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For Editors

Providing Electronic Solutions

KXCNL Dual State Machines Accelerometer

What it can do for you and how it works

Willow Technologies Limited (www.willow.co.uk) recently introduced the first Kionix accelerometer with **integrated dual user-programmable state machines**, the KXCNL. This **advanced accelerometer** is proving to be very popular for a wide variety of applications due to its ability to simultaneously run multiple applications at the chip level, taking significant processing load off the system's main applications processor and **conserving power**. In this article we take a closer look at how the device works and how it can be used by developers.

KXCNL features include:

- Dual user-programmable state machines
- User-selectable 2g, 4g, 6g, and 8g ranges
- User-programmable ODR
- Current consumption 2 - 250µA
- XAC sensor with outstanding stability over temperature, shock and post-reflow performance
- Support for I2C High Speed, Fast Speed, and Standard Speed
- 1.7V to 3.6V operating voltage
- Internal voltage regulator
- Self-test function

How it Works

The KXCNL accelerometer has two independent, finite state machines that can be defined with up to 16 states each, along with programmable actions initiated at state transitions. This allows users to implement a wide range of recognition algorithms, such as wake-up, free-fall, screen orientation, Tap/Double-Tap, step recognition and more.

Currently, Kionix provides algorithms for Tap/double-tap, screen orientation, free-fall and motion detection. Source code will be provided to customers for their use with the KXCNL. Customers can also write their own programs, consisting of a list of commands with thresholds and timing settings sent to specific registers and incorporate them with the driver package for the part, using whatever interface they normally use to communicate with the part.

At any given time, the KXCNL can contain and run two programs simultaneously. The device is loaded from the host, so to swap programs, when an app indicates that it wants to load a particular programme, it finds it in the host memory and loads it. Load time is dependent on speed of the bus and the size of the programme.

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Developers also have the flexibility to choose from two options to initialise the part. These methods can vary based on the desired operation, but generally the initial operations a developer is interested in are:

1) read back acceleration data, or

2) use one of the state machines.

These cursory solutions are provided as a means for configuring the part to a known operational state. Note that these conditions just provide a starting point; the values may vary as developers refine their application requirements.

Take free-fall detection and motion detection, for example. Generally, for free-fall detection, you want to know when total acceleration (see Equation 1) has stayed below a given threshold for a certain amount of time. In motion detection, though, you generally want to know when acceleration on one or more axis is above a threshold for a certain amount of time. However, total acceleration in the KXCNL is calculated with an approximation formula (see Equation 2). The calculated total acceleration vector length result is filtered (if enabled) with an adjustable Band Pass filter.

$$a_{total} = \sqrt{x^2 + y^2 + z^2}$$

Equation 1: Total Acceleration

$$a_1 = |x| + |y| + |z|$$

$$a_2 = \max(|x|, |y|, |z|)$$

$$v_{raw} = (45 * a_1 + 77 * a_2) / 256$$

Equation 2: Approximation for Total Acceleration

In evaluating free-fall detection, consider that when a tri-axis accelerometer is stationary, its total acceleration measures 1g (9.8 m/s^2), regardless of orientation. When a tri-axis accelerometer is dropped in any orientation, it is in free-fall and the measured acceleration on all three axes is 0g. Therefore, the total vector is zero as well. Total vector can be monitored by the state programs to determine if the accelerometer has been dropped.

Similarly, for motion detection, in order for all three axes to be equally sensitive when triggering a motion interrupt, we need to take out the gravitational component. When a tri-axis accelerometer is moved in any direction that yields a stimulus greater than a pre-defined threshold, it is deemed to be in motion and an interrupt will be sent.

Free-fall and motion-detection algorithms, along with many others, can each be described as a finite state machine. The KXCNL supports this type of decoding without CPU intervention because of its two highly configurable state machines with up to 16 states each, where the behaviour of each state can be individually configured.

Furthermore, Willow offers an Accelerometer USB Development Kit that can be used to quickly begin the development of applications and firmware that incorporate accelerometers, including the KXCNL. The Development Kit provides a common interface to Kionix evaluation boards. The applications and utilities supported by the development kit include SensorScope (to monitor real-time data coming from the attached sensor), SensorCalc (to test and calculate the zero-g offset and sensitivity parameters of the accelerometer) and SensorMap (to read and write to specific registers of the accelerometer). From a hardware perspective, there are no physical changes with the KXCNL that would affect how you use Development and Evaluation kits with this part.

Additional guidance regarding example state programs, a detailed description of Conditions and Commands usage and information on which registers to program (including required theory, equations and sample event signature), can be found on our website in our "Getting Started with the KXCNL" application note.

For what applications would you use the KXCNL?

The KXCNL's dual user-programmable state machines allow users to implement a wide range of recognition algorithms, such as wake-up, free-fall, screen orientation, Tap/Double-Tap, step recognition and more. Currently, Kionix provides algorithms for Tap/double-tap, screen orientation, free-fall and motion detection.

Editor Information

Founded in 1989, Willow Technologies is located in Copthorne, West Sussex in the UK. We provide electronic solutions to customers by designing, manufacturing and supplying components and systems globally to the electrical and electronic marketplace. Specialists in switching, sensing, resistive and hermetic seal solutions we have a wide portfolio of sensing technologies and over 100 years of application experience. Our in-house engineering capability and rapid prototyping facility for custom parts enable us to develop products to match specific application requirements. Willow is ISO9001:2000 registered.

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