Application Note

Peak Detection vs. RMS Detection

By Wolf Campbell • SKF Service

As reliability monitoring systems expand over the years, a mix of different types of data collection instruments may be installed. Confusion may arise when comparing the overall values measured by each device, since differing signal detection and signal conditioning processes may be integrated into the instruments. This is especially true when accelerometers are installed and measurements are compared using a portable data collector to verify a permanently installed monitor system. Often, the values from these two different instruments may be quite different. Two signal processing methods may be in use to derive an overall amplitude value:

- True peak detection, and
- RMS detection.

Each system may display information derived from the same sensor source, but the overall values will not agree. The answer lies in the signal conditioning processes.

RMS overall value

Some instruments, such as portable data collectors, perform a true RMS (root mean squared) measurement based on the point setup frequency range of interest. For peak scaling, the RMS amplitudes of each signal component is then multiplied by 1,414 to derive a peak overall value (peak = 1,414 × RMS). This measurement is reproducible, trendable and analyzed for machine condition. The SKF Micrologs, MIMs (monitor interface modules), and LMUs (SKF Multilog local monitoring units) utilize this technique when measuring acceleration and velocity signals.

Fig. 1. The SKF Condition Monitoring's M800A programmable machinery monitoring and protection system.

True peak overall value

Many permanently installed machinery protection systems utilize a **true peak** or **true peak-to-peak** detector to measure the input signal. A true peak detector delivers the full peak amplitude of any signal detected, regardless of frequency content. This measurement is reproducible and trendable for general machine condition.

The M800A system and CMCP (Condition Monitoring Custom Products) transmitters utilize true peak or true peak-to-peak detection when measuring acceleration and velocity signals. No additional scaling is needed to derive a peak overall value.

Why there are differences

Both methods of deriving an overall value will produce the same overall value only when the input signal contains a single frequency. Once the input signal becomes more complex, as most real machinery signals are, the overall values will differ.

Consider a simple signal containing only three frequencies:

- 0,324 g peak at 100 Hz
- 0,259 g peak at 200 Hz
- 0,194 g peak at 300 Hz

This is depicted in **fig. 2** as a simple spectrum.

When an instrument that performs a true RMS signal processing technique measures this signal, a spectrum of the signal is produced based on the frequency range of interest. The individual frequencies that make up the total signal are processed as true RMS values. Thus, a frequency of 1,00 v-pk at 100 Hz is measured as 0,707 v-rms at 100 Hz. If a peak overall value is desired for trending purposes, the calculated overall value from the spectrum is multiplied by 1,414 to derive a peak overall value.

Calculation of the RMS overall value for the spectrum above involves the following formula:

- Overall RMS = $(A^2 + B^2 + C^2 + ...)^{1/2}$

For this example, the individual frequencies are detected as 0,229 g RMS at 100 Hz, 0,183 g RMS at 200 Hz and 0,127 g RMS at 300 Hz. The calculated overall value is:

- Overall RMS:
  $= (0{,}229^2 + 0{,}183^2 + 0{,}127^2)^{1/2}$
  $= (0{,}052 + 0{,}034 + 0{,}016)^{1/2}$
  $= (0{,}102)^{1/2}$
- Overall RMS = 0,319 g

The peak overall value for this spectrum would be 0,452 g (0,319 g-rms × 1,414).

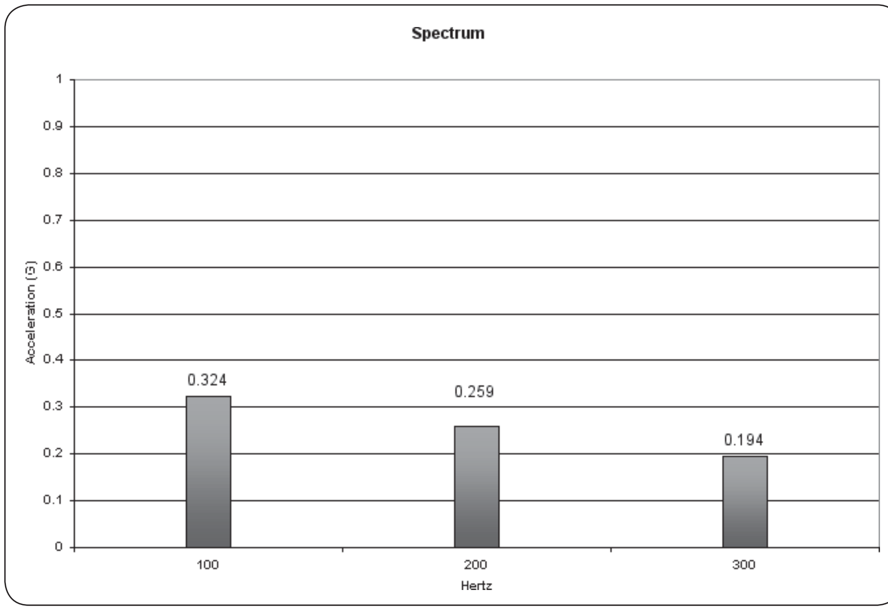

Fig. 2.

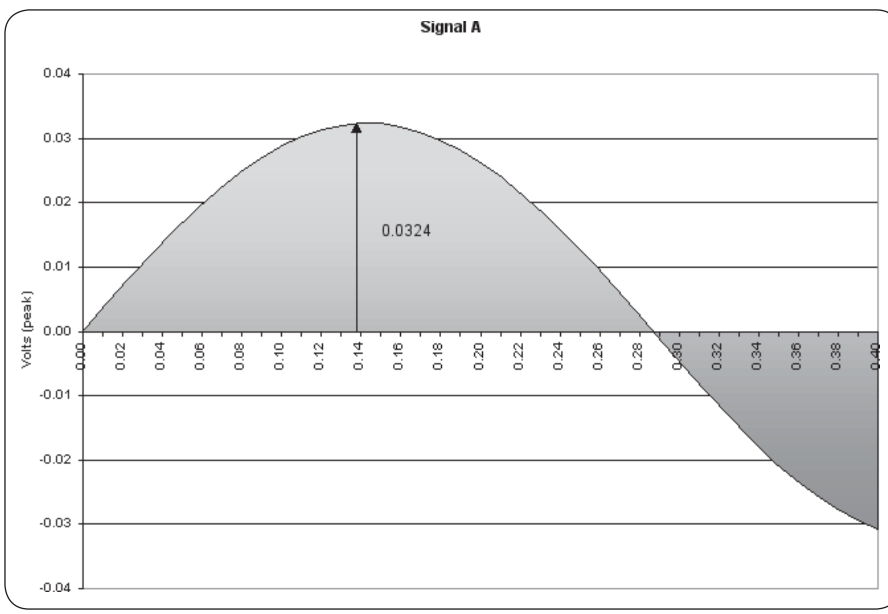

Fig. 3.

Now let's consider how a true peak detector would derive its overall value. True peak or true peak-to-peak detectors, like those used in a machinery protection system, simply report the maximum amount of signal at any instant in time. When signals only contain one frequency (and the signal amplitude is constant), the output is very predictable.

Things start to get complicated when the signal become complex with many included frequencies. Signals containing more than one frequency can actually result in a "processed" output that is higher than any individual frequency component of the original input signal. This increased output is due to the phase relationships of the individual frequencies as they are combined.

To illustrate, let's consider our example signal consisting of the three individual frequency components. Since a true peak detector reacts to the "raw" signal, we will illustrate the signals as time waveforms. The frequency A (→ **fig. 3**) represents the 0,324 g at 100 Hz portion of the spectrum as a time waveform. It has a frequency of 100 Hz and an amplitude of 0,0324 V (0,324 g × 100 mV/g). The peak amplitude will be the determining measurement once signal B (→ **fig. 4**) and signal C (→ **fig. 5**) are included. This amplitude is what the true peak detector reacts to when deriving overall amplitude value.

Signal B and signal C represent the two other frequencies in the measurement. Signal B is 0,0259 V at 200 Hz and signal C is 0,0193 V at 300 Hz. When these three sinusoidal signals are combined, they produce the time waveform shown in **fig. 6**.

The combined time waveform is no longer sinusoidal due to the phase relationship at any one instant. Of particular interest is that the peak amplitude of the combined signal is larger than any of the individual components due to the phase relationships between the individual signals! The signal has a peak amplitude of 0,0628 V. This amplitude equates to 0,628 g if a 100 mV/g accelerometer is used to sense the signal via a true peak detector.

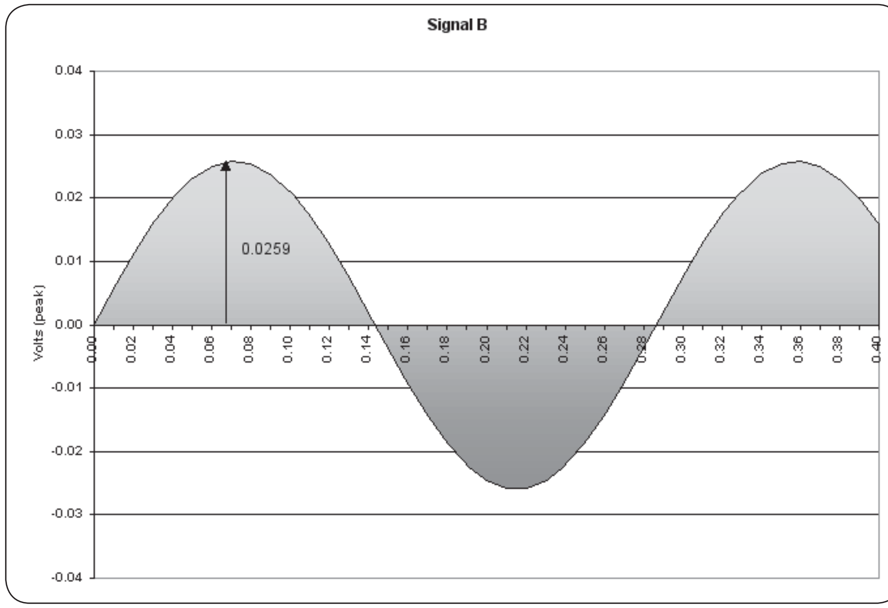

Fig. 4.

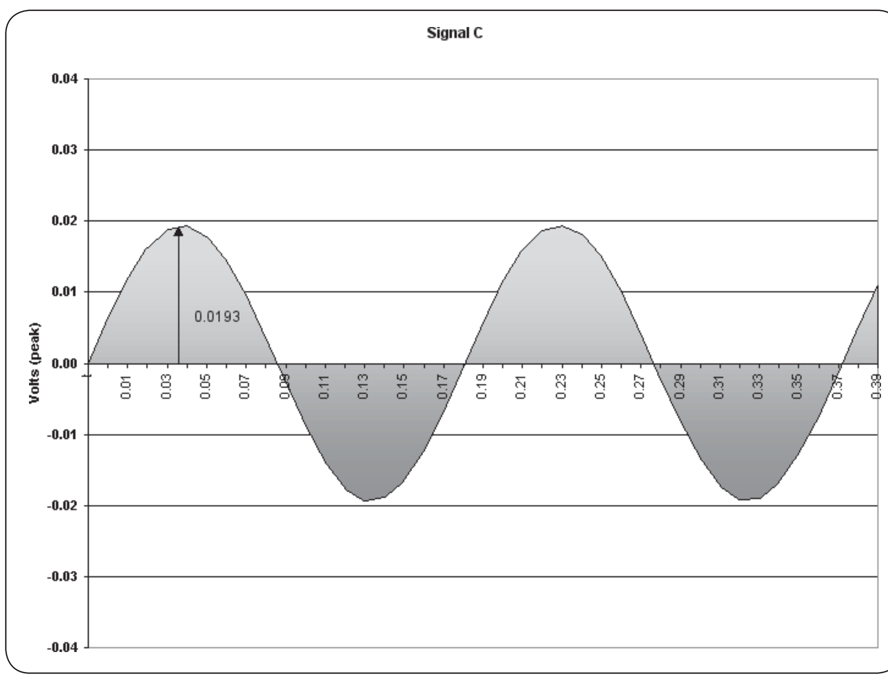

Fig. 5.

Now when the overall value of the signals are measured by the different instruments, the following will be witnessed:

- The instrument that calculates peak scaled from true RMS shows 0,452 g-peak
- The true peak instrument shows 0,628 g-peak

This difference appears to be a discrepancy, but will always be true whenever the measured signal contains more than one frequency. Both methods are reproducible and trendable, they just measure the signal differently.

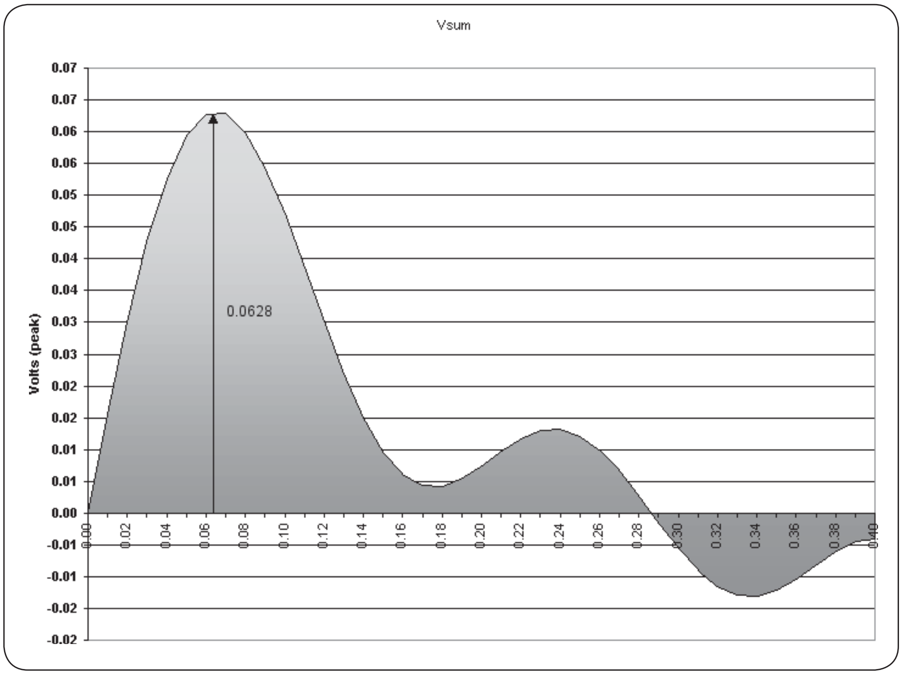

Fig. 5.

Please contact:

SKF USA Inc.
Condition Monitoring Center – San Diego
5271 Viewridge Court · San Diego, California 92123 USA
Tel: +1 858-496-3400 · Fax: +1 858 496-3531

Web: www.skf.com/cm

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