Introduction

Self Test is a standard feature in Kionix MEMS accelerometers that enables our customers to verify that the part is functional. However the customer must use the proper algorithm to ensure functionality. Applicable theories, plots, and equations are provided with this note as guidelines.

Self Test Function

The accelerometer's self test is activated when 'logic high or 1' is applied to the ST pin or when commanded digitally via I^2C or SPI. Once activated, an electrostatic force is applied to the sense element that causes the mass to move and the outputs to change, as shown in Figure 1. The product specification states the expected amount of output change. The self test function exercises the sense element and portions of the ASIC. The output change of the self test function is modified by the internal Low Pass Filter (LPF), where applicable, and any external low pass filter.

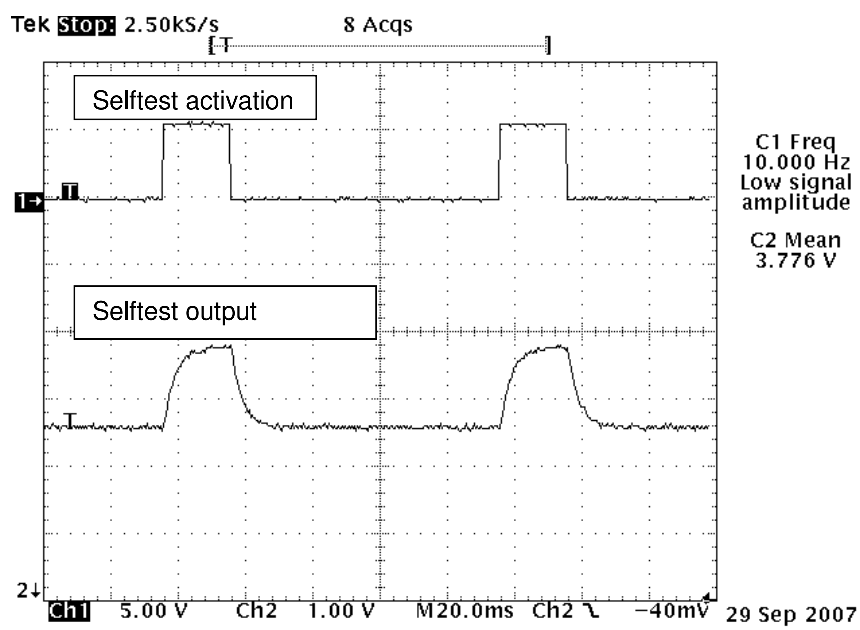

Figure 1: Selftest Function for KXR94 ±1.5g

Figure 1. An example of the self test output with a 50Hz external LPF. The self test is actuated at 10 Hz and 25% duty cycle.

Recommended Self Test Algorithm

1. Check the outputs under normal operation. At this time, the carrier voltages on the sense element are balanced so the only force on the sensor is from acceleration.
2. Self test sequence
   a. A microcontroller activates self test by applying a voltage greater than 0.8*Vdd to the ST pin or by turning on the ST bit in the appropriate control register.
   b. The carrier voltages are adjusted to create a net electrostatic force on the sense element.
   c. The sense element is deflected and a subsequent change in capacitance (ΔC) occurs.
   d. This ΔC is amplified and converted to an output voltage by the charge amplifiers of the ASIC. For a digital part, this voltage is fed into an analog-digital converter.
   e. Measure the outputs after a delay determined by the bandwidth of the LPF. Note this response is superposed on any acceleration.
   f. Deactivate self test by applying a voltage less than 0.2*Vdd to the ST pin or by turning off the ST bit in the appropriate control register. The accelerometer outputs return to normal operation after the appropriate delay time.
3. Compute the self test response. The output measured with self test off is subtracted from the output measured with the self test on. This delta is divided by the sensitivity of the part to compute the self test response in g's, as shown in the following equation:

$$ST(in\ g) = \frac{\left(Output_{STon} - Output_{SToff}\right)}{Sensitivity}$$

This self test response should be compared to the product specification to determine if the product is functioning correctly.

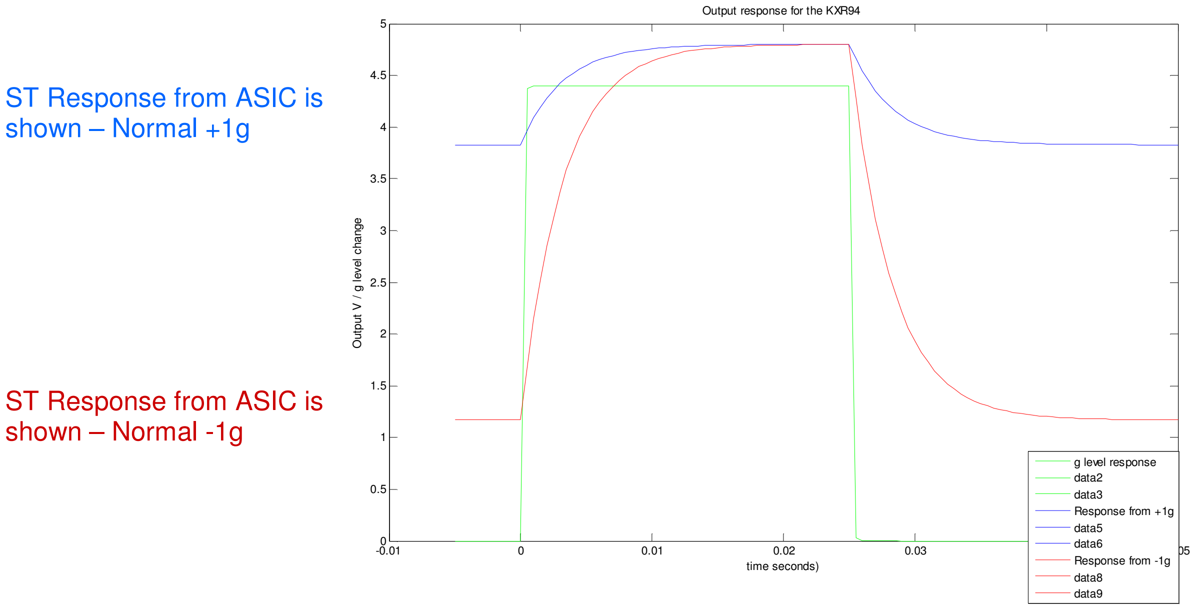

Figure 2. An example of the output response for the KXR94. In this example, the KXR94 is operating at 5V with a sensitivity of 1.33 V/g

Response Time

The self test response time is determined by the low pass filter on the outputs. For an RC filter, it takes 1 time constant (τ) to achieve 63.2% of the voltage change. As shown in the figure below, it takes 5 time constants to achieve 99.3% of the output voltage change.

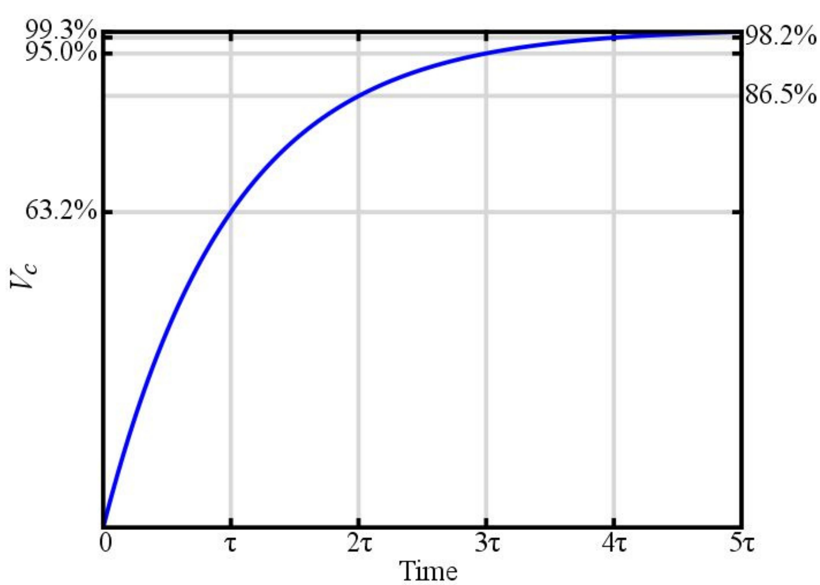

Figure 3. The output response of an RC filter to a step function change in input voltage

Thus, the response time is defined as 5 RC time constants. The table below shows typical LPF cutoff frequencies and their associated response times.

LPF cutoff frequency	RC time constant	Response time
1000 Hz	0.16 ms	0.8 ms
500 Hz	0.32 ms	1.6 ms
250 Hz	0.64 ms	3.2 ms
100 Hz	1.6 ms	8 ms
50 Hz	3.2 ms	16 ms
25 Hz	6.4 ms	32 ms
10 Hz	16 ms	80 ms

When performing self test checks on the accelerometer, it is critical that the measurements after activation or de-activation are delayed by a time greater than or equal to the response time of the output filter.

Self Test Response Specifications

The self test response of each accelerometer that Kionix has to offer varies from product to product. For a given product, the self test response will vary greatly with operating voltage. For this reason in the product specifications you will be able to find the typical self test response along with the min/max self test response values so you can verify that the product is working properly. This feature is a plus for customers that are not able to flip or rotate to verify that the accelerometer is functioning within specification.

The Kionix Advantage

Kionix technology provides for X, Y, and Z-axis sensing on a single, silicon chip. One accelerometer can be used to enable a variety of simultaneous features including, but not limited to:

Hard Disk Drive protection
Vibration analysis
Tilt screen navigation
Sports modeling
Theft, man-down, accident alarm
Image stability, screen orientation & scrolling
Computer pointer
Navigation, mapping
Game playing
Automatic sleep mode

Theory of Operation

Kionix MEMS linear tri-axis accelerometers function on the principle of differential capacitance. Acceleration causes displacement of a silicon structure resulting in a change in capacitance. A signal-conditioning CMOS technology ASIC detects and transforms changes in capacitance into an analog output voltage, which is proportional to acceleration. These outputs can then be sent to a micro-controller for integration into various applications. For product summaries, specifications, and schematics, please refer to the Kionix MEMS accelerometer product sheets at http://www.kionix.com/sensors/accelerometer-products.html.