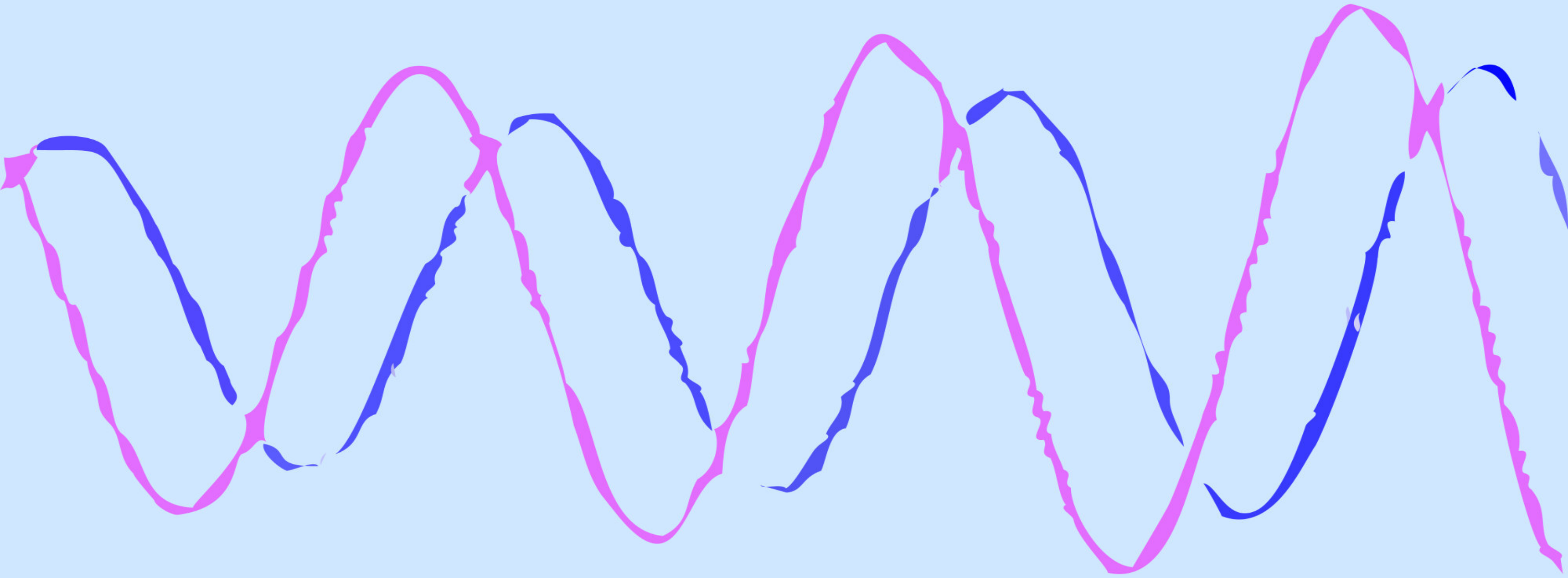

EASY(ER) ELECTRICAL PRINCIPLES

FOR

GENERAL CLASS HAM LICENSE

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This book deals just with the electrical principles portion of the general class exam. While exam questions might seem simple to someone who already plays with electronics, often they look overly complex to those just starting their journey.

Idea of this (mini) book is to show you each question with correct answer in addition to a small comment by me that might help you remember it when you take your exam.

Thus, the intention of any comment given is to simplify your exam and therefore they'll often lead into oversimplification or (partial) untruths. Those comments are intended to help you remember the answer and nothing else.

Once you have your license sorted out, the real learning can start. But use some other book for that.

Good luck!

Josip Medved, AF7RG

G5
ELECTRICAL PRINCIPLES

G5A
Reactance; inductance; capacitance; impedance; impedance matching

There are only three components you need to understand here.

Resistor *is a component that* ***resists flow*** *of the electrical current and its property of resistance is expressed in the unit of* ***Ohm*** *(Ω).*

Capacitor is a component that resists signals at low frequencies but passes whatever comes at a high frequency. I personally simply remember that ***capacitor loves high frequencies*** *(since it passes them through).*

Inductor is a component that resists signals at high frequencies but passes whatever comes at a low frequency. It is essentially quite the opposite of how a capacitor behaves. That is, ***inductor loves low frequencies****.*

Impedance *is an opposition to the* ***flow of current*** *in AC circuit. When connecting two components (e.g., feed line and antenna)* ***closer their impedances are, less power is lost****.*

Reactance *is pretty much the same thing as* ***impedance*** *but narrowed for* ***capacitance and/or inductance*** *in a circuit only. Both have Ohm (Ω) as the unit.*

G5A01
What is impedance?

A: The electric charge stored by a capacitor
B: The inverse of resistance
C: The opposition to the flow of current in an AC circuit
D: The force of repulsion between two similar electric fields

As the name says, something is impeded. In this case it is the current.

G5A02
What is reactance?

A: Opposition to the flow of direct current caused by resistance
B: Opposition to the flow of alternating current caused by capacitance or inductance
C: A property of ideal resistors in AC circuits
D: A large spark produced at switch contacts when an inductor is de-energized

Impedance and reactance share quite a lot together. It is just that the former is specific for capacitors and inductors.

G5A03
Which of the following causes opposition to the flow of alternating current in an inductor?

A: Conductance
B: Reluctance
C: Admittance
D: Reactance

Reactance applies to capacitors and inductors only.

G5A04
Which of the following causes opposition to the flow of alternating current in a capacitor?

A: Conductance
B: Reluctance
C: Reactance
D: Admittance

Reactance applies to both a capacitor and an inductor. And to the déjà vu feeling you have.

G5A05
How does an inductor react to AC?

A: As the frequency of the applied AC increases, the reactance decreases
B: As the amplitude of the applied AC increases, the reactance increases
C: As the amplitude of the applied AC increases, the reactance decreases
D: As the frequency of the applied AC increases, the reactance increases

An inductor loves low frequencies. Since reactance is essentially an opposition to the flow of current, we can deduce that any rise in a frequency will not be appreciated. For an inductor, the increase in a frequency leads to the increase of reactance.

G5A06
How does a capacitor react to AC?

A: As the frequency of the applied AC increases, the reactance decreases
B: As the frequency of the applied AC increases, the reactance increases
C: As the amplitude of the applied AC increases, the reactance increases
D: As the amplitude of the applied AC increases, the reactance decreases

A capacitor loves high frequencies and thus it won't oppose any increase. As the reactance is a measure of opposition, we can tell that capacitor's reactance will decrease as frequency increases.

G5A07
What happens when the impedance of an electrical load is equal to the output impedance of a power source, assuming both impedances are resistive?

A: The source delivers minimum power to the load
B: The electrical load is shorted
C: No current can flow through the circuit
D: The source can deliver maximum power to the load

Any mismatch in the impedance will cause a loss of power. No mismatch means that a maximum power is delivered to the load.

G5A08
What is one reason to use an impedance matching transformer?

A: To minimize transmitter power output
B: To maximize the transfer of power
C: To reduce power supply ripple
D: To minimize radiation resistance

Any mismatch in impedance will cause a loss of power. And you don't want that.

G5A09
What unit is used to measure reactance?

A: Farad
B: Ohm
C: Ampere
D: Siemens

Pretty much any opposition (or resistance) is measured in Ohms. This goes for the reactance too.

G5A10
Which of the following devices can be used for impedance matching at radio frequencies?

A: A transformer
B: A Pi-network
C: A length of transmission line
D: All these choices are correct

Pretty much everything impacts impedance matching (or lack thereof) if you can push power through it. That also means (almost) anything can be used to adjust the same.

G5A11
Which of the following describes one method of impedance matching between two AC circuits?

A: Insert an LC network between the two circuits
B: Reduce the power output of the first circuit
C: Increase the power output of the first circuit
D: Insert a circulator between the two circuits

LC network consists of inductors (L) and capacitors (C). Both of these components have a major impact on impedance.

Increasing or reducing the power doesn't change the mismatch. A circulator, while actually an actual device, has nothing to do with impedance (or power at all).

G5B
The decibel; current and voltage dividers; electrical power calculations; sine wave root-mean-square (RMS) values; PEP calculations

*Decibels look weird as they use logarithms. However, they become just an exercise in conversion once you understand that **every 3 dB is doubling of power**.*

Assuming you start with 1 W, a 3 dB increase will result in 2 W; a 6 dB increase will result in 4 W; and a 9 dB increase will result in 8 W. Conveniently a 10 dB is the same as tenfold increase.

***A single dB is around 20% of a value**.*

There are many formulas for power, but you need only three for this exam:

- $P = E \times R$ (aka Power = Voltage × Current, $W = V \times A$)
- $P = I^2 \times R$ (aka $Power = Current^2 \times Resistance$, $W = A^2 \times \Omega$)
- $P = E^2 \div R$ (aka $Power = Voltage^2 \div Resistance$, $W = V^2 \div \Omega$)

*It's really important to take into account that formulas assume DC voltage. For AC voltage, we need to convert it to RMS value first (that's essentially DC-equivalent). If we see a peak voltage, we can easily convert it to the equivalent RMS value by multiplying it with **0.7**. If we see peak-to-peak, then multiplying with **0.35** grants you the same.*

G5B01
What dB change represents a factor of two increase or decrease in power?
A: Approximately 2 dB
B: Approximately 3 dB
C: Approximately 6 dB
D: Approximately 12 dB

Every 3 dB we double the power.

G5B02
How does the total current relate to the individual currents in each branch of a purely resistive parallel circuit?
A: It equals the average of each branch current
B: It decreases as more parallel branches are added to the circuit
C: It equals the sum of the currents through each branch
D: It is the sum of the reciprocal of each individual voltage drop

Current in electronic circuits behaves as its river namesake. If you have multiple branches, total current is divided among them.

G5B03
How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load?
A: 0.5 watts
B: 200 watts
C: 400 watts
D: 3200 watts

If we apply the formula for power ($P = E^2 \div R$), to values given, we get to $P = (400\,V)^2 \div 800\,\Omega$. Assuming calculator is not nearby, the good news is that we can ignore all extra zeros and just do $4^2 \div 8$.

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

- **A: 2.4 watts**
- B: 24 watts
- C: 6 watts
- D: 60 watts

If we apply the formula for power ($P = E \times I$), to values given, we get to $P = 12\,V \times 0.2\,mA$.

G5B05
How many watts are dissipated when a current of 7.0 milliamperes flows through a 1250 ohm resistance?

- **A: Approximately 61 milliwatts**
- B: Approximately 61 watts
- C: Approximately 11 milliwatts
- D: Approximately 11 watts

If we apply the formula for power ($P = I^2 \times R$), to values given, we get to $P = (0.007\,A)^2 \times 1250\,\Omega$.

G5B06
What is the output PEP from a transmitter if an oscilloscope measures 200 volts peak-to-peak across a 50 ohm dummy load connected to the transmitter output?

- A: 1.4 watts
- **B: 100 watts**
- C: 353.5 watts
- D: 400 watts

For PEP (peak envelope power), we can still use one of the main power formulas: $Power = Voltage^2 \div Resistance$. However, because this formula is for DC (direct current) world and we're dealing with AC (alternating current) here, we need to get an equivalent voltage value (aka RMS) first.

Once you insert numbers, this ends up as $P = (200\,V \times 0.35)^2 \div 50\,\Omega$. Once written into a calculator, the final result gets you close to 100 W answer.

If you're wondering why our result is not exact, that's because the factor is not actually 0.35 but more precisely ($\sqrt{2} \div 4$). In reality, 0.35 is close enough.

G5B07
What value of an AC signal produces the same power dissipation in a resistor as a DC voltage of the same value?

- A: The peak-to-peak value
- B: The peak value
- **C: The RMS value**
- D: The reciprocal of the RMS value

RMS value of an AC voltage gives you a DC voltage equivalent.

G5B08
What is the peak-to-peak voltage of a sine wave with an RMS voltage of 120.0 volts?

- A: 84.8 volts
- B: 169.7 volts
- C: 240.0 volts
- **D: 339.4 volts**

We know that, to convert peak-to-peak voltage to RMS, we need to use factor 0.35. If we apply that factor to all answers above, 339.4 V is the only plausible answer.

G5B09
What is the RMS voltage of a sine wave with a value of 17 volts peak?

- A: 8.5 volts
- **B: 12 volts**
- C: 24 volts
- D: 34 volts

To convert a peak voltage value to RMS, we need to use the factor of 0.7. If we multiply 17 V with 0.7, we get about 12 V.

G5B10
What percentage of power loss would result from a transmission line loss of 1 dB?

A: 10.9 percent
C: 20.6 percent
B: 12.2 percent
D: 25.9 percent

1 dB is about 20%.

G5B11
What is the ratio of peak envelope power to average power for an unmodulated carrier?

A: 0.707
B: 1.00
C: 1.414
D: 2.00

If there's no modulation, the ratio is 1:1.

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

A: 173 volts
B: 245 volts
C: 346 volts
D: 692 volts

We can use the following power formula here: $P = E^2 \div R$. *Once we put numbers in, we get* $1{,}200\,W = E^2 \div 50\,\Omega$. *A bit of rearranging brings us to the final* $E = \sqrt{(1{,}200\,W \times 50\,\Omega)}$ *calculation.*

G5B13
What is the output PEP of an unmodulated carrier if an average reading wattmeter connected to the transmitter output indicates 1060 watts?

A: 530 watts
B: 1060 watts
C: 1500 watts
D: 2120 watts

This is a trick question. If you have unmodulated carrier, your output PEP and average readings are the same.

G5B14
What is the output PEP from a transmitter if an oscilloscope measures 500 volts peak-to-peak across a 50 ohm resistive load connected to the transmitter output?

A: 8.75 watts
B: 625 watts
C: 2500 watts
D: 5000 watts

This is essentially the same calculation as one we already did for PEP a few questions ago. Formula is the same: $Power = Voltage^2 \div Resistance$ *with all the same notes about the conversion to RMS.*

Once you insert numbers, this ends up as $P = (500\,V \times 0.35)^2 \div 50\,\Omega$. *Entering that into a calculator will get you close enough to 625 W.*

G5C
Resistors, capacitors, and inductors in series and parallel; transformers

A transformer is just a weird inductor. It takes energy on the primary side and "converts" it to the secondary windings.

More resistors you have in a line (aka series), the more resisting they will cause*. If they are connected in the* ***parallel, a total value will always be smaller than smallest individual resistor value****. If resistors are the same in size (e.g., three parallel resistors of 100Ω), the final value will be the individual value divided by number (100Ω / 3).*

Inductors follow the same parallel/serial values principle as resistors do.

Capacitors *on the other hand have their total value* ***increase when connected in parallel*** *and it is lower when in series. The exact opposite behavior as compared to resistors and inductors.*

Prefixes ***pico, nano, and micro*** *are in the ascending order. That is, picofarad capacitor would be much smaller than microfarad capacitor. Nanofarad falls in between.*

G5C01
What causes a voltage to appear across the secondary winding of a transformer when an AC voltage source is connected across its primary winding?

A: Capacitive coupling
B: Displacement current coupling
C: Mutual inductance
D: Mutual capacitance

If you imagine a transformer as a weird inductor and you remember that inductors love voltage, you'll find the answer.

G5C02
What happens if a signal is applied to the secondary winding of a 4:1 voltage step-down transformer instead of the primary winding?

A: The output voltage is multiplied by 4
B: The output voltage is divided by 4
C: Additional resistance must be added in series with the primary to prevent overload
D: Additional resistance must be added in parallel with the secondary to prevent overload

If you reverse the windings, you reverse the roles of the primary and the secondary side thus reversing their ratio too.

G5C03
Which of the following components increases the total resistance of a resistor?

A: A parallel resistor
B: A series resistor
C: A series capacitor
D: A parallel capacitor

Resistors resist more when they are one after another.

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

A: 0.30 ohms
B: 0.33 ohms
C: 33.3 ohms
D: 300 ohms

Resistors connected in parallel will have their total value always lower than any individual value would be. And since they are all the same, you only need to divide the value by 3.

G5C05
If three equal value resistors in series produce 450 ohms, what is the value of each resistor?

A: 1500 ohms
B: 90 ohms
C: 150 ohms
D: 175 ohms

We know that resistance values are added together if they are in series. Since question talks about equal values, dividing 450 by 3 gives us 150 Ω as the answer.

G5C06
What is the RMS voltage across a 500-turn secondary winding in a transformer if the 2250-turn primary is connected to 120 VAC?

A: 2370 volts
B: 540 volts
C: 26.7 volts
D: 5.9 volts

This is just a matter of ratios. The higher turn count, the higher voltage goes. Since primary has around 2000 turns and secondary has about 500 turns, we know their ratio is 4:1. If we then apply the same ratio to 120 V from question, we get 30 V. The closest value to 30 volts is 26.7 V.

And yes, had we used the exact values from question, our calculation would lead us to the exact answer. However, heavy rounding will still point us toward the correct value and it's much easier.

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?

A: 12.2 to 1
B: 24.4 to 1
C: 150 to 1
D: 300 to 1

The reflex answer here would be 150:1 and it would be true if we were dealing with voltages. However, the impedance has a square relation with the turn ratio. Square root of 150 is slightly more than 12 so ration 12.2:1 is the correct answer.

Thankfully, this question is an oddball.

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

A: 576.9 nanofarads
B: 1733 picofarads
C: 3583 picofarads
D: 10.750 nanofarads

Capacitors connected in parallel will have their values added. Just based on two 5 nanofarad capacitors connected, we know value will be at least 10 nanofarads. The additional picofarad capacitor brings it up just a smidgen.

G5C09
What is the capacitance of three 100 microfarad capacitors connected in series?

A: 0.30 microfarads
B: 0.33 microfarads
C: 33.3 microfarads
D: 300 microfarads

Capacitors connected in series behave opposite of how resistors would. Therefore, values for three serial capacitors will behave same as they would for three parallel resistors. In other words, just divide by 3.

G5C10
What is the inductance of three 10 millihenry inductors connected in parallel?
A: 0.30 henries
B: 3.3 henries
C: 3.3 millihenries
D: 30 millihenries

The same formula as for parallel resistors applies – just divide by 3.

G5C11
What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor?
A: 0.07 millihenries
B: 14.3 millihenries
C: 70 millihenries
D: 1000 millihenries

Resistors and inductors both add their values together when connected in series.

G5C12
What is the capacitance of a 20 microfarad capacitor connected in series with a 50 microfarad capacitor?
A: 0.07 microfarads
B: 14.3 microfarads
C: 70 microfarads
D: 1000 microfarads

Values of capacitors connected in series can be calculated in the same manner as for resistors connected in parallel. That is, their total value will be just a smidge smaller than any one of them.

G5C13
Which of the following components should be added to a capacitor to increase the capacitance?
A: An inductor in series
B: A resistor in series
C: A capacitor in parallel
D: A capacitor in series

Capacitors connected in parallel behave as resistors and inductors do when connected in series. That is, their total value will be increased.

G5C14
Which of the following components should be added to an inductor to increase the inductance?
A: A capacitor in series
B: A resistor in parallel
C: An inductor in parallel
D: An inductor in series

Both inductors and resistors sum their values when placed in series.

G5C15
What is the total resistance of a 10 ohm, a 20 ohm, and a 50 ohm resistor connected in parallel?
A: 5.9 ohms
B: 0.17 ohms
C: 10000 ohms
D: 80 ohms

Total resistance of resistors connected in parallel will always be slightly below the value lowest of them has.

G5C16
Why is the conductor of the primary winding of many voltage step-up transformers larger in diameter than the conductor of the secondary winding?
A: To improve the coupling between the primary and secondary
B: To accommodate the higher current of the primary
C: To prevent parasitic oscillations due to resistive losses in the primary
D: To ensure that the volume of the primary winding is equal to the volume of the secondary winding

Thicker the wire, bigger current it supports.

G5C17
What is the value in nanofarads (nF) of a 22,000 picofarad (pF) capacitor?

A: 0.22
B: 2.2
C: 22
D: 220

Nanofarads are three zeros away from picofarads, so we get to the correct answer by simply moving three decimal places to the left.

G5C18
What is the value in microfarads of a 4700 nanofarad (nF) capacitor?

A: 47
B: 0.47
C: 47,000
D: 4.7

Microfarads are three zeros away from nanofarads, so we again get to the correct answer by simply moving three decimal places to the left.

Congratulations on going through all the questions.
Do go over them one more time.