New method reveals all you need to know about 'waveforms'

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The National Institute of Standards and Technology has unveiled a method for calibrating entire waveforms -- graphical shapes showing how electrical signals vary over time -- rather than just parts of waveforms as is current practice. The new method improves accuracy in calibrations of oscilloscopes, common test instruments that measure voltage in communications and electronics devices, and potentially could boost performance and save money in other fields ranging from medical testing to structural analysis to remote sensing.

A waveform can take many different shapes, from staircase steps to irregular curves. A waveform typically is described by a single number—some key parameter of interest in a particular application. For example, engineers have described waveforms using terms such as pulse duration, or transition time between the levels representing '0' and '1' (the binary code used in digital electronics). But waveforms can be diverse and complex, especially in advanced high-speed devices, and a traditional analysis may not distinguish between similar shapes that differ in subtle ways. The result can be signal mistakes (a 1 mistaken for a 0, for instance) or misidentification of defects.

NIST's new calibration method* defines waveforms completely, providing both signal reading and measurement uncertainty at regular intervals along the entire wave, and for the first time makes waveform calibrations traceable to fundamental physics. The mathematics-intensive method is laborious and currently is performed only at NIST (which has more than 750 oscilloscopes), but the developers plan to write a software program that will automate the technique and make it transferable to other users.

The new method offers NIST calibration customers, including major manufacturers and the military, more comprehensive characterization of a greater variety of waveforms, and helps to meet current and future demands for measurements at ever-higher frequencies, data rates, and bandwidths. The impact could be far reaching. The global market for oscilloscopes is $1.2 billion. Anecdotal data suggest that for one product alone, Ethernet optical fiber transceivers, industry could save tens or even hundreds of millions of dollars through manufacturing innovations (such as the new NIST method) that reduce component reject rates and/or boost yields.

Of particular interest to scientists and engineers, the NIST calibration method incorporates new techniques for quantifying errors in waveform measurements. This allows, for the first time, accurate transfer of measurement uncertainties between the time domain (results arranged by time) and the frequency domain (the same data arranged by frequency). Researchers in many fields have long used a technique called "Fourier transform," which reveals patterns in a sequence of numbers, to transfer data from the time domain to the frequency domain. "The new NIST method is, in effect, a Fourier transform for uncertainty," says NIST physicist Paul Hale.

Although the new method was developed for common lab test instruments, it also may have applications in measuring other types of waveforms, such as those generated in electrocardiograms for medical testing, ultrasound diagnostics of structural defects and failures, speech recognition, seismology and other remote sensing activities.

More information: P. Hale, A. Dienstfrey, J.C.M. Wang, D.F. Williams, A. Lewandowski, D.A. Keenan and T.S. Clement. Traceable waveform

calibration with a covariance-based uncertainty analysis. *IEEE Transactions on Instrumentation and Measurement*. Vol. 58, No. 10. Oct.

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