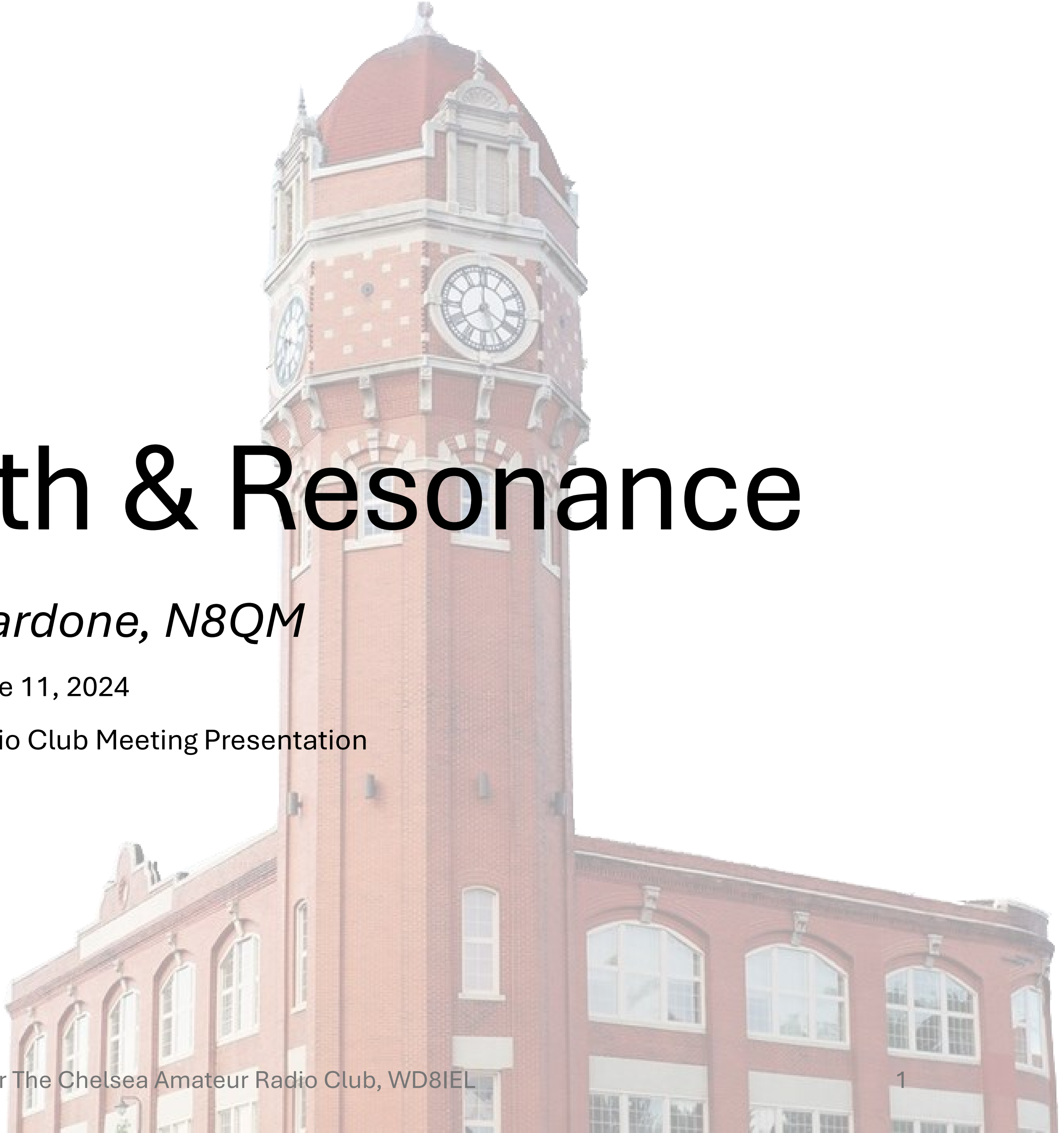

Feedline Length & Resonance

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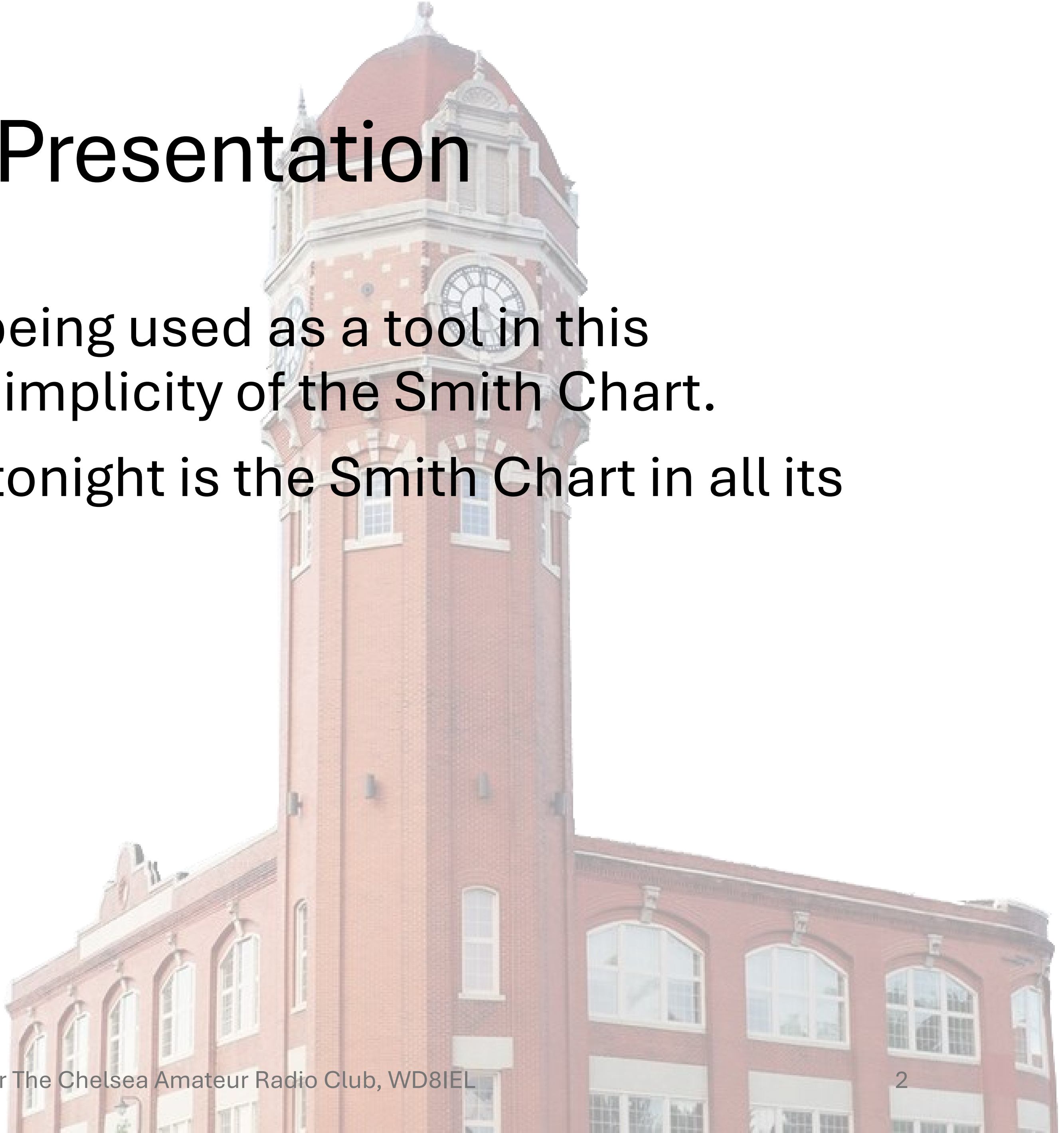
June 11, 2024

Chelsea Amateur Radio Club Meeting Presentation

Objective of Tonight’s Presentation

- The topic of feedline length is being used as a tool in this presentation to introduce the simplicity of the Smith Chart.
- What you are REALLY learning tonight is the Smith Chart in all its simplistic glory.

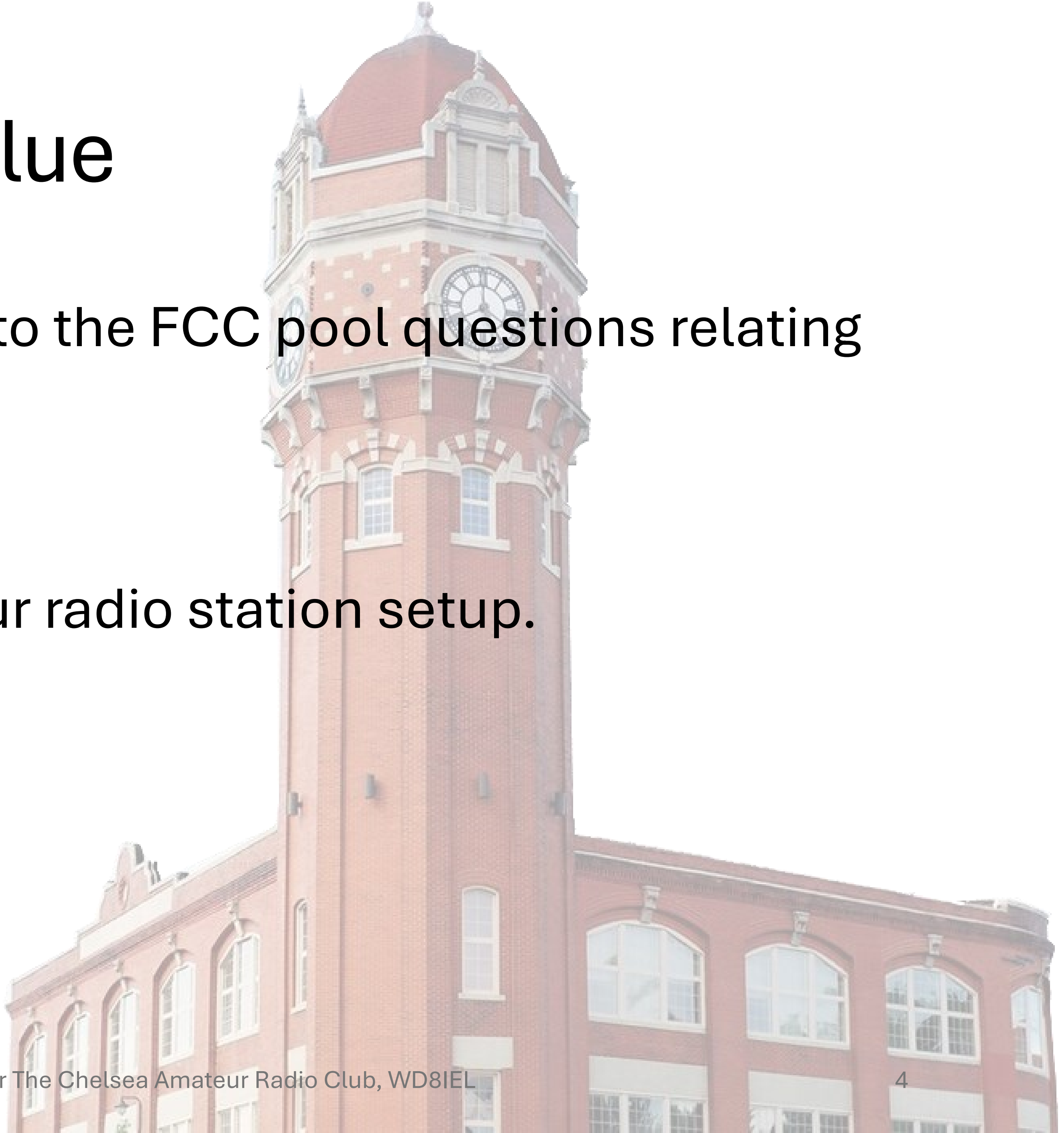


A Word of Caution

- For those having never seen a Smith Chart…
- Much of tonight’s presentation will be elusive.
- Nevertheless, you may expect to take home a qualitative perspective.
- You will have a vague understanding why the length of a feedline is irrelevant to changing SWR.
- MORE IMPORTANTLY: You will know the three components of the Smith Chart and what they represent.

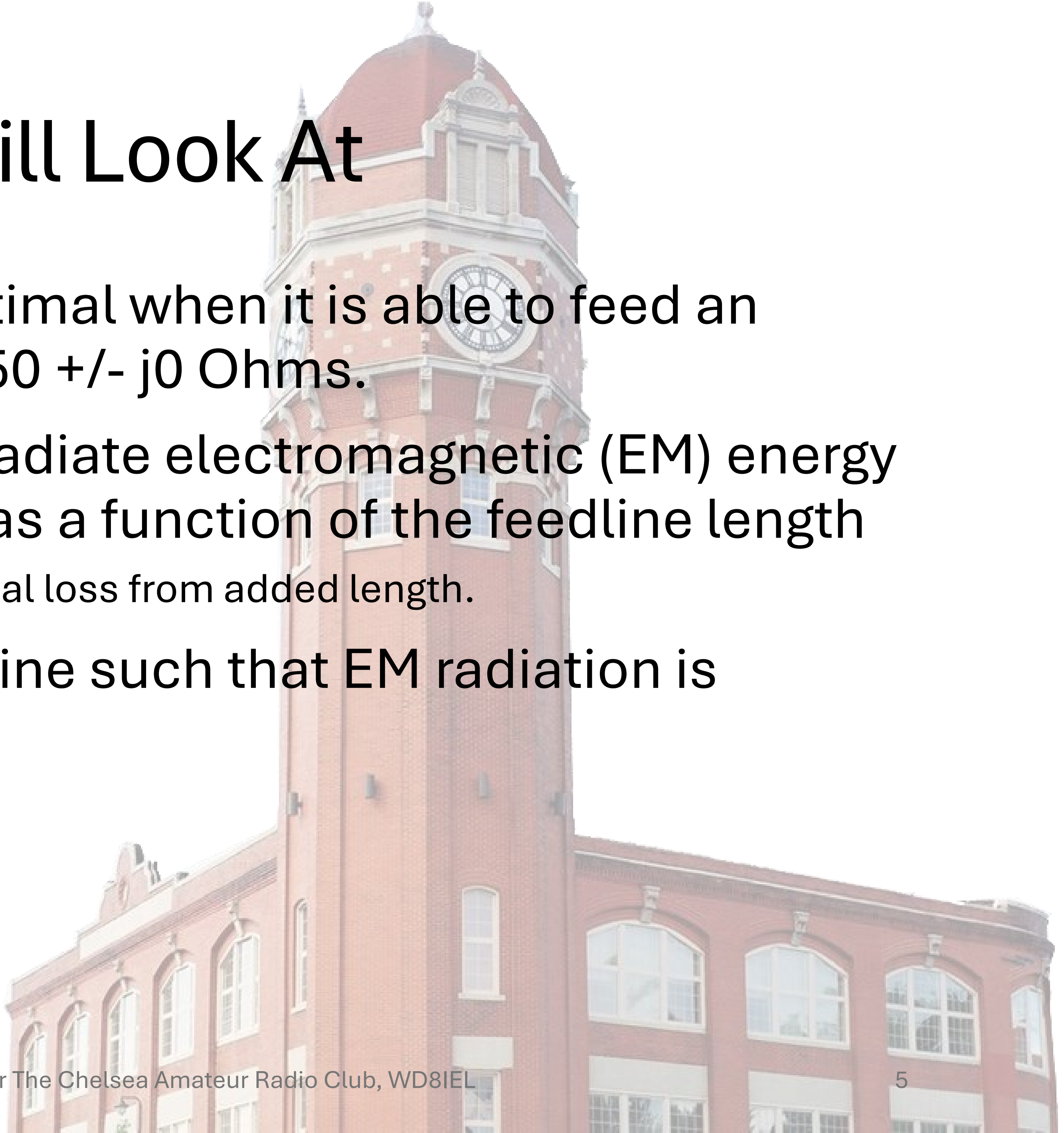
This Presentation’s Value

- Nearly ALL content is relevant to the FCC pool questions relating to antennas for
  - General
  - Extra Class licenses
- Knowledge is pivotal to amateur radio station setup.



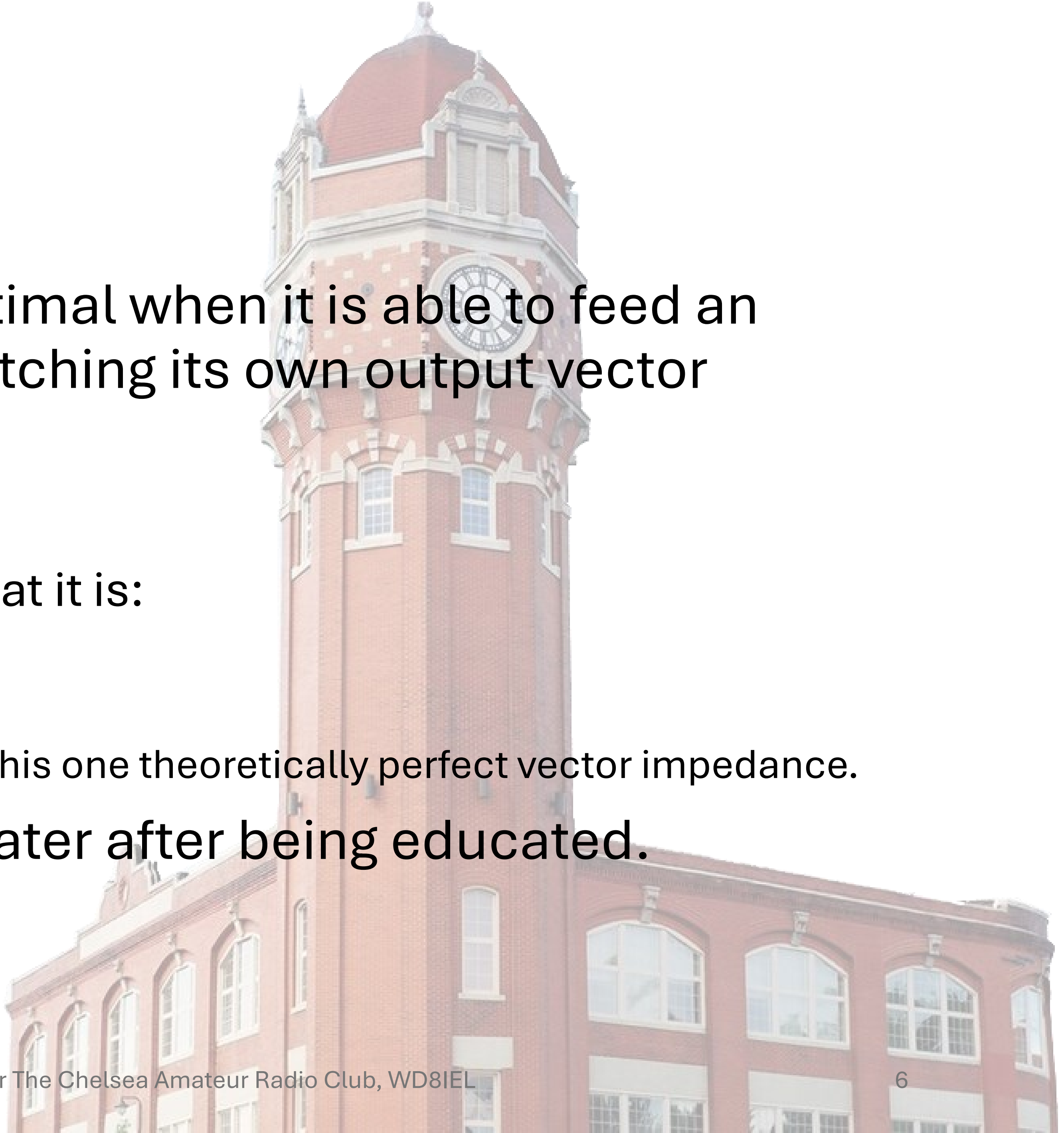
Considerations We Will Look At

- A transmitter's efficiency is optimal when it is able to feed an antenna vector impedance of 50 +/- j0 Ohms.
- How is an antenna's ability to radiate electromagnetic (EM) energy into the environment affected as a function of the feedline length from the transmitter? Exclude signal loss from added length.
- Is there an ideal length of feedline such that EM radiation is optimal?
- What is a vector impedance?



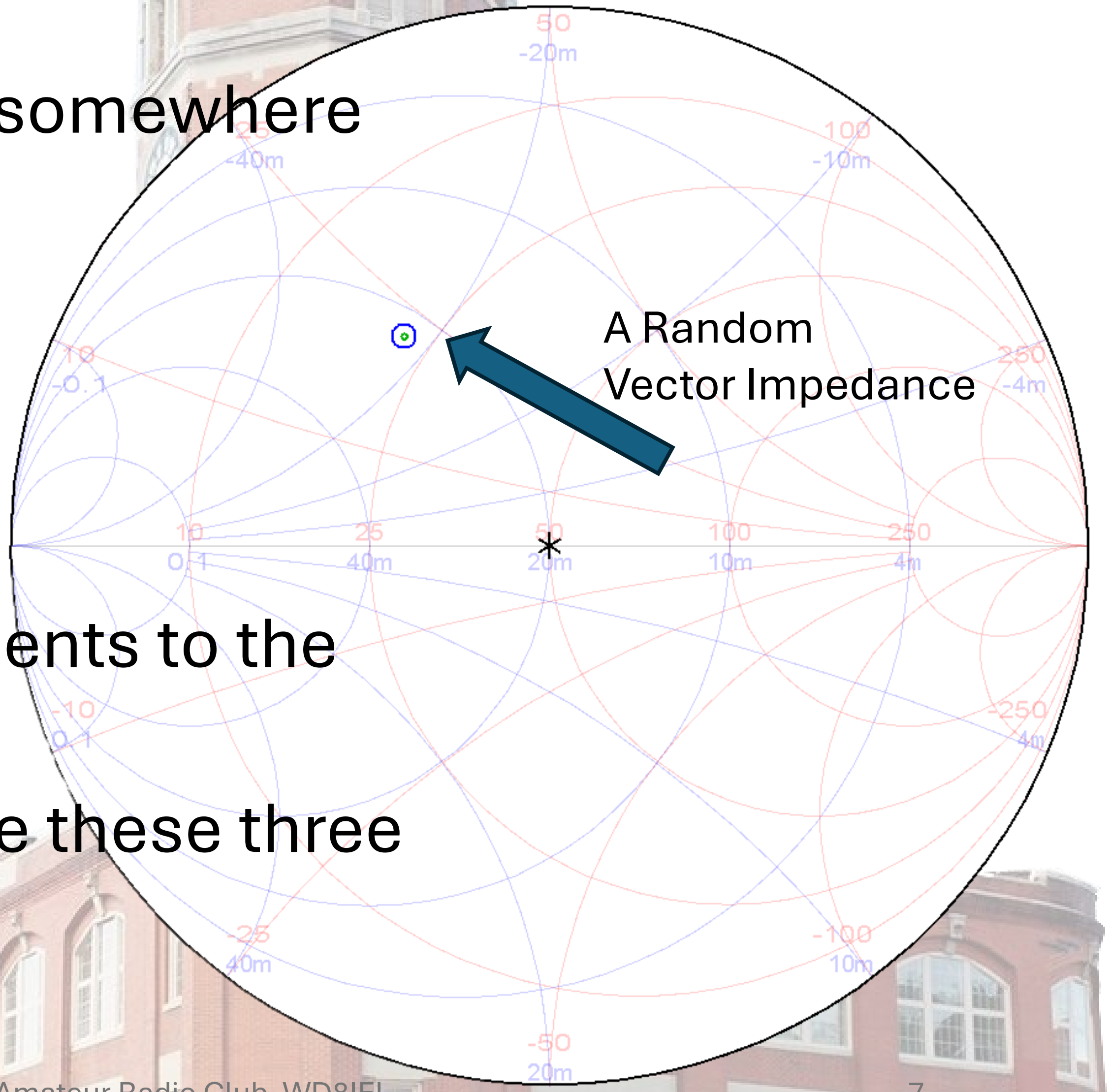
Question

- A transmitter's efficiency is optimal when it is able to feed an antenna vector impedance matching its own output vector impedance.
- Assume this is 50 ± j0 Ohms.
  - What is 50 ± j0 Ohms? This is what it is:
    - 50 Ohms real
    - Zero Ohms reactive
    - In theory, phase is not defined for this one theoretically perfect vector impedance.
- We will address this question later after being educated.



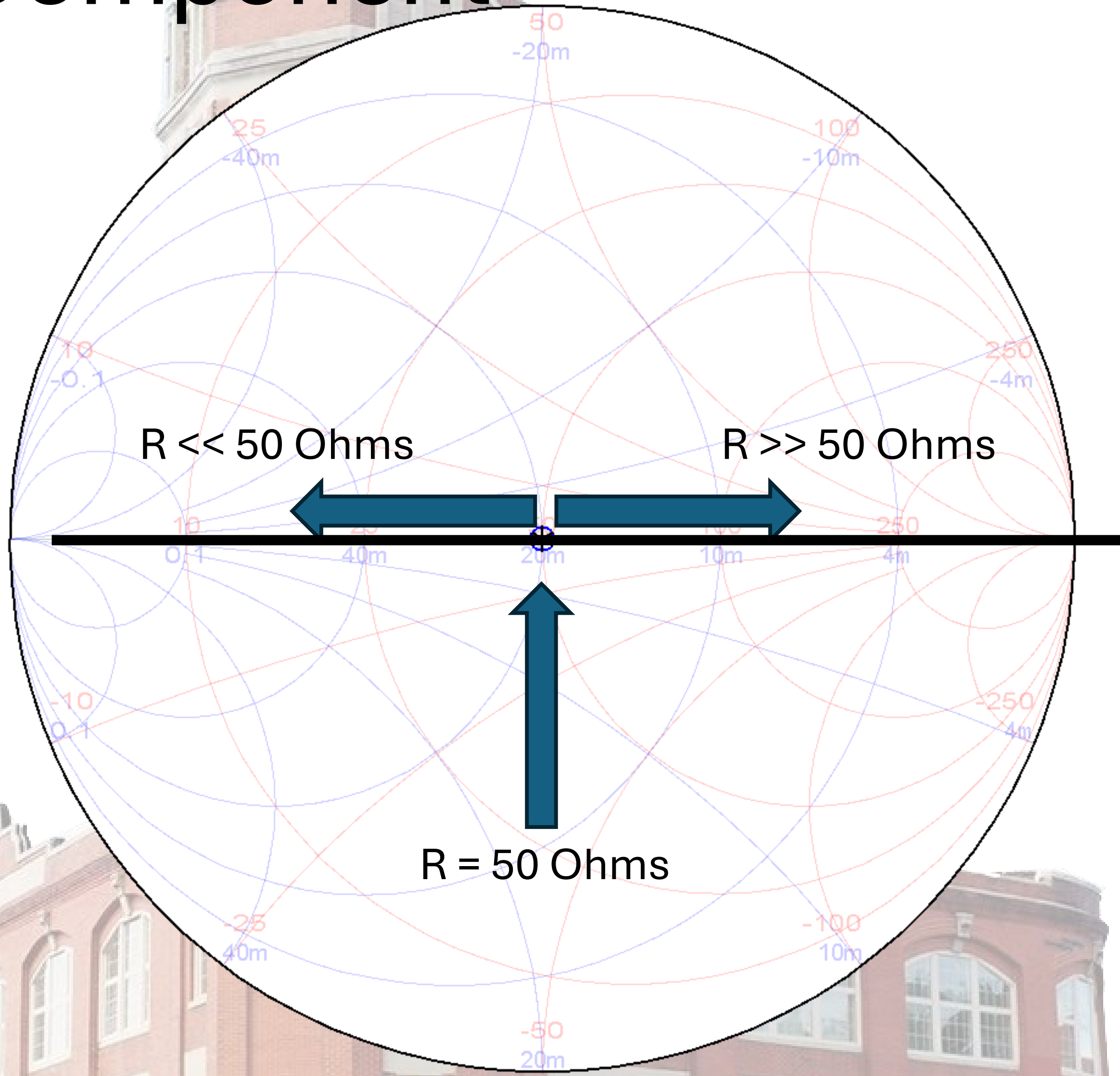
A Vector Impedance on the Smith Chart

- Any one vector impedance is a point somewhere on the Smith Chart.
- That one point defines a
  - real impedance
  - Reactive impedance
  - Phase
- There are therefore only four components to the Smith Chart.
- In the following slides we will examine these three components.



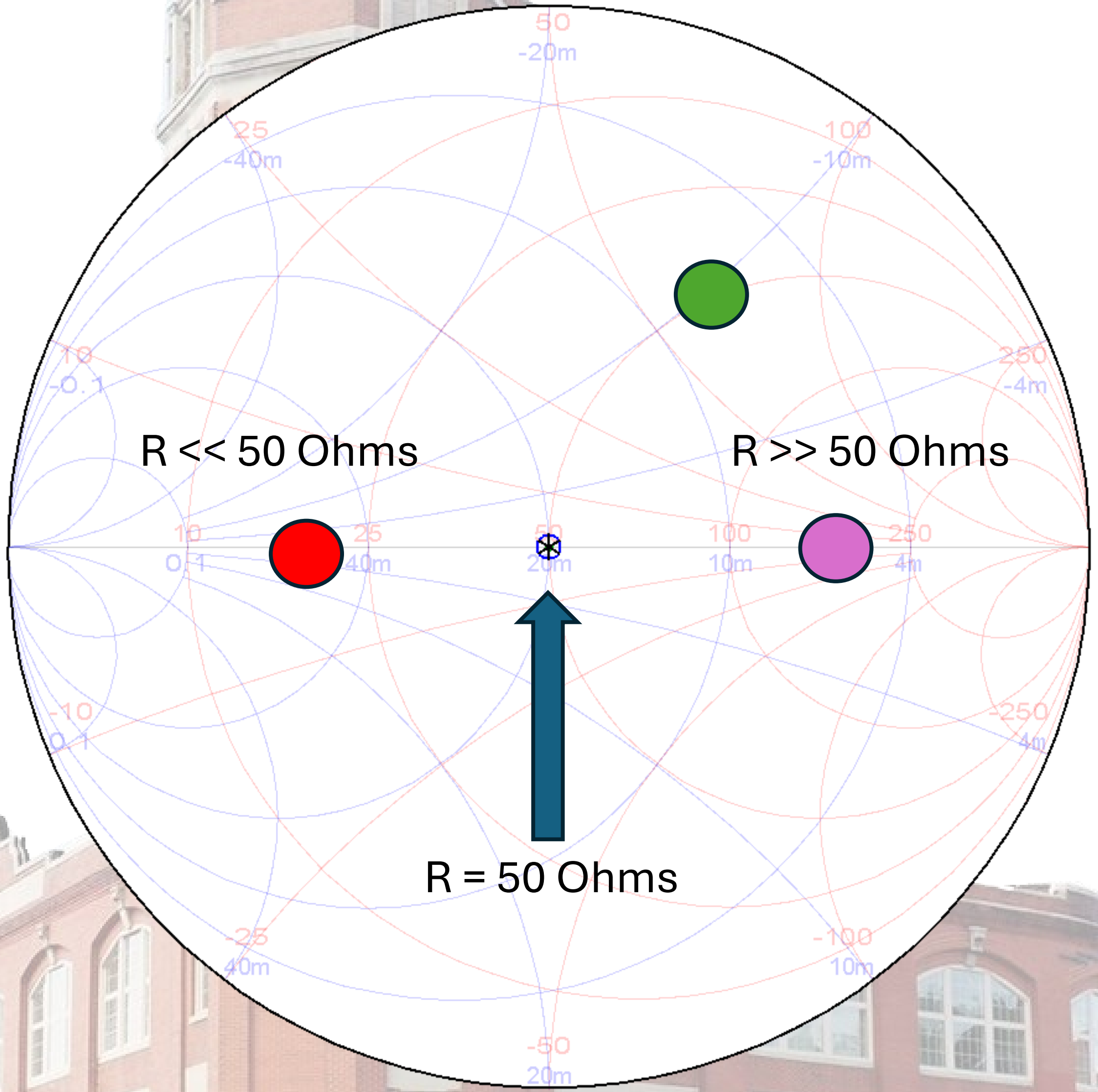
Smith Chart Real—Real Component

- Impedance
  - Real on the equator--Resistance
    - At "home plate" = 50 Ohms
    - Moving RIGHT from home R INCREASES
    - Moving LEFT from home R DECREASES
- When a vector impedance is exactly on the equator
  - it has a numerical real component.
  - Its net reactive component is zero.



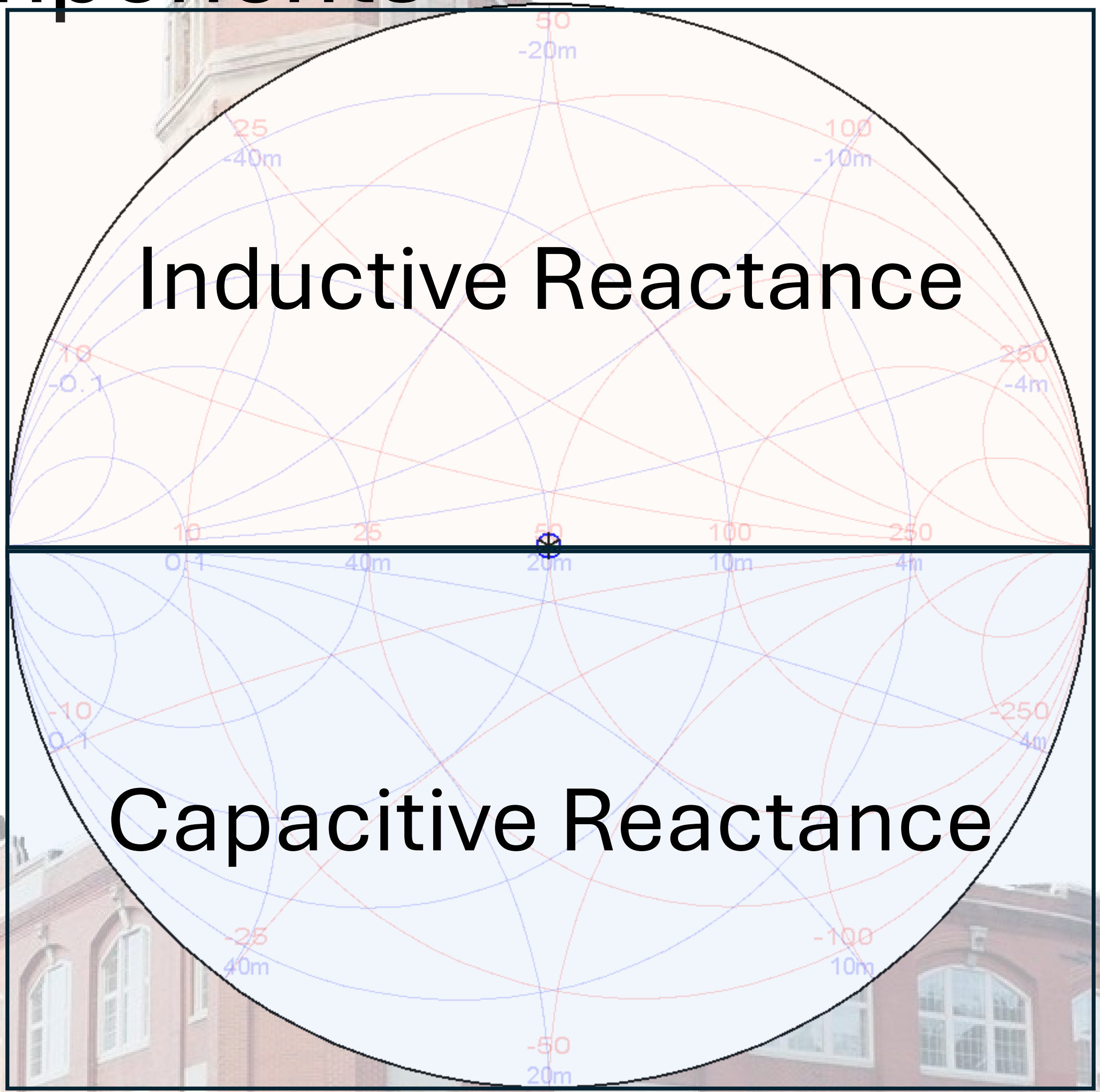
Pop Quiz

- Red dot position. Is it:
  - Less than 50 Ohms?
  - Greater than 50 Ohms?
  - Equal to 50 Ohms?
- Purple dot position. Is it:
  - Less than 50 Ohms?
  - Greater than 50 Ohms?
  - Equal to 50 Ohms?
- Green dot position. ***(Don't answer yet)***
  - Less than 50 Ohms?
  - Greater than 50 Ohms?
  - Equal to 50 Ohms?



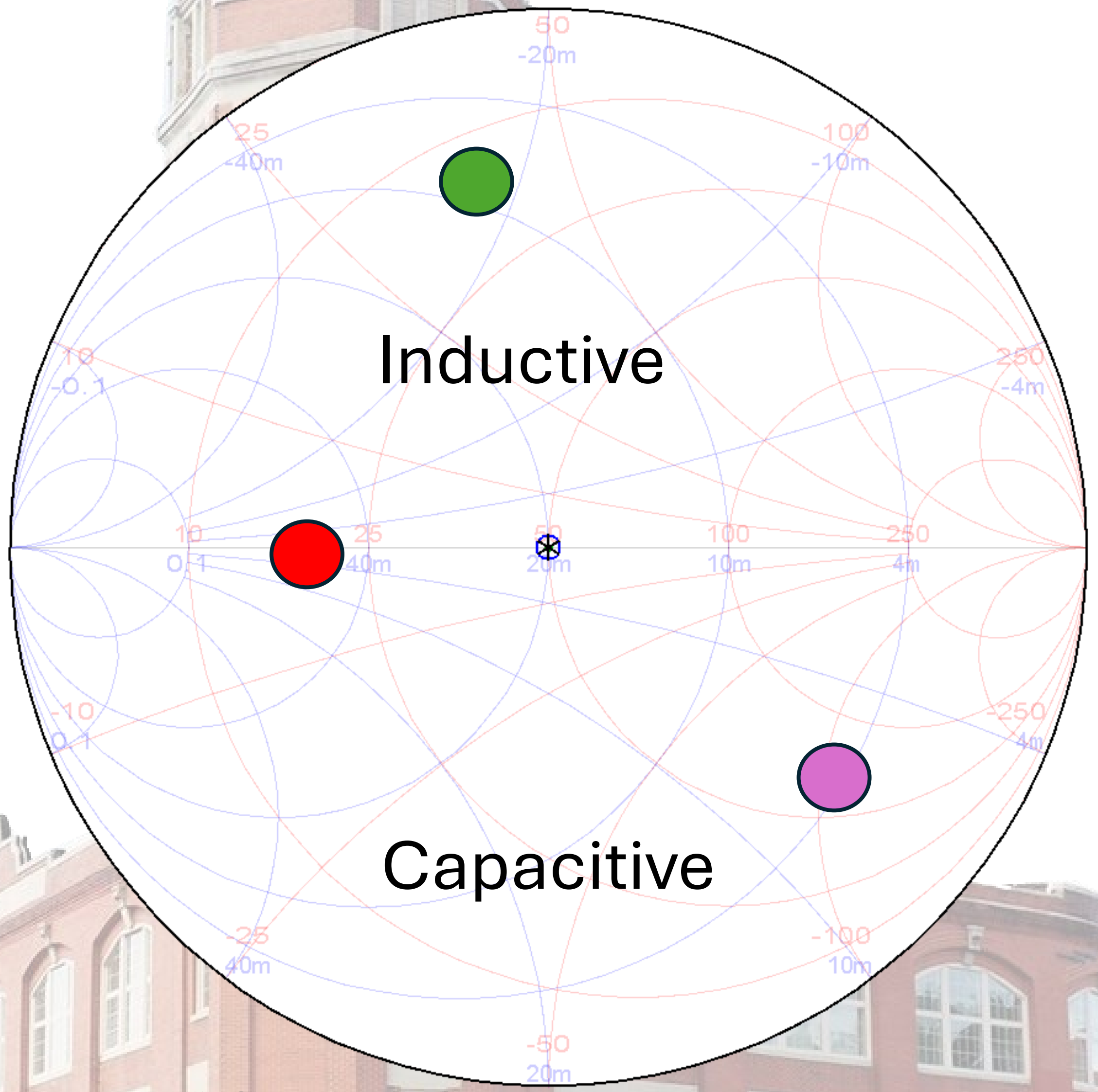
Smith Chart Reactive Components

- Above the equator—Inductive
- Below the equator—Capacitive
- On the equator--Zero



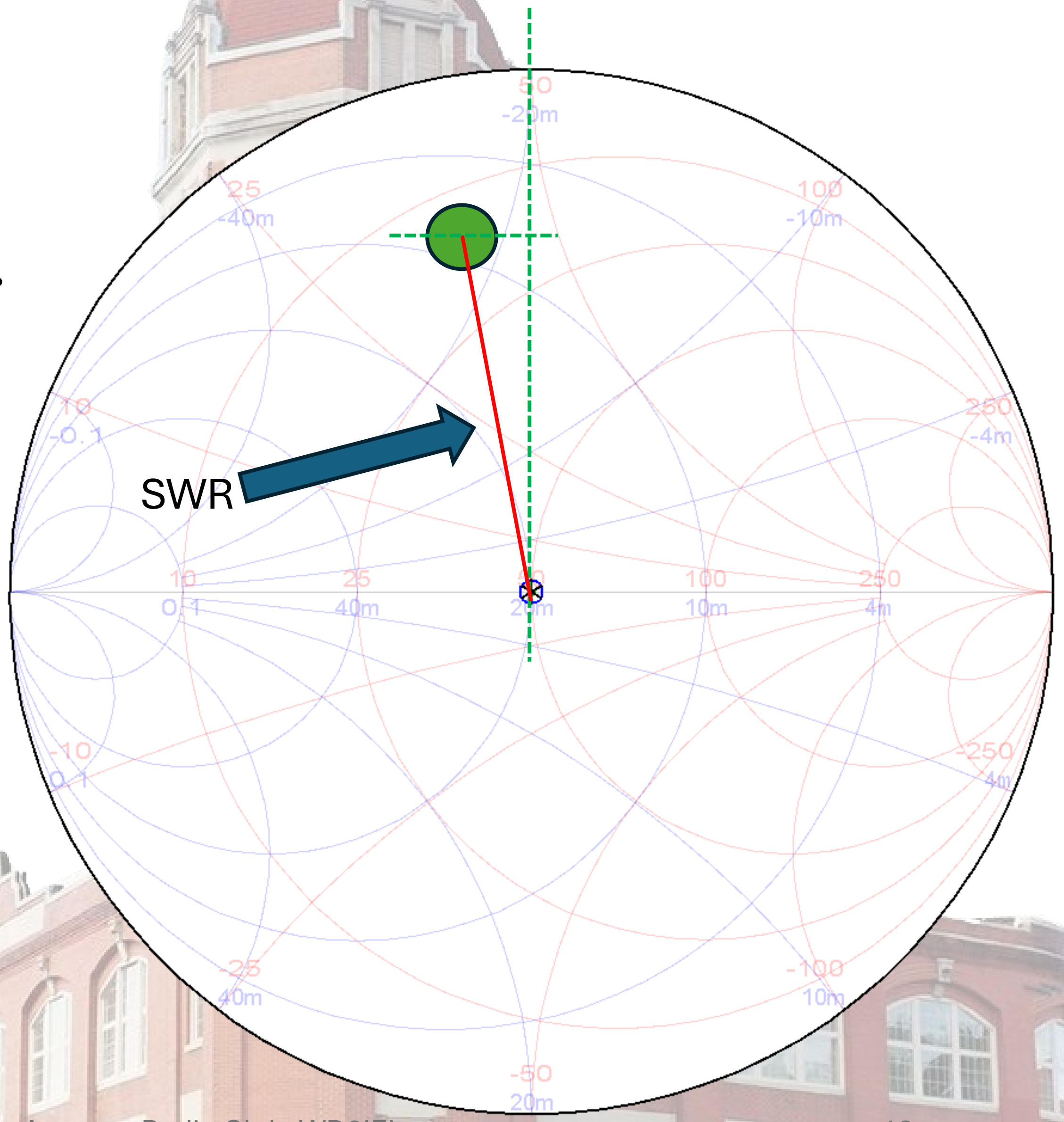
Pop Quiz

- Red dot position. Is it:
  - Inductive?
  - Capacitive?
  - Zero reactance?
- Purple dot position. Is it:
  - Inductive?
  - Capacitive?
  - Zero reactance?
- Green dot position. Is it:
  - Inductive?
  - Capacitive?
  - Zero reactance?



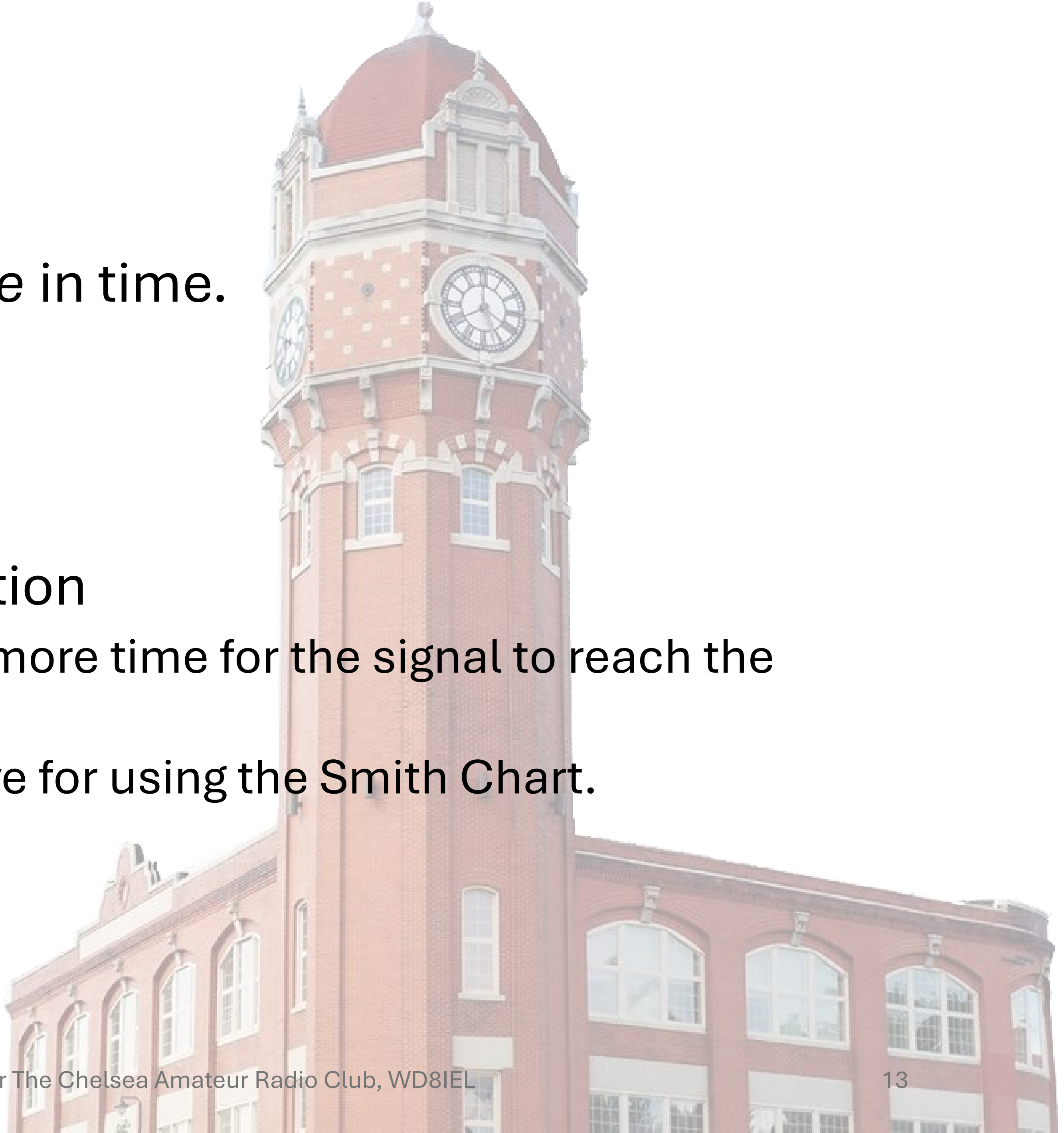
SWR—Reflected Wave

- The reflected wave (SWR) is the magnitude distance from Z to home.



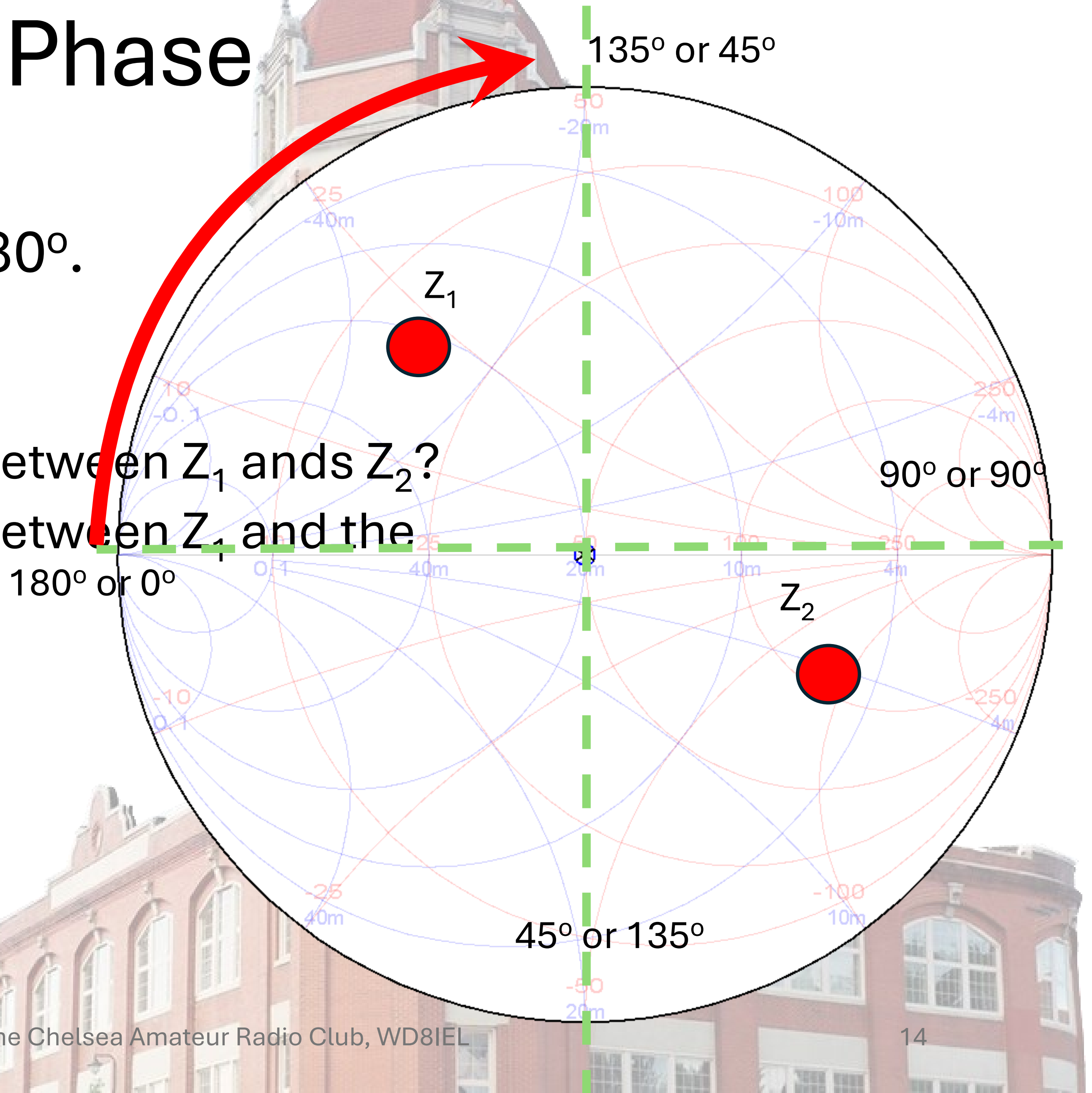
What is Phase

- Phase is time but is a *difference* in time.
- Phase therefore
  - dependent on the speed of light
  - feedline velocity factor.
- Key note for tonight’s presentation
  - When you add feedline, it takes more time for the signal to reach the antenna.
  - Thus, a phase difference we solve for using the Smith Chart.



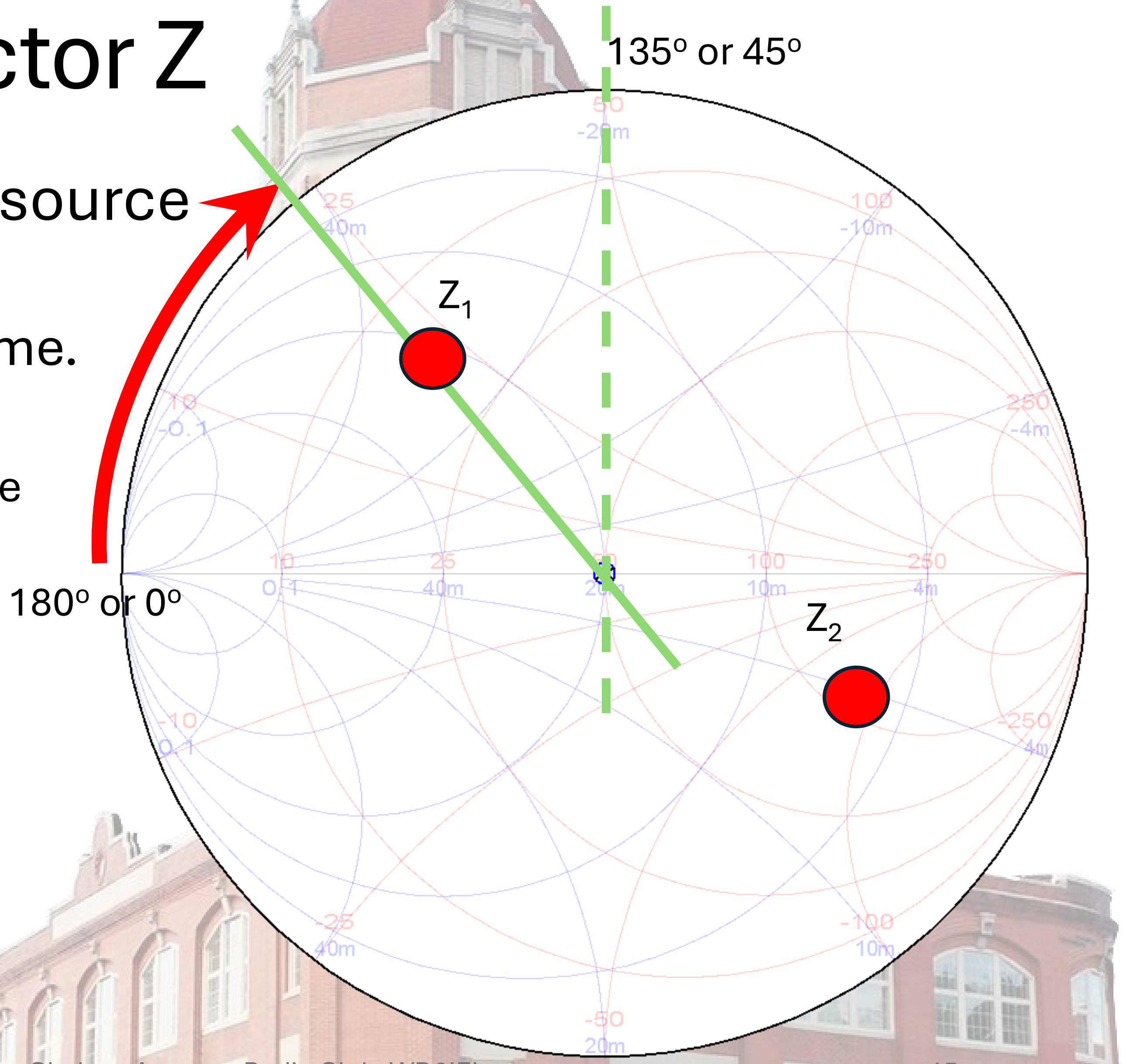
Smith Chart Measures Phase

- One trip around the "globe" is 180º.
  (a half-wavelength)
- Phase is relative
  - i.e. What is the phase difference between Z_1 ands Z_2?
  - i.e. What is the phase difference between Z_1 and the source?



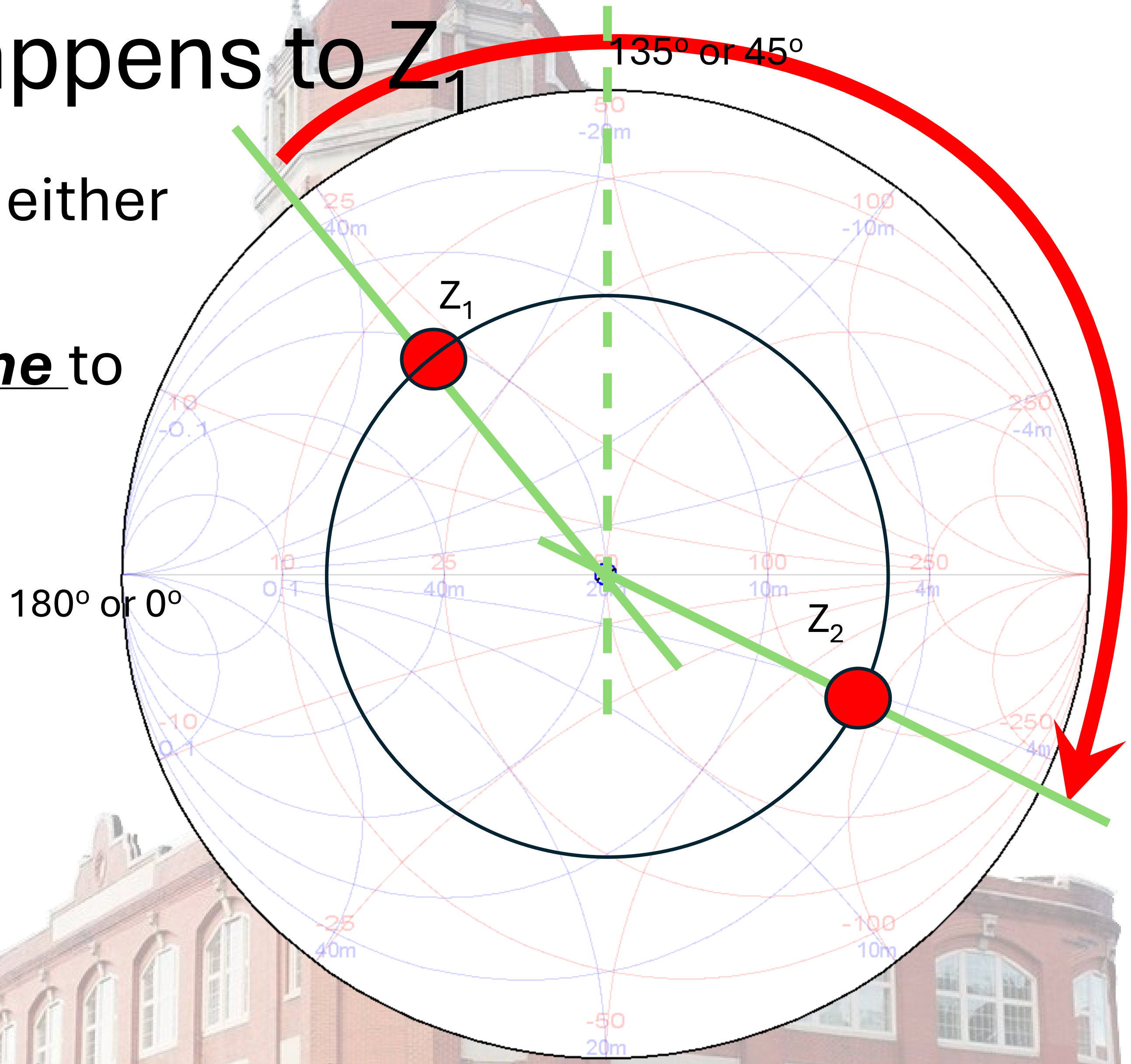
Find Phase Given a Vector Z

- Given Z_1, find phase from either source or load.
  - Draw a line intersecting Z_1 and home.
  - Phase is
    - Greater than 135° towards the source
    - Less than 45° towards the load



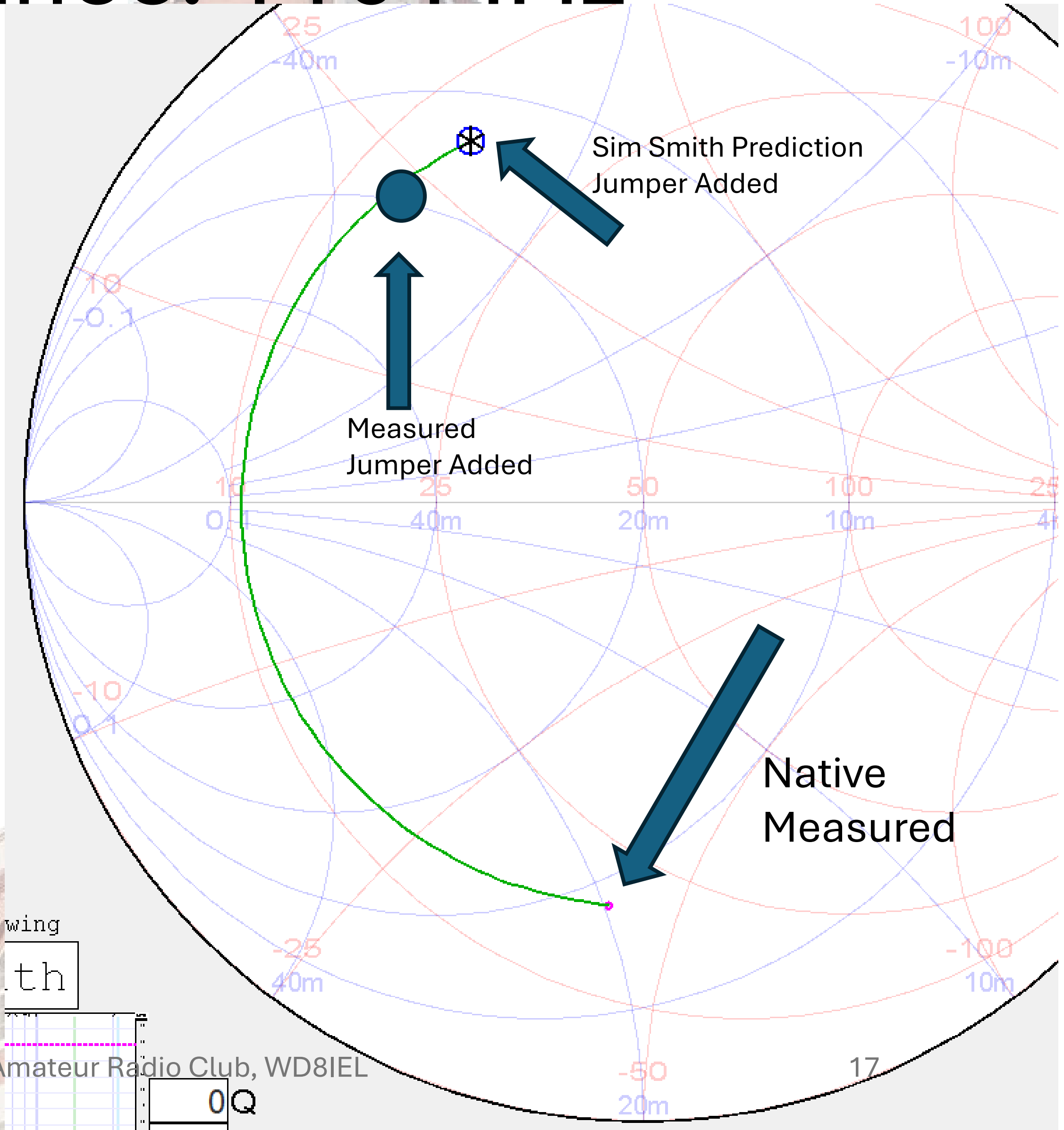
Add Feedline. What Happens to Z_1

- Given Z_1 (inductive). find phase from either source or load.
- Adding feedline means more ***time*** to reach the antenna.
- Resulting Z_2 is capacitive
- But SWR is unchanged.



Experiment Native Resonance: 110 MHz

- Native Measured at 130.5 MHz
  - Z = 18.7 – j42.3 Ohms
  - SWR = 4.8
  - C = 29 pF
- Add 12.5” of RG-8X Coax, vf=0.68
  - SimSmith Predicts
    - 14.3 + j28.0 Ohms
    - SWR = 4.7
    - L =
  - Measured
    - 13.7 + j24.2
    - SWR = 4.5
    - L = 29.6 nH



Conclusion

- Adding feedline can dramatically change the reactive component of a vector impedance seen by a transmitter.
- Thus, by cutting a feedline to length, you may potentially be able to cause the transmitter to see a resonant antenna.
- But the reflected wave is unchanged.
- The magnitude of energy is being reflected back to the transmitter is unchanged.
- You have gained no advantage.
- Adding length, of course, increases losses in all cases.

Next Month…

- Two antennas for directional RF gain.
- What must be:
  - The distance between antennas?
  - The feeding phase difference?
  - And still have 50 Ohms vector impedance