

Calibration

ActiGraph's activity monitors employ the use of solid state accelerometer circuitry and digital filtering. The incorporation of these technologies improves the reliability and repeatability beyond its predecessor, the 7164 series of products. More importantly from a users standpoint is removal of the need to periodically calibrate the units. Each unit is calibrated as part of ActiGraph, LLC's standard manufacturing process and this calibration holds through the life of the product.

Why Calibrate?

When performing calibration (regardless of the technology or type of device), the primary goal is to ensure all devices yield the same output to a known signal on the input. In the case of ActiGraph's activity monitors, every device that is subjected to 1 g of acceleration will yield the same 'count' value. The ability to achieve this depends on a number of factors, including the type and construction of the activity sensor and the tolerance in semiconductor properties.

ActiGraph's History of Calibration

Prior to the introduction of the GT1M, ActiGraph's activity monitors included neither a solid state accelerometer nor digital filtering, thus making them subjective to tolerance stack-ups of many devices. Movement data was detected with a weighted bi-morph piezoelectric beam that deflected when subjected to an acceleration. The amount of deflection was dependent on the weight and location of a mass placed on the end of the beam. A transient voltage signal was produced that is proportional to the amount of deflection and thus the amount of acceleration. The filtering of this signal was performed with a hardware based filter, consisting of many semiconductor devices, each with its own tolerance and drift characteristics. Each semiconductor in the circuit provided a potential for device to device variation.

Error Sources

ActiGraph's accelerometer based products have swapped out the piezoelectric beam for a highly accurate and stable solid state Micro-Electro-Mechanical Systems (MEMS) accelerometer that undergoes a precise batch manufacturing process to ensure an unprecedented level of repeatability. The accelerometer vendor manufactures the device to ensure the initial tolerance specification on sensitivity only varies by $\pm 10\%$. Additionally, this sensitivity drifts with temperature by only $0.01\%/^{\circ}\text{C}$ (or 0.9% across the entire operating range) thus making it a negligible component of error. The other primary contributor to error was the hardware based filter. Each component used to construct the filter in the 7164, for example, offers up another source for error and with component to component tolerance stack-up the potential for unit to unit variation is significant. This filter is now implemented in firmware, effectively removing unit to unit variability due to this source. This leaves only the accelerometer vendor's initial tolerance specification on sensitivity as a source of error.

The Calibration

The calibration routine utilized by ActiGraph during the manufacturing process removes the accelerometer to accelerometer variance due to the initial tolerance specifications. This is performed by first determining the sensitivity of the accelerometer (output voltage at 1 G) and then calculating the filter coefficient to match this sensitivity (or add proper gain to get the correct value out). The coefficient then remains unchanged through out the life of the Actigraph.