

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Don't be Mean - be Root Mean Square!

Q. How do you measure a varying signal?

A. Very carefully! Archimedes had to measure gold in a crown; measuring arbitrary waveforms is even tougher.

The simplest measure of a varying signal is its mean or average value over some time interval, but this can be misleading. Suppose that we have a square wave with a 1:1 mark-space ratio and 1 V peak-to-peak amplitude. What is its mean value?

With a positive peak of +1 V and a negative peak of 0 V, the mean value is 0.5 V. With a positive peak of 0.5 V and a negative peak of -0.5 V, the mean is 0V. If this signal were applied to a resistor, however, it would get warm; this would not happen with a steady 0-V signal.

So perhaps we should disregard the polarity for power purposes? If, in the second case above, we removed the sign or polarity before taking the mean, then the "mean absolute" value would be 0.5 V just like the first case. But if we applied these two signals to the same resistor, it will get much warmer with the first signal than with the second, so the mean value of a varying voltage or current does not tell us enough about its heating effects. DC, sine waves, square waves, sawtooths, and gaussian noise with the same mean voltage have very different heating effects.

This is because the power in a resistive load is proportional to the square of the applied voltage. In fact, the measure we need is the Root Mean Square or



rms value of the varying signal. This is the square root of the mean value of the square of the signal. We could get very mathematical here, but there is no need. Although it is possible to use analog-to-digital conversion and high-speed digital signal processing (DSP) to obtain the rms value of a varying signal, the same job can be done more accurately with a simple analog circuit using multipliers and op-amps—easily built but even more easily (and cheaply) bought as an IC.

Such rms-to-dc converter ICs are a convincing example of signal processing that is still more effective with analog rather than digital technology. Analog rms-to-dc converters use less power and board space than their DSP counterparts, and are available for use at LF or at RF up to almost 10 GHz, where DSP cannot yet work at all. Their architectures and performance are described in the linked articles.

**To Learn More About
Measuring Varying Signals**

<http://designnews.hotims.com/27736-100>



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Have a question involving a perplexing or unusual analog problem? Submit your question to: raq@reedbusiness.com

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