# Smith Charts and More

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

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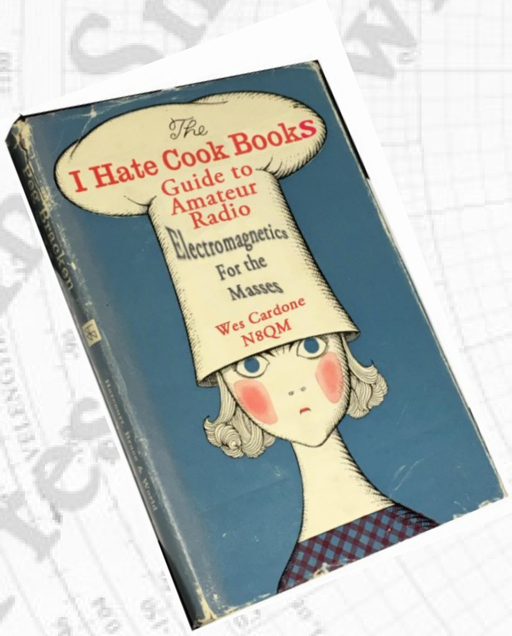

# Strategic Overall Class Objectives

- 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…

- dB
- dBm
- noise

# What is a Decibel (dB)

- Decibels make life easy
- Decibels are formulated using logarithms
  - $Log_{10}(1) = 0$
- They are most useful for comparing small number with big numbers
- What is big and what is small?
  - It's relative
  - The "big" is the difference
    - Such as 1 pico Ohm and 100 kOhms

# $Log_{base}$(value)

- Logarithms come in any size.
  - $Log_2$(value), $Log_e$(value), $Log_{10}$(value)
- $Log_{10}$(unity) or $Log_{10}$(1)
- Quantifying $Power_{in}$ vs $Power_{out}$
  - $Power_{out}/Power_{in}$ is gain
  - This is an amplifier
  - Receiver gets S9 in (50uV) and sends maybe 50 Volts out
  - Gain = 20 log (50V/50uV)
    - 50/50u = 5/5u = 5e0/5e-6 = 5/5 [(e0-(-e6)] = 5/5 [e0+e6] = 5e6/5 = 1e6
    - Gain = 20 log (1e6) = 20 * 6 = 120 dB
  - The amplifier gain is 120 dB

# Negative Gain

- What happens when we express a loss of gain
  - Harmonic reduction by 60 dB
  - Harmonic gain of -60 dB
- dB rejection = $20 \log_{10} (50uV/50V) = -120$ dB

# Noise Voltage

- Physicist John Jonson discovered in 1926
- Discovered
  - Irreducible low level of noise
  - Whose power was proportional to temperature

# Noise Figure Voltage--$V_{ns}$

- Is defined at terrestrial temperatures (290°K or 62°F)
- Noise
  - exists in the environment
  - Is very small but detected by radio receivers
  - Principle contributors: the ground, atmosphere, and the sun.
  - Dependent on temperature.
- $V_{noise-source} = \sqrt{4kTB}$
  - k = Boltzmann's constant of $1.380\ 649\ {}^{Joules}/_{\circ K}$
  - T = temperature °K
  - B = bandwidth (Hz)

# Noise Figure Power--$N_{sa}$

- Is a measure of how much a device degrades the signal-to-noise ratio (SNR).
- Voltage noise source: $V_{ns} = \sqrt{4kTB}$
  - k = Boltzmann's constant of $1.380\ 649\ {}^{Joules}/_{\circ K}$
  - T = temperature $^{o}$K
  - B = bandwidth (Hz)
- Power: $N_{sa} = {}^{V_{na}^2}/_{R_s} = {}^{kTB}/_{R_s}$
- When T=290$^{o}$K, $N_{sa} = {}^{4kTB}/_{R_s}$
- SNR at an output will always be smaller than at its input since circuits always add noise to a system.

# Noise Factor

- Is a measure of a receiver's ratio of SNR (signal-to-noise ratio) at its input to the ratio of the SNR at its output.
- Defined at a named frequency
- Defines the ratio of total noise Power per Hz available at the output port when the noise temperature of the input is at 290$^{o}$K to that portion of engendered at the input.

# Noise Power Density (dBm/Hz)

# Noise Floor

- Microsoft Word - 2012 rev 2.00 Amateur Extra syllabus (zebrahamradio.com)
- A noise floor will increase as a receiver's bandwidth is increased.

# MDS—Minimum Discernable Signal

- Site noise floor
- Receiver
  - Noise Figure
    - Ratio in dB of the noise generated within the receiver itself compared to the theoretical minimum noise.
  - Sensitivity
  - selectivity

# FCC Pool Question E4C05

- What does a receiver noise floor of -174 dBm represent?
  - The theoretical noise in a 1 Hz bandwidth at the input of a perfect receiver at room temperature.

# FCC Pool Question E4C06

- A CW receiver with the AGC off has an equivalent input noise power density of -174 dBm/Hz. What would be the level of an unmodulated carrier input to this receiver that would yield an audio output SNR of 0 dB in a 400 Hz noise bandwidth?
  - Answer: -148 dBm
- Discussion
  - The level with a 400 Hz receiver bandwidth is the dB difference between a 1 Hz bandwidth and the 400 Hz bandwidth.
    - dB = 10 log(400/1) = 26 dB

# FCC Pool Question E4C07

- What does the MDS of a receiver represent
  - The minimum discernable signal

# 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