Math for the General Class Ham Radio Operator

A prerequisite math refresher for the math phobic ham

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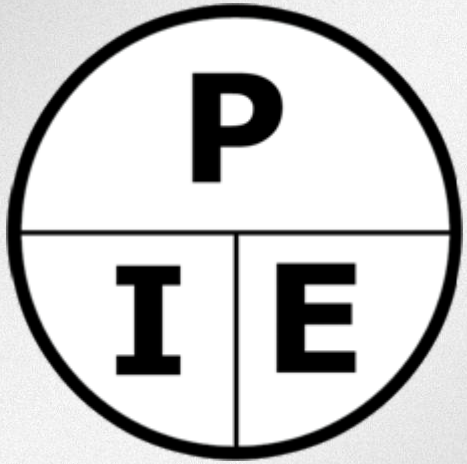
What We Will Cover

Write these down!

Ohm’s Law



Power Circle

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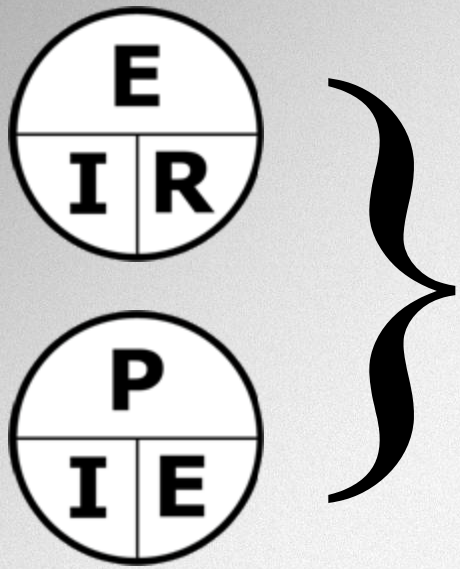
What We Will Cover

Write these down!



$$P = E \times I$$

$$P = I^2 \times R$$

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

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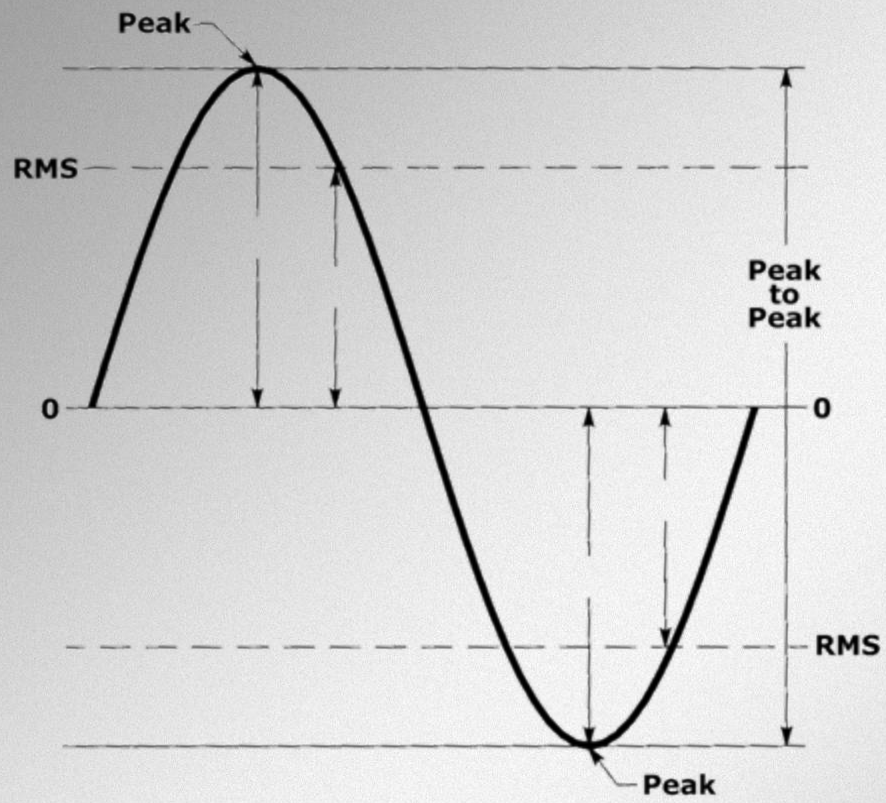
What We Will Cover



Write this down!

How to calculate RMS (root mean square) of an AC voltage

RMS = .707 x Peak

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What We Will Cover

Write these down!

$$V_{Peak} = 1.414 V_{RMS}$$

Peak Voltage to RMS

$$V_{P-to-P} = 2 \times V_{Peak}$$

Peak-to-Peak Voltage to Peak Voltage

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

Peak Envelope Power

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What We Won't Cover

Power Measurement in dB

$$dB = 10 \log_{10}\left(\frac{P2}{P1}\right)$$

$$\log_{10} N = L$$

Why? Only 1 math question on test dealing with dB

Yes, this is important, but will take too much class time, sorry

Pages 4-3 thru 4-5

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Teach to the Test

Not generally a good idea, but:

- Section 5 = 3 questions out of 3 groups
- Section 5 = 3 groups, 1 from each group
- Section 5B = 1 test question out of 13

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Pages 11-42 thru 11-43

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Math Vocabulary

- What are equations and formulas?
- What do variables mean?
- What does solving an equation mean?
- Getting the final answer!

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Math Vocabulary
What are equations and formulas?

- Equations are relationships between things that are exactly equivalent (have the same overall value).
- Two equivalent sets of things are shown equal by using the equal sign (=).
- The left side of the = has the same value as the right side.

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Math Vocabulary
What do variables mean?

It’s all about the cheese!

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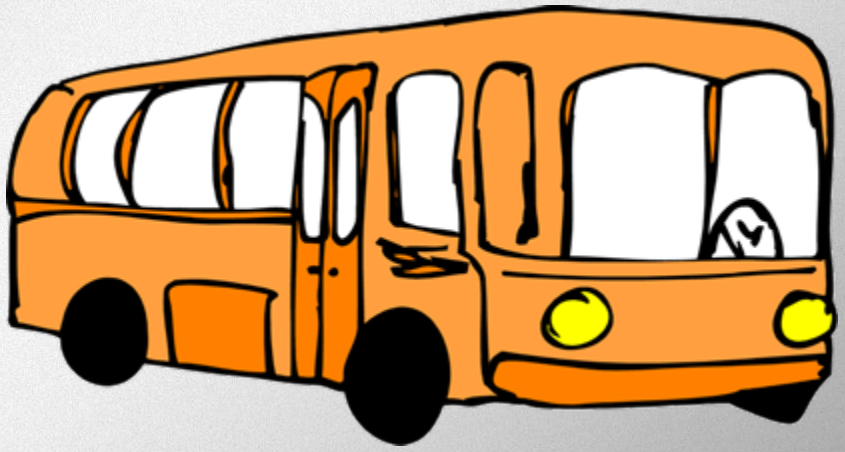
Math Vocabulary
What do variables mean?

50 x  =



If 50 cheese-heads can fit into 1 bus…

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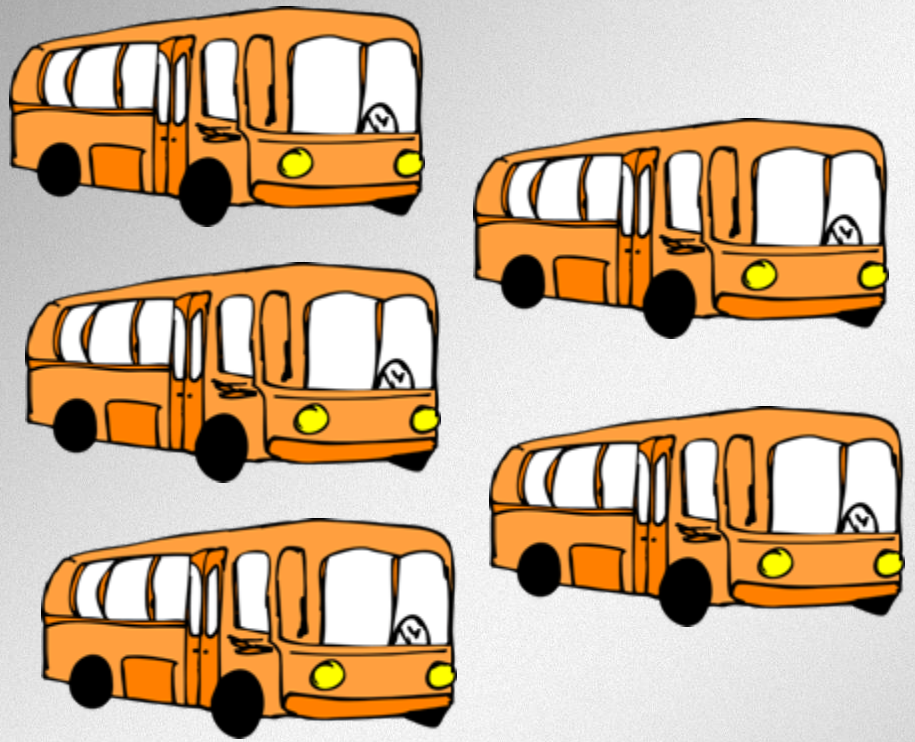
Math Vocabulary
What do variables mean?



= ?

How many cheese-heads are there in 5 busses?

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Math Vocabulary
What do variables mean?

5 x 50 = 250

That’s a lot of cheese-heads!

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Math Vocabulary
What do variables mean?

E = Voltage (Volts)

The electromotive force it takes to push electrons

I = Current (Amps)

The flow of electrons

R = Resistance (Ohms)

Opposition of a material to current flow

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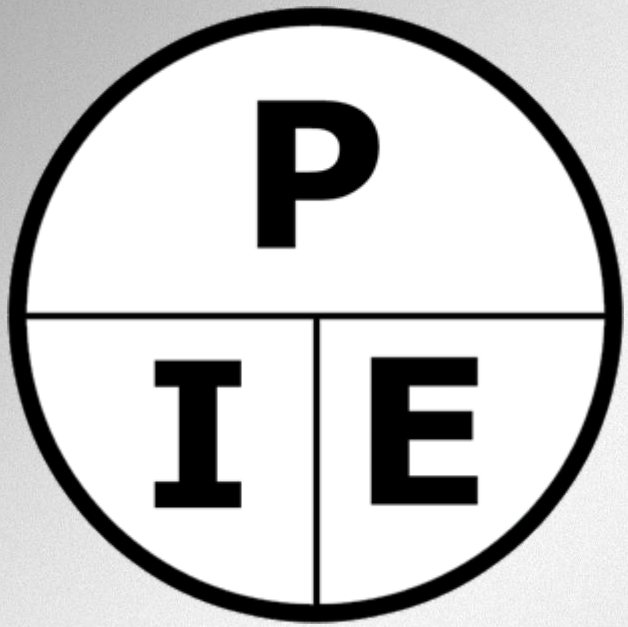
Math Vocabulary
What do variables mean?



P = Power (Watts)

The product of voltage and current

I = Current (Amps)

The flow of electrons

E = Voltage (Volts)

The electromotive force it takes to push electrons

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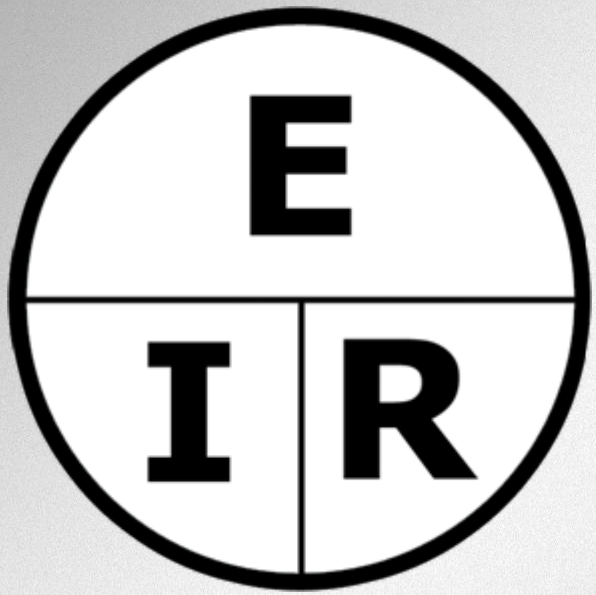
Math Vocabulary
Equations from Ohm's Law



$$E = I \times R$$

$$I = E \div R$$

$$R = E \div I$$

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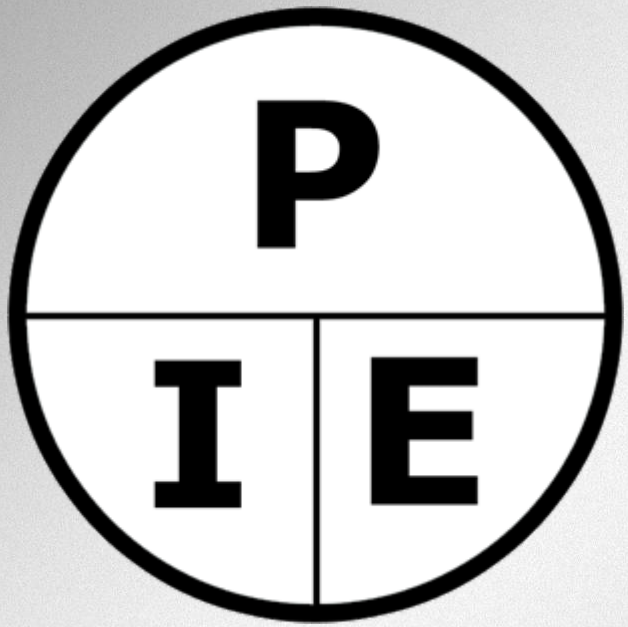
Math Vocabulary
Equations from Power Circle

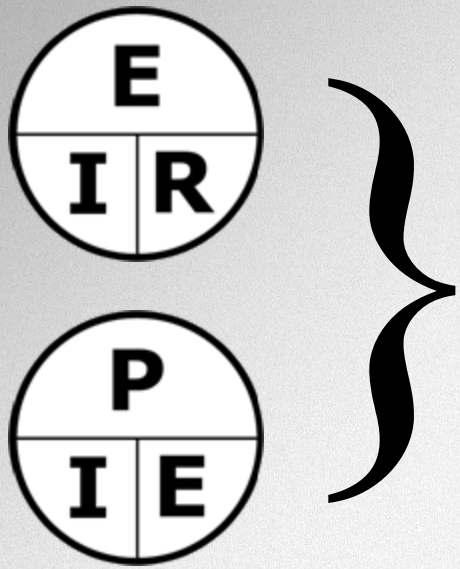


$P = I \times E$

$I = P \div E$

$E = P \div I$

Let's Put Them Together

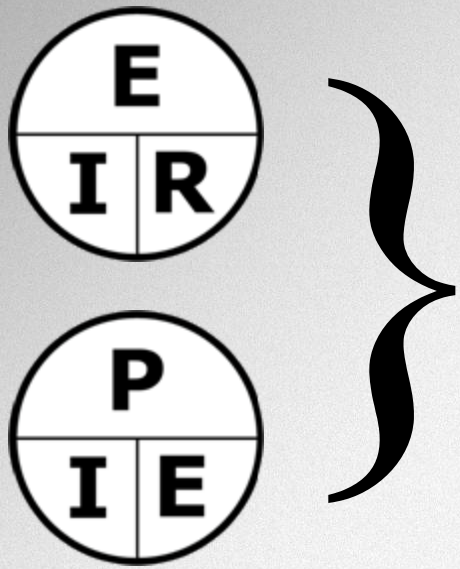


What is P if given I & R?

You need E, so use Ohm's law, then you can solve for P

$$P = I^2 \times R$$

Let's Put Them Together



What is P if given E & R?

You need I, so use Ohm's law, then you can solve for P

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

Page 4-2

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G5B03

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

P = ?

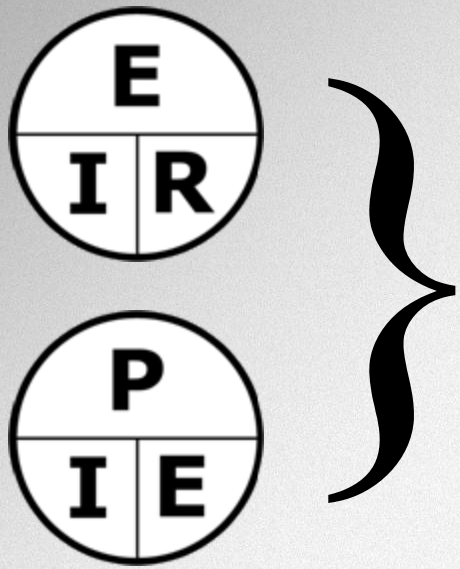
E = 400

R = 800

What do we want to find out and what do we know?

G5B03

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



P = ?

E = 400

R = 800

You need I, so use Ohm's law, then you can solve for P

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

P = 200 Watts

G5B04

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

P = ?

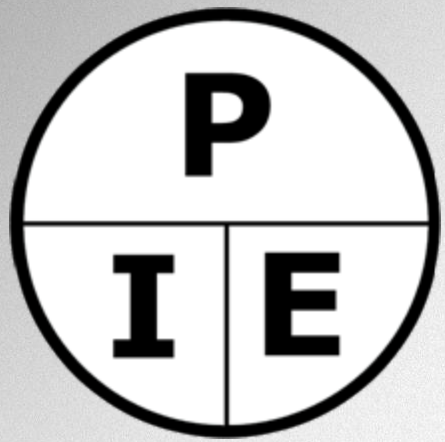
We know that we want to solve for P (watts), we have 12 volts (E) and .2 amps (I)

E = 12

I = .2

G5B04

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



P = ?

E = 12

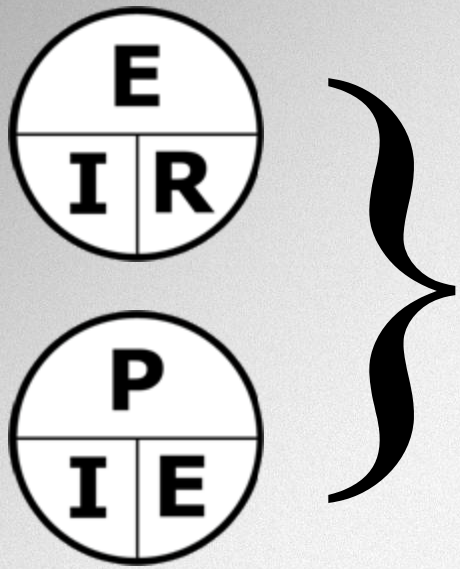
I = .2

P = I x E

P = 2.4 Watts

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?



P = ?

I = 7.0 milliamps

R = 1.25 kilohms

Let’s first convert to amps and ohms!

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?

I = 7.0 milliamps (mA)

0.007 amps

tenths
hundredths
thousandths

1 amp = 1000 mA

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?

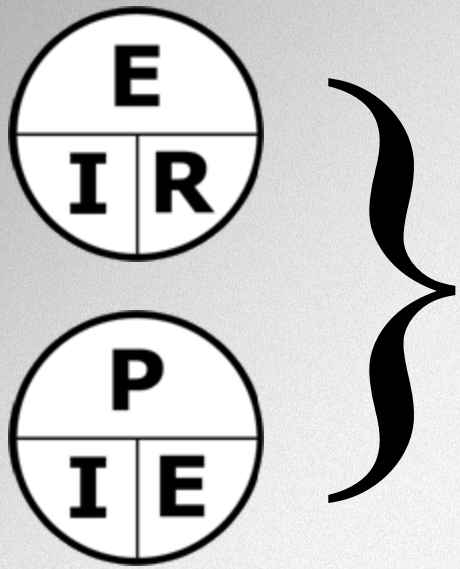
R = 1.25 kilohms

1250 ohms

Kilo = 1,000
Meg = 1,000,000

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?



P = ?

I = .007 amps

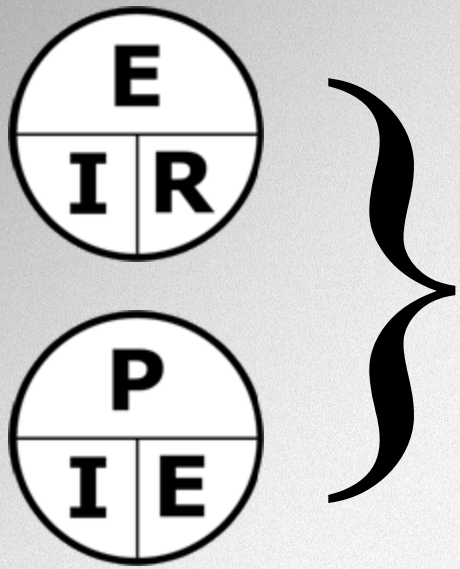
R = 1,250 ohms

Now we have converted our values, next we need E (volts)

E = .007 x 1250

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?



P = ?

I = .007 amps

R = 1,250 ohms

8.75 volts = .007 x 1250

P = 8.75 x .007

G5B05

How many watts are being dissipated when a current of 7.0 milliampers flow through 1.25 kilohms?

$$0.06125 \text{ watts} = 8.75 \times .007$$

Now, convert to milliwatts

(1 watt = 1000 milliwatts)

$$0.06125 \times 1000 = 61.25 \text{ milliwatts}$$

G5B01

A two-times increase or decrease in power results in a change of how many dB?

3 dB = twice the increase (or decrease) in power

3 dB increase = P x 2

3 dB decrease = P x .5

G5B13

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

1 dB = .79 decrease

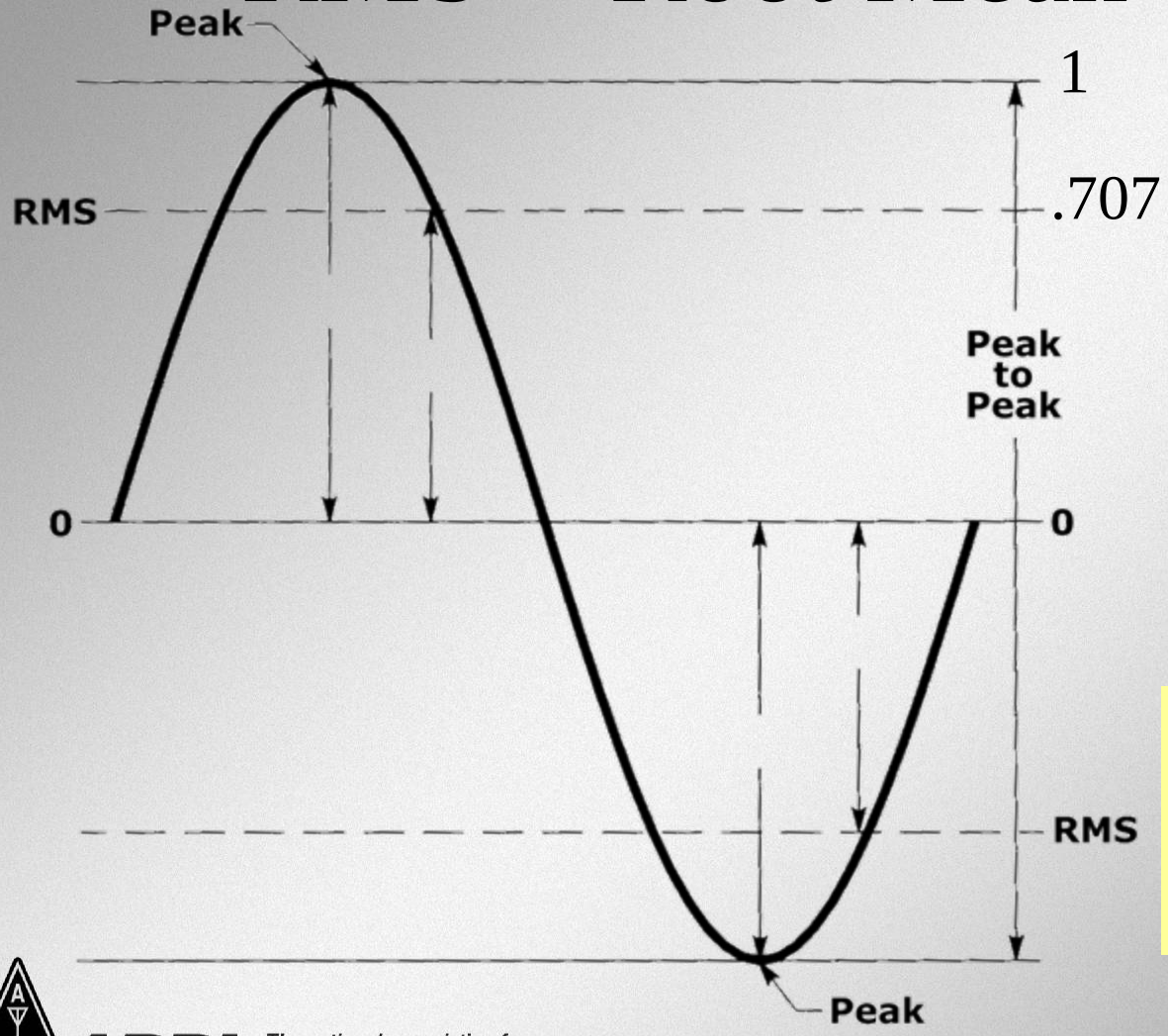
% = 100 – (100 x .79)

21% power loss

1 dB increase = P x 1.26

1 dB decrease = P x .79

RMS = Root Mean Square



To use the power circle or Ohm's law for AC, we must first convert AC into a DC value.

RMS = Peak x .707
RMS = E (volts) or
RMS = I (amps)

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Pages 4-5 thru 4-7

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G5B07

Which measurement of an AC signal is equivalent to a DC voltage of the same value?

The RMS value

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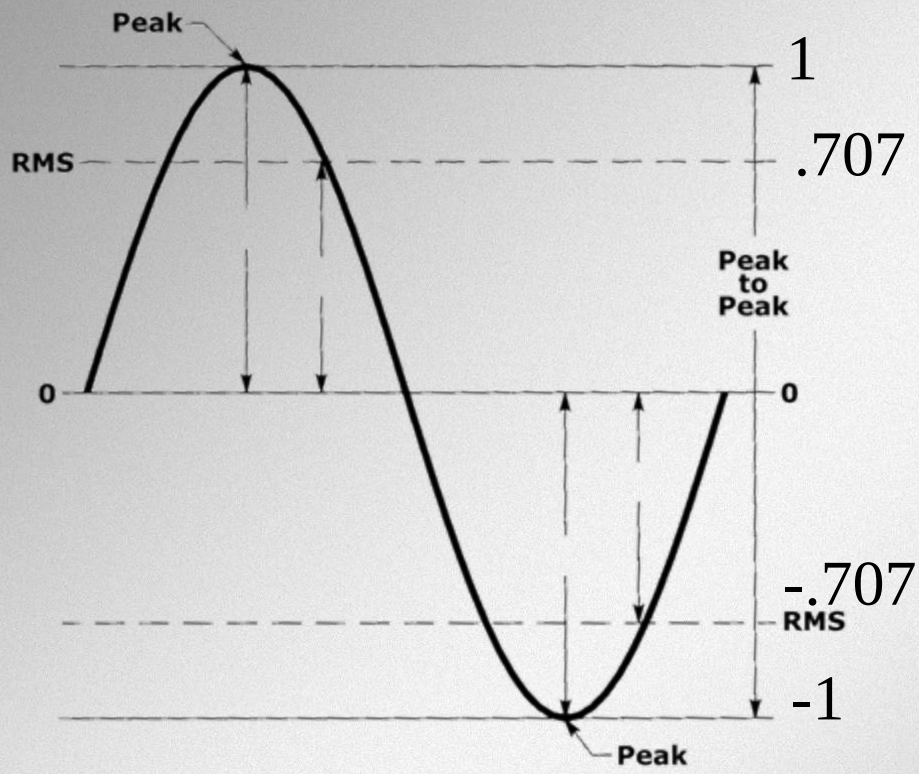
Peak-to-Peak vs. Peak



Peak = RMS x 1.414

RMS = Peak x .707

Peak-to-peak = Peak x 2

Peak = Peak-to-peak ÷ 2

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Pages 4-5 thru 4-7

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G5B08

What is the peak-to-peak voltage of a sine wave that has an RMS voltage of 120 volts?

First, solve for the Peak voltage

120 x 1.414 = 168.68 volts (peak)

Then, solve for the Peak-to-Peak voltage

168.68 volts (peak) x 2 = 339.36 peak-to-peak

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Pages 4-5 thru 4-7

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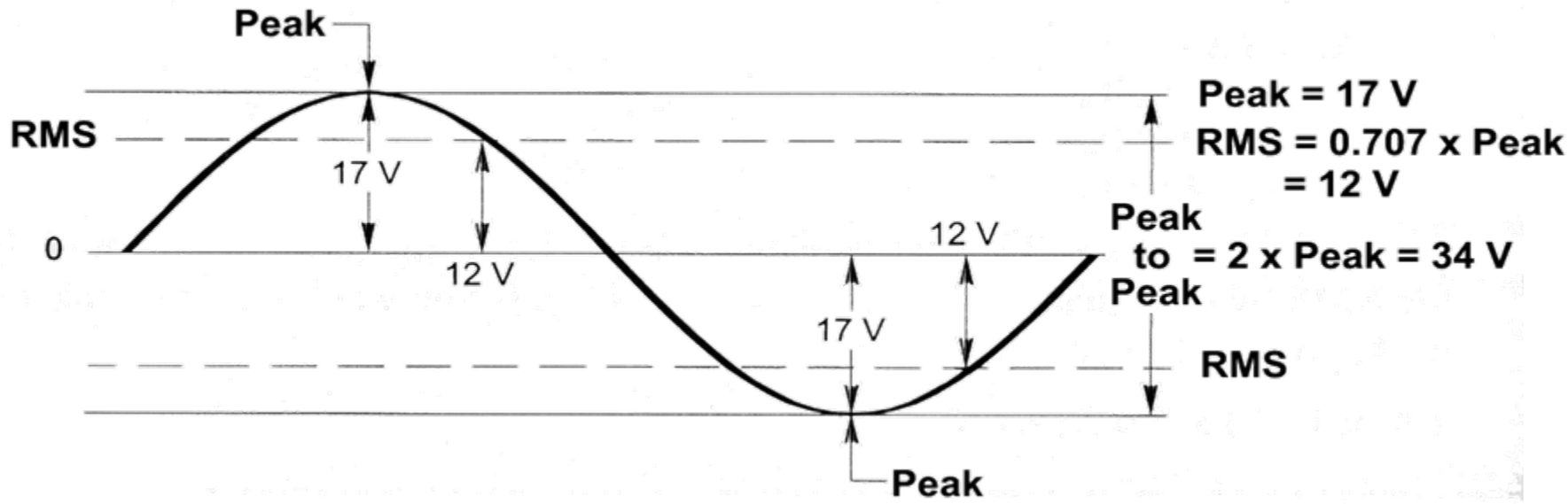
G5B09

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



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Pages 4-5 thru 4-7

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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?

What are we looking for?

Peak Envelope Power output in Watts

What do we know?

Peak-to-Peak = 200 Volts (AC)

Load Resistance = 50

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Pages 4-7

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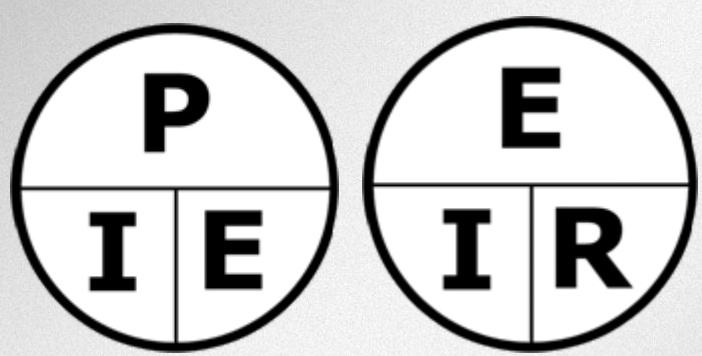
G5B06

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?

200 Peak-to-Peak Volts (AC) needs to be converted to RMS (DC) so we can use our Power Circle.



RMS = Peak x .707

Peak = PtoP ÷ 2

RMS = (200 ÷ 2) x .707

Pages 4-7

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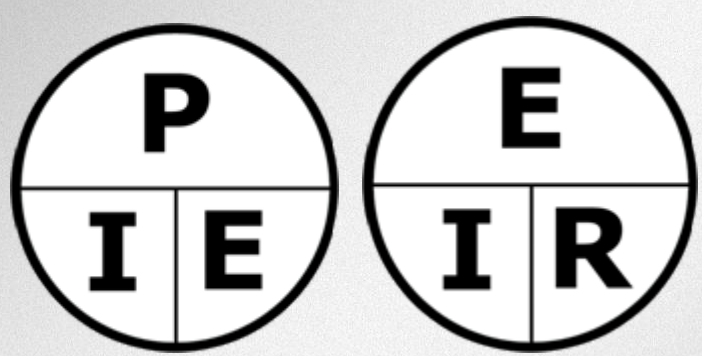
G5B06

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?

RMS = 70.7 So that now gives us our E Voltage!



E = 70.7

R = 50

I = 70.7 ÷ 50

I = 1.414

Pages 4-7

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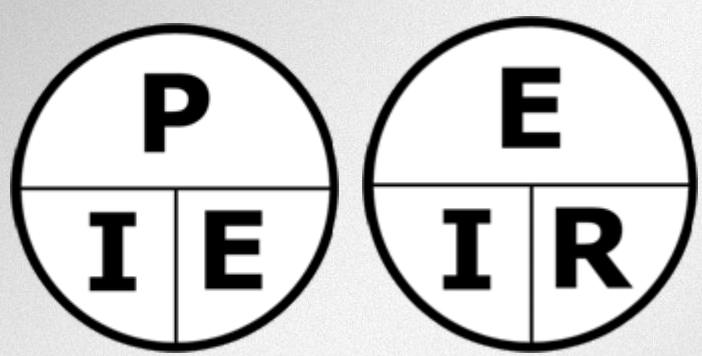
G5B06

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?

Finally, let's solve for P

P = 1.414 x 70.7



P = 99.9698 Watts

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Pages 4-7

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G5B12

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

We are looking for the Voltage (E) at the load

Here is what we know:

R = 50 ohms

P = 1200 watts

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G5B12

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

We are looking for the Voltage (E) at the load

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

$$P = E^2 \div R$$

$$1200 = E^2 \div 50$$

$$E = \sqrt{1200 \times 50}$$

Pages 4-7

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G5B12

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

E (Voltage) = 244.95

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

$P = E^2 \div R$

$1200 = E^2 \div 50$

$E = \sqrt{1200 \times 50}$

Pages 4-7

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G5B14

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

We want to know the PEP (Watts) from the transmitter

Here's what we know:
Volts peak-to-peak = 500
Resistance = 50

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Pages 4-7

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G5B14

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

Need to convert peak-to-peak voltage to RMS

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

RMS = Peak x .707

Peak = P2P ÷ 2

RMS = (500 ÷ 2) x .707

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Pages 4-7

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G5B14

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

RMS = 176.75 volts (E)

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

RMS = Peak x .707

Peak = P2P ÷ 2

RMS = (500 ÷ 2) x .707

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Pages 4-7

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G5B14

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

P = 624.811

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

$P = E^2 \div R$

$P = 176.75^2 \div 50$

Pages 4-7

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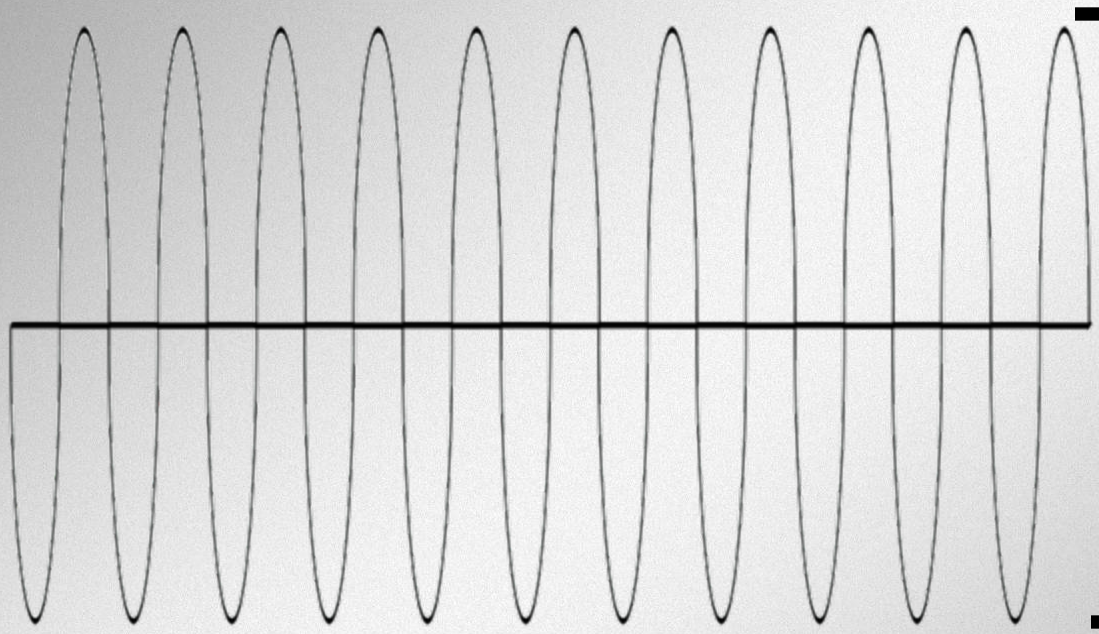
G5B11

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



100 watts PEP

100 watts Avg Pwr

Ratio = 1:1

Un-Modulated Carrier

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Pages 4-7

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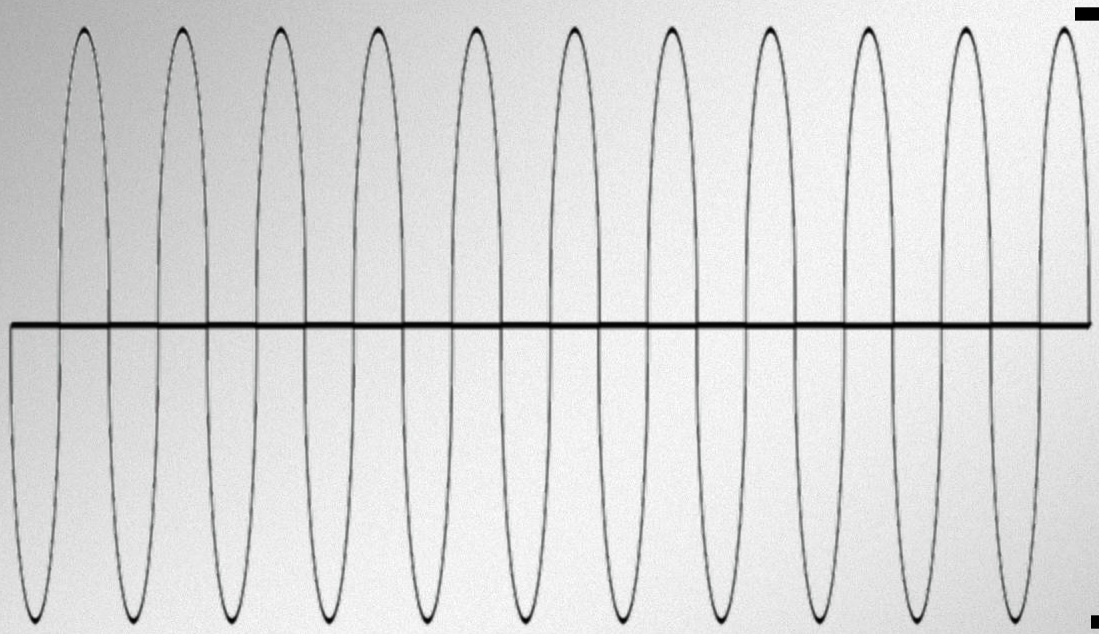
G5B15

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



1060 watts PEP

1060 watts Avg Pwr

Ratio = 1:1

Un-Modulated Carrier

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Pages 4-7

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