MEMS

Sensor Modules with Integrated Algorithms

Usage-Ready Values

Contributed by Würth Elektronik eiSos

The signals that a sensor provides contain a wealth of information. MEMS-based (Micro-Electro-Mechanical Systems) sensors in particular provide an extremely large number of values per period of time with impressive accuracy. However, the useful information must first be separated through data processing and interpretation of the raw data from the sensor. To reduce this effort, Würth Elektronik eiSos has given its sensors some intelligence in the form of integrated algorithms.

Sensors have to be calibrated, as only the comparison with a reference system results in usable information from an output. It must also be decided in which spectrum, with which resolution and sampling rate measured values will be generated. Does a system only need to be "woken up" by a certain threshold value or should a measured value be permanently monitored by a high-frequency sampling rate? For this reason, Würth Elektronik eiSos developed MEMS sensors that are as easy to integrate into applications as possible while maintaining high quality production as required for industrial applications. As a further step, Würth Elektronik eiSos cultivates our customer's innovations through unparalleled levels of design-in support.

Calibrated and Programmable

What does such a product range look like? As an example, the temperature sensor WSEN-TIDS from Würth Elektronik has a measuring range of -40 °C to 125 °C with an accuracy of ±0.25 C. Besides calibration ex factory, special features include a customer-adjustable output data rate up to a maximum of 200 Hz and the option of a programmable threshold value that addresses an interrupt pin directly. With a current consumption of only 1.75 µA, the module is ideally suitable for battery-operated applications. Likewise, the calibrated and temperature-compensated humidity sensor WSEN-HIDS can for example use the sensor's interrupt pin to wake up the microcontroller needed for the overall application in the event of a change in humidity — ideal for economical and low-maintenance monitoring functions.

The absolute pressure sensor WSEN-PADS contains an ASIC (application-specific integrated circuit) and a temperature sensor to generate calibrated output values. Using an additional interrupt pin, the function can also be modified by the user. The output data rate can be selected between 1 and 200 Hz. An application example is the use of the pressure sensor as an altimeter. Due to the high resolution, even a position assignment of individual floors in buildings is possible.

Application Example

Sensors can be used in various ways. For example, with an output data rate of up to 1.6 kHz and a signal bandwidth of up to 400 Hz, the calibrated 3-axis acceleration sensor WSEN-ITDS from Würth Elektronik can be used for vibration monitoring in predictive maintenance of machines or in low-power mode to detect a single pulse, for example as a switch that is tapped. Four measurement ranges are available (±2, ±4, ±8 or ±16 g) and register settings can be used to select the application-specific functionalities of free-fall, wake-up, jog, activity, motion and orientation detection. The example of a fall detection system is a good way to show how an

application is put together from these algorithms already provided by Würth Elektronik. With the availability of preset functions and selectable parameters, the development of a fall detection application is more like configuring than programming. The big advantage: the built-in functions eliminate the need to retrieve acceleration data continuously from the sensor to perform complex calculations. This saves energy and processing performance at the application level.

Fall detection sensors in home emergency call systems for the elderly are supposed to automatically detect when a person falls and remains motionless. In physical terms, a fall means that a brief moment of weightlessness occurs, i.e. an acceleration of approximately 0 g is measured, followed by a high negative acceleration, caused by the impact on the ground. If no changes in the acceleration values are then measured for a certain period, the motionlessness of the person wearing the sensor can be assumed from this.

Programmable Interrupt Pins

The 3 Axis Acceleration Sensor WSEN-ITDS has two programmable interrupt pins INT_0 and INT_1. The interrupt pins can be activated or deactivated individually. The interrupt signals of the sensor functions are routed to these two pins (**Figure 1**).

For use as fall detection, the three functions "Free Fall", "Wake up" and "Stationary/Motion" are required. The combination of these sensor functions provides reliable information about whether a person falls and whether they can move afterwards or not. The interrupt signals from these events are routed to pins INT_0 and INT_1. This is where the monitoring system that triggers the alarm — if required — can then start. During the free-fall event, the acceleration value of all three axes goes towards zero. In the register of the sensor module, two application-specific values must be defined at the occurrence of which the interrupt for reporting a fall is generated: the threshold value, from when a free fall is assumed, and the duration of the free fall. In order for the sensor data to be interpreted in response to the question "fall or no fall", the waking up of the sensor must also be defined, again by defining a threshold value of changed acceleration and a minimum duration of this impulse. To exclude the gravity vector and very low frequency noise during the detection of the wake-up event, the integrated high pass filter should be used. The integrated "Stationary/Motion" algorithm is the function that informs the alarm function whether the wearer of the sensor remains motionless after the fall. The Stationary function combines the two detection events "sleeping" and "waking up" to register motionlessness. The wake-up threshold and duration parameters can be defined according to the user application.

The diagram (**Figure 2**) shows how the integrated functions are applied to the phases of a fall event by defining threshold values:

a. Before the fall, the vector sum of the acceleration values from all three axes will be close to 1 g.
b. In the free fall condition, the acceleration tends towards the 0 g level (interrupt signal FF_IA), but a strong acceleration peak occurs immediately afterwards.
c. Immediately after the fall, the person will try to move or is unable to do so.

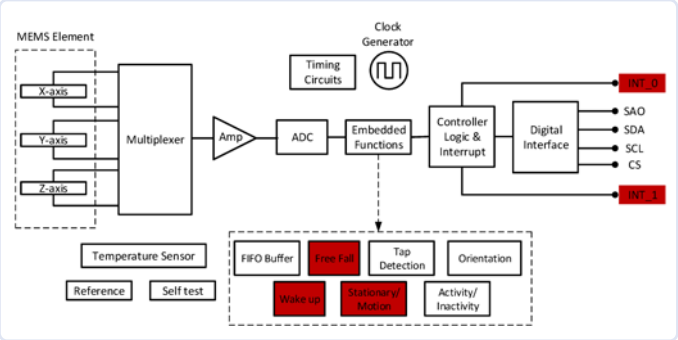

Figure 1: Function block diagram of the 3-Axis-Acceleration Sensor WSEN-ITDS.

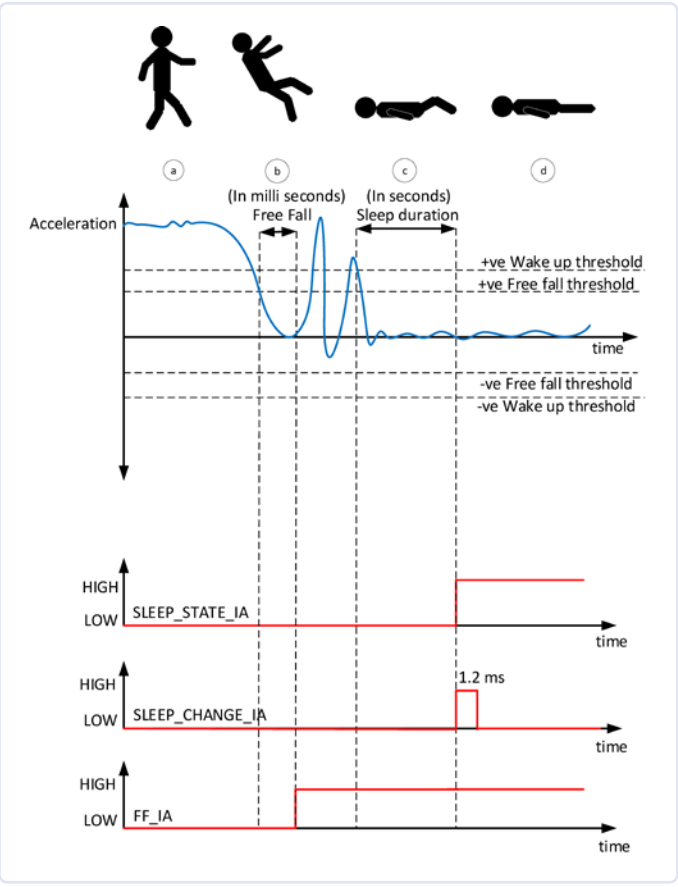

Figure 2: No-motion detection via wake-up and sleep thresholds.

d. If the person does not move after a certain time configured in the Stationary function, the interrupt signal SLEEP_STATE_IA and SLEEP_CHANGE_IA are generated. By comparing the orientation of the resulting acceleration vector before and after the fall, the fall detection system can be instructed to generate an alarm.

Conclusion

MEMS sensors with factory calibration and interrupt function, controlled by implemented intelligent algorithms, can be easily integrated into applications when connected to microcontrollers via SPI or I²C interface. Currently, Würth Elektronik offers sensor modules and evaluation kits for the detection of temperature, acceleration, differential pressure, absolute pressure and humidity.

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