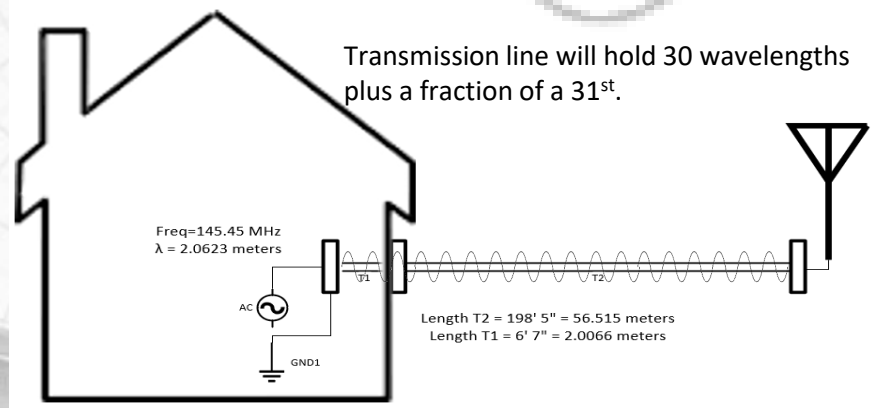
What does this mean?

30λ or 60λ/2

0.30λ

30.30λ or or 60λ/2 + 0.3λ

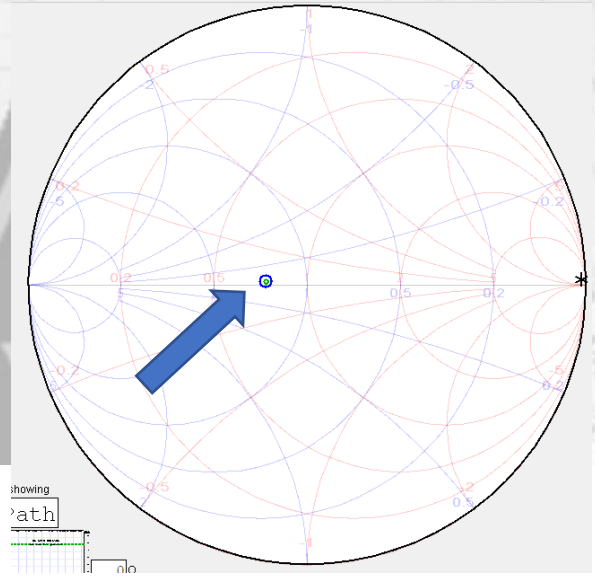


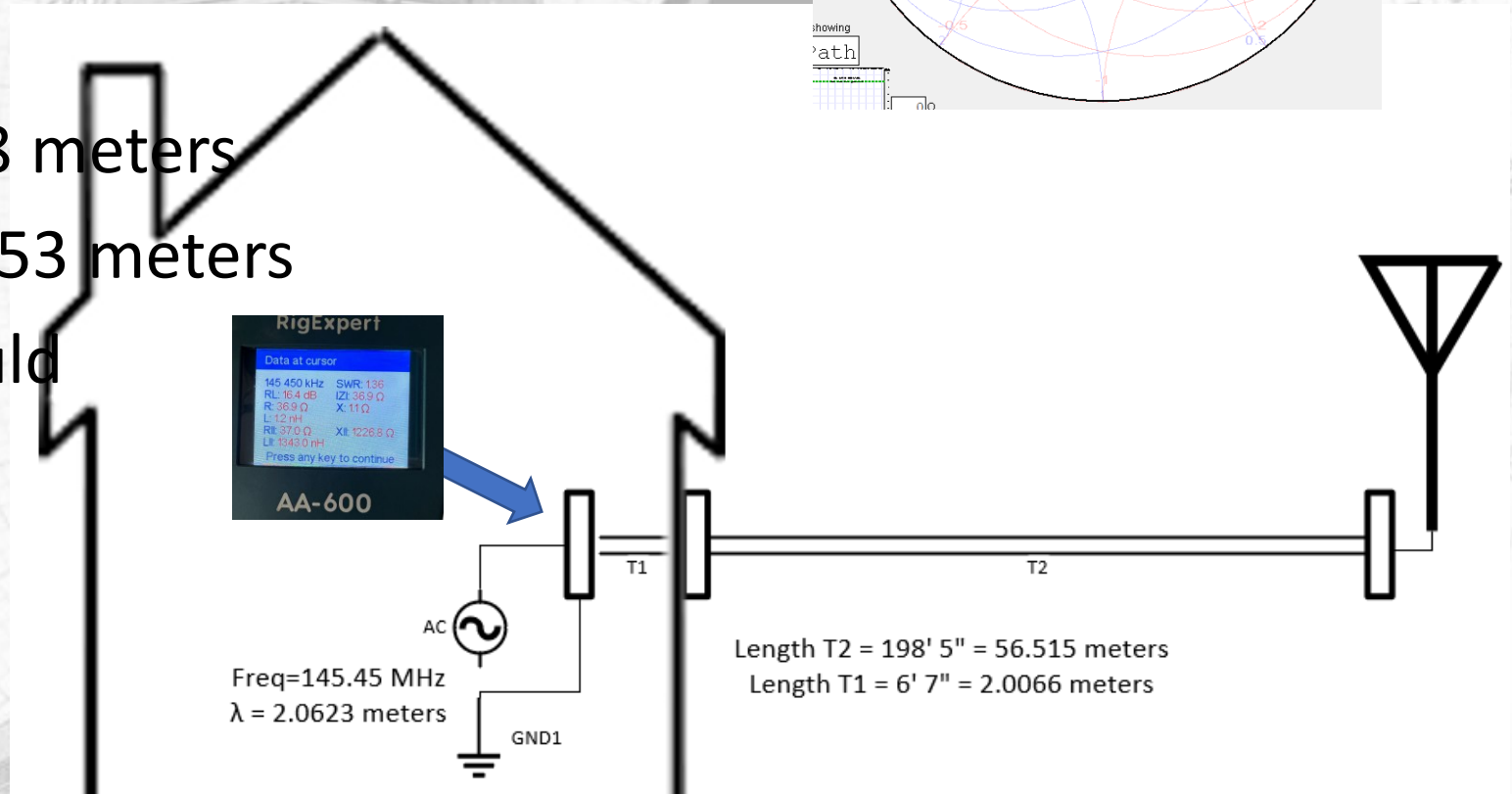


Transmission line will hold 30 wavelengths plus a fraction of a 31st.

What You Measure

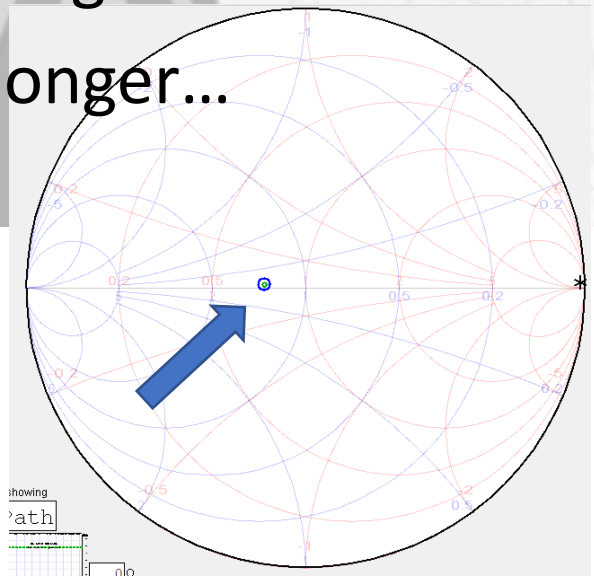
- The transmitter sees 36.9 Ohms which is
  - 36.9 Ohms real
  - 1.1 Ohms reactive
- You replaced T_1
- New length T_1=8’=2.438 meters
- New total length = 58.953 meters
- What new reading should be expected?





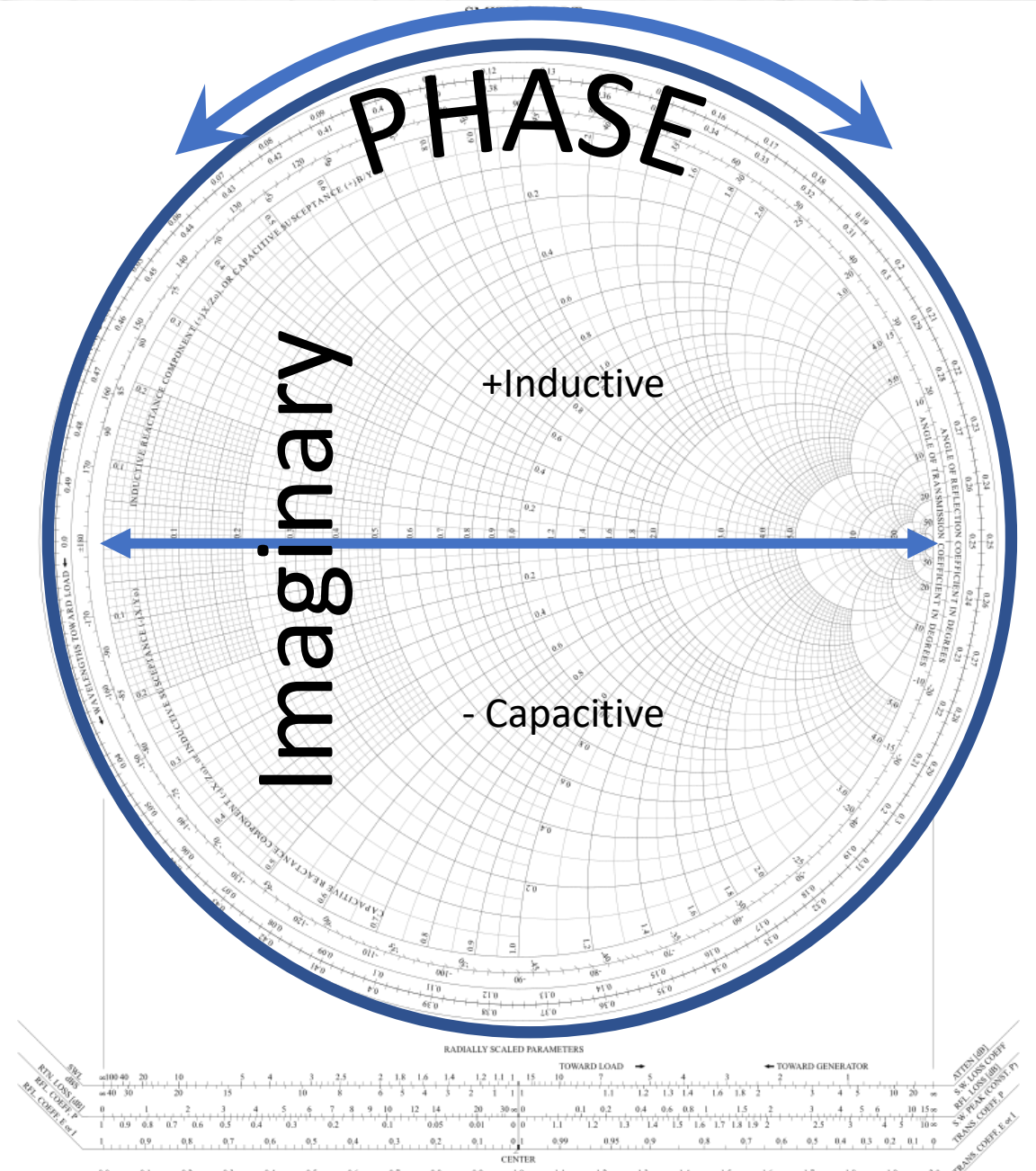
Replaced Cable

- Because a signal only travels at about the speed of light…
- And the transmission path to the antenna is now longer…
- The time to reach the antenna has increased.



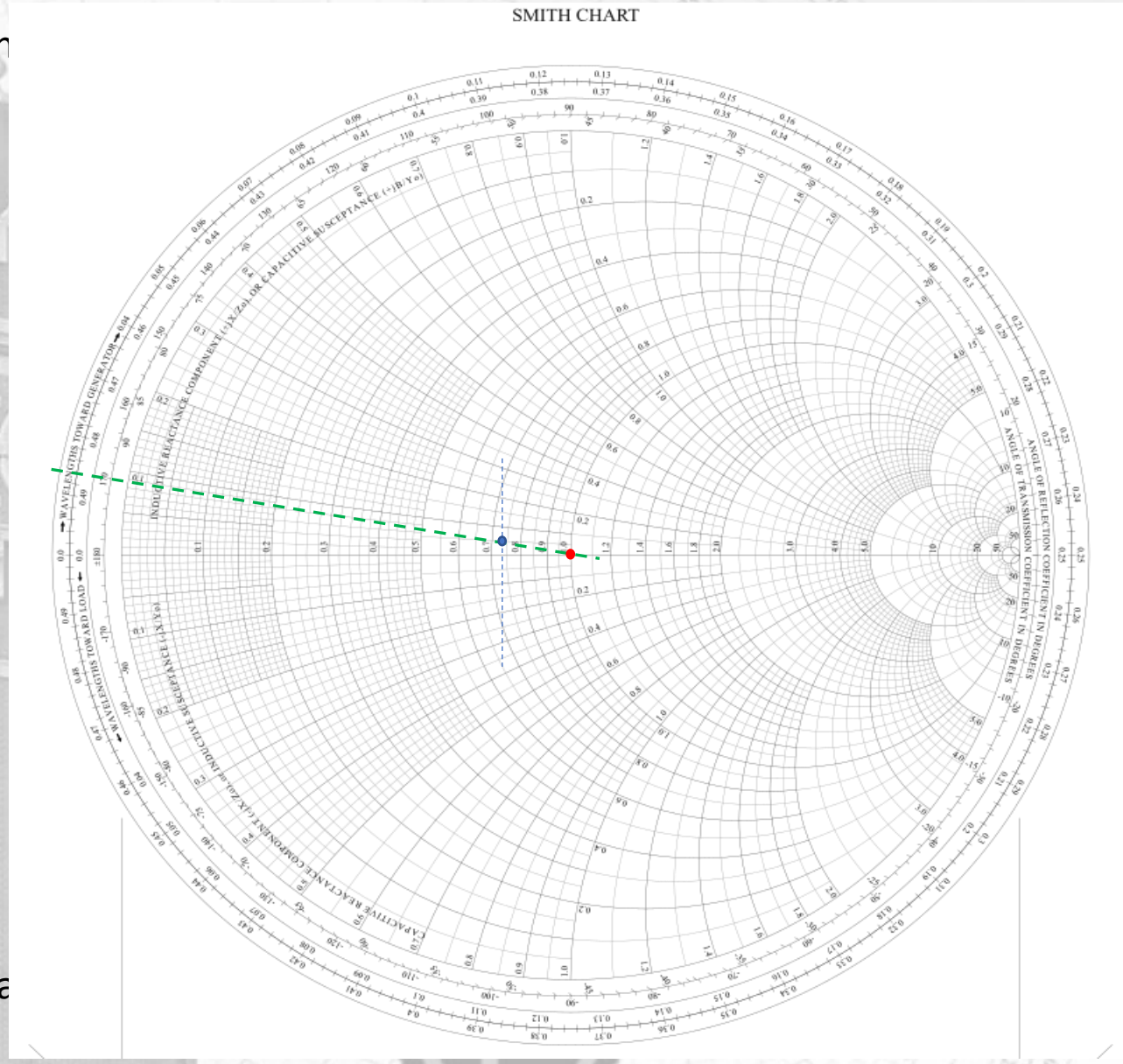
Smith Chart Review

- Hemispherical Reactances
  - Inductive are in the northern hemisphere
  - Capacitive in the southern
- Points directly on the equator are real with zero value reactances.
- The outside circle
  - Where the circle appears is irrelevant in theory.
  - On the outside merely allows more precision in reading it.
  - 360^{o} represents a half-wave



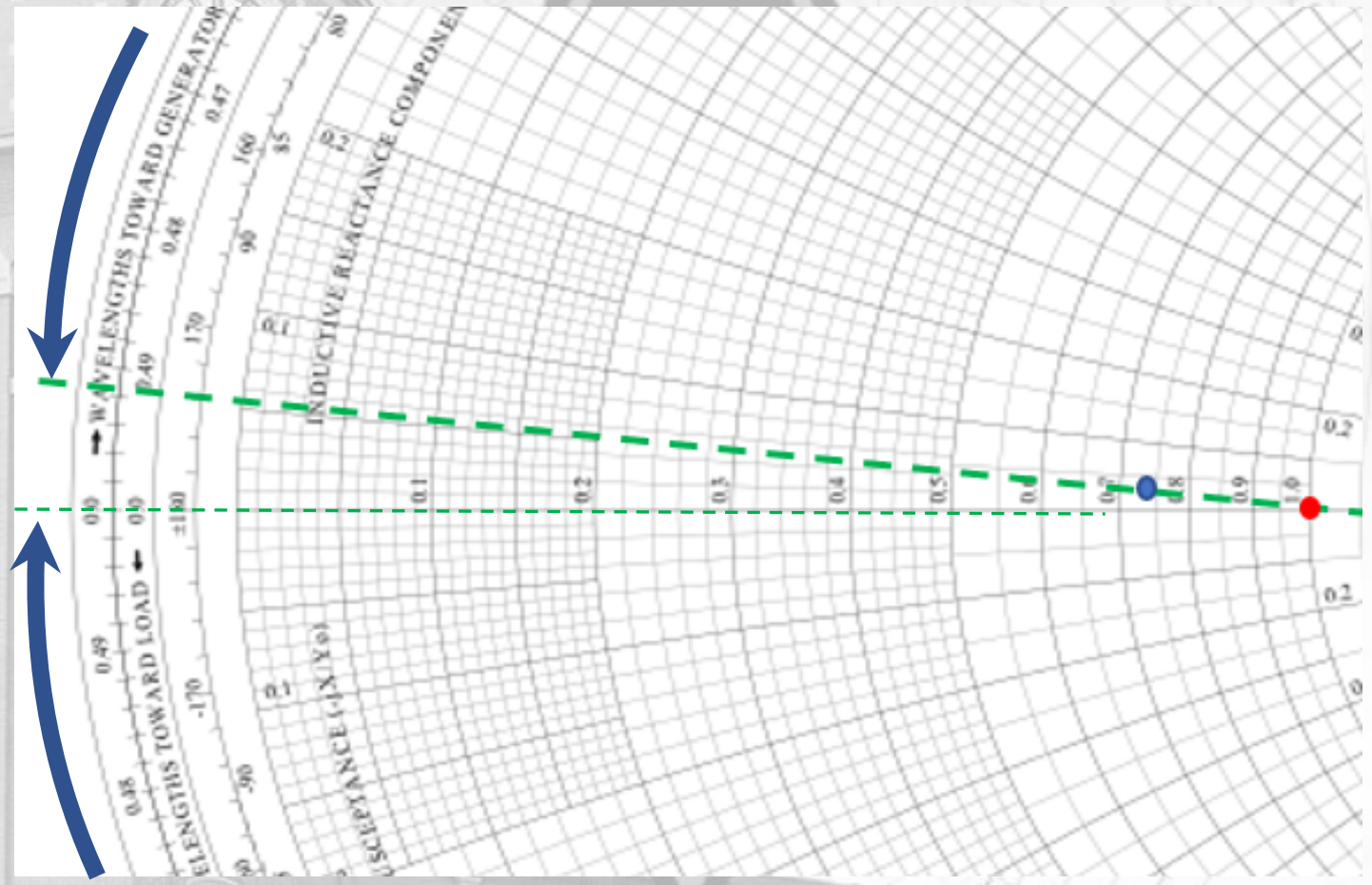
Polar on Smith

- Similar to rectangular
- But new information gained.



Angle From the Long Way

- 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

The Smith Chart
Presented with Elegance