General License Class

Math Review

Decibels
Ohm's Law & Joule's Law
Basic Components in Parallel
Basic Components in Serial
Impedance Matching
AC Power
Amplitude and Frequency Modulation
Antenna Wave Length

How Much Math?

- Six groups of question in the general pool have math related questions.
- The maximum number of math questions is 6 but typically is only 2 to 3 questions.
- If you answer all math questions wrong and all other non-math question right you will still pass the test.
- See How Much Math is on the Amateur Radio Exams

Calculator Rules

- No Cell Phone Apps
- No Programmable Calculators
- Scientific Calculator Preferred

Decibel

$$Power_{gain} = \frac{Power_{output}}{Power_{input}} = 10^{\frac{dB}{10}}$$

$$dB = 10 \times \log\left(Power_{gain}\right) = 10 \times \log\left(\frac{Power_{out}}{Power_{input}}\right)$$

- Given dB want Power Gain, use exponentiation
- Given Power Gain want dB, use logarithm

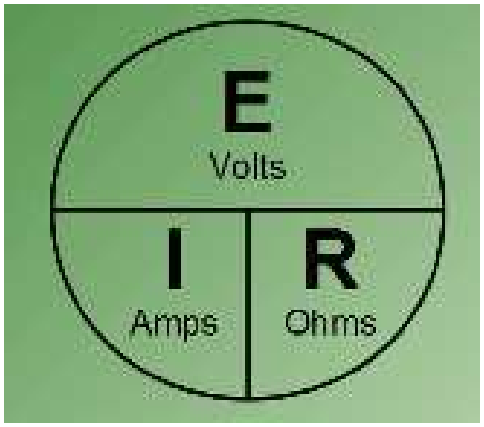
G4D05 How does a signal that reads 20 dB over S9 compare to one that reads S9 on a receiver, assuming a properly calibrated S meter?

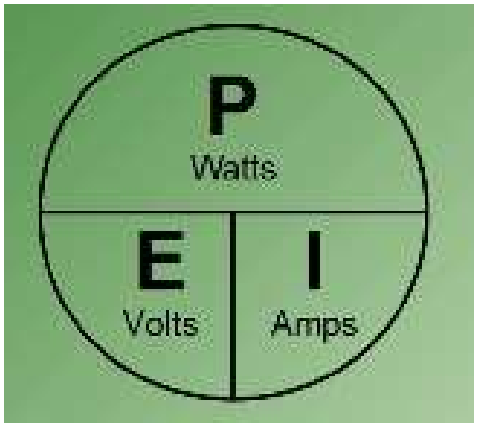
- Given dB and want Power Gain thus use exponentiation equation.
- $10^{\frac{20}{10}} = 10^2 = 10 \times 10 = 100$
- It is 100 times more powerful
- EL-501X: 20 ÷ 10 = 2nd F 10^x

G5B01 What dB change represents a two-times increase or decrease in power?

- Given power gain/attenuation and want dB, use logarithm equation
- $$dB = 10 \times \log\left(\frac{2}{1}\right) = 10 \times 0.301 \approx 3 \text{ dB}$$
- $$dB = 10 \times \log\left(\frac{1}{2}\right) = 10 \times (-0.301) \approx -3 \text{ dB}$$
- Approximately 3 dB
- EL-501X: 2 ÷ 1 = log x 10 =
- EL-501X: 1 ÷ 2 = log x 10 =

Ohm's Law & Joule's Law





- Use Ohm's Law when given two parameters, ohms, volts, or amps and want to find the third.
- Use Joule's Law when given two parameters, watts, volts, or amps and want to find the third.

G5B03 How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load?

- Given volts and ohms, want power.
- Must use both Ohm's Law and Joule's Law
- $I = \frac{E}{R} = \frac{400}{800} = 0.5 \text{ amps}$
- $P = 400 \times 0.5 = 200 \text{ watts}$
- 200 watts
- EL-501X: 400 x .5 =

G5B04 How many watts of electrical power are used by a 12 VDC light bulb that draws 0.2 amperes?

- Given volts and amps and find power, use Joule's Law
- $P = E \times I = 12 \times 0.2 = 2.4$ watts
- 2.4 watts
- EL-501X: 12 x .2 =

Basic Components

- Resistors in series share current
- $R_{\text{eq}} = R_1 + R_2 + \ldots + R_n$
- Resistors in parallel share voltage
- $\frac{1}{R_{eg}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$
-

	Series	Parallel
Inductor	As R in series	R in parallel
Capacitor	As R in parallel	As R in series

G5C03 Which of the following components should be added to an existing resistor to increase the resistance?

- Only same type components combine to equivalent
- $\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{5} = \frac{3}{10}$ $\qquad R_{eq} = \frac{10}{3} = 3.33 \text{ ohms}$
- $R_{eq} = 10 + 5 = 15 \text{ ohms}$
- A resistor in series
- EL-501X: 10 + 5 =
- EL-501X: 10 2nd F 1/x = + 5 = 2nd F 1/x
- Pick largest of the two which is resistors in series

G5C04 What is the total resistance of three 100 ohm resistors in parallel?

- Use parallel resistors equation
- $$\frac{1}{R_{eq}} = \frac{1}{100} + \frac{1}{100} + \frac{1}{100} = \frac{3}{100}$$
- $$R_{eq} = \frac{100}{3} = 33.3 \text{ ohms}$$
- 33.3 ohms
- EL-501X: 100 2nd F 1/x = + 100 2nd F 1/x 100 2nd F 1/x = 2nd F 1/x

Capacitors

- Capacitors in series add like resistors in parallel
- $$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}$$
- Capacitors in parallel add like resistors in series
- $$C_{eq} = C_1 + C_2 + \ldots + C_n$$

G5C08 What is the equivalent capacitance of two 5.0 nanofarad capacitors and one 750 picofarad capacitor connected in parallel?

- Capacitors in parallel add like resistors in series
- $C_{eq} = C_1 + C_2 + C_3 = 5 \times 10^{-9} + 5 \times 10^{-9} + 750 \times 10^{-12}$
- $10{,}750^{-12} = 10.750^{-9}$
- 10.75 nanofarads
- EL-501X: 5 Exp 9 +/- + 5 Exp 9 +/- +750 Exp 12 +/- F↔E

G5C12 What is the capacitance of a 20 microfarad capacitor connected in series with a 50 microfarad capacitor?

- Capacitors in series add like resistor in parallel
- $$\frac{1}{C_{eq}} = \frac{1}{20\times10^{-6}} + \frac{1}{50\times10^{-6}} = \frac{5}{100\times10^{-6}} + \frac{2}{100\times10^{-6}} = \frac{7}{100\times10^{-6}}$$
- $$C_{eq} = \frac{100}{7}\times10^{-6} = 14.29\times10^{-6} = 14.29 \text{ microfarads}$$
- 14.3 microfarads
- EL-501X: 20 Exp 6 +/- 2nd F 1/X + 50 Exp 6 +/- 2nd F 1/X = 2nd F 1/X F⇔E

Inductors

- Inductors in series add like resistors in series
- $L_{eq} = L_1 + L_2 + \ldots + L_n$
- Inductors in parallel add like resistors in parallel
- $\frac{1}{L_{eg}} = \frac{1}{L_1} + \frac{1}{L_2} + \ldots + \frac{1}{L_n}$

G5C10 What is the inductance of three 10 millihenry inductors connected in parallel?

- Inductors in parallel add like resistor in parallel
- $$\frac{1}{L_{eq}} = \frac{1}{10 \times 10^{-3}} + \frac{1}{10 \times 10^{-3}} + \frac{1}{10 \times 10^{-3}} = \frac{3}{10 \times 10^{-3}}$$
- $$L_{eq} = \frac{10 \times 10^{-3}}{3} = 3.3 \times 10^{-3} = 3.3 \text{ millihenrys}$$
- 3.3 milihenrys
- EL-501X: 10 Exp 3 +/- 2nd F 1/X + 10 Exp 3 +/- 2nd F 1/X + 10 Exp 3 +/- 2nd F 1/X = 2nd F 1/X F↔E

G5C11 What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor?

- Inductors in series add like resistors in series
- $L_{eq} = 20 \times 10^{-3} + 50 \times 10^{-3} = 70 \times 10^{-3} = 70$ milihenrys '
- 70 milihenrys
- EL-501X: 20 Exp 3 +/- + 50 Exp 3 +/- = F↔E

Transformers

- On exam used for impedance matching
- $Z_2 = \left(\frac{N_2}{N_1}\right)^2 \times Z_1$
- Also used for step-up or step-down transformer in real life
- $E_2 = \frac{N_2}{N_1} \times E_1$

G5C07 What is the turns ratio of a transformer used to match an audio amplifier having 600 ohm output impedance to a speaker having 4 ohm impedance?

- From Maximum Power Transfer Theorem we want the 600 ohm output of amplifier to match 600 ohm input to trans former with 4 ohm load
- $Z_{in} = (\frac{N_2}{N_1})^2 \times Z_{spkr}$
- $600 = (\frac{N_2}{N_1})^2 \times 4$
- $\frac{N_2}{N_1} = \sqrt{\frac{600}{4}} = 12.2$
- 12.2 to 1
- EL-501X: 600 ÷ 4 = √

AC Power

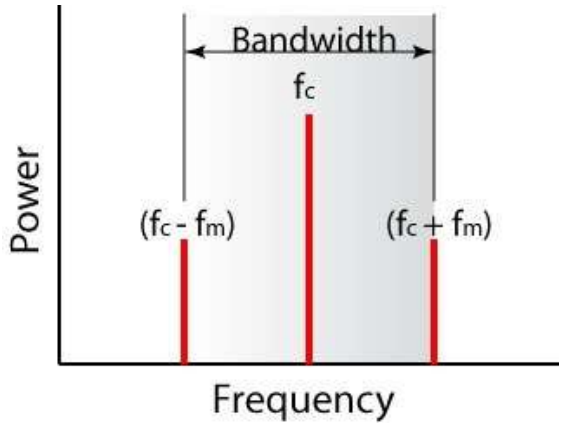
- Parameters can be measured in peak-to-peak, peak or root-mean-squared
- $$V_{\text{peak}} = \frac{V_{\text{peak-to-peak}}}{2}$$
- $$V_{\text{RMS}} = 0.707 \times V_{\text{peak}}$$
- All problems are without modulation
- Peak-Envelope-Power is Power RMS

G5B12 What would be the RMS voltage across a 50 ohm dummy load dissipating 1200 watts?

- $I = \frac{E}{R}$
- $P = E \times I = \frac{E \times E}{R} = \frac{E^2}{R}$
- $E = \sqrt{R \times P}$
- $E_{RMS} = \sqrt{50 \times 1200} = 244.9 \text{ or } 245 \text{ volts}_{RMS}$
- EL-501X: 50 x 1200 = √

Amplitude Modulation

- With a carrier wave of frequency f_c and a modulating sine-wave of frequency f_m the output of the modulator is carrier wave of the original amplitude and frequency, an upper side band signal of up to ½ the carrier amplitude and a frequency of $f_c + f_m$, and a lower side band signal of up to ½ the carrier amplitude and a frequency of $f_c - f_m$



G4D08 What frequency range is occupied by a 3 kHz LSB signal when the displayed carrier frequency is set to 7.178 MHz?

- The displayed frequency is the virtual carrier frequency, f_c.
- f_{lsb} = 3 kHz = 0.003 MHz
- Since lower side band f_c - f_{lsb}=7.175 MHz to f_c = 7.178 MHz
- EL-501X: 7.178 Exp 6 – 3 Exp 3 = F↔E

Frequency Modulation

- Mathematics of FM much more complex than AM
- Carson's Rule states 98% of the power in FM signal is within the bandwidth B_T where

  $B_T = 2x(f_{deviation} + f_m)$

G8B06 What is the total bandwidth of an FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency?

- Use Cramer's Rule for 98% of the power
- $B_T = 2x(5+3) = 2x8 = 16$ kHz
- EL-501X: 2 x (5 Exp 3 + 3 Exp 3) = F↔E

Standing Wave Ratio

- Defined as: $$SWR = \frac{1 + \sqrt{\frac{P_r}{P_f}}}{1 - \sqrt{\frac{P_r}{P_f}}}$$

- For problems on exam use $$SWR = \frac{Z_{\text{Largest}}}{Z_{\text{Smallest}}}$$

G9A09 What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 200 ohm impedance?

- $SWR = Z_{\text{Largest}} / Z_{\text{Smallest}} = 200/50 = 4$
- SWR is 4:1
- EL-501X: 200 ÷ 50 =

Antenna Wave Length

- Wave length, λ, velocity of wave, *v*, and frequency *f*
- All waves $\lambda = \frac{v}{f}$
- Radio wave is metric units $\lambda = \frac{300}{f}$
- Radio wave in feet $\lambda = \frac{984}{f}$
- ½ wave dipole in feet $\lambda = \frac{492}{f}$

G9B10 What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 MHz?

- $\lambda = (2 \text{ x } 246) / f = 492 / 14.250 = 34.5$ feet
- Closest answer is 32 feet
- EL-501X: 2 x 246 ÷ 14.250 =
- 2-4-6-8 who do we appreciate