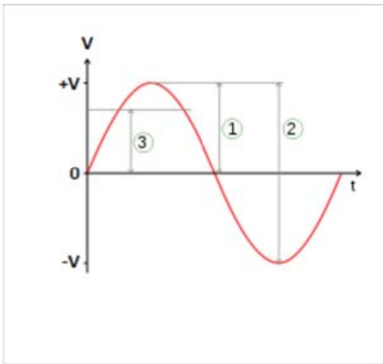
AC Power[1]

The RMS value of the waveform stands for the root-mean-square of the waveform. The root part is the square root. As an example for a pure sine wave, $V(t)=V_{Peak}\times\sin(2\times\pi\times t)$, the RMS value is given by, $V_{RMS}=\sqrt{\frac{1}{T}\times\int_{o}^{T}V(t)^{2}dt}$. For a sine wave this results in, $V_{RMS}=\frac{V_{Peak}}{\sqrt{2}}=\frac{V_{Peak}}{1.414}=0.707\times V_{Peak}$. Note this 0.707 constant only applies to sine waves. For example for a square wave the constant is 1 $(1\neq0.707)$ and for a triangular waveform the constant is $\frac{1}{\sqrt{3}}=0.577$ $(0.577\neq0.707)$. Therefore $I_{RMS}=0.707\times I_{Peak}$ and $V_{RMS}=0.707\times V_{Peak}$ for sine waves.



There are different ways of measuring the voltage of a signwave. One way is to measure the signal from the zero crossing to the positive peak. See measurement 1 in the figure to the right. In this case $V_{PEAK}=V$. Another way is the voltage from the negative peak to the positive peak as shown as measurement 2 in the figure to the right. In this case $V_{\text{PEAK-TO-PEAK}}=+V-(-V)=2\text{V}=2V_{PEAK}$. The third way is $V_{RMS}=0.707\times V_{PEAK}=\frac{0.707\times V_{\text{PEAK-TO-PEAK}}}{2}$. See measurement 3 in the figure to the right. Note 0.707 is actually $\frac{1}{\sqrt{2}}=\frac{1}{1.414}=0.707$. This may help if you forget the 0.707 factor but remember for a sine wave the conversion factor is 1 over the square root of 2.

We now have enough knowledge to answer the questions. PS: AC voltmeters are calibrated to read the RMS value for an assumed sine wave input. The reading will be off for other wave forms because as stated above the conversion factor changes.

Questions

G5B06 (B)
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

1 2015-2019 Element 3 Question Pool, revised 11 February 2015

Let's convert the 200 volts peak-to-peak to volts peak by dividing by two which yields 100 volts peak and then multiply by 0.707 which is volts root-mean-square = 70.7 volts. From Ohm's law we know the current through the resistor is 70.7 divided by 50 or 1.414 amps. From Joule's law we know that the $P=E\times I=70.7\times 1.414=99.99 \text{ or } 100$ Watts. The answer is B. Why did we do the conversion from peak-to-peak to root-mean-squared? That is because RMS is the effective DC value for power calculations. A 12 V_{DC} across a resistor dissipates the same power as a 12 V_{RMS} sine wave across the same resistor.

G5B07 (C)
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

There is no calculation here. You just have to remember that the RMS voltage, also called effective voltage produces the same power dissipation in a resistor as a DC voltage of the same magnitude. The answer is C.

G5B09 (B)
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

The peak voltage is 17, and the RMS voltage is $E_{RMS}=0.707\times E_{PEAK}=0.707\times 17=12.019 \text{ or } 12.$ Therefore B is the answer.

G5B11 (B)
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

From the definition the peak envelope power is the average power for an unmodulated carrier. That is to say $\frac{P_{\text{PEP}}}{P_{\text{Avg}}}=P_{\text{Avg}}/P_{\text{Avg}}=1$. Therefore B is the correct answer.

G5B12 (B)
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

The current through the 50 ohm load when V volts is across the load is $I = \frac{E}{R}$ and from Joule's law we have $P = E \times I = \frac{E \times E}{R} = \frac{E^2}{R}$. Now solve for R and $E^2 = R \times P$ or $E = \sqrt{R \times P}$. Now let's plug and chug and we get $E_{RMS} = \sqrt{50 \times 1200} = 244.9$ or 245 volts. Therefore B is the correct answer. If you don't want to do the algebraic manipulation you should memorize $P = \frac{E^2}{R}$ and $P = I^2 \times R$ along with $P = E \times I$.

G5B13 (B)
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

No calculation need be made. Since there is no signal modulating the carrier sine wave, the PEP, or Peak Envelope Power is the same as the watt meter reading or 1060 watts. Therefo9re B is the correct answer. In the next problem the data is in peak-to-peak voltage and the watts must be calculated

G5B14 (B)
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

To find the power we must convert the 500 volts peak-to-peak to volts root-mean-squared. First let's convert to volts peak, $E_{PEAK} = E_{\text{PEAK-TO-PEAK}}/2 = 500/2 = 250$ volts. Next convert to volts root-mean-squared, $E_{RMS} = 0.707 \times E_{PEAK} = 0.707 \times 250 = 176.75$ volts root-mean-squared. For the 50 ohm load the current is, $I_{RMS} = 176.75/50 = 3.535$ amps. There for the power is, $P = E_{RMS} \times I_{RMS}$ = $176.75 \times 3.53 = 624.81$ or 625 watts. Therefore the correct answer is B. You could of also used, $P = E^2_{RMS}/R = 176.72^2/50$ = $31240.56/50 = 624.81$ or 625 watts and the answer is the same.

The reason the problem gives the $E_{\text{PEAK-TO-PEAK}}$ is because this can read off of an oscilloscope screen. This is an instrument that displays the instantaneous voltage as a function of time. This instrument will be discussed in future topics.