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Dynamic calibration of sensors with exclusive digital output

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Summary:
For the processing of dynamic data (e.g. vibrations) an exact knowledge of the temporal relations is necessary. In this topic we present a GPS based method for time stamping of dynamic signals. As well as dynamic calibration methods based on this data for sensors with exclusively digital output.

Keywords: dynamic calibration, MEMS, uncertainty

In the field of accelerometry, MEMS accelerometers and gyroscopes have become ubiquitous.
Unlike typical analog sensors, the analog to digital conversion in digital MEMS sensors is performed asynchronously in the sensor. This offers the advantage from a system integration point of view that no interference-prone analogue signals have to be transmitted. From a meterological point of view, however, it is disadvantageous that the sampling time is determined by the sensor. The sensors normally signal at least the beginning or the end of the AD-conversion by an interrupt signal. In this session we will show how this signal can be absolute timestamped with an uncertainty of about 200 ns using common microcontroller hardware, our own open source software and a GPS module. Synchronous to the data of the digital sensor, analog reference values are read in from the µC system. Thus a synchronization signal can be acquired, which can be e.g. the excitation signal in a classical dynamic calibration system. This allows to make the analog calibration system fit for digital sensors without changing them. Figure 1 shows a classical calibration system which has been extended by a digital Data Aqusitiuon Unit (DAU). The calibration system and the DAU sample the same reference signal, so a time reference can be established between both systems, which is essential for the determination of the phase response. Since the DAU is based on low-cost hardware, it also serves as the basis for a smart sensor in networked systems. Since the DAU delivers the measured values acquired by the sensors as an absolute-time stamped data stream with metadata. The meta data are physical size, unit, quantization resolution and fulls scale values. The description of the units is based on the D-SI [1]. In this session we will introduce the microcontroller system and a Python based open source software for the dynamic calibration of one and more axis MEMS accelerometers and gyroscopes.

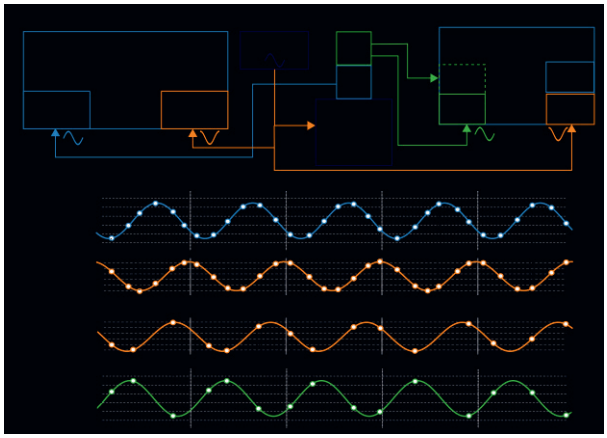

Figure 1 An Analog Calibration System (ACS) extended with a Digital Aquisition Unit (DAU) for dynamic calibration of digital acceleration sensors.

References [1] Hutzschenreuter, D., et al. "SmartCom Digital System of Units (D-SI) Guide for the use of the metadata-format used in metrology for the easy-to-use, safe, harmonised and unambiguous digital transfer of metrological data." *Available:*. 2019.