General Class Unit 5
Question Pool §5

Electrical Principles

3 Questions

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Impedance

Impedance is a measure of *the opposition to the flow of current in an AC circuit*.

Impedance is measured in Ohms (Ω) and represented by the letter *Z*.

Impedance matching of a power source to an electrical load is important because then *the source can deliver maximum power to the load*.

Impedance is the sum of resistance and reactance.

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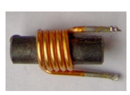
G5A01 G5A07

Reactance

Reactance is *the opposition to the flow of alternating current caused by capacitance or inductance*.

Reactance is measured in *Ohms* (Ω).



In an inductor as *the frequency of the applied AC increases, the reactance increases*.

Inductors block AC and pass DC.

In a capacitor as *the frequency of the applied AC increases, the reactance decreases*.

Capacitors block DC and pass AC.

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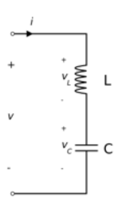
G5A03/G5A04 G5A02 G5A09 G5A05 G5A06

Impedance Matching

A method of matching impedance is to *insert an LC network between the two circuits*.



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G5A11

Impedance Matching

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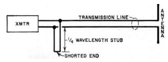
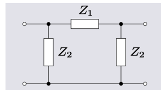
G5A10 G5A08
Z1 is usually an inductor. Z2 is usually a capacitor.

When needing to match impedances, one can use:

- *A length of transmission line.*
- *A Pi-network* or π-network.
- *A transformer.*

One reason to use an impedance matching transformer *to maximize the transfer of power*.





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Ohm's and Watt's Laws

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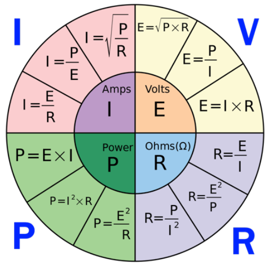
(G5B04)



Power, Voltage, Current & Resistance Calculator

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Ohm's and Watt's Laws

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(G5B04)

Ohm's Law	Watt's Law
$E=IR$	$P=IE$
$I=\frac{E}{R}$	$P=I^2R$
$R=\frac{E}{I}$	$E=\sqrt{PR}$

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Power Example

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$$P=\frac{E^2}{R}$$

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

$$P=\frac{(400V)(400V)}{800\Omega}$$

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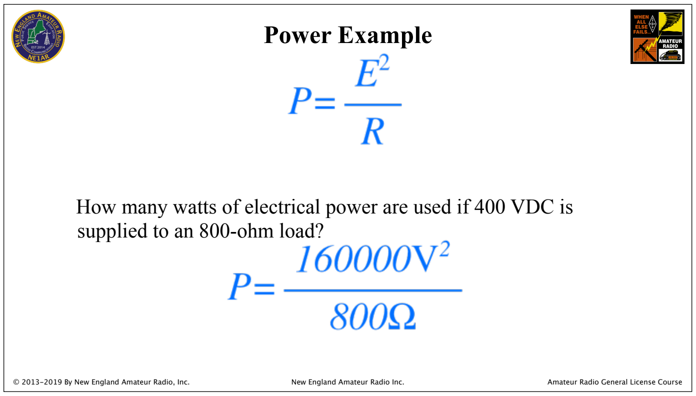

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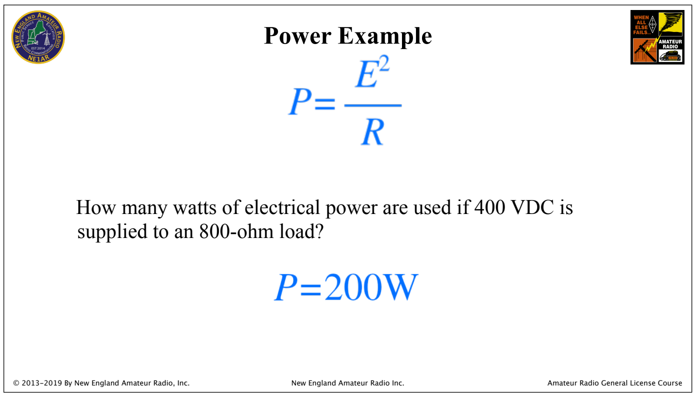

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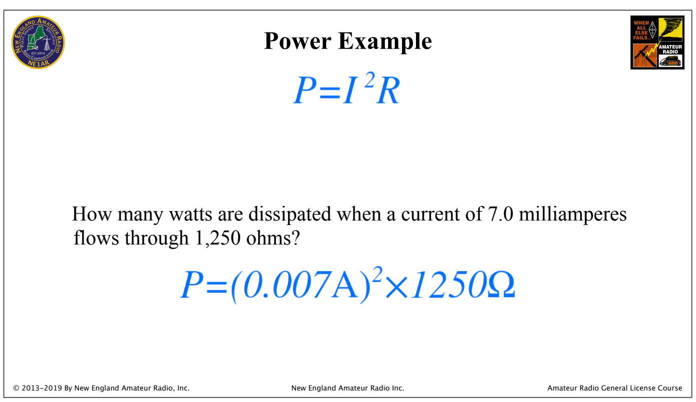
G5B03 (G5B012)



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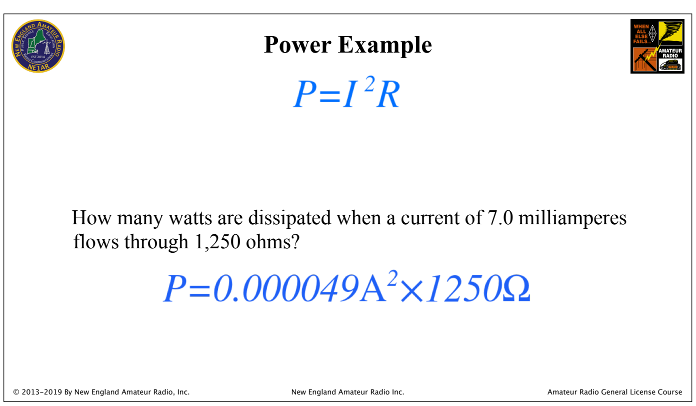

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Power Example

$$P=I^2R$$

How many watts are dissipated when a current of 7.0 milliamperes flows through 1,250 ohms?

$$P=0.06125\text{W}$$

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Power Example

$$P=I^2R$$

How many watts are dissipated when a current of 7.0 milliamperes flows through 1,250 ohms?

$$P=61.25\text{mW}$$

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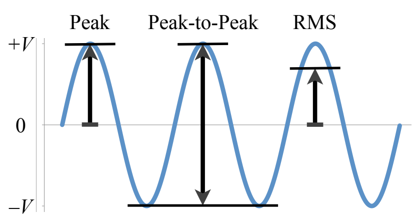
Measuring AC Voltages



$\frac{1}{2}PP$ $2P$ $\frac{1}{\sqrt{2}}P$

$\sqrt{2}\,RMS$

$1.414\times RMS$ $0.7071\times P$

39 (G5B07 G5B08 G5B09)

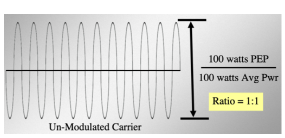
PEP & PP

Peak envelope power (PEP) is calculated using the RMS voltage in Watt's Law.

$$PEP=\frac{(V_{RMS})^2}{R}$$

The ratio of peak envelope power to average power is *1.00* for an unmodulated carrier.

An unmodulated carrier gives a straight RF carrier wave, so the average and peak envelope voltages are the same, so the ratio is 1:1 or 1.00.



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PEP & PP

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G5B06 (G5B13 G5B14)

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?

So we know E_{PP} = 200V and R = 50Ω, but we need E_{RMS}.

$$E_P = \frac{1}{2} E_{PP} = \frac{1}{2} 200\text{V} = 100\text{V}$$

$$E_{RMS} = \frac{1}{\sqrt{2}} E_P = 0.7071 E_P = 0.7071 \times 100\text{V} = 70.71\text{V}$$

$$P = \frac{E_{RMS}^2}{R} = \frac{(70.71\text{V})^2}{50\Omega} = \frac{5000\text{V}^2}{50\Omega} = 100\text{W}$$

Decibels

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G5B01 G5B10

Decibels measure the ratio of change between two values.

They are used to talk about a large range of values.

$$dB = 10\log\left(\frac{P_1}{P_2}\right) \quad P_1 = 10^{\frac{dB}{10}} P_2$$

A factor of two increase or decrease in power results in *approximately 3 dB* change.

A 1 dB line loss would result in a *20.6 percent* power loss.

Parallel and Series Circuits

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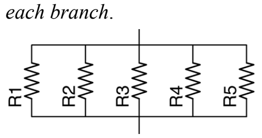
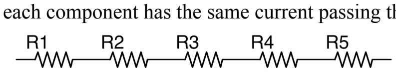
G5B02

A parallel circuit allows each component to have the same voltage potential across each component.

The total current through a parallel circuit is *the sum of the currents through each branch*.



A series circuit has each component connected along a single path, so each component has the same current passing through it.



Parallel and Series Circuits

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How do you calculate the total value of a circuit when you arrange a type of component together in a parallel or series circuit?

The total value of a set of components can be calculated using one of two equations:

$$N_{Total} = N_1 + N_2 + \cdots + N_n$$

$$N_{Total} = \frac{1}{\frac{1}{N_1} + \frac{1}{N_2} + \cdots + \frac{1}{N_n}}$$

Parallel and Series Circuits

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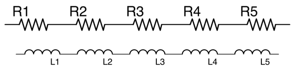
G5C03 G5C13 G5C14 (G5C05 G5C08 G5C11)

$$N_{Total}=N_1+N_2+\cdots+N_n$$

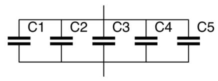
Add the values of each component together.

Used for:

- Resistors in series
- Inductors in series



- Capacitors in parallel



Parallel and Series Circuits

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$$N_{Total}=\frac{1}{\frac{1}{N_1}+\frac{1}{N_2}+\cdots+\frac{1}{N_n}}$$

When dealing with only two components this can be simplified to:

$$N_{Total}=\frac{N_1N_2}{N_1+N_2}$$

Parallel and Series Circuits

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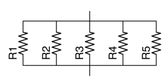
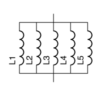
$$N_{Total}=\frac{1}{\frac{1}{N_1}+\frac{1}{N_2}+\cdots+\frac{1}{N_n}} \qquad N_{Total}=\frac{N_1N_2}{N_1+N_2}$$

Used for:

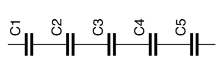
- Resistors in parallel



- Inductors in parallel



- Capacitors in series



Parallel Resistor Calculation

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G5C15 (G5C04 G5C09 G5C10)

$$N_{Total}=\frac{1}{\frac{1}{N_1}+\frac{1}{N_2}+\cdots+\frac{1}{N_n}}$$

What is the total resistance of a 10 ohm, 20 ohm, and 50 ohm resistor in parallel?

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Series Capacitor Calculation

$$N_{Total} = \frac{N_1 N_2}{N_1 + N_2}$$

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

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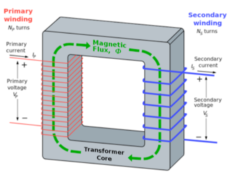
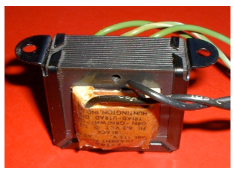
Transformers





Transformers have a primary and a secondary winding.

The primary winding is connected to the incoming source of energy.

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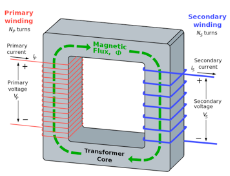
Transformers



Transformers work by *mutual inductance* between the primary and secondary windings.

RMS voltage and current between the primary and secondary windings are related to the ratio of the number of windings.

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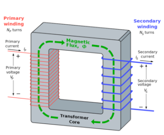
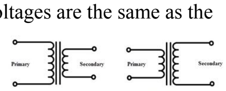
Transformers



$$\frac{E_P}{E_S} = \frac{N_P}{N_S} = a$$

The ratio of the primary and secondary voltages are the same as the ratio of the number of windings of wire.



If $a > 1$, it is a step-down transformer; if $a < 1$, it is a step-up transformer.

If a signal is applied to the secondary winding of a 4:1 voltage step-down transformer instead of the primary winding, *the output voltage is multiplied by 4.*

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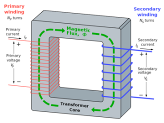
G5C16

Transformers



$$\frac{E_P}{E_S} = \frac{N_P}{N_S} = a$$

The conductor of the primary winding of many voltage step-up transformers is larger in diameter than the conductor of the secondary winding *to accommodate the higher current of the primary*.

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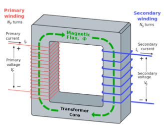
Transformers



$$\frac{E_P}{E_S} = \frac{N_P}{N_S} = a$$

$$Z_P = a^2 Z_S \qquad a = \sqrt{\frac{Z_P}{Z_S}}$$

A transformer can also be used for impedance matching.

Impedance matching through a transformer is related to the square of the ratio of the windings.

Transformers are often used to match audio (speaker) or RF (antenna) impedance between sources and loads.

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G5C06

Transformers

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

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G5C07

Transformers

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

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