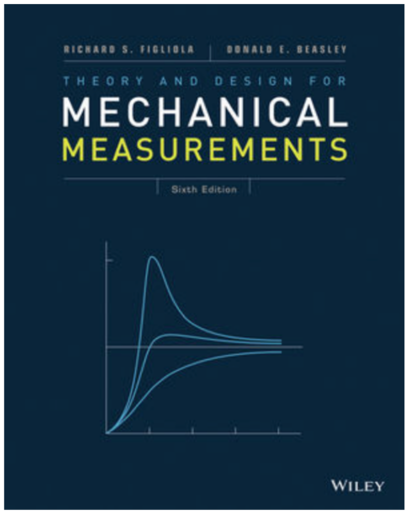

AC Signals

Engr325

Instrumentation

Dr Curtis Nelson

Laboratory Measurements

- Rules of thumb - often gained through experience.
- Resistance – no problem.
- DC volts or amps – no problem.
- AC volts or amps – difficult because the mathematical expression of the quantity being measured is unknown.
- RMS is the best indicator for AC measurements.
  - Because true RMS is the only AC voltage or current reading that does not depend on the shape of the signal, as far as a meter is concerned.

$$\boxed{X_{rms} = \sqrt{\frac{1}{T}\int_0^T x^2 dt}}$$

RMS Measurements

- RMS is described as a measure of equivalent heating value, with a relationship to the amount of power dissipated by a resistive load driven by the equivalent DC value. For example, a 1Vpk sine wave will deliver the same power to a resistive load as a 0.707Vdc signal. A reliable RMS reading on a signal will give you a better idea of the effect the signal will have in your circuit.

$$\boxed{X_{rms} = \sqrt{\frac{1}{T}\int_0^T x^2 dt}}$$

Was: Thermal AC-to-DC Converters

- This older technology for RMS measurements uses the equivalent-heating-value approach. The AC signal heats a thermo-couple, then the DC section of the meter reads the thermo-couple output. Advantages include wide bandwidth and the ability to handle very high crest factors (peak value divided by the RMS value of the waveform), meaning this approach can deliver true RMS for a wide variety of real-world signals.
- Fluke patent.

Is: Digital Sampling and Processing

- This method uses sampling techniques similar to those in digital oscilloscopes to create a set of data points that are sent through an RMS algorithm.
- This technique has several advantages: true RMS on a wide range of signals, high accuracy, and the capability to create very fast, effective sampling rates and wider bandwidths, even with fairly slow analog-to-digital converters.

AC Measurements

- V_{AVG} vs. V_{RMS}
- Why V_{AVG}?
  - Because V_{RMS} is hard to do.

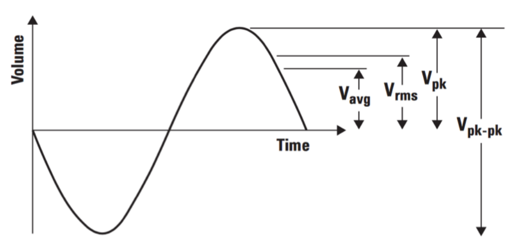

Figure 1. Common voltage parameters

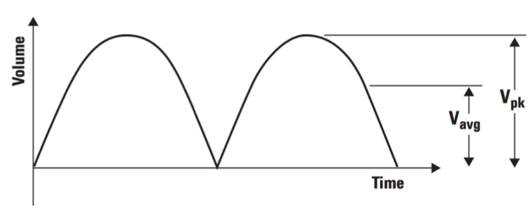

Figure 2. V_{avg} is calculated based on the absolute value of the waveform.

AC Measurements

- For sine waves, the negative half of the waveform cancels out the positive half and averages to zero over one cycle. This type of average would be useless so most meters compute V_{avg} based on the absolute value of the waveform. For a sine wave, this works out to V_{pk} x 0.637
- This scaling factor applies only to pure sine waves. For every other type of signal, **using this approach produces misleading answers**. If you are using a meter that is not really designed for the task, you can easily end up with significant error depending on the meter and the signal.

RMS Measurements

- You can derive V_{RMS} by squaring every point in the waveform, finding the average (mean) value of the squares, then finding the square root of the average. With pure sine waves, you can take a couple of shortcuts: just multiply V_{pk} x 0.707 or V_{avg} x 1.11. Inexpensive peak-responding or average-responding meters rely on these scaling factors.

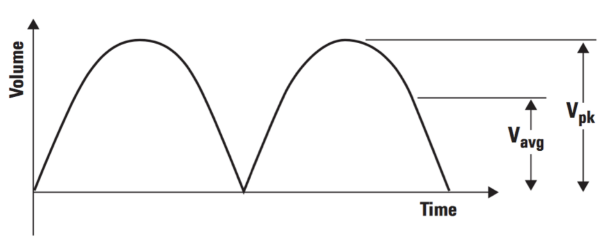

Figure 2. V_{avg} is calculated based on the absolute value of the waveform.

True RMS Measurements

AC-COUPLED INPUT WAVEFORM	PEAK VOLTAGES		METERED VOLTAGES			DC AND AC TOTAL RMS
			AC COMPONENT ONLY		DC COMPONENT ONLY	
	PK-PK	0-PK	RMS CAL*	FLUKE 45		TRUE RMS = $\sqrt{ac^2 + dc^2}$
SINE PK 0 PK-PK	2.828	1.414	1.000	1.000	0.000	1.000
RECTIFIED SINE (FULL WAVE) PK 0 PK-PK	1.414	1.414	0.421	0.436	0.900	1.000
RECTIFIED SINE (HALF WAVE) PK 0 PK-PK	2.000	2.000	0.779	0.771	0.636	1.000

True RMS Measurements

AC-COUPLED INPUT WAVEFORM	PEAK VOLTAGES		METERED VOLTAGES			DC AND AC TOTAL RMS
			AC COMPONENT ONLY		DC COMPONENT ONLY	
	PK-PK	0-PK	RMS CAL*	FLUKE 45		TRUE RMS = $\sqrt{ac^2 + dc^2}$
SQUARE PK 0 PK-PK	2.000	1.000	1.111	1.000	0.000	1.000
			Fluke 112			**Fluke 8846A**

* RMS CAL IS THE DISPLAYED VALUE FOR AVERAGE RESPONDING METERS THAT ARE CALIBRATED TO DISPLAY RMS FOR SINE WAVES